DOE/EIS-0218F
February 1996

Volume 1

FINAL ENVIRONMENTAL IMPACT STATEMENT

on a

Proposed Nuclear Weapons Nonproliferation

Department of Energy
Washington, DC 20585

February 8, 1996

Dear Interested Party:

I am enclosing a copy of the final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel. The Department of Energy, in cooperation with the State Department, prepared the final Environmental Impact Statement.

This study analyzes the potential environmental impacts of adopting a policy to manage foreign research reactor spent fuel containing uranium enriched in the United States. In particular, the study examines the comparative impacts of several alternative approaches to managing the spent fuel. The analyses demonstrate that the impacts on the environment, workers and the general public of implementing any of the alternative management approaches would be small and within applicable Federal and state regulatory limits.

The Department's preferred approach to managing the spent fuel, referred to in the study as the "preferred alternative," is for the Department to receive the spent fuel into the United States, and to manage it at the Department's Savannah River Site in South Carolina and the Idaho National Engineering Laboratory. The spent fuel would be shipped to the United States over 13 years through two military ports. The Charleston Naval Weapons Station in South Carolina would receive about one to two shipments every month beginning in 1996. The Concord Naval Weapons Station in California would receive far fewer shipments (as few as five shipments over a 13-year period) beginning in 1997.

The final Environmental Impact Statement is a three-volume document, approximately 4000 pages in length. Volume 1 (494 pages) describes the policy considerations of adopting a policy to manage foreign research reactor spent fuel, and the potential environmental impacts. Volume 2 (1111 pages) contains eight appendices relating to the technical analyses. Volume 3 (2230 pages) contains the public's comments on the draft Environmental Impact Statement, the Department's responses to those comments, and summaries of the 17 public hearings held throughout the United States during the 90-day comment period on the draft.

If you would like another copy of the entire study, a particular volume, or an additional copy of the Summary, we would be pleased to send it to you. Please let us know by calling the Department's Center for Environmental Management Information at 1-800-736-3282 (toll-free). The entire document will be placed in the public reading rooms and information locations listed in the Summary.

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The Department will not make a final decision on whether to adopt the proposed policy until late March 1996. Thank you for your interest in this proposed action.

Sincerely,

Thomas P. Grumbly
Assistant Secretary for
Environmental Management

Enclosure

Cover Sheet

Responsible Agencies: Lead Agency: United States Department of Energy
Cooperating Agency: United States Department of State

Title: Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel

Contact: For further information, concerning this Final Environmental Impact Statement, contact:

Charles Head, Program Manager
Office of Spent Nuclear Fuel Management (EM-67)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

For general information on the United States Department of Energy's National Environmental Policy Act process, call 1-800-472-2756 to leave a message, or contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance (EH-42)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
202-586-4600

Abstract: The United States Department of Energy and United States Department of State are jointly proposing to adopt a policy to manage spent nuclear fuel from foreign research reactors. Only spent nuclear fuel containing uranium enriched in the United States would be covered by the proposed policy. The purpose of the proposed policy is to promote U.S. nuclear weapons nonproliferation policy objectives, by seeking to reduce and eventually eliminate highly-enriched (weapons-grade) uranium from civilian commerce worldwide. Environmental effects and policy considerations of three Management Alternative approaches for implementation of the proposed policy are assessed. The three Management Alternatives analyzed are: (1) acceptance and management of the spent nuclear fuel by the Department of Energy in the United States, (2) facilitate the management of the spent nuclear fuel at one or more foreign facilities (under conditions that satisfy United States nuclear weapons nonproliferation policy objectives), and (3) a combination of elements from one or both of Management Alternatives 1 and 2 (Hybrid Alternative). A No Action Alternative is also analyzed.

For each Management Alternative, there are a number of implementation alternatives. For Management Alternative 1, this document addresses the environmental effects of various implementation alternatives, such as varied policy durations, management of various quantities of spent nuclear fuel, chemical separation, developmental treatment and/or packaging technologies, and differing financing arrangements. Environmental impacts are also examined at various potential ports of entry, along truck and rail transportation routes, at candidate management sites, and for alternate storage technologies. For Management Alternative 2, this document addresses the environmental effects of two implementation alternatives: (1) assisting foreign nations with storage; and (2) assisting foreign nations with reprocessing

of the spent nuclear fuel. With respect to Management Alternative 3, an example Hybrid Alternative is analyzed wherein a portion of the spent nuclear fuel would be processed at overseas facilities and the remaining portion would be managed in the United States.

The United States Department of Energy and United States Department of State, in consultation with other government agencies, designate the acceptance and management of the foreign research reactor spent nuclear fuel in the United States (i.e., Management Alternative 1 with modifications to several basic implementation elements) as the preferred alternative.

Public Comments: The public comment period on the Draft EIS was conducted from April 21, 1995 to July 20, 1995. During this period, DOE held 17 public hearings in the locations most likely to be directly affected by the EIS alternatives, including the 10 candidate ports of entry and 5 candidate spent nuclear fuel management sites. In addition, a public hearing was held in Washington, D.C. The Draft EIS was made available to the public through mailings, requests to DOE's Environmental Management Information Center, and at DOE Public Reading Rooms and other designated information locations.

Foreword

This Final Environmental Impact Statement presents an evaluation of policy considerations and potential environmental impacts resulting from the U.S. Department of Energy and the U.S. Department of State joint proposal to adopt a policy to manage spent nuclear fuel from foreign research reactors. Only spent nuclear fuel that contains uranium enriched in the United States would be covered by the proposed policy. The purpose of the proposed policy would be to promote nuclear weapons nonproliferation objectives of the United States, specifically by seeking to reduce, and eventually to eliminate, highly-enriched (weapons-grade) uranium from civil commerce worldwide. This policy is jointly proposed by the U.S. Department of Energy and the U.S. Department of State. This document was prepared in compliance with the National Environmental Policy Act and in accordance with regulations issued and published by the Council on Environmental Quality (40 CFR Parts 1500-1508) and the U.S. Department of Energy (10 CFR Part 1021).

Environmental effects and policy considerations of several alternative approaches for implementation of the proposed policy are assessed. Three Management Alternatives are analyzed: (1) acceptance and management of the spent nuclear fuel by the Department of Energy in the United States; (2) facilitate the management of the spent nuclear fuel at one or more foreign facilities under conditions that satisfy United States nuclear weapons nonproliferation policy objectives; and (3) a combination of components of Management Alternatives 1 and 2 (Hybrid Alternative Example). A No Action Alternative is also analyzed.

For each Management Alternative, there are a number of alternatives for its implementation. For Management Alternative 1, this document addresses the policy implications and environmental effects of various implementation alternatives such as varied policy durations, management of various quantities of spent nuclear fuel, and differing financing arrangements. Environmental impacts at various potential ports of entry, along truck and rail transportation routes, at candidate management sites, and for alternate storage technologies are also examined. For Management Alternative 2, this document addresses two subalternatives: (1) assisting foreign nations with storage; and (2) assisting foreign nations with reprocessing of the spent nuclear fuel. With respect to Management Alternative 3, a hybrid alternative example is analyzed, utilizing the analysis provided for Management Alternatives 1 and 2, wherein a portion of the spent nuclear fuel would be processed at overseas facilities and the remaining portion would be managed in the United States.

A Notice of Intent to prepare this document was published in the Federal Register on October 21, 1993. Nine public scoping meetings were conducted during November and December of 1993. The period for acceptance of public comments on this document closed on December 8, 1993. However, the United States Department of Energy continued to accept written comments through January 31, 1994. In October 1994, the Implementation Plan for this Environmental Impact Statement was issued to provide guidance for its preparation and to record the U.S. Department of Energy's disposition of comments received during the scoping process.

The Draft Environmental Impact Statement was issued in April 1995. The public comment period on the Draft Environmental Impact Statement was from April 21, 1995 to July 20, 1995. During this period, DOE held 17 public hearings in the locations most likely to be directly affected by the EIS alternatives, including the 10 candidate ports of entry and 5 candidate spent nuclear fuel management sites. In addition,

a public hearing was also held in Washington, D.C. The Draft EIS was made available to the public through mailings, requests to DOE's Environmental Management Information Center, and at DOE Public Reading Rooms and other designated information locations.

Results of the environmental analyses are presented in two volumes. Volume 1 is composed of eight chapters. Chapter 1 gives the background description of the United States nuclear weapons nonproliferation policy and describes the purpose and need for the proposed action. Chapter 2 then states the proposed policy and describes the three Management Alternatives for its implementation. It includes a discussion of the basic implementation components of Management Alternative 1, as well as implementation alternatives that vary one component of the basic implementation of Management Alternative 1. The implementation alternatives include variations on the duration of the policy, alternative amounts of material that might be covered by the policy, and various financing alternatives. The potential ports of entry, transportation routes, candidate spent nuclear fuel management sites and storage technologies are also described. This chapter also describes Management Alternative 2, which contains two subalternatives for its implementation. Subalternative 1 is to provide assistance to foreign nations with storage of the spent nuclear fuel. Subalternative 2 is to provide assistance with reprocessing of the spent nuclear fuel at one or more foreign locations. Management Alternative 3 is also discussed in this Chapter by tiering off the evaluation and analyses provided for Management Alternatives 1 and 2. The potentially affected environment under Management Alternatives 1 and 3 is described in Chapter 3. Essential results of the environmental analyses are then given in Chapter 4

shipments of foreign research reactor spent nuclear fuel. In addition, Volume 1 and each appendix in Volume 2 provide a unique reference list to enable the reader to further review and research selected topics. The U.S. Department of Energy has established reading rooms and information locations across the United States where these references may be reviewed or obtained for review through interlibrary loan. The addresses and phone numbers for these reading rooms and information locations are provided at the end of the accompanying Summary.

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Acronyms and Abbreviations

BNFP	Barnwell Nuclear Fuels Plant
CFR	Code of Federal Regulations
Ci	Curie
cm	centimeter
DOE	Department of Energy
EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
E-MAD	Engine Maintenance and Disassembly
FAST	Fluorinel Dissolution and Fuel Storage
FMEF	Fuel Maintenance and Examination Facility
ha	hectare
HEU	Highly-Enriched Uranium
ICPP	Idaho Chemical Processing Plant
IFSF	Irradiated Fuel Storage Facility
ISO	International Organization for Standardization
kgTM	kilograms of Total Mass
km	kilometer
l	liter
LCF	latent cancer fatality
LEU	Low Enriched Uranium
m	meters
MACCS	MELCOR Accident Consequences Code System
MEI	Maximally Exposed Individual
mg	milligram
mg/l	milligrams per liter
mi	mile
min	minute
ml	milliliter
mm	millimeter
MOTSU	Military Ocean Terminal at Sunny Point
mrem	millirem
MTHM	Metric Tons of Heavy Metal
MTR	Material Test Reactor
NEPA	National Environmental Policy Act
NPAI	Nearest Public Access Individual
NRC	Nuclear Regulatory Commission
NWS	Naval Weapons Station
ppt	parts per thousand
rad	radiation absorbed dose
[illegible]	[illegible] Basin for Offsite Fuels

1. Introduction

Reducing the threat of the proliferation of nuclear weapons is one of the foremost goals of the United States. Proper management of spent nuclear fuel from foreign research reactors is essential to the efforts aimed at achieving these goals since much of this fuel contains highly-enriched uranium[1] (HEU), which can be directly used in simple nuclear weapons.

The concern over appropriate management of foreign research reactor spent nuclear fuel was reiterated in the Presidential Directive on Nonproliferation and Export Controls, issued by President Clinton on September 27, 1993. In particular, the Presidential Directive included the following language: "We will also seek to minimize the use of highly-enriched uranium in civil nuclear programs. To this end, the Secretary of Energy will review the need for programs to develop alternative fuels for research reactors and accelerate steps towards implementation of a policy of taking back U.S.-origin spent fuels from foreign research reactors."

1.1 Policy Background

Since 1945, every U.S. Administration has recognized that preventing the further spread of nuclear weapons must be a fundamental national security and foreign policy objective of the United States. The initial U.S. approach to nuclear technology was to classify all nuclear activities. However, the United States soon realized that it would be impossible to prevent other nations from acquiring nuclear technology.

Consequently, since the 1950's, beginning with the "Atoms for Peace" program, the United States has

and also provide a tool for fundamental scientific research. For example, research reactors are a vital tool in cancer therapy and radioimmunoassay blood testing. There are approximately 30,000 medical procedures per day in North America, 8,000 to 10,000 procedures per day in Europe, and 8,000 to 10,000 procedures per day on other continents using medical isotopes produced in research reactors in other countries. Neutron radiography provided by research reactors has enabled researchers to diagnose defects in metals and engines of many varieties and to conduct research on new materials, computer chips, and chemicals. Radioisotopes produced in research reactors have been used in leak detection in industrial components and equipment, aluminum production, and semiconductor and solar panel research. Neutron scattering experiments done in research reactors have provided insight into the biostructure of organic substances and have advanced the development of magnetic and superconducting materials. Research reactors have also been used in the environmental sciences to study waste migration, mine drainage, diffusion and transport of pollutants, water chemistry, sediment transport, atmospheric dispersion, and toxic waste management. Another important use of research reactors is irradiation testing of materials and fuel forms, including safety experimentation, to support advanced fuel design and waste management development for use in the power industry. Research reactors also have served as major training facilities in nuclear technology. For example, the research reactor operating in Austria is used by the International Atomic Energy Agency to train personnel who conduct international inspections of weapons and civil nuclear facilities worldwide.

The transfer of enriched uranium from the United States to other nations under the "Atoms for Peace" program was usually supported by a bilateral research agreement for each foreign research reactor. Before 1964, these agreements provided for the lease of the enriched uranium, with explicit provision for the return of the spent nuclear fuel to the United States. After 1964, most agreements provided for the sale of this material to the foreign nation.

After its use (irradiation) in a research reactor, the used (spent) fuel was generally returned to the United States where it was reprocessed to extract the uranium still remaining in the spent fuel. In this way, the United States maintained control over the HEU, which otherwise could be used in the production of nuclear weapons. The United States began accepting HEU spent nuclear fuel from foreign research reactors in 1958.

After 1964, the operative policy under which the United States accepted foreign research reactor spent nuclear fuel containing uranium enriched in the United States became known as the "Off-Site Fuels Policy." This policy was implemented through a series of *Federal Register* Notices issued until 1987, and was incorporated into bilateral international agreements with recipient countries. The term "Off-Site Fuels

As a part of the RERTR program, DOE developed LEU fuel and worked with foreign research reactor operators to modify their reactors to run on such fuel. The foreign research reactor operators who converted to LEU fuel did so in support of nuclear weapons nonproliferation objectives, even though such conversions were expensive and generally resulted in reductions in the capabilities of the reactors and increased operating costs.

From the beginning of the RERTR program, foreign research reactor operators made it clear that their willingness to convert their research reactors to LEU fuel was contingent upon the continued acceptance by DOE of their spent nuclear fuel for disposition in the United States. In 1986, to further encourage foreign research reactor operators to convert to LEU fuel, the DOE "Off-Site Fuels Policy" was extended to include the acceptance of spent nuclear fuel containing LEU enriched in the United States.

The RERTR program has been highly successful and many foreign research reactors have been modified to operate, or have been designed to operate, with the high-density LEU fuels developed by the RERTR program, instead of HEU fuel. Of the 42 foreign research reactors with power levels equal to or above one million watts that use U.S. enriched fuel, 37 could operate with the currently available high-density LEU fuels. Of these, 25 are either operating on LEU fuel, or have ordered LEU fuel, and DOE anticipates that an additional eight reactors will convert to LEU fuel by 2001. Work is underway to develop improved high-density LEU fuels that would enable the remaining HEU fueled reactors to convert as well. Thus, the RERTR program has contributed to a significant reduction in the use of HEU in foreign research reactors.

The RERTR [illegible] also developing the technology necessary to substitute LEU for the HEU in targets

Even if the spent nuclear fuel is kept in pristine condition (a relatively straightforward task given the resources and determination to store it correctly), the accumulation of large quantities of spent nuclear fuel containing HEU raises the possibility that some of the spent nuclear fuel might be stolen and its uranium diverted into a nuclear weapons program. In addition, spent nuclear fuel storage is an expensive undertaking (partially so because of the steps needed to avoid the problems outlined above) and is limited by local regulation in many countries. As a result, the cessation of the U.S. acceptance of foreign research reactor spent nuclear fuel associated with the expiration of the "Off-Site Fuels Policy" has created significant problems for the research reactor operators and has undercut the perceived reliability of the United States as a partner in peaceful nuclear cooperation, a cornerstone of U.S. nuclear weapons nonproliferation commitments enshrined in the *Treaty on the Non-Proliferation of Nuclear Weapons*.

With respect to the broader role that the United States plays in worldwide peaceful nuclear cooperation, President Reagan warned as early as July 1981, that "if we are not such a partner, other countries will tend to go their own ways and our influence will diminish. This would reduce our effectiveness in gaining the support we need to deal with proliferation problems." (Statement on the U.S. Nuclear Nonproliferation Policy, July 16, 1981.) More recent correspondence from the United States National Security Council, Department of State, Department of Defense, and the Nuclear Regulatory Commission (NRC) underscores the importance and urgency of support for the RERTR program objectives and the need for immediate action to reduce the use of HEU in civil programs. For example, in a recent letter to Secretary of Energy Hazel R. O'Leary, Secretary of State Warren Christopher stated, "The spent fuel acceptance policy which the EIS supports is central to our goal of preventing the spread of nuclear weapons -- and therefore to a major national security objective of this administration" (see Appendix G).

If the United States does not accept the foreign research reactor spent nuclear fuel, some of the foreign research reactors may be forced to shut down, as they will have no way to store any additional spent nuclear fuel. Other research reactor operators may have the option of reprocessing[2] their spent nuclear

HEU fuels. Hence, if the research reactors decide to use reprocessing as it has been managed up to this point to prevent backlogs of spent nuclear fuel from building up, they would have to continue to use HEU fuels. This could result in reactor operators delaying or canceling plans to convert to LEU, or in some cases, withdrawing from the RERTR program and reconverting from LEU to HEU fuels. The United Kingdom Atomic Energy Authority is considering adding an LEU processing capability to its plant in Dounreay. At this time, it is not clear that this plant will continue to operate. If the Dounreay facility continues to operate and if an LEU reprocessing capability is installed, that would mean that Dounreay customers could operate their research reactors on LEU.

If some foreign research reactor operators were to withdraw from the RERTR program and rely instead on HEU fuels, with attendant lower costs and enhanced performance, other research reactor operators would be under pressure to convert to the use of HEU for competitive reasons. Since the United States, under the Energy Policy Act of 1992, is barred from exporting HEU to virtually all foreign research reactors, research reactor operators seeking continued use of HEU would be forced to seek alternate suppliers. Russia and China are sources of HEU; and, should they choose to provide a ready supply of HEU, many foreign research reactor operators would be forced to consider abandoning the RERTR program and reconverting to HEU. In addition, the United States is currently attempting to convince Russia and China to implement programs similar to the United States' RERTR program to encourage their nuclear fuel customers to phase out use of HEU in their research reactors. However, if the United States cannot convince those countries to which it has exported nuclear fuel to stop using HEU, the United States would stand little chance of convincing Russia and China to do so with the countries to which they export nuclear fuel.

Additionally, several developed countries involved in the RERTR program are exporters of research reactors. In recent years, they have required that reactors exported to other countries be fueled with LEU. However, if foreign research reactor operators begin delaying or canceling plans to convert to LEU, and thereby continue to use HEU, foreign research reactor purchasers would demand HEU-fueled reactors. This could lead to renewed international commerce in weapons-usable HEU, and would be antithetical to the policy goal of seeking to minimize and eventually eliminate the civil use of HEU.

Another crucial consideration in proposing to accept spent nuclear fuel shipments from foreign research reactors is the *Treaty on the Non-Proliferation of Nuclear Weapons*. The Non-Proliferation Treaty is the basis for the world's nuclear weapons nonproliferation regime. The purpose of the Non-Proliferation Treaty is to keep the number of countries with nuclear weapons from growing. Five countries acknowledge having nuclear weapons: the United States, Russia, the United Kingdom, France, and China. In addition to the five acknowledged nuclear weapons States, 175 other nonnuclear weapons States are members of the treaty. The obligations for compliance with the Non-Proliferation Treaty apply to both nuclear weapons States and nonnuclear weapons States. While nonnuclear weapons States agree not to pursue development or acquisition of nuclear weapons or other nuclear explosive devices, the nuclear weapons States commit to the eventual elimination of their nuclear weapons arsenals and to assist nonnuclear weapons States with peaceful applications of nuclear energy. The Off-Site Fuels Policy and RERTR program are examples of how the United States has helped other nations with peaceful applications of nuclear energy in the past.

The parties to the Non-Proliferation Treaty met in May of 1995 and agreed by consensus to extend the treaty indefinitely and without conditions. Making this vital treaty a permanent part of the international nonproliferation regime was an important U.S. foreign policy achievement. One key to the success of the 1995 Non-Proliferation Treaty Conference was the ability of the United States to convince other

Non-Proliferation Treaty parties that the nuclear weapons States were in compliance with their obligations under Article IV of the Non-Proliferation Treaty to assist the nonnuclear weapons States with applications of nuclear energy for peaceful purposes.

Although the Non-Proliferation Treaty was extended indefinitely at the 1995 Non-Proliferation Treaty Conference, the parties also agreed to review the treaty every five years to ensure that all parties are in compliance. Any country which has been compelled to shut down its research reactors, or has been forced to seek reprocessing, could accuse the United States of not having fulfilled its treaty obligations. This

the RERTR program (to develop high-density LEU fuels to replace the HEU fuels). The United States also previously prevented the development of foreign stockpiles of HEU in foreign research reactor spent nuclear fuel by conducting the "Off-Site Fuels Policy" (i.e., by accepting the spent nuclear fuel into the United States and reprocessing it).

To illustrate the level of concern that exists regarding the proposed action, DOE has received letters from the U.S. Department of State, the Nuclear Regulatory Commission, the Arms Control and Disarmament Agency, the International Atomic Energy Agency, and the foreign research reactor operators, all urging DOE to resume acceptance and management of foreign research reactor spent nuclear fuel. Failure to manage this spent nuclear fuel would encourage international commerce in HEU.

HEU fuel in research reactors is more of a proliferation concern than the plutonium in these reactors for three reasons.

First, it is much easier to fashion a simple nuclear weapon out of HEU than plutonium. The chemical separation of HEU metal from HEU spent nuclear fuel would be simpler than the chemical separation of plutonium metal from LEU spent nuclear fuel. HEU is also less radioactive than plutonium, so it presents less of a health hazard to the people working with it. Furthermore, pure plutonium metal is extremely pyrophoric; that is, small chips of pure plutonium metal can ignite spontaneously unless the metal is handled very carefully in special facilities. All these problems with plutonium make HEU fuel a more attractive target for diversion into a nuclear weapons program.

Second, the amount of HEU that would be removed from current civil commerce under the proposed action is much greater than the amount of plutonium that would be produced in replacement LEU fuel elements in the same reactors. The proposed action involves the removal of approximately 4.6 metric tons (5.1 tons) of HEU. For comparison, the plutonium that would be produced in the replacement LEU [illegible] extracted only about 120 kg (265 lb)

Second, some of the foreign research reactors might continue operating and allow their inventory of spent nuclear fuel to build up, much of it containing HEU. The United States could, theoretically, assist such countries (and those with shutdown reactors still holding spent nuclear fuel) in building modern, diversion-resistant spent nuclear fuel storage facilities. This could be extremely expensive, as there are approximately 104 research reactors located in 41 foreign countries. Furthermore, even if perfectly secure storage facilities were built, all that would be required to frustrate their function would be a coup or other change in government leaving a regime in power that is unconcerned about the proliferation of nuclear weapons. Then the spent nuclear fuel could be diverted into a weapons production program, despite the storage assistance that had been provided by the United States. It seems clear that the potential for such an event to occur would increase with the number of spent nuclear fuel stockpiles that are allowed to build up around the world and the length of time they exist.

Finally, some foreign research reactors would be likely to reprocess their spent nuclear fuel. Much of the U.S.-origin enriched uranium was exported under agreements that require prior consent by the United States before the spent nuclear fuel can be shipped to another country, as would be required for almost all reprocessing of foreign research reactor spent nuclear fuel containing uranium enriched in the United States. However, approximately 50 percent of the foreign research reactor spent nuclear fuel is located in countries where such prior consent is not required. The current practice of the most likely reprocessing plant (i.e., the facility in Dounreay, Scotland) is to allow the customer (i.e., the foreign research reactor operator) to specify the form of the separated uranium and its disposition. Thus, the foreign research reactor operator could specify that any separated HEU should be returned as HEU. Furthermore, neither Dounreay nor any other reprocessing facility currently accepts or has the capability to reprocess the high-density LEU fuels that the United States is encouraging foreign research reactors to use to replace the HEU fuels. Thus, in the absence of action to resolve the questions of the disposition of spent nuclear fuel, outlined above, any foreign research reactor operator that reprocesses to control the inventory of spent nuclear fuel must continue to use, or convert back to, fuel containing HEU. Reprocessing under these circumstances leads to perpetuation of the HEU fuel cycle.

While there is some danger of diversion of the HEU in the spent nuclear fuel while it is in storage, the threat is relatively low since the uranium is an integral part of the solid metal spent nuclear fuel elements and is mixed with highly radioactive fission products. A sophisticated chemical processing plant would be required to separate the uranium and convert it into a form suitable for use in a nuclear weapon. However, once the uranium has been separated from the spent nuclear fuel in a reprocessing plant, the situation is fundamentally changed. Any HEU separated in a reprocessing plant would be readily usable for nuclear weapons production, essentially the same as fresh HEU that has never been in a reactor. Therefore, despite U.S. confidence in the capability and determination of the United Kingdom and France to properly safeguard any separated HEU in their reprocessing plants, once the uranium leaves their facilities, the potential for illegal diversion of the material during transit or in the country of destination increases markedly. The rate of increase for potential diversion depends both on the countries and international waterways through which the material must be shipped, the country of final destination, and the number and size of the shipments being made.

Although it is unlikely that all the HEU that has been exported can be recovered or blended down to LEU through the proposed action, it is in the best interest of the United States to make every effort to ensure the

By proposing a policy for management of certain foreign research reactor spent nuclear fuel, DOE and the Department of State do not seek to indefinitely accept or otherwise manage spent nuclear fuel from foreign research reactors. Rather, the purpose of the proposed new policy is to remove as much U.S.-origin HEU as possible from international commerce while giving the foreign research reactors and their host countries time to convert to operation with LEU fuel and make their own arrangements for disposition of subsequently generated LEU spent nuclear fuel. The foreign research reactor operators and countries in which the research reactors are operating must be prepared to implement their own arrangements for disposition of their spent nuclear fuel after the policy expires.

1.3 Scope of the Environmental Impact Statement (EIS)

This EIS evaluates the potential environmental impacts that could result from the DOE and Department of State joint proposal to adopt a policy to manage spent nuclear fuel from foreign research reactors. Only spent nuclear fuel containing uranium enriched in the United States would be covered by the proposed policy. The purpose of the proposed policy is to promote U.S. nuclear weapons nonproliferation policy objectives, specifically by seeking to reduce, and ultimately eliminating, HEU from civilian commerce. This EIS identifies and evaluates the potential environmental impacts of management alternatives to the proposed action. Implementation of Management Alternative 1 to the proposed action could include the receipt of foreign research reactor spent nuclear fuel at one or more U.S. marine ports of entry, overland transport to one or more DOE sites, and management (interim storage and ultimate disposition) in the United States. DOE will also analyze near-term chemical separation as an alternative to storing the intact spent nuclear fuel pending ultimate disposition.

Under Management Alternative 1 to the proposed action, DOE would accept or otherwise manage spent nuclear fuel containing HEU and LEU from 41 foreign nations, if such spent nuclear fuel is already discharged[4] or would be discharged within the 10-year policy period. Figure 1-1 displays the geographic locations of these nations. The United States would bear the full cost for the management of the foreign research reactor spent nuclear fuel from developing nations.[5] For developed nations, however, the United States would charge a fee for spent nuclear fuel management activities conducted by the United States.[6]

DOE recognizes that Figure 1-1 lists nations that would currently not be considered to be nuclear weapons proliferation risks. History indicates that the United States cannot predict today, with assurance, which countries may develop into proliferation risks in the future. On the other hand, there are good reasons for accepting spent nuclear fuel from nations that are in accord with U.S. nuclear nonproliferation goals, and that have stable governments and excellent nonproliferation credentials. First, several of these countries manufacture research reactors for sale to third world countries. If the United States refuses to help these countries with the management of the spent nuclear fuel from their research reactors, several of their reactors are likely to convert to use of HEU for fuel. If that occurs, their customers in the third world countries would probably also demand to be supplied with reactors fueled with HEU.

Second, both the Soviet Union and China also exported research reactors in the past. The United States is currently engaged in discussions to convince Russia (as the successor supplier to the Soviet Union's allies) and China to work with their nuclear fuel customers to convert their research reactors from HEU to LEU.

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4 *"Discharged" refers to removal of irradiated fuel from a reactor.*

5 *Developing nations are defined by the World Development Report as having other than high-income economies (World Bank, 1994).*

6 *For purposes of determining which nations are eligible for assistance from the United States in handling their foreign research reactor spent nuclear fuel, Taiwan is considered to be in the high-income economy category.*

ies (World Bank, 1994)

re Expected to Generate Spent
e United States

If the United States were to take action that caused its nuclear fuel customers to reconvert their research reactors to HEU, that would likely ensure the failure of U.S. efforts to get Russia and China to encourage their nuclear fuel customers to switch to LEU.

A second alternative (Management Alternative 2) for implementation of the proposed action has been identified and evaluated in this EIS. This alternative includes two subalternatives: (1) to provide assistance to foreign nations with storage of their spent nuclear fuel overseas, and (2) to provide non-technical assistance (financial and/or logistical) in the reprocessing of their spent nuclear fuel. The third alternative (Management Alternative 3) would consist of a combination of various elements of Management Alternatives 1 and 2. For example, a portion of the spent nuclear fuel could be managed overseas, and the remaining portion could be managed in the United States. A No Action Alternative is also evaluated in this EIS.

Under any of these action alternatives, no definitive proposals can be specified at this time for management of the foreign research reactor spent nuclear fuel beyond a 40-year interim management period because insufficient data are available to allow future management proposals to be defined, or for the potential environmental impacts of the final disposition of spent nuclear fuel to be evaluated. As a result, the EIS analysis for the time period beyond 40 years is qualitative rather than quantitative. The qualitative assessment includes consideration of disposal of intact foreign research reactor spent nuclear fuel, as well as disposal of vitrified high-level waste resulting from chemical separation of foreign research reactor spent nuclear fuel.

Certain potential actions discussed in this EIS will depend on decisions to be made under other National Environmental Policy Act (NEPA) analyses. Specifically, the site at which the foreign research reactor

1.4 Decisions to be Made Based on this EIS

The principal policy decision for which this EIS will provide a basis is whether DOE and the Department of State should adopt a policy for the United States to manage foreign research reactor spent nuclear fuel containing U.S.-enriched uranium. A necessary part of this decision is the amount and types of foreign research reactor spent nuclear fuel to be managed under such a policy.

If a decision is made to adopt such a policy, then decisions on management implementation must also be made. This EIS is intended to provide the necessary analysis, not only for the decision on adoption of a policy, but also for decisions on management implementation of such a policy, if adopted. Should the decision be to manage the spent nuclear fuel in the United States, decisions to be made on implementation of such a policy include:

- the duration of any foreign research reactor spent nuclear fuel management policy;
- the modes of ocean and overland transport required for shipping any foreign research reactor spent nuclear fuel to be accepted into the United States;
- the ports of entry through which DOE would receive foreign research reactor spent nuclear fuel;

2. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (Programmatic SNF&INEL EIS).* Volume 1 analyzes at a programmatic level the potential environmental impacts over the next 40 years of alternatives related to the transportation, receipt, processing, and storage of spent nuclear fuel under the responsibility of DOE. This EIS was prepared in compliance with the order of the U.S. District Court for the District of Idaho [*Public Service Company of Colorado v. Andrus*, Memorandum of Opinion (December 22, 1993)]. The Final EIS and the Record of Decision were published on April 28, 1995 and May 30, 1995, respectively. This EIS formed the basis for deciding, on a programmatic level, which sites will be used for the management of the various types of spent nuclear fuel to which DOE holds title. It included the amount of foreign research reactor spent nuclear fuel that might be accepted in its assessment of potential impacts, and addressed the sites at which the foreign research reactor spent nuclear fuel could be stored if a decision is made to accept foreign research reactor spent nuclear fuel. The Record of Decision indicated that aluminum clad spent fuel will be consolidated at the Savannah River Site and non-aluminum clad fuel will be managed at the Idaho National Engineering Laboratory. On October 17, 1995, litigation with the State of Idaho was settled by stipulation of the parties and entry of a Consent Order. This settlement would provide for the transportation of up to 61 shipments of foreign research reactor spent fuel to Idaho National Engineering Laboratory prior to the year 2000, if DOE and the Department of State choose to adopt a policy of accepting such foreign research reactor spent nuclear fuel. After the year 2000, additional shipments of such spent nuclear fuel could be made to Idaho National Engineering Laboratory under the stipulated settlement and Consent Order. Notwithstanding the Record of Decision, a full analysis of all five management sites considered in the Programmatic SNF&INEL Final EIS has also been included in this EIS to maintain maximum consistency with the analysis provided in the Programmatic SNF&INEL EIS.

3. *Waste Management Programmatic EIS.* The Waste Management Programmatic EIS has evolved from the formerly named Environmental Management Programmatic EIS, as was most recently described in a *Federal Register* Notice (55 FR 42633), on August 22, 1990. The Draft Waste Management Programmatic EIS was issued in August 1995 and analyzes programmatic alternatives for DOE-wide management of five waste types: high-level radioactive waste, low-level radioactive waste, low-level mixed waste, transuranic waste, and hazardous waste. DOE expects to issue the Final Waste Management Programmatic EIS in late 1996.

4. *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.* The Spent Fuel Working Group Report, dated November 1993, presents a comprehensive assessment of the conditions of spent nuclear fuel and other irradiated materials stored at DOE facilities. Eight DOE sites were identified as containing storage facilities with major vulnerabilities that need to be resolved. The vulnerabilities identified in this report have been considered in the analysis of the actions that would be involved in management of foreign research reactor spent nuclear fuel in the United States.

5. *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities.* The Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities is a three-phased approach to remedy vulnerabilities identified in the Spent Fuel Working Group Report. The Phase-I Plan of Action, dated

February 1994, addressed 31 of 33 high-priority vulnerabilities and 48 lower-priority issues. The Phase-II Plan of Action, dated April 1994, was the product of follow-on work to the Phase-I report, and resolved a majority of the funding issues associated with spent fuel vulnerabilities. The Phase-III Plan of Action, issued in October 1994, focused on the resolution of critical policy issues and provided individual action plans that addressed all the identified vulnerabilities. In the preparation of this EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, the actions being taken to resolve these issues have been evaluated to ascertain that any existing facilities considered for use in receipt, handling, or storage of foreign research reactor spent nuclear fuel are capable of performing satisfactorily. The EIS evaluates storage capabilities and alternatives at the interim storage sites and whether potential storage sites would be capable of immediately implementing the proposed action.

6. *Interim Management of Nuclear Materials Final Environmental Impact Statement.* This EIS considers the impacts of managing nuclear materials stored at the Savannah River Site, including stabilization by separating the nuclear materials from fission and decay products in the chemical separation facilities and conversion of the resulting liquids to solids in waste and material conversion facilities, including the Defense Waste Processing Facility, the FB-, HB, and FA-Lines, and the saltstone facility. The Final EIS was issued in October 1995. A Record of Decision and Notice of Preferred Alternative was published in the *Federal Register* (60 FR 65300) on December 19, 1995. Decisions were made for the majority of materials covered by the EIS in the Record of Decision and processing Mark-16 and Mark-22 fuels and blending down the resulting HEU to LEU was identified as the preferred

in order to eliminate the proliferation risk by making the material as proliferation-resistant as spent fuel. The Savannah River Site will be analyzed in conjunction with the various alternatives for both storage and disposition. The Notice of Intent to prepare a programmatic EIS was issued in June 1994 (59 FR 31985), and the scope of the EIS was revised in April 1995 (60 FR 17344). The Draft EIS is expected in early 1996, and the Final EIS and Record of Decision are expected in late 1996.

9. *Environmental Impact Statement Evaluating Container Systems for the Management of Spent Nuclear Fuel.* This EIS was originally titled *Environmental Impact Statement for a*

The Final Programmatic EIS was completed and issued to the public in October 1995. The DOE Record of Decision was issued on December 12, 1995 (60 FR 63891) with a decision to implement the preferred alternatives.

13. *Stockpile Stewardship and Management Programmatic Environmental Impact Statement.* This EIS was originally a part of the Nuclear Weapons Complex Reconfiguration Programmatic Environmental Impact Statement. The Notice of Intent of this EIS was published on June 14, 1995 (60 FR 31291) after a prescoping workshop on May 19, 1995. This Programmatic EIS will examine activities required to maintain a high level of confidence in the safety and reliability of a reduced stockpile of nuclear weapons in the absence of underground nuclear testing. The Savannah River Site at Aiken, South Carolina, which houses the tritium loading/unloading and surveillance of tritium reservoirs, will receive the aluminum-based foreign research reactor spent nuclear fuel should the proposed action be implemented in the United States. This draft EIS is expected to be issued for public comment in February 1996.

1.6 Structure of this EIS

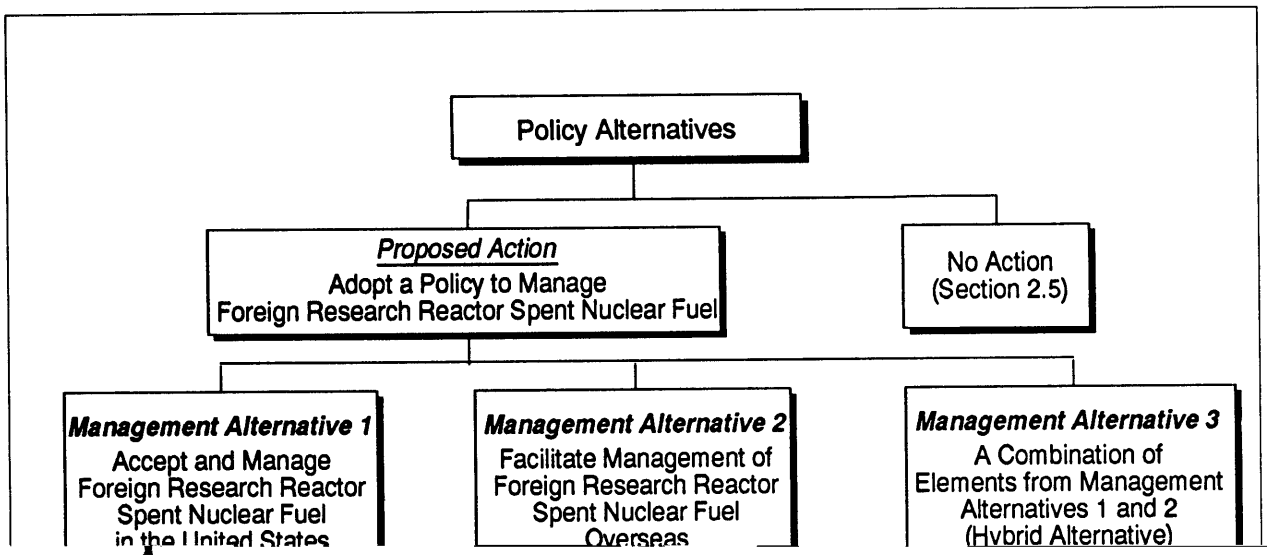
The remainder of this EIS is structured as follows:

- Chapter 2 presents the proposed action, describes management alternatives for implementation of the proposed action, alternative means of implementing each management alternative, and a No Action Alternative. Chapter 2 specifies the Preferred Alternative that has been developed by DOE and the Department of State.
- Chapter 3 characterizes the affected environments at potential ports of entry and at potential foreign research reactor spent nuclear fuel management locations.
- Chapter 4 addresses the policy considerations and the potential environmental impacts of each management alternative for implementation of the proposed action, alternative means of implementing each management alternative, and a No Action Alternative.
- Chapter 5 describes the international and domestic regulations governing radioactive materials that apply to DOE actions that might be taken under this EIS.
- Chapters 6, 7, and 8 contain primarily reference information, such as the List of Preparers, Agencies Consulted, and References, respectively.

The appendices to this document present details of the evaluations and analyses performed for this EIS.

2. Proposed Action and Alternatives

This chapter states the proposed action and describes the management alternatives analyzed in this [illegible] (EIS) for implementation of the proposed action. Environmental and


Policy Alternatives
Proposed Action
Adopt a Policy to Manage
Foreign Research Reactor Spent Nuclear Fuel
No Action
(Section 2.5)
Management Alternative 1
Accept and Manage
Foreign Research Reactor
Spent Nuclear Fuel
Management Alternative 2
Facilitate Management of
Foreign Research Reactor
Spent Nuclear Fuel
Management Alternative 3
A Combination of
Elements from Management
Alternatives 1 and 2
(Hybrid Alternative)

4. Taking title to the foreign research reactor spent nuclear fuel at the U.S. territorial waters limit (19 km or 12 mi), or continental U.S. borders for shipments from Canada.

5. Marine transport of the foreign research reactor spent nuclear fuel by chartered and/or regularly scheduled commercial ships.

6. Ports of entry that qualify on the basis of criteria discussed in this EIS.

7. Ground transport from ports of entry to storage sites, and between sites (by truck, rail, or barge, or a combination of these modes.)

8. Potential storage sites identified in the Programmatic SNF&INEL Final EIS (DOE, 1995c) for foreign research reactor spent nuclear fuel, namely the Savannah River Site, the Idaho National Engineering Laboratory, the Hanford Site, the Oak Ridge Reservation, and the Nevada Test Site.

9. Use of dry storage technology for construction of new storage facilities.

The basic implementation components are depicted in Figure 2-2 and described in Section 2.2.1. Environmental impacts and policy considerations of the basic implementation components of Management Alternative 1 are presented in Section 4.2.

Utilizing the components provided above, DOE has evaluated seven implementation alternatives for Management Alternative 1 in addition to the basic implementation. Each implementation alternative is comprised of the same components as the basic implementation; however, for the purpose of analysis, one of the components has been varied. The seven implementation alternatives are given below.

1. Acceptance of amounts of foreign research reactor spent nuclear fuel different from the amounts identified in the basic implementation.

2. Acceptance of foreign research reactor spent nuclear fuel for a period of time different from the time period identified in the basic implementation.

3. Financial arrangements different from those identified in the basic implementation.

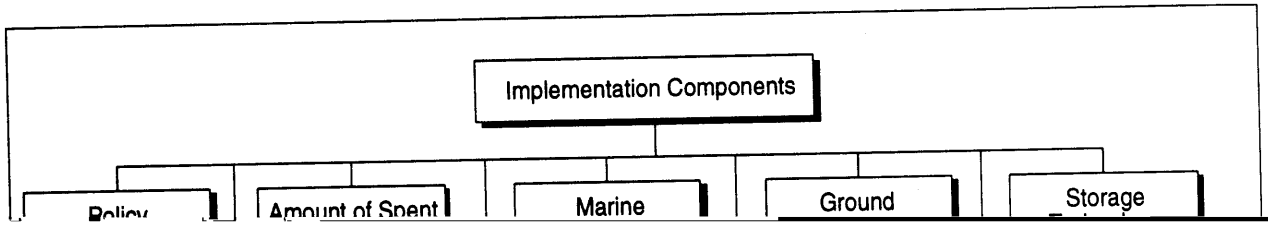
4. Taking title to foreign research reactor spent nuclear fuel at locations different from those identified in the basic implementation.

5. Use of wet storage technology for construction of new storage facilities instead of dry storage technology as identified in the basic implementation.

6. Use of near term conventional chemical separation in the United States to reduce the duration of, and amount of, spent nuclear fuel storage required.

7. Use of new developmental treatment and/or packaging technologies in addition to storage as identified in the basic implementation.

Implementation alternatives for Management Alternative 1 are discussed in Section 2.2.2. The environmental impacts and policy considerations of the implementation alternatives are discussed in Section 4.3.


Implementation Components
Policy
Amount of Spent
Marine
Ground
Storage

- Spent nuclear fuel (HEU and/or LEU) would be accepted from research reactors which operate on HEU fuel when the policy becomes effective and which agree to convert to LEU fuel. Spent nuclear fuel would not be accepted from research reactors that could convert to LEU fuel but refuse to do so.
- Spent nuclear fuel (HEU) would be accepted from research reactors having lifetime cores, from research reactors planning to shut down by a specific date while the policy is in effect, and from research reactors for which a suitable LEU fuel is not available.
- Spent nuclear fuel (HEU and/or LEU) would be accepted from research reactors that are already shut down.
- Unirradiated fuel (HEU and/or LEU) from eligible research reactors would be accepted as spent nuclear fuel.
- For research reactors with both HEU and LEU spent nuclear fuel available for shipment, LEU spent nuclear fuel would not be accepted until the HEU spent nuclear fuel is exhausted, unless there are extenuating circumstances (e.g., deterioration of one or more LEU elements sufficient to cause a safety problem).
- Spent nuclear fuel (HEU and/or LEU) would not be accepted from new research reactors starting operation after the date of implementation of the policy.

Ultimate Disposition

Ultimate disposition of DOE's spent nuclear fuel, including foreign research reactor spent nuclear fuel, is a high priority. For planning purposes, DOE has determined that its spent nuclear fuel that is not otherwise managed (e.g., chemically separated, with the high-level waste being converted into a vitrified glass for repository disposal) is authorized for disposal in a geologic repository. The Nuclear Waste Policy Act of 1982 (as amended) authorizes disposal of the foreign research reactor spent nuclear fuel in a geologic repository (if DOE takes title to such spent nuclear fuel). However, since the repository characterization program is in its early stages, the waste acceptance criteria for deposit of DOE's spent nuclear fuel in a repository have not been developed. Thus, a determination cannot be made at this time as to the requirements that must be met to allow placement of the foreign research reactor spent nuclear fuel in the repository. As a result, the EIS analysis for the time period beyond 40 years is qualitative rather than quantitative. The qualitative assessment includes consideration of disposal of intact foreign research reactor spent nuclear fuel, disposal of vitrified high-level waste resulting from chemical separation, as well as utilization of various potential new technologies to process the spent nuclear fuel into a more stable form prior to its ultimate disposition. In the event that the geologic repository schedule is delayed beyond the 40-year program period, DOE would continue to manage the foreign research reactor spent nuclear fuel or any resultant stable waste forms in existing facilities at the DOE management site(s) until a geologic repository becomes available. Decisions regarding the actual disposition of DOE's spent nuclear fuel will follow appropriate review under the National Environmental Policy Act (NEPA).

2.2 Management Alternative 1 - Manage Foreign Research Reactor Spent Nuclear Fuel in the United States

2.2.1 Basic Implementation Components

2.2.1.1 Policy Duration

The policy duration of the basic implementation of Management Alternative 1 would be 10 years, beginning on the date when the management policy becomes effective. Spent nuclear fuel containing HEU and LEU of U.S. origin that is currently being stored or is to be generated during the 10-year period of the policy would be accepted.

Actual shipments of spent nuclear fuel to the United States could be made for a period of 13 years starting from the effective date of the policy implementation, as long as the spent nuclear fuel was generated [redacted] would allow for a cooling time for fuel

Table 2-1 Estimated Number of Aluminum-Based Spent Nuclear Fuel Elements Generated by Foreign Research Reactor Operators by January 2006

Country	*Estimated Number of Spent Nuclear Fuel Elements*	*Initial Mass of Uranium (MTHM)*[a]	*Estimated Number of Shipments*

Table 2-2 Estimated Number of TRIGA[a] Reactor Spent Nuclear Fuel Elements Generated by Foreign Research Reactor Operators by January 2006

Country	*Estimated Number of Spent Nuclear Fuel Elements*	*Initial Mass of Uranium (MTHM)*[b]	*Estimated Number of Shipments*

in Appendix B. Table 2-1 shows the inventory of aluminum-based fuel clad in aluminum, while Table 2-2 shows zirconium-based TRIGA fuel clad in either aluminum or stainless steel. These two tables are combined to yield the approximately 22,700 elements (or about 19.2 MTHM) that are estimated to be currently stored or generated by the year 2005. The tables also provide the estimated number of shipments expected from each country. The number of shipments is a key parameter in evaluating the risks associated with the handling and transportation of the foreign research reactor spent nuclear fuel.

It should be noted that the number of elements and number of shipments presented for each country in Tables 2-1 and 2-2 are estimates based on projections of the numbers of elements to be generated over a ten-year period into the future. These estimates are intended to conservatively bound the total number of foreign research reactor spent nuclear fuel elements and shipments associated with the proposed policy. However, the actual distribution of elements and shipments among the listed countries might change, within the limits of the total number of elements and shipments listed, based on actual experience gained during the lifetime of any policy that may be established.

[illegible] foreign research reactor spent nuclear fuel has been categorized by fuel

2.2.1.5 Marine Transport

Under the basic implementation of Management Alternative 1, the foreign research reactor spent nuclear fuel would be shipped by chartered and/or regularly scheduled commercial ships from foreign ports to the United States. Chartered shipments would be on purpose-built ships or general purpose commercial cargo ships meeting appropriate International Marine Organization regulations. Regularly scheduled commercial shipments would be on general purpose commercial ships carrying other cargo at the same time.

Marine transport of the foreign research reactor spent nuclear fuel, as well as ground transport between ports and management sites in the United States, would be carried out in approved and certified spent nuclear fuel casks. These casks would be certified for use in the United States by the U.S. Department of Transportation if the cask was designed and fabricated in a foreign country, or by the U.S. Nuclear Regulatory Commission (NRC) if the cask was designed and fabricated in the United States. The design and fabrication of casks in a foreign country is based on the International Atomic Energy Agency standards which are the bases for those promulgated by the NRC. Marine transport activities are discussed in more detail in Section 2.6.3.

All ships entering U.S. territorial waters are required to comply with U.S. Coast Guard safety regulations and are subject to U.S. Coast Guard inspection. In addition, international transportation of hazardous material is governed by the International Movement of Dangerous Goods Code, which is one of a series of safety codes associated with the International Maritime Organization. This code establishes the international rules for shipping hazardous cargos, which includes foreign research reactor spent nuclear fuel. While most nations have agreed to follow the International Maritime Organization codes, including the International Movement of Dangerous Goods Code, compliance by individual shippers would be voluntary.

Unless DOE were to take title to the foreign research reactor spent nuclear fuel overseas (Section 2.2.2.4), the responsibility for shipping the spent nuclear fuel to the United States (if the fuel is to be accepted into the United States) belongs to the foreign research reactor operators. Under these conditions, DOE would ensure that the shipment of the spent nuclear fuel was accomplished on well-equipped, -maintained, and -operated ships through the contract that would be signed between DOE and every participating foreign research reactor operator. DOE would require the use of carriers that commit to following the International Movement of Dangerous Goods Code and all other safety requirements, such as the Safety of Life at Sea, through these contracts. If DOE were to be responsible for shipping, only shipping firms that guaranteed to follow U.S. Coast Guard regulations and international safety codes would be used to ship foreign research reactor spent nuclear fuel.

2.2.1.6 Port(s) of Entry

The basic implementation of Management Alternative 1 would involve receipt of foreign research reactor spent nuclear fuel at any of the 10 ports of entry chosen on the basis of criteria discussed in Section 2.6.3.1. All 10 candidate ports offer standard cargo container unloading services. These potential ports of entry have been identified subsequent to the application of criteria, (including appropriate experience, safe transit, adequate facilities, and population) to the universe of potential U.S. marine ports of entry. These ports are: Charleston, SC (includes Naval Weapons Station [NWS] Charleston and Wando Terminal); Galveston, TX; Hampton Roads, VA (includes Newport News, Norfolk, and Portsmouth terminals); Jacksonville, FL; Military Ocean Terminal Sunny Point (MOTSU), NC; NWS Concord, CA; Portland, OR; Savannah, GA; Tacoma, WA; and Wilmington, NC. The geographic location of each of these ports is displayed in Figure 2-3. This EIS will also assess the potential impacts of foreign

Hanford

2.2.2.1 Implementation Alternative 1 - Alternative Amounts of Spent Nuclear Fuel to be Accepted

This implementation alternative involves choosing to accept and manage one of three subalternative amounts of foreign research reactor spent nuclear fuel:

1a. Accept spent nuclear fuel (HEU and/or LEU) only from developing countries. The foreign research reactor spent nuclear fuel from these countries contains approximately 1.9 MTHM, representing 5,000 individual elements, with a volume of 13 m^3 (500 ft^3).

1b. Accept only HEU from the research reactors eligible under the proposed action. The amount of this HEU would be approximately 4.6 MTHM, representing 11,200 elements, with a volume of 61 m^3 (2,250 ft^3).

1c. In addition to foreign research reactor spent nuclear fuel, accept HEU and LEU target materials that were used in Canada, Belgium, Argentina, and Indonesia for the production of medical isotopes. Isotope production targets[3] are irradiated in research reactors and dissolved in acid or base to extract radioisotopes that are used in medical imaging applications. The residual materials after dissolution and extraction of the radioisotopes are referred to here as target material. It is expected that this target material would contain about 0.6 MTHM, representing the uranium content of approximately 620 typical foreign research reactor spent nuclear fuel elements.

Under the last subalternative, HEU target material would be accepted until a suitable LEU target is available. After such a time, target material would be accepted from a foreign research reactor only if that foreign research reactor agrees to convert to use of LEU target.

2.2.2.2 Implementation Alternative 2 - Alternative Policy Durations

The basic implementation of Management Alternative 1 has a duration of 10 years. Two policy duration subalternatives were assessed. These are:

2a. *Five-Year Policy:*

- For foreign research reactors operating on LEU fuel or in the process of converting to LEU fuel when the policy becomes effective, spent nuclear fuel (HEU and LEU) currently stored or generated during the 5-year policy period would be accepted.
- For foreign research reactors operating on HEU fuel when the policy becomes effective and agreeing to convert to LEU fuel, or having life time cores, or planning to shut down by a specific date while the policy is in effect, or for which a suitable LEU fuel is not available, HEU fuel currently stored or generated during the 5-year policy period would be accepted.
- For foreign research reactors that are already shut down, spent nuclear fuel (HEU and LEU) currently stored would be accepted.

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3 *Canada, Argentina, and Belgium currently use aluminum-based targets containing HEU, and Indonesia currently uses a target that consists of a layer of HEU oxide material plated on the interior surface of a stainless steel tube.*

The amount of spent nuclear fuel estimated to be accepted for a 5-year policy period under this subalternative is up to approximately 18,800 individual elements containing approximately 13 MTHM, with a volume of 87 m^3 (3,300 ft^3). The distribution by fuel type and geography is as follows:

- By Fuel Type: Aluminum-based — approximately 14,100 elements; 12 MTHM, 83 m^3 (3,100 ft^3).

  TRIGA — approximately 4,700 elements, 1.0 MTHM, 4 m^3 (200 ft^3).

- By Geography: Eastern — approximately 13,400 elements, 9.5 MTHM, 65 m^3 (2,400 ft^3)

  Western — approximately 5,400 elements, 3.4 MTHM, 22 m^3 (900 ft^3)

This subalternative would allow shipments and receipt of foreign research reactor spent nuclear fuel to be made for 8 years starting from the effective date of the policy implementation, as long as the fuel had been generated within the 5-year policy period. The additional 3 years would allow for a cooldown time of fuel discharged late in the 5-year period, the logistics in arranging shipment of this fuel, as well as other possible delays from strikes, court actions, and mechanical problems.

2b. *Indefinite HEU/10-Year LEU Policy:*

- For foreign research reactors operating on LEU fuel or in the process of converting to LEU fuel when the policy becomes effective, LEU spent nuclear fuel currently stored or generated in the 10-year policy period would be accepted within the time period allowed in the basic implementation (13 years). Acceptance of HEU spent nuclear fuel that had been or would be discharged from the reactor would continue indefinitely, until all such HEU spent nuclear fuel had been accepted.

- For foreign research reactors operating on HEU fuel when the policy becomes effective and agreeing to convert to LEU fuel, or planning to shut down by a specific date within 10 years of the effective date of the policy, LEU spent nuclear fuel generated in the 10-year policy period would be accepted within the time period allowed in the basic implementation (13 years). Acceptance of HEU spent nuclear fuel would continue indefinitely, until all such HEU spent nuclear fuel had been received.

- For foreign research reactors operating on HEU fuel when the policy becomes effective and for which a suitable LEU fuel is not available, or having life time cores, HEU spent nuclear fuel would be accepted:

  - from foreign research reactors with lifetime cores, until all such HEU spent nuclear fuel had been accepted, and

  - from other foreign research reactors until all HEU spent nuclear fuel at the reactor on the date the policy becomes effective, or generated within 5 years of that date, had been accepted.

- For foreign research reactors that are already shut down, the LEU spent nuclear fuel would be accepted within the period allowed in the basic implementation. The HEU spent nuclear fuel would be accepted indefinitely, until all such HEU spent nuclear fuel had been accepted.

Under this implementation subalternative, the total amount of foreign research reactor spent nuclear fuel

- Taking title to the foreign research reactor spent nuclear fuel before shipment,
- Taking title at the port(s) of entry, and
- Taking title at the management site(s).

The amount of spent nuclear fuel that would be accepted under this implementation alternative would be the same as that identified under the basic implementation or under the implementation subalternatives discussed in Section 2.2.2.1.

2.2.2.5 Implementation Alternative 5 - Wet Storage Technology for New Construction

Under the basic implementation, storage requiring new construction would employ dry storage technology. As an implementation alternative, DOE has assessed the use of wet storage technologies for new construction, which use water-filled pools to store spent nuclear fuel. Wet storage methods have been used historically at DOE sites and by the nuclear industry.

The amount of spent nuclear fuel that would be accepted under this implementation alternative would be the same as that identified under the basic implementation or under the implementation subalternatives discussed in Section 2.2.2.1.

2.2.2.6 Implementation Alternative 6 - Near Term Conventional Chemical Separation in the United States

Under this implementation alternative, near term conventional chemical separation would be conducted at either the Savannah River Site or the Idaho National Engineering Laboratory. There are both advantages and disadvantages to chemical separation of foreign research reactor spent nuclear fuel. The advantages include the following:

- The high-level radioactive waste from the foreign research reactor spent nuclear fuel would be transformed into forms that are more suitable (i.e., more compact and stable) for storage than intact aluminum-based spent nuclear fuel.
- The high-level waste would be converted to a form that is expected to be acceptable for disposal in a geologic repository.
- Construction of some or all of the new spent nuclear fuel storage space would be avoided.
- The conventional chemical separation facilities already exist, as well as the waste treatment facilities required to put the high-level radioactive and other wastestreams in forms suitable for disposal. In contrast, there are the large technical, cost, and regulatory uncertainties associated with direct disposal of intact foreign research reactor spent nuclear fuel (much of it containing HEU).
- If disposal of intact spent nuclear fuel is shown to be technically infeasible, or if the waste acceptance criteria for a geologic repository require significant dilution of the HEU due to criticality concerns, DOE estimates that the life-cycle costs of chemical separation may be substantially lower than the cost of storage and geologic disposal of intact spent nuclear fuel. (Alternatively, if direct disposal of intact foreign research reactor spent nuclear fuel,

including that containing HEU, is shown to be technically feasible, DOE estimates that the costs of chemical separation and the storage/direct disposal option would be nearly the same.)

The disadvantages include the following:

- Chemical separation would increase the total volume of the waste (including liquid high-level waste raffinates, transuranic wastes, various solid and liquid low-level wastestreams, acidic wastes, chelating and complexing agents, and solvents). Volume

Near term conventional chemical separation of foreign research reactor spent nuclear fuel at the other three potential foreign research reactor spent nuclear fuel management sites was not analyzed because the Oak Ridge Reservation and the Nevada Test Site do not have facilities in which such chemical separation could be conducted, and the facilities at the Hanford Site are no longer operable. To consider chemical

Transuranic wastes[4] would be stored on the site where the chemical separation would be accomplished until a permanent disposal facility, such as the Waste Isolation Pilot Plant, becomes available. Site treatment plans for low-level and transuranic mixed wastes are now being developed. Hazardous wastes would be sent to a licensed commercial treatment, storage and disposal facility. Saltstone, a mixture of low-level waste and concrete that is a by-product of high-level radioactive waste vitrification at the Savannah River Site's Defense Waste Processing Facility, would be pumped into above-ground concrete vaults onsite, where it would harden into a concrete monolith.

The Savannah River Site currently has chemical separation facilities. This capability, however, is limited to aluminum-based spent nuclear fuel. In contrast, the Idaho National Engineering Laboratory has facilities that can chemically separate both aluminum-based and TRIGA foreign research reactor spent nuclear fuel. However, these facilities would require some upgrades in order to accomplish this chemical separation. The existing dissolvers and calcination vessel could be used at the start of chemical separation activities, but would have to be replaced within a few years. A new tank farm and set of calcine bins would have to be built. Furthermore, this site does not have an existing vitrification facility or a glass waste storage building, as the Savannah River Site does. Upgrading the facilities at the Idaho National Engineering Laboratory would require additional time and funding. This EIS analyzes the impacts of chemically separating aluminum-based foreign research reactor spent nuclear fuel at both the Savannah River Site and the Idaho National Engineering Laboratory, but considers chemical separation of TRIGA foreign research reactor spent nuclear fuel only at the Idaho National Engineering Laboratory.

Under the near term chemical separation alternative, there are two components: Extent of the Chemical Separation and Uranium Disposition. Each of these components is discussed below.

Extent of the Chemical Separation

At each of the two potential sites, the foreign research reactor spent nuclear fuel could be chemically separated in a dedicated mode or as part of larger scale chemical separation activities.

Chemical Separation at the Savannah River Site Dedicated to Foreign Research Reactor Spent Nuclear Fuel: DOE would chemically separate all 18.2 MTHM of the aluminum-based foreign research reactor spent nuclear fuel, shown previously in Table 2-1. The Savannah River Site has facilities that could perform the chemical separation, so no new chemical separation facilities would need to be constructed.

DOE and the Department of State have included in this EIS analysis all 18.2 MTHM of aluminum-based foreign research reactor spent nuclear fuel in Table 2-1 because this is the maximum that could be considered. It is not possible to specify how much of the aluminum-based foreign research reactor spent nuclear fuel might be chemically separated before the chemical separation facilities would have been shut down, so the analysis is based on the entire amount. If chemical separation of all the foreign research reactor spent nuclear fuel were selected, existing chemical separation facilities would be required to remain operational for the 13-year duration of receipts. Maintenance and operation of a facility dedicated solely to chemical separation of foreign research reactor spent nuclear fuel is considered to be an inefficient use of such facilities. Thus, this is a nonpreferred subalternative.

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4 *No transuranic waste would be generated if the transuranic elements (mostly plutonium) were not extracted during chemical separation. The trace amounts of these elements that exist in the foreign research reactor spent nuclear fuel could remain in the high-level wastestream.*

Chemical Separation at the Idaho National Engineering Laboratory Dedicated to Foreign Research Reactor Spent Nuclear Fuel: DOE would restart the facilities and chemically separate all the aluminum-based and TRIGA foreign research reactor spent nuclear fuel, shown previously in Tables 2-1 and 2-2. The Idaho National Engineering Laboratory does not have all the facilities required to perform the chemical separation, so some new facilities would need to be constructed. Furthermore, DOE announced a Record of Decision on May 30, 1995 for the Programmatic SNF&INEL Final EIS. Chemical separation at Idaho National Engineering Laboratory was not included in this Record of Decision, so additional site-specific NEPA documentation would be required to restart these chemical separation facilities.

DOE and the Department of State have included in this analysis all 19.2 MTHM of foreign research reactor spent nuclear fuel in Tables 2-1 and 2-2, because this is the maximum that could be considered. It is not possible to specify how much of the foreign research reactor spent nuclear fuel might be chemically separated in this case, so the analysis is based on the entire amount. Up to approximately 12 years of operation would be required to chemically separate this amount. The construction and operation of new facilities for chemical separation dedicated to foreign research reactor spent nuclear fuel is considered inefficient, and therefore, this subalternative is not preferred.

Chemical Separation at the Savannah River Site as Part of Larger Scale Activities: DOE is in the process of preparing other NEPA reviews and making decisions that could affect the decisions to be made in this EIS. The Interim Management of Nuclear Materials Final EIS (DOE, 1995a) analyzed alternatives for stabilization of nuclear materials currently stored at the Savannah River Site that represent health and safety risks, as stored in their current forms and locations. The nuclear materials in the Interim Management of Nuclear Materials Final EIS that most closely resemble the aluminum-based foreign research reactor spent nuclear fuel are the Mark-16 and Mark-22 fuels. The preferred alternative for these fuels, as announced in the *Federal Register* (60 FR 65300), is chemical separation. Therefore, the near term chemical separation of aluminum-based foreign research reactor spent nuclear fuel at the Savannah River Site as part of larger scale activities is predicated upon a decision by DOE to use the chemical separation facilities at the Savannah River Site to chemically separate the Mark-16 and Mark-22 fuels under the Interim Management of Nuclear Materials Final EIS.

The Programmatic SNF&INEL Final EIS (DOE, 1995c) considered the alternative site(s) where DOE's spent nuclear fuel (including foreign research reactor spent nuclear fuel) would be managed. DOE announced in its Record of Decision on May 30, 1995 that it intends to consolidate all its aluminum-based spent nuclear fuel at the Savannah River Site. DOE could also chemically separate other aluminum-based spent nuclear fuel that is transported to the Savannah River Site under this EIS.

The aluminum-based foreign research reactor spent nuclear fuel shown in Table 2-1 would be chemically separated along with other DOE aluminum-based spent nuclear fuel selected for chemical separation. This could amount to a maximum of 18.2 MTHM of aluminum-based foreign research reactor spent nuclear fuel, 0.56 MTHM of target material under Implementation Subalternative 1c (Section 2.2.2.1), approximately 28.8 MTHM of other aluminum-based spent nuclear fuel currently stored at the Savannah River Site (Wichmann, 1995), and approximately 3.4 MTHM of aluminum-based spent nuclear fuel that could be transported to the Savannah River Site (Wichmann, 1995). In all, about 51 MTHM could be chemically separated at the Savannah River Site, requiring up to approximately 13 years of operation. The environmental impacts analysis is presented in Section 4.3.6.

Chemical Separation at the Idaho National Engineering Laboratory as Part of Larger Scale Activities: Volume 2 of the Programmatic SNF&INEL Final EIS (DOE, 1995c) includes a brief analysis of the alternative of restarting the chemical separation facilities at the Idaho National Engineering Laboratory for

stabilization of nuclear materials. These facilities are currently being cleaned up in preparation for decommissioning, so restarting them would require additional site-specific NEPA documentation, but DOE is not currently performing NEPA analysis on restarting these facilities.

Volume 1 of the Programmatic SNF&INEL Final EIS (DOE, 1995c) considered the alternative site(s) where DOE's spent nuclear fuel (including foreign research reactor spent nuclear fuel) would be managed. DOE could chemically separate other spent nuclear fuel that is transported to the Idaho National Engineering Laboratory under this EIS.

All the aluminum-based spent nuclear fuel would be chemically separated along with all the TRIGA foreign research reactor spent nuclear fuel and certain other spent nuclear fuel from the Idaho National Engineering Laboratory. The amount of aluminum-based spent nuclear fuel would be approximately 51 MTHM, as described above. The additional spent nuclear fuel would include 1.0 MTHM of TRIGA foreign research reactor spent nuclear fuel and approximately 13 MTHM of TRIGA and zirconium-based spent nuclear fuel from onsite facilities (Cottam, 1995). In all, about 65 MTHM could be chemically separated under this program at Idaho National Engineering Laboratory, requiring up to approximately 12 years of operation. The environmental impact analysis is presented in Section 4.3.6.

Uranium Disposition

Chemical separation, as the name implies, would separate the uranium from the waste products. The separated LEU could be sold to the commercial sector for reuse as reactor fuel. The HEU disposition issue is being considered in a separate DOE NEPA document, the Disposition of Surplus Highly Enriched Uranium EIS. If DOE decides to blend down the HEU that is within the scope of the Disposition of Surplus Highly Enriched Uranium EIS, then the HEU that would be recovered in this implementation alternative would also be blended down. Conversely, if DOE decides not to blend down the HEU that is within the scope of the Disposition of Surplus Highly Enriched Uranium EIS, then the HEU that would be recovered in this implementation alternative would also not be blended down. Until this decision is made, however, DOE may decide to blend down HEU in specific instances. For example, DOE recently announced its decision (60 FR 65300), to blend down the HEU solutions at the Savannah River Site under the Interim Management of Nuclear Materials Final EIS.

The options for HEU disposition at the Savannah River Site are:

1. Blending it down to less than 20 percent enrichment inside the chemical separation facilities;
2. Blending it down to less than two percent enrichment inside the chemical separation facilities and then processing it to an oxide in the existing FA-Line at the Savannah River Site; and
3. Completing construction of the Uranium Solidification Facility at the Savannah River Site, then processing the HEU directly to an oxide, followed by storage in a safe, secure facility.

The options for HEU disposition at Idaho National Engineering Laboratory are:

1. Blending it down to less than 20 percent inside the chemical separation facilities, and
2. Processing the HEU directly to an oxide.

Some minor modifications to the facility would be necessary to blend down the HEU. No modifications would be necessary to process it directly to an oxide. For either option, additional NEPA documentation would be required.

Under any of the blending down options, the nuclear weapons nonproliferation goal would be satisfied because the material would not be usable in weapons after it was blended down. This material could be returned to the commercial sector and reused in nuclear reactors.

If the HEU were not blended down, DOE and the Department of State might be accused of accepting the foreign research reactor spent nuclear fuel in order to stockpile HEU for future weapons use. To address this concern, DOE and the Department of State would, over time, place the separated HEU under International Atomic Energy Agency safeguards. DOE and the Department of State have identified three possible means of implementing this International Atomic Energy Agency safeguards initiative which would require the use of a finite storage area (Material Balance Area) subject to inspections by the International Atomic Energy Agency. These are:

1. DOE could use the only available Material Balance Area: Vault 16 at the Y-12 Plant on the Oak Ridge Reservation. This vault's capacity is about 40 MTHM of HEU and it presently contains only about 10 MTHM, so the available capacity is about 30 MTHM. Chemical separation of all the spent nuclear fuel in this implementation alternative would recover less than 25 MTHM of HEU, so there is sufficient capacity in Vault 16 to store all this material.

2. A new Material Balance Area could be set up at the Savannah River Site or the Idaho National Engineering Laboratory.

3. The HEU could be stored in existing vaults, and brought out to a temporary Material Balance Area for each International Atomic Energy Agency inspection.

If a decision is made to chemically separate the foreign research reactor spent nuclear fuel, it would be DOE's preference to blend down the HEU to LEU and thus preclude the possibility of this material ever being used in a nuclear weapon.

2.2.2.7 Implementation Alternative 7 - Developmental Treatment and/or Packaging Technologies

Under this implementation alternative, DOE and the Department of State would initiate a development program that could lead to a decision to construct and operate a new facility for treatment and/or packaging of foreign research reactor spent nuclear fuel. The purpose of this potential new facility would be to treat, package and store the foreign research reactor spent nuclear fuel in a manner suitable for geologic disposal, without necessarily separating the fissile materials. Other goals of the development process would be to define a technology and facility that would operate safely, meet or exceed all applicable environmental requirements (including minimization of waste volumes, toxicity, and mobility), and be consistent with U.S. nuclear weapons nonproliferation policies.

There are numerous technologies that DOE and the Department of State could consider under such a development program. These technologies could be applied at any one of the five potential foreign research reactor spent nuclear fuel management sites, and most would require the construction of totally new facilities (although some could be implemented through modifications to existing facilities). The potential environmental impacts of the construction and operation of such a new facility cannot be estimated at this time because the technologies are still developmental and the hypothetical new facility has not been designed. Implementation of any of these technologies would require additional NEPA analysis and documentation, including additional opportunities for public review and comment.

Many of the potentially applicable technologies are already being considered under the DOE Office of Spent Fuel Management Technology Integration Working Group. A development program, such as the one that would be implemented under this alternative, is outlined in the DOE Spent Nuclear Fuel

Technology Integration Plan (DOE, 1994c). A number of these developmental technologies have progressed beyond initial technical feasibility studies and have reasonably defined cost and schedule estimates for further development. Technologies, such as the Plasma Arc Treatment Process and the Electrometallurgical Treatment Process, are being developed by the Pacific Northwest Laboratory and the [illegible] Other developmental technologies, however, require

Dissolve and Poison: The foreign research reactor spent nuclear fuel could be dissolved in acid and a neutron poison could be added to prevent a criticality in the repository. Then the solution would be vitrified (WSRC, 1994a).

Developmental Packaging Technologies

Direct Disposal in Small Packages: This is a variation of the "direct disposal"concept. The foreign research reactor spent nuclear fuel could be packed intact into small waste packages to limit the amount of fissile material in any single package. Neutron poisons would also be packed in the packages in the spaces between the fuel element plates or rods to prevent a criticality in the repository.

Can-in-Canister: The foreign research reactor spent nuclear fuel could be canned, then the cans could be encapsulated in glass inside of canisters. The encapsulation process could be performed in the Defense Waste Processing Facility at the Savannah River Site, using a high-level waste glass. In effect, the cans containing foreign research reactor spent nuclear fuel would displace an equal volume of high-level waste glass inside standard Defense Waste Processing Facility canisters.

2.3 Management Alternative 2 — Facilitate the Management of Foreign Research Reactor Spent Nuclear Fuel Overseas

Under this management alternative, DOE and the Department of State would seek to encourage and facilitate the management of foreign research reactor spent nuclear fuel overseas in a manner that would be consistent with U.S. nuclear weapons nonproliferation policy. DOE and the Department of State have evaluated the following two subalternatives:

1a. Overseas Storage - Encourage and assist foreign research reactors that are able to store their spent nuclear fuel in facilities in their own countries, or in developing countries, as a step toward the final disposition of the spent nuclear fuel. U.S. assistance would be provided to ensure that appropriate storage technologies, regulations, and safeguards were applied.

In some cases, this subalternative might be implemented by expansion of the storage facilities located at the foreign research reactor sites. However, many foreign research reactor operators are associated with academic institutions with limited budgets, or have building restrictions for site-specific reasons (e.g., no physical space for expansion). Thus, the opportunities for expanded spent nuclear fuel storage at foreign research reactor sites may be limited or even nonexistent. In countries with established nuclear power programs, management might also be provided at the sites where such countries will store their power reactor spent nuclear fuel. Some foreign research reactor operators may also be able to make arrangements for indefinite storage at sites in developing countries. Ultimate disposition of the foreign research reactor spent nuclear fuel would still have to be arranged at the conclusion of the management period. In the meantime, foreign research reactor spent nuclear fuel containing HEU would be stored in up to 41 countries around the world.

1b. Overseas Reprocessing - Provide nontechnical (financial and/or logistical) assistance to foreign research reactors and reprocessors to facilitate reprocessing spent nuclear fuel overseas in facilities operated under international safeguards sufficient to satisfy U.S.

The advantages and disadvantages of the technology used for reprocessing overseas would be essentially the same as those described for chemical separation in the United States as discussed in Section 2.2.2.6.

The overseas reprocessing option will be evaluated in terms of whatever is supportive of the U.S. nuclear weapons nonproliferation policy on HEU minimization. For example, factors such as the following would have to be considered:

- An expectation that HEU separated during reprocessing would be blended down to LEU for research reactors which are converting to LEU.
- The foreign reprocessors would provide the capability to reprocess LEU as well as HEU.
- Research reactors would be encouraged to convert to LEU if an LEU fuel exists or is developed that will allow such operation.

Arrangements would have to be worked out with foreign reprocessors that would be supportive of U.S. nuclear weapons nonproliferation objectives to minimize the civil use of HEU worldwide.

Reprocessing of spent nuclear fuel is a well-established technology which is based on the same principles as chemical separation in the United States as discussed in Section 2.6.5.2, and an international commercial market has developed with a total annual capacity of several thousand MTHM (BNFL, 1994; Cogema, 1994). Large portions of this capacity are oriented toward commercial spent nuclear fuel. While these facilities are technically capable of reprocessing foreign research reactor spent nuclear fuel with relatively minor modifications [e.g., blending of the foreign research reactor spent nuclear fuel in the dissolver(s) with depleted uranium], for contractual, economic, and schedule considerations, these commercial spent nuclear fuel reprocessing facilities are less inclined to consider the potential foreign research reactor spent nuclear fuel market.

Several large (hundreds of MTHM per year) spent nuclear fuel reprocessing facilities exist for LEU spent nuclear fuel, and the annual capacity of existing facilities for research and HEU spent nuclear fuel is in the tens of MTHM range. The British facilities at Dounreay are currently capable of reprocessing foreign research reactor spent nuclear fuel. The French facilities at Marcoule are planning reprocessing of French research reactor spent nuclear fuel in the near future, and the Dounreay facility is pursuing additional contracts with foreign research reactor operators for reprocessing their spent nuclear fuel. The estimated schedule of foreign research reactor spent nuclear fuel shipments corresponds to a maximum of 2 MTHM per year, which could be accommodated by the existing reprocessing capacity for these fuels. Significantly, the most likely candidate facilities for reprocessing foreign research reactor spent nuclear fuel are located in Europe and are operated under Euratom and International Atomic Energy Agency safeguards. These facilities also offer full spent nuclear fuel management capabilities, including spent nuclear fuel storage prior to reprocessing, solidification of wastes, product and waste transportation, and assay adjustments (i.e., blending of HEU to LEU). Arrangements for shipment and disposition of the processing wastes would have to be implemented. Most processing contracts with European facilities require return of the wastes to the generator (in this case, the foreign research reactor operators) of the spent nuclear fuel.

DOE has considered the possibility of accepting, in the United States, the vitrified waste from the reprocessing of foreign research reactor spent nuclear fuel overseas. The environmental impacts from the receipt and storage of the waste in the United States are presented in Section 4.4.2.

2.4 Management Alternative 3 - Combination of Elements from Management Alternatives 1 and 2 (Hybrid Alternative)

In implementing the proposed action, DOE and the Department of State could combine implementation elements from the management alternatives analyzed in Sections 2.2 and 2.3. For example, DOE and the Department of State could consider partial storage or reprocessing overseas and partial storage or chemical separation in the United States. The impacts to the U.S. environment from hybrid alternatives would be bounded by the analysis presented in this EIS for each of the implementation alternatives for Management Alternative 1, because for each implementation alternative, the analysis considers the maximum amount of spent nuclear fuel that could be accepted, stored, and/or chemically separated in the United States.

For the purpose of illustration, DOE and the Department of State have considered an example of a hybrid alternative which is a combination of implementation elements of Management Alternatives 1 and 2. This hybrid alternative is described below.

Under this hybrid alternative, DOE and the Department of State would provide nontechnical (financial and/or logistical) assistance to foreign research reactor operators and reprocessors to facilitate the reprocessing of any foreign research reactor spent nuclear fuel at western European reprocessing facilities (i.e., Dounreay or Marcoule), as in Management Alternative 2, for foreign research reactors in countries that could accept back the reprocessed waste; and DOE and the Department of State would accept and manage the rest of foreign research reactor spent nuclear fuel in the United States, as in Management Alternative 1.

In order to comply with U.S. nuclear weapons nonproliferation policy, bilateral agreements would need to be established with the foreign governments involved to ensure that the conditions discussed in Section 2.3 for overseas reprocessing (Management Alternative 2, Implementation Alternative 1b) would be met before DOE and the Department of State would consider implementation of this hybrid alternative.

Based on the current capabilities of the reprocessors overseas, the spent nuclear fuel to be considered for reprocessing would be aluminum-based. TRIGA spent nuclear fuel could also be considered if such capability is developed; however, for the purposes of the analysis, TRIGA spent nuclear fuel would be assumed to be accepted in the United States for storage. Table 2-3 lists the countries that may be able to accept the reprocessing waste and the amount of spent nuclear fuel to be considered for reprocessing overseas. Table 2-4 shows the amount of spent nuclear fuel that would be accepted in the United States.

Under this hybrid alternative, the aluminum-based foreign research reactor spent nuclear fuel to be accepted in the United States would be chemically separated at the Savannah River Site as in Implementation Alternative 6, which is discussed in Section 2.2.2.6. The TRIGA spent nuclear fuel would be transported to the Idaho National Engineering Laboratory, where it would be stored at existing storage facilities until ultimate disposition. The distribution of the spent nuclear fuel considered in this hybrid alternative is consistent with the Programmatic SNF&INEL Final EIS (DOE, 1995c) Regionalization by Fuel Type alternative.

All the other components of this hybrid alternative are the same as the basic implementation of Management Alternative 1, specifically:

- a policy duration of 10 years with a period of acceptance of spent nuclear fuel in the United States of 13 years;

Table 2-3 Spent Nuclear Fuel Considered for Reprocessing Overseas (Hybrid Alternative Example)

Country	Number of Elements	Mass (MTHM)[a]
Belgium	1,766	0.730
France	1,962	3.442
Germany	1,504	0.909
Italy	150	0.043
Spain	40	0.016
Switzerland	159	0.128
United Kingdom	12	0.004
Total	**5,593**	**5.272**

[a] *To derive mass in kilograms, multiply by 1,000.*

Table 2-4 Amount and Distribution of Foreign Research Reactor Spent Nuclear Fuel to be Accepted in the United States (Hybrid Alternative Example)

Type	Number of Elements	Mass (MTHM)[a]	Number of Shipments
Aluminum-Based	12,210	12.912	406
Eastern[b]	7,593	8.647	275
Western[b]	4,617	4.263	131
TRIGA	4,940	1.033	162
Eastern[b]	3,245	0.528	107
Western[b]	1,695	0.505	55
Total	**17,150**	**13.945**	**568**

[a] *To derive mass in kilograms, multiply by 1,000.*

[b] *Refers to the location of the likely port(s) of entry to the United States.*

- a financing arrangement by which the United States would bear the full cost for transporting and managing the foreign research reactor spent nuclear fuel received from developing countries, but would charge developed countries (if any) a competitive fee;
- taking title to the foreign research reactor spent nuclear fuel at the U.S. territorial waters limit or continental U.S. borders for shipments from Canada;
- marine transport of the foreign research reactor spent nuclear fuel by chartered and/or regularly scheduled commercial ships;
- ports of entry that qualify on the bases of criteria discussed in this EIS; and
- ground transport from ports of entry to the Savannah River Site and Idaho National Engineering Laboratory by truck, rail, or barge, or a combination of these modes.

The impacts to the U.S. environment from this hybrid alternative would be bounded by the Savannah River Site portion of Implementation Alternative 6 (Near Term Chemical Separation in the United States at the Savannah River Site), which considers the acceptance of approximately 22,700 elements of foreign research reactor spent nuclear fuel in the United States versus approximately 17,100 (13.9 MTHM) elements in this hybrid alternative; the chemical separation of approximately 17,800 aluminum-based elements versus approximately 12,200 aluminum-based elements in this hybrid alternative; and the storage of approximately the same number of TRIGA elements as under the basic implementation.

