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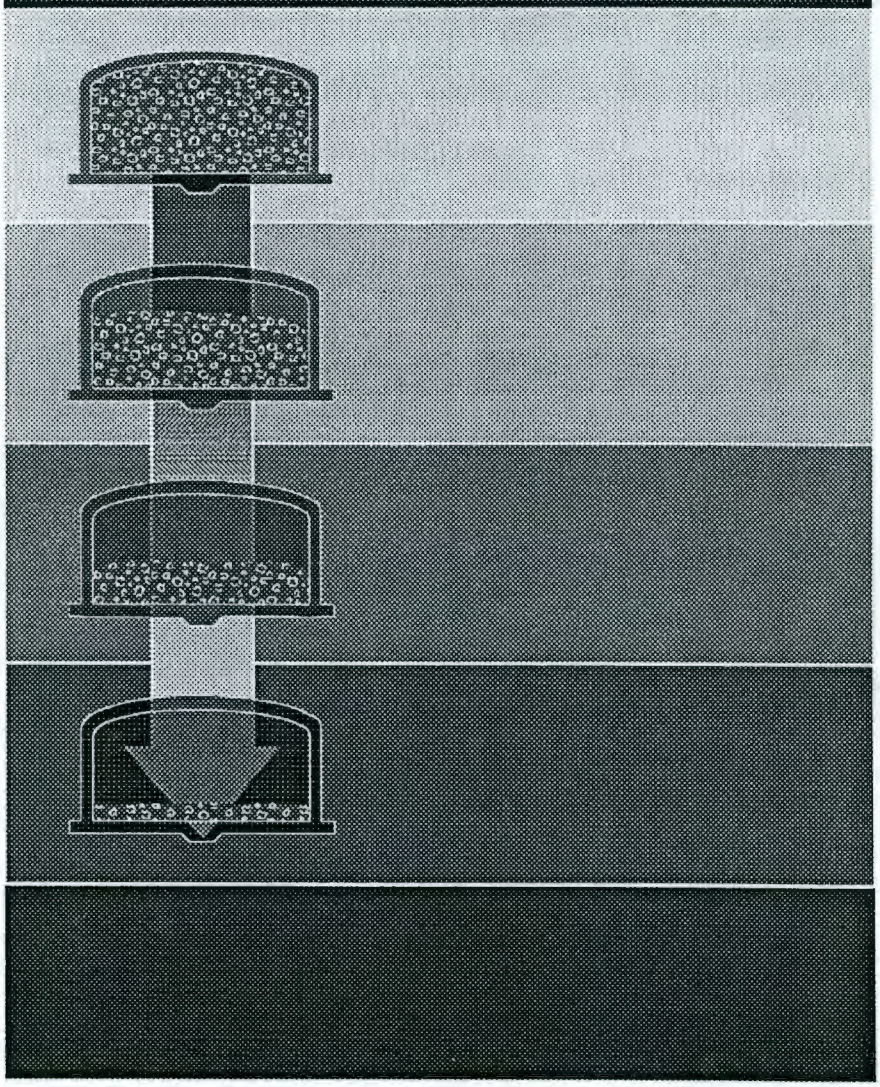
Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement

Volume One



Prepared by:

U.S. Department of Energy
and
Washington State Department of Ecology

August 1996

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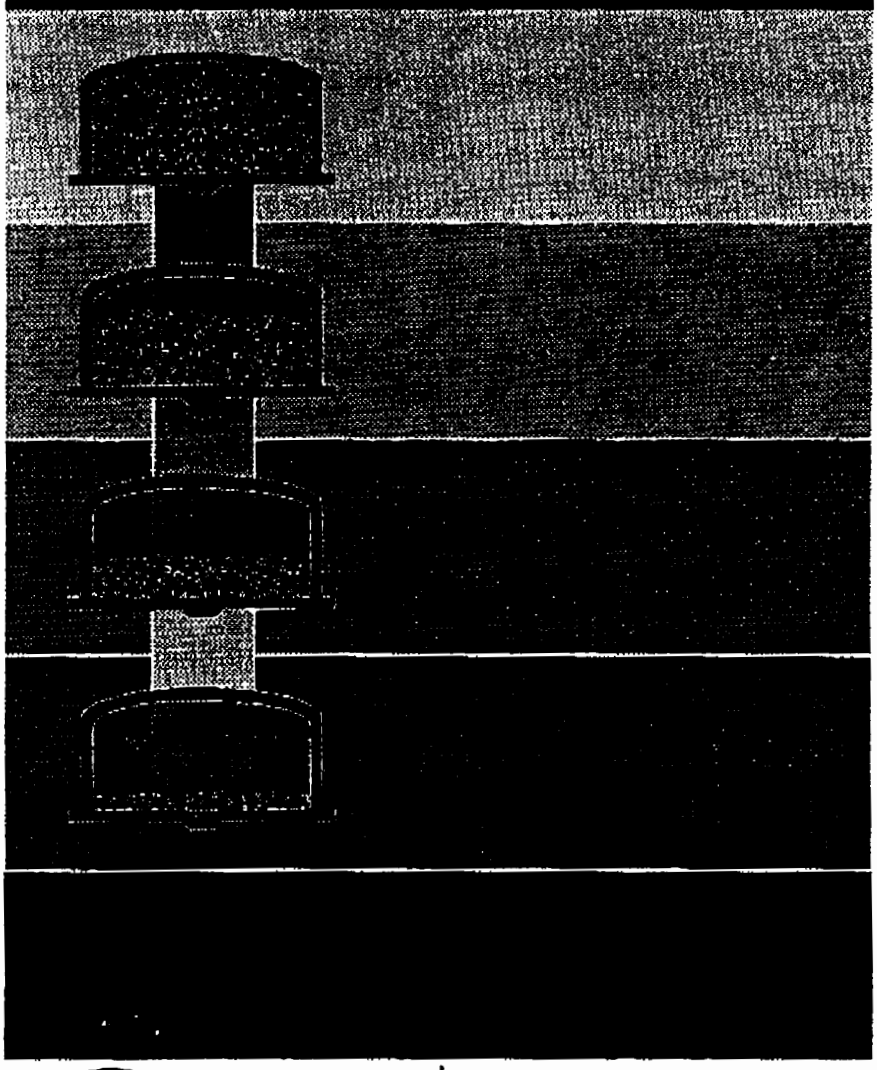

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TO: Anne Sada, Hanford
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FROM: Lois Chalmers
TOTAL # OF PAGES (including cover): 4

Dear Ms Sada

We would like a camera ready copy of Figure 3.2.1.

We would like it sent to us by next week -

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Lois Chalmers.

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NEPA COVER SHEET

TITLE: Final Environmental Impact Statement for the Tank Waste Remediation System, Hanford Site, Richland, Washington

RESPONSIBLE AGENCIES: Lead Federal Agency: U.S. Department of Energy (DOE), Richland Operations Office; Lead State Agency: Washington State Department of Ecology (Ecology).

ABSTRACT: This document analyzes the potential environmental consequences related to the Hanford Site Tank Waste Remediation System (TWRS) alternatives for management and disposal of radioactive, hazardous, and mixed waste, and the management and disposal of approximately 1,930 cesium and strontium capsules located at the Hanford Site. This waste is currently or projected to be stored in 177 underground storage tanks and approximately 60 miscellaneous underground storage tanks. This document analyzes the following alternatives for remediating the tank waste: No Action, Long-Term Management, In Situ Fill and Cap, In Situ Vitrification, Ex Situ Intermediate Separations, Ex Situ No Separations, Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1, and Ex Situ/ In Situ Combination 2. This document also addresses a Phased Implementation alternative (the DOE and Ecology preferred alternative for remediation of tank waste). Alternatives analyzed for the cesium and strontium capsules include: No Action, Onsite Disposal, Overpack and Ship, and Vitrify with Tank Waste. The DOE and Ecology preferred alternative for the cesium and strontium capsules is the No Action alternative.

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PUBLIC COMMENT: Public meetings on the TWRS Draft Environmental Impact Statement were held at five locations during the comment period. Written and oral comments on the TWRS Draft Environmental Impact Statement were accepted from April 12, 1996 until May 28, 1996. DOE and Ecology considered all public comments in preparing the TWRS Final Environmental Impact Statement.

SEPA FACT SHEET

DOCUMENT TITLE AND LOCATION OF PROJECT: Environmental Impact Statement for the Tank Waste Remediation System, Hanford Site, Richland, Washington

PROPONENT: U.S. Department of Energy

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ISSUE DATE: August 30, 1996

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POTENTIAL PERMITS REQUIRED:

Activity and Waste Type	Regulatory Action Required	Regulation	Regulatory Agency
Air emissions	Radiation Air Emissions Program (Approval)	Washington Administrative Code 246-247	Washington State Department of Health
Air emissions	Controls for New Sources of Toxic Air Pollutants (Approval)	Washington Administrative Code 173-460 and 40 Code of Federal Regulations (CFR) 61	Ecology and EPA
Air emissions	Notice of Construction and possible modification to the Sitewide permit (Approval)	Washington Administrative Code 173-400 and 173-460	Ecology and Benton County Clean Air Authority
Air emissions	Ambient Air Quality Standards and Emissions Limits for Radionuclides (Approvals)	Washington Administrative Code 173-480	Ecology
Soil column waste water disposal	State Waste Discharge Permit (Permit)	Washington Administrative Code 173-216	Ecology
Effluent, spills	Groundwater Quality Standards (Approval and possible permit)	Washington Administrative Code 173-200	Ecology
Effluent	Water Quality Standards for Surface Waters (Permit)	Washington Administrative Code 173-201A	Ecology
Effluent	National Pollutant Discharge Elimination System Permit Program (Permit)	Washington Administrative Code 173-226-100	Ecology
Dangerous (including mixed) waste generation, storage, treatment, and disposal	Dangerous Waste Permit, RCRA Permit (Permit)	Washington Administrative Code 173-303 and 40 CFR 260-270	Ecology and EPA
All media	Cultural Resource Review Clearance	36 CFR 800	DOE and Washington State Historic Preservation Officer
All media	Endangered Species Review	50 CFR 402.6	U.S. Fish and Wildlife Service
Onsite management and disposal of high-level and transuranic waste	Waste Disposal Review and Standards (Approval)	40 CFR 191	EPA

DATES FOR FINAL ACTIONS: The TWRS Record of Decision is anticipated in October 1996. The Record of Decision will be published in the Federal Register.

RELATED DOCUMENTS: Environmental Impact Statement technical reports, background data, materials incorporated by reference, and other related documents are available either through the contacts listed in the Contact Section, or at:

DOE Freedom of Information
Reading Room
Forrestal Building
1000 Independence Ave. S.W.
Washington, D.C.

DOE Public Reading Room
Washington State University
Tri-Cities Branch
100 Sprout Road
Richland, WA

and at the following U.S. Department of Energy information repositories:

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Seattle, WA

Gonzaga University
Foley Center
E. 502 Boone
Spokane, WA

Portland State University
Bradford Price Millar Library
SW Harrison and Park
Portland, OR

Copies of the Environmental Impact Statement are available free of charge to the interested public through the contacts listed in the Contact Section.

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ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
dBA	decibels on the A scale
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ERPG	Emergency Response Planning Guidelines
FR	Federal Register
HLW	high-level waste
HMPC	Hanford Multi-Purpose Canister
ILCR	Incremental Lifetime Cancer Risk
ISC2	Industrial Source Complex Model
ISCST2	short-term ISC2
ISCLT2	long-term ISC2
Kd	distribution coefficient
LAW	low-activity waste
Leq	equivalent sound level
MUST	miscellaneous underground storage tank
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
SEPA	Washington State Environmental Policy Act
SST	single-shell tank
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TWRS	Tank Waste Remediation System
WAC	Washington Administrative Code
WASRD	Waste Acceptance System Requirements Document
WESF	Waste Encapsulation and Storage Facility

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CHEMICAL COMPOUNDS AND RADIOACTIVE ISOTOPE DESIGNATIONS

Chemical Compounds

CO	carbon monoxide
NO_2^-	nitrite ion
NO_3^-	nitrate ion
NO_x	nitrogen oxides (gaseous form) including NO and NO_2
SO_2	sulfur dioxide
UO_2	uranium dioxide

Radioactive Isotopes

barium-137 (Ba-137)	barium isotope having an atomic weight of 137
carbon-14 (C-14)	carbon isotope having an atomic weight of 14
cesium-137 (Cs-137)	cesium isotope having an atomic weight of 137
cobalt-60 (Co-60)	cobalt isotope having an atomic weight of 60
iodine-129 (I-129)	iodine isotope having an atomic weight of 129
plutonium-239 (Pu-239)	plutonium isotope having an atomic weight of 239
plutonium-240 (Pu-240)	plutonium isotope having an atomic weight of 240
strontium-90 (Sr-90)	strontium isotope having an atomic weight of 90
technetium-99 (Tc-99)	technetium isotope having an atomic wight of 99
uranium-234 (U-234)	uranium isotope having an atomic weight of 234
uranium-235 (U-235)	uranium isotope having an atomic weight of 235
uranium-238 (U-238)	uranium isotope having an atomic weight of 238
zirconium-93 (Zr-93)	zirconium isotope having an atomic weight of 93

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Introduction

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1.0 INTRODUCTION

SECTION HIGHLIGHTS

- Overview of tank waste and capsules
- Policy and regulatory background
- Tri-Party Agreement
- Alternative development process
- Preferred alternative
- Guide to EIS contents
- Readers guide and helpful information

The U.S. Department of Energy (DOE), in cooperation with the Washington State Department of Ecology (Ecology), must make decisions on how to manage and dispose of Hanford Site tank waste and encapsulated cesium and strontium to reduce existing and potential future risk to the public, Site workers, and the environment. The waste includes radioactive, hazardous, and mixed waste currently stored in 177 underground storage tanks, approximately 60 other smaller active and inactive miscellaneous underground storage tanks (MUSTs), and additional Site waste likely to be added to the tank waste, which is part of the tank farm system. In addition, DOE proposes to manage and dispose of approximately 1,930 cesium and strontium capsules that are by-products of tank waste. The tank waste and capsules are located in the 200 Areas of the Hanford Site near Richland, Washington (Figure 1.0.1).

The alternatives selected for the final management and disposal of this waste must comply with Federal and Washington State environmental laws and regulations, and be within the context of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology et al. 1994). Permanent solutions to tank waste risk are a major goal of the agreement. The Tri-Party Agreement was signed by DOE, Ecology, and the U.S. Environmental Protection Agency (EPA) to address waste management and cleanup of the Hanford Site.

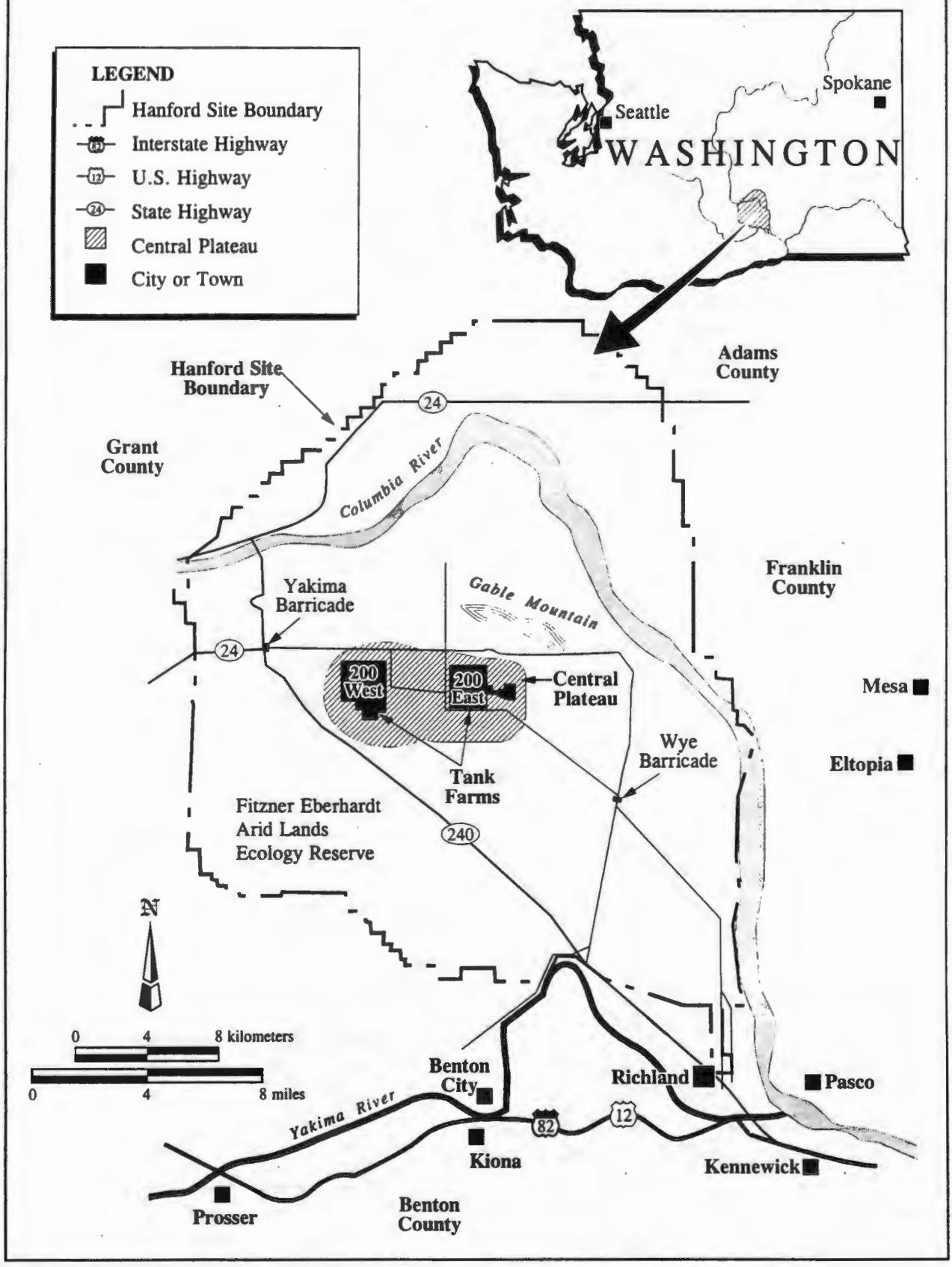
National Environmental Policy Act and Washington State Environmental Policy Act Terms

Alternatives: The range of reasonable alternatives, including the No Action alternative, considered in selecting an approach to meet the need for agency action.

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

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

Figure 1.0.1 Hanford Site Map



On January 28, 1994, in a Notice of Intent published in the Federal Register (FR), DOE announced its intent to prepare two Environmental Impact Statements (EISs): 1) an interim action EIS to resolve urgent tank safety issues; and 2) this Tank Waste Remediation System (TWRS) EIS (59 FR 4052).

Revisions to the EIS

Revisions to the EIS in response to comments on the Draft EIS and emerging information and technical data unavailable prior to publication of the Draft EIS, are indicated in the Final EIS by a bar at the end of each line of text modified. For a summary of major changes to the EIS in response to public comments, please see Volume One, Section 7.5. Volume Six, Appendix L contains the comments on the EIS received during the public comment period and DOE and Ecology's responses to those comments.

The TWRS proposed action is subject to the Council on Environmental Quality's National Environmental Policy Act (NEPA) (10 Code of Federal Regulations [CFR] Parts 1500 to 1508) and the Washington State Environmental Policy Act (SEPA) (Revised Code of Washington [RCW] 43.21C). Both acts require analysis of potential environmental impacts in the decision-making process. DOE and Ecology signed a Memorandum of Understanding on February 15, 1994 to jointly prepare the EIS for the proposed TWRS action (MOU 1994). The co-preparation of the EIS streamlines the environmental review process while ensuring compliance with applicable Federal and State laws, regulations, and policies.

A 45-day scoping and public participation process began on January 28, 1994 and ended on March 15, 1994. During the scoping process, DOE and Ecology conducted five public meetings and accepted both verbal and written comments. The scoping process provided opportunities for the public to review information and comment on the proposed action. DOE and Ecology considered both verbal and written comments on the scope of the proposed action, alternatives, and environmental issues in preparing the TWRS EIS Implementation Plan (DOE 1995b) and the TWRS EIS.

On April 12, 1996, in a Notice of Availability published in the Federal Register (FR 16248), DOE announced the availability of the Draft EIS for review and comment. A 45-day public comment period began on April 12, 1996 and ended on May 28, 1996. During the public comment period, DOE and Ecology conducted five public meetings and accepted both verbal and written comments. Consultation meetings were also held with local, State, and Federal agencies, Tribal Nations, and DOE advisory boards. DOE and Ecology considered both verbal and written comments on the Draft EIS in preparing the Final EIS. Information on the public comment period is provided in Volume One, Section 7.0. Verbal and written comments and DOE and Ecology responses to comments are presented in Volume Six, Appendix L.

NEPA and SEPA provide decision makers with an analysis of environmental impacts (both positive and negative) of proposed actions for consideration during decision making. This EIS presents the impacts of the proposed action and its reasonable alternatives for review and comment by the public and interested parties.

The decisions made by DOE will be discussed in a Record of Decision to be issued no earlier than 30 days after issuing the Final EIS. Also to be issued following the completion of the Final EIS is a Mitigation Action Plan, which will detail the commitments to mitigate impacts to the environment made in the Record of Decision.

In the following sections, an overview of the history of the tank waste and capsules is provided, along with an explanation of the policy and regulatory developments that require DOE to manage and dispose of the tank waste. This is followed by a review of technical and programmatic developments that have influenced DOE's tank waste remediation plans. The section concludes with a brief summary of the alternatives development process, an explanation of the contents of the EIS, and definitions of technical terms, data, and concepts used in the EIS.

1.1 POLICY BACKGROUND

The Federal government established the Hanford Site near Richland, Washington in 1943 to produce plutonium for national defense purposes. The Hanford Site occupies approximately 1,450 square kilometers (km^2) (560 square miles [mi^2]) of land north of the city of Richland. The production mission ended at the Hanford Site in 1988. The current Hanford Site mission is waste management and environmental restoration, which includes programs to manage and dispose of radioactive, hazardous, and mixed waste that exists at the Site. This TWRS EIS addresses tank waste, MUST waste, and cesium and strontium capsules located in the 200 Areas of the Site.

1.1.1 Hanford Site Tank Waste and Cesium and Strontium Capsules

At the Hanford Site, there are 149 single-shell tanks (SSTs) constructed between 1944 and 1964, which received waste until 1980. Waste in the SSTs

Waste Definitions

High-Level Waste: Highly radioactive waste that results from the reprocessing of spent nuclear fuel, which includes liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains fission products in sufficient concentration. It may include other highly dangerous radioactive material that requires shielding, special handling, and when disposed of, permanent isolation in a deep geologic repository.

Low-Activity Waste: Waste that remains following the process of separating from high-level waste as much of the radioactivity as is practicable and that, when solidified, may be disposed of as low-level waste as defined in the Atomic Energy Act of 1954 in a near-surface facility.

Transuranic Waste: Waste containing more than 100 nanocuries per gram of alpha-emitting transuranic isotopes with half-lives of greater than 20 years. This does not include high-level waste; waste that DOE, with EPA agreement, determines not to need the degree of isolation required for high-level waste; or waste that the Nuclear Regulatory Commission has approved for disposal in a near-surface disposal facility.

Hazardous or Dangerous Waste: Waste that is ignitable, corrosive, reactive, characteristic, toxic, persistent, or appears on special EPA lists. It may pose a present or future risk to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous waste is regulated under RCRA.

Mixed Waste: Waste that contains both hazardous or dangerous waste under RCRA and radioactive material regulated by the Atomic Energy Act.

consists of liquid, sludges, and saltcake (i.e., crusty solids made of crystallized salts). Over the years, much of the liquid stored in SSTs has been evaporated or pumped to double-shell tanks (DSTs). There are 28 DSTs at the Hanford Site that were constructed between 1968 and 1986. The DSTs are used to store liquid radioactive waste from the SSTs and various Hanford Site processes. The waste is partially segregated and stored in tanks based on composition, level of radioactivity, or origin.

In addition to the 177 underground storage tanks, there are approximately 40 inactive and 20 active MUSTs located in the 200 Areas. The MUSTs contain small quantities of radioactive, hazardous, and mixed waste similar in content and composition to the waste in the SSTs and DSTs. The MUSTs, which are part of the tank waste system, consist of buried steel tanks used for collecting spills and leaks during waste transfer and buried concrete vaults with carbon or stainless-steel tanks used for waste recovery (WHC 1994a).

200 Areas Waste Overview

The 200 Areas of the Central Plateau, where the waste tanks and cesium and strontium capsules are located, have been used extensively for fuel reprocessing, waste management, and disposal activities. In addition to the waste tanks and capsules, the 200 Areas are the location of several fuel processing facilities that are inactive or scheduled for deactivation (REDOX Plant, PUREX Plant, T Plant, B Plant, U Plant, and PFP), buried solid waste, and irradiated fuel storage. The 200 Areas are also the location of 43 of the Hanford Site's 72 Superfund areas (past waste disposal or release sites requiring investigation and potential remediation), nearly 2,500 ha (6,200 ac) of surface contamination, and past contaminant releases to the ground, which have resulted in groundwater contamination plumes that underlie approximately 520 km^2 (200 mi^2) of the Site.

Of the radionuclides in the 200 Areas (254 million curies), the waste in the tanks (177 million curies) and the cesium and strontium capsules (68 million curies) account for approximately 97 percent of the inventory. Another 1 million curies are estimated to have been released or leaked to the ground, approximately 5 million curies have been disposed of in solid waste burial grounds, and 3 million curies are stored in solids or contained in irradiated fuel storage. The TWRS EIS addresses management and disposal of tank waste and the cesium and strontium capsules once final disposition has been implemented. The TWRS EIS also analyzes the cumulative impacts of other past, present, and reasonably foreseeable future actions at the Hanford Site.

Other waste disposal activities in or near the 200 Areas that are addressed in the cumulative impact analysis in this EIS include the following:

- Site waste from the Environmental Restoration program to be disposed of in the Environmental Restoration Disposal Facility;
- Commercial low-level waste disposed of at the US Ecology site; and
- Past waste disposal and tank leaks.

Cesium and strontium are stored in approximately 1,930 double-walled capsules. In the 1960's and 1970's, radioactive cesium and strontium were extracted from waste in some SSTs to reduce the sources of heat in the tanks (WHC 1995h). The cesium and strontium were converted to salt forms and placed in capsules. Some capsules were shipped offsite to be used as heat or radiation sources. All the capsules will be returned to the Hanford Site for final disposal (DOE 1994c). All strontium capsules have been returned to the Site, and all cesium capsules are scheduled to be returned to the Site in 1997. The capsules at the Hanford Site are stored in the 200 Areas in the Waste Encapsulation and Storage Facility, which began operating as a capsule production facility in 1974. For the purpose of analysis in this EIS, it is assumed that all capsules will be returned to the Hanford Site and stored in the Waste Encapsulation and Storage Facility. The capsules currently are classified as waste by-product material, which means they could be put to productive uses if a need is identified and a user acceptable to DOE desires the material. For example, the strontium could be used as a source of heat and the cesium could be used to sterilize medical equipment or to irradiate food to extend its shelf life. DOE is attempting to find uses for these materials. If no future use can be found, the cesium and strontium capsules may be classified as high-level waste (HLW) for disposal purposes. The final determination as to whether the capsules are HLW will be made in consultation with the Nuclear Regulatory Commission. The number of capsules requiring treatment and disposal could increase slightly if capsule contents, previously removed during research and development programs, are reencapsulated. The volume of tank waste and number of capsules are summarized in Figure 1.1.1.

1.1.2 Regulatory Developments

From the 1943 to 1989, the Hanford Site's principal mission was the production of weapons-grade plutonium. To produce plutonium, uranium metal was irradiated in a plutonium production reactor. The irradiated uranium metal, also known as spent fuel, was cooled and then treated in a chemical separations or reprocessing plant. At the reprocessing plant, the spent fuel was dissolved in acid and the plutonium was separated from uranium and many radioactive by-products. The plutonium then was used for nuclear weapons production. Several tons of spent fuel were produced to generate enough plutonium to make a nuclear weapon. The process resulted in a large volume of radioactive waste.

The Hanford Site processed more than 100,000 metric tons (mt) (110,000 tons) of irradiated uranium and generated several hundred thousand metric tons of chemical and radioactive waste. The waste included HLW, transuranic waste, low-activity waste (LAW), hazardous waste, and mixed waste (radioactive and hazardous waste).

For many years, the waste produced at the Hanford Site was managed in a manner that complied with standards at that time. For the HLW generated by the chemical reprocessing plants, waste management initially involved making the waste caustic with sodium hydroxide and calcium carbonate and storing the waste in large underground tanks until a long-term solution could be found for disposal of HLW. In the 1940's through the early 1960's, 149 SSTs were built to store HLW in the 200 Areas of the Hanford Site.

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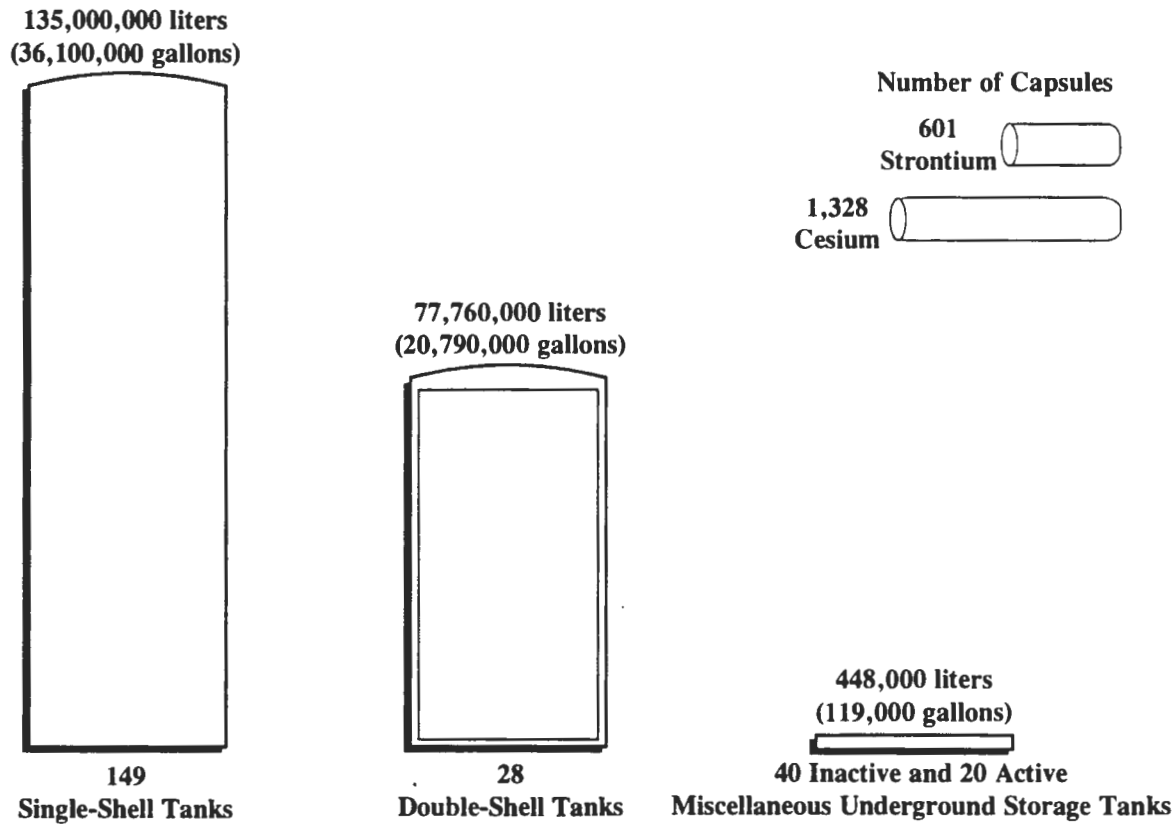
Figure 1.1.1 Hanford Site Tank Waste and Capsule Overview



NOTE: The heights of the tank waste symbols illustrated the relative amounts.

During the 1950's, uranium was extracted from some of the SSTs, an action that introduced new chemicals to the tanks. Also, to free up tank space for the large volume of new waste being generated by fuel reprocessing, chemicals were added to the tanks to cause many of the radionuclides to settle to the bottom of the tanks (Gephart-Lundgren 1995). The remaining liquid contained a low concentration of radioactivity that did not require tank storage. Large volumes of the liquid waste could be siphoned off and disposed of as LAW. As waste flowed from one tank to another, much of the solids were separated off from the waste along the way, and the LAW liquid that resulted was sent to unlined cribs where it percolated into the soil. This process resulted in increasing the concentration of the cesium-137 and strontium-90, which concentrated the heat being generated enough that waste in some

Major TWRS Regulatory Compliance Requirements

The regulatory changes that have occurred since the 1970's have significantly altered the way DOE manages and disposes of Hanford Site's tank waste. The major laws, regulations, and agreements that would affect which tank waste management and disposal alternative DOE can implement include the following:

- Clean Air Act;
- Clean Water Act;
- RCRA;
- Washington State Hazardous Waste Management Act;
- Atomic Energy Act;
- Nuclear Waste Policy Act; and
- Tri-Party Agreement.

tanks began to boil and the heat threatened the integrity of the tanks. To address this problem, chemicals were added to the tanks in the 1960's to separate cesium and strontium from the waste and waste was recovered from the tanks. Cesium and strontium then were extracted from the waste in B Plant, placed in capsules, and stored in a separate facility.

In the mid-1950's, leaks were detected in SSTs. By the late 1980's, 67 of the SSTs were known or suspected leakers, and an estimated 3.8 million liters (L) (1 million gallons [gal]) of HLW had been released into the soil beneath the tanks. To address concerns with the design of SSTs, the Hanford Site adopted a new DST design. The DST design would allow leaks to be detected and remedial action taken before waste could reach soil surrounding the tanks. Between 1968 and 1986, 28 DSTs were constructed. Through the end of July 1996, 115 SSTs have been stabilized by removing pumpable liquids to minimize future leaks. The stabilization program will be completed in 2000. Newly generated waste and pumped interim SST stabilization waste is stored in the DSTs.

Throughout much of the history of plutonium production at the Hanford Site, there were few laws regulating waste management and environmental protection. In the 1970's and 1980's, new environmental laws were enacted regulating waste management, storage, disposal, and pollution emissions to the air and water. Because of national security concerns, nuclear production facilities like the Hanford Site were self-regulated. Under the provisions of the Atomic Energy Act, DOE was authorized to establish standards to protect health or minimize dangers to life or property for activities under DOE's jurisdiction. In the 1980's, much of DOE's authority to self-regulate facilities was eliminated, and other agencies became responsible for regulating many aspects of DOE's activities. The Clean Air Act originally was passed in 1970 and has been amended several times, including extensive amendments in 1977 and 1990. This law requires DOE to meet national air quality standards, ensure hazardous air emissions from existing and new sources are controlled to the extent practical, and obtain an operating permit for all major emission sources. The Clean Water Act, which underwent major amendments in 1972, 1977, and 1987, and the Safe Drinking Water Act, originally passed in 1974 and amended in 1986, regulate discharges to surface water, set national drinking water standards, and regulate emissions of hazardous constituents to surface and groundwater.

In 1976, with the passage of the Resource Conservation and Recovery Act of 1976 (RCRA), the Federal government for the first time assumed a major role in the management of hazardous waste. Through RCRA, the 1984 amendment to RCRA (known as the Hazardous and Solid Waste Amendments of 1984), and as amended by the Federal Facility Compliance Act of 1992, the EPA and EPA-authorized states were authorized to regulate hazardous waste generation, treatment, storage, and disposal. RCRA's provisions excluded radioactive waste from regulation by EPA, and it was not until 1984 that EPA's jurisdiction over DOE's nonradioactive waste was firmly established. In 1987, mixed waste at DOE facilities was recognized under RCRA regulations. In November 1987, Ecology, the administrating agency for the state Hazardous Waste Management Act, was delegated RCRA enforcement authority. RCRA established regulations for newly generated hazardous waste but did not address past waste disposal practices. To clean up past hazardous and radioactive waste disposal sites, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act

(CERCLA) in 1980. CERCLA was significantly amended in 1986 by the Superfund Amendments and Reauthorization Act. The 1986 amendments required Federal agencies to investigate and remediate releases of hazardous substances, including radioactive contaminants, from their facilities.

Beginning in 1986, regulators from EPA, Ecology, and DOE's Richland Operations Office began to examine how best to bring the Hanford Site into compliance with RCRA and CERCLA. The regulators and DOE agreed to develop one compliance agreement that set agreed-upon milestones for cleaning up past disposal sites under CERCLA and bring operating facilities into compliance with RCRA. Negotiations concluded in late 1988, and the Tri-Party Agreement was signed by the three agencies on January 15, 1989. The Tri-Party Agreement is the primary framework for CERCLA and RCRA regulation of the Hanford Site, including the tank farms. The existing hazardous and mixed waste and new waste added to the tank farms is regulated through the Tri-Party Agreement's RCRA enforcement provisions. Hazardous, mixed, and radioactive waste from the tanks that was disposed of through the cribs to the soil is regulated through the Tri-Party Agreement's CERCLA enforcement provisions. Neither RCRA nor CERCLA provide the regulatory framework for the disposal of radioactive waste.

In response to the continued accumulation of spent nuclear fuel, high-level radioactive waste, other hazardous waste, and growing public awareness and concern for public health and safety, Congress has passed numerous laws including the Nuclear Waste Policy Act of 1982. The purpose of these laws was to establish a national policy and programs that would provide reasonable assurance that the public and the environment would be adequately protected from the hazards posed by these wastes. The action by Congress was influenced by a national consensus that the potential hazards of spent nuclear fuel and HLW needed to be permanently isolated from the human environment with minimal reliance on institutional controls. Permanent isolation consists of containment of the waste within engineered and natural barriers, which are likely to contain the material for a very long time. Minimal reliance on institutional controls means the isolation is not dependent on ongoing maintenance of facilities, human attention, or commitment by governments or other institutions. The national consensus has been reflected in the Northwest by strong support among DOE, Federal and State agencies, Tribal Nations, and citizens and stakeholders to clean up the Hanford Site.

In 1974, Congress passed the Energy Reorganization Act, which authorized the Nuclear Regulatory Commission to regulate and license DOE facilities constructed for the express purpose of long-term storage and disposal of high-level radioactive waste, which is not part of DOE's research and development program. The Nuclear Regulatory Commission has established regulations for radioactive waste that can be disposed of in land disposal sites (10 CFR Part 61), as well as radioactive waste requiring geologic disposal (10 CFR Part 60). The EPA was authorized to establish standards for managing and disposing of spent nuclear fuel, HLW, and transuranic waste. These regulations are contained in 40 CFR Part 191 and would apply to HLW disposed of at the Hanford Site.

A number of evaluations and decisions regarding the disposal of commercial and defense HLW were completed in the late 1970's and early 1980's. These evaluations included NEPA analysis for

management of commercial radioactive waste, the Waste Isolation Pilot Plant, and the Immobilization Research and Development program at Savannah River. For these evaluations, it was decided that HLW and transuranic waste should be disposed of in potential geologic repositories.

Congress then enacted the Nuclear Waste Policy Act, authorizing Federal agencies to develop geologic repositories for disposing of high-level radioactive waste and spent nuclear fuel from commercial reactors. In 1983, DOE submitted the Defense Waste Management Plan, which provided deep potential geologic repository disposal of HLW as the planning basis for all DOE HLW, and in 1985, the President approved a DOE recommendation to dispose of defense waste in a commercial repository. In 1987, Congress amended the Nuclear Waste Policy Act to focus potential geologic repository development activity at one site, the Yucca Mountain site in Nevada.

In addition to applicable laws and regulations, DOE has established a set of policies to guide DOE activities. In 1988, DOE issued DOE Order 5820.2A, which stated DOE's policy to process and dispose of HLW in a potential geologic repository. For planning purposes, DOE assumes that some or all of the defense HLW that satisfies the repository acceptance criteria could be placed in the first potential geologic repository developed under the Nuclear Waste Policy Act. By law, the first repository is limited to a total capacity of 70,000 mt (77,000 tons) of spent nuclear fuel or HLW, or a quantity of solidified HLW resulting from the reprocessing of such a quantity of spent fuel prior to operating a second repository. The allocated capacity for defense HLW in the first repository is 7,000 mt (7,700 tons). At this time, sufficient quality and quantity of information is not available to determine whether the Yucca Mountain site is a suitable candidate for geologic disposal of spent nuclear fuel and HLW. DOE will prepare a repository EIS to evaluate potential environmental impacts associated with the repository's construction and operation.

1.1.3 Hanford Defense Waste Environmental Impact Statement Record of Decision

In April 1988, after completing the Hanford Defense Waste EIS, DOE decided to proceed with preparing the DST waste for final disposal. Based on the Hanford Defense Waste EIS Record of Decision, the waste was to be processed in a pretreatment facility to separate DST waste into two waste streams (53 FR 12449). The larger waste stream would be LAW, and a smaller waste stream would be HLW. The LAW was to be mixed with a cement-like material to form grout. The grout was to be encased in large underground concrete vaults at the Hanford Site. The HLW portion was to be vitrified into a glass-like material and encased in stainless-steel canisters at the proposed Hanford Waste Vitrification Plant. The canisters were to be stored at the Hanford Site until a potential geologic repository was available to receive this waste. The Hanford Defense Waste EIS Record of Decision also called for the continued storage of cesium and strontium capsules until a potential geologic repository was ready to receive the capsules for disposal. Before shipment to the repository, the capsules would be packaged to meet the repository acceptance criteria.

In the Hanford Defense Waste EIS Record of Decision, DOE decided to perform additional development and characterization before making decisions on final disposal of SST waste. The SST waste would continue to be stored and monitored. The development and characterization effort was to

focus on methods to retrieve and process SST waste for disposal and stabilize and isolate the waste near the surface. Before a decision would be made on the final disposal of the waste, alternative disposal methods were to be examined in a supplemental analysis to the Hanford Defense Waste EIS.

The Hanford Defense Waste EIS Record of Decision formed the planning basis for DOE programs to manage tank waste and cesium and strontium capsules at the Hanford Site. The TWRS program is responsible for tank farm routine operations, including tank farm management, regulatory compliance, reporting, surveillance, and operations and maintenance of facilities and equipment. Additional ongoing TWRS activities include: 1) characterizing waste to support safety, retrieval and transfer, processing, treatment, and disposal; 2) addressing tank safety issues; 3) isolating and removing pumpable liquid from SSTs to reduce the potential of future leakage; and 4) operating the 242-A Evaporator to concentrate waste by reducing the amount of liquid. Other projects initiated under the 1988 Record of Decision included technology development, design, and construction of the facilities needed to implement the planned retrieval, pretreatment, immobilization, and storage and disposal of DST waste.

1.1.4 Developments Since the Hanford Defense Waste Record of Decision

The TWRS EIS satisfies the DOE commitment made in the Hanford Defense Waste EIS Record of Decision to prepare a supplemental NEPA analysis. The TWRS EIS also is being prepared in response to several important changes since the 1988 Hanford Defense Waste Record of Decision requiring DOE to prepare the TWRS EIS. The following changes affected the planned approach for managing the disposal of Hanford Site tank waste.

- B Plant, which was selected in the Hanford Defense Waste Record of Decision as the facility for pretreatment processes to comply with current environmental and safety requirements, was found not to be viable or cost-effective.
- The Tri-Party Agreement was signed by DOE, Ecology, and EPA in 1989, establishing an approach for achieving environmental compliance at the Hanford Site, including specific milestones for the retrieval, treatment, and disposal of tank waste.
- Safety issues were identified for about 50 DSTs and SSTs, which became classified as Watchlist tanks in response to the 1990 enactment of Public Law 101-510.
- The planned grout project was terminated, and a vitrified waste form was adopted as the proposed approach as a result of stakeholders' concerns with the long-term adequacy of near-surface disposal of grouted LAW in vaults.
- The construction of the Hanford Waste Vitrification Plant was delayed because of insufficient capacity to vitrify the HLW fraction of all DST and SST waste in the planned time frame.
- The planning basis for retrieval of the waste from underground storage tanks was changed to include the SSTs and treating the retrieved SST waste in combination with DST waste.

These changes resulted in an extensive reevaluation of the waste treatment and disposal plan that culminated in adopting a revised strategy to manage and dispose of tank waste and encapsulated cesium and strontium. The reevaluation of the waste treatment and disposal plan began following a December 1991 decision by the Secretary of Energy to reconsider the entire tank safety and treatment and disposal program and to accelerate the retrieval and disposal of SST waste (DOE 1995i) (Figure 1.1.2).

Tri-Party Agreement

The Tri-Party Agreement is an enforceable agreement among DOE, Ecology, and EPA for achieving environmental compliance at the Hanford Site. The agreement accomplishes the following:

- Defines CERCLA cleanup provisions for past contamination;
- Defines RCRA waste treatment, storage, and disposal requirements and corrective actions for waste management;
- Establishes the responsibilities for each agency;
- Provides a basis for budgeting; and
- Establishes enforceable milestones for achieving cleanup and regulatory compliance.

In March 1993, DOE submitted proposed changes to the Tri-Party Agreement to Ecology and EPA to reflect the new technical strategy. DOE, Ecology, and EPA agreed to negotiate changes to the agreement. As part of the reevaluation process and the renegotiation of the Tri-Party Agreement, DOE involved the public by conducting a series of 10 public meetings and forming the Tank Waste Task Force to receive stakeholder input on the revised technical strategy (HTWTF 1993). In September 1993, formal negotiations ended, and the negotiated changes underwent a public comment period from October through December 1993. The changes to the Tri-Party Agreement were incorporated into an amended agreement signed by DOE, Ecology, and EPA in January 1994.

The agencies negotiated changes to the Tri-Party Agreement in 1996. The proposed changes underwent a 45-day public comment period that ended on February 15, 1996 and were approved in July 1996. Major changes to the tank waste system program contained in the amendment reflect the incorporation of DOE's proposed privatization (contracting with private companies) using one of two approaches.

The primary approach would involve two or more facilities that would be designed, owned, built, and operated by private contractors. The alternative approach, which would be implemented only if the primary approach was abandoned, would provide a fall back technical and regulatory approach to privatization. Under the primary approach, all LAW would be processed by 2024, which is 4 years earlier than under the alternative approach or the current Tri-Party Agreement schedule. The proposed changes also would result in the LAW pretreatment milestones being included with milestones for LAW vitrification. Under the alternative approach, DOE and Ecology have agreed to milestones that serve as a fall back technical and regulatory approach for privatization.

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Figure 1.1.2 Hanford Site Tank Waste Remediation System Timeline

Plutonium Production Ends at the Hanford Site	DOE, EPA, and Ecology Sign Tri-Party Agreement		DOE Begins to Revise Tank Waste Program		DOE Proposes Tri-Party Agreement Amendment	TWRS EIS and Safe Interim Storage EIS Begin	DOE Considers Phased Approach to Tanks	TWRS EIS Issued
1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
DOE Issues Hanford Defense Waste EIS Record of Decision		Watchlist Tank Law Passed by Congress	DOE Ends LAW Grout Program		DOE, EPA, and Ecology Negotiate Tri-Party Agreement	Tri-Party Agreement Amendment Signed	Safe Interim Storage EIS Record of Decision Issued	TWRS EIS Record of Decision Scheduled for Issuance

The revised technical strategy embodied in the Tri-Party Agreement addressed the need to manage and dispose of tank waste because the waste has an unacceptable potential to release radioactive and hazardous waste to the environment and thereby poses risk to human health and the environment. The risk posed by tank waste includes urgent tank safety issues and long-term risk. Urgent tank safety issues include flammable gas generation, potential uncontrolled reaction of ferrocyanide-containing waste, potential uncontrolled reaction of organic-containing waste, high heat, tank vapor, and the potential for nuclear criticality. DOE is implementing corrective actions or mitigation measures to resolve urgent tank safety issues.
As part of the technical strategy to address tank farm safety issues, DOE proposed implementing tank farm improvements to address near-term safety

Relationship of the Safe Interim Storage EIS Record of Decision and the TWRS EIS

The Safe Interim Storage EIS Record of Decision resulted in a decision to construct a replacement cross-site transfer system to transfer waste from the 200 West Area tank farms to DSTs in the 200 East Area. These transfers would be undertaken to address urgent waste storage concerns and would involve only a small percentage of the total waste volume in the 200 West Area. Several TWRS EIS alternatives would involve the transfer of tank waste from the 200 West Area tank farms to the 200 East Area for waste separation and immobilization.
These waste transfers would use the replacement cross-site transfer system to move the waste from the 200 West Area to the 200 East Area.
The TWRS EIS examines the potential environmental impacts associated with these waste transfers.

issues that required resolution before the completion of the TWRS EIS. These improvements included constructing new storage tanks (DSTs), a replacement cross-site transfer system between the 200 East Area and the 200 West Area, and associated tank waste retrieval systems.

In January 1994, the interim action Safe Interim Storage of Hanford Tank Waste EIS was initiated by DOE and Ecology to analyze the potential environmental impacts associated with the proposed interim actions and their reasonable alternatives (DOE 1995i). The Safe Interim Storage EIS dealt with only urgent tank waste safety concerns that require action before implementing decisions based on the TWRS EIS. The Final Safe Interim Storage of Hanford Tank Waste EIS was issued in October 1995, and a Record of Decision was issued in November 1995 (60 FR 61687).

In the Safe Interim Storage EIS and the Record of Decision, DOE and Ecology decided that existing mitigation measures and tank farm waste inventory management strategies had diminished the risk associated with Watchlist tanks. Therefore, DOE decided not to construct additional DSTs to store waste retrieved from Watchlist tanks. In the Record of Decision, DOE also stated that safe interim storage of tank waste required constructing a replacement cross-site transfer system between the 200 West Area and the 200 East Area. The transfer system will permit DOE to continue to stabilize SST waste in the 200 West Area. The waste transfer system also will provide operational flexibility should one or more tanks in the 200 West Area require retrieval before implementing the management and disposal decisions based on the TWRS EIS.

1.2 DEVELOPMENT OF EIS ALTERNATIVES

In this EIS, DOE and Ecology examine a range of reasonable alternative approaches, including no action, for implementing the technical strategy for retrieving, pretreating, and immobilizing tank waste. These approaches include either full implementation by DOE or phased implementation. The phased approach to implementing the TWRS technical strategy would have, as a first phase, constructing and operating demonstration-scale tank waste pretreatment and immobilization facilities at the Hanford Site. Following completion of the demonstration phase, a second phase would be implemented. The second phase would consist of full-scale waste separations and immobilization.

Managing and disposing of the tank waste and the encapsulated cesium and strontium involves a number of components including waste retrieval, pretreatment, immobilization, storage, and disposal. Numerous technologies are available to

Closure

Closure is a regulatory term for those activities involved in remediating the tank equipment, contaminated soil, and contaminated groundwater after the tank waste has been remediated.

Closure decisions are not part of this EIS but are interrelated with the decisions made concerning remediating the waste.

For purposes of analysis, closure as a landfill was included in all of the alternatives except the No Action and Long-Term Management alternatives so the alternatives could be meaningfully compared. This does not mean that closure as a landfill has been proposed or would be selected for final tank closure.

accomplish each component. For analysis in the EIS, DOE and Ecology developed alternatives that cover the full range of reasonable alternatives and reflect the results of the public scoping process for this EIS. Representative alternatives that incorporate the range of cost, human and ecological health risk, and technologies have been developed for analysis in the EIS. To provide a meaningful comparison of the alternative, a representative tank farm closure scenario was assumed for all tank waste alternatives. However, closure is beyond the scope of this EIS, and the EIS does not provide sufficient analysis to support a closure decision.

The first step in developing the alternatives for analysis in the EIS was to identify the available components and associated technologies. The candidate technologies then were screened to identify technologies that would be incorporated into the representative alternatives analyzed in the EIS. The screening process resulted in three groups of alternatives: 1) representative alternatives analyzed in the EIS (Section 3.0 and Volume Two, Appendix B); 2) technologies that, though not directly included in the representative alternatives, are considered in the EIS and are therefore available for potential implementation by decision makers (Volume Two, Appendix B); and 3) alternatives that were considered but excluded from analysis and therefore would not be available for selection by the decision makers (Volume Two, Appendix C). This process resulted in the development of 10 tank waste alternatives and four cesium and strontium capsule alternatives.

TWRS EIS Alternatives Development Process

Step #1: Identify components and applicable technologies

Step #2: Screen technologies

Step #3: Combine screened technologies into representative alternatives for detailed EIS analysis

A detailed description of the alternative development process is provided in Section 3.3 and Volume Two, Appendix B.

1.3 DOE AND ECOLOGY PREFERRED ALTERNATIVE

DOE and Ecology have identified the Phased Implementation alternative as the preferred alternative for managing and disposing of tank waste. The Phased Implementation alternative analyzed in the EIS is based on the integrated technical strategy for tank waste outlined in the Tri-Party Agreement. The DOE and Ecology preferred alternative for managing and disposing of encapsulated cesium and strontium is the No Action alternative.

1.4 CONTENTS OF THE EIS

A separate summary provides an overview of the EIS. Volume One includes the text of the EIS and is organized into eight sections, including this introduction. The sections in Volume One are described as follows.

1.0 Introduction

This section provides background on the development of the TWRS EIS, the content of the EIS, and information to help the reader understand technical information and data presented in the EIS.

2.0 Purpose and Need for Action

The need for agency action is described in this section. The environmental conditions and the legal and regulatory requirements that the proposed action and alternatives address are summarized in this section.

3.0 Description and Comparison of Alternatives

This section explains the approach used for developing the alternatives and describes each of the alternatives in detail. Each alternative then is summarized, and the major features of the alternatives are compared. Other technologies available for inclusion in the alternatives are identified. Alternatives considered but dismissed from further analysis are identified, and the decisions to dismiss these alternatives are explained.

4.0 Affected Environment

This section describes the current environment (e.g., land, water, air, wildlife, and socioeconomics) that potentially would be affected by the proposed TWRS action and the alternatives addressed in the EIS. The description of the affected environment provides the basis for 1) analyzing the impacts of the proposed action and the alternatives; and 2) making comparisons among the potential impacts of the alternatives (Section 5.0).

Areas of Environmental Analysis

Areas of the existing environment described and analyzed for potential impacts in the EIS include the following:

Accidents	Occupational Health
Air Quality	Public Health
Biodiversity	Public Services
Cultural Resources	Sensitive Habitats
Economy	Sensitive Species
Employment	Species of Concern
Environmental Justice	Surface Water
Geology	Transportation
Groundwater	Vegetation
Land Use	Wildlife
Noise	

5.0 Environmental Consequences

This section describes the potential environmental impacts of each alternative. The impacts analysis is presented in terms of the specific components of the natural and human environment (e.g., air, water, wildlife, and socioeconomics). For each component of the environment, the potential positive and negative impacts of each alternative are presented to provide a basis for comparing the environmental consequences of the proposed action and alternatives.

Methods to mitigate adverse impacts are described in this section. The section also summarizes: 1) cumulative impacts of TWRS activities plus the impacts of other Federal and non-Federal activities; 2) short-term impacts and long-term environmental productivity and

irretrievable resource commitments; and 3) potential conflicts among land-use plans of various agencies. Identified are energy and natural resource consumption and conservation and pollution prevention measures related to each alternative. Also identified are any adverse impacts and disproportionate impacts on minority communities and low-income communities.

6.0 Statutory and Regulatory Requirements
This section describes Federal and Washington State statutes, regulations, and policies applicable to each alternative and the ability of each alternative to meet these requirements.

7.0 Scoping, Public Participation, and Consultations
This section describes how the scope of the TWRS EIS was established and the public participation processes through the public comment period of the Draft EIS. A summary of interagency and intergovernmental consultations also is provided.

8.0 List of Preparers
The agencies responsible for preparing the EIS are identified, and the names and roles of the individuals primarily responsible for preparing the EIS are listed.

Volumes Two through Six consist of appendices to the EIS. The 12 appendices provide detailed technical materials and data to support the analyses summarized in the text of the EIS. Figure 1.4.1 illustrates the relationship between the major volumes and sections of the EIS.

1.5 READERS GUIDE AND HELPFUL INFORMATION

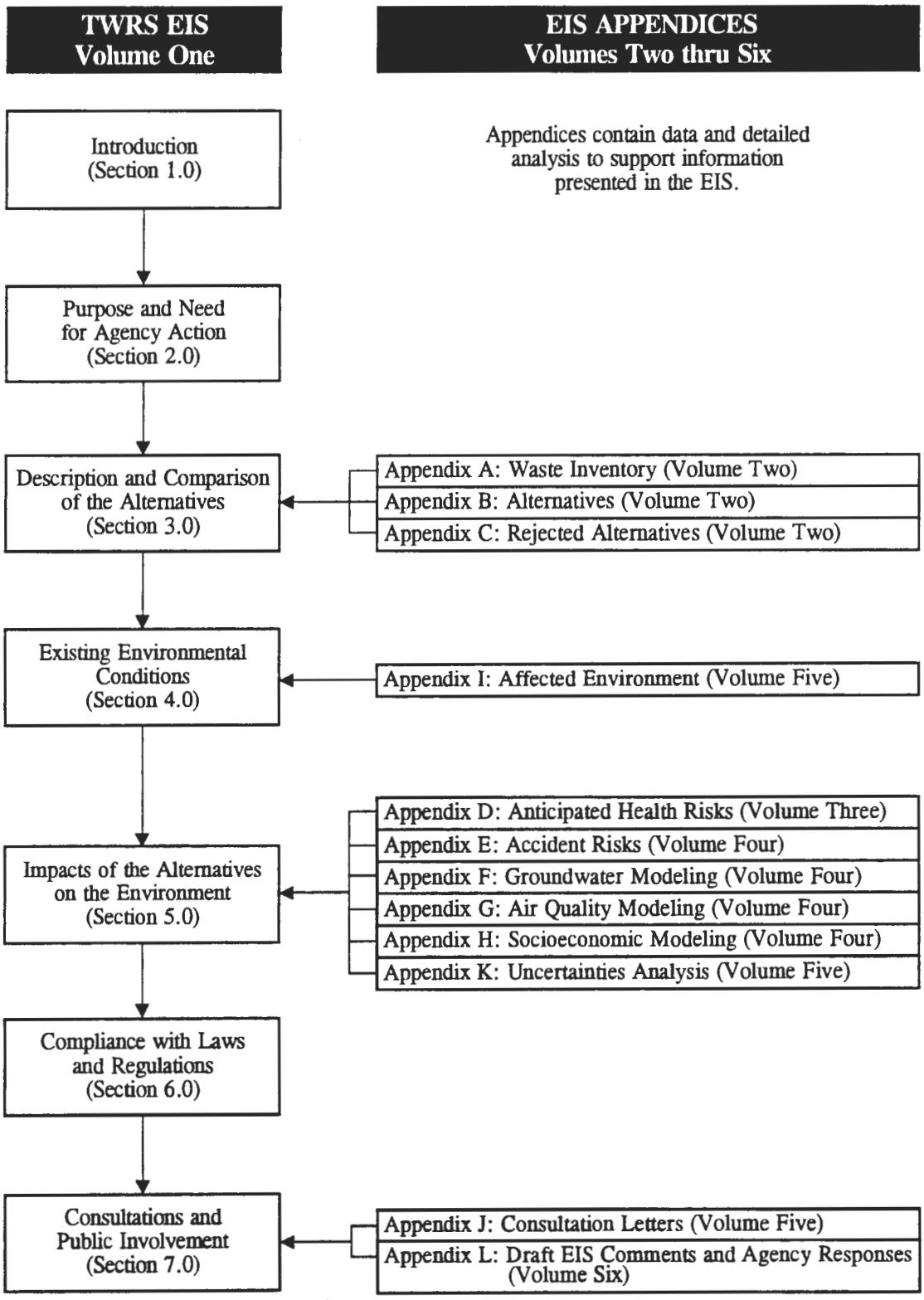
The following information is provided to help the reader understand the technical data and format of this EIS. Definitions of technical terms can be found in the Glossary at the end of this volume. Listings of acronyms, and abbreviations, radionuclides, and chemical compounds can be found following the Table of Contents.

Reference Citations

Throughout the text of this document, in-text reference citations are presented where information from the referenced document was used. These in-text reference citations are contained within parentheses and provide a brief identification of the referenced document. This brief identification corresponds to the complete reference citation located on the reference list at the end of Volume One and following each appendix in Volumes Two to Five. An example of an in-text reference citation is (DOE 1995b), which corresponds to the complete reference citation provided at the end of the volume or appendix. On the reference list, DOE 1995b is listed in the following manner.

DOE 1995b. Implementation Plan for the Tank Waste Remediation System Environmental Impact Statement. DOE/RL-94-88. U.S. Department of Energy and Washington State Department of Ecology. Richland, Washington. December 1995.

Figure 1.4.1 Relationship of the Contents of the TWRS EIS



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Rounding

Throughout the text of this document, numbers were rounded to two significant figures (e.g., 212 would be rounded to 210 and 0.126 would be rounded to 0.13). In many cases, rounding is done to reflect the degree of uncertainty inherent in the analysis or to simplify the relative differences among alternatives. In certain cases, numbers were not rounded to two significant digits to preserve the differences in impacts between alternatives.

Scientific Notation

Scientific notation is used in this document to express very large or very small numbers. For example, the number one million could be written in scientific notation as 1.0E+06 or in traditional form as 1,000,000. Translating from scientific notation to the traditional number requires moving the decimal point either right or left from the number being multiplied by 10 to some power depending on the sign of the power (negative power move left or positive power move right).

Translating Scientific Notation

Example 1: 2.6E+06 = 2,600,000
Example 1 shows a positive power of six. To translate, move the decimal to the right six places adding zeros as necessary to achieve 2,600,000.

Example 2: 2.6E-07 = 0.00000026
Example 2 shows a negative power of seven. To translate, move the decimal to the left seven places adding zeros as necessary to achieve 0.00000026.

Chemical Elements and Radioactive Isotopes

Many chemical elements and radioactive isotopes are referenced in this document. Examples of the chemical elements are cesium-137, strontium-90, plutonium-239, and uranium-235. For the most part, these elements are spelled out; however, these elements may be presented in tables and figures in this format: Cs-137 or cesium-137, Sr-90 or strontium-90. The most common chemical elements and radioactive isotopes used in this EIS are listed following the Table of Contents.

Units of Measure

The primary units of measure used in this EIS are metric. However, the approximate equivalent in the U.S. Customary System of units is shown in parentheses directly following the use of a metric unit. For example, a distance presented as 10 meters (m) is followed by 33 feet [ft]. This example would be presented in the text of the document as follows: 10 m (33 ft).

Radioactivity Units

Radioactivity is presented in radioactivity units. The curie (Ci) is the basic unit used to describe an amount of radioactivity. Concentrations of radioactivity generally are expressed in terms of curies or fractions of curies per unit mass, volume, and area. One curie is equivalent to 37 billion disintegrations per second, and is the quantity of any radionuclide that decays at a rate of 37 billion disintegrations per

Units of Radioactivity

Symbol	Name
Ci	curie
MCi	megacurie (1.0E+06 Ci)
mCi	millicurie (1.0E-03 Ci)
μCi	microcurie (1.0E-06 Ci)
nCi	nanocurie (1.0E-09 Ci)
pCi	picocurie (1.0E-12 Ci)

second. Disintegrations generally produce emissions of alpha or beta particles, gamma radiation, or combinations of these. An explanation of radiation is contained in Section 4.11.

Radiation Dose Units

The amount of energy deposited by radiation in a living organism is the radiation dose. For humans, the radiation dose usually is reported as effective dose equivalent, expressed in terms of rem.

For example, the average dose rate from natural sources (cosmic radiation, natural radioactivity in the earth, and other natural sources) is approximately 0.3 rem/year. This document reports radiation dose in millirems (mrem). One millirem is equal to one-thousandth of a rem. Therefore, 0.3 rem per year could be restated as 300 mrem/year or 3.0E-01 rem/year.

Names and Symbols for Units of Measure

Length		Area		Volume	
cm	centimeter	ha	hectare	cm^3	cubic centimeter
ft	foot	ac	acre	ft^3	cubic foot
in.	inch	km^2	square kilometer	gal	gallon
km	kilometer	mi^2	square mile	L	liter
m	meter	ft^2	square foot	m^3	cubic meter
mi	mile			ppb	parts per billion
				ppm	parts per million
				yd^3	cubic yard

Mass		Temperature		Electricity/Energy	
kg	kilogram	°C	degrees centigrade	A	amphere
mg	milligram	°F	degrees Fahrenheit	J	joule
lb	pound			KV	kilovolt
mt	metric ton			KW	kilowatt
				MeV	million electron volts
				MW	megawatt
				V	Volt
				W	Watt

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Purpose and Need for Action

2.0 PURPOSE AND NEED FOR ACTION

SECTION HIGHLIGHTS

- Reduce risk to the public, workers, and the environment
- Comply with regulations
- Manage and dispose of waste

The U.S. Department of Energy (DOE), in cooperation with the Washington State Department of Ecology (Ecology), must make decisions on how to manage and dispose of Hanford Site tank waste and encapsulated cesium and strontium to reduce existing and potential future risk to the public, Site workers, and the environment. The waste, which is classified as radioactive high-level and low-activity, hazardous, and mixed waste (radioactive and hazardous waste), is stored in 177 underground storage tanks and approximately 60 other smaller active and inactive miscellaneous underground storage tanks in the tank farm system. DOE also must manage and dispose of waste that may be added to the tanks from current and planned cleanup operations at the Hanford Site. DOE also must address the management and disposal of the approximately 1,930 cesium and strontium capsules, which are either stored in the Waste Encapsulation and Storage Facility in water basins at the Hanford Site or are being returned to the Hanford Site.

The Hanford Site defense activities created a wide variety of waste. Because the tank waste and associated inactive miscellaneous underground storage tank waste contain by-products of reactor fuel processing, they are classified by the Nuclear Regulatory Commission as high-level radioactive waste (10 Code of Federal Regulations [CFR] Part 60). The high-level waste presently stored in 28 double-shell tanks (DSTs), 149 single-shell tanks (SSTs), and approximately 60 miscellaneous underground storage tanks came from a variety of operations and includes a variety of waste types. This waste has been processed and transferred between tanks, which has caused the chemical and physical characteristics of the waste to vary greatly among and within individual tanks. In addition, the tank waste contains chemicals or characteristics classified as hazardous waste under the Resource Conservation and Recovery Act regulations (40 CFR Parts 260 to 268 and 270 to 272) and as dangerous waste under the Washington Administrative Code (WAC) Dangerous Waste Regulations (WAC 173-303). Planned future waste to be stored in the tanks includes radioactive high-level and low-activity, hazardous, and mixed waste that will be transferred to the DSTs during deactivation and cleanout of Hanford Site facilities.

In April 1988, the Hanford Defense Waste Record of Decision was published in the Federal Register (53 FR 12449). In this Record of Decision, DOE decided to proceed with preparing DST waste for final disposal and develop additional information before making a final decision on disposal of SST waste. However, several important changes have occurred since the 1988 Hanford Defense Waste Record of Decision. Because of these changes, DOE and Ecology must examine alternative ways to manage and dispose of tank waste and encapsulated cesium and strontium. The changes include the following:

- Upgrading B Plant, which the Hanford Defense Waste Record of Decision proposed as the facility for pretreatment processes to comply with current environmental and safety requirements, was found not to be viable or cost-effective; consequently, B Plant was eliminated from consideration as a waste pretreatment facility.
- Signing the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) by DOE, Ecology, and EPA in 1989, which established an agreed-upon approach for achieving environmental compliance at the Hanford Site, and included specific milestones for the retrieval, treatment, and disposal of tank waste.
- Identifying tank safety issues for about 50 DSTs and SSTs, which became classified as Watchlist tanks in response to the 1990 enactment of Public Law 101-510.
- Terminating the planned grout project and adopting a vitrified waste form as the proposed approach as a result of stakeholders' concerns with the long-term adequacy of near-surface disposal of grouted low-activity waste in vaults.
- Delaying the construction of the Hanford Waste Vitrification Plant because of insufficient capacity to vitrify the high-level waste fraction of all DST and SST waste in the planned time frame.
- Changing the planning basis for addressing retrieval of the waste from underground storage tanks by DOE to include the SSTs and treating the retrieved SST waste in combination with DST waste.