The environmental impacts and policy considerations of the hybrid alternative are discussed in Section 4.5.

2.5 No Action Alternative

In the No Action Alternative, the United States would neither manage foreign research reactor spent nuclear fuel containing uranium enriched in the United States, nor provide technical assistance or financial incentives for overseas storage or reprocessing. In this case, no foreign research reactor spent nuclear fuel shipments to the United States and no assistance to foreign countries for managing foreign research reactor spent nuclear fuel overseas would take place. The No Action Alternative would have environmental impacts outside the United States which are not in the scope of this EIS. Policy considerations are discussed in Section 4.6.

2.6 Characteristics of the Components of the Basic Implementation

This section summarizes information on the selection process for some of the components of the basic implementation, as well as characteristics, assumptions and physical parameters used in the environmental impact analysis. This section provides characteristics of the spent nuclear fuel to be received, the types of transportation casks considered, the marine ports considered and method of their identification, the ground transportation routes considered, method of identification, typical characteristics of the wet and dry storage technologies, descriptions of the designs of facilities for both dry and wet storage technologies, descriptions of chemical separation facilities, and details on the site-specific options in managing the foreign research reactor spent nuclear fuel.

2.6.1 Characteristics and Types of Foreign Research Reactor Spent Nuclear Fuel

Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. Fuel in a reactor consists of fuel elements that come in many configurations; but generally consist of the fuel matrix, cladding and structural parts. The matrix, which contains the fissionable material is typically in the form of plates or cylindrical pellets. The cladding (typically zirconium, aluminum, or stainless steel) surrounds the fuel, confining and protecting it. Structural parts (generally nickel alloys, stainless steel, zirconium, or aluminum) hold the fuel elements in the proper configuration in the reactor core.

Spent nuclear fuel is radioactive because of the presence of the radioactive isotopes, which are products of the fission process. The radiation of most concern from spent nuclear fuel is gamma rays. Although the radiation levels can be very high, the gamma ray intensities are readily reduced by shielding the spent nuclear fuel elements with such materials as steel, lead, concrete, and water during the various management phases of handling, transporting, or storing the spent nuclear fuel elements.

An issue associated with the management of spent nuclear fuel containing significant amounts of fissionable material is the potential for a self-sustaining nuclear fission process called criticality. Prevention of criticality conditions enters in the design of the spent nuclear fuel transportation casks, the spent nuclear fuel storage and processing facilities, and the spent nuclear fuel packaging for ultimate disposition. In general, criticality prevention is accomplished by either controlling the amount of fissionable material present within a certain volume (dilution or spatial separation techniques) or by introducing neutron absorbing materials that reduce the number of neutrons available to the fission process (poisoning technique). The criticality issue has been addressed in all implementation alternatives considered for the management of the foreign research reactor spent nuclear fuel.

Two types of foreign research reactor spent nuclear fuel are covered under the proposed action. They are aluminum-based fuel and TRIGA reactor type fuel. The aluminum-based fuel refers to fuels that consist of an alloy of uranium and aluminum, or a dispersion of uranium-bearing compound in aluminum, both

clad in aluminum. The enrichment of uranium can be either HEU or LEU. Details on the physical and nuclear characteristics of the aluminum-based foreign research reactor spent nuclear fuel can be found in Appendix B. The aluminum-based fuels are used in various reactor types in different forms and geometries. The spent nuclear fuel element geometries are either cylindrical, boxed type, annular with hundreds of involute plates, or pin cluster. The aluminum-based fuel forms are either plates, tubes, rods, or pins. The ^{235}U[5] content of a fuel element prior to irradiation in a reactor (i.e., fresh fuel element) can vary from about 3 g (.11 oz) to about 8,500 g (300 oz). The length of an individual element can vary from 22 cm (8.7 in) to about 300 cm (118 in).

The TRIGA reactor fuel uses uranium-zirconium hydride ($U\text{-}Zr\text{-}H_x$) fuel material in which the hydrogen moderator is homogeneously contained within the fuel material. The initial ^{235}U content of each rod varies between 38 g (1.3 oz) and 133 g (4.7 oz). The overall length of a TRIGA fuel rod is approximately 76 cm (30 in), and the weight is between approximately 1 kg (2.2 lb) and about 4 kg (8.8 lb). Details on the physical and nuclear characteristics of the TRIGA foreign research reactor spent nuclear fuel can be found in Appendix B.

In contrast, a typical nuclear power reactor fuel (e.g., pressurized water reactor fuel) is three to five percent enriched uranium-oxide. The fuel form is ceramic pellets combined into rods, and the cladding is zircaloy or stainless steel. A typical pressurized water reactor fuel assembly weighs 682 kg (1,500 lb) and has a length of 389 cm (13 ft). Figure 2-5 graphically depicts the differences in size of a typical pressurized water reactor assembly, a typical aluminum-based fuel element, and a TRIGA fuel element. Additional detailed information on the aluminum-based and TRIGA fuels are provided in Appendix B of this EIS.

In addition to aluminum-based and TRIGA-type spent nuclear fuel, target material containing HEU is considered for management under Implementation Alternative 1, subalternative 1c (Section 2.2.2.1). Targets are irradiated in a research reactor to produce molybdenum-99, a medical isotope. Molybdenum production peaks at a low burnup, about three percent. Once the target is removed from the reactor, the fuel is dissolved in acid, and molybdenum-99 is separated from the solution. The residual material after removal of molybdenum-99 is called target material, and is currently kept in solution form. The target material considered for management would be put in U_3O_8 or UO_2 form and canned for transport to the United States. It is expected that the target material would contain about 0.6 MTHM (the uranium content of 620 typical Material Test Reactor [MTR] elements) and a volume of 6.5 m^3 (229.5 ft^3). This material could be brought to the United States in cans having a cavity of 6.4 cm (2.5 in) in diameter and 28 cm (11 in) long, and containing between 40 g to 200 g (1.41 oz to 7 oz) of ^{235}U each.

2.6.2 Transportation Casks

Spent nuclear fuel elements are transported in stainless steel packages called transportation casks, or just casks. A typical cask for the transportation of foreign research reactor spent nuclear fuel elements is shown in Figure 2-6. Detailed descriptions of typical casks are provided in Appendix B (Section B.2).

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5 *During the enrichment process, the amount of fissionable Uranium-235 (^{235}U) is increased. Uranium increased to less than 20 percent ^{235}U is called LEU. Uranium enriched to 20 percent or greater ^{235}U is called HEU.*

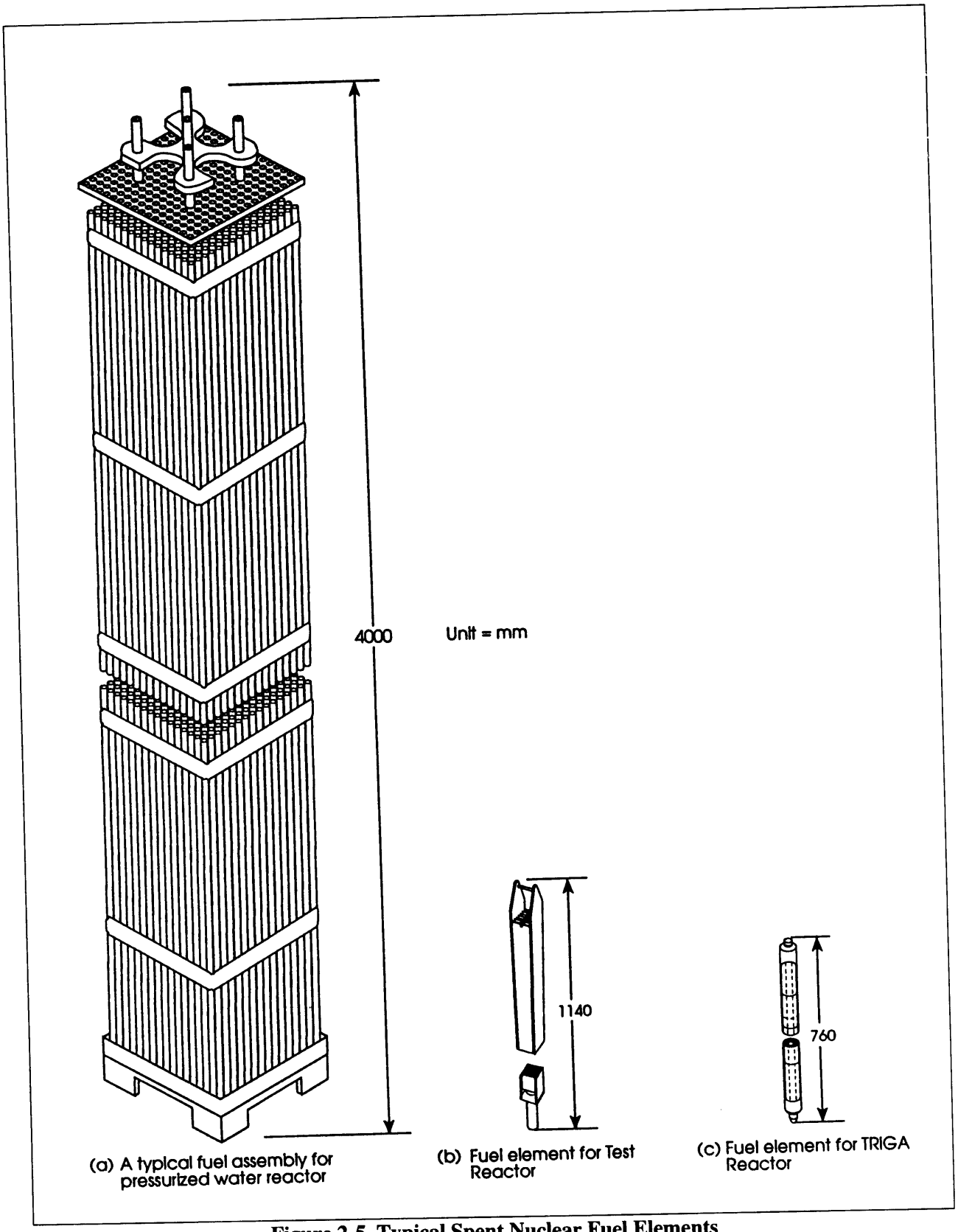


Figure 2-5 Typical Spent Nuclear Fuel Elements

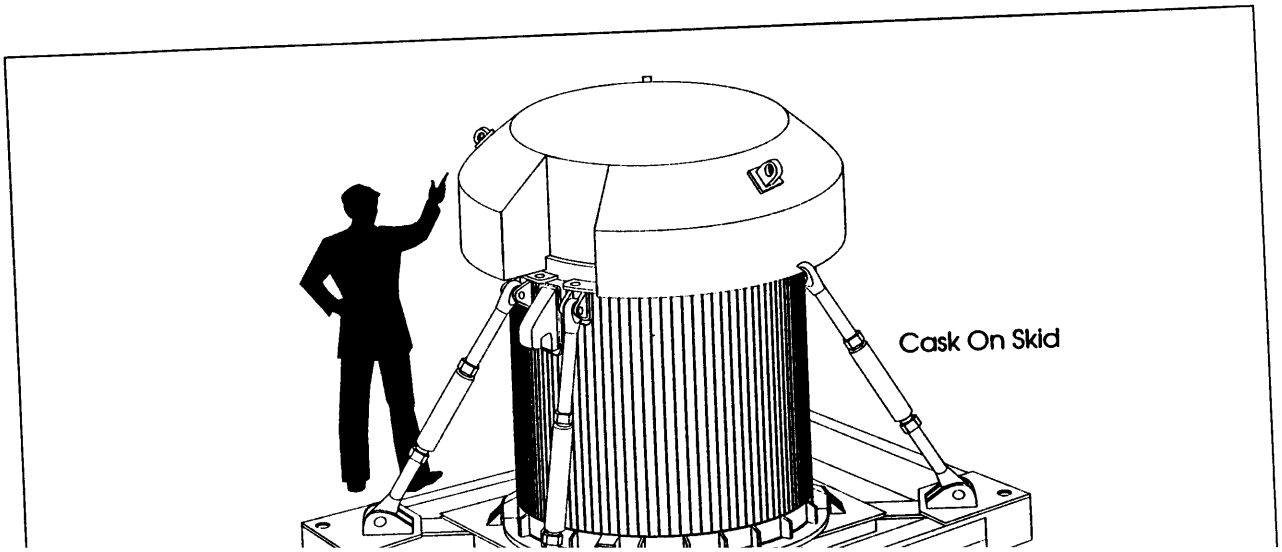

Cask On Skid

Table 2-5 Representative Transportation Casks for Foreign Research Reactor Spent Nuclear Fuel

Transportation Cask	*Country of Origin*	*Certificate of Compliance*	*Estimated Capacity Number of Elements*
Marine Transport			
LHRL-120	Australia	USA/0389/B(U)F	114
GNS-11	Germany	USA/0381/B(U)F	21-33
TN-1	Germany	USA/0316/B(U)F	126
IU-04	France	USA/0100/B(U)F	36-40
TN-7 (TN-7/2)	Germany	USA/0130/B(U)F	60-64
NAC-LWT	United States	USA/9225/B(U)F	48-64
UNIFETCH	United Kingdom	GB/1113/B(M)F	24-40
GOSLAR	Germany	USA/0094/B(M)F	13
Ground Transport (Between Sites)			
NL1-10/24	United States	USA/9023/B( )F	120-160
IF-300	United States	USA/9001/B( )F	84-112
BMI-1	United States	USA/5957/B(U)F	24
GE-2000	United States	USA/9228/B(U)F	24
TN-8	Germany	USA/9015/B()F	36-48
NLI-1/2	United States	USA/9010/B( )F	48-64
NAC-LWT	United States	USA/9225/B(U)F	48-64

A full cask can carry from 13 to 120 spent nuclear fuel elements from foreign research reactors, depending on fuel element design, size, and cask capacity. The casks are certified as "Type B" under regulations. To receive this certification, a cask must successfully pass tests simulating severe accident conditions. The tests include being dropped onto an unyielding surface, dropped onto a steel post, subjected to extremely high temperatures of 802°C (1,475°F) for 30 minutes, and submersion in water for 8 hours.

As discussed in Section 2.7.2, "Type B" casks have been used for years to transport spent nuclear fuel elements within the United States and around the world (DOE, 1994d). To date, no spent nuclear fuel transportation cask has ever been punctured or released any of its radioactive contents, even in actual highway accidents (NRC, 1993).

The casks are designed to provide shielding from radiation. However, a low radiation field is present outside the cask — usually less than one mrem per hour at 1 m (3.3 ft) away from the cask.

Table 2-5 identifies typical transportation casks that could potentially be used for transporting foreign research reactor spent nuclear fuel from the foreign research reactor sites to the candidate United States ports of entry and to the potential management sites. A majority of these have already been used by DOE for transporting foreign research reactor spent nuclear fuel.

As explained in Section 2.6.4, the inability of certain management sites to accept foreign research reactor spent nuclear fuel at the beginning of the implementation period could necessitate temporary (as long as 10 years from the start of the policy) management of foreign research reactor spent nuclear fuel at an available site and the eventual transport of this foreign research reactor spent nuclear fuel to another site. At the time of the intersite transport, the foreign research reactor spent nuclear fuel elements would contain less radioactivity and less heat because of the decay process. The transportation, therefore, could be carried out in casks with larger capacity than those considered for marine transport. Such casks, currently licensed only for the transportation of commercial spent nuclear fuel in the United States, would need to be certified for foreign research reactor spent nuclear fuel. The size of these casks would allow the transport

of up to 4 (truck-size casks) or up to 10 (rail-size casks) times as many elements in a single shipment as those considered for the marine transport casks. The bottom part of Table 2-5 identifies typical casks for intersite transportation. Description and design information is included in Appendix B (Section B.2).

2.6.3 Marine Transport and Ports

This section describes the potential activities related to foreign research reactor spent nuclear fuel marine port identification and marine transport activities.

2.6.3.1 Marine Port Identification

In this EIS, port screening and selection were performed to identify candidate ports of entry for the foreign research reactor spent nuclear fuel. The criteria used in this process were based on several sources, including:

- A DOE-sponsored workshop on port selection criteria for spent nuclear fuel held at the U.S. Merchant Marine Academy at Kings Point, NY, on November 15-16, 1993 (USMMA, 1994).
- Public input to the scoping meetings for this EIS, as summarized in the DOE Implementation Plan (DOE, 1994h).
- Factors identified in Section 3151 of the National Defense Authorization Act for Fiscal Year 1994.

These sources are described in more detail in Appendix D. After consulting the above-mentioned sources, a list of criteria for ports eligible to receive spent nuclear fuel was developed. These criteria are:

- Appropriate port experience - port terminal(s) and operators should routinely handle containerized dry cargoes that require the same type of handling as containerized spent nuclear fuel, or will have the capability to handle these cargo types during the proposed management policy period;
- Port transit - the port should be within reasonable distance from the open sea, with a good ship channel;
- Appropriate port facilities - the port should have adequate crane(s), piers, and depth of water alongside the pier;
- Ready intermodal access - the port should have ready access for intermodal transport; and
- Low human population - the human population of the ports and along transportation routes to potential management sites should be low to the extent feasible and maximum extent practicable.

These criteria, taken collectively, provided DOE and the Department of State with the basis for identifying and analyzing potential ports of entry. Additionally, port identification was expanded (i.e., the NWS Charleston was added to the Port of Charleston) as a result of public comment on the Draft EIS.

2.6.3.2 Marine Transport and Port Activities

2.6.3.2.1 Marine Transport

DOE and the Department of State estimate that approximately 721 cask loads of foreign research reactor spent nuclear fuel would be sent to the United States by ship over the 13-year acceptance period under the basic implementation of Management Alternative 1. The International Maritime Organization currently limits the typical commercial cargo ship (Class INF-2) to a maximum of 200 petrabecquerels of radioactivity (IMO, 1993), which equates to approximately 5.4 million Ci. A typical cask of foreign research reactor spent nuclear fuel is predicted to contain 1 million Ci (see Appendix C). Therefore, a shipment in a commercial cargo ship could contain several casks.

Two types of analysis were conducted to evaluate the impacts of the marine transport of foreign research reactor spent nuclear fuel: first, assuming there are no accidents (incident-free); second, assuming various accidents occur. The incident-free analyses were conducted for ships' crews and port workers, assuming ships carrying two and eight casks of foreign research reactor spent nuclear fuel. Accident analyses were conducted for accidents in port and for accidents in coastal waters and the open ocean. The number of shipments is a parameter of primary importance in the incident-free analysis as well as the accident analysis in port, coastal waters, and open ocean. As noted above, 721 shipments were considered for the basic implementation of Management Alternative 1. In implementing the proposed policy, DOE would attempt to minimize the number of shipments by maximizing the number of casks that would be carried in a single shipment. However, for the purpose of assessing the environmental impacts, a single-cask per shipment assumption is made for the purpose of conservatism. The number of shipments for the implementation alternatives discussed in Sections 2.2.2.1 through 2.2.2.7 and Management Alternative 3 discussed in Section 2.4 are roughly proportional to the amount of foreign research reactor spent nuclear fuel to be accepted in the United States under each alternative. The exact number of shipments assumed in the analysis is provided in Appendices C and D, Section C.4 and D.4, respectively. The results of both the incident-free and the accident analyses are presented in Chapter 4, with details in Appendices C and D.

There are four types of ships that could be used to transport foreign research reactor spent nuclear fuel casks. These are:

Container vessels: These are typically large ships specifically intended for the transport of containerized cargo. Some modern container ships can transport up to about 5,000 containers, although a more typical capacity is in the range of 800 to 1,000 containers. A principal advantage of container ships, because of standardization of containers, is that the vessel can be rapidly loaded or off-loaded at those ports equipped with container gantry cranes. Containers can be removed from, or placed on, the vessel at an average rate of about 45 containers per hour. At well-equipped container ports, two cranes are used to move containers.

Roll-on/roll-off ships: These ships are vehicle carriers used for the ocean transport of cars and trucks. The ships are loaded and unloaded using a ramp between the vessel and dock. Typically, the vessel carries its own ramp, which is deployed by an on-board crane, hydraulic cylinders, or chain drives. The ramp may extend from the stern of the vessel or from a hatch in the side of the vessel hull. At docks intended for roll-on/roll-off service, additional ramps may be deployed from the dock to expedite loading or unloading. This type of ship could carry foreign research reactor spent nuclear fuel casks secured on trailers.

General/cargo (breakbulk) ships: General cargo vessels are smaller ships that typically call on less well-developed or equipped ports. They have on-board jib or boom type cranes that can be used to load or unload the ship if dockside crane service is not available. As the name implies, these vessels are intended to accommodate a wide variety of cargoes that may have any reasonable configuration. Since the advent of the widespread use of containers, most of these ships are equipped with lock fixtures to secure containers during transport. If necessary, containers can be lifted on and off these ships by using four-legged slings between the corners of the container and hook of the crane.

Purpose-built ships: For the purposes of this EIS, the ships discussed here are specifically designed to transport spent nuclear fuel casks. These ships are not used for the transport of any other cargo, and they operate as chartered vessels. Casks are loaded directly into the holds of the ship because the cargo compartments contain the hardware needed to mate with the tiedown fixtures of the cask. If the ship has no crane, dockside cranes are used for loading and unloading. The cargo compartments are typically intended to handle only one cask type, however, other casks may be used with minor modifications. For the relatively efficient transport of spent nuclear fuel, the casks are large. These type vessels are intended for the transport of commercial power nuclear reactor fuel, and they generally operate between nuclear installations (power plants and spent nuclear fuel end-use facilities) having dedicated docks. Commercial docks are not normally used, but could be. These vessels have double bottoms and hulls and collision damage-resisting structures within the hull. The vessel crew is trained in the handling of the cargo and in emergency response like most other commercial vessels.

The potential exists that spent nuclear fuel would be accepted from all 41 countries that have expressed interest in this program. Ships carrying the foreign research reactor spent nuclear fuel would follow normal shipping routes from a convenient port in or near the country of origin, and would go to a U.S. port that is consistent with the port identification, evaluation, and selection process as described in Appendix D.

Regularly scheduled commercial service cargo ships could be used to ship foreign research reactor spent nuclear fuel. Some, if not most, of the regularly scheduled commercial ships might initially call at a port other than the port of destination of the foreign research reactor spent nuclear fuel, and may make additional stops. Therefore, marine transport may involve entry into and departure from intermediate ports and shipping in coastal waters. Typically, ships spend 1 day in each port of call and 1 or 2 days passing between ports.

Risks to the ships carrying foreign research reactor spent nuclear fuel and to the spent nuclear fuel itself

to the cask containing the foreign research reactor spent nuclear fuel for a short period of time. Effects on inspectors and other incident-free impacts were evaluated, and are described in Chapter 4 and detailed in Appendix C.

Both commercial and military ports were evaluated for potential use as ports of entry for the foreign research reactor spent nuclear fuel. DOE determined that the security provisions specified by 10 CFR 73, which are required for all spent fuel shipments, could be implemented at either commercial or military ports. Any additional security that might be available at a military port would not be required for foreign research reactor spent nuclear fuel shipments.

2.6.3.2.2 Port Activities

Entry into a port by commercial vessels is accomplished under the control of the port authority. The port authority is responsible for the area from the sea buoy to the dock, except where the approaches are long, such as the case with the Chesapeake Bay. Normally, each ship is required to have a pilot familiar with local conditions to direct it while underway in the harbor or channel and during both entry and exit approaches. The pilot's job is to ensure that the ship follows the marked channel and arrives safely at its dock or other assigned location. In the event of bad weather or low visibility, radar and other instruments are available on all ships that would be considered for carrying foreign research reactor spent nuclear fuel.

In most cases, the ship moves directly to its assigned dock. However, if the assigned dock is still occupied or is not immediately available for other reasons, the ship may anchor in the harbor or its approaches for a period of time prior to docking. Most ocean-going vessels are not highly maneuverable in confined spaces, so docking is normally accomplished with the help of one or more tugs.

At the ship's first port of call in the United States, the U.S. Coast Guard and other authorities would inspect the ship, its cargo, and documentation. In the case of radioactive cargoes, the NRC may inspect the container with the radioactive material and its documentation. State and local officials could also perform inspections of documents and cargo. At ports of call after the initial port(s) of entry, additional inspections may be performed by Federal, State, or local officials.

Except for roll-on/roll-off ships, all cargo ships that would potentially carry foreign research reactor spent nuclear fuel are unloaded with cranes. Unloading of a foreign research reactor spent nuclear fuel cask, whether in a container or not, involves connecting a lifting fixture to the container or to the cask pallet, lifting the container or cask, and placing it dockside, either on an intermediate vehicle or directly on the primary mode of land transportation. Typically, container ships can be unloaded at the same rate as they are loaded (approximately 45 containers per hr), while unloading a cask on a handling platform in a breakbulk ship would require more time.

All shipments of foreign research reactor spent nuclear fuel would be anticipated well in advance, so the container housing the foreign research reactor spent nuclear fuel cask would normally be loaded immediately on the ground transportation to be used to carry it out of the port. Should there be a delay, the container may be temporarily stored at the port for up to 24 hours. Port security at any of the ports selected for analysis is adequate to protect the container in the event of this unexpected delay.

In spite of all of the precautions taken, accidents in the port would be possible. In fact, most ship accidents occur in or around ports. DOE has had no radioactivity released in the past due to port accidents; however, a range of accidents, both at the dock and in the port or its approaches, has been evaluated. See Chapter 4 for a discussion of the results of these analyses.

All ports considered for receiving foreign research reactor spent nuclear fuel would have emergency plans for responding to an accident in the port.

2.6.4 Ground Transport Route Options and Route Identification Process

2.6.4.1 Ground Transport Route Options

Route options for the potential ground transportation of foreign research reactor spent nuclear fuel depend on the marine ports considered, the management sites and the various ways that foreign research reactor spent nuclear fuel would be distributed among the potential management sites according to the alternatives considered in the Programmatic SNF&INEL Final EIS (DOE, 1995c). Accordingly, routes and the amount of fuel to be shipped would be established based on one of the following spent nuclear fuel distributions:

- an even distribution of foreign research reactor spent nuclear fuel between the Savannah River Site and the Idaho National Engineering Laboratory under the Decentralization and the 1992/1993 Planning Basis alternatives;
- a distribution that sends TRIGA spent nuclear fuel to the Idaho National Engineering Laboratory and aluminum-based spent nuclear fuel to the Savannah River Site under the Regionalization by Fuel Type alternative;
- a distribution that sends the spent nuclear fuel entering the United States from the Eastern ports to the Savannah River Site or the Oak Ridge Reservation and the spent nuclear fuel entering the United States from the Western ports to the Idaho National Engineering Laboratory, the Nevada Test Site, or the Hanford Site under the Regionalization by Geography alternative; or
- a distribution that sends all foreign research reactor spent nuclear fuel to one of the five potential management sites under the Centralization alternative.

For the purposes of this EIS, the distribution of foreign research reactor spent nuclear fuel between sites under Regionalization by Geography and by Fuel Type has been analyzed in detail. The more detailed planning performed in preparation for the analyses of the various alternatives considered in this EIS did not reveal any physical situation in which an even distribution of the spent nuclear fuel between two sites was advantageous. Furthermore, the impacts of activities associated with the even distribution at either site would be bounded by and equal to roughly 50 percent of the impacts of the centralization of all foreign research reactor spent nuclear fuel management activities at that site. As a result, this alternative is not analyzed in detail in this EIS.

An additional factor which would affect the route options for ground transportation is the inability of certain potential spent nuclear fuel management sites to implement the foreign research reactor spent nuclear fuel management policy immediately. Of the five sites, only two (the Savannah River Site and the Idaho National Engineering Laboratory) would be immediately available in late 1995. The other three could become available at a later date when appropriate facilities for accepting and managing foreign research reactor spent nuclear fuel become available. This constraint affects the ground transportation route options in the case that a site, other than the Savannah River Site or the Idaho National Engineering Laboratory, is considered and for DOE's spent nuclear fuel management under either the Regionalization by Geography or the Centralization alternative. If the Nevada Test Site, the Oak Ridge Reservation, or the Hanford Site is one of the management sites, the foreign research reactor spent nuclear fuel would have to

be shipped first to one of the available management sites (the Savannah River Site and/or the Idaho National Engineering Laboratory) and later, when appropriate facilities are completed, to either the Nevada Test Site, the Oak Ridge Reservation, or the Hanford Site.

Certain assumptions are required in order to simply and consistently describe the manner in which foreign research reactor spent nuclear fuel would be transported to the management sites. The shipments, which were identified earlier in Tables 2-1 and 2-2, were divided into east coast and west coast shipments, depending on the country of origin. Spent nuclear fuel shipments from Europe, Africa, the Middle East, and parts of Central and South America were designated as east coast shipments. All others were designated as west coast shipments. Shipments from Canada were assumed to enter the United States from either an eastern or western point of entry, depending on the point of origin in Canada. Under these assumptions, for the basic implementation of Management Alternative 1, the Eastern points of entry would receive 651 cask shipments (535 from ports, 116 from Canada) and the Western ports of entry would receive 186 cask shipments (all from ports).

No intersite shipments would be necessary under the Programmatic SNF&INEL Final EIS alternatives (DOE, 1995c) that use the Savannah River Site and/or the Idaho National Engineering Laboratory for managing the foreign research reactor spent nuclear fuel. The estimated number of shipments for the basic implementation of Management Alternative 1 in these cases would be as follows:

- Decentralization, 1992/1993 Planning Basis, or Regionalization by Geography to the Savannah River Site and the Idaho National Engineering Laboratory - the Savannah River Site would receive 651 casks from the east coast and the Idaho National Engineering Laboratory would receive 186 casks from the west coast.

- Regionalization by Fuel Type - the Savannah River Site would receive 675 casks of aluminum-based fuel; 544 from the east coast and 131 from the west coast. The Idaho National Engineering Laboratory would receive 162 casks of TRIGA-type fuel; 107 from the east and 55 from the west.

- Centralization to the Idaho National Engineering Laboratory or Centralization to the Savannah River Site - the site would receive 837 casks; 651 from the east coast and 186 from the west coast.

A two-phased program would be required if a site other than the Idaho National Engineering Laboratory or the Savannah River Site is considered as a central or regional site. Phase 1 is defined as the period from the beginning of the policy (late 1995) until the Phase 2 site (the Hanford Site, the Nevada Test Site and/or the Oak Ridge Reservation) would be ready to receive fuel, which is estimated to be 10 years for new construction; less time would be required for refurbishment of an existing facility. During Phase 1, DOE would manage the fuel at the Savannah River Site and/or the Idaho National Engineering Laboratory. During Phase 2, DOE would ship any fuel that is being managed during Phase 1 at a non-Phase 2 site to a Phase 2 site, and manage the fuel at that site until a repository becomes available. The phases are defined to help describe the implementation of the foreign research reactor spent nuclear fuel management policy and to analyze the transportation impacts of the implementation of the policy.

If the Hanford Site, the Nevada Test Site, and/or the Oak Ridge Reservation were selected under the Programmatic SNF&INEL EIS, DOE and the Department of State would select from the following four strategies for managing fuel at the Savannah River Site and/or the Idaho National Engineering Laboratory during Phase 1. DOE could: (1) divide the fuel by geography, (2) divide the fuel by type (aluminum-based and TRIGA), (3) ship all fuel to the Savannah River Site, or (4) ship all fuel to the Idaho National

Engineering Laboratory. Therefore, in Phase 2, the Hanford Site and the Nevada Test Site could receive all foreign research reactor spent nuclear fuel, or TRIGA or Western spent nuclear fuel managed at the Idaho National Engineering Laboratory during Phase 1. Similarly, the Oak Ridge Reservation could eventually receive all foreign research reactor spent nuclear fuel or the aluminum-based or Eastern spent nuclear fuel managed at the Savannah River Site during Phase 1.

An assumption on the rate at which spent nuclear fuel arrives is necessary to estimate the number of shipments that would arrive during Phases 1 and 2. The demand to ship fuel by the foreign research reactor operators would be highest at the beginning and the end of the proposed policy period. However, the limited availability of casks would compel DOE to receive fuel at a steady rate. DOE could control the rate at which fuel is delivered by managing the contracts with shippers. Therefore, for the purposes of this

Table 2-6 Shipment Summary for Regionalization by Geography Alternatives

Spent Nuclear Fuel Site Option Western/Eastern	*Phase 1 Approach*	*Phase 1 Port-to-Site Shipments*	*Site-to-Site Shipments*[a]	*Phase 2 or Port-to-Final Site Shipments*	*Total Number of Shipments*[a]
INEL/ORR	Geographic	East to SRS: 501 West to INEL: 143	SRS to ORR: 126/51	East to ORR: 150 West to INEL: 43	963/888
	By Fuel	MTR to SRS: 520 TRIGA to INEL: 124	SRS to ORR: 130/52	East to ORR: 150 West to INEL: 43	967/889
	All to INEL	644	None	East to ORR: 150 West to INEL: 43	837
[illegible]	Geographic	East to SRS: 501	INEL to NTS: 36/15	East to SRS: 150	[illegible]

Table 2-7 Shipment Summary for Centralization Alternatives

Spent Nuclear Fuel Site Option	Phase 1 Approach	Phase 1 Port-to-Site Shipments	Site-to-Site Shipments[a]	Phase 2 or Port-to-Final Site Shipments	Total Number of Shipments[a]
SRS	N/A - Single phase			837	837
INEL	N/A - Single phase			837	837
HS	Geographic	East to SRS: 501 West to INEL: 143	From SRS: 126/51 From INEL: 36/15	From East: 150 From West: 43	999/903
	By Fuel	MTR to SRS: 520 TRIGA to INEL: 124	From SRS: 130/52 From INEL: 31/13	From East: 150 From West: 43	998/902
	All SRS	644	161/65	From East: 150 From West: 43	998/902
	All INEL	644	161/65	From East: 150 From West: 43	998/902
ORR	Geographic	East to SRS: 501 West to INEL: 143	From SRS: 126/51 From INEL: 36/15	From East: 150 From West: 43	999/903
	By Fuel	MTR to SRS: 520 TRIGA to INEL: 124	From SRS: 130/52 From INEL: 31/13	From East: 150 From West: 43	998/902
	All SRS	644	161/65	From East: 150 From West: 43	998/902
	All INEL	644	161/65	From East: 150 From West: 43	998/902
NTS	Geographic	East to SRS: 501 West to INEL: 143	From SRS: 126/51 From INEL: 36/15	From East: 150 From West: 43	999/903
	By Fuel	MTR to SRS: 520 TRIGA to INEL: 124	From SRS: 130/52 From INEL: 31/13	From East: 150 From West: 43	998/902
	All SRS	644	161/65	From East: 150 From West: 43	998/902
	All INEL	644	161/65	From East: 150 From West: 43	998/902

SRS = Savannah River Site, INEL = Idaho National Engineering Laboratory, HS = Hanford Site, ORR = Oak Ridge Reservation, NTS = Nevada Test Site

[a] *Truck/rail shipments assuming that the truck casks used for intersite shipments are capable of carrying 4 times as much fuel and rail casks 10 times as much fuel as the shipping cask received from the foreign research reactor due to consolidation.*

The HIGHWAY and INTERLINE computer codes are used to assist in route selection and estimations of exposed population (DOE, 1995c). The collective population risk, maximally exposed individual (MEI) risk, accident risk, accident consequence, and nonradiological risk assessments are performed using the RADTRAN and RISKIND computer codes established for shipment by both railroad and highway. Additional details of the treatment and analysis methodology used in the ground transportation assessment are given in Appendix E.

2.6.5 Activities and Alternatives at the Foreign Research Reactor Spent Nuclear Fuel Management Sites

The potential sites for receipt and management of foreign research reactor spent nuclear fuel are the same as those considered in the Programmatic SNF&INEL Final EIS (DOE, 1995c), namely: the Savannah River Site, the Idaho National Engineering Laboratory, the Hanford Site, the Oak Ridge Reservation, and the Nevada Test Site.

Since foreign research reactor spent nuclear fuel is part of the overall DOE spent nuclear fuel management program, the potential site-specific options are consistent with the site management alternatives considered in the Programmatic SNF&INEL Final EIS. The alternatives are: Decentralization and 1992/1993 Planning Basis (even distribution of foreign research reactor spent nuclear fuel between the Idaho National Engineering Laboratory and the Savannah River sites), Regionalization (distribution by fuel type and geography), and Centralization (all foreign research reactor spent nuclear fuel at the potential site).

As discussed earlier, the site-specific foreign research reactor spent nuclear fuel management options also depend on the availability of the management sites to implement the policy immediately. Of the five sites, only the Savannah River Site and the Idaho National Engineering Laboratory will be available in late 1995. The other three could become available at a later date when construction or refurbishment of appropriate facilities is completed. This constraint has resulted in the two-phased approach considered in some cases (see discussion in Section 2.6.4.1). For the purpose of the site impact analysis, the implementation of the policy was divided into two functional periods — the period during which receipt and management of foreign research reactor spent nuclear fuel is accomplished by using existing facilities (Phase 1), and the period during which new or refurbished facilities are used (Phase 2). For the [illegible] activities only, while the second

Protection of the public and workers from the radioactive materials within each spent nuclear fuel element is achieved by:

- [illegible] or encapsulating the spent nuclear fuel so that any accidental release of [illegible]
- maintaining a benign chemical and thermal environment around the spent nuclear fuel so that its structural integrity is preserved;
- providing adequate shielding of the radiation emanating from the spent nuclear fuel so that dose rates outside the facility are lowered; and
- utilizing security barriers to isolate spent nuclear fuel from workers and public.

The technology for safely storing spent nuclear fuel (as defined by the above criteria) has been in use, in one form or another, for over 40 years in the nuclear industry. Spent nuclear fuel storage is generally characterized as either wet or dry, denoting whether the spent nuclear fuel elements reside in a water-filled pool or a dry atmosphere. Details of the concepts are provided in Appendix F, Section F.1.

The wet pool type of spent nuclear fuel storage is used at almost every water-cooled nuclear reactor in the world. There are currently more than 600 operating water-cooled power and research nuclear reactors, each with an individual storage pool. The pool design uses common materials (water and concrete) for spent nuclear fuel shielding, heat removal, and the confinement of any radioactive material that might be released from the spent nuclear fuel. An additional benefit is the ability to visually inspect spent nuclear fuel, since the water purity and clarity are maintained at a high level. Spacing, fissionable material limits, and in some cases, the use of neutron-absorbing material prevent criticality in a wet storage environment. The pool is enclosed in a suitably qualified structure or building. Construction of a wet storage facility involves excavating earth, backfilling, pouring concrete, setting piping, erecting a building around the pool, and installing piping, electrical systems, and heating, ventilating, and air conditioning systems. In many ways, a spent nuclear fuel storage pool is like a swimming pool, except its depth is greater and its [illegible] walls and floors are much thicker to provide for structural integrity. Wet storage facility designs

Dry storage methods are not as efficient in removing heat from the spent nuclear fuel as wet storage pools. Thus, as explained in Appendix F, this EIS assumes that high decay heat foreign research reactor spent nuclear fuel would initially be placed in wet storage. This would allow sufficient time for the spent nuclear fuel radioactive decay heat to decrease and not be a deciding factor in sizing a dry storage facility.

Dry storage facility construction involves the preparation and pouring of concrete foundations upon which the concrete or metal cask or building is then erected. Metal casks would be built away from the DOE site in a factory, since they involve thick metal fabrication techniques not used at DOE facilities. Concrete casks or buildings are constructed at the site using the same general principles (e.g., forms, rebar) as in nonnuclear concrete construction. Qualified concrete foundation pads are also poured for support bases of the casks.

Whether wet or dry storage were used, the facility would be designed to withstand natural phenomena such as earthquakes, floods, tornadoes, hurricanes, high and low temperatures, and wind generated missiles (branches, poles, etc.). The design would also include provisions to preclude sabotage or terrorist acts. Security requirements for a dry storage facility after the spent nuclear fuel has decayed to low levels of radioactivity and is no longer self-protecting would be met by the establishment of a Perimeter Intrusion Detection and Alarm System zone, which is the standard procedure for DOE. Each design has specific provisions for periodic inspection or surveillance, and must meet the highest quality standards associated with all safety requirements specified for nuclear facilities.

The current alternative types of storage technology are discussed and evaluated in detail in Appendix F. The basic categories are: wet (pool), dry concrete vault or building, dry concrete horizontal cask/module, dry concrete vertical cask/silo, dry metal vertical cask, hot cells, multi-purpose casks, and dry inground vertical holes. There are significant differences between these technologies in terms of construction, operations and maintenance costs and various design details. However, these differences do not result in any important variations in environmental impacts and consequences. With the exception of multi-purpose casks (which are still under development), all of these technologies have proven records of successful safe operation while storing spent nuclear fuel. Appendix F provides detailed descriptions concerning generic dry and wet storage facilities for foreign research reactor spent nuclear fuel. Brief descriptions of both wet and dry storage facilities are provided in the following sections.

2.6.5.1.1 Description of Dry Storage Facilities

Spent Nuclear Fuel Storage Using a Modular Dry Vault:

An aboveground dry vault is a self-contained concrete structure that would allow for dry spent nuclear fuel handling and storage. This design represents an integrated spent nuclear fuel storage approach and would consist of four major components: a receiving/loading/inspection area, spent nuclear fuel storage canisters, a shielded canister handling machine, and a modular array for storing the spent nuclear fuel storage canisters. Figure 2-7 displays an illustration of a typical modular dry vault storage facility. The receiving area would use a wet pool for unloading the casks and for short-term (1 to 3 years) storage of foreign research reactor spent nuclear fuel elements with a heat load exceeding 40 Watts per element. The vault would consist of several modular units, and each unit could provide storage for hundreds of spent nuclear fuel assemblies. The vault itself would contain a charge/discharge bay with a spent nuclear fuel handling machine above a floor containing steel tubes that house the (removable) spent nuclear fuel canisters. The bay would be shielded from the stored spent nuclear fuel by the thick concrete floor and shield plugs inserted into the top of the steel storage tubes. The steel tubes would serve as secondary containment for the foreign research reactor spent nuclear fuel and would descend into an open storage

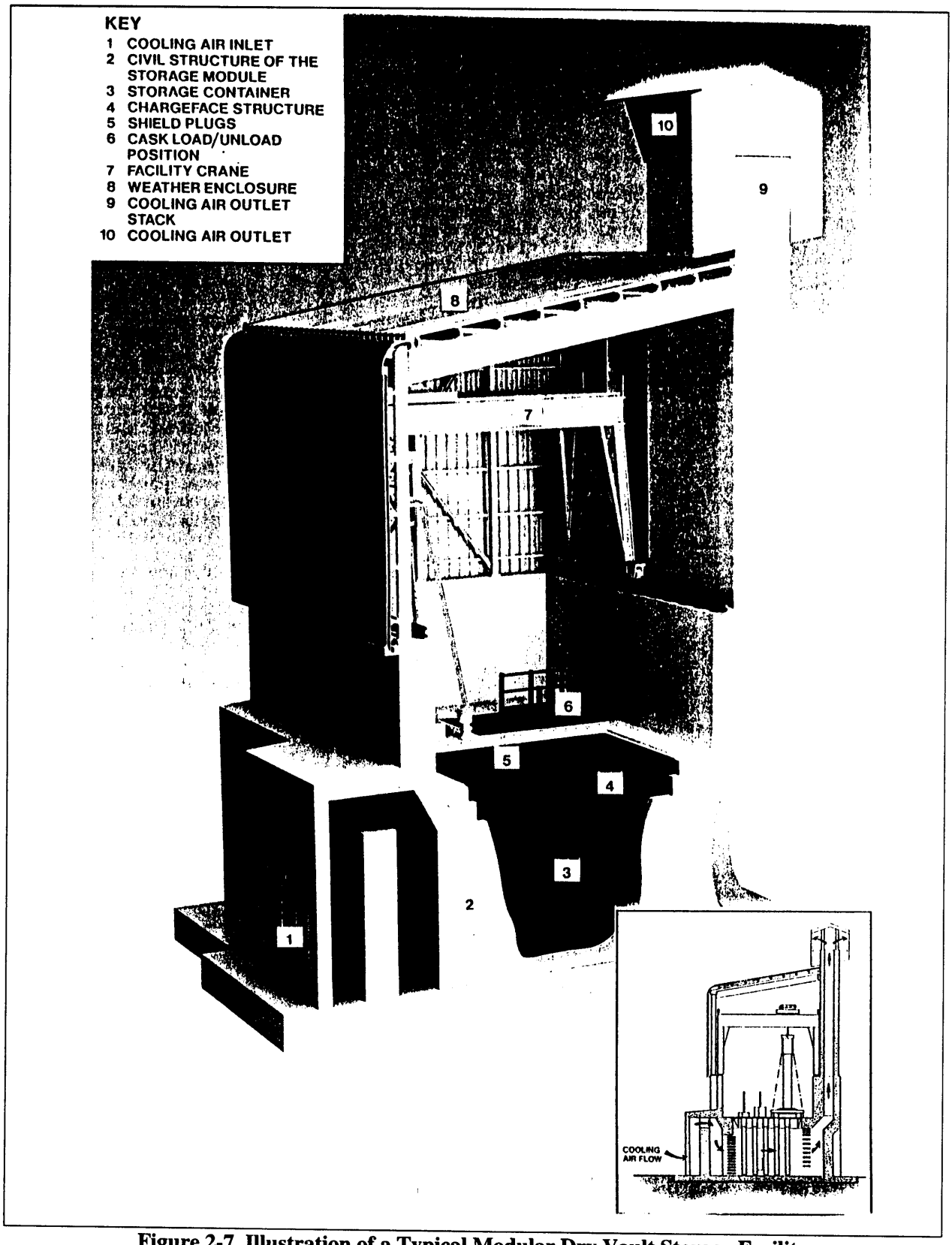


Figure 2-7 Illustration of a Typical Modular Dry Vault Storage Facility

Table 2-8 Summary of Modular Dry Vault Storage Parameters for Foreign Research Reactor Spent Nuclear Fuel[a]

Construction Phase:	
Disturbed Land Area	3.7 ha (9 acres)
Facility: size (area) concrete steel	 5,000 m^2 (54,000 ft^2) 21,800 m^3 (28,500 yd^3) 5,200 metric tons (5,750 tons)
Soil Moved	11,000 m^3 (14,400 yd^3)
Equipment Fuel	835,000 l (221,000 gal)
Construction Debris/Waste	1,800 m^3 (2,400 yd^3)
Work Force	190/yr (average), 234/yr (peak)
Duration (years)	4 years for construction, 1.5 years for design
Capital Cost	$370 million[b]
Operation Phase:	
Electricity	800 - 1,000 MW-hr/yr (staging facility)
Water	2.1 million l/yr (550,000 gal/year) during receipt 0.9 million l/yr (238,000 gal/yr) thereafter
Wastestreams Solid Low-Level Waste Waste Water	 22 m^3/yr (780 ft^3/yr) during receipt 1 m^3/yr (35 ft^3/yr) thereafter 1.59 million l/yr (420,000 gal/yr) during receipt 0.4 million l/yr (109,000 gal/yr) thereafter
Staff (Full-Time Equivalents)	30 during receipt 8 thereafter
Annual Operating Cost	$15.6 million during handling, $0.6 million during storage[b]

[a] *Staging facility parameters are based upon the regionalized, small wet pool (Dahlke, et al., 1994)*

[b] *Cost estimates are in 1993 dollars (EG&G, 1993)*

area. Large, labyrinth air supply ducts and discharge chimneys would permit natural convection cooling of the steel spent nuclear fuel storage tubes, while the perimeter concrete walls would provide for shielding. The design would allow for expansion by adding additional units of arrays to the end of the vault or by construction of another vault. The vault facility would also include a receiving and loading bay that would allow handling of shielded transportation casks and unloading of the foreign research reactor spent nuclear fuel into the short-term wet storage pool. The receiving bay provides for spent nuclear fuel inspection, canning as required and could be used for spent nuclear fuel characterization with additional equipment and modifications. Although it is not expected that the physical condition of the foreign research reactor spent nuclear fuel elements would require extensive canning, the capability of canning the entire foreign research reactor spent nuclear fuel inventory would be provided by the design. Table 2-8 summarizes modular dry vault storage parameters for foreign research reactor spent nuclear fuel storage.

In operation, the transportation cask would be lifted by a crane and placed in the unloading area of the small wet pool. The fuel elements would be removed underwater, examined, and if the heat generation rate is below 40 Watts per element, the spent nuclear fuel would be placed within the transfer canister. The transfer canister would be subsequently drained, dried, and seal-welded. The handling machine then would place the spent nuclear fuel inside of the spent nuclear fuel storage canister, and would transport the loaded canister to the storage tubes. The handling machine would include radiation shielding. Heat dissipation would be accomplished by natural convection from the surfaces of the handling machine and canister. Decay heat would be dissipated by natural convection: air would enter through inlet ducts at the bottom of the vault module, pass around the outside of the steel storage tubes containing the spent nuclear

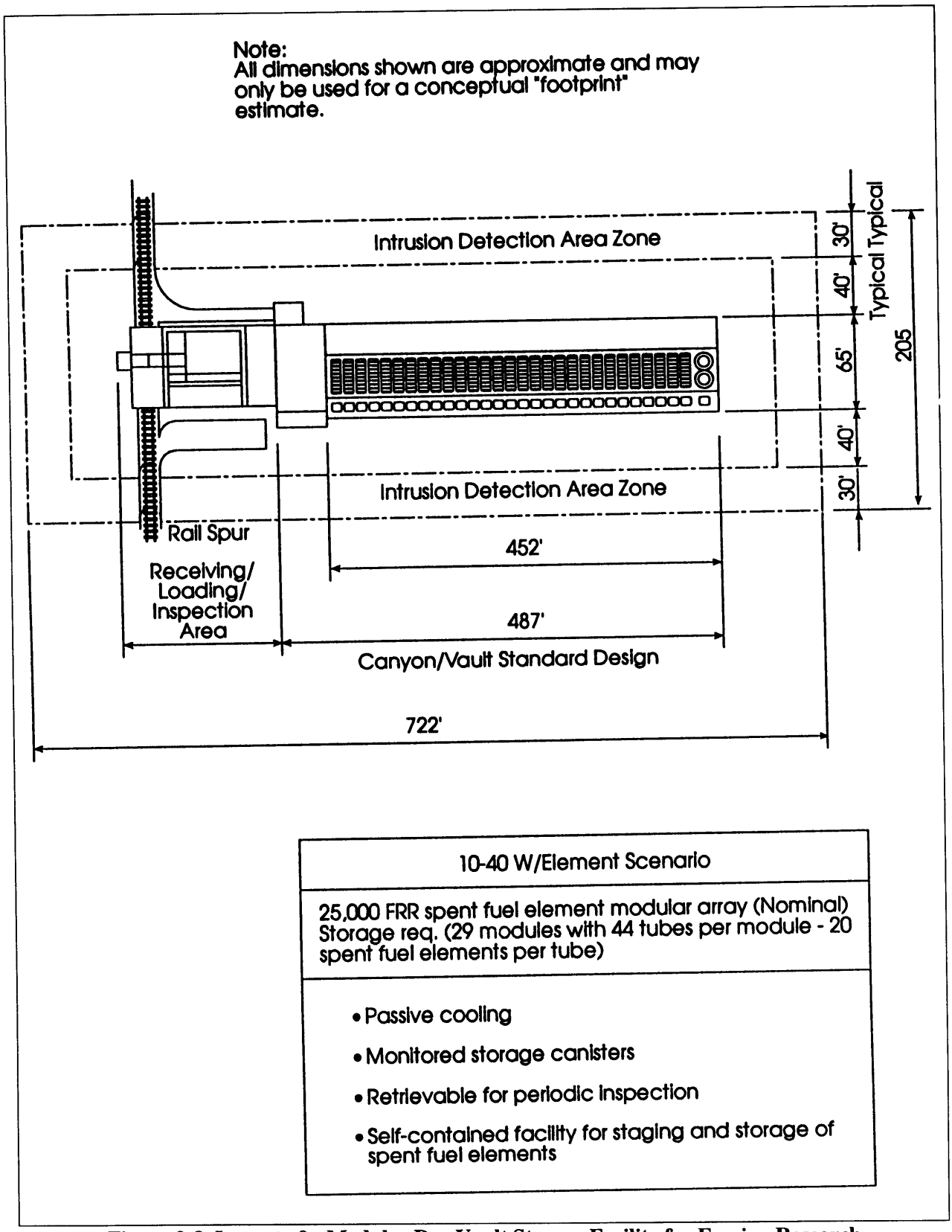


Figure 2-8 Layout of a Modular Dry Vault Storage Facility for Foreign Research Reactor Spent Nuclear Fuel (10 Watt to 40 Watt Element Basis)

fuel canisters, and exit through outlet ducts at the top of the module. Therefore, the vault would be a complete, integrated facility with all of the required capabilities for foreign research reactor spent nuclear fuel handling and storage.

The vault facility would store spent nuclear fuel in canisters that are approximately 40.6 cm (16 in) in diameter by 4.6 m (15 ft) long. As currently envisioned, foreign research reactor spent nuclear fuel would be stored within the canister in 5 levels with 4 elements per level, for a total of 20 spent nuclear fuel elements per canister (MTR-type design). The vault design would allow for 36 to 44 canisters per array unit, depending upon the decay heat of the spent nuclear fuel and a cladding temperature limit nominally 175°C (347°F) for aluminum-cladding with an air inlet temperature of 49°C (120.2°F). Thus, the number of vault units/arrays required for the storage of elements having a decay heat between 10 Watts and 40 Watts per element would be 27.

Most of the foreign research reactor spent nuclear fuel is expected to have decay heats between 10 Watts and 40 Watts per element. For "cold" fuel (less than 10 Watts per element), potentially more than 44 spent nuclear fuel canisters could be placed per vault unit. However, this would require a customized design, which could unnecessarily increase costs and implementation time. Figure 2-8 displays the layout of the modular dry vault storage facility (10 Watt to 40 Watt element basis).

Criticality concerns would be addressed primarily by the tube spacing in the vault. Borated concrete could also be used. For foreign research reactor spent nuclear fuel, criticality would not be expected to be a significant concern because a considerable fraction of the fissile uranium would have been consumed, and neutron-absorbing fission products would be present.

This vault design, without a pool, has been licensed by NRC for the Fort St. Vrain nuclear power plant site. It represents a complete, stand-alone facility that could be dedicated to foreign research reactor spent nuclear fuel without requiring the utilization of any other facilities at the host site. Cask handling, spent nuclear fuel transfer to a canister, and spent nuclear fuel storage could be accomplished within the facility. Additional facilities or modifications to the inspection area, including a pool, would be required for foreign research reactor spent nuclear fuel characterization.

The cost to construct a modular dry vault storage facility with a staging area sufficient to unload, characterize, can, temporarily store in a small pool, and transfer the spent nuclear fuel to the vault storage area is estimated to be $370 million. The annual operating cost for this facility is estimated to be $15.6 million during the period of handling and transfers of the spent nuclear fuel and $0.6 million during the period of storage. The cost estimate for the facility is based on a cost report prepared by Idaho Inc. (EG&G, 1993) with the addition of the cost of a small wet storage facility reported by Dahlke et al. (Dahlke et al., 1994).

Spent Nuclear Fuel Storage Using Dry Casks:

Dry cask storage would include the use of concrete casks, both vertical and horizontal versions, metal casks, and multipurpose casks and would consist of the following components:

- A staging facility for cask receipt and unloading, and for loading foreign research reactor spent nuclear fuel into the dry storage casks. The staging facility would have a wet pool for unloading the casks and for short-term (1 to 3 years) storage of spent nuclear fuel with a heat load exceeding 40 Watts per element. This facility would include capabilities for drying the spent nuclear fuel/canister, inserting the spent nuclear fuel/canister with helium or nitrogen, and welding the storage canister closed.

- An inspection/characterization facility, for examining spent nuclear fuel integrity and canning leaking spent nuclear fuel as required. This may be incorporated into the staging facility (as an inspection cell) or be immediately adjacent to it. Although it is not expected that the physical condition of the foreign research reactor spent nuclear fuel elements would require extensive canning, the capability of canning the entire foreign research reactor spent nuclear fuel inventory would be provided by design.

- A dry storage cask (usually concrete). This would provide for the shielding and the structural stability of the spent nuclear fuel storage. The Multi-purpose Canister undergoing development could also be used (see Appendix F, Section F.1).

- A transfer mechanism, such as a dedicated truck/trailer combination with a ram for horizontal modules or a crane for vertical modules.

- A separate spent nuclear fuel canister may or may not be used. If used, it would typically be approximately 4.6 m (15 ft) long and 1.7 m (5.5 ft) in diameter, and would weigh approximately 33 metric tons (36 tons).

The dry cask approach would require the staging facility to receive and inspect the spent nuclear fuel shipment. The transportation cask would be unloaded in a small wet pool within the facility. Subsequently, spent nuclear fuel would be loaded into the dry cask (or spent nuclear fuel canister for the horizontal cask), and the cask would be placed on a concrete slab located outdoors. The horizontal approach would use a dry spent nuclear fuel transfer canister for containing the spent nuclear fuel. This would be placed within a shielded transfer cask and moved to the outside modular storage facility. A hydraulic ram would insert the transfer canister inside the horizontal storage module, followed by sealing with a shield plug. Thus, dry cask storage would always rely on the use of another facility.

Dry storage casks would be designed to withstand normal loads and design basis accident effects, such as earthquakes, tornadoes, and floods. Concrete would provide radiation shielding for gamma rays and neutrons. Natural air circulation would dissipate the heat; air would enter through inlet vents near the bottom of the cask, pass around the spent nuclear fuel canister, and exit near the top. Screens and grills would keep birds and animals out of the cooling duct area.

Some of the potential management sites have facilities which could be used for cask receipt and unloading and spent nuclear fuel inspection and transfer to storage. Utilization of these facilities would be considered.

The application of dry cask storage technology to foreign research reactor spent nuclear fuel would depend upon the heat load. Horizontal casks are anticipated to be slightly more restrictive than the vertical casks with respect to the heat load and are thus the focus of discussion. The standard design for a horizontal fuel canister would provide for 24 or 52 sleeves (i.e., pressurized water reactor or boiling water reactor spent nuclear fuel, respectively), each about 4.6 m (15 ft) long. As with the vault approach, it would be conservatively assumed that each sleeve contains 5 foreign research reactor spent nuclear fuel elements (i.e., in layers) within a basket or can arrangement for maintaining spacing and retrievability. Also, as with the vault approach, the number of dry storage casks would depend upon the decay heat of the spent nuclear fuel and a cladding temperature limit [nominally, 175°C (347°F) for aluminum-cladding with an air inlet temperature of 49°C (120.2°F)]. The 24-sleeve design would allow for a maximum of 120 elements for foreign research reactor spent nuclear fuel with 40 Watts to 80 Watts per element of

decay heat, while the 52-sleeve design would provide for a minimum of 260 elements per dry storage cask with 10 Watts to 40 Watts per element. Thus, based on the total number of elements for which the facilities are sized, the number of casks required would be:

- ninety-four casks, predicated upon a 3-year cooldown period (i.e., less than 40 Watts per element). Note that this value is conservative and corresponds to a maximum of around 40 percent of the NRC-licensed heat loads per cask. Again, most foreign research reactor spent nuclear fuel is expected to have decay heats between 10 Watts and 40 Watts per element. Initially, foreign research reactor spent nuclear fuel with higher heat loads could be unsuitable for the dry storage cask pending detailed heat transfer analysis and a final determination of limiting fuel storage temperature for aluminum-based and TRIGA-type spent nuclear fuel. However, the relatively high decay heat spent nuclear fuel represents such a small percentage of the currently identified foreign research reactor spent nuclear fuel that its impact would be small, such that after 3 years of wet storage, it would all be below a heat output of 40 Watts per element.

Figure 2-9 displays the general layout for the dry cask storage facility predicated upon a horizontal cask design. Table 2-9 summarizes dry cask storage parameters.

Dry storage cask technology would require a separate staging facility for foreign research reactor spent nuclear fuel unloading, canning, and storage cask loading, and transportation cask maintenance. This facility would have the following operational areas:

- Transportation Cask Handling: this incorporates transportation cask maintenance, truck/railcar unloading, decontamination/washdown, radioactive material control, and cask sampling/flushing/degassing.
- A Small Wet Storage Pool: for fuel transfer and short-term storage.
- Spent Nuclear Fuel Unit Handling: fuel removal, decontamination, fuel drying, fuel canning, inserting with helium, and thermal measurements.
- Spent Nuclear Fuel Unit Transfer: this constitutes placement of the spent nuclear fuel into the cask or canister, followed by sealing.
- Radwaste Treatment: this includes collection, treatment, and preparation for disposal of contaminated effluents, and radioactive waste treatment and solidification.
- Heating, Ventilating, and Air Conditioning: this represents the component of the facility that helps ensure that contamination of workers and the environment is avoided.

The inspection/characterization facility would include a shielded dry hot cell for spent nuclear fuel analysis and examination, and canning of leaking spent nuclear fuel. All equipment and instrumentation within the cells would be remotely operated. The facility would be maintained under negative pressure with exhaust through high-efficiency particulate air filters to mitigate the environmental effects of any radionuclide releases. This facility is normally

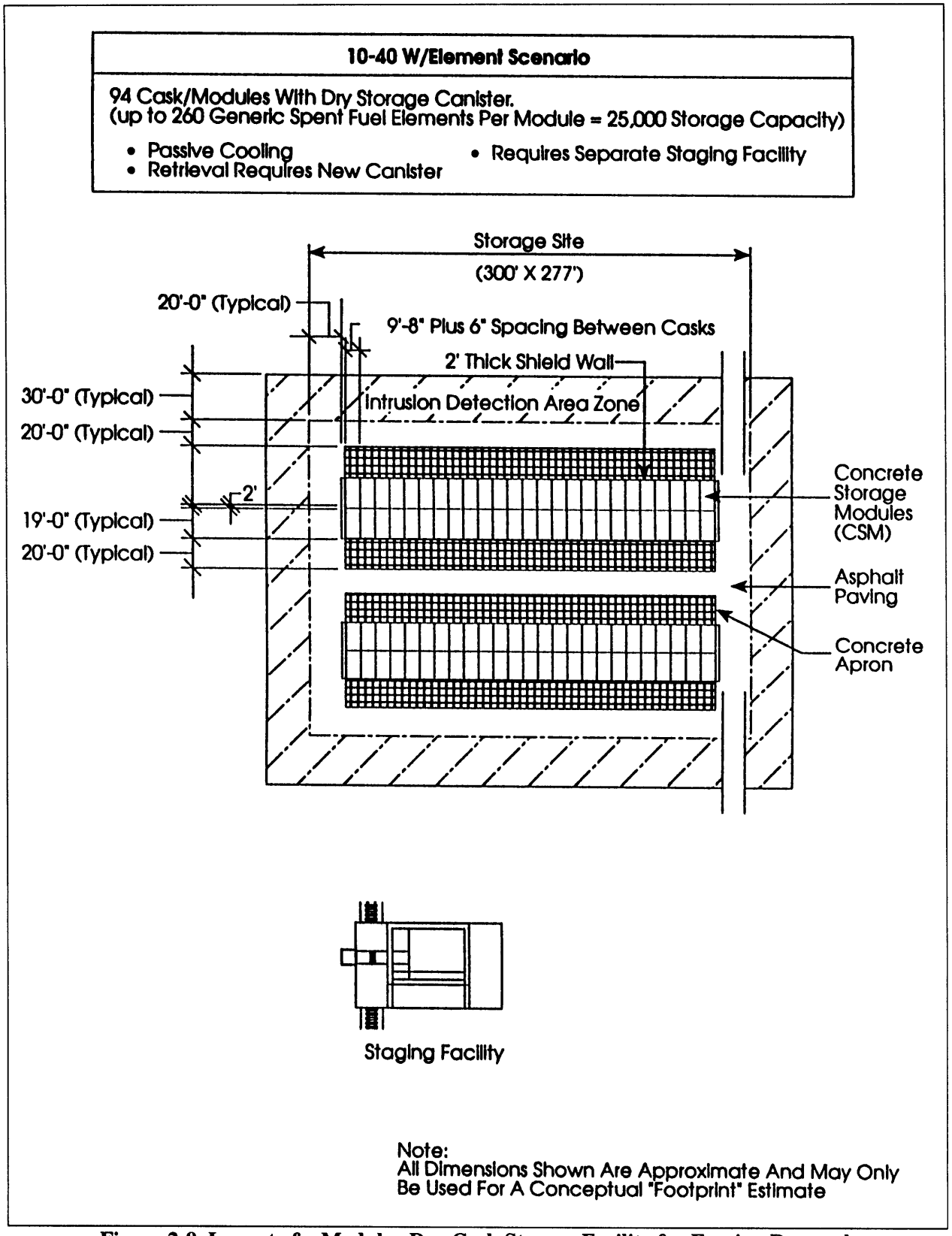


Figure 2-9 Layout of a Modular Dry Cask Storage Facility for Foreign Research Reactor Spent Nuclear Fuel (10 Watt to 40 Watt Element Basis)

Table 2-9 Summary of Dry Cask Storage Parameters for Foreign Research Reactor Spent Nuclear Fuel[a]

Construction Phase:	
Disturbed Land Area	3 ha (7.7 acres)
Facility: size (area) concrete steel	 2,200 m^2 (24,000 ft^2) 17,500 m^3 (22,900 yd^3) 4,500 metric tons (5,000 tons)
Soil Moved	11,000 m^3 (14,400 yd^3)
Equipment Fuel	810,000 l (214,000 gal)
Construction Debris/Waste	1,800 m^3 (2,400 yd^3)
Work Force	50/yr for staging facility 50 per 24 cask array, 1 array per year
Duration (years)	5.5 for staging facility 4 years for construction, 1.5 years for design
Capital Cost	$366 million[b]
Operation Phase:	
Electricity	800 - 1,000 MW-hr/yr (staging facility)
Water	2.1 million l/yr (550,000 gal/year) during receipt 0.9 million l/yr (238,000 gal/yr) thereafter
Wastestreams Solid Low-Level Waste Waste Water	 16 m^3/yr (565 ft^3/yr) during receipt 1 m^3/yr (35 ft^3/yr) thereafter 1.58 million l/yr (412,000 gal/yr) during receipt 0.4 million l/yr (109,000 gal/yr) thereafter
Staff (Full-Time Equivalents)	30 during receipt 8 thereafter
Annual Operating Cost	$17.3 million during handling, $0.3 million during storage[b]

[a] *Staging facility parameters are based upon the regionalized, small wet pool (Dahlke et al., 1994)*

[b] *Cost estimates are in 1993 dollars (EG&G, 1993)*

Basin for Offsite Fuels (RBOF) at the Savannah River Site and the CPP-666 storage pool area at the Idaho National Engineering Laboratory. For dry cask storage, the spent nuclear fuel would be shipped to the existing facility and unloaded from the transportation cask. The spent nuclear fuel would be inspected, canned if identified as a leaking element, and placed inside the storage canister. Spent nuclear fuel elements with heat loads exceeding 40 Watts per element would be stored in the existing facility to allow cooldown prior to cask storage. After filling, the canister would be sealed and placed inside the storage cask. The only new construction required would be the concrete storage pad (for vertical casks) or the concrete storage modules (for horizontal casks).

The cost to construct a dry cask storage facility with a staging area sufficient to unload, characterize, can, temporarily store in a small pool, and transfer the spent nuclear fuel to the cask storage area is estimated to be $366 million. The annual operating cost for this facility is estimated to be $17.3 million during the period of handling and transfers of the spent nuclear fuel and $0.3 million during the period of storage. The cost estimate for the facility is based on a cost report prepared by Idaho Inc. (EG&G, 1993) with the addition of the cost of a small wet storage facility reported by Dahlke et al. (Dahlke et al., 1994).

2.6.5.1.2 Description of Wet Storage Facilities

A wet storage facility consists of a spent nuclear fuel storage area and support areas (Dahlke et al., 1994). The spent nuclear fuel management area would provide for the receipt of cask transport vehicles, cask unloading and decontamination, and spent nuclear fuel handling, transfer, and storage. Support areas would provide for the equipment necessary to maintain and operate the storage area (e.g., heating, ventilating, and air conditioning; water treatment; and waste management). The general layout of a wet storage facility is presented in Figure 2-10. The wet storage facility would be constructed as a safety class structure that meets all current nuclear regulations to withstand natural events such as seismic activity, tornadoes, and floods, as well as aircraft impact. Systems supporting the operation of the spent nuclear fuel management facility would also be required to meet these safety requirements. The facility would be equipped with a 118-metric ton (130-ton) overhead crane and a 9-metric ton (10-ton) spent nuclear fuel handling crane. Figure 2-11 displays a schematic of the facility, and Table 2-10 summarizes wet storage parameters for foreign research reactor spent nuclear fuel handling and storage.

Each cask transport vehicle would enter the facility through one of two bays where it would be monitored and washed to remove transportation dust. When the external surfaces are cleaned, the cask would be placed into a decontamination room where the cask would be prepared as needed to facilitate underwater unloading. The cask would then be placed in an unloading pool. The cask receiving area can accept two simultaneous shipments on 3 m by 24.4 m (10 ft by 80 ft) trucks or railcars, and casks weighing up to 114.3 metric tons (126 tons) each with a total individual cask and transport vehicle weight of 176 metric tons (195 tons). There are two unloading pools [6.1 m long and wide by 11.0 m deep (21 ft long and wide by 36 ft deep) and 6.4 m long by 5.8 m wide by 13.4 m deep (21 ft long by 19 ft wide by 44 ft deep)] and two decontamination rooms. Prior to being placed in one of the two storage pools, each fuel element would be checked to ensure that it is properly configured for direct transfer to the fuel storage pool buckets. If not, it would be transferred to the fuel cutting/canning pool [10.4 m long by 5.8 m wide by 9.4 m deep (34 ft long by 19 ft wide by 31 ft deep)] where it would be prepared for transfer to the storage pool buckets.

If cask measurements indicated that the spent nuclear fuel might be leaking, the spent nuclear fuel would be transferred to the isolation pool [3.7 m long by 3.0 m wide by 9.4 m deep (12 ft long by 10 ft wide by 31 ft deep)] for sipping. Sipping is a methodology for determining leaking spent nuclear fuel. This pool would be equipped so that wet sipping, dry sipping, or vacuum sipping of the suspect spent nuclear fuel element could be performed. An identified leaking spent nuclear fuel element would then be transferred to the cutting/canning pool where it would be canned before transfer to one of the storage pools. If it was not found to be leaking, it would be transferred directly to a storage pool.

All six pools in this facility (two unloading, two storage, one cutting/canning, and one leak check/isolation) would be hydraulically connected by a transfer channel/pool which would be 6.1 m long by 3.3 m wide by 9.4 m deep (20 ft long by 11 ft wide by 31 ft deep). Gates between this transfer channel and each pool would allow for hydraulic watertight isolation of the other pools. All pools and channels would be constructed of concrete with stainless steel floors and liners. Pool water leak detection and collection systems in accordance with NRC Regulatory Guide 1.13 (NRC, 1975) and American National Standards Institute, Standard N305-1975 (ANSI, 1975) would be provided for the pools.

Each of the two storage pools would be 16.5 m long by 10.4 m wide by 9.4 m deep (54 ft long by 34 ft wide by 31 ft deep), and each would contain 40 stainless steel storage racks. This would provide 1,000 storage holes with a 20 cm (8 in) spacing maintained between adjacent holes. The 20 cm (8 in) space provides neutron isolation between adjacent spent nuclear fuel elements, and would ensure criticality safety. Each rack would be 2.0 m square and 3.2 m high (6.7 ft square and 10.5 ft high) and consist of a

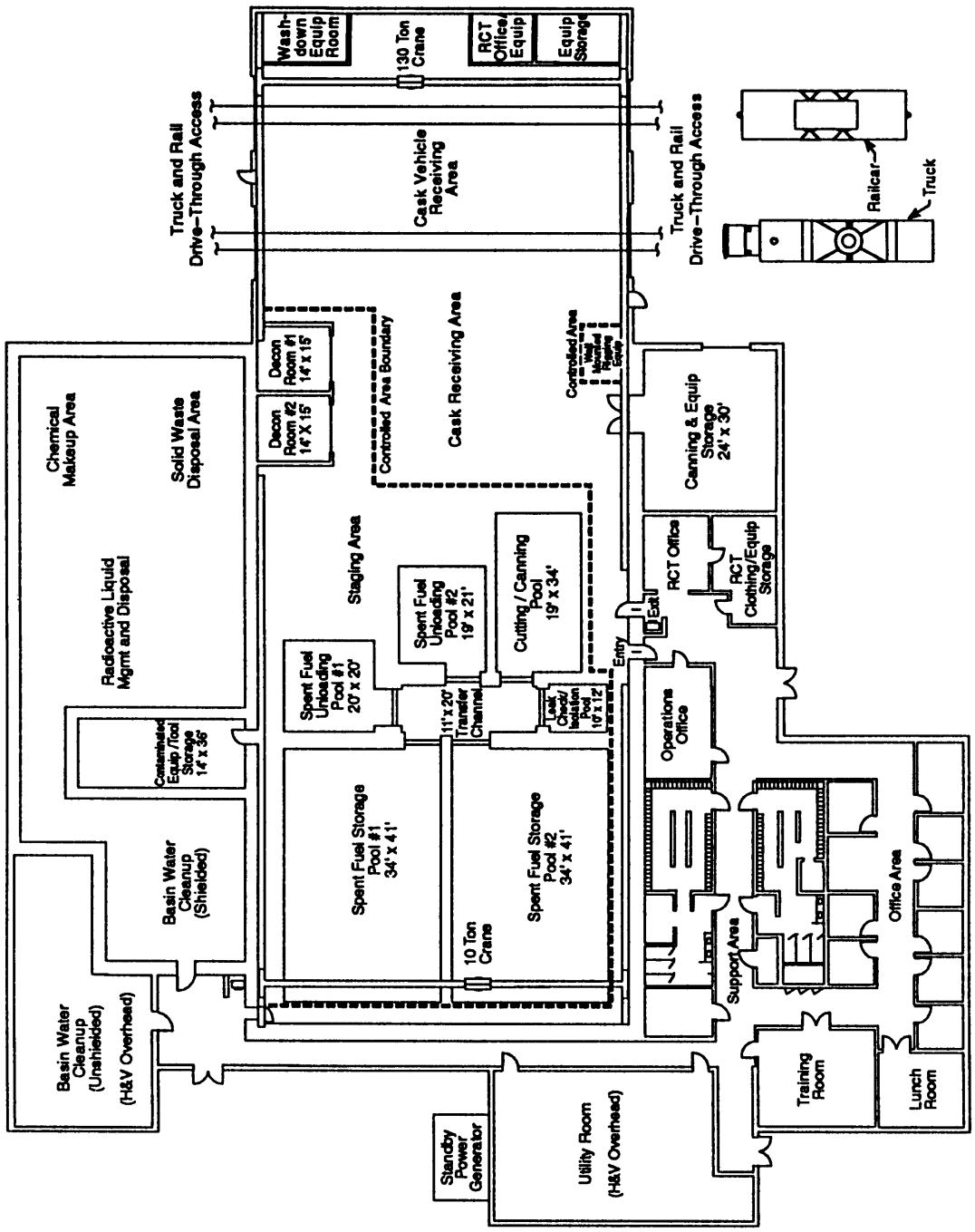


Figure 2-10 Generic Wet Storage Facility for Foreign Research Reactor Spent Nuclear Fuel

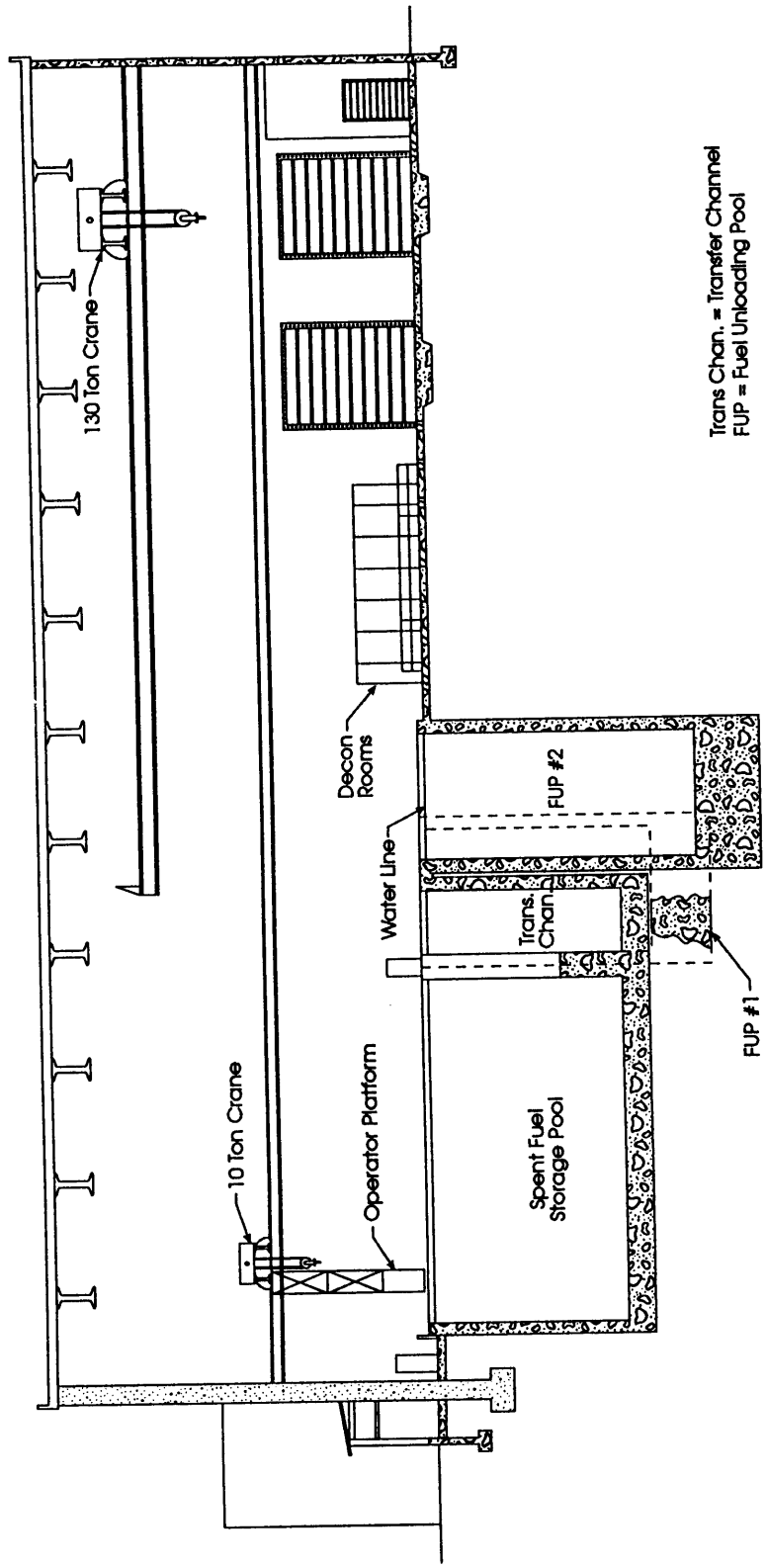


Figure 2-11 Schematic of a Wet Storage Facility for Foreign Research Reactor Spent Nuclear Fuel

Table 2-10 Summary of Wet Storage Parameters for Foreign Research Reactor Spent Nuclear Fuel

Construction Phase:	
Disturbed Land Area	2.8 ha (7 acres)
Facility: size (area) concrete steel	 3,800 m^2 (41,000 ft^2) 12,400 m^3 (16,260 yd^3) 3,100 metric tons (3,443 tons)
Soil Moved	18,000 m^3 (24,000 yd^3)
Equipment Fuel	600,000 l (159,000 gal)
Construction Debris/Waste	2,600 m^3 (10,300 yd^3)
Work Force	157/yr (average), 184 peak
Duration (years)	4 years for construction, 1.5 years for design
Cost	$449 million[a,b]
Operation Phase:	
Electricity	1,000 - 1,500 MW-hr/yr
Water (liters)	2.7 million l/yr (720,000 gal/yr) during receipt 1.5 million l/yr (409,000 gal/yr) thereafter
Waste Streams:	
High-Level Waste	none
TRU	none
Solid Low-Level Waste	16 m^3/yr (580 ft^3/yr)
Waste Water	1.59 million l/yr (420,000 gal/yr) during receipt 0.4 million l/yr (109,000 gal/yr) thereafter
Staff (Full-Time Equivalents)	30
Annual Cost	$23.3 million during handling, $3.5 million during storage[b]

[a] *Cost estimates are in 1993 dollars (EG&G, 1993)*

[b] *The cost may include duplicate facilities and equipment present in both the staging and the rest of the wet storage facility.*

5 by 5 array of 25 spent nuclear fuel positions. A hinged lid would be above each of these spent nuclear fuel positions. Spent nuclear fuel elements would be stored in the racks so that at least 30 cm (12 in) of rack would protrude above the top of the fuel. Each position in the rack can hold up to three storage buckets, which would be stacked vertically on top of each other. The bucket, made up of 3.175 mm (0.125 in) thick stainless steel, would be fitted with ceramic spaces to prevent galvanic corrosion, and could store either two or four spent nuclear fuel elements, depending on the specific fuel design. This would provide a total capacity of approximately 12,000 elements for each storage pool.

The heating, ventilation, and air conditioning system for the wet storage facility would include a room of air supply equipment and a room for air exhaust equipment with separate filtering and monitoring. All exhaust air would be directed through pre-filters, high-efficiency particulate air filters, radiation monitors, filter fire protection components, and heat recovery coils before it would exhaust to the atmosphere.

The wet storage facility's water treatment system would consist of redundant pumps, piping, filters, deionizers and microorganism control systems. A heat removal system would be sized to maintain the bulk water temperature to acceptable levels. The system's filters and deionizers would include anion and cation exchangers that maintain water chemistry and remove radionuclides from the pool water.

The staff required to operate the wet storage facility would be a maximum of 30 when 24-hour-a-day fuel loading was being performed.

No high activity solid radioactive waste would be generated by the wet storage facility (equivalent to Class B or C low-level waste) over the life of the facility. Low-level solid radioactive waste that would be generated over the life of the facility would be about 640 m^3 (22,600 ft^3). Nonradioactive solid waste generated over the facility's life would be about 300 m^3 (10,600 ft^3). All ventilation air would pass through roughing and high-efficiency particulate air filters prior to exhaust. No nonradioactive, hazardous air emissions would be generated by this facility.

The cost to construct a wet storage facility with a staging area sufficient to unload, characterize, can, and transfer the spent nuclear fuel to the storage area is estimated to be $449 million. This cost may include some duplicate facilities and equipment present in both the staging facility and the rest of the wet storage facility which were costed separately. The annual operating cost for this facility is estimated to be $23.3 million during the period of handling the spent nuclear fuel and $3.5 million during the period of storage. The cost estimate for the facility is based on a cost report prepared by Idaho Inc. (EG&G, 1993).