DOE is addressing the immediate and near-term safety and environmental issues posed by this waste to minimize short-term potential risks to human health and the environment through ongoing safety programs. DOE also must implement long-term actions to safely manage and dispose of the tank waste, associated inactive miscellaneous underground storage tanks, and the cesium and strontium capsules to permanently reduce potential risk to human health and the environment. These long-term actions also are needed to ensure compliance with Federal and Washington State laws regulating the management and disposal of radioactive, hazardous, and mixed waste. Federal and State laws and regulations require DOE to safely manage the tank waste and encapsulated cesium and strontium and to dispose of high-level and low-activity waste.

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Description and Comparison of Alternatives

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3.0 DESCRIPTION AND COMPARISON OF ALTERNATIVES

SECTION HIGHLIGHTS

- Background information on the tank waste and cesium and strontium capsules
- How the alternatives were developed
- Tank waste alternatives addressed in the EIS
- Cesium and strontium capsule alternatives addressed in the EIS
- Comparison of the engineering aspects of each alternative
- Description of the alternatives considered but rejected from detailed evaluation.

3.1 INTRODUCTION

This section provides background information on the Tank Waste Remediation System (TWRS) and describes each of the alternatives addressed in this Environmental Impact Statement (EIS). This section summarizes the waste to be remediated and the remediation alternatives. Estimates of cost, schedules, and the technical feasibility of each alternative are also discussed. Additional information concerning the waste inventory, alternatives addressed, and alternatives considered but rejected from detailed evaluation is provided in Volume Two, Appendices A, B, and C, respectively.

The TWRS program involves a wide variety of both ongoing and planned activities that may extend over the next several decades. Some of these activities are interrelated with, but not directly a part of, the remediation of the tank waste or cesium and strontium capsules. The activities analyzed in the TWRS EIS and their relationship with other TWRS program activities are addressed in the following sections.

3.2 SITE AND WASTE DESCRIPTION

3.2.1 Tank Waste

3.2.1.1 History

Tank waste is the by-product of producing plutonium and other defense-related materials. From 1944 through 1990, chemical processing facilities at the Hanford Site processed irradiated or spent nuclear fuel from defense reactors to separate and recover plutonium for weapons production. As new, improved processing operations have been developed over the last 50 years, processing efficiency has improved and the waste compositions sent to the tanks for storage have changed both chemically and radiologically. T and B Plants were the first separations facilities built at the Site. The separations processes carried out at these plants recovered only plutonium; consequently, all remaining components of the dissolved fuel elements, including uranium, were sent to the waste tanks.

Later, processes were developed to recover uranium, which was recycled back into the reactor fuel cycle. Many of the chemical processes associated with plutonium recovery from spent nuclear fuel involved dissolving the material in nitric acid. The resulting acidic waste streams were made alkaline by adding sodium hydroxide or calcium carbonate before being transferred to the tanks. These

processing steps produced large volumes of sodium nitrate salts in the tanks. Table 3.2.1 shows the major processing facilities that served as sources of tank waste (see Figure 3.2.3 for locations).

Table 3.2.1 Waste Generating Facilities

Facility	Function	Operations Period
T Plant	Plutonium recovery, decontamination facility	1944 to 1956 Plutonium Recovery. 1957 to Present; decontamination and repair facility
B Plant	Plutonium recovery and separation of cesium and strontium from other waste	1945 to 1952, 1968 to 1985
REDOX (S Plant)	Plutonium and uranium recovery	1952 to 1966
PUREX Plant	Plutonium and uranium recovery	1956 to 1972, 1983 to 1990
PFP (Z Plant)	Refine plutonium from PUREX Plant	1949 to 1989; future plans include waste storage
U Plant	Uranium recovery from reclaimed tank waste	1952 to 1958

Notes:
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
REDOX = Reduction-Oxidation

Chemical processing generated approximately 1.5E+09 liters (L) (4.0E+08 gallons [gal]) of waste. More than 1.1E+09 L (3.0E+08 gal) of waste was sent to underground storage tanks throughout the production period. Volume reduction practices were followed to maintain waste volumes within available tank space. The tanks were single-shell tanks (SSTs) or double-shell tanks (DSTs).

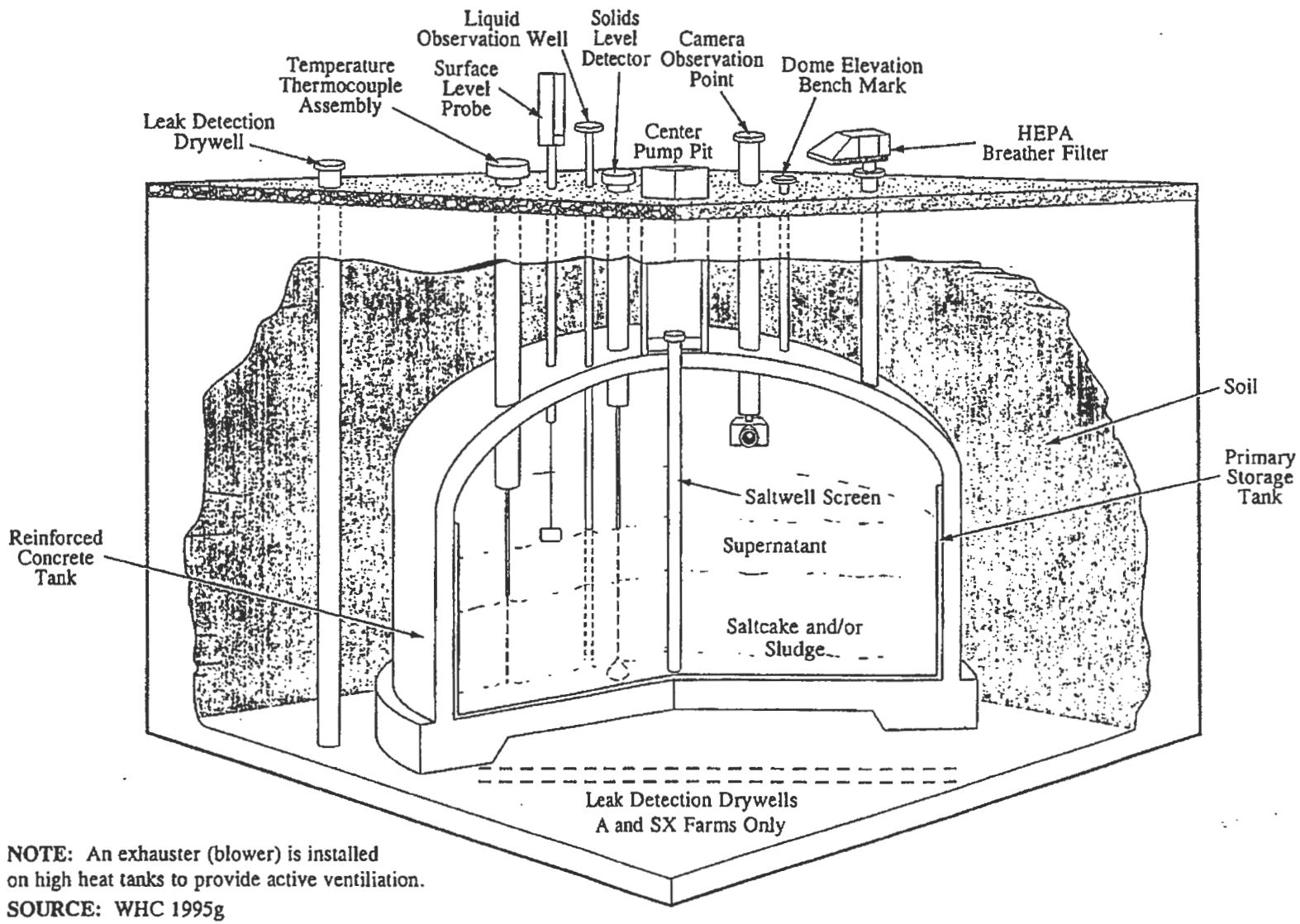
Through evaporation, concentration, and the past practice of discharging dilute waste to the ground, the waste volume has been reduced to approximately 2.1E+08 L (5.6E+07 gal) (Hanlon 1996). Discharging SST liquid to the ground was stopped in 1966, and since then, no waste from SSTs or DSTs has been discharged to the ground intentionally.

3.2.1.2 Tank Farm Description

The first 149 waste storage tanks constructed were SSTs. An SST is an underground storage tank with carbon-steel sides and bottom surrounded by a reinforced concrete shell (Figure 3.2.1). The tops of the tanks are buried approximately 2.5 meters (m) (8 feet [ft]) belowground for radiation shielding. The larger tanks have multiple risers (shielded openings) that provide tank access from the surface. These risers provide access points for monitoring instrumentation, camera observation, tank ventilation systems, and sampling. Sixty-seven of the SSTs are known or assumed to have leaked 2.3 million to 3.4 million liters (600,000 to 900,000 gallons) of liquids (Hanlon 1996).

An ongoing vadose zone characterization program that was initiated in April 1995 (DOE 1995t) is providing new baseline characterization data on the potential contaminant distribution in the vadose zone beneath and in the vicinity of the SSTs. This has resulted in additional information for the SX Tank Farm. The characterization effort relies on geophysical logging of existing drywells

Figure 3.2.1 Single-Shell Tank Configuration



NOTE: An exhauster (blower) is installed on high heat tanks to provide active ventiliation.

SOURCE: WHC 1995g

using a spectral gamma logging system with a high-purity intrinsic germanium detection device to provide assays of gamma-emitting radionuclides near the drywells (Brodeur 1996).

Ten of the 15 tanks in the SX Tank Farm are assumed or verified as leaking, as discussed in Volume Five, Appendix K. Ninety-five drywells ranging in depth from 23 m (75 ft) to 38 m (125 ft) from ground surface were logged with the Spectral gama logging system in the SX Tank Farm. The most abundant and highest concentration radionuclide detected was cesium-137, which was detected in virtually every borehole (Brodeur 1996). Cesium-137 was detected at the following depths in several drywells: 23 m (75 ft) in drywells 41-09-03 and 41-08-07, 32 m (105 ft) in 41-09-04, 27 m (90 ft) in 41-11-10, and 38 m (125 ft) in 41-12-02.

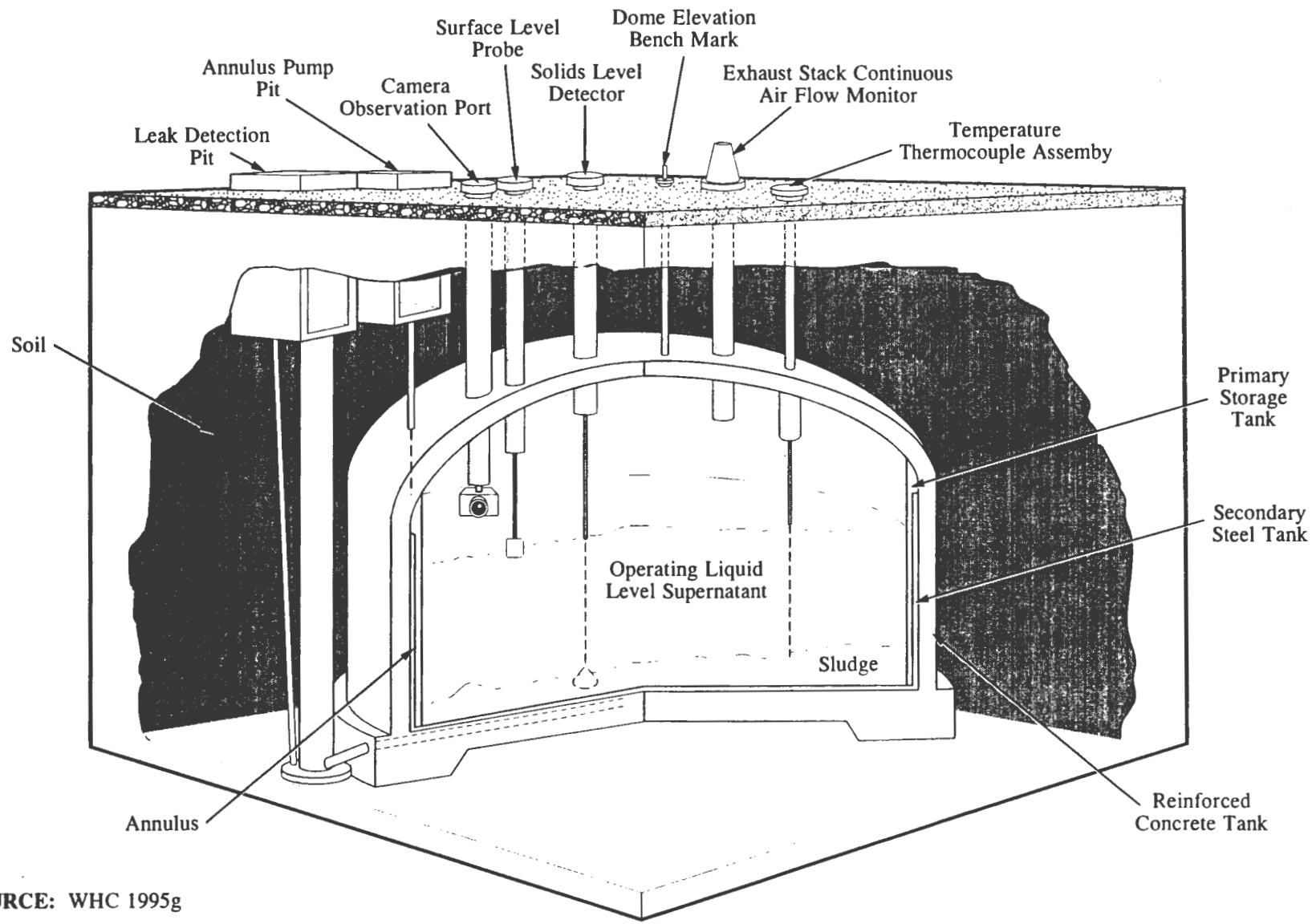
Other gamma-emitting radionuclides detected include cobalt-60, europium-152, and europium-154, which were generally found near the surface and are believed to be the result of spills (Brodeur 1996). Cobalt-60 was found in drywell 41-14-06 only and was detected at a depth of 17 to 23 m (55 to 76 ft) below ground surface. The data are unclear as to whether relatively immobile contaminants such as cesium-137 would be found dispersed laterally within the vadose zone (i.e., at observed concentrations laterally several meters from the drywells) at the depths of over 30 m (100 ft) based on ambient conditions and vadose zone contaminant transport via advective flow in interstitial pore spaces. There may be other transport mechanism(s) occurring. The viability of any other potential transport mechanism has not yet been demonstrated but is one of the objectives of the ongoing investigations.

The last 28 tanks constructed were DSTs, which have two carbon-steel tanks inside a reinforced concrete shell (Figure 3.2.2). This design provides improved leak detection and containment of the waste. To the present time, no leaks have been detected in the annulus, the space between the inner and outer tanks. The space between the tanks houses equipment to detect and recover waste in the event that the inner tank develops a leak. Like the SSTs, the DSTs are buried belowground and have risers for tank monitoring and access.

The tanks are arranged in groups, referred to as tank farms, with each tank farm containing 2 to 18 tanks. The SST farms typically were interconnected in a series or cascade that allowed the waste to be pumped into the first tank, overflow into the next tank, and so on throughout the cascade series. This process allowed solid particles to settle into the first few tanks of a cascade and allowed the liquid in the last tank to be discharged into a crib (subsurface drain system). The practice of discharging tank waste to cribs no longer occurs. A summary of the number and size of SSTs and DSTs and their locations is shown in Table 3.2.2 and Figure 3.2.3.

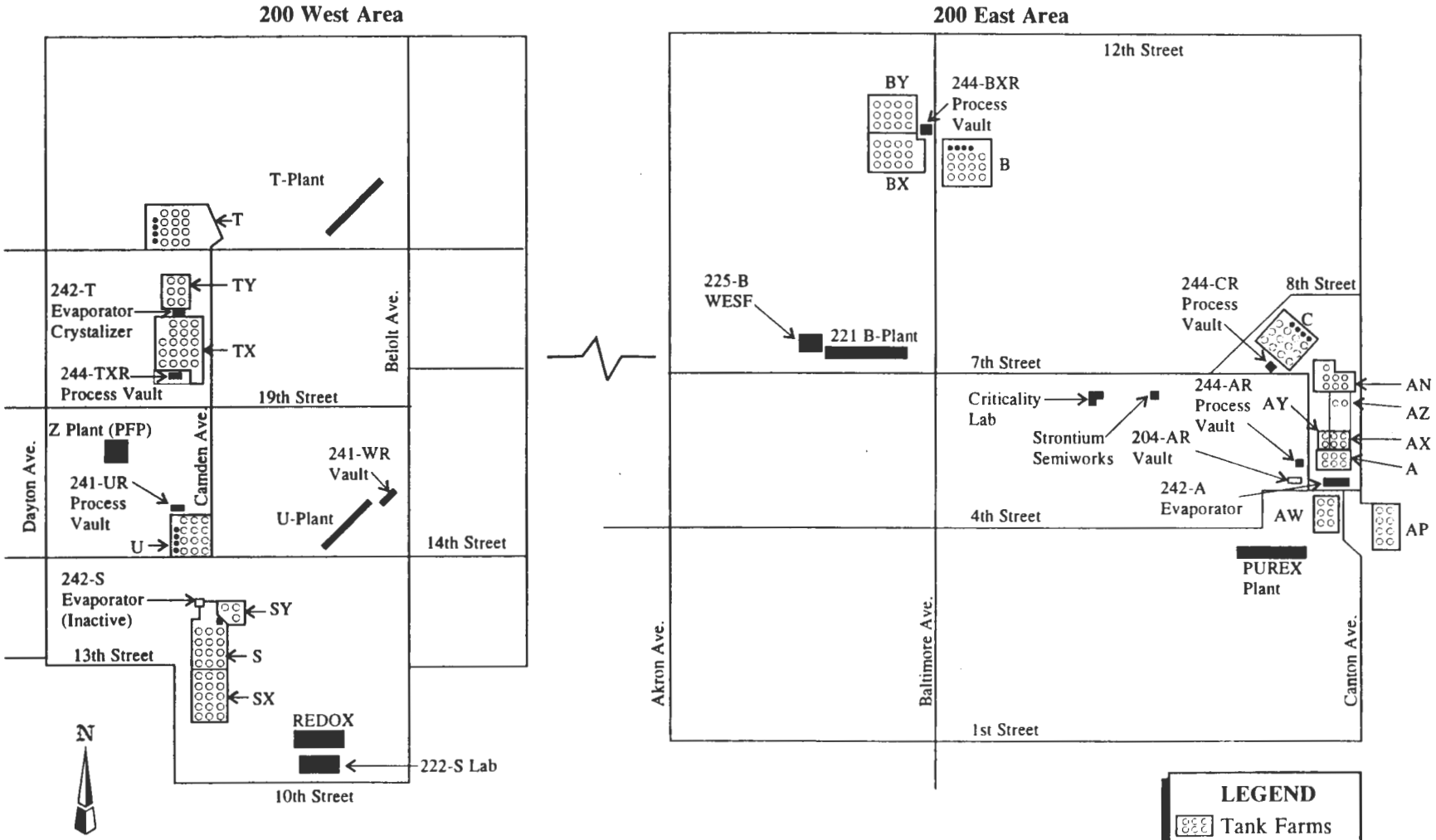
Also included in the tank farm system are approximately 40 inactive and 20 active miscellaneous underground storage tanks (MUSTs). The inactive MUSTs, which are smaller than the SSTs and DSTs, were used for settling solids out of liquid waste before decanting the liquid to cribs, reducing the acidity of process waste, uranium recovery operations, collecting waste transfer leakage, and waste handling and experimentation. The active MUSTs still are used as receiver tanks during waste

Figure 3.2.2 Double-Shell Tank General Configuration



SOURCE: WHC 1995g

Figure 3.2.3 Tank Farm Locations in 200 East and 200 West Areas



Not to Scale

SOURCE: Adapted from WHC 1994f

SST Farms: T, TX, TY, U, S, SX, B, BY, BX, C, AX, and A

DST Farms: SY, AN, AZ, AY, AP, and AW

Table 3.2.2 Size and Number of Tanks by Type

Tank Type	Storage Capacity	Number of Tanks
SST	2.1E+05 L (55,000 gal)	16
SST	2.0E+06 L (530,000 gal)	60
SST	2.9E+06 L (758,000 gal)	48
SST	3.8E+06 L (1,000,000 gal)	25
DST	3.8E+06 L (1,000,000 gal)	4
DST	4.4E+06 L (1,160,000 gal)	24
MUST[1]	3,400 to 190,000 L (900 to 50,000 gal)	60

Notes:
[1] Includes active and inactive miscellaneous underground storage tanks.
DST = Double-shell tank
MUST = Miscellaneous underground storage tank
SST = Single-shell tank

transfer activities or as catch tanks to collect potential spills and leaks. The volume of waste in all the MUSTs combined is less than one-half of 1 percent of the total tank inventory (WHC 1995n).

3.2.1.3 Waste Characterization

Tank waste characterization is the process of determining the physical, radiological, and chemical properties of the waste. Considerable historical data are available and have been used to estimate the contents of the storage tanks. Historical data provide a basis for an overall tank waste inventory and are compiled from invoices of chemical purchases and records of waste transfers and processing.

Historical-based data for SSTs and laboratory data and characterization reports for DSTs provide the basis for radioactive and mixed waste inventory estimates used in this EIS. These inventory estimates, as provided in Volume Two, Appendix A, are adequate for a detailed evaluation of impacts (WHC 1995d).

A considerable amount of inventory information is available from process records and past sampling activities. However, this information is not considered adequate to characterize the waste in individual tanks in support of safety issues and final design activities for remediation. There is an ongoing waste characterization program to better determine the contents of each tank through analyzing samples to help resolve safety issues and support design decisions for implementing the remediation alternative.

The tank waste is categorized as liquid, sludge, or saltcake. Liquid is made up of water and organic compounds that contain dissolved salts. The organics in liquid form, depending on the type, either are dissolved in the water or exist in separate phases. Liquid is present in the tanks as either free standing, where the liquid volume is relatively free of solid particles, or as interstitial liquid, where the liquid volume is contained within the void spaces surrounding the sludge and saltcake particles. Sludge is a mixture of insoluble (i.e., will not dissolve in tank liquid) metal salt compounds that have precipitated

and settled out of solution after the waste was made alkaline. Saltcake is primarily sodium and aluminum salt that crystallizes out of solution following evaporation.

These three types of waste exist in the tanks in numerous combinations and proportions, which results in complex combinations of waste with varied physical and chemical properties. Sludge has been found with consistencies from mud to hardened clay. Layers of organic compounds have been found in some tanks floating on top of solid waste. Crusts have formed in some tanks where a layer of solid has formed on top of the liquid. Table 3.2.3 is a summary of the waste forms in both the SSTs and DSTs (Hanlon 1995). The percentages shown may change as additional data become available.

Table 3.2.3 Waste Form Summary

Tank Type	Liquid	Sludge	Saltcake	Double-Shell Slurry (Considered Solid)	Total
SST	2%	33%	65%	N/A	100%
DST	77%	9%	4%	10%	100%

Notes:
DST = Double-shell tank
N/A = Not applicable
SST = Single-shell tank

3.2.1.4 Ongoing Activities

All U.S. Department of Energy (DOE) facilities that store hazardous or radioactive materials require documented authorization bases that establish a range of operating parameters (e.g., temperature, pressure, concentration) within which routine operations are conducted. These authorization bases also evaluate the effects of potential accidents, abnormal events, and natural disasters.

Watchlist Tanks

The identification of tank safety issues and the concern for the potential of an uncontrolled release of high-level radioactive waste to the environment resulted in the passing of Public Law 101-510, Section 313, Safety Measures for Waste Tanks at the Hanford Nuclear Reservation (also known as the Wyden Amendment) in 1990. In response to this law, a program was created to identify tanks with potential safety problems. Many of the tank safety issues that became Watchlist tank categories were already known to DOE, and the maintenance and operations for these tanks were being reviewed and managed. The enactment of the public law and the establishment of the Watchlist provided a more formalized and rigorous basis for addressing specific tank safety issues. Safety issues associated with the tanks were grouped into four categories: flammable gas, ferrocyanide, high organic content, and high heat generation. Tanks having any of these characteristics, referred to as Watchlist tanks, are categorized as shown in Table 3.2.4 (Hanlon 1996, Cowan 1996). There currently are 50 Watchlist tanks with several tanks listed in more than one category.

Unreviewed Safety Questions

DOE has a formal administrative program to identify, communicate, and establish corrective actions for known or suspected operating conditions that have not been analyzed or that fall outside of the

Table 3.2.4 Watchlist Tanks

Watchlist Tank Category	Number of Tanks	Concern
Flammable Gas	25 [1]	Potential for an uncontrolled gas burn due to generation of flammable gas inside the tank dome above the flammability limit resulting in the release of radioactive material to the environment.
Ferrocyanide	14	Potential for an uncontrolled reaction due to heat generation during postulated ferrocyanide oxidation reaction resulting in the release of radioactive material to the environment.
High Organic	20	Potential for an uncontrolled reaction due to heat generation during postulated organic oxidation reaction and subsequent release of radioactive material to the environment.
High Heat	1	Potential failure of a tank due to loss of cooling water and subsequent high heat-induced structural damage resulting in waste releases from the tank.

Notes:
[1] Recently, internal Site controls have been applied to all 177 tanks for possible flammable gas generation/retention. Final resolution of how many tanks present a risk due to flammable gas has not occurred.

established authorization bases as an Unreviewed Safety Question. Following the identification of an Unreviewed Safety Question, a review is conducted, and corrective action is taken if applicable. Following the review process, the Unreviewed Safety Questions may be closed from an administrative standpoint, which means that conditions surrounding the safety issue have been analyzed. However, the conditions on which the safety issue is based still may exist and may require mitigation, controls, or corrective action. In this way, safety issues and Unreviewed Safety Questions are related. The safety issues that were identified under the Watchlist program also were analyzed as Unreviewed Safety Questions. Those issues that had not been addressed in the documented authorization bases were established as Unreviewed Safety Questions. Following the review processes, the Unreviewed Safety Question can be closed while the tank remains on the Watchlist. The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) requires the resolution of all existing Unreviewed Safety Questions by September 1998 (Ecology et al. 1994).

Technical evaluation has resulted in closing the following Unreviewed Safety Questions identified for the tanks: ferrocyanide (closed in March 1994); floating organic layer in tank 241-C-103 (closed in May 1994); and criticality (closed in March 1994). Criticality was addressed on a tank farm basis and did not result in identifying any individual tanks to be added as Watchlist tanks. Criticality, which would be an issue during tank waste retrieval and transfer, would be evaluated on a tank-by-tank basis during final design. Closure of the Unreviewed Safety Questions was accomplished by defining the parameters (e.g., concentrations and temperature) of potential reactions that could lead to an uncontrolled release, collecting physical and chemical data on the waste, and establishing safe operating specifications.

The remaining Unreviewed Safety Questions are undergoing resolution. Mitigative action has been implemented for tank 241-SY-101 (commonly known as 101-SY), the most widely known flammable-gas-generating tank. This mitigative action involved installing a mixer pump to control the periodic

release of flammable hydrogen gas and provide a more frequent and gradual release of hydrogen. This mitigative action reduced the maximum concentration of flammable gas that can exist in the tank and greatly reduced the potential for an uncontrolled gas burn.

There is a safety screening and characterization program ongoing to determine if any additional tanks should be placed under special controls. Recently, all 177 tanks (Watchlist and non-Watchlist) were placed under flammable gas controls, which means that flammable gas may exist in all 177 tanks and special safety measures will be taken during maintenance, monitoring, and waste transfer activities. Until the necessary characterization data are obtained, the tank farm system will continue to operate under these special waste management requirements to maintain a safe operating envelope. Additional data may allow for relaxed operating procedures, where appropriate. Volume Four, Appendix E contains a more detailed description of the tank safety issues.

Continued Operations of Tank Farm System

Numerous tank waste activities are ongoing to provide continued safe storage of the tank waste until remediation measures are implemented. These activities consist of a number of routine activities as well as a number of additional activities required for safe storage.

Routine operations include management oversight, regulatory compliance and reporting activities, and operations and maintenance of facilities and equipment. Tank monitoring activities support waste management by gathering information on waste temperature, liquid levels, solid levels, and tank status. Leak detection activities involve in-tank liquid level monitoring, leak detection monitoring of the annulus for the DSTs, drywell monitoring around tanks for increases in radioactivity levels, and groundwater monitoring. Other routine operations include:

- Calculating operational waste volume projections by comparing projected waste volumes against tank capacity. The projections also provide for identification and management of risk that could negatively impact available tank storage space;
- Combining compatible waste types. Transferring tank waste between tanks and tank farms through the existing cross-site transfer system to provide the required tank space and to address safety issues;
- Implementing a waste minimization program to reduce the generation of new waste requiring storage in the tanks. This program includes job preplanning and identification of new technologies such as low-volume hazardous waste decontamination practices to limit the generation of new waste. The waste minimization program also includes a support program for other onsite organizations (non-TWRS) that generate waste to encourage waste minimization practices;
- Screening and characterizing the waste on a tank-by-tank basis to gather data in support of safety and remedial action design activities;
- Isolating and removing pumpable liquid from SSTs to reduce the potential for future leakage (interim stabilization by saltwell pumping);
- Operating the 242-A Evaporator to concentrate waste; and

- Treating the evaporator effluents at the Effluent Treatment Facility to remove the contaminants prior to discharge.

These activities are not within the scope of this EIS because they were addressed in previous National Environmental Policy Act (NEPA) documents: the Safe Interim Storage of Hanford Tank Waste EIS (Safe Interim Storage EIS) (DOE 1995i), the Waste Tank Safety Program Environmental Assessment (DOE 1993h), and the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes at the Hanford Site (DOE 1987).

3.2.1.5 Planned Activities

Several tank waste activities are planned for implementation in the near future. These activities would address urgent safety or regulatory compliance issues.

Safe Interim Storage

One issue that requires action is the safe storage of tank waste in the interim period before implementing actions for the permanent remediation of tank waste. To address this issue, the Safe Interim Storage EIS was prepared to consider alternatives for maintaining safe storage of Hanford Site tank waste (DOE 1995i). The actions considered in the Safe Interim Storage EIS include interim actions to 1) mitigate the generation of high concentrations of flammable gases in tank 241-SY-101; and 2) contribute to the interim stabilization of older SSTs, many of which have leaked.

The most pressing interim need identified by DOE and the Washington State Department of Ecology (Ecology) was for a safe, reliable, and regulatorily compliant replacement cross-site transfer capability to move waste between the 200 West and 200 East Area tank farms. This transfer capability is needed because the 200 West Area has far less useable DST capacity than there is waste in SSTs. The replacement waste transfer capability would provide a safe, reliable, and regulatory compliant means to move waste from the 200 West Area to the available DST capacity located in the 200 East Area.

Based on tank waste management and operation activities when the Safe Interim Storage EIS was prepared, the following needs were addressed:

- Removing saltwell liquid from older SSTs to reduce the likelihood of liquid waste escaping from corroded tanks into the environment. Many of these tanks have leaked, and historically, new leaks, either known or assumed, have developed at a rate of more than one per year;
- Providing the ability to transfer the tank waste via a regulatorily compliant system to mitigate any future safety concerns and use current or future tank space allocations;
- Providing adequate tank waste storage capacity for future waste volumes associated with tank farm operations and other Hanford Site facility operations; and
- Mitigating the flammable gas safety issue in tank 241-SY-101.

The alternatives evaluated in the Safe Interim Storage EIS provided DOE with the ability to continue safe storage of high-level tank waste and upgrade the regulatory compliance status with regard to the

Resource Conservation and Recovery Act (RCRA) (40 Code of Federal Regulations [CFR] 260) and the Washington Administrative Code (WAC) Dangerous Waste Regulations (WAC 173-303).

On December 1, 1995, DOE published the Record of Decision in the Federal Register (FR) (60 FR 61687). The decision was to implement most of the actions of the preferred alternative, including the following.

- Construct and operate a replacement cross-site transfer pipeline system.
- Continue operating the existing cross-site transfer pipeline system until the replacement system is operational.
- Continue operating the mixer pump in tank 241-SY-101 to mitigate the unacceptable accumulation of hydrogen and other flammable gases.
- Perform activities to mitigate the loss of shrub-steppe habitat.

The existing cross-site transfer system has been used to transfer waste from the 200 West Area to the 200 East Area for 40 years. This underground pipeline system is at the end of its original design life. Currently, four of six lines are out of service and unavailable to perform transfers because of plugging. The two useable lines do not meet current engineering standards such as double containment and leak detection, which are required for waste management facilities. The design and operation of the replacement cross-site transfer system will meet the requirements of RCRA and WAC for secondary containment and Tri-Party Agreement Milestone M-43-07, which required construction of the replacement cross-site transfer system to commence by November 1995. Construction of the replacement cross-site transfer system has begun and the system is scheduled to be operational in 1998.

DOE will continue to use the existing cross-site transfer system until the replacement cross-site transfer system is operational to provide access to 200 East Area DSTs for storage of 200 West Area facility waste and retrieved liquid waste from SSTs. Saltwell liquid retrieval will continue to reduce the risk to the environment from leaking SSTs. Operational procedures will ensure the integrity of the existing cross-site transfer system before any waste transfers. The current planning base estimates that the existing cross-site transfer system will operate for approximately 625 hours during 5 transfers before the replacement cross-site transfer system is operational in 1998.

The mixer pump in tank 241-SY-101 was proven to be effective in mitigating flammable gas as a safety issue in that tank during more than 1 year of operation. DOE and Ecology revised their preferred alternative between release of the Draft and Final Safe Interim Storage EIS, based on the demonstrated success of the mixer pump, and determined that the construction of new DSTs to resolve safety concerns was not necessary.

Based on new information available to DOE regarding nuclear criticality safety concerns during retrieval, transfer, and storage actions since the issuance of the Final Safe Interim Storage EIS, DOE has decided to defer a decision on the construction and operation of a retrieval system in tank 241-SY-102. Through an ongoing safety evaluation process, DOE recently revisited its operational assumptions regarding the potential for the occurrence of a nuclear criticality event during waste

storage and transfers. Changes to the Tank Farm Authorization Basis for Criticality approved in September 1995 were rescinded by DOE in October 1995, pending the outcome of a criticality safety evaluation process outlined for the Defense Nuclear Facility Safety Board on November 8, 1995. Until these criticality safety evaluations are completed, the Site will operate under historic limits, which maintain reasonable assurance of subcritical conditions during tank farm storage and transfer operations.

Of the actions evaluated in the Final Safe Interim Storage EIS, only the retrieval of solids from tank 241-SY-102 was affected by the technical uncertainties regarding criticality. Based on the quantities of plutonium in tank 241-SY-102 sludge, retrieval of the solids falls within the scope of the criticality safety issues that will be evaluated over the next few months. As a result, a decision on retrieval of solids from tank 241-SY-102 was deferred in the Safe Interim Storage EIS Record of Decision (60 FR 61687). Pending the outcome of the technical initiative to resolve the tank waste criticality safety issue, waste transfers (primarily saltwell liquid) through tank 241-SY-102 will be limited to noncomplexed waste. Tank 241-SY-101 mixer pump operations, existing cross-site transfer system interim operations, replacement cross-site transfer system operations, saltwell liquid retrievals, and 200 West Area facility waste generation would occur within applicable criticality limits and be subcritical.

Privatization of Tank Farm Activities

Currently, DOE is considering contracting with private companies for waste remediation services for the tank waste. DOE is interested in encouraging industry to use innovative approaches and in using competition within the private marketplace to bring new ideas and concepts to tank waste remediation. The goal of the privatization effort is to streamline the TWRS mission, transfer a share of the responsibility, accountability, and liability for successful performance to industry, improve performance, and reduce cost without sacrificing worker and public safety or environmental protection. DOE issued a TWRS Privatization Request for Proposal in mid-February 1996 and has received two bids to treat tank waste (Briggs 1996). DOE plans to issue contracts to perform the first phase of the work in late summer 1996. As currently envisioned, DOE would select contractors to construct and operate commercial demonstration facilities for two tank waste separations and low-activity waste (LAW) immobilization facilities, one of which may include a high-level waste (HLW) vitrification facility. If these commercial demonstrations are successful, DOE may use the lessons learned from those demonstration facilities and proceed with contracting for full-scale facilities to remediate additional tank waste. The planning process for these privatization activities is not complete and is subject to the final decision concerning remediation of the tank waste, which is the subject of this EIS.

The potential environmental impacts associated with the activities included in the contracting strategy are analyzed in the EIS. The DOE plan is to require potential contractors to propose technologies that meet specified performance criteria for the waste product, as established by DOE. DOE will require potential offerers to submit environmental information and analyses reasonably available to them as a discrete part of their proposals. DOE will independently evaluate and verify the accuracy of the environmental data and analyses and, as appropriate, use the information to help ensure the consideration of environmental factors in the selection process in accordance with 10 CFR 1021.216.

DOE has received two proposals under the privatization initiative for constructing and operating demonstration-scale facilities for separating selected portions of the tanks waste into LAW and HLW fractions and immobilizing the separated waste. The two proposals would follow the same general approach described in the EIS for Phase 1 of the Phased Implementation alternative including: separating the waste into LAW and HLW streams, immobilizing the HLW by forming a borosilicate glass, and using high-temperature processes to generate immobilized LAW. Evaluation of the two proposals has shown that they would have similar overall environmental impacts and that the impacts would be less than or approximately the same as the impacts described in Phase 1 of the Phased Implementation alternative assessed in this EIS.

One proposal has the potential to substantially reduce the volume of LAW requiring disposal and would result in less disposal-related land disturbance. However, the total amount of radioactivity in the LAW would be approximately the same for both proposals, and the associated impacts on groundwater would be the same (i.e., small). This proposal also offers the potential for recycling a portion of the LAW, and some of the raw material used in LAW processing might be suitable for other beneficial uses within DOE or the nuclear industry. There is uncertainty about whether markets for these materials will be available. If such markets were not available then the potential benefits of LAW volume reduction would not occur and these materials would need to be disposed of. Differences between the proposals in environmental impacts associated with the use of resources such as fuel and from air emissions such as nitrogen oxides would be small.

DOE will also require selected offerers to submit further environmental information and analyses, and will use the additional information, as appropriate, to assist in the NEPA compliance process, including a determination under 10 CFR 1021.314 of the potential need for a supplemental EIS.

Tank Farm Upgrades

Upgrades to the tank farms are planned to improve the reliability of safety-related systems, minimize onsite health and safety hazards, upgrade the regulatory compliance status of the tank farms, and place the tank farms in a controlled, stable condition until disposal is complete. Upgrades planned include: 1) instrumentation including the automatic tank data gathering and management control system and the closed-circuit television monitoring to minimize personnel exposure; 2) tank ventilation to replace outdated ventilation systems; and 3) an electrical system to provide electrical power service with sufficient capacity and in compliance with current electrical codes. These three components of the tank farm upgrades are not addressed in the TWRS EIS but will be the subject of other analyses. Upgrades to the existing waste transfer system that would be used in conjunction with the replacement cross-site transfer system also are planned. Waste transfer system upgrades are included in the TWRS EIS and are discussed in Section 3.4.1.1.

Initial Tank Retrieval System

This project would provide systems for retrieving waste from up to 10 DSTs. Initial tank retrieval capabilities also would allow consolidation of compatible tank waste to create additional DST storage capacity and support passive mitigation such as diluting hydrogen-gas-generating Watchlist tanks,

should that become necessary. Retrieval and transfer of waste from all tanks is addressed in this EIS, so the Initial Tank Retrieval System project is a subset of the actions included in this EIS and not addressed separately.

Hanford Tanks Initiative

Under this program, several waste retrieval activities discussed in the TWRS EIS would be demonstrated in support of the ex situ alternatives. This program would reduce the uncertainties associated with waste retrieval by developing and demonstrating the technologies required to meet retrieval requirements. The Hanford Tanks Initiative includes activities associated with waste retrieval and tank closure. Those activities associated with waste retrieval are covered under this EIS while activities associated with the closure would be the subject of future NEPA analysis.

This program would demonstrate equipment and systems for removal of tank residuals from tank 241-C-106 that are expected to remain following initial retrieval by sluicing. The objective would be to retrieve sufficient waste to meet waste retrieval requirements. This program also would attempt to develop technologies and criteria to retrieve waste from known or assumed leaking SSTs.

3.2.2 Cesium and Strontium Capsules

3.2.2.1 History

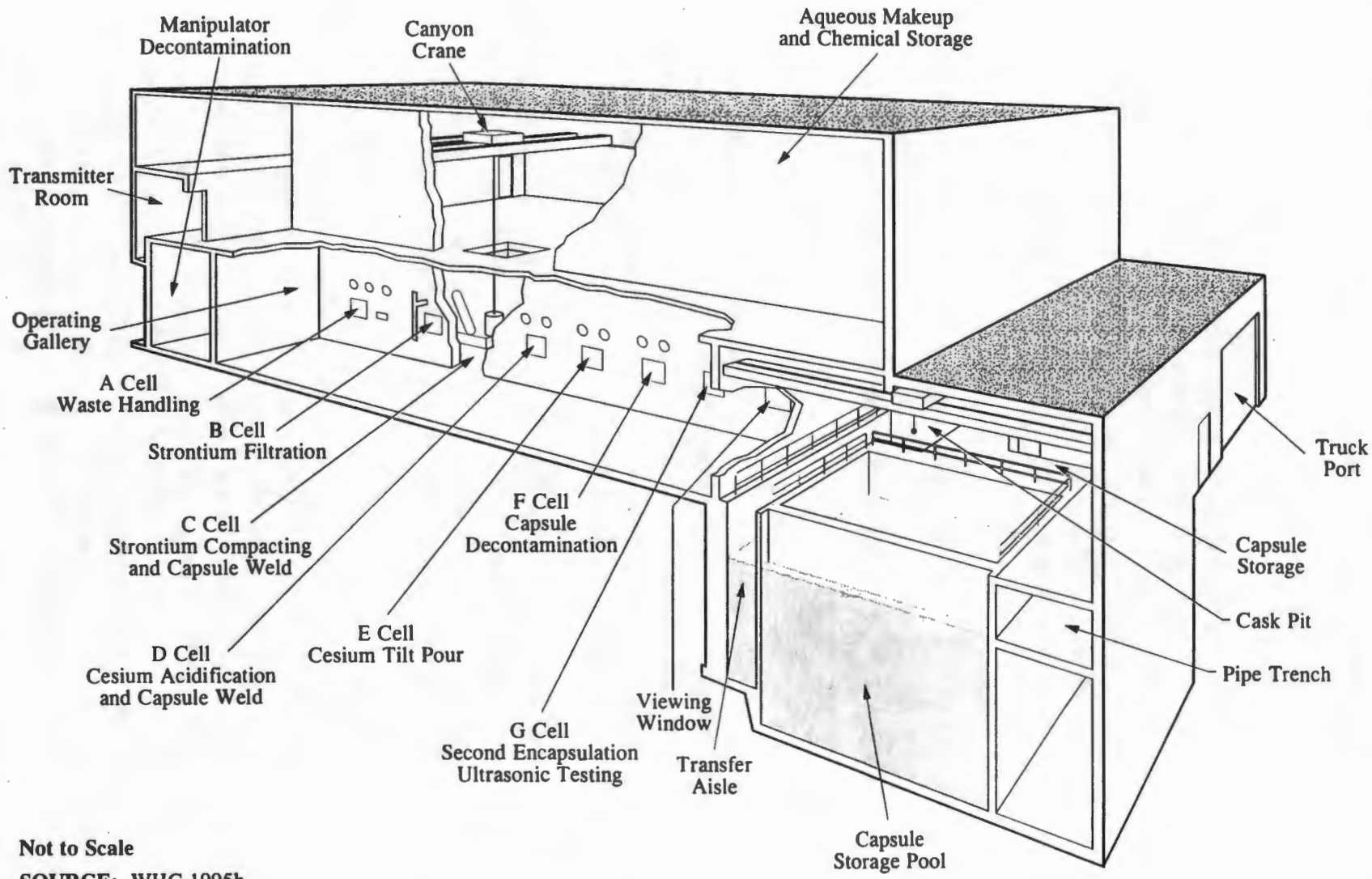
The cesium and strontium capsule program was initiated in the early 1970's to remove heat-generating cesium and strontium isotopes from the waste for safer storage. The waste used for this purpose either was existing waste retrieved from tanks or waste from the processing facilities enroute to the tanks. Removing cesium and strontium from the waste reduced the heat generation in the tanks and provided for safer storage of the waste remaining in the tanks.

The capsule fabrication program took place between 1974 and 1985 at the Waste Encapsulation and Storage Facility (WESF), which adjoins B Plant in the 200 East Area (Figure 3.2.4). Capsules were fabricated to hold the stabilized cesium chloride and strontium fluoride salts in an effort to provide a physical form for the cesium and strontium suitable for long-term storage.

3.2.2.2 Capsule Description

The capsules are double-walled, high-temperature metal alloy tubes that contain cesium and strontium (Figure 3.2.5). The capsules are stored in water-filled basins at WESF and are approximately 6.7 centimeters (cm) (2.6 inches [in.]) in diameter and 51 cm (20 in.) in length. The decay reactions taking place within the capsules generate approximately 200 to 300 watts (W) of heat continuously from each capsule. Storing the capsules underwater provides radiation protection for workers as well as cooling for the capsules. Basins or pool cells are filled with water to a depth of 4 m (13 ft) and house metal storage racks to control capsule storage within the cells. WESF has a total of eight pools: five are active and used for capsule storage, one is used for temporary storage, and two are not used. The size and number of capsules are presented in Table 3.2.5. The capsules currently are classified as

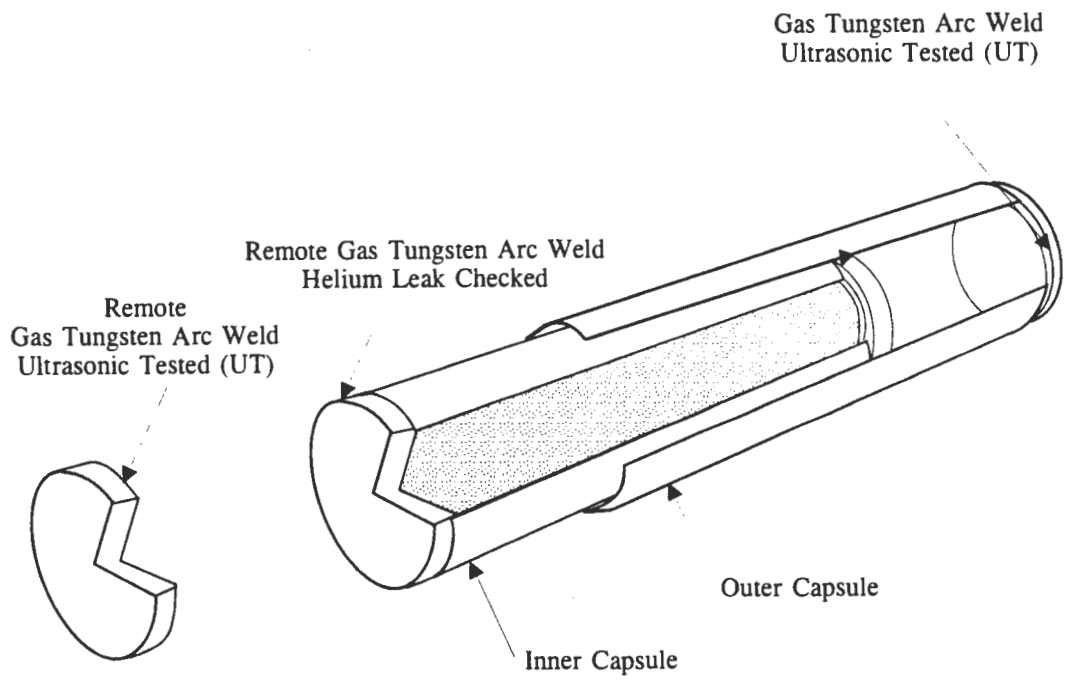
Figure 3.2.4 Waste Encapsulation and Storage Facility



Not to Scale

SOURCE: WHC 1995h

Figure 3.2.5 Typical Cesium and Strontium Capsule Configuration



SOURCE: WHC 1995h

waste by-product, which means that they are available for productive uses if uses can be found. The final classification of the cesium and the strontium would be made in correlation with the Nuclear Regulatory Commission (NRC) if and when the capsules are classified as waste.

3.2.2.3 Capsule Characterization

The chemical form of the cesium in the capsules is cesium chloride and the chemical form of the strontium in the capsules is strontium fluoride. The combined total capsule volume is approximately 2 cubic meters (m^3) (70 cubic feet [ft^3]) (WHC 1995h).

The cesium content of the capsules is primarily cesium-137, which has a half-life of 30.17 years. Cesium-137 decays to the stable isotope barium-137, either directly or through a two-step process, first into metastable barium-137m, and then to stable barium-137. Strontium capsules contain mainly strontium-90, which has a half-life of 28.6 years. Strontium-90 decays to yttrium-90 and then to the stable isotope zirconium-90. The quantities, heat loading, and radioactivity levels for the cesium and strontium capsules are presented in Table 3.2.6. Reduction in the number of curies, heat load, and concentration over time is due to radioactive decay of cesium and strontium into stable decay products.

Table 3.2.5 Cesium and Strontium Capsules

Property	Cesium Capsules	Strontium Capsules
Number produced	1,577	640
Size	6.67 cm (2.6 in.) diameter by 52.77 cm (20.8 in.) long	6.67 cm (2.6 in.) diameter by 51.05 cm (20 in.) long
Number of capsules cut or destroyed [1]	249	39
Number of capsules for disposal [2]	1,328	601

Notes:
[1] Capsules were cut up to repackage the cesium and strontium into smaller volumes for research or commercial uses. Cut capsules are not subject to treatment and disposal under TWRS.
[2] Total number of capsules for disposal is approximately 1,930 because some cut capsules may be reencapsulated when returned to WESF.

Table 3.2.6 Characteristics of Existing Capsules

Characteristics	Strontium (601 capsules) [1]		Cesium (1,328 capsules) [1]	
	As filled	12/31/94	As filled	12/31/94
Cumulative (MCi)	32.7	23.1	73.9	53.2
Cumulative (kW)	220.8	156.3	355.3	255.7
Average (kCi)	54.4	38.5	55.7	40.1
Average (W)	367.4	260.1	267.6	192.6
Highest curies loading (kCi)	146.6	93.3	74.5	54.4

Notes:
[1] The values for megacuries and highest curies loading reflect only parent radionuclide activity for strontium-90 - yttrium-90 decay chain and cesium-137 - barium-137m decay chain (decay products are accounted for in the impact analysis). The cumulative radioactivity level for both the cesium and strontium capsules including the decay products was approximately 150 MCi as of 12/31/94. DOE is evaluating the total inventory of the cesium and strontium capsules, therefore, the total curie count for the capsules may vary from the inventory presented in the EIS.
kCi = Kilocurie
kW = Kilowatt
MCi = Megacuries
W = Watt

3.2.2.4 Current and Planned Activities

The only ongoing and planned activities for the capsules are the continued storage of the capsules in WESF, return of the remaining cesium capsules to WESF, and attempts to find productive uses for the cesium and strontium capsules. Continued operations include monitoring capsule integrity and maintaining support facilities (ventilation, monitoring, radiation alarms, and waste handling systems).

DOE is in the early planning stages of considering whether the capsules should remain in WESF or be placed in alternative locations for storage. Among the possible alternatives are placing the capsules in the proposed Canister Storage Building originally planned to store HLW. DOE is currently upgrading WESF to operate independently of B Plant. No decisions have been made to proceed with any alternative storage options. For purposes of analyzing impacts in the TWRS EIS, it is assumed that the

capsules will remain in WESF until ready for final disposition. If DOE proposes to change the method or location for the interim storage of the capsules, an appropriate NEPA review will be performed. A cesium and strontium capsule management program will provide for management of the capsules until final disposition has been implemented.

Strontium capsules previously were used as heat sources, and the cesium capsules were used at commercial facilities for strengthening wood products, sterilizing medical products, and sterilizing saline solutions. Cesium and strontium capsules also have been used by DOE programs for research activities at Pacific Northwest National Laboratory, Sandia National Laboratory, and Oak Ridge National Laboratory. DOE has requested that all capsules be returned to the Hanford Site for storage at WESF (DOE). Some cesium capsules have not yet been returned, but plans call for all capsules to be returned to the Hanford Site by the end of 1997. There are four strontium capsules located offsite that will not be returned to the Hanford Site.

DOE is pursuing alternative uses for the cesium and strontium capsules. If no future uses for these capsules are found, the capsules eventually would be managed and disposed of consistent with the Tri-Party Agreement (Ecology et al. 1994) and the TWRS EIS alternative selected for implementation.

3.3 DEVELOPMENT OF ALTERNATIVES

This section explains the process followed to develop and select alternatives for remediating the tank waste, alternatives for implementing the remediation of the tank waste, and remediating the cesium and strontium capsules. This section also discusses TWRS activities that are beyond the scope of this EIS.

3.3.1 Tank Waste

3.3.1.1 TWRS Elements

Final remediation of TWRS involves three distinct activities: remediation of the tank waste, disposition of the tanks and all associated equipment (a process called closure), and decontamination and decommissioning of any new facilities constructed to remediate the tank waste. These activities are described in this section.

Actions Analyzed in the TWRS EIS

- Continued safe operations of tank farms
- Upgrades to tank farm waste transfer system
- Remediation of the tank waste
- Remediation of MUSTs
- Closure of tank farms after remediation (analyzed one potential closure scenario to provide a meaningful comparison of alternatives)
- Decontamination and decommissioning of facilities constructed for remediation (analyzed relative impacts to provide a meaningful comparison of alternatives)

Remediating Tank Waste

Remediating tank waste in the 177 underground tanks and approximately 60 MUSTs is the subject of this EIS and is discussed in detail in Section 3.3.1.2.

Disposition of the Tank Farms (Closure)

The final disposition of the tanks and associated equipment and the remediation of contaminated soil and groundwater associated with leaks from the tanks is a process called closure. Closure is not within the scope of this EIS because there is insufficient information concerning the amount of contamination to be remediated. The amount and type of waste that ultimately remains in the tanks after remediation may also affect closure decisions. The Notice of Intent to prepare the TWRS EIS stated that: "The impacts of closure cannot be meaningfully evaluated at this time. DOE will conduct an appropriate NEPA review, such as an EIS to support tank closure, in the future" (59 FR 4052).

In response to emerging technical information and the need to support DOE's integrated approach to remediating the Central Plateau and the Hanford Site as a whole, DOE will prepare a future NEPA analysis to address tank farm closure and other issues associated with TWRS remediation. The analysis will address alternatives for closing the tank farms including disposition of the tanks and associated equipment, residual waste remaining after retrieval, and contaminated soils; resolution of emerging information concerning contamination of the vadose zone; and the integration of tank farm closure with the remediation of other Central Plateau areas. To support this analysis, DOE is implementing the Hanford Tanks Initiative to obtain operational experience on a number of important factors, which will provide data to support decisions on closure of the tank farms. Data that will be obtained include information on waste retrieval methods and waste volume sampling and characterization of residual waste, as discussed in Section 3.2.1.4.

Some of the decisions to be made concerning how to treat and dispose of tank waste may impact future decisions on closure, so the tank waste alternatives provide information on how tank waste remediation and closure are interrelated. Under the Tri-Party Agreement, the tanks are classified as hazardous waste management units that eventually would be closed under the State Dangerous Waste Regulations (WAC 173-303) and the requirements of the Tri-Party Agreement.

Three options exist for closure of the tanks. The first option is clean closure, which would involve the removal of all contaminants from the tanks and associated equipment, soil, and groundwater until natural background levels or health-based standards are achieved.

The second option is modified closure, which would involve a variety of closure methods but require periodic (at least once after 5 years) assessments to

Closure

Closure is a regulatory term for those activities involved in remediating the tank equipment, contaminated soil, and contaminated groundwater after the tank waste has been remediated.

Closure would be performed under State Dangerous Waste Regulations (WAC 173-303).

Closure decisions are not part of this EIS, but are interrelated with the decisions made concerning remediating the waste.

Closure as a landfill was included in all of the alternatives except the No Action and Long-Term Management alternatives so the alternatives could be meaningfully compared. This does not mean that closure as a landfill has been proposed or would be selected for final tank closure.

determine if the modified closure requirements are met. If modified closure requirements were not being met, additional remediation would be performed. Modified closure is a method specific to the Hanford Site Permit under the State Dangerous Waste Regulations (WAC 173-303).

The third option is closure as a landfill, which would involve leaving some waste in place with corrective action taken for contaminated soil and groundwater performed under post-closure requirements. This type of closure usually involves the construction of a low permeability cover over the contaminated media to reduce water infiltration and prevent inadvertent human intrusion.

Although sufficient information is not available to make final decisions on closure, some of the alternatives affect future closure decisions, so information is provided to allow the public and decision makers to understand how the alternatives would be interrelated with future closure of the tank farm system. For example, some of the alternatives addressed in the EIS involve removing most of the waste from the tanks (the ex situ alternatives) and would not substantially affect options for future closure decisions. Conversely, some of the alternatives do not involve removing the waste from the tanks (the in situ alternatives) but rather, would treat and dispose of the waste in the tanks. These alternatives include placing a low permeability cover over the tank farms to reduce water infiltration and prevent inadvertent human intrusion (e.g., Hanford Barrier). This would be considered closure as a landfill.

DOE plans to implement a program, the Hanford Tanks Initiative, to gather information and reduce uncertainties associated with tank closure. This would include developing and demonstrating systems to determine the residual waste volumes remaining in a tank following retrieval. The residual waste would be analyzed by developing systems for sampling and characterization. Site specific information on tank leaks would be obtained by developing systems to sample and characterize contamination in the soils surrounding the tanks. The information that would be gathered through the Hanford Tanks Initiative would be used to establish processes and criteria for future closure options.

Clean closure would be precluded by implementing the In Situ Fill and Cap and In Situ Vitrification alternatives because these alternatives would involve leaving most of the waste in place and placing a low permeability cover over the tank farms. This would constitute closure as a landfill. Similarly, the Ex Situ/In Situ Combination 1 and 2 alternatives would preclude clean closure of the tanks that contain waste that is not retrieved; 107 tanks for the Ex Situ/In Situ Combination 1 alternative and 152 tanks for the Ex Situ/In Situ Combination 2 alternative. The tanks that contain waste that is retrieved could be clean closed. The ex situ alternatives would not preclude clean closure.

For purposes of comparing the alternatives, a single and consistent method of closure was assumed for all of the alternatives. Closure as a landfill was chosen as the representative closure method for purposes of analysis and is included in all of the alternatives (except the No Action and Long-Term Management alternatives). This does not mean that closure as a landfill is proposed or necessarily would be selected in the future. It is included to allow a meaningful comparison of the in situ and

ex situ alternatives and to provide information to the public and the decision makers of the total cost and impacts of final restoration of the Site.

Because decisions on closure cannot be made at this time, but are interrelated with decisions to be made on remediation of the tank waste, the EIS presents an analysis of impacts with and without closure in Section 5.0. In each applicable subsection of Section 5.0, the impacts of the activities associated with remediating the waste are presented first. This is followed by the presentation of the combined impacts of remediating the tank waste and closing the tank farms by closure as a landfill. This provides the public and the decision makers with information on the impacts of the issues that are ripe for decision making (remediation of the tank waste) and information on the total project impacts (remediation and closure) as well as how they may be interrelated with the decisions on remediation of the tank waste.

Decontamination and Decommissioning

Decontamination and decommissioning of new facilities constructed to implement any of the alternatives are not evaluated in detail in this EIS because decisions on the appropriate method would not be required until the treatment and disposal of waste is complete (which is up to 30 years in the future) and because insufficient information is available presently to provide a meaningful evaluation. However, decontamination and decommissioning of these facilities is foreseeable. Therefore, the cost, personnel requirements, and volume of contaminated and noncontaminated materials resulting from decontamination and decommissioning were developed and analyzed using general practice assumptions to show how tank waste remediation and decontamination and decommissioning are interrelated. This provides an assessment of the relative environmental impacts of future decontamination and decommissioning activities so that the alternatives can be meaningfully compared. DOE will conduct an appropriate NEPA review to support future decontamination and decommissioning decisions.

3.3.1.2 Alternatives for Remediating Tank Waste

A wide range of potentially applicable technologies exists for treating tank waste. One of the challenges for DOE and Ecology is to eliminate from consideration technologies that are not viable and develop a range of reasonable alternatives for detailed analysis and presentation in the TWRS EIS. This section describes how the alternatives were developed.

There is a distinction between technologies and alternatives. Technologies are specific processes (e.g., cesium ion exchange) that relate to a component (e.g., retrieval or treatment) of an alternative. Alternatives include a set of technologies, or building blocks, that have been engineered to work together, forming complete systems for accomplishing the purpose and need for action. Alternatives are made up of a number of technologies linked together.

The first step in developing alternatives was to screen out technologies that were not viable. The full range of available technologies for each component of the proposed action was evaluated, and technologies that were not viable were eliminated from further consideration. The technologies eliminated by this screening process are described in Section 3.8 and Volume Two, Appendix C.

After rejecting technologies that were not viable, a large number of potential technologies remained for inclusion in the EIS. It would not be practicable to develop alternatives that include all of the potential combinations of technologies. In accordance with NEPA, representative alternatives were developed for detailed analysis to bound the full range of reasonable alternatives. Upper, lower, and intermediate bounding alternatives were developed in terms of cost, risk, and technologies for the two primary decisions that affect environmental impacts: the amount of waste to be retrieved from the tanks and the degree of separations of retrieved waste into HLW and LAW. The full range of applicable technologies and alternatives therefore is included in the EIS.

Because representative alternatives were developed for detailed analysis in the EIS, there are many other viable technologies for individual components of the alternatives that could not be included. These technologies are included in Volume Two, Appendix B and could be substituted for one of the technologies that is included in an alternative without a substantial change in the impacts of that alternative. An evaluation was performed for each of the technologies identified in Appendix B. Where there would be changes in impacts, the changes are discussed in Volume Two, Appendix B. The level of analysis was dependent on the magnitude of the change on impacts.

The alternatives developed for presentation in the EIS were chosen to be representative of many of the possible variations of the alternative. The design information for all alternatives is at an early planning stage, and the details of the alternative that ultimately is selected and implemented may change as the design process matures. Therefore, the alternatives are intended to represent an overall plan for remediation at a level of detail sufficient for impact analysis and alternative comparisons.

NEPA requires that an EIS includes a No Action alternative, which addresses not taking the proposed action (i.e., not initiating the project). For the TWRS project, there is a management program in place to continue the safe management of the tank waste and the capsules; therefore, the No Action alternatives addressed in this EIS (continue the current waste management program), consist of the activities currently being conducted to safely manage the waste. Further, under the No Action alternatives, no new facilities would be constructed other than those for which decisions already have been made based on other NEPA reviews (e.g., the Safe Interim Storage EIS).

Since the late 1950's, there have been numerous studies analyzing alternatives for tank waste treatment and disposal. The technologies contributing to the alternatives presented in the EIS come from different sources. The initial set of technologies used in the report was obtained by reviewing literature for processing radioactive, hazardous, and mixed waste. The literature review was supplemented by several DOE-sponsored workshops on treatment technologies for Hanford Site tank waste. Objectives and technologies were also proposed for consideration in the EIS during the public scoping process.

Four general categories of response actions have emerged through the alternative identification process. These categories are: 1) continue waste storage in the tanks; 2) waste treatment and disposal in the tanks, referred to as in situ treatment, 3) waste treatment outside of the tanks in a processing facility, referred to as ex situ treatment, and 4) a combination of in situ and ex situ treatments. In situ waste

treatment would not involve removing the waste from the tanks. Ex situ treatment would require that the waste be removed from the tanks for treatment and disposal.

Continued waste storage would not result in remediation of the waste but would postpone the impacts of the uncontrolled release of the waste. In situ alternatives eliminate the need for waste retrieval and would result in leaving all of the waste onsite following treatment. Ex situ alternatives require removing waste from the tanks for treatment and provide the opportunity to separate the waste into HLW and LAW components. The purpose of separating the waste is to meet onsite disposal requirements for LAW and minimize the volume of HLW requiring offsite disposal. Combination alternatives provide the opportunity to selectively retrieve waste for ex situ treatment based on waste type to achieve acceptable post remediation risk levels.

Ex situ alternatives provide for disposal of HLW at a potential geologic repository. Solely for the purpose of analysis, the potential geologic repository at Yucca Mountain, Nevada was assumed to be the final destination because it currently is being characterized to determine its suitability as a repository. It was assumed that the potential geologic repository would be operational and accept HLW generated by the ex situ alternatives (see Section 3.7 and Volume 2, Section B.10).

New Technical Strategy

In January 1994, DOE, Ecology, and U.S. Environmental Protection Agency (EPA) renegotiated the Tri-Party Agreement, which led to a new proposed technical strategy for remediating the tank waste. This technical strategy provides the basis for the TWRS EIS Ex Situ Intermediate Separations alternative and includes the following activities:

- Retrieve present and future waste from all DSTs and SSTs;
- Separate the waste into HLW and LAW streams to the extent required to meet onsite disposal requirements for LAW and to maintain an acceptable volume of HLW for offsite disposal;
- Vitrify the LAW and dispose of it onsite in a near-surface disposal facility in a retrievable form;
- Vitrify the HLW and store it onsite at a designated storage facility for future disposal at the potential geologic repository; and

Tri-Party Agreement Technical Strategy for Remediation

A strategy for remediating the tank waste, negotiated among DOE, Ecology, and EPA, was incorporated into the Tri-Party Agreement. This strategy identified an overall plan for remediation and is the proposed action in this EIS. This strategy is presented as the Ex Situ Intermediate Separations alternative. The agencies currently are negotiating changes to the Tri-Party agreement, which are expected to result in an amendment to the agreement in 1996. The primary changes to the agreement are 1) incorporate DOE's proposed approach to contract with private companies to perform certain aspects of the TWRS activities; and 2) combine the LAW pretreatment and LAW vitrification milestones.

Implementation of Alternatives

There are many technical uncertainties associated with the alternatives for remediating the tank waste. These

uncertainties involve the types of waste contained in the tanks and the effectiveness of the retrieval techniques, waste separations, waste immobilization, and cost of implementing the alternatives. These uncertainties exist because some of the technologies that may be implemented are first-of-a-kind technologies, have not previously been applied to the TWRS tank waste, or have not been applied on a scale as large as would be required for the TWRS tank waste.

Because of these uncertainties, DOE considered different approaches to implementing the alternatives to reduce the financial risk involved if one or more of the technical uncertainties could not be readily resolved. DOE identified two approaches to implementing the alternatives: full-scale implementation and phased implementation. Under full implementation, DOE would design, construct, and operate full-scale facilities to remediate the tank waste. Under phased implementation, either DOE or a private contractor would design, build, and operate demonstration-scale facilities to prove that the remediation concept would function adequately before constructing and operating full-scale facilities. All calculations performed for this EIS are based on DOE implementing the alternatives through the existing Management and Operations contractor system. This phased implementation approach has the potential to prove that the technologies work before committing large capital expenditures that could not be recovered.

A phased approach could be developed for any of the alternatives, but not all phased approaches would involve changes to environmental impacts from the full-scale approach. Therefore, not all phased approaches need to be addressed in the EIS. To decide which of the full-scale alternatives would need to have an associated phased implementation alternative addressed in this EIS, the following two criteria were used.