2.6.5.2 Chemical Separation

Chemical separation involves separating the fissile material in the spent nuclear fuel from the other material (i.e., cladding material, fission products, etc.). Uranium and plutonium isotopes constitute the fissile materials; and with foreign research reactor spent nuclear fuel, relatively little plutonium and actinide elements are produced because the ^{238}U precursor is present in relatively small quantities. Waste materials would be mainly fission products (radioactive species such as cesium and strontium) in the form of liquid raffinates, low-level radioactive wastes, mixed radioactive/chemical wastes, waste acids, chelating and complexing agents, and organic solvents. The highly radioactive nature of fission products would require that the chemical separation activities be performed. Plutonium can be handled in facilities without radiation shielding, although these materials would still have to be handled under special procedures and precautions due to their radioactive, fissile nature. The other waste forms would require specialized handling, including volume reduction in some cases, to allow for safe storage and disposal.

Aqueous chemical methods are the only processing method applied on a large scale. All existing plants use an extraction process, which has been used for some 40 years. The spent nuclear fuel is initially dissolved in an acid and contacted with an organic solvent containing an extractant, such as tributylphosphate. The uranium and plutonium form a complex with the tributylphosphate and transfer to the organic phase. The cladding and waste materials remain in the aqueous phase, which is termed high-level waste. The uranium and plutonium are subsequently recovered by contact of the organic phase with weak acidic solutions. Vitrification of the high-level waste is the preferred waste management approach.

As discussed in Section 2.2.2.6 chemical separation is not a preferred technology for managing spent nuclear fuel in the United States.

Processing facilities exist at several DOE and foreign sites. The main domestic facilities are located at the Savannah River Site and Idaho National Engineering Laboratory. The main foreign facilities are in France and the United Kingdom.

Savannah River Site Facilities

At the Savannah River Site, two facilities are available to chemically separate the foreign research reactor spent nuclear fuel. These facilities are the F- and H-Canyons. The F- and H-Canyon facilities are nearly identical structures that use similar radiochemical processes for the separation and recovery of plutonium, neptunium, and uranium isotopes. The F-Canyon primarily recovered ^{239}Pu and ^{238}U from irradiated natural or depleted uranium, and the H-Canyon primarily recovered ^{238}Pu, ^{237}Np, and ^{235}U from irradiated reactor fuels and targets. The following paragraphs apply to both canyons unless noted.

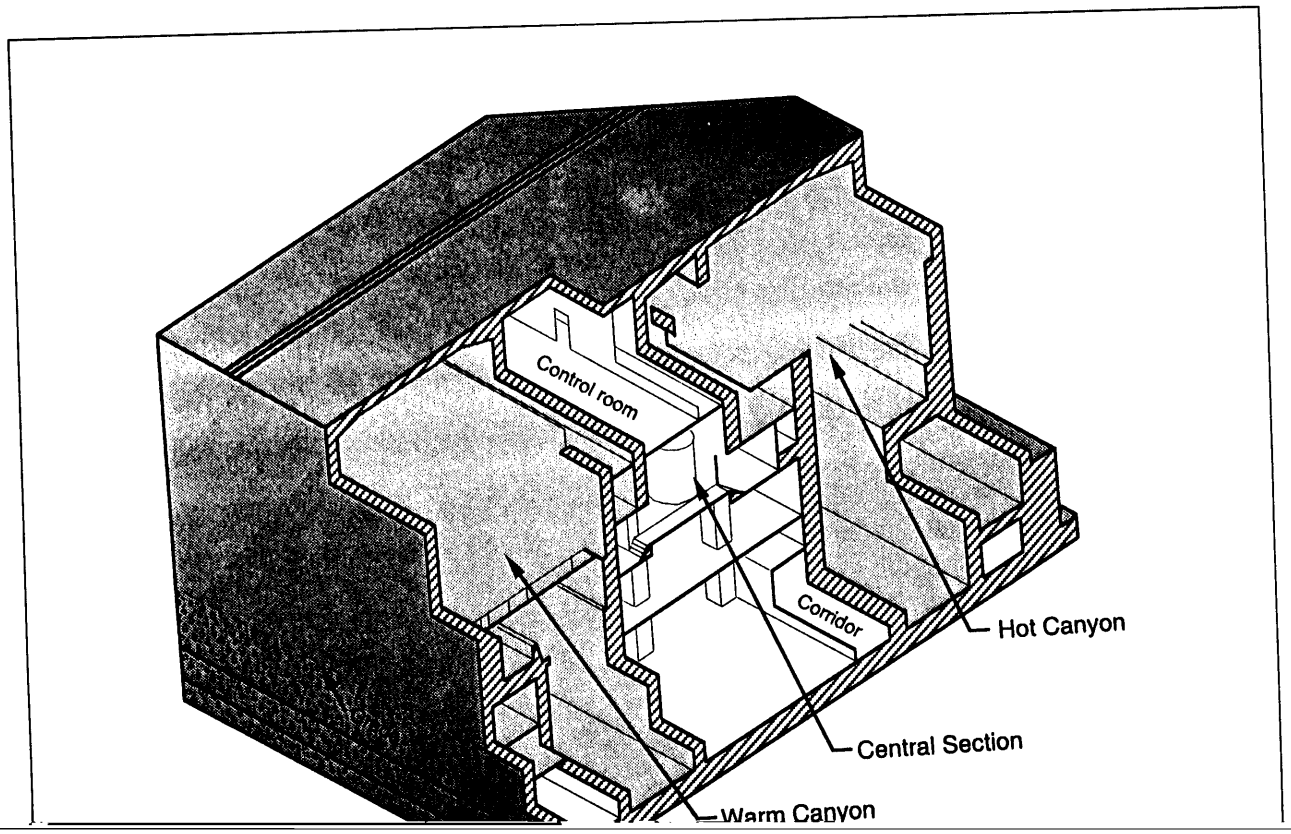
The F- and H-Canyons are reinforced concrete structures, 255 m long by 37 m wide, and 20 m high (836.6 ft by 308 ft by 121.4 ft). They are named for the two areas ("canyons") in each structure that house the large equipment (tanks, process vessels, evaporators, etc.) used in the chemical separations processes performed in each facility. These areas are 170 m long by an average of 6 m narrow and 20 m deep (557.7 ft by 19.7 ft by 65.6 ft). The two canyons are parallel and open from floor to roof. A center section, which has four floors or levels, separates the canyons. The center section contains office space, the control room for all facility operations, chemical feed systems, and support equipment such as ventilation fans. Processing operations involving high radiation levels (dissolution, fission product separation, and high-level radioactive waste evaporation) occur in the "hot" canyon, which has thick concrete walls to shield people outside the facility and in the center section from radiation. The final steps of the chemical separations process, which generally involve lower radiation levels, occur in the "warm" canyon. Figure 2-12 shows the layout of F-Canyon.

Services typical for a large industrial facility are required to support the canyon operations. Such services include steam and cooling water for process vessels and a ventilation system.

A separate ventilation system serves portions of the facility, such as the hot and warm canyons, that contain the radioactive process equipment. This system ensures that the air pressure in such areas is below the pressure of the air outside the facility and the area occupied by workers. This design helps prevent the release of radioactive material outside the facility by ensuring that air always flows from the outside of the facility to the inside of the process areas. Air in the process areas is exhausted from the facility through a large filter that removes 99.5 percent of any airborne radioactive material from the air. A 61-meter-tall (200-ft) stack behind each canyon discharges this air to the atmosphere. This stack is the pathway for airborne emissions associated with the normal operation of the canyons.

Even though DOE has maintained the chemical separation facilities since their construction, they contain equipment and systems that have become degraded because of their age and changes in mission. In some cases the degraded condition of equipment can pose operational limitations. For example, at one time the H-Canyon contained equipment that provided the capability to dissolve not only aluminum-clad reactor fuel but also fuel clad in stainless steel. The electrolytic dissolver used for this purpose is no longer functional and has been abandoned in place.

Because of the ages of the facilities, they do not satisfy all current DOE requirements for the design and construction of nuclear facilities. For example, the canyons and associated B-Line facilities were built (during the Cold War when a primary concern was the potential for an attack) to resist a large external blast. The blast-resistant features of the canyons also make them resistant to such external natural phenomena as tornadoes and earthquakes. However, the canyons were not designed to withstand a severe earthquake (defined as producing a lateral ground acceleration that is 20 percent that of gravity or 0.2 g),


Control room
Corridor
Hot Canyon
Central Section
Warm Canyon

DOE has conducted many reviews to evaluate facility vulnerabilities and has assessed its facilities for compliance with current requirements. DOE has also analyzed the effect on workers and the public from normal and potential accident conditions which could result from operation of facilities with these vulnerabilities. The analysis work was accomplished as a part of ongoing safety review programs and is separate from the NEPA process. Such impact information is represented in the Final Interim Management of Nuclear Materials EIS and in this EIS. The analysis of impacts has, in some cases, prompted DOE to take corrective action based on potential impact alone. For example, DOE has disconnected some tanks of radioactive solutions in the canyons from the canyon cooling system and has isolated canyon tanks by removing interconnected piping to preclude leaks or an inadvertent transfer which could result in a release of radioactive material outside the canyon. In other cases, the potential impact was determined to be small and not sufficient to warrant actions beyond those which could be taken using existing facilities, equipment, and personnel. For example, one vulnerability common to many facilities is that the facility could sustain structural damage in the event of a severe earthquake. This type of earthquake has been estimated to occur once every several thousand years. It would be prohibitively expensive to modify facilities to ensure that no structural damage would occur from such an accident. Rather, DOE has provided mitigation for the consequences of such accidents using engineering safeguards, such as structurally reinforcing tanks, and administrative controls, such as limiting the amount of radioactive material that can be contained in a facility.

H-Canyon Process

The H-Canyon utilized a modified plutonium uranium extraction process (HM process). The HM process unit operations were dissolution, head end, first solvent extraction cycle, second uranium solvent extraction cycle, and second neptunium (or second actinide) solvent extraction cycle. Figure 2-13 shows the historic general H-Canyon process flow.

- Dissolution - Irradiated foreign research reactor spent nuclear fuel was brought into the hot canyon in water-filled casks and through an air lock by railcar. The spent nuclear fuel consists of HEU and LEU aluminum-based irradiated fuel. The spent nuclear fuel was removed from the casks and loaded into a dissolver tank. Heated nitric acid in the tank dissolved the foreign research reactor spent nuclear fuel, resulting in a solution containing enriched uranium, ^{237}Np, small quantities of plutonium, and fission products from the reactor irradiation process, and the cladding material. ^{237}Np should be insignificant in the chemical separation of foreign research reactor spent nuclear fuel.

- Head End - The head end process prepared the target solution for uranium, plutonium, and neptunium separation. First, gelatin was added to precipitate silica and other solid impurities. Then the solution was transferred to a centrifuge, where silica and other impurities were removed as waste, and the clarified product solution was adjusted with nitric acid and water. The wastestream generated from the head-end process was chemically neutralized and sent to high-level waste tanks.

- First Cycle - First cycle operation removed fission products and other chemical impurities, and separated the solution into two product streams for further processing. The chemical properties of acid/solvent/product solutions in contact with each other caused the fission products, the uranium, and the neptunium to separate from the solution containing plutonium.

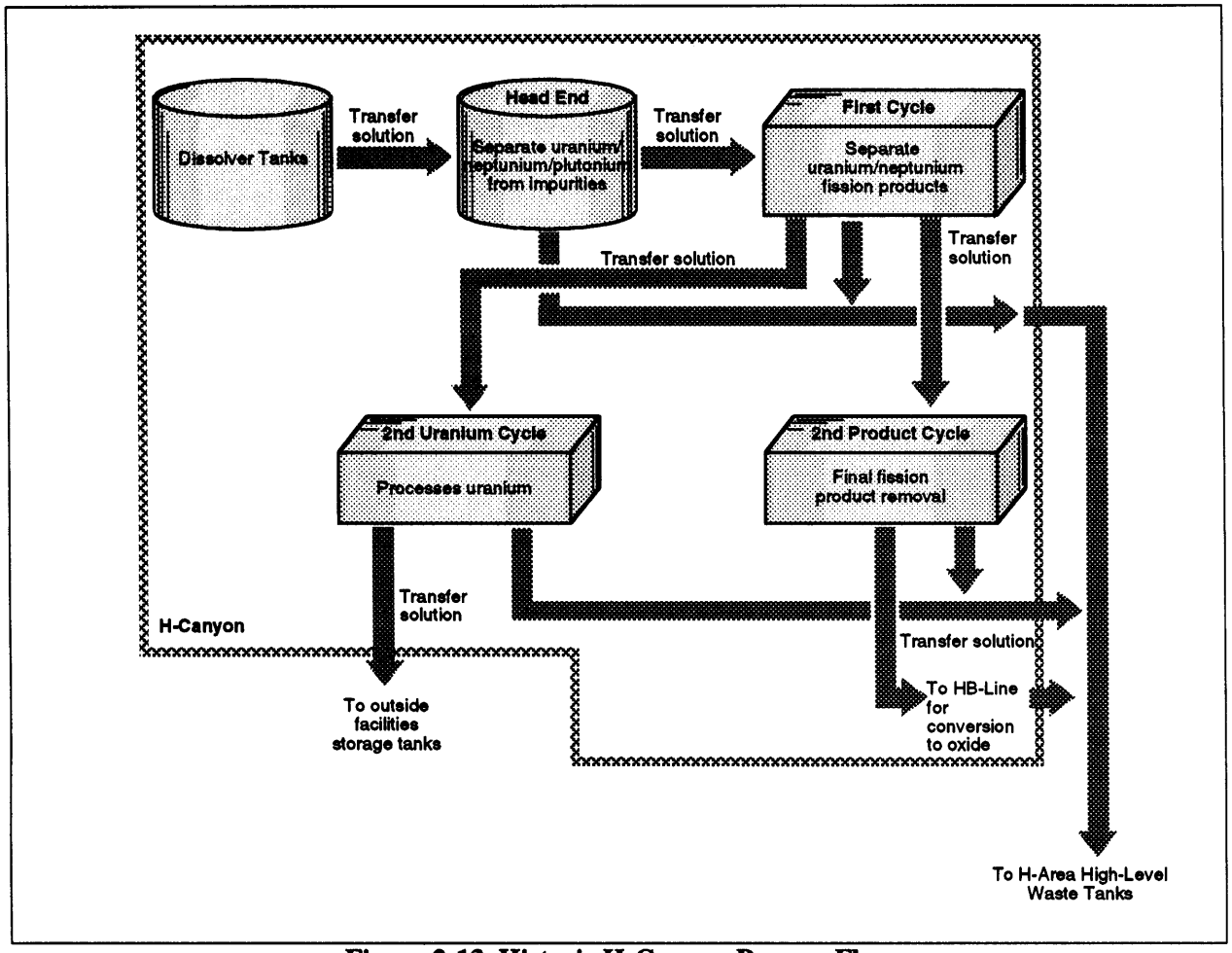


Figure 2-13 Historic H-Canyon Process Flow

- Second Uranium Cycle - The second uranium cycle purified the uranium solution from the first cycle and prepared the uranium for transfer. The purification occurred in a manner similar to that described for the first cycle. The ^{235}U product solution was transferred to storage tanks.

- Second Product Cycle - The second product cycle purified the neptunium solution from the first cycle by removing residual fission products, and prepare the neptunium for transfer. The process occurred in a manner similar to that for the first cycle. The impurities were removed and sent to the low-activity waste unit operation for processing. This cycle would probably be bypassed in the chemical separation of foreign research reactor spent nuclear fuel. Trace neptunium would be discarded as waste.

- High- and Low-Activity Waste - These unit operations reduced the volume of the aqueous streams containing fission products. The streams originate from the separation process unit operations, such as the first cycle. The fission product streams were then separated and sent to high-level waste tanks.

- Solvent Recovery - The primary purpose of this unit operation was to recover and recycle the solvent used in the first cycle. This operation reconditioned and removed impurities from the solvent. The purified solvent was returned to the first and second cycle, cycle reuse and the impurities were transferred to low-activity waste for processing.

F-Canyon Process

The Plutonium Uranium Extraction process at the F-Canyon includes unit operations such as dissolution, head end, first cycle, second uranium cycle, and second plutonium cycle. Unit operations that support the product recovery process were high-activity waste, low-activity waste, and solvent recovery. These were similar to those described for the HM process at H-Canyon with the exception of the Plutonium Uranium Extraction process. In the Plutonium Uranium Extraction process, the second plutonium cycle was equivalent to the second product cycle in the HM process.

Idaho National Engineering Laboratory Facilities

The Idaho Chemical Processing Plant (ICPP) facilities would use a Uranium Extraction process to chemically separate the foreign research reactor spent nuclear fuel for recovery of uranium, and isolation and solidification of the waste fission products resulting from the process. The principal facilities for foreign research reactor spent nuclear fuel chemical separation would be CPP-601, CPP-666, and CPP-602.

Foreign research reactor spent nuclear fuel would be received at the ICPP by truck or rail shipment. Both water-cooled and dry storage facilities would be used. Head-end equipment for initially dissolving or processing the spent nuclear fuel would be available. Aluminum-based clad fuel chemical separation could be conducted in CPP-601. TRIGA-type fuels would be processed in the Fluorinel Dissolution Process in CPP-666. The Fluorinel Dissolution Process cell could require some equipment modifications and additions to accommodate stainless steel-clad dissolution of the TRIGA fuel. However, the process knowledge and equipment is readily available. A new processing facility for uranium fuels is partially completed at the ICPP site. This facility, the Fuel Processing Restoration, is structurally complete but would require completion of services and installation of equipment for foreign research reactor spent nuclear fuel chemical separation.

The high-level liquid waste generated at ICPP during chemical separation of the spent nuclear fuel assemblies would be stored in several large stainless steel underground tanks until it could be processed. Liquid wastes would be converted to a solid calcine form, and then stored dry in bins housed in concrete vaults.

Aluminum and zircaloy fuel processing at ICPP consists of three principal stages. The first is the dissolution stage where fuels were dissolved forming a controlled solution. The second stage is the extraction process, which consists of first, second, and third extraction cycles. These cycles serve to separate and purify the uranium from fission products and material wastes prior to final operations. In the final operation, the solution is fed through a denitrator that conditions the feed material to a solid uranium product that can be packaged, transported, and recycled.

Foreign Reprocessing Facilities

Both France and the United Kingdom have modern fuel cycle facilities and offer reprocessing services to international customers. Either country could sign contracts with foreign research reactor owners/operators for receipt and reprocessing of their spent nuclear fuel, treatment of the waste, and fabrication of fresh fuel. Both France and the United Kingdom would require the country operating the reactor to take back the treated waste.

The French UP1 plant at Marcoule has reprocessed a variety of nuclear fuels, including gas/graphite power reactor fuel and magnesium-clad natural uranium metal fuel. The UP2 plant at La Hague is nearing completion of major renovations that will double its throughput and make it dedicated to oxide fuels. The UP3 plant, also at La Hague, is the newest French reprocessing plant. It started operations in 1990 and is also dedicated to oxide fuels. The French are vigorously engaged in reprocessing commercial power reactor fuel for foreign customers.

The British Prototype Fast Reactor Reprocessing Plant at Dounreay is a small plant associated with the

nuclear fuel for reprocessing. The Magnox Fuel Reprocessing Plant at Sellafield reprocesses magnesium-clad uranium metal fuel from British gas-cooled reactors. The Thermal Oxide Reprocessing Plant (Thorp) is another large plant at Sellafield for Advanced Gas Reactor and light water reactor fuels. It

As a potential Phase 1 site under Management Alternative 1, the Savannah River Site would receive and manage foreign research reactor spent nuclear fuel at its existing wet storage facilities: RBOF and L-Reactor disassembly basin are considered for this purpose. RBOF is located at the H-Area. It is a facility with provisions for the receipt and storage of irradiated nuclear fuel elements. Since 1963, irradiated spent nuclear fuel elements have been received from offsite reactors and from the Savannah River Site reactors. RBOF provides the capability for underwater unloading of the transportation casks and the handling and storage of the foreign research reactor spent nuclear fuel. The foreign research reactor spent nuclear fuel would be stored in RBOF until the storage capacity is exhausted. Currently, RBOF has space for approximately 1,170 foreign research reactor spent nuclear fuel elements. This capacity could be increased to a total of 2,425 elements by rearranging and consolidating existing inventory. Descriptions of RBOF, the Savannah River Site reactor disassembly basins, and dry cask storage are provided in Appendix F, Section F.3.

The Savannah River Site reactor disassembly basins are not currently configured for storage of MTR type foreign research reactor spent nuclear fuel, however, minor modifications which would provide new storage racks, new handling equipment, safety documentation, etc., along with upgrades in progress to address vulnerabilities associated with water chemistry control, would permit receipt and management of foreign research reactor spent nuclear fuel. Installation of racks equivalent to those in RBOF would provide storage for approximately 20,000 foreign research reactor spent nuclear fuel elements per reactor basin. DOE is considering the L-Reactor disassembly basin for this purpose in this EIS. The modifications to RBOF and L-Reactor disassembly basin

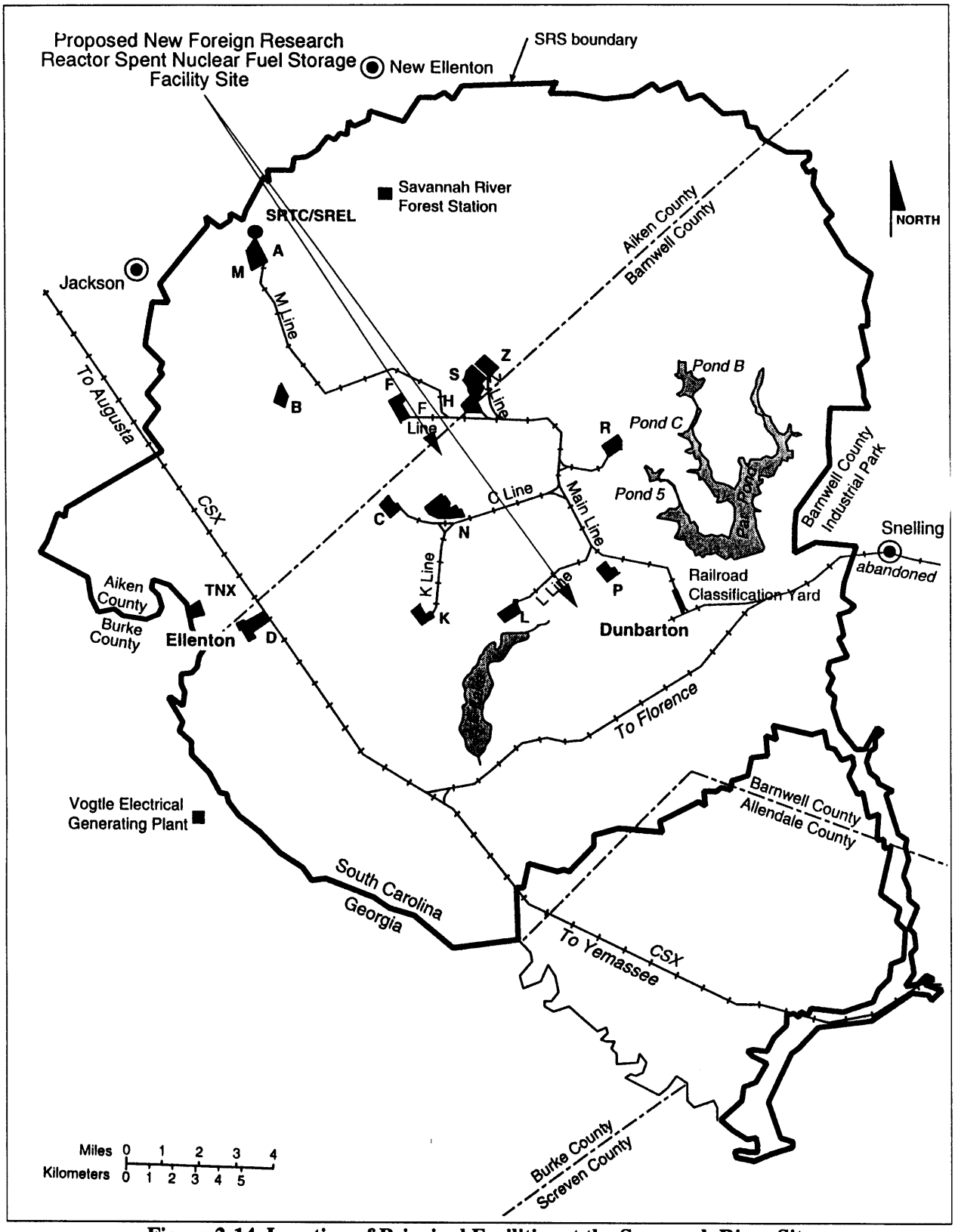


Figure 2-14 Location of Principal Facilities at the Savannah River Site

1A. The Savannah River Site would receive and manage foreign research reactor spent nuclear fuel during Phase 1 and store it at the RBOF and/or the L-Reactor disassembly basin. For the purpose of the analysis, the amount of fuel to be managed is all foreign research reactor spent nuclear fuel that would be received in a 10-year period (17,500 elements). The fuel would be shipped offsite at the end of Phase 1.

1B. Foreign research reactor spent nuclear fuel managed under analysis option 1A would be transferred to a newly constructed dry storage facility, where it would be managed until ultimate disposition. Spent nuclear fuel arriving in the United States after Phase 1 concludes would be received and managed at the new dry storage facility. For the purpose of the analysis, the amount of spent nuclear fuel that would be managed would be all the foreign research reactor spent nuclear fuel (22,700 elements).

The implementation alternatives of Management Alternative 1, discussed in Section 2.2.2, introduce additional analysis options that could be considered for the Savannah River Site as follows:

- Under Implementation Subalternative 1a (Section 2.2.2.1), the amount of fuel to be received in the United States would be reduced to 5,000 elements. In this case, the Savannah River Site would be likely to receive and manage foreign research reactor spent nuclear fuel in existing facilities during the Phase 1 period. The impacts would be bounded by analysis option 1A (above). Impacts of construction and operation of the dry storage facility considered in analysis option 1B would bound those of the facility required to accommodate this amount of fuel. The spent nuclear fuel would either be shipped offsite after Phase 1, or it would be managed along with the rest of the spent nuclear fuel that would be managed at the Savannah River Site.

- Under Implementation Subalternative 1b (Section 2.2.2.1), the Savannah River Site would receive only HEU from the foreign research reactors eligible under the policy. The amount of HEU would be approximately 4.6 MTHM, representing 11,200 elements. The impacts from the management of this amount of fuel at the Savannah River Site would be bounded by analysis options 1A and 1B above.

- Under Implementation Subalternative 1c (Section 2.2.2.1), the Savannah River Site would receive target material in addition to the foreign research reactor spent nuclear fuel considered under the basic implementation of Management Alternative 1. The receipt and management of this material, which, in uranium content, represents approximately 620 typical foreign research reactor spent nuclear fuel elements, would increase the impacts of analysis options 1A or 1B (above) by a small percentage.

- Under Implementation Subalternative 2a (Section 2.2.2.2), the duration of the policy would be decreased to 5 years; and, therefore, the amount of spent nuclear fuel available for management would also be decreased. The impacts from the management of the decreased amount of spent nuclear fuel at the Savannah River Site would be bounded by analysis options 1A or 1B above.

- Under Implementation Subalternative 2b, (Section 2.2.2.2) the acceptance of a small portion of the spent nuclear fuel would be extended over an indefinite period of time, but the amount of spent nuclear fuel to be received and managed would remain constant. The impacts would be the same as in analysis options 1A or 1B.

- Under Implementation Alternative 3 (Section 2.2.2.3), DOE and the Department of State would consider alternative financial arrangements. These arrangements would affect the amount of spent nuclear fuel that would be managed in the United States because the foreign research reactors would consider their own alternatives as to whether or not to send the spent nuclear fuel to the United States. The amount of foreign research reactor spent nuclear fuel in this case cannot be quantified. The upper limit, however, is considered under analysis options 1A and 1B (above), which would be bounding.

- Under Implementation Alternative 4 (Section 2.2.2.4), DOE and the Department of State would consider alternatives for the location where title of foreign research reactor spent nuclear fuel would be taken. The choices do not affect the management options at the Savannah River Site.

- Under Implementation Alternative 5 (Section 2.2.2.5), DOE would consider wet storage technology for Phase 2 management. DOE would implement this alternative by constructing a new wet storage facility at the H-Area or by using the Barnwell Nuclear Fuels Plant (BNFP), owned by Allied General Nuclear Services. DOE would have to acquire the facility which could be ready for use in approximately 5 years. Therefore, if the Savannah River Site was a selected site under either the Regionalization by Fuel Type or Centralization alternatives, Phase 2 at the Savannah River Site could start as early as 5 years from the start of the implementation period if BNFP were used under this implementation alternative. The new wet storage facility is described in Section 2.6.5.1.2. BNFP is described in Appendix F, Section F.1. For this implementation alternative, an analysis option 1C is considered, which is similar to 1B, as follows:

1C. The spent nuclear fuel managed under analysis option 1A would be transferred to a newly constructed wet storage facility or the BNFP where it would be managed until ultimate disposition. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would be received and managed at these facilities. For the purpose of the analysis, the amount of spent nuclear fuel that would be managed in these facilities would be all the foreign research reactor spent nuclear fuel (22,700 elements).

- Under Implementation Alternative 6 (Section 2.2.2.6), DOE and the Department of State would consider chemical separation of foreign research reactor spent nuclear fuel in the United States. As noted in Section 2.3.6, the Savannah River Site is limited to chemical separation of aluminum-based foreign research reactor spent nuclear fuel.

Under Management Alternative 2, discussed in Section 2.3, DOE and the Department of State would assess the management of foreign research reactor spent nuclear fuel in a foreign location which would include an evaluation of foreign reprocessing with acceptance by the United States of the vitrified high-level waste resulting from reprocessing. The waste would be received and managed at the Defense Waste Processing Facility at the Savannah River Site. DOE and the Department of State estimate that the total volume of the vitrified high-level waste would be about 2.4 m^3 (85 ft^3) and it would fill about 16 European-size canisters. A European-sized canister is about four times smaller than the canister used in the Defense Waste Process Facility at the Savannah River Site. Some modification to the waste handling facility at the Savannah River Site would be necessary to accommodate the smaller canisters.

Under Management Alternative 3 (Hybrid Alternative) discussed in Section 2.4, the Savannah River Site would receive the aluminum-based fuel which would not be reprocessed overseas. This spent nuclear fuel would be processed at the Savannah River Site chemical separation facilities in the same manner as

Implementation Alternative 6 above. The amount of aluminum-based spent nuclear fuel to be chemically separated would be approximately 12,200 elements, 12.9 MTHM, 72 m^3 (2,700 ft^3) as indicated in Table 2-4.

Table 2-11 presents an overview of the foreign research reactor spent nuclear fuel management options, quantities of foreign research reactor spent nuclear fuel assumed for the analysis, and facilities considered.

Table 2-11 Proposed Quantities of Foreign Research Reactor Spent Nuclear Fuel and Management Options at the Savannah River Site

FRR EIS Management Alternative	*FRR*	*Percentage of FRR*	*Storage Option/Technology*			
			Dry Storage	*Wet Storage*	*Existing Facilities*	

distribution considered in the Programmatic SNF&INEL Final EIS (DOE, 1995c). Accordingly, the Idaho National Engineering Laboratory could receive one-half of the foreign research reactor spent nuclear fuel under the Decentralization and the 1992/1993 Planning Basis alternatives, all of the TRIGA-type foreign research reactor spent nuclear fuel under the Regionalization by Fuel Type alternative, only the foreign research reactor spent nuclear fuel from Western ports under the Regionalization By Geography alternative, or all foreign research reactor spent nuclear fuel under the Centralization alternative.

As a potential Phase 1 site, the Idaho National Engineering Laboratory would receive and manage foreign research reactor spent nuclear fuel at existing dry and wet storage facilities. The existing facilities identified for this purpose would be the Fluorinel Dissolution and Fuel Storage (FAST) facility in CPP-666, the Irradiated Fuel Storage Facility (IFSF) in CPP-603, and the CPP-749 storage area. Descriptions of these facilities are provided in Appendix F, Section F.3.

The FAST facility is a modern underwater storage facility which has been used in the past for receipt and storage of foreign research reactor spent nuclear fuel. It has the capability to receive and unload spent nuclear fuel casks at a rate of approximately five per week. Storage capacity for up to 8,400 foreign research reactor spent nuclear fuel elements could be provided in a 10-year period by using the spent nuclear fuel storage racks that would be installed. The capability of the FAST facility to receive foreign research reactor spent nuclear fuel in the near term is limited due to the number of activities scheduled through FY 1998. Considering these activities, DOE estimates that 3,600 elements could be received by the end of 1999 at the FAST facility.

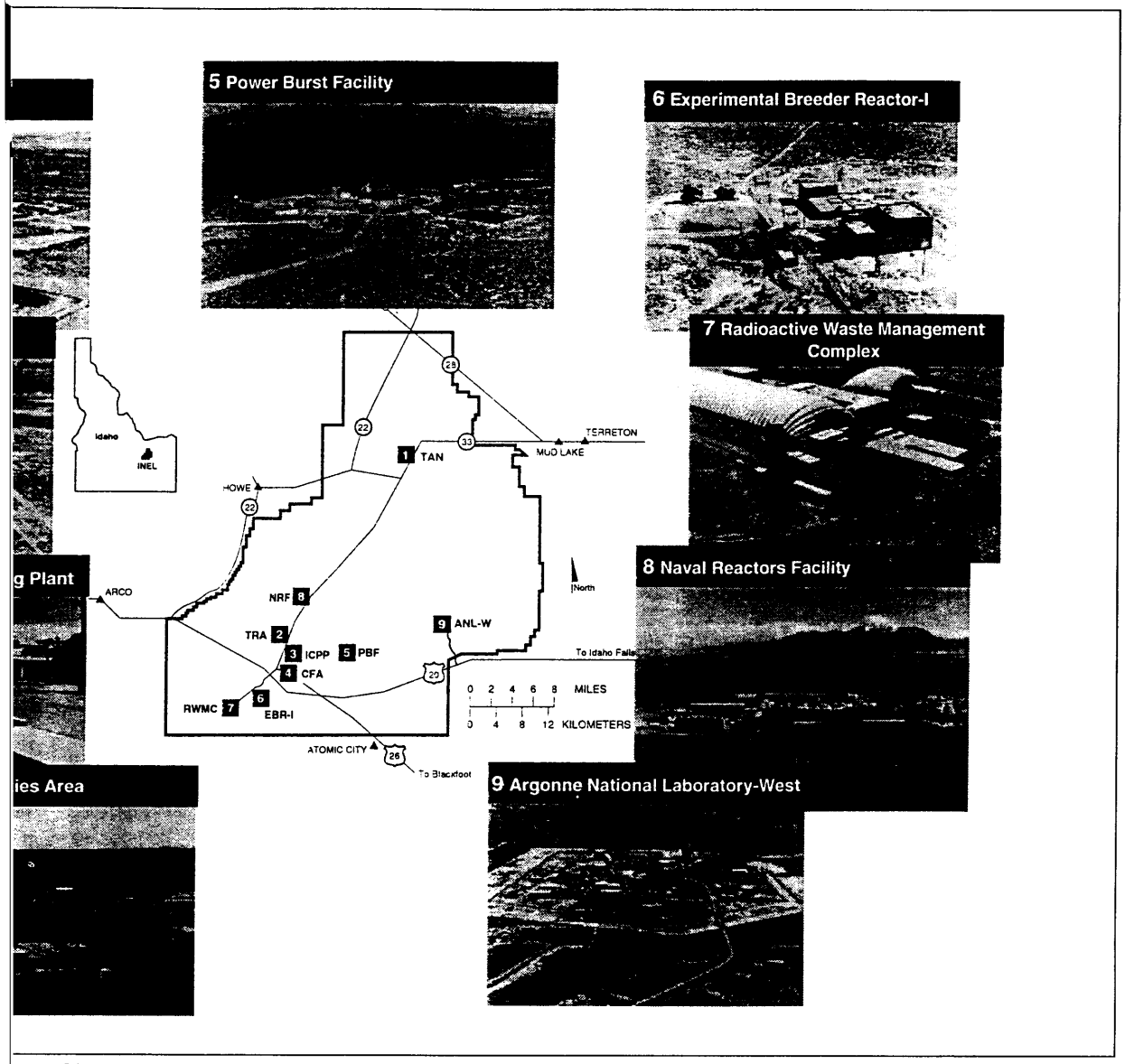
The IFSF is a shielded dry storage vault originally constructed for Fort St. Vrain reactor fuel. The storage capacity available is for approximately 9,000 foreign research reactor spent nuclear fuel elements. However, as with the FAST facility, many activities are already scheduled for the facility. Considering these activities, foreign research reactor spent nuclear fuel could not be received until sometime in FY 1997 and could continue at the rate of 50 shipments per year (approximately 1,500 elements) thereafter.

The CPP-749 underground spent nuclear fuel storage area is a dry storage facility with a remote unloading area and vault storage. With some refurbishment it could provide space for 3,600 elements starting in FY 1998. The spent nuclear fuel would go through the IFSF to be placed in baskets and transferred to a compatible storage cask. The refurbishments of existing facilities are part of the ongoing programs at the site, to be performed independent of the proposed action in this EIS.

Between these facilities there is sufficient storage space and handling capacity to accommodate the receipt and management of foreign research reactor spent nuclear fuel at the Idaho National Engineering Laboratory during the Phase 1 period. The storage capacity available and estimated maximum receipt rate of foreign research reactor spent nuclear fuel at the Idaho National Engineering Laboratory are shown in Figure F-18 of Appendix F.

An additional option to enhance storage capacity during Phase 1 would be to use the existing facilities to unload the transportation casks, and provide storage capacity in dry storage casks which would be placed near the existing facility. Descriptions of the Idaho National Engineering Laboratory existing facilities are provided in Appendix F. The location of these facilities at the Idaho National Engineering Laboratory are shown in Figure 2-15.

As a Phase 2 site, the Idaho National Engineering Laboratory would continue to receive and manage foreign research reactor spent nuclear fuel at existing facilities until a new dry storage facility were to become operational at the site. Foreign research reactor spent nuclear fuel managed at existing facilities



on of Principal Facilities at the Idaho National Engineering Laboratory

would then be transferred to the new facility where it would remain until ultimate disposition. The new facility would also receive foreign research reactor spent nuclear fuel shipments directly from ports after the 10-year policy period. Dry storage encompasses both the dry vault design and the dry cask design as described in Section 2.6.5.1.1.

The analysis of environmental impacts from management of foreign research reactor spent nuclear fuel at the Idaho National Engineering Laboratory is based on the above considerations. The analysis options selected do not represent all possible combinations, but a reasonable set which provides a typical, and in many cases, bounding estimate of the resulting impacts.

The specific analysis options under the basic implementation of Management Alternative 1, discussed in Section 2.2.1, are as follows:

2A. The Idaho National Engineering Laboratory would receive and manage foreign research reactor spent nuclear fuel during Phase 1 and store it at the FAST, the IFSF, and/or the CPP-749 facilities. For the purpose of the analysis, the amount of fuel to be managed is all foreign research reactor spent nuclear fuel that would be received in a 10-year period (17,500 elements). The fuel would be shipped offsite at the end of Phase 1.

2B. Foreign research reactor spent nuclear fuel managed under analysis option 2A would be transferred to a newly constructed dry storage facility where it would be managed until ultimate disposition. Spent nuclear fuel arriving at the United States after Phase 1 concludes would be received and managed at the new dry storage facility until ultimate disposition. For the purpose of the analysis, the amount of spent nuclear fuel that would be stored in the dry storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements).

The implementation alternatives of Management Alternative 1 discussed in Section 2.2.2 introduce additional analysis options that could be considered for the Idaho National Engineering Laboratory as follows:

- Under Implementation Subalternative 1a (Section 2.2.2.1), the amount of spent nuclear fuel to be received in the United States would be reduced to 5,000 elements. In this case, the Idaho National Engineering Laboratory would be likely to receive and manage foreign research reactor spent nuclear fuel in existing facilities during the Phase 1 period. The impacts would be bounded by analysis option 2A above. The dry storage facility considered in analysis option 2B would be sized to accommodate this amount of fuel. The fuel would either be shipped offsite after Phase 1 or it would be managed along with the rest of the spent nuclear fuel that would be managed at the Idaho National Engineering Laboratory.

- Under Implementation Subalternative 1b (Section 2.2.2.1), the Idaho National Engineering Laboratory would receive only HEU from the reactors eligible under the proposed action. The amount of HEU would be approximately 4.6 MTHM, representing 11,200 elements. The impacts from the management of this amount of fuel at the Idaho National Engineering Laboratory would be bounded by analysis options 2A and 2B above.

- Under Implementation Subalternative 1c (Section 2.2.2.1), the Idaho National Engineering Laboratory would receive target material in addition to the foreign research reactor spent nuclear fuel considered under the basic implementation of Management Alternative 1. The

receipt and management of this material, which represents, in uranium content, approximately 620 typical foreign research reactor spent nuclear fuel elements, would increase the impacts of analysis options 2A or 2B (above) by a small percentage.

- Under Implementation Subalternative 2a (Section 2.2.2.2), the duration of the policy would be decreased to 5 years and therefore the amount of spent nuclear fuel available for management would also be decreased. The impacts from the management of the decreased amount of spent nuclear fuel at the Idaho National Engineering Laboratory would be bounded by analysis options 2A or 2B above.

- Under Implementation Subalternative 2b, (Section 2.2.2.2) the acceptance of a small portion of the spent nuclear fuel would be extended over an indefinite period of time, but the amount of spent nuclear fuel to be received and managed would remain constant. The impacts would be the same as in analysis options 2A or 2B.

- Under Implementation Alternative 3 (Section 2.2.2.3), DOE and the Department of State would consider alternative financial arrangements. These arrangements would affect the amount of spent nuclear fuel that would be managed in the United States because the foreign research reactors would consider their own alternatives about whether to send the spent nuclear fuel to the United States. The amount of foreign research reactor spent nuclear fuel in this case cannot be quantified. The upper limit, however, is considered under analysis options 2A or 2B which would be bounding.

- Under Implementation Alternative 4 (Section 2.2.2.4), DOE and the Department of State would consider alternatives for the location where title of the foreign research reactor spent nuclear fuel would be taken. The choices do not affect the management options at the Idaho National Engineering Laboratory.

- Under Implementation Alternative 5 (Section 2.2.2.5), DOE would consider construction of a new wet storage facility at the Idaho National Engineering Laboratory for Phase 2 until ultimate disposition. The new wet storage facility is described in Section 2.6.5.1.2. For this implementation alternative, an analysis option 2C, which is similar to analysis option 2B, is considered as follows:

2C. The spent nuclear fuel managed under analysis option 2A would be transferred to a newly constructed wet storage facility where it would be managed until ultimate disposition. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would be received and managed at the new wet storage facility until ultimate disposition. For the purpose of the analysis, the amount of spent nuclear fuel that would be managed in the wet storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements).

- Under Implementation Alternative 6 (Section 2.2.2.6), DOE and the Department of State would consider chemical separation of foreign research reactor spent nuclear fuel in the United States. As noted in the discussion in Section 2.3.6, chemical separation of both aluminum-based and TRIGA foreign research reactor spent nuclear fuel is evaluated for the Idaho National Engineering Laboratory.

Under Management Alternative 3 (Hybrid Alternative), discussed in Section 2.4, the Idaho National Engineering Laboratory would receive the foreign research reactor TRIGA spent nuclear fuel. This spent nuclear fuel would be managed at the Idaho National Engineering Laboratory in existing facilities until final disposition. The amount of TRIGA spent nuclear fuel to be stored would be 4,900 elements, 1.0 MTHM, and about 4 m^3 (200 ft^3) as indicated in Table 2-4.

Table 2-12 presents an overview of the foreign research reactor spent nuclear fuel management options, quantities of foreign research reactor spent nuclear fuel assumed for the analysis, and facilities considered.

Table 2-12 Proposed Quantities of Foreign Research Reactor Spent Nuclear Fuel and Management Options at the Idaho National Engineering Laboratory

FRR EIS Management Alternative		*FRR SNF Elements*	*Percentage of Total FRR SNF Elements*	*Storage Option/Technology*					
				Dry Storage		*Wet Storage*		*Existing Facilities plus Casks*[c]	*Chemical Separation*
Management Alternative 1				*New*	*Existing*[a]	*New*	*Existing*[b]		
All FRR SNF	Phase 1	17,500	77%	NA	A	NA	A	A	NA
	Phase 2[d]	22,700	100%	A	NA	A	NA	NA	NA
Western FRR SNF	Phase 1	4,800	21%	NA	A	NA	A	A	NA
	Phase 2	6,300	28%	A	NA	A	NA	NA	NA
TRIGA FRR SNF	Phase 1	3,800	17%	NA	NA	NA	A	A	NA
	Phase 2	4,900	22%	NA	A	A	NA	NA	NA
Chemical Separation/Storage		22,700	100%	NA	A	NA	A	A	A
Management Alternative 3									
TRIGA FRR SNF/ Storage		4,900	22%	NA	A	NA	A	A	NA

A = Applicable
NA = Not Applicable
FRR = foreign research reactor
SNF = spent nuclear fuel
[a] *IFSF, CPP-749*
[b] *FAST*
[c] *Existing facilities augmented by dry cask storage.*
[d] *Phase 2 values represent total number of foreign research reactor spent nuclear fuel elements requiring management at the site.*

2.6.5.3.3 The Hanford Site

Options for receiving and managing foreign research reactor spent nuclear fuel at the Hanford Site are primarily dictated by the Programmatic SNF&INEL Final EIS (DOE, 1995c) alternatives, and the lack of suitable facilities at the Hanford Site to receive foreign research reactor spent nuclear fuel at the beginning of the proposed policy period.

If the Hanford Site is the site to manage DOE-owned spent nuclear fuel under the Programmatic SNF&INEL Final EIS, foreign research reactor spent nuclear fuel would be received and managed first at the Savannah River Site and/or the Idaho National Engineering Laboratory for the period (Phase 1) required for the Hanford Site to have new facilities constructed and operational to accommodate the spent nuclear fuel. As discussed in previous sections, Phase 1 is estimated to be about 10 years. At the end of Phase 1 (e.g., start of Phase 2) the Hanford Site would be able to receive and manage foreign research reactor spent nuclear fuel that would be shipped from the Savannah River Site and/or the Idaho National

Engineering Laboratory and directly from the ports for those shipments made after Phase 1 concludes. Management of the foreign research reactor spent nuclear fuel would continue at the Hanford Site until ultimate disposition.

The amount of spent nuclear fuel that would be received and managed at the Hanford Site under the basic implementation of Management Alternative 1 is dictated by the distribution considered in the Programmatic SNF&INEL Final EIS (DOE, 1995c). Accordingly, in Phase 2, the Hanford Site could receive the TRIGA foreign research reactor spent nuclear fuel managed at the Idaho National Engineering Laboratory during Phase 1, Western foreign research reactor spent nuclear fuel under the Regionalization By Geography alternative, or all foreign research reactor spent nuclear fuel under the Centralization alternative.

Under the basic implementation of Management Alternative 1, and as a Phase 2 site, the Hanford Site would receive and manage foreign research reactor spent nuclear fuel at a new dry storage facility constructed at the 200 Area Plateau or the Fuel Material Examination Facility (FMEF), which is a partially completed, large, hot cell facility. The new dry storage facility is described in Section 2.6.5.1.1. Description of the FMEF is provided in Appendix F, Section F.3. Figure 2-16 displays the potential construction locations for foreign research reactor spent nuclear fuel storage at the Hanford Site. FMEF is located near the Fast Flux Test Facility.

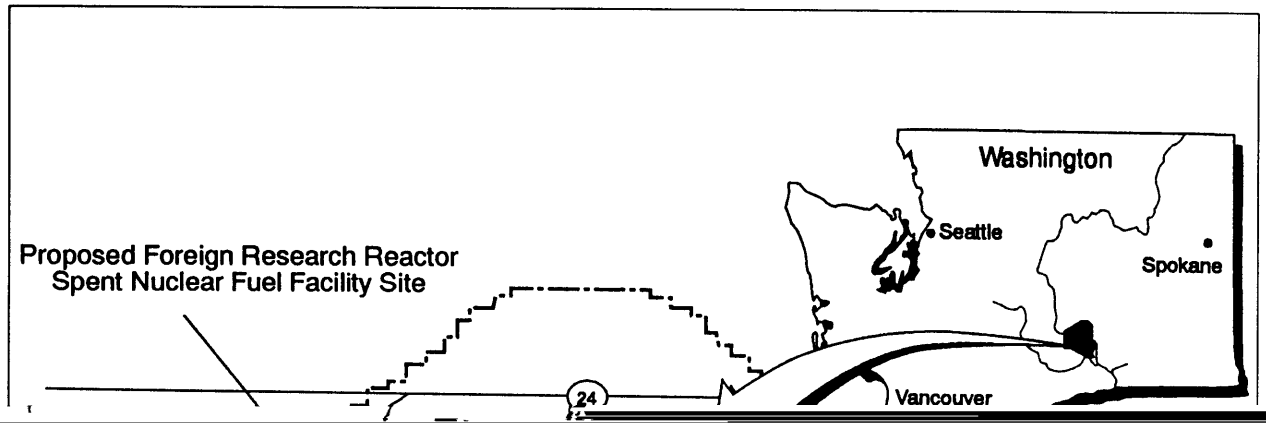
The analysis of environmental impacts from management of foreign research reactor spent nuclear fuel at the Hanford Site is based on the above considerations. The analysis options selected do not represent all possible combinations, but a reasonable set that provides a typical, and in some cases, bounding estimate of the resulting impacts.

The specific analysis option under the basic implementation of Management Alternative 1, discussed in Section 2.2.1, is as follows:

3A. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Hanford Site where it would be managed at a new dry storage facility constructed either at the 200 Area Plateau or at FMEF. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would also be received and managed at the new facility until ultimate disposition. For the purposes of the analysis, the total amount of spent nuclear fuel that would be managed in the dry storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements). If the Hanford Site were to receive TRIGA from the Idaho National Engineering Laboratory or only western spent nuclear fuel, the dry storage facility would be sized accordingly. The impacts from a smaller size facility would be bounded by the option analyzed.

The implementation alternatives of Management Alternative 1, which are discussed in Section 2.2.2, introduce additional analysis options that could be considered for the Hanford Site as follows:

- Under Implementation Subalternative 1a (Section 2.2.2.1), the amount of spent nuclear fuel to be received in the United States would be reduced to 5,000 elements. In this case, the Hanford Site would receive the foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory and/or the Savannah River Site and manage it in facilities sized for this amount. The impacts from the management of this amount of spent nuclear fuel would be bounded by analysis option 3A.


Washington
Seattle
Spokane
Proposed Foreign Research Reactor
Spent Nuclear Fuel Facility Site
24
Vancouver

- Under Implementation Subalternative 1b (Section 2.2.2.1), the Hanford Site would receive only HEU from the Idaho National Engineering Laboratory and/or the Savannah River Site. The amount would be approximately 4.6 MTHM, representing 11,200 elements. The impacts from the management of this amount of fuel at the Hanford Site would be bounded by analysis option 3A above.

- Under Implementation Subalternative 1c (Section 2.2.2.1), the Hanford Site would receive target material in addition to the foreign research reactor spent nuclear fuel considered under the basic implementation of Management Alternative 1. The receipt and management of this material, which represents in uranium content approximately 620 typical foreign research reactor spent nuclear fuel elements, would increase the impacts of analysis option 3A by a small percentage.

- Under Implementation Subalternative 2a (Section 2.2.2.2), the duration of the policy would be decreased to 5 years; and, therefore, the amount of spent nuclear fuel available for management would also be decreased. In this case, the Hanford Site would receive all foreign research reactor spent nuclear fuel from the Savannah River Site and/or the Idaho National Engineering Laboratory. The impacts from the management of the decreased amount of spent nuclear fuel at the Hanford Site would be bounded by analysis option 3A above.

- Under Implementation Subalternative 2b (Section 2.2.2.2), the acceptance of a small portion of the fuel would be extended over an indefinite period of time, but the amount of spent nuclear fuel to be received and managed would remain constant. The impacts would be the same as in option 3A.

- Under Implementation Alternative 3 (Section 2.2.2.3), DOE and the Department of State would consider alternative financial arrangements. These arrangements would affect the amount of spent nuclear fuel that would be managed in the United States as the foreign research reactors would consider their own alternatives on whether to send the spent nuclear fuel to the United States. The amount of spent nuclear fuel in this case cannot be quantified; however, the upper limit, which is considered under analysis option 3A, would be bounding.

- Under Implementation Alternative 4 (Section 2.2.2.4), DOE and the Department of State would consider alternatives for the location where title of the foreign research reactor spent nuclear fuel would be taken. The choices do not affect the management options at the Hanford Site.

- Under Implementation Alternative 5 (Section 2.2.2.5), DOE would consider construction of a new wet storage facility at the Hanford Site for Phase 2 until ultimate disposition. For this implementation alternative, an analysis option 3B, which is similar to 3A, is considered as follows:

3B. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 is shipped to the Hanford Site where it would be managed at a new wet storage facility constructed at either the 200 Area Plateau or the WNP-4 Spray Pond facility. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would also be received and managed at the new facility until ultimate disposition. For the purposes of analysis, the total amount of spent nuclear

fuel to be managed in the wet storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements). If the Hanford Site were to receive only TRIGA fuel from the Idaho National Engineering Laboratory, or only western fuel, the wet storage facility would be sized accordingly. The impacts from a smaller size facility would be bounded by the option analyzed.

- Under Implementation Alternative 6 (Section 2.2.2.6), DOE and the Department of State would consider chemical separation of foreign research reactor spent nuclear fuel in the United States. Based on the discussion in Section 2.3.6, the Hanford Site would not be considered as a site for chemical separation. The Hanford Site is also not considered under the Hybrid Alternative discussed in Section 2.4.

Table 2-13 presents an overview of the foreign research reactor spent nuclear fuel management options, quantities of foreign research reactor spent nuclear fuel assumed for the analysis, and facilities considered.

Table 2-13 Proposed Quantities of Foreign Research Reactor Spent Nuclear Fuel and Management Options at Hanford Site

Management Alternative 1		*FRR SNF Element*	*Percentage of Total FRR SNF Elements*	*Storage Option/Technology*			
				Dry Storage		*Wet Storage*	
				New at FMEF	*New*	*New at WNP-4*	*New*
All FRR SNF	Phase 2	22,700	100%	A	A	A	A
Western FRR SNF	Phase 2	6,300	28%	A	A	A	A
TRIGA FRR SNF	Phase 2	4,900	22%	A	A	A	A

A = Applicable
FRR = foreign research reactor
SNF = spent nuclear fuel

2.6.5.3.4 The Oak Ridge Reservation

The options for receiving and managing foreign research reactor spent nuclear fuel at the Oak Ridge Reservation are primarily dictated by the Programmatic SNF&INEL Final EIS (DOE, 1995c) alternatives and the lack of suitable facilities at the Oak Ridge Reservation to receive foreign research reactor spent nuclear fuel at the beginning of the proposed policy period.

If the Oak Ridge Reservation is the site to manage DOE-owned spent nuclear fuel under the Programmatic SNF&INEL Final EIS, foreign research reactor spent nuclear fuel would be received and managed first at the Savannah River Site and/or the Idaho National Engineering Laboratory for the period (Phase 1) required for the Oak Ridge Reservation to construct and to place in operation new facilities to accommodate the spent nuclear fuel. As discussed in previous sections, Phase 1 is estimated to be about 10 years. At the end of Phase 1 (e.g., start of Phase 2) the Oak Ridge Reservation would be able to receive and manage foreign research reactor spent nuclear fuel that would be shipped from the Savannah River Site and/or the Idaho National Engineering Laboratory and directly from the ports for those shipments made after Phase 1 concludes. Management of the foreign research reactor spent nuclear fuel would continue at the Oak Ridge Reservation until ultimate disposition.

The amount of spent nuclear fuel that would be received and managed at the Oak Ridge Reservation under the basic implementation of Management Alternative 1 is dictated by the distribution considered in the Programmatic SNF&INEL Final EIS (DOE, 1995c). Accordingly, in Phase 2, the Oak Ridge Reservation could receive aluminum-based foreign research reactor spent nuclear fuel managed at the Savannah River

Site during Phase 1, Eastern foreign research reactor spent nuclear fuel under the Regionalization by Geography alternative, or all foreign research reactor spent nuclear fuel under the Centralization alternative.

Under the basic implementation of Management Alternative 1, and as a Phase 2 site, the Oak Ridge Reservation would receive and manage foreign research reactor spent nuclear fuel at a new dry storage facility to be constructed at the West Bear Creek Valley Site. The location is preferred among the four locations considered in a siting study performed for spent nuclear fuel management (MMES, 1994). The four locations considered are shown in Figure 2-17. Description of the new dry storage facility is provided in Section 2.6.5.1.1.

The analysis of environmental impacts from management of foreign research reactor spent nuclear fuel at the Oak Ridge Reservation is based on the above considerations. The analysis options selected do not represent all possible combinations but a reasonable set that provides a typical, and in some cases, bounding estimate of the resulting impacts.

The specific analysis option under the basic implementation of Management Alternative 1, discussed in Section 2.2.1, is as follows:

4A. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Oak Ridge Reservation where it would be managed at a new dry storage facility until ultimate disposition. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would also be received and managed at the new facility until ultimate disposition. For the purposes of the analysis, the total amount of spent nuclear fuel that would be managed in the dry storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements).

The implementation alternatives of Management Alternative 1, which are discussed in Section 2.2.2, introduce additional analysis options that could be considered for the Oak Ridge Reservation as follows:

- Under Implementation Subalternative 1a (Section 2.2.2.1), the amount of spent nuclear fuel to be received in the United States would be reduced to 5,000 elements. In this case, the Oak Ridge Reservation would receive the foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory or the Savannah River Site and manage it in facilities sized for this amount. The impacts from the management of this amount of spent nuclear fuel would be bounded by analysis option 4A.

- Under Implementation Subalternative 1b (Section 2.2.2.1), the Oak Ridge Reservation would receive only HEU from the Idaho National Engineering Laboratory and/or the Savannah River Site. The amount of spent nuclear fuel would be approximately 4.6 MTHM, representing 11,200 elements. The impacts from the management of this amount of fuel at the Oak Ridge Reservation would be bounded by analysis option 4A above.

- Under Implementation Subalternative 1c (Section 2.2.2.1), the Oak Ridge Reservation would receive target material in addition to the foreign research reactor spent nuclear fuel considered under the basic implementation of Management Alternative 1. The analysis assumes that the receipt and management of this material, which represents in uranium content approximately 620 typical foreign research reactor spent nuclear fuel elements, would increase the impacts of analysis option 4A by a small percentage.

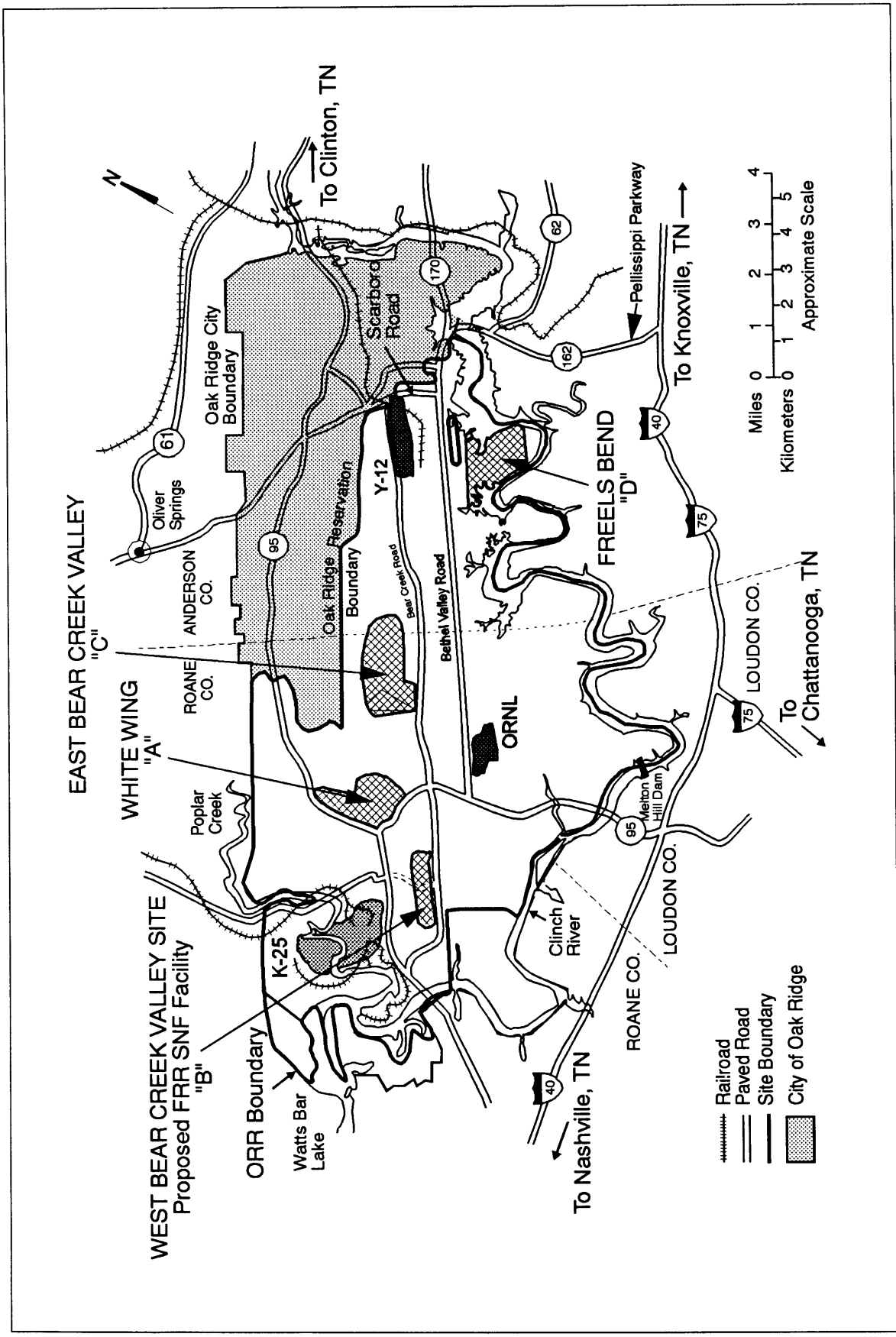


Figure 2-17 Candidate Sites at the Oak Ridge Reservation for Foreign Research Reactor Spent Nuclear Fuel Storage

- Under Implementation Subalternative 2a (Section 2.2.2.2), the duration of the policy would be decreased to 5 years; and, therefore, the amount of spent nuclear fuel available for management would also be decreased. In this case, the Oak Ridge Reservation would receive all foreign research reactor spent nuclear fuel from the Savannah River Site and/or the Idaho National Engineering Laboratory. The impacts from the management of the decreased amount of spent nuclear fuel at the Oak Ridge Reservation would be bounded by analysis option 4A above.

- Under Implementation Subalternative 2b (Section 2.2.2.2), the acceptance of a small portion of the spent nuclear fuel would be extended over an indefinite period of time, but the amount of spent nuclear fuel to be received and managed would remain constant. The impacts would be the same as in option 4A.

- Under Implementation Alternative 3 (Section 2.2.2.3), DOE and the Department of State would consider alternative financial arrangements. These arrangements would affect the amount of spent nuclear fuel that would be managed in the United States as the foreign research reactors would consider their own alternatives on whether to send the spent nuclear fuel to the United States. The amount of spent nuclear fuel in this case cannot be quantified; however, the upper limit, which is considered under analysis option 4A, would be bounding.

- Under Implementation Alternative 4 (Section 2.2.2.4), DOE and the Department of State would consider alternatives for the location where title of the foreign research reactor spent nuclear fuel would be taken. The choices do not affect the management options at the Oak Ridge Reservation.

- Under Implementation Alternative 5 (Section 2.2.2.5), DOE would consider construction of a new wet storage facility at the Oak Ridge Reservation for Phase 2 until ultimate disposition. For this implementation alternative an analysis option 4B, which is similar to 4A, is considered as follows:

4B. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Oak Ridge Reservation where it would be managed at a new wet storage facility. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would also be received and managed at the new facility until ultimate disposition. For the purposes of analysis, the total amount of spent nuclear fuel to be managed in the wet storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements).

- Under Implementation Alternative 6 (Section 2.2.2.6), DOE and the Department of State would consider chemical separation of foreign research reactor spent nuclear fuel in the United States. Based on the discussion in Section 2.3.6, the Oak Ridge Reservation would not be considered as a site for chemical separation. The Oak Ridge Reservation is also not considered under the Hybrid Alternative discussed in Section 2.4.

Table 2-14 presents an overview of the foreign research reactor spent nuclear fuel management options, quantities of foreign research reactor spent nuclear fuel assumed for the analysis, and facilities considered.

Table 2-14 Proposed Quantities of Foreign Research Reactor Spent Nuclear Fuel and Management Options at Oak Ridge Reservation

Management Alternative 1	*FRR SNF Elements*	*Percentage of Total FRR SNF Elements*	*Storage Option/Technology*	

As a Phase 2 site, the Nevada Test Site would receive and manage foreign research reactor spent nuclear fuel at a newly constructed dry storage facility or a modified E-MAD facility. Description of the new dry storage facility is provided in Section 2.6.5.1.1. Figure 2-18 displays the potential construction location and the area where the E-MAD facility is located at the Nevada Test Site.

The analysis of potential environmental impacts from management of foreign research reactor spent nuclear fuel at the Nevada Test Site is based on the above considerations. The analysis options selected do not represent all possible combinations, but a reasonable set that provides a typical, and in some cases, bounding estimate of the resulting impacts.

The specific analysis option under the basic implementation of Management Alternative 1, discussed in Section 2.2.1, is as follows:

5A. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Nevada Test Site where it would be managed at a new dry storage facility or a modified E-MAD facility. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would also be received and managed at the new or E-MAD facility until ultimate disposition. For the purposes of the analysis, the total amount of spent nuclear fuel that would be stored would be all the foreign research reactor spent nuclear fuel (22,700 elements).

The implementation alternatives of Management Alternative 1, discussed in Section 2.2.2, introduce additional analysis options that could be considered for the Nevada Test Site as follows:

- Under Implementation Subalternative 1a (Section 2.2.2.1), the amount of spent nuclear fuel to be received in the United States would be reduced to 5,000 elements. In this case, the Nevada Test Site would receive the foreign research reactor spent nuclear fuel from the Idaho National Engineering Laboratory or the Savannah River Site and manage it in facilities sized for the reduced amount. The impacts from the management of this amount of spent nuclear fuel would be bounded by analysis option 5A.

- Under Implementation Subalternative 1b (Section 2.2.2.1), the Nevada Test Site would receive from the Idaho National Engineering Laboratory and/or the Savannah River Site only HEU. The amount of HEU would be approximately 4.6 MTHM, representing 11,200 elements. The impacts from the management of this amount of fuel would be bounded by analysis option 5A above.

- Under Implementation Subalternative 1c (Section 2.2.2.1), the Nevada Test Site would receive target material in addition to the foreign research reactor spent nuclear fuel considered under the basic implementation of Management Alternative 1. The receipt and management of this material, which represents in uranium content approximately 620 typical foreign research reactor spent nuclear fuel elements, would increase the impacts of analysis option 5A by a small percentage.

- Under Implementation Subalternative 2a (Section 2.2.2.2), the duration of the policy would be decreased to 5 years; and, therefore, the amount of spent nuclear fuel available for management would also be decreased. In such a case, the Nevada Test Site would receive all foreign research reactor spent nuclear fuel from the Savannah River Site and/or the

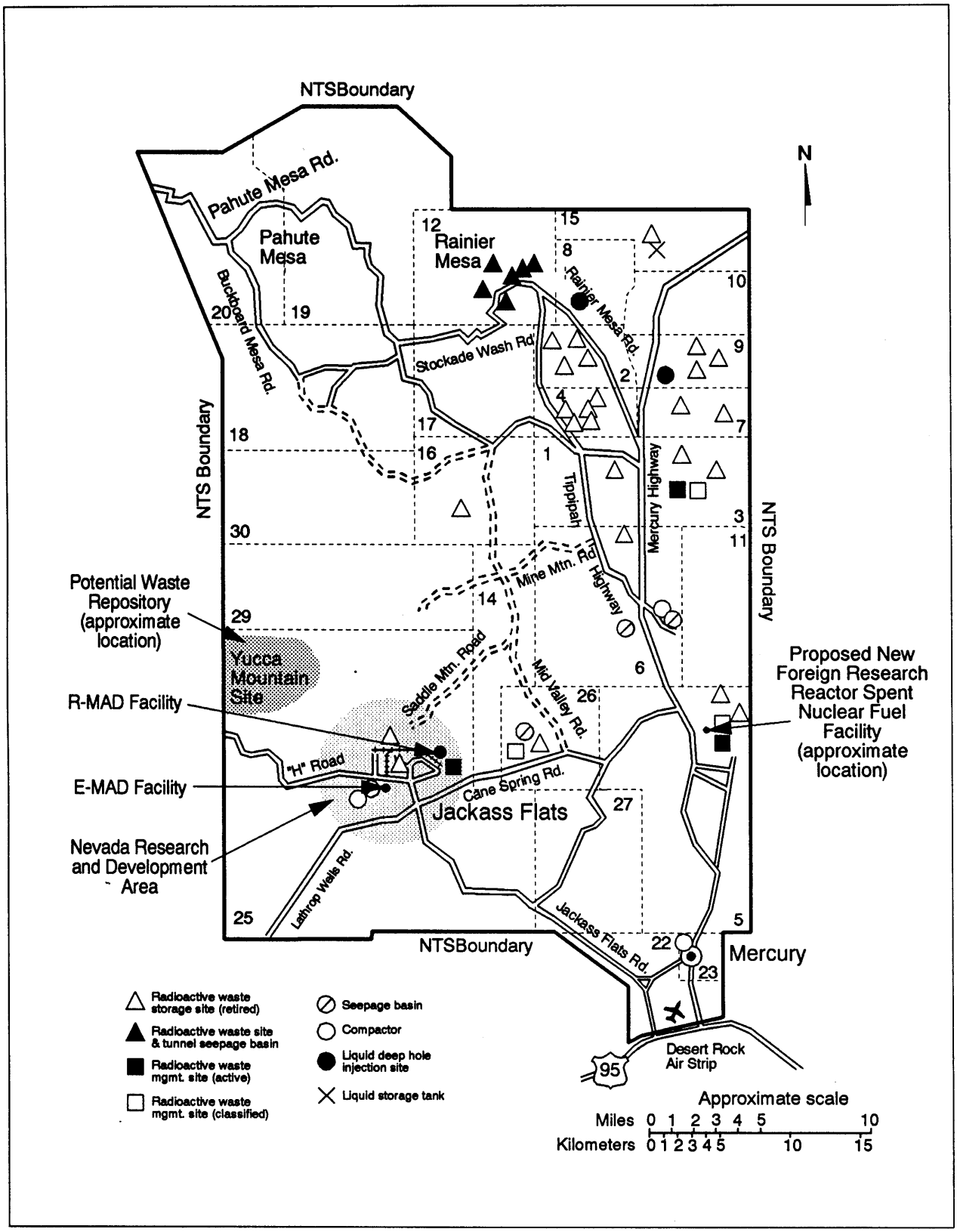


Figure 2-18 Map for Foreign Research Reactor Spent Nuclear Fuel Storage at the Nevada Test Site

Idaho National Engineering Laboratory. The impacts from the management of the decreased amount of spent nuclear fuel at the Nevada Test Site would be bounded by analysis option 5A above.

- Under Implementation Subalternative 2b (Section 2.2.2.2), the acceptance of a small portion of the spent nuclear fuel would be extended over an indefinite period of time, but the amount of spent nuclear fuel to be received and managed would remain constant. The impacts would be the same as in analysis option 5A.

- Under Implementation Alternative 3 (Section 2.2.2.3), DOE and the Department of State would consider alternative financial arrangements. The various arrangements would affect the amount of spent nuclear fuel that would be managed in the United States as the foreign research reactors would consider their own alternatives on whether to send the spent nuclear fuel to the United States. The amount of spent nuclear fuel in this case cannot be quantified; however, the upper limit, considered under analysis option 5A, would be bounding.

- Under Implementation Alternative 4 (Section 2.2.2.4), DOE and the Department of State would consider alternatives for the location where title of foreign research reactor spent nuclear fuel would be taken. The choices do not affect the management options at the Nevada Test Site.

- Under Implementation Alternative 5 (Section 2.2.2.5), DOE would consider construction of a new wet storage facility at the Nevada Test Site for Phase 2 until ultimate disposition. For this implementation alternative an analysis option 5B, which is similar to 5A, is considered as follows:

5B. The spent nuclear fuel managed at the Idaho National Engineering Laboratory and/or the Savannah River Site during Phase 1 would be shipped to the Nevada Test Site where it would be managed at a new wet storage facility. Spent nuclear fuel arriving in the United States after Phase 1 concludes (i.e., during Phase 2) would also be received and managed at the new facility until ultimate disposition. For the purposes of analysis, the total amount of spent nuclear fuel that would be managed in the wet storage facility would be all the foreign research reactor spent nuclear fuel (22,700 elements). If the Nevada Test Site were to receive only TRIGA spent nuclear fuel from the Idaho National Engineering Laboratory or only western spent nuclear fuel, the wet storage facility would be sized accordingly. The impacts from a smaller size facility would be bounded by the option analyzed.

- Under Implementation Alternative 6 (Section 2.2.2.6), DOE and the Department of State would consider chemical separation of foreign research reactor spent nuclear fuel in the United States. Based on the discussion in Section 2.3.6, the Nevada Test Site would not be considered as a site for chemical separation. The Nevada Test Site is also not considered for the Hybrid Alternative discussed in Section 2.4.

Table 2-15 presents an overview of the foreign research reactor spent nuclear fuel management options, quantities of foreign research reactor spent nuclear fuel assumed for the analysis, and facilities considered.

Table 2-15 Proposed Quantities of Foreign Research Reactor Spent Nuclear Fuel and Management Options at the Nevada Test Site

Management Alternative 1		*FRR SNF Elements*	*Percentage of Total FRR SNF Elements*	*Storage Option/Technology*		
				Dry Storage		*Wet Storage*
				E-MAD[a]	*New*	*New*
All FRR SNF	Phase 2[b]	22,700	100%	A	A	A
Western FRR SNF	Phase 2	6,300	28%	A	A	A
TRIGA FRR SNF	Phase 2	4,900	22%	A	A	A

A = Applicable
NA = Not Applicable
FRR = foreign research reactor
SNF = spent nuclear fuel
[a] *E-MAD could be available for use five years after the start of implementation.*
[b] *Phase 2 values represent total number of foreign research reactor spent nuclear fuel elements requiring management at the site.*

2.7 Characteristics of Emergency Management and Response

This section addresses the emergency management and response infrastructure that exists to support the possible implementation of those management alternatives of the proposed action that would have an impact in the United States. This section considers emergency management and response at the ports of entry, along ground transport routes, and at the management sites.

2.7.1 DOE and the National Response System

In the United States, State and local governments are responsible for emergency management and response programs. These programs must be capable of managing all hazards ranging from natural disasters to hazardous material incidents on a day-to-day basis. In order to maintain these programs, various State, Tribal, and local governments receive Federal funding. DOE historically has provided a variety of support to governmental jurisdictions in fulfilling its responsibilities under regulatory and National emergency plan taskings (FEMA, 1994; Rogoff, 1994; and DOE, 1994g).

There are three national emergency response plans (i.e., Federal Response Plan, Federal Radiological Emergency Response Plan, and the National Contingency Plan) under which DOE provides radiological monitoring and assessment assistance. Under these plans, DOE provides technical advice and assistance to State, Tribal, and local agencies involved with a radiological incident (DOE, 1989). For a foreign research reactor spent nuclear fuel incident, DOE actions would be guided by the Federal Radiological Emergency Response Plan (FEMA, 1985) and its own internal emergency management and response system.

DOE maintains an emergency management and response system that is based on regulatory requirements as outlined in various DOE Orders (e.g., DOE Order Series 5500 and 5530). These orders require an emergency management and response system that generally follows the models and practices established by the Federal Emergency Management Agency, National Fire Protection Association, American National Standards Institute, and National Council on Radiation Protection and Measurements.

2.7.2 Foreign Research Reactor Spent Nuclear Fuel Transportation

Foreign research reactor operators, their shipping agents, and commercial carriers would have the primary responsibility to coordinate and arrange all activities associated with foreign research reactor spent nuclear fuel shipments and cask return including emergency management and response. DOE, along with other Federal agencies (e.g., Department of Transportation, NRC, Federal Emergency Management Agency, U.S. Department of Defense, and the U.S. Environmental Protection Agency) would provide support and assistance to State, Tribal, and local government agencies responsible for responding to a foreign research reactor spent nuclear fuel incident.

DOE fulfills its role and responsibilities as the Federal agency tasked with developing and maintaining a capability to safely manage spent nuclear fuel (DOE, 1995c), in part by setting overall spent nuclear fuel program management responsibility and policy for transportation and emergency management and response; resolving policy questions; issuing guidance; providing information; and accomplishing

by monitoring the performance of those involved.

According to DOE records, from 1985 to 1993 there were 102,213 DOE shipments consisting of 1,009,357.6 metric tons (1,112,626 tons) of radioactive materials. Of these, 457 shipments

Table 2-16 DOE Summary of Financial Assistance to States and Indian Tribes

Total Allocations for Transportation Programs: FY 1994	
Activity	***Amount***
Waste Isolation Pilot Plant	$1,410,848
Cesium Shipment Support	330,000
Spent Fuel Shipment Support	125,000
Transportation External Coordination Working Group[a]	34,921
Urban Energy & Transportation Corporation[b]	150,137
Office of Civilian Radioactive Waste Management	1,332,000
State of Washington Emergency Management Funds	637,570
Total Allocations	**$4,020,476**

[a] *The amount shown reflects the cost to DOE of furnishing travel, food, and lodging for non-DOE participants at two Transportation External Coordination meetings. Participation in Transportation*

out State and Tribal costs separately.

[b] *The amount shown reflects the cost to DOE of furnishing travel, food and lodging for non-DOE participants at three Urban Energy & Transportation Corporation meetings. Urban Energy & Transportation Corporation is a non-profit corporation organized primarily to address local government concerns.*

Besides funding, much of DOE's assistance is provided in the form of technical assistance, for which DOE bears the cost. Assistance may be provided through DOE's Radiological Assistance Program and under the National Contingency Plan, as well as through training, DOE sponsored meetings, informal discussions, and informational materials (DOE, 1994g).

- Transportation Emergency Training for Response Assistance includes several modules. The Public Affairs module, which is specifically designed to include States and Tribes, is scheduled for piloting during Fiscal Year 1995 (DOE, 1994g).

In addition, the DOE-funded Radiation Emergency Assistance Center/Training Site located in Oak Ridge, Tennessee, conducts courses in medical management of radiation emergencies. These courses include:

- Handling of Radiation Accidents by Emergency Personnel;
- Medical Planning and Care in Radiation Accidents;
- Health Physics in Radiation Accidents; and
- Occupational Health in Nuclear Facilities (REACT/TS, n.d.a.).

2.7.3.3 Transportation External Coordination/Working Group

DOE recognizes the need for ongoing partnerships with external organizations: health and safety; emergency management and response; law enforcement; technical; State, Tribal, and local government; and industrial organizations involved in radiological emergency response. This "stakeholder" involvement has been formalized in the Transportation External Coordination/Working Group.

The Transportation External Coordination/Working Group (Table 2-17) is a 35 member body of emergency management and response professional associations (DOE, 1994i). Through this group DOE looks at crosscutting transportation and emergency response issues that all DOE programs either are addressing or will address in the future. In turn, these groups are able to provide input to DOE for its decision-making process involving these issues (Holm, 1994).

2.7.3.4 Transportation Emergency Preparedness Program

The Transportation Emergency Preparedness Program helps integrate DOE's existing emergency management and response capabilities into an effective response system for transportation incidents involving DOE shipments. Through its extensive external coordination program with State, Tribal, and local agencies, DOE develops interfaces for meeting its various national response plan taskings to provide radiological monitoring and assessment technical assistance needed for transportation incidents involving radioactive materials including any possible incidents associated with a foreign research reactor spent nuclear fuel shipment.

Under the Transportation Emergency Preparedness Program Field Assistance Program, DOE provides support for emergency exercises (Table 2-18) that include State, Tribal, and local agencies through the Operations Offices (DOE, 1994g; DOE, 1994n; SSEB, 1994).

2.7.3.5 Radiological Assistance Program

The primary DOE response groups that would assist at a foreign research reactor spent nuclear fuel incident are the Radiological Assistance Program teams that operate from eight strategically located DOE Regional Coordinating Offices (Figure 2-19) around the country. These teams, upon State, Tribal, or local jurisdiction request, provide technical expertise and assistance to monitor and assess radiological hazards. Figure 2-19 displays pertinent information for contacting each regional office.

Table 2-17 Transportation External Coordination/Working Group Membership

Invited Organizations	*Guest Organizations*[c]
American Association of State Highway and Transportation Officials[a]	Emergency Services Representatives
American College of Emergency Physicians	Arizona Division of Emergency Services
AFL-CIO Transportation Trades Department[a]	City of Jacksonville, FL, Fire Department
American Indian Law Center[a]	Louisiana State Police/TESS
American Trucking Association[a]	St. Charles Parish Department of Emergency Management
Association of American Railroads	Ohio Emergency Management Agency
Chemical Manufacturers Association[b]	County Representatives
Columbia River Inter-tribal Fish Commission	Transportation Advisor, Nuclear Waste Project, Carson City, NV
Commercial Vehicle Safety Alliance	Clark County Comprehensive Planning Department, Esmeralda, NV
Conference of Radiation Control Program Directors	Transportation Planner, Nuclear Waste Division, Las Vegas, NV
Cooperative Hazardous Materials Enforcement Development[a]	Mineral County Office of Nuclear Projects, Hawthorne, NV
Council of Energy Resource Tribes	Nye County, NV
Council of State Governments, Midwestern Office	Nye County Nuclear Waste Repository Office, Tonopah, NV
Edison Electric Institute	White Pine County, NV
Emergency Nurses Association	White Pine County Nuclear Waste Project Office, Ely, NV
Hazardous Materials Advisory Council[a]	Tribal Representatives
International Association of Chiefs of Police	Manager, ERWM Program, Nez Perce Tribe, Lapwai, ID
International Association of Fire Chiefs	Industry Representatives
International Association of Fire Fighters	Union Pacific Railroad
International City Management Association[a]	Environmental Evaluation Group
National Association of Counties	PIC
National Association of Emergency Medical Technicians	
National Association of Regulatory Utility Commissioners[a]	
National Conference of State Legislators	
National Conference of State Transportation Specialists[a]	
National Congress of American Indians	
National Coordinating Council on Emergency Management	
National Emergency Management Association	
National Governors' Association[a]	
National Indian Policy Center	
National League of Cities[a]	
Southern States Energy Board	
Urban Energy and Transportation Corporation	
Western Governors' Association	
Western Interstate Energy Board	

[a] *Denotes organizations invited to attend, but have not yet participated.*

[b] *Denotes organizations invited to attend, but do not wish to participate.*

[c] *Denotes organizations who have attended Transportation External Coordination/Working Group meetings, but are not full-time members.*

Table 2-18 Radiological Emergency Response Exercises

Exercise	Location	Date
TRANSAX 1994	Ontario, OR	August 3, 1994
TRANSAX 1993	Lamy, NM	September 1, 1993
TRANSAX 1992	Fort Hall, ID	September 16, 1992
TRANSAX 1990	Colorado Springs, CO	November 8, 1990
WIPPTREX 93-1	Laramie, WY	April 14, 1993
WIPPTREX 92-1	Raton, NM	October 28, 1992

Radiological Assistance Program teams are composed of a range of technical specialists who volunteer for team membership. The teams are activated on an "as needed" basis and generally can be ready to deploy from their home station within 4 hours of notification. Response times to the scene vary depending on the accident's location and the level of assistance required (Taylor, 1995).