- Would the full-scale alternative involve large front-end expenditures of funds that could be lost if an unproven technology did not function adequately?
- Would the environmental impacts of the phased implementation approach be different than those of the full-scale alternative?

If either criterion were met, a phased approach would be included in the EIS.

Applying these criteria showed that most alternatives did not warrant a separate analysis of a phased implementation approach. A phased implementation approach to the No Action and Long-Term Management alternatives would not involve changes in environmental impacts, large front-end expenditures, or unproven technologies, so no phased approach was included in the EIS for these alternatives. A phased implementation approach to the In Situ Fill and Cap alternative would involve the simple process of filling several tanks as a demonstration, and therefore would not involve different environmental impacts or large front-end expenditures of funds that could be lost, so no phased approach was included in the EIS. Similarly, a phased approach to the In Situ Vitrification alternative would involve testing the in situ vitrification process first on MUSTs, then small tanks, and then large tanks. Although this technology previously has not been performed on the tank waste, it could be tested gradually without any differences in environmental impacts or large expenditures of funds that could be lost if the process did not function adequately. Therefore, the In Situ Vitrification alternative

did not warrant a separate phased implementation alternative, and no phased approach was included in the EIS.

All of the ex situ alternatives involve the application of technologies that have not been applied to the tank waste and all would involve large front-end expenditures of funds to construct large, complex separations and immobilization facilities. The phased implementation approach for these alternatives would involve constructing and operating demonstration-scale facilities before constructing the full-scale facilities, and would result in environmental impacts substantially different than the full-scale implementation alternative. Therefore, a phased implementation alternative has been included in the EIS to bound the impacts for the ex situ alternatives.

The Phased Implementation alternative consists of two phases: a proof of concept or demonstration phase (Phase 1) and a full-scale treatment phase (Phase 2). Phase 1 would include the construction and operation of one combined separations and LAW vitrification facility and one combined separations, LAW vitrification, and HLW vitrification facility. A sufficient quantity of a variety of tank waste types would be processed to demonstrate the effectiveness of the process and provide the necessary data to design a full-scale treatment facility. Phase 2 would include completing tank waste remediation by constructing and operating new full-scale separations, LAW immobilization, and HLW vitrification facilities. The degree of separations into LAW and HLW was assumed to be similar to the Ex Situ Intermediate Separations alternative, and includes additional processes to separate out the strontium, technetium, and transuranic elements from the LAW.

The tank waste alternatives addressed in this EIS include:

- No Action;
- Long-Term Management;
- In Situ Fill and Cap;
- In Situ Vitrification;
- Ex Situ Intermediate Separations;
- Ex Situ No Separations;
- Ex Situ Extensive Separations;
- Ex Situ/In Situ Combination 1;
- Ex Situ/In Situ Combination 2; and
- Phased Implementation (preferred alternative).

The alternatives developed for detailed analysis cover the full range of actions as well as the No Action alternative. The tank waste alternatives range from waste containment with the Long-Term Management alternative to extensive processing (separating HLW from LAW fractions) and immobilization using new technologies with the Ex Situ Extensive Separations alternative. the relationship among the alternatives is shown in Figure 3.3.1.

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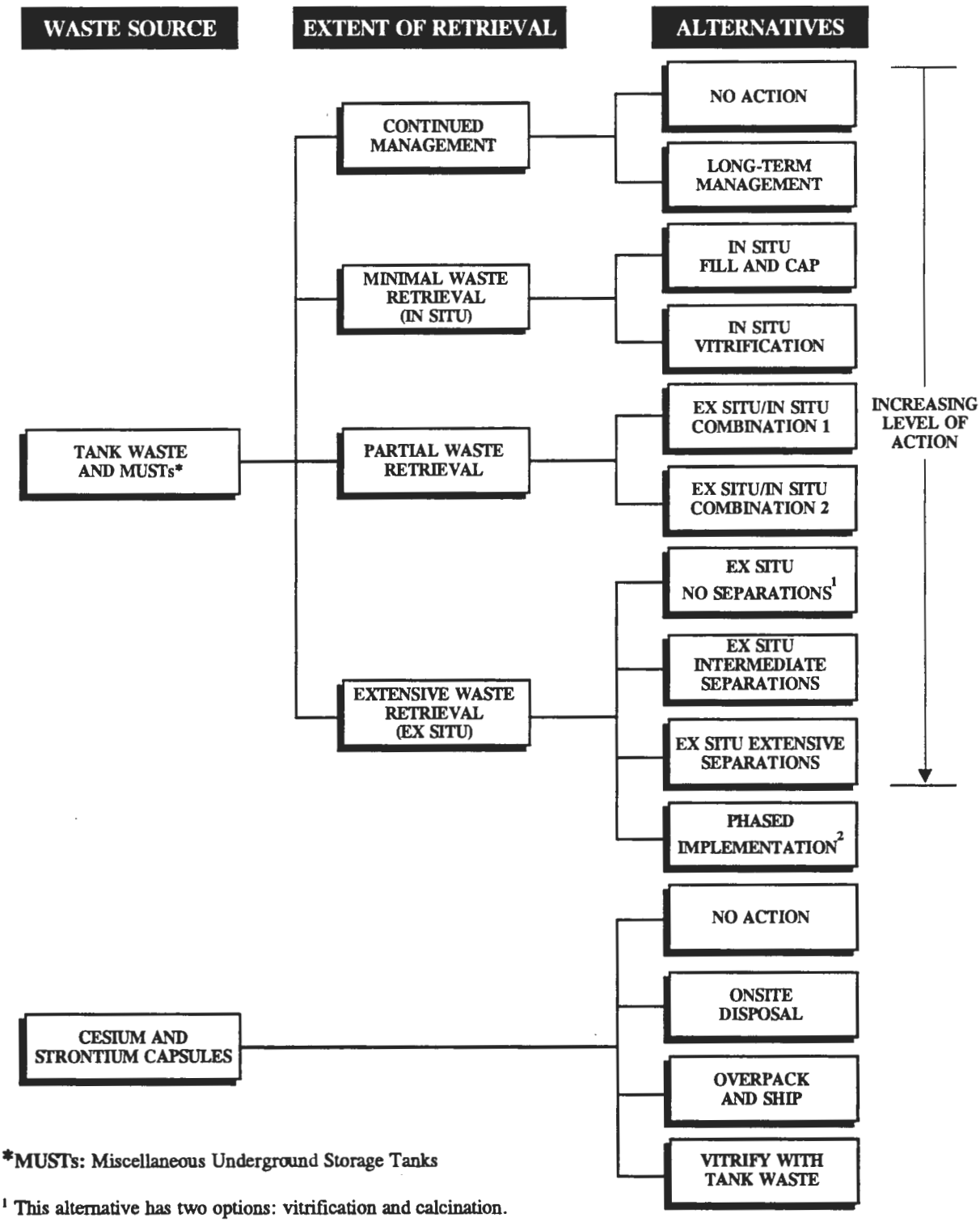
Figure 3.3.1 Relationship Among TWRS EIS Alternatives



*MUSTs: Miscellaneous Underground Storage Tanks

[1] This alternative has two options: vitrification and calcination.

[2] A phased approach could be taken to all alternatives except No Action and Long-Term Management. The phased approach would have the same impacts as the full implementation approach for all alternatives except the ex situ alternatives. A single phased alternative called Phased Implementation was included in the EIS to be representative of implementing the phased approach for any of the ex situ alternatives and to bound impacts.

3.3.2 Cesium and Strontium Capsules

The cesium and strontium capsules currently are classified as waste by-product, and this EIS is only addressing measures to remediate the capsules when and if they are determined to have no productive uses. The development of alternatives to remediate the cesium and strontium capsules is much less technically complicated than for the tank waste.

Cesium and Strontium Capsule Actions Analyzed in the TWRS EIS

- Continued storage in WESF
- Remediation of the cesium and strontium capsules if and when they are reclassified as waste

There are two distinct activities related to remediation of the capsules: the disposition of the capsules, which is analyzed in this EIS; and decontamination and decommissioning of WESF, the current capsule storage facility. WESF is part of B Plant and would be decontaminated and decommissioned in the future with B Plant. This is not within the scope of the EIS.

3.3.2.1 Alternatives for Remediating Capsules

The alternatives for remediation of the capsules include No Action, disposal on the Hanford Site, or disposal off the Hanford Site either with or separate from the tank waste. None of these alternatives involve unproven technologies or the construction of major process facilities. The following capsule alternatives are addressed in this EIS:

- No Action (preferred alternative);
- Onsite Disposal;
- Overpack and Ship; and
- Vitrify with Tank Waste.

3.4 TANK WASTE ALTERNATIVES

This section describes the alternatives for remediating the tank waste. Additional details may be found in Volume Two, Appendix B.

3.4.1 Elements Common to Tank Waste Alternatives

3.4.1.1 Current Operations

Included in each alternative are the operations necessary to maintain the tanks and associated facilities until they are no longer required for waste management. Routine operations include the following activities:

- Managing operations;
- Operating and maintaining facilities and equipment;
- Monitoring tanks to gather information including data on waste temperatures, liquid levels, and tank status;
- Monitoring leak detection equipment, including drywells around the tanks for increases in radioactivity, groundwater monitoring, and in-tank liquid level monitoring;
- Adhering to regulatory compliance and reporting;
- Conducting security and surveillance of facilities and grounds;
- Performing interim stabilization of SSTs by saltwell pumping;

- Operating the 242-A Evaporator to concentrate waste;
- Maintaining tank safety including diluting tank waste as necessary and maintaining adequate storage capacity; and
- Characterizing MUST waste associated with TWRS.

The 242-A Evaporator is an existing facility in the 200 East Area. This facility, which recently has been upgraded, is used for routine operations and would continue to be used (until approximately 2005) for waste management under all of the tank waste alternatives.

The functions and activities for routine operations are the same for each alternative but the cost, schedule, and staffing levels vary according to the schedule for completion of waste treatment and subsequent closure of the tank farms. The impacts of these routine operations are included in the calculations of the impacts for each alternative (Section 5.0).

Included in all of the alternatives (except No Action) are upgrades to the existing waste transfer system. Waste transfer system upgrades would involve constructing buried waste transfer pipelines in the 200 East Area. These upgrades would provide for safe, reliable, and compliant waste transfer between waste-generating facilities and the tank farms. Selected valve pits and diversion boxes would be upgraded by installing liners to provide secondary containment in the event of a leak or spill. Also included are new jumper and cover installations for selected valve pits and diversion boxes. The various flow path combinations would be indicated on the new cover blocks. The replaced buried lines would be abandoned in place, whereas the replacement items such as valve and diversion box jumpers and box covers would be removed and disposed of onsite (WHC 1996c). These waste transfer system upgrades do not include the replacement cross-site transfer system.

Future additions of waste to the tank farms would occur during routine operations. Some of these waste additions would involve loading the waste as liquid or slurry into a tank truck or rail car at the generating facility, transporting to the tank farms, and unloading and transferring the waste into existing DSTs for storage. This waste could be transferred using existing rail or specialized truck (LR-56[H]) systems. Volume Two, Appendix B contains a description of the LR-56(H) truck, which was specially designed for the transport of nuclear waste. Waste will be generated and require transport to the tank farms from the following:

- 300 Area laboratory facility cleanout;
- Plutonium-Uranium Extraction (PUREX) Plant, Plutonium Finishing Plant (PFP), and B Plant cleanout;
- T Plant decontamination waste;
- Routine laboratory waste; and
- K Basins cleanout.

Some future waste volume projections are provided in Volume Two, Appendix A.

In December 1995, all 177 tanks (Watchlist and non-Watchlist) were placed under flammable gas controls. Until the necessary characterization data are obtained, the tank farm systems will continue to operate under a conservative management program to maintain a safe operating envelope. These controls may slightly increase the cost of performing maintenance and monitoring activities on the tanks until the issue is resolved.

3.4.1.2 Multi-Purpose Canister

For comparison, it has been assumed that each of the ex situ alternatives would use a large multi-purpose canister for interim onsite storage and transportation to the potential geologic repository. This canister is designated the Hanford Multi-Purpose Canister. The Hanford Multi-Purpose Canister would be approximately 4.6 m (15 ft) long and 1.4 m (4.5 ft) in diameter and would be used as an overpack canister to house up to four individual HLW canisters depending on canister size. The sizing of the HLW canisters and the decision to use a multi-purpose overpack canister are in the conceptual stage and have not been finalized. There may be potential economic and handling benefits to using a multi-purpose canister for the TWRS program. There may be potential additional costs associated with using Hanford Multi-Purpose Canisters if future evaluations determine that the Hanford Multi-Purpose Canisters were not acceptable for disposal or if the Hanford Multi-Purpose Canisters would require costly changes in repository design and operations. Such a multi-purpose type canister has also been proposed as a waste package for commercial spent nuclear fuel. Additional information on canister sizing is presented in Volume Two, Appendix B.

3.4.1.3 Liquid Effluent Processing

Liquid effluent processing for all of the alternatives would be provided by the secondary radioactive liquid-waste processing system. This system, which has been constructed and currently is undergoing acceptance testing, is assumed to be permitted and operational in time to support each of the alternatives. The environmental impacts of this facility were analyzed in an environmental assessment (DOE 1992a). The secondary radioactive liquid-waste processing system consists of the Liquid Effluent Retention Facility, the Effluent Treatment Facility, and the State-approved land disposal site.

To be accepted into the effluent treatment facilities, waste must meet specific waste acceptance criteria. It is assumed that the liquid effluent streams generated at the waste processing facilities identified for the various alternatives would meet the waste acceptance criteria for the Liquid Effluent Retention Facility and the Effluent Treatment Facility.

The Liquid Effluent Retention Facility provides up to 49 million L (13 million gal) of temporary storage capacity for liquid waste. This storage capacity is provided by two 25 million-L (6.5 million-gal) lined and covered basins. An additional storage basin is provided for emergency backup. Waste accumulated in the Liquid Effluent Retention Facility basins would be sent to the nearby Effluent Treatment Facility for treatment.

The Effluent Treatment Facility provides the final processing step before disposal. This facility includes a treatment system to reduce the concentrations of radioactive and hazardous waste

constituents in the effluent streams to acceptable levels. The treated effluent is held in storage tanks to allow for verification before being transferred to the State-approved land disposal site for discharge.

3.4.1.4 Major Assumptions and Uncertainties

To develop engineering data required to perform impact analyses for each of the alternatives discussed in the EIS, assumptions were made regarding the technologies that have been configured to create a remediation alternative. These assumptions were based either on the best information available, applications of a similar technology, or engineering judgement. By definition when an assumption is made, there is some level of uncertainty associated with it that can be expressed as a range for the assumed value that reasonably could be expected. This section identifies the major assumptions used for the alternatives. Additional information on assumptions is provided in Volume Two, Appendix B, Section B.8.0 and uncertainties in Volume Five, Appendix K.

In Situ Alternatives

It was assumed that there would be no leaks to the soil from the SSTs or DSTs during the administrative control period for the No Action, Long-Term Management, or In Situ Fill and Cap alternatives. This assumption is based on ongoing SST interim stabilization to remove pumpable liquids, the ability to detect and recover leaks from the space between the inner and outer liners of the DSTs, and ongoing monitoring activities within the tank farms. The SSTs and DSTs were assumed to maintain their structural integrity throughout the administrative control period under the No Action and Long-Term Management alternatives.

The In Situ Vitrification, In Situ Fill and Cap, and the in situ portion of the Ex Situ/In Situ Combination 1 and 2 alternatives were assumed to require additional characterization data to evaluate the acceptability of in place disposal and address RCRA land disposal requirement considerations. This requirement would be in addition to the current characterization requirements for the ex situ alternatives. These additional characterization efforts could involve extensive laboratory analysis of additional tank samples and may require modifications to the tanks to install additional risers for sampling access.

In Situ Vitrification

The in situ vitrification system was assumed to be capable of vitrifying each of the tanks to the required depth resulting in a consistent waste form. It was also assumed that the variation in waste composition and inventory from tank to tank would not impact the ability to produce an acceptable waste form.

In Situ Fill and Cap

The concentrated liquid waste contained in the DSTs was assumed to be acceptable for gravel filling. Under this alternative, the DST liquids would be concentrated using the 242-A Evaporator to remove as much water from the waste as possible, but the waste would still contain substantial volumes of liquid. It has been estimated that concentration by the 242-A Evaporator would reduce the current liquid volumes contained in the tanks by approximately one-third (WHC 1995f).

Ex Situ Alternatives

The major assumptions used for the ex situ alternatives are outlined in the following paragraphs and summarized in Table 3.4.1.

Table 3.4.1 Ex Situ Alternatives Major Assumptions

Parameter	Ex Situ Intermediate Separations	Ex Situ No Separations Vitrification	Ex Situ Extensive Separations	Ex Situ/ In Situ Combination 1 (ex situ portion)	Ex Situ/ In Situ Combination 2 (ex situ portion)	Phased Implementation
Retrieval Efficiency (percent recovered from the tanks)	99%	99%	99%	99%	99%	99%
Treatment Plant Size HLW LAW	20 mt/day 200 mt/day	200 mt/day	1 mt/day 200 mt/day	8 mt/day 120 mt/day	5 mt/day 70 mt/day	Phase 1: 1 at 1 mt/day HLW 2 at 20 mt/day LAW Phase 2: 1 at 10 mt/day HLW 2 at 100 mt/day LAW
Operating Efficiency	60%	60%	60%	60%	60%	Phase 1: 60% Phase 2: 70%
HLW Canister Size	1.17 m^3 (41 ft^3)	10 m^3 (360 ft^3)	1.17 m^3 (41 ft^3)	1.17 m^3 (41 ft^3)	1.17 m^3 (41 ft^3)	1.17 m^3 (41 ft^3)
Waste Loading[1] HLW LAW	20% 15%	20% [2] N/A	20% 15%	20% 15%	20% 15%	20% 15%
Blending Factor HLW LAW	1.2 1.0	1.2 N/A	1.2 1.0	1.2 1.0	1.2 1.0	1.2 1.0

Notes:
[1] HLW loading is in terms of weight percent waste oxides excluding the sodium and silica in the tank waste. LAW loading is in terms of weight percent sodium oxide.
[2] HLW loading is in terms of weight percent sodium oxide.
mt = Metric tons
N/A = Not applicable

Retrieval Efficiency

Retrieval efficiency is the assumed percentage of the tank waste that would be retrieved. The amount and type of waste that would remain in the tanks after retrieval is uncertain. The Tri-Party Agreement (Ecology et al. 1994) set a goal for the SSTs that no more than 1 percent of the tank inventory would remain as a residual following waste retrieval activities. The engineering data for the waste retrieval and transfer function common to all ex situ alternatives was developed using 99 percent retrieval as a goal.

The residual contaminants left in the tanks either would be insoluble and hardened on the tank walls or bottom or of a size that could not be broken up or removed from the tanks. In either case, the residual would have low solubility because the retrieval technologies proposed would use substantial quantities of liquid in an attempt to dissolve or suspend the waste during retrieval. Because of the uncertainties regarding the amount and type of residual waste that would remain in the tanks, a conservative assumption was made to bound the impacts of the residual waste. For purposes of the analysis, it was assumed that 99 percent recovery would be achieved for ex situ alternatives, and the residual waste left in the tanks would contain 1 percent of all the original tank inventory, including the water-soluble contaminants. The water-soluble contaminants provide the long-term potential human health risk because they would be transported into the groundwater and then could be consumed by humans.

The assumption that 1 percent of the water-soluble waste would remain in the tanks yields an upper bound on the impacts that would occur under the ex situ alternatives. The In Situ Fill and Cap and Ex Situ/In Situ Combination 1 and 2 alternatives leave more waste in the tanks for disposal and provide an upper bound on the impacts associated with the amount and type of waste that is disposed of onsite.

Releases During Retrieval

To provide a conservative estimate of the impacts that could occur following retrieval, the analysis performed for the EIS assumed that each of the 149 SSTs would leak an average of 15,000 L (4,000 gal) to the soils surrounding the tank during retrieval operations. No leakage was assumed to occur from the DSTs during retrieval operations because DSTs have provisions for leak containment and collection. The leakage volume estimate was based on current information from the retrieval program and the assumption that the average leakage volume from an SST would be one order of magnitude lower than the maximum release volume estimated for tank 241-C-106 during sluicing operations (DOE 1995d). The leakage estimated for tank 241-C-106 was based on a series of conservative assumptions that would not be applicable for developing an average lead estimate for all SSTs. It was also assumed that the contaminant concentrations in the liquids released would be at maximum predicted concentrations; therefore, dilution of the waste during retrieval was not taken into account.

Bounding and Nominal Risks

To account for the uncertainties involved with the contents of the tank waste and some of the processes involved in remediating the waste, a **bounding** impact analysis was performed and is presented in this EIS. Bounding impacts represent the reasonable maximum impacts that are likely to occur and are developed using conservative assumptions and calculations.

Because the reasonable maximum impacts do not always occur, **nominal** impacts also are presented for those impacts that have the greatest uncertainty: impacts from operational accidents and long-term human health risks from residual waste that remains onsite and potential leaks during retrieval. Nominal impacts are developed using less conservative assumptions and calculations and represent the average impacts that are likely to occur based on currently available data.

DOE is currently working with Ecology to define the operating envelope for allowable leakage during retrieval systems would include measures to detect and control leakage.

Nominal Case

A nominal case retrieval release and residual tank inventory was developed to assess the impacts that would result from nominal, as compared to bounding, assumptions for tank releases during retrieval and the residual waste left in the tanks following retrieval. Additional information on the nominal case is in Volume Two, Section B.3.

The nominal retrieval release inventory was developed by assuming that the waste would be diluted by one-third through the addition of water during waste retrieval. The nominal case retrieval release volume was assumed to be 15,000 L (4,000 gal) from each SST, and the contaminant concentrations were assumed to be two-thirds of the bounding case.

The nominal tank residual inventory was developed by modifying the bounding tank residual inventory to reduce the mobile constituents of concern based on solubility. The mobile constituents of concern were evaluated because of their contribution to post-remediation risk. The isotopes of carbon, technetium, and iodine were reduced in the nominal case tank residual inventory to 10 percent of the bounding tank residual inventory.

The nominal case for operation accidents was analyzed by using average tank inventory for the potential releases during accidents. This nominal inventory was developed by estimating the inventory of radioactive materials contained in the fuel from the single-pass reactors and N Reactor and sent to the tank farms. Reduction factors were applied to account for extracted plutonium, uranium, cesium, and strontium. This nominal radiological inventory is shown in Appendix E, Section E.1.0.

Operating Efficiency

The operating efficiency is a combination of the online efficiency and the production efficiency of the treatment facilities. The assumed operating efficiency is used in combination with the operating schedule to determine the size of the treatment facilities required to treat the waste. The 60 percent operating efficiency assumption was selected as a reasonable value for facility sizing. This value is considerably lower than operating efficiencies obtained in the commercial chemical processing industry to account for regulatory and safety requirements associated with nuclear waste processing. The operating efficiency for Phase 2 of the Phased Implementation alternative was assumed to be higher than the other alternatives to account for the phased implementation approach. Once a treatment facility is designed and constructed, the inability to achieve the assumed operating efficiency would result in a longer operating schedule.

Waste Loading

Waste loading or waste oxide loading is the percentage of waste that is in the final vitrified waste form. The waste oxide loading is controlled by the amount of glass formers that are added during the vitrification process. The higher the waste loading, the more waste contained in the vitrified glass, and

the lower the overall waste volume. Conservative waste loading factors have been assumed for the ex situ alternatives. Current development work may result in the selection of higher waste loading factors. The sensitivity of the HLW and LAW volume and the engineering data to the waste loading assumptions is provided in Volume Two, Section B.8.0.

Blending Factor

Blending is the mixing of the wastes from different tanks during retrieval to obtain an average waste feed stream for treatment. Because there are 177 tanks that contain waste and the waste composition varies from tank to tank, it would be difficult to achieve a completely uniform blending of the waste during retrieval. To account for the uncertainties associated with achieving a uniformly blended waste feed stream, blending factors have been assumed for the HLW vitrification processes.

One of the major uncertainties associated with the ex situ alternatives is the volume of HLW that would be produced. The largest uncertainty range would be for alternatives that rely on an intermediate level of separations. The estimated volume of HLW produced is a function of the inventory and assumptions made for separations efficiencies, waste loading, and blending.

The waste loading and blending factors assumed for the ex situ alternatives represent a reasonable and conservative technical basis for the EIS. This basis was developed through an independent technical review (Taylor-Lang 1996). The assumptions made for waste loading and blending result in approximately 12,200 HLW canisters (1.17 m^3 [41 ft^3]) for the Ex Situ Intermediate Separations and Phased Implementation alternatives.

Assumption on Disposal of Hanford Site HLW in a Geologic Repository

For purposes of analysis, a geologic repository candidate site at Yucca Mountain, Nevada was assumed to be the final disposal site for all TWRS HLW sent offsite for disposal. Current legislation prohibits the placement, in the first repository, of spent fuel in excess of 70,000 mt (77,000 tons) of heavy metal or a quantity of solidified high-level radioactive waste from the reprocessing of such a quantity of spent fuel until a second repository is operating. DOE will evaluate the need for a second repository no sooner than year 2007.

Currently, Yucca Mountain is the only site being characterized as a geologic repository for HLW. If selected as the site for development, it would be ready to accept HLW no sooner than 2015. The potential environmental impacts that would occur at the geologic repository from the disposal of HLW from TWRS are not addressed in this EIS. Potential impacts at the repository will be addressed in an EIS that DOE will prepare in accordance with the Nuclear Waste Policy Act to analyze the site-specific environmental impacts from construction, operation, and eventual closure of a potential geologic repository for spent nuclear fuel and HLW at Yucca Mountain. Detailed evaluations to support decisions on the disposal of HLW from the Hanford Site would be made following completion of the repository EIS. The repository EIS will also asses the impacts of transporting spent nuclear fuel and HLW from various storage locations to the potential geologic repository.

Each of the ex situ alternatives addressed in this EIS include sufficient interim onsite storage facilities to store all of the immobilized HLW produced while awaiting offsite transport and disposal at the potential geologic repository. This would allow each of the alternatives to operate independent of the acceptance schedule for the potential geologic repository.

Safety Issues

Because of the uncertainty involved with the tank waste inventory and the application of some first of a kind technologies, there are uncertainties involved with the estimates of accidents. Therefore, a bounding approach was taken for the calculation of consequences from accidents. A full safety review of all aspects of the alternative selected would be performed during the final design phase, and changes could be made to the selected alternative to provide engineering or administrative controls to mitigate accidents unforeseen at the current time. This is a standard design procedure.

The possibility of driving heavy equipment over an unstabilized tank during construction or operations that could potentially result in a tank dome collapse was considered. To reduce the potential for this accident, engineered features would be installed and administrative controls would be used to prevent large vehicles from driving on top of the domes. These engineered barriers would be mechanical barriers such as closely spaced posts installed around the tanks or tank farms.

3.4.1.5 Waste Compositions

Vitrification, or glassmaking, is a waste stabilization and solidification technology that incorporates radioactive and hazardous waste into a glass matrix. This process involves blending the waste material with glass formers or additives and heating the mixture to glass-forming temperatures. The types of glass formers added to the waste define the resulting glass type.

Borosilicate glass is based on a composition of silicon dioxide, boron trioxide, sodium oxide, and lithium oxide. Borosilicate glass is the standard final waste form for treating high-level radioactive waste because of its durability and ability to accommodate a varied range of waste feeds (DOE 1990). Additionally, borosilicate glass is currently identified as the only standard HLW form that will be accepted at the potential geologic repository (DOE 1994g).

Other types of glass could be selected for the vitrification of HLW or LAW; however, they would have to meet the repository or performance assessment criteria. One example is the soda-lime glass that would be produced by the Ex Situ No Separations (Vitrification) alternative. Soda-lime glass consists of mainly silicon dioxide, sodium oxide, and calcium oxide.

Two types of vitrified waste forms described in the alternatives are monoliths and cullet. Monoliths would be produced by casting the molten glass into a canister, resulting in a single piece of glass. The cullet would be produced by quenching the molten glass in water following vitrification, resulting in gravel-sized pieces of glass.

Cullet would provide processing and material handling advantages for the high-capacity processing facilities. The disadvantage of cullet as a waste form is its high surface area-to-volume ratio, which results in lower long-term performance. Matrices or coating material can be used in conjunction with the cullet to improve the waste-form performance.

All of the ex situ alternatives that produce vitrified LAW for onsite disposal have assumed cullet in a matrix material as the waste form for onsite LAW disposal. This provides a conservative analysis of the long-term impacts resulting from onsite disposal of LAW.

Grouting the retrieved tank waste is a technology that could be applied to any of the ex situ alternatives in place of vitrifying the waste. Grout is a common solidification and stabilization technology employed in the management of hazardous and radioactive waste. Grout is a general term that refers to a waste form obtained by mixing waste with chemical additives to stabilize and immobilize the hazardous constituents.

The grouting process applied to the ex situ treatment of the tank waste would involve waste retrieval and transfer to a grout facility where the waste would be mixed with appropriate mixtures of grout formers. After the grout is mixed, it could be placed into containers or pumped into large vaults for solidification and disposal.

Grouting tank waste has been studied extensively at the Hanford Site as a technology for LAW disposal. Grouting of the LAW was selected as the treatment method in the Hanford Defense Waste EIS (DOE 1987). The LAW described in the Hanford Defense Waste EIS included liquid waste from the tanks (after separation of HLW components) and secondary waste from the HLW vitrification facility, which would consist of waste from canister decontamination, drying feed material, and recovered liquid from off-gas treatment.

Each of the alternatives that involve treating the waste would involve collecting small sample quantities (up to about 2.5 L [0.65 gal] per sample) of tank waste and shipping the samples to offsite locations for bench-scale waste treatment and immobilization performance demonstration and testing purposes. The general approach would include collecting grab and/or core samples from the tanks, verifying that the samples and sample contents meet appropriate specifications (using existing onsite laboratory facilities, including necessary laboratory preparatory work [e.g., preparing composite samples]), and appropriately packaging and transporting the samples to other DOE facilities or to private contractor facilities. Initially, collecting and transferring small quantities of such samples would be to support contractor selection for DOE's TWRS privatization initiative.

3.4.1.6 Waste Minimization

Each alternative would involve waste minimization practices for primary, secondary, and tertiary waste. Primary waste is the treated tank waste and capsule contents requiring disposal. Primary waste minimization practices would be used to control the volume of HLW and LAW requiring disposal.

Secondary waste is generated during handling and processing of the waste and includes off-gases, contaminated filters, spent ion-exchange resins, and liquid effluents. Secondary waste minimization would involve practices such as using metal high-efficiency particulate air filters that could be washed in place and reused. In some process configurations, spent ion-exchange resin would be fed into the waste treatment process to reduce the volume of secondary waste.

Tertiary waste generation primarily would be a function of the number of operating personnel and includes such things as personal protective equipment and other incidental waste. Secondary and tertiary waste would be divided into low-level waste and transuranic waste based on characterization. Secondary low-level waste would be disposed of at the onsite low-level waste burial grounds. Secondary transuranic waste would be retrievably stored for future packaging at the Waste Receiving and Processing Facility. Current plans are for disposal of transuranic waste at the Waste Isolation Pilot Plant. Liquid effluent from all alternatives would be treated at the Effluent Treatment Facility in the 200 East Area before release.

Each of the tank waste alternatives that use high-temperature processing (vitrification or calcination) would make extensive use of recycle streams to recycle volatile radionuclide and chemical constituents, which are captured in the off-gas systems, back into the treatment process. These recycle streams would be used to minimize the generation of secondary waste. It has been determined that a bleed stream would be required for each alternative to avoid a continuous buildup of certain volatile radionuclide and chemical constituents (e.g., technetium-99 and mercury) in these recycle streams. For comparison purposes, it has been assumed for each alternative that the bleed stream percentage would be 1 percent of the recycle stream and that this secondary waste stream would be stabilized by some low-temperature process.

Hanford Site waste minimization would involve the use of chemicals and materials from other Hanford Site facilities where appropriate. One example would be the conversion of the sodium from the Fast-Flux Test Facility cooling system to sodium hydroxide for use during enhanced sludge washing for the Ex Situ Intermediate Separations and Ex Situ Extensive Separations alternatives, or other alternatives using waste stream separation processing. The conversion facility, with its process-inherent safety issues, would require a cost and safety analysis.

3.4.1.7 Cost Estimates

Cost estimates are presented for each alternative. These estimates are based on conceptual designs and have an associated level of uncertainty. This uncertainty is accounted for in the cost uncertainty analysis and results in a cost range that is estimated for each alternative. Additional information on the cost uncertainty is provided in Volume Two, Section B.8.0.

Capital cost is included in the cost for the alternatives and includes the direct cost (i.e., materials, labor, and equipment for facility construction), construction management, project management, engineering, and contingency. The contingency is obtained by multiplying the sum of the capital cost

components by a contingency factor. Each of the estimates includes a value for current operations, which is the estimated cost associated with routine operations identified in Section 3.4.1.1.

Research and development cost is included in the cost estimates for each alternative. This cost is assumed to provide for development of the technologies required to implement an alternative. The resolution of implementability issues identified for each alternative would be part of the development work; thus the research and development cost partially reflects the implementation uncertainties.

Repository fees for alternatives that include shipment of HLW to the potential geologic repository are discussed in Section 3.7.

The cost estimates for each of the alternatives were prepared using the same methodology and estimating practices to ensure comparability among the alternatives. Additional detail on the cost estimates is provided in Volume Two, Appendix B.

3.4.1.8 Facility Sizing

The design capacities for the full-scale ex situ processing facilities were developed using a consistent approach. Each facility was sized to treat the projected volume of waste within the schedule outlined in the Tri-Party Agreement using a consistent set of assumptions for total operating efficiency. The total operating efficiency for the ex situ vitrification facilities was assumed to be 60 percent. The operating efficiency for the Phased Implementation alternative during Phase 2 was assumed to be higher to account for the advantages of the phased implementation approach.

3.4.1.9 Facility Siting

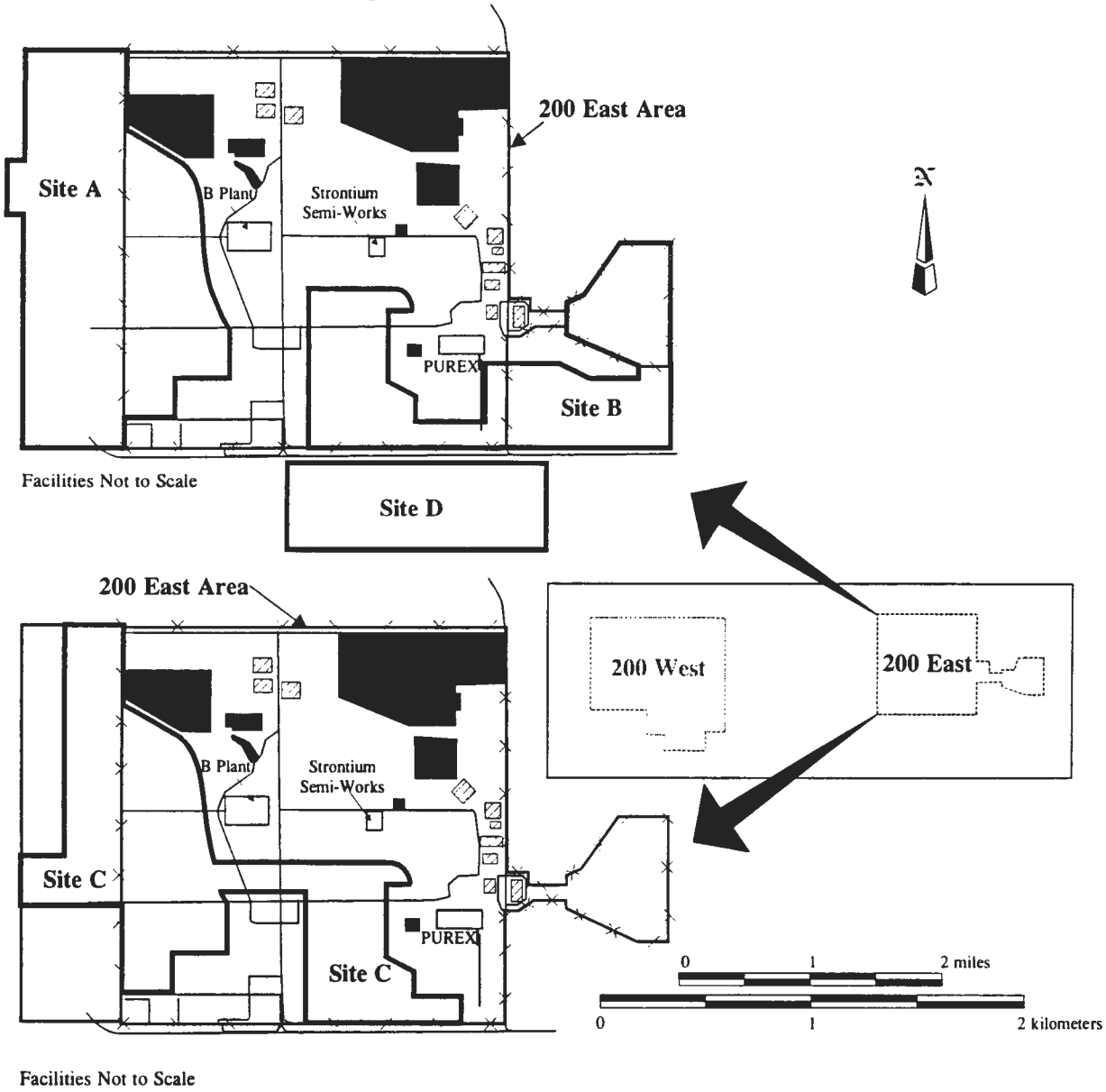
A site evaluation process was conducted and four potential sites were identified as suitable locations for the onsite treatment and disposal activities for the ex situ treatment and disposal alternatives. A suitable site, which would accommodate all of the full-scale ex situ alternatives, is a combination of Sites B and C shown in Figure 3.4.1. This representative site is for ex situ tank waste remediation activities for the purpose of alternative evaluation in the EIS and does not preclude the other sites from ultimately being selected. Prior to selecting the representative site, one of the other sites, or a combination of sites, appropriate NEPA analysis would be completed. All of the full-scale ex situ alternatives are assessed as if they were located on this representative site.

The representative site is located close to a potential support facility for the 200 East Area infrastructure on vacant land, which has been disturbed partially by past actions. The location of the Phase 1 facilities for the Phased Implementation alternative is assumed to be Site B, maintaining Site C for Phase 2 facilities (WHC 1996).

3.4.1.10 Hanford Barrier

The Hanford Barrier would be a horizontal, abovegrade, engineered soil structure used to isolate the waste site from the environment by preventing or reducing the likelihood of wind erosion, water

Figure 3.4.1 Potential Site Location



LEGEND

- 200 East Tank Farms
- 200 East Burial Grounds
- 200 East Roads
- Existing 200 East Boundary

SOURCE: Shord 1995

infiltration, and plant, animal, and human intrusion. It would be composed of 10 layers with a combined thickness of 4.5 m (15 ft), and placed over the top of the stabilized tanks and the LAW disposal sites. Each Hanford Barrier would extend 9 m (30 ft) beyond the perimeter of the area to be protected. For additional information on the Hanford Barrier, see Volume Two, Section B.6.0.

For purposes of analysis only, the earthen borrow material was assumed to be obtained from three potential borrow sites on the Hanford Site. The use of these sites to allow the potential impacts to be calculated does not mean that these sites would be used. The evaluation and selection of borrow sites for closure activities will be addressed in a future NEPA analysis.

3.4.1.11 Interim HLW Storage

Each of the ex situ alternatives would include sufficient interim onsite storage capacity to store all of the immobilized HLW produced while awaiting shipment to the potential geologic repository. Interim HLW storage would consist of placing Hanford Multi-Purpose Canisters on a concrete storage pad and placing a concrete shielding cover over each Hanford Multi-Purpose Canister. This method of interim storage would be used for all ex situ alternatives except for Phase 1 of Phased Implementation. During Phase 1 HLW canisters would be placed in the Canister Storage Building for interim storage. The Canister Storage Building is a facility that is being constructed in the 200 East Area for storage of DOE spent fuel.

3.4.2 No Action Alternative (Tank Waste)

3.4.2.1 Overview

The No Action alternative would provide for continued storage and monitoring of tank waste. For purposes of assessing impacts, it is assumed that administrative controls (e.g., site security and management) would be maintained for 100 years. However, DOE and Ecology currently have no policies or plans that would permit the loss of administrative control for radioactive and hazardous material.

No Action Alternative (Tank Waste)

- Continue current waste management activities
- No remediation performed

The SST waste would have minimal free liquid remaining and would be left in place and monitored. Existing DSTs and MUSTs would be left in place and monitored, similar to the SSTs. No construction activities would be involved with the No Action alternative.

The information used in describing this alternative was obtained from the No Disposal Action Engineering Data Package for the TWRS EIS (WHC 1995g and Jacobs 1996).

3.4.2.2 Process Description

For the SSTs, it is assumed that current operations to remove pumpable liquid (interim stabilization) from the tanks would be completed. This would result in SST waste that primarily is solid but contains some interstitial liquid (the interstitial liquid is held within the void spaces of the sludge and saltcake). The SSTs would be monitored for releases and indications of tank dome settling or collapse. The SSTs

showing signs of deterioration would be filled with grout or gravel as a corrective action or emergency response.

The DST waste mainly is liquid; consequently, a tank leak from a DST would represent a greater threat to the environment than a tank leak from a SST because of the potential volume and migration of contaminants to the groundwater. The DSTs were put into service between 1971 and 1987, and all DSTs would exceed their 50-year design life during the No Action alternative. Monitoring and maintenance activities would continue to ensure safe storage of waste in the DSTs. This would include maintaining spare DST capacity and leak recovery from the annulus of a tank if a leak were detected. Spare DST capacity would be maintained within the existing DSTs through periodic operation of the 242-A Evaporator and waste minimization practices. If a DST were to fail, its waste would be transferred to other DSTs as an emergency response. Administrative controls would be maintained for items such as monitoring, routine maintenance, fire protection, and security throughout the 100-year administrative control period.

3.4.2.3 Construction

No construction activities would take place for this alternative.

3.4.2.4 Operations

Operations would involve continued monitoring and maintenance of the tank farms.

3.4.2.5 Post Remediation

There would be no post-remediation activities associated with the No Action alternative. It is assumed for purpose of analyses that administrative control of the area would be discontinued after 100 years, and human intrusion could occur.

3.4.2.6 Schedule, Sequence, Cost

The No Action alternative schedule is shown in Table 3.4.2. The cost for the No Action alternative is shown in Table 3.4.3.

Table 3.4.2 Schedule - No Action Alternative (Tank Waste)

Activity	Schedule
Construction	N/A
Operation (Continued Operation)	1997 to 2097
Decontamination and Decommissioning	N/A
Loss of Administrative Control	2097

Notes:
N/A = Not applicable

Table 3.4.3 Cost - No Action Alternative (Tank Waste) [1]

Cost Component	Totals
Current Operations	$14,300
Research and Development	$0
Capital	$0
Operating[2]	$0
Closure	N/A
Total	$14,300
Cost Range (Estimated) [3]	$12,555 - $16,083

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

3.4.2.7 Implementability

The objective of the No Action alternative would be to provide continued management of the tank waste. This alternative would not provide remedial action for the tank waste. This alternative would provide for the continuation of current operations and, as such, does not present specific process uncertainties. There is some uncertainty in estimating the functional life of the DSTs. Current design life of the DSTs is approximately 50 years.

Extensive additional characterization would be required to address RCRA land disposal requirements if waste was left in place.

One implementability issue that would require additional analysis is the potential for interim stabilized SSTs to develop leaks. Following interim stabilization, an SST could contain as much as 190,000 L (50,000 gal) of interstitial liquid.

This alternative would not comply with Federal and State requirements for storing hazardous waste. When administrative control is assumed to be discontinued after 100 years, the waste left in place would not comply with State and Federal (including DOE Order 5820.2A) requirements for disposal of hazardous, radioactive, or mixed waste (Section 6.2).

Long-Term Management Alternative

- Continue current waste management activities
- Similar to No Action except includes replacing DSTs in 40 years and again in 90 years
- Includes upgrades to tank farm system to address safety and regulatory compliance issues
- No remediation performed

3.4.3 Long-Term Management Alternative

3.4.3.1 Overview

The Long-Term Management alternative would provide continued storage and monitoring of tank waste and is similar to the No Action alternative except that the DSTs would be replaced twice during the 100-year administrative control period to prevent the release of

DST liquid. For purposes of assessing impacts, it is assumed that administrative controls (e.g., site security and management) would be maintained for 100 years. However, DOE and Ecology currently have no policies or plans that would permit the loss of administrative control for radioactive and hazardous material.

The SST waste would have minimal free liquid remaining and would be left in place and monitored. The DST waste, which is currently 77 percent liquid, would be monitored, retrieved, and placed into new DSTs at 50-year intervals corresponding to the design life of the DSTs (Figure 3.4.2). Existing MUSTs would be left in place and monitored similarly to the SSTs. Construction activities for the Long-Term Management alternative involve building new DSTs along with the retrieval, transfer, and evaporator facilities to accommodate two retanking campaigns for the DST waste during the 100-year administrative control period.

The information used in describing this alternative was obtained from the No Disposal Action Engineering Data Package for the TWRS EIS (WHC 1995g and Jacobs 1996).

3.4.3.2 Process Description

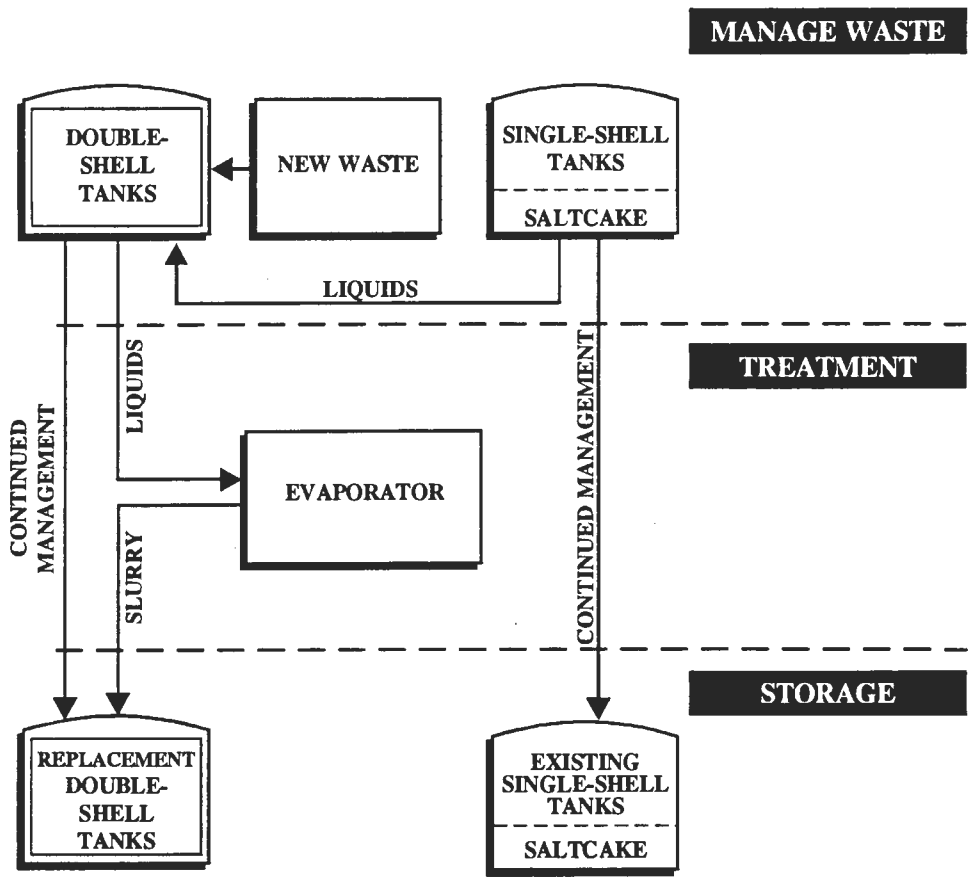
For the SSTs, it is assumed that current operations to remove pumpable liquid (interim stabilization) from the tanks would be completed. This would result in SST waste that is primarily solid but that contains some interstitial liquid (the interstitial liquid is held within the void spaces of the sludge and saltcake). The SSTs would be monitored for releases and indications of tank dome settling or collapse. The SSTs showing signs of deterioration would be filled with grout or gravel as a corrective action or emergency response.

The DST waste is mainly liquid, and consequently, a tank leak to the ground from a DST (both shells failing) would represent a greater threat to the environment than a tank leak from a SST because of the potential volume and migration of contaminants to the groundwater. The DST waste would be removed and transferred into new DSTs at two intervals corresponding to the 50-year design life of the tanks. The design life corresponds to a minimum length of service time that a tank would be expected to remain functional, though the DSTs may remain functional for more than 50 years. The DSTs were put into service between 1971 and 1987, and the first retanking campaign would correspond to using the full 50-year service life of the newest DSTs, which were placed into service in 1987. The first retanking campaign for the 28 DSTs would begin in the year 2037. It is recognized that some DSTs would exceed their design life prior to the first retanking campaign; however, it is assumed that these tanks would be safely managed. Monitoring and maintenance activities would continue to ensure safe storage of waste in those DSTs that would exceed the 50-year design life. This would include maintaining additional DST capacity and leak recovery from the annulus of the DSTs.

Based on waste volume projections, each retanking campaign would require 26 new 3.8-million-L (1-million-gal) tanks to replace the existing DSTs. This estimate includes maintaining a spare tank for contingency. A total of two retanking campaigns would be required during the 100-year administrative control period.

9613459.0278

Figure 3.4.2 Long-Term Management Alternative



Following retrieval, the empty DSTs would contain waste residuals and would be managed in the same manner as the SSTs. Administrative controls would be maintained for monitoring, routine maintenance, fire protection, and security throughout the 100-year administrative control period.

3.4.3.3 Construction

Construction activities for this alternative would consist of building 26 new DSTs along with the required retrieval and transfer systems for each DST retanking campaign. The 242-A Evaporator was assumed to be obsolete by the time the first retanking operation would take place, and a new evaporator would be constructed in the vicinity of the new DSTs for each retanking. A total of 52 new DSTs and 2 new evaporators would be built under this alternative.

3.4.3.4 Operations

Operations would involve continued monitoring and maintenance of the tank farms as well as retrieving and transferring the DST waste during the retanking campaigns.

Waste retrieval would be accomplished during a DST retanking campaign as follows.

- Pump tank liquid (supernate) from existing to new DSTs.

- Add water to existing tanks and use mixer pumps to suspend solid and sludge into a slurry.
- Pump the slurry to the evaporator for water removal and volume reduction.
- Pump concentrated slurry to new DSTs.
- Send evaporator condensate and excess retrieval water to the Effluent Treatment Facility for treatment and discharge.

3.4.3.5 Post Remediation

There would be no post-remediation activities associated with the Long-Term Management alternative. The evaporator facility constructed with each set of new tanks would be decontaminated and decommissioned after each retanking campaign. It was assumed that administrative control of the area would be discontinued after 100 years, and human intrusion could occur.

3.4.3.6 Schedule, Sequence, Cost

The Long-Term Management alternative schedule is shown in Table 3.4.4. The two separate time periods shown correspond to building and transferring the DST waste to new tanks during the 100-year administrative control period. The overall cost for the Long-Term Management alternative is shown in Table 3.4.5.

Table 3.4.4 Schedule - Long-Term Management Alternative

Activity	DST Waste Retrieval and Transfer Schedule	Long-Term Management Schedule
Construction	2033 to 2037 2083 to 2087	2033 to 2037 2083 to 2087
Operation	2037 to 2042 2087 to 2092	2037 to 2042 2087 to 2092
Monitoring and Maintenance	N/A	1997 to 2097
Decontamination and Decommissioning	2042 to 2047 2092 to 2097	2042 to 2047 2092 to 2097
Loss of Administrative Control	N/A	2097

Notes:
N/A = Not applicable

3.4.3.7 Implementability

The objective of the Long-Term Management alternative would be to provide continued storage of the tank waste. This alternative would not provide remedial action for the tank waste. This alternative would provide for the continuation of current operations and, as such, does not present any process uncertainties. There is some uncertainty in estimating the functional life of the DSTs. Design life of the current DSTs is approximately 50 years. Many tanks are expected to exceed their design life; however, a structural integrity assessment has not been completed to date. One implementability issue that would require additional analysis would be the potential for interim stabilized SSTs to develop leaks. Following interim stabilization, an SST could contain as much as 190,000 L (50,000 gal) of interstitial liquid.

Table 3.4.5 Cost - Long-Term Management Alternative [1]

Cost Component	Totals
Current Operations	$14,300
Research and Development	$100
Capital	$5,930
Operating [2]	$440
Closure	N/A
Total	$20,770
Cost Range (Estimated) [3]	$18,962 - $23,208

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

Extensive additional characterization would be required to address RCRA land disposal requirements if waste was left in place.

This alternative would not comply with Federal and State requirements for storing hazardous waste. When administrative control is assumed to be discontinued after 100 years, the waste left in place would not comply with State and Federal (including DOE Order 5820.2A) requirements for disposal of hazardous, radioactive, or mixed waste (Section 6.2).

3.4.4 In Situ Fill and Cap Alternative

3.4.4.1 Overview

In Situ Fill and Cap Alternative

- Remove and treat liquid
- Fill tanks with gravel (no waste immobilization)
- Cover tanks with Hanford Barriers
- Dispose of all waste onsite

The In Situ Fill and Cap alternative would leave the tank waste in place for disposal. This alternative would involve containing the waste by evaporating excess water from the DST waste using the 242-A Evaporator; filling the tanks with gravel to prevent subsidence; and installing a Hanford Barrier over each tank farm. These actions would slow the migration of contaminants from the waste by removing water from the waste and using the Hanford Barrier to limit the amount of rainwater that would infiltrate through the waste to the water table. The current barrier design is composed of 10 layers of material with a combined thickness of approximately 4.5 m (15 ft) (WHC 1995i). Additional information on the Hanford Barrier is contained in Volume Two, Appendix B. Information used in describing this alternative is from the In Situ and Closure engineering data packages (WHC 1995f, i, and Jacobs 1996).

3.4.4.2 Process Description

The 242-A Evaporator would be used to remove most of the liquid in the DSTs. The tanks would be filled with basalt gravel using commercially available equipment. Gravel filling the tanks would prevent future tank dome collapse and loss of integrity of the Hanford Barrier.

3.4.4.3 Construction

Construction for this alternative would include activities to fill the tanks with gravel: installing gravel handling equipment required to convey the gravel from a stock pile to individual tanks and distribute the gravel evenly into the tank; modifying tank openings to accommodate gravel handling equipment, and constructing four gravel stockpile storage sites.

3.4.4.4 Operations

Operations would take place during a 9-year period between 2000 and 2009. Major activities during operations would include evaporating DST liquid in the 242-A Evaporator to remove as much water from the liquid waste as practical, and filling SSTs and DSTs with gravel.

3.4.4.5 Post Remediation

After all tanks were filled, the equipment used for gravel filling would be decontaminated and decommissioned. The MUSTs (both active and inactive) and ancillary equipment in the tank farms would be filled with grout, and a Hanford Barrier would be constructed over each tank farm. The regulatory aspects of closure are discussed in Section 6.2.

3.4.4.6 Schedule, Sequence, and Cost

The schedule of major activities associated with this alternative is presented in Table 3.4.6. These estimates include the cost necessary to fill each of the tanks with gravel and cover each tank farm with a Hanford Barrier. The estimated cost for this alternative is shown in Table 3.4.7.

Table 3.4.6 Schedule - In Situ Fill and Cap Alternative

Activity	In Situ Fill Schedule	Closure Schedule
Construction	2003 to 2005	2012 to 2029
Operation	2000 to 2009	N/A
Monitoring and Maintenance	2009 to 2029	2029 to 2129
Decontamination and Decommissioning	2009 to 2012	N/A

Notes:
N/A = Not applicable

3.4.4.7 Implementability

The primary issue associated with implementing this alternative would be the possibility of spontaneous or radiolytic decomposition reactions occurring in the tanks following the gravel fill operations. Following gravel filling operations, oxidizing chemicals would be in contact with organics and safely disposing of these waste combinations would require further investigation. The regulatory issues associated with this alternative are discussed in Section 6.2.

Table 3.4.7 Cost - In Situ Fill and Cap Alternative [1]

Cost Component	Totals
Current Operations	$7,469
Research and Development	$0
Capital	$25
Operating [2]	$275
Closure	$116
Total	$7,885
Cost Range (Estimated)[3]	$6,973 - $8,816

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

This alternative would not meet the land disposal requirements of RCRA for hazardous waste. Near-surface disposal of HLW would not meet DOE policy to dispose of readily retrievable HLW in a potential geologic repository (Section 6.2).

3.4.5 In Situ Vitrification Alternative

In Situ Vitrification Alternative

- Remove and treat liquid
- Vitrify waste in place
- Immobilize and dispose of all waste onsite

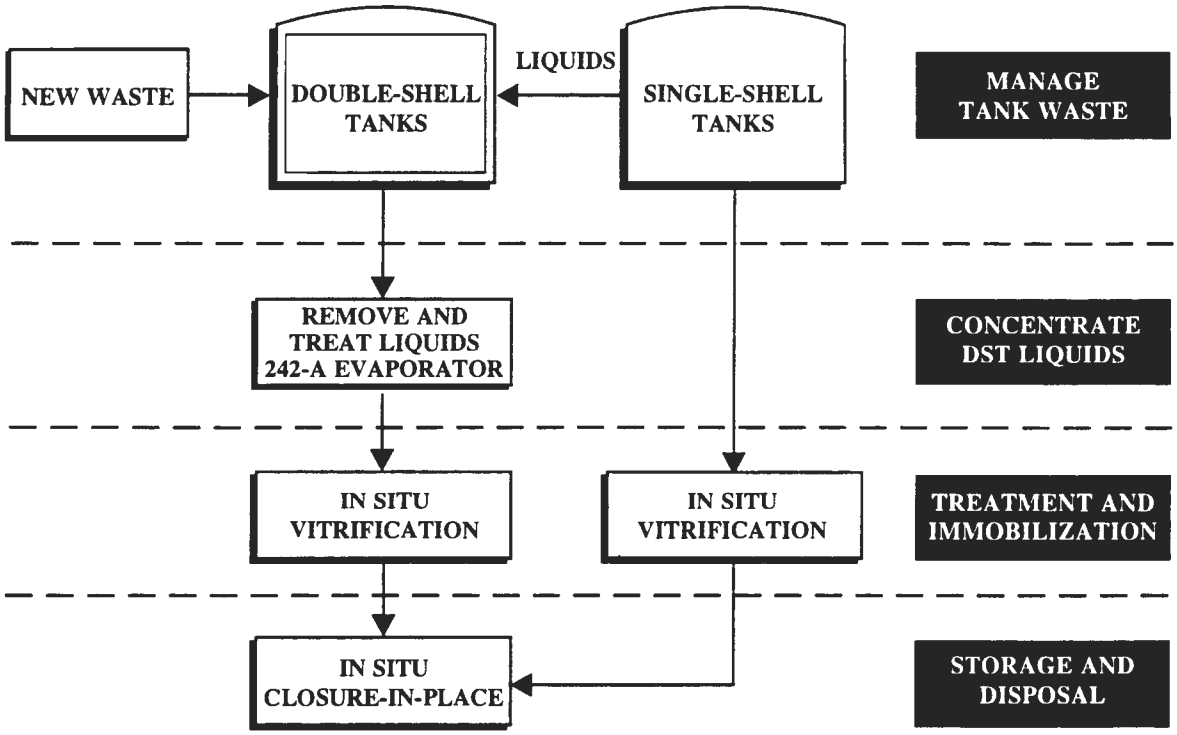
3.4.5.1 Overview

The In Situ Vitrification alternative would immobilize all of the tank waste by vitrifying the tanks and their contents in place (Figure 3.4.3).

This process would require the use of electrical resistance heating, referred to as joule heating, to create a high-temperature region of molten soil and waste that would solidify when cooled into a stable, glass-like form. During this process, various components of the waste either would be incorporated into the glass, destroyed, or vaporized into the off-gas treatment stream. A confinement facility would be constructed over each tank farm or smaller group of tanks to provide containment and collect the off-gases generated during vitrification for subsequent treatment. Each facility would span an entire tank farm or a smaller group of tanks and would be supported around the perimeter. Information and data used throughout this section to describe this alternative are from the Site Management and Operations contractor (WHC 1995f, i) and the TWRS EIS contractor (Jacobs 1996).

Operations for this alternative would involve preparing the tanks for vitrification, operating the vitrification equipment, and treating the off-gases. At least two vitrification systems would be in operation at all times during the operational phase.

Figure 3.4.3 In Situ Vitrification Alternative



Following remediation, the vitrified waste would be left in place for disposal. A Hanford Barrier would be constructed over each of the tank farms to reduce infiltration of precipitation, penetration by plant roots and burrowing animals, and to prevent inadvertent human intrusion.

3.4.5.2 Process Description

In situ vitrification is a thermal treatment process in which electricity would be used to generate a high-temperature region in the range of 1,450 to 1,600 degrees centigrade (°C) (2,600 to 2,900 degrees Fahrenheit [°F]). This would be accomplished by placing electrodes in a pattern at the surface of the soil. After the electrodes were energized and a current path established, the soil surrounding the electrodes would begin to melt. As the process continued, the electrodes would be fed down into the melt and the molten region would spread down and out, melting waste, tank, and soil. The process would be controlled by varying the amount of electricity flowing to the electrodes to maintain the temperature and rate at which the melt progressed. The melt would be continued until an entire tank and its waste contents were vitrified (converted to glass).

As the waste heated to the vitrification temperatures, some of the waste would decompose into gases and be released. The remainder of the waste would be incorporated into the glass that formed during

cooling and solidification of the molten material. The gases generated during the operation would be vented from the top of or from around the molten region and collected for treatment before atmospheric release. A Hanford Barrier then would be constructed over each of the tank farms.

This alternative would involve the following major steps:

- Remove the maximum amount of water practicable from the DST waste by processing through the 242-A Evaporator;
- Construct the Tank Farm Confinement Facilities;
- Isolate the tanks electrically by disconnecting all support systems connections such as piping, instrumentation, and ventilation systems;
- Fill the tanks with sand, which would function as a glass former and eliminate all empty space within the tanks;
- Place electrodes and supply electrical current to melt waste;
- Collect and treat the off-gases;
- Decontaminate and decommission the Tank Farm Confinement Facilities;
- Grout fill MUSTs and ancillary equipment that is not vitrified; and
- Construct Hanford Barriers.

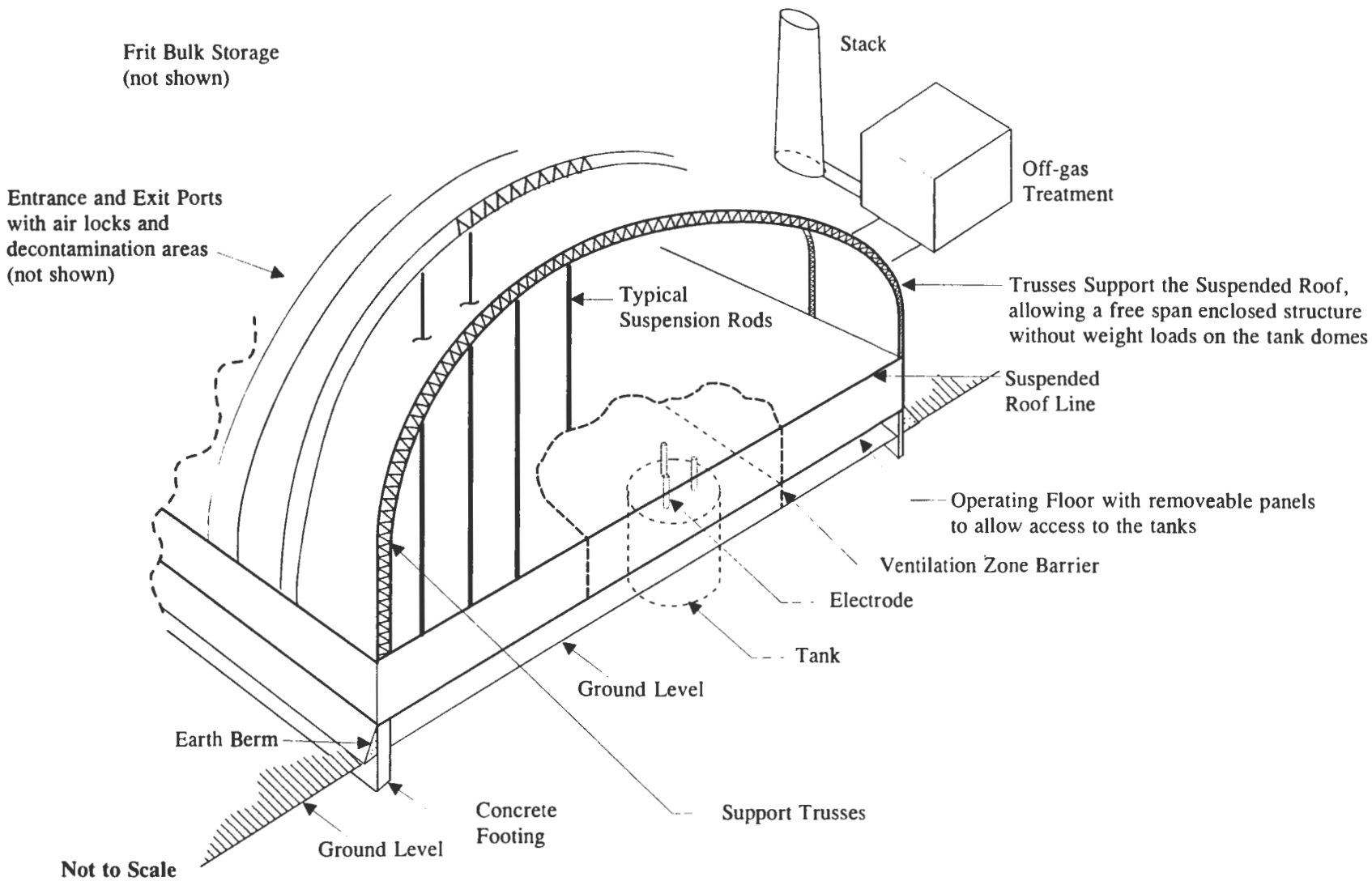
Removing liquid from the DSTs by pumping prior to vitrification would provide a more efficient operation and reduce the amount of vapor in the off-gas system. The liquid would be pumped to the 242-A Evaporator for evaporation. The concentrated waste would be returned to the tanks and the evaporator condensate would be treated at the Effluent Treatment Facility and discharged.

The Tank Farm Confinement Facility would be a free-span structure providing confinement to an entire tank farm. The Tank Farm Confinement Facility would consist of two main components: 1) the truss structure that would sit on a concrete foundation running around the perimeter of the tank farm; and 2) the confinement facility that would be suspended from the trusses. This would allow the entire tank farm to be enclosed without putting additional weight loads on the tank domes. The confinement facility would consist of an operating floor with removable panels to provide access to the tanks. The confinement facility would also provide multi-zone ventilation to collect and treat the off-gases and maintain the operating zones (Figure 3.4.4).

Before beginning the vitrification operation, each tank would be electrically isolated from all support systems. This would include disconnecting and removing piping, instrumentation wiring, and ventilation systems shared with other tanks. This would prevent potential accidents and damage resulting from stray electrical current. Piping and equipment removed to electrically isolate the tanks would be decontaminated as necessary for onsite burial or placed in the tank and vitrified with the waste.

Because the vitrification process would rely on electrical resistance heating to create the melt zone, two important parameters in the process would be the resistance (which would affect melt temperature) and maintaining a continuous electrical path through the material being heated. All of the tanks have a void

Figure 3.4.4 In Situ Vitrification Arrangement and Features



space between the surface of the waste and the dome of the tank. Those tanks with the least volume of waste have the largest void spaces. These void spaces would be filled with Hanford Site sand to act as a filler and a glass former. This would require a total of 540,000 m^3 (714,000 cubic yards [yd^3]) of sand compared to 230,000 m^3 (304,000 yd^3) of waste currently stored in the tanks.

After filling the tanks with sand, the electrodes would be placed at the surface of the existing soil. An estimated 19 electrodes, each approximately 30 cm (12 in.) in diameter, would be used for a standard 23-m (75-ft)-diameter tank. An off-gas hood would be placed over the area to be melted to collect the off-gases for cooling and treatment. A conductive material such as graphite then would be placed between the electrodes to help start the melt. An electrical potential would be applied to the electrodes starting the melt. As the melt progressed down, the individual electrodes would be fed through the off-gas collection system and down into the melt zone.

Each vitrification system would be configured to melt approximately 225 metric tons (mt) (248 tons) per hour consuming 160 MW, which would be required to vitrify the tank waste and the material between the tanks during a 5-year period. This rate of power consumption is about 14 percent of the output from a 1,100-MW power plant (e.g., Washington Public Power Supply System No. 2 Nuclear Power Plant). The electrical power required to vitrify a tank would be approximately 25,000 MW-hours (about 1 day's output from the Washington Public Power Supply System No. 2 Nuclear Power Plant). Four vitrification units would be built with at least two units in continuous operation.

The off-gas system would collect and treat gases from the melt before releasing them to the atmosphere. The off-gases would contain the reaction products resulting from the thermal destruction of the nitrates, nitrites, organic compounds, and some of the more volatile radionuclides contained in the waste. The off-gases would undergo substantial treatment before being released to the atmosphere. Specific control equipment used in the treatment of the off-gases would quench and cool the off-gases, remove radionuclide particulates, and remove nitrogen oxides and sulfur oxides.

Following vitrification operations, each of the Tank Farm Confinement Facilities would be taken down and decontaminated and decommissioned. The MUSTs and ancillary equipment located outside of the vitrified area (limited by the Tank Farm Confinement Facilities) would be filled with grout. Decontamination and decommissioning of a Tank Farm Confinement Facility would require a substantial level of effort because of the amount of surface area that would be contaminated during the vitrification process.

A Hanford Barrier would be constructed over each of the tank farms as well as those MUSTs that fall outside of the tank farm boundaries.

3.4.5.3 Construction

The main construction activity for this alternative would be building 18 Tank Farm Confinement Facilities to cover all of the tanks. The confinement facilities would be constructed in one of five

configurations. The smallest configuration would cover a 2 by 2 tank farm (i.e., a tank farm that is two tanks wide by two tanks deep) and the largest would cover a 4 by 5 tank farm. The smaller Tank Farm Confinement Facility would be used for tank farms with two to four tanks.

Systems that would be constructed for the In Situ Vitrification alternative include the following:

- Tank Farm Confinement Facilities to provide confinement and ventilation control, (18 facilities total);
- Off-gas treatment systems to collect, treat, and filter process off-gases before discharge;
- Handling system to fill tank domes with sand by transporting sand from stock pile and uniformly filling the tank dome spaces;
- Electrical power distribution system to supply high-voltage power to the vitrification system;
- New electrical substation to connect the power distribution system to the existing electrical grid;
- Approximately 8 kilometers (km) (5 miles [mi]) of 115-kilovolt (kV) transmission line; and
- Temporary 115-kV lines from transmission lines to individual tank farms in the 200 Areas.

3.4.5.4 Operation

Operations for this alternative would take place during an 11-year period between 2005 and 2016. This would include 3 years to start up the project, 3 years to shut down the project, and an additional 5 years until the vitrification process would take place. Activities that would take place during the operations phase include the following:

- Remove and treat DST liquid in the 242-A Evaporator (treated slurry would be returned to tank);
- Disconnect and remove piping, instrumentation, and ventilation system connections;
- Fill tank void spaces with sand to provide an uninterrupted electrical path;
- Install electrodes in the electrode feed system that would lower the electrodes into the molten region as it progressed down consuming the tank and waste;
- Vitrify waste by starting the melt and controlling the applied power;
- Operate an off-gas treatment system to collect, treat, and filter process off-gases before discharge; and
- Treat liquid condensed in the off-gas system by evaporating to reduce the volume followed by low-temperature treatment or transporting to the Effluent Treatment Facility;

3.4.5.5 Post Remediation

When in situ vitrification was complete, the vitrified waste and the tank farms would be closed, and all facilities constructed for vitrifying the waste would be decontaminated and decommissioned. Activities that would take place include grout filling tank farm ancillary equipment (e.g., pump pits, diversion

boxes, valve boxes) that would not be vitrified; constructing a Hanford Barrier over each tank farm; and decontaminating and decommissioning Tank Farm Confinement Facilities and equipment.

3.4.5.6 Schedule, Sequence, Cost

The schedule of major activities associated with this alternative is presented in Table 3.4.8. The estimated cost for this alternative is shown in Table 3.4.9.

Table 3.4.8 Schedule - In Situ Vitrification Alternative

Activity	In Situ Vitrification Schedule	Closure Schedule
Research and Development [1]	1997 to 2002	N/A
Construction	1999 to 2016	2016 to 2033
Operation	2005 to 2016	N/A
Monitoring and Maintenance	2016 to 2033	2033 to 2133
Decontamination and Decommissioning	2013 to 2016	N/A

Notes:
[1] Research and development includes resolution of implementability issues.
N/A = Not applicable

Table 3.4.9 Cost - In Situ Vitrification Alternative [1]

Cost Component	Totals
Current Operations	$8,652
Research and Development	$70
Capital	$4,900
Operating [2]	$2,740
Closure	$116
Total	$16,478
Cost Range (Estimated) [3]	$15,933 - $27,434

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

3.4.5.7 Implementability

Implementability of a remedial alternative will be a function of two factors: the history of the demonstrated performance of a technology; and the ability to construct and operate the technology given the existing conditions at the Site. The primary issues applicable to the implementability of the In Situ Vitrification alternative include the following.

- This alternative is more conceptual in design and development than the ex situ alternatives and thus has a higher degree of uncertainty associated with the supporting data.

- In situ vitrification previously has not been performed and may not work on the scale described for this alternative. Substantial research, development, and demonstration activities would be required. Current commercial experience is limited to melting areas 15 m (49 ft) in diameter by 6 m (20 ft) deep, while this alternative assumes an entire tank that is 23 m (75 ft) in diameter by 18 m (60 ft) deep can be vitrified. Concerns with implementing this alternative are not as great for small tanks such as MUSTs or larger tanks with small volumes of waste. Multiple melts using smaller in situ vitrification systems could be used to vitrify larger diameter tanks.
- The established safety envelope for much of the waste as it is stored in the tanks is dependent on the waste being wet. The vitrification process would dry out the waste before it was heated to melting temperatures and thereby raise the temperature of the waste and create the potential for initiating an uncontrolled reaction. This issue would require further analysis.
- The Tank Farm Confinement Facility design is conceptual, and further development would be required for it to comply with current DOE facility design requirements.
- The Tank Farm Confinement Facility could be difficult to construct because of the atypical nature of the design and restrictions associated with working in and around the tank farms. Smaller tank farm confinement facilities in a portable or moveable design could be used to replace the larger tank farm confinement facilities.
- Inspection of the final waste form to confirm that all of the waste is stabilized and the waste form is acceptable for disposal would be difficult to perform. Reprocessing waste that fails to meet disposal criteria would involve remelting sections of the vitrified waste form, which could affect the operating schedule.
- Decontamination and decommissioning of the Tank Farm Confinement facilities would be difficult because of the size of the facilities and the amount of surface area that would be contaminated.

Additional details on the implementability of this alternative are contained in Volume Two, Appendix B. This alternative could meet the RCRA land disposal requirements if hazardous waste is adequately treated during vitrification. Near-surface disposal of HLW would not meet DOE policy to dispose of readily retrievable HLW in a potential geologic repository (Section 6.2).

Ex Situ Intermediate Separations Alternative

- Retrieve maximum amount of waste practicable
- Separate waste into LAW and HLW using sludge washing and ion exchange
- Vitrify waste
- Dispose of LAW onsite in subsurface vaults
- Dispose of HLW offsite at the potential geologic repository

3.4.6 Ex Situ Intermediate Separations Alternative

3.4.6.1 Overview

Under the Ex Situ Intermediate Separations alternative, as much of the tank waste as practicable would be retrieved from each tank. This is assumed to be a minimum of 99 percent of the waste volume in each tank. The recovered waste stream then would be separated into HLW and LAW streams for

vitrification in separate facilities (Figure 3.4.5). Separating the waste streams into HLW and LAW fractions would allow for processing and disposal methods best suited to the waste types and requirements.

The HLW stream would be vitrified and placed in canisters for disposal at the potential geologic repository. The LAW stream would be vitrified and quenched into glass cullet and placed into onsite near-surface vaults for retrievable disposal. Retrievable disposal means that the design of the disposal facility would be for permanent disposal, but the waste could be retrieved from the disposal facility within a certain amount of time (assumed to be approximately 50 years) if a different disposal method was determined to be necessary.

Information used throughout this section is from the Site Management and Operations contractor (WHC 1995 i, j, n) and the TWRS EIS contractor (Jacobs 1996).

Two vitrification facilities, one for HLW and one for LAW, as well as the shared support facilities, would be constructed. The HLW facility would be designed to produce 20 mt (22 tons) of HLW glass per day. The LAW facility would produce 200 mt (220 tons) of LAW glass cullet per day. The facilities are assumed to be located on the representative site in the 200 East Area, as shown in Figure 3.4.6. The vitrification facilities would be designed to treat all of the tank waste during a 21-year operating period.

The following major operations would be implemented to treat waste under this alternative.

- Retrieve the waste.
- Pretreat the waste by sludge washing and enhanced sludge washing followed by separation of the liquid and solids.
- Remove cesium from the liquid waste stream and transfer cesium to the HLW vitrification stream.
- Transfer liquid and dissolved solids to the LAW vitrification facility.
- Transfer solids (as a slurry) to the HLW vitrification facility.
- Vitrify both HLW and LAW.
- Pour the molten HLW into canisters.
- Package the canisters into Hanford Multi-Purpose Canisters for interim storage and shipment.
- Place the vitrified LAW in disposal containers.
- Place the LAW disposal containers in onsite near-surface disposal vaults.
- Ship the HLW canisters to the potential geologic repository.

Following the treatment phase, the processing facilities and storage tanks would be decontaminated and decommissioned. Contaminated materials and equipment from the processing facilities would be disposed of onsite in the low-level waste burial grounds. Noncontaminated materials and equipment from the processing facility would be entombed in place. Closure activities would be performed on the LAW disposal vaults and tank farms.

Figure 3.4.5 Ex Situ Intermediate Separations Alternative

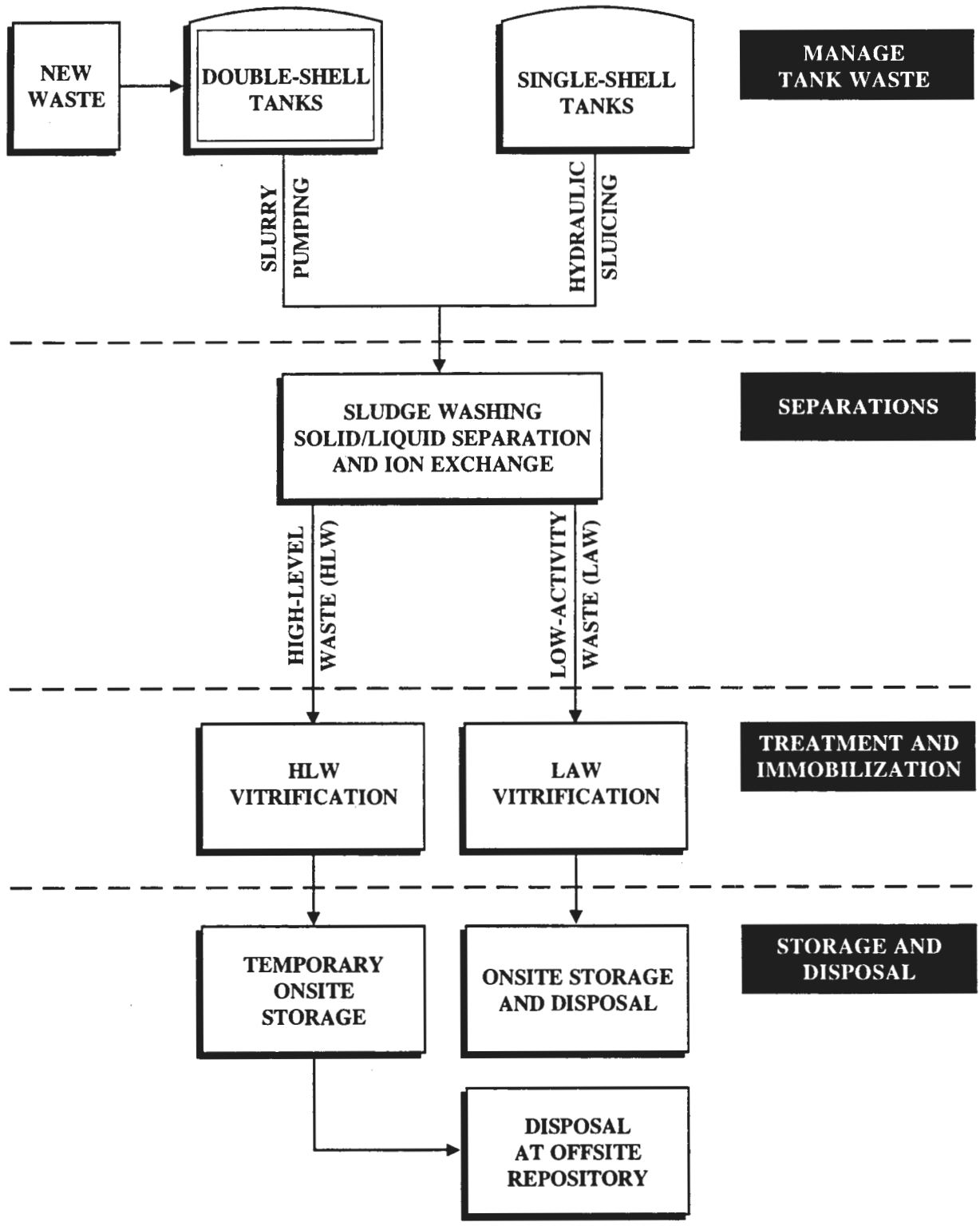


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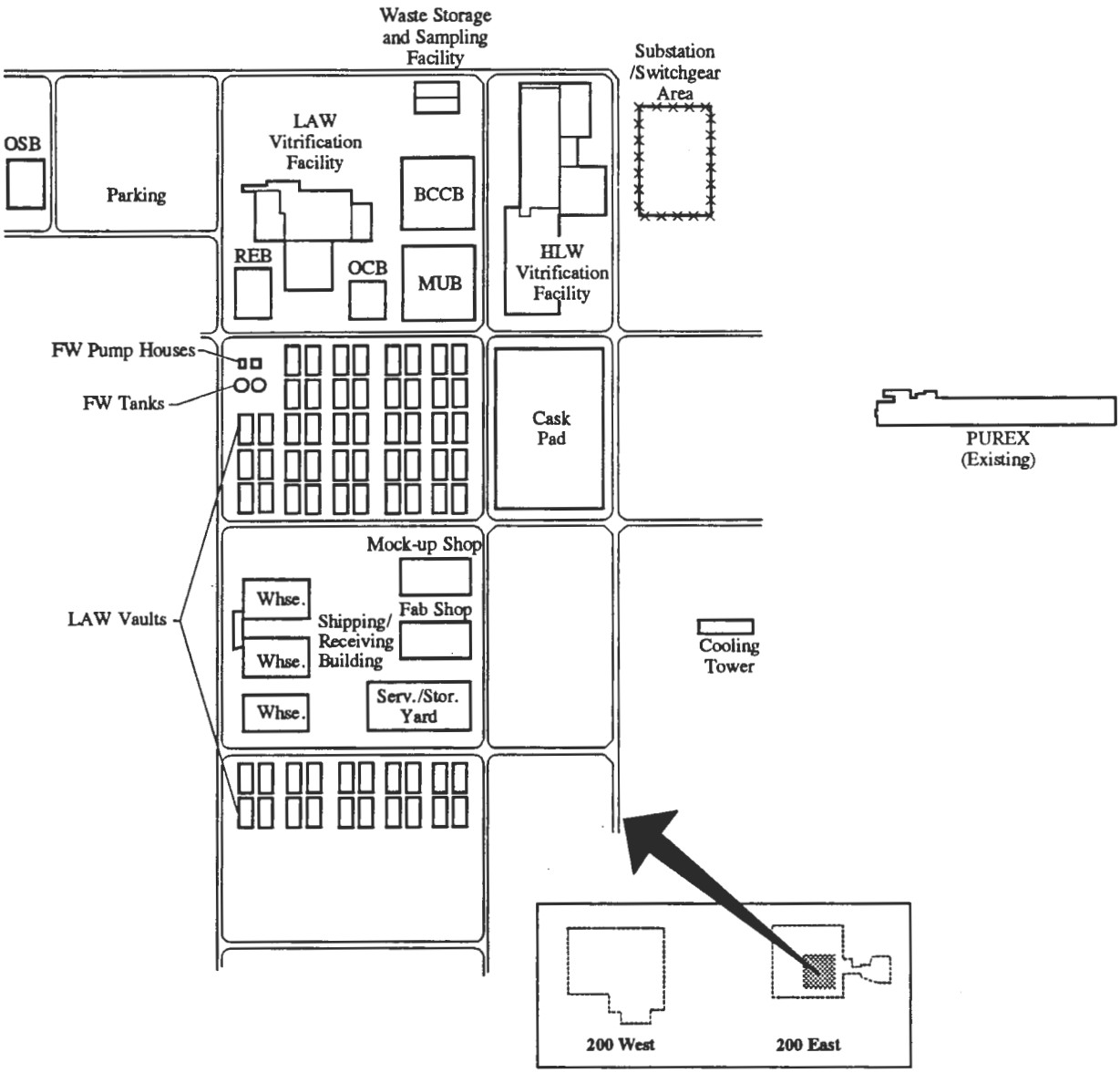
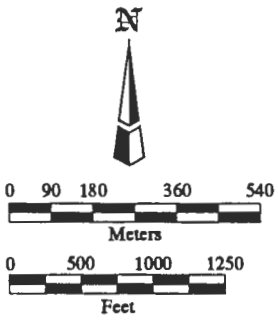
Figure 3.4.6 Ex Situ Intermediate Separations Site Plan



200 East Area LEGEND

BCCB	Bulk Handling & Cold Chemical Make-up Building	OCB	Operations Control Building
Fab	Fabrication	OSB	Operations Support Building
FW	Fire Water	REB	Regulated Entrance Building
HLW	High-Level Waste	Serv./Stor.	Service/Storage
LAW	Low-Activity Waste	Whse.	Warehouse
MUB	Mechanical Utilities Building		



SOURCE: Adapted from WHC 1995j

3.4.6.2 Process Description

The first step in waste processing would be to recover and transfer waste from the storage tanks to the separations facility. The waste recovery function would retrieve and blend waste to provide, as close as possible, an average or blended feed stream that would be batch transferred to the separations facility. The Tri-Party Agreement requires that the retrieval function remove waste to the extent that SST waste residues meet specific volume requirements based on tank type, or that as much waste is removed as technically possible, whichever action results in the least residual volume (Ecology et al. 1994).

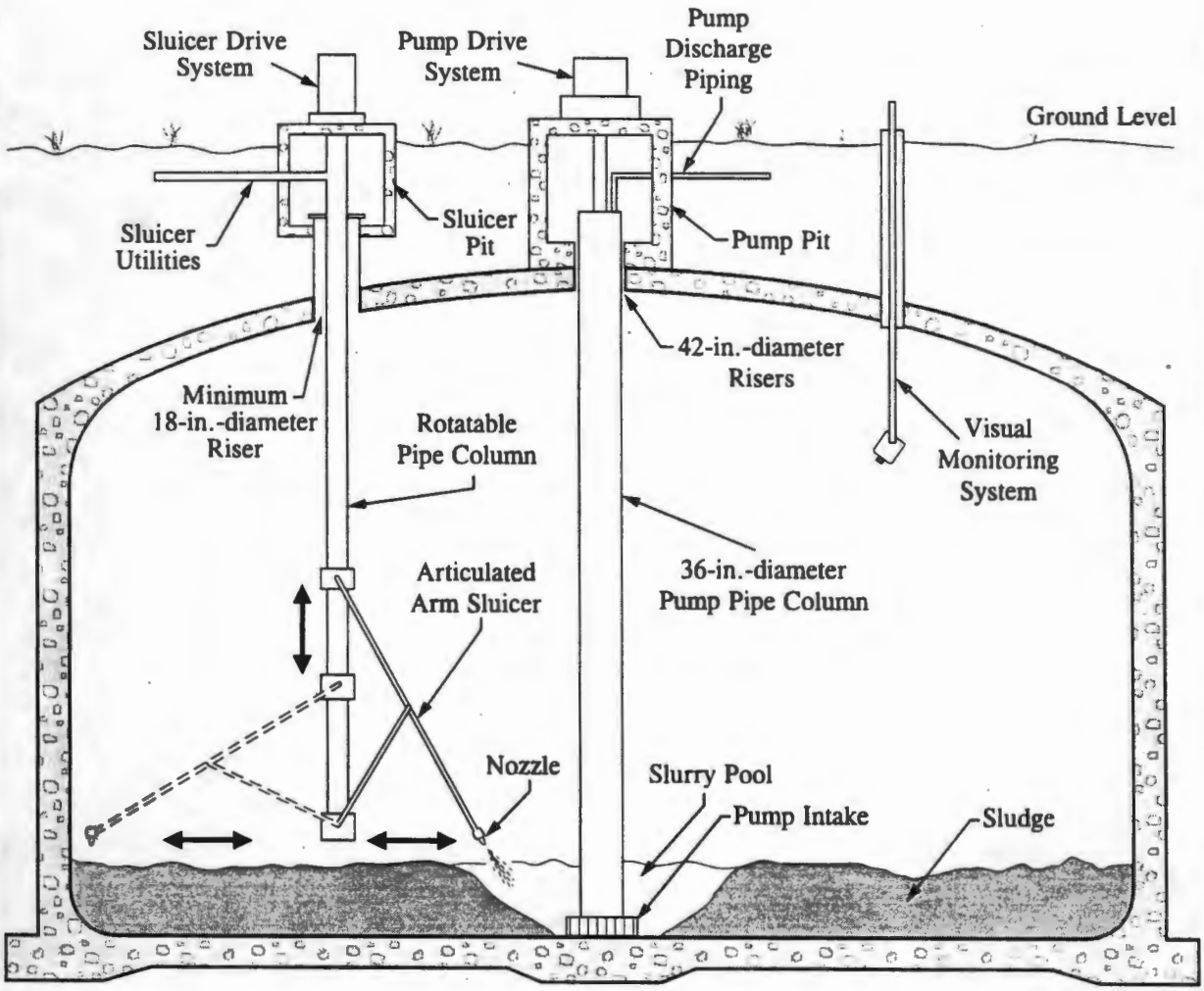
Two methods for removing waste from the SSTs would be hydraulic sluicing and robotic arm-based retrieval systems. Hydraulic sluicing would use pressurized water and recycled tank liquid sprayed from a nozzle to dissolve, dislodge, and suspend the waste into a slurry, which has a thick, soup-like consistency (Figure 3.4.7). The sluicing nozzles would be rotated and angled to direct the slurry to a pump for removal from the tank. Remote cameras installed with the retrieval system would aid in the waste recovery operation. Hydraulic sluicing has been performed in the past to recover tank waste and is assumed to be capable of recovering the majority of SST waste.

For those cases where hydraulic sluicing could not achieve 99 percent recovery, where sluicing would not be deployed because of a known leak, or where sluicing was to be discontinued because of tank leakage, robotic arm-based recovery systems would be used for waste recovery (Figure 3.4.8). Robotic arm-based systems would allow using various engineered components on the end of a long-reach arm to minimize the addition of sluicing water to the tank or to provide remote cut up and removal of in-tank equipment. Recovered equipment, including hardware discarded in the tanks, would be containerized for onsite burial. A confinement structure would be needed over the enlarged tank access required by the arm-based systems.

Slurry pumping would be used for retrieving the waste from the DSTs (Figure 3.4.9) using mixer pumps to break up and suspend solids into a slurry. The current mixer pump design takes liquid from the upper liquid level and discharges it through nozzles approximately 0.6 m (2 ft) above the bottom of the tank. This directs the tank liquid at the solids that have settled in the bottom of the tank. Future DST mixer pumps would function in a similar manner. Future mixer pumps would be designed to accommodate the decreasing waste levels encountered during retrieval. The slurry would then be pumped out of the tank for transfer to the separations facility. Between two and four mixer pumps would be used in each DST. The retrieval for DSTs is assumed to be at least 99 percent.

The waste recovery system would consist of four waste transfer annexes and a waste staging and sampling facility. Each system would circulate sluicing liquid to the tanks as well as receive and accumulate slurry for batch transfer to the central separations facility located in the 200 East Area. The waste in the 200 West Area would be accumulated in the waste staging and sampling facility for cross-site transfer from the 200 West Area to the 200 East Area. A typical piping layout and location of a transfer annex are shown in Figure 3.4.10. The transfer annexes would be centrally located near groups of tank farms to expedite retrieval operations.

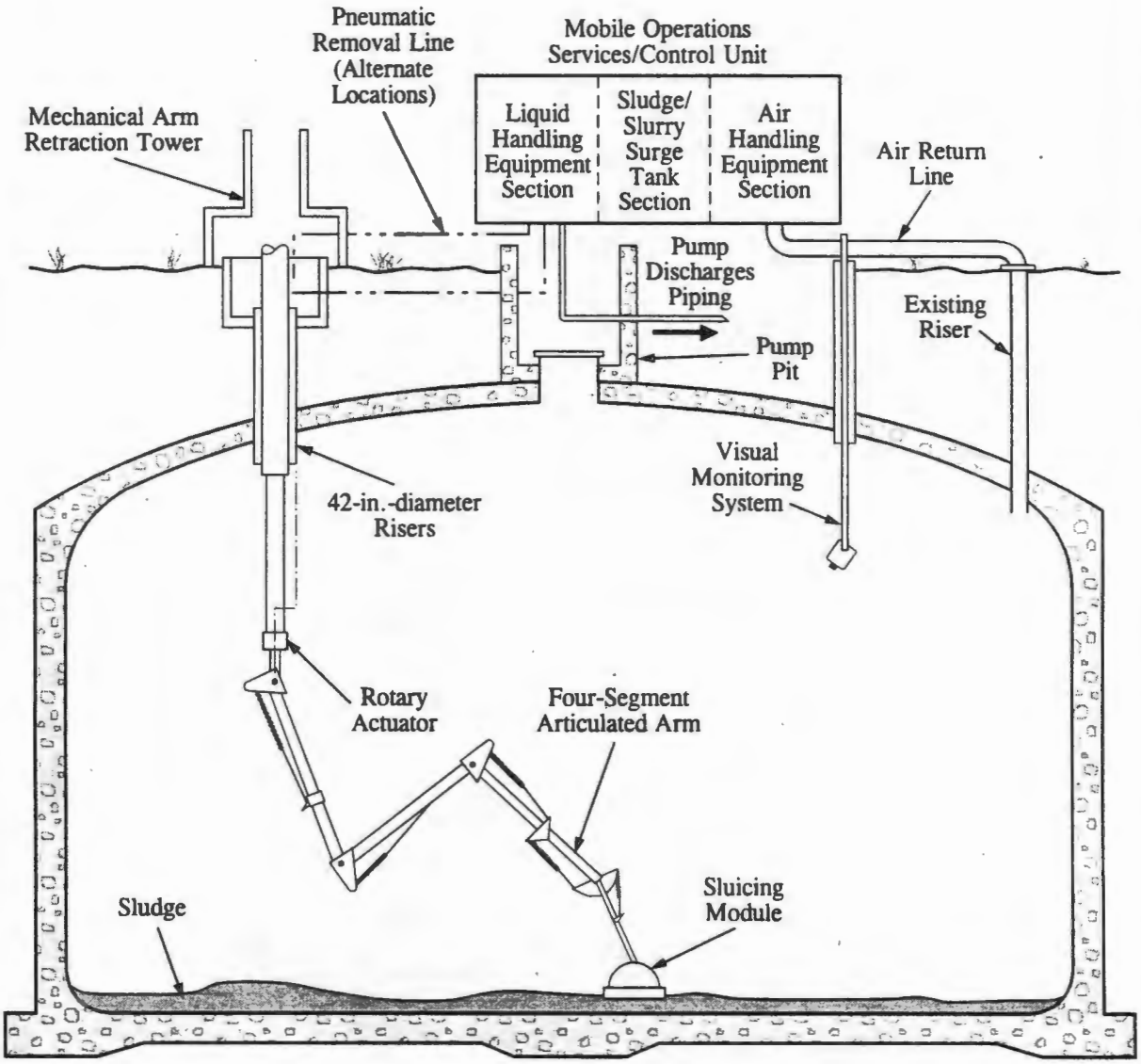
Figure 3.4.7 Sluicing Arrangement for Single-Shell Tank Waste Retrieval



Not to Scale

SOURCE: Adapted from WHC 1995n

Figure 3.4.8 Robotic Arm-Based Arrangement for Single-Shell Tank Waste Retrieval



Not to Scale

SOURCE: Adapted from WHC 1995a

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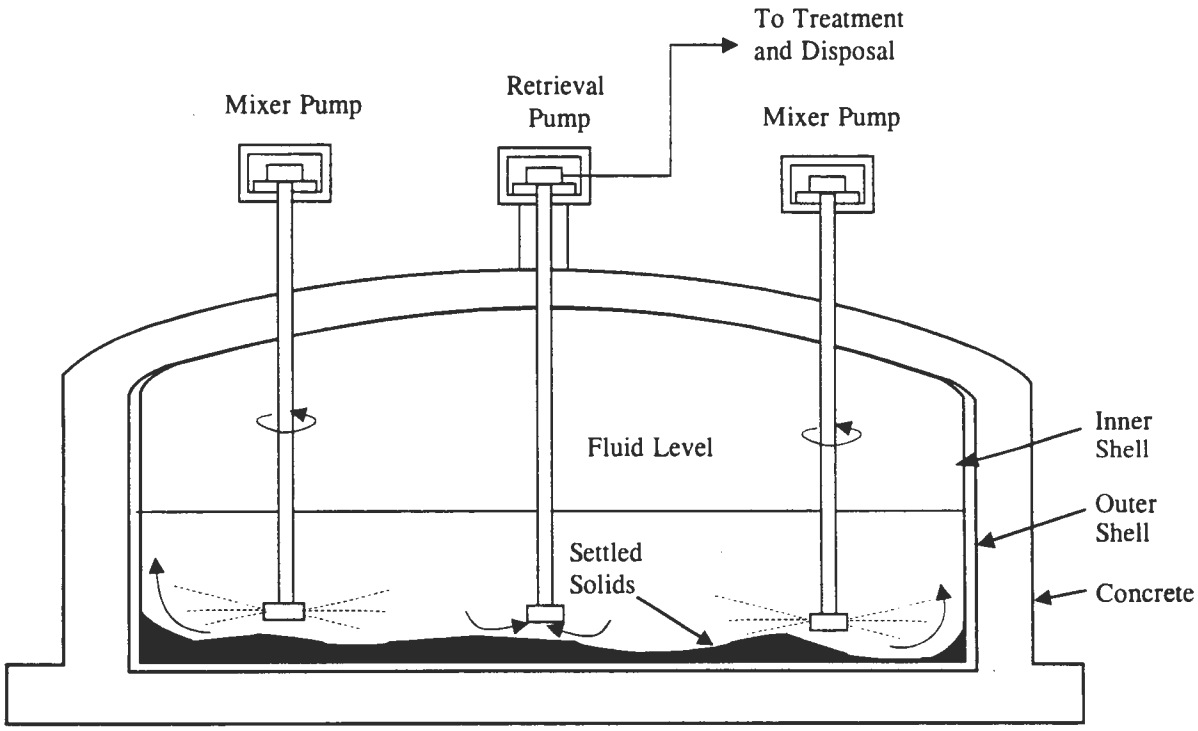
Figure 3.4.9 Double-Shell Tank Mixer Pump Retrieval Arrangement



SOURCE: Adpated from WHC 1995n **Not to Scale**

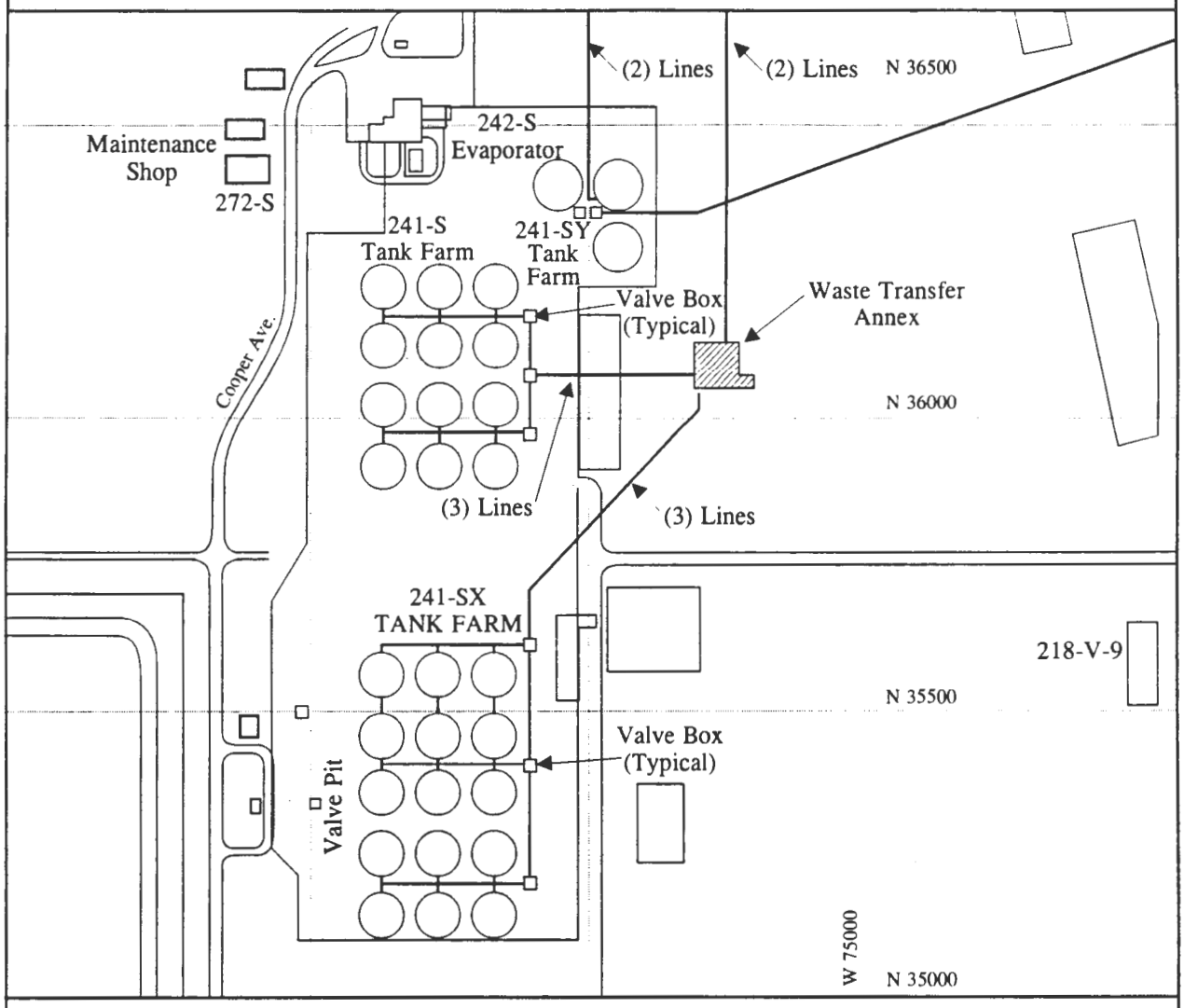
As a part of retrieval, piping would be installed to supply sluicing liquid to each tank and to transfer slurried waste from the tanks to the transfer annex or waste staging and sampling facility. The piping run from the transfer annexes or waste staging and sampling facility to the individual tanks would consist of three lines (i.e., supply, return, and spare). In the 200 West Area, waste transfer lines (one line and a spare) also would be installed to connect the waste transfer annexes to the waste staging and sampling facility. In the 200 East Area, transfer lines would be installed to connect the waste transfer annexes directly to the treatment facility. Waste retrieval and transfer lines all would be double-wall (encased) piping located on the ground inside concrete shielding enclosures. Locating these shielded transfer lines on the ground would facilitate removal following waste retrieval operations.

The waste retrieved in the 200 West Area would be collected in the waste staging and sampling facility, where it would be sent to the replacement cross-site transfer system for transfer to the treatment facilities located in the 200 East Area.

The waste transfer lines planned for the waste retrieval and transfer system would be used in conjunction with other waste transfer systems, such as the replacement cross-site transfer system and the waste transfer system upgrades, to meet the requirements for waste retrieval and transfer.

Waste contained in MUSTs would be retrieved using methods similar to those described for SST and DST waste retrieval. Waste recovered from MUSTs would be transported to the waste transfer system

Figure 3.4.10 Slurry Transfer Piping and Facilities Layout



Not to Scale

SOURCE: Adapted from WHC 1995n

or directly to the treatment facilities in containers or a specialized truck (LR-56[H]) designed for the transport of nuclear waste (see discussion on LR-56[H] truck in Volume Two, Appendix B).

The next step in the process would be to separate the waste into LAW and HLW streams. The purpose of separations would be to split the waste volume into a small-volume HLW fraction and a larger-volume fraction that would be classified as LAW (Figure 3.4.11). This would reduce the volume of HLW requiring costly disposal at the potential geologic repository. The other goal of separations would be to limit the generation of additional waste during the separations processes.

The separations process would begin with a sludge wash followed by an enhanced sludge wash to remove the soluble components of the waste stream. The washing of solids and liquid-solid separation could be performed out-of-tank in a processing facility or in tank. For this alternative, sludge washing in the DSTs has been included as a representative process for analysis in the EIS. Future evaluation could result in the selection of other methods or combinations of methods, such as cross-flow filters or centrifuges. Most HLW constituents, which are made up of long-life and high-activity isotopes, are found as solid waste in the tanks and are intermixed with other nonradioactive solid waste. Washing the waste would involve adding water or sodium hydroxide solutions to dissolve a portion of the LAW solids and then separating the liquid and solids.

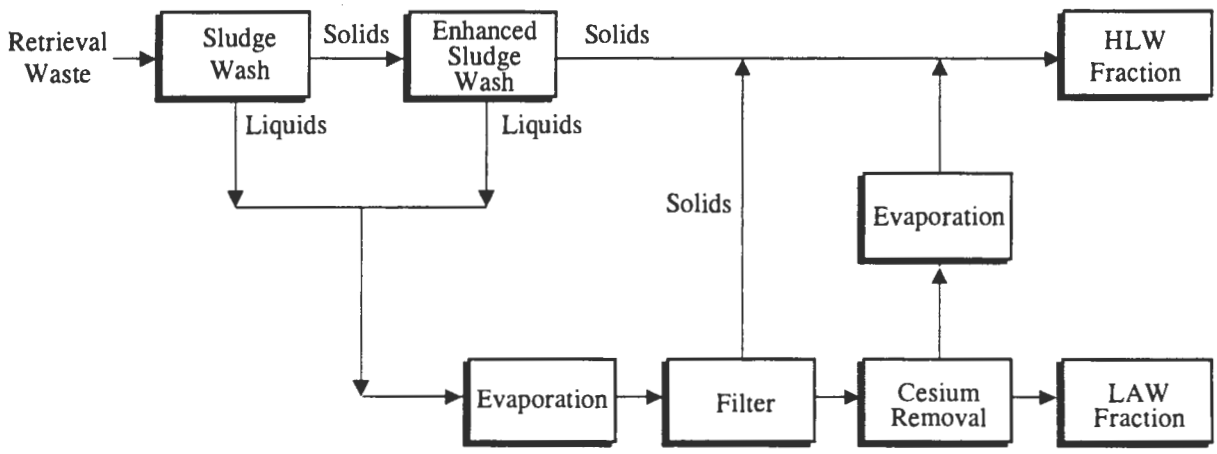
For SSTs, the dissolution of the waste would begin during retrieval when the waste is sluiced out of the SSTs and transferred. The second phase would take place in DSTs and the enhanced wash would dissolve some of the nonradioactive elements present in the solid waste and further reduce the volume of HLW. The third phase of separations would take place in the separations facility, which would be attached to the LAW vitrification facility. The third phase in the separations process would be to remove the cesium present in the liquid stream by ion exchange and feed it into the HLW stream. Cesium-137 is a high-activity isotope that is highly soluble and removing it from the liquid stream would allow the final LAW waste form to meet the assumed onsite LAW disposal criteria. Other radioisotopes, such as technetium, could also be removed during separations.

On receiving the waste from the separations operations, the waste would be sent to lag storage tanks within the vitrification facilities where it would be characterized before entering the melter feed section in either the HLW or LAW facility. In this area, the waste would be sampled, evaporated to remove excess water, and provided as a concentrated liquid or slurry feed stream to the melter.

The LAW vitrification facility and its support facilities would be designed to produce 200 mt (220 tons) of vitrified glass per day. This capacity would be provided by two melters operating in parallel, each making 100 mt (110 tons) of glass per day.

The glass product produced by each melter would be a combination of two separate material feed streams, the waste stream, and the glass formers. The energy source providing the heat to the melter would be separate kerosene and oxygen streams supplied directly to the melter. Fuel-fired melters have been included as a representative configuration for analysis in the EIS. Future evaluation may

Figure 3.4.11 Ex Situ Intermediate Separations HLW/LAW Separations Process Flow Diagram



result in selection of another melter configuration. To make suitable glass with acceptable properties for waste immobilization, it has been determined that the LAW glass produced by this alternative would be limited to 15 weight percent sodium oxide in the glass. This means that glass formers would be added to the melter feed to maintain the required sodium oxide loading. Glass formers, primarily silica or sand and boron oxide, are similar to the components used to make commercial glass.

The molten glass produced in the melter would flow into a water bath tank and be quenched into gravel-sized pieces of glass (referred to as cullet) and placed into containers approximately 1.8 m long by 1.2 m wide by 1.2 m high (6 ft long by 4 ft wide by 4 ft high) for onsite disposal. The engineering data supporting this alternative molten were based on a process that would blend the LAW glass cullet with a matrix material that would surround the glass cullet when placed into the disposal container. Disposing of LAW as glass cullet encapsulated by a matrix material has been included as a bounding condition for transportation and resource analysis in the EIS. Future evaluation of matrix materials and disposal forms may result in selecting other glass forms or eliminating the requirements for matrix materials. The potential benefits of a matrix material and glass cullet combination as a disposal waste form are reduced contaminant release rates and migration rates out of the disposal system. Additional details on matrix materials for LAW glass cullet are presented in Volume Two, Appendix B.

The HLW vitrification facility would be designed to produce 20 mt (22 tons) of HLW glass per day. This would be accomplished by using one electrically heated (joule-heated) melter making vitrified glass at 20 weight percent waste oxide. Following vitrification, the molten glass would be poured directly into a stainless-steel canister. The canisters then would be welded closed, the outside surfaces decontaminated, and the canisters placed into Hanford Multi-Purpose Canisters and transported to

onsite storage pads for interim storage. Concrete shielding casks would be placed over the Hanford Multi-Purpose Canisters during interim storage.

Vitrifying waste would generate a large off-gas stream (gaseous air stream containing combustion gases) the would require mitigation measures to minimize air emissions. The off-gas treatment equipment would capture and partially recycle contaminants in the off-gas stream back into the melter feed stream.

3.4.6.3 Construction

New facilities that would be constructed for this alternative would include a HLW vitrification facility, a combined separations and LAW vitrification facility, a LAW disposal facility, an interim HLW storage facility, and multiple support facilities. When completed, the facilities would be in place to remove the waste from the tanks and provide the processing required to produce vitrified HLW for disposal at the potential geologic repository and vitrified LAW for disposal in onsite retrievable disposal vaults. Vitrification support facilities would support functions such as waste retrieval and transfer, utilities, raw material, storage and supply, and operations control. Several facilities and systems would be constructed for the Ex Situ Intermediate Separations alternative.

A retrieval and transfer system would be constructed to provide the facilities and systems to retrieve, blend, and transfer waste to the separations facility, which would include the following:

- Waste transfer annexes that would support sluicing and slurry transfer (two in the 200 East Area and two in the 200 West Area);
- Waste staging and sampling facility in the 200 West Area that would collect and blend batches of waste for cross-site transfer to the separations facility in the 200 East Area;
- 24 SST sluicing systems;
- 12 SST arm-based systems with confinement structures (includes modification to tank risers);
- Mixer pumps in DSTs (two to four mixer pumps per tank); and
- MUSTs retrieval and transfer system (retrieval similar to SSTs except that transfer would be by truck or container).

Support facilities would be constructed to provide utilities, resources, and personnel support to the vitrification facility, which would include the following:

- Mechanical utilities building (shared utilities);
- Cooling tower that would provide process water cooling;
- Cold chemical facilities that would provide bulk process chemical storage and chemical makeup;
- Warehouses and other support facilities;
- Operations control and operations support buildings that would provide administrative offices and centralized control rooms; and
- Electrical substation and 2.5 km (1.6 mi) of high-voltage electrical line.

A separation and LAW vitrification facility would be constructed that would separate the waste into HLW and LAW fractions and vitrify the LAW, which would include the following:

- Sludge-washing systems (the first step in the HLW and LAW separation process);
- Waste storage and sampling facility used for waste receipt and lag storage;
- Cesium ion-exchange system that would remove cesium from the liquid stream sent to the LAW vitrification facility;
- Melter feed system that would support the vitrification melter and include an evaporator, waste feed system, glass former handling systems, and fuel and oxygen supply systems;
- Two 100-mt/day (110-ton/day) combustion LAW melters;
- Cullet quench and handling system that would cool and fracture the molten glass into uniform-sized pieces and place them into containers;
- Cullet transport system that would transfer the containers of LAW cullet to the disposal vaults;
- Off-gas system that would collect, treat, and filter process off-gases before discharge; and
- Recycle systems that would recycle contaminants captured in the off-gas system and undersized cullet from the cullet handling system back into the melter feed system.

A LAW disposal facility would be constructed that would provide retrievable disposal of the LAW. This facility would consist of LAW vaults (66 vaults) constructed belowgrade, each with a capacity to hold 5,300 m^3 (7,000 yd^3) of LAW. These vaults would be constructed throughout operational period.

A HLW vitrification facility would be constructed that would include the systems to support the HLW vitrification melter including centrifuges, an evaporator, glass former handling systems, a waste feed system, and an electrical power supply. This HLW vitrification system would include one 20-mt/day (22-ton/day) joule-heated HLW melter; an off-gas system that would collect, treat, and filter process off-gases before being discharged; a canister handling system that would remotely fill canisters with molten glass, weld on a lid, and decontaminate the outer surface of the canister; and recycle streams that would recycle contaminants captured in the off-gas system back into the melter feed system.
A HLW interim storage facility also would be constructed that would consist of concrete storage pads for interim storage of the Hanford Multi-Purpose Canisters.

Hanford Barriers would be constructed for LAW retrievable disposal facility and tank farms. Hanford Barrier construction would occur after completion of LAW vitrification, and barrier construction at the tank farms would take place after waste removal and tank stabilization.

3.4.6.4 Operation

Operations for this alternative would take place in a 21-year period between 2001 and 2022. These dates would comply with the schedule for tank waste treatment in the Tri-Party Agreement. Several activities would take place during the operations period. Waste retrieval would involve the following:

- Sluice 110 SSTs. Sluicing is the preferred waste retrieval method and would be employed in as many tanks as possible where there would not be a high potential for leakage or an expected difficulty in waste recovery (engineering estimates were used to identify the number of SSTs that could be sluiced);
- Robotic arm-based retrieval from 50 SSTs. This recovery method would be employed only for tanks with high leakage potential or difficult waste (11 SSTs would assumed to be subject to both types of retrieval); and
- Slurry pump DST waste supplemented by sluicing or robotic arm-based retrieval if required.

Retrieval and confinement systems would be moved from tank to tank after completing waste retrieval from a tank. The SST sluicing systems would be moved 4 to 5 times during the 21-year operations time period and SST arm-based systems and confinement structures would be moved 4 times.

Waste would be separated to create separate HLW and LAW streams. This would involve sludge washing and enhanced washing with sodium hydroxide; solid/liquid separations evaporating the liquid stream to concentrate waste; and removing cesium from the LAW feed using ion exchange.
The separated cesium-containing liquid stream that would come out of the ion-exchange process would be further evaporated and fed into the HLW stream. Waste would be transferred to the separation facility from the waste staging and sampling facility in the 200 West Area or from the transfer annexes in the 200 East Area.

The LAW vitrification facility would be operated to accomplish the following:

- Receive and sample waste;
- Evaporate water from waste and collect evaporator condensate for treatment or reuse for waste retrieval;
- Operate two combustion melters. Fuel-fired melters have been included as a representative process detail for analysis in the EIS. Future evaluation may result in the selection of another melter configuration;
- Quench molten glass to make cullet;
- Size and dry cullet to uniform size for handling; recycle undersize cullet back to melter; and
- Place cullet into disposal containers.

The LAW containers with vitrified cullet would be transported to nearby LAW retrievable disposal vaults.

The HLW vitrification facility would be operated to accomplish the following:

- Receive and sample waste;
- Separate solids and liquid with a centrifuge;
- Evaporate excess water from liquid waste and collect condensate for treatment;
- Operate one joule-heated melter with a capacity of 20 mt/day (22 ton/day);

- Form glass at approximately 20 weight percent waste oxides;
- Pour glass monoliths in 1.17-m^3 (41-ft^3) canisters; and
- Package glass into Hanford Multi-Purpose Canisters, four glass monoliths per canister.

The off-gas treatment system at both HLW and LAW vitrification facilities would be operated to quench and cool off-gas; remove radionuclides and recycle to vitrification process; and destroy nitrogen oxides and recover sulfur from sulfur dioxides.

Liquid effluent from both HLW and LAW vitrification facilities would be treated by transferring liquid effluent to the Effluent Treatment Facility. The liquid effluent would be similar to the 242-A Evaporator condensate liquid that meets current waste acceptance criteria for the Effluent Treatment Facility.

The Hanford Multi-Purpose Canisters containing HLW would be transported to onsite interim storage pads and covered with a shielding casks for long-term storage. The stored canisters would be monitored and maintained through routine surveillance of the 12,200 HLW canisters (3,050 Hanford Multi-Purpose Canisters) pending offsite disposal, and the Hanford Multi-Purpose Canisters would be transported by rail to the potential geologic repository.

3.4.6.5 Post Remediation

To provide a basis for comparison in this EIS, it was assumed that each ex situ alternative would involve the same post-remediation activities. Following remediation, processing facilities would be decontaminated and decommissioned, SSTs and DSTs and ancillary facilities would be filled, and tank farms and LAW disposal vaults would be capped with a Hanford Barrier. Post-remediation activities are discussed in detail in Volume Two, Appendix B. Regulatory compliance aspects of closure are discussed in Section 6.2.

Post-remediation activities would include closing tank farms and decontaminating and decommissioning facilities. Closing tank farms would involve ensuring that the tanks would contain a residual equal to no more than 1 percent of the initial tank inventory and would be stabilized by gravel filling; tank farm structures, such as MUSTs, pump pits, valve boxes, and diversion boxes would be stabilized with grout; and Hanford Barriers would be placed over SSTs, DSTs, and LAW disposal vaults. Facility decontaminating and decommissioning would involve disposing of noncontaminated facilities onsite (entombed in place) and contaminated material and equipment at an onsite low-level waste burial ground.

3.4.6.6 Schedule, Sequence, Cost

A schedule of the major components of the Ex Situ Intermediate Separations alternative is shown in Table 3.4.10. Construction for waste retrieval and transfer would involve installing pipelines between the tanks and the transfer facilities throughout the retrieval period, which explains the difference in the construction periods shown. The cost estimate summary for the Ex Situ Intermediate Separations alternative is shown in Table 3.4.11.

Table 3.4.10 Schedule - Ex Situ Intermediate Separations Alternative

Activity	Waste Retrieval and Transfer Schedule	Ex Situ Intermediate Separations Schedule	Closure Schedule
Research and Development	Ongoing to 2003	1997 to 2018	N/A
Construction	1998 to 2017	1999 to 2009	2010 to 2034
Operating	2001 to 2022	2004 to 2022	N/A
Decontamination and Decommissioning	2013 to 2025	2021 to 2031	N/A
Monitoring and Maintenance	N/A	2022 to 2040	2034 to 2134
HLW Disposal	N/A	2022 to 2040	N/A

Notes:
N/A = Not applicable

Table 3.4.11 Cost - Ex Situ Intermediate Separations Alternative [1]

Cost Component	Totals
Current Operations	$8,600
Research and Development	$820
Capital	$5,880
Operating [2]	$9,368
Closure	$169
Total Treatment Cost	$24,837
Treatment Cost Range (Estimated) [3]	$23,887 - $29,950

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

3.4.6.7 Implementability

Some of the technologies involved in this alternative would be first-of-a-kind and thus do not have a performance history. Performance histories would provide increased confidence in the feasibility of the technology and cost estimates. Other issues associated with implementing this alternative include the following.

- The waste loading and canister size criteria have not been finalized, and future negotiations could result in different canister sizes and waste loadings. Waste loading in the glass would directly affect the volume of HLW and number of waste packages for disposal.
- The proposed LAW form is unique and has not been used before.
- Performance of key processes (e.g., solid/liquid separation) has been assumed in the absence of substantive data.
- Cost estimates may have a high degree of uncertainty because some of the processes are first-of-a-kind.

- Retrieval criteria based on recovering 99 percent of the waste volume in each tank are uncertain in that hardened sludge present in some tanks may be difficult to retrieve to the extent required to meet the retrieval criteria.
- The disposal criteria for LAW have not been determined. When these criteria are decided on, additional separations steps could be required to meet LAW disposal criteria.
- A performance assessment has not been completed defining the LAW form requirements for storage and disposal at the Hanford Site, and DOE and the Nuclear Regulatory Comission have not yet completed negotiations on what constitutes "incidental waste" for disposal of LAW at the Hanford Site. Additional separations steps therefore may be required to meet LAW disposal criteria.

The design of the HLW vitrification facility would be similar to the vitrification facility built at the DOE Savannah River Site. Following startup of the Savannah River facility, performance data would be available for application to this implementability analysis and enhancement of the alternative design. Other key technology development or demonstration activities identified for the TWRS program include the following:

- Tank retrieval systems design and testing;
- Sludge washing evaluation;
- Solid/liquid separation;
- Cesium ion-exchange evaluation;
- HLW melter testing and evaluation; and
- LAW melter testing and evaluation.

This alternative would meet all applicable regulations for disposal of hazardous, radioactive, or mixed waste assuming that the hazardous waste components are adequately treated during waste processing or vitrification.

3.4.7 Ex Situ No Separations Alternative

3.4.7.1 Overview

Under the Ex Situ No Separations alternative, as much of the tank waste as practicable would be recovered from each tank. This is assumed to be 99 percent of the waste volume in each tank. The recovered waste stream then would be vitrified or calcined and placed into containers for disposal at the potential geologic repository. All of the waste would be HLW and there would be no onsite LAW disposal of tank waste associated with this alternative.

Ex Situ No Separations (Vitrification or Calcination) Alternative

- Retrieve maximum amount of waste practicable
- Vitrify or calcine waste
- Dispose of all waste offsite at the potential geologic repository

Information and data used in describing the Ex Situ No Separations (Vitrification) alternative are from the Site Management and Operations contractor (WHC 1995c, i, n) and the TWRS EIS contractor (Jacobs 1996). Information and data used in describing the Ex Situ No Separations (Calcination) alternative are from the Site Management and Operations contractor (WHC 1995c) and the TWRS EIS contractor (Jacobs 1996).

One processing facility, as well as the support facilities, would be constructed. The HLW vitrification facility would be designed to produce 200 mt (220 tons) of HLW glass per day. The HLW calcination facility would produce 92 mt (100 tons) of HLW calcined briquettes per day. The calcination process would produce about 70 percent less HLW for disposal to the potential geologic repository than the vitrification process. The facilities are assumed to be located on the representative site in the 200 East Area similar to those shown for Ex Situ Intermediate Separations alternative (Figure 3.4.6). The following major operations are associated with waste treatment under this alternative:

- Retrieve waste;
- Vitrify or calcine the HLW;
- Place vitrified or calcined HLW in canisters;
- Place the canisters into Hanford Multi-Purpose Canisters for interim storage and shipment; and
- Ship the Hanford Multi-Purpose Canisters by rail to the potential geologic repository.

Following the treatment phase, the processing facilities and storage tanks would be decontaminated and decommissioned. Contaminated materials and equipment from the processing facilities would be disposed of onsite in the low-level waste burial grounds. Noncontaminated materials and equipment from the processing facility would be entombed in place. Closure activities, including filling the tanks and constructing Hanford Barriers, would be performed at the tank farms.

3.4.7.2 Process Description

The first step in waste processing would be to recover and transfer the waste from the storage tanks to the treatment facility. The waste recovery function would retrieve and blend waste to provide, as close as possible, an average or blended feed stream that would be transferred to the vitrification or calcination facility. A recovery rate of a minimum of 99 percent of the tank contents is a requirement for the retrieval function. The waste retrieval and transfer process for the Ex Situ No Separations alternative would be identical (without radioisotopic separation) to the process for the Ex Situ Intermediate Separations alternative (Section 3.4.6.2).

The waste received from the retrieval operations would be sampled, evaporated to remove excess water, and provided as a slurry feed stream to the melter or calciner in the HLW facility.

Vitrification Process

The HLW vitrification facility and its support facilities would be designed to produce 200 mt (220 tons) of vitrified glass per day. This capacity would be provided by two melters operating in parallel, each making 100 mt (110 tons) of glass per day.

The glass product produced by each melter would be a combination of two separate material feed streams, the waste stream and the glass formers. The energy source providing the heat to the melter would be separate kerosene and oxygen streams supplied directly to the melter. Fuel-fired melters have been included as a representative configuration for analysis in the EIS. Future evaluation could result in selection of another melter configuration. To make suitable glass with acceptable properties for waste immobilization, the HLW glass produced by this alternative would be limited to 20 weight percent sodium oxide in the glass. The glass formers, primarily silica or sand and calcium oxide, would be added to make a soda-lime glass and maintain the required sodium oxide loading.

The molten glass produced in the melter would flow into a water bath quench tank producing gravel-like glass cullet. The cullet would be screened for proper size, loaded into 10-m^3 (360-ft^3) stainless-steel canisters, and then placed into Hanford Multi-Purpose Canisters for interim storage and transport to the potential geologic repository.

Vitrifying waste would generate a large off-gas stream requiring mitigation measures to minimize air emissions. Treatment equipment would capture and recycle contaminants from the off-gas systems back into the melter feed stream.

Calcination Process

Calcination would heat precipitates or residues to a temperature high enough to break down chemical compounds such as hydroxides or nitrates. It differs from vitrification in that calcination temperatures would not necessarily cause the reacting materials to melt and form a glass. The final form of the calcined waste would be a dry powder material that would be hot processed in a roll-type compactor machine to produce small pellets or briquettes of high bulk density that would be loaded into 10-m^3 (360-ft^3) canisters, seal welded, and then placed into Hanford Multi-Purpose Canisters for interim storage and transport to the potential geologic repository.

The HLW calcination facility and its support facilities would be designed to produce 92 mt (100 tons) of calcined waste per day. This capacity would be provided by two spray calciners operating in parallel, each making 46 mt (50 tons) of calcined waste product per day. The same quantity of tank waste would be fed to the calciners as fed to the glass melters each day.

The prepared waste feed stream would be blended with sugar and pumped to the feed nozzles of a spray calciner, which would be externally heated by fuel-fired burners. The sugar supplied to the feed would act as a reducing agent to decompose the nitrate and nitrite in the waste to nitrogen oxides, carbon oxides, and water vapor. The atomized waste droplets would be dried through evaporation, and the remaining solids would react to release the gaseous decomposition products. The solid particles then would be collected in a tank and held at a temperature to allow further reaction. The product would be discharged to a roll-type compactor machine to produce small briquettes. The waste briquettes would be screened to remove the fines, if any, and then would be transported to the HLW cyclone bin by an air-cooled conveyor. The calcined product next would be transferred to a canister filling operation, where it would be placed in 10-m^3 (360-ft^3) canisters, identical to the canisters

described for the Vitrification Process. The canisters would be welded shut, decontaminated, and placed in Hanford Multi-Purpose Canisters for interim storage and subsequent transport to the potential geologic repository.

Calcining waste would generate a large off-gas stream that would require mitigation measures to minimize air emissions. Treatment equipment would capture and recycle contaminants from the off-gas stream back into the calciner feed stream, if required. The calcined fines from the dust collection screen and hot gas filtering would be returned to the waste product tank as feed to the roll-type compactor machine.

3.4.7.3 Construction

New facilities that would be constructed for this alternative would include a HLW processing facility and multiple support facilities. A retrieval and transfer system identical to the system described for the Ex Situ Intermediate Separations alternatives (Section 3.4.6) would be constructed. When completed, the facilities would be in place to remove the waste from the tanks and provide the processing required to produce vitrified or calcined HLW. Support facilities similar to those described for the Ex Situ Intermediate Separations alternative (Section 3.4.6) would be constructed. Support facilities would supply waste retrieval and transfer, utilities, raw material, and operations control to the HLW processing facility.

A HLW processing facility would be constructed to include the systems to support the HLW vitrification melter including an evaporator, glass former handling system, and fuel and oxygen supply system. This HLW processing facility would include two combustion melters operating in parallel; a treated waste handling system that would remotely place the vitrified waste into canisters; and an off-gas system that would collect, treat, and filter process off-gases before being discharged.

A HLW processing facility would be constructed to include the systems to support the HLW calciner, including an evaporator, sugar addition system (dry bulk), fuel, oxygen, and hot gas filter system. This HLW processing facility would include two radiant heat spray calciners operating in parallel; a treated waste handling system that would remotely place the calcined waste into canisters; a roll-type compactor to densify the calcined product into briquettes; and an off-gas system that would collect, treat, and filter process off-gases before being discharged.

A HLW interim storage facility would be constructed consisting of concrete storage pads for interim HLW canister storage. In addition, Hanford Barriers for the tank farms would be installed after waste removal and tank stabilization.

3.4.7.4 Operation

Operations for this alternative would take place during a 17-year period between 2003 and 2020. Operations are the actions required to treat, store, and transport the waste. Several major activities would take place during the operations period. Waste would be retrieved and transferred in the same manner described for the Ex Situ Intermediate Separations alternatives (Section 3.4.6).

A HLW vitrification facility (vitrification option) would be operated to accomplish the following.

- Receive and sample waste;
- Evaporate excess water from waste;
- Collect evaporator condensate for treatment;
- Operate two combustion melters;
- Form glass at approximately 20 weight percent sodium oxide;
- Quench molten glass to make cullet;
- Size and dry cullet to uniform size for handling, recycle undersize cullet back to melter; and
- Place cullet into 10-m^3 (360-ft^3) canisters and overpack canisters into Hanford Multi-Purpose Canisters for storage and handling.

A HLW calcination facility (calcination option) would be operated to accomplish the following.

- Receive and sample waste;
- Evaporate water from waste;
- Collect evaporator condensate for treatment;
- Operate spray calciners; and
- Place calcined product into 10-m^3 (360-ft^3) canisters and overpack canisters into Hanford Multi-Purpose Canisters for storage and handling.

An off-gas treatment system at the HLW facilities would be operated to quench and cool off-gas; remove radionuclides and recycle to process; and destroy nitrogen oxides and recover sulfur from sulfur dioxides.

Liquid effluent from HLW facilities would be treated by transferring liquid effluent to a retention basin for later transfer to the Effluent Treatment Facility. The HLW multi-purpose canisters would be transported to onsite interim storage pads. Stored canisters would be monitored and maintained through routine surveillance of the 29,100 HLW canisters of vitrified glass or 10,300 HLW canisters of calcined waste in interim storage pending offsite disposal. Hanford Multi-Purpose Canisters would be transported to the potential geologic repository.

3.4.7.5 Post Remediation

Following waste treatment operations, the tank farms would be closed and processing facilities decontaminated and decommissioned. Closing tank farms would involve ensuring that tanks contained a residual less than or equal to approximately 1 percent of the initial tank inventory; stabilizing tanks by gravel filling; stabilizing tank farm structures such as MUSTs, pump pits, valve boxes, and diversion boxes would be with grout or gravel; and placing Hanford Barriers over SSTs and DSTs.

Facility decontaminating and decommissioning activities would involve disposal of noncontaminated facilities onsite (entombed in place), and disposal of contaminated material and equipment at the onsite low-level waste burial ground.

3.4.7.6 Schedule, Sequence, Cost

A schedule of the major components of the Ex Situ No Separations alternative is shown in Table 3.4.12. Construction for waste retrieval and transfer would involve installing pipelines between the tanks and the transfer facilities throughout the retrieval period, which explains the difference in the construction periods shown. The cost estimate summary for the Ex Situ No Separations (Vitrification) alternative is shown in Table 3.4.13. The cost estimate summary for the Ex Situ No Separations (Calcination) alternative is shown in Table 3.4.14.

Table 3.4.12 Schedule Ex Situ No Separations (Vitrification or Calcination) Alternative

Activity	Waste Retrieval and Transfer Schedule	No Separations Schedule (Vitrification or Calcination)	Closure Schedule
Research and Development	Ongoing to 2003	1997 to 2007	N/A
Construction	1998 to 2017	1999 to 2005	2011 to 2025
Operating	2003 to 2020	2006 to 2020	N/A
Decontamination and Decommissioning	2015 to 2023	2020 to 2026	N/A
Monitoring and Maintenance	N/A	2020 to 2040	2025 to 2125
HLW Disposal	N/A	2020 to 2040 (Vitrification) 2020 to 2040 (Calcination)	N/A

Notes:
N/A = Not applicable

Table 3.4.13 Cost - Ex Situ No Separations (Vitrification) Alternative [1]

Cost Component	Totals
Current Operations	$8,325
Research and Development	$470
Capital	$4,890
Operating [2]	$9,797
Closure	$152
Total Treatment Cost	$23,634
Treatment Cost Range (Estimated) [3]	$22,646 - $27,717

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

3.4.7.7 Implementability

Some technologies involved in this alternative would be first-of-a-kind and thus do not have a performance history. Performance histories would provide increased confidence in the feasibility of technology and cost estimates.

Table 3.4.14 Cost - Ex Situ No Separations (Calcination) Alternative [1]

Cost Component	Totals
Current Operations	$8,325
Research and Development	$470
Capital	$4,890
Operating [2]	$7,863
Closure	$152
Total Treatment Cost	$21,700
Treatment Cost Range (Estimated) [3]	$20,776 - $25,642

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

Other issues would be associated with implementing this alternative. First, the vitrification option would have the same uncertainties as those listed for the Ex Situ Intermediate Separations alternative (Section 3.4.6). In addition, this alternative would result in a large volume of HLW. Second, calcination using sugar as a reducing agent on Hanford Site tank waste has had limited laboratory testing, and the proposed facilities, such as off-gas treatment, are conceptual. Calcination as a unit operation has been in use for many years on an industrial scale. The processing steps described for this alternative have been based on experience and engineering judgement. Third, the largest cost item for the Ex Situ No Separations (Vitrification) alternative would be the repository fee associated with disposal of the large volume of HLW.