In 1994, Radiological Assistance Program teams responded 37 times to a variety of radiological situations throughout the country. Upon evaluation, a number of these responses were determined to be nonradiological hazards (Taylor and Hauptman, 1994).

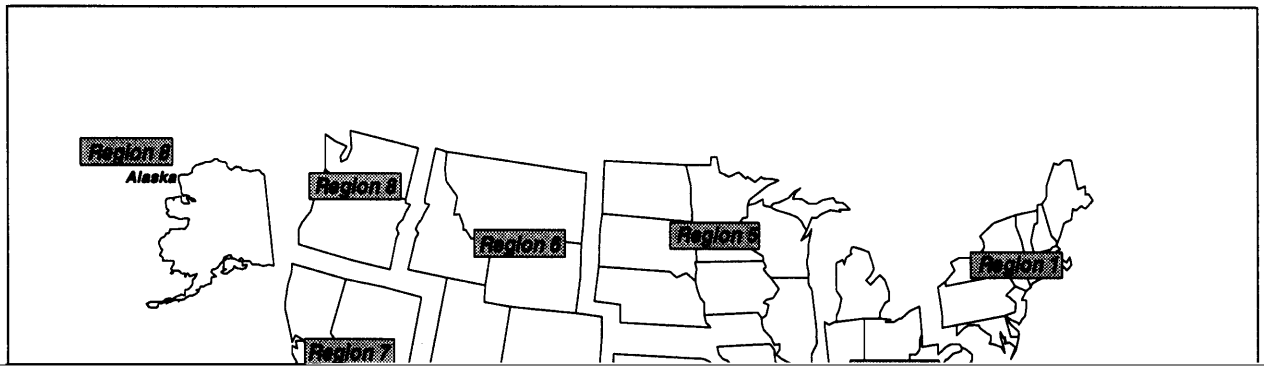
Typically, Radiological Assistance Program teams are involved in identifying personnel, equipment, or property that may be radiologically contaminated, recommending sources of medical advice for the treatment of personal injuries sustained as a result of exposure to radioactivity, and providing advice or assistance in monitoring, decontamination, material recovery, or other post-emergency operations (Gordon-Hagerty, 1993).

2.7.4 Emergency Management and Response at Ports of Entry

From 1979 to 1992, 317 spent nuclear fuel shipments in "Type B" transportation casks were made through various United States ports (NRC, 1993) with no releases of radioactive materials. The "Type B" cask shipments were placed in standard maritime shipping containers the same as any other material being sent to the port. Foreign research reactor spent nuclear fuel shipments are subject to the same types of potential hazards as those of other ships carrying nonradioactive hazardous materials.

Under the Oil Spill Prevention Act of 1990, each port is required to develop an Area Contingency Plan. While the main focus of these plans is an oil spill response, they have been expanded in many cases to address other types of hazardous material responses including radioactive material. These plans outline response capabilities, procedures, and authorities for responding to and recovering from hazardous material incidents.

These ports of entry have a specially designated and prepared terminal or dock area for unloading hazardous materials. They have either a dedicated hazardous material response team or access to a local team through some type of mutual aid agreement. These emergency response teams receive ongoing training and participate in various types of drills and exercises. Also, the dock workers receive varying levels of ongoing hazardous materials response training.


Region 8
Alaska
Region 9
Region 6
Region 5
Region 1
Region 7

These Strike Teams have limited responsibilities in the course of an incident. Their two main duties are containment and clean-up. They use booms, skimmers, absorbents, and chemicals in their response. The vessels used as platforms for booms and skimmers are usually provided by the Marine Safety Office or Boat Station in the area of the incident. Strike Teams consist of highly trained pollution response and clean-up personnel.

There are three Strike Teams under the command of the National Strike Force Coordination Center in Elizabeth City, NC, that could be called on for a foreign research reactor spent nuclear fuel accident. These teams are located on the three coasts of the United States: the Gulf Strike Team located in Mobile, AL; the Pacific Strike Team located in Novato, CA; and the Atlantic Strike Team located in Fort Dix, NJ.

For a foreign research reactor spent nuclear fuel accident, the U.S. Coast Guard On-Scene Coordinator would request an NRC or DOE representative. DOE Radiological Assistance Program teams would be requested as needed.

2.7.5 Emergency Management and Response Along Ground Transport Routes

During transport of the spent nuclear fuel received as a result of the Urgent Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel Environmental Assessment, the foreign research reactor operator's shipping agents were required to ensure that all activities of the agent's and the commercial carrier's personnel conformed to regulatory requirements, as well as all plans and procedures developed for the foreign research reactor spent nuclear fuel (DOE, 1994m). DOE and other Federal and State government agencies monitored the activities of the shipping agent and the commercial carrier to ensure that the regulatory requirements were met. If foreign research reactor spent nuclear fuel is managed in the United States, DOE will prepare a Transportation Plan before any shipments are undertaken. The Transportation Plan will detail all transportation activities necessary for the safe and secure transport of the foreign research reactor spent nuclear fuel from the point of origin to the management site in the United States. The general provisions for such a plan are included in Appendix H.

Primary responsibility for emergency response to a foreign research reactor spent nuclear fuel incident would reside with local authorities (DOE, 1989). Each corridor State or Tribe would be responsible for augmenting their existing emergency management and response plans and procedures with any foreign research reactor spent nuclear fuel specific information they felt was necessary.

States coordinate with their local jurisdictions on emergency planning and information. States and Tribes would be responsible for notifying DOE of any conditions that could affect the safe and secure transport of foreign research reactor spent nuclear fuel shipments through their jurisdictions. DOE would provide technical advice and assistance to the shippers and affected government jurisdictions to ensure safe transportation.

Spent nuclear fuel shipments transported by rail, barge, or commercial truck carrier would be subject to the same potential problems as any other hazardous materials shipment that travels daily by these means, namely severe weather, mechanical problems, derailments, and collisions.

DOE would seek to mitigate potential highway foreign research reactor spent nuclear fuel accident consequences by ensuring commercial carriers comply with NRC guidelines for shipment security and the Department of Transportation Highway Route Controlled Quantity routing regulations (DOE, 1995c) which are designed to reduce radiological transportation risk impacts.

The rail and barge industries are similar to the trucking industry in the hazardous material transportation regulatory regime. Documentation, manifesting, placarding, labeling, and other communications are controlled by 49 CFR Parts 100-199.

The carriers used for the transportation of foreign research reactor spent nuclear fuel would be required to develop emergency response plans. In developing these plans, the carriers would be required to consider the following responsibilities:

- protect life, health, and the environment;
- notify appropriate railroad officials in a timely manner;
- notify the appropriate Federal, State, and local authorities, and the shipper;
- initiate a prompt and proper response;
- provide appropriate resources and expertise for resolution of the incident;
- perform cleanup functions; and
- establish and maintain a working contact with the responsible Governmental authorities until they declare the incident closed.

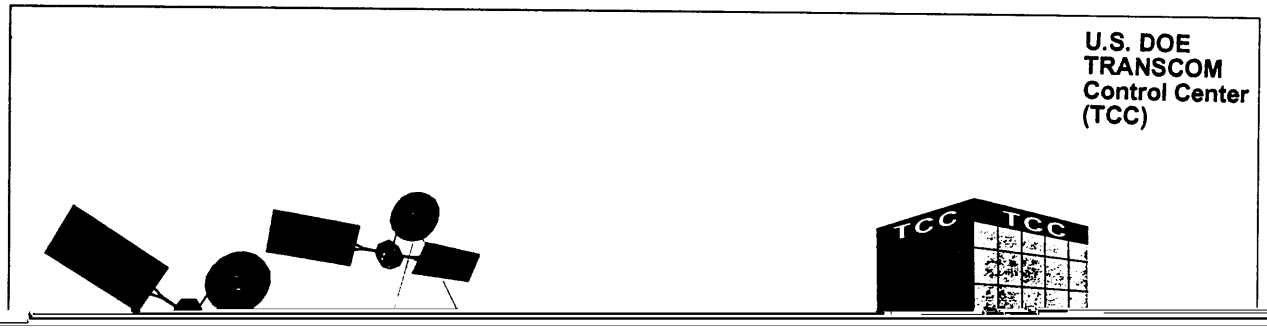
As discussed in Section 2.7.2, spent nuclear fuel shipments, like other hazardous material shipments, have been involved in transportation accidents. Those that have occurred have not resulted in a radiological hazard or damage to the public or the environment. This is primarily due to the rigorous packaging.

Each State and Tribe along a shipping route would be notified of the foreign research reactor spent nuclear fuel shipment's itinerary through that jurisdiction to enable the appropriate agencies to notify the necessary response personnel. Also, DOE would maintain continuous communications through its communications and tracking systems (DOE, 1989).

Foreign research reactor spent nuclear fuel shipments would be tracked either by the commercial carrier or by a satellite tracking system similar to DOE's Transportation Tracking and Communications System (Figure 2-20). The satellite tracking system would provide a "real-time" satellite tracking and voice communications system that would link the truck or train and its escorts with a control center. Some commercial carriers have established their own satellite tracking systems. The DOE system would interface with these systems and co-monitor the shipment's progress to ensure maximum accountability and security. The satellite tracking system would also coordinate "SAFE PARKING" requests from the states.

If a situation would arise (e.g., severe weather, mechanical difficulties, protesters, security threat, personnel illness or injury) that presented a hazard or threat to a highway foreign research reactor spent nuclear fuel shipment, DOE would have arranged through Memoranda of Agreement for the commercial carrier to divert to any Federal installation (e.g., a DOE site or military base) and request "SAFE PARKING" at that facility until the situation is resolved. The receiving facility would assist in providing security and logistical support until the shipment was prepared to depart.

State, Tribal, and local agencies, as well as the commercial carriers, maintain various emergency response plans and procedures. During a foreign research reactor spent nuclear fuel highway, barge, or rail accident, the personnel accompanying the shipment would be the immediate contact for information to the local emergency responders having jurisdiction and Incident Commander authority over the situation.


U.S. DOE
TRANSCOM
Control Center
(TCC)
TCC
TCC

Each of these sites routinely handles hazardous materials that have potential emergency management and response considerations similar to foreign research reactor spent nuclear fuel. These, along with the usual risks posed by any industrial environment, are regularly evaluated through various Safety Analysis Reports and Hazards Assessment studies. These situations are then mitigated to the greatest extent possible.

2.8 Security Measures

Domestic transportation of foreign research reactor spent nuclear fuel would be under the regulatory jurisdiction of the U.S. Department of Transportation and NRC. In the event that foreign research reactor spent nuclear fuel were to be transported through a military port of entry, applicable requirements would be established in advance by the U.S. Department of Defense, DOE and NRC to provide the appropriate level of security.

The objective of the security measures during transportation of spent nuclear fuel are to minimize the possibilities for radiological sabotage of spent nuclear fuel shipments and facilitate the location and recovery of spent nuclear fuel shipments that may have come under control of unauthorized persons. The elements of the security measures would be considered when developing the Transportation Plan to be developed by DOE in consultation with State, local, and Tribal officials prior to any actual spent nuclear fuel shipments. The general provisions of the Transportation Plan, which would include requirements relative to emergency response planning, security considerations, and communications during actual shipments of foreign research reactor spent nuclear fuel, are included in Appendix H.

The security measures provided by the regulations would make the hijacking of a transportation cask a highly unlikely event. In the first place, the large size and weight of these casks (9.1 to 22.7 metric tons, or 10 to 25 tons) and the inherent radioactivity of the spent nuclear fuel make spent fuel in a transportation cask an unlikely hijacking target. For a malicious act of sabotage, there are, in fact, more accessible targets than spent nuclear fuel, that would provide more spectacular detrimental effects; especially considering the fact that, aside from the radioactivity of the spent nuclear fuel, which is a relatively short range effect, the spent nuclear fuel elements are simply pieces of metal (which might be somewhat warm). In the event of a hijack attempt aimed at some long-term use of the contents of the cask, the communications systems required to be used during the shipment would enable timely notification of authorities who would mobilize response forces. Tracking systems would allow the location of the cask to be determined in real time, thereby aiding in the timely interception of the hijackers by response forces.

The successful completion of attempts aimed at short-term destructive acts, such as explosions from within the cask or inducement of criticality, are not considered credible because they would require sufficient time to breach the cask at a great personal risk to the hijackers (probably lethal exposure), special tooling and techniques, and/or the use of specialized materials (for sufficient moderation) that in themselves are safeguarded materials.

Malicious attack scenarios from a distance, such as the explosion of a bomb near a transportation cask, or an attack by an armor-piercing weapon could be within the realm of possibility. The risk to the health and safety of the public associated with such an event cannot be calculated since there is no basis for estimating either the probability of such an event occurring or that damage sufficient to release radioactive material from the cask would occur. Appendix D, Section D.5.9, provides a discussion of the consequences of some sabotage/terrorist initiated events for the purpose of emergency response planning.

2.9 Preferred Alternative

In selecting a preferred alternative for the management of foreign research reactor spent nuclear fuel, DOE and the Department of State took several factors into consideration, including the following:

1. U.S. Government nuclear weapons nonproliferation policies and objectives;
2. DOE responsibilities (e.g., safe handling of hazardous materials, safety/health risks to workers, compatibility with other ongoing missions, etc.);
3. Potential environmental impacts (e.g., public safety, etc.);
4. Public comments received and concerns expressed following issuance of the Draft EIS;
5. Analysis of impacts and alternatives in the Programmatic SNF&INEL Final EIS (DOE, 1995c), as well as the Record of Decision for that EIS;
6. Estimated costs of alternatives for management of foreign research reactor spent nuclear fuel;
7. Public issues/concerns/perceptions (e.g., fairness/equity to affected States and populations, etc.); and
8. Uncertainties (e.g., future budget priorities and continuity of funding, technology

- Spent nuclear fuel (HEU) would be accepted from research reactors having lifetime cores, from research reactors planning to shut down by a specific date while the policy is in effect, and from research reactors for which a suitable LEU fuel is not available.
- Spent nuclear fuel (HEU and/or LEU) would be accepted from research reactors that are already shut down.
- Unirradiated fuel (HEU and/or LEU) from eligible research reactors would be accepted as spent nuclear fuel.
- For research reactors with both HEU and LEU spent nuclear fuel available for shipment, LEU spent nuclear fuel would not be accepted until the HEU spent nuclear fuel is exhausted, unless there are extenuating circumstances (e.g., deterioration of one or more LEU elements sufficient to cause a safety problem).
- Spent nuclear fuel (HEU and/or LEU) would not be accepted from new research reactors starting operation after the date of implementation of the policy.

The policy duration under this preferred alternative would be 10 years, beginning on the date when the management policy would become effective, as discussed in Section 2.2.1.1. Shipments of spent nuclear fuel to the United States could be made for a period of 13 years, starting from the effective date of policy implementation, as long as the spent nuclear fuel had already been discharged prior to the beginning of the policy period or is discharged during the policy period.

The aluminum-based foreign research reactor spent nuclear fuel would be managed at the Savannah River Site and the TRIGA foreign research reactor spent nuclear fuel would be managed at the Idaho National Engineering Laboratory, in accordance with the Record of Decision for the Programmatic SNF&INEL Final EIS (DOE, 1995c) and the settlement agreement reached between DOE and the State of Idaho [Public Service Co. of Colorado v. Batt, No. CV 91-0035-S-EJL (D. Id.) and United States v. Batt, No. CV-91-0054-S-EJL (D. Id.)]. Under this preferred alternative, up to approximately 19 MTHM of aluminum-based foreign research reactor spent nuclear fuel (approximately 17,800 elements), representing up to approximately 675 casks, and target material representing up to approximately 140 additional casks would be accepted and managed at the Savannah River Site. Also, up to approximately 1 MTHM of TRIGA foreign research reactor spent nuclear fuel (approximately 4,900 elements), representing up to approximately 162 casks would be accepted and managed at the Idaho National Engineering Laboratory.

The candidate U.S. ports of entry are listed in Section 2.2.1.6 and are described in detail in Section 3. Although all of the ports are acceptable based on the port selection criteria discussed in Appendix D, DOE would prefer to candidate use the military ports in proximity to the spent nuclear fuel management sites (i.e., Charleston NWS and the Concord NWS). Under this preferred alternative, a maximum of 38 casks of TRIGA foreign research reactor spent nuclear fuel (estimated to require about 5 shipments) could be accepted at a Western port, with 150 to 300 shipments being accepted via an Eastern port.

The foreign research reactor spent nuclear fuel and target material would be shipped by either chartered or regularly scheduled commercial ships from the foreign ports to the United States, as specified in Section 2.2.1.5.

DOE would take title to the foreign research reactor spent nuclear fuel and target material that is shipped by sea after it is offloaded at the port of entry, and to the spent nuclear fuel and target material shipped solely overland (i.e., from Canada) at the border crossing between Canada and the United States.

The foreign research reactor spent nuclear fuel and target material would be transported from the United States ports to the management sites by truck and rail as specified in Section 2.2.1.7.

The financing arrangement under this preferred alternative would be for the United States to bear the full cost for transporting and managing the foreign research reactor spent nuclear fuel and target material accepted from countries with other-than-high-income economies, and to charge high-income economy countries a competitive fee. The fee would be established in a Federal Register Notice (as opposed to being published in this Final EIS), to allow DOE flexibility to adjust the fee to account for inflation, or changes in spent nuclear fuel management practices in the United States.

For the aluminum-based foreign research reactor spent nuclear fuel, a three point strategy is proposed, as follows:

1. DOE would embark immediately on an accelerated program at the Savannah River Site to identify, develop, and demonstrate one or more non-reprocessing, cost-effective treatment and/or packaging technologies to address potential health and safety issues that may develop and to prepare the foreign research reactor spent nuclear fuel for ultimate disposal. The purpose of any new facilities that might be constructed to implement these technologies would be to change the foreign research reactor spent nuclear fuel into a form that is suitable for geologic disposal, without necessarily separating the fissile materials, while meeting or exceeding all applicable safety and environmental requirements. Examples of technologies that would be considered include: *can-in-canister, chop and dilute/poison, melt and dilute/poison, plasma arc treatment, electrometallurgical treatment, glass material oxidation and dissolution, chloride volatility, dissolve and vitrify, direct disposal in small packages*, etc. Functional schematics of these technologies are shown in Figure 2-21. In conjunction with the examination of new technologies, variations of conventional direct disposal methods would also be explored. After treatment and/or packaging, the foreign research reactor spent nuclear fuel would be managed on site in "road ready" dry storage until transported off-site for continued storage or disposal. DOE would select, develop, and implement, if possible, one or more of these treatment and/or packaging technologies by the year 2000. DOE is committed to avoiding indefinite storage of this spent nuclear fuel in a form that is unsuitable for disposal.

2. Despite DOE's best efforts, it is possible that a new treatment and/or packaging technology may not be ready for implementation by the year 2000. It may become necessary, therefore, for DOE to use the F-Canyon to reprocess some foreign research reactor spent nuclear fuel elements, while the F-Canyon is operating to stabilize at-risk materials as recommended by the Defense Nuclear Facilities Safety Board. (For example, under current schedules this activity could take place between the years 2000 and 2002.) In that event, the foreign research reactor spent nuclear fuel would be converted into LEU and wastes generated during reprocessing. Certain wastes would be vitrified in the Defense Waste Processing Facility, while others would be solidified in the Saltstone facility. In order to provide a sound policy basis for making a determination on whether and how to utilize the F-Canyon for processing tasks that are not driven by health and safety considerations, DOE will commission or conduct an independent study of the nonproliferation and other (e.g., cost and timing) implications of reprocessing spent nuclear fuel from foreign research reactors. The study will be initiated in mid-1996 and will be completed in a timely fashion to allow a subsequent decision about possible use of the F-Canyon for foreign research reactor spent nuclear fuel reprocessing to be fully considered by the public, the Congress and the Executive Branch agencies. Pending disposition of the foreign research reactor spent

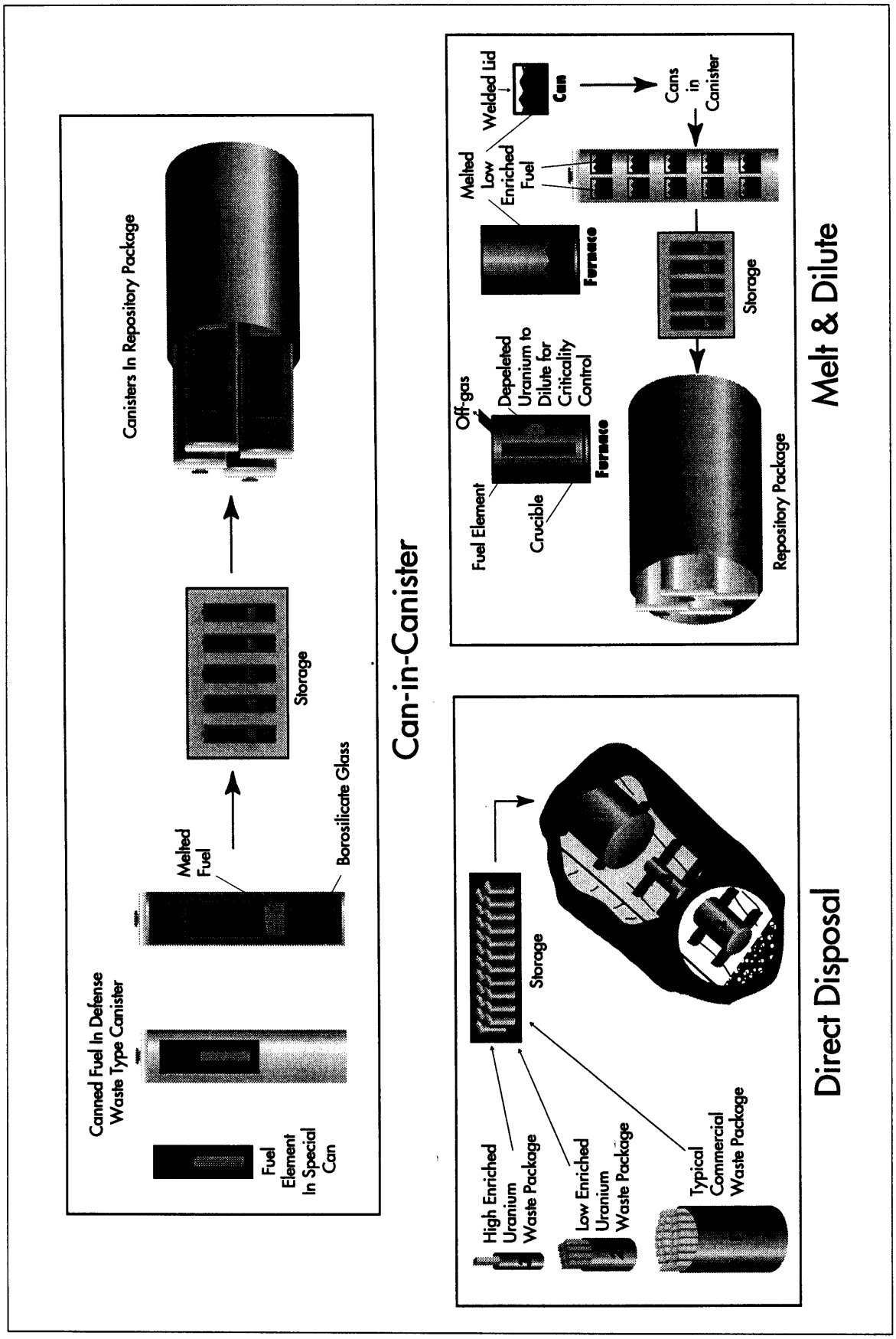


Figure 2-21 New Treatment and Packaging Technologies (Functional Schematic Diagrams)

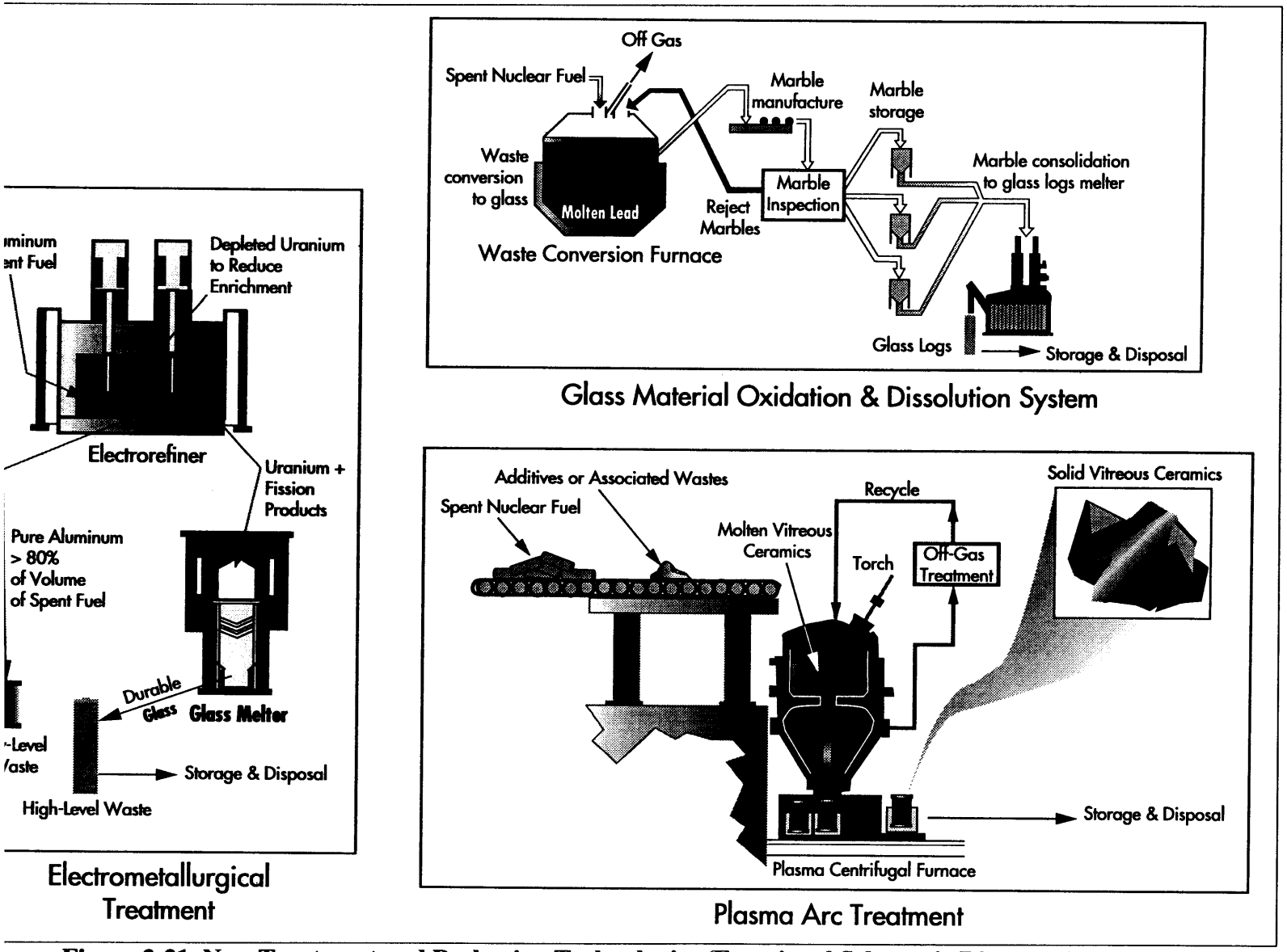


Figure 2-21 New Treatment and Packaging Technologies (Functional Schematic Diagrams) (Continued)

nuclear fuel by either a new treatment and/or packaging technology or reprocessing in the F-Canyon, the spent nuclear fuel would be placed in existing wet storage at the Savannah River Site.

3. DOE would conduct a program of close monitoring of any foreign research reactor spent nuclear fuel and target material that would be accepted for storage in existing wet storage facilities. DOE is presently unaware of any technical basis for believing that this spent nuclear fuel cannot be safely stored until one or more of the treatment and/or packaging technologies becomes available. Nevertheless, if health and safety concerns involving any of the foreign research reactor spent nuclear fuel elements are identified prior to development of an appropriate treatment and/or packaging technology, DOE would use the F-Canyon to reprocess the affected spent nuclear fuel elements, if it is still operating to stabilize at-risk materials.

   Because of criticality constraints stemming from the configuration of the F-Canyon, under no circumstances would it be possible to produce separated HEU that is suitable for a nuclear weapon. Instead, depleted uranium would be added to the foreign research reactor spent nuclear fuel near the beginning of the reprocessing process, so that only LEU would be produced when the uranium is separated from the fission products. The trace quantities of plutonium in the spent nuclear fuel would be left in and solidified along with the high-level radioactive reprocessing wastes. This would further the President's policy to discourage the accumulation of excess weapons grade fissile materials, to strengthen controls and constraints on these materials and, over time, to reduce worldwide stocks.

The TRIGA foreign research reactor spent nuclear fuel would be stored at the Idaho National Engineering Laboratory in the Fluorinel Dissolution and Fuel Storage (FAST) facility (wet storage) or preferably the dry storage Irradiated Fuel Storage Facility (IFSF) and the CPP-749 dry storage area. After 2003, all foreign research reactor spent nuclear fuel would be managed in accordance with the provisions of the settlement agreement between DOE and the State of Idaho, until transported off-site for ultimate disposition. Depending on the nature of any new treatment and/or packaging technology that might be developed, the TRIGA spent nuclear fuel would also be processed using such a new technology, if necessary for disposal.

A critical result of implementing this preferred alternative would be the continued viability and vitality of the Reduced Enrichment for Research and Test Reactors (RERTR) Program, whose goal is minimizing and eventually eliminating the use of HEU in civil nuclear programs, by providing foreign research reactor operators with a continued incentive to participate. Similarly, the successful development of alternative fuels for research reactors and the expansion of the program to Russia, the other Newly Independent States, China, South Africa, and other countries, and the establishment of a world-wide norm discouraging the use of HEU, are dependent on the United States' commitment to action such as that embodied in this preferred alternative.

DOE is aware that the inclusion of chemical separation within the preferred alternative could be interpreted by some nations, organizations and persons as a signal of endorsement of the use of reprocessing as a routine method of waste management for spent nuclear fuel or a reversal of U.S. policy on reprocessing. This would not be an accurate interpretation. The U.S. policy regarding reprocessing was established in Presidential Decision Directive 13. DOE and the Department of State have determined that this preferred alternative is not inconsistent with that policy. The draft version of this EIS indicated that reprocessing is a non-preferred technology and would not be used unless one or more of a set of specific conditions occurred (see Draft EIS Section 2.2.2.6). This final preferred alternative, which

States geologic repository. Accordingly, acceptance of such waste in the United States likely could require expensive, currently unproven treatment and/or packaging technologies to transform it into a form that would be acceptable for disposal.

d. The sample hybrid alternative (Management Alternative 3) analyzed in the Draft EIS involved partial reprocessing overseas coupled with partial management in the United States. In order for this alternative to be consistent with United States nuclear weapons nonproliferation policy objectives, certain conditions would have to be met by either the reprocessor (e.g., Dounreay) or the research reactor operators. Staff from both DOE and the Department of State have addressed this issue with representatives of the United Kingdom Department of Trade and Industry and reactor operators, and have determined that it would not be possible to ensure compliance with the United States nuclear weapons nonproliferation policy objectives. The primary concern was the inability to ensure that any separated HEU would be blended down to LEU. Obtaining the reactor operators' agreement to such a policy would likely require significant financial subsidies. The potential cost of achieving agreement to blend down the uranium, plus uncertainties regarding Dounreay's long-term availability, led DOE and the Department of State to conclude that successful implementation of this alternative could not be relied on.

None of the alternatives analyzed in the Draft EIS could be implemented without some degree of difficulty. However, a modification of Management Alternative 1 (Manage Foreign Research Reactor Spent Nuclear Fuel in the United States), incorporating a combination of alternatives to the basic implementation components balances policy, technical, cost and schedule requirements. DOE and the Department of State consider that this approach provides the highest assurance that programmatic requirements could be met. This combination also provides the strongest support for United States nuclear weapons nonproliferation policy objectives as all aspects of the alternative would be under the control of DOE, either directly or through the spent nuclear fuel acceptance contracts with the reactor operators.

2. ***Management Technology*** - The alternative spent nuclear fuel management technologies considered are discussed in Sections 2.2.2.7 and 2.6.5 of the EIS. The approaches fall into four broad categories, as follows:

Wet Storage - Wet storage is a proven technology, the impacts of which would be small, and completely within the applicable regulatory limits, if it were used to implement the proposed action. Furthermore, DOE currently has wet storage facilities in operation at the Savannah River Site and the Idaho National Engineering Laboratory that could be used for storage of foreign research reactor spent nuclear fuel. However, wet storage requires attention to ensure that the storage conditions do not foster slow degradation of the spent nuclear fuel through corrosion.

Dry Storage - Dry storage is also a proven technology, that would also have no more than small impacts, completely within the applicable regulatory limits, if used to implement the proposed action. It is the storage medium that is being selected at all commercial power reactor sites where additional storage capacity is being built. However, it has not been used for research reactor spent nuclear fuel in the United States. Dry storage capacity could be provided at the management sites in time to meet the program's projected needs, if initial spent nuclear fuel receipts were placed into the available wet storage.

Chemical Separation - Chemical separation is also a proven technology, the impacts of

4. ***Amount of Material to Manage*** - The alternative amounts of material that might be covered by the proposed policy are defined in Sections 2.2.1.3 and 2.2.2.1 of the EIS. DOE and the Department of State concluded that management of spent nuclear fuel only from other-than-high-income economy countries would strongly encourage the resurgence of the use of HEU in the high-income economy countries, as well as opening the United States, fairly or unfairly, to charges that we are not living up to our commitments under the *Treaty on the Non-Proliferation of Nuclear Weapons*. Management of only spent nuclear fuel containing HEU would penalize those reactors that have already converted to the use of LEU fuel, and would provide an incentive for reactors to continue to use HEU fuel, or switch back to its use. The impacts that would result from management of any of these different amounts of material would be small, and within the applicable regulatory limits.

   DOE and the Department of State concluded that management of all of the aluminum-based and TRIGA foreign research reactor spent nuclear fuel currently in storage or projected to be discharged during the policy period, and target material containing uranium enriched in the United States, would provide the best support for the objectives of the proposed policy. Implementation of this preferred alternative would provide an opportunity for removal of the maximum amount of HEU from civil commerce and would provide an incentive for the continued conversion to and use of LEU as fuel for foreign research reactors, in place of highly enriched (weapons grade) uranium.

5. ***Marine Transport*** - The alternative approaches to marine transport of foreign research reactor spent nuclear fuel are discussed in Section 2.2.1.5 of the EIS. The analysis in the EIS demonstrates that the impacts to the environment, workers or the public from transport of the spent nuclear fuel using any of these types of ships would be small, and within the regulatory limits. The analyses do not identify any difference in the small impacts that would result from the use of purpose-built vs. general purpose ships. Since "military transports" are in fact the same type of ship as the chartered commercial cargo ships and are crewed by civilians, use of "military transports" would not actually result in any difference in impacts. DOE and the Department of State believe that use of actual warships would be both unnecessary from a security standpoint and could entail additional risk to the environment and the public, since such ships do not routinely carry cargo.

   The approach selected by DOE and the Department of State for the preferred alternative provides maximum flexibility for marine transport.

6. ***Ground Transport*** - The ground transportation alternatives are defined in Section 2.2.1.7 of the EIS. The analyses in the EIS demonstrate that the impacts to the environment, workers or the public, from any of these modes of ground transport (counting barge as a mode of "ground transport") would be small and within the applicable regulatory limits. Furthermore, the differences in potential impacts between the truck, rail and barge alternatives were not significant.

   Both the truck and rail transportation options have been used successfully to transport foreign research reactor spent nuclear fuel in the past. Truck transport was the predominant mode used for over twenty years, until the old "Off-Site Fuels Policy" lapsed in 1988. Rail was the mode used for both shipments under the *Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel* (DOE, 1994m). Since neither

of the preferred ports of entry (see item 8 below) can reasonably provide barge transport to either of the proposed management sites, barge transport was dismissed from consideration in the preferred alternative.

By providing for either truck or rail transport, the preferred alternative would build on previous satisfactory experience while providing maximum flexibility for dealing with changes in the transportation process in the future.

7. ***Title Transfer Location*** - The alternative points at which DOE might take title to the spent nuclear fuel and target material are discussed in Sections 2.2.1.4 and 2.2.2.4 of the EIS. The point at which title would be transferred has no effect on the physical processes that would take place, and thus would not have any effect on the impacts on the environment, workers or on the public. The Price-Anderson Act would provide liability protection in the unlikely event of a nuclear accident in the United States, whether or not DOE had taken title to the spent nuclear fuel at the time of such an accident. As a result, DOE and the Department of State concluded that the selection of the title transfer location could be made solely on programmatic considerations.

   Acceptance of title at the foreign research reactor sites could make the United States Government liable for any accident that might occur in the country of origin, or on the high seas. DOE and the Department of State have been unable to identify any advantage to the United States of taking title outside the United States.

   Taking title at the limit of United States territorial waters makes the title transfer depend solely on when the ship enters United States waters, which could be difficult for DOE to control in certain circumstances (e.g., a storm).

   Acceptance of title when the foreign research reactor spent nuclear fuel actually enters the land mass of the United States provides the most certainty for implementation.

   The approach incorporated into the preferred alternative ensures that liability for accidents during the transportation process outside the United States would remain with the reactor operators while reinforcing in the minds of the public that the United States Government would be accountable in the unlikely event of an accident within United States territory.

8. ***Ports of Entry*** - The alternative ports of entry considered are discussed in Sections 2.2.1.6 and 3.2 of the EIS. The analyses in the EIS demonstrate that the impacts on either the environment, workers or the public due to use of any of the potential ports of entry analyzed would be small and within applicable regulatory limits.

   Although any one or all of the ten ports of entry described in Sections 2.2.1.6 and 3.2 of this EIS would be acceptable ports of entry, DOE and the Department of State concluded that foreign research reactor spent nuclear fuel marine shipments to the United States should be made via the military ports (selected from among those analyzed in the EIS and found acceptable) in close proximity to the spent nuclear fuel management sites. DOE would seek to transport multiple casks per ship to keep the total number of shipments as low as possible, as well as to reduce risks. The exact number of shipments that might be made would be determined by several factors that are unknown at this time, such as the times at which the reactor operators need to make shipments over the 13 year shipping period, the geographic distribution of the reactors, and the availability of suitable ships that would stop at the required ports to pick up and drop off the spent nuclear fuel and target material.

Use of military ports would provide additional confidence in the safety of the shipments due to the increased security associated with the military ports. It could also require much of the spent nuclear fuel to be shipped via chartered ships since commercial ships would not have stops scheduled at military ports, increasing the cost of spent nuclear fuel shipping. This additional cost would be borne by the reactor operators for shipments from high-income economy countries, and by the United States for shipments from other-than-high-income economy countries. Additional costs would be kept to a minimum by shipping as many casks as possible on each ship (up to a maximum of 8 per ship).

9. ***Management Sites*** - The question of which sites should be used for management of all of DOE's spent nuclear fuel was addressed in the Programmatic SNF&INEL Final EIS (DOE, 1995c). That EIS included consideration of the potential receipt of the foreign research reactor spent nuclear fuel. The Record of Decision for that EIS, issued on May 30, 1995, specifies that any aluminum-based foreign research reactor spent nuclear fuel accepted in the United States shall be managed at the Savannah River Site; and that the remaining foreign research reactor spent nuclear fuel shall be managed at the Idaho National Engineering Laboratory. The site for management of the target material was left to be decided under this EIS. All of the target material currently in DOE's possession is managed at the Savannah River Site. The approach incorporated into the preferred alternative is in compliance with the decision specified in the Record of Decision for the Programmatic SNF&INEL Final EIS.

   The analyses in the EIS demonstrate that the impacts to either the environment or the public through use of any of the sites for management of the foreign research reactor spent nuclear fuel and target material would be small, and within the applicable regulatory limits.

10. ***Financing Arrangement*** - The alternative financing arrangements are discussed in Sections 2.2.1.2 and 2.2.2.3 of the EIS. The financing arrangement used for the proposed action would have no effect on the physical processes that would take place, and thus would not have any effect on the potential impacts on the environment, or on the public. However, it could affect how many foreign research reactor operators elect to ship spent nuclear fuel to the United States. For instance, if DOE and the Department of State chose to charge a full cost recovery fee to all reactors, many, if not all, of the reactors in other-than-high-income economy countries would not have the financial resources to participate. On the other hand, if the United States subsidized all of the reactors, the United States would bear the full financial burden, even for reactors which can afford to pay their fair

without encouraging any of them to resort to reprocessing of their spent nuclear fuel, and would provide a mechanism through which to account for inflation and future definition of program details.

2.10 Additional Alternatives Considered But Dismissed

Besides ocean transport by vessel, carriage by air is the only other mode of transportation from overseas nations to the United States. There are two distinct reasons why the air mode is not a feasible alternative to the sea mode for transportation of foreign research reactor spent nuclear fuel.

First, with the possible exception of small sample quantities, spent nuclear fuel is required to be transported in packagings (casks) weighing several tons. As a general rule, casks would have to be shipped singly by air (i.e., one per airplane) because of their weight. This has made the air alternative so costly as to be prohibitive. As a result, there is no commercial operational experience in the United States with air transport of spent nuclear fuel. No "Standard Operating Procedures" have been written and no intermodal transfer procedures (air-truck or air-rail) have been developed. No agreements have been negotiated regarding airspace overflight of other nations or states. Because the United States has no experience with this type of transportation, no meaningful comparison can be made between air transport and ship transport regarding either incident-free doses to workers and the public or accident risks.

Second, plutonium air transport packaging standards clearly apply to movement by air of any non-exceptional package containing more than 0.005 curies of plutonium (10 CFR 71.88a). The foreign research reactor spent nuclear fuel considered in this EIS is non-excepted and could contain more than 0.005 curies of plutonium per cask. Therefore, the spent nuclear fuel would have to be transported in a cask meeting plutonium air transport packaging standards. Because no spent nuclear fuel transportation

peaceful application of nuclear energy. This would damage the credibility of the United States as a reliable partner in the implementation of international nuclear materials management. In consideration of the above summarized flaws, DOE dismissed this alternative from consideration in this EIS.

As a result of public comments, the possibility of managing foreign research reactor spent nuclear fuel on an isolated island was considered, and dismissed. A new facility on an island could not be ready to receive foreign research reactor spent nuclear fuel for at least five years, necessitating temporary management at another location (Savannah River site or Idaho National Engineering Laboratory) for at least the first half of the policy period. Furthermore, management of spent nuclear fuel on such an island is undesirable from the standpoint of security and safety. Provision of physical security would be much more difficult on a remote island than at a mainland site, due to isolation and the greater challenges of protecting open coastlines. Small isolated islands are subject to a greater frequency of severe weather than occurs in the mainland, and after a severe storm it can be more difficult to restore services than it would be in a mainland area.

3. The Affected Environment

This chapter describes the marine, port, and site environments. Marine environments (Section 3.1) would be potentially impacted by the ocean transport of spent nuclear fuel, and port environments (Section 3.2) would be potentially impacted by the transfer of the casks that would contain the foreign research reactor

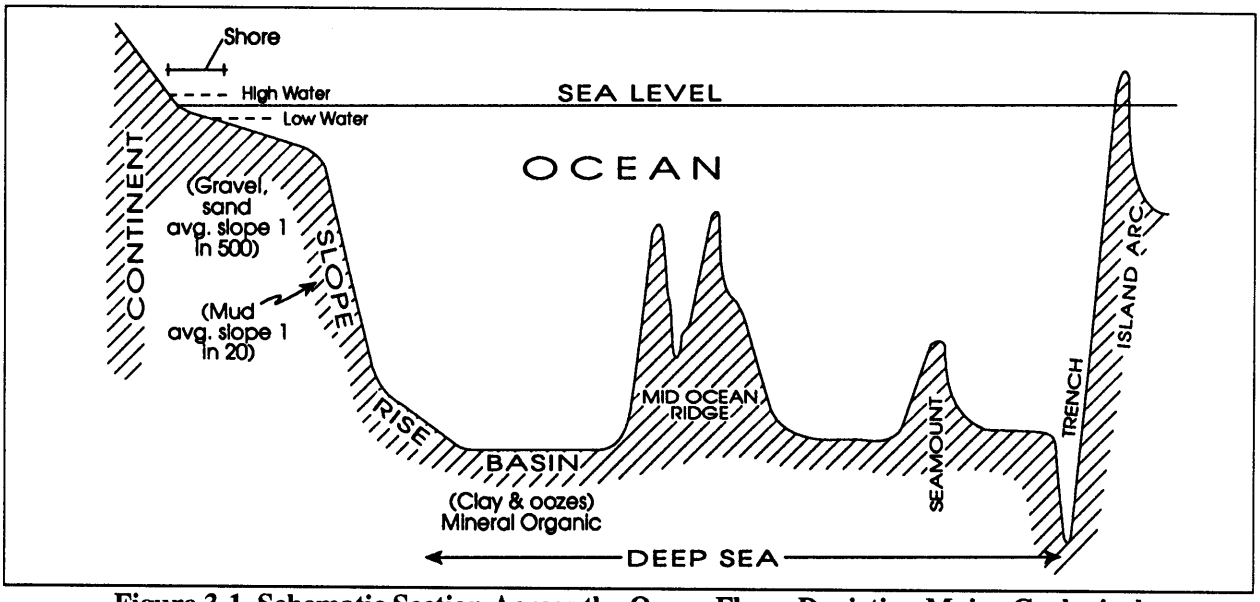


Figure 3-1 Schematic Section Across the Ocean Floor, Depicting Major Geological Features (Pickard and Emery, 1982)

where the saltwater is considerably diluted with freshwater. In general, the freshwater flowing into the estuary eventually exits the system in the upper (water) layer of the estuary, while the denser seawater enters the estuary through lower subsurface layers.

3.1.2 Chemical Oceanography

Seawater is a complex solution of minerals, salts, and elements, containing approximately 80 of the 92 naturally occurring elements. Hydrogen and oxygen, as water, constitute the largest elemental percent of seawater, with sodium chloride (NaCl) being the most abundant salt (78 percent) in the solution. Magnesium, calcium, and potassium chlorides and carbonates provide the bulk of the remaining constituents of the seawater solution. The ratio of these elements within the solution is relatively constant from ocean to ocean. However, in coastal areas where freshwater river influences are significant, the water chemistry can be substantially different. In addition to the major and minor constituents described above, trace metals, nutrient elements, dissolved atmospheric gases, and other organic matter also form important components of seawater. While trace metals are essential to the growth and development of certain organisms at low concentrations, these elements can become toxic when concentrated at high levels. Table 3-1 summarizes the concentration of major elements and trace elements, expressed in milligram per liter (mg/L), in seawater. The major nutrients (phosphates, silicates, and nitrates) provide the chief limiting agent for oceanic phytoplankton production. Atmospheric gases (e.g., oxygen and carbon dioxide) absorbed by the ocean play important roles in the overall global climate of the earth.

Naturally occurring radionuclides of uranium (such as ^{234}U, ^{235}U, ^{238}U), and polonium-210 (^{210}Po), are present in seawater, and in marine organisms, at concentrations generally greater than those found in terrestrial ecosystems. The ocean water concentrations of uranium isotopes are: ^{234}U, 1.30 picocuries per liter (pCi/l); ^{235}U, 0.05 pCi/l; and ^{238}U, 1.2 pCi/l (IAEA, 1976). For comparison, other major radioisotopes found in ocean water are: potassium-40 (40K), 486 pCi/l; thorium-232 (232Th), 540 pCi/; tritium (3H), 3 pCi/l; rubidium-87 (87Rb), 3 pCi/l; and Carbon-14 (14C), 1.8 pCi/l (IAEA, 1988).

Table 3-1 Concentration of Major Elements and Trace Elements in Seawater (CRC, 1991)

Element	*mg/L*	*Trace Element*	*mg/L*
Chlorine	19,000	Strontium	8.1
Sodium	10,500	Arsenic	0.003
Magnesium	1,350	Iron	0.01
Sulphur	885	Copper	0.003
Calcium	400	Zinc	0.01
Potassium	380	Cesium	0.0005
Bromine	65	Uranium	0.003
Fluorine	1.3	Lead	0.00003
Iodine	0.06	Zirconium	0.000022

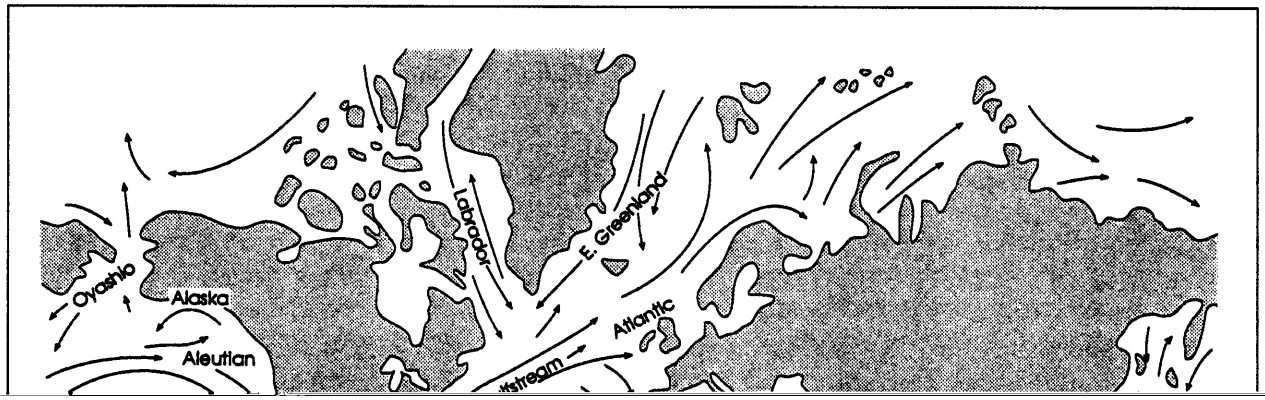
The relationship between environmental concentrations of radionuclides and the concentration found in organisms is important in the study of food chain effects. Bioamplification, the increase in concentration of radionuclides in organisms progressively further up the food chain (as with organic pesticides in terrestrial environments), is observed in marine food chains. In the marine environment, uranium has not been found to bioamplify in fish, and there is only slight bioamplification in crustaceans and mollusks (IAEA, 1976). The readiness with which other radionuclide constituents of spent nuclear fuel may enter the food chain is variable, but generally low.

3.1.3 Physical Oceanography

The science of physical oceanography involves the development of a systematic quantitative description of ocean characteristics and circulations. Ocean circulations include not only the major, permanent ocean features (e.g., the Gulf Stream) that circulate continuously with fluctuating velocity and position dynamics, but also the smaller-scale circulation features (e.g., tides, waves, coastal currents, etc.). Gradients in temperature, salinity, and seawater density give rise to vertical and lateral circulations.

The primary forces behind the generation and maintenance of surface currents in the world ocean are the winds in the lower portions of the atmosphere. Low-level winds generate stresses on the ocean surface that give rise to the surface currents. However, these currents only affect the uppermost layers of the ocean. Thus, the global wind patterns establish the direction and magnitude of the surface currents. Figure 3-2 depicts the major components of the wind-induced surface circulation of the world ocean.

Northern hemisphere ocean basins are characterized by strong western basin boundary currents that transport warmer, less dense water poleward, and are balanced by weaker, colder return flows along the eastern basin boundaries. Examples of these flows in the northern hemisphere are the Gulf Stream and


Oyashio
Alaska
Aleutian
Labrador
E. Greenland
Atlantic
Gulfstream

3.2 Individual Port Marine Environments

This section presents general environmental information for ten U.S. ports that have been identified as potential ports of entry. The ten ports are:

> Charleston, SC [includes the Naval Weapons Station (NWS) at Charleston and the Wando Terminal]; Galveston, TX; Hampton Roads (includes terminals at Newport News, Norfolk, and Portsmouth), VA; Jacksonville, FL; the Military Ocean Terminal at Sunny Point (MOTSU), NC; the NWS at Concord, CA; Portland, OR; Savannah, GA; Tacoma, WA; and Wilmington, NC.

These ports are more fully described in Appendix D of this Environmental Impact Statement (EIS). Appendix D identifies the ports that were considered as potential ports of entry for foreign research reactor spent nuclear fuel, the criteria used in the port evaluation process, the method of evaluation, and the results of the evaluation process. Appendix D also presents population data for ports and transportation routes considered in the evaluation. Potential overland and barge transportation routes are described in Appendix E, and Appendix C presents information on the environmental impacts of marine transport.

The various policy, management, and implementation alternatives being considered in this EIS do not involve any construction or modification of port facilities, nor would the use of one or more ports for the receipt of foreign research reactor spent nuclear fuel be expected to noticeably increase the number of

The State of South Carolina has classified the water quality of the portion of the Cooper River above the confluence with the Ashley River as SB (SB waters are tidal saltwaters suitable for secondary contact recreation, crabbing, and fishing, except the harvesting of clams, mussels, or oysters for market purposes and human consumption). The waters of Goose Creek, upstream of the confluence with the Cooper River

capable of loading trucks or trains directly from the ships. Pier Charlie and the Military Traffic Management Command Terminal would have to use shipboard or mobile cranes to load trucks. Several facilities on the NWS could be used to transfer spent fuel casks or containers from trucks to rail cars. A map of the port is shown in Figure 3-3.

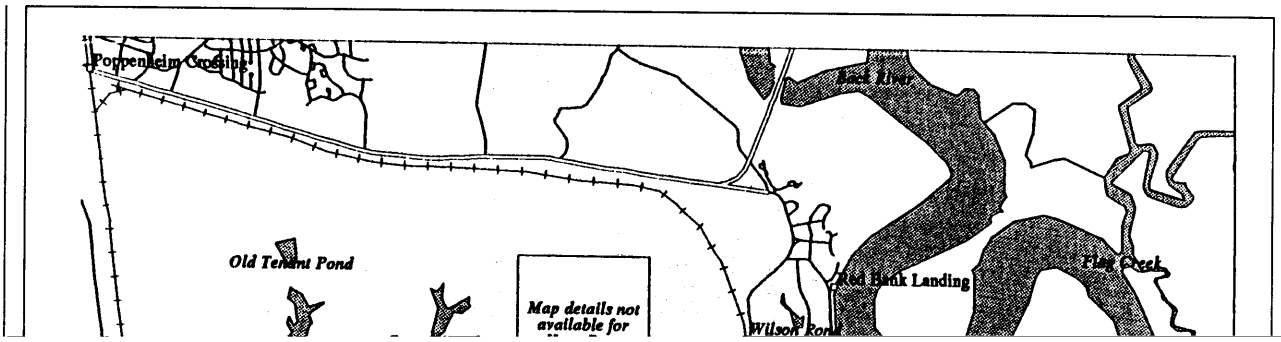
The 1990 population within 16 km (10 mi) of the Wharf Alpha was 209,188. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five U.S. Department of Energy (DOE) management sites are: the Savannah River Site, 46,200; the Oak Ridge Reservation, 108,000; the Idaho National Engineering Laboratory, 498,000; the Hanford Site, 550,000; and the Nevada Test Site, 540,000. Populations along rail routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 303 km (188 mi), the Oak Ridge Reservation, 647 km (402 mi), the Idaho National Engineering Laboratory, 3,930 km (2,442 mi), the Hanford Site, 4,601 km (2,859 mi), and the Nevada Test Site, 4,094 km (2,544 mi). Distances along rail routes are slightly longer.

Ethnic and Income Characteristics: Figure 3-4 shows the ethnic composition for the area surrounding the port at the NWS Charleston. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans constituted about 31 percent of the total population, and approximately 88 percent of the minority population for the area surrounding the port. Figure 3-5 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

Wando Terminal: This South Carolina State Port Authority terminal is located at the confluence of the Wando and Cooper rivers, on the east bank of the Wando River, near the incorporated city of Mount Pleasant. The facility has three modern container berths, with a fourth under construction, and a large paved container storage yard. The Wando terminal is about 8.1 km (5 mi) from the nearest Interstate highway and 15 km (9 mi) from the nearest intermodal rail yard. A map of the port is shown in Figure 3-6.

The 1990 population within 16 km (10 mi) of the Wando Terminal was 233,424. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five U.S. Department of Energy (DOE) management sites are: the Savannah River Site, 65,700; the Oak Ridge Reservation, 127,000; the Idaho National Engineering Laboratory, 518,000; the Hanford Site, 569,000; and the Nevada Test Site, 559,000. Populations along rail routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 327 km (203 mi), the Oak Ridge Reservation, 671 km (417 mi), the Idaho National Engineering Laboratory, 3,954 km (2,457 mi), the Hanford Site, 4,625 km (2,879 mi), and the Nevada Test Site, 4,118 km (2,559 mi). Distances along rail routes are slightly longer.

Ethnic and Income Characteristics: Figure 3-7 shows the ethnic composition for the area surrounding the Wando Terminal. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans constituted about 33 percent of the total population, and approximately 93 percent of the minority population for the area surrounding the port. Figure 3-8 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.


Poppenheim Crossing
Old Tenant Pond
Map details not available for
Red Bank Landing
Flat Creek

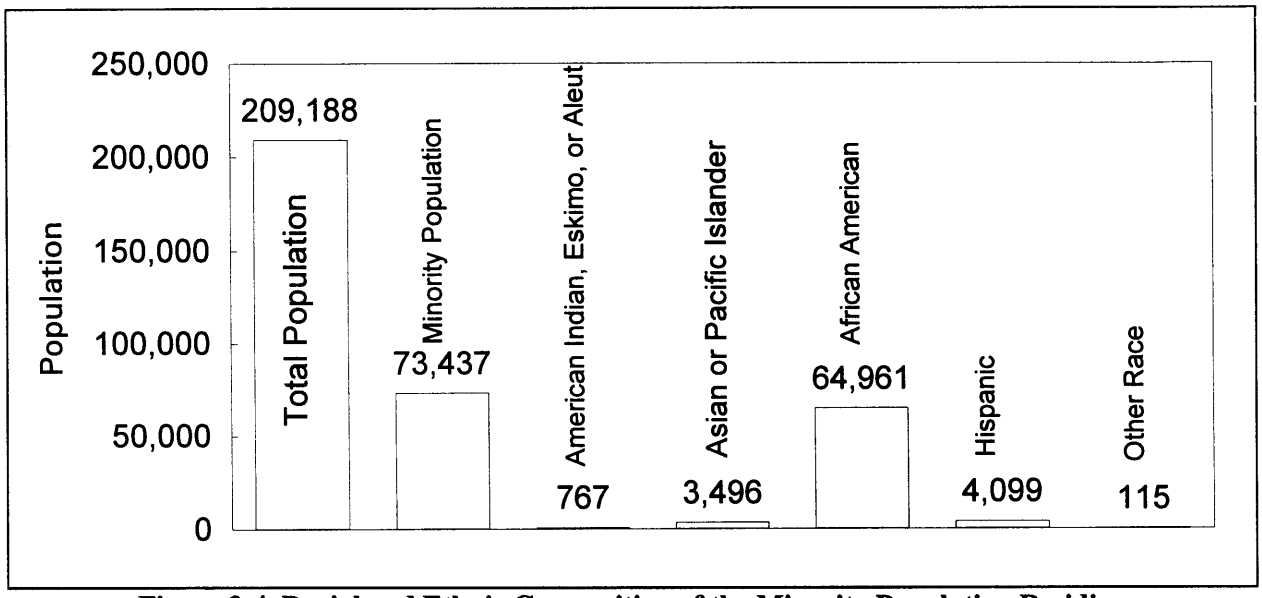


Figure 3-4 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Naval Weapons Station, Charleston

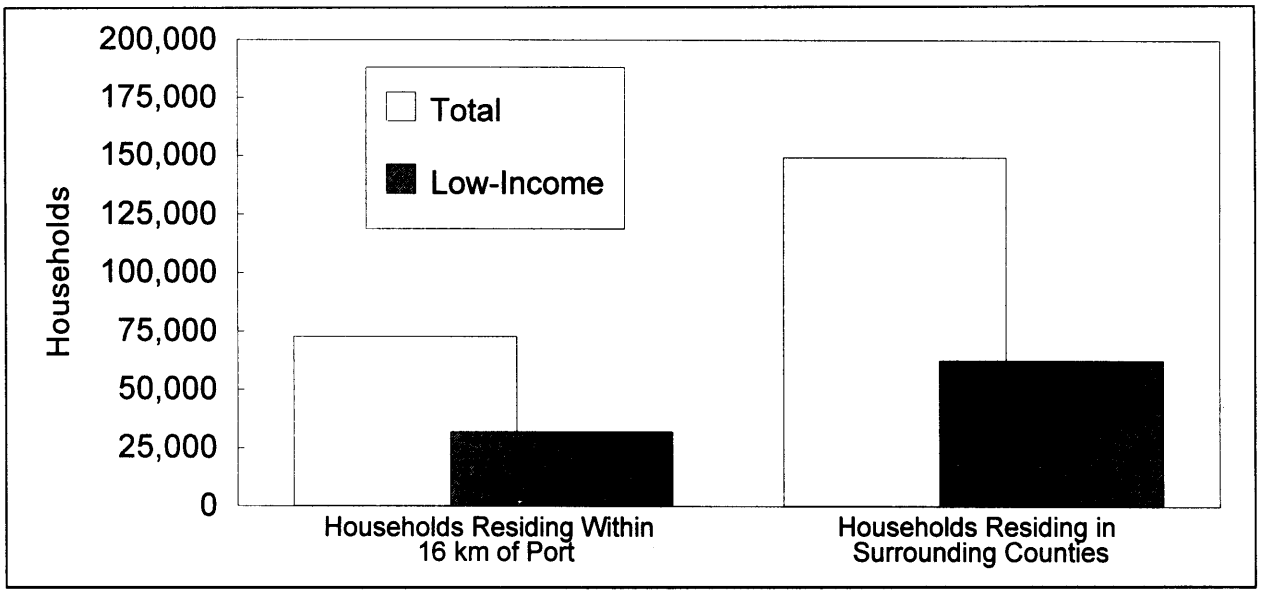
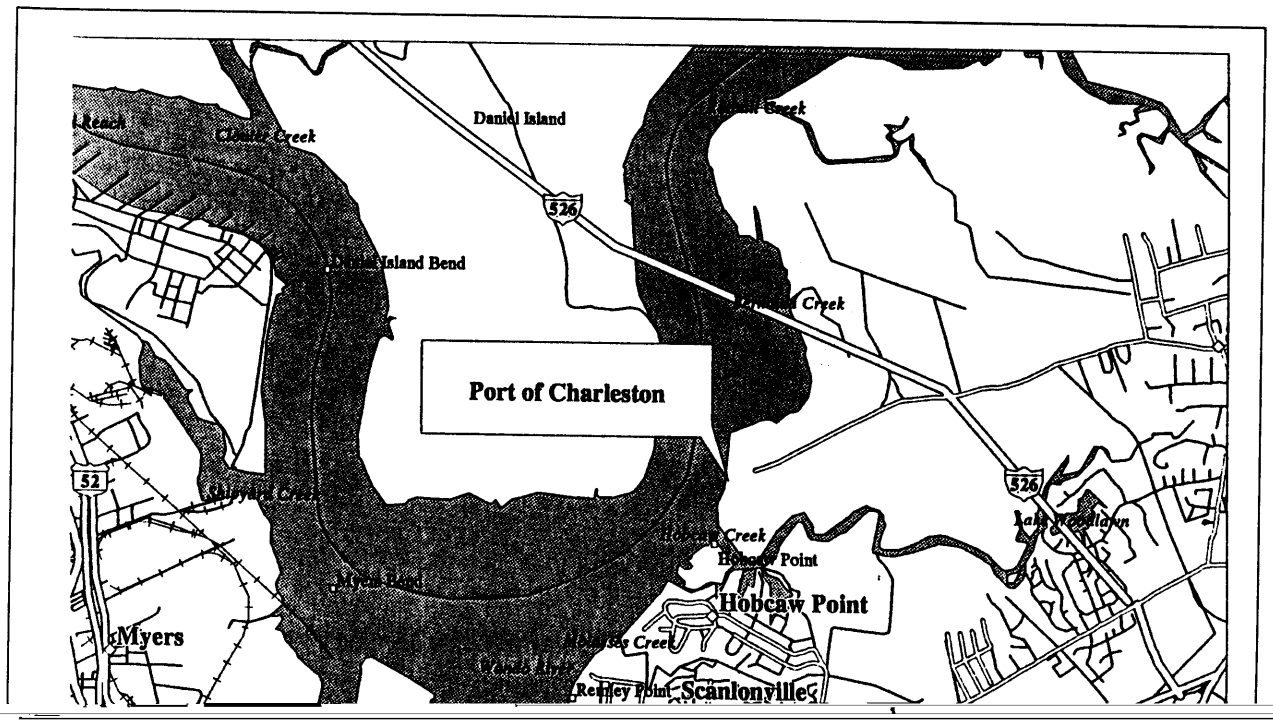


Figure 3-5 Low-Income Households Residing within 16 km (10 mi) of the Naval Weapons Station, Charleston

3.2.1.2 Galveston, TX

Galveston, TX is situated within 16 km (10 mi) of the entrance to the Gulf of Mexico. The city of Galveston occupies the entire width of the east end of Galveston Island. The shipping wharves are on the north side of the island and the Gulf of Mexico is on the south. The Port of Galveston is located in the heart of the city. A map of the port is shown in Figure 3-9.

Galveston is a major resort and tourist center for the Southwest. There is a waterfront tourist attraction at "Pier 21" close to the port area. A public park on Pelican Island, reached by causeway, is located across the Intracoastal Waterway from the Port of Galveston. A cruise ship terminal is located at Pier 25 in the


Daniel Island
526
Port of Charleston
52
526
Hobcaw Point
Hobcaw Point
Myers
Scanlonville

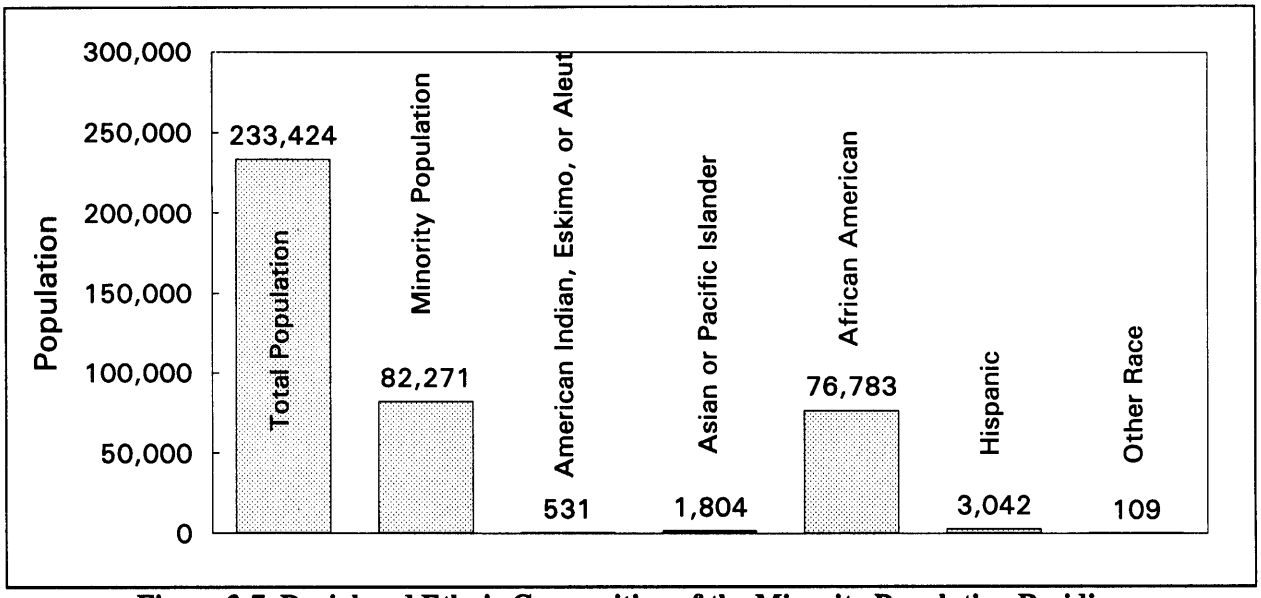


Figure 3-7 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Wando Terminal, Charleston

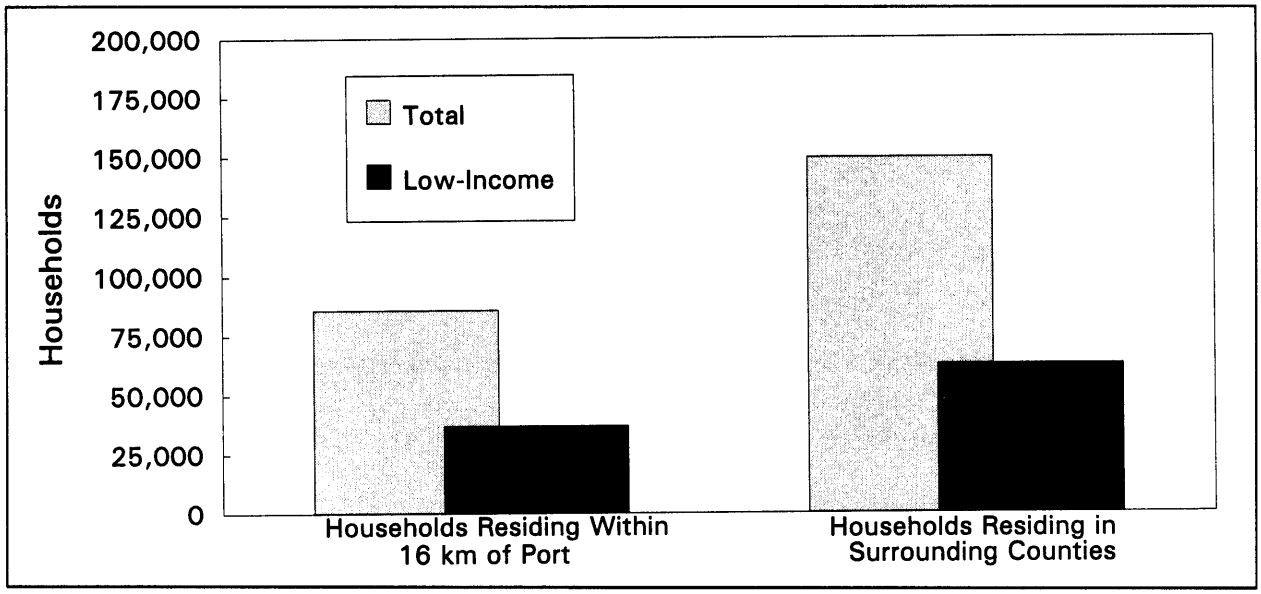
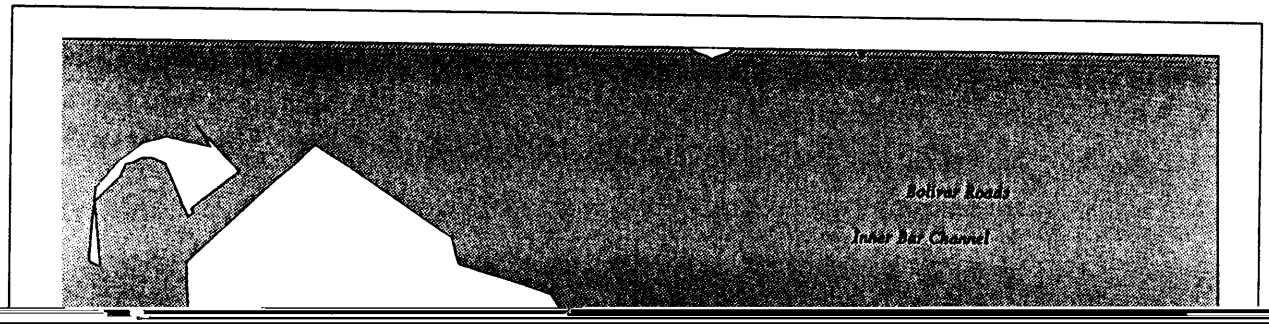


Figure 3-8 Low-Income Households Residing within 16 km (10 mi) of the Wando Terminal, Charleston

heart of the Port of Galveston complex, and there is a tanker terminal on Pelican Island across from the Port of Galveston at its southern end. A Federal project provides for an entrance channel, and an outer bar channel both dredged to 12.8 m (42 ft).

The Port of Galveston's principal container handling facility is the container terminal at Pier 10. This facility has a controlled all-weather truck entrance and interchange area. The terminal is connected to Interstate Highway 45 on the mainland by a 9.3 km (5.8 mi) four-lane State highway and two 2.8 km (1.75 mi) causeways that cross the southwest end of Galveston Bay. The container handling facility is served by four major railroads, the Burlington Northern, Santa Fe, Southern Pacific, and Union Pacific


Bolivar Roads
Inner Bar Channel

Lines. Galveston Railway, Inc., provides terminal connections and performs switching of all port rail traffic. An intermodal container transfer terminal is located within the container terminal, and trackage extends to within 30.5 m (100 ft) of ship berths.

The 1990 census population within 16 km (10 mi) of the port terminals was 73,322. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 403,000; the Oak Ridge Reservation, 337,000; the Idaho National Engineering Laboratory, 526,000; the Hanford Site, 575,000; and the Nevada Test Site, 595,000. Populations along rail routes to these sites are slightly larger for the Savannah River Site and the Oak Ridge Reservation, but slightly less for the Idaho National Engineering Laboratory, the Hanford Site, and the Nevada Test Site. The distances to the five potential sites on interstate routes are: the Savannah River Site, 1,600 km (1,000 mi); the Oak Ridge Reservation, 1,550 km (963 mi), the Idaho National Engineering Laboratory, 3,070 km (1,908 mi); the Hanford Site, 3,740 km (2,324 mi); and the Nevada Test Site, 3,000 km (1,864 mi). Distances along rail routes are slightly longer.

Environmental Conditions: A large number of aquatic and terrestrial species frequent the Galveston Bay area. A variety of birds migrate, winter, and breed along the Texas Coast including shorebirds, songbirds, waterfowl and raptors (Breslin, 1993; FWS, 1992). These endangered/threatened bird species include the brown pelican, peregrine falcon, bald eagle, Atwater's greater prairie-chicken, piping plover, and the Eskimo curlew (State-threatened only). Endangered/threatened marine mammals and sea turtles also are found in the coastal bay systems and the Gulf of Mexico. Galveston Bay is within the range of the green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles. While no protected species are known to be located within the Port of Galveston, significant populations of the endangered brown pelican and the threatened piping plover exist nearby (Werner, 1994). The U.S. Fish and Wildlife Service reported that as many as 600 brown pelicans have been sighted loafing on the north end of Little Pelican Island, which is approximately 5.6 km (3.5 mi) northwest of the port. In addition, approximately 125 pairs nested and produced 90 young ones at this site in 1994. This was the first time that brown pelicans had successfully nested in Galveston Bay in over 40 years. Wintering populations of the threatened piping plover use the northeastern end of Galveston Island and the southeastern end of Bolivar Peninsula. Of the 3,187 birds observed during the first Gulf Coast count of wintering piping plovers, 1,904 were observed on the Texas coastline (Werner, 1994).

A great amount of commercial and recreational fishing occurs in Galveston Bay and the Gulf of Mexico. Shellfish are the most important commercial species, particularly shrimp followed by eastern oysters and blue crabs (TPWD, 1989a). The most valuable finfish landed from the Galveston Bay system are black-

Ethnic and Income Characteristics: Figure 3-10 shows the ethnic composition for the area surrounding the Port of Galveston. This figure shows the population residing within 16 km (10 mi) of the port, according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census

African Americans made up about 27 percent of the total population, and approximately 54 percent of the minority population for the area surrounding the port. Hispanics made up about 20 percent of the total population, and approximately 40 percent of the minority population around the port. Figure 3-11 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

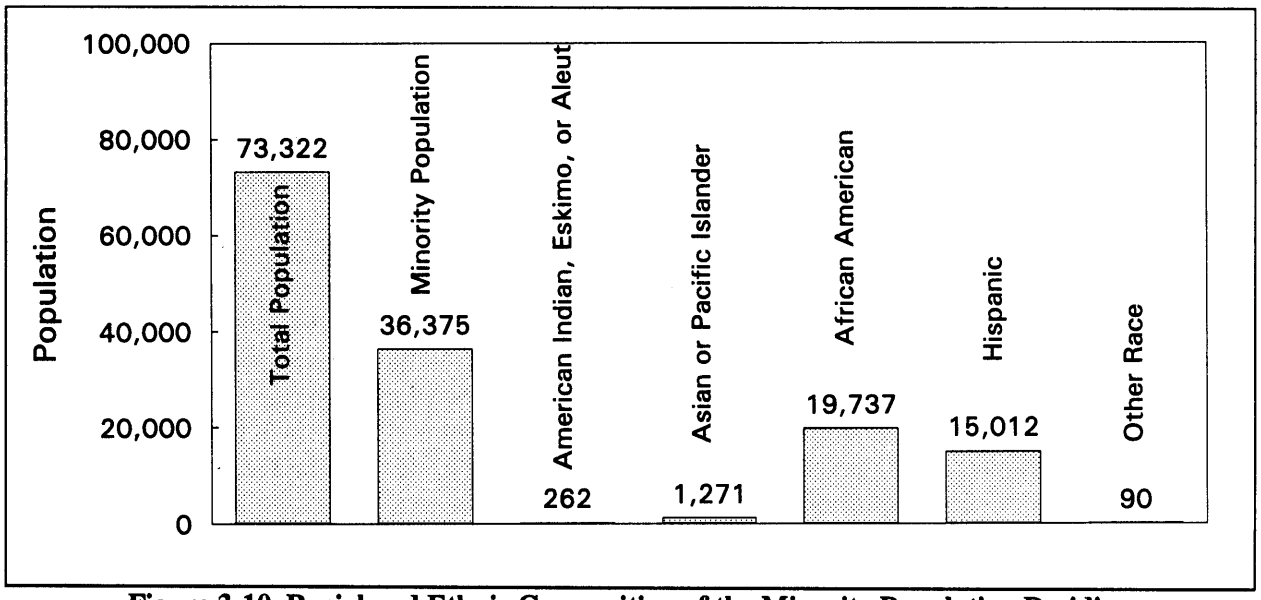
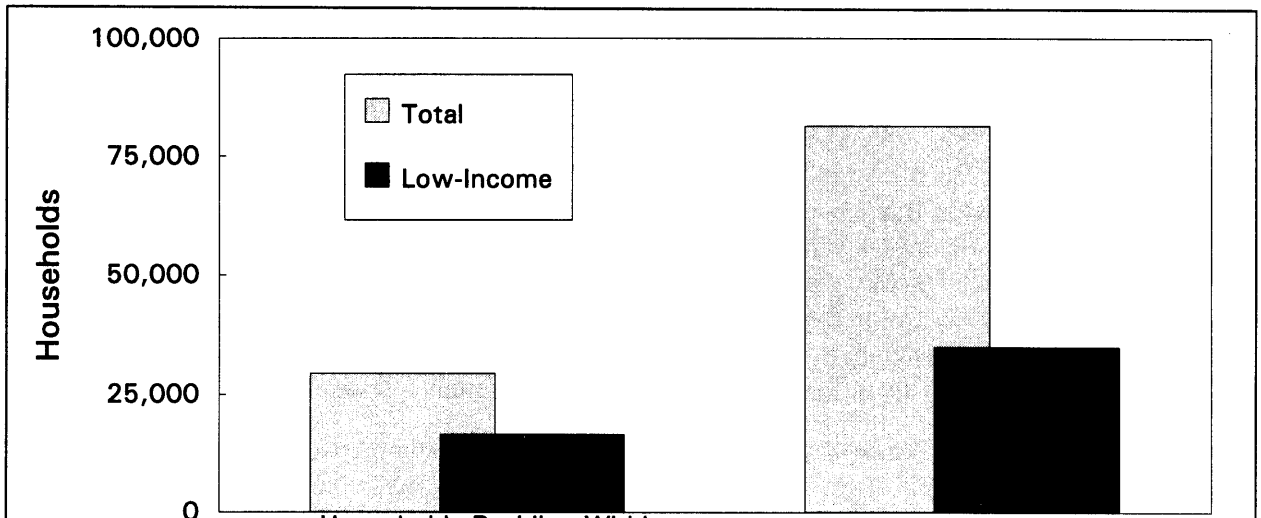


Figure 3-10 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Galveston



3.2.1.3 Hampton Roads, VA (Includes Terminals at Newport News, VA; Norfolk, VA; and Portsmouth, VA)

Hampton Roads is one of the world's foremost bulk cargo harbors, and has more collective experience handling spent nuclear fuel than any other port in the United States. It is a multi-terminal port with privately and publicly owned marine cargo handling facilities, and is located at the southwest corner of the Chesapeake Bay at the confluence of the James and the Elizabeth Rivers. The port is about 26 km (16 mi) from the Virginia Capes and the entrance from the Atlantic Ocean. The major terminals located on the Elizabeth and James Rivers are approximately another 10 to 13 km (6 to 8 mi) from the Chesapeake Bay. The port includes the port terminals at Norfolk, Portsmouth, and Newport News. All three terminals are located in commercial port districts of their respective cities, somewhat separated from other community activities, in areas dedicated primarily to port industrial usage. Adjacent communities include the cities of Chesapeake and Virginia Beach.

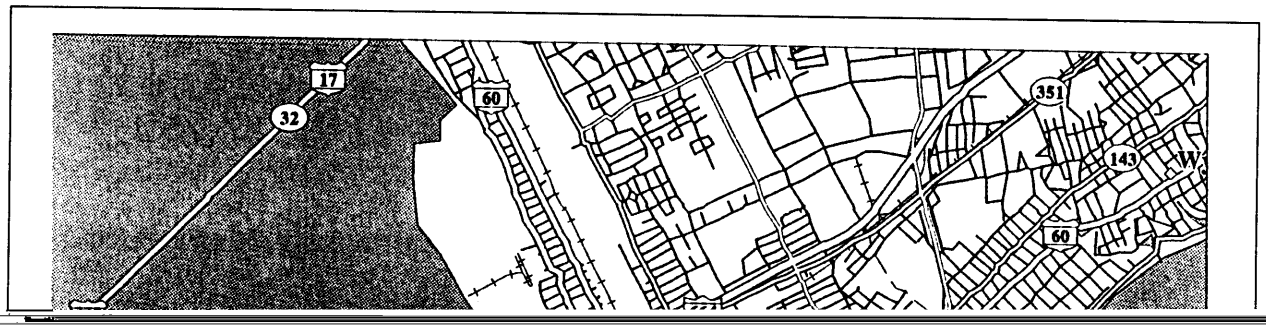
Environmental Conditions: The Port of Hampton Roads is located at the confluence of the James River and the Chesapeake Bay, approximately 29 km (18 mi) west of the Atlantic Ocean. The average elevation of this region is approximately 4 m (13 ft) above sea level. There are no known areas of special environmental concern other than the growing interest in preservation of the Chesapeake Bay and its tributary rivers. The Dismal Swamp National Wildlife Refuge is located about 16 km (10 mi) from the two terminals on the Elizabeth River, but water drainage from the swamps is toward the port area. The swamp refuge is far enough from the terminals that potential negative impacts of low-probability, severe accidents in the ports on wildlife populations would be negligible. The three port terminals at Hampton Roads are described separately below.

Climatic Conditions: The geographic location of this region is especially favorable, tending to be located south of the predominant winter extratropical cyclone tracks which originate at higher latitudes and north of the usual tropical cyclone (e.g., tropical storms and hurricanes) paths. In general, the winters are mild with slightly warmer temperatures during the spring and fall seasons. The summer season is warm and long, but is characterized by frequent cool periods, generated by cool northeasterly winds off of the North Atlantic. Extreme cold waves are infrequent, and temperatures below -18°C (0°F) are almost nonexistent. In general, winters pass without measurable snowfall and most snowfall melts within 24 hours. The average first sub-freezing day in the fall is November 17th and the last occurrence in the spring is March 23rd. The predominant wind directions since 1984 are from the south-southwest and north-northeast and vary seasonally (NOAA, 1992c).

The likelihood of severe natural phenomena such as high winds and earthquakes is reflected in the structural requirements for buildings in each area of the United States. These are shown in the Uniform Building Code (UBC, 1991). For the Port of Hampton Roads, the Uniform Building Code provides a basic wind speed of about 140 km per hour (90 mph). The port is located in a low seismic zone with an acceleration of 0.075 g.

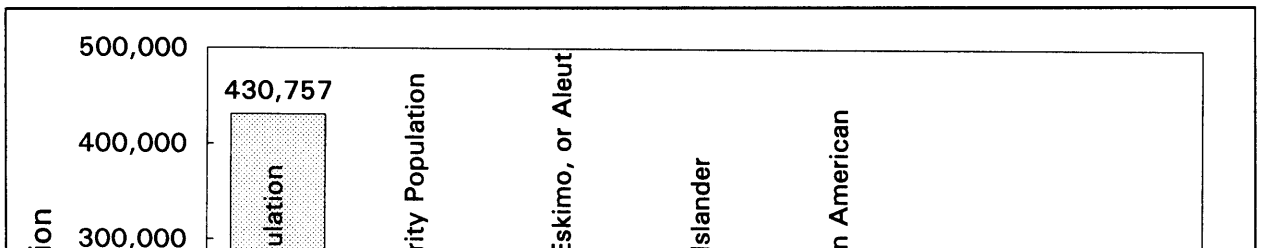
Newport News Marine Terminal: This terminal is located on the north shore of the Port of Hampton Roads on the James River. It is a combination container, roll-on/roll-off, and breakbulk terminal. The facility has two piers, two container vessel berths, and four container cranes. There is covered storage on both piers. A map of the Newport News Marine Terminal is shown in Figure 3-12.

The 1990 population within 16 km (10 mi) of the port terminal was 430,757. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 181,000; the Oak Ridge Reservation, 209,000; the Idaho National Engineering Laboratory, 628,000; the Hanford Site, 677,000; and the Nevada Test Site, 691,000. Populations along rail


17
32
60
351
143
60
W

routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 840 km (522 mi); the Oak Ridge Reservation, 890 km (553 mi); the Idaho National Engineering Laboratory, 4,010 km (2,492 mi); the Hanford Site, 4,680 km (2,908 mi); and the Nevada Test Site, 4,172 km (2,592 mi). Distances along rail routes are slightly longer.

Ethnic and Income Characteristics: Figure 3-13 shows the ethnic composition for the area surrounding the port at Newport News. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 32 percent of the total population, and approximately 86 percent of the minority population for the area surrounding the port. Figure 3-14 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.



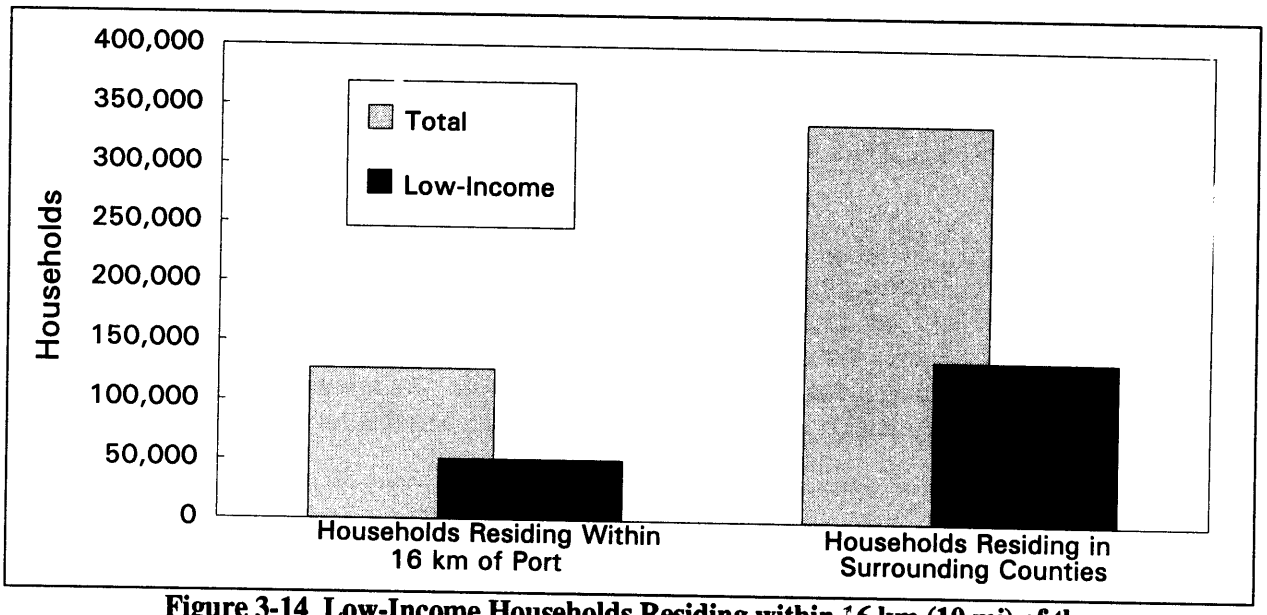


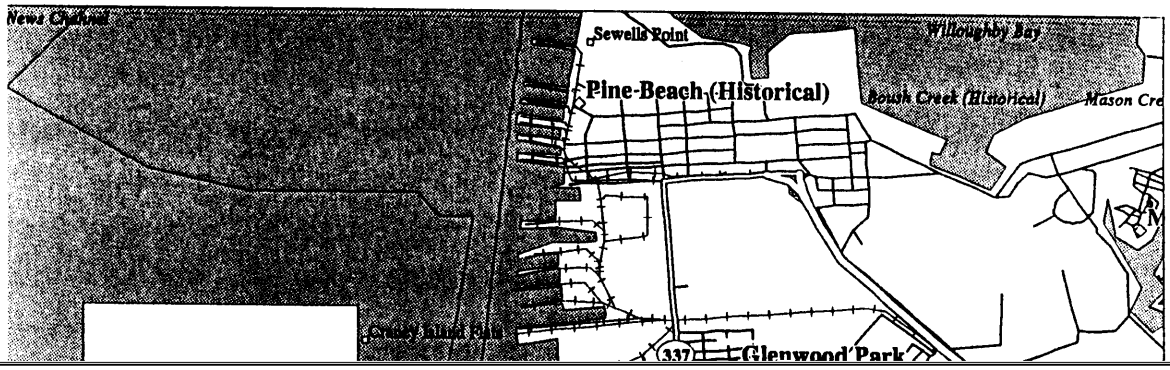
Figure 3-14 Low-Income Households Residing within 16 km (10 mi) of the Port of Newport News

Ethnic and Income Characteristics: Figure 3-16 shows the ethnic composition for the area surrounding the port at Norfolk, VA. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 33 percent of the total population, and approximately 93 percent of the minority population for the area surrounding the port. Figure 3-17 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

Portsmouth Marine Terminals: Portsmouth Marine Terminals are located at the confluence of the Elizabeth River and its western branch in the city of Portsmouth. The terminals have 3 berths that handle container, breakbulk and roll-on/roll-off cargoes. The terminals have 3 container cranes, and more than 14,000 m^2 (150,000 ft^2) of warehouse space. A map of the Portsmouth Marine Terminals is shown in Figure 3-18.

The 1990 population within 16 km (10 mi) of the Portsmouth Marine Terminals was 665,700. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 135,000; the Oak Ridge Reservation, 257,000; the Idaho National Engineering Laboratory, 670,000; the Hanford Site, 718,000; and the Nevada Test Site, 732,000. Populations along rail routes to these sites are about the same for eastern sites and slightly larger for western sites. The distances to the five potential sites on interstate routes are: the Savannah River Site, 810 km (503 mi); the Oak Ridge Reservation, 780 km (485 mi); the Idaho National Engineering Laboratory, 4,040 km (2,510 mi); the Hanford Site, 4,710 km (2,927 mi); and the Nevada Test Site, 4,210 km (2,616 mi). Distances along rail routes are slightly longer.

Ethnic and Income Characteristics: Figure 3-19 shows the ethnic composition for the area surrounding the port at Portsmouth. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 22 [illegible]


Sewells Point
Willoughby Bay
Pine Beach (Historical)
Mason Cre
337
Glenwood Park

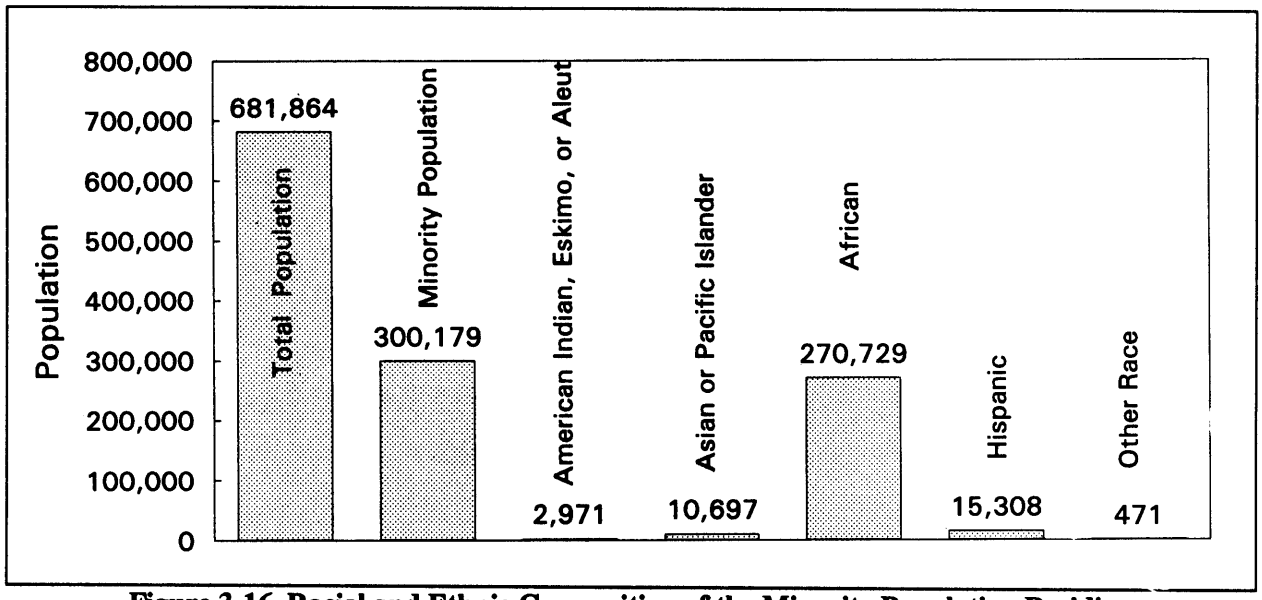


Figure 3-16 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Norfolk

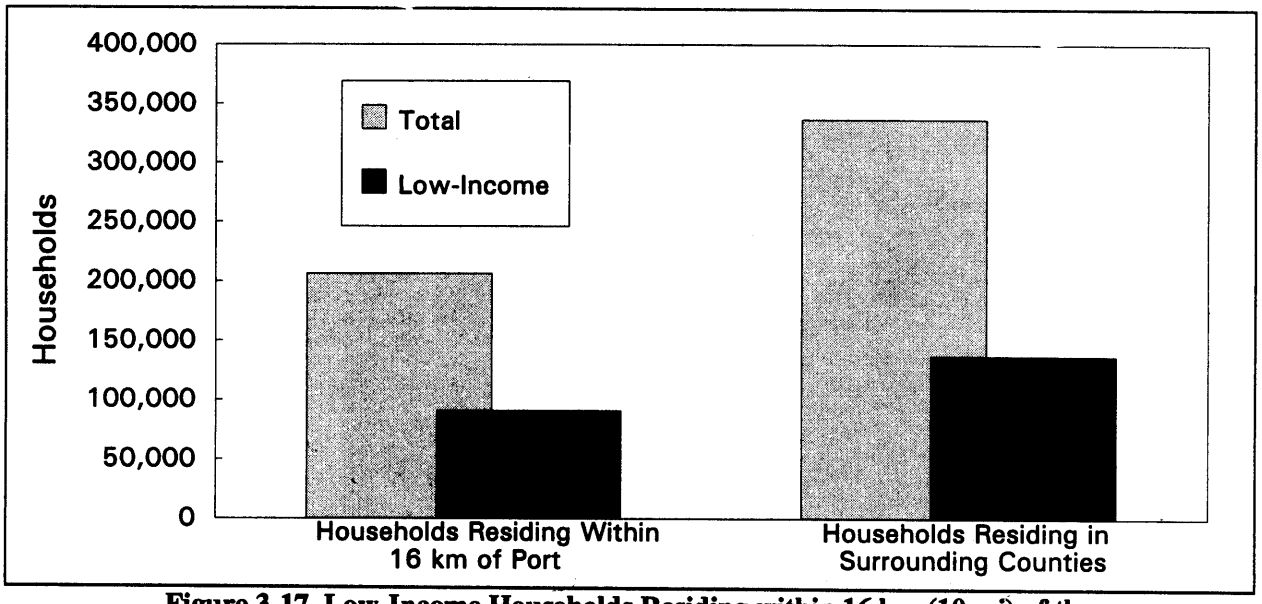
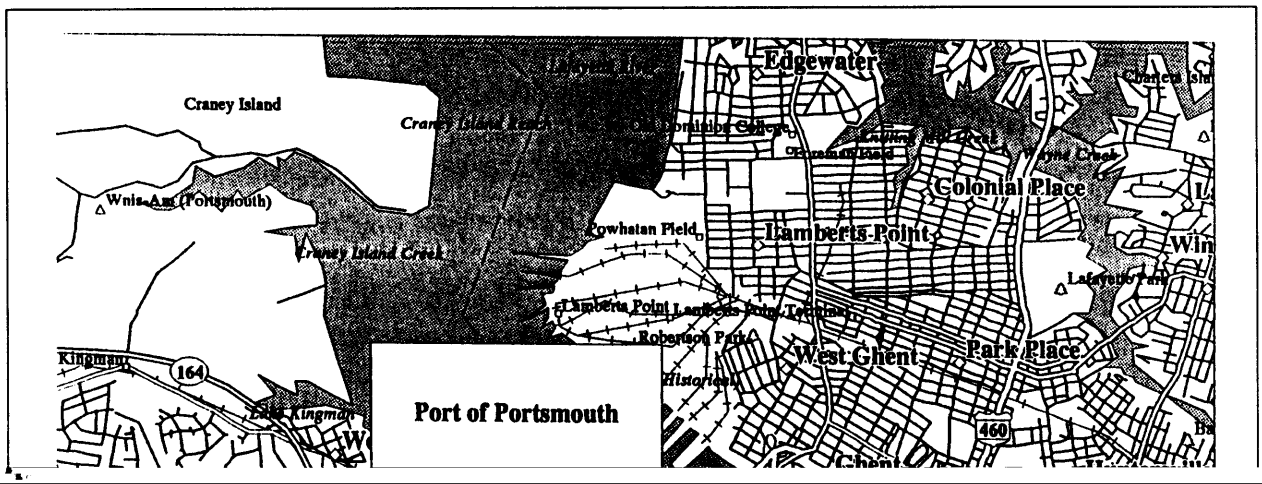


Figure 3-17 Low-Income Households Residing within 16 km (10 mi) of the Port of Norfolk

low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

3.2.1.4 Jacksonville, FL

The Port of Jacksonville is located on the Atlantic Coast of northern Florida, along the St. Johns River. It


Craney Island
Edgewater
Wnis-Am (Portsmouth)
Colonial Place
Powhatan Field
Lamberts Point
Lamberts Point
Robertson Park
West Ghent
Park Place
Historical
Port of Portsmouth
Kingman
164
460

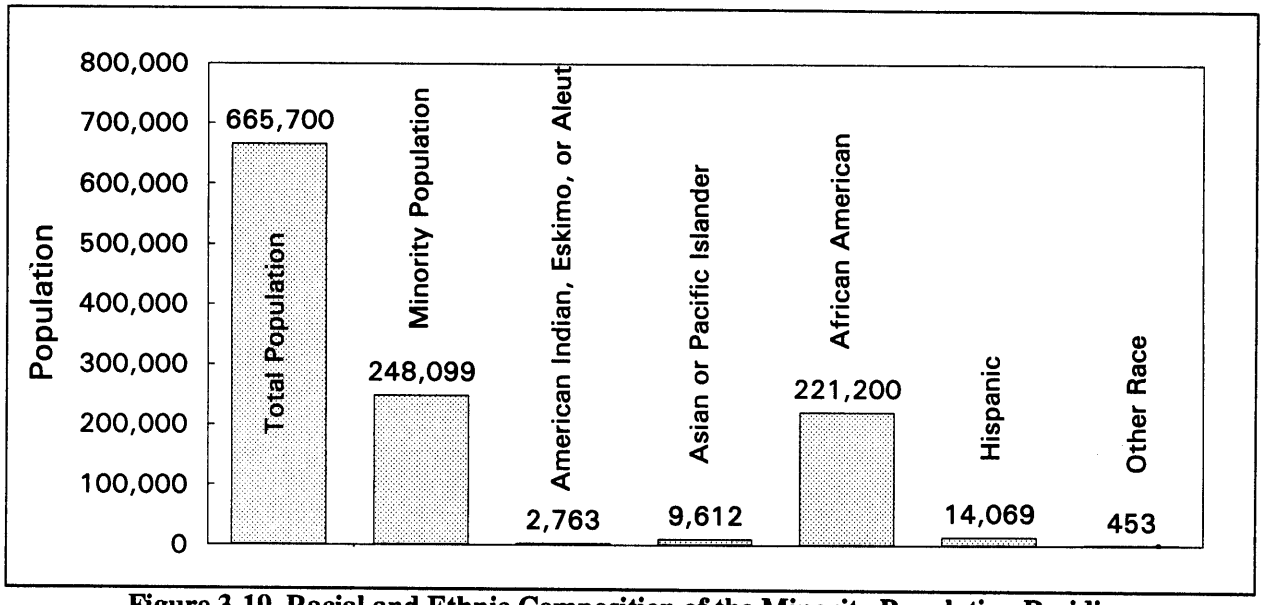


Figure 3-19 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Portsmouth

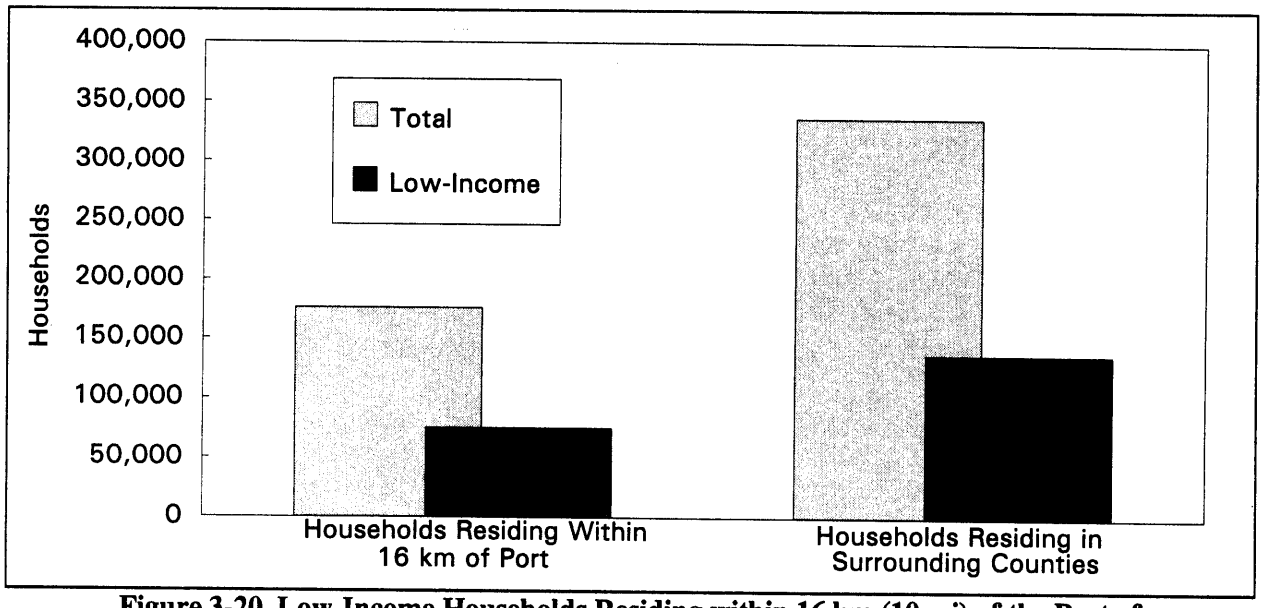
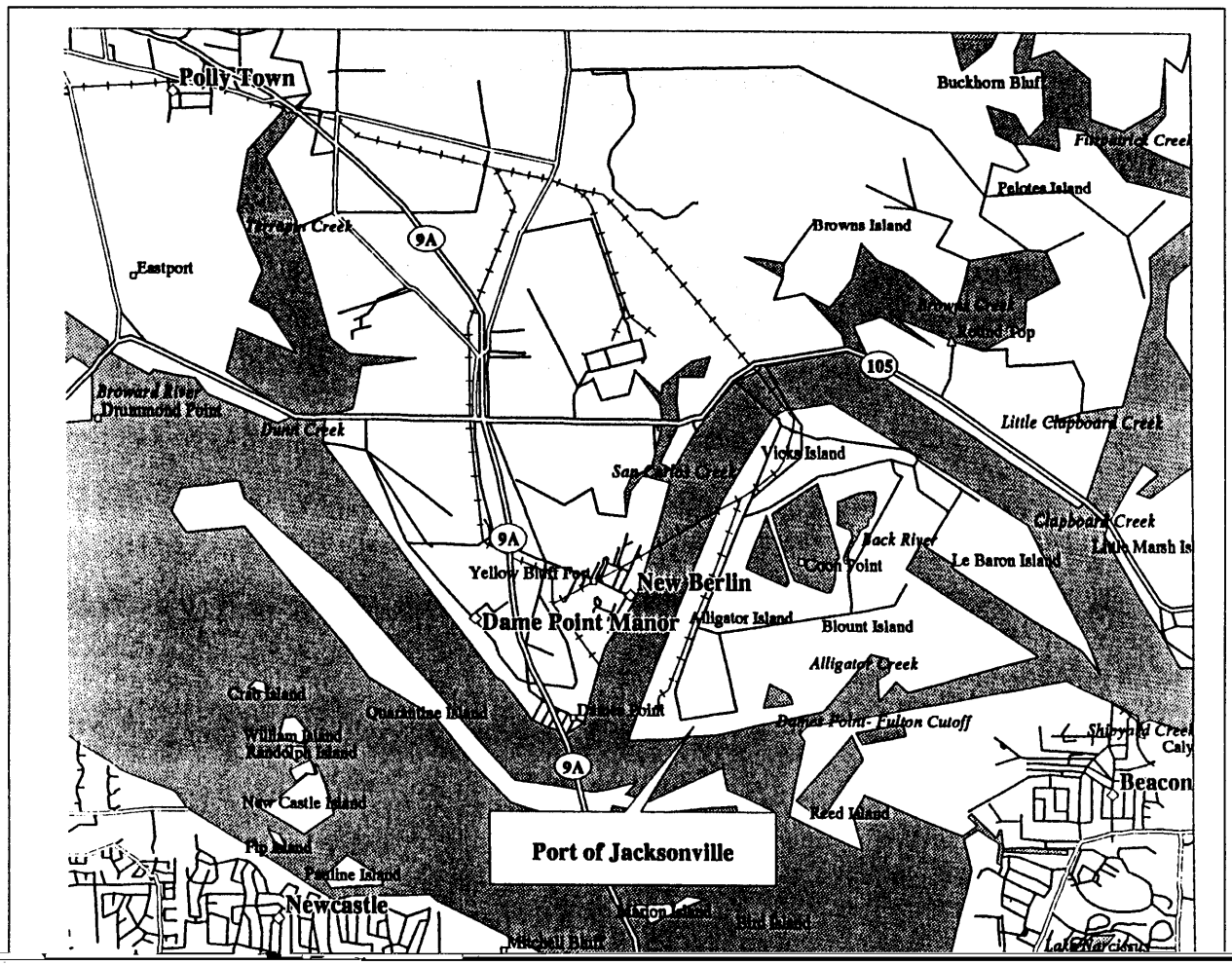


Figure 3-20 Low-Income Households Residing within 16 km (10 mi) of the Port of Portsmouth

separated from the city, and is only about 11 km (7 mi) from the harbor entrance. A map of the port is shown in Figure 3-21. A Federal project maintains a channel depth of 12.2 m (40 ft) to 12.8 m (42 ft) at the entrance to the river.

The St. Johns River has a deep, steep-sided channel cut through rock in some areas. Tidal currents are strong in the river as far as Jacksonville, approaching 3 knots in several places.


Polly Town
Buckhorn Bluff
Fitzpatrick Creek
Pelotes Island
Browns Island
Terrapin Creek
9A
Eastport
Browns Creek
Round Top
105
Broward River
Drummond Point
Dunn Creek
Little Clapboard Creek
Vicks Island
San Carlos Creek
Clapboard Creek
Back River
Little Marsh Is
Le Baron Island
Coon Point
Yellow Bluff Fort
New Berlin
Dame Point Manor
Alligator Island
Blount Island
Alligator Creek
Crab Island
Quarantine Island
Dames Point
Dames Point- Fulton Cutoff
Shipyard Creek
Caly
William Island
Randolph Island
Beacon
New Castle Island
Reed Island
Port of Jacksonville
Pip Island
Pauline Island
Newcastle
Marion Island
Bird Island
Mitchell Bluff
Lake Narcissus

There are two deepwater container/general cargo terminals: Blount Island, located approximately 11 km (7 mi) from the harbor entrance, and Talleyrand Docks and Terminals located about 34 km (21 mi) from the entrance. Both terminals are equipped with modern cranes, handle breakbulk and other types of cargo, and have warehouse as well as open storage areas. Of the two, Blount Island would be preferred because of its separation from the high-density downtown area and closer proximity to the sea.

Blount Island Terminal: Blount Island is a 356 ha (880 acre) facility with 1,920 m (6,336 ft) of berthing space. Blount Island berths 7-13 have 11.6 m (38 ft) of water alongside at mean low water, and five container cranes. This terminal is connected to the mainland via a fixed highway bridge which joins State Highway 105 (Necksher Drive) and connects with I-95 and Route 17 about five miles north of the city of Jacksonville. Blount Island has pierside service by the CSX Railroad, which connects with the Norfolk Southern Railroad.

Talleyrand Terminal: Talleyrand Docks is a 70 ha (173 acre) facility with 1,250 m (4,100 ft) of wharf on deep water (11.6 m or 38 ft at mean low water). It has two container cranes and two large gantry cranes. Talleyrand Terminal is located in downtown Jacksonville's shopping and commercial zone, about 2.9 km (1.8 mi) downstream of the John R. Matthews Bridge (alternate U.S. Route 90), and less than 1.0 km (0.6 mi) via city streets from the city Expressway system.

The 1990 population within 16 km (10 mi) of the port terminals was 334,212. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 46,900; the Oak Ridge Reservation, 175,000; the Idaho National Engineering Laboratory, 576,000; the Hanford Site, 643,000; and the Nevada Test Site, 639,000. Populations along rail routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 607 km (377 mi); the Oak Ridge Reservation, 912 km (567 mi); the Idaho National Engineering Laboratory, 4,030 km (2,504 mi); the Hanford Site, 4,700 km (2,920 mi); and the Nevada Test Site, 4,190 km (2,604 mi). Distances along rail routes are about the same.

Environmental Conditions: The area between the mouth of the St. Johns River and Blount Island is characteristic of typical coastal lowlands found along the southeastern United States. Numerous creeks meander through large expanses of marshes and swamps. With the exception of the U.S. Naval Station Mayport and the village of Mayport, which occupy the first several miles along the southern bank of the river, the land bordering the lower portion of the river is largely undeveloped with the exception of riverfront residences, mainly along the northern bank. Most of the land to the north of the river between Blount Island and the coast is part of the Nassau River - St. Johns River Marshes Aquatic Preserve. The Fort Caroline National Memorial is located southeast of Blount Island on the southern bank of the river. The Little Talbot Island State Park is located approximately 1.6 km (1 mi) north of the channel entrance.

The lower 24.2 km (15 mi) of the St. Johns River has been designated as critical habitat for the manatee, a listed endangered species. The river is also used as a migratory area for the shortnose sturgeon, a listed endangered species (FWS, 1980b). According to the Florida Natural Areas Inventory, the following rare species have been reported within 3.2 km (2 mi) of the Blount Island Terminal: West Indian manatee (State and Federally Listed Endangered Species), shortnose sturgeon (State and Federally Listed Endangered Species), Atlantic sturgeon (State-Listed Species of Special Concern and Federally Listed Threatened Species), sea lamprey, and the opossum pipefish (Murray, 1994).

A variety of wading birds is also found in the vicinity of the Fort Caroline National Memorial. Several species of birds, including shorebirds, waterfowl, and gannets frequent the area around the jetties at the channel entrance. In particular, the brown pelican, a State Species of Special Concern, is found in this

area. A variety of birds inhabits the Little Talbot Island State Park, including the American oystercatcher, a State Species of Special Concern. Loggerhead sea turtles, a listed endangered species, use the beaches along this portion of Florida as a nesting area (FWS, 1980b).

While environmental awareness is high throughout the state of Florida, there are no known sensitive wildlife sanctuaries in the immediate area of the Port of Jacksonville. Blount Island is surrounded by extensive marsh and wetlands.

Climatic Conditions: The Port of Jacksonville is located along the upper 39.4 km (24.5 mi) of the St. Johns River. The terrain in this area is relatively level, providing very little change in relief proceeding inland from the coastal region. The National Weather Service has been archiving meteorological information for this area since 1880.

The climate of this area is modified by the influence of the Atlantic Ocean. Easterly winds occur roughly 40 percent of the time, producing a true maritime climate for the Jacksonville area. The greatest rainfall occurs during summer, usually associated with afternoon and evening thunderstorms. During summer, measurable precipitation can be recorded nearly every two days. The prevailing winds are northeasterly in the fall and winter months, becoming more southwesterly during spring and summer. Although Jacksonville is along the eastern U.S. coast, it has been very fortunate in escaping hurricane-force winds. The majority of systems in recent years which have reached this latitude have moved parallel to the coastline, keeping well offshore. Others have weakened significantly moving overland prior to reaching metropolitan Jacksonville. The combination of these two factors has spared the area from any major devastation due to tropical systems in recent years (NOAA, 1992b). The likelihood of severe natural phenomena such as high winds and earthquakes is reflected in the structural requirements for buildings in each area of the United States. These are shown in the Uniform Building Code (UBC, 1991). For the Port of Jacksonville, the Uniform Building Code provides a basic wind speed of about 160 km per hour (100 mph). The port is located in a very low seismic zone with an acceleration of less than 0.075 g.

Ethnic and Income Characteristics: Figure 3-22 shows the ethnic composition for the area surrounding the port at Jacksonville. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans were the largest minority group. Figure 3-23 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

3.2.1.5 Military Ocean Terminal Sunny Point, NC

The Military Ocean Terminal at Sunny Point (MOTSU) is a U.S. Department of Defense transportation facility located north of Southport, NC. The facility is located on the Cape Fear River, approximately 16 km (10 mi) upstream (north) from the mouth of the river, and 26 km (16.1 mi) south of the Port of Wilmington, NC. A map of MOTSU is shown in Figure 3-24. The port is easily accessed from the ocean, and all commercial vessels bound for Wilmington, NC must pass by MOTSU. It is served by a 12.1 m- (40 ft-) deep by 152 m- (500 ft-) wide channel from the ocean.

The water depth (channel and alongside the wharves) of 10.3 m (34 ft) at mean low water is adequate for most commercial breakbulk, roll-on/roll-off, and container ships. The terminal has three 600 m (2,000 ft) wharves, each with three berths. All wharves have three parallel sets of rail tracks. Berth 1, on the south

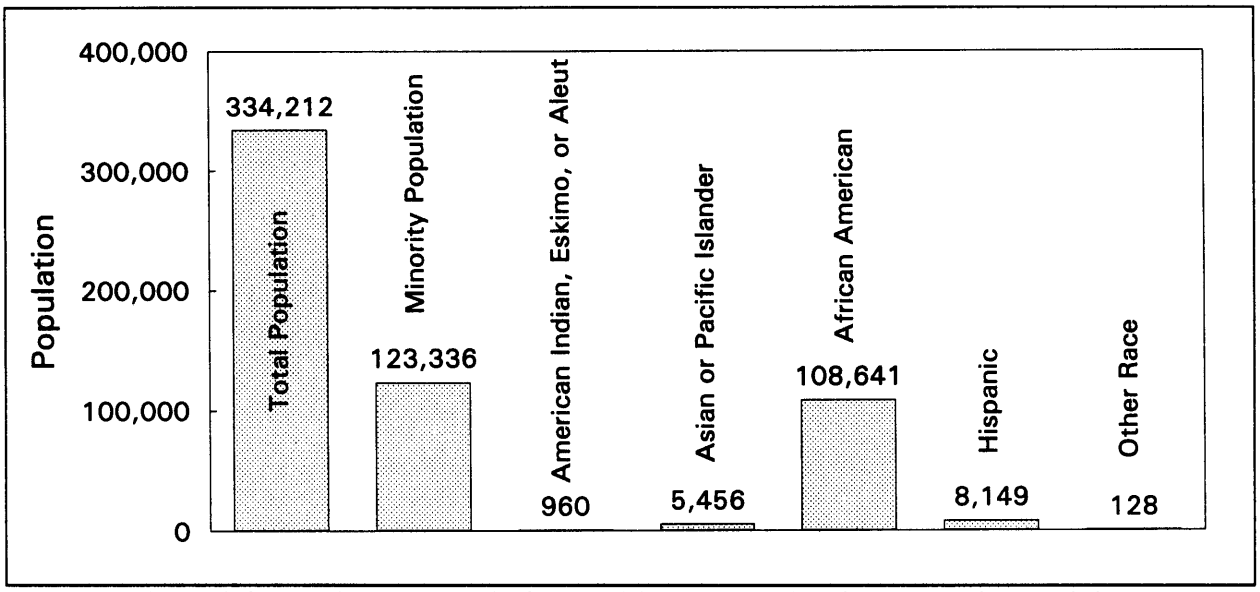


Figure 3-22 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Jacksonville

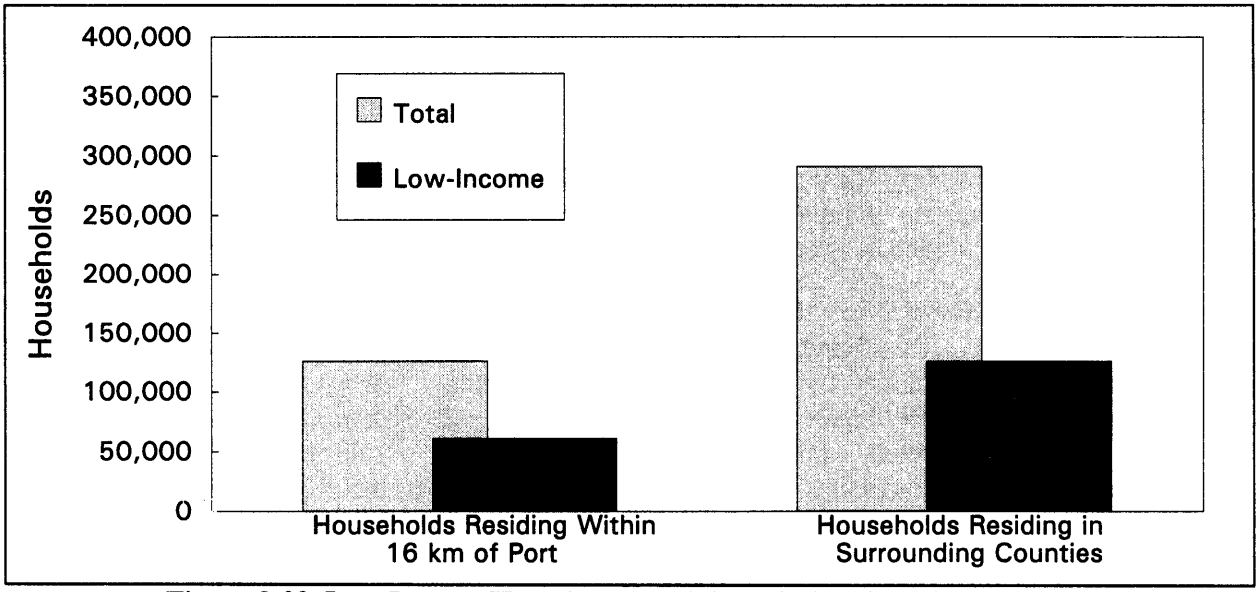
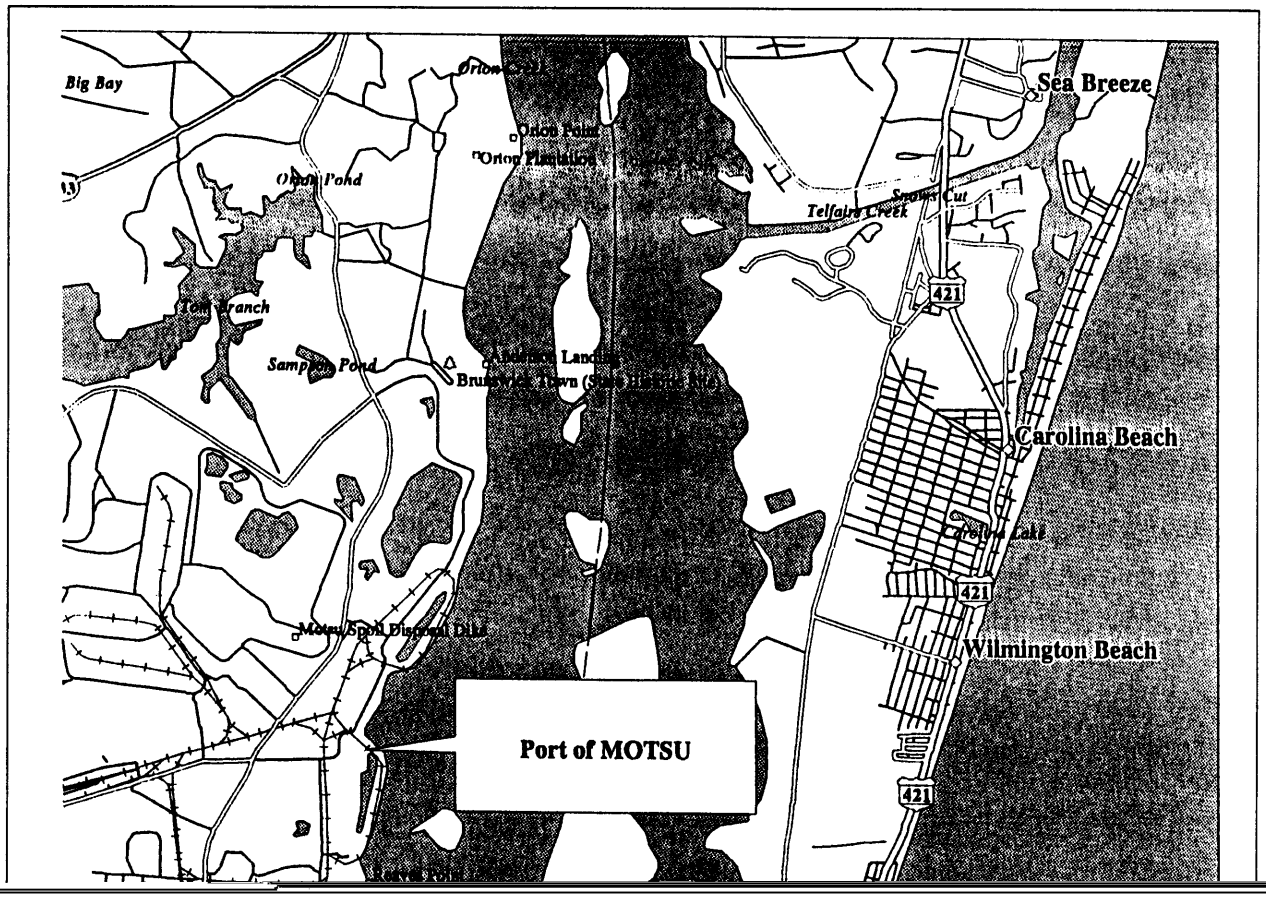


Figure 3-23 Low-Income Households Residing within 16 km (10 mi) of the Port of Jacksonville

wharf, has two 50 metric ton (55 ton) container cranes capable of off-loading container or container/breakbulk vessels. Berth 3 has been modified with a 30 m (100 ft) wide, reinforced concrete apron that permits breakbulk and roll-on/roll-off operations, in addition to containerized cargoes.

MOTSU is serviced by well-maintained roads, and has a dedicated 157 km (98 mi) U.S. Army rail line that connects the CSX network directly to the terminal. Truck access is provided by State Route 87 from the northwest and State Route 133 from the north. Route 87 provides access to U.S. 17, which runs southwest or northeast. The distance from the terminal gate to Route 133 is about 3.7 km (2.2 mi). Route 133 runs directly to U.S. 17 just outside Wilmington. From Wilmington, U.S. 74 runs west 120 km (75 mi) to Interstate 95, the nearest major north-south highway.


Big Bay
Orion Pond
Orion Plantation
Sea Breeze
Telfairs Creek
Snows Cut
421
Sampson Pond
Carolina Beach
Carolina Lake
421
Wilmington Beach
Port of MOTSU
421

The 1990 population within 16 km (10 mi) of the port terminals was 7,995. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 34,200; the Oak Ridge Reservation, 128,000; the Idaho National Engineering Laboratory, 463,000; the Hanford Site, 548,000; and the Nevada Test Site, 619,000. Populations along rail routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 402 km (250 mi); the Oak Ridge Reservation, 798 km (496 mi); the Idaho National Engineering Laboratory, 3,873 km (2,407 mi); the Hanford Site, 4,615 km (2,868 mi); and the Nevada Test Site, 3,953 km (2,456 mi). Distances along rail routes are slightly longer.

Environmental Conditions: The environmental conditions at MOTSU are similar to those at the Port of Wilmington, NC, and are described in Section 3.2.1.10. MOTSU has been identified as an area with sinkhole activities (Koch, 1984). Sinkholes can occur naturally or as a result of human activity. Occurrences of sinkholes are closely tied to the drainage pattern in areas where geologic formations provide a collapse mechanism. Human activities which modify the natural drainage pattern in such an area can increase the rate of sinkhole formation. Sinkholes pose a potential hazard to truck and rail traffic in the Sunny Point area. Due to the robust casks which would be used to transport spent nuclear fuel from foreign research reactors (see Appendix B for a description of the casks), sinkholes would not be expected to cause a radiological accident.

Climatic Conditions: The likelihood of severe natural phenomena such as high winds and earthquakes is reflected in the structural requirements for buildings in each area of the United States. For MOTSU, the Uniform Building Code provides a basic wind speed of about 160 km per hour (100 mph) (UBC, 1991). The port is located in a low seismic zone with an acceleration of 0.075 g.

Other climatic conditions at MOTSU are similar to those at the Port of Wilmington, NC, and are described in Section 3.2.1.10.

Ethnic and Income Characteristics: Figure 3-25 shows the ethnic composition for the area surrounding MOTSU. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 17 percent of the total population, and approximately 91 percent of the minority population for the area surrounding the port. Figure 3-26 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

3.2.1.6 Naval Weapons Station, Concord, CA

Naval Weapons Station (NWS) Concord is located on the southern edge of Suison Bay, an estuarine area immediately west of the junction of the Sacramento and San Joaquin Rivers. By water, the NWS is approximately 58 km (36 mi) northeast of the Golden Gate Bridge. The city of Concord, CA, is about 8 km (5 mi) south of the NWS. A map of the NWS military port is shown in Figure 3-27.

The 1990 population within 16 km (10 mi) of the port terminal was 381,070. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 1,040,000; the Oak Ridge Reservation, 742,000; the Idaho National Engineering Laboratory, 271,000; the Hanford Site, 263,000; and the Nevada Test Site, 437,000. Populations along rail routes to these sites are slightly smaller for the Oak Ridge Reservation, the Idaho National Engineering Laboratory and the Nevada Test Site, and slightly larger for the Savannah River Site and the Hanford Site. The distances to the five potential sites on interstate routes are: the Savannah River Site, 4,476 km (2,781 mi); the Oak Ridge Reservation, 4,111 km (2,554 mi); the Idaho National Engineering Laboratory,

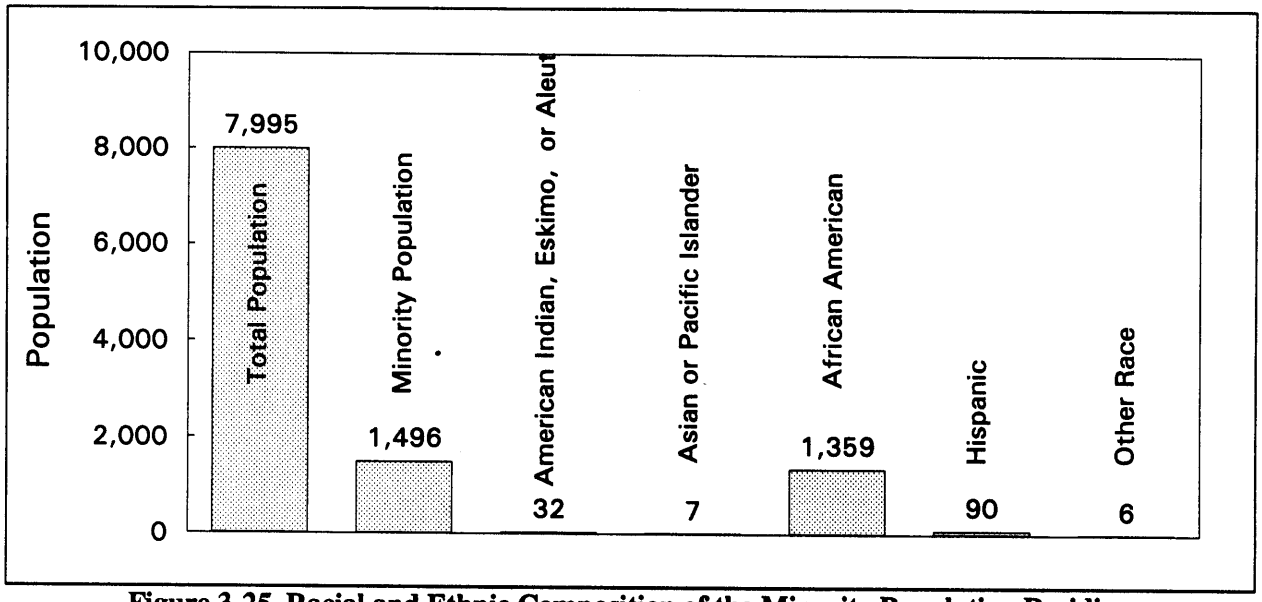


Figure 3-25 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of MOTSU

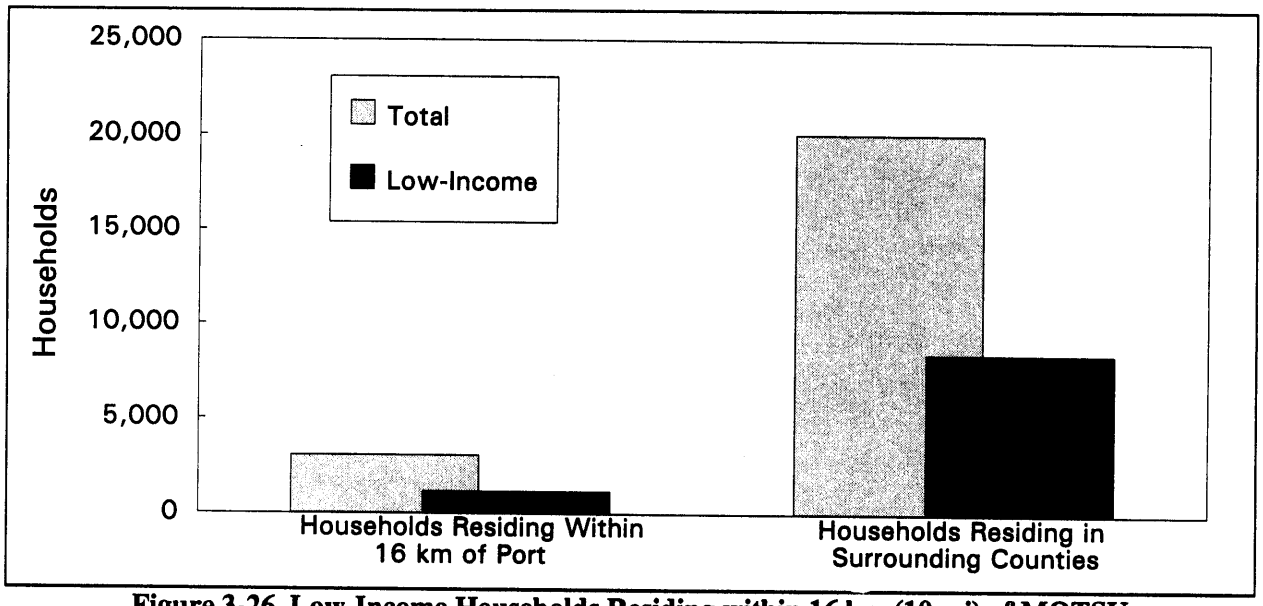
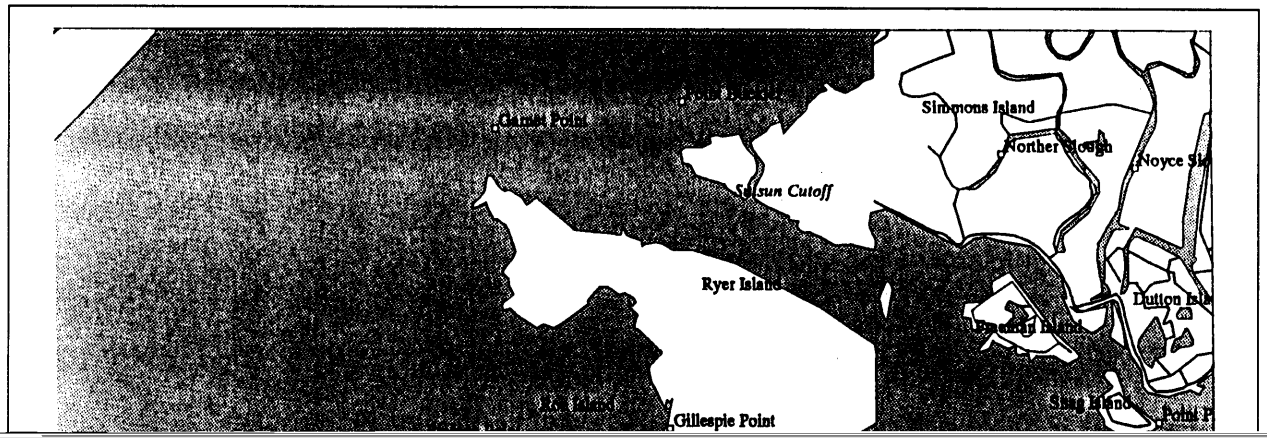


Figure 3-26 Low-Income Households Residing within 16 km (10 mi) of MOTSU

1,516 km (942 mi); the Hanford Site, 1,376 km (855 mi); and the Nevada Test Site, 1,145 km (711 mi).


Simmons Island
Norther Slough
Noyce Sl
Solsun Cutoff
Ryer Island
Dutton Isla
Gillespie Point

directly north of Suison Bay. The waters of Suison Bay are characterized as a mid-salinity estuarine habitat (generally 5 to 16.5 ppt). Chinook salmon, steelhead trout, striped bass, sturgeon, and American shad are typically found in this area (FWS, 1981a; FWS, 1981b).

Portions of the inland area at NWS Concord serve as a sanctuary for Tule elk, a formerly endangered species (Yocum, 1994). Other terrestrial species found in the area include the river otter, the salt-marsh harvest mouse (a Federally protected species), and the white-tailed kite. Adult concentrations and nesting areas of the California clapper rail (a Federally protected bird species) and the California black rail (a State protected species) are also found in this area. The Federally and State protected figwort plant family is also found in the vicinity of NWS Concord. In general, the greater San Francisco Bay area annually supports large numbers of shorebirds, wintering waterfowl, raptors, seabirds, and passerlings. In addition, shorebirds, wading birds, waterfowl, seabirds, and songbirds migrate through this coastal area.

Climatic Conditions: The climate is mild, with plenty of sunshine year round. Cloudless skies prevail during the spring, summer, and fall. Winter is the rainy season. Snow is rare, as are freezing temperatures. Sometimes torrential rains on the slopes can cause flooding along the Sacramento River (NOAA, 1993b).

The likelihood of severe natural phenomena, such as high winds and earthquakes, is reflected in the structural requirements for buildings in each area of the United States. These are shown in the Uniform Building Code (UBC, 1991). For the Port of Concord NWS, the Uniform Building Code provides a basic wind speed of about 110 km per hour (70 mi per hour). The port is located on the edge of a very high seismic zone with an acceleration of 0.45 g.

Ethnic and Income Characteristics: Figure 3-28 shows the ethnic composition for the area surrounding NWS Concord. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans

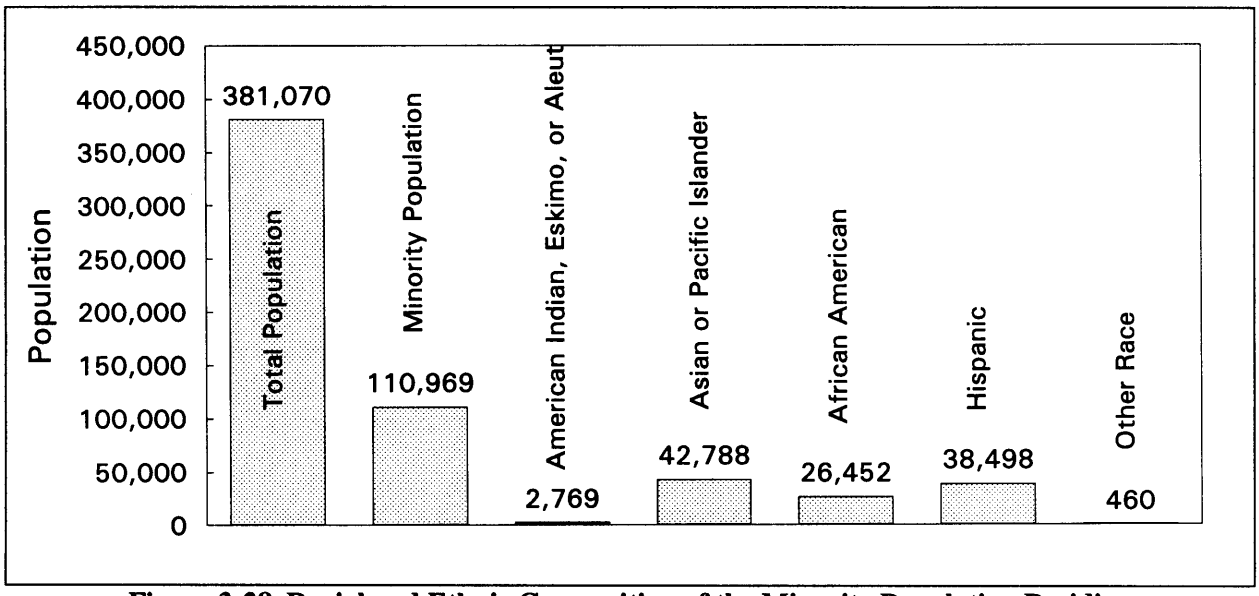


Figure 3-28 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of NWS Concord

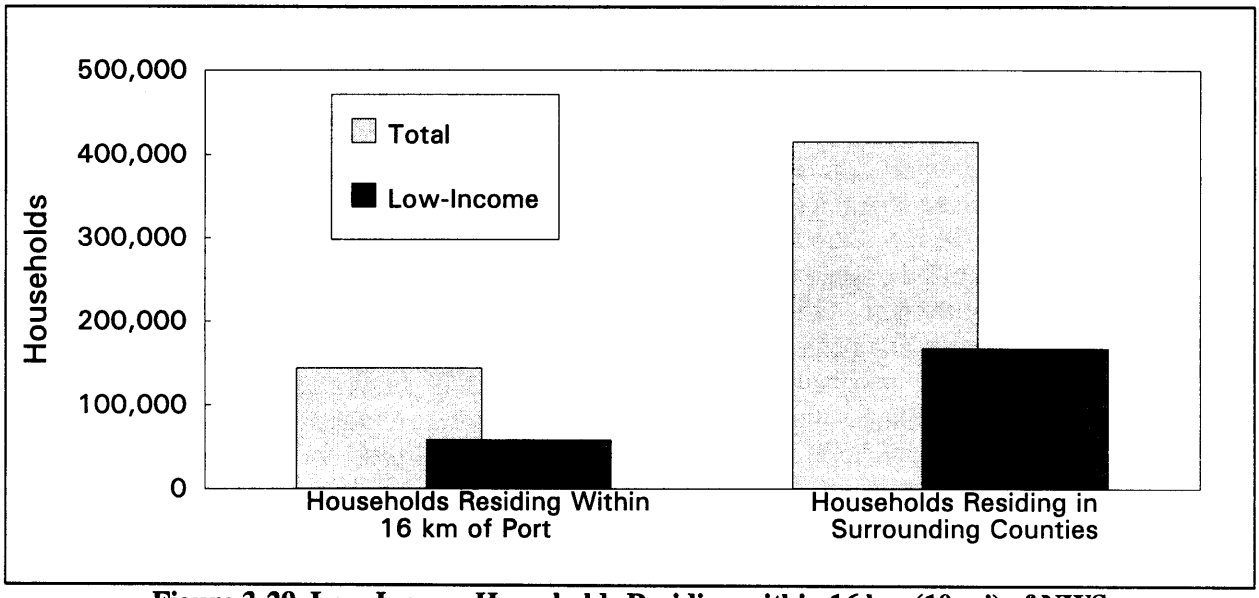


Figure 3-29 Low-Income Households Residing within 16 km (10 mi) of NWS Concord

Site. The distances to the five potential sites on interstate routes are: the Savannah River Site, 4,630 km (2,877 mi); the Oak Ridge Reservation, 4,200 km (2,610 mi); the Idaho National Engineering Laboratory, 1,190 km (739 mi); the Hanford Site, 407 km (253 mi); and the Nevada Test Site, 2,040 km (1,268 mi). Distances along rail routes are slightly longer, with the exception of the Hanford Site, which is slightly shorter.

Environmental Conditions: There are no known areas of special environmental concern in the immediate vicinity of the port, although concern for the environment runs high throughout the Pacific Northwest. The areas surrounding the Terminal are in river-oriented industrial land use. Wildlife habitat along the

Broad Slough
Willow Upper Range Channel
Morgan Lower Range
501
Buckmire Slough

Oregon Slough is limited because of the industrial development, although some waterfowl use the area. While the primary uses in the Terminal area are commercial navigation and industry, some recreational fishing and boating occurs in Oregon Slough and the Columbia River.

The U.S. Fish and Wildlife Service's Ecological Inventory for the Vancouver, Washington-Oregon area indicates that the Columbia River generally includes the following fish species: salmonids, chinook salmon, coho salmon, chum salmon, pink salmon, sockeye salmon, steelhead trout, Dolly Varden, smelts, river lamprey, white sturgeon, American shad, eulachon and cutthroat trout (FWS, 1981c). South of Portland, the various islands and wetlands along the Columbia River provide habitat for a wide variety of terrestrial organisms. Areas of special interest include the Sauvie Island Game Management Area, which is located approximately 8 km (5 mi) downriver of Terminal 6, and the Ridgefield National Wildlife Refuge, which is approximately 16 km (10 mi) downriver.

The U.S. Army Corps of Engineers reports that raptors such as the red-tail hawk, bald eagle, and peregrine falcon are occasional visitors to this area and the U.S. Fish and Wildlife Service has indicated that the endangered American peregrine falcon and threatened bald eagle may winter in this area. In addition, the National Marine Fisheries Service has listed the Snake River sockeye salmon as endangered, and two Snake River chinooks stocks as threatened (Kurkoski, 1994). The State of Oregon's Natural Heritage Program reports that there are at least two rare species that occur in the vicinity of Terminal No. 6 (Gaines, 1994). These species are the painted turtle (a State-Sensitive-Critical species) and the Columbia water-meal.

Climatic Conditions: The port area is subject to earthquakes and volcanism (NOAA, 1992d). The likelihood of severe natural phenomena such as high winds and earthquakes is reflected in the structural requirements for buildings in each area of the United States. For the Port of Portland, the Uniform Building Code provides a basic wind speed of about 140 km per hour (90 mph) (UBC, 1991). The port is located in a moderate seismic zone with an acceleration of 0.20 g. There have been two major earthquakes in the Puget Sound area this century (Bolt, 1978). On May 18, 1980, nearby Mount St. Helens suffered a major volcanic eruption. All the mountains along the Cascade Range are volcanic in origin and have some potential for eruption.

Ethnic and Income Characteristics: Figure 3-31 shows the ethnic composition for the area surrounding the port at Portland. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 8 percent of the total population, and approximately 50 percent of the minority population for the area surrounding the port. Hispanics and Asian or Pacific Islanders each accounted for about 20 percent of the minority population. Figure 3-32 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

3.2.1.8 Savannah, GA

The Port of Savannah is located on the south bank of the Savannah River, about 35 km (22 mi) above the entrance from the Atlantic Ocean. Savannah is the third largest city in Georgia, and is the chief port of the State of Georgia. The Savannah River serves as the boundary between Georgia and South Carolina. There are three large cargo terminals at the port. One of these terminals, Containerport, is a dedicated container handling terminal. It is located about 45.6 km (28.3 mi) up the Savannah River from the Atlantic Ocean. A map of the port is shown in Figure 3-33.

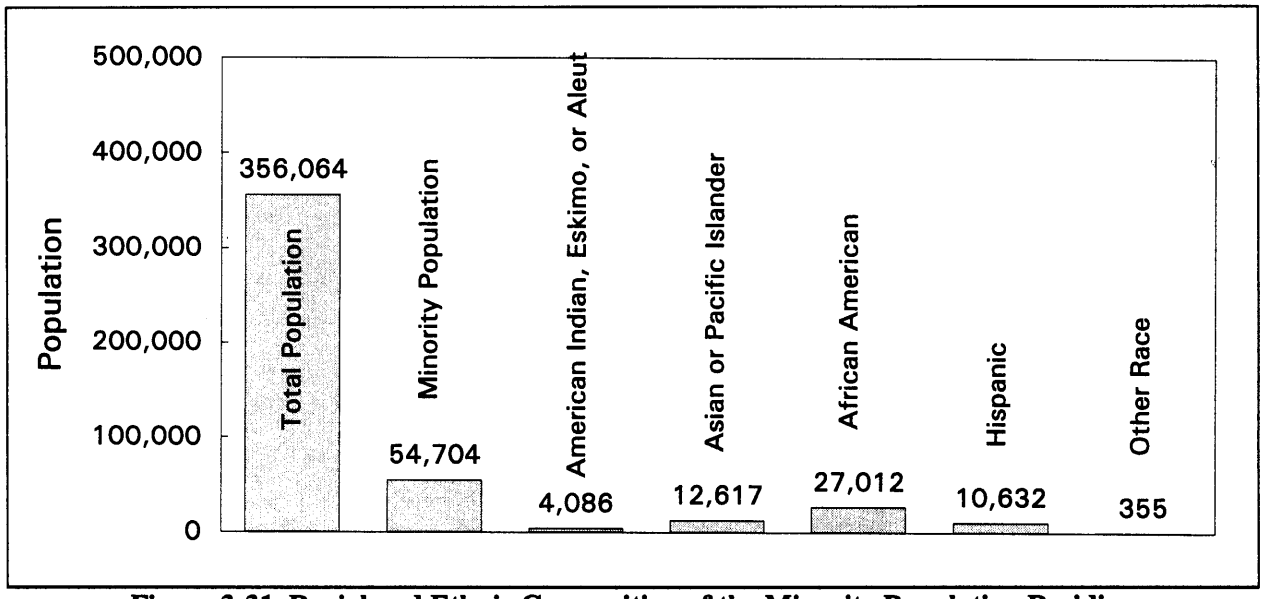


Figure 3-31 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Portland

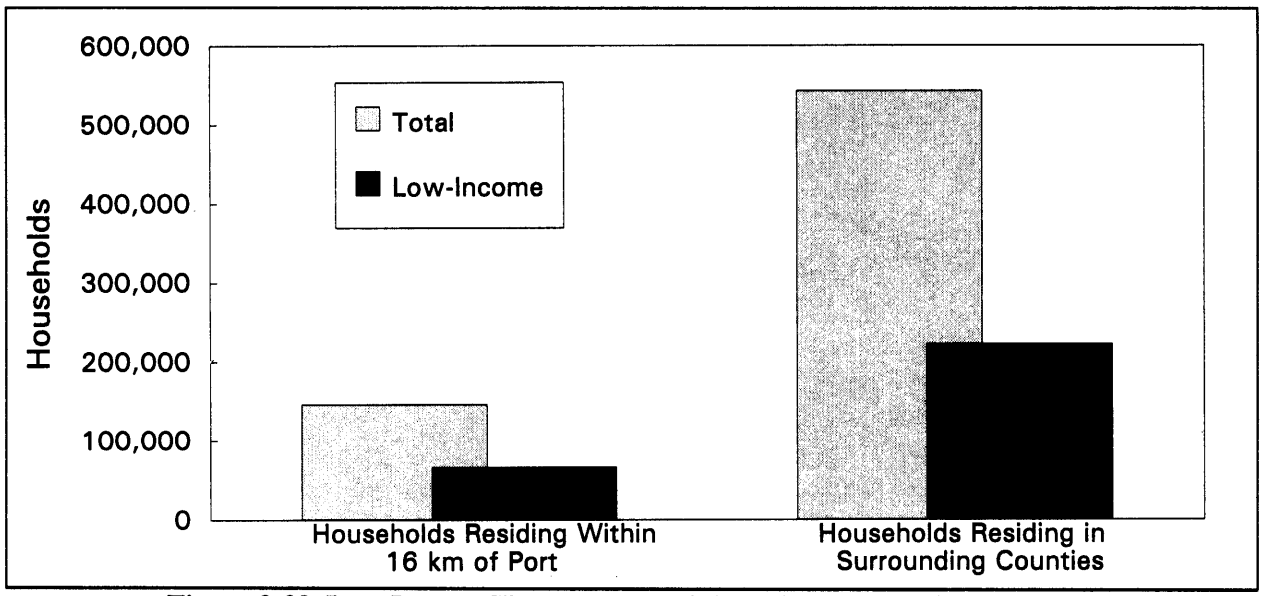
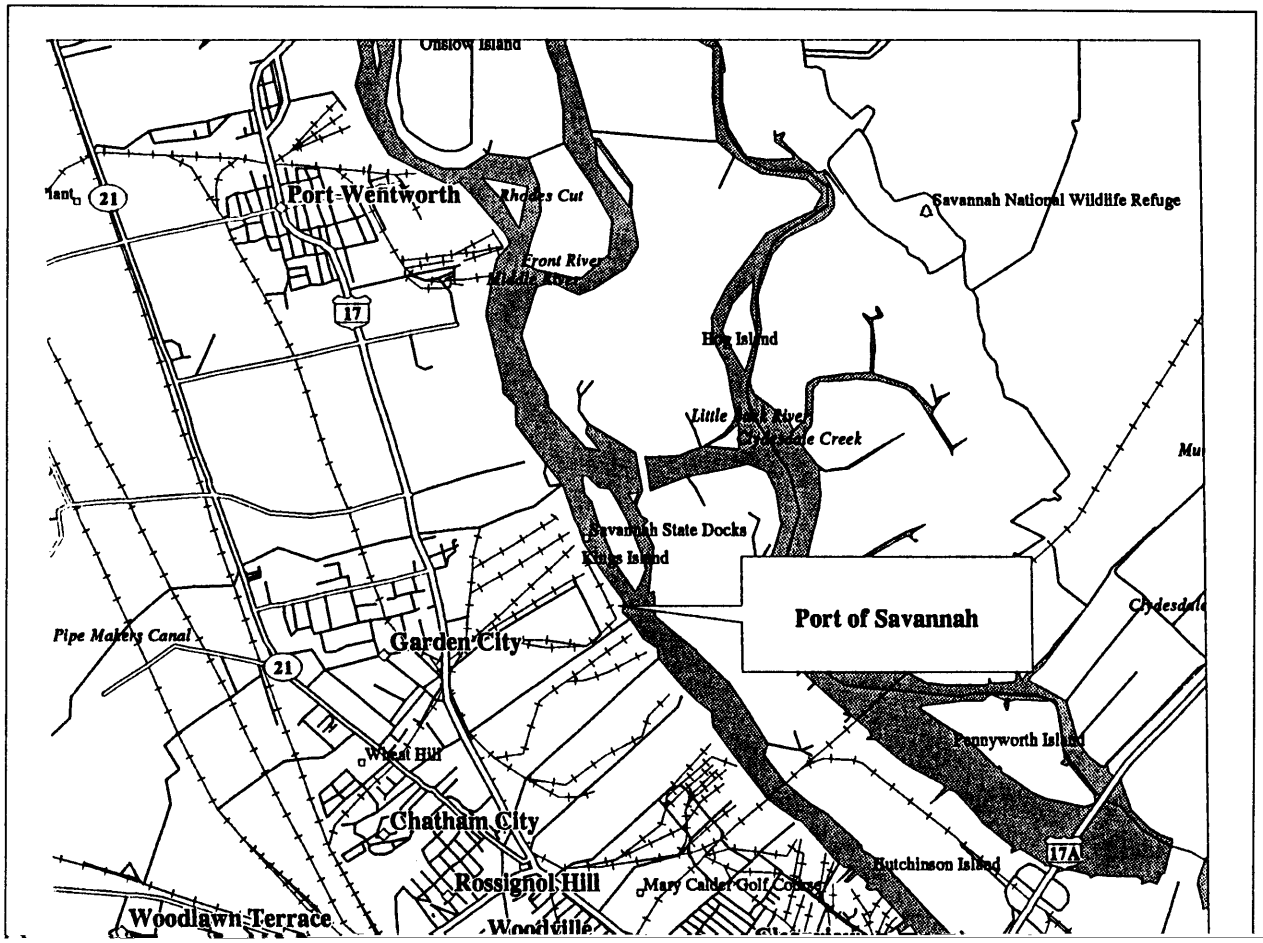


Figure 3-32 Low-Income Households Residing within 16 km (10 mi) of the Port of Portland

The 1990 population within 16 km (10 mi) of the port terminals was 155,166. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 37,300; the Oak Ridge Reservation, 101,000; the Idaho National Engineering Laboratory, 553,000; the Hanford Site, 602,000; and the Nevada Test Site, 616,000. Populations along rail routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 400 km (249 mi); the Oak Ridge Reservation, 720 km (447 mi); the Idaho National Engineering Laboratory, 3,860 km (2,398 mi); the Hanford Site, 4,530 km (2,815 mi); and the Nevada Test Site, 4,020 km (2,498 mi). Distances along rail routes are slightly longer.


Onslow Island
Port-Wentworth
Rhodes Cut
Front River
Savannah National Wildlife Refuge
Hog Island
Little Back River
Clydesdale Creek
Savannah State Docks
Kings Island
Port of Savannah
Pipe Makers Canal
Garden City
Wheat Hill
Chatham City
Rossignol Hill
Mary Calder Golf Course
Hutchinson Island
Pennyworth Island
Woodlawn Terrace
Woodville
21
17
17A

Environmental Conditions: The lower Savannah River has multiple branches that meander through a variety of coastal lowlands including salt marshes, tidal creeks, freshwater marshes, and freshwater impoundments. South Carolina has classified its portion of the Savannah harbor upstream from Fort Pulaski (located at the mouth of the Savannah River) as Class B, and the portion oceanward as Class SA. Class B waters are freshwaters suitable for secondary contact recreation, use as a drinking water source following conventional treatment, fishing, industrial, and agricultural use. Class SA waters are defined as tidal salt waters suitable for primary contact recreation, and for all the uses listed in Class B. The State of Georgia has classified the Savannah River from mile 0 at Fort Pulaski north to mile 5 at Field's Cut as recreation waters. North of Field's Cut, the waters are classified as Coastal Fishing (U.S. Army, 1991). The river in the vicinity of Containerport is characterized as a transitional estuarine habitat, where the salinity ranges from low (generally 0.5 to 5 ppt) to mid-salinity (generally 5 to 16.5 ppt) (FWS 1980c).

A large number of aquatic and terrestrial species are found in and around the Savannah River near Containerport. State or Federally protected, endangered, or threatened aquatic species in the vicinity of Containerport include the Shortnose sturgeon and the Florida manatee, both identified as State and Federally endangered species. The Shortnose sturgeon uses the Savannah River as a migratory area. In addition, the Loggerhead turtle, the Bald eagle, and the American alligator are found along the lower reaches of the Savannah River (FWS, 1980c).

Both invertebrate and fish species of commercial and recreational value are found in the Savannah River. Commercial fishing is primarily for the American shad, sturgeon, shrimp, and blue crab. Public shellfishing is allowed in some areas near the mouth of the Savannah River, in the vicinity of Fort Pulaski. The Savannah River hosts the migration of several important commercial and game fishes, including the American shad, the hickory shad, and the blueback herring. Game species include the spotted seatrout, red drum, croaker, spot, striped bass, flounder, silver perch, white catfish, channel catfish, largemouth bass, sunfish, and crappies. The State of Georgia has closed the striped bass fishery for population recovery purposes (Schmitt, 1993).

There are several wildlife refuges and/or game management areas located along the lower portion of the Savannah River. Tybee National Wildlife Refuge is located at the mouth of the Savannah River at the confluence with the Atlantic Ocean. Just north of Tybee National Wildlife refuge is the Turtle Island Game Management Area. Containerport itself is located across the river from the southern end of the 10,371 ha (25,627 acre) Savannah National Wildlife Refuge. The Savannah National Wildlife Refuge and the Tybee National Wildlife Refuge are managed by the U.S. Fish and Wildlife Service.

Climatic Conditions: The area has a temperate climate, which is greatly influenced by winds coming into the area off the ocean. Nominally, 50 percent of the rainfall occurs during thunderstorms, with the remainder being equally distributed over the year and generally related to weather front passages. Severe tropical systems affect the Savannah area roughly once every 10 years and cause heavy, sustained precipitation, high winds, and extreme, but usually localized, coastal flooding. Rainfall measurements in excess of 51 cm (20 in) have been observed as a result of tropical systems impacting the area. Based on the 1951-1980 climatology, the first freeze occurs on average around November 15, and the last near March 10 (NOAA, 1992e).

Ethnic and Income Characteristics: Figure 3-34 shows the ethnic composition for the area surrounding the port at Savannah. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 49 percent of the total population, and approximately 95 percent of the minority population for the area surrounding the port. Figure 3-35 shows analogous information for low-income households residing within 16 km of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

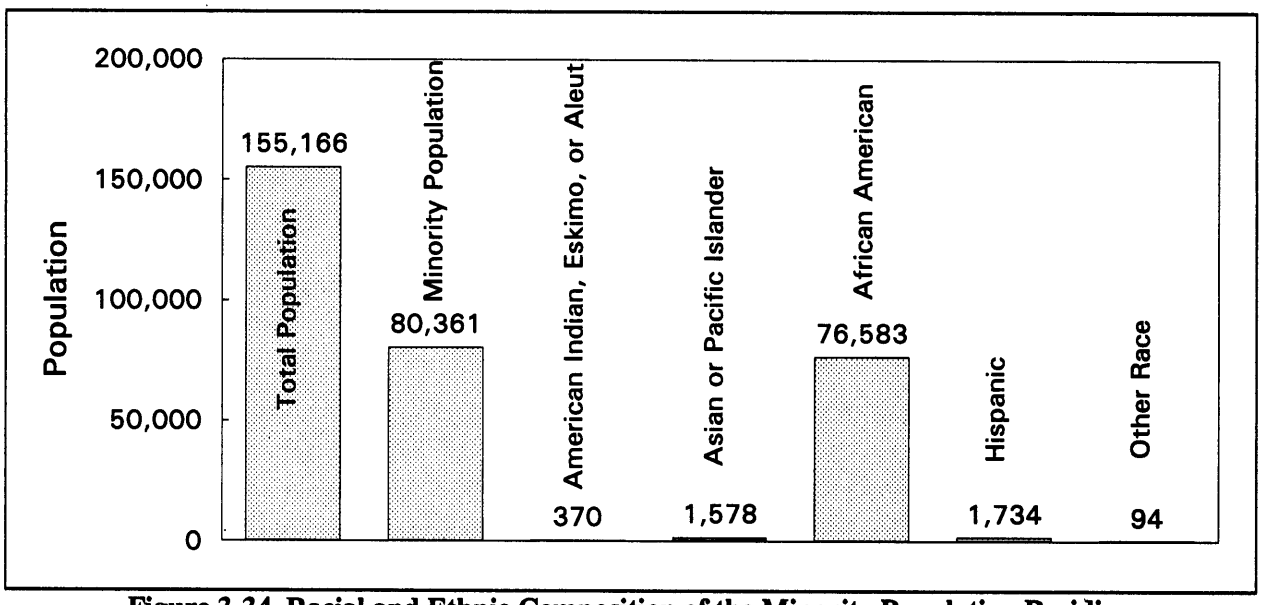


Figure 3-34 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Savannah

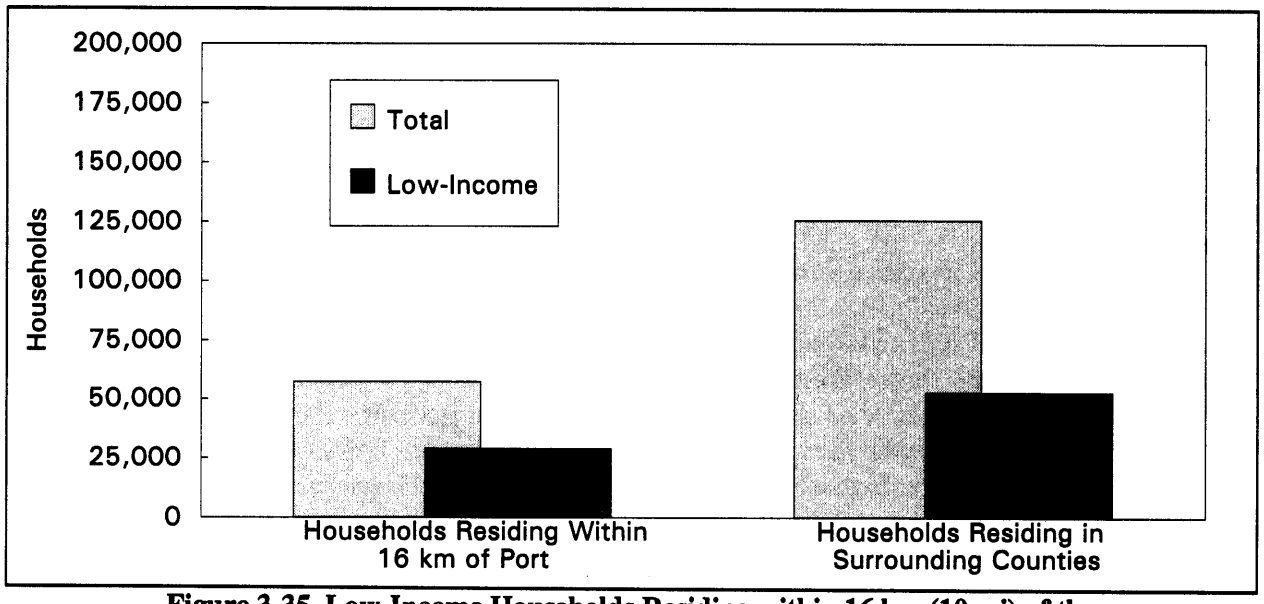


Figure 3-35 Low-Income Households Residing within 16 km (10 mi) of the Port of Savannah

3.2.1.9 Tacoma, WA

The Port of Tacoma is located in the southeastern corner of Puget Sound on the deep waters of Commencement Bay about 5 km (3 mi) from the Sound. It is a rapidly expanding major port second only to Seattle in maritime importance on Puget Sound. The distance from the entrance into Puget Sound is approximately 130 km (80 mi). A map of the port is shown in Figure 3-36.

Terminal 7, Berth D is the primary container terminal. It has one 274 m (904 ft) long container berth, 3 container cranes, and 15.2 m (50 ft) of depth alongside at mean low water.