This alternative would meet all applicable regulations for disposal of hazardous, radioactive, or mixed waste, assuming that the hazardous waste components were adequately treated during waste processing and vitrification or calcining. However, neither of the HLW forms (soda-lime glass and calcine) meet the current standard waste form (borosilicate glass) specified in the waste acceptance requirements for the potential geologic repository. The glass cullet waste form assumed for vitrification, with its high surface area to volume ratio, may not be acceptable for disposal at the potential geologic repository. The compacted powder calcine also would not meet the waste acceptance requirement for immobilization of particulates. In addition, the number of canisters of HLW produced under this alternative would greatly exceed the defense HLW limit of the first potential geologic repository (Volume One, Section 6.2).

3.4.8 Ex Situ Extensive Separations Alternative

3.4.8.1 Overview

The Ex Situ Extensive Separations alternative would be similar to the Ex Situ Intermediate Separations alternative except that multiple complex chemical separations processes would be performed to separate the HLW components from the recovered tank waste. These separations processes would concentrate and provide a smaller volume of HLW for disposal at the potential geologic repository, while at the same time provide a LAW that contained lower concentrations of radioactive contaminants than the Ex Situ Intermediate Separations alternative. Information and data used in describing the Ex Situ Extensive Separations alternative are from the Site Management and Operations contractor (WHC 1995e, i, n) and the TWRS EIS contractor (Jacobs 1996).

Ex Situ Extensive Separations Alternative

- Retrieve maximum amount of waste practicable
- Separate waste into LAW and HLW using multiple separation processes
- Vitrify waste
- Dispose of LAW onsite in subsurface vaults
- Dispose of HLW offsite at the potential geologic repository

The Ex Situ Extensive Separations alternative would be similar to the Ex Situ Intermediate Separations alternative in that the waste recovered from the SSTs, DSTs, and MUSTs would be separated into HLW and LAW streams. The HLW would be vitrified and placed into canisters. The LAW would be vitrified and placed into onsite near-surface vaults for retrievable disposal.

3.4.8.2 Process Description

The first step in waste processing would be to recover and transfer the waste from the storage tanks to the separations facility. The waste recovery function would retrieve and blend waste to provide, as close as possible, an average or blended feed stream that would be transferred to the combined separations and HLW vitrification facility. A minimum recovery rate of 99 percent of the tank contents is a requirement for retrieval. The waste retrieval and transfer process for the Extensive Separations alternative would be identical to the process for the Ex Situ Intermediate Separations alternative (Section 3.4.6).

The term separations describes the process of separating the waste stream into HLW and LAW streams. Separations would split the waste volume into a smaller HLW fraction and a larger LAW fraction. This would reduce the volume of HLW requiring costly disposal at the potential geologic repository. The Ex Situ Extensive Separations alternative would include multiple processing steps for separating the tank waste, including the following.

- Cross-flow filters and centrifuges would be used to perform liquid-solid separations.
- Caustic leaching would be used to decrease the high-level solids fraction followed by additional sludge washing and liquid/solids separation.
- Acid dissolution would be used to dissolve the HLW solids.
- Solvent extracting and ion exchanging of acidic solutions would be used to concentrate HLW radionuclides.
-

- Ion exchange would be used to remove cesium, strontium, and technetium from the alkaline LAW stream.
- Recycling water, nitric acid, and sodium hydroxide would be used to reduce LAW volumes.

Following receipt of waste from the separations operations, the waste would enter the melter feed section in either the HLW or LAW facility. In this area of each facility, the waste would be sampled, evaporated to remove the excess water, and provided as a slurry feed stream to the melter.

The LAW vitrification facility and its support facilities would be designed to produce 200 mt (220 tons) of vitrified glass per day. This capacity would be provided by two combustion melters operating in parallel, each making 100 mt (110 tons) of glass per day. Fuel-fired melters have been included as a bounding condition for analysis in the EIS. Future evaluation may result in the selection of another melter configuration.

The glass product produced by each melter would be a combination of two separate material feed streams, the waste stream, and the glass formers. The energy source providing the heat to the melter would be separate kerosene and oxygen streams supplied directly to the melter. To make suitable glass with acceptable properties for waste immobilization, it has been determined that the LAW glass produced by this alternative would contain approximately 15 weight percent sodium oxide. Glass formers (primarily silica or sand and boron oxide), would be added to the melter feed to maintain the required oxide loading.

The molten glass produced in the melter would flow into a water bath tank and be quenched into gravel-like cullet, placed into large disposal containers, and transported to onsite near-surface vaults for disposal. The engineering data supporting this alternative were based on a process that would blend the LAW glass cullet with a matrix material before it was placed into the disposal containers. Disposing of LAW as glass cullet in a matrix material has been included as a bounding condition for analysis in the EIS. Future evaluation of matrix materials and disposal forms could result in selecting other glass forms, alternate matrix materials, or disposal without a matrix material.

The HLW vitrification facility would be designed to produce 1 mt (1.1 tons) of HLW glass per day. This would be accomplished using one electrically heated (joule-heated) melter making a vitrified glass containing approximately 20 weight percent waste oxides. Following vitrification, the molten glass would be poured directly into stainless-steel canisters. The canisters then would be welded shut, the outside surfaces decontaminated, and they would be placed into Hanford Multi-Purpose Canisters. The sealed units would be transported to onsite interim storage pads where they would be covered with concrete shielding casks pending future transport to the potential geologic repository.

Vitrifying waste would generate a large off-gas stream requiring mitigation measures to minimize air emissions. Treatment equipment would capture and recycle contaminants from the off-gas stream back into the melter feed stream.

3.4.8.3 Construction

New facilities that would be constructed for this alternative would include a combined HLW vitrification and separations facility, a LAW vitrification facility, and multiple support facilities. A retrieval and transfer system identical to the system described for the Ex Situ Intermediate Separations alternative (Section 3.4.6) would be constructed. When completed, the facilities would be in place to remove the waste from the tanks and provide the processing required to produce vitrified HLW for disposal at the potential geologic repository and vitrified LAW for disposal in onsite near-surface retrievable disposal vaults. Support facilities similar to those described for the Ex Situ Intermediate Separations alternative (Section 3.4.6) would be constructed. Support facilities would provide support functions to the vitrification facility, such as waste retrieval and transfer, utilities, raw material, and operations control. The facilities are assumed to be located on the representative site in the 200 East Area similar to those shown for the Ex Situ Intermediate Separations alternative (Figure 3.4.6).

A combined separations and HLW vitrification facility would be constructed and include the following:

- Separations facility that would perform the 15-unit separations processes;
- Melter feed system, which would provide the melter with an evaporated waste feed stream, and a stream of glass formers;
- Single 1-mt/day (1.1-ton/day) joule-heated HLW melter;
- Off-gas system that would collect, treat, and filter process off-gases before release;
- Canister handling system that would remotely fill canisters with molten glass; and
- Recycle systems that would recycle contaminants captured in the off-gas system back into the melter feed system.

A LAW vitrification facility would be constructed and include the following:

- Melter feed system that would include an evaporator, a glass former handling system, and a fuel and oxygen supply system to fire the melter;
- Two 100-mt/day (110-ton/day) combustion melters;
- Cullet quench and handling system that would cool and fracture the molten glass into uniform-sized pieces (cullet) and place them in disposal containers;
- Cullet transport system that would transfer the LAW cullet in disposal containers to the disposal vaults;
- Off-gas system that would collect, treat, and filter process off-gases before discharge; and
- Recycle systems that would recycle contaminants captured in the off-gas system and undersized cullet from the cullet handling system back into the melter feed.

A LAW disposal facility would be constructed that would provide for retrievable disposal of the LAW. Vaults would be constructed throughout the operational period (66 vaults), and vaults would be belowgrade with a capacity of 5,300 m^3 (7,000 yd^3) each.

A HLW interim storage facility would be constructed that would consist of concrete storage pads for interim storage of the Hanford Multi-Purpose Canisters.

Hanford Barriers for the LAW disposal facility and tank farms would be installed. Barrier construction for disposal vaults would commence after completion of LAW vitrification, and barrier construction for tank farms would take place after completion of waste removal and tank stabilization.

3.4.8.4 Operation

Operations for this alternative would take place in a 20-year period between the years 2003 and 2023. Several major activities would take place during the operations period. Waste would be retrieved in the same manner described for the Ex Situ Intermediate Separations alternative (Section 3.4.6). Waste would be separated as follows into HLW and LAW streams:

- Sludge wash to remove water-soluble fractions;
- Caustic leach to decrease the high-level solids fraction;
- Acid dissolution to dissolve HLW solids;
- Solvent extraction and ion exchange of acidic solutions;
- Ion exchange of alkaline solutions; and
- Recycling to reduce LAW volumes.

The LAW vitrification facility would be operated to accomplish the following.

- Receive and sample waste;
- Evaporate excess water from waste;
- Collect evaporator condensate for treatment;
- Operate two combustion melters (feed streams of oxygen, kerosene, waste, and glass formers);
- Form glass at approximately 15 weight percent sodium oxide;
- Quench molten glass to make cullet; and
- Size and dry cullet to uniform size for handling, and recycle undersize cullet back to melter.

Vitrified cullet would be placed into disposal containers and transported to nearby LAW disposal vaults.

The HLW vitrification facility would be operated to accomplish the following.

- Receive and sample waste;
- Evaporate water from waste;
- Collect evaporator condensate for treatment;
- Operate one joule-heated melter
- Form glass at approximately 20 weight percent waste oxides;
- Pour glass monoliths 0.6 m (2 ft) in diameter by 4.5 m (15 ft) long; and
- Overpack glass into Hanford Multi-Purpose Canisters, four glass monoliths per canister.

The off-gas treatment system at both HLW and LAW vitrification facilities would be operated to quench and cool off-gas, remove radionuclides and recycle to vitrification process, and destroy nitrogen oxides. The LAW vitrification facility also would recover sulfur from the sulfur oxides.

Liquid effluent would be transferred from the HLW and LAW vitrification facilities to the Effluent Treatment Facility. The HLW multi-purpose canisters would be transported to interim storage pads. Stored canisters would be monitored and maintained through routine surveillance of the Hanford Multi-Purpose Canisters in interim storage pending offsite disposal, and Hanford Multi-Purpose Canisters would be transported to the potential geologic repository.

3.4.8.5 Post Remediation

Following waste treatment operations, the tank farms would be closed and processing facilities would be decontaminated and decommissioned. Closing tank farms would involve ensuring that the tanks contained a residual less than or equal to approximately 1 percent of the initial tank inventory; stabilizing tanks by gravel filling; stabilizing tank farm structures such as pump pits, valve boxes, and diversion boxes with grout or gravel; and placing Hanford Barriers over SSTs, DSTs, and LAW burial vaults.

Facility decontaminating and decommissioning activities would involve disposal of noncontaminated facilities onsite (entombed in place), and disposal of contaminated material and equipment at the onsite low-level waste burial grounds.

3.4.8.6 Schedule, Sequence, Cost

A schedule of the major components of the Ex Situ Extensive Separations alternative is shown in Table 3.4.15. Construction for waste retrieval and transfer would involve installing pipelines between the tanks and the transfer facilities throughout the retrieval period, which explains the difference in the construction periods shown. The cost estimate summary for the Ex Situ Extensive Separations alternative is shown in Table 3.4.16.

Table 3.4.15 Schedule - Ex Situ Extensive Separations Alternative

Activity	Waste Retrieval and Transfer Schedule	Extensive Separations Schedule	Closure Schedule
Research and Development	Ongoing to 2003	1997 to 2018	N/A
Construction	1998 to 2016	1999 to 2006	2012 to 2032
Operating	2003 to 2023	2004 to 2023	N/A
Decontamination and Decommissioning	2014 to 2024	2023 to 2028	N/A
Monitoring and Maintenance	N/A	2023 to 2025	2032 to 2132
HLW Disposal	N/A	2022 to 2025	N/A

Notes:
N/A = Not applicable

Table 3.4.16 Schedule - Ex Situ Extensive Separations Alternative[1]

Cost Component	Totals
Current Operations	$8,600
Research and Development	$1,490
Capital	$7,482
Operating [2]	$9,983
Closure	$170
Total Treatment Cost	$27,725
Treatment Cost Range (Estimated) [3]	$26,935 - $37,464

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

3.4.8.7 Implementability

The Ex Situ Extensive Separations alternative would have the same uncertainties as the Ex Situ Intermediate Separations alternative, plus additional uncertainties associated with the chemical separations processes (Section 3.4.6.7). The key implementability issue associated with this alternative is that the performance of key separations processes has been assumed in the absence of substantive data. Further testing and development would be required to determine if the processes would function as intended to make the required separations.

The HLW canisters produced under this alternative would have a higher thermal loading than other alternatives and the assumed method of interim onsite storage, which would rely on dry storage with passive cooling, would require further evaluation. This alternative could require using a storage facility with active cooling to remove decay heat generated by the vitrified HLW.

This alternative would meet all applicable regulations for disposal of hazardous, radioactive, or mixed waste assuming that the hazardous waste components were adequately treated during waste processing and vitrification.

3.4.9 Ex Situ/In Situ Combination 1 and 2 Alternatives

3.4.9.1 Overview

The ex situ/in situ combination alternatives were developed to assess the impacts that would result if a combination of two or more of the tank waste alternatives were selected for implementation. Because the tank waste differs greatly in the physical, chemical, and radiological characteristics, it might be appropriate to implement different alternatives for different tanks. There are a wide variety of potential combinations of alternatives that could be developed and criteria that could be used to select a combination of alternatives for implementation. Two ex situ/in situ combination alternatives were developed to bound the impacts that could result from a combination of alternatives, and are intended

to represent a variety of potential alternative combinations that could be developed to remediate the tank waste.

The Ex Situ/In Situ Combination 1 and 2 alternatives represent a combination of the In Situ Fill and Cap and Ex Situ Intermediate Separations alternatives (Figure 3.4.12). Tanks would be evaluated on a tank-by-tank basis to determine the appropriate remediation method based on the contents of the tanks. The objective would be to effectively treat the tank waste in a manner that has acceptable risk and less overall cost than using the Ex Situ Intermediate Separations alternative for all tanks. This objective could be achieved by selecting tanks for ex situ treatment based on their contribution to post-remediation risk. The tanks that were not selected for ex situ treatment would be treated in situ by filling and capping. Two Ex Situ/In Situ Combination alternatives exist, one based on the recovery of approximately 90 percent of the long-term risk contaminants and the other based on recovery of approximately 85 percent of the long-term risk contaminants. See Volume Two, Section B.3.8 for discussion on tank selections methodology

Ex Situ/In Situ Combination 1

Waste from tanks selected for ex situ treatment would be retrieved and transferred to processing facilities for treatment. Closure activities would consist of filling those tanks selected for ex situ treatment with gravel and constructing a Hanford Barrier over all tank farms and the LAW retrievable disposal vaults from ex situ treatment. Approximately one-half of the volume of the tank waste would be treated using the ex situ method and one-half would be treated using the in situ method.

Ex Situ/In Situ Combination 1 Alternative

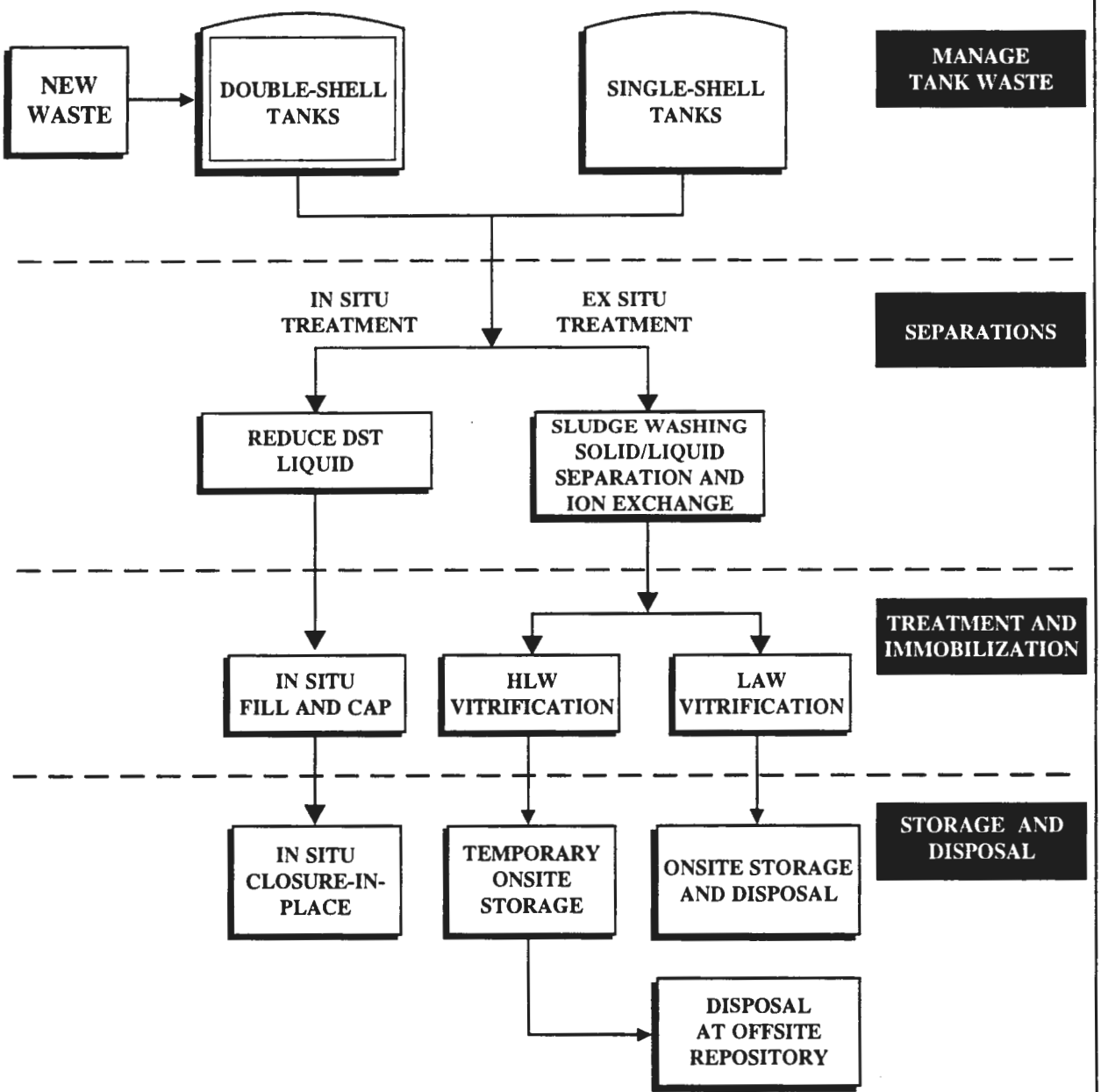
- Retrieve approximately 50 percent of the waste volume based on long-term risk
- Fill remaining tanks with gravel and cover with Hanford Barriers
- Separate retrieved waste into LAW and HLW using sludge washing and ion exchange
- Vitrify all waste retrieved
- Dispose of LAW onsite in subsurface vaults
- Dispose of HLW offsite at the potential geologic repository

By selecting the appropriate tanks for ex situ treatment, approximately 90 percent of the contaminants that contribute to long-term risk would be disposed of ex situ while retrieving only 50 percent of the waste (Jacobs 1996). The process used to determine which tank waste would be retrieved for the purpose of analyzing this alternative is described in Volume Two, Appendix B. The human health risk associated with selectively retrieving tanks is discussed in Section 5.0.

Ex Situ/In Situ Combination 2

Waste from tanks selected for ex situ treatment would be retrieved and transferred to processing facilities for treatment. Closure activities would consist of filling those tanks selected for ex situ treatment with gravel and constructing a Hanford Barrier over all tank farms and the LAW retrievable disposal vaults from ex situ treatment. Approximately one-quarter of the volume of the tank waste

Figure 3.4.12 Ex Situ/In Situ Combination (1 and 2) Alternatives



would be treated using the ex situ method and three-quarters would be treated using the in situ method.

Ex Situ/In Situ Combination 2 Alternative

- Retrieve approximately 25 percent of the waste volume based on long-term risk
- Fill remaining tanks with gravel and cover with Hanford Barriers
- Separate retrieved waste into LAW and HLW using sludge washing and ion exchange
- Vitrify all waste retrieved
- Dispose of LAW onsite in subsurface vaults

By selecting the appropriate tanks for ex situ treatment, approximately 85 percent of the contaminants that contribute to long-term risk would be disposed of ex situ while retrieving only 25 percent of the waste (Jacobs 1996). The purpose of developing the Ex Situ/In Situ Combination 2 alternative was to analyze lower cost methods for remediation of the tank waste while maintaining long-term risk reduction. The process used to determine which tank waste would be retrieved for the purpose of analyzing this alternative is described in Volume Two, Appendix B. The human health risk associated with selectively retrieving tanks is discussed in Section 5.0.

3.4.9.2 Process Description

Ex Situ/In Situ Combination 1

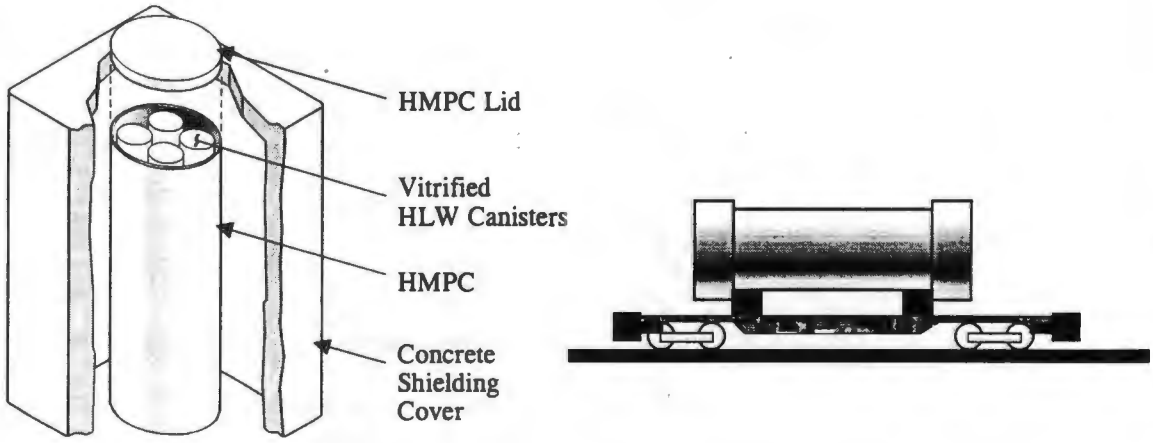
The waste that would be retrieved for ex situ treatment would be treated using the process identified for the Ex Situ Intermediate Separations alternative (Section 3.4.6). The retrieved waste stream would be separated into HLW and LAW streams. Separations processes would include liquid solid separations followed by cesium recovery from the liquid stream, which would be fed back into the high-level stream. Both HLW and LAW streams would be vitrified in separate vitrification facilities. The HLW facility would be designed to produce 8 mt/day (8.8 tons/day) and the LAW facility would be sized to produce 120 mt/day (130 tons/day).

Following vitrification, the HLW would be poured into canisters. The canisters would be overpacked into Hanford Multi-Purpose Canisters (Figure 3.4.13) for onsite interim storage. The LAW would be quenched into gravel-like cullet, placed into disposal containers, and transported to onsite vaults for near-surface disposal. The engineering data supporting this alternative were based on a process that would blend the LAW glass cullet with a matrix material before placing it into the disposal containers. Disposing of LAW as glass cullet in matrix material has been included as a representative condition for analysis in the EIS. Future evaluation of matrix materials and disposal forms could result in selecting other glass forms, alternate matrix materials, or elimination of the matrix material.

Tanks not selected for retrieval would be treated in situ using the In Situ Fill and Cap process (Section 3.4.4). This process would involve reducing the DST liquid using the 242-A Evaporator, filling the tanks with gravel, and installing a Hanford Barrier over the tank farms.

Existing MUSTs (both inactive and active) would be filled with grout to stabilize the waste. All MUSTs would be covered with a Hanford Barrier during post remediation.

Figure 3.4.13 Hanford Multi-Purpose Canister (HMPC) System for High-Level Waste



View #1
HMPC Onsite Interim Storage

View #2
HMPC Rail Transport

Not to Scale

SOURCE: Adapted from Green 1995

Ex Situ/In Situ Combination 2

The waste that would be retrieved for ex situ treatment would be treated using the process identified for the Ex Situ Intermediate Separations alternative (Section 3.4.6). The retrieved waste stream would be separated into HLW and LAW streams. Separations processes would include liquid solid separations followed by cesium recovery from the liquid stream, which would be fed back into the HLW stream. Both HLW and LAW streams would be vitrified in separate vitrification facilities. The HLW facility would be designed to produce 5 mt/day (5.5 tons/day) and the LAW facility would be sized to produce 70 mt/day (77 tons/day).

Following vitrification, the HLW would be poured into canisters. The canisters would be overpacked into Hanford Multi-Purpose Canisters (Figure 3.4.13) for interim onsite storage and eventual transport to the potential geological repository. The LAW would be quenched into gravel-like cullet, placed into disposal containers, and transported to onsite vaults for near-surface disposal. The engineering data supporting this alternative were based on a process that would blend the LAW glass cullet with a matrix material before placing it into the disposal containers.

Tanks not selected for retrieval would be treated in situ using the In Situ Fill and Cap process (Section 3.4.4). This process would involve reducing the DST liquid using the 242-A Evaporator, filling the tanks with gravel, and installing a Hanford Barrier over the tank farms. Existing MUSTs (both inactive and active) would be filled with grout to stabilize the waste. All MUSTs would be covered with a Hanford Barrier during post remediation.

3.4.9.3 Construction

Ex Situ/In Situ Combination 1

Construction activities required for this alternative would involve constructing all of the facilities identified for the Ex Situ Intermediate Separations alternative and the In Situ Fill and Cap alternative, but on a reduced scale. For the ex situ portion, the volume of waste requiring treatment and immobilization would come from approximately 70 tanks instead of 177 tanks. In situ treatment would be required for the remaining tanks.

The following major activities would take place during the construction phase for the ex situ component of the Ex Situ/In Situ Combination 1 alternative.

- Install retrieval and transfer facilities.
- Construct separations (pretreatment) facilities.
- Construct an 8-mt/day (8.8-ton/day) HLW vitrification facility.
- Construct a HLW interim storage facility.
- Construct a 120-mt/day (130-ton/day) LAW vitrification facility.
- Construct a LAW disposal facility (vaults).

For the in situ component of this alternative, construction activities would involve installing gravel handling systems, constructing gravel storage sites for stockpiles, and modifying tank openings to accommodate gravel handling equipment.

Ex Situ/In Situ Combination 2

Construction activities required for this alternative would involve constructing all of the facilities identified for the Ex Situ Intermediate Separations alternative and the In Situ Fill and Cap alternative, but on a reduced scale. For the ex situ portion, the volume of waste requiring treatment and immobilization would come from approximately 25 tanks instead of 177 tanks. In situ treatment would be required for the remaining tanks.

The following major activities would take place during the construction phase for the ex situ component of the Ex Situ/In Situ Combination 2 alternative.

- Install retrieval and transfer facilities.
- Construct separations (pretreatment) facilities.
- Construct a 5-mt/day (5.5-ton/day) HLW vitrification facility.
- Construct a HLW interim storage facility.
- Construct a 70-mt/day (77-ton/day) LAW vitrification facility.
- Construct a LAW disposal facility (vaults).

For the in situ component of this alternative, construction activities would involve installing gravel handling systems, constructing gravel storage sites for stockpiles, and modifying tank openings to accommodate gravel handling equipment.

3.4.9.4 Operations

Operations for the Ex Situ/In Situ Combination 1 and 2 alternatives would be a combination of the operations described for the Ex Situ Intermediate Separations alternative in Section 3.4.6 and the In Situ Fill and Cap alternative in Section 3.4.4, but on a reduced scale.

Waste retrieved from the tanks for treatment would be retrieved and processed in the same manner as described for extensive retrieval. The operation would be scaled down to accommodate the smaller waste volume to be treated.

Those tanks not selected for ex situ treatment would be remediated using the process described for the In Situ Fill and Cap alternative. The DST liquid in those tanks not selected for retrieval would be retrieved and reduced in the 242-A Evaporator. Following waste reduction operations for the DSTs, the tanks would be stabilized by filling with gravel.

3.4.9.5 Post Remediation

After remediation, tank farm closure and decontamination and decommissioning would take place. Tank farm closure would involve the following activities. First, retrieved tanks would be stabilized with gravel (in situ tanks would have been stabilized during in situ operations). Second, tank farm structures such as MUSTs, pump pits, valve boxes, and diversion boxes would be stabilized with grout. Finally, Hanford Barriers would be constructed over SSTs, DSTs, and LAW retrievable disposal vaults.

Decontamination and decommissioning of equipment and facilities would include disposing of noncontaminated material by in place entombing onsite and disposing of contaminated equipment and materials at the onsite low-level waste burial grounds.

3.4.9.6 Schedule, Sequence, Cost

Ex Situ/In Situ Combination 1

A schedule for the major components of the Ex Situ/In Situ Combination 1 selective retrieval alternative is shown in Table 3.4.17. This schedule covers both in situ and ex situ portions of the alternative. The estimated cost for this alternative is provided in Table 3.4.18.

Ex Situ/In Situ Combination 2

A schedule for the major components of the Ex Situ/In Situ Combination 2 alternative is shown in Table 3.4.19. This schedule covers both in situ and ex situ portions of the alternative. The estimated cost for this alternative is provided in Table 3.4.20.

Table 3.4.17 Schedule - Ex Situ/In Situ Combination 1 Alternative

Activity	Waste Retrieval and Transfer Schedule [1]	Ex Situ Vitrification Schedule [1]	In Situ Fill and Cap Schedule [2]	Closure Schedule [1]
Research and Development	Ongoing-2002	1997 to 2018	2000 to 2002	N/A
Construction	1998 to 2016	1999 to 2009	2003 to 2005	2010 to 2034
Operating	2002 to 2022	2005 to 2023	2000 to 2009	N/A
Decontamination and Decommissioning	2013 to 2024	2023 to 2032	2022 to 2025	N/A
Monitoring and Maintenance	N/A	2023 to 2040	2018 to 2034	2035-2135
HLW Disposal	N/A	2022 to 2040	2005 to 2018	N/A

Notes:
[1] Schedule assumed to be similar to the Ex Situ Intermediate Separations alternative.
[2] Schedule assumed to be similar as the In Situ Fill and Cap alternative.
N/A = Not applicable

Table 3.4.18 Cost - Ex Situ/In Situ Combination 1 Alternative[1]

Cost Component	Totals
Current Operations	$9,142
Research and Development	$816
Capital	$3,314
Operating [2]	$6,267
Closure	$137
Total Treatment Cost	$19,676
Treatment Cost Range (Estimated) [3]	$18,322 - $23,266

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.
N/A = Not applicable

Table 3.4.19 Schedule - Ex Situ/In Situ Combination 2 Alternative

Activity	Waste Retrieval and Transfer Schedule [1]	Ex Situ Vitrification Schedule [1]	In Situ Fill and Cap Schedule [2]	Closure Schedule [1]
Research and Development	Ongoing-2002	1997 to 2018	2000 to 2002	N/A
Construction	1998 to 2016	1999 to 2008	2003 to 2005	2010 to 2032
Operating	2002 to 2022	2004 to 2022	2000 to 2009	N/A
Decontamination and Decommissioning	2013 to 2024	2022 to 2031	2022 to 2025	N/A
Monitoring and Maintenance	N/A	2022 to 2040	2018 to 2034	2032-2132
HLW Disposal	N/A	2022 to 2040	2005 to 2018	N/A

Notes:
[1] Schedule assumed to be similar to the Ex Situ Intermediate Separations alternative.
[2] Schedule assumed to be similar as the In Situ Fill and Cap alternative.
N/A = Not applicable

Table 3.4.20 Cost - Ex Situ/In Situ Combination 2 Alternative [1]

Cost Component	Totals
Current Operations	$9,080
Research and Development	$813
Capital	$2,353
Operating [2]	$3,061
Closure	$125
Total Treatment Cost	$15,432
Treatment Cost Range (Estimated) [3]	$14,442 - $17,733

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.

3.4.9.7 Implementability

Because this alternative represents a combination of alternatives, the implementability issues would be a combination of those issues identified for the implementability of both the In Situ Fill and Cap alternative and the Ex Situ Intermediate Separations alternative (Sections 3.4.4 and 3.4.6). Developing acceptable tank selection criteria would be an issue unique to the ex situ/in situ combination concept and would require more complete and accurate waste characterization than currently exists.

Implementability issues relating to both the in situ and ex situ portions of this alternative would include the following.

- LAW form (glass cullets in a matrix material) is unique and has not been used before.
- Successful performance of key processes (e.g., sludge washing) has been assumed in the absence of substantive data.
- Final design of a combination alternative would consider retrieval and treatment of all DST liquids.
- Cost estimates could have a high degree of uncertainty because these would be first-of-a-kind systems.
- The ability to achieve retrieval criteria based on recovering 99 percent of the waste volume in each tank would be uncertain.
- Incidental blending of waste during retrieval would be more uncertain for the ex situ/in situ combination alternatives because fewer tanks would be subject to retrieval. The affect of blending on HLW volumes for the combination alternatives would require further evaluation.
- Additional separations steps could be required to meet LAW disposal criteria.

The in situ portion of this alternative would not meet the RCRA land disposal requirements for hazardous waste or DOE policy to dispose of readily retrievable HLW in a geologic repository. The ex situ portion of the alternative would meet all regulations for disposal of hazardous, radioactive,

or mixed waste assuming that the hazardous waste components are adequately treated during processing or vitrification.

3.4.10 Phased Implementation Alternative

3.4.10.1 Overview

The Phased Implementation alternative includes remediating the tank waste in two phases. The first phase would be a demonstration of the separations and immobilization processes for selected tank waste. The second phase would involve scaling-up the demonstration processes and constructing larger treatment facilities to remediate the remaining tank waste.

Phased Implementation Alternative

- Construct and operate two demonstration-scale facilities to prove the concept for immobilization is effective before building a full-scale facility
- Perform retrieval, separations, immobilization, and disposal similar to the Ex Situ Intermediate Separations alternative

This two-phased implementation approach could be applied to any of the tank waste alternatives involving ex situ waste treatment. However, for the purposes of analysis, the processes and activities described for the Ex Situ Intermediate Separations alternative, with some additional separations, was selected as the basis for developing the Phased Implementation alternative. This basis included vitrified glass cullet as a LAW form and vitrified borosilicate glass as a HLW form. Other types of glass or wastes forms could be selected for HLW or LAW treatment; however, they would have to meet the repository acceptance criteria or performance assessment criteria. The Phased Implementation alternative is presented in two parts; Phase 1 first, then Phase 2.

This alternative also could be implemented by decommissioning the two demonstration-scale facilities after the demonstration phase and constructing and operating two larger size facilities. The environmental impacts of each approach would be approximately the same.

Phase 1

During Phase 1, readily retrievable and well-characterized DST waste would be retrieved and processed in two separate demonstration facilities. The waste processed during Phase 1 could also include selected SST waste. One of the facilities would process liquid waste to produce immobilized LAW, while the other facility would produce immobilized LAW and vitrified HLW. The facility for both LAW and HLW immobilization could be constructed as separate facilities. Information used in describing this alternative was developed by the TWRS EIS contractor (Jacobs 1996).

The immobilized LAW would be sealed in containers at the treatment facilities and then transported to an interim onsite storage facility where it would be stored for disposal during Phase 2. The vitrified HLW would be placed in canisters and transported to an interim onsite storage facility, where it would be stored awaiting shipment and disposal at the potential geologic repository.

During Phase 1, canisters of vitrified HLW and canisters of separated radionuclides would be placed into shipping casks and transported to the onsite Canister Storage Building for interim storage. Each canister would be placed into a storage tube in one of the Canister Storage Building vaults. The Canister Storage Building is located in the 200 East Area and was constructed as an interim storage facility. The NEPA analysis for construction of the Canister Storage Building was performed under the K Basins Spent Nuclear Fuel EIS (DOE 1995j).

The Phase 1 immobilized LAW would be placed into disposal containers and transported to the existing grout vaults for interim storage until the permanent onsite disposal vaults were constructed during Phase 2. The NEPA analysis for the construction of the grout vaults was previously performed in the Hanford Defense Waste EIS (DOE 1987). The LAW placed in interim storage during Phase 1 would be retrieved and transported to the LAW disposal vaults during Phase 2.

Each of the LAW treatment facilities would operate for a 10-year period. The HLW treatment facility would operate for a 6-year period, which could be extended to a 10-year period.

The following operations would be implemented under Phase 1.

- Retrieve selected liquid waste for LAW processing.
- Retrieve selected DST and SST waste for HLW processing.
- Transfer liquid waste to receiver tanks.
- Transfer selected waste for HLW processing directly to the HLW facility.
- Perform separations to remove cesium, technetium, strontium, transuranic elements, and sludge from the LAW stream.
- Store separated cesium and technetium at the treatment facilities or package and transport to the Canister Storage Building for onsite interim storage pending future HLW waste treatment.
- Return the sludge, strontium, and transuranic waste separated prior to LAW processing to DSTs for storage.
- Immobilize the LAW and vitrify the HLW.
- Place the vitrified HLW into canisters.
- Place the immobilized LAW into containers.
- Transport the immobilized waste to onsite interim storage facilities.

Phase 2

Phase 2 would be implemented to complete the remediation of the tank waste following successful implementation of Phase 1. Implementation of Phase 2 would involve the continued operation of Phase 1 facilities plus construction of two full-scale separations and LAW vitrification facilities and a full-scale HLW vitrification facility. Phase 2 would include the retrieval and treatment of the remaining DST and SST waste as well as the waste contained in the MUSTs. As much of the tank waste as practicable (assumed to be 99 percent) would be recovered from each tank. The recovered waste stream then would be transferred to one of the treatment facilities where it would be separated into HLW and LAW waste streams for immobilization.

The HLW stream would be vitrified, placed into canisters and then placed into Hanford Multi-Purpose Canisters for interim storage and disposal at the potential geologic repository. The LAW would be immobilized and placed into sealed containers similar to those used in Phase 1. The immobilized LAW would be placed into near-surface retrievable disposal vaults.

For purposes of analysis and in order to present a complete and representative alternative, the complete Phased Implementation alternative would include the following components:

- Completion of the waste retrieval and transfer system as described for the Ex Situ Intermediate Separations alternative;
- Construction and operation of the ex situ treatment facilities, similar to those described for the Ex Situ Intermediate Separations alternative, to provide the treatment capacity required to complete tank waste remediation; and
- Construction and operation of interim HLW storage and LAW disposal vaults of the same size and type as described for the Ex Situ Intermediate Separations alternative to provide for interim HLW storage and LAW disposal.

3.4.10.2 Process Description

Phase 1

The first step in waste processing would be to recover and transfer selected waste for treatment. Liquid waste retrieval and transfer would use equipment and systems currently in place in the DST farms. Waste retrieved from selected SSTs also could be used as waste feed for the treatment facilities. The waste feed to the LAW facilities would be retrieved and transferred in batches from selected DSTs into two existing DSTs used as feed tanks. Each LAW facility would have one designated DST as a feed tank. The waste feed to the HLW facility would be retrieved, sludge washed, and transferred directly to the HLW processing facility. The waste treated at the HLW facility would be the HLW recovered from selected tanks and sludge washed and might or might not include the HLW separated out of the LAW stream.

The separations and immobilization technologies employed for waste immobilization would be based on waste product specifications, which would set the requirements for the physical properties, chemistry, radionuclide content, and volume of the immobilized LAW and HLW. During the demonstration phase, different types of waste would be processed to demonstrate process capability for easy, moderate, and difficult-to-process waste. For purposes of this analysis, the technologies employed would be assumed to be similar to those described for the other ex situ alternatives.

Separations prior to LAW immobilization would be performed to remove the cesium, strontium, technetium, transuranic elements, and entrained sludge particles from the waste stream to the extent required to meet LAW product specifications. The separated cesium and technetium would be stored at the treatment facilities or packaged in canisters for onsite dry storage; the sludge and other radionuclides would be returned to the DST farms for storage; and the remaining liquid waste stream then would be immobilized. The immobilization process would include evaporation of the waste stream followed by vitrification. The LAW processing facilities each would be designed to treat up to

3.8 million L (1 million gal) of liquid waste per year. This is equivalent to a treatment facility with a capacity of 20 mt (22 tons) of vitrified glass per day at a 15 weight percent sodium oxide waste loading, operating at an overall efficiency of 60 percent. The immobilized LAW would be placed into containers approximately 1.8 m long by 1.2 m wide by 1.2 m high (6 ft long by 4 ft wide by 4 ft high).

The HLW treatment process, which would involve only sludge washing and solid/liquid separations processes, would convert the entire waste feed stream into vitrified borosilicate HLW glass. The HLW facility would be designed to produce the equivalent of 1 mt/day (1.1 ton/day) of HLW glass at a 20 weight percent waste oxide loading. The HLW would be placed directly into 1.17-m^3 (41-ft^3) canisters for packaging in a Hanford Multi-Purpose Canister for interim storage.

Phase 2

Under Phase 2, the waste retrieval and transfer operations would use the same processes and would be subject to the same requirements for tank residuals as the retrieval and transfer function described for the Ex Situ Intermediate Separations alternative. Waste would be retrieved and blended for batch transfer to the treatment facilities. Radionuclides that previously had been separated from the LAW stream and placed in containers for storage would be transported to a HLW vitrification facility and blended with a HLW feed stream.

The HLW and LAW separations processes would be similar to those described for the Ex Situ Intermediate Separations alternative, but would include additional separations processes to remove strontium, technetium, and transuranic elements from the LAW stream to the extent required to meet the LAW product specifications.

During Phase 2, a HLW vitrification facility and two LAW treatment facilities would be constructed. The HLW vitrification facility would be designed to produce 10 mt (11 tons) of HLW glass per day. The LAW treatment facilities would each be designed to produce 100 mt (110 tons) of glass per day. The LAW produced during Phase 1 and the LAW produced during Phase 2 would be disposed of onsite in near-surface retrievable disposal vaults.

3.4.10.3 Construction

Phase 1

The two facilities would be located on the east side of the 200 East Area within the area previously identified as the grout disposal area. Separate treatment and support facilities would be constructed (Figure 3.4.14). The following systems and facilities would be constructed:

- Waste transfer systems - This would include pipelines from the receiver tanks to each of the treatment facilities and a separate pipeline to transfer HLW from the existing waste transfer system to one of the treatment facilities.
- Electrical service to each of the sites - This would involve installing overhead power lines from the existing 200 East Area power grid to the designated sites.

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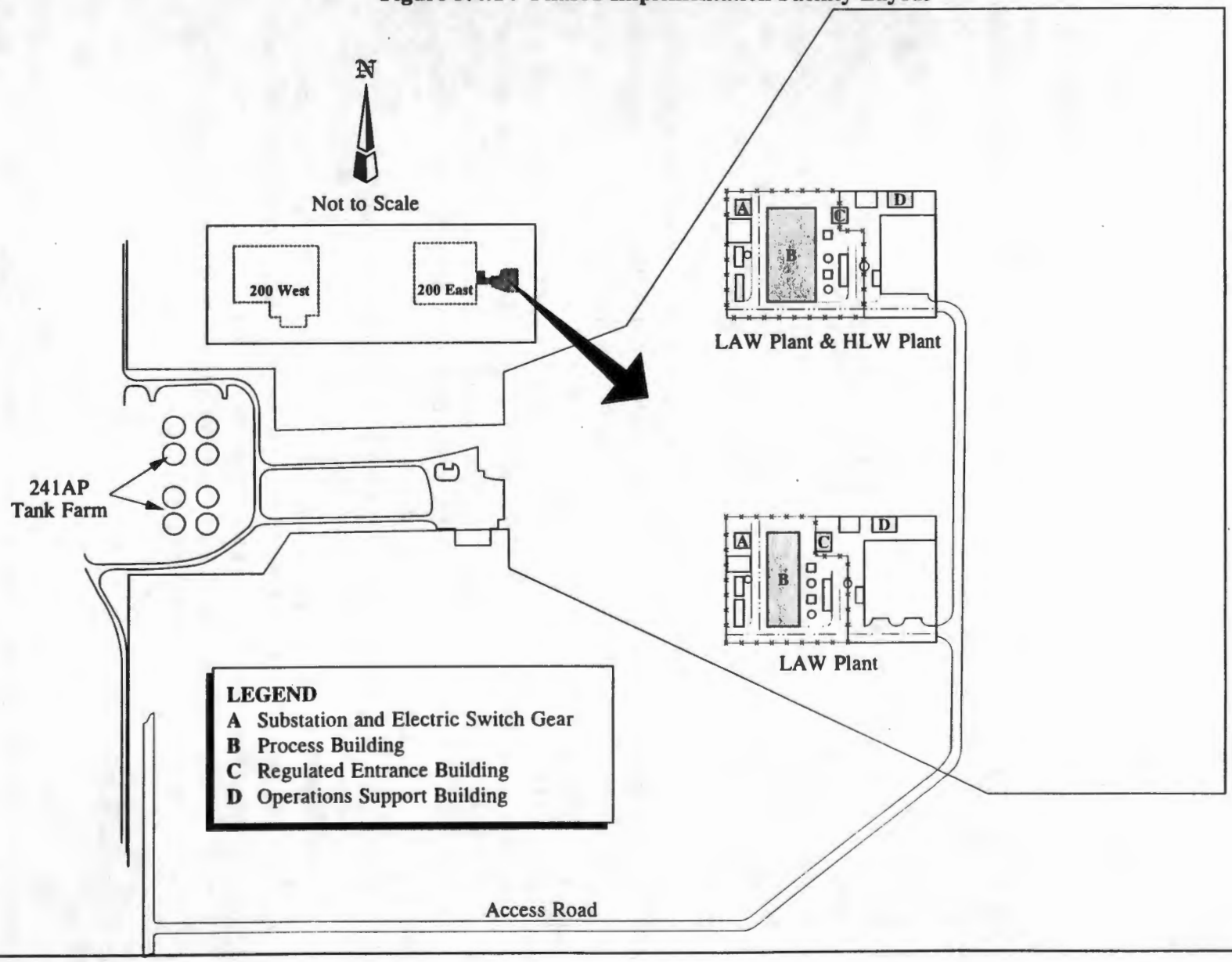
Figure 3.4.14 Phased Implementation Facility Layout



- Process water and potable water - These services would be installed to connect the sites with existing distribution lines in the 200 East Area.
- Treatment facilities - This would include one separations/LAW processing facility and one separations/LAW/HLW processing facility.
- Modify the Canister Storage building for interim storage of vitrified HLW. This would include modifying the underground vaults and ventilation system to accommodate the physical and thermal loading associated with interim storage of all HLW produced during Phase 1.
- Modify the existing grout vaults to accommodate interim LAW storage during Phase 1 operations. This would include modifications to the existing vaults to allow placement and interim storage of the LAW disposal containers pending future retrieval and disposal during Phase 2.

Phase 2

Constructing new facilities for Phase 2 would include new treatment facilities with higher capacities than the Phase 1 demonstration facilities. The new facilities constructed during Phase 2 would include a HLW vitrification facility, two combined separations and LAW treatment facilities, a LAW disposal facility, an interim HLW storage facility, waste retrieval and transfer facilities, and support facilities (Figure 3.4.15). The facilities that would be constructed for Phase 2 operations would include the following:

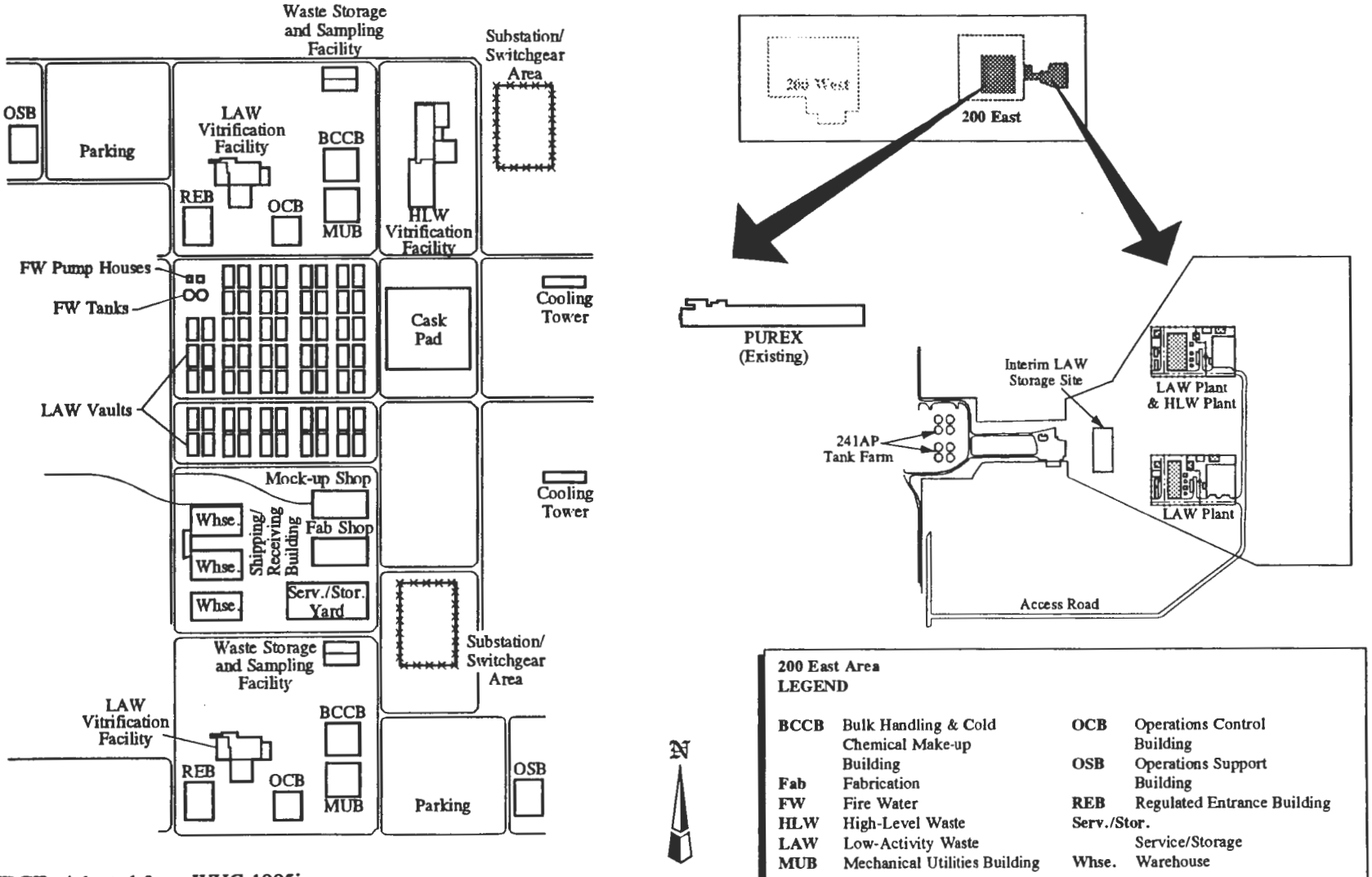
- Waste retrieval and transfer facilities as described for Ex Situ Intermediate Separations;
- Support facilities that would provide utilities, resources, and personnel support to the Phase 2 treatment facilities (these support facilities would be similar to those described for the Ex Situ Intermediate Separations alternative);
- Two separations and LAW treatment facilities that would be similar to the LAW vitrification facility described for the Ex Situ Intermediate Separations alternative;
- A LAW disposal facility for retrievable disposal of LAW produced throughout Phase 1 and Phase 2 (this facility would be similar to the LAW disposal facility described for the Ex Situ Intermediate Separations alternative);
- A HLW vitrification facility that would be similar to the HLW vitrification facility described for the Ex Situ Intermediate Separations alternative;
- A HLW interim storage facility for interim storage of the Hanford Multi-Purpose Canisters (this facility would be similar to the interim storage facility described for the Ex Situ Intermediate Separations alternative); and
- Hanford Barriers over the LAW retrievable disposal facility and tank farms at the completion of remediation.

3.4.10.4 Operations

Phase 1

Operations under Phase 1 would take place simultaneously at the two treatment facilities. Both LAW facilities would operate for 10 years. The HLW treatment operations would take place for 6 years but could be extended to 10 years.

Figure 3.4.15 Phased Implementation (Total Alternative) Facility Layout



SOURCE: Adapted from WHC 1995j

The waste (mainly DST liquid waste) would be retrieved and transferred to receiver tanks for LAW treatment. The waste then would be transferred from the receiver tanks to the treatment facilities on an as-needed basis. The HLW would be retrieved from selected tanks and transferred to DSTs for in-tank sludge washing. The washed HLW would then undergo solid/liquid separation followed by vitrification of the HLW.

Each facility would perform the necessary separations processes on the waste stream. Separated cesium and technetium radionuclides would be stored at the treatment facilities or packaged for interim onsite storage at the Canister Storage Building. The LAW stream would be vitrified to meet established performance characteristics. The HLW stream would be vitrified to produce borosilicate glass and then would be placed into canisters. The HLW produced would meet established acceptance criteria.

Each of the waste treatment facilities would operate off-gas treatment systems using control technologies for priority pollutants and radionuclides. The treatment of the off-gas would use processes and equipment similar to those described for the Ex Situ Intermediate Separations alternative.

Phase 2

Phase 2 operations would follow Phase 1 and would consist of the following:

- Retrieve waste from the tanks and MUSTs. This operation would be the same as described for waste retrieval under Ex Situ Intermediate Separations alternative;
- Perform sludge washing and solid/liquid separation; and
- Operate the two LAW vitrification facilities and the HLW vitrification facility. Waste treatment operations would be similar to those described for the Ex Situ Intermediate Separations alternative but at a reduced scale.

3.4.10.5 Post Remediation

Following waste treatment and tank farm closure, decontamination and decommissioning would take place. Post-remediation activities for the Phased Implementation alternative would be the same as those described for the Ex Situ Intermediate Separations alternative. The tank farms would be closed and the processing facilities would be decontaminated and entombed in place.

3.4.10.6 Schedule, Sequence, and Cost

A schedule for the major components of the Phased Implementation alternative is shown in Table 3.4.21. The cost estimate for the Phased Implementation alternative was developed by combining applicable components from other ex situ alternatives and applying ratios as required to account for differences in facility sizes and capacities and the degree of separations in LAW and HLW. This approach inherently assumes that the Phased Implementation alternative would use similar types of processes and facilities to those described for the other ex situ alternatives. The estimated cost for the Phased Implementation alternative is shown in Table 3.4.22.

Table 3.4.21 Schedule - Phased Implementation Alternative

Activity	Phase 1 Schedule	Phase 2 Schedule		Closure Schedule
		Waste Retrieval and Transfer	Treatment	
Construction	1998 to 2002	2004 to 2020	2006 to 2012	2016 to 2040
Operations	2002 to 2012	2008 to 2028	2011 to 2028	N/A
Decontamination and Decommissioning	N/A	2015 to 2031	2015 to 2031	N/A
Post-Closure Monitoring	N/A	N/A	N/A	2040 to 2140
HLW disposal	N/A	N/A	2022 to 2040	N/A

Notes:
N/A = Not applicable

Table 3.4.22 Cost - Phased Implementation Alternative [1]

Cost Component	Totals
Current Operations	$8,600
Research and Development	$190
Capital	$7,580
Operating [2]	$10,618
Closure	$211
Total Treatment Cost	$27,199
Treatment Cost Range (Estimated) [3]	$25,091 - $33,010

Notes:
[1] Cost in millions of 1995 dollars.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
[3] Cost range obtained from uncertainty analysis. See Volume Two, Section B.8.3 for additional detail.

3.4.10.7 Implementability

Many of implementability issues identified for the ex situ alternatives would not be as well defined for the Phased Implementation alternative. Issues related to the implementability of phased implementation would include successfully producing immobilized waste that would meet waste form specifications. Successful implementation of Phase 1 would be required to start Phase 2.

Phase 1 would share some of the same implementability issues as the Ex Situ Intermediate Separations alternative because several of the processes were assumed to be similar. Performance of key processes was assumed in the absence of substantive data. Cost estimates could have a high degree of uncertainty because some of the processes are unproven.

The phased implementation approach would reduce uncertainties as compared to the other ex situ alternatives because the process would be demonstrated on a smaller scale and optimized before being used on a larger scale.

Retrieval criteria based on recovering 99 percent of the waste volume in each tank would be uncertain because hardened sludge present in some tanks could be difficult to retrieve, making it difficult to meet the retrieval criteria. This would be an implementability issue associated with Phase 2. The ability of the alternative to comply with regulatory requirements is discussed in Section 6.2.

This alternative would meet all applicable regulations for disposal of hazardous, radioactive, or mixed waste assuming that the hazardous waste components are adequately treated during waste processing or vitrification.

3.5 CESIUM AND STRONTIUM CAPSULE ALTERNATIVES

3.5.1 No Action Alternative (Capsules)

3.5.1.1 Overview

The capsules No Action alternative would involve the continued storage of the cesium capsules and strontium capsules in WESF. Current planning indicates that WESF will be maintained until approximately 2007. Selecting this alternative would require that DOE select an alternate storage method for the capsules within the next 10 years. If the No Action alternative were selected for implementation, one of the other capsule alternatives would have to be selected and implemented by 2007. This will be considered in the Cesium and Strontium Capsule Management Plan.

No Action Alternative (Capsules)

- Continue safe storage in WESF
- No remediation would be performed

3.5.1.2 Process Description

Cesium and strontium capsules would continue to be stored in water-filled basins. The capsules would continue to be monitored for signs of leakage and physical change, and the facility would be maintained to provide for continued safe management.

3.5.1.3 Construction

No major construction activities would take place under this alternative. Limited construction activities would be required to complete life extension programs required for continued safe operations.

3.5.1.4 Operations

The operational activities associated with this alternative would involve the continued storage and management of these capsules at WESF.

3.5.1.5 Post Remediation

There would be no post-remediation activities associated with the No Action alternative. Administrative controls would be assumed to be effective until another capsule alternative were implemented.

3.5.1.6 Schedule, Sequence, Cost

A schedule for major activities for this alternative is shown in Table 3.5.1. The estimated cost for this alternative is summarized in Table 3.5.2.

Table 3.5.1 Schedule - No Action Alternative (Capsules)

Activity	Schedule
Continued Operations	1997 to 2007

Table 3.5.2 Cost - No Action Alternative (Capsules)[1]

Cost Component	Total
Continued Operations	$112

Notes:
[1] Cost in millions of 1995 dollars. Cost uncertainties have not been estimated for the capsule alternatives, so no cost ranges are shown.

3.5.1.7 Implementability

Implementing this alternative would include continued storage of the capsules in WESF and present no new processes or technology challenges. This alternative would meet all applicable regulations (Section 6.2).

3.5.2 Onsite Disposal Alternative

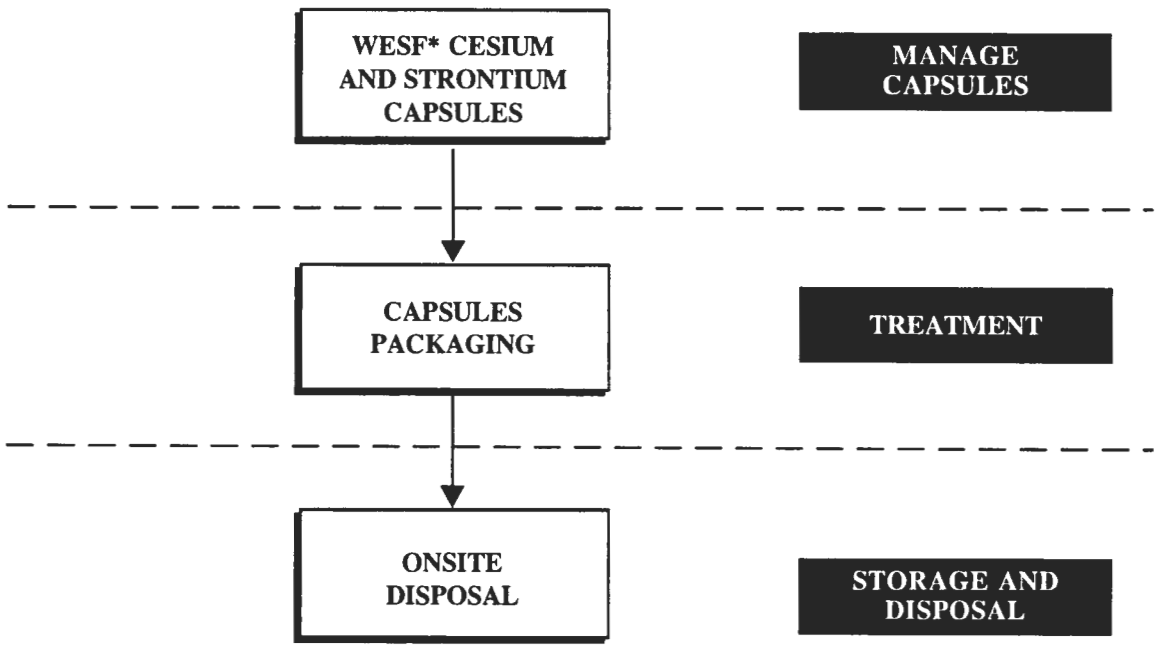
3.5.2.1 Overview

The Onsite Disposal alternative would involve removing the capsules from their current storage in water-filled basins at WESF and packaging them in 3-m [10-ft]-long canisters for onsite disposal. Disposal would consist of placing the sealed canisters into onsite engineered subsurface wells at specified intervals to provide safe, long-term, passively-cooled disposal (Figure 3.5.1). Information used in describing cesium and strontium capsule alternatives is from Disposition of Cesium and Strontium Capsules Engineering Data Package for the TWRS EIS (WHC 1995h and Jacobs 1996).

Onsite Disposal Alternative

- Retrieve capsules from WESF and package for disposal
- Dispose of in shallow subsurface drywells
- All capsules would be disposed of onsite

Figure 3.5.1 Capsules - Onsite Disposal Alternative



***WESF:** Waste Encapsulation and Storage Facility

Construction activities associated with this alternative would involve minor modifications to WESF for capsule packaging and building the Drywell Disposal Facility. Operations would involve placing the capsules into sealed canisters and placing the canisters in the drywells for disposal.

3.5.2.2 Process Description

Cesium and strontium capsules would continue to be stored in water-filled basins until the packaging and canister handling facilities were ready to begin operations. Disposal of the capsules would involve the following process steps: 1) retrieve the capsules from storage basins; 2) inspect the capsules for integrity; 3) place the capsules in a rack to support the capsule within the canister; 4) insert the capsules into canisters (three or four capsules placed in each canister); 5) seal the canisters by welding closed; 6) decontaminate and inspect the canisters; 7) place the canisters into drywells for disposal; and 8) monitor the capsules and maintain the facility.

3.5.2.3 Construction

The subsurface disposal facility would be the main construction activity for this alternative. This facility would cover approximately 3.8 hectares (ha) (9.4 acres [ac]) including a 30-m (100-ft)-

wide surrounding buffer zone. The proposed location is shown in Figure 3.5.2. The site would be leveled, and security fencing and an estimated 672 drywells would be installed (Figure 3.5.3). The drywells would be 4.6 m (15 ft) deep by 0.76 m (2.5 ft) in diameter. A steel encasement would be placed into each hole to house the canister (Figure 3.5.4). A shielded transporter vehicle would be designed and constructed to place the capsules into the drywells.

Capsule packaging operations would require modifications and upgrades to WESF. These modifications would involve installing equipment and utilities to perform remote capsule handling and packaging, as well as canister welding, decontamination, and inspection.

3.5.2.4 Operation

The major operational activities for this alternative would include the following:

- Operating the capsule/canister packaging facility;
- Transporting the canisters to the disposal facility;
- Placing the canisters into the drywells;
- Placing intrusion prevention barriers over the drywells; and
- Monitoring and maintaining the disposal facility.

3.5.2.5 Post Remediation

Post-remediation activities would consist of decontamination and decommissioning of capsule packaging facilities and closure of the disposal facility. Decontamination and decommissioning activities associated with this alternative would include facility decontamination. Contaminated equipment would be decontaminated to the extent possible and disposed of according to State and Federal regulations. Closure of the disposal facilities would involve placing intrusion prevention barriers over the drywells.

3.5.2.6 Schedule, Sequence, Cost

The schedule of major activities for this alternative is shown in Table 3.5.3. The cost associated with this alternative is shown in Table 3.5.4.

Table 3.5.3 Schedule - Onsite Disposal Alternative

Activity	Schedule
Continued Storage of Capsules in WESF	1997 to 2028
Construction of Onsite Disposal Facility	2002 to 2009
Capsule Packaging Operations	2010 to 2029
Capsule Placement in Disposal Facility	2010 to 2029
Monitoring and Maintenance	2029 to 2129

3.5.2.7 Implementability

Implementing this alternative would involve storage practices used periodically in the past and thus would present no new technology challenges.