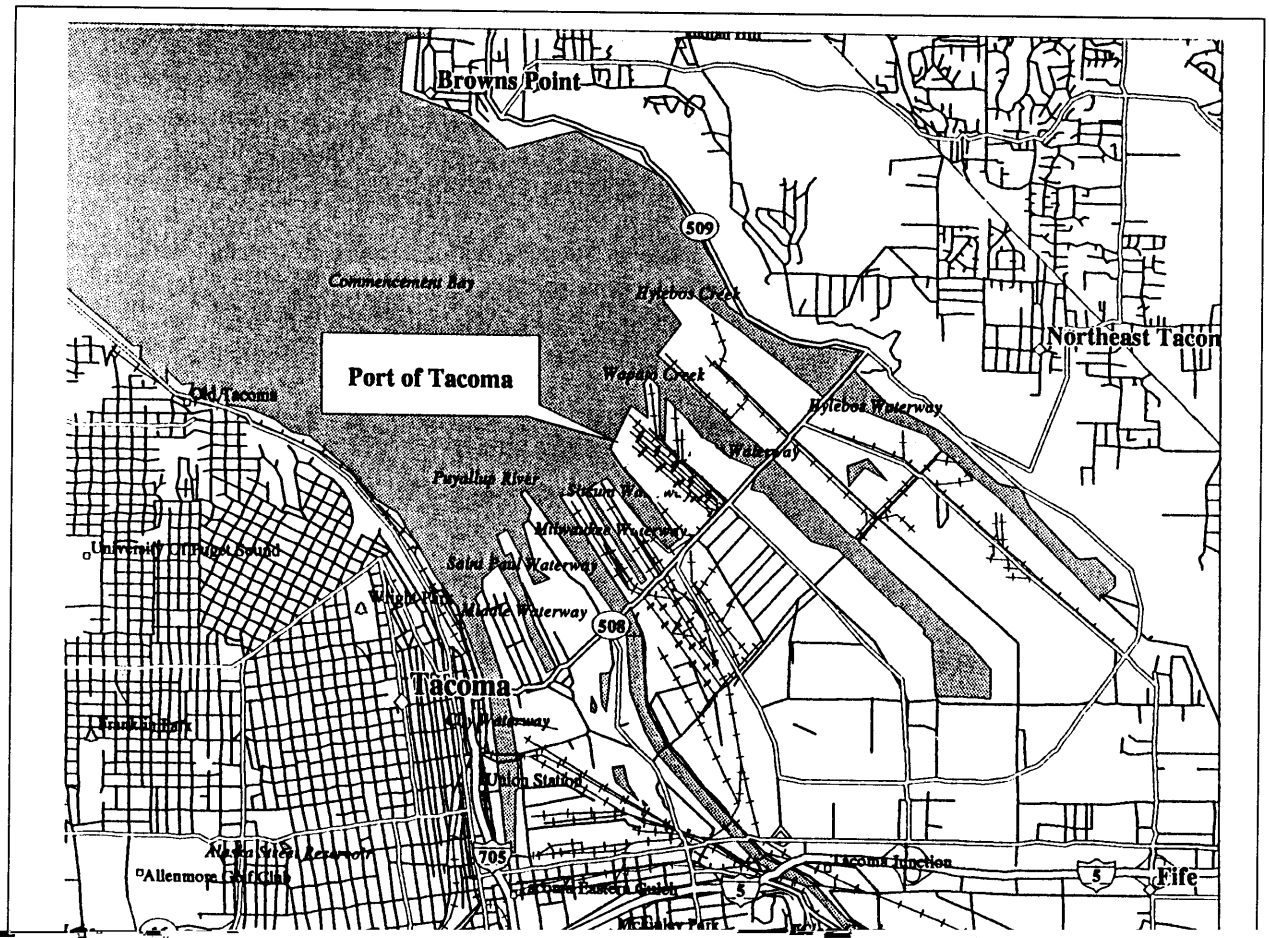
The terminal is about 4.8 km (3 mi) from the Port of Tacoma road access to Interstate 5 immediately outside the port complex. A somewhat longer route, Interstate 5 South, connects with I-84 East near Portland, OR. Ship berths are served by the Port Belt Line Railroad, and the port is served by the Burlington Northern and Union Pacific Railroads, which interline with eastern and southern railroads.

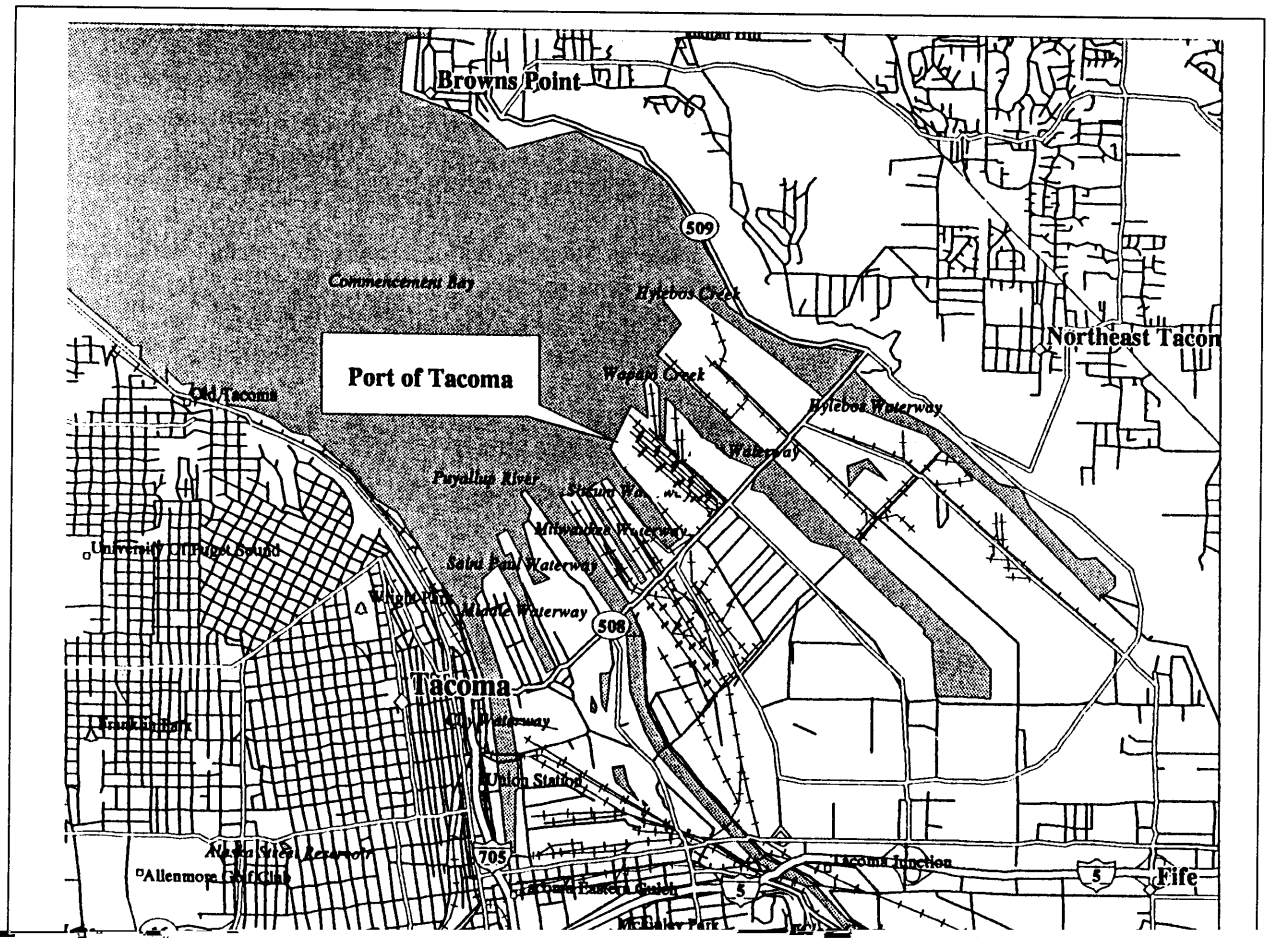
The 1990 population within 16 km (10 mi) of the port was 511,575. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 601,000; the Oak Ridge Reservation, 431,000; the Idaho National Engineering Laboratory, 157,000; the Hanford Site, 98,600; and the Nevada Test Site, 379,000. Populations along rail routes to four of these sites are slightly larger, but the population along the rail route to the Nevada Test Site is slightly smaller (this is largely due to primary use of interstate highways through Salt Lake City, UT and Las Vegas, NV). The distances to the five potential sites on interstate routes are: the Savannah River Site, 4,720 km (2,933 mi); the Oak Ridge Reservation, 4,280 km (2,659 mi); the Idaho National Engineering Laboratory, 1,310 km (814 mi); the Hanford Site, 399 km (248 mi); and the Nevada Test Site, 2,160 km (1,342 mi). Distances along rail routes are much longer.

Environmental Conditions: A variety of marine mammals can be found in central Puget Sound including the Pacific harbor seal, California sea lion, killer whale, Dall porpoise, and harbor porpoise. In 1991, the U.S. National Marine Fisheries Services reported that the following endangered and/or threatened species may occur in the Puget Sound: the gray whale, the humpback whale, the Stellar sea lion, and the endangered leatherback sea turtle (DOE, 1995c), although these species are not reported at the port. Bald eagles can be found throughout this coastal zone, and American peregrine falcons are uncommon winter visitors (FWS, 1981a). The U.S. Fish and Wildlife Services' Ecological Inventory for the Puget Sound area indicates that the habitat of Commencement Bay is used by a variety of birds including shorebirds, gulls, sandpipers, turnstones, yellowlegs, herons, rails, great blue herons, waterfowl, loons, grebes, swans, geese, dabbling ducks, diving ducks, mergansers, American wigeons, pintails, mallards, seabirds, cormorants, alcids, common murres, and pigeon guillemots. Adult concentrations of all of these species may be found in the Bay. Some of these species may also use this area as an overwintering area, a migratory area, and/or a nesting area (FWS, 1981a). It is also indicated that adult concentrations of chinook salmon, coho salmon, chum salmon, and pink salmon are found in the Puyallup Waterway/River and use this water body and upstream segments as migratory and nursery areas.

According to the State of Washington's Department of Wildlife, a number of seabird colonies exist along the shoreline of Commencement Bay. Areas of the Puget Sound, north of Commencement Bay, are also used as haulouts by the California Sea Lion. Areas of estuarine wetlands are located along the northern shore of Commencement Bay (WDW, 1994).

Climatic Conditions: The mild climate of the Pacific Coast is modified by the Cascade Mountains and to a lesser extent by the Olympic Mountains. The climate is characterized by mild temperatures, a well-defined rainy season and prolonged cloud cover, especially during the winter months. The Cascades act as a very effective barrier in both winter and summer, shielding the region from both extreme cold and


Browns Point
509
Commencement Bay
Hylebos Creek
Northeast Tacom
Port of Tacoma
Wapato Creek
Old Tacoma
Hylebos Waterway
Waterway
Puyallup River
Milwaukee Waterway
University of Puget Sound
Saint Paul Waterway
Middle Waterway
508
Tacoma
City Waterway
Union Station
Allen Street Reservoir
705
Allenmore Golf Club
Tacoma Junction
5
Fife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Port of Tacoma
Wapato Creek
Old Tacoma
Hylebos Waterway
Waterway
Puyallup River
Milwaukee Waterway
University of Puget Sound
Saint Paul Waterway
Middle Waterway
508
Tacoma
City Waterway
Union Station
Allen Street Reservoir
705
Allenmore Golf Club
Tacoma Junction
5
Fife

heat, respectively. The rainy season extends from October through March, with December accounting for the most rainfall. Approximately 75 percent of the annual total precipitation occurs during the winter rainy season. The dry season is centered around July and August. The majority of Seattle's precipitation is associated with normal, mid-latitude disturbances, which are most vigorous during the winter months. During summer, the dominant storm track (e.g., the polar jet) shifts northward into southern Canada, reducing the precipitation in the area. Summer thunderstorms do occur but do not contribute measurably to the annual rainfall budget. Prevailing winds are from the southwest, but occasional severe winter storms will produce strong northerly winds. Summer winds are generally rather light, with the occasional evidence of land-sea breeze effects creating northerly flows. Fog and low-level stratocumulus clouds form over the southern Puget Sound area in the late summer, fall, and early winter months, and often dominate the weather conditions of the early morning hours, reducing surface visibility. Based on 1951-1980 climatology, the first occurrence of freezing temperatures should occur around November 11, and the last incidence in spring around March 24 (NOAA, 1992f).

The likelihood of severe natural phenomena such as high winds and earthquakes is reflected in the structural requirements for buildings in each area of the United States. These are shown in the Uniform Building Code. For the Port of Tacoma, the Uniform Building Code provides a basic wind speed of about 130 km per hour (80 mph) (UBC, 1991). The port is located in a high seismic zone with an acceleration of 0.30 g. There have been two major earthquakes in the Puget Sound area this century (Bolt, 1978). On May 18, 1980, Mount St. Helens suffered a major volcanic eruption (IPA, 1993). All the mountains along the Cascade Range from Canada to Northern California are volcanic in origin and are potentially active.

Ethnic and Income Characteristics: Figure 3-37 shows the ethnic composition for the area surrounding the port at Tacoma, WA. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans constituted the largest minority group at about 6 percent of the total population, and approximately 38 percent of the minority population for the area surrounding the port. Asian and Hispanic minorities make up approximately 33 percent and 20 percent, respectively, of the minority population. Native Americans make up about 8 percent of the minority population near the port of Tacoma. Figure 3-38 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

3.2.1.10 Wilmington, NC

The Port of Wilmington, NC, is located on the east bank of the Cape Fear River, about 42 km (26 mi) above its mouth. It is the leading port of North Carolina, and its major export is wood pulp. The major terminals are down river from the city. A Federal project maintains a 12.2 m (40 ft) channel at the mouth of the Cape Fear River, 11.6 m (38 ft) to the port. A new dredging program will deepen the approach channel to 12.2 m (40 ft). A map of the port is shown in Figure 3-39.

The Wilmington wharves are of concrete pile construction, rubber fendered, with a total frontage of about 2,000 m (6,600 ft). Berths 6 to 9 are dedicated containership berths, with the remaining berths used for various kinds of general cargo. All of the main cargo berths have a depth alongside of 11.6 m (38 ft) at mean low water. The terminal has five container cranes, plus three gantry cranes (Jane's, 1992; AAPA, 1993; FHI, 1993).

Truck shipments from the port to southern destinations are along U.S. Routes 17, 74, 76, and 421 to Interstates 95 and 40 (POW, 1994). Northern and western long-distance routes are via Interstate 40, which connects with State Highway 132 about 16 km (10 mi) north of the city. The 1990 population within

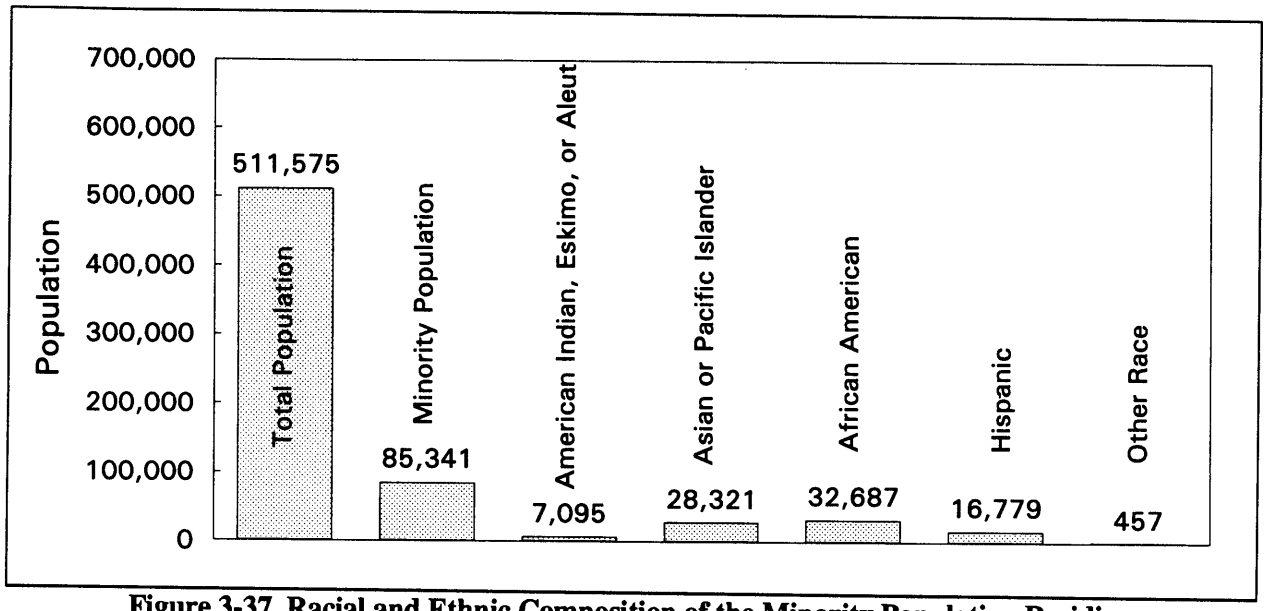


Figure 3-37 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Tacoma

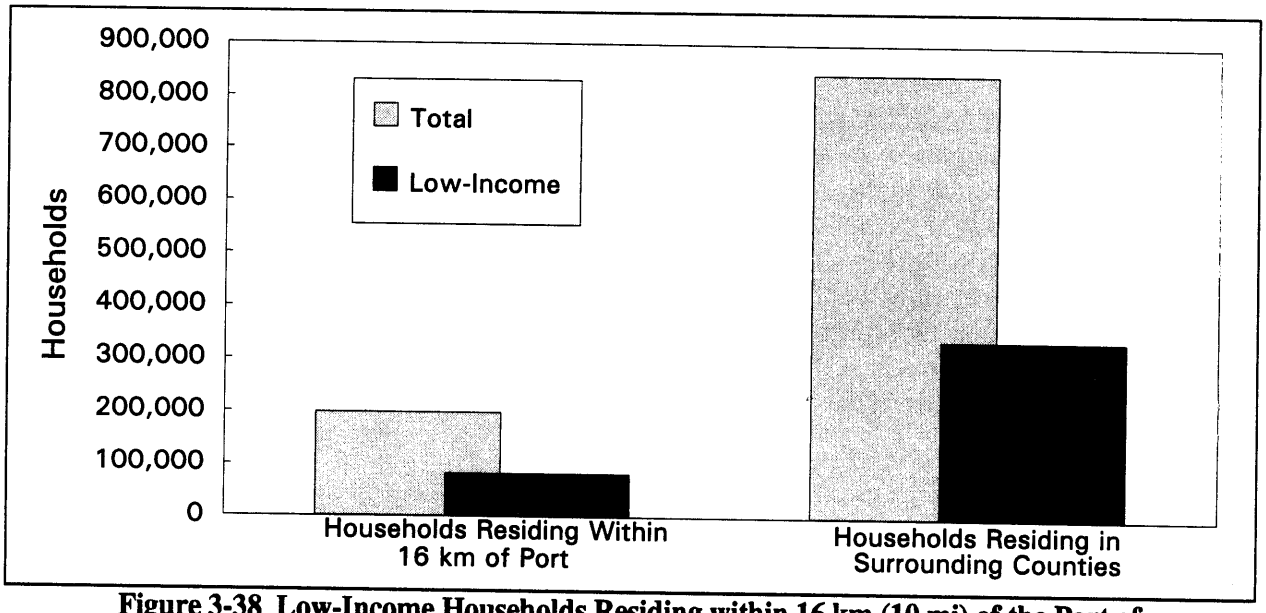


Figure 3-38 Low-Income Households Residing within 16 km (10 mi) of the Port of Tacoma

16 km (10 mi) of the port terminals was 115,057. The affected populations within 0.8 km (0.5 mi) of the interstate routes to the five potential DOE management sites are: the Savannah River Site, 64,700; the Oak Ridge Reservation, 128,000; the Idaho National Engineering Laboratory, 507,000; the Hanford Site, 556,000; and the Nevada Test Site, 570,000. Populations along rail routes to these sites are slightly larger. The distances to the five potential sites on interstate routes are: the Savannah River Site, 500 km (311 mi); the Oak Ridge Reservation, 820 km (510 mi); the Idaho National Engineering Laboratory, 4,100 km (2,548 mi); the Hanford Site, 4,770 km (2,964 mi); and the Nevada Test Site, 4,260 km (2,647 mi). Distances along rail routes are slightly longer for western sites, but about the same for eastern sites.

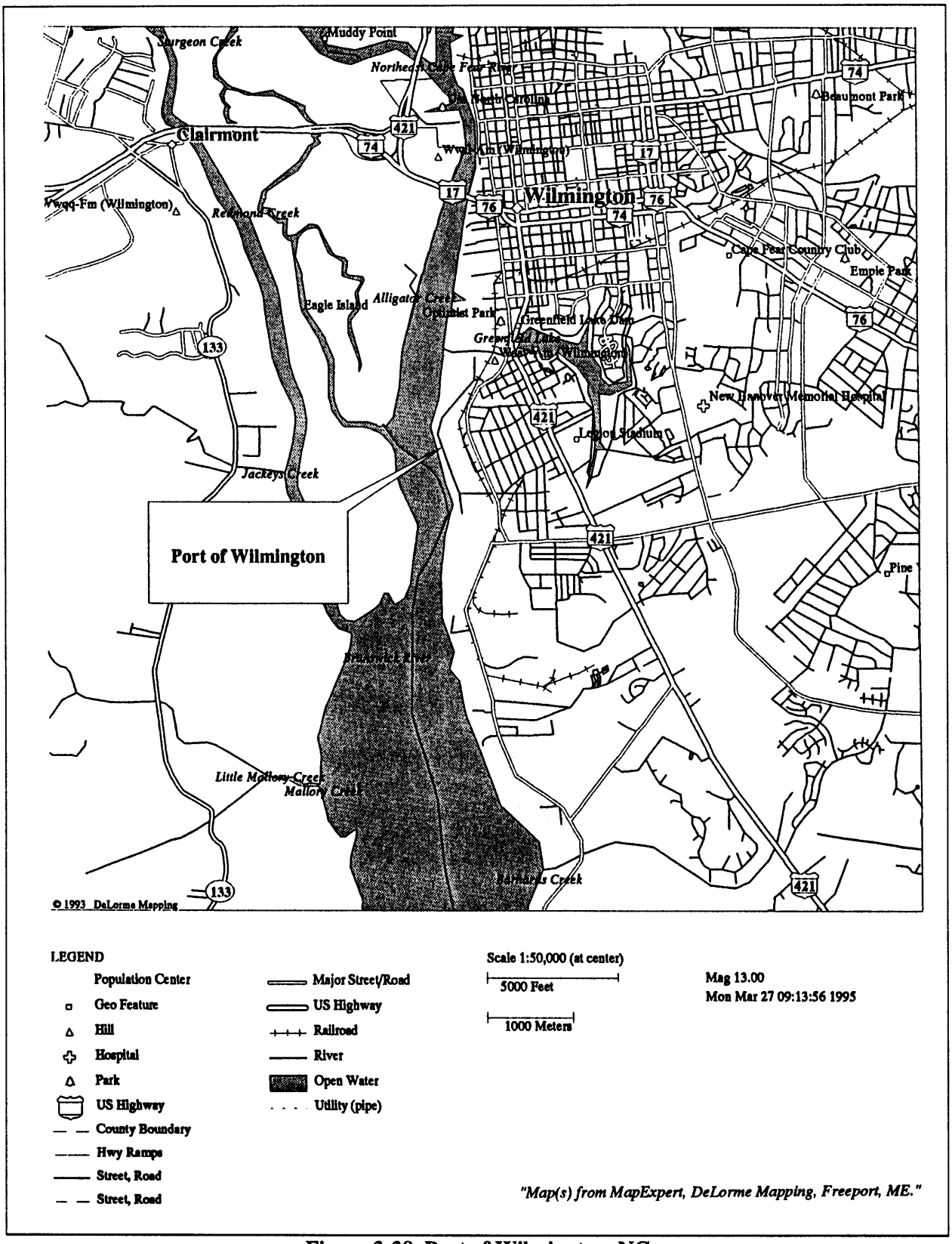


Figure 3-39 Port of Wilmington, NC

Environmental Conditions: There are no known environmentally sensitive areas in the immediate vicinity of the terminal, but due to resorts and recreational activity, there is heightened environmental awareness.

North Carolina has given the lower portion of the Cape Fear River three different stream classifications. From the Northeast Cape Fear River to the confluence with the Cape Fear River the waters are classified as SC-swamp. From the mouth of the Northeast Cape Fear to a point between Snow and Federal Points, the waters are classified as SC, and from Snow and Federal Points oceanward the waters are classified as SA. SC waters are tidal waters suitable for fishing, fish and wildlife propagation, secondary recreation, and other water uses requiring lower quality. The term "swamp" denotes waters with slow velocity. Class SA waters are suitable for shellfishing and primary recreation, as well as all of the activities approved for Class SC waters. According to the U.S. Fish and Wildlife Service's Ecological Inventory Map for Beaufort, NC, the Port of Wilmington is located in a low salinity estuarine habitat (generally 0.5 to 5 ppt) and tidal freshwater habitat. Below Wilmington at Campbell Island, the river changes to a mid-salinity estuarine habitat (generally 5 to 16.5 ppt). The Cape Fear River near MOTSU changes once again to a high-salinity estuarine habitat (generally 16.5 to 30 ppt).

The lower Cape Fear River supports a large number of aquatic and terrestrial species. There are both invertebrate and fish species of commercial and recreational value found in the Cape Fear River near the Port of Wilmington. Species sought by commercial and recreational fishermen include flounder, trout, spot, croaker, bluefish, Spanish mackerel, and king mackerel. Shellfish sought include penaeid shrimp and blue crabs.

The Natural Heritage Program of the North Carolina Department of Environment, Health and Natural Resources reports that the area around the port has not been systematically inventoried for rare species. However, they also report that the lower Cape Fear River, from Wilmington to the mouth of the river at Smith Island, is brackish and contains numerous rare animals. The shortnose sturgeon (State and Federal Endangered Species) rarely occurs in the river, whereas manatees (State and Federal Endangered Species) occasionally occur, especially in the summer. American alligators (a designated threatened species) can be found in tributary streams. The freckled blenny, spinycheek sleeper, opossum pipefish, and marked goby are other rare marine fishes that inhabit the river.

There are many animals with special status in this area including various types of whales, sea turtles, and birds. State or Federally protected, endangered, or threatened aquatic species in this area include the shortnose sturgeon (fish), finback whale, Florida manatee, humpback whale, right whale, sei whale, and sperm whale (mammals), Arctic peregrine falcon, bald eagle, piping plover, red-cockaded woodpecker, wood stork (birds), and the American alligator, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, and the loggerhead sea turtle (reptiles and amphibians).

Climatic Conditions: The Port of Wilmington is located on the Cape Fear River, 42 km (26 mi) from the open Atlantic Ocean. This general area also includes MOTSU, which is also located on the Cape Fear River, north of Southport, NC, and south of Wilmington, NC. The elevation of this region is approximately 12 m (40 ft) above sea level, and is more variable than the coastal plain surrounding the Norfolk, VA area. The National Weather Service has been archiving meteorological information for this

The maritime location of the Wilmington area makes the climate unusually mild for its northern latitude. All wind directions from the east-northeast through the southwest have some moderating effect on the local climate, due to the relatively warm and cool ocean in the winter and summer seasons, respectively. The area rarely experiences cold episodes where the temperature falls below -18°C (0°F). However, cold air outbreaks do occur, causing sharp fluctuations in winter temperatures. Rainfall in the area is generally considered ample and evenly distributed throughout the year, with the bulk of the precipitation occurring during the summer months. The bulk of this rainfall is generally associated with afternoon and evening thunderstorms. In contrast, the winter rains tend to be of the slow, steady type, generally lasting one to two days. As is common at Atlantic coastal localities at this latitude, the late summer and early fall months bring the possibility of hurricanes and tropical storms to the Wilmington area. These storms are capable of generating high winds, above normal tides and torrential rains. The latter two are also capable of creating widespread local flooding of low-lying coastal areas (NOAA, 1992g).

Ethnic and Income Characteristics: Figure 3-40 shows the ethnic composition for the area surrounding the port at Wilmington. This figure shows the population residing within 16 km (10 mi) of the port according to 1990 data published by the U.S. Bureau of the Census. At the time of the 1990 census, African Americans made up about 33 percent of the total population, and approximately 93 percent of the minority population for the area surrounding the port. Figure 3-41 shows analogous information for low-income households residing within 16 km (10 mi) of the port. As discussed in Appendix A, the percentage of low-income households near the port is nearly the same as that for counties surrounding the port.

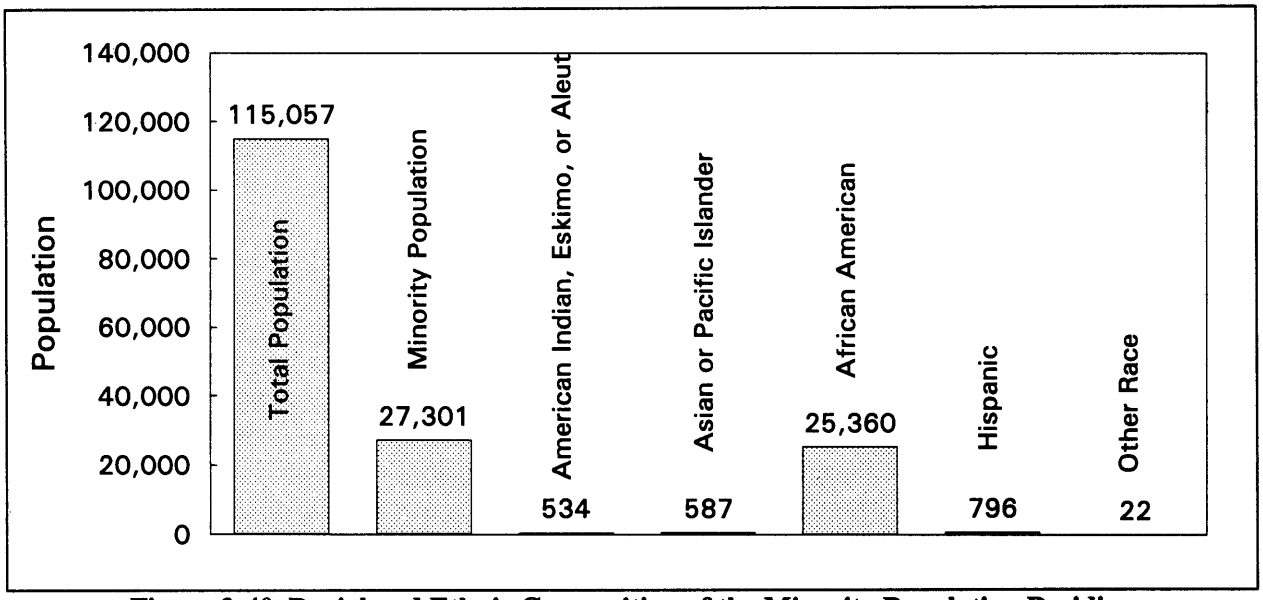


Figure 3-40 Racial and Ethnic Composition of the Minority Population Residing within 16 km (10 mi) of the Port of Wilmington

3.3 Management Site(s) Environments

This section describes the affected environment of the five potential DOE management sites for the foreign research reactor spent nuclear fuel. The five management sites are the Savannah River Site, the Idaho National Engineering Laboratory, the Hanford Site, the Oak Ridge Reservation, and the Nevada Test Site.

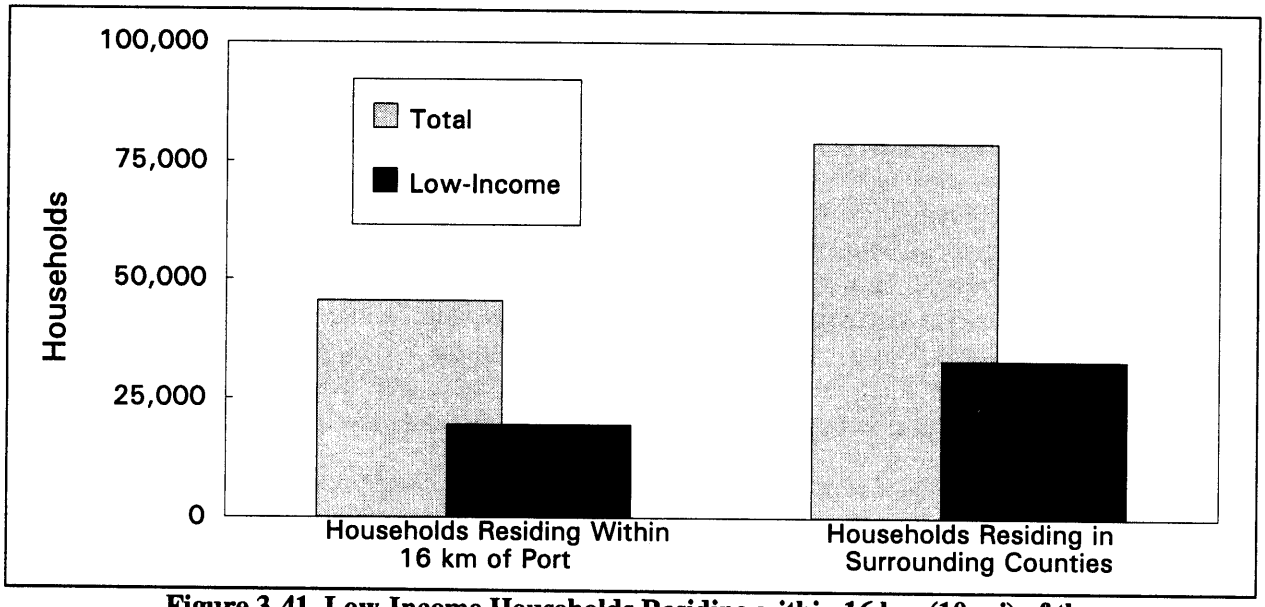


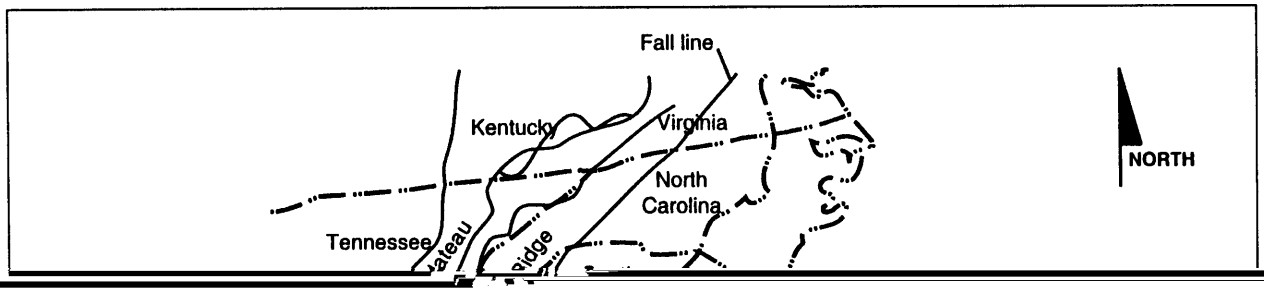
Figure 3-41 Low-Income Households Residing within 16 km (10 mi) of the Port of Wilmington

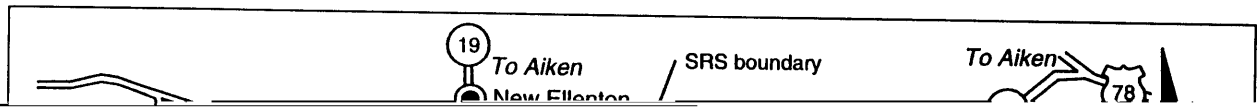
3.3.1 Description of the Affected Environment at the Savannah River Site

The Savannah River Site is a key DOE facility for research and production of special nuclear materials. The site was built in the early 1950's to produce the basic materials used in the fabrication of nuclear weapons. The DOE Savannah River Operations Office manages the Savannah River Site, and the Westinghouse Savannah River Company operates the site under contract to DOE. This section describes the potentially affected environment of the Savannah River Site. The location of the site is shown in Figure 3-42.

3.3.1.1 Geology

The Savannah River Site is located in the Upper Atlantic Coastal Plain physiographic province of western South Carolina, approximately 32 km (20 mi) southeast of the Fall Line, which separates the Piedmont and Coastal Plain provinces (Figure 3-42). The Coastal Plain in South Carolina is subdivided to include the Aiken Plateau, the Congaree Sand Hills, and the Coastal Terraces. The Coastal Plain consists of 213 to 366 m (700 to 1,200 ft) of gently seaward (southeast) dipping sands, clays, and limestones of Cretaceous and Tertiary age. These sediments are underlain by sandstones of Triassic age and older dense metamorphic and igneous basement rocks (Arnett et al., 1993). Coastal Plain sediments form a wedge of seaward-dipping and thickening unconsolidated and semi-consolidated sediments that begin at zero at the Fall Line and increase to more than 1,212 m (4000 ft) at the Continental Shelf. The Coastal Plain sediments underlying the Savannah River Site consist of sandy clays and clayey sands, with occasional beds of clean sand, gravel, clay, or carbonate. Two bioclastic limestone zones ranging from 0.6 m (2 ft) to 24 m (80 ft) occur within the Tertiary sequence. Most of the clastic sediments are unconsolidated, but thin semi-consolidated beds also occur (DOE, 1991a). The Triassic formations and older igneous and metamorphic rocks are hydrologically separated from the overlying Coastal Plain sediments by a regional aquitard (Arnett et al., 1993) (Figure 3-43).


Fall line
Kentucky
Virginia
North
Carolina
Tennessee
NORTH


19
To Aiken
SRS boundary
To Aiken
78

3.3.1.2 Seismology and Volcanology

Seismicity in the Coastal Plain of South Carolina occurs in three distinct seismic zones near the Charleston area: Middleton Place Summerville, about 19 km (12 mi) northwest of Charleston; Bowman, about 59 km (37 mi) northwest of the Middleton Place-Summerville; and Adams Run, about 30 km (19 mi) southwest of the Middleton Place-Summerville (WSRC, 1993a). Of the three seismic zones within the Coastal Plain province, the Charleston area has been and remains the most seismically active. The Charleston area is also the most significant source of seismicity affecting the Savannah River Site, both in terms of maximum

historic site intensity and the number of earthquakes felt in the area (WSRC, 1993a).

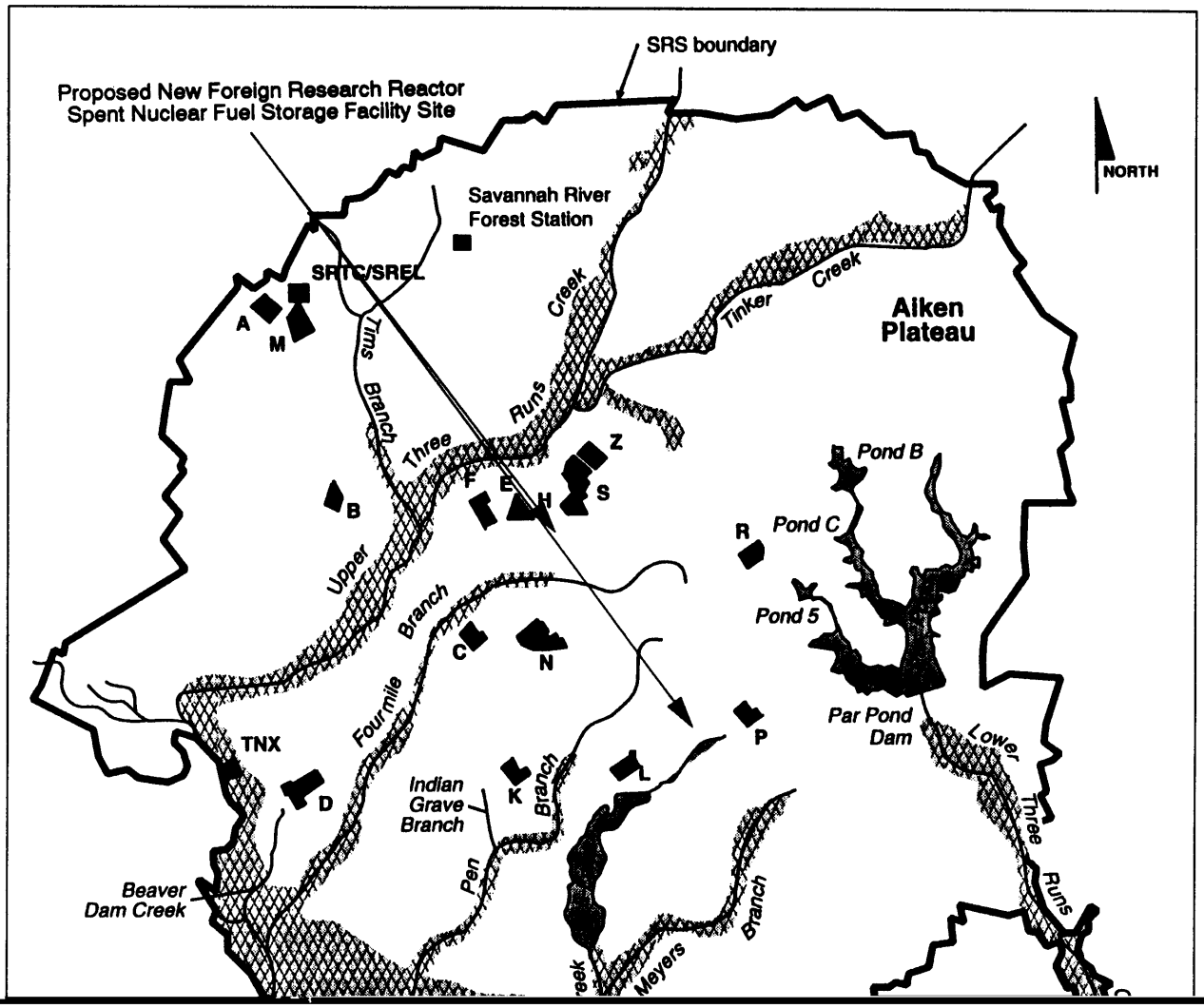
The closest offsite fault system is the Augusta Fault Zone, approximately 40 km (25 mi) from the Savannah River Site. In this fault zone, the Belair Fault has experienced the most recent movement, but is not considered capable of generating major earthquakes (DOE, 1987). There is no conclusive evidence of recent displacement along any fault within 320 km (200 mi) of the Savannah River Site, with the possible exception of the buried faults in the epicentral area of the 1886 Charleston, SC earthquake, approximately 144 km (90 mi) away (DOE, 1991a).

Two notable earthquakes have occurred within 320 km (200 mi) of the Savannah River Site. The first was a major earthquake in 1886 centered in the Charleston area, which had an estimated Richter magnitude of 6.8. The second earthquake was the Union County, SC earthquake of 1913, which had an estimated Richter magnitude of 6.0, and occurred about 160 km (100 mi) from the Savannah River Site (WSRC, 1993a).

Two earthquakes have occurred at the Savannah River Site during recent years. In June 1985, onsite instruments recorded an earthquake with a magnitude of 2.6 and a focal depth of about 1.0 km (0.6 mi) (DOE, 1995c). The epicenter was just west of the C- and K-areas. In August 1988, an earthquake of magnitude 2.0 and a focal depth of approximately 2.7 km (1.7 mi) occurred (Stephenson, 1988).

3.3.1.3 Hydrology

3.3.1.3.1 Surface Water


SRS boundary
Proposed New Foreign Research Reactor
Spent Nuclear Fuel Storage Facility Site
NORTH
Savannah River
Forest Station
SRTC/SREL
A
M
Tims Branch
Three Runs Creek
Tinker Creek
Aiken
Plateau
Z
F
E
H
S
B
Pond B
R
Pond C
Upper Fourmile Branch
Pond 5
C
N
Par Pond
Dam
P
TNX
Lower Three Runs
D
Indian
Grave
Branch
K
L
Pen Branch
Beaver
Dam Creek
Meyers Branch

of the Savannah River Site, the river supplies domestic and industrial water needs for Savannah, GA, and Beaufort and Jasper Counties in South Carolina. The South Carolina Department of Health and Environmental Control regulates the physical properties and concentrations of chemicals and metals in the Savannah River Site effluent under the National Pollutant Discharge Elimination System. This department also regulates chemical and biological water quality standards for the Savannah River Site waters. On April 24, 1992, the department changed the classification of the Savannah River and the Savannah River Site streams from "Class B waters" to "Freshwaters." The definitions of "Class B" waters and "Freshwaters" are the same, but the Freshwaters classification imposes a more stringent set of water quality standards (Arnett et al., 1993). Tables 4-10 and 4-11 of Appendix C, Volume 1 of the Programmatic SNF&INEL Final EIS list the characteristics of the Savannah River Site surface water quality (DOE, 1995c).

3.3.1.3.2 Groundwater

There are two hydrogeologic provinces in the subsurface beneath the Savannah River Site. The deepest Piedmont hydrogeologic province includes Paleozoic metamorphic and igneous basement rocks, and Triassic-aged lithified mudstone and sandstone. The Southeastern Coastal Plain hydrogeologic province lies above the Piedmont province and consists of a seaward thickening wedge of unconsolidated sediments of Late Cretaceous and Tertiary age. The Southeastern Coastal Plain hydrogeologic province is more important from a resource point of view because it holds an abundant supply of high-quality groundwater.

The sediments that make up the Southeastern Coastal Plain hydrogeologic province in west-central South Carolina are grouped into three major aquifer systems divided by two major confining systems, all of which are underlain by the Appleton confining system. The Appleton system separates the Southeastern Plain hydrogeologic province from the underlying Piedmont hydrogeologic province. Locally, individual aquifer and confining units are delineated. The complexly interbedded strata that form the three aquifer systems primarily consist of fine-to-coarse-grained sand and local gravel and limestone deposited under relatively high energy conditions in fluvial to shallow marine environments.

supplies where necessary (WSRC, 1993b). Table 4-12 of Appendix C, Volume 1 of the Programmatic SNF&INEL Final EIS summarizes the Savannah River Site groundwater quality data, and Table 4-13 lists data for radiological constituents (DOE, 1995c).

The groundwater beneath 5 to 10 percent of the Savannah River Site has been contaminated by industrial solvents, metals, tritium, or other constituents used or generated on the site. Figure 3-45 shows the locations of facilities monitored by the Savannah River Site and areas with constituents that exceeded drinking water standards in 1992. In general, contaminated groundwater at the Savannah River Site is beneath a few facilities, and the contaminants reflect operations and chemical processes at those facilities. For example, contaminants in the groundwater beneath A- and M-Areas include chlorinated volatile organics, radionuclides, metals, and nitrate. At F- and H-Areas, contaminants in the groundwater include tritium and other radionuclides, metals, nitrate, chlorinated volatile organics (at values much smaller than found at A- and M-Areas), and sulfate. The groundwater beneath the Sanitary Landfill contains chlorinated volatile organics, radionuclides, and metals. The groundwater beneath all the reactor areas except R-Area contains tritium, other nuclides, metals, and chlorinated volatile organics, and at R-Area, groundwater contaminants include radionuclides and cadmium. The groundwater beneath D-Area contains metals, radionuclides, sulfate, and chlorinated volatile organics. At TNX-Area, the groundwater contains chlorinated volatile organics, radionuclides, and nitrate (Arnett et al., 1993).

The McQueen Branch aquifer, which becomes shallower toward the Fall Line, forms the base for most municipal and industrial water supplies in Aiken County. Toward the coast, in Allendale and Barnwell Counties, this aquifer exists at increasingly greater depths. As a consequence, the shallower Gordan aquifer supplies some municipal, industrial, and agricultural users. The Gordan and Upper Three Runs Creek aquifers are the primary sources of domestic water supplies in the vicinity of the Savannah River Site for rural non-municipal water. DOE has identified 56 major municipal, industrial, and agricultural groundwater users within 32 km (20 mi) of the center of the Savannah River Site (DOE, 1987). The total pumpage for these users is about 136,260 m^3 per day (36 million gal per day).

Excellent quality groundwater is abundant in this region of South Carolina from many local aquifer units. As a result, the South Carolina Department of Health and Environmental Control has classified all aquifers in the State as Class GB (DOE, 1995c), or U.S. Environmental Protection Agency Class II, meaning that the aquifers can provide resource-quality water, but are not the sole source of supply (as are South Carolina Class GA or U.S. Environmental Protection Agency Class 1 aquifers) (DOE, 1991a).

3.3.1.4 Meteorology

Wind: Figure 3-46 shows annual wind direction frequencies and wind speeds for the Savannah River Site from 1987 through 1991. The maximum wind directional frequencies are from the northeast and west-southwest. The average wind speed for this 5-yr period was 3.8 m per sec (8.5 mph). Calm winds (less than 2 m per sec or 4.5 mph) occurred less than 10 percent of the time during the 5-yr period. Seasonally, wind speeds were greatest during the winter at 4.1 m per sec (9.2 mph), and lowest during the summer at 3.4 m per sec (7.6 mph) (Shedrow, 1993). Winter snow storms in the Savannah River Site area occasionally bring strong and gusty surface winds with speeds as high as 32 m per sec (72 mph). Thunderstorms can generate winds with speeds as high as 18 m per sec (40 mph) and even stronger gusts. The fastest wind speed recorded at Augusta between 1950 and 1986 was 37 m per sec (83 mph) (DOE, 1995c).

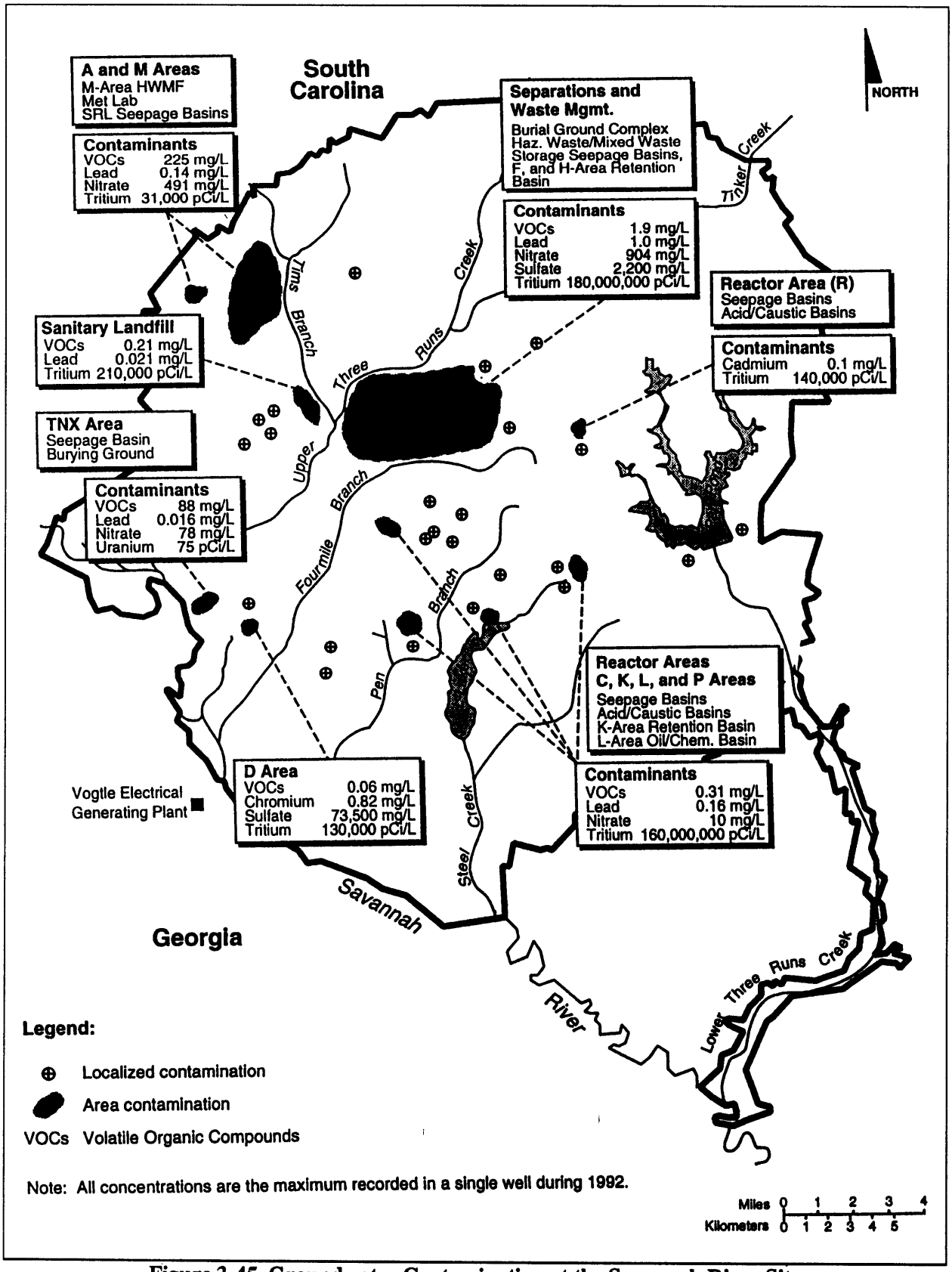
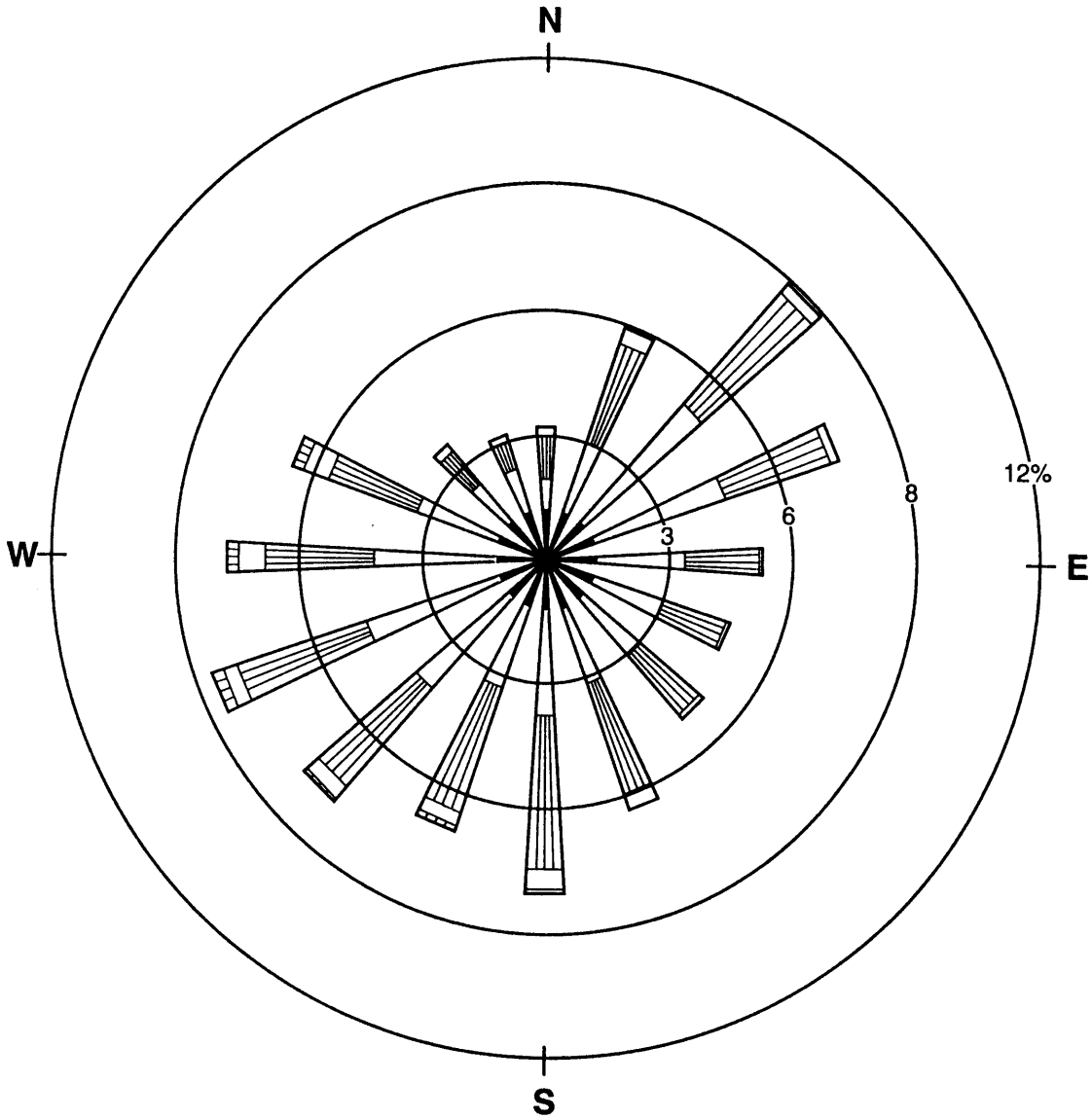
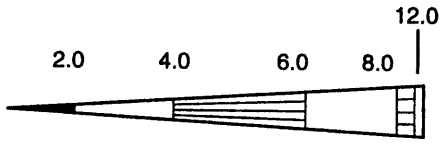


Figure 3-45 Groundwater Contamination at the Savannah River Site



The wind rose plot shows percent occurrence frequencies of wind direction and speed at SRS. It is based on a composite of hourly averaged wind data from the SRS meteorological tower network for the 5-year period 1987-1991. Measurements were taken from 200 feet above ground. Directions indicated are *from* which the wind blows.



Wind Speed Class Boundaries
(meters/second)

Figure 3-46 Wind Rose for the Savannah River Site (1987-1991)

Temperature and Humidity: The annual average temperature at the Savannah River Site is 17.8°C (64°F), and monthly averages range from a low of 7.22°C (45°F) in January to a high of 27.2°C (81°F) in July. Average daily relative humidity ranges from a maximum of 90 percent in the morning to a minimum of 43 percent in the afternoon on an annual basis.

Precipitation: The average annual precipitation at the Savannah River Site is approximately 121.9 cm (48 in). Precipitation distribution is fairly even throughout the year, with the highest precipitation in the summer [36.1 cm (14.2 in)] and the lowest in autumn [22.5 cm (8.8 in)] (Arnett et al., 1993). Snowfall has occurred in the months of October through March, with the average annual snowfall at 3.0 cm (1.2 in). Large snowfalls are rare (DOE, 1995c).

The area encompassing the Savannah River Site experiences an average of 56 thunderstorm days per year. From 1954 to 1983, 37 tornadoes were reported for a one-degree square of latitude and longitude that includes the Savannah River Site. This frequency of occurrence is equivalent to an average of about one tornado per year. The estimated probability of a tornado striking a point on the Savannah River Site is 0.00007 per year, which is less than one in ten thousand (DOE, 1995c). Since operations began at the Savannah River Site in 1953, nine tornadoes have been confirmed on or near the site. Winds exceeding hurricane force have been observed only once at the Savannah River Site (Hurricane Gracie in 1959) (Shedrow, 1993).

Atmospheric Dispersion: Based on measurements at onsite meteorological stations, dispersion conditions in the Savannah River Site region were classified unstable approximately 56 percent of the time, neutral 23 percent of the time, and stable about 21 percent of the time. On an annual basis, inversion conditions occur 21 percent of the time at the Savannah River Site (Shedrow, 1993).

Air Quality: The local air quality management region which includes the Savannah River Site is in attainment with National Ambient Air Quality Standards for criteria pollutants, which include sulfur

areas, natural succession has reclaimed other previously disturbed areas. Satellite imagery of the site shows a circle of wooded habitat within a matrix of cleared uplands and narrow forested riparian corridors. The Savannah River Site provides nearly 73,250 ha (181,000 acres) of contiguous forested cover broken only by unpaved secondary roads, transmission line corridors, and a few paved primary roads. Carolina bays, the Savannah River swamp, and several relatively intact longleaf pine-wiregrass communities make important contributions to the biodiversity of the region.

The Savannah River Site is near the transition area between the oak-hickory-pine forest and the southern mixed forest. As a consequence, species typical of both associations occur (Dukes, 1984). A variety of vascular plant communities occur in the upland areas. Typically, scrub oak communities occur on the drier, sandier areas. Longleaf pine, turkey oak, bluejack oak, blackjack oak, and dwarf post oak dominate these communities, which typically have understories of wire grass and huckleberry. Oak-hickory hardwood communities occur on more fertile, dry uplands, and characteristic species are white oak, post oak, southern red oak, mockernut hickory, pignut hickory, and loblolly pine, with an understory of sparkleberry, holly, greenbriar, and poison ivy (DOE, 1995c).

The Savannah River Site has provided excellent habitat to wildlife associated with the wetlands of the Savannah River and the pine-dominated sandhills of coastal South Carolina. Furbearers such as gray fox, raccoon, opossum and beaver are relatively common throughout the Savannah River Site. Game species such as gray and fox squirrel, cottontail rabbit, and wild turkey are also common. The Savannah River Site contains suitable habitat for white-tailed deer and feral hogs, as well as other faunal species common to the mixed pine/hardwood forests of South Carolina.

The Savannah River Site has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks, and impoundments. The southwestern Savannah River Site boundary adjoins the Savannah River for approximately 32 km (20 mi). The river floodplain supports an extensive swamp, covering about 4,916 ha (12,148 acres) of the site. At present, the swamp forest consists of second-growth bald cypress, black gum, and other hardwood species (USDA, 1991). Five major streams drain the Savannah River Site, and eventually flow into the Savannah River. Each stream has floodplains characterized by bottomland hardwood forests or scrub-shrub wetlands in varying stages of succession. Dominant species include the red maple, box elder, bald cypress, water tupelo, sweetgum, and black willow (DOE, 1995c). Carolina bays, unique wetland features of the southeastern United States, are islands of wetland habitat dispersed throughout the uplands of the Savannah River Site. The more than 200 bays on the site exhibit extremely variable hydrology and a range of plant communities from herbaceous marsh to forested wetland (Shields et al., 1982; Schalles et al., 1989).

Threatened, Endangered, and Candidate Plant and Animal Species: Threatened, endangered, and candidate plant and animal species on the Savannah River Site include 5 bird species, 1 mammal species, 5 amphibian species, 5 reptile species, 1 fish species, 2 invertebrate species, and 19 plant species. The following Federally listed endangered animals are known to occur on the Savannah River Site or in the Savannah River adjacent to the site: the red-cockaded woodpecker, the southern bald eagle, the wood stork, and the shortnose sturgeon (DOE, 1995c). Researchers have found one Federally listed endangered plant species, the smooth coneflower, on the Savannah River Site, along with several Federally listed Category 2 species, and several listed species (Knox and Sharitz, 1990).

3.3.1.6 Land Use

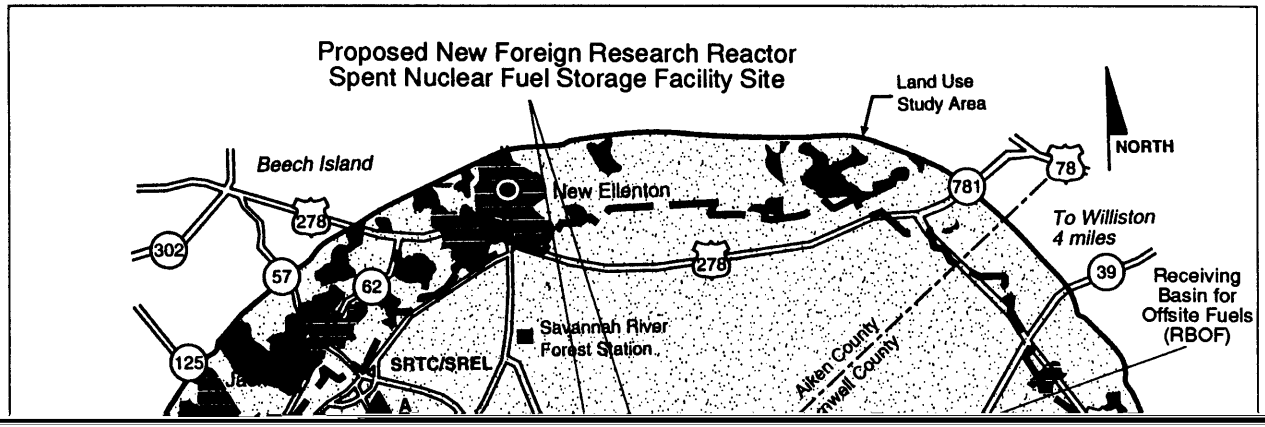
The Savannah River Site occupies an area of approximately 800 km^2 (310 mi^2) in western South Carolina, in a generally rural area about 40 km (25 mi) southeast of Augusta, GA. The Savannah River Site, which is bordered by the Savannah River to the southwest, includes portions of Aiken, Barnwell, and Allendale

Counties. Land use on the Savannah River Site can be grouped into three major categories: forest/undeveloped, water/wetlands, and developed facilities. Ninety-six percent of the Savannah River Site area, about 73,450 ha (181,500 acres), is undeveloped (USDA, 1991). Approximately 90 percent of this area is forested (Cummins et al., 1990). In 1972, DOE designated the Savannah River Site as a National Environmental Research Park. At present, approximately 57 km^2 (22 mi^2), or 7 percent of the Savannah River Site area is designated as "Set-Asides," which are areas specifically protected for environmental research activities that are coordinated either through the University of Georgia Savannah

present, administrative production and support facilities occupy approximately 5 percent of the total the Savannah River Site land area.

Land bordering the Savannah River Site is primarily forest and agricultural. There is also a significant amount of open water and forested wetlands along the Savannah River Valley. Urbanized and industrial areas are the only other significant use of land in the vicinity (Figure 3-47). None of the three counties in which the Savannah River Site is located has zoned any of the site land. The only adjacent area with any zoning is the Town of New Ellenton, which has two zoning categories for lands that bound the Savannah River Site, urban development and residential development. The closest residences to the Savannah River Site boundary include several within 61 m (200 ft) of the site perimeter to the west, north, and northeast.

The Savannah River Site is a controlled area, with public access limited to through traffic on South


Proposed New Foreign Research Reactor
Spent Nuclear Fuel Storage Facility Site
Land Use
Study Area
NORTH
Beech Island
New Ellenton
278
302
57
62
125
SRTC/SREL
Savannah River
Forest Station
278
781
78
To Williston
4 miles
39
Receiving
Basin for
Offsite Fuels
(RBOF)
Aiken County

Noise from the Savannah River Site Traffic: During a normal week, about 20,000 employees travel to the Savannah River Site each day in private vehicles from surrounding communities. Both Government-owned and private trucks pick up and deliver materials at the site. The contribution of the Savannah River Site operations to traffic volumes along SC 125 and SC 19, especially during peak traffic periods, affects noise levels in the towns of New Ellenton and Jackson and the city of Aiken. Noise measurements taken during 1989 and 1990 along SC 125 in the town of Jackson (at a point about 15 m or 50 ft from the roadway) indicate that the one-hour equivalent sound level from traffic ranged from 48 to 72 decibels. The estimated day/night average sound level along this route was 66 decibels for summer and 69 decibels for winter. Similarly, noise measurements along SC 19 in the town of New Ellenton indicate that the one-hour equivalent sound level from traffic ranged from 53 to 71 decibels. The estimated day/night average sound level along this route was 66 decibels for both summer and winter (HNUS, 1990). Employment at the Savannah River Site has increased by about 17 percent since 1989, potentially causing increases in traffic noise, especially during peak traffic periods (approximately between 6:30 and 8:30 a.m., and between 3:30 and 5:30 p.m. corresponding to major shift changes). Since some residences and at least two schools are within 30 to 60 m (100 to 200 ft) of these routes, some annoyance to members of the public residing along these highways can occur based on the relationship between the day/night average sound level (Schultz 1978; FICON, 1992).

Noise from Railroad Traffic: Approximately 18 trains per day pass through the Savannah River Site on the CSX line, with five trains delivering shipments to the Savannah River Site. Noise sources from rail transport include diesel engines, wheel-track contact, and whistle-warnings at rail crossings.

3.3.1.8 Transportation

The Savannah River Site 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 (Aiken, Allendale, Bamberg, and Barnwell), and two Georgia counties (Columbia and Richmond) that generate about 90 percent of the Savannah River Site commuter traffic (DOE, 1995c). Two major railroads—CSX Transportation and Norfolk Southern Corporation—also serve the Savannah River Site vicinity. Norfolk Southern serves Augusta and Savannah, GA, as well as Columbia and Charleston, SC. CSX serves the same locations and the Savannah River Site. Figure 3-48 shows the regional transportation infrastructure.

Two Interstate highways serve the Savannah River Site area. Interstate 20 (I-20) provides a primary east-west corridor and I-520 links I-20 with Augusta, GA. U.S. Highways 1 and 25 are principal north-south routes, and U.S. 78 provides east-west connections. Several other highways (U.S. 221, U.S. 301, U.S. 321, and U.S. 601) provide additional transport routes in the region. Several State routes provide direct access to the Savannah River Site. From the northwest and north, access is provided by SC 125 and SC 19, respectively, and SC 125 is open to through traffic. Access to the site is provided from the northeast by SC 39, from the east by SC 64, and from the southeast by SC 125. These are all two-lane roads. The public has access to U.S. 278 and SC 125, but only the Savannah River Site employees are permitted access to the site on the other routes.

The Savannah River Site transportation infrastructure consists of more than 230 km (143 mi) of primary roads, 1,931 km (1,200 mi) of unpaved secondary roads, and 103 km (64 mi) of railroad track (DOE, 1995c). These roads and railroads provide connections among the various Savannah River Site facilities and offsite transportation linkages. Figure 3-49 shows the Savannah River Site network of primary roadways and access points, and the Savannah River Site railway system.

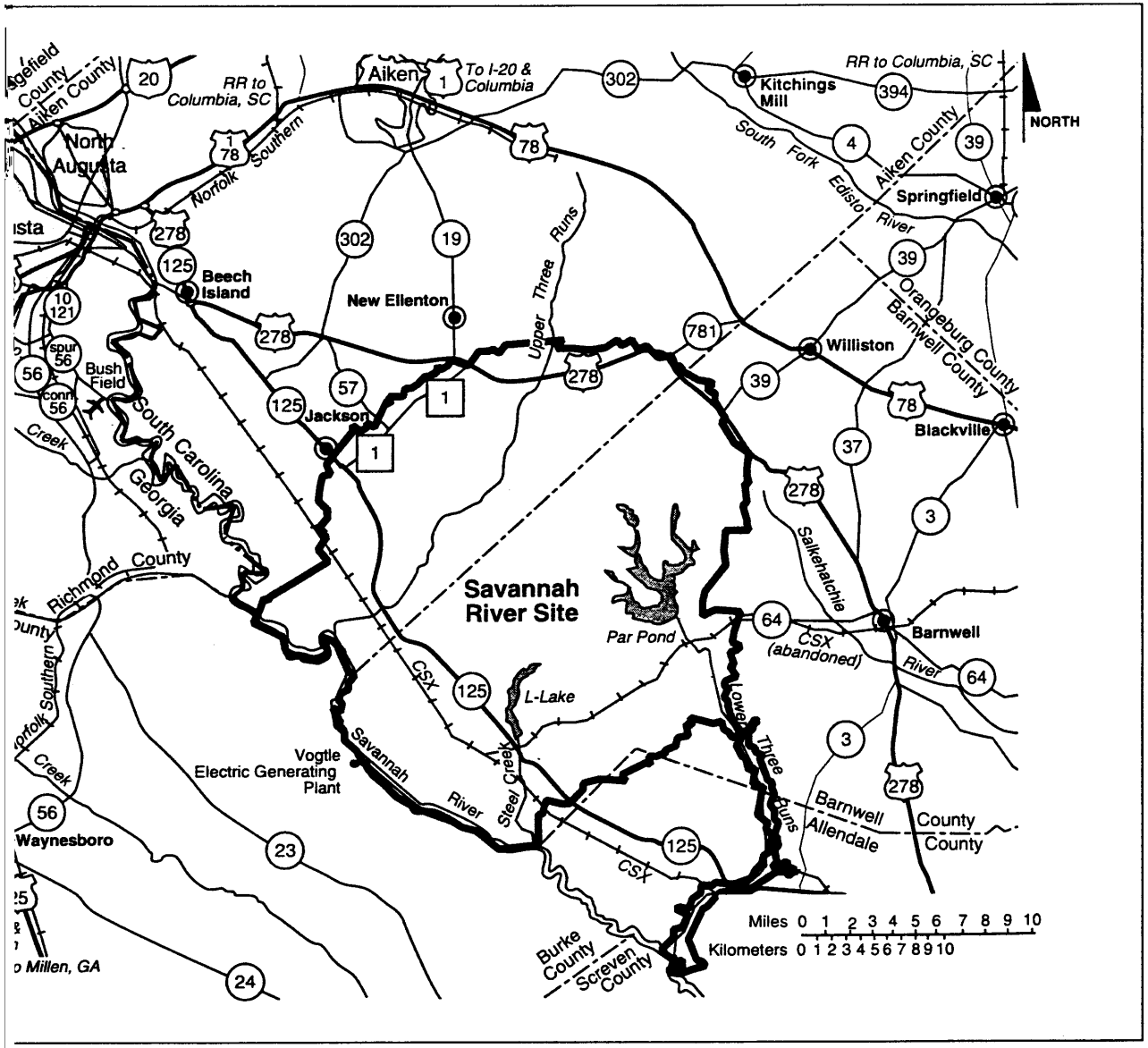
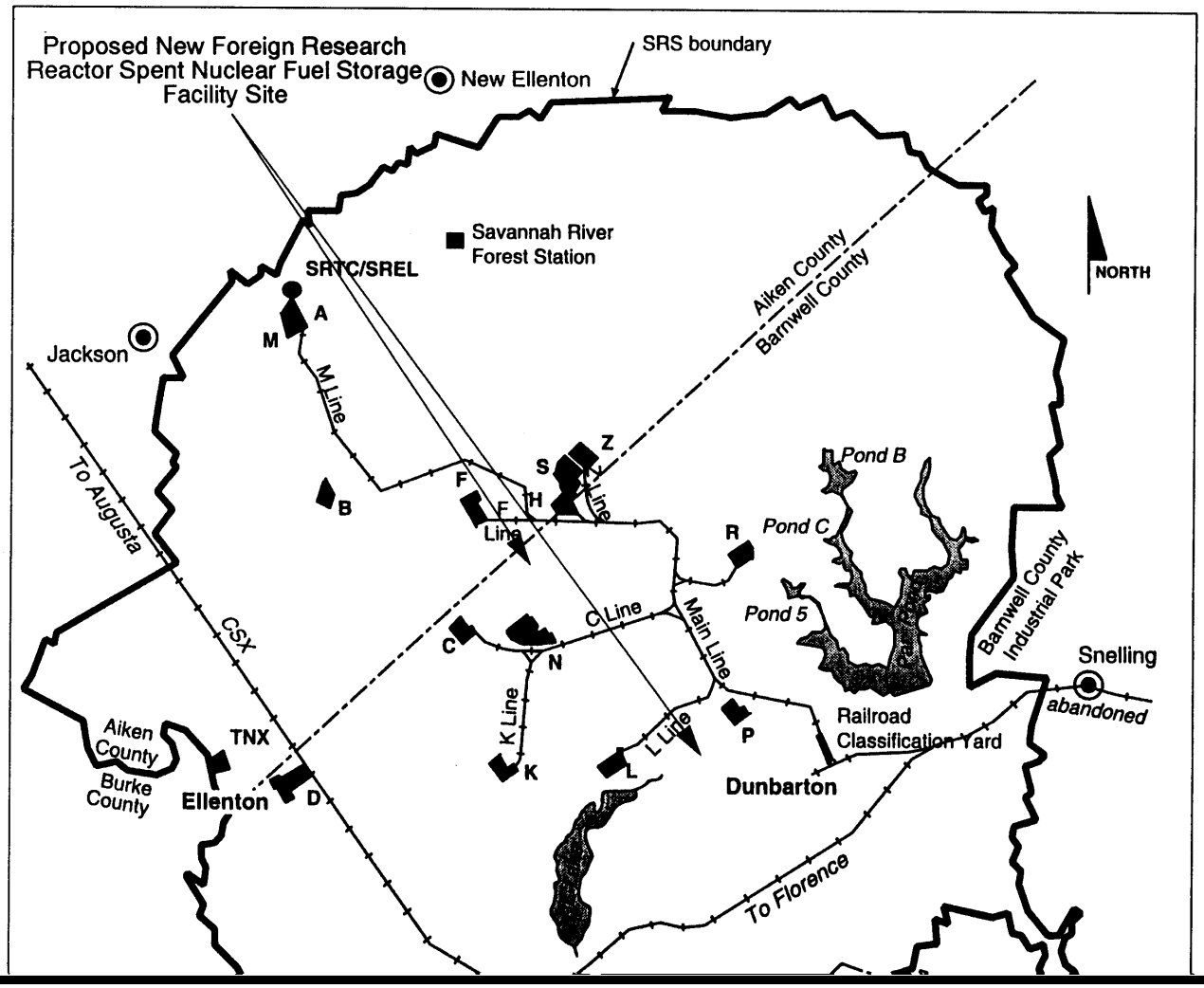


Figure 3-48 Regional Transportation Infrastructure


Proposed New Foreign Research Reactor Spent Nuclear Fuel Storage Facility Site
New Ellenton
SRS boundary
Savannah River Forest Station
SRTC/SREL
A
M
M Line
Jackson
To Augusta
CSX
B
F
F Line
S
Z
H
Y Line
Aiken County
Barnwell County
NORTH
Pond B
Pond C
R
Pond 5
C Line
Main Line
C
N
K Line
K
L
L Line
P
Railroad Classification Yard
Dunbarton
Barnwell County Industrial Park
Snelling
abandoned
Aiken County
Burke County
TNX
Ellenton
D
To Florence

Two major public highways traverse the Savannah River Site: SC 125 and U.S. 278. SC 125 connects Allendale, SC, to Augusta, GA, by crossing the site in a northwest-to-southeast direction. U.S. 278 also connects Augusta and Allendale, but its route generally follows the northern and eastern Savannah River Site boundaries. In general, the primary Savannah River Site roadways are in good condition, and are smooth and free from potholes. Typically, wide, firm shoulders border roads that are either straight or have wide gradual turns. Intersections are well marked for both traffic and safety identification, and are sufficiently cleared of trees and brush that might obstruct a driver's view of oncoming traffic. Railings along the side of the roadways offer protection at appropriate locations from dropoffs or other hazards. In general, the roadways are lighted only at gate areas and near major facilities.

In general, heavy traffic occurs early in the morning and late in the afternoon when workers from surrounding communities commute to and from the Savannah River Site. During working hours, official vehicles and logging trucks constitute most of the traffic. At any time, as many as 60 logging trucks, which can impede traffic, might be operating on the Savannah River Site, with an annual average of about 25 trucks per day. Table 4-16 of Appendix C, Volume 1 of the Programmatic SNF&INEL Final EIS provides data on traffic counts for various roads and access points around the Savannah River Site (DOE, 1995c).

Railroads on the Savannah River Site include both CSX tracks and the Savannah River Site rolling stock and tracks. Two routes of the CSX distribution system run through the Savannah River Site: a line between Florence, SC, and Augusta, GA, and a line between Yemassee, SC, and Augusta. The two lines join on the site near the L-Lake dam (Figure 3-49). Early in 1989, CSX discontinued service on the line from the Savannah River Site junction to Florence. The 103 km (64 mi) of the Savannah River Site railroad tracks are well maintained. The rails and crosslines are in good condition, and the track lines are clear of vegetation and debris. Significant clear areas border the tracks on both sides. Intersections of railroads and roadways are marked by railroad crossing signs with lights where appropriate. The Savannah River Site rail classification yard is east of P-Reactor. This eight-track facility sorts and redirects railcars. Deliveries of the Savannah River Site shipments occur at two onsite rail stations at the former towns of Ellenton and Dunbarton. From these stations, a Savannah River Site engine moves the railcars to the appropriate receiving facility. The Ellenton station, which is on the main Augusta-Yemassee line, is the preferred delivery point. The Dunbarton station, which is on the discontinued portion of the Augusta-Florence line, receives less use.

3.3.1.9 Socioeconomics

The Savannah River Site region of influence includes Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. Between 1980 and 1990, total employment in the region of influence increased from 139,504 to 199,161, an average annual growth rate of approximately 5 percent. Table 4-1 of Appendix C, Volume 1 of the Programmatic SNF&INEL Final EIS lists projected employment data for the six-county region of influence. As shown, by the year 2000, employment levels should increase 27 percent to approximately 253,000. The unemployment rates for 1980 and 1990 were 7.3 percent and 4.7 percent, respectively (DOE, 1995c).

In 1990, employment at the Savannah River Site was 20,230, representing 10 percent of the region of influence employment (DOE, 1993d). In Fiscal Year 1992, employment at the Savannah River Site increased approximately 15 percent to 23,351, with an associated payroll of more than $1.1 billion. From 1980 to 1990, the labor force in the six-county region of influence grew 39 percent, from 150,551 to 208,984. In 1990, 75.3 percent of the region of influence labor force lived in Richmond and Aiken Counties, SC. Current projections call for the region's labor force to increase to approximately 257,000 workers by 1995 (DOE, 1995c).

Between 1980 and 1990, population in the region of influence increased 13 percent, from 376,058 to 425,607. More than 88 percent of the 1990 population lived in Aiken (28.4 percent), Columbia (15.5 percent), and Richmond (44.6 percent) Counties. According to 1990 census data, the estimated average number of persons per household in the six-county region was 2.72, and the median age of the population was 31.2 years (DOE, 1995c). Based on 1990 census population data, the general ethnic composition of the immediate area of influence, which is within an 80 km (50 mi) radius of the site, is shown in Figure 3-50. Low-income households are presented in Figure 3-51. Low-income households are those with incomes of 80 percent or less than the median income of the counties. As indicated in this figure, approximately 42 percent of the total households are low-income households.

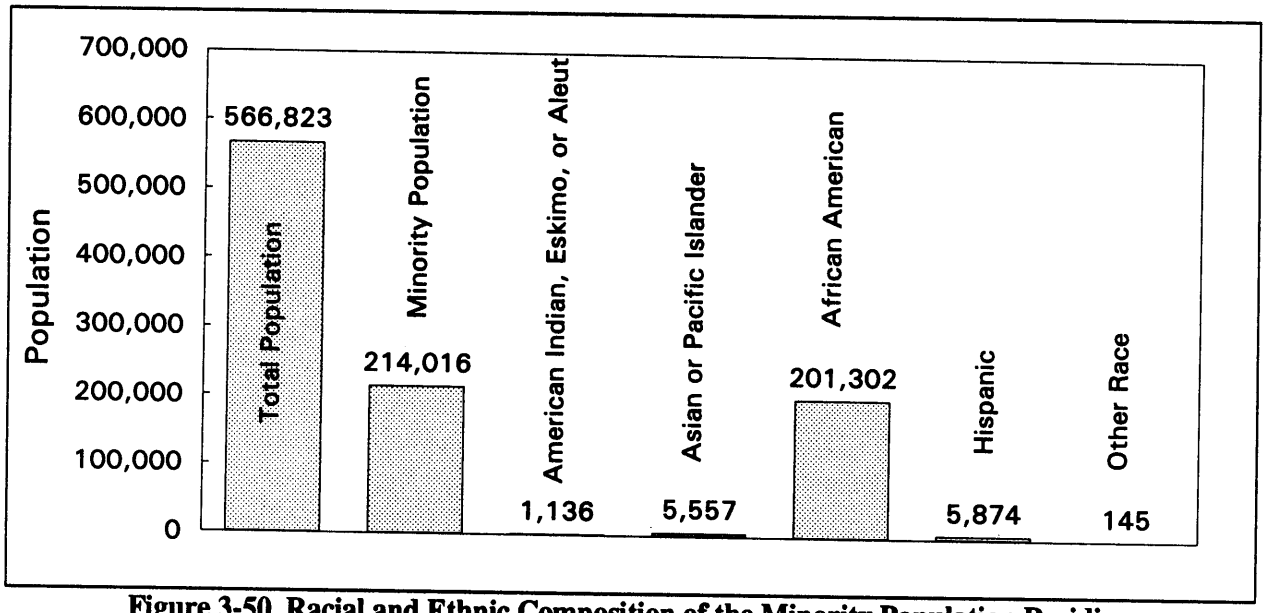


Figure 3-50 Racial and Ethnic Composition of the Minority Population Residing within 80 km (50 mi) of the Savannah River Site

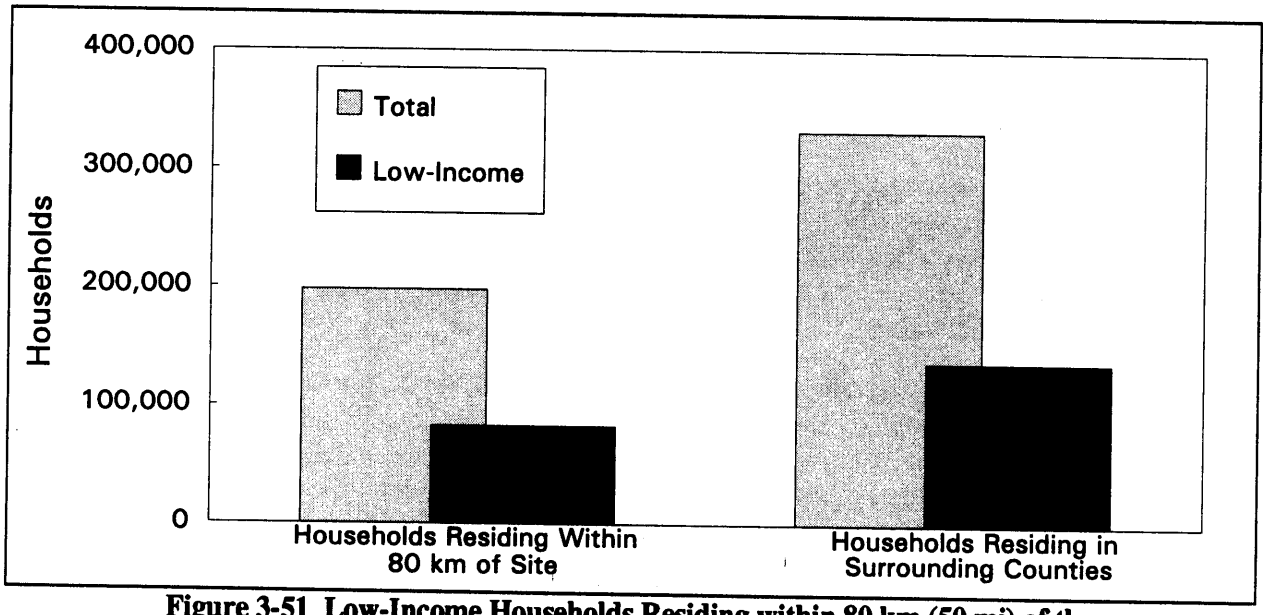


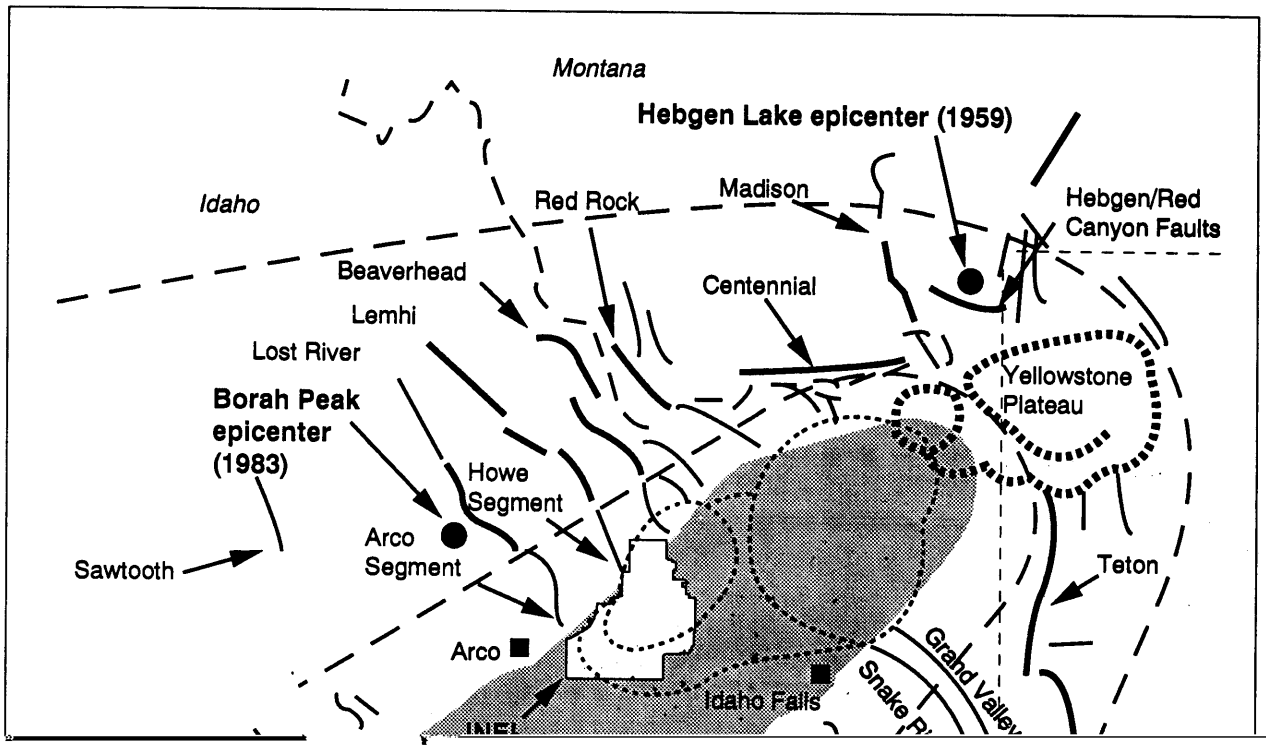
Figure 3-51 Low-Income Households Residing within 80 km (50 mi) of the Savannah River Site

3.3.1.10 Historical, Archaeological and Cultural Resources

By the end of Fiscal Year 1992, approximately 60 percent of the 800 km^2 (310 m^2) of the Savannah River Site had been examined, and 858 archaeological sites had been identified. Of these, 53 have been determined to be eligible for the National Register of Historic Places, and 650 have not been evaluated (DOE, 1995c).

Three Native American groups, the Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy, have expressed concerns over sites and items of religious significance on the Savannah River Site.

Archaeologists have divided areas of the Savannah River Site into three sensitivity zones related to their


Montana
Hebgen Lake epicenter (1959)
Idaho
Red Rock
Madison
Hebgen/Red
Canyon Faults
Beaverhead
Centennial
Lemhi
Lost River
Yellowstone
Plateau
Borah Peak
epicenter
(1983)
Howe
Segment
Arco
Segment
Sawtooth
Teton
Arco
Idaho Falls
Grand Valley

mainstream alluvium extends along the course of the Big Lost River (southwestern corner of the Idaho National Engineering Laboratory) to the Lost River Sinks area in the north-central portion of the Idaho National Engineering Laboratory. Lacustrine clay and sand deposits from the Ice Age Lake Terreton occur in the northern part of the site. Some of these beach sands were reworked by winds in late Pleistocene and Holocene times to form large dune fields in the northeastern part of the Idaho National Engineering Laboratory (Scott, 1982). Several Quaternary rhyolite domes occur along the Axial Volcanic

limestones, late-Tertiary rhyolitic volcanic rocks, and large alluvial fans occur in limited areas along the northwest margin of the site.

3.3.2.2 Seismology and Volcanology

The effusion of basaltic-lava flows from volcanic rift zones has been the predominant style of volcanism on the Eastern Snake River Plain, including the Idaho National Engineering Laboratory area, during the past 4 million years. Broad uplift of the ground surface, together with the opening of fissures and faults, accompany the ascending magma before eruptions. Vents for the basaltic volcanism are concentrated in northwest-trending volcanic rift zones and along the Axial Volcanic Zone (Kuntz, 1992).

reaches site boundaries (Barraclough et al., 1981). This has resulted in little or no flow in these surface water bodies for several years within the boundaries of the Idaho National Engineering Laboratory (Pittman et al., 1988).

The Big Lost River is the major surface water body at the Idaho National Engineering Laboratory. The river flows between the Lost River Range and the Pioneer Mountains, draining approximately 3,755 km^2 (1,450 mi^2) of land before reaching the site. Approximately 48 km (30 mi) upstream of Arco, ID, Mackay Dam controls and regulates the flow of the river. During heavy runoff events, surface water from the Big Lost River is diverted to four spreading areas located south of the Idaho National Engineering Laboratory Diversion Dam. North of the diversion dam, the Big Lost River continues northward across the site to an area of natural infiltration basins (playas or sinks) near Test Area North. Flow within the Big Lost River channel may only reach a few kilometers southeast of Arco during drought years.

Birch Creek flows through an elongated, southeast-trending valley located between the Lemhi and Beaverhead Mountain Ranges, which cross the northwest corner of the Idaho National Engineering Laboratory to Playa 4 near Test Area North. Birch Creek drains an area of approximately 1,943 km^2 (750 mi^2). In the summer, upstream of the Idaho National Engineering Laboratory, surface water from

Birch Creek is diverted for irrigation and to produce hydropower. In the winter, water flows in a man-made channel constructed 6.4 km (4 mi) north of Test Area North, where it infiltrates into channel gravel.

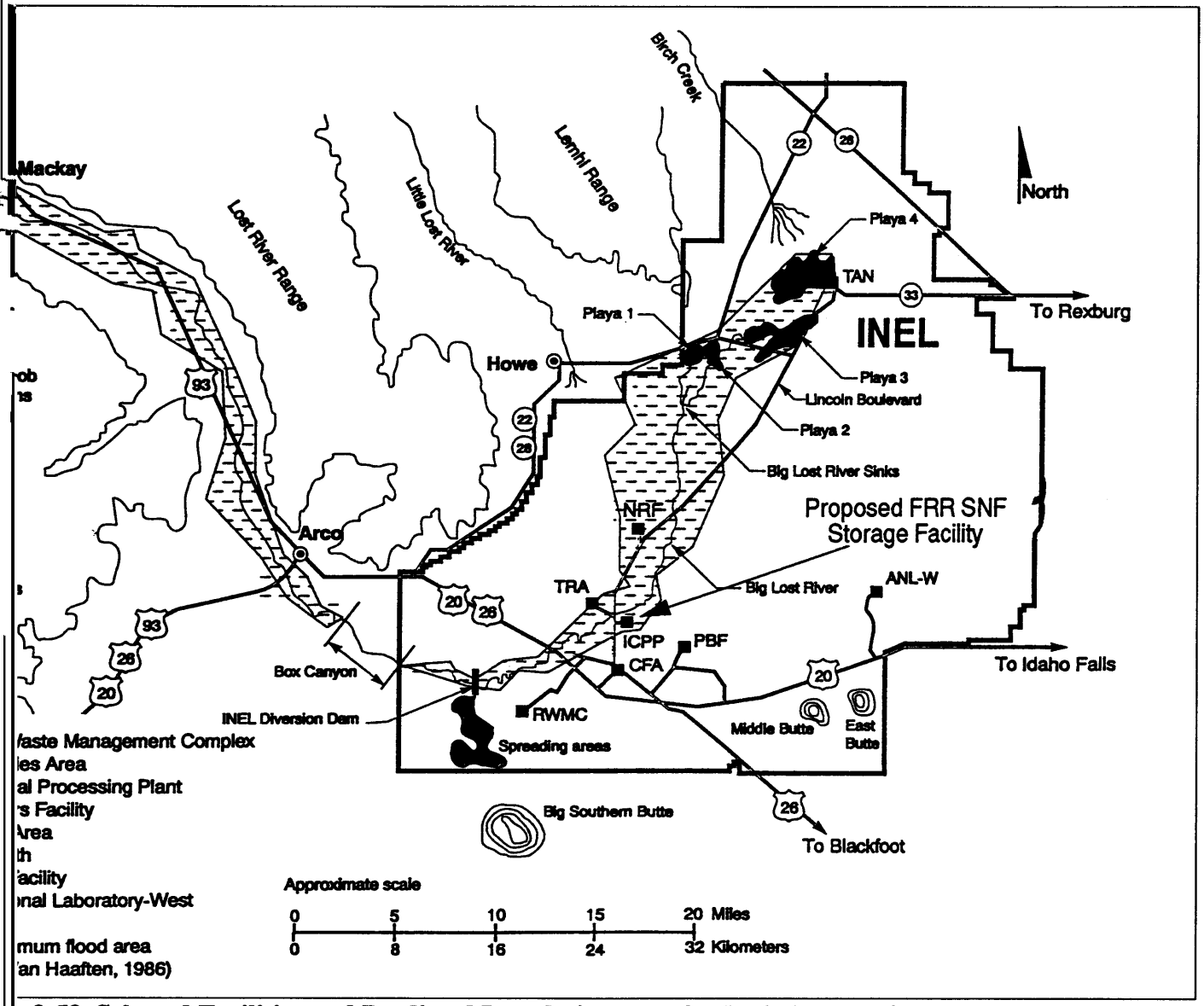
The Little Lost River drains the slopes of the Lemhi and Lost River Ranges, an area of approximately 1,826 km^2 (705 mi^2). Surface water from the Little Lost River has not reached the Idaho National Engineering Laboratory in recent times; during high streamflow years, however, water will reach the site and infiltrate into the subsurface (EG&G Idaho Inc., 1984).

Surface water generated from local precipitation will flow into topographic depressions (lower elevations than the surrounding terrain). Surface water within the depressions either evaporates or infiltrates into the ground. Localized flooding can occur at the Idaho National Engineering Laboratory when the ground is frozen and melting snow is combined with heavy spring rains. Other facility areas have been threatened by flooding because of ice jams in the Big Lost River and its diversion channel (McKinney, 1985).

Intermittent surface flow and the Idaho National Engineering Laboratory Diversion Dam have effectively prevented the Big Lost River from flooding onto the site. Flood plains in existence before the diversion dam and channels were built are not active. Based on historical data from past storm events, if heavy runoff occurs and surface water flow from the Big Lost River is diverted to the four spreading areas, water will not overflow the banks of the existing Big Lost River channel onsite during 100- and 500-yr floods (floods that occur on an average of every 100 or 500 years).

Onsite flooding from the Big Lost River may occur if high water in the MacKay Dam or the Big Lost River is coupled with a dam failure. Assuming the Mackay Dam fails, significantly higher flows and greater flooding would be associated with the probable maximum flood than either the 100- or 500-year floods (Figure 3-53).

Surface Water Quality: Water quality in the Big Lost River, Little Lost River, and Birch Creek is similar



e 3-53 Selected Facilities and Predicted Inundation Map for Probable Maximum Induced Overtopping Failure of Mackay Dam at the Idaho National Engineering Laboratory

(Robertson et al., 1974; Bennett, 1990). Chemical and physical parameters measured in the Big Lost River, Little Lost River, and Birch Creek do not exceed drinking water quality standards for the parameter analyzed (DOE, 1995c).

The Idaho National Engineering Laboratory activities do not directly affect the quality of surface water outside the site, because discharges from the Idaho National Engineering Laboratory facilities are made to man-made seepage and evaporation basins or stormwater injection wells. Surface water is not withdrawn by humans for use at the Idaho National Engineering Laboratory, and discharge of effluents to natural surface waters does not occur. In addition, surface water does not flow directly offsite (Hoff et al., 1990). However, water from the Big Lost River, as well as from seepage of evaporation basins and stormwater injection wells, does infiltrate into the Snake River Plain Aquifer, and will eventually reach the Snake River (Robertson et al., 1974; Wood and Law, 1988; Bennett, 1990).

3.3.2.3.2 Groundwater

Groundwater at the site occurs in the Snake River Plain Aquifer and the vadose zone. The Idaho National Engineering Laboratory overlies the Snake River Plain Aquifer, which covers an area of approximately 24,900 km^2 (9,614 mi^2). Groundwater in the aquifer generally flows south and southwestward across the Snake River Plain, discharging into the Snake River at the Thousand Springs Area near Twin Falls, ID.

The Snake River Plain Aquifer is recharged by seepage of irrigation water, stream channel and canal leakage, tributary drainage basin underflow, and direct infiltration from precipitation (Garabedian, 1989). The drainage basin recharging the aquifer covers an area of approximately 90,643 km^2 (35,000 mi^2). Most recharge occurs in surface water-irrigated areas and along the northeastern margins of the plain. A majority of the groundwater discharged from the aquifer is through springs that flow into the Snake River, and through pumping for irrigation purposes. Major springs and seepages that flow from the aquifer are located near the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area between Milner Dam and King Hill (near Twin Falls, ID).

Water storage in the Snake River Plain Aquifer is estimated at $2.5 \times 10^{+12} m^3$ ($8.8 \times 10^{+13} ft^3$) (Robertson et al., 1974). Irrigation wells yield as much as 26.5 m^3 per min (7,000 gal per min) of water (Garabedian, 1989). Groundwater discharges primarily from the aquifer through springs that flow into the Snake River and from pumping for irrigation purposes. Major springs and seepages that flow from the aquifer are localized near the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area between Milner Dam and King Hill.

The Idaho National Engineering Laboratory covers 2,305 km^2 (890 mi^2) of the north-central portion of the Snake River Plain Aquifer. Most of the aquifer is composed of a thick sequence of relatively thin basaltic lava flows with sedimentary interbeds extending to depths greater than 1,067 m (3,500 ft) below the land surface (Irving, 1993). The basalt flows are interbedded with sedimentary layers formed during periods between volcanic eruptions when the basalt was exposed and sediments collected on the land surface. A majority of the groundwater moves horizontally through fractured, basaltic interflow zones (broken and rubble zones) that occur at various depths. Water also moves vertically along joints and the interfingering edges of interflow zones (Garabedian, 1986). Sedimentary interbeds restrict the vertical movement of groundwater.

Depths to the water table from the land surface at the Idaho National Engineering Laboratory range from approximately 61 m (200 ft) in the north, to more than 274 m (900 ft) in the south (Pittman et al., 1988). The upper surface of the aquifer is unconfined over most of its extent. However, the aquifer generally behaves as if it were partially confined, because water moves through dense basalt with interbedded

sediments and water-bearing basaltic fracture zones at different rates. The base of the aquifer coincides with the tip of a thick, widespread sequence of clay, silt, sand, and basalt that occurs at depths ranging from 244 to 457 m (800 to 1,500 ft) below the land surface. The thickness of the aquifer is primarily controlled by the geologic setting, and therefore varies across the Idaho National Engineering Laboratory (Anderson, 1991).

groundwater entering the aquifer (Pittman et al., 1988; Orr and Cecil, 1991). Radionuclides released and observed in the soil and groundwater include tritium, strontium-90, iodine-129, cobalt-60, cesium-137, plutonium-238, plutonium-239/240, and americium-241 (Golder Associates, 1993).

The Idaho National Engineering Laboratory has released sodium, chromium, lead, and mercury on the site and into the subsurface through unlined ponds and deep wells. Sodium is the greatest quantity of material released from the waste treatment processes. However, sodium is not toxic. In 1988, chromium concentrations exceeding the maximum allowable contaminant level were measured near the Test Reactor Area. Lead and mercury have occurred at concentrations below the maximum contaminant level near the Idaho Chemical Processing Plant (Orr and Cecil, 1991).

Concentrations of volatile organic compounds have been detected in the aquifer beneath the Idaho National Engineering Laboratory. Concentrations of the following compounds exceeding the maximum contaminant levels have occurred in and near the Test Area North disposal well: Carbon tetrachloride; chloroform; 1,2-cis-dichloroethylene; 1,1-dichloroethylene; 1,2-trans-dichloroethylene; trichloroethylene; tetrachloroethylene; and vinyl chloride (Leenheer and Bagby, 1982; Mann and Knobel, 1987; Liszewski and Mann, 1993).

Groundwater uses on the Snake River Plain include irrigation, food processing and agriculture, and domestic, rural, public, and livestock supply. Water use for the upper Snake River drainage basin and Snake River Plain Aquifer was 16.4 x 10^{+10} cubic m (4.3 x 10^{+12} gal) per year during 1985, which was more than 50 percent of the water used in Idaho, and approximately 7 percent of agricultural withdrawals in the nation. Site activities withdraw water at an average rate of 7,400,000 m^3 (1.9 x 10^{+9} gal) per year. This rate is equal to approximately 0.4 percent of the water consumed in the Eastern Snake River Plain Aquifer (DOE, 1995c).

Since groundwater supplies 100 percent of the drinking water consumed within the Eastern Snake River Plain (Gaia Northwest, 1988), and an alternative drinking water source or combination of sources is not

rotational cooling of the near-ground air layer on mountain slopes. Wind directions with the highest frequency of occurrence as measured onsite, are from south to west-southwest and from northwest to northeast (Clawson et al., 1989).

The highest hourly average near-ground (6.1 m, 20 ft level) windspeed measured onsite is 22.8 m per sec (51 mph) from the west-southwest. The maximum instantaneous gust at this level was 34.9 m per sec (78 mph). Some of the highest windspeeds occur in the spring, which coincides with strong prevailing westerlies at higher altitudes (Clawson et al., 1989). Apart from thunderstorms, severe weather is uncommon. Visibility in the region is good due to the low moisture content of the air and minimal sources of visibility-reducing pollutants. The background visibility is estimated at 60 km (37.5 mi).

Temperature and Humidity: Average seasonal temperatures measured onsite range from -7.3°C (18.8°F) in winter to 18.2°C (64.8°F) in summer, with an annual average temperature of about 5.6°C (42°F). Temperature extremes measured at the Idaho National Engineering Laboratory range from a summertime maximum of 39.4°C (103°F), to a wintertime minimum of -45°C (-49°F). Temperature differences in excess of 13.9°C (25°F) have been observed onsite (Clawson et al., 1989).

The annual average relative humidity at the Idaho National Engineering Laboratory is 50 percent, with monthly average maximum values ranging from 59 percent in July to 89 percent in February and December, and with monthly average minimum values ranging from 16 percent in June and July to 47 percent in January (Clawson et al., 1989).

Precipitation: Annual precipitation is light, averaging 22.12 cm (8.71 in). The monthly average precipitation peaks in May and June. For the rest of the year, precipitation is uniformly distributed, averaging 1.27 to 1.78 cm (0.5 to 0.7 in) monthly. The highest monthly average snowfall of 16.26 cm (6.4 in) occurs in December, with similar amounts during January. The average annual snowfall is 70.1 cm (27.6 in). Maximum annual snowfall is 151.6 cm (59.7 in), and minimum annual snowfall is 17.3 cm (6.8 in) (Clawson et al., 1989).

Atmospheric Dispersion: Vertical diffusion of pollutants may be restricted or enhanced by the vertical temperature gradient of the atmosphere (that is, lapse or inversion conditions). These inversions are often ground-based, meaning that the temperature increases with height from the ground (Clawson et al., 1989).

Air Quality: The population of the Eastern Snake River Plain is exposed to environmental radiation from both natural and man-made sources.

Background radiation includes sources such as cosmic rays, radioactivity naturally present in soil, rocks, and the human body, and airborne radionuclides of natural origin (such as radon). Radioactivity still remaining in the environment as a result of atmospheric testing of nuclear weapons also contributes to the background radiation level, although in very small amounts.

The Programmatic SNF&INEL Final EIS presents a summary of the estimated natural background dose by exposure source for residents of the Eastern Snake River Plain (DOE, 1995c). The cumulative annual dose, 351 mrem, is caused largely by the inhalation of radioactive particles formed by the decay of naturally occurring radon.

Sources of radiological emissions at the Idaho National Engineering Laboratory result from operation of research and training reactors, spent nuclear fuel testing and processing, irradiated material and fuel examination, nuclear waste treatment and storage, and depleted uranium armor production. These operations can result in the release of radioactivity to air, either directly (e.g., through stacks or vents) or indirectly (e.g., by re-suspension of radioactivity on contaminated grounds). Concentrations of

radionuclides in direct releases are monitored or estimated based on knowledge of the materials used and activities performed. Indirect releases are estimated using engineering calculations that relate surface contamination levels to expected airborne concentrations.

Table 4.7-2 of Appendix B, Volume 1 of the Programmatic SNF&INEL Final EIS provides a summary of the principal types of airborne radioactivity emitted from the Idaho National Engineering Laboratory

Engineering Laboratory. The bald eagle and peregrine falcon are Federally listed endangered species. The bald eagle is a winter resident and is locally common in the far north end of the Idaho National Engineering Laboratory, and on the western edge of the site near Howe. Peregrine falcons have been rarely observed in the winter. Neither species is known to nest on the site, and neither species is commonly observed near facilities (Reynolds, 1993).

The Candidate Category 2 species identified by the U.S. Fish and Wildlife Service as potentially existing at the Idaho National Engineering Laboratory include four birds and two mammals. Both the long-billed curlew and the white-faced ibis are uncommon migrants at the Idaho National Engineering Laboratory, associated with aquatic and riparian habitats. Swainson's hawk and ferruginous hawk nest on and migrate through the site. These species are found throughout the site, but are observed more frequently in the juniper woodlands and riparian areas where they nest. The loggerhead shrike, which uses shrub-steppe vegetation to nest, is also found on the Idaho National Engineering Laboratory. Breeding and hibernation caves for Townsend's big-eared bat have been observed on the Idaho National Engineering Laboratory. About six caves are used, the nearest being in excess of 7 km (3 mi) from the nearest facility. The pygmy rabbit is common on the Idaho National Engineering Laboratory (DOE, 1995c). The habitat for this species is grass and shrub communities found throughout much of the Idaho National Engineering Laboratory.

State species-of-special-concern include three aquatic, one raptor, and three bat species. The aquatic bird species are rare migrants (DOE, 1995c). The gray falcon has only been observed a few times. Of the bats, only the California myotis has been observed, and it is rare. Ten plant species identified by other Federal agencies (U.S. Bureau of Land Management and U.S. Forest Service) and the Idaho Native Plant Society as sensitive, rare, or unique are known to occur on the Idaho National Engineering Laboratory (Chowlewa and Henderson, 1984). These species are not, however, protected under State or Federal laws. Most of these species are not found near any the Idaho National Engineering Laboratory facilities, and are uncommon on the Idaho National Engineering Laboratory because they require unique microhabitat conditions.

Potential wetlands are found throughout the Idaho National Engineering Laboratory and cover about 0.25 percent (3,322 ha or 8,206 acres) of the site. The wetlands are associated primarily with drainages, although some wetlands are associated with natural playas, man-made ponds, and drainage ditches. More than 70 percent of the potential wetlands are identified as palustrine (marsh lands). These wetlands are found mainly near the Big Lost River and its spreading areas and playas, the Birch Creek Playa, and an area to the north and in the general vicinity of Argonne National Laboratory-West. Potential lacustrine wetlands are found in the central and south central portions of the site. Potential riverine wetlands were mapped by the U.S. Fish and Wildlife Service near the Big Lost River, Birch Creek, and Big Lost River Playas. Man-made wetlands include industrial waste and sewage treatment ponds, borrow pits, and gravel pits associated with site facilities. Limited riparian communities with large trees are found along the drainages of the Big Lost River, and very limited riparian habitat is located on Birch Creek.

3.3.2.6 Land Use

The Idaho National Engineering Laboratory encompasses 231,049 ha (570,934 acres). Only about two percent of the land (4,614 ha or 11,400 acres) is used for facilities and operations supporting energy research and development and waste management. In addition to industrial and support land uses associated with each of the facility areas at the Idaho National Engineering Laboratory, other land uses exist within the Idaho National Engineering Laboratory site boundaries.

Approximately five percent of the total the Idaho National Engineering Laboratory site area, or 13,349 ha (33,000 acres), is devoted to public road, utility, and railway rights-of-way crossing the site (DOE, 1995c). Rights-of-way at the Idaho National Engineering Laboratory are granted and administered by the U.S. Department of the Interior and the Bureau of Land Management.

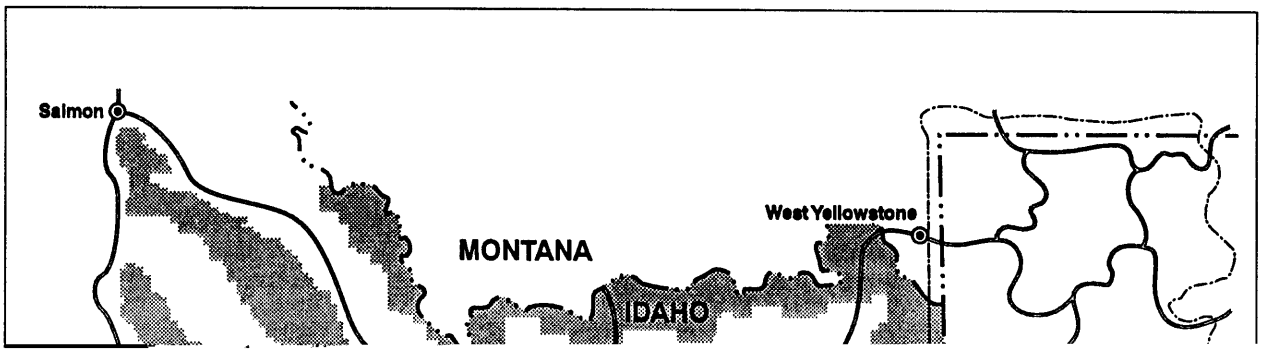
More than half of the Idaho National Engineering Laboratory is used for grazing. The actual amount of the Idaho National Engineering Laboratory land used for grazing varies from year to year, but is usually between 121,410 and 141,645 ha (300,000 and 350,000 acres). In 1992 for example, 121,853 ha (301,094 acres) were grazed (DOE, 1995c). Grazing is not allowed within 3.2 km (2 mi) of any nuclear facility, and dairy cattle are not permitted on the site to avoid the possibility of milk contamination by long-lived radionuclides. The U.S. Sheep Experiment Station, located approximately 42.6 km (26.5 mi) northeast of the site, uses a 364 ha (900 acre) portion of the Idaho National Engineering Laboratory for a winter feed lot for approximately 5,000 sheep.

The Idaho National Engineering Laboratory also supports periodic uses associated with onsite resources. Two sites within the Idaho National Engineering Laboratory site boundary are listed in the National Register of Historic Places: Experimental Breeder Reactor-I, designated in 1966, and Goodale's Cutoff, a portion of the Oregon Trail that crosses the southwest corner of the Idaho National Engineering Laboratory, designated in 1974. In addition to public tours, the Idaho National Engineering Laboratory occasionally supports controlled hunting within the site boundaries. Each year the Idaho Department of Fish and Game and DOE jointly determine whether or not to allow controlled hunts of wild game populations living on the Idaho National Engineering Laboratory property (DOE, 1995c).

Several uses associated with the National Environmental Research Park designation occur at the Idaho National Engineering Laboratory. The Idaho National Engineering Laboratory's cool desert ecosystem provides a controlled outdoor laboratory where scientists can study changes to the natural environment caused by human activities.

3.3.2.7 Noise

Sources of man-made noise at the Idaho National Engineering Laboratory include noise from operation and construction activities; bus, car, and truck traffic; aircraft; security force training exercises; and the Idaho National Engineering Laboratory railroad. Previous studies have assessed noise impacts of existing the Idaho National Engineering Laboratory operational activities (Abbott et al., 1990). These studies concluded that because of the remote location of the Idaho National Engineering Laboratory, the


Salmon
MONTANA
West Yellowstone
IDAHO

hourly transport between in-town facilities. Four major modes of transit use the regional highways, community streets, and site roads to transport people and commodities: DOE buses and shuttle vans, DOE motor pool vehicles, commercial trucks, and private automobiles.

Idaho Falls receives railroad freight service from Butte, Montana to the north, and from Pocatello, and Salt Lake City, Utah to the south via Union Pacific. The Union Pacific Railroad's Mackay Branch, which crosses the southern portion of the Idaho National Engineering Laboratory, provides rail service to the Idaho National Engineering Laboratory. This branch connects with a DOE-owned spur line at Scoville Siding, and then links with developed areas within the Idaho National Engineering Laboratory. Rail shipments to and from the Idaho National Engineering Laboratory are usually limited to bulk commodities, spent nuclear fuel, and radioactive materials.

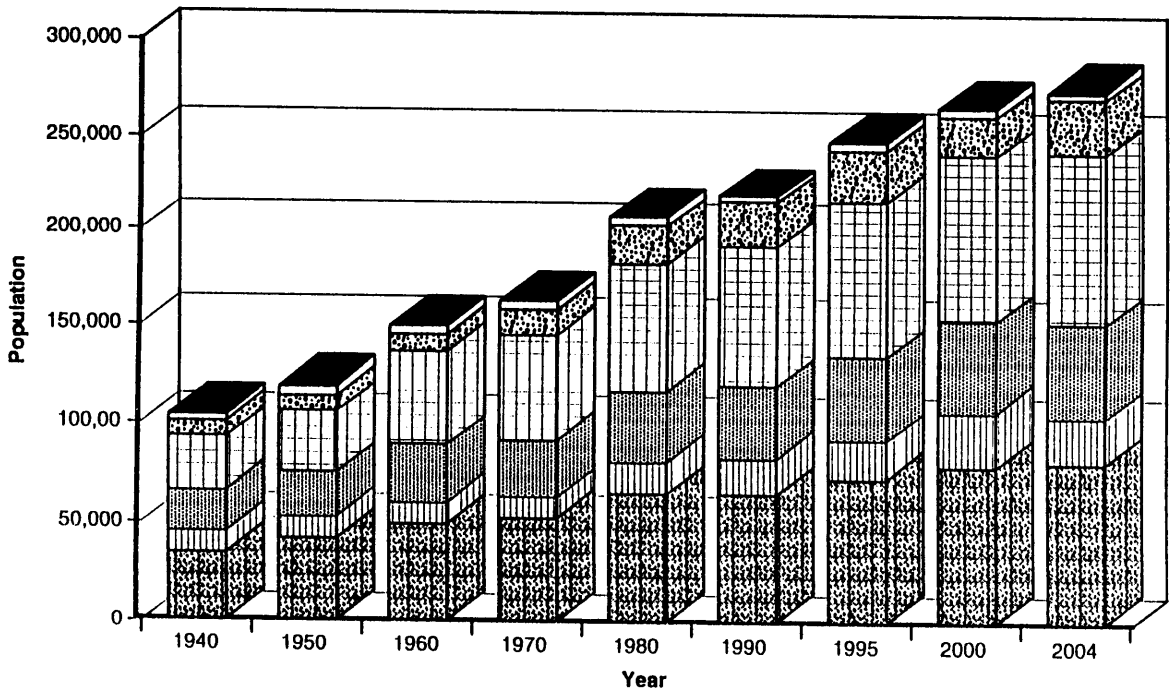
One major airline carrier, Delta Airlines, provides Idaho Falls with jet aircraft passenger and cargo service. Two other air carriers, Horizon and Skywest, provide commuter service. Daily service includes flights to and from Boise and Salt Lake City. Landings in Idaho Falls for 1991 and 1992 totalled 5,367 and 5,578, respectively. The combined number of passengers leaving and arriving at Idaho Falls and Pocatello for 1991 and 1992 was 282,185 and 285,047, respectively. Non-DOE air traffic over the Idaho National Engineering Laboratory is restricted, and non-DOE aircraft are not permitted to use the site.

From 1987 through 1992, the average motor vehicle accident rate was 0.94 accident per million km (1.5 accidents per million mi) for Idaho National Engineering Laboratory vehicles, which compares with an accident rate of 1.5 accidents per million km (2.4 accidents per million mi) for all DOE complex vehicles and 8 accidents per million km (12.8 accidents per million mi) nationwide for all motor vehicles. There are no recorded rail or air accidents associated with the Idaho National Engineering Laboratory and, to date, no fatal air traffic accidents have involved flights through either the Idaho Falls or Pocatello airports (DOE, 1995c). Spent nuclear fuel and radioactive, hazardous, industrial, municipal, and recyclable wastes are transported at the Idaho National Engineering Laboratory.

3.3.2.9 Socioeconomics

In general, population growth in the region has mirrored population growth in Idaho as a whole over the past 30 years (Figure 3-55). Although growth was not evenly distributed among the counties, total regional population increased by 47 percent between the years 1960 to 1990, which is comparable to a Statewide growth rate of 51 percent. During this period, Madison County experienced the most rapid growth in the region, its population increasing by more than 150 percent. By contrast, the two smallest counties in the region, Butte and Clark, actually lost population between the years 1960 and 1990. The largest increases in the population of Idaho Falls occurred during the 1950's, which can be partially explained by the formation and the development of the National Reactor Testing Station, which evolved into the Idaho National Engineering Laboratory. By contrast, Pocatello grew primarily in the 1940's and the 1960's. Idaho Falls has continued to grow, increasing in population by 11 percent from the years 1980 to 1990. During the same period, however, Pocatello's population declined by 0.7 percent.

Historically, the economy of the seven-county region relied predominantly on natural resource use and extraction. To this day, farming, ranching, and mining remain important components of the regional economy. Almost all manufacturing in the region is a form of food processing, and mining or mineral processing. Idaho Falls is a regional retail and service center for southeastern Idaho. Similarly, Pocatello has evolved into an important processing and distribution center for the surrounding agricultural areas, and is a regional center for higher education. Retail trade and educational services are the two largest regional employment categories, providing 17.6 and 11.4 percent of the total employment in the region. Tourism is also considered to be an important component of the regional economy. The economy of the seven-county



Note: 1995 to 2004 represent population projection

Legend:

- Clark
- Butte
- Madison
- Bonneville
- Bingham
- Jefferson
- Bannock

Figure 3-55 Actual and Projected Total Population for the Seven-County Region Surrounding the Idaho National Engineering Laboratory for the Years 1940 through 2004

region, however, currently revolves around agriculture and the Idaho National Engineering Laboratory (the single largest employer in the seven-county region). As of January 1991, DOE and its contractors employed more than 12,425 persons, with an estimated annual payroll of $440 million. Annual funding for the Idaho National Engineering Laboratory in 1991 was more than $1.1 billion.

As of January 1992, 12,803 contractor and Government personnel were employed at the Idaho National Engineering Laboratory, representing about 12 percent of the total available jobs in the seven-county region. Total employment at the Idaho National Engineering Laboratory has increased by more than 23 percent in the past 4 years. The Idaho National Engineering Laboratory has a large influence on both the regional economy and the economy of Idaho. During Fiscal Year 1992, total expenditures at the Idaho National Engineering Laboratory directly and indirectly supported 36,395 jobs, and generated an estimated $945 million in total earnings within the seven-county region.

Bonneville and Bannock Counties are the focal points of the housing market. These two counties provide 67 percent of the total housing in the region. A shortage of single-family housing presently exists near Idaho Falls because construction has not kept up with increasing demand. Total population living within the 80 km (50 mi) radius around the site is about 176,311. The ethnic composition of this population is presented in Figure 3-56. The number of low-income households within the same area of influence is presented in Figure 3-57. Approximately 40 percent of these households are low income families.

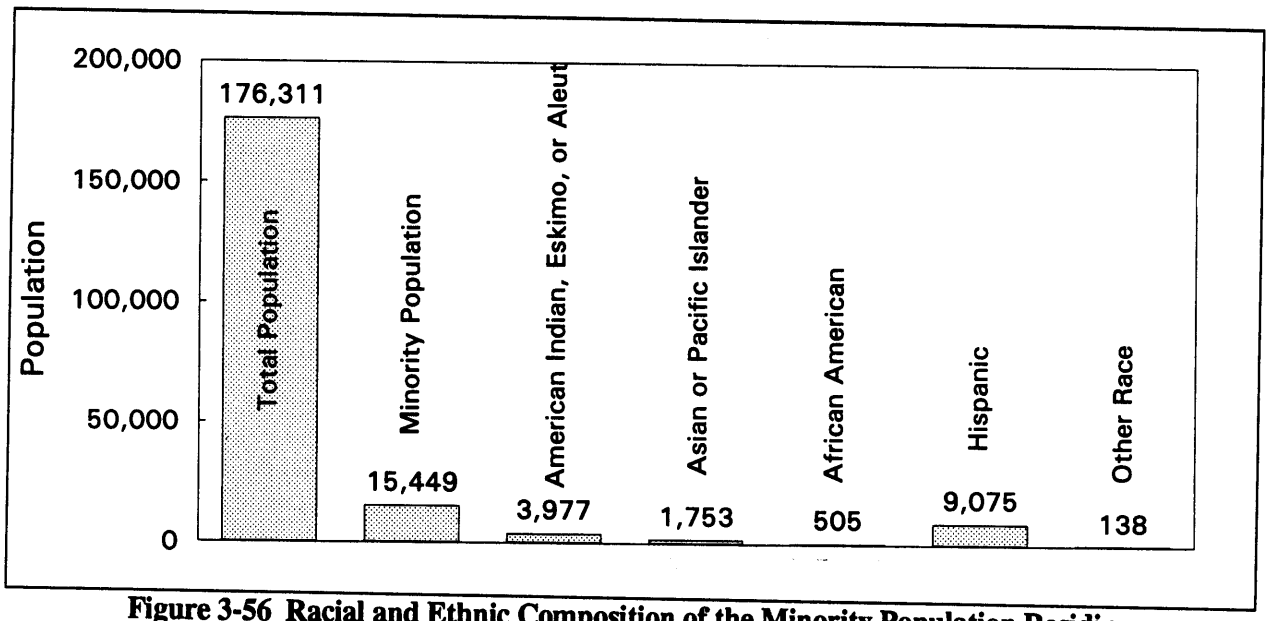
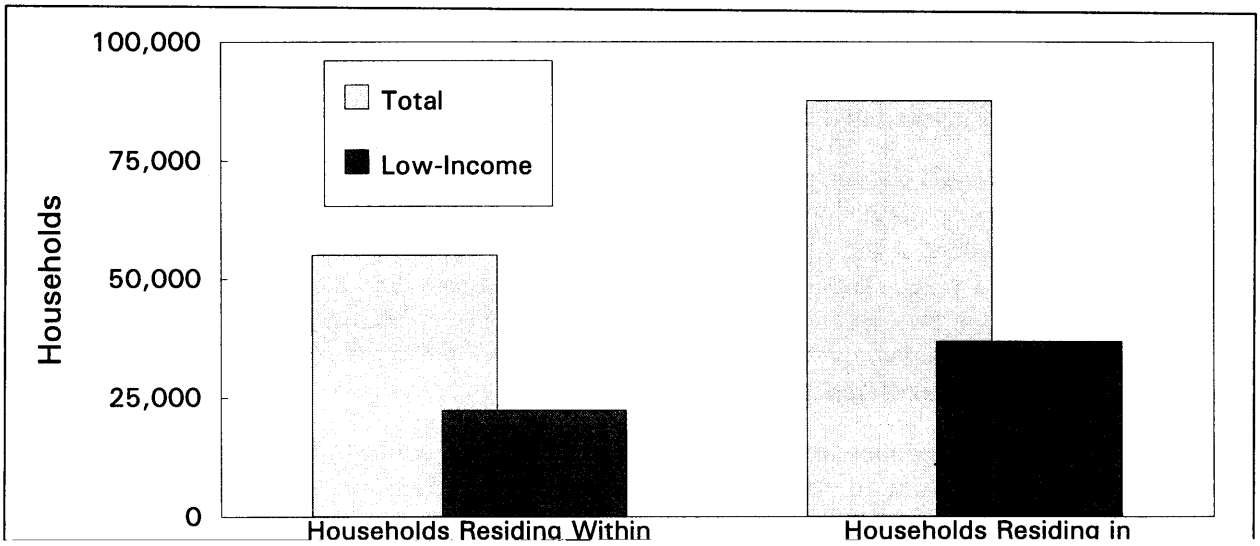


Figure 3-56 Racial and Ethnic Composition of the Minority Population Residing within 80 km (50 mi) of the Idaho National Engineering Laboratory

Seventeen public school districts provide educational services for 56,899 school-aged children within the seven-county region. Most of the public schools in the seven-county region operate at levels at or above the design capacity of their classroom facilities.

There are 18 fire districts in the seven-county area surrounding the Idaho National Engineering Laboratory. These 18 districts operate a total of 30 fire stations staffed by 179 paid and 313 volunteer firefighters. Bingham, Bonneville, Butte, Clark, and Jefferson counties, which surround the Idaho National Engineering Laboratory, have developed emergency plans to be implemented in the event of a radiological or hazardous materials emergency. Eight hospitals serve the seven-county region. The Eastern Idaho Regional Medical Center in Idaho Falls, with 311 beds, is the largest hospital in the region. Occupancy rates range from 22.0 to 89.2 percent in the region. Law enforcement services in the


100,000
75,000
50,000
25,000
0
Households
Total
Low-Income
Households Residing Within
Households Residing in

As of March, 1993, 38 historic sites and 27 historic isolated finds had been recorded on the Idaho National Engineering Laboratory (Gilbert and Ringe, 1993). These resources include small homesteads and irrigation canals, temporary campsites of sheep and cattle drivers, stage and wagon roads, and some mining-related features.

In most instances, a property must be at least 50 years old to be considered for inclusion in the National Register of Historic Places, unless it meets certain criteria. The unique nature of existing DOE site facilities at the Idaho National Engineering Laboratory and their historic role in nuclear research and

development make them eligible for special consideration regardless of their age. Two buildings dating from 1942 appear on a partial inventory of potentially significant historic the Idaho National Engineering Laboratory facilities (Braun et al., 1993). The Experimental Breeder Reactor-I is listed in the National Register of Historic Places, and is designated as a National Historic Landmark. Although the Experimental Breeder Reactor-I is the only nuclear property less than 50 years old that has been formally listed in the National Register, other DOE facilities eligible for listing have been identified, including the Auxiliary Reactor Areas I, II, III; Boiling Water Reactor Experiment V; Materials Test Reactor; Engineering Test Reactor; and the Test Area North hangar (Braun et al., 1993). The Idaho State Historic

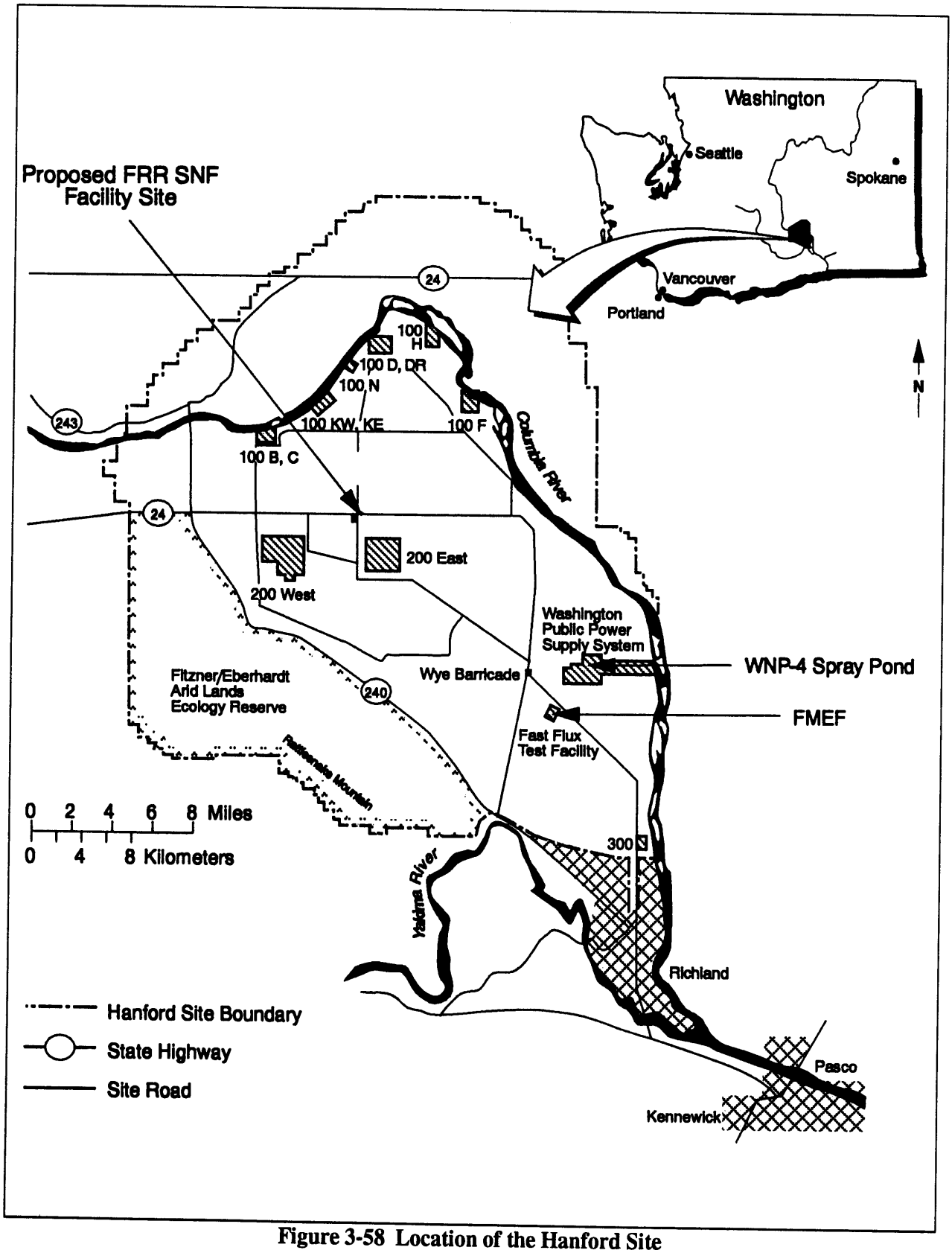


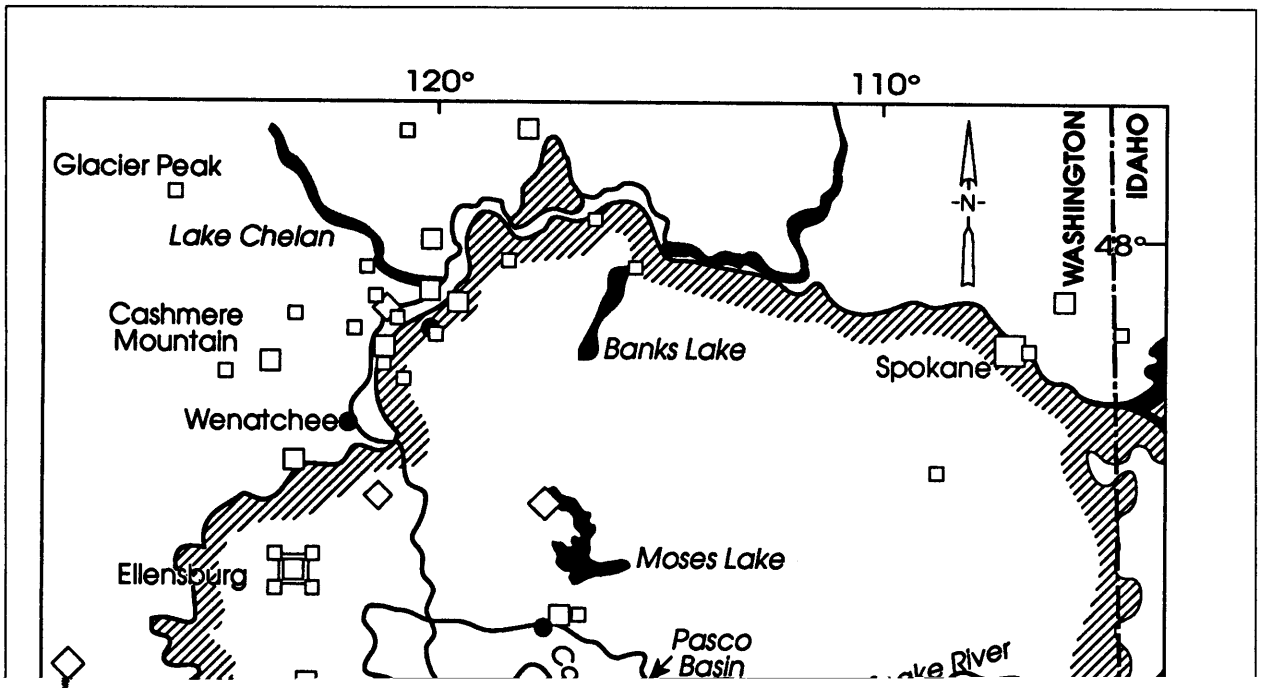
Figure 3-58 Location of the Hanford Site

the Channeled Scabland and Central Plains section. Fluvial and lacustrine processes associated with the ancestral Columbia River system have been active since the late Miocene. Sedimentary deposits indicate that deposition was continuous from about 10.5 million years ago until about 3.5 million years ago (DOE, 1988c). Quaternary volcanism has been limited to the extreme western margin of the Columbia Basin subprovince, and is associated with the Cascade Range Province.

The Hanford Site is located within the Pasco Basin, which was formed by the deformation of the lava flows into broad structural and topographic basins. The Pasco Basin is defined by anticlinal structures of basaltic rock known as the Saddle Mountains to the north, the Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills to the west, and a series of doubly plunging anticlines merging with the Horse Heaven Hills to the south.

Most known faults within the [illegible]

concurrently with the folding (DOE, 1986a). Existing known faults within the Hanford Site area include tear faults with lengths of up to 3 km (1.9 mi) on Gable Mountain, and the Rattlesnake-Wallula alignment. Strike-slip faults have not been observed crosscutting the Pasco Basin. Structures within the Hanford Site have shown the greatest deformation along the hinge area of the anticlinal ridges, decreasing with distance


120°
110°
Glacier Peak
Lake Chelan
Cashmere Mountain
Wenatchee
Ellensburg
Banks Lake
Spokane
Moses Lake
Pasco Basin
N
WASHINGTON
IDAHO
48°

There are several major volcanoes in the Cascade Range west of the Hanford Site. The nearest volcano is Mount Adams, about 165 km (103 mi) from the Hanford Site, and the most active is Mount St. Helens, approximately 220 km (137 mi) west-southwest from the Hanford Site.

3.3.3.3 Hydrology

The major geologic units of the Hanford Site are, in ascending order: basement rocks of unknown origin and composition, the Columbia River Basalt Group with interbedded sediments of the Ellensburg Formation, the Ringold Formation, the Plio-Pleistocene unit, and the Hanford formation.

3.3.3.3.1 Surface Water

The Hanford Site occupies approximately 33 percent of the land area within the Pasco Basin. Primary surface-water features associated with the Hanford Site are the Columbia and Yakima Rivers. Several surface ponds and ditches are present, and are generally associated with fuel and waste processing activities (Figure 3-60). There is no significant surface water flow from the Hanford Site to nearby rivers.

Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system along the southern boundary of the Hanford Site. Rattlesnake Springs, located on the western part of the Hanford Site, forms a small surface stream that flows for about 3 km (1.9 mi) before disappearing into the ground.

Normal river elevations within the Hanford Site range from 120 m (396 ft) above mean sea level when the river enters the Hanford Site near Vernita, to 104 m (343 ft) where it leaves the Hanford Site near the 300 Area.

Large Columbia River floods have occurred in the past (DOE, 1986a), but the likelihood of recurrence of large-scale flooding has been reduced by the construction of several flood control/water storage dams upstream from the Hanford Site. The maximum historical flood on record occurred June 7, 1894, with a peak discharge at the Hanford Site of 21,000 m^3 per sec (741,600 ft^3 per sec) (Figure 3-61). The largest recent flood took place in 1948, with an observed peak discharge of 20,000 m^3 per sec (706,300 ft^3 per sec) at the Hanford Site. The probability of flooding at the magnitude of the 1894 and 1948 floods has been greatly lowered because of upstream regulation by dams (Figure 3-60). There have been fewer than

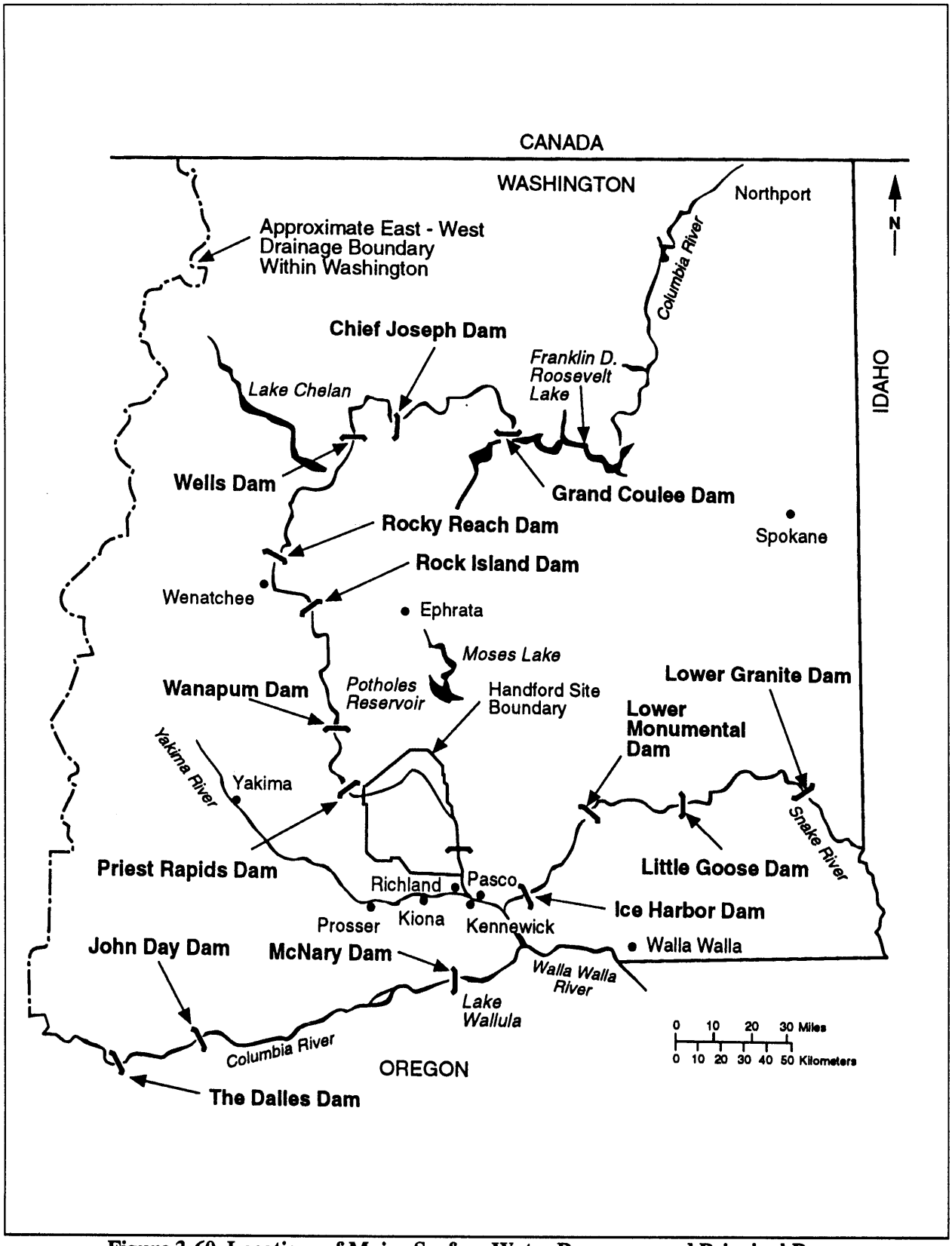
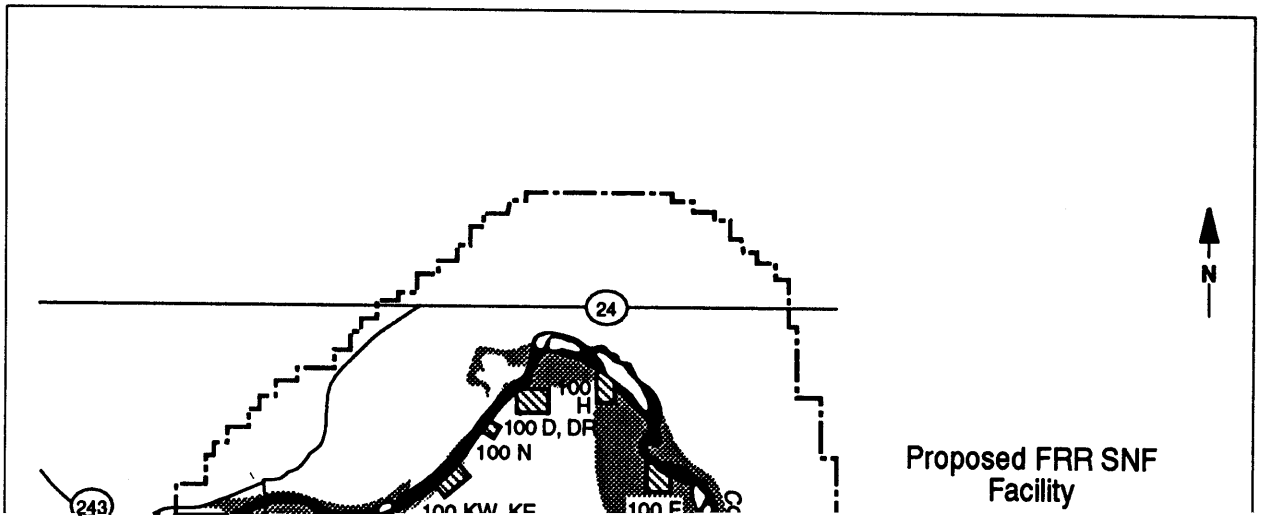


Figure 3-60 Locations of Major Surface Water Resources and Principal Dams within the Columbia Plateau


24
243
N
100 H
100 D, DR
100 N
Proposed FRR SNF Facility

Radiological monitoring shows low levels of radionuclides in samples of Columbia River water. Hydrogen-3 (tritium), iodine-129, and uranium are found in slightly higher concentrations downstream from the Hanford Site than upstream (DOE, 1995c), but were well below concentration guidelines established by DOE and U.S. Environmental Protection Agency drinking water standards. Cobalt-60 and iodine-131 were not consistently found in measurable quantities during 1987 samples of Columbia River water from Priest Rapids Dam, the 300-Area water intake, or the Richland City pumphouse. The average annual strontium-90 concentrations were essentially the same at Priest Rapids Dam and the Richland Pumphouse for 1987, and were well below the State of Washington and U.S. Environmental Protection Agency drinking water standards.

3.3.3.3.2 Groundwater

Groundwater under the Hanford Site occurs in unconfined and confined conditions. The unconfined aquifer is contained within the glaciofluvial sands and gravel and within the Ringold Formation. The bottom of the aquifer is the basalt surface or, in some areas, the clay zones of the lower member of the Ringold Formation. The confined aquifers consist of sedimentary interbeds and/or interflow zones that occur between dense basalt flows in the Columbia River Basalt Group. The main water-bearing portions of the interflow zones occur within a network of interconnecting vesicles and fractures of the flow tops or flow bottoms.

Sources of natural recharge to the unconfined aquifer are rainfall and runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima River and Columbia River.

From the recharge areas to the west, the groundwater flows downgradient to the discharge areas, primarily along the Columbia River. This general west-to-east flow pattern is interrupted locally by the groundwater mounds in the 200 Areas. From the 200 Areas, there is also a component of groundwater flow to the north

Areal and stratigraphic changes in groundwater chemistry characterize basalt groundwaters beneath the Hanford Site (Graham et al., 1981). The stratigraphic position of these changes is believed to delineate flow system boundaries, and to identify chemical evolution taking place along groundwater flow paths. Overall, waters of the shallow basalts are of a sodium-bicarbonate chemical type, while those of the deep basalts are of a sodium-chloride chemical type (DOE, 1986a). Iodine-129 and tritium have been detected in confined groundwater in the Saddle Mountains Basalt beneath the Hanford Site (DOE, 1986a).

3.3.3.4 Meteorology

The Hanford Site is located in a semi-arid region of southeastern Washington State. A summary of the following data (through 1980) has been published (Stone et al., 1983).

Wind: Prevailing wind directions on the 200-Area Plateau are from the northwest in all months of the year. Monthly and annual joint frequency distributions of wind direction versus wind speed for the Hanford Meteorological Station have been recorded (Stone et al., 1983). Monthly average wind speeds are lowest during the winter months, averaging 10 to 11 km per hr (6.2 to 6.8 mph), and highest during the summer, averaging 14 to 16 km per hr (8.7 to 9.9 mph). High winds are also associated with thunderstorms. The average occurrence of thunderstorms is 10 per year. Although thunderstorms are most frequent during the summer, they have occurred in each month (DOE, 1995c). It is estimated that the probability of a tornado striking a point at the Hanford Site is 0.0000096 per year, or less than one in one-hundred thousand.

Temperature and Humidity: Diurnal and monthly averages and extremes of temperature, dew point, and humidity have been recorded (Stone et al., 1983). Ranges of daily maximum and minimum temperatures vary from normal maxima of 2°C (35.6°F) in early January to 35°C (95°F) in late July. The record maximum temperature is 46°C (114.8F), and the record minimum temperature is -32.8°C (-27.0°F). The annual average relative humidity at the Hanford Meteorological Station is 54 percent. It is highest during the winter months, averaging about 75 percent, and lowest during the summer, averaging about 35 percent.

Precipitation: Average annual precipitation at the Hanford Meteorological Station is 16 cm (6.3 in). Most of the precipitation occurs during the winter, with nearly half of the annual amount occurring in the months of November through February. Winter monthly average snowfall ranges from 0.8 cm (0.3 in) in March to 13.5 cm (5.3 in) in January. Snowfall accounts for about 38 percent of all precipitation during the months of December through February

The Hanford Site vegetation has been characterized as a shrub-steppe (DOE, 1995c) with relatively low productivity. In the early 1800s, the dominant plant was the big sagebrush with an understory of perennial bunchgrasses, but with the advent of livestock and crop raising, the natural vegetation was overtaken by what is today the dominant plant, cheatgrass. Some planted trees exist and serve as nesting platforms for several species of birds, including hawks, owls, ravens, magpies, and great blue herons, and as night roosts for wintering bald eagles (Rickard and Watson, 1985). Today, the vegetation picture at the Hanford Site consists of eight major kinds of plant communities: sagebrush/bluebunch wheatgrass, sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass, sagebrush-bitterbrush/cheatgrass, greasewood/cheatgrass-saltgrass, winterfat/Sandberg's bluegrass, thyme buckwheat/Sandberg's bluegrass, cheatgrass-tumble mustard, willow or riparian, spiny hopsage, and sand dunes. More than 600 species of plants have been identified at the Hanford Site (Sackschewsky et al., 1992). A distribution of the dominant plant communities is shown in Figure 3-62.

More than 300 species of terrestrial and aquatic insects have been found on the Hanford Site. Grasshoppers and darkling beetles are among the more conspicuous groups, and along with other species, are important in the food web of the local birds and mammals. Approximately 12 species of amphibians and reptiles are known to exist on the Hanford Site (Fitzner and Gray, 1991). The most abundant reptile is the side-blotched lizard, although short-horned and sagebrush lizards are also seen frequently. Also common are gopher snakes, yellow-bellied racers, the Pacific rattlesnake, toads, and frogs.

More than 125 species of birds have been identified on the Hanford Site (Rogers and Rickard, 1977). The horned lark and western meadowlark are the most abundant nesting birds in the shrub-steppe. The Hanford Site supports populations of chukar partridge, gray partridge, and sage grouse, with the greatest concentration in the Rattlesnake Hills. Wastewater ponds at the Hanford Site are important habitats for songbirds, shore birds, ducks, and geese. The most important waterfowl is the Canada goose. Hawks and owls use the Hanford Site as a refuge, especially during nesting (DOE, 1995c).

Approximately 39 species of mammals have been identified on the Hanford Site (Fitzner and Gray, 1991). Most are small and nocturnal. Of this group, the Great Basin pocket mouse is the most abundant, and others include the deer mouse, Townsend ground squirrel, pocket gopher, harvest mouse, Norway rat, sagebrush vole, grasshopper mouse, vagrant, Leasts chipmunk, and Merriam vole. Larger mammals include the mule deer and elk. The largest vertebrate predator inhabiting the Hanford Site is the coyote. A herd of wild, free-roaming elk is centered almost entirely on the Arid Lands Ecology Reserve, a part of the Hanford Site established as an environmental research study area in 1968.

The Columbia River is the dominant aquatic ecosystem, and the river supports a large and diverse community of plankton, benthic invertebrates, fish, and other communities. Plankton populations in the Hanford reach are influenced by communities that develop in the reservoir of upstream dams, with phytoplankton and zooplankton populations being largely transient, flowing from one reservoir to another. Phytoplankton species include diatoms, golden or yellow-brown algae, red algae, and dinoflagellates. Zooplankton populations in the Hanford reach of the Columbia are generally sparse. All major freshwater benthic taxa are represented in the river. Forty-three species of fish had been identified in the river (DOE, 1995c), and since then the brown bullhead has been collected, bringing the number to 44. Of these, the Chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas, and are of the greatest economic importance. Small spring streams contain diverse biotic communities and are extremely productive, consisting of dense blooms of watercress and aquatic insects. Temporary wastewater ponds and ditches on the Hanford Site develop riparian communities and become quite attractive to migrating birds in autumn and spring.

Threatened, Endangered, and Candidate Plant and Animal Species: Threatened and endangered species, as listed by both the Federal Government and the State of Washington, are shown in Table 4.9-1 of Appendix A, Volume 1 of the Programmatic SNF&INEL Final EIS (DOE, 1995c). No plants or mammals on the Federal list are known to occur on the site. There are, however, several species of plants and animals that are under consideration for formal listing. Two species of plants are included in the State listing. Columbia milk-vetch, found on dry land benches along the river, is listed as threatened, and yellowcress, found on the wetted zone of the water's edge, is designated as endangered. The Federal Government lists the American peregrine falcon as endangered and the bald eagle as threatened. The State of Washington lists (in addition to the peregrine falcon and bald eagle) the white pelican and sandhill crane as endangered, and the ferruginous hawk as threatened. The peregrine falcon is a casual migrant to the Hanford Site and does not nest there. The bald eagle is a regular winter resident, foraging on dead salmon and waterfowl along the river, but not nesting on the Hanford Site. Ferruginous hawks have increasingly used power poles for nesting sites. Mammals considered endangered by the State are the pygmy rabbit, the Merriam shrew, the pallid bat, and the long-eared myotis.

Several small spring streams, wetlands, temporary water bodies, and national and State wildlife refuges are located on, or adjacent to, the Hanford Site.

3.3.3.6 Land Use

The Hanford Site encompasses 1,450 km^2 (560 mi^2), and includes several DOE operational areas. The major areas are:

- The entire Hanford Site, which has been designated a National Environmental Research Park;
- The 100 Areas, bordering on the right bank (south shore) of the Columbia River, which are the sites of the eight retired plutonium production reactors. The 100 Areas occupy about 11 km^2 (4.2 mi^2);
- The 200-West and 200-East Areas are located on a plateau about 8 and 11 km (5.0 and 6.8 mi), respectively, from the Columbia River. For some time, these areas have been dedicated to fuel reprocessing and waste processing management and disposal activities. The 200 Areas cover about 16 km^2 (6.2 mi^2);
- The 300 Area, located just north of the city of Richland, is the site of nuclear research and development and nuclear fuel fabrication. This area covers 1.5 km^2 (0.6 mi^2);
- The 400 Area covers about 0.6 km^2 (0.25mi^2) and is about 8 km (5 mi) north of the 300 Area and is the site of the Fast Flux Test Facility used in the testing of breeder reactor systems. Also included in this area is the Fuels and Material Examination Facility;
- The 600 Area includes all of the Hanford Site not occupied by the 100, 200, 300, or 400 Areas. Land uses within the 600 Area include:
  - The Arid Lands Ecology Reserve, a 310 km^2 (120 mi^2) tract set aside for ecological studies,
  - 4 km^2 (1.5 mi^2) leased by the State of Washington, part of which is used for low-level radioactive waste disposal,

- 4.4 km^2 (1.7 mi^2) for Washington Public Power Supply System nuclear power plants,
- 2.6 km^2 (1.0 mi^2) transferred to the State of Washington as a potential site for the disposal of nonradioactive hazardous wastes,
- About 130 km^2 (50 mi^2) under revocable use permit to U.S. Fish and Wildlife Refuge,
- 225 km^2 (87 mi^2) under revocable use permit to the Washington State Department of Game for recreational game management,
- Support facilities for the controlled access areas, and
- Laser Intercrometer Gravitational Wave Observatory.

Surrounding the Hanford Site, 660 km^2 (255 mi^2) have been designated for Arid Lands Ecology Reserve, U.S. Fish and Wildlife Refuge, and Washington State Department of Game (DOE, 1986a).

Land use in other areas includes urban and industrial development, irrigated and dry-land farming, and grazing. In 1985, wheat represented the largest single crop in terms of area planted in Benton and Franklin counties with 116,145 ha (287,000 acres). Corn, alfalfa, hay, and barley are other major crops in Benton and Franklin counties.

In 1986, the Columbia Basin Project, a major irrigation [illegible]

are neither Class A (residential) nor Class B (commercial). Maximum noise levels are established based on the environmental designation for noise abatement classification of the receiving area and the source

area (DOE, 1995c).

3.3.3.8 Transportation

The Tri-Cities serve as a regional transportation and distribution center with major air, land, and river connections. The Tri-Cities area has direct rail service, provided by Burlington Northern and Union Pacific, which connects the area to more than 35 States (Figure 3-63). Union Pacific operates the largest fleet of refrigerated railcars in the United States, and is essential to food processors that ship frozen food from this area. Passenger rail service is provided by Amtrak, which has a station in Pasco.

The Hanford Site infrequently uses docking facilities at the ports of Benton on the Columbia River. No barge accidents were reported in 1988 (DOE, 1995c).

Daily air passenger and freight services connect the area with most major cities through the Tri-Cities Airport in Pasco. The airport is currently served by two commuter-regional and two national airlines. The main runway is 2,350 m (7,755 ft) in length, and can accommodate landings and takeoffs by medium-range commercial aircraft, such as the Boeing 727-200 and Douglas DC-9. Two additional airports, located in Richland and Kennewick, are limited to serving private aircraft.

The Tri-Cities are linked to the region by five major roads. Route 395 joins the area with Spokane to the northeast. Both route 395 and route 240, which crosses through the Hanford Site, connect with Interstate 90 to the north. Route 12 links the region with Yakima to the northwest, Lewiston, ID to the east, and Walla Walla to the southeast. Finally, the area is linked to Interstate 84 to the south, via Interstate 82 and Route 14. Routes 240 and 24 traverse the Hanford Site and are maintained by the State of Washington. Other roads within the Hanford Site are maintained by DOE.

3.3.3.9 Socioeconomics

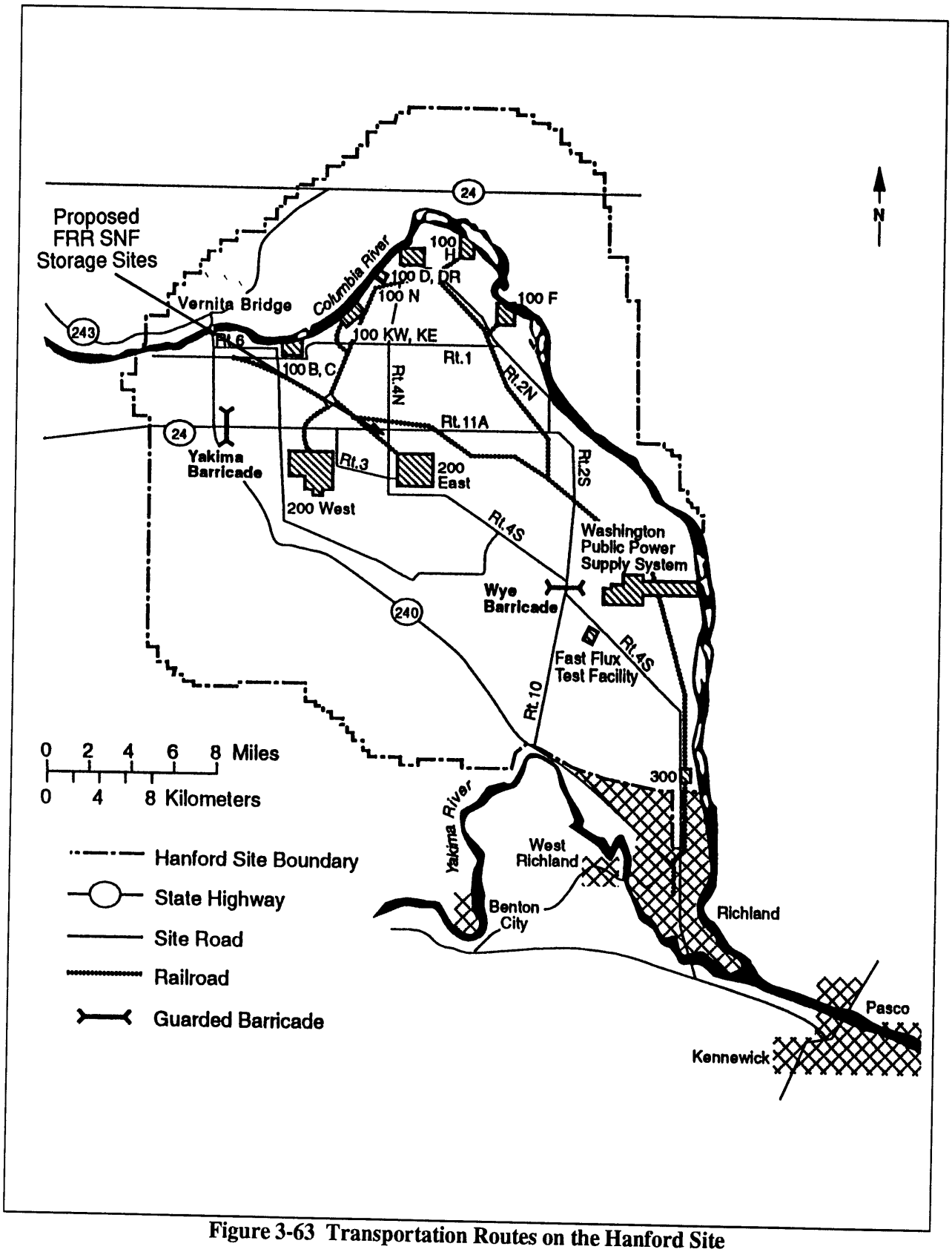


Figure 3-63 Transportation Routes on the Hanford Site

24 percent of total nonagricultural employment in Benton and Franklin counties, and slightly more than 0.6 percent of all nonagricultural Statewide jobs. In 1991, the Hanford Site operations directly accounted for an estimated 42 percent of the payroll dollars earned in the area.

The Washington Public Power Supply System continues to be a major employer in Richland, with more than 1,700 workers and an approximate $71.6 million in payroll during the year. In 1990, agriculture was responsible for nearly 12,900 jobs, nearly 17 percent of total employment. This includes about 2,200 farm proprietors accounting for $121 million in crop and livestock production which provides 7,600 wage and salary jobs, and "agri-business" (farm and ranch supporting activities such as application of fertilizers, sales of farm supplies and equipment, etc.) accounting for 900 jobs. Employment in the food processing sector included 20 food processors producing potato products, canned fruits and vegetables, wine, and animal feed.

Other major employers include about 3,500 workers in Benton and Franklin counties. Tourism has increased in the area, and overall tourism expenditures in the Tri-Cities were roughly $77.5 million in 1990. In 1990, 15,903 people over the age of 65 resided in Benton and Franklin counties. This segment of the population supports the local economy on the basis of income received from Government transfer payments and pensions, private pension benefits, and prior individual savings. A summary of estimated major Government pension benefits received by the residents of Benton and Franklin counties in 1990 is shown in Table 4.3-7 of Appendix A, Volume 1 of the Programmatic SNF&INEL Final EIS (DOE, 1995c). The estimated income of this component of the basic sector is roughly equivalent to the entire agricultural sector.

Estimates by the U.S. Bureau of the Census for 1990 place Benton and Franklin counties' population totals at 112,560 and 37,473, respectively. Within each county, the 1990 estimates distribute the Tri-Cities population as follows: Richland, 32,315; Kennewick, 42,159; and Pasco, 20,337. The 1990 estimates of racial categories by the Bureau of the Census indicate that in Benton and Franklin counties, Asians represent a lower proportion, and individuals of Hispanic origin represent a higher proportion of the racial distribution than those in the State of Washington. Fifty-six percent of the population of Benton and Franklin counties is under the age of 35, compared to 54 percent for the State of Washington, and the 65-yr-old and older group constitutes 10 percent of the population, compared to 12 percent for the State.

Social and economic impacts of the Hanford Site operations are concentrated in Benton County, Franklin County, and the Tri-Cities area made up of Pasco, Richland, and Kennewick. The region of influence for the Hanford Site is represented by the 80 km (50 mi) radius around the site. Figure 3-64 represents the general ethnic characteristics of the population within the 80 km (50 mi) radius. Low income data for the region of influence is shown in Figure 3-65. A low-income household is one with an income of 80 percent or lower than the median income of the county. Approximately 42 percent of the households in the region of influence are low income families.

In 1990, nearly 92 percent of all housing (38,781 total units) in the Tri-Cities was occupied. Single-unit housing, which represents nearly 58 percent of the total units, has a 96 percent occupancy rate. Multiple-unit housing has an occupancy rate of nearly 91 percent. Pasco has the lowest occupancy rate, 89 percent in all categories of housing, followed by Kennewick (93 percent) and Richland (94 percent). Representing nine percent of the housing unit types, mobile homes have an 81 percent occupancy rate.

Primary and secondary education are served by the Richland, Kennewick, Pasco, and Kiona-Benton school districts. In 1992, spring enrollment for all districts was approximately 24,876 students. Post-secondary education in the Tri-Cities area is provided by a junior college, Columbia Basin College, and the Tri-Cities branch campus of Washington State University.