Figure 3.5.2 Capsules - Onsite Disposal Location

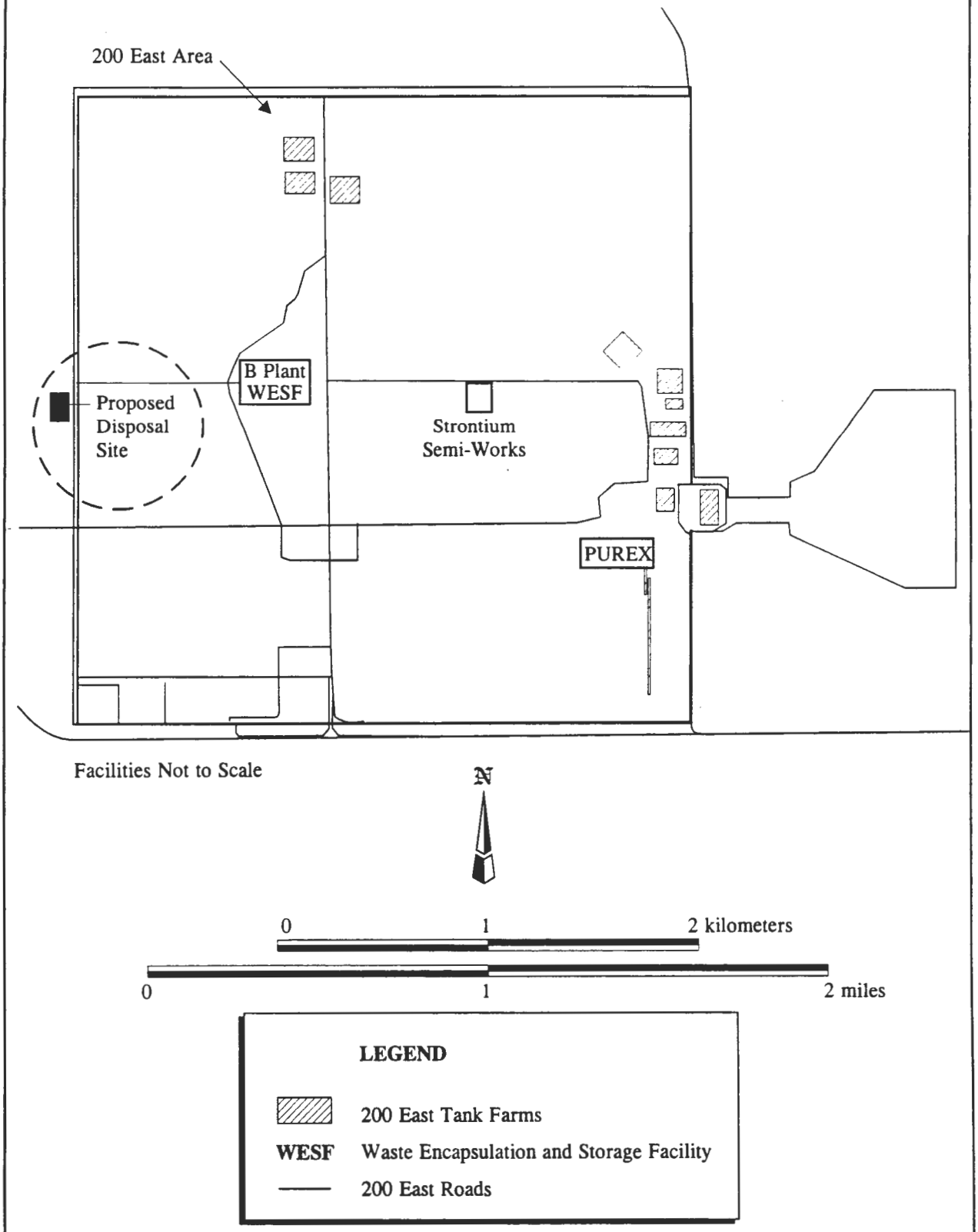
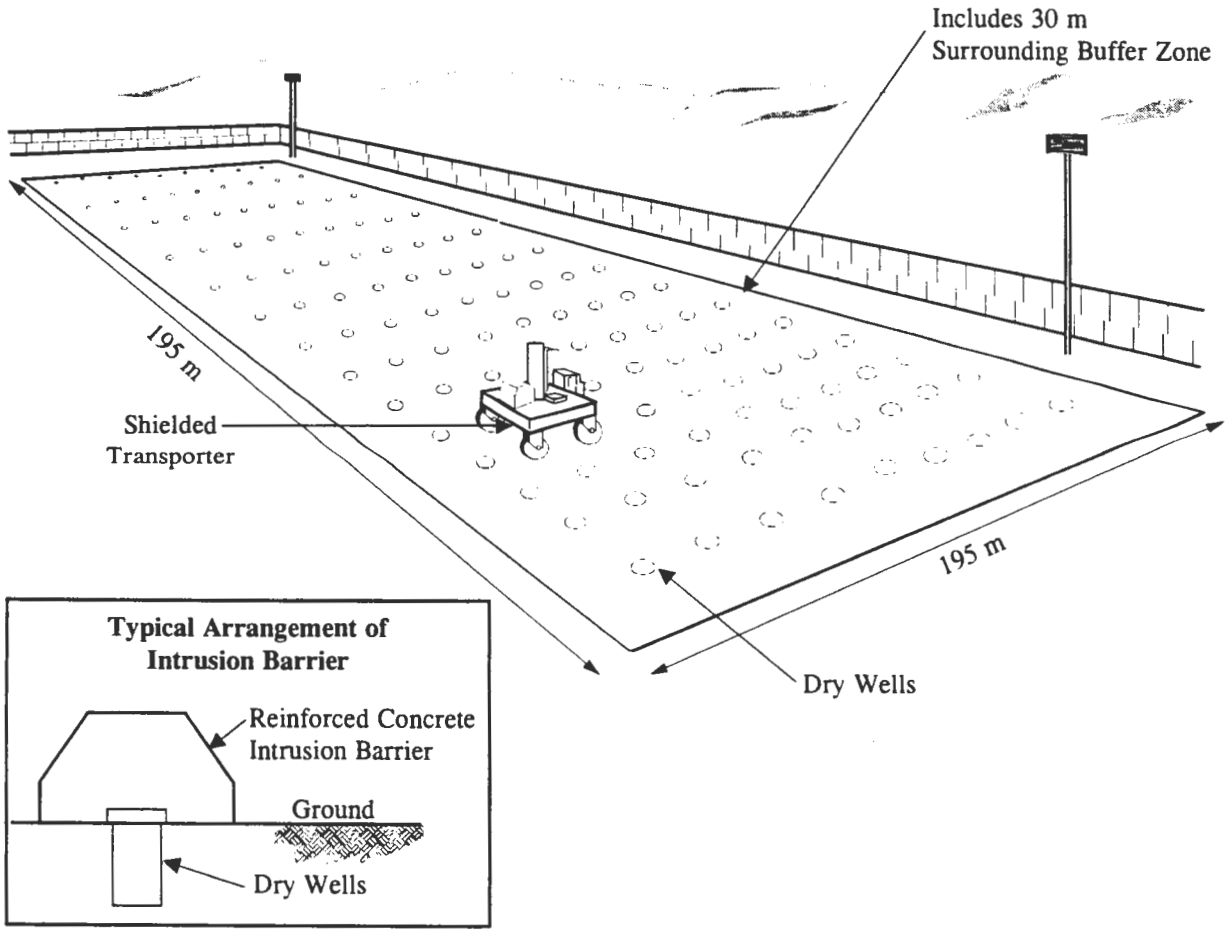


Figure 3.5.3 Capsules Onsite Disposal Arrangement (Conceptual)



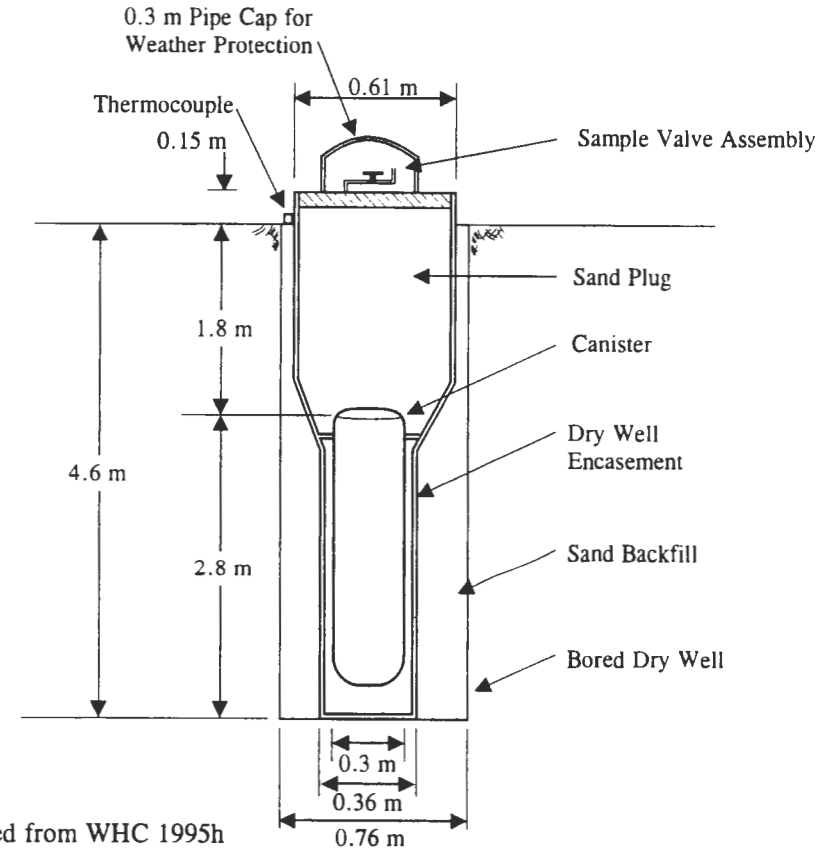
Not to Scale

Table 3.5.4 Cost - Onsite Disposal Alternative

Cost Component	Totals
Current Operations	$377
Research and Development	$19
Capital	$64
Operating [2]	$232
Closure	$5
Total	$697

Notes:
[1] Cost in millions of 1995 dollars. Cost uncertainties have not been estimated for the capsule alternatives so no cost ranges are shown.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
N/A = Not applicable

Figure 3.5.4 Capsule Dry-Well Disposal Assembly



SOURCE: Adapted from WHC 1995h

This alternative would not meet the land disposal requirements of RCRA for hazardous waste. Near-surface disposal of HLW would not meet DOE policy for disposal of readily retrievable HLW in a potential geologic repository (Section 6.2).

3.5.3 Overpack and Ship Alternative

3.5.3.1 Overview

The Overpack and Ship alternative would consist of placing the capsules into canisters (4.6 m [15 ft] long), which then would be overpacked into Hanford Multi-Purpose Canisters. Four canisters containing capsules would be placed into each Hanford Multi-Purpose Canister. The Hanford Multi-Purpose Canisters would be stored temporarily onsite pending shipment and disposal at the potential geologic repository (Figure 3.5.5).

Overpack and Ship Alternative

- Retrieve capsules from WESF and package for offsite shipment
- Ship capsules to the potential geologic repository for disposal

Construction activities for this alternative would involve modifying WESF to support capsule packaging operations. Operations would involve packaging the capsules into sealed canisters, overpacking the

canisters into Hanford Multi-Purpose Canisters for interim storage, and transporting the Hanford Multi-Purpose Canisters by rail to the potential geologic repository. Final design of the canister packaging would include design criteria for waste acceptance at the potential geologic repository.

3.5.3.2 Process Description

Cesium and strontium capsules would continue to be stored in water-filled basins until the packaging facilities were ready to begin operations. Overpacking the capsules would involve the following process steps.

1) Retrieve capsules from storage basins.
2) Inspect capsules for integrity.
3) Place capsules in a rack to support the capsule within the canister.
4) Insert capsule into canisters (three to four capsules placed in each canister).
5) Seal canister by welding closed.
6) Decontaminate and inspect canisters.
7) Overpack sealed canisters into Hanford Multi-Purpose Canisters.
8) Place canisters into storage.
9) Monitor and maintain canisters.

3.5.3.3 Construction

Capsule packaging would require minor modifications and upgrades to WESF. These modifications would involve installing equipment and utilities and modifying existing facilities to perform remote capsule handling and packaging, as well as canister welding, decontamination, and inspection activities.

Interim storage of the Hanford Multi-Purpose Canisters containing the sealed capsule canisters would require the construction of a concrete storage pad similar to the interim HLW storage pads. The interim storage location would be adjacent to the HLW interim storage associated with the tank waste Ex Situ Extensive Separations alternative or other ex situ alternatives.

3.5.3.4 Operation

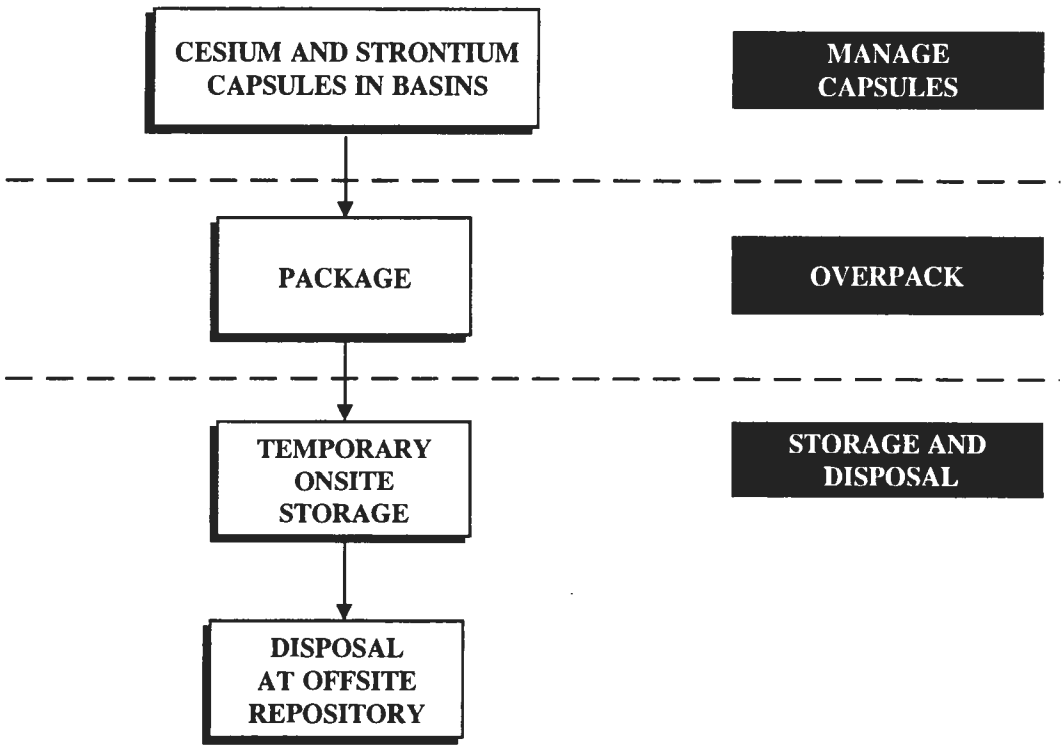
The major operational activities for this alternative would include the following.

- Remove capsules from wet storage.
- Operate packaging facility.
- Transport Hanford Multi-Purpose Canisters to onsite interim storage pad and cover with a shielding cask.
- Monitor Hanford Multi-Purpose Canisters in interim storage.
- Transport Hanford Multi-Purpose Canisters to the potential geologic repository for disposal.

3.5.3.5 Post Remediation

After all of the capsules were packaged and transported to the interim storage pad, the equipment installed for capsule handling and packaging would be decontaminated and decommissioned. After

Figure 3.5.5 Capsules - Overpack and Ship Alternative



transporting the Hanford Multi-Purpose Canisters to the repository, the storage pad associated with the interim storage of capsules would be decontaminated and decommissioned.

3.5.3.6 Schedule, Sequence, Cost

The schedule of activities for this alternative is shown in Table 3.5.5. The cost associated with this alternative is shown in Table 3.5.6.

3.5.3.7 Implementability

This alternative would use common practices, which present no new technology issues. This alternative might not meet the land disposal restrictions of RCRA because of the characteristic corrosivity of the cesium chloride and strontium fluoride. Also, assuming the waste was mixed waste, it would not meet the DOE restriction against disposal of mixed waste in the first potential geologic repository. Also, the powder waste form of the strontium fluoride would not meet the waste acceptance requirements to immobilize particulate waste (Section 6.2). Further evaluation would be required to resolve technical and programmatic concerns associated with disposal of the cesium and strontium capsules in the potential geologic repository.

Table 3.5.5 Schedule - Overpack and Ship Alternative

Activity	Schedule
Continued Storage of Capsules in Waste Storage and Encapsulation Facility	1997 to 2028
Construction for Capsule Packaging	2002 to 2009
Capsule Packaging Operations	2010 to 2028
Interim Storage	2010 to 2029
Ship to Repository	2028 to 2029

Table 3.5.6 Cost - Overpack and Ship Alternative [1]

Cost Component	Totals
Current Operations	$377
Research and Development	$14
Capital	$32
Operating [2]	$40
Closure	N/A
Total	$463

Notes:
[1] Cost in millions of 1995 dollars. Cost uncertainties have not been estimated for the capsule alternatives so no cost ranges are shown.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
N/A = Not applicable

3.5.4 Vitrify with Tank Waste Alternative

3.5.4.1 Overview

Vitrifying the capsule contents with the tank waste would involve removing the capsule contents, dissolving or suspending it in a slurry, possibly chemically processing it, and blending it into the vitrification feed stream at the HLW vitrification facility. This would combine the high-activity cesium chloride and strontium fluoride from the capsules with the HLW waste for vitrification. Following the vitrification step, the cesium and strontium would be handled in the same manner as described previously for HLW glass. This eventually would lead to offsite disposal in the potential geologic repository (Figure 3.5.6).

Vitrify with Tank Waste Alternative

- Retrieve capsules from WESF and transport to tank waste vitrification facility
- Vitrify capsule contents with high-level tank waste
- Ship to potential geologic repository for disposal with tank waste

This alternative could be implemented only if one of the ex situ alternatives involving vitrification were selected for the tank waste.

Construction activities associated with this alternative would involve installing the equipment required to remove the capsule contents, processing the cesium chloride and strontium fluoride, and feeding the capsule waste into the HLW vitrification feed stream. This equipment would be installed in a dedicated area of the HLW vitrification facility.

The capsules would be taken from their current storage location to the HLW vitrification facility where they would be cut up, possibly chemically processed, and metered into the waste stream, which would be fed to the HLW vitrification melter. Following remediation, the capsule contents would be a part of the vitrified high-level tank waste and stored onsite temporarily awaiting transport and disposal at the potential geologic repository.

3.5.4.2 Process Description

Cesium and strontium capsules would continue to be stored in water-filled basins at WESF until the HLW vitrification facility was operating and ready to accept the capsules. Vitrifying the capsule contents with the tank waste would involve retrieving the capsules from storage basins; transporting the capsules to the HLW facility in shielded transport casks; dismantling the capsules and remove the cesium and strontium salts; and blending the capsule contents into the HLW stream.

3.5.4.3 Construction

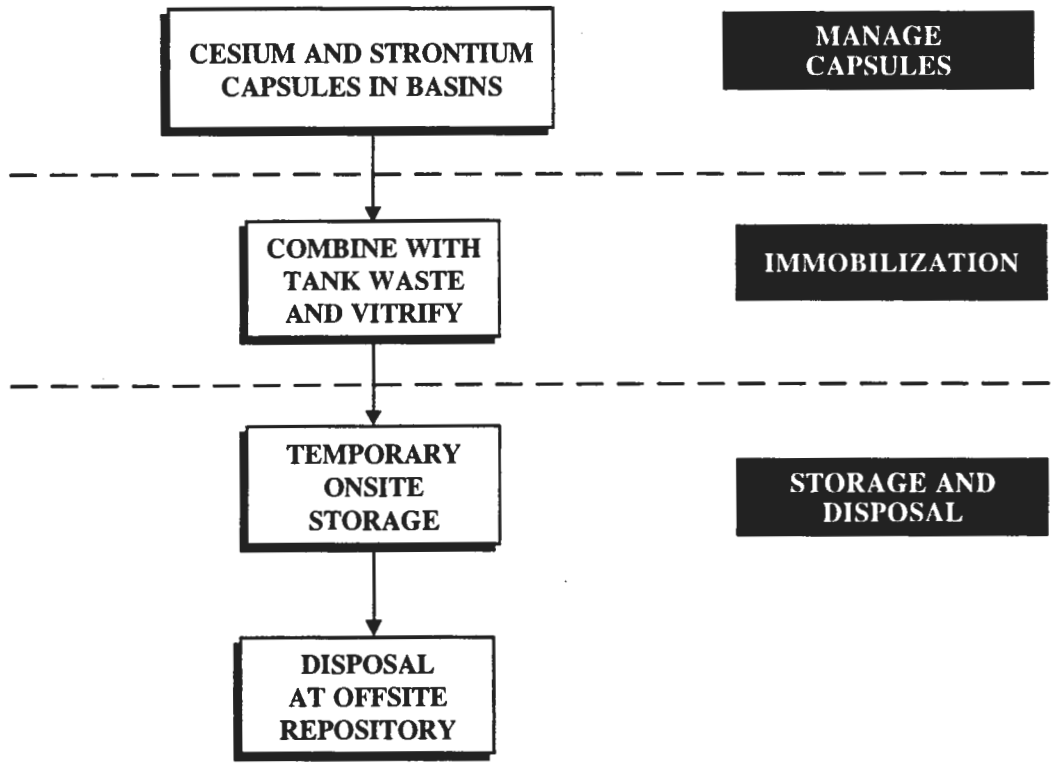
This alternative would require additional construction within the HLW vitrification facility to accommodate capsule-related activities. Construction in the HLW vitrification facility would include shielding and remote equipment to cut up the capsules, removing the contents, chemically treating the cesium chloride and strontium fluoride if required, and blending the capsule material into the HLW feed stream.

3.5.4.4 Operation

Operations for this capsule alternative would be conducted in the HLW vitrification facility and WESF and include the following.

- Continue storing the capsules in WESF until all capsules are removed.
- Remove and truck transport the capsules to the HLW vitrification facility in shielded transport casks.
- Cut up the capsules and remove the contents.
- Perform chemical processing of the capsule contents as required.
- Blend the capsule contents into the vitrification feed stream by slowly metering the dissolved cesium chloride and slurry containing strontium fluoride just before the waste enters the HLW melter.
- Decontaminate and shred the empty capsule containers.
- Dispose of the shredded capsule container materials onsite at the low-level waste burial grounds.

Figure 3.5.6 Capsules - Vitrify with Tank Waste Alternative



3.5.4.5 Post Remediation

Following vitrification, the contents of the capsules would be incorporated into the vitrified HLW. The HLW produced would be stored onsite temporarily and then transported to the potential geologic repository for permanent disposal.

After all HLW was been vitrified, the equipment and facilities dedicated to capsule processing in the HLW vitrification facility would be decontaminated and decommissioned. Contaminated equipment would be disposed of according to State and Federal regulations. The capsule facility portion of the HLW vitrification facility would be decommissioned along with the HLW vitrification facility.

3.5.4.6 Schedule, Sequence, Cost

The schedule of activities for this alternative is provided in Table 3.5.7. Cost associated with this alternative is shown in Table 3.5.8.

3.5.4.7 Implementability

This alternative could be implemented only if one of the ex situ alternatives were selected. This cesium and strontium could require chemical processing to remove the chloride and fluoride from the cesium and strontium salts. The cesium and strontium would need to meet the required feed specifications that

Table 3.5.7 Schedule - Vitrify with Tank Waste Alternative

Activity	Schedule [1]
Continued Storage of Capsules in WESF	1997 to 2023
Construction	2007 to 2012
Operating	2012 to 2028
Monitoring and Maintenance	2028 to 2040
Decontamination and Decommissioning	2028 to 2033

Notes:
[1] No schedule was provided with the capsule data package. The dates listed previously were taken from the Extensive Separations data package (WHC 1995e).

Table 3.5.8 Cost - Vitrify with Tank Waste Alternative [1]

Cost Component	Totals
Current Operations	$315
Research and Development	$5
Capital	$36
Operating [2]	$44
Closure	N/A
Total	$400

Notes:
[1] Cost in millions of 1995 dollars. Cost uncertainties have not been estimated for the capsule alternatives so no cost ranges are shown.
[2] Operating cost includes start-up, decontamination and decommissioning, and monitoring and maintenance cost.
N/A = Not applicable

would be developed for the HLW stream as part of the vitrification process. This alternative would meet all applicable regulations for disposal of hazardous, radioactive, or mixed waste assuming that the hazardous waste components were adequately treated during waste processing or vitrification.

3.6 BORROW SITE SUMMARY

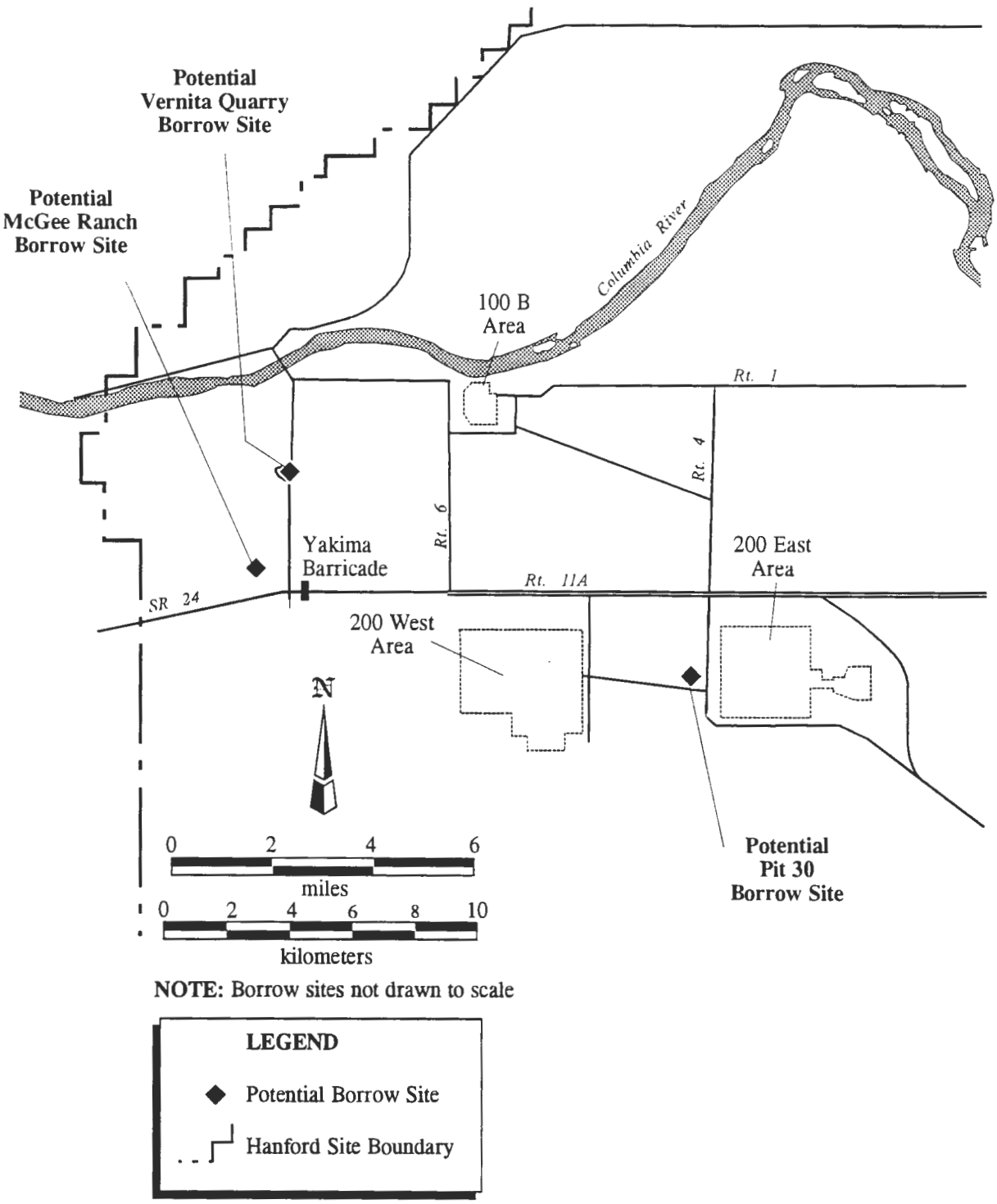
A summary of the earthen borrow materials that would be required by each of the alternatives is shown in Tables 3.6.1, 3.6.2, and 3.6.3. These tables identify the type, amount, and possible sources of the borrow. The final selection of borrow sites for earthen material has not been made; however, the locations indicated represent potential borrow sites that would support each of the alternatives in both volume and location. Future borrow site decisions will be made in future NEPA analysis. Figure 3.6.1 identifies the potential borrow site locations for the TWRS alternatives.

3.7 DISPOSAL OF HANFORD SITE HLW AT THE POTENTIAL GEOLOGIC REPOSITORY

3.7.1 Number of HLW Canisters for Disposal

The range in number of canisters that would be produced under the different alternatives would vary widely based on the amount of separations and would not agree with the current planning basis for the geologic repository. The current geologic repository technical planning baseline includes acceptance of

Figure 3.6.1 Potential Borrow Sites for TWRS



NOTE: Borrow sites not drawn to scale

LEGEND

◆ Potential Borrow Site

Hanford Site Boundary

SOURCE: Adapted from DOE 1993e

Table 3.6.1 Borrow Site Summary - Materials Used During Construction and Operations

Alternative	Borrow Type	Amount (m^3 [ft^3])	Potential Location
No Action (Tank Waste)	N/A	N/A	N/A
Long-Term Management	Aggregate/Sand	3.8E+05 (1.34E+07)	Pit 30
In Situ Fill and Cap [1]	Aggregate/Sand	7.54E+05 (2.67E+07)	Pit 30
In Situ Vitrification [1]	Aggregate/Sand	6.79E+05 (2.40E+07)	Pit 30
Ex Situ Intermediate Separations	Aggregate/Sand	1.66E+06 (5.87E+07)	Pit 30
Ex Situ No Separations:			
Vitrification	Aggregate/Sand	2.90E+06 (1.03E+08)	Pit 30
Calcination	Aggregate/Sand	1.33E+06 (4.71E+07)	Pit 30
Ex Situ Extensive Separations	Aggregate/Sand	9.50E+05 (3.36E+07)	Pit 30
Ex Situ/In Situ Combination 1 [1]	Aggregate/Sand	1.03E+06 (3.65E+07)	Pit 30
Ex Situ/In Situ Combination 2 [1]	Aggregate/Sand	1.03E+06 (3.65E+07)	Pit 30
Phased Implementation (Phase 1 only)	Aggregate/Sand	3.20E+04 (1.13E+06)	Pit 30
Phased Implementation (Phase 2)	Aggregate/Sand	1.20E+06 (4.24E+07)	Pit 30

Notes:
[1] Includes material to fill tanks that would be treated in situ.
N/A = Not applicable

Table 3.6.2 Borrow Site Summary - Materials Used for Backfill of Empty Tanks for all Ex Situ Alternatives

Alternative	Method	Kind	Amount (m^3 [ft^3])	Potential Location
Ex Situ (all)	Tank Stabilization	Aggregate	7.58E+05 (2.70E+07)	Pit 30
Ex Situ/In Situ Combination 1	Tank Stabilization	Aggregate	3.30E+05 (1.17E+07)	Pit 30
Ex Situ/In Situ Combination 2	Tank Stabilization	Aggregate	1.18E+05 (4.17E+06)	Pit 30
Phased Implementation (Phase 2)	Tank Stabilization	Aggregate	7.58E+05 (2.70E+07)	Pit 30

up to 13,200 standard sized (0.62-m^3 [22-ft^3]) canisters of defense HLW (DOE 1994g). This baseline number of HLW canisters would come from multiple DOE Sites with the number allocated to each Site based on waste inventory and volume projections. The number of canisters used for the technical planning baseline was developed using assumptions for canister size, vitrified waste volume, and the amount of the repository capacity set aside for DOE (10 percent). These assumptions resulted in identifying approximately 7,100 canisters (1,800 Hanford Multi-Purpose Canisters) for the Hanford Site. The number of canisters and Hanford Multi-Purpose Canisters that would be produced under the different alternatives would be subject to change during final design (see Table 3.7.1).

Two factors that would affect disposal of TWRS HLW in the potential geologic repository are the statutory limit on the number of metric tons of uranium or equivalent in the waste and the physical limit on the number of waste packages that would require placement in the potential geologic repository. Allex situ alternatives would process the same waste and would contain approximately the same amount

Table 3.6.3 Borrow Site Summary - Materials Used for Construction of Hanford Barriers

Alternative	Borrow Kind	Amount (m^3 [ft^3])	Potential Location
In Situ Fill and Cap, In Situ Vitrification, Ex Situ No Separations [1]	Silt	3.77E+05 (1.30E+07)	McGee Ranch
	Riprap	6.38E+05 (2.30E+07)	Vernita Quarry
	Aggregate/Sand	4.24E+05 (1.50E+07)	Pit 30
Ex Situ Intermediate Separations, Extensive Separations, or Phased Implementation (Phase 2) [2]	Silt	5.66E+05 (2.0E+07)	McGee Ranch
	Riprap	9.85E+05 (3.48E+07)	Vernita Quarry
	Aggregate/Sand	5.81E+05 (2.06E+07)	Pit 30
Ex Situ/In Situ Combination 1[2]	Silt	4.72E+05 (1.67E+07)	McGee Ranch
	Riprap	7.85E+05 (2.8E+07)	Vernita Quarry
	Aggregate/Sand	5.16E+05 (1.83E+07)	Pit 30
Ex Situ/In Situ Combination 2[2]	Silt	4.25E+05 (1.50E+07)	McGee Ranch
	Riprap	7.18E+05 (2.54E+07)	Vernita Quarry
	Aggregate/Sand	4.82E+05 (1.71E+07)	Pit 30

Notes:
[1] Includes materials to construct barriers over tank farms.
[2] Includes materials to construct barriers over tank farms and the LAW disposal vaults.
N/A = Not applicable

of uranium or equivalent. The alternatives that generate fewer Hanford Multi-Purpose Canisters than the geologic repository planning baseline would have little or no physical limitation on repository placement. The alternatives that greatly exceed the number of Hanford Multi-Purpose Canisters used in the geologic repository planning baseline could exceed the physical limitations of the potential geologic repository.

3.7.2 HLW Disposal Cost

Repository fees for alternatives that included shipment of HLW to the potential geologic repository were based on analysis performed by the Office of Civilian and Radioactive Waste Management in support of the TWRS EIS (Milner 1996a). This analysis was performed using a consistent methodology, as used by the Civilian Radioactive Waste Management Program in development of the Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program of September 1995 (DOE 1995u). Life cycle cost estimates for four alternative scenarios were provided for disposal of vitrified HLW from the Hanford Site. The four alternatives varied the volume and HLW canister sizes from the 1995 Total System Life Cycle Cost estimate basis. The analysis included estimates for two new HLW waste packages, two new transportation casks, and estimates of changes to repository surface facilities, subsurface impacts, transportation, and other program cost elements. The analysis provided scoping level detail, scaled from the detailed point estimate reported in the 1995 Total System Life Cycle Cost analysis.

Table 3.7.1 HLW Disposal Fees

Alternative	Canister Size	Number of Canisters	Number of Waste Hanford Multi-Purpose Canisters[1]	Disposal Fee[2]
Ex Situ Intermediate Separations	1.2 m^3 (41 ft^3)	12,200	3,050	$5,280
Ex Situ No Separations Vitrification	10 m^3 (360 ft^3)	29,100	29,100	$38,900
Ex Situ No Separations Calcination	10 m^3 (360 ft^3)	10,300	10,300	$14,630
Ex Situ Extensive Separations	1.2 m^3 (41 ft^3)	570	143	$270
Ex Situ/In Situ Combination 1	1.2 m^3 (41 ft^3)	8,500	2,130	$3,710
Ex Situ/In Situ Combination 2	1.2 m^3 (41 ft^3)	4,900	1,230	$2,150
Phased Implementation	1.2 m^3 (41 ft^3)	12,200	3,050	$5,280
Capsules - Overpackaged Ship	1.2 m^3 (41 ft^3)	400	100	$124
Capsules - Vitrify with Tank Waste	1.2 m^3 (41 ft^3)	342	86	$111

Notes:
[1] Hanford Multi-Purpose Canisters are the assumed packaging configuration for placement of canistered HLW in a geologic repository. One Hanford Multi-Purpose Canister would be placed into a disposal waste package at the geologic repository and would contain four 1.17-m^3 (41-ft^3) canisters or one 10-m^3 (360-ft^3) canister.
[2] Cost in millions of 1995 dollars.

Estimates of the total defense share, based on application of the 1987 Federal Register methodology were provided in the cost estimate report. Allocating the defense share between the Hanford Site and other defense sites was estimated by the ratio of the number of Hanford Site waste packages to the total number of defense waste packages. A waste package consists of up to four canisters of HLW and is equivalent to a Hanford Multi-Purpose Canister from a quantity standpoint. Repository fees for alternatives that were not addressed in the Office of Civilian and Radioactive Waste Management report were estimated by extrapolating data from the estimate. The estimated disposal fees for placement of HLW in the potential geologic repository are shown in Table 3.7.1. For additional detail see Volume Two, Section B.10.

3.8 COMPARISON OF ACTIVITIES ASSOCIATED WITH THE ALTERNATIVES

The alternatives described in this section provided a range of alternatives from continued storage under the No Action alternative to retrieval and treatment of as much of the waste as practical under the ex situ alternatives. These alternatives also provided for varying levels of waste treatment from containment under the In Situ Fill and Cap alternative to extensive immobilization of all retrieved waste

using vitrification under the Ex Situ Intermediate Separations alternative. It should be recognized that there are differences in the level of development between the alternatives, which means there are additional uncertainties associated with the data for some of the alternatives.

Closure for each of the alternatives (except No Action and Long-Term Management) is described to assess the cumulative impacts only. Each of the alternatives included continued routine operations, which included monitoring, maintenance, and waste management activities. Closure will be the subject of future NEPA decision making.

Major activities for each of the tank waste alternatives are summarized as follows:

- No Action alternative:
  - The waste would be left in the current state. Current operations would be continued for 100 years, at which time administrative control would assumed to be lost.
- Long-Term Management alternative:
  - The SST waste would remain in the current state.
  - DST waste would be retrieved and transferred to replacement DSTs at 50-year intervals (two times) during the 100-year period.
  - Current operations would be continued for 100 years, at which time administrative control would assumed to be lost.
- In Situ Fill and Cap alternative:
  - All of the tank waste would remain onsite where it would be disposed of in place following DST waste evaporation and tank stabilization operations.
  - No measures would be taken to immobilize the waste.
  - Minimal construction would be required (no Tank Farm Confinement Facilities are assumed to be required).
- In Situ Vitrification alternative:
  - All of the tank waste would remain onsite where it would be vitrified (turned into glass) and disposed of in place.
  - Considerable construction would be involved in building the Tank Farm Confinement Facilities over each tank farm.
  - In Situ Vitrification has not been attempted on this scale before and would require development.
- Ex Situ Intermediate Separations alternative:
  - Major construction would be involved building the retrieval systems and processing, disposal, and support facilities.
  - All tank waste practicable (assumed to be 99 percent) would be retrieved and processed into vitrified HLW or LAW.
  - LAW would be vitrified and disposed of onsite in a retrievable manner in near-surface vaults, and HLW would be vitrified and shipped to the potential geologic repository for final disposal.

- Ex Situ No Separations (Vitrification or Calcination) alternative:
  - Major construction would be involved with building the retrieval systems, HLW processing facility, and support facilities.
  - All tank waste practicable (assumed to be 99 percent) would be retrieved and processed into vitrified or calcined HLW.
  - All recovered waste would be disposed of in the potential geologic repository.
- Ex Situ Extensive Separations alternative:
  - Major construction would be involved with building the retrieval, processing, and disposal facilities.
  - All tank waste practicable (assumed to be 99 percent) would be retrieved and processed into vitrified HLW or vitrified LAW.
  - The volume of HLW requiring transportation and disposal would be minimized by extensive separations of waste into HLW and LAW streams.
  - HLW would be disposed of at the potential geologic repository and LAW would be disposed of onsite in vaults.
- Ex Situ/In Situ Combination 1 alternative:
  - Tanks would be selected for retrieval and processing based on their potential contribution to long-term risk.
  - This alternative would use a combination of in situ and ex situ waste treatment aimed at achieving acceptable risk levels at a lower cost than ex situ treatment of all tank waste.
  - Using the aforementioned assumption, the waste from approximately 70 of the tanks would be retrieved and the remaining tanks would be filled and disposed of in place.
  - Considerable construction would be involved in building retrieval systems, processing, and disposal facilities. These facilities would be similar in type, but smaller than those described for the Ex Situ Intermediate Separations alternative.
  - Retrieved HLW would be vitrified and shipped to the potential geologic repository; retrieved LAW would be vitrified and disposed of onsite in vaults; and waste that is not recovered would be disposed of in place.
- Ex Situ/In Situ Combination 2 alternative:
  - Tanks would be selected for retrieval and processing based on their potential contribution to long-term risk.
  - This alternative would use a combination of in situ and ex situ waste treatment aimed at achieving acceptable risk levels at a lower cost than the Ex Situ/In Situ Combination 1 alternative.
  - Using the aforementioned assumption, the waste from approximately 25 of the tanks would be retrieved and the remaining tanks would be filled and disposed of in place.
  - Considerable construction would be involved in building retrieval systems, processing, and disposal facilities. These facilities would be similar in type,

but smaller than those described for the Ex Situ Intermediate Separations alternative.

- Retrieved HLW would be vitrified and shipped to the potential geologic repository; retrieved LAW would be vitrified and disposed of onsite in vaults; and waste that was not recovered would be disposed of in place.

- Phased Implementation alternative:

  Phase 1

  - Two demonstration-scale processing facilities would be constructed. One facility would process LAW, and one facility would process both LAW and HLW.
  - Selected HLW would be retrieved and processed.
  - Immobilized HLW and LAW would be stored onsite for disposition during Phase 2.

  Phase 2

  - Major construction would be involved with building the retrieval, processing, disposal, and support facilities.
  - All tank waste practicable (assumed to be 99 percent) would be retrieved and processed into vitrified HLW or LAW.
  - LAW would be vitrified and disposed of in a retrievable manner onsite in near-surface vaults. HLW would be vitrified and shipped to the potential geologic repository for final disposal.

Major activities for each of the capsule alternatives are summarized as follows:

- No Action alternative:
  - Storage of capsules would continue in WESF for a period of 10 years, at which time one of the other alternatives would have to be implemented.
- Onsite Disposal alternative:
  - Capsules would be retrieved, packaged into canisters (3 m [10 ft] long), and placed in drywells for indefinite storage.
  - Monitoring and maintenance would continue for 100 years, at which time administrative control is assumed to be lost.
- Overpack and Ship alternative:
  - Capsules would be retrieved and packaged into sealed canisters (4.5 m [15 ft] long).
  - Canisters would be overpacked into Hanford Multi-Purpose Canisters for interim storage and disposal at the potential geologic repository.
- Vitrify with Tank Waste alternative:
  - Capsules would be retrieved, cut up, and the contents would be vitrified with the HLW from the tanks.
  - This alternative assumes that a tank waste alternative using ex situ vitrification would be selected.

- Following vitrification, the capsule waste would become part of the vitrified HLW for disposal at the potential geologic repository.

A comparison of the waste volumes produced, schedule, and cost for the alternatives is presented in Table 3.8.1 for tank waste and in Table 3.8.2 for capsules.

Table 3.8.1 Comparison of Tank Waste Alternatives

Alternative	Onsite Disposal Volume (m^3)	Activity of LAW Disposed Onsite[5] (MCi)	Offsite Disposal Volume (m^3)	Waste Treatment Operations Beginning-Ending Year	Estimated Alternative Treatment Cost Range [1] (Total Cost Range)
No Action	N/A	N/A	N/A	N/A	$12,555 - $16,083
Long-Term Management	N/A	N/A	N/A	N/A	$18,962 - $23,208
In Situ Fill and Cap	50,000	177	0	2000 to 2009	$6,973 - $8,816
In Situ Vitrification	3,800,000 [2]	177	0	2005 to 2016	$15,933 - $27,434
Ex Situ Intermediate Separations	351,000	16.8	14,200	2004 to 2022	$23,887 - $29,950 ($29,037 - $35,145)
Ex Situ No Separations:					
Vitrification	0	0	291,000	2006 to 2020	$22,646 - $27,717 ($59,184 - $74,538)
Calcination	0	0	67,000	2006 to 2020	$20,776 - $25,642 ($35,185 - $42,524)
Ex Situ Extensive Separations	349,000	0.320	667	2004 to 2023	$26,935 - $37,464 ($27,205 - $37,734)
Ex Situ/In Situ Combination 1	320,600 [3]	14.3	9,990	2005 to 2023	$18,322 - $23,266 ($22,132 - $26,983)
Ex Situ/In Situ Combination 2	491,900 [4]	10.4	5,780	2004 to 2022	$14,442 - $17,733 ($16,617 - $19,870)
Phased Implementation	351,000	16.8	14,300	2002 to 2028	$25,091 - $33,010 ($30,388 - $38,148)

Notes:
[1] Cost is in million of 1995 dollars. Treatment cost range shown does not include repository fee. Total cost range includes treatment cost plus repository fee.
[2] Includes vitrification of the soil between the tanks throughout the tank farm.
[3] Includes 105,600 m^3 of waste disposal in situ and 219,000 m^3 of vitrified LAW disposed of in vaults.
[4] Includes 366,900 m^3 of waste disposal in situ and 125,000 m^3 of vitrified LAW disposed of in vaults.
[5] Does not include tank residuals for ex situ alternatives
MCi = Megacurie (1 MCi = 1 million curies)
N/A = Not applicable

3.9 ALTERNATIVES CONSIDERED BUT DISMISSED

The evaluation of alternatives to dispose of tank waste has been an ongoing effort since recognizing that waste storage in underground tanks is a temporary solution to a long-term problem. One of the most recent and comprehensive analyses of the options available for tank waste disposal is the Tank Waste Technical Options Report (Boomer et al. 1993).

Table 3.8.2 Comparison of Capsule Alternatives

Alternative	Final Disposal Location	Waste Treatment Schedule Beginning-Ending Year	Estimated Treatment Cost [2] (Total Cost)
No Action	N/A	N/A	$112
Onsite Disposal	Onsite	2010 to 2029 [1]	$697
Overpack and Ship	Potential geologic repository	2010 to 2028	$463 ($587)
Vitrify with Tank Waste	Potential geologic repository	2012 to 2028	$400 ($511)

Notes:
[1] Capsule packaging operations only no waste treatment.
[2] Cost is in millions of 1995 dollars. Cost uncertainties have not been estimated for the capsule alternatives so no cost ranges are shown.
N/A = Not applicable

The public scoping process resulted in identifying several technologies and alternatives for consideration. Several technologies and alternatives were included in the alternatives presented in this section. Others were addressed in the EIS as technologies available for consideration by decision makers (Volume Two, Appendix B).

Other technologies and alternatives were dismissed from detailed consideration. These are presented in Volume Two, Appendix C along with the reasoning behind dismissal of the technology.

The criteria used to evaluate alternatives for consideration in the EIS involved asking the following questions.

- Is the alternative within the scope of the EIS?
- Is the alternative technically viable and practicable?
- Can the alternative be designed to be protective of human health and the environment with reasonable mitigative measures?
- Is the technology sufficiently mature to allow detailed evaluation?

The dismissed specialized alternatives, or alternatives that proposed exceptional treatment or disposal components, included the following:

- Seabed disposal, space disposal, deep hole disposal, ice sheet disposal, and island disposal;
- Geologic disposal of tank contents, tanks, equipment and contaminated soil;
- Rock melting or injecting the waste into a deep mined cavity; and
- Transmutation.

Alternatives identified during the public scoping process for this EIS but dismissed from further consideration included the following:

- Grouting the retired canyon facilities with hot grout;
- Launching to the sun, seabed subduction, deep hole disposal; and

- Disposing of glass logs in grout vaults and allowing solids in tanks to decay.

Specific technologies identified in the public scoping process for this EIS but dismissed from further consideration include the following:

- Using contaminated lead or steel from onsite for HLW containers;
- Building an unenclosed furnace in the ground;
- Using clinkers or marbles, not ingots, for vitrified waste;
- Placing marbles or clinkers into casks of currently contaminated steel and concrete;
- Filling the interstitial space around clinkers or marbles with lead or graphite from material onsite; and
- Burning the waste in a breeder reactor or at a Washington Public Power Supply System reactor.

Numerous technologies were examined for the retrieval, transfer, separations, and immobilization of the tank waste. Those technologies examined and dismissed are discussed in Volume Two, Appendix C.

Affected Environment

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4.0 AFFECTED ENVIRONMENT

SECTION HIGHLIGHTS

- Description of existing environmental conditions in the areas potentially impacted by the EIS alternatives.
- Topics covered include the following:

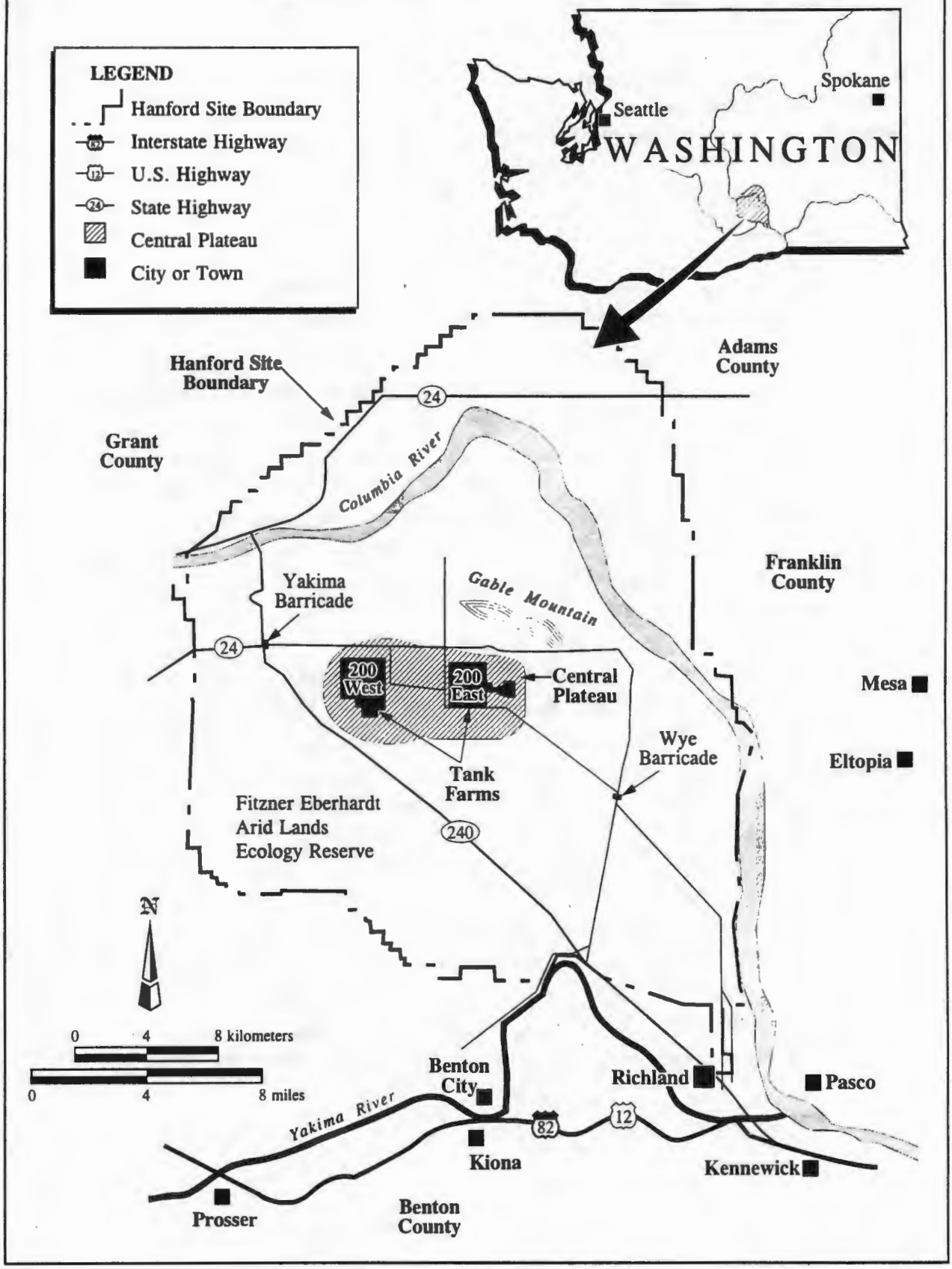
Geology	Land Use
Water Resources	Visual Resources
Climate and Air Quality	Noise
Biology and Ecology	Transportation
Resources	Radiological Environment
Socioeconomics	

This section provides a summary description of the existing environment that could be impacted by the Tank Waste Remediation System (TWRS) activities at the Hanford Site. More detailed descriptions of environmental baseline conditions are provided in Volume Five, Appendix I of this Environmental Impact Statement (EIS), in the Hanford Site National Environmental Policy Act Characterization Report (Cushing 1994 and 1995 and Neitzel 1996), in the Hanford Site Environmental Report for Calendar Years 1994 and 1995, (PNL 1995 and 1996), and in the Site Evaluation Report for Candidate Basalt Quarry Sites (Duranceau 1995). All information contained in this section is from these sources unless otherwise noted.

The Hanford Site is in the semi-arid region of the Columbia Plateau in southeastern Washington State (Figure 4.0.1). The Hanford Site occupies about 1,450 square kilometers (km^2) (560 square miles [mi^2]) of shrub-steppe and grasslands just north of Richland, Washington. The majority of this large land area, with restricted public access, provides a buffer to the smaller areas within the Hanford Site historically used for producing nuclear materials, waste storage, and waste disposal. About 6 percent of the land has been disturbed and is actively used. The Hanford Site extends approximately 77 kilometers (km) (48 miles [mi]) north to south and 61 km (38 mi) east to west.

The Columbia River flows through the northern part of the Hanford Site, turning south to form part of its eastern boundary. The Yakima River runs along part of the southern boundary and joins the Columbia River within the city of Richland. Adjoining lands to the west, north, and east are principally range and agricultural land. The cities of Richland, Kennewick, and Pasco (also known as the Tri-Cities) comprise the nearest population centers and are located southeast of the Site.

Figure 4.0.1 Hanford Site Map and Vicinity



4.1 GEOLOGY

The geology section, which provides an overview of the Hanford Site's subsurface environment, focuses primarily on the 200 Areas, which are located in the center of the Site. With the exception of two potential borrow sites found approximately 6.5 km (4 mi) to the north and west of the 200 Areas and a third potential borrow site located between the 200 East and 200 West Areas, the 200 Areas would be the location of virtually all TWRS activities under all tank waste and cesium and strontium capsule alternatives. The section describes Hanford Site topography, geologic structure, stratigraphy, soil, and seismicity (including earthquake history). Reports by Delaney (Delaney et al. 1991), Reidel (Reidel et al. 1992), and Cushing (Cushing 1994), summarize information collected in various earlier Hanford Site projects and are the primary basis for the material presented.

Geologic Information

The Hanford Site is underlain by basalt flows. Sedimentary layers referred to as the suprabasalt sediments lie on top of the basalts. A thin layer of silt, sand, and gravel is found on the surface across much of the Site.

Soil in the 200 Areas consists of sand, loamy sand, and sandy-loam soil types.

Soil in the 200 Areas and at other locations on the Hanford Site is contaminated by various radionuclides.

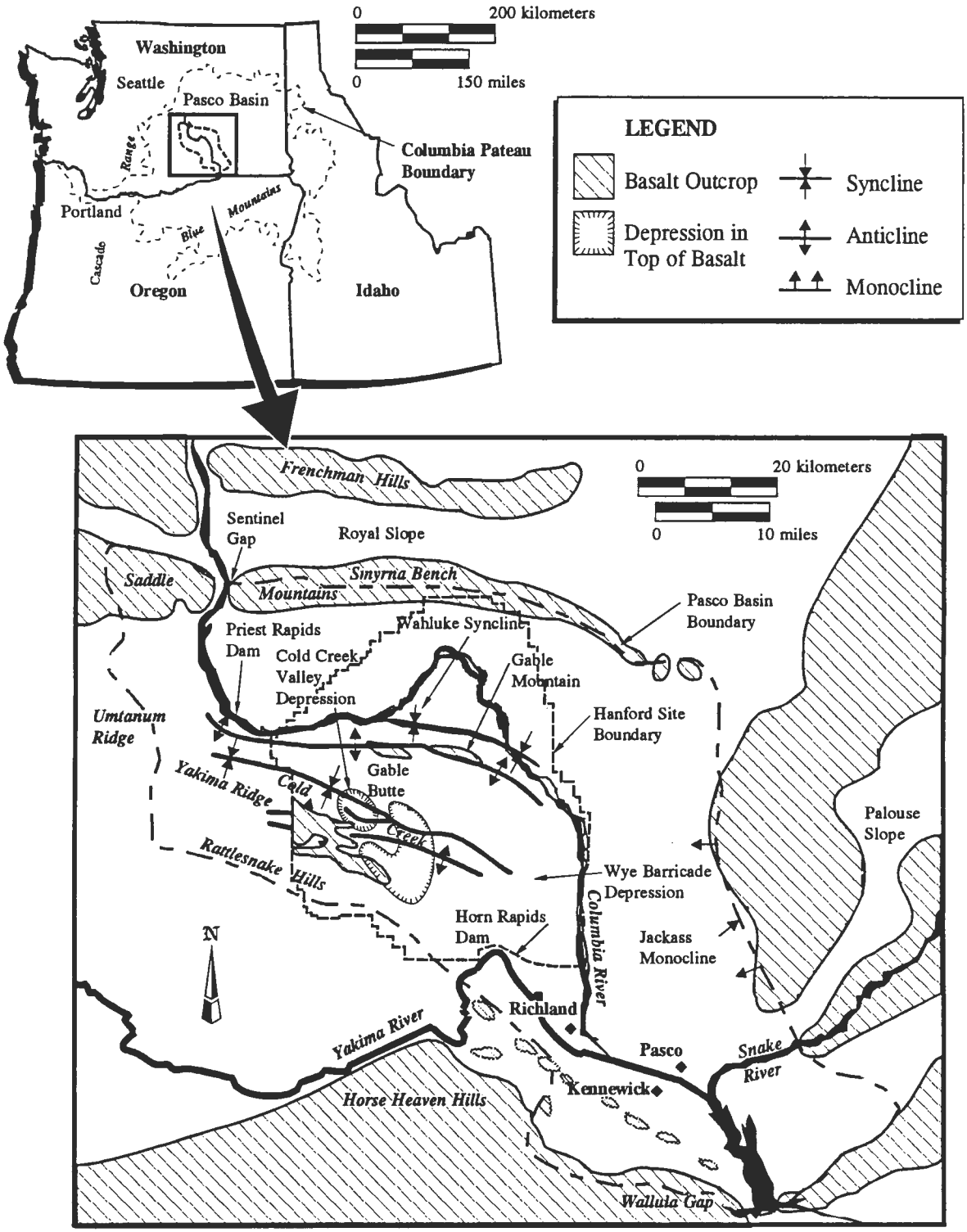
The Hanford Site is in an area of low seismic activity compared to other portions of the Pacific Northwest.

4.1.1 Topography

The TWRS sites are located on and near a broad flat area of the Hanford Site commonly referred to as the Central Plateau. The Central Plateau is within the Pasco Basin, a topographic and structural depression in the southwest corner of the Columbia Basin, characterized by generally low-relief hills with deeply incised river drainage (Figure 4.1.1). The Hanford Site is an area of generally low relief, ranging from 120 meters (m) (390 feet [ft]) above mean sea level at the Columbia River to 230 m (750 ft) above mean sea level in the vicinity of the TWRS sites.

Geologic processes that alter topography include landslides, floods, and volcanic activity. Landslides are not a common occurrence in the 200 Areas because of flat topography, the deep water table, and the absence of any actively eroding streams. The nearest potential flooding source to the TWRS sites is Cold Creek, located in the southwest portion of the Hanford Site. Studies of the probable maximum flood show its effect would be limited to the southwestern corner of the 200 West Area (Cushing 1994). The potential McGee Ranch and Vernita Quarry borrow sites, possible sources of rip rap (Vernita) and silt (McGee) for post-remediation surface barrier construction, are located in the northwest corner of the Hanford Site and are not within the probable maximum flood area (Figure 3.6.1) (Cushing 1994). The third potential borrow site (Pit 30) is located on the Central Plateau between the 200 East and 200 West Areas and is well removed from potential flooding sources. The only likely source of volcanic activity that could impact the TWRS sites would be volcanism in the Cascade Mountain Range more than 100 km (60 mi) west of the Hanford Site. The 1980 eruption of Mount St. Helens is an example of such a volcanic event. This eruption caused ashfalls at the Site but had no other effect.

Figure 4.1.1 Geographic Setting and General Structural Geology of the Pasco Basin and Hanford Site



SOURCE: Adapted from Lindsay 1992

4.1.2 Geologic Structure

The Hanford Site lies in the Pasco Basin near the eastern boundary of the Yakima Fold Belt. The Pasco Basin is bounded by anticlinal ridges on the north, west, and south. A monocline bounds the east. The Pasco Basin is divided by the Gable Mountain anticline, and the Wahluke syncline to the north and the Cold Creek syncline to the south.

The 200 Areas are situated between the Gable Mountain anticline and the Cold Creek syncline. The Gable Mountain anticline is of particular importance to the groundwater flow. Portions of this anticline have been uplifted to a point where basalt is above the current water table (Figure 4.1.1). These basalts have a low hydraulic conductivity and act as a barrier to horizontal groundwater flow in the unconfined aquifer.

Geologic Terms

Basalt is a dark to medium-dark rock that is volcanic in origin.

Stratigraphy refers to the origin, composition, distribution, and sequence of different layers or strata of rock or earth.

Suprabasalt sediments at the Site are a series of sedimentary layers that overlie the basalt.

Synclines, **anticlines**, and **monoclines** refer to folds in the layers of a geologic structure.

Topography refers to the general configuration of a land surface (e.g., hills, valleys) including its relief and its natural and human-made features.

4.1.3 Stratigraphy

Hanford Site stratigraphy is summarized in Figure 4.1.2. A generalized west to east cross-section depicting the Site's structure and topography is shown as Figure 4.1.3. Basalt flows more than 3,000 m (10,000 ft) thick, called the Columbia River Basalt Group, lie beneath the Hanford Site. Interbedded between many of these basalt flows is the Ellensburg Formation, a series of sand, gravel, or silt layers deposited by the ancestral Clearwater and Columbia rivers. The stratigraphy beneath the Hanford Site is described in the following paragraphs in ascending order, from the deepest formation directly overlying the Columbia River Basalt Group upward to the ground surface.

The suprabasalt sediments are a sedimentary sequence up to 230 m (750 ft) thick overlying the Columbia River Basalt Group, and include the Ringold and Hanford Formations.

Thin, laterally discontinuous alluvial deposits, referred to as the Plio-Pleistocene unit, pre-Missoula gravels, and early Palouse soil, separate the Ringold Formation from the overlying Hanford Formation in various parts of the Hanford Site. Alluvial deposits are sediments deposited by flowing water. Of particular note is the Plio-Pleistocene Unit, which in the TWRS project vicinity is generally restricted to the 200 West Area. Depending on location, two types of material may be present in the Plio-Pleistocene unit. It may consist either of carbonate-cemented silt (locally referred to as a caliche layer) interfingered with sand and gravel, or of carbonate-poor silt and sand interfingered with basaltic material, sand and gravel, or both (Trent 1992a).

Figure 4.1.2 Generalized Stratigraphy of the Hanford Site

Period	Epoch	Group	Formation	Isotopic Age Dates Years x 10^6	Member (Formal and Informal)	Sediment Stratigraphy or Basalt Flows	
Quaternary	Holocene				Surficial Units	Loess; Sand Dunes; Alluvium and Alluvial Fans; Land Slides; Talus; Colluvium	
	Pleistocene		Hanford		Touchet beds / Pasco Gravels		
Tertiary						Plio-Pleistocene Unit	
	Pliocene		Ringold				
	Miocene	Columbia River Basalt Group	Saddle Mountains Basalt	8.5	Ice Harbor Member	basalt of Goose Island basalt of Martindale basalt of Basin City	
						Levey interbed	
				10.5	Elephant Mountain Member	basalt of Ward Gap basalt of Elephant Mountain	
						Rattlesnake Ridge interbed	
				12.5	Pomona Member	basalt of Pomona	
						Selah interbed	
					Esquarzel Member	basalt of Gable Mountain	
						Cold Creek interbed	
				13.5	Asatin Member	basalt of Huntzinger	
					Wilbur Creek Member	basalt of Laowai basalt of Wahluke	
					Umatilla Member	basalt of Sillusi basalt of Umatilla	
				14.5		Mabion interbed	
			Wanapum Basalt		Priest Rapids Member	basalt of Lolo basalt of Rosalia	
						Quincy interbed	
					Roza Member	basalt of Roza	
						Squaw Creek interbed	
					Frenchman Springs Member	basalt of Lyons Ferry basalt of Sentinel Gao basalt of Sand Hallow basalt of Silver Falls basalt of Ginkgo basalt of Palouse Falls	Ellensburg Formation
				15.6		Vantage interbed	
			Grande Ronde Basalt*		N_2: Sentinel Bluffs Unit	basalt of Museum basalt of Rocky Coulee basalt of Levering basalt of Cohassett basalt of Birkett basalt of McCoy Canyon	
				16.5	N_2: Umtanum Unit	basalt of Umtanum	
					N_2: Stack Canyon Unit		
					N_2: Ortley Unit	basalt of Benson Ranch	
					R_2: Grouse Creek Unit		
					R_2: Waoshita Ridge Unit		
					R_2: Mt. Horrible Unit		
					N: China Creek Unit		
					R_1: Teepee Butte Unit		
					R_1: Buckham Spring Unit		
				17.5	Rock Creek Unit		
			Imnaha		American Bar Unit		

*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named.
N_2, R_2 are magneiostratigraphic units.
SOURCE: DOE 1993b

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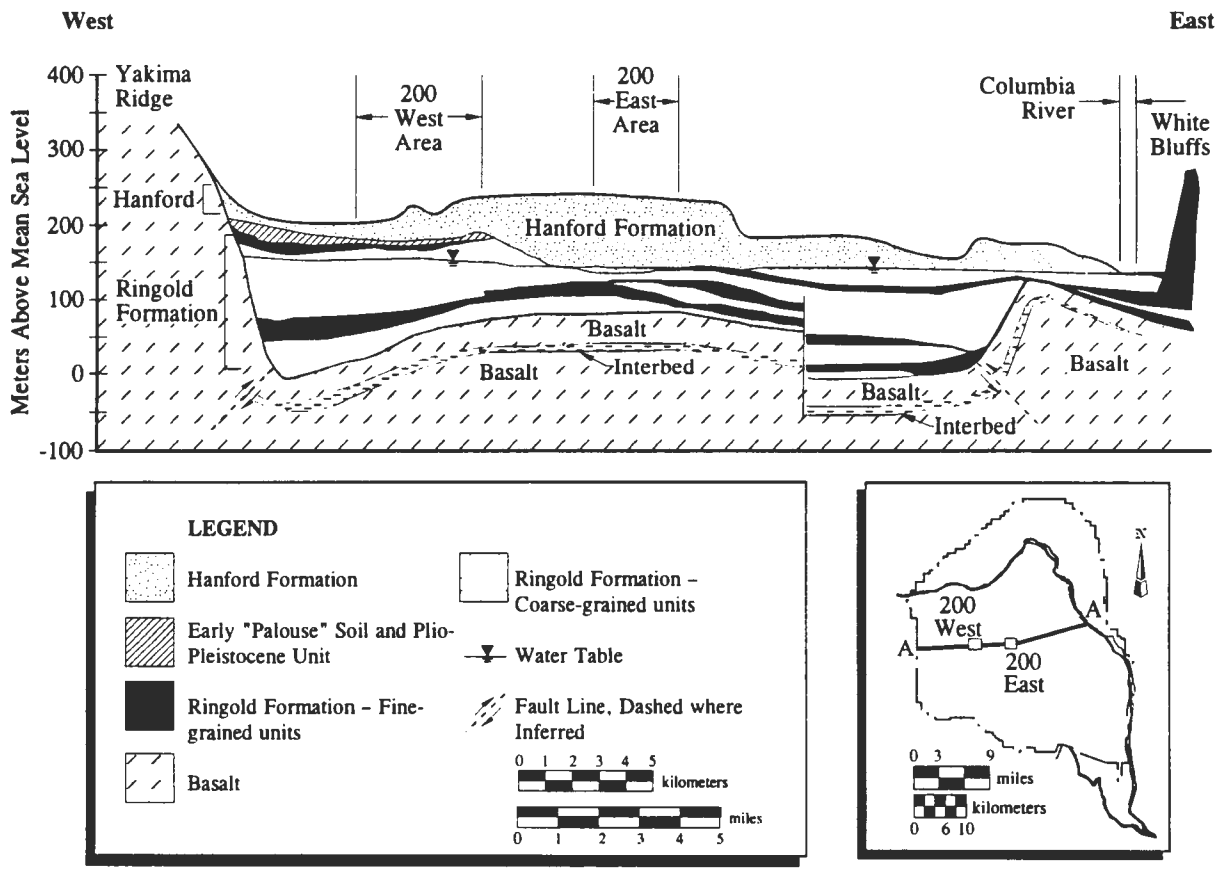
Figure 4.1.3 Geologic Cross Section of the Hanford Site

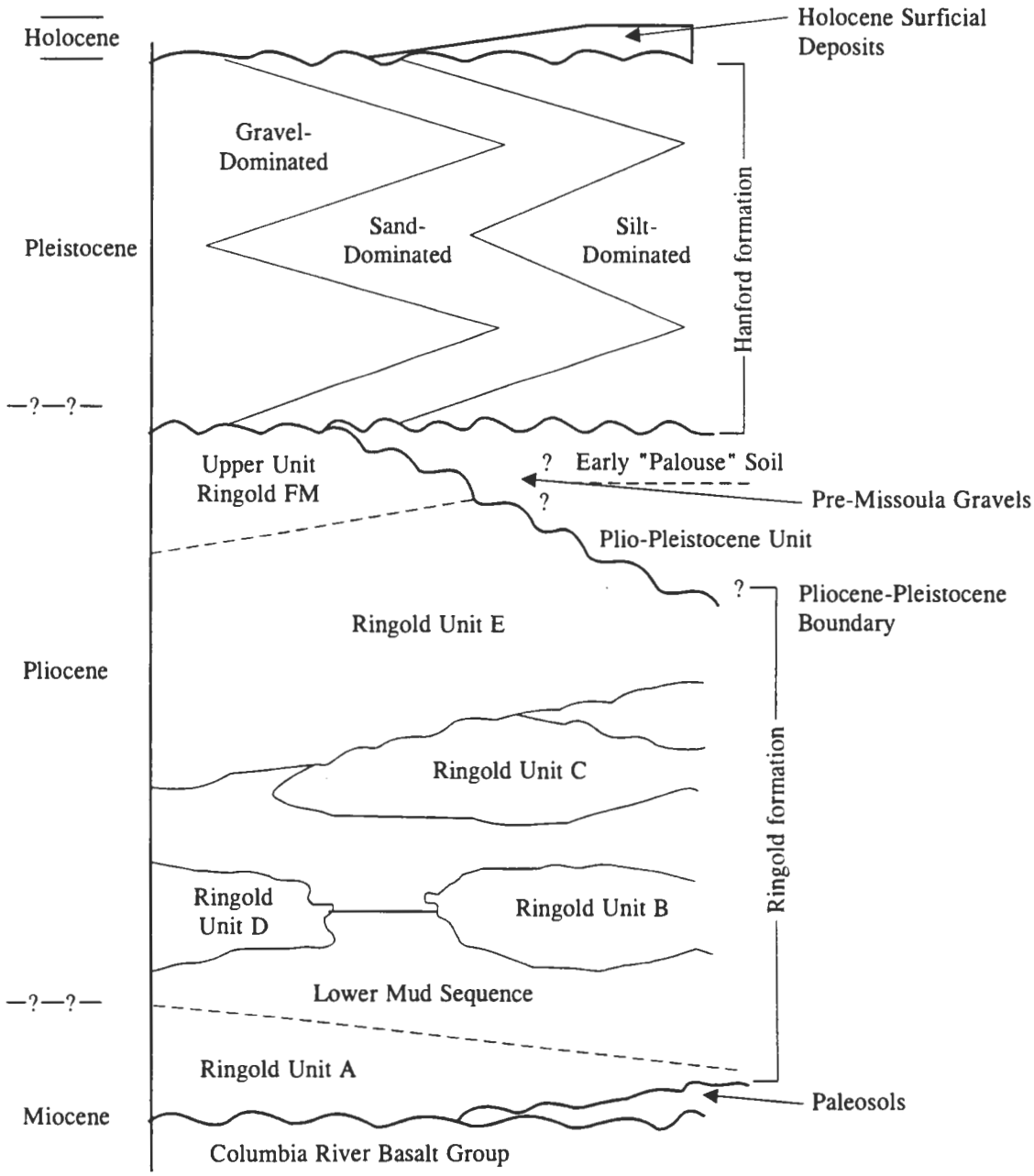


SOURCE: Adapted from PNL 1995

The Ringold Formation consists of clay, silt, fine-to coarse grained sand, and gravel. The Ringold Formation is up to 180 m (600 ft) thick south of the 200 West Area, but is largely absent in the northern and northeastern portions of the 200 East Area and adjacent areas to the north. The Ringold Formation is delineated by five different kinds of sediments, associated with fluvial (river-related) sands and gravels, floodplain and lake deposits, and alluvial fan deposits. The lower portion of the formation contains five separate stratigraphic intervals dominated by gravels known as Units A, B, C, D, and E. These gravels are separated by finer materials, including what is referred to as the lower mud sequence (Figure 4.1.4).

The lower mud sequence is important hydrologically because it is a potential confining layer that may offer some hydraulic separation between the saturated Ringold Formation above and the underlying

Figure 4.1.4 General Stratigraphy of the Suprabasalt Sediments of the Hanford Site



SOURCE: Lindsey et al. 1992

Unit A gravels below. The lower mud sequence is generally absent in the northern part of the 200 East Area and at the main lobe of B Pond (Trent 1992b). The lower mud sequence is generally present throughout the 200 West Area, except in the northeast corner (Trent 1992a).

The Hanford Formation consists of pebble to boulder gravel, fine to coarse grained sand, and silt. The Hanford Formation, which is thickest in the vicinity of the Central Plateau (up to 65 m [210 ft] thick), was deposited by cataclysmic flood waters in glacial times. Gravel dominates the Hanford Formation in the northern part of the Central Plateau. Sand-dominated material is found most commonly in the central to southern parts of the Central Plateau. The silty materials are found within and south of the Central Plateau. Holocene surficial deposits consisting of silt, sand, and gravel form a thin (less than 10 m [33 ft]) surface layer across much of the Hanford Site. These surficial materials were deposited by a mix of eolian (wind) and alluvial processes.

4.1.4 Soil

The surface and near-surface soils in the 200 Areas are generally not well developed and consist of a number of soil types such as Rupert sand, Burbank loamy sand, and Ephrata sandy loam. An additional soil unit, Hezel sand, is also present on the western boundary of the 200 West Area (Cushing 1994).

The vicinity of the potential McGee Ranch borrow site contains two soil types: Warden silt-loam and Ritzville silt-loam. Soil at the potential Vernita Quarry borrow site includes the Burbank loamy sand, Ephrata silt-loam, and Kiona silt-loam. The Burbank loamy sand is the predominant soil type in the vicinity of the potential Pit 30 borrow site.

Soil monitoring is conducted at the Hanford Site for radionuclides. Concentrations of cobalt-60, strontium-90, cesium-137, plutonium-239, plutonium-240, and uranium were consistently detected at higher levels in Hanford Site soil than at offsite locations in 1994 and 1995. In general, radionuclide concentrations near waste disposal sites are higher than concentrations further away. Data for 1995 are quite similar to data for 1994. In general, over the 11-year period from 1983 to 1994, concentrations of cobalt-60, cesium-137, uranium isotopes, and plutonium isotopes in soil did not change. Concentrations of strontium-90 in soil declined because of radiological decay and a downward migration of strontium-90 from the 2.5-centimeters (cm) (1-inch [in.]) soil sampling horizon (PNL 1996).

200 Area Soil

Soil types in the 200 Areas include the following.

Rupert sand consisting of coarse sand, covers the majority of the 200 West Area and approximately one-half of the 200 East Area.

Burbank loamy sand is coarse-textured sand that covers approximately one-third of the 200 West Area, a small portion of the 200 East Area, and the majority of the area between the 200 Areas.

Ephrata sandy loam is a medium-textured soil that covers the northern portion of the 200 East Area.

Hezel sand is similar to Rupert sand and covers a portion of the area on and immediately west of the 200 West Area boundary.

There are over 2,500 hectares (ha) (6,200 acres [ac]) of surface on the Site that are posted as radiologically controlled areas because contamination exceeds specified levels. Ninety percent of this total is within and near the 200 Areas (PNL 1996).

4.1.5 Mineral Resources

The only mineral resources produced from the Pasco Basin are crushed rock, sand, and gravel. Deep natural gas production has been tested in the Pasco Basin without commercial success. Local borrow areas would supply rock, silt, sand, and gravel for those alternatives requiring the materials. Although specific borrow sites have not been selected for potential TWRS use, the EIS analyzes the possible use of three potential onsite borrow sites: 1) Pit 30, a potential source of sand and gravel for concrete during construction activities; 2) Vernita Quarry, a potential source of basalt to use as riprap for post-remediation surface barriers; and 3) McGee Ranch, a possible source of silt for post-remediation surface barriers (BHI 1995).

4.1.6 Seismicity

Earthquakes are the result of stresses that build up in the tectonic plates comprising the earth's surface. These stresses build up due to friction between tectonic plates as they move past each other. Movement can occur within tectonic plates or between plates, such as in subduction zones, where one plate slides underneath another. Seismicity at the Hanford Site is associated with the Cascadia Subduction Zone off the coast of the Pacific Northwest, more than 300 km (180 mi) to the west. The Cascadia Subduction Zone is where the Juan de Fuca tectonic plate slides beneath the North American tectonic plate. Other relevant sources of seismic activity are shallow geologic structures of the Yakima Fold Belt or the Columbia River basalts, and deep structures of the Columbia Basin that underlie the Columbia Plateau.

Seismic activity in the Hanford Site area is low compared to other regions of the Pacific Northwest. In 1936, the largest known earthquake (a Richter magnitude of 5.75) in the Columbia Plateau occurred near Milton-Freewater, Oregon (Cushing 1994). Other earthquakes with a Richter magnitude of 5.0 or larger have occurred near Lake Chelan, Washington to the northwest, along the boundary of the Columbia Plateau and the Cascade Mountain Range, west and north of the Hanford Site, and east of the Hanford Site in Washington State and northern Idaho. In addition, earthquake swarms of small magnitudes that are not associated with mapped faults occur on and around the Hanford Site. An earthquake swarm is a series of earthquakes closely related in terms of time and location.

Four earthquake sources are considered relevant for the purpose of seismic design of TWRS sites: the Rattlesnake-Wallula alignment, Gable Mountain, an earthquake anywhere in the tectonic province, and the swarm area. For the Rattlesnake-Wallula alignment, which passes along the southwest boundary of the Hanford Site, a maximum Richter magnitude of 6.5 has been estimated. For Gable Mountain, an east-west structure that passes through the northern portion of the Hanford Site a maximum Richter magnitude of 5.0 has been estimated. The earthquake for the tectonic province was developed from the Milton-Freewater earthquake, with a Richter magnitude of 5.75. A Richter magnitude 4.0 event is considered the maximum swarm earthquake, based on the maximum swarm earthquake in 1973

(Cushing 1994). The Hanford Site current design basis for new facilities is for facilities to withstand a 0.2 gravity earthquake (Richter magnitude of approximately 6.4) with a reoccurrence frequency of 2.0E-04.

4.2 WATER RESOURCES

Baseline conditions for water and hydrology encompass surface water, the vadose zone (the area between the ground surface and underlying groundwater), and groundwater. The contaminants that presently exist in the Hanford Site water resources are not within the scope of the EIS. The behavior and remediation of existing surface water, the vadose zone, or groundwater contamination will be the subject of other environmental documentation. However, potential cumulative impacts of the TWRS EIS alternatives are discussed in Section 5.13.

4.2.1 Surface Water

West Lake and two small spring-fed streams in the Fitzner Eberhardt Arid Lands Ecology Reserve are the only naturally-occurring water bodies on the Hanford Site other than the Columbia River. West Lake is several hectares in size and is located approximately 8 km (5 mi) northeast of the 200 West Area and about 3 km (2 mi) north of the 200 East Area. The lake, which is situated in a topographically low-lying area, is sustained by groundwater inflow. West Lake was considered to be an ephemeral water body before Hanford Site operations began, with water level fluctuations dependent on groundwater level fluctuations. Water levels in West Lake became more stable because of recharge primarily from B Pond, which contains secondary wastewater and cooling water from the B Plant. The two small streams in the Fitzner Eberhardt Arid Lands Ecology Reserve are fed by Rattlesnake Springs and Snively Springs (Cushing 1994).

Surface Water Information

There are no naturally-occurring water bodies or flooding areas near the TWRS sites.

The Hanford Site and the surrounding communities draw all or most of their water from the Columbia River, which has radiological and nonradiological contamination levels below drinking water standards.

The onsite ponds (not used for human consumption) and springs that flow into the Columbia River all show radiological contamination from Hanford Site activities.

Nonradiological contamination levels in the onsite ponds and springs are generally below limits set by drinking water standards.

Two ephemeral creeks, Cold Creek and Dry Creek, traverse the uplands of the Hanford Site southwest and south of the 200 Areas. These creeks drain southeasterly toward the Yakima River, located south of the Hanford Site. Surface runoff from the uplands is minor, and creeks flow only during and shortly after rainfall and snow melt. The Columbia River is 11 km (7 mi) or more downgradient from the 200 Areas. The river forms the eastern boundary of the Hanford Site and it comprises the base level and receiving water for groundwater and surface water in the region.

There are no floodplains in the 200 Areas or between the 200 East and 200 West Areas where the potential Pit 30 borrow site is located. Floods in Cold Creek and Dry Creek have occurred historically; however, there have not been any observed flood events or evidence of flooding that has reached the 200 Areas. Natural runoff generated onsite or from offsite upgradient sources is not known to occur in the 200 Areas (Newcomb et al. 1972).

The potential Vernita Quarry borrow site is about 3 km (2 mi) south of the Columbia River. The potential McGee Ranch borrow site is approximately 5 km (3 mi) south of the River. No perennial streams, wetlands, or bodies of surface water have been observed on either site, although the McGee Ranch is dissected by numerous eastward ephemeral drainage systems.

4.2.2 Groundwater

4.2.2.1 Hydrogeologic Setting

A thick vadose zone (70 to over 90 m [230 to over 300 ft] thick) as well as both confined and unconfined aquifers are present beneath the 200 Areas (DOE 1993a, 1993b). The vadose zone is over 90 m (300 ft) thick in the vicinity of the TWRS sites in the 200 East Areas (DOE 1993a). The confined aquifers are found primarily within the Columbia River Basalts. These aquifers are not a major focus of this EIS because they are separated from the TWRS sites by the vadose zone, unconfined aquifer, and confining layer(s) and thus are not likely to be impacted. The unconfined aquifer has not been formally named. This aquifer consists variably of the Ringold Formation (where the Ringold is present) and the lower portion of the Hanford Formation.
The occurrence and flow of groundwater in the unconfined aquifer is inferred from discrete water level measurements in monitoring wells. The following five important concepts describe flow in this aquifer.

Groundwater Information

Groundwater beneath the 200 Areas begins at a depth of 70 to over 90 m (230 to over 300 ft) below the ground surface.

Artificial recharge to the groundwater from Hanford Site ponds, trenches, and cribs is approximately 10 times greater than the natural recharge.

Groundwater flow from the 200 Areas is mostly to the east and southeast and eventually reaches the Columbia River.

Groundwater is not used in the 200 Areas except for three emergency cooling water wells near B Plant.

The groundwater beneath the 200 Areas is contaminated by a variety of radionuclides and chemicals.

- The numerous strata within the Ringold Formation that were described previously in the stratigraphy discussion result in a much lower vertical hydraulic conductivity compared to the horizontal hydraulic conductivity. This results in a strong preference for groundwater to move horizontally rather than vertically.
- Most groundwater movement occurs in the sands and gravel that predominate in the upper portions of the Ringold Formation (Unit E gravels).

- The lower mud sequence and overbank deposits near the base of the Ringold Formation act as confining layers, hydraulically separating the overlying unconfined aquifer from the confined aquifer.
- Recharge to the unconfined aquifer is primarily from artificial sources such as B Pond, groundwater inflow from the Dry Creek and Cold Creek synclines, and recharge from the Columbia River in the general area of N Reactor in the northern portion of the Site.
- Discharge from the unconfined aquifer is primarily to the Columbia River, approximately from the point where the river turns southward in the northern portion of the Site south to the 300 Areas, and in the vicinity of B and C Reactors. Groundwater discharge also occurs to West Lake.

Natural recharge to the unconfined aquifer of the Hanford Site is extremely low and occurs primarily in the upland areas west of the Hanford Site. Artificial recharge from retention ponds and trenches contribute approximately 10 times more recharge than natural recharge. Seasonal water table fluctuations are small because of the low natural recharge.

4.2.2.2 Vadose Zone

At the Hanford Site the vadose zone often includes the Hanford Formation and the Ringold Unit E gravel. The thick vadose zone (70 to over 90 m [230 to over 300 ft]) thick beneath the 200 Areas), combined with the arid climate, result in natural infiltration rates ranging from near 0 to approximately 11 cm/year (4.3 in./year).

The total natural recharge in the 200 West Area is estimated to be approximately 1.3E+08 liters per year (L/year) (3.4E+07 gallons per year [gal/year]) (DOE 1993b). This is based on a recharge rate of 0.1 cm/year (0.04 in./year) through fine-textured soil with deep-rooted vegetation. This value is approximately 10 times lower than recharge volumes from artificial sources.

The current principal sources of artificial recharge in the 200 West Area are four cribs and one ditch associated with the U Plant area, located near the

Groundwater Terms

Aquifer: A body of permeable rock, rock fragments, or soil through which water moves.

Confined Aquifer: A subsurface water-bearing region that has defined, relatively impermeable upper and lower boundaries. The impermeable boundary is referred to as a confining layer.

Groundwater Gradient: The slope of the water table that, together with permeability of the rock and soil material, determines the direction and rate of groundwater movement. Groundwater gradients include both a horizontal and vertical dimension.

Recharge: The process of restoring or replenishing water to an aquifer through percolation downward through the soil. Recharge can be natural (e.g., precipitation) or artificial (intentional discharge of water to the ground).

Unconfined Aquifer: A subsurface water-bearing region that does not have impermeable confining boundary layers to restrict water movement. In an unconfined aquifer the water table forms the upper boundary.

Vadose Zone: The region of soil and rock between the ground surface and the top of the water table in which pore spaces are only partially filled with water. Over time, contaminants in the vadose zone often migrate downward to the underlying aquifer.

western edge of the 200 West Areas (DOE 1993b). There are also four septic tanks and drain fields that actively discharge water to the vadose zone. The combined volume discharged from these drain fields is estimated to be 12,000 L/day (3,200 gal/day). The total wastewater discharged from these facilities from 1944 to 1992, including the U Plant cribs and ditches, is estimated to have been 1.7E+11 L (4.4E+10 gal). T Plant and S Plant operations also resulted in large volumes of wastewater discharged to the soil. Liquid is no longer discharged from T, U, or S Plants.

DOE injects treated wastewater from the Effluent Treatment Facility, at the State- approved land disposal site located slightly north of the 200 West Area and at the Treated Effluent Disposal Facility, located in the 200 East Area. This water meets all State and Federal discharge requirements except for tritium. The treated water is injected at a location where it is projected that the tritium levels will be within drinking water standards in the groundwater before it reaches the Columbia River.

Natural recharge in the 200 East Area is estimated to be approximately 2E+07 L/year (5E+06 gal/year) (DOE 1993a). This is based on a similar natural recharge rate through fine-textured soil with deep-rooted vegetation, as noted previously for the 200 West Area. Artificial recharge in the 200 East Area is associated with approximately 140 ponds, trenches, cribs, and drains that were used to dispose of approximately 1E+12 L (3E+11 gal) of wastewater. Currently, there are 11 active waste management units and 20 active drain fields. The primary recipients of the wastewater were the ponds and trenches associated with B Plant and the Plutonium-Uranium Extraction (PUREX) Plant; the 216-A-25 trench and 216-B-3 Pond received approximately 8.0E+11 L (2.1E+11 gal). Liquids are no longer discharged from B Plant or the PUREX Plant.

Vadose Zone Contamination

Based on the observed contaminants in the groundwater beneath the 200 Areas, there are a wide variety of both undecayed radioactive, and nonradioactive contaminants. These occur in various concentrations in the vadose zone beneath the 200 Areas, particularly near the waste management facilities and locations of unplanned releases (DOE 1993a). Over time, the contaminants in the vadose zone have been carried down into the groundwater and then toward the Columbia River. These include transuranic elements (e.g., americium and plutonium), uranium, thorium, tritium, and fission products (e.g., radioisotopes of cesium and strontium), as well as nonradioactive metals, volatile organic compounds, semivolatile organics, and inorganics. The present vadose zone contamination will be the subject of other environmental documentation. It is not within the scope of the EIS. Emerging data regarding vadose zone contamination from past tank leaks are discussed in Volume Five, Appendix K.

Perched water (small pockets of water trapped in the vadose zone) may occur in the 200 West Area within the vadose zone upon a layer of silt and sand cemented by calcium carbonate (caliche layer). The caliche layer is located approximately 55 m (180 ft) beneath the ground surface (DOE 1993b). Measured hydraulic conductivities of this unit range from 0.0009 to 0.09 m/day (0.003 to 0.3 ft/day). Caliche layers have not been identified in the 200 East Area and generally, perched groundwater is not

expected except in localized areas (Hoffman et al. 1992). Perched water has been reported in the vicinity of B Pond within the lower part of the Hanford Formation.

In areas where artificial recharge is occurring from ponds and trenches, soil is expected to be close to saturation and would not likely be capable of holding large amounts of additional liquid. In addition, two groundwater mounds have developed beneath recharge areas, one each in the 200 East and West Areas. Drier soil in portions of the 200 Areas where there is no artificial recharge has a large moisture holding capacity.

4.2.2.3 Aquifer Characterization

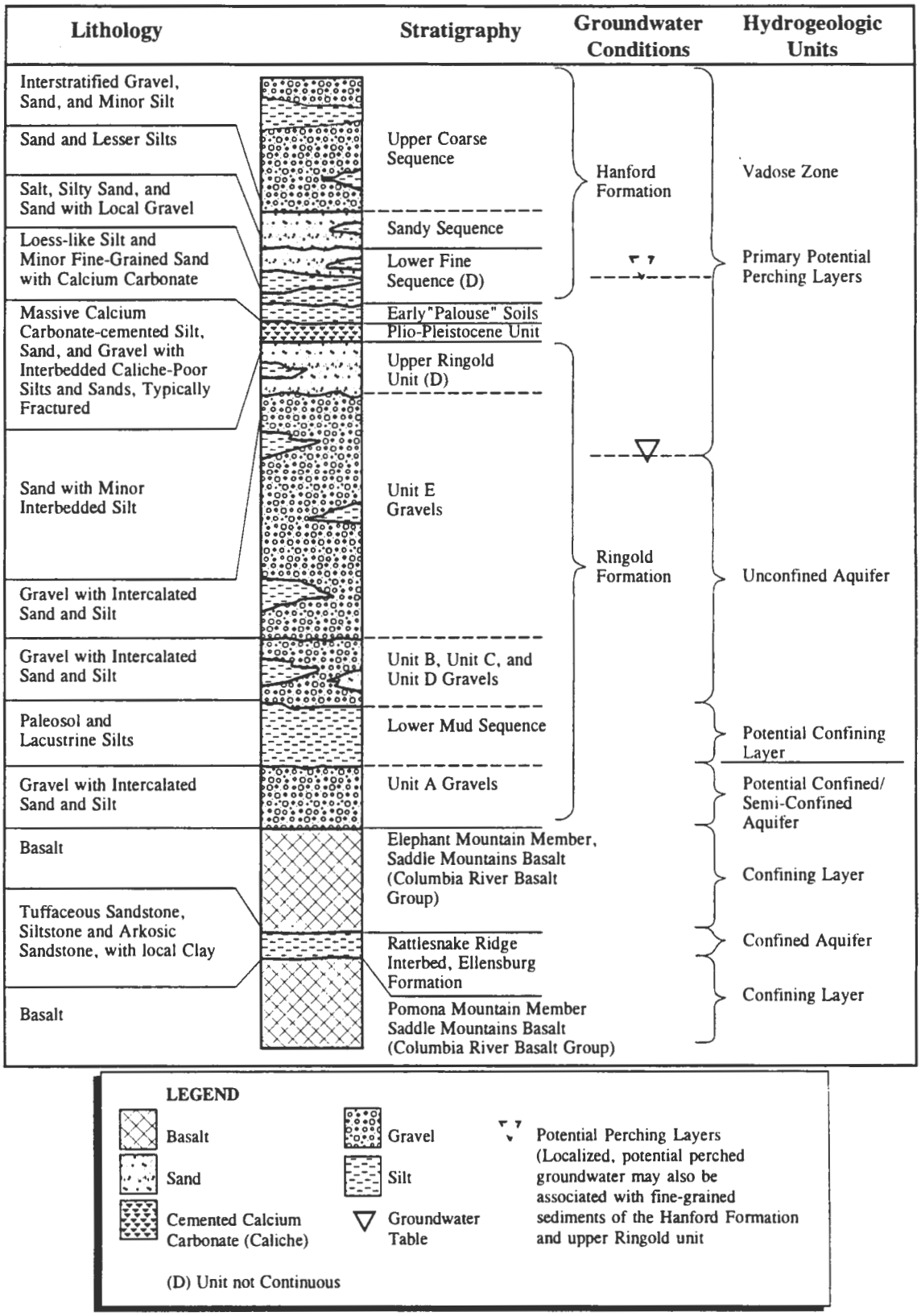
Groundwater of the unconfined aquifer occurs throughout the Hanford Site in the sediment layers above the basalt known as the suprabasalt sediments. The relationship between the various stratigraphic units and the hydrogeologic units is shown in Figure 4.2.1. The depth to groundwater on the Hanford Site is illustrated in Figure 4.2.2.

Groundwater occurs in the 200 West Area within the Ringold Formation primarily under unconfined conditions, approximately 70 m (230 ft) beneath the surface. The saturated section is approximately 110 m (350 ft) thick. Hydraulic conductivities measured in the 200 West Area in the Ringold Unit E aquifer range from approximately 0.02 to 60 m/day (0.06 to 200 ft/day). Hydraulic conductivities range from 0.5 to 1.2 m/day (1.6 to 4 ft/day) in the semiconfined to confined Ringold Unit A gravels (DOE 1993b).

A discontinuous layer of silt and sand cemented by calcium carbonate with thickness of up to 9 m (30 ft) occurs locally at a depth of about 55 m (180 ft) below the 200 West Area. This unit is believed to be responsible for perched water conditions in the vicinity of the TWRS sites in the 200 West Area.

Depth to groundwater in the 200 East Area ranges from 97 m (320 ft) in the southeast to 37 m (120 ft) in the vicinity of the 216-B-3C pond (B Pond mound), which is located approximately 5 km (3 mi) east of the TWRS sites (DOE 1993a). Groundwater near the TWRS sites occurs under unconfined conditions within Ringold Unit A, approximately 96 m (320 ft) deep. The saturated (groundwater) section is approximately 34 m (110 ft) thick. Interconnection between the unconfined and lower confined aquifer is possible across the Central Plateau; however, except for the area near the erosional windows that occur in the basalt several kilometers north of the 200 East Area and B Pond vicinity in the 200 East Area, there is no indication of aquifer interconnection. In the vicinity of B Pond, groundwater mounding from discharges from B Pond have resulted in a downward hydraulic gradient. Several kilometers north of the 200 East Area, there is an absence of confining layer(s) associated with an erosional window which has results in enhanced interconnection of the aquifers in this area. Hydraulic conductivities of the unconfined aquifer near the TWRS sites in the 200 East Area range from 150 to 300 m/day (500 to 1,000 ft/day) (DOE 1993a).

Figure 4.2.1 Conceptual Hydrologic Column for the Hanford Site



SOURCE: Lithology, stratigraphy, and groundwater condition based on data from Lindsey 1992 and Delany et al. 1991.

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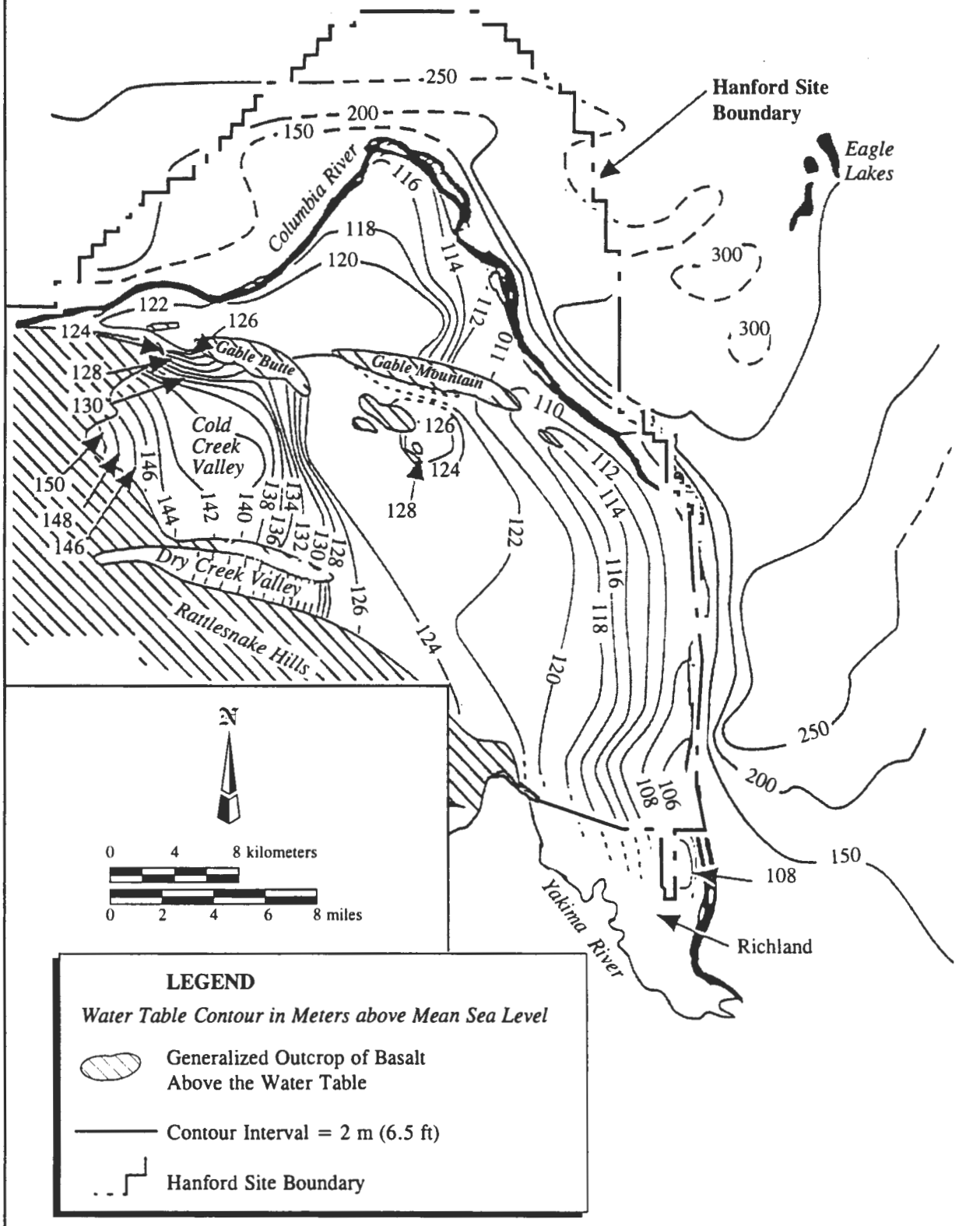
Figure 4.2.2 Groundwater Elevation Map of the Hanford Site



SOURCE: Adapted from PNL 1993a

4.2.2.4 Groundwater Flow

Groundwater in the 200 West Area generally flows from west to east with some localized exceptions (PNL 1993a). In the northwest corner of the 200 West Area, groundwater flows northward. Also, it appears that flow from the 200 West Area branches out east of Gable Butte, with a flow component northerly toward the gap between Gable Butte and Gable Mountain and the remaining flow branching eastward and southeastward toward the Columbia River.

Groundwater flow in much of the 200 East Area is characterized by relatively low hydraulic gradients, ranging from 0.01 percent to 0.02 percent. Water table elevations in the uppermost aquifer generally decrease from the margins of the Yakima Ridge in the west to the Columbia River in the east. Data indicate that groundwater flow in the vicinity of the TWRS sites in the 200 East Area is toward the southeast (Figure 4.2.2) (PNL 1993a).

The mound resulting from discharge from the 216-B-3 pond (approximately 5 km [3 mi] east of the TWRS site in the 200 Areas) is a notable difference from the generally easterly flow direction. Near the western portion of the mound, the groundwater gradient is reversed to a westerly direction. The magnitude of this gradient direction reversal is currently diminishing as the mound diminishes. The groundwater gradient in the southeastern portion of the 200 East Area is expected to resume a more easterly trend as the mound continues to decline.

Downward hydraulic gradients have been observed in both the 200 East and 200 West Areas. In general, these downward gradients are associated with the groundwater mounds that have been created from infiltration of water discharged to the U Pond and B Pond. Interconnection between the unconfined and lower confined aquifer is possible across the Central Plateau; however, except for the area near the erosional windows that occur in the basalt several kilometers north of the 200 East Area and B Pond vicinity in the 200 East Area, there is no indication of aquifer interconnection. In the vicinity of B Pond, groundwater mounding from discharges from B Pond have resulted in a downward hydraulic gradient. Several kilometers north of the 200 East Area, there is an absence of confining layer(s) associated with an erosional window, which has results in enhanced interconnection of the aquifers in this area.

The groundwater impact analysis provides calculated concentrations of tank waste contaminants for a 10,000-year period of interest. These calculations rely on a conceptual model of the hydrogeologic conditions on the Site and monitoring and characterization data.

The conceptual model for the TWRS EIS is based on characterization data that include geologic structure, the pattern of geologic materials deposited in the vadose zone and underlying aquifer, existing contaminant migration, and the bounding affects of features such as the Columbia River, Yakima River, and Horse Heaven Hills. This results in an expectation that most of the contaminants from the tank sources would move in a west to east/southeast direction with a very small amount flowing northerly through the gap between Gable Butte and Gable Mountain.

The approach used in the TWRS EIS for groundwater impact assessment includes transient contaminant transport through the vadose coupled with steady state contaminant transport through the unconfined aquifer. Data that have been used include measurement of vadose zone and aquifer characteristics and geometry that will remain constant (e.g., hydraulic conductivities, grain size and distribution, and strata thicknesses) and data that are transient (e.g., moisture contents in the vadose zone and groundwater levels in the unconfined aquifer). Of importance here are the transient groundwater data sets that were used for the TWRS EIS and the Hanford Remedial Action EIS (DOE 1996c) analyses. The TWRS groundwater impact analysis focuses on impacts in the groundwater that would occur from about 100 years to 10,000 years from the present based on contaminants reaching the groundwater within about 130 years for the No Action alternative, up to about 3,400 years for the In Situ Vitrification alternative, and a 10,000-year period of interest for all of the alternatives. The TWRS groundwater impact assessment is based on the December 1979 groundwater level data, considering the period in which impacts are expected to occur. The December 1979 groundwater levels used in the TWRS EIS represent a point in time where 1) conditions were relatively steady; and 2) groundwater contaminant transport in the unconfined aquifer is primarily in a southeast/east direction with a small component going in a northerly direction through the gap between Gable Butte and Gable Mountain. For these two reasons, the December 1979 Site groundwater levels were selected as the basis for the TWRS EIS long-term, steady-state groundwater contaminant transport calculation. A slight drawback to use of the December 1979 groundwater level data is that the groundwater mounds associated with B Pond, U Pond, and Gable Mountain Pond are present but they would be expected to be absent in the future (i.e., within 100 years). The presence of the mounds result in a faster vadose zone contaminant transport because the vadose zone was thinner in 1979 than it would be in the future.

The Hanford Remedial Action EIS used 1992 groundwater levels for the impact assessment. These groundwater levels represent a point in time where many transients are ongoing in the groundwater system. Waste water discharges to the vadose zone are decreasing or have been terminated. The groundwater mound associated with Gable Mountain Pond is not present, the mounds associated with B Pond and U Pond have declined, and groundwater is being released from storage in the interstitial pore space of the unconfined aquifer. All of the contaminants originating in the 200 Areas would flow through the gap between Gable Mountain and Gable Butte into the 100 Areas, based on the 1992 groundwater levels used in the Hanford Remedial Action assessment. This is an accurate assumption for the near-term flow directions.

The proportion of contaminants flowing in an easterly direction would be expected to increase from zero percent in 1992 to near 100 percent as the groundwater mound associated with B Pond declines. Therefore by the time contaminants from tank waste remediations reaches the groundwater, the groundwater flow would be to the east as shown in the TWRS EIS. Additional discussion of the sensitivity and potential affect of groundwater mounding is provided in Volume Five, Appendix K.

4.2.3 Water Quality and Supply

4.2.3.1 Surface Water

Water at the Hanford Site is supplied by the Columbia River, which is a source of raw water. River water is supplied to Hanford Site facilities through several distribution systems. In addition, wells supply water to the 400 Area and several remote facilities.

The Tri-Cities draw most (Richland and Kennewick) or all (Pasco) of their water supplies from the Columbia River. In 1994, water usage ranged from 8.7E+09 L (2.3E+09 gal) in Pasco to 2.6E+10 L (6.9E+09 gal) in Richland (Cushing 1995). Each community operates its own water supply and treatment system.

The Columbia River provides water for both irrigation and municipal uses. Washington State has classified the stretch of the Columbia River that includes the Hanford Reach as Class A, Excellent (Neitzel 1996). Class A waters must be suitable for essentially all uses, including raw drinking water, recreation, and wildlife habitat. Both Federal and State drinking water quality standards apply to the Columbia River and are currently being met (Neitzel 1996).

Samples from the Columbia River and three onsite ponds are routinely collected (Figure 4.2.3). Radionuclides consistently detected during 1994 were tritium, strontium-90, uranium-234, uranium-238, iodine-129, plutonium-239, and plutonium-240. The iodine-129, plutonium-239, plutonium-240, strontium-90, and tritium may come from worldwide fallout as well as from releases of Hanford Site effluent. Tritium and uranium also occur naturally in the environment. Total alpha and beta measurements are useful indicators of the general radiological quality of the river; they provide a useful early indication of changes in radiological contamination because results are obtained quickly. Total alpha and beta measurements in 1994 were similar to 1993 and were approximately 5 percent less than the applicable State and Federal drinking water standards at 15 and 50 picocuries per liter (pCi/L), respectively. In general, radiological concentrations at Priest Rapids Dam (upstream of the Site) were generally lower than those at the Richland Pumphouse (downstream of the Site). Concentrations in 1995 were generally similar to those observed in recent years and in most cases were slightly lower than in 1994. Radiological contaminant concentrations measured in 1995 were less than the DOE Derived Concentration Guides and Washington State water quality criteria.

Nonradiological contaminants measured in the Columbia River in 1995 were similar to levels observed in recent years. All nonradiological water quality standards for Class A-designated water were met (PNL 1995). During 1995, there was no indication of any deterioration of water quality resulting from Site operations along the Hanford Reach (PNL 1996).

The three ponds routinely sampled onsite are West Lake (north of the 200 East Area), B Pond (east of the 200 East Area), and the Fast Flux Test Facility Pond (southeast of the 200 Areas). Monitoring data show that all three ponds are impacted by Site activities, although pond water is not used for human consumption. With the exception of uranium-234 and -238 in the October 1995 sample of West Lake, all radionuclide concentrations were less than the DOE Derived Concentration Guides. Average annual

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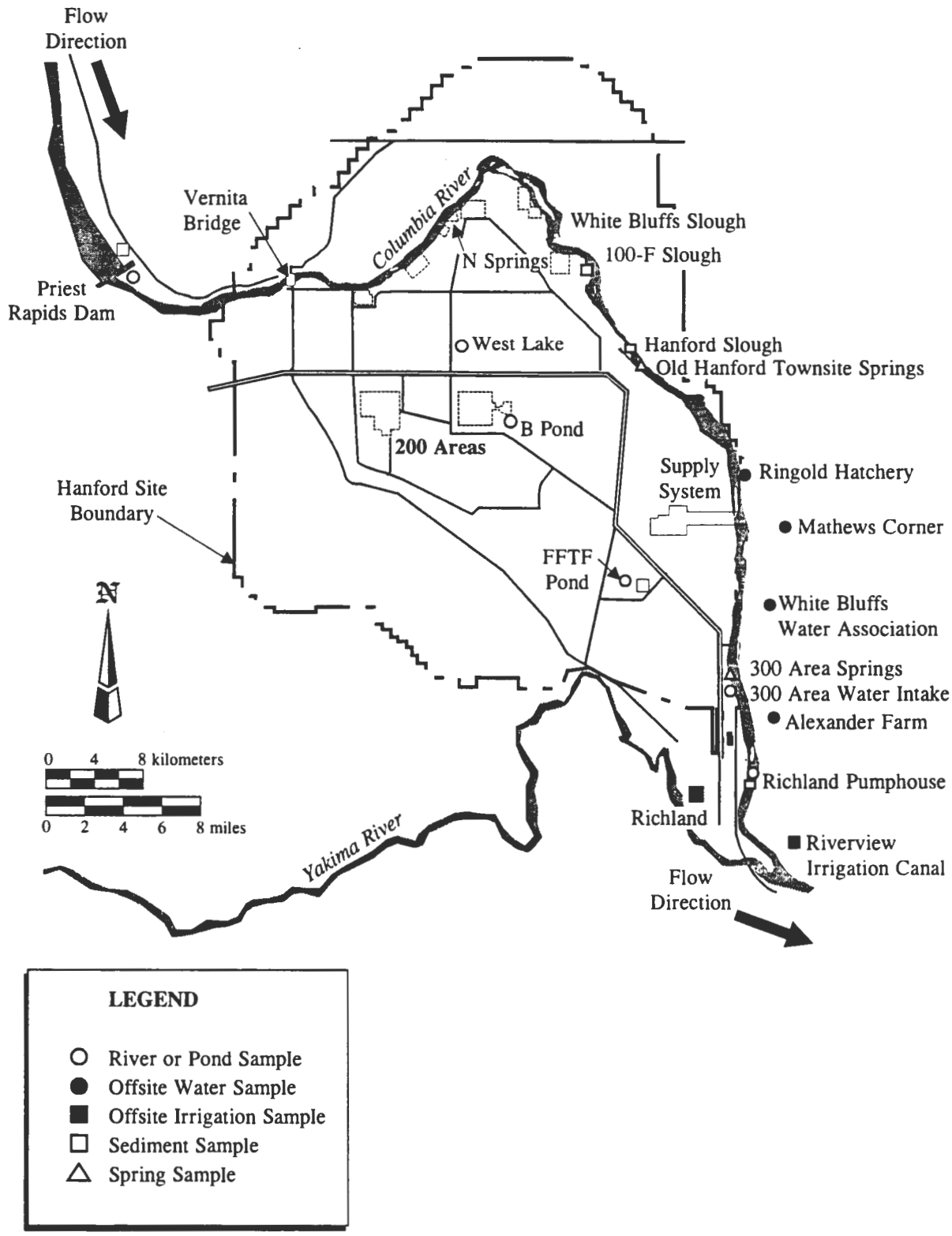
Figure 4.2.3 Water and Sediment Sampling Locations, 1992



SOURCE: Adapted from PNL 1993a

total beta concentrations exceeded the ambient surface water quality criteria level in West Lake. The EPA's proposed Hanford Site-specific drinking water standard for uranium also was exceeded in West Lake. The concentrations of all other radionuclides were less than the applicable surface water quality criteria (PNL 1996). West Lake surface water quality reflects the quality of the groundwater that feeds it and thus is potentially impacted by groundwater transport (PNL 1993a).

Several springs in the 100 Areas, the old Hanford Townsite Springs and the 200 Area Springs, are routinely sampled. Water flows from these springs are a mechanism by which groundwater contaminated by past Site activities enters the Columbia River. All radiological contaminants measured in 1995 were less than the DOE Derived Concentration Guides. However, strontium-90 in the 100-H Area, and tritium in the 100-B Area and along the Old Hanford Townsite exceeded Federal and Washington State drinking water standards. Total uranium exceeded the EPA's proposed Hanford Site-specific standards in the 300 Area. All other radionuclide concentrations were below applicable surface water quality standards (PNL 1996). The 1995 nonradiological contaminant concentrations were below Washington State ambient surface water acute toxicity standards with the exception of copper and zinc in the 100-K Area spring. The chronic toxicity level of cadmium and the EPA standard for trichlorethylene also were exceeded at the 100-K Area Spring (PNL 1996).

4.2.3.2 Groundwater

Groundwater is not used in the 200 Areas except for emergency cooling water, nor do any water supply wells exist downgradient of the 200 Areas. Three wells for emergency cooling water are located near B Plant in the 200 East Area. However, there are dry and groundwater monitoring wells in and around the 200 Areas. Hanford Site water supply wells are located at the Yakima Barricade, the Fast Flux Test Facility, and at the Hanford Safety Patrol Training Academy, all 13 km (8 mi) or more from the TWRS sites in the 200 East Area.

Groundwater Contamination

Unconfined groundwater beneath the 200 East Area contains 13 different contaminants (DOE 1993a) that have been mapped as plumes: arsenic, chromium, cyanide, nitrate, gross alpha, gross beta, tritium, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, and plutonium-239 and -240. The tritium, iodine-129, and nitrate contaminant plumes are illustrated in Figures 4.2.4, 4.2.5, and 4.2.6.

In the 200 West Area, 13 overlapping contaminant plumes are located within the unconfined gravels of Ringold Unit E: technetium, uranium, nitrate, carbon tetrachloride, chloroform, trichloroethylene, iodine-129, gross alpha, gross beta, tritium, arsenic, chromium, and fluoride.

The tank farms are within the boundaries of all the 200 West Area contaminant plumes except for chromium, chloroform, trichloroethylene, fluoride, and arsenic. Plumes of technetium, gross alpha, and gross beta are associated with the U Plant area.

Groundwater Quality

Contamination by both radionuclide and nonradionuclide contaminants has been identified in the groundwater on the Hanford Site. Liquid effluents have been discharged to various ponds, cribs, and other waste management structures located onsite. Adsorption onto soil particles, chemical

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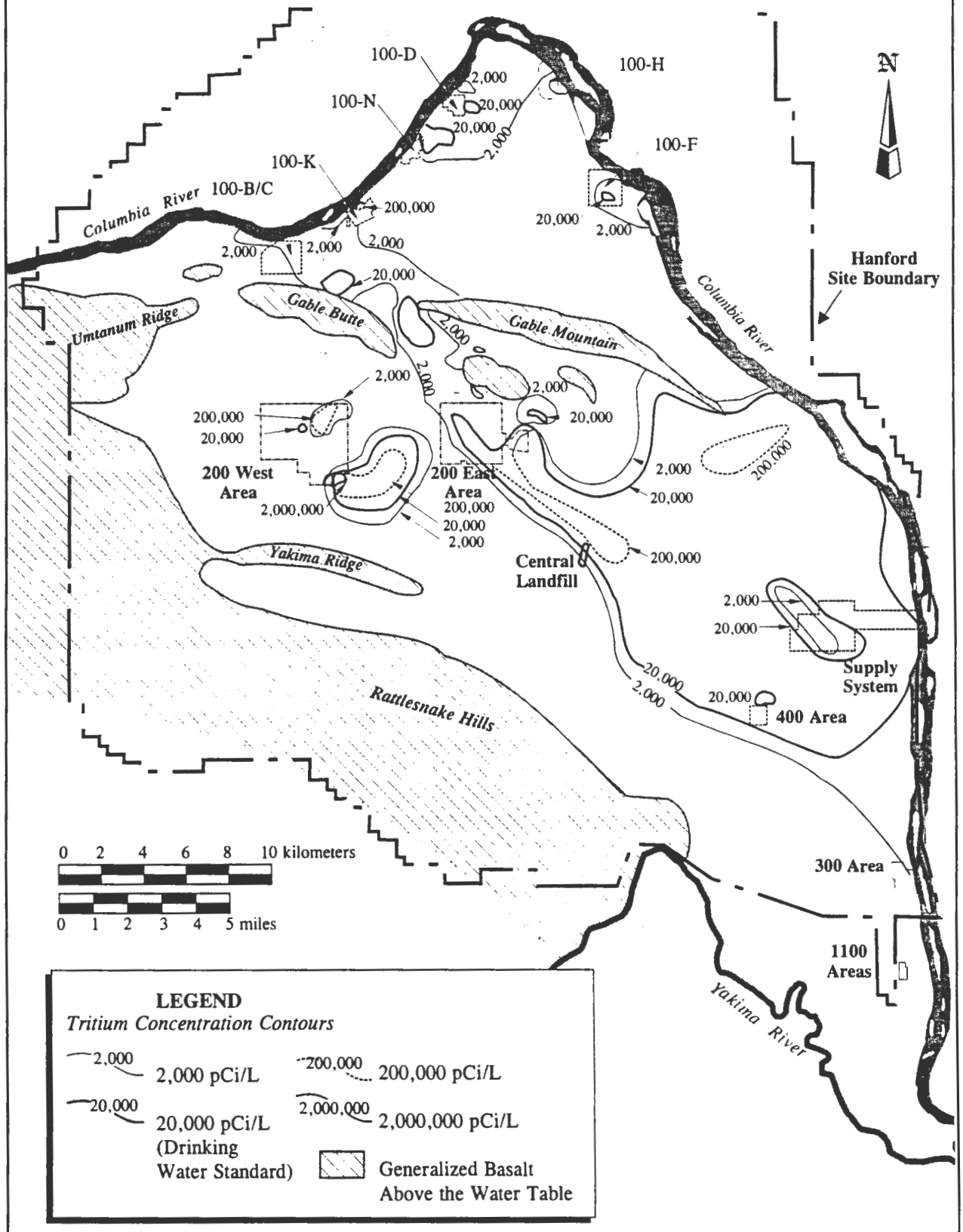
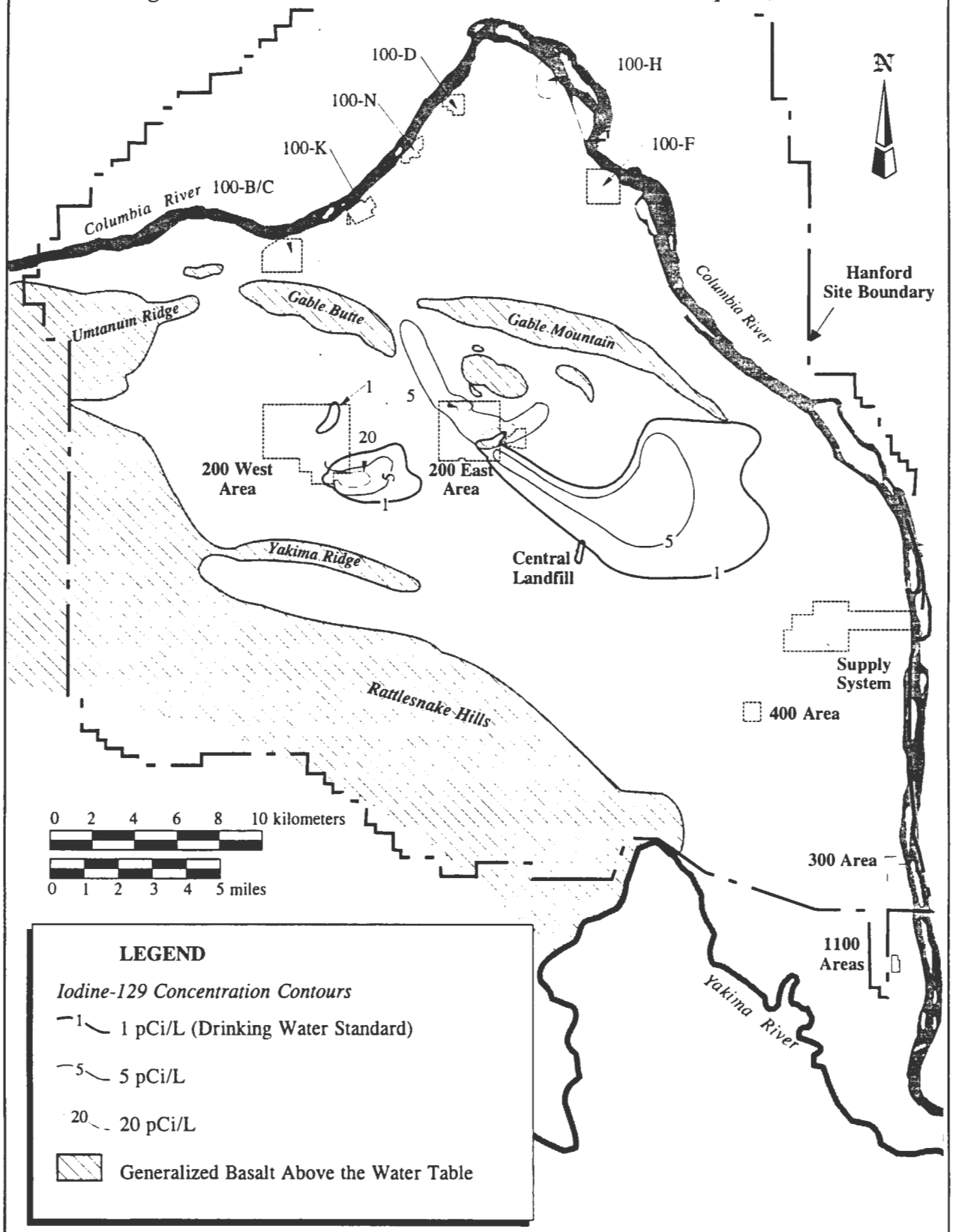
Figure 4.2.4 Distribution of Tritium in the Unconfined Aquifer, 1994



SOURCE: Adapted from PNL 1995

Figure 4.2.5 Distribution of Iodine-129 in the Unconfined Aquifer, 1994



SOURCE: Adapted from PNL 1995

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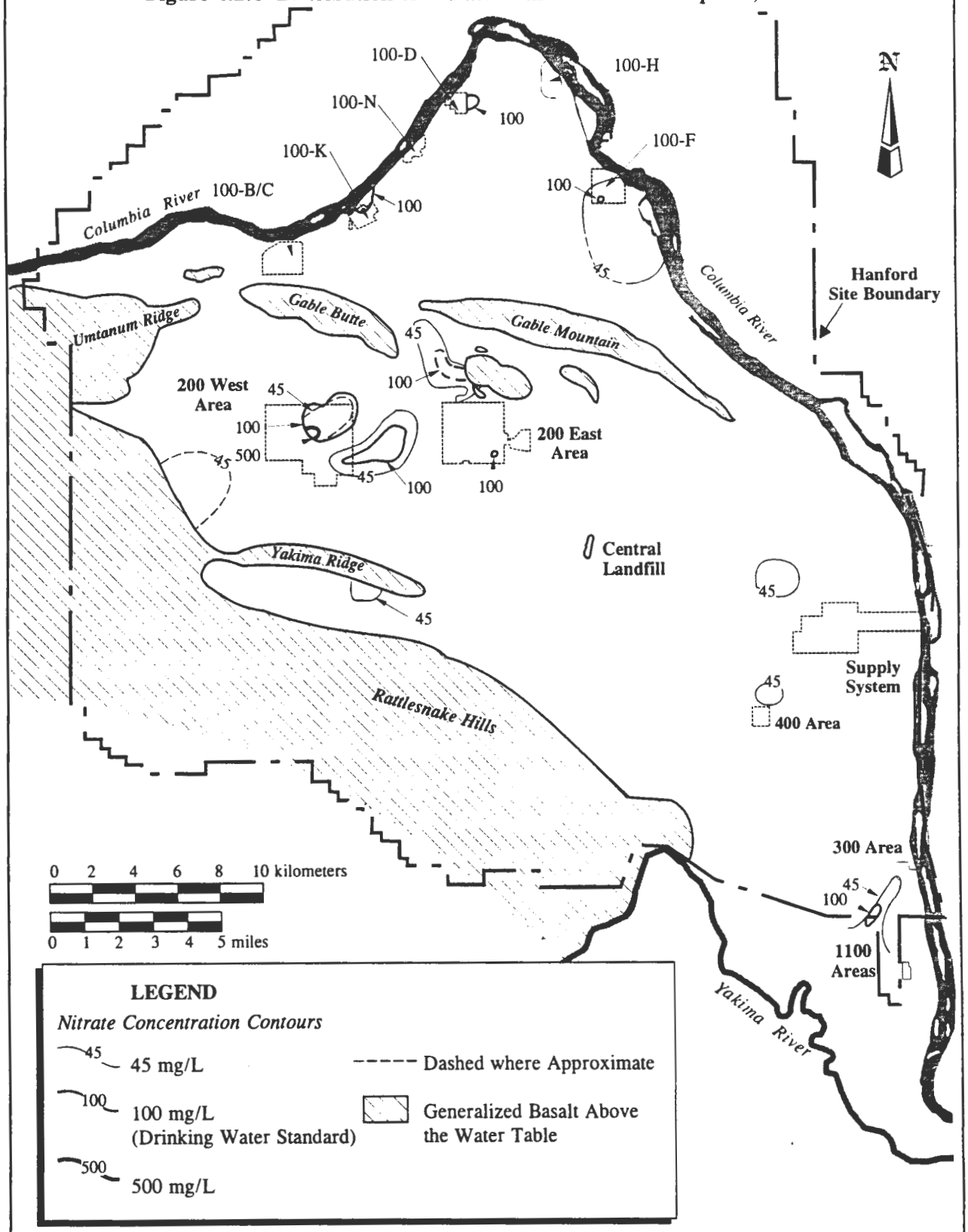
Figure 4.2.6 Distribution of Nitrate in the Unconfined Aquifer, 1994



SOURCE: Adapted from PNL 1995

precipitation, and ion exchange delay the movement of some radionuclides and nonradionuclide contaminants in the effluent as they percolate downward through the vadose zone. Constituents such as strontium-90, cesium-137, and plutonium-239 and -240 are attenuated to varying degrees but eventually may enter the groundwater. Ions such as nitrate and radionuclides such as tritium, technetium-99, and iodine-129, which are not readily attenuated in the soil, reach the groundwater sooner than those that are readily attenuated, and then travel downgradient at essentially the same rate as the natural groundwater. The potential sources of groundwater contamination in the tank farms area are the focus of ongoing investigations (Caggiano 1996 and DOE 1995t). DOE is conducting a RCRA assessment to determine the nature and extent of groundwater contamination beneath certain tank farms (Ecology 1996).

4.3 METEOROLOGY AND AIR QUALITY

4.3.1 Meteorology

The Hanford Site is located in a semi-arid region. The Cascade Mountains to the west greatly influence the Hanford Site's climate by providing rainshadow. This range also serves as a source of cold air drainage, which has a considerable effect on the Site's wind regime. The following meteorological discussion is based on the Hanford Climatological Summaries (Stone et al. 1972 and PNL 1994g) and information compiled by Cushing (Cushing 1994 and 1995).

Prevailing winds at the Hanford Meteorological Station, located between the 200 Areas, are from the west-northwest and northwest in all months of the year. Monthly average wind speeds are lowest during December, averaging approximately 10 km/hr (6 mi/hr), and highest during June, averaging approximately 15 km/hr (9 mi/hr).

Meteorology and Air Quality Information

Air quality is good in the Hanford Site vicinity. The only air pollutant for which regulatory standards are exceeded is particulates.

In 1994, concentrations of radionuclides and hazardous air pollutants were lower than regulatory standards both onsite and offsite.

From 1961 through 1990, average monthly temperatures varied from -1 degrees centigrade (°C) (30 degrees Fahrenheit [°F]) in January to 24 °C (76 °F) in July with a yearly average of 12 °C (53 °F). On the average, 51 days during the year have maximum temperatures greater than or equal to 32 °C (90 °F) and 12 days have a maximum greater than or equal to 38 °C (100 °F). Also, an average of 25 days during the year have maximum temperatures less than 0 °C (32 °F) and 106 days per year have minimum temperatures less than 0 °C (32 °F).

The average annual precipitation measured is 16 cm (6.5 in.) with over half of this occurring from November through February. December, the wettest month, receives an average of 2.5 cm (1 in.), while July, the driest month, averages 0.5 cm (0.2 in.) of precipitation. The annual average snowfall is 38 cm (15 in.).

Although fog has been recorded throughout the year, nearly 90 percent of the occurrences are during the late fall and winter months. Other phenomena that restrict visibility to 10 km (6 mi) or less include dust and smoke (typically from wildfires, orchard smudging, and agricultural field burning). Reduced visibility from blowing dust occurs an average of five days per year, and reduced visibility resulting from smoke occurs an average of two days per year.

Severe high winds are often associated with thunderstorms. On average, the Hanford Site experiences 10 thunderstorms per year, most frequently (80 percent) during May through August.

Good atmospheric dispersion conditions exist at the Hanford Site about 57 percent of the time during the summer (PNL 1994g). Less favorable dispersion conditions occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter when moderately to extremely stable stratification exists about 66 percent of the time. The probability of an inversion period (e.g., poor dispersion conditions) extending more than 12 hours varies from a low of about 10 percent in May and June to a high of about 64 percent in September and October (Holzworth 1972).

4.3.2 Air Quality

Air quality in the Hanford Site area is good. However, levels of particulate matter occasionally exceed regulatory standards. These elevated levels are believed to result from natural sources such as the dust storms and brush fires that occur in arid eastern Washington State (PNL 1993a and Cushing 1994).

National Ambient Air Quality Standards have been established, as mandated in the Clean Air Act. Ambient air refers to air outside of buildings to which the general public has access. The National Ambient Air Quality Standards define levels of air quality that are considered protective of public health (primary standards) and welfare (secondary standards). The standards exist for the following pollutants: sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, particulate matter (a particle that is less than 10 micrometers in diameter), lead, and ozone. The air quality standards specify maximum allowable pollutant concentrations and frequencies of occurrence for averaging periods ranging from one hour to one year, depending on the pollutant. Washington State has largely adopted the current Federal standards. However, Washington State has established more stringent standards for sulfur dioxide and ozone and also maintains an air quality standard for total suspended particulates and gaseous fluorides. Air quality standards are provided in Volume Five, Appendix G.

For selected pollutants for which no Federal or State air quality standards exist, the Hanford Site uses alternate methods of evaluation. For toxic organic compounds (e.g., benzene, toluene), comparisons are made to Occupational Health and Safety Administration's maximum allowable concentrations (29 Code of Federal Regulations [CFR] 1910). Polychlorinated biphenyls are evaluated against National Institute of Occupational Safety and Health occupational limits.

Sources of airborne emissions at the Hanford Site include combustion equipment (e.g., steam boilers, electric generation plants), coal handling operations, storage tanks, and waste handling and disposal. Operations such as these result in routine emissions of air pollutants, including radionuclides.

Under the Clean Air Act Amendments of 1990, the Hanford Site is classified as a major source for one or more criteria pollutants, as well as hazardous air pollutants. The Hanford Site is currently subject to the radionuclide National Emission Standard for Hazardous Air Pollutants (10 millirems per year [mrem/year]). The Clean Air Act requires an operating permit covering all emission sources of pollutants for which the Site is considered a major source. DOE has applied for a Sitewide Air Operating Permit for the Hanford Site.

For areas in attainment of the National Ambient Air Quality Standards, the EPA's Prevention of Significant Deterioration program is designed to protect existing ambient air quality in an area while also allowing a margin for future growth. Under the Prevention of Significant Deterioration program, new stationary sources of air pollution may only impact air quality by set increments, and best available control technology emission controls must be installed. The Hanford Site obtained a Prevention of Significant Deterioration permit in 1980 requiring specific limits for oxides of nitrogen emitted from the PUREX Plant and U Plant. These facilities were not operated in 1995 and no Prevention of Significant Deterioration permit violations occurred (Neitzel 1996).

Onsite air quality monitoring data are available for nitrogen oxides, polychlorinated biphenyls, and volatile organic compounds (PNL 1995). Monitoring of nitrogen oxides was discontinued after 1990 because the primary source (the PUREX Plant) ceased operation. The highest annual average nitrogen oxides concentration was approximately an order of magnitude below the Federal and Washington State standard of 0.05 parts per million. Nine out of 17 polychlorinated biphenyls samples collected during 1993 were below the detection limit of 0.29 nanograms per cubic meter, and thus well below the level of concern. Eight samples were above the detection limit, with results from 0.25 to 3.9 nanograms per cubic meter (Cushing 1995).

Based on a review of chemicals of concern for surveillance at the Site, three types of semi-volatile organic compounds were identified for monitoring, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and a phthalate ester plasticizer. Organochlorine pesticides also were analyzed. No phthalate esters were found above detection limits. Polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and organochlorine pesticides were found above detection limits. The measured pesticide concentrations were orders of magnitude below occupational exposure limits (PNL 1996).

Ten volatile organic compound samples were collected and analyzed in 1994. The samples were analyzed for halogenated alkanes and alkenes, benzene, and ethylbenzenes. Overall, the concentrations measured in 1994 were within the range of values reported in previous studies and also were within allowable regulatory limits (PNL 1995).

During 1993, the only offsite monitoring near the Hanford Site showed the 24-hour particulate matter standard of 50 micrograms per cubic meter ($\mu g/m^3$) being exceeded twice at the Columbia Center monitoring location in Kennewick. The maximum 24-hour concentration of 150 $\mu g/m^3$ was exceeded twice, with the highest level reaching 1,166 $\mu g/m^3$. The suspected cause was windblown dust. The annual primary standard of 50 $\mu g/m^3$ was not exceeded.

Radiological data were collected during 1995 through a network of 47 continuously operating samplers at onsite radiological monitoring stations, at the Site perimeter, and at nearby and distant communities. Cesium-137, plutonium-239, plutonium-240, strontium-90, and uranium were consistently detected in air samples collected in the 200 Areas. Concentrations were higher than those measured at offsite locations and were in the same range as measured in previous years. Levels measured at both onsite and offsite locations were much lower than the applicable standards (PNL 1996).

4.4 BIOLOGICAL AND ECOLOGICAL RESOURCES

The Hanford Site and adjacent region are a shrub-steppe vegetation zone that is dominated by a shrub overstory (top layer) with an understory (bottom layer) of grasses (Daubenmire 1970). Ecological resources on the Site are extensive, diverse, and important. Because the Hanford Site has not been farmed or grazed for over 50 years, it has become a refuge for a variety of plant and animal species (Gray-Rickard 1989). The Site contains one of the largest remaining undisturbed shrub-steppe areas in Washington State. Approximately 665 km^2 (257 mi^2) of undeveloped lands located onsite (nearly half the Site's total area) have been designated as ecological study areas or refuges.

Biological and Ecological Resources Information

The Hanford Site is one of the largest shrub-steppe vegetation areas remaining in Washington State and nearly half of the Site's 1,500-km^2 (560-mi^2) area is designated as ecological study areas or refuges.

Shrub-steppe vegetation areas are considered priority habitat by Washington State because of their relative scarcity and their importance to wildlife species.

The 200 Areas and the nearby potential borrow sites consist mostly of shrub-steppe habitat. The TWRS sites in the 200 Areas are currently heavily disturbed. However, the potential borrow sites are largely undisturbed.

No Federally-listed threatened or endangered plant or animal species are found in any TWRS sites.

The fishery resource of the Columbia River is important to Native Americans.

4.4.1 Biodiversity

Biodiversity is the diversity of ecosystems, species and genes, and the variety and variability of life (CEQ 1993). Major components of biodiversity are plant and animal species, microorganisms, ecosystems, ecological processes, and the interrelationships between and among these components. Biodiversity is a qualitative measure of the richness and abundance of ecosystems and species in a given area (NPS 1994). Biodiversity also provides a moderating effect on wide fluctuations in environmental conditions.

Two major factors contributing to biodiversity on the Hanford Site are that 1) the Site is one of the largest relatively undisturbed tracts of native shrub-steppe left in the State of Washington; and 2) the Hanford Reach is the last free-flowing nontidal stretch of the Columbia River in the United States (Sackschewsky et al. 1992 and Cushing 1992). Other factors contributing to the Site's biodiversity include topographic features such as Rattlesnake Mountain, Gable Butte, and Gable Mountain; a variety of soil textures ranging from sand to silty and sandy loam; and the lack of human use and development over much of the Hanford Site. Specialized terrestrial habitats contributing to the biodiversity of the Hanford Site include areas of sagebrush-steppe, basalt outcrops, cliffs, and sand dunes. Aquatic components of biodiversity are mainly associated with the Columbia River and include aquatic habitats, wetland and riparian areas, and riverine habitats along the Hanford Reach shoreline and islands in the Columbia River.

Ecologically important plant and animal species on the Hanford Site include Federal and Washington State protected wildlife and plant species (Section 4.4.5); commercial and recreational wildlife species such as salmon, steelhead, mule deer, and upland game birds; and plant species used as a source of food, medicine, fiber, and dye by native people of the Columbia Basin (Section 4.4.6) (Sackschewsky et al. 1992).