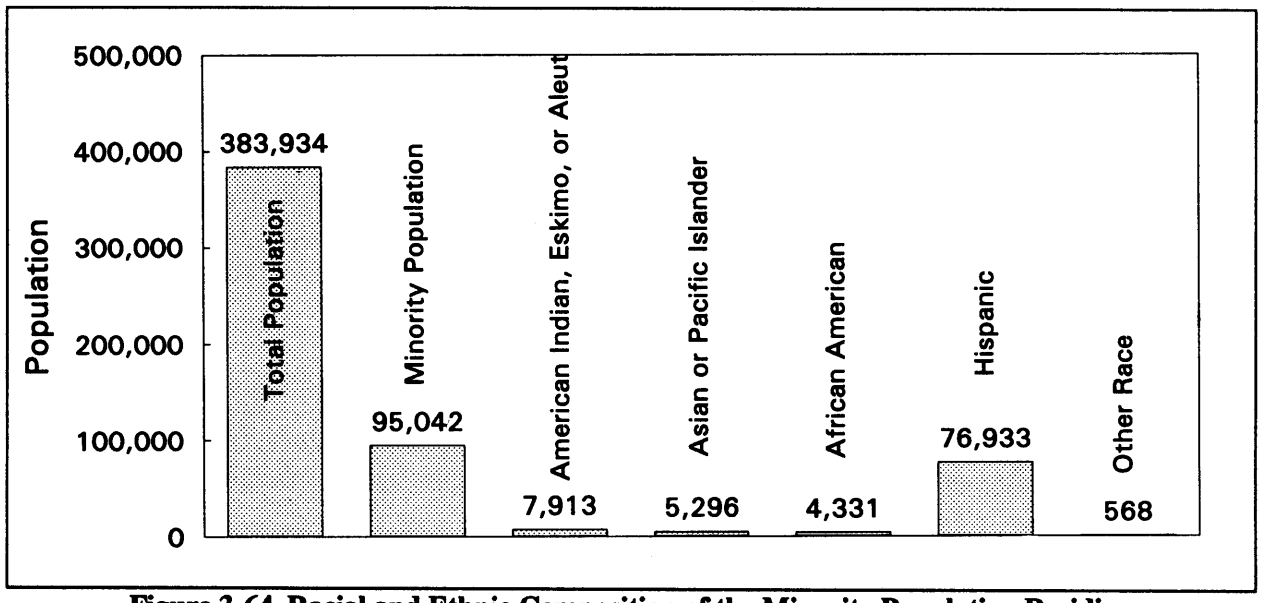


Figure 3-64 Racial and Ethnic Composition of the Minority Population Residing within 80 km (50 mi) of the Hanford Site

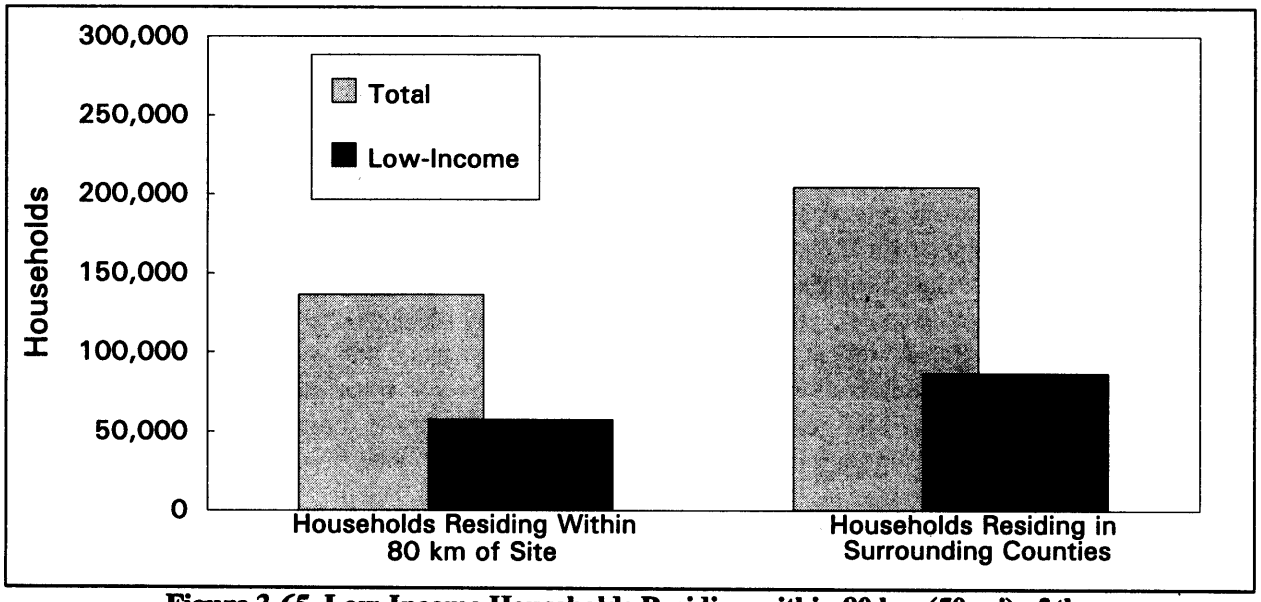


Figure 3-65 Low-Income Households Residing within 80 km (50 mi) of the Hanford Site

The Tri-Cities have three major hospitals and four minor emergency centers. Kadlec Medical Center, located in Richland, has 136 beds and functions at an average of 39.5 percent capacity. Kadlec Medical Center's 5,754 annual admissions represent more than 42 percent of the Tri-Cities market. Kennewick General Hospital maintains an average 45.5 percent occupancy rate of its 71 beds with 3,619 admissions. Our Lady of Lourdes Hospital, located in Pasco, reports an average occupancy rate of 36.5 percent.

Police and fire protection in Benton and Franklin counties is provided by Benton and Franklin county sheriff's departments, local municipal police departments, and the Washington State Patrol Division, headquartered in Kennewick. The Hanford Fire Patrol is composed of 126 trained firefighters.

The principal source of water in the Tri-Cities and the Hanford Site is the Columbia River, from which the water systems of Richland, Pasco, and Kennewick draw a large portion of the average 43 billion liters (11.4 billion gal) used in 1991. Electricity is provided by the Benton County Public Utility District, Benton Rural Electric Association, Franklin County Public Utility District, and city of Richland Energy Services Department. In the Pacific Northwest, hydropower, and to a lesser extent, coal and nuclear power, constitute the region's electrical generation system. Throughout the 1980's, the Northwest had more electric power than it required, and was operating at a surplus. This surplus has been exhausted, and there is only approximately enough power supplied by the existing system to meet the current electricity needs.

3.3.3.10 Historical, Archaeological, and Cultural Resources

The Hanford Site is rich in cultural resources, and contains numerous well-preserved archaeological sites representing both prehistoric and historical periods. The area is considered a homeland by many Native Americans.

More than 10,000 years of prehistoric human activity in the Middle Columbia River region have left extensive archaeological deposits along river shores (DOE, 1995c) and well-watered areas inland from the river (DOE, 1995c; Greene, 1975;). Graves are common in various settings, and spirit quest monuments are found on high, rocky summits (Rice, 1968). By virtue of their inclusion in the Hanford Site, from which the public is restricted, archaeological deposits found in the Hanford reach of the Columbia River, on adjacent plateaus, and mountains have been spared some of the disturbances that have befallen other sites.

There are currently 248 prehistoric archaeological sites recorded in the files of the Washington State Office of Archaeology and Historic Preservation. Forty-seven of these sites are included on the National Register of Historic Places, two as single sites (45BN121, the Hanford Island Site; 45GR137, Paris Site), and the rest in seven archaeological districts. In addition, a nomination has been prepared for one cultural district (Gable Mountain/Gable Butte), and a renomination for two additional archaeological districts is pending (Wahluke, Coyote Rapids). Two other sites, 45BN90 and 45BN412, are considered eligible for the National Register. Archaeological sites include remains of numerous pithouse villages, various types of open campsites, and cemeteries along the riverbanks (DOE, 1995c), spirit quest monuments, hunting camps, game drive complexes and quarries in mountains and rocky bluffs, hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water located away from the river (Rice, 1968).

Native American people of various tribal affiliations have populated the Hanford reach of the Columbia River since prehistoric and early historic times. Wanapums and Yakama people of the Chamnapum band, and some of their descendants still live nearby, while others have been incorporated into the Yakama and Umatilla Reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford reach and inhabited the river's west bank (DOE, 1995c). Walla Walla and Umatilla people also made periodic visits to the area to fish. These groups retain traditional and secular ties to the region, with native plant and animal foods, some found on the Hanford Site, being used in ceremonies. Certain landmarks, especially Rattlesnake Mountain, Gable Mountain, Gable Butte, Goose Egg Hill and others along the river are considered sacred. The many cemeteries found along the river are considered sacred by these groups.

Two hundred-two historic archaeological sites and 11 other historic localities have been recorded in the published literature. Localities include the Allard Pumping Plant at Coyote Rapids, the Hanford Irrigation Ditch, the Hanford townsite, Wahluke Ferry, the White Bluffs townsite, the Richmond Ferry, Arrowsmith

townsite, a cabin at East White Bluffs ferry landing, the White Bluffs road, the old Hanford high school, and the Cobblestone Warehouse at Riverland (DOE, 1995c). In addition to recorded sites, numerous data from additional unrecorded sites, including homesteads, corrals, and dumps, have been recorded by the Hanford Cultural Resources Laboratory since 1987. The 100-B Reactor has been listed on the National Register of Historic Places. Other Manhattan Project facilities remain to be evaluated.

3.3.4 Description of the Affected Environment at the Oak Ridge Reservation

The Oak Ridge Reservation is a key DOE site hosting three separate facilities with missions including basic and applied research and development; storage of special nuclear materials; weapons dismantlement, storage, and evaluation; and environmental restoration and waste management. The site is operated for DOE by Martin Marietta Energy Systems. This section describes the potentially affected environment at the Oak Ridge Reservation.

3.3.4.1 Geology

The Oak Ridge Reservation lies within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau, in the State of Tennessee (Figure 3-66). The Valley and Ridge Province is characterized by numerous linear ridges and valleys that trend approximately southwest-northeast. A generalized geologic map of the Oak Ridge Reservation is shown in Figure 3-67. The Oak Ridge Reservation is mostly underlain by the Rome Formation and Conasauga, Knox, and Chickamauga Groups, sedimentary rocks of Cambrian and Ordovician age. A detailed description of these formations is given in the Programmatic SNF&INEL Final EIS (DOE, 1995c).

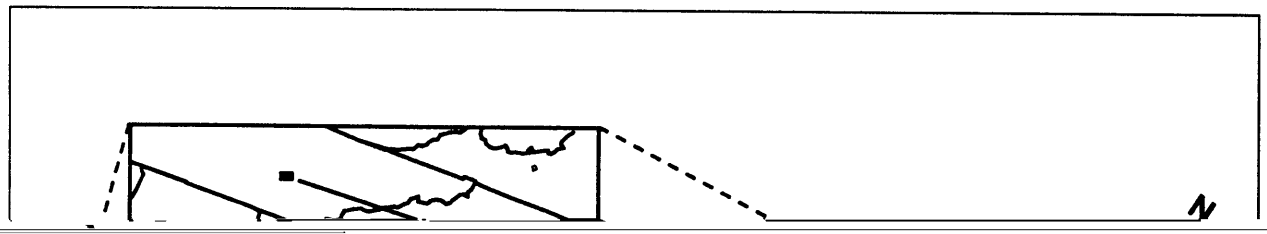
Sinkholes, large springs, caves, and other karst features are common in the Knox Group, and those parts of the Oak Ridge Reservation underlain by limestones and dolomites are classified as karst terrains. Although no site-specific geologic characterization has been conducted at the West Bear Creek Valley site, it appears that the proposed site for the construction of a foreign research reactor spent nuclear fuel storage facility is located over the lower Conasauga Group strata not normally characterized by karst development.

The soils found in the Oak Ridge Reservation vicinity generally contain clay minerals, chert, and quartz sand (Hatcher et al., 1992). Soils on the Oak Ridge Reservation tend to retain moisture, and are typically 90 percent saturated below a depth of 3 m (10 ft) (Ketelle and Huff, 1984). Depth of soil profiles on the Oak Ridge Reservation vary from 15 cm (5.9 in) on slopes, to 18 m (60 ft) over dolomites in the Knox Group (Boyle et al., 1982).

3.3.4.2 Seismology and Volcanology

The Oak Ridge Reservation 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 inactivity. From 1811 to 1975, only five major earthquakes or earthquake series have affected the Oak Ridge Reservation area. 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). During the 1811 to 1975 period, none of the earthquakes were of a magnitude that caused severe damage to buildings or structures.

The underlying structure of the Oak Ridge Reservation is complex due to the extensive faulting and deformation characteristic of the region. There are three regional thrust faults in the Oak Ridge Reservation area, the Kingston, Whiteoak Mountain, and Copper Creek Faults. All three strike to the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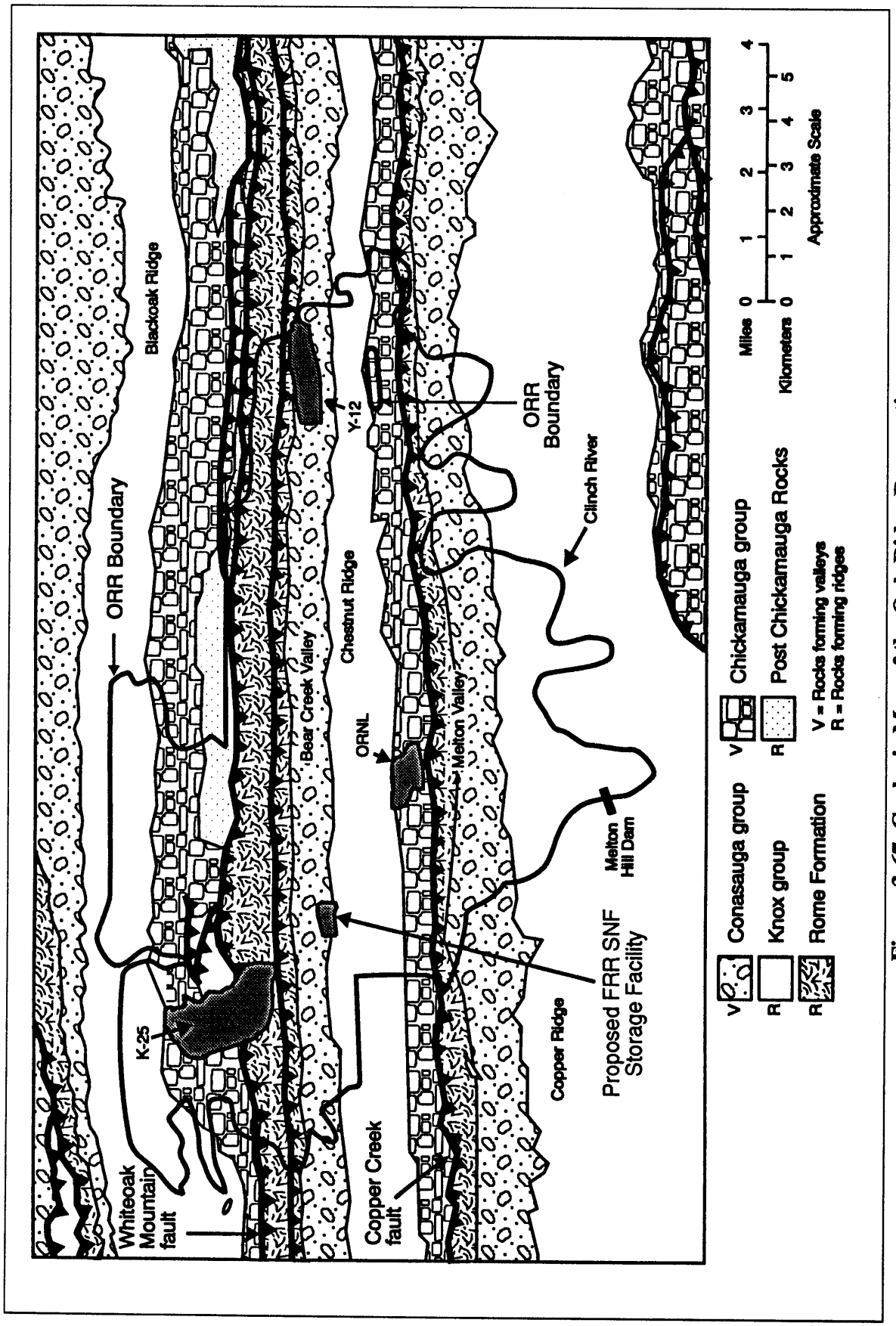


Figure 3-67 Geologic Map of the Oak Ridge Reservation

3.3.4.3 Hydrology

3.3.4.3.1 Surface Water

The hydrologic system on the Oak Ridge Reservation is controlled by the Clinch River (MMES, 1993a). Its drainage area is about 11,422 km^2 (4,410 mi^2) (Boyle et al., 1982). All water that drains from the Oak Ridge Reservation enters the Clinch River, and subsequently the Tennessee River. Flow in the Clinch-Tennessee river system is regulated by multi-purpose dams of the Tennessee Valley Authority.

The Oak Ridge Reservation is drained by a network of tributaries of the Clinch River. A Statewide stream classification system based on water quality, water use, and resident aquatic biota designates most streams on the Oak Ridge Reservation for fish and aquatic life, irrigation and livestock watering (MMES, 1993b). The drainage pattern on the Oak Ridge Reservation is a weakly developed "trellis" pattern (Lee and Ketelle, 1987), and the surface drainage patterns are also affected by karst topography.

Heavy precipitation in the area causes localized flooding, primarily in the city of the Oak Ridge (MMES, 1993a) and along the Clinch River. Figure 3-68 shows approximate 500-yr floodplains. A number of wetlands occur on the Oak Ridge Reservation (MMES, 1993b), including characteristic forested wetlands along creeks, wet meadows and marshes associated with streams and seeps, and emergent communities in shallow embayments and ponds.

Surface Water Quality: Water quality in the Clinch River is affected by the Oak Ridge Reservation activities, by contaminants introduced upstream from the Oak Ridge Reservation, 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.

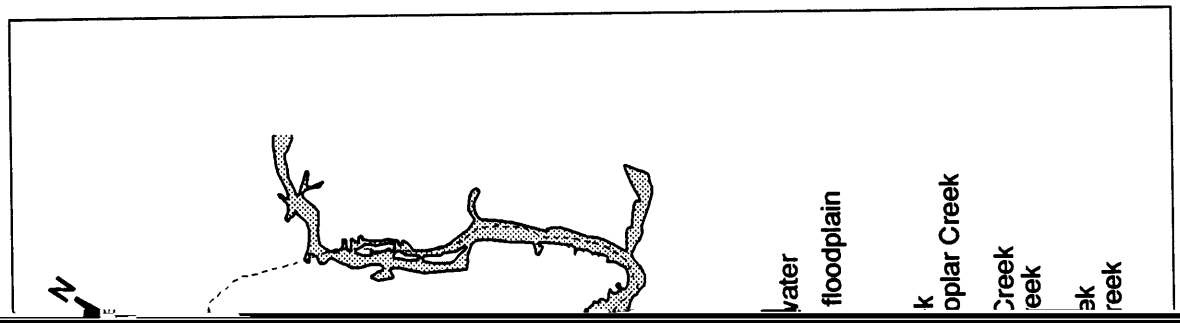
The Clinch River supplies most of the water to the Oak Ridge Reservation, the city of Oak Ridge, and other cities along the river (MMES, 1993a). Major water uses in the Oak Ridge area include withdrawals for industrial and public water supplies, commercial and recreational navigation, and other recreational activities such as fishing, boating and swimming. Water for the city of Oak Ridge is withdrawn upstream from any of the Oak Ridge Reservation discharge points. Five public water supplies, including the cities of Kingston and Harriman, TN, are located downstream of the Oak Ridge Reservation (MMES 1993a). These are located 4 km (2.5 mi) above and 34 km (21 mi) below the mouth of Poplar Creek, respectively.

3.3.4.3.2 Groundwater

Groundwater beneath the Oak Ridge Reservation is heavily influenced by the site geologic structure (Solomon et al., 1992). Geologic units of the Oak Ridge Reservation are assigned to two broad hydrologic groups, Knox Aquifer and the Oak Ridge Reservation aquitards. These aquitards may store fairly large volumes of water, but they transmit only limited amounts.

The Knox Aquifer is the only true aquifer of the Oak Ridge Reservation, and is the primary source of sustained natural flow in perennial streams (Solomon et al., 1992). Flow volumes and potential groundwater flow path length in the Knox Aquifer are greater than in the aquitard. No spent nuclear fuel management facilities would be sited in areas overlying the Knox aquifer.

Recently published reports such as "Status Report; A Hydrologic Framework for the Oak Ridge Reservation", and "Status Report on the Geology of the Oak Ridge Reservation" have all used the term "aquitard" to describe the Pumpkin Valley Shale and a number of the other geologic units beneath the Oak Ridge Reservation. No site-specific data are available to determine at what depth Pumpkin Valley Shale is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encountered at the West Bear Creek Valley, the proposed site for the construction of foreign research reactor spent nuclear fuel storage facilities. It would be logical, however, to think that at depths of 18 m (60 ft) or less on the site, the water-bearing unit most likely to be encountered would be an aquitard (DOE, 1995c).

Groundwater Quality: Background groundwater quality at the Oak Ridge Reservation is generally good in the surficial aquifer zones, and poor in the bedrock aquitards at depths greater than 305 m (1,000 ft) (DOE, 1993d). Groundwater has been contaminated downgradient from waste management facilities and other industrial sources, and discharge of contaminated groundwater has introduced contaminants to streams. Principal groundwater contaminants that exceed applicable standards at the Y-12 Plant include volatile organics, nitrates, heavy metals, and radioactivity (MMES, 1993b). There is one known instance of offsite migration of contaminants from the Oak Ridge Reservation. In 1994, DOE announced that elevated levels of four industrial solvents (carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene) had been detected in the Knox Aquifer monitoring wells east of the Y-12 Plant (Bowdle, 1994). The same solvents are found in groundwater monitoring wells within the Y-12 Plant.

There are no sole-source aquifers beneath the Oak Ridge Reservation (DOE, 1993d). Water rights are not an issue in the region. All groundwater at the Oak Ridge Reservation is classified as Class II (current and potential sources of drinking water and those waters having other beneficial uses).

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, 1993b). Single-family wells are common in areas not served by public water supplies (MMES, 1992). Due to the abundance of surface water and its proximity to the points of use, almost no groundwater is used at the Oak Ridge Reservation (DOE, 1993d).

3.3.4.4 Meteorology

The Oak Ridge Reservation is located within the Great Valley of Tennessee, in which Cumberland Plateau borders to the northwest and the Great Smoky Mountains lie to the southeast. The climate at the Oak Ridge Reservation is influenced by these terrain features.

Wind: 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. This situation is reversed in the fall. Damaging winds are uncommon in the region. Peak gusts recorded in the Great Valley are generally in the 27 to 31 m per sec (60 to 70 mph) range for the months of January through July, in the 22 to 27 m per sec (50 to 60 mph) range for August, September, and December, and in the 16 to 20 m per sec (36 to 45 mph) range in October and November.

Temperature and Humidity: The average daily temperature at the Oak Ridge National Weather Service Station was 14.2°C (57.6°F) for the period of record 1961-1990. The average daily temperature 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. The mean 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.

Precipitation: Winter is the wettest of the seasons in the Oak Ridge Reservation area, March and December are the wettest months, and October is the driest. The maximum monthly precipitation was 48.9 cm (19.3 in) in July, while maximum rainfall in a 24-hr period observed at the Oak Ridge National Weather Service was 19 cm (7.5 in), recorded in August 1960 (DOE, 1995c). The annual average precipitation reported by the National Weather Service for the Oak Ridge was 137.2 cm (54 in).

On average, about 51 thunderstorm days per year are recorded at the Oak Ridge National Weather Service station. 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 Oak Ridge Reservation is located. The Oak Ridge Reservation did experience a tornado from a severe thunderstorm on February 21, 1993. The tornado path passed the Y-12 Plant in an east-northeast direction for approximately 21 km (13 mi), ending just north of Knoxville. The wind speeds associated with this tornado ranged from 18 m per sec (40 mph) to nearly 58 m per sec (130 mph), depending on the location along the path (DOE, 1993c). Hurricanes are rarely sustained once they reach as far inland as the Great Valley, due to the rapid loss of energy.

Atmospheric Dispersion: The transport and dispersion of airborne material are direct functions of air movement. The atmospheric conditions are unstable (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 m (33 ft) level.

Air Quality: A summary of the Oak Ridge Reservation airborne radionuclide emissions for 1992 is presented in Table 4.7-1 of Appendix F, Volume 1 of the Programmatic SNF&INEL Final EIS (DOE, 1995c). The maximum effective dose equivalent at the Oak Ridge Reservation boundary is 3.3 mrem as calculated by the GENII code. This is 33 percent of the National Emissions Standards for Hazardous Air Pollutants.

The Oak Ridge Reservation 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 (40 CFR 81.343).

3.3.4.5 Ecology

Land for the Oak Ridge Reservation was primarily in agricultural use, including woodlots and woodlands used for pasture, at the time of acquisition by DOE's predecessor agencies. At least half of the Oak Ridge Reservation was forested. Most of the forest had been partially cut for timber, but not completely cleared on steep slopes. Natural plant communities have re-established themselves on most of the Oak Ridge Reservation, although many areas are maintained as pine plantations or nonforested areas (ORNL, 1988). Approximately 10 percent of the Oak Ridge Reservation has been developed since it was withdrawn from public access, and the remainder of the site has reverted to or been planted with natural vegetation (MMES, 1989).

The vegetation of the Oak Ridge Reservation has been categorized into seven plant communities (Parr and Pounds, 1987). The Oak Hickory forest is one of the most extensive plant communities on the Oak Ridge Reservation. Another abundant plant community is the Pine Hardwood forest and Pine plantations. A total of 899 species, subspecies, and varieties of plants have been identified on the Oak Ridge Reservation (Cunningham and Pounds, 1991). The Oak Ridge Reservation also provides habitat for a large number of animal species. Twenty-six species of amphibians, 33 species of reptiles, 169 species of birds, and

Vegetative communities of the West Bear Creek site are typical of the Oak Ridge Reservation 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). Fauna of the site would also be similar to those expected throughout the Oak Ridge Reservation.

Wetlands on the Oak Ridge Reservation include emergent, scrub/shrub, and forested wetland located in embayments of the Melton Hill and Watts Bar Reservoirs that border the Oak Ridge Reservation, 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. Originating on the lower slopes of Pine Ridge are several headwater tributary systems on Grassy Creek that flow from north to south across the West Bear Creek site. The stream valleys contain forested wetlands.

Aquatic habitats on or adjacent to the Oak Ridge Reservation range from small, free-flowing streams in undisturbed watersheds to larger streams with altered flow patterns due to dam construction. These aquatic habitats include tailwaters, impoundments, reservoir embayments, and large and small perennial streams.

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 spent nuclear fuel management site. Grassy Creek has a diverse assemblage of invertebrates and fish species for a stream its size. The Oak Ridge Reservation uses Grassy Creek as a reference area for studies of other streams affected by site development (Pounds et al., 1993).

Threatened, Endangered, and Candidate Plant and Animal Species: No animal species listed by the Federal Government as threatened or endangered are known to reside on the Oak Ridge Reservation (Kroodsma, 1987). The bald eagle is a winter visitor to Watts Bar Lake and Melton Hill Lake. None of the species listed in Table 4.9-1 of Appendix F, Volume 1 of the Programmatic SNF&INEL Final EIS have been recorded on the proposed West Bear Creek Valley site (DOE, 1995c). Table 4.9-1 of Appendix F, Volume 1 of the Programmatic SNF&INEL Final EIS lists 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 (DOE, 1995c). 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 (DOE, 1995c). No intensive threatened and endangered species surveys have been completed for the site, but they are currently in progress for the entire the Oak Ridge Reservation (King et al., 1994).

3.3.4.6 Land Use

The Oak Ridge Reservation occupies an area of approximately 14,029 ha (34,667 acres) in eastern Tennessee, in a predominantly rural area about 40 km (25 mi) west of Knoxville. The Oak Ridge Reservation is within the jurisdictional boundaries of the city of Oak Ridge, and also lies within Roane and Anderson Counties (MMES, 1989).

Land use activities at the Oak Ridge Reservation have historically occurred within the boundaries of the three main plant sites (Y-12, the Oak Ridge National Laboratory, and K-25). The Oak Ridge Reservation has been used by research institutions, universities, and Government agencies as a site for the study of terrestrial ecology, aquatic ecology, forestry, and agriculture. Land uses bordering the Oak Ridge Reservation 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 boundaries of the Oak

Ridge Reservation in the city of Oak Ridge. Figure 3-69 shows the land use in and around the Oak Ridge Reservation. The entire Oak Ridge Reservation has been placed under the forestry, agriculture, industry, and research zoning classification by the city of Oak Ridge. This classification does not bind DOE land use decisions on the site.

The region surrounding the Oak Ridge Reservation has numerous local, State, and national public recreation areas. Several lakes exist within the region surrounding the Oak Ridge Reservation, offering year-round recreational activities such as fishing and boating. The Oak Ridge Reservation is a controlled area, with public access limited to through traffic on Tennessee State Routes 95, 58, 62, 162, and 170 (MMES, 1991). There are no onsite areas that are subject to Native American Treaty rights or that contain any prime or unique farmland.

3.3.4.7 Noise

The major noise sources within the Oak Ridge Reservation occur primarily in developed operational areas

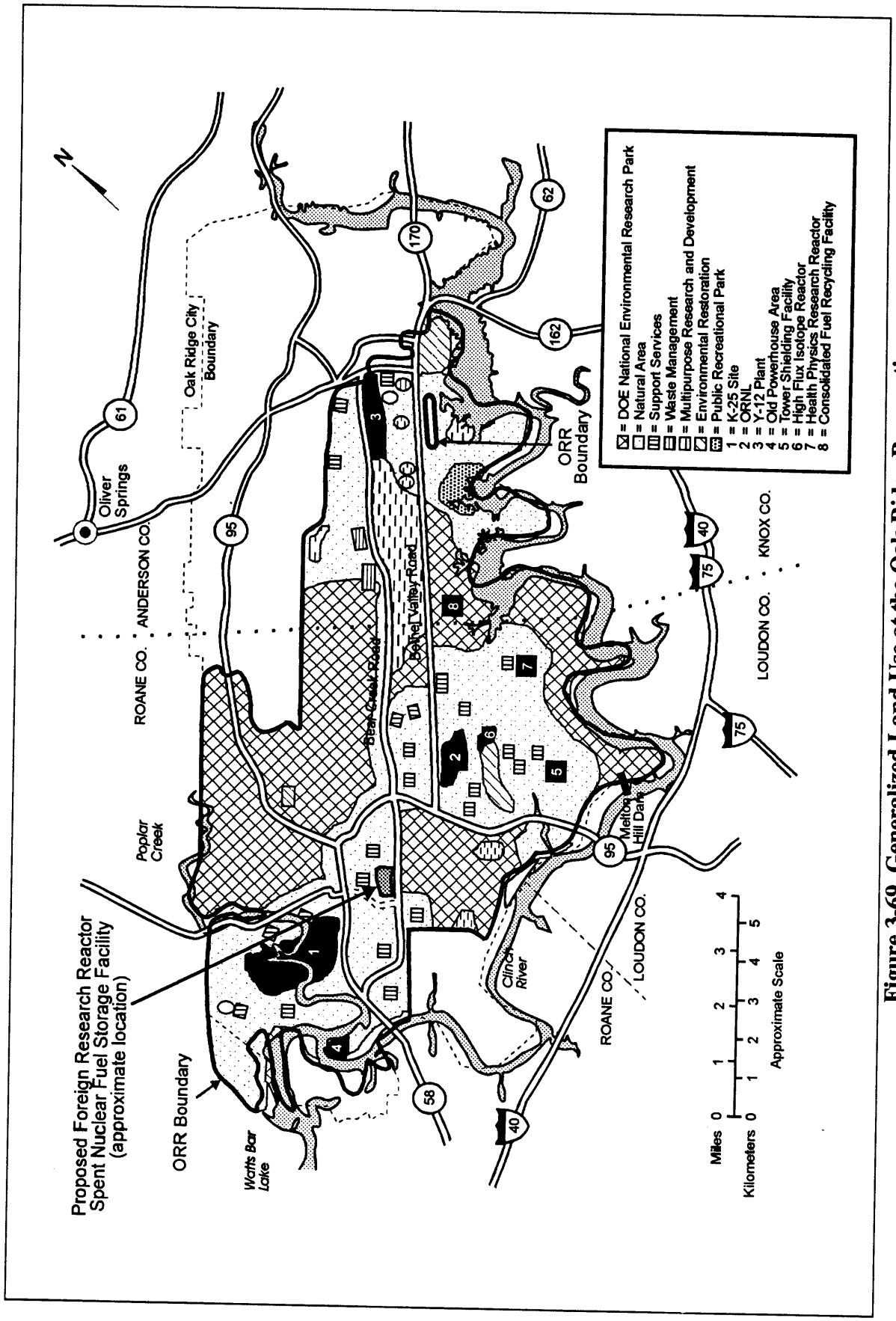
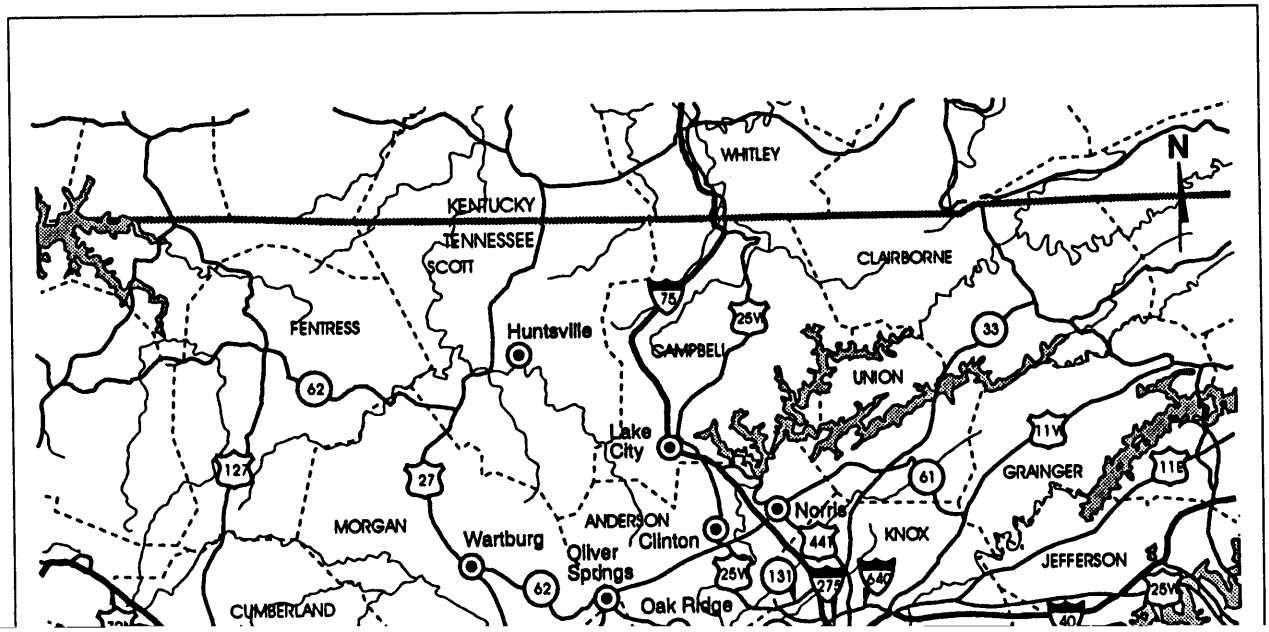


Figure 3-69 Generalized Land Use at the Oak Ridge Reservation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Wartburg
ANDERSON
Clinton
Norris
KNOX
Oliver Springs
Oak Ridge
JEFFERSON
CUMBERLAND
75
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62
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27
11W
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131
275
640
40

McGhee Tyson Airport in Knoxville, 64 km (40 mi) from the Oak Ridge Reservation, receives jet air passenger and cargo services from both national and international carriers. The closest air transportation facility to the Oak Ridge Reservation is Atomic Airport in Oliver Springs. Numerous other private airports are located throughout the region of influence (DOE, 1995c).

3.3.4.9 Socioeconomics

The region of influence includes the current residential distribution of DOE and contractor personnel employed by the Oak Ridge Reservation, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the Oak Ridge Reservation. The region of influence includes the counties where 92 percent of DOE and contractor personnel employed by the Oak Ridge Reservation reside.

Regional economic linkage supporting production activity at the Oak Ridge Reservation occurs primarily with Anderson, Knox, Loudon, and Roane counties, where most of the offsite supporting contractors and labor and capital supporting indirect economic activity linked to the Oak Ridge Reservation are located. The total population of the region of influence is projected to be 489,230 persons in 1995 (DOE, 1995c), and is projected to grow at an annual average rate of less than 1 percent, reaching 538,820 persons in 2004. The labor force 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 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.

Figure 3-71 shows the racial and ethnic composition of minorities within 80 km (50 mi) of spent nuclear fuel management sites on the Oak Ridge Reservation. In comparison with the other four candidate sites, the Oak Ridge Reservation has the smallest percentage, about 6 percent, of minorities in the population residing around the site. African Americans make up approximately 76 percent of the minority population, while Hispanics and Asian Americans make up 8 to 9 percent of the minority population.

Figure 3-72 presents the low-income households residing within 80 km (50 mi) of the Oak Ridge Reservation. About 44 percent of the households are classified as having an income no larger than 80 percent of the median income for the county of residence. This percentage is typical of that for counties within 80 km (50 mi) of the spent nuclear fuel management sites.

The Oak Ridge Reservation fire protection services are provided by the fire departments on the reservation. The Oak Ridge Reservation fire departments have mutual aid agreements among themselves and with the city of Oak Ridge (DOE, 1995c). Twelve city, county, and State law enforcement agencies provide police protection in the region of influence. Law enforcement on the Oak Ridge Reservation is provided by the city of Oak Ridge Police Department. Security enforcement is provided by the prime management and operations contractor (MMES, 1989). Four county school districts (Anderson, Knox, Loudon, and Roane) and five city school districts (Clinton, Oak Ridge, Lenoir City, Kingston, and Harriman) provide public education services in the region of influence. In 1992, the nine school districts had an average daily membership of 75,825 students. 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 (DOE, 1995c).

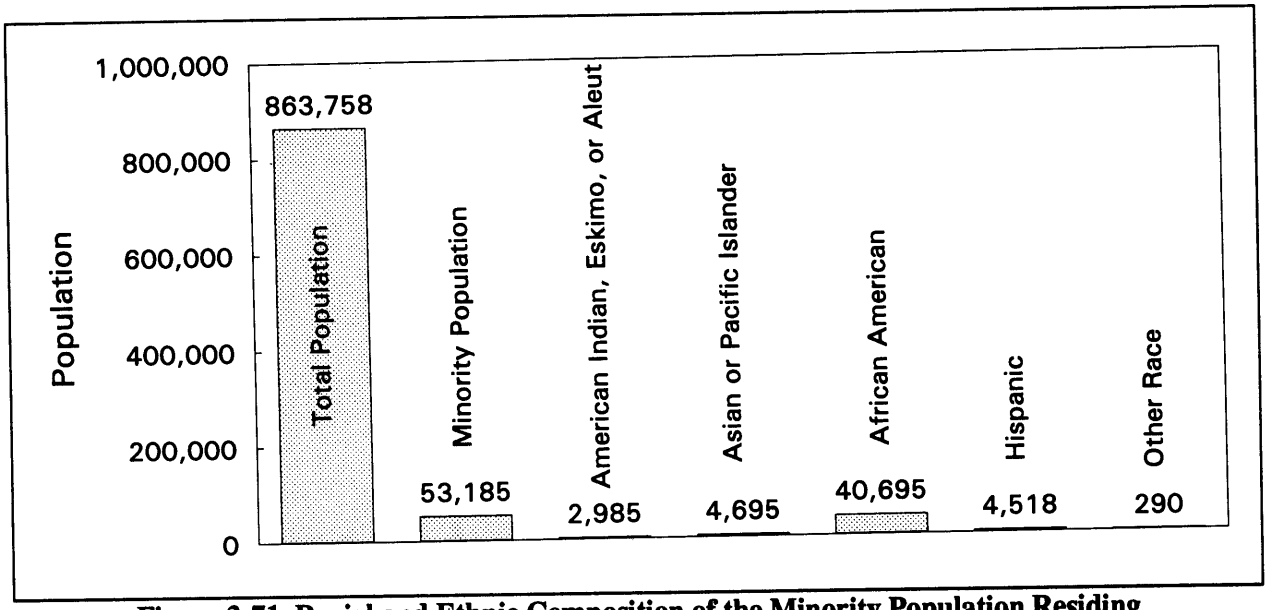


Figure 3-71 Racial and Ethnic Composition of the Minority Population Residing within 80 km (50 mi) of the Oak Ridge Reservation

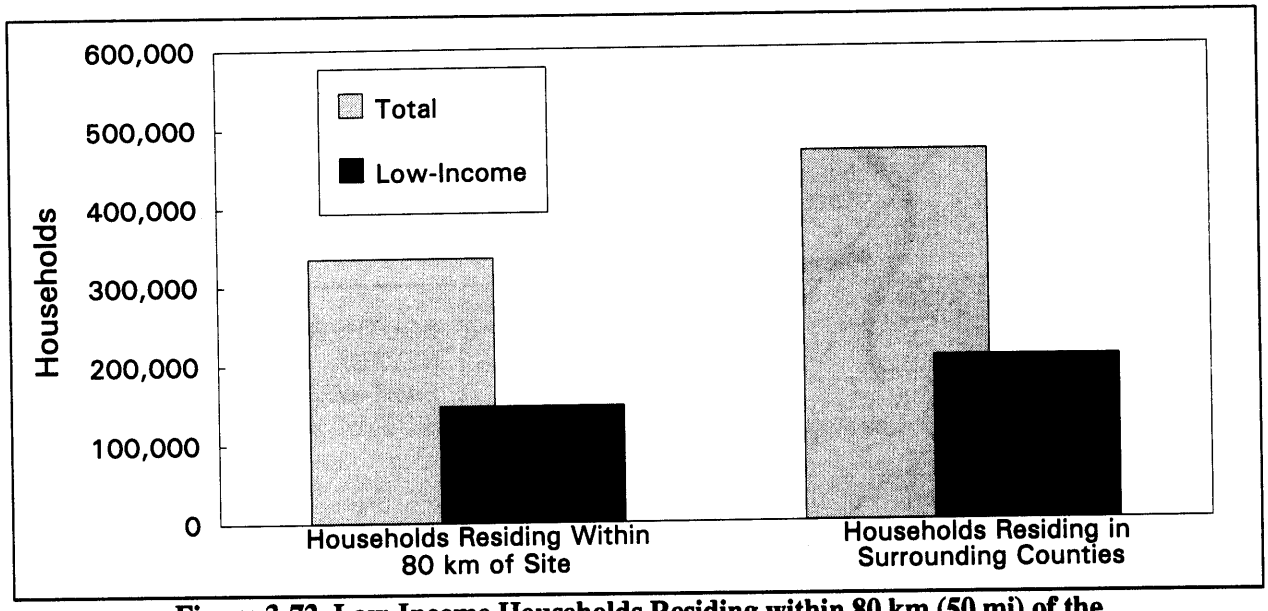


Figure 3-72 Low-Income Households Residing within 80 km (50 mi) of the Oak Ridge Reservation

3.3.4.10 Historical, Archaeological, and Cultural Resources

A limited survey conducted in 1975 did not identify any cultural resources on the Oak Ridge Reservation at the West Bear Creek Valley site (DOE, 1995c). No prehistoric or historic resources are expected to be located on the site. There are no known Native American resources on the proposed site.

3.3.5 Description of the Affected Environment at the Nevada Test Site

The Nevada Test Site is primarily used for the development and testing of nuclear weapons. This section describes the potentially affected environment of the site. The location of the site is shown in Figure 3-73.

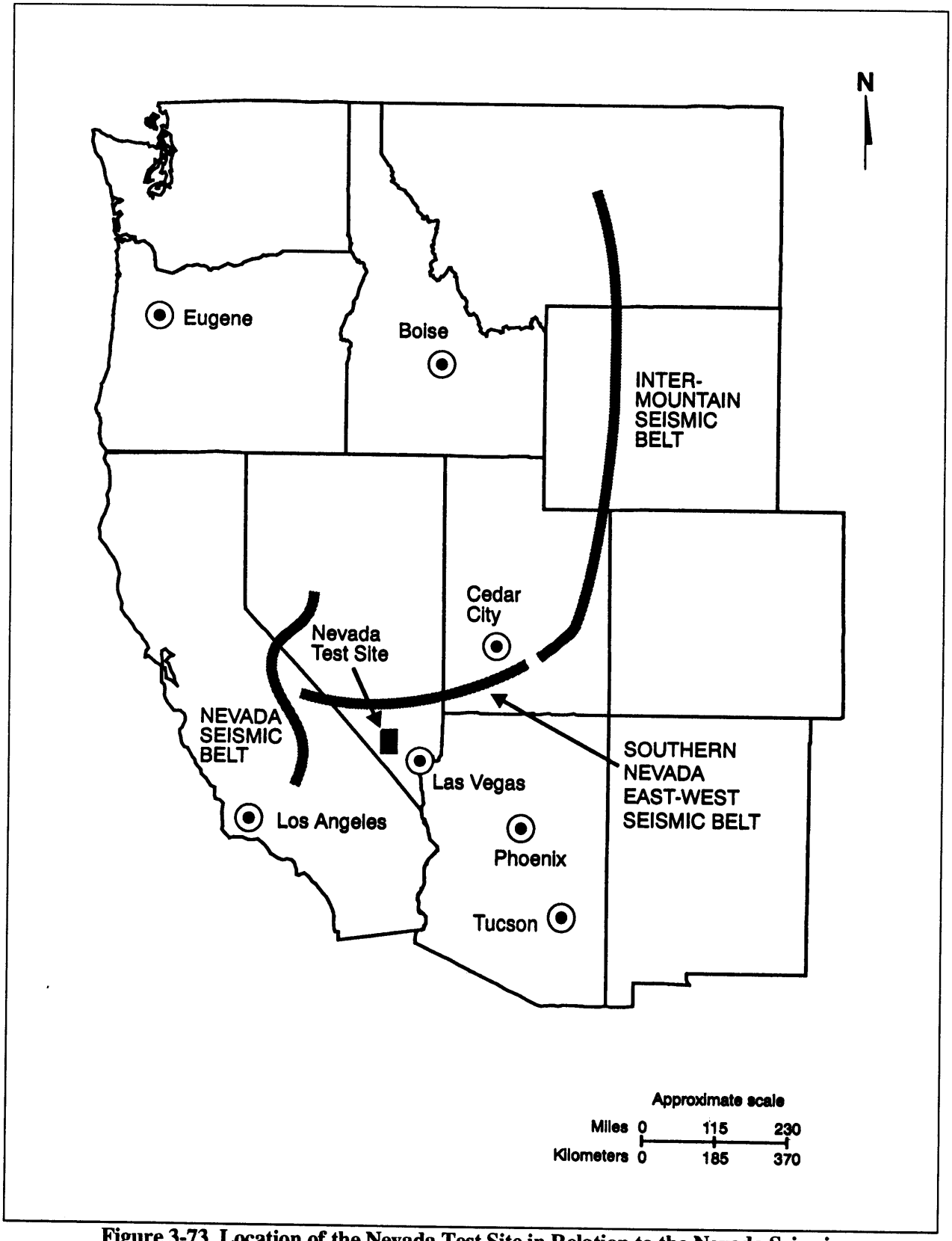
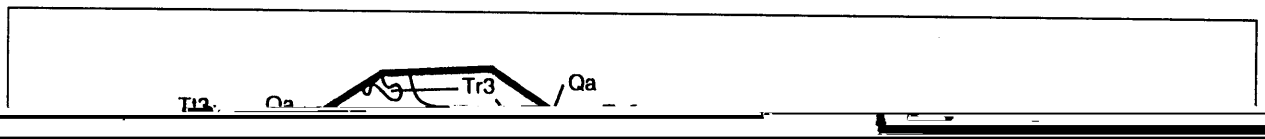


Figure 3-73 Location of the Nevada Test Site in Relation to the Nevada Seismic Belt, the Intermountain Seismic Belt, and the Southern Nevada East-West Seismic Belt

3.3.5.1 Geology

The Nevada Test Site 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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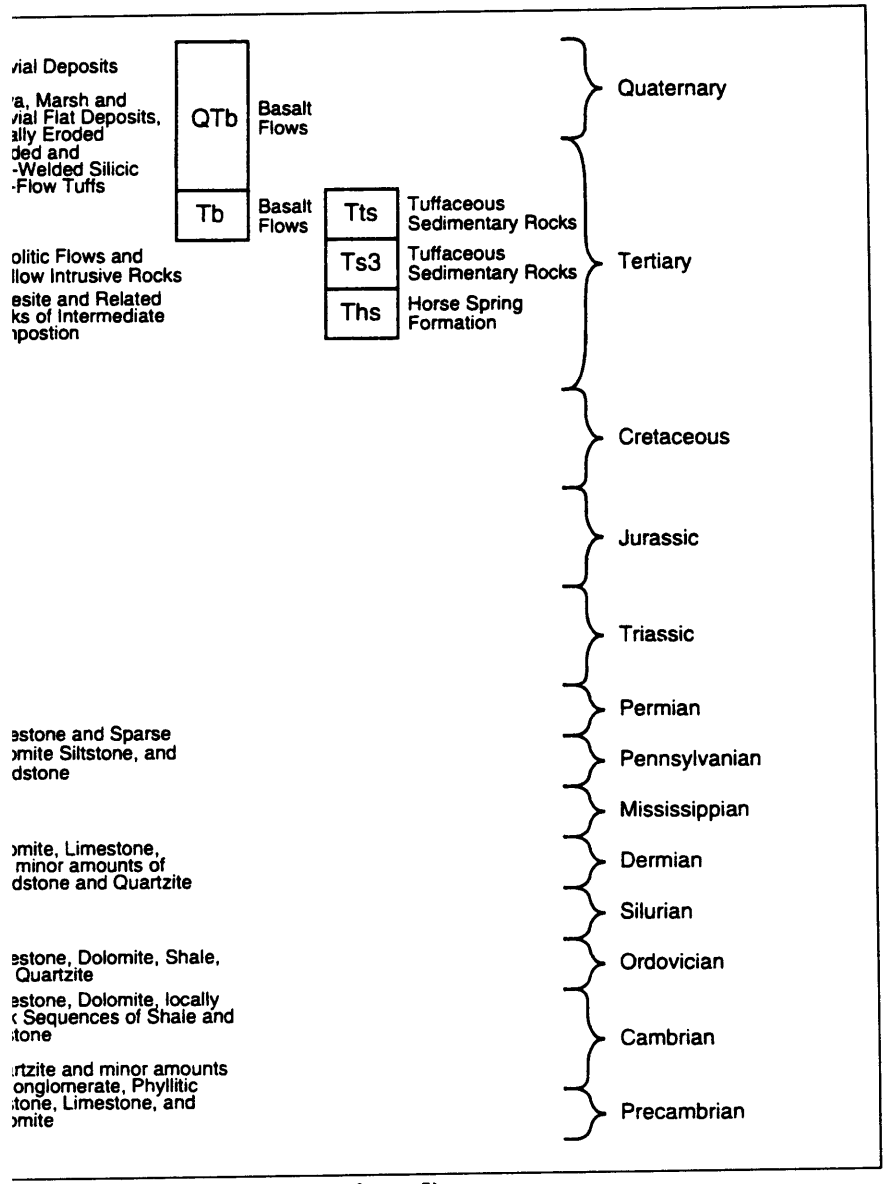
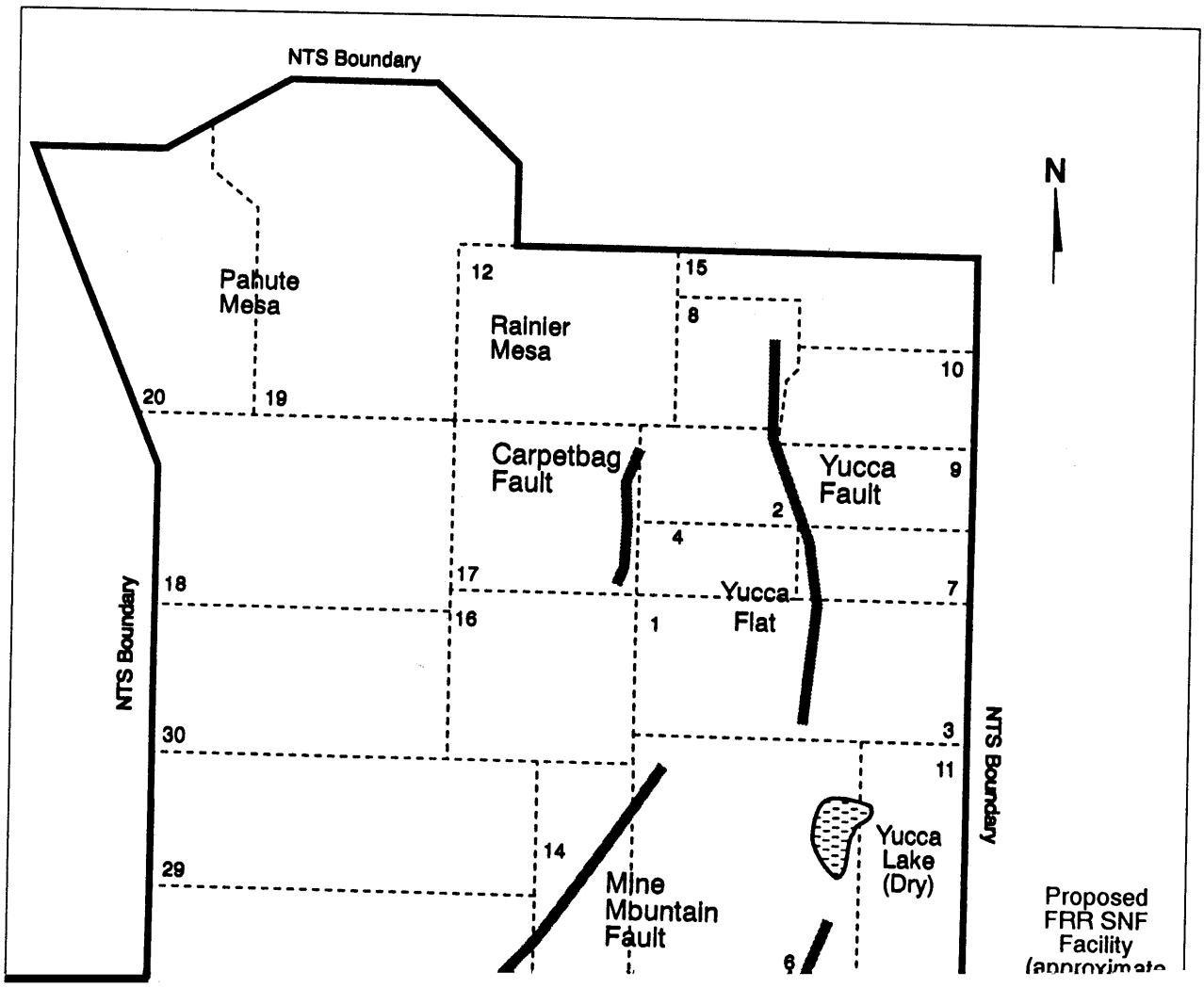


e Nevada Test Site (Continued)


NTS Boundary
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Rainier Mesa
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Yucca Fault
Yucca Flat
Yucca Lake (Dry)
Mine Mountain Fault
NTS Boundary
NTS Boundary
Proposed FRR SNF Facility
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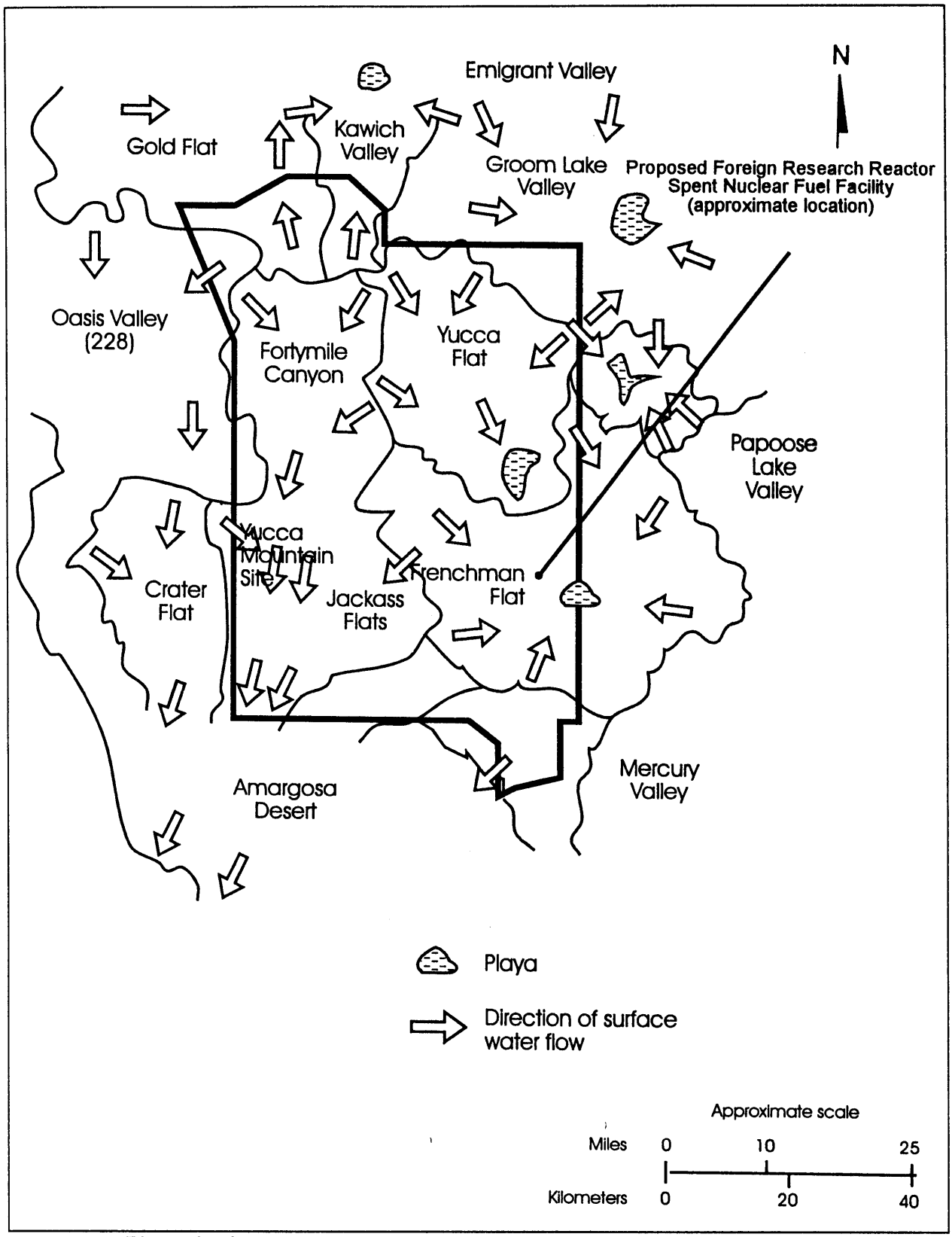


Figure 3-76 The Nevada Test Site Hydrologic Basins and Surface Drainage Direction

ephemeral, and therefore almost no streamflow data have been collected. The ephemeral character of streamflow has also limited the onsite monitoring of surface water quality. Perennial surface water originates from springs, and is restricted to source pools at some large springs. Because of the extreme aridity of this region, most of the spring discharge travels only a short distance before evaporating or infiltrating back into the ground (DOE, 1986b). The western half and southernmost part of the Nevada Test Site have channel systems which carry runoff beyond the Nevada Test Site boundaries during infrequent, very intense storms.

Two watersheds, Fortymile Canyon and Jackass Flats, have the potential for endangering offsite public health and safety due to flooding. Regional peak-flood flow equations for the southern Nevada area indicate that the 100-yr peak flow from the Fortymile Canyon drainage is approximately 370 m^3 per sec (97,744 gal per sec), and 230 m^3 per sec (60,760 gal per sec) from the Jackass Flats drainage (USAF et al., 1991). Underground nuclear testing has resulted in the release of radioactive materials at the land surface. There is the potential for 100-yr floods to transport these contaminants beyond the boundaries of the Nevada Test Site.

3.3.5.3.2 Groundwater

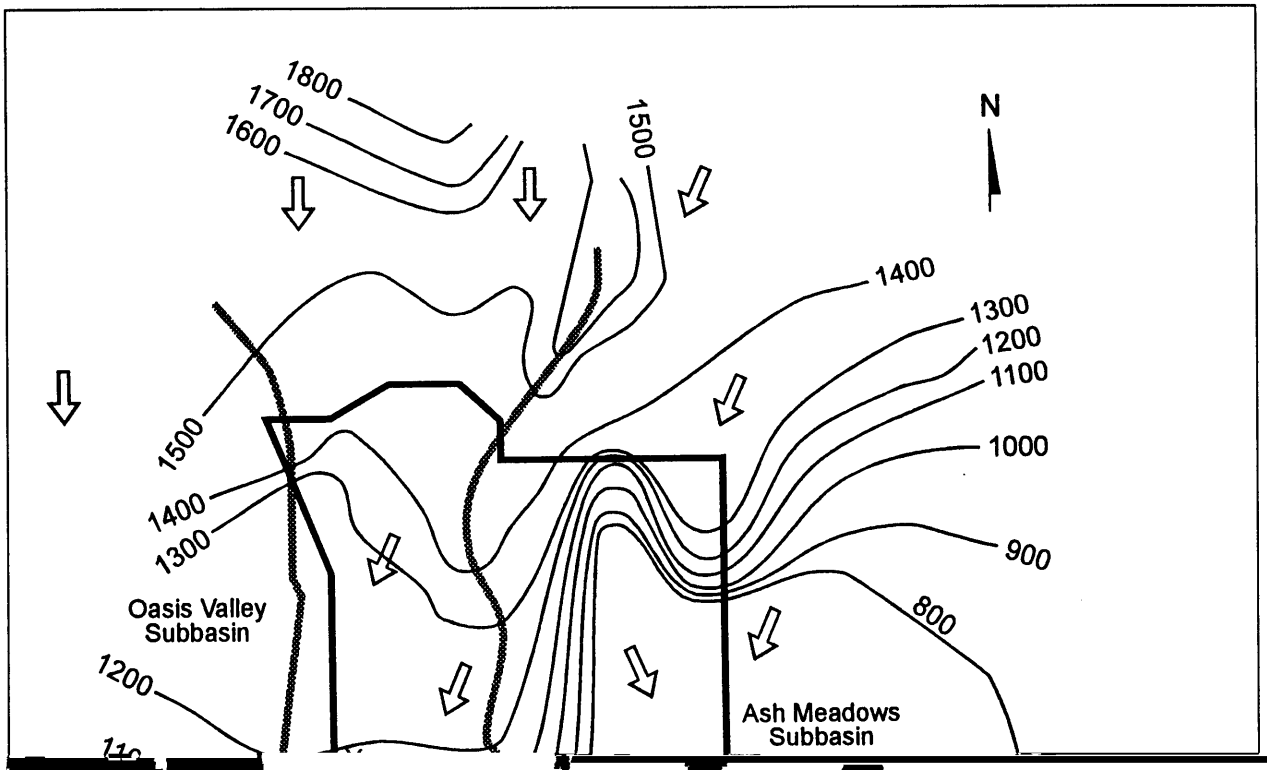
The hydrogeology at the Nevada Test Site is characterized by great depths to the groundwater table, and slow velocity of movement of water in the saturated and unsaturated zones (DOE, 1992c). Depth to groundwater varies from about 200 m (660 ft) beneath valleys in the southern part of the Nevada Test Site, to more than 500 m (1,650 ft) beneath Pahute Mesa. Locally, there are perched water tables at shallow depths (USAF et al., 1991). Perched aquifers have been reported at depths of 21 m (70 ft) in the southwestern part of Frenchman Flat. In the eastern portions of the Nevada Test Site, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer (DOE, 1993a).

Six major aquifers occur in the area. The hydrologic and geologic properties of these aquifers vary (DOE, 1988a). The lower carbonate and valley fill aquifers are the main sources of groundwater in the eastern part of the Nevada Test Site (DOE, 1986b). Four major aquitards (units tending to retard the flow of groundwater) have been reported in the area (DOE, 1986b).

Regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert (Figure 3-77). In the western portions of the area, the regional flow is from the northwest to the south and southwest. Groundwater recharge to the Ash Meadows Sub basin occurs primarily from precipitation over the mountainous areas in the northern, eastern, and southern portions of the basin (DOE, 1988a).

The hydrogeologic units that supply potable water to the Nevada Test Site have been classified as Class IIA (currently a source of drinking water) and IIB (potentially a source of drinking water), in accordance with the U.S. Environmental Protection Agency's guidelines for groundwater classification. No aquifers at the Nevada Test Site have been designated as sole-source aquifers.

Groundwater Quality: The quality of the Nevada Test Site groundwater is suitable for most purposes, and generally meets U.S. Environmental Protection Agency secondary standards for major cations and anions, and the primary standards for deleterious constituents. Contamination by radionuclides occurs below the water table as well as in the unsaturated zone above it. This contamination is a result of underground nuclear testing. The principal confirmed or suspected contaminants from these tests include various radionuclides (primarily tritium) and heavy metals.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Oasis Valley
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Ash Meadows
Subbasin

Groundwater contamination could be transported toward the Nevada Test Site boundary by one of the regional groundwater flow systems. Groundwater flow velocities in these systems range between 1.8 and 183 m per year (6 and 600 ft per year). Due to sorption, most nuclides (other than tritium) would move at a much slower rate. The groundwater travel time from the Nevada Test Site to Ash Meadows Discharge Area is approximately 300 years. Radioactive decay, coupled with dilution and sorption, should reduce radioactivity to well below regulatory limits (USAF et al., 1991). Thus, there are no current effects on public health and safety, nor are any expected in the foreseeable future.

3.3.5.4 Meteorology

The climate at the Nevada Test Site 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.

Wind: Low-level surface winds at the Nevada Test Site are influenced by the large-scale weather patterns interacting with the mountain ranges. Predominant winds are from the south during the summer, and the north during the winter. At Las Vegas, the peak wind gust on record is 145 km per hour (90 mph). Strong winds interacting with dry soil conditions are responsible for occasional duststorms or sandstorms.

Temperature and Humidity: At Area 6 (Figure 3-75) of the Nevada Test Site, the average daily maximum/minimum temperatures during the month of January are 10.6°C/-6.1°C (51.1°F/21.0°F). The average daily maximum/minimum temperatures are 35.6°C/13.9°C (96.1°F/57.0°F) in July. At Las Vegas, the coldest temperature on record is -13.3°C (8.1°F), and the warmest temperature on record is 46.7°C (116°F). The average relative humidity at 4 a.m. in Las Vegas is 40 percent. The average relative humidity at 4 p.m. is 20 percent (DOE, 1995c).

Precipitation: The average annual precipitation at Area 6 is 15 cm (5.9 in). Precipitation amounts for each month are generally less than 1.3 cm (.5 in). At Las Vegas, the greatest precipitation recorded in a 24-hr period is 6.6 cm (2.6 in). 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 (DOE, 1995c).

Atmospheric Dispersion: Data collected at Desert Rock for calendar year 1990 indicated that atmospheric conditions were unstable (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 (DOE, 1995c).

Air Quality: In 1992, the majority of radioactive effluents at the Nevada Test Site originated from underground nuclear tests designed and conducted by two national laboratories and the Defense Nuclear Agency. Onsite monitoring of airborne particulates, noble gases, and tritiated water vapor indicated onsite concentrations that were generally not statistically different from background concentrations. Results of offsite environmental monitoring indicated none of the Nevada Test Site-related radioactivity was detected at any air sampling station, and there were no apparent net exposures detectable by the offsite dosimetry network (DOE, 1993a).

The nonradiological air emissions from the Nevada Test Site originate from concrete batch plants, aggregate crushing and processing, surface disturbance, fire training exercises, motor vehicle operations, boilers, and fuel storage. Based on the data collected by Engineering Science, Inc. at the ambient air monitoring stations, air quality at the Nevada Test Site is within applicable Federal and State standards (DOE, 1995c).

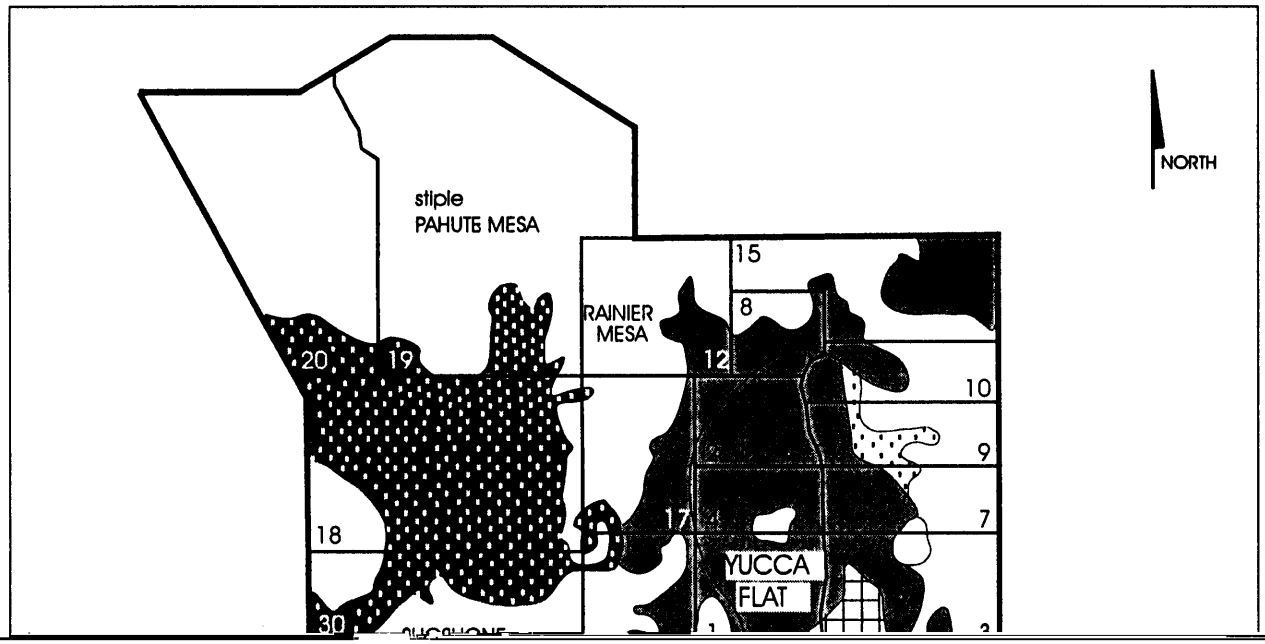
3.3.5.5 Ecology

The Nevada Test Site lies within the transition area of the Mojave desert and the Great Basin. The Nevada Test Site covers about 3,500 km^2 (1,350 mi^2), of which only 0.55 percent is developed (DOE, 1988b).

Plant communities on the Nevada Test Site have been classified according to the dominant shrub. Approximately 700 taxa have been identified on the Nevada Test Site (ERDA 1976; DOE, 1991b, DOE, 1993b). Figure 3-78 presents the general plant communities identified on the Nevada Test Site. The dominant plant communities in the Mojave desert are creosote bush. The dominant plant communities in the transition zone between the Mojave desert and the Great Basin are blackbrush, desert thorn, and hopsage. The dominant plant communities in the Great Basin are big sagebrush and black sagebrush, saltbush, and desert thorn.

There are more than 30 species of reptiles and amphibians, 190 species of birds, and 50 species of mammals on the Nevada Test Site (ERDA, 1976; RSN, 1993). Sewage ponds and man-made reservoirs have become an important resource for wildlife. Reptiles and amphibians on the Nevada Test Site include 1 species of desert tortoise, 14 species of lizards, and 17 species of snakes. Birds on the Nevada Test Site are often migratory and seasonal residents. The most-distributed species include the black-throated sparrow, house fin, red-tailed hawk, common raven, loggerhead shrike, mockingbird, ash-throated flycatcher, and mourning dove (Greger, n.d.a.; ERDA, 1976). The most abundant group of mammals on the Nevada Test Site are rodents.

There are several natural springs on the Nevada Test Site that feed flowing streams (Greger, n.d.a.)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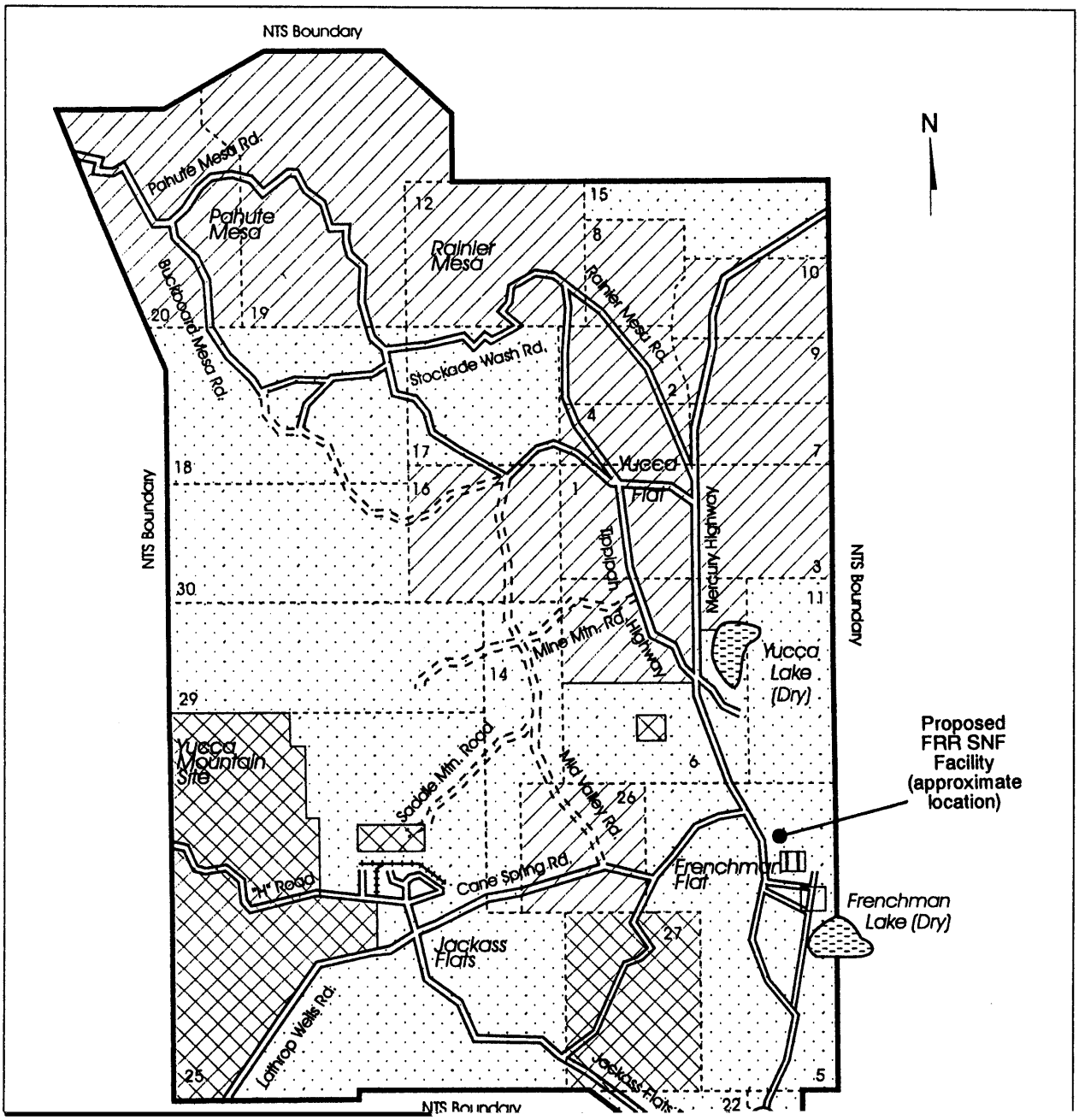
3.3.5.6 Land Use

The Nevada Test Site occupies an area of approximately 3,500 km^2 (1,350 mi^2) in southern Nevada, in a sparsely populated area approximately 105 km (65 mi) northwest of Las Vegas. The Nevada Test Site is almost entirely surrounded by other Federally-owned lands that buffer it from lands open to the public. The Nevada Test Site is bordered by the Nellis Air Force Range on the north, east, and west, and by Bureau of Land Management lands on the south and southwest (DOE, 1993b).

Existing land use on the Nevada Test Site


NTS Boundary
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Pahute Mesa Rd.
Pahute Mesa
Rainier Mesa
Buckboard Mesa Rd.
Rainier Mesa Rd.
Stockade Wash Rd.
Yucca Flat
Mercury Highway
Uplift
Mine Mtn. Rd.
Highway
Yucca Lake (Dry)
Yucca Mountain Site
Saddle Mtn. Road
Mid Valley Rd.
Cane Spring Rd.
Frenchman Flat
Frenchman Lake (Dry)
Proposed FRR SNF Facility (approximate location)
Jackass Flats
Lathrop Wells Rd.
Jackass Flats
NTS Boundary
NTS Boundary
NTS Boundary

Clark County: Clark County is composed of five incorporated cities (Las Vegas, Henderson, North Las Vegas, Boulder City, and Mesquite), and large expanses of unincorporated land. The area experiencing the majority of the county's development is the Las Vegas Valley (DOE, 1995c). Economic conditions in southern Nevada have improved continuously since the mid-1980's. The economy is driven by the growth in the hotel and gaming industry. Service employment accounts for nearly 45 percent of total employment, trade employment accounts for 21 percent, and Government and construction each account for an additional 10 percent (DOE, 1995c).

The unemployment rate reached a low of 4.9 percent in 1990, and increased to 7.5 percent as of June, 1993. However, the unemployment level is expected to decrease with new hotel, gaming, and amusement properties which opened at the end of 1993 (DOE, 1993a).

Nye County: The employment level in Nye county is low relative to Clark County, and includes opportunities in the services, mining, and Government sectors (DOE, 1993a). Nye County is sparsely populated, with the two largest population groupings in the communities of Pahrump and Tonopah. While

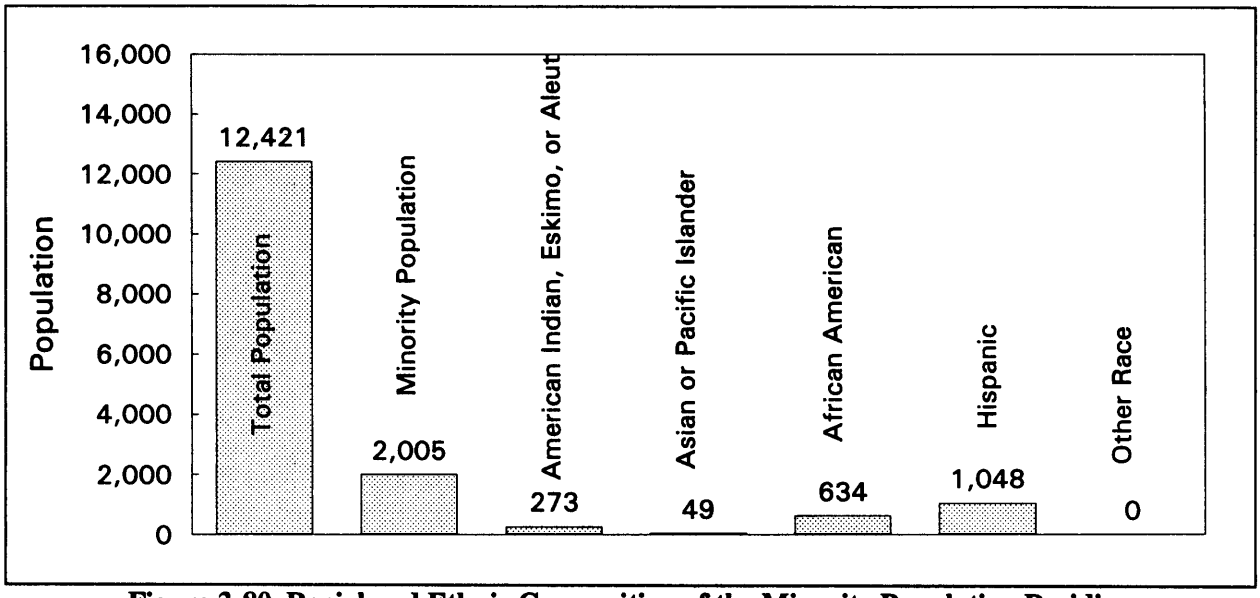

Figure 3-80 Racial and Ethnic Composition of the Minority Population Residing within 80 km (50 mi) of the Nevada Test Site

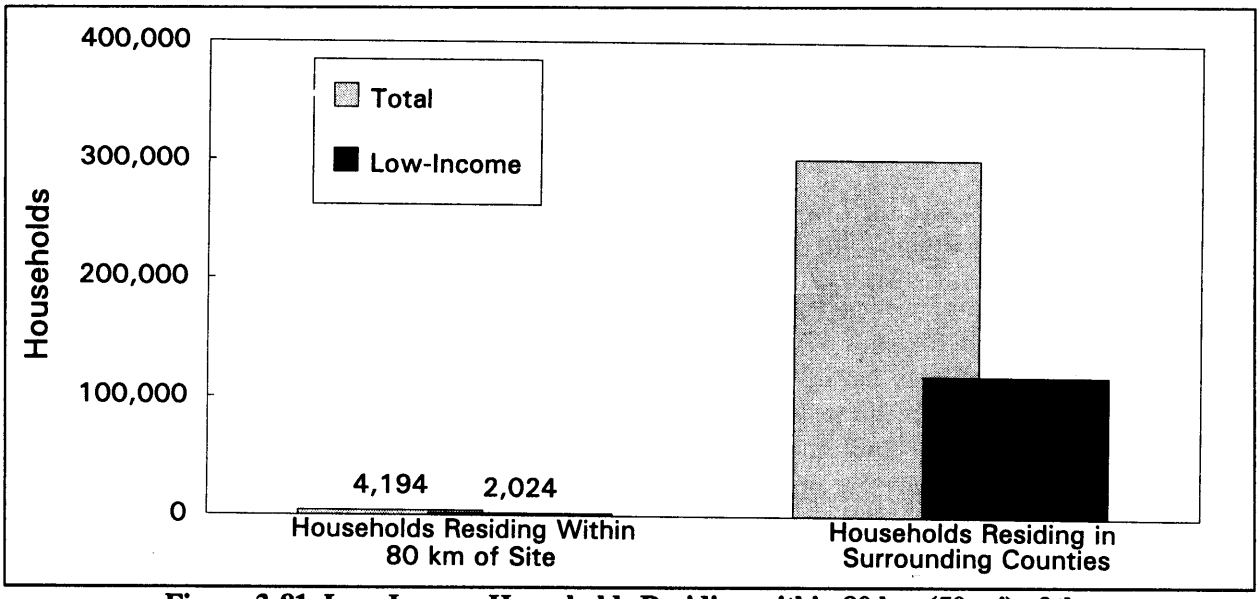

Figure 3-81 Low-Income Households Residing within 80 km (50 mi) of the Nevada Test Site

3.3.5.10 Historical, Archaeological, and Cultural Resources

People have inhabited the lands that comprise the Nevada Test Site for 12,000 years. The availability of the surface water was the primary determinant governing the location of past human occupation on these lands.

The Southern Paiute and Shoshone Native American tribes are known to have inhabited southern Nevada, including parts of what is now the Nevada Test Site. No known Native American resources are located on the Nevada Test Site (DOE, 1995c).