As an indication of the Site's biodiversity, the Nature Conservancy of Washington has recently discovered 21 new plant and insect species on the Site. This includes new species of buckwheat and bladderwart plants and 19 species of insects (Nature Conservancy 1996).

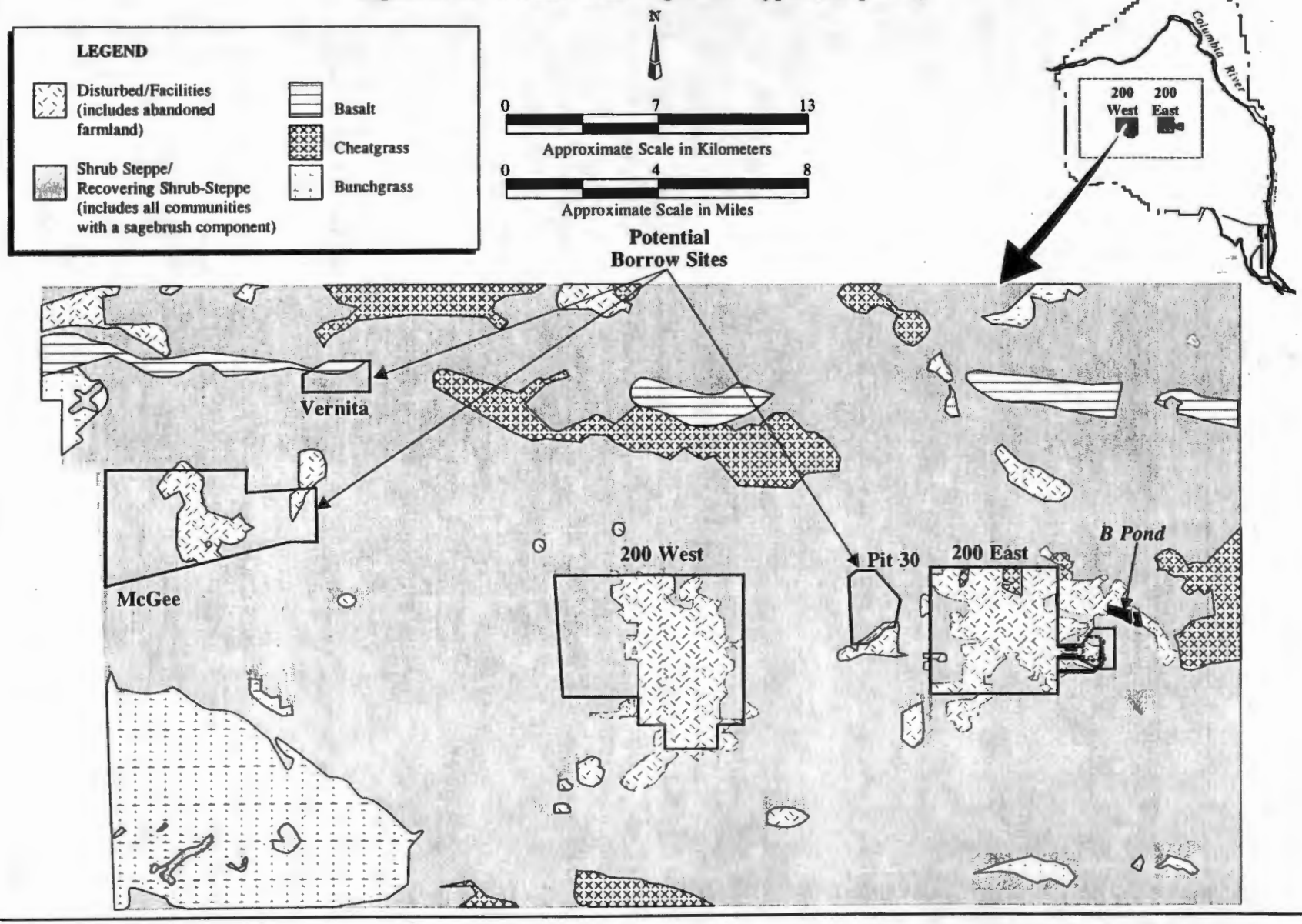
4.4.2 Vegetation

The Hanford Site is a relatively undisturbed area of shrub-steppe (Sackschewsky et al. 1992). Approximately 600 different plant species exist on the Site (Cushing 1994). Historically, the predominant plant in the area was big sagebrush with an understory of perennial bunch grasses. Following Euro-American settlement that began in the early 1800's, grazing and agriculture disrupted the native vegetation and opened the way for invader species such as tumbleweed, Russian-thistle, and cheatgrass.

The Central Plateau and the nearby area that contains the potential Vernita Quarry and McGee Ranch borrow sites predominantly consist of shrub-steppe. Figure 4.4.1 is a simplified vegetation map of the areas of the Hanford Site where TWRS activities are proposed. This includes plant communities dominated by big sagebrush and bitterbrush with an understory of cheatgrass or Sandbergs bluegrass. Shrub-steppe is considered a priority habitat by Washington State because of its importance to wildlife species of concern. Also, the National Biological Service has listed native shrub- and grassland-steppe in Washington State and Oregon as an endangered ecosystem. Over 100 plant species occur on the Central Plateau. Common species include big sagebrush, rabbitbrush, cheatgrass, and Sandbergs bluegrass. Much of the land surface of the 200 Areas has been disturbed by human activities. Introduced species such as Russian-thistle and cheatgrass are common in these disturbed areas (Cushing 1994). Approximately 58 percent of the 200 Area's 2,600 ha (6,400 ac) is disturbed by facilities, about 40 percent is shrub-steppe or recovering shrub-steppe, and 2 percent is cheatgrass (ASI 1995).

9613459.0334

Figure 4.4.1 TWRS Areas Vegetation Types (Simplified)



Other vegetation in the 200 Areas includes wetland species associated with human-made ditches and ponds and introduced perennial grass planted to revegetate disturbed areas. Wetland species (e.g., cattail, reeds, and trees such as willow, cottonwood, and Russian-olive) are established around some of these ponds, none of which are in the immediate vicinity of any of the TWRS sites. Introduced perennial grass, such as Siberian crested wheatgrass, also has been used in the 200 Areas to revegetate and stabilize waste burial grounds against wind and water erosion.

Biological surveys of the TWRS sites in the 200 East Area and the immediately surrounding vicinity show that approximately 40 percent of the area is big sagebrush and grey rabbitbrush, both native species characteristic of shrub-steppe communities. Another 20 percent is Russian-thistle, with the remainder being either disturbed vegetation or bare gravel (PNL 1994e). The area of the proposed Phased Implementation alternative site in the easternmost portion of the 200 East Area contains both mature sagebrush habitat and areas disturbed by the development of grout vaults in the 1980's. None of the new plant species recorded by the Nature Conservancy were identified at any of the potential TWRS locations in the 200 Areas (Brandt 1996).

The tank farms and immediate surrounding areas in both the 200 East and West Areas are heavily disturbed. The potential Vernita Quarry, McGee Ranch, and Pit 30 borrow sites are all largely undisturbed shrub-steppe areas, with species such as big sagebrush, rigid sage, and spiny hopsage, and an understory of grasses such as Sandbergs bluegrass. Portions of the potential McGee Ranch borrow site were farmed in the early part of the twentieth century, and these farmed areas are dominated by cheatgrass and Russian-thistle. The McGee Ranch area is also an important wildlife and vegetation corridor connecting the Site with the Yakima Training Center further to the west. The Yakima Training Center and the Hanford Site are the two largest tracts of shrub-steppe remaining in Washington State (Fitzner 1992). The Washington State Department of Fish and Wildlife has asked DOE to preserve the McGee Ranch area as a wildlife corridor (Baker 1996).

4.4.3 Wildlife

Approximately 290 species of terrestrial vertebrates have been observed at the Hanford Site, including 41 species of mammals, 238 species of birds, 3 species of amphibians, and 9 species of reptiles (Weiss-Mitchell 1992). Major terrestrial habitat types on the Hanford Site include basalt outcrops, scarps (cliffs) and screes, riparian areas, shrub-steppe, sand dunes, and abandoned fields (Downs et al. 1993).

Predominant mammal species include the mule deer and Rocky Mountain elk; predators such as coyotes, bobcats, and badger; and a variety of small mammals (marmots, squirrels, rabbits) (Cushing 1992). The elk population, which has grown during the Hanford Site's existence, occurs primarily on the Fitzner Eberhardt Arid Lands Ecology Reserve, although elk reportedly also have been sighted on the islands in the Columbia River and along the Columbia River (CTUIR 1996). Mule deer may occur almost anywhere on the Hanford Site, although they are found more commonly along the Columbia River. White-tailed deer have been sighted occasionally along the Columbia River and at the Yakima River Delta in Richland.

The approximately 240 bird species on the Hanford Site include a variety of raptors (birds of prey), songbirds, and species associated with riparian and upland habitats (Landeen et al. 1992). No riparian or upland habitats exist within 3 km (2 mi) of any of the TWRS sites under any alternative. Twenty-six species of raptors have been sighted, 11 of which are known to nest on the Site. These include five species of owls, the northern harrier, three hawk species, the prairie falcon, and the American kestrel. Songbird species known to occur in the Hanford Site's shrub-steppe vegetation include the loggerhead shrike, sage sparrow, western meadowlark, grasshopper sparrow, common raven, horned lark, and sage thrush. The western meadowlark, sage sparrow, and horned lark are the most abundant shrub-steppe songbird species that breed on the Site. Common upland game bird species include the chukar partridge, California quail, and Chinese ring-necked pheasant. Sage grouse and gray partridge are less common, with the once common sage grouse now essentially displaced from the Site since a major wildfire occurred in 1984. None of the upland birds are native to the area except the sage grouse.

Nine species of reptiles and three species of amphibians occur on the Hanford Site. The most abundant reptile is the side-blotched lizard. The short-horned lizard and northern sagebrush lizard also are common in habitats such as mature sagebrush. Common snakes include the gopher snake, yellow-bellied racer, and Pacific rattlesnake. Less common are the striped whipsnake and desert night snake. Amphibians on the Hanford Site, which are associated with riparian habitats located along permanent water bodies of the Columbia River, include the Great Basin spadefoot, Woodhouses toad, and the Pacific treefrog. More than 300 species of terrestrial and aquatic insects occur on the Hanford Site (Cushing 1992). Grasshoppers and darkling beetles represent some of the more conspicuous groups.

Aquatic habitats on the Hanford Site, none of which are near any TWRS sites, are associated primarily with the Columbia River, two small spring-fed streams on the Fitzner Eberhardt Arid Lands Ecology Reserve, West Lake, and artificial ponds and ditches occurring in or near the 200 Areas (Cushing-Watson 1974, Emery-McShane 1978, and Cushing 1994). The Columbia River supports a large and diverse community of plankton, benthic invertebrates, and fish. The springs are also diverse and productive (e.g., dense watercress blooms and a fairly high insect production). The artificial ponds and ditches, many of which are abandoned and dried out, often provide lush riparian habitat and support populations of migrating and breeding birds, particularly waterfowl.

4.4.4 Sensitive Habitats

Sensitive habitats on the Hanford Site include wetlands and riparian habitats. However, there are no sensitive habitats at or near any TWRS sites (Cowardin et al. 1979). The Hanford Site's primary wetlands occur along the Columbia River. Other Hanford Site wetland habitats are associated with human-made ponds and ditches (e.g., B Pond and its associated ditches located near the 200 East Area). Wetland plants occurring along the shoreline of B Pond include herbaceous and woody species such as showy milkweed, western goldenrod, three square bulrush, horsetail rush, common cattail, and mulberry, among others (Sackschewsky et al. 1992). Wildlife species observed at B Pond include a variety of mammals and waterfowl species (Meinhardt-Frostenson 1979).

4.4.5 Species of Concern

Species of concern on the Hanford Site include Federally-listed threatened and endangered species, Federal candidate species (50 CFR 17), Washington State threatened or endangered species, Washington State candidate species, monitor species, and sensitive plant species.

No Federally-listed threatened or endangered plant or animal species occur on or around the Central Plateau (Sackschewsky et al. 1992). Pipers daisy, a Washington State sensitive species, has been found at B Pond near the 200 East Area and at the potential Pit 30 borrow site between the 200 East and 200 West Areas. The crouching milkvetch, stalked-pod milkvetch, and squill onion, all Washington State Class 3 monitor species, also are found in the vicinity (Duranceau 1995). Class 3 monitor species are either more abundant or less threatened than previously assumed, or both.

Wildlife species of concern on the Central Plateau and vicinity include the loggerhead shrike, which is a Federal and Washington State candidate species, and the sage sparrow, which is a Washington State candidate species. Both species nest in undisturbed sagebrush habitat in the Central Plateau and nearby areas. Other bird species of concern that may occur in shrub-steppe habitat of the Hanford Site are the burrowing owl, a Washington State candidate species; the ferruginous hawk, a Washington State threatened and Federal Category 2 candidate species; the golden eagle, a Washington State candidate species; the long-billed curlew, a Washington State monitor species; the sage thrasher, a Washington State candidate species; the prairie falcon, a Washington State monitor species; and Swainsons hawk, a Washington State candidate species (Downs et al. 1993, Sacksewsky et al. 1992, and Landeen et al. 1992).

The western sage grouse, a Federal and State-listed threatened species, was present in areas near the Central Plateau until the local population was displaced by a major wildfire in 1984. The sage grouse has not been observed on the Site since that time. The bald eagle, also a Federal and State-listed species, has been a regular winter resident in recent years of the Hanford Reach of the Columbia River. The bald eagle forages on salmon carcasses and waterfowl along the river and is not known to use the Central Plateau of the Site, which is 10 km (6 mi) or more from the river.

Nonavian wildlife species of concern include the striped whipsnake, a Washington State candidate species; the desert night snake, a Washington State monitor species; the pygmy rabbit, a Federal Category 2 candidate species; and the northern sagebrush lizard, also a Federal Category 2 candidate species.

Prehistorically and historically, the Native Americans of the Hanford Site vicinity fished for salmon in the Columbia River, gathered roots in the areas now called Moses Lake and Ephrata, and hunted and gathered berries in the mountains. They wintered in the lowlands by the Columbia River. However, the Native Americans hunted, fished, and gathered foods whenever the opportunities presented themselves.

Big game, including elk and antelope, were abundant on the Columbia Plateau, according to affected Tribal Nations (CTUIR 1996). Smaller mammals (marmots, squirrels, rabbits) were important food sources in the area. Bird species were a food source, and birds and bird parts also were used for medicinal and religious purposes (Hunn 1990). Fish were and remain an important part of the Native American diet in the Columbia River area. Although the 200 Areas themselves have no fishery resources, the fishery resource of the Hanford Reach of the Columbia River is important to Native Americans.

Plants have been and remain important to Native Americans for food, medicine, cordage, building materials, and as materials of religious and spiritual significance. For example, a substantial portion of the aboriginal diet was composed of food plants, with tubers being the most important food plant type (Hunn 1990). Several dozen plant species with specific uses (e.g., medicine, food) in traditional Native American culture and lifestyles have been identified on the Hanford Site by non-Native American researchers. A number of these species were identified in the 200 East Area during 1994 biological surveys (Fortner 1994). In the Native American view, however, identifying specific plant species as being of particular value is inappropriate because "any such attempts at separating interdependent components of a holistic system are contrary to tribal and cultural resources values" (CTUIR 1994).

4.5 CULTURAL RESOURCES

Three categories of cultural sites at the Hanford Site include 1) prehistoric sites, which represent Native American cultures and societies; 2) historic era sites, which generally must be at least 50 years old, although items and structures built in support of the Hanford Site's defense mission during World War II and the Cold War Era must also be considered (PNL 1989); and 3) ethnographic sites (traditional cultural sites) that are important to the heritage of contemporary Native American communities. The Hanford Site contains a rich diversity of known cultural sites in all three categories.

Cultural Sites

The Hanford Site as a whole contains extensive prehistoric and historic archaeologic sites.

The arid 200 Areas contain very limited prehistoric or historic archaeological sites.

The potential Vernita Quarry and McGee Ranch borrow sites contain both prehistoric and historic archeological cultural sites.

The Hanford Site contains seven districts listed in the National Register of Historic Places, as well as numerous other well-preserved archaeological sites. The overall condition and thus potential importance of the Hanford Site's cultural sites is high because the area has had limited public access for over 50 years. Limited access has preserved most archaeological sites from looting and other adverse impacts. Areas similar to the Hanford Site along the Columbia River have been inundated by water from hydroelectric development. Because the Hanford Site has not experienced this type of development and the resulting depletion of cultural sites, it represents a uniquely preserved area.

In addition to its archaeological and historic sites, the Hanford Site land is of importance to Native American peoples because "all natural resources are also cultural resources to indigenous peoples" (CTUIR 1996). The Hanford Site also is part of the original homeland of several Hanford Site Nations (CTUIR 1996).

Archaeological sites in the 200 Areas are scarce (Chatters-Cadoret 1990). Cultural resource surveys have been conducted within the 200 East Area covering all undeveloped areas (Chatters-Cadoret 1990). The number of prehistoric and historic archaeological sites recorded as the result of these surveys is very limited. Findings recorded in the areas around and including the TWRS sites consist of isolated artifacts and four archaeological sites (ASI 1994). Cultural resources surveys of the TWRS sites and immediate vicinity in the 200 East Area, which were conducted in 1994, found no sites eligible for the National Register of Historic Places (PNL 1994a, b, c). Past surveys of the Phased Implementation alternative site in the easternmost portion of the 200 East Area revealed no archaeological sites (Cadoret 1995). However, both the 200 East and 200 West Areas contain potentially historic buildings and structures associated with the Hanford Site's defense mission (Crist 1994).

Surveys of the 200 West Areas recorded a few historic sites, isolated archaeological artifacts, and a segment of the historic White Bluffs Road that runs across the Site between Rattlesnake Springs and the Columbia River (Chatters-Cadoret 1990). The White Bluffs Road, which has been nominated for the National Register of Historic Places, traverses the northwest corner of the 200 West Area. This road was used in prehistoric and historic times by Native Americans and was an important transportation route for Euro-Americans in the 19th and early 20th century for mining, agriculture, and other development uses. The segment in the 200 West Area is not considered an important element in its historic value because it has been fragmented by past activities (Cadoret 1995). However, the Confederated Tribes of the Umatilla Indian Reservation have indicated that the White Bluffs Road is important culturally to Native Americans even though it has been affected by past activities (CTUIR 1996).

The potential Vernita Quarry and McGee Ranch borrow sites have potential for both historic and prehistoric materials. Surveys have identified prehistoric isolated artifacts and prehistoric or historic sites at both Vernita and McGee Ranch (Duranceau 1995). The McGee Ranch area has been determined to be eligible for nomination to the National Register of Historic Places as the McGee Ranch/Cold Creek District (Cadoret 1995). No prehistoric sites are known at the potential Pit 30 borrow site, which is located between the 200 East and 200 West Areas, although one structure from the homestead era is located at Pit 30.

4.5.1 Prehistoric Resources

As indicated previously, survey data for the 200 East Area revealed no substantial prehistoric resources (Chatters-Cadoret 1990). Much of the land surface in the 200 Areas has been extensively disturbed by previous construction and other development activity, although disturbed areas still have the potential to contain cultural resources. The 1994 survey of the TWRS sites and surrounding vicinity in the 200 East Area revealed only isolated artifacts and sites (scattered stone tool fragments) (PNL 1994a, b, c).

There also are very few known prehistoric sites in the relevant portions of the 200 West Area. Prehistoric materials have been found at the potential Vernita Quarry and McGee Ranch borrow sites.

4.5.2 Historical Resources

The first Euro-Americans to enter this region were Lewis and Clark in the beginning of the nineteenth century. By the early twentieth century, cattle ranching, farming and several small, thriving towns were present, including Hanford, White Bluffs, and Ringold. The towns, settlements, and nearly all other structures were razed after the Federal government acquired the land for the Hanford Site in the early 1940's (PNL 1989 and Cushing 1994). Today, the remnants of homesteads, farm fields, ranches, and abandoned military installations can be found throughout the Hanford Site. There are nearly 5,200 ha (13,000 ac) of abandoned agricultural lands on the Site.

More recent are the nuclear reactors and associated processing facilities developed during the Manhattan Project and the Cold War era that are found on the Site. The various reactor sites around the Hanford Site cover over 900 ha (2,300 ac) of land area. All of the reactor buildings and major processing facilities still stand, although many ancillary support structures have been removed. The 100-B Reactor has been listed individually on the National Register of Historic Places and is a National Mechanical Engineering Monument and approximately 110 other buildings have been evaluated. The Washington State Historic Preservation officer and DOE have determined that the Hanford Site is a Manhattan Project/Cold War era historic district (Neitzel 1996). There are plans to complete the process of inventorying and evaluating the remaining buildings and structures associated with the Manhattan Project and Cold War Era in the 200 Areas by the end of 2000 (DOE 1996e). Currently, historic structure evaluations at the Hanford Site are conducted on an as-needed basis before altering or demolishing a structure.

Historic buildings associated with the development of nuclear technology exist in both of the 200 Areas, particularly plutonium production and processing facilities. Few of these have been evaluated for National Register of Historic Places eligibility, although none are expected to be impacted by TWRS activities under any alternative (PNL 1989 and Cushing 1995). The underground storage tanks that currently contain the tank waste may be considered historically important. A Programmatic Agreement concerning cultural resources management of the built environment at the Hanford Site has been signed by the U.S. Department of Energy (DOE), the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office (DOE 1996e). Under the agreement, DOE will document one SST and one DST on historic property inventory form.

4.5.3 Native American Sites

The Hanford Site vicinity contains lands ceded to the United States by both the Confederated Tribes and Bands of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation in the treaties of 1855. Until 1942, the Wanapum resided on land that is now part of the Hanford Site. In 1942, the Wanapum People moved to Priest Rapids when the Hanford Site was established. The Nez Perce Tribe also retained rights to the Columbia River under a separate treaty with the U.S. Government.

The area of the Hanford Site near the Columbia River has been occupied by humans for over 10,000 years, as reflected by the extensive archaeological deposits along the river shores. Inland areas with water resources also point to evidence of concentrated human activity. Recent surveys indicate extensive although dispersed use of semi-arid lowlands for hunting. However, surveys have recorded very few Native American sites or artifacts in and around the 200 Areas (Chatters-Cadoret 1990). Native American sites and artifacts have been identified at both McGee Ranch and the Vernita Quarry (potential borrow sites).

Native Americans have retained traditional secular and religious ties to the Hanford Site. No specific sites of religious significance have been identified at the TWRS sites. However, affected Tribal Nations indicate that there are culturally important biota, sacred sites such as Gable Mountain, and other culturally important properties within areas that might be impacted by TWRS alternatives (i.e., groundwater downgradient from TWRS sites, the Columbia River, and locations downwind of possible TWRS air releases) (CTUIR 1996).

Tribal Nation Cultural Values Perspective

"All natural resources are cultural resources to indigenous people" (CTUIR 1996). "The soils themselves and the groundwater contained within them are critical components of the structure and functions of the ecosystem as a whole and cannot be separated in piecemeal fashion. Any such attempts at separating interdependent components of a holistic system are contrary to tribal cultural and natural resources values" (CTUIR 1994). Cultural values "not directly related to public health and safety or the ecological aspects of the environment should be protected. These other cultural values stem from what could be termed religious beliefs and are associated with the sanctity of the land forms and other natural resources at Hanford" (YIN 1996).

4.6 SOCIOECONOMICS

The socioeconomic analysis focuses on Benton and Franklin counties. The counties make up the Richland-Kennewick-Pasco Metropolitan Statistical Area, also known as the Tri-Cities, a term that is frequently used to designate the Metropolitan Statistical Area. Other jurisdictions in Benton County include Benton City, Prosser, and West Richland. Connell is the largest city in Franklin County after Pasco. Neighboring counties (Yakima, Walla Walla, Adams, and Grant counties in Washington and Umatilla and Morrow counties in Oregon) are impacted by activities at the Hanford Site; however, in terms of socioeconomics, the Site's impacts on these counties is very small (Serot 1995).

On February 11, 1994, Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, was published in the Federal Register. The Order requires Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. Currently, no formal guidelines have been adopted to implement the Executive Order; however, EPA has published relevant studies and information on environmental justice. DOE is a participating member of this task force.

In accordance with Executive Order 12898, information is provided in Section 4.6.1 concerning the minority populations and low-income populations within an 80-km (50-mi) radius of the Hanford Site. This discussion provides the basis for analyzing potential disproportionate and adverse environmental impacts of TWRS EIS alternatives on minority populations and low-income populations. The 80-km (50-mi) radius includes counties not otherwise addressed in this section because overall Hanford Site socioeconomic impacts on these counties are very minor. However, the section does describe minority population and employment within the Hanford Site's primary zone of socioeconomic influence, the Tri-Cities area (Benton and Franklin counties).

Before World War II, the economy in the Tri-Cities area was based primarily on agriculture. Since World War II, the Hanford Site has been the largest factor in the local economy. Plutonium production and processing was the primary mission of the Site until 1988, when the mission changed to environmental restoration and waste management. Basic and applied research are an important secondary mission.

Socioeconomic Information

In 1995 the Hanford Site represented 22 percent of the area's total nonfarm employment.

With the rapid economic growth from the late 1980's, population rose as did the housing market. Housing prices declined in 1995 as the market softened when Hanford Site jobs were reduced.

As of 1990, the population within an 80-km (50-mile) radius around the Hanford Site contained 19.3 percent minority and Native American residents and 17.3 percent low-income residents.

Most public service systems in the Tri-Cities operate well within their service capacity. Local school systems and some local public safety agencies are operating at or near their capacities.

Historically, changes in the Hanford Site's mission and the cancellation in the early 1980's of a Washington Public Power Supply System project at the Hanford Site have had measurable impacts on the economy of the Tri-Cities area. Boom-bust cycles have occurred that have had ramifications for employment, population, housing, and infrastructure. Table 4.6.1 shows Hanford Site employment, Washington Public Power Supply System employment, and total nonfarm employment for the Tri-Cities area, together with the area's population for 1980 to 1994. These data do not reflect the ongoing reductions in Site employment in 1995 (i.e., an expected reduction from 1994 levels of approximately 4,500 jobs by the end of 1995). The Washington Public Power Supply System workforce was reduced to approximately 1,500 by mid-1995.

4.6.1 Demographics

4.6.1.1 Population Trends

Population tended to follow changes in nonfarm employment in the Tri-Cities area during the 1980's and early 1990's (Table 4.6.1). The population trends apparently reflected not only existing employment at the Hanford Site and elsewhere in the area, but also expectations about future employment opportunities.

Table 4.6.1 Population and Employment in the Tri-Cities Area, 1980 to 1994

Year	Hanford Site Employment	Washington Public Power Supply System Employment	Total Nonfarm Employment	Total Tri-Cities Area Population
1980	12,100	7,935	58,710	144,469
1981	11,880	11,728	63,940	150,100
1982	11,357	8,841	58,860	147,900
1983	11,740	5,498	55,360	144,700
1984	12,891	2,015	52,870	144,000
1985	13,570	1,800	54,020	140,900
1986	14,015	1,745	55,230	139,300
1987	14,298	1,677	56,970	139,600
1988	13,433	1,633	55,400	139,600
1989	12,871	1,680	57,300	138,300
1990	14,152	1,762	62,200	150,030
1991	15,101	1,842	64,100	153,400
1992	16,209	1,904	66,400	157,700
1993	17,075	1,950	70,000	163,900
1994	18,388	1,750	73,800	169,900
1995	15,767	1,320	72,200	175,000

Notes:
Data for 1990 through 1992 reflect revised estimates made in April 1994. Hanford Site employment includes DOE and its major contractors. Washington Public Power Supply System employment includes contractors. Washington Public Power Supply System 1993 and 1994 employment levels are estimates.
Source: WSDES 1995, WSDFM 1987-95, Meeker 1994, Cushing 1995, and Neitzel 1996.

Table 4.6.2 shows the 1990 population for Benton and Franklin counties and, for comparison, Washington State by race and minority status. The data show that minorities are a smaller percentage of Benton County population (8.7 percent) than in Franklin County (28.2 percent) or in Washington State (11.5 percent). The largest minority group in the area is the Hispanic Origin group, which makes up 30.2 percent of the population of Franklin County and 7.7 percent of Benton County. African Americans make up 1 percent of Benton County's population and 3.5 percent of Franklin County's population. Native Americans account for less than 1 percent of the population in each county, while Asians and Pacific Islanders account for approximately 2 percent of each county's population.

Benton County's farm population is more than twice as large (as a percentage of total population), than for Washington State as a whole (12.6 percent to 5.5 percent). Franklin County's farm population is almost five times as large on a percentage basis (24.9 percent) as Washington State's farm population. Franklin County's nonfarm rural population makes up 30 percent of the county's total population, which is virtually the same as the State's (29.3 percent), while more than twice the percentage in

Table 4.6.2 Population by Race and Minority Status, 1990

Category	Benton County Population	Percent	Franklin County Population	Percent	Washington State Population	Percent
Total Population	112,560	100.0	37,473	100.0	4,866,692	100.0
White	102,832	91.4	26,917	71.8	4,308,937	88.5
African American	1,085	1	1,310	3.5	149,801	3.1
American Indian, Eskimo, Aleut (Native American)	861	0.8	263	0.7	81,483	1.7
Asian and Pacific Islanders	2,246	2	869	2.3	210,958	4.3
Other	5,536	4.9	8,114	21.7	115,513	2.4

Notes:
Other is primarily a count of persons who marked Other Race on the Census form.
Source: WSDES 1993a.

Benton County (13.0 percent). These data suggest the relative importance of farming in Franklin County and to a lesser extent in Benton County as compared to Washington State as a whole.

4.6.1.2 Minority and Native American Populations and Low-Income Populations Within an 80-km (50-mi) Radius of the Hanford Site

Federal environmental justice policy requires identifying all minority and Native American and low-income populations that potentially could be subject to disproportionately high and adverse impacts resulting from the proposed action (EO 12898). Identifying potentially impacted minority and Native American populations and low-income populations in the 80-km (50-mi) area surrounding the Hanford Site's Central Plateau (where TWRS activities would be focused) involved analyzing the 1990 census data (DOC 1991). In 1990 the 80-km (50-mi) radius surrounding the Hanford Site contained a total population of approximately 448,000 and includes all of Benton County and portions of another nine surrounding counties (seven in Washington State and two in Oregon). Much of the Yakama Indian Reservation is located within the 80-km (50-mi) radius. The Wanapum People maintain a small residential community north of the Site near Priest Rapids Dam. In addition, the Confederated Tribes of the Umatilla Indian Reservation (located in northeastern Oregon) and the Nez Perce Tribe (located in northern Idaho) have historical and treaty interests in the Hanford Site area.

The process of identifying minority and Native American and low-income communities for the EIS environmental justice analysis is described in Volume Five, Appendix I (Section I.6.1).

Environmental Justice Demographic Analysis Terms

Minority and Native American population: Individuals identified in the U.S. Bureau of the Census data for 1990 as Negro, Black or African American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and any other non-Caucasian person. The minority and Native American population consists of the number of individuals residing in the 80-km (50-mi) radius of the Hanford Site who are members of a minority group.

Low-income population: Individuals identified in U.S. Bureau of the Census data for 1990 as having incomes at or below the Federal poverty level. The low-income population consists of the number of individuals residing in the 80-km (50-mi) radius of the Hanford Site who have incomes below the Federal poverty level.

Minority and Native American communities and low-income communities: For the purposes of this EIS, minority and low-income population were analyzed at the census tract level. All tracts within a 80-km (50-mi) radius of the Hanford Site were included in the analysis. The 80-km (50-mi) area of interest is the same area used for the analysis of environmental and human health impacts in other sections of the EIS.

Minority and Native American Populations

As of the 1990 census, the 80-km (50-mi) area surrounding the Hanford Site's Central Plateau had a total minority and Native American population of 86,400. The area's minority and Native American population of 19.3 percent exceeded the Washington State average of 13.1 percent. The Hispanic population (14.3 percent or 64,300 individuals) is the area's principal minority group. The Hispanic population is relatively evenly dispersed throughout the area. African American (1.2 percent or 5,200 individuals) and Asian (1.4 percent or 6,100 individuals) populations are very small and are located predominantly in Yakima, Benton, and Franklin counties. The Native American population consists of 2.4 percent or 10,800 of the area's population. The Native American population is predominantly located on the Yakama Indian Reservation. Other Native American populations include members of the Confederated Tribes of the Umatilla Indian Reservation, the Wanapum People, and the Nez Perce Tribe.

Of the 97 census tracts that are contained completely or partially within the 80-km (50-mi) radius of the Site in 1990, 17 had minority and Native American populations greater than 33 percent of the census tracts, total population (Figure 4.6.1). These 17 census tracts contained less than one-fifth of the area's total population, but more than half of its total minority and Native American population. Moreover, these 17 census tracts were home to over 63 percent of the area's Native American residents and at least 56 percent of the area's Hispanic population. The 17 tracts had an average minority and Native American population of nearly 52 percent per tract. The fact that these 17 tracts contained more than half of the 80-km (50-mi) area of interest's total minority and Native American population is the reason that they are the focus of the EIS environmental justice analysis.

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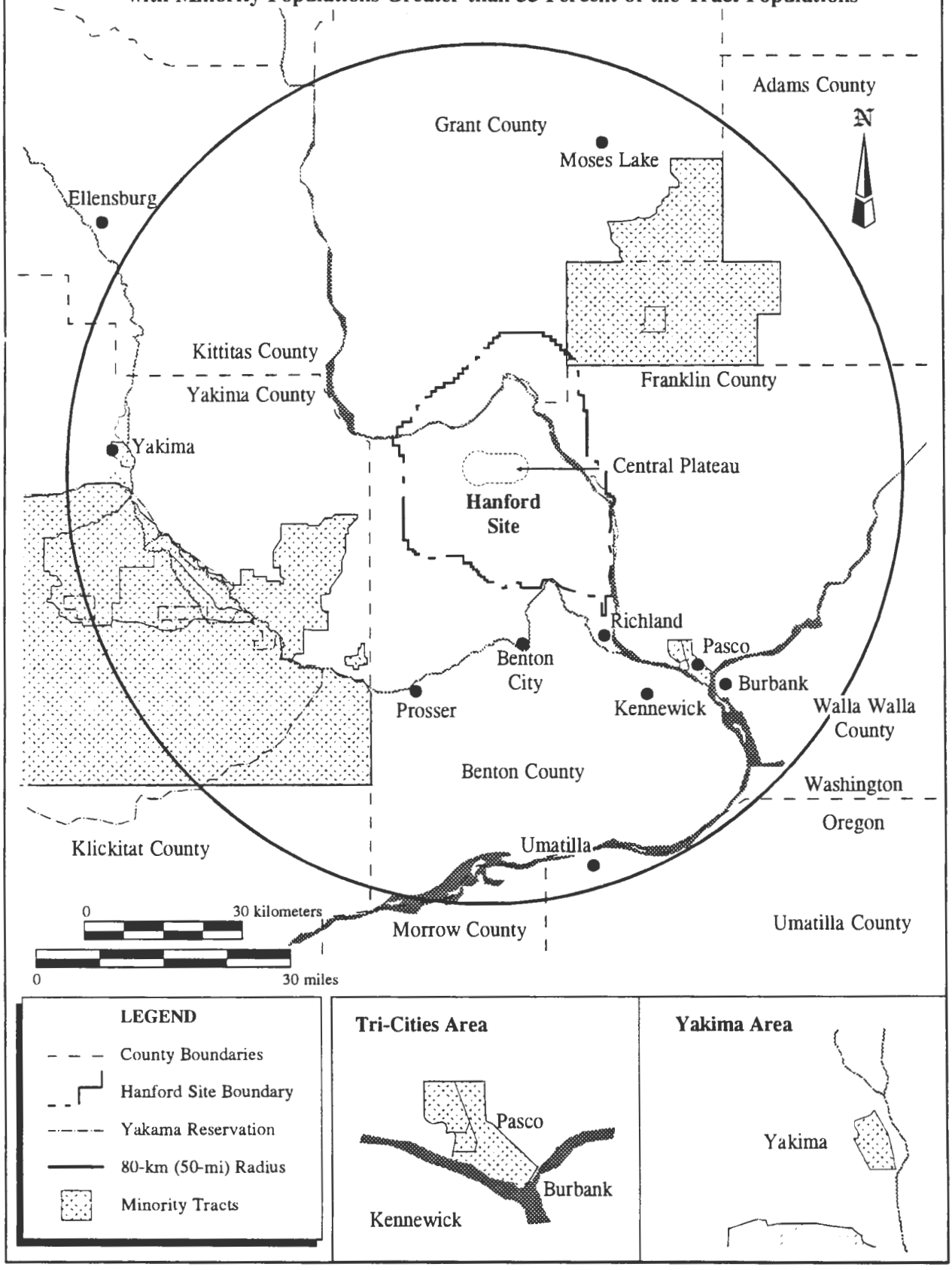
Figure 4.6.1 Census Tracts within an 80-km (50-mi) Radius of the Hanford Site with Minority Populations Greater than 33 Percent of the Tract Populations



Geographically, the tracts with the highest fraction of minority and Native American populations are located in Adams, Grant, Franklin, and Yakima counties, and the Yakama Indian Reservation. Of the remaining 80 census tracts in the area of interest, 49 had 1990 minority and Native American populations of less than 10 percent, 23 had minority and Native American populations under 20 percent, and eight had minority and Native American populations between 21 percent and 33 percent. Five census tracts, all located within the Yakama Indian Reservation, contained substantial Native American populations. In 1990, these tracts had nearly 57 percent of the 80-km (50-mi) radius area's Native American population and were the only census tracts in the area where the percentage of Native American population exceeded 8 percent of the census tract's total population.

All of the 17 census tracts with a minority and Native American population greater than 33 percent in 1990 had large numbers of individuals listed in the census "Other" category (census categories include White, Black, American Indian, Asian, and Other; the Other category generally is thought to include many Hispanics). In all but 3 of the 17 tracts, the Other category alone accounted for more than 33 percent of the tract's total population. Two of these three tracts are located on the Yakama Indian Reservation and have substantial Native American populations; the third tract is located in Franklin County.

Low-Income Populations

In all, 25 of the 97 census tracts within the 80-km (50-mi) radius of the Hanford Site had 1990 low-income populations greater than 22 percent of their total population (Figure 4.6.2). These 25 census tracts contained approximately 28 percent of the area's total residents and 51 percent of the region's total low-income population. The fact that the 25 tracts contained more than half of the region's total low-income population is the reason that they are the focus of the environmental justice analysis of low-income populations. The 25 tracts had a total average low-income population of more than 31 percent. The tracts with high low-income populations (22 percent or greater) are located in Adams, Grant, Franklin, and Yakima counties (including the Yakama Indian Reservation). Of the remaining 72 census tracts, 30 tracts had low-income populations in 1990 less than the Washington State average of 10.9 percent; 27 tracts had low-income populations between 11 percent and 17.3 percent (the average low-income population level for the 80-km [50-mi] radius); and 15 tracts had low-income populations between 17.4 percent and 21.4 percent. Fourteen of the 26 census tracts with low-income populations under the Washington State average of 10.9 percent were located in Benton County (12 tracts) or in the two Franklin County tracts closest to the Hanford Site transportation access.

4.6.1.3 Household Income and Educational Attainment

The largest fraction of Franklin County's households is in the $15,000 to $24,999 yearly income range (DOC 1991). Benton County has the largest fraction of its households in the $35,000 to $49,999 yearly income range. Median household yearly income in Benton County was $41,800 in 1993, while per capita income was $21,030. Median household yearly income in Franklin County was $30,525 in 1990, while per capita income was $17,230. For Washington State, 1993 median household yearly income was $37,316, per capita income was $21,770 and the largest fraction of its households have yearly incomes in the $35,000 to $49,000 range (Neitzel 1996).

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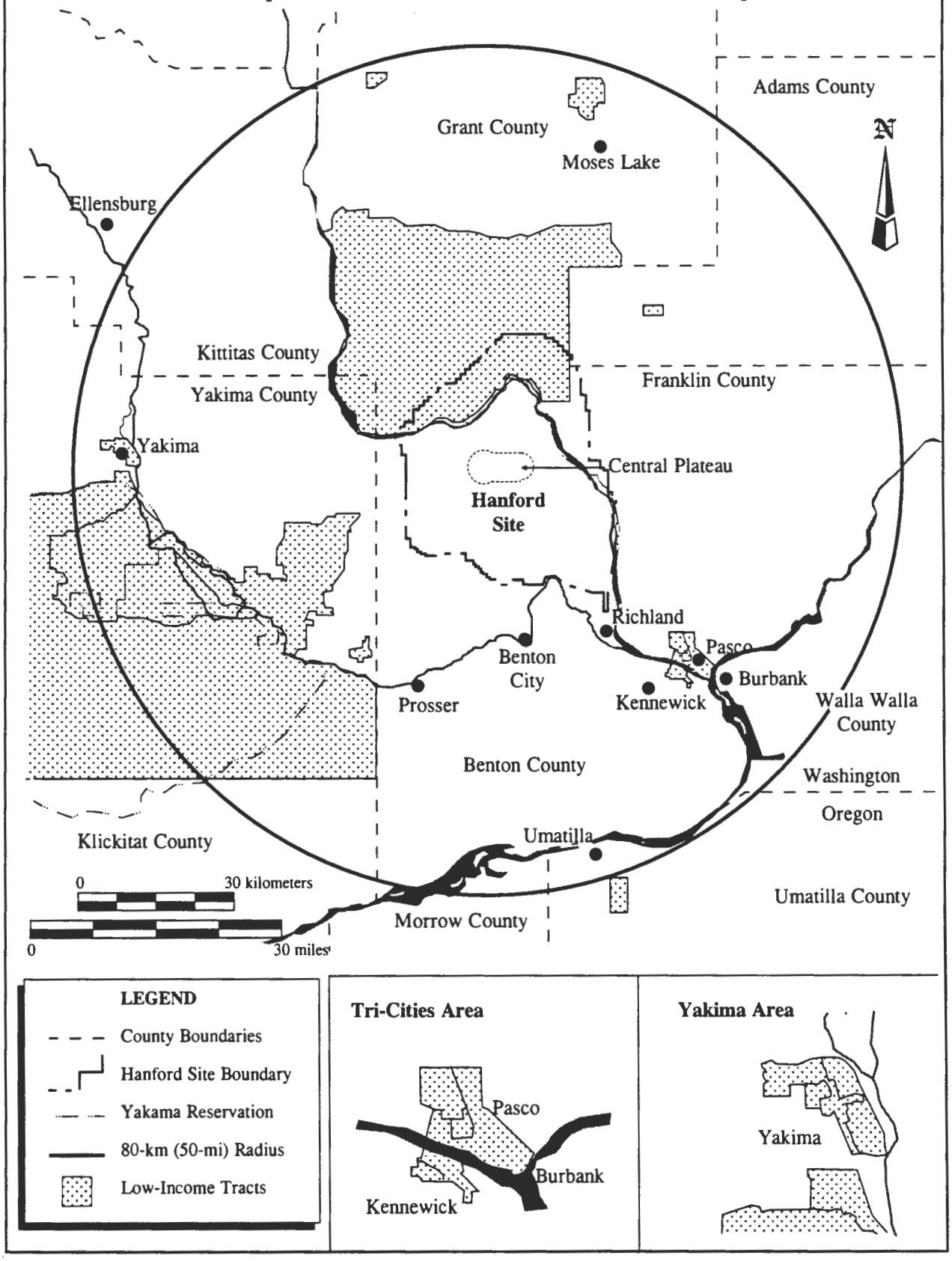
Figure 4.6.2 Census Tracts within an 80-km (50-mi) Radius of the Hanford Site with Low-Income Populations Greater than 22 Percent of the Tract Populations



Data on persons and families below the poverty level indicate that for most categories, Benton County has very similar poverty rates to Washington State as a whole (11.1 percent compared to 10.9 percent), while Franklin County has substantially higher poverty rates, at 23 percent of the population. Benton County residents have approximately the same level of educational attainment as residents statewide, while Franklin County residents tend to have a lower level of educational attainment.

4.6.2 Public Facilities and Services

Police protection is provided by the county sheriff departments of Benton and Franklin counties, local municipal police departments (Pasco, Richland, Kennewick, and West Richland), and the Washington State Patrol division in Kennewick. Fire protection in the Tri-Cities area is provided by fire departments in the cities of Kennewick, Pasco, and Richland, a volunteer fire department in West Richland, and three rural fire departments in Benton County. While recent population growth has created additional stress on local public safety agencies' service capabilities, discussions with local government representatives indicated that to date it has not impacted the agencies' ability to adequately serve their jurisdictions. Pasco, Richland, and West Richland indicate that any additional growth will require augmenting public safety agencies' capabilities (McDonald 1995, Milspa 1995, Corcoran 1995). Kennewick's existing agencies could handle modest growth (up to 1,000 additional residents) before additional capabilities are needed (White 1995).

Public safety services are also provided at the Hanford Site. Historically, the Hanford Patrol has provided security and law enforcement services at the Site, although the Benton County Sheriff's Department began providing law enforcement support at the Site in 1994. The Hanford Fire Department has five fire stations onsite and a complement of 155 firefighters (Neitzel 1996).

There are three major hospitals in the Tri-City area; the Kadlec Medical Center in Richland, Kennewick General Hospital in Kennewick, and Our Lady of Lourdes Hospital in Pasco, all of which operate at 35 to 50 percent of their capacity (Neitzel 1996). There are also four minor emergency centers in the area. The Hanford Environmental Health Foundation operates five health service centers on the Hanford Site.

Educational services at the primary and secondary levels are provided by four school districts. Kennewick is the largest district, serving approximately 13,000 students in 1994, with 8,700 students in the Richland district, 7,800 students in the Pasco district, and 1,500 students in the Kiona-Benton district. Enrollments have been on the rise over the last few years and all four districts were operating at or near their capacity during the 1994 school year (Cushing 1995). Preliminary data for the 1995 school year show enrollment growth continuing at 2.6 percent in Kennewick, 0.9 percent in Richland, 1.1 percent in Pasco, and 5.1 percent in Kiona-Benton over 1994 levels (Foley 1995, Marsh 1995, Brown 1995, Meilour 1995, and Haun 1995). In 1995, the Richland, Kennewick, and Kiona-Benton districts were operating at capacity, while the Pasco district was at capacity in the primary grades but had more room for secondary students (Neitzel 1996). Post-secondary education in the area is provided by Columbia Basin College (1995 enrollment of 6,700) and the Washington State University Tri-Cities branch campus (1995 enrollment of 1,200).

Electricity in the Tri-Cities is provided by the Benton County Public Utility District, Benton Rural Electrical Association, Franklin County Utility District, and the city of Richland Energy Services Department. The Bonneville Power Administration, a Federal power marketing agency, supplies all the power that these utilities provide in the local area as well as the Hanford Site's electrical power. Hydroelectric is the region's largest electrical power source. Throughout the 1980's, the Pacific Northwest had more electrical power than it needed and operated with a surplus. This surplus has been exhausted, however, and the regional system generates only enough power to meet regional needs (Neitzel 1996). Natural gas serves only a small portion of the region's residents (Neitzel 1996).

The major incorporated areas of Benton and Franklin counties are served by municipal wastewater treatment systems and the unincorporated areas are served by onsite septic systems. The wastewater treatment systems of the cities of Richland, Kennewick, and Pasco all currently operate well under their capacity (Cushing 1995).

Sanitary waste in the Hanford Site's 200 Areas is currently disposed of through septic tanks and drain fields. There are concerns about the ability of the current system to handle projected sanitary waste disposal needs. Planned construction of a central collection and treatment facility in the 200 Areas was cancelled in 1995 because of funding problems (Harvey 1995).

The city-operated Richland Sanitary Landfill (with a current life expectancy of 50 years), serves Richland and Benton County (Penour 1994). The city of Kennewick contracts for solid waste disposal; city waste is disposed of at a landfill in Arlington, Oregon, which has a life expectancy of approximately 50 years (Denley 1994). The cities of Pasco and West Richland also contract for solid waste disposal; wastes from both communities are taken to a facility in Roosevelt, Washington, which has a life expectancy of 40 years (Thiele 1995).

The existing Hanford Site nonradioactive solid waste landfill is expected to reach its capacity in 1996. In October 1995 it was announced that DOE and the city of Richland reached an agreement to send the Site's nonregulated, nonradioactive solid waste to the Richland Sanitary Landfill (DOE 1995k).

4.6.3 Economy

The Hanford Site is the largest employer in the Tri-Cities area and is a key factor in the local economy. In 1994, total nonfarm employment in the area averaged about 72,300, while Hanford Site employment averaged about 18,400. The Hanford Site thus represents approximately 25 percent of total nonfarm employment in the Tri-Cities. Most Hanford Site employees are considered as part of the services sector of the local economy. In addition, other workers not included in DOE's count of Hanford Site employees provided goods and services to the Site or its contractors.

Nonfarm employment grew to approximately 72,300 in 1994. However, as Hanford Site employment declined in 1995 from 18,100 to 14,500 from August 1994 to August 1995, and as construction employment also declined with a slowdown in housing construction, total nonfarm employment as of August 1995 declined to approximately 70,900 (Schafer 1995a). Agriculture, food processing, retail

trade, and other industries provide a considerable and increasing amount of economic diversity to the Tri-Cities area. Farm employment, which fluctuates seasonally, averages a total of nearly 8,000 in the Tri-Cities area. Because farm employment is not impacted by Hanford Site activities it is not discussed further in this section.

4.6.3.1 Industries and Employment

Table 4.6.3 details average annual employment by different sectors of the economy in 1993. The economic sector with the highest employment is services, which includes most of the Hanford Site workforce. The next largest sector is wholesale and retail trade. The Tri-Cities area is the main retailing center for southeastern Washington State and northeastern Oregon. Government is the third largest sector, including Federal, State, and local governments and the public schools. Construction has been a key employment sector in the past few years. Food processing is the largest manufacturing industry, followed by chemicals. The 1995 decline in nonfarm employment previously mentioned most strongly impacted the services sector (which includes most Site employees) and the construction sector.

The services sector dominates the Tri-Cities economy, accounting for $769 million in wages, or about 43 percent of total wages paid in the two counties (WSDES 1994). Statewide, services accounted for only 21 percent of annual wages paid. The average annual wage in the services sector in Benton County was more than $34,000, compared to $17,000 in Franklin County and $23,000 statewide. The higher annual wage in the services sector in Benton County reflects the Hanford Site-related technical and professional work force.

4.6.3.2 Labor Force

Data for 1990 show that the Benton County labor force is concentrated in the managerial and professional, and the technical, sales, and administrative occupations, each of which accounts for about 30 percent of the work force (WSDES 1994). Franklin County has far lower percentages in these categories.

Table 4.6.3 Average Annual Employment by Sector Tri-Cities Area, 1993 and 1995

	Annual Average Employment		Percent of Total Employment	
Industry	1993	1995	1993	1995
Manufacturing	5,600	5,600	8.0	7.8
Construction	3,900	4,400	5.6	6.1
Transport and Public Utilities	2,200	2,300	3.1	3.2
Wholesale and Retail Trade	14,000	15,600	20.0	21.6
Finance, Insurance, Real Estate	2,100	2,300	3.0	3.2
Services	28,900	28,400	41.3	39.3
Government	12,900	13,600	18.4	18.8
Total	70,000	72,200	100.0	100.0

Notes:
Totals may not equal sum of components because of rounding.
Source: WSDES 1990-1995, Neitzel 1996

Technical, sales, and administrative occupations and farming, forestry, and fishing occupations each account for about 21 percent of the Franklin County labor force. Franklin County also has a higher percentage of workers in the operators, fabricators, and laborers occupational category (17.3 percent) than Benton County (12.0 percent).

Hispanics make up 6.9 percent of the total Benton County labor force, 2.2 percent of the managerial and professional category, 46 percent of the agricultural workers, and 11.9 percent of the operators, fabricators, and laborers category. In Franklin County, Hispanics make up 28.3 percent of the total labor force, 7.2 percent of the managerial and professional occupational category, 63 percent of the agricultural workers, and 28 percent of the precision production, craft, and repair occupational category.

African Americans, who make up 0.9 percent of the labor force in Benton County, account for 1.4 percent of the managerial and professional category, while in Franklin County they account for 2.1 percent of the labor force and 2 percent of the managerial and professional category. Native Americans account for a slightly larger percentage of the service (1.3 percent); precision production, craft, and repair (1.1 percent); and operators, fabricators, and laborers (1.2 percent) categories in Benton County than their percentage of the total labor force (0.7 percent). In Franklin County, Native Americans account for a larger percentage of the managerial and professional (1.1 percent) and precision production, craft, and repair categories (1.5 percent) than in the total labor force (0.8 percent).

Asians and Pacific Islanders account for 2 percent of the labor force in Benton County and 2.7 percent of the managerial and professional category. The same group accounts for 2 percent of the labor force in Franklin County, but only 1.2 percent of the managerial and professional category. Service occupations show the highest rate of Asian and Pacific Islander representation in both counties.

Women account for 40.4 percent of the labor force in Benton County and 42.7 percent in Franklin County. Women account for 51.5 percent of the managerial and professional category in Benton County and 39.4 percent in Franklin County. In the other occupational categories the representation of women is similar in the two counties.

4.6.3.3 Tax Base

Local government revenues in Benton and Franklin counties come primarily from property taxes and the local share of sales taxes (Serot 1993). In 1993, assessed property values were about $3.8 billion in Benton County and $1.3 billion in Franklin County. These assessed values were $500 million more than 1992 assessments in Benton County (15 percent increase) and $86 million more in Franklin County (7 percent increase).

In 1992, the last year for which complete data are available, taxable retail sales in Benton County were $1,054 million and $400 million in Franklin County (WSDR 1993). This was a 14 percent increase in

Benton County over 1991 levels and a 16 percent increase in Franklin County. Between 1988 and 1992, combined taxable retail sales for the two counties increased about 10.5 percent per year.

4.6.3.4 Housing and Real Estate

The growth in employment and population in the Tri-Cities area between 1989 and 1994 created a very tight housing market and rising home prices, which began to soften in early 1995 due to reductions in Hanford Site employment (TAR 1980-95). The tight housing market also was reflected in very low vacancy rates and increasing prices in rental housing, although new construction and Hanford Site employment reductions caused a softening of the rental market in 1995 as well (Sivula 1995).
The Hanford Site's environmental restoration and waste management mission also stimulated some new commercial construction.

4.7 LAND USE

This section describes current and future land uses on and adjacent to the Hanford Site. The description focuses on the 200 Areas but includes the remainder of the Hanford Site and the surrounding offsite land-use patterns. Also addressed are the future planning efforts of tribes and Federal, State, and local agencies. Prime and unique farmlands and recreational opportunities also are discussed.

Land Use Information

Approximately 6 percent of the Hanford Site has been actively used by Site operations, with the remainder left undeveloped. Nearly half the Site's area is designated for ecological or wildlife purposes.

The 200 Areas historically have been used for processing facilities and waste management activities. Current plans envision the 200 Areas to be dedicated exclusively as a waste management and disposal area for the entire Hanford Site.

DOE is preparing a Comprehensive Land-Use Plan for the Hanford Site, which was released August 1996. Both Benton County and the city of Richland will release their land-use plans for the Site in 1996.

4.7.1 Existing Land-Use Types

4.7.1.1 Hanford Site Development Plan and Comprehensive Land-Use Plan

The Hanford Site Development Plan (DOE 1993e) provides an overview of existing Site land use, infrastructure, and facilities, and presents DOE's vision as of 1993 for future Site land uses and infrastructure as needed by Hanford Site missions. A Draft Comprehensive Land-Use Plan for the Hanford Site was released for public review and comment in August 1996 (DOE 1996c). DOE invited the affected Tribal Nations, county and city government, and stakeholders to participate in the land-use planning process. Final land-use planning decisions are scheduled for 1997.

The purpose of the Site Development Plan, which is not a comprehensive formal land-use plan and does not mandate specific Federal actions, was to present Site development issues that require a commitment of resources. Until the Comprehensive Land-Use Plan is completed, the Hanford Site Development Plan and its Future Land-Use Map (Figure 4.7.1) represent the most currently available document on DOE's concepts for future Site land uses.

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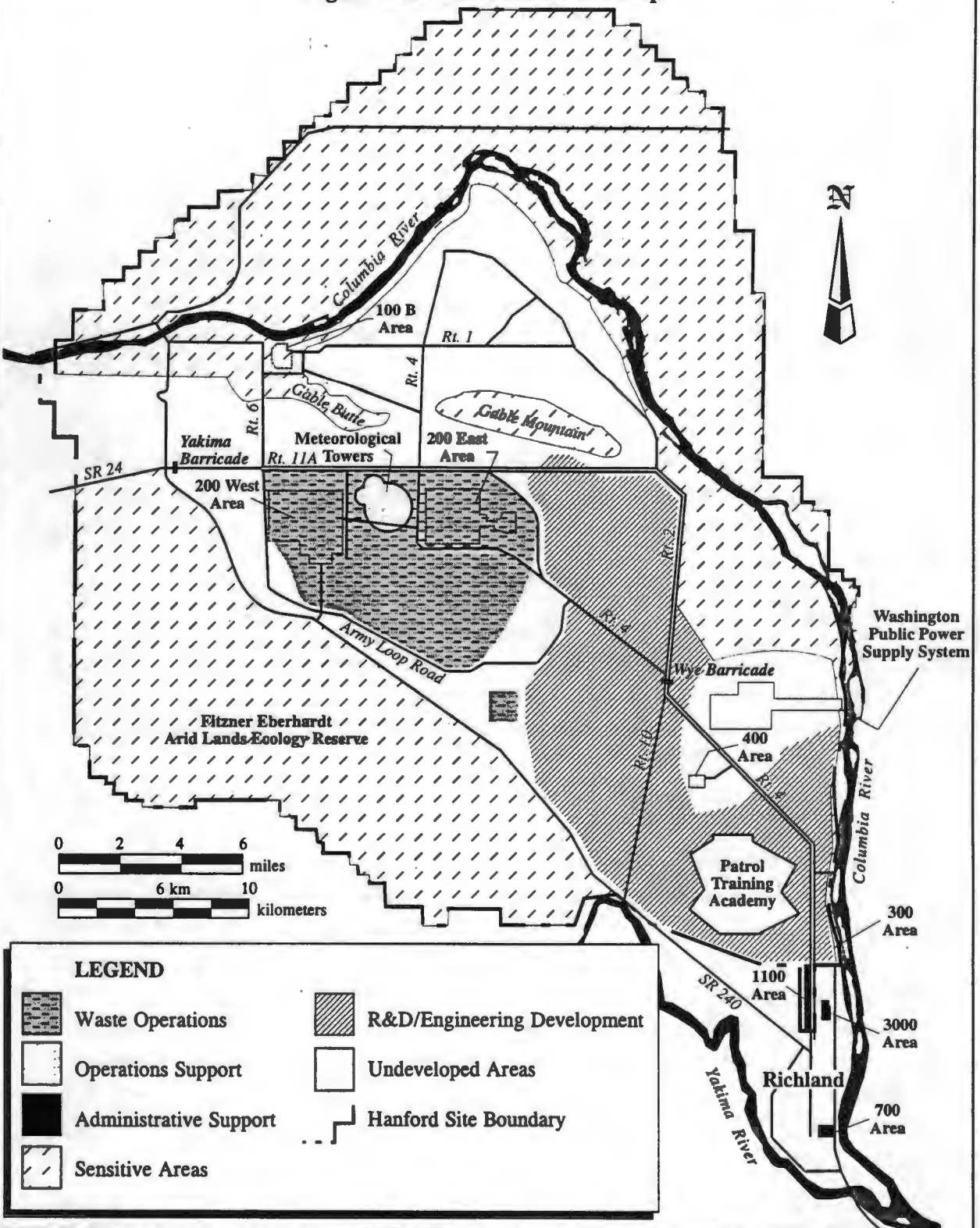
Figure 4.7.1 Future Land Use Map



NOTE: The land uses identified in this map represent DOE's 1993 vision of future land uses based on existing and potential Hanford missions. This map will be superseded by the Hanford Site Comprehensive Land Use Plan, which was released for public comment in August 1996 (DOE 1996c).

SOURCE: Adapted from DOE 1993e

Figure 4.7.2 identifies the existing land uses on the Hanford Site. The seven major Hanford Site land-use categories are 1) Reactor Operations; 2) Waste Operations; 3) Operations Support; 4) Administrative Support; 5) Research and Development and Engineering Development; 6) Sensitive Areas (including environmentally or culturally important areas); and 7) Undeveloped Areas (both previously undeveloped or restored).

The largest category of existing Hanford Site land use is the Sensitive Areas. Approximately 665 km^2 (257 mi^2), or nearly half of the Site has been designated as ecological study areas or refuges. This includes the Fitzner Eberhardt Arid Lands Ecology Reserve and the entire Site area north of the Columbia River (the North Slope). Both of these areas are being considered by DOE for release.

Proposals are being considered by DOE to release the Fitzner Eberhardt Arid Lands Ecology Reserve to the Yakama Indian Nation or to another Federal agency such as the Bureau of Land Management.

The North Slope could be designated by Federal legislation as a National Wildlife Refuge, as proposed by the National Park Service (NPS 1994), although other proposals have been made that include some agricultural uses in addition to wildlife areas. A public hearing was held in the summer of 1995 on the Fitzner Eberhardt Arid Lands Ecology Reserve ownership issue, but no final decisions have been made for either area.

The Waste Operations land use is primarily confined to the 200 Areas. The 200 Areas, the focus of proposed TWRS activities, have been used to reprocess irradiated nuclear fuel and to store the resulting waste (including the tank waste). Existing facilities in this area include the PUREX Plant, the Plutonium Finishing Plant, U Plant, the tank farms, the Central Waste Complex, the Waste Sampling and Characterization Facility, and the Waste Encapsulation and Storage Facility. Currently, the PUREX Plant, the Plutonium Finishing Plant, and U Plant are being deactivated.

The Future Land-Use Map from the Hanford Site Development Plan (DOE 1993e) was based on consideration of existing and potential Site missions (Figure 4.7.1). Recommendations of the Hanford Future Site Uses Working Group also were considered (HFSUWG 1992). The Reactor Operations, Sensitive Areas, and Administrative Support areas remain unchanged from the existing land-use map. Of primary importance for the TWRS EIS is the Waste Operations area. The location of the Waste Operations area remains the same, although it has been expanded. This expansion reflects land dedicated to a potential cleanup scenario where Sitewide waste is collected and placed in a central location dedicated to exclusive use as a waste disposal area. This includes relocating waste sites contaminants and associated structures, such as the 100 Area facilities, as well as implementing the proposed TWRS action.

The Hanford Site Development Plan future land-use concept is designed to provide a compatible land-use transition from offsite agricultural uses in Adams, Grant, Franklin, and Benton counties to passive uses onsite in the Fitzner Eberhardt Arid Lands Ecology Reserve and the proposed National Wildlife Refuge and Wild and Scenic River north of and along the Columbia River. The areas of the Hanford

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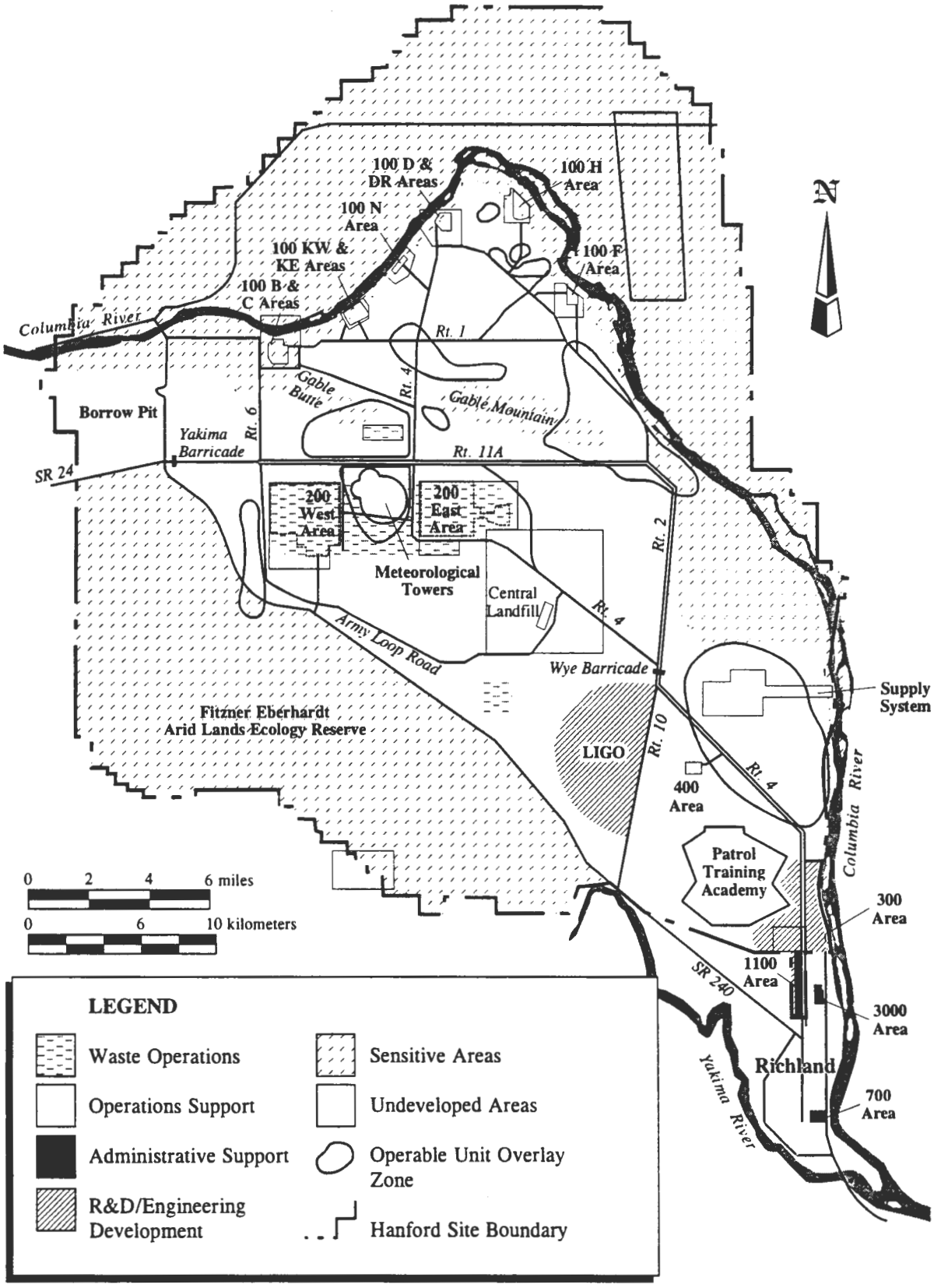
Figure 4.7.2 Hanford Site Existing Land-Use Map



SOURCE: Adapted from DOE 1993e

Site nearest to the river are proposed in the Hanford Site Development Plan to remain undeveloped, providing an additional buffer area between sensitive natural areas and more intensely developed Site uses such as on the Central Plateau. The Hanford Site Development Plan accommodates future intensive uses, such as industrial development and research, in the southeast area of the Hanford Site near the urban development of Richland. Although in the Hanford Site Development Plan the Undeveloped Areas were reduced in size to reflect the future release and reuse of portions of the Hanford Site, DOE is working with various government agencies and other organizations to ensure proper preservation, protection, and management of sensitive ecological and cultural resources.

In 1994, the U.S. Department of Interior recommended that Congress designate the Hanford Reach of the Columbia River as a Recreational River under the Wild and Scenic Rivers Act and also designate the area north and east of the river as a National Wildlife Refuge (NPS 1994). This proposal would transfer management of the river and a 0.40-km (0.25-mi) strip of land along both shores of the river, along with approximately 40,000 ha (100,000 ac) of adjacent lands, to the U.S. Fish and Wildlife Service. Development restrictions would be included for the protection of cultural resources, threatened and endangered species, water quality, unique scenic geologic features, and Native American access and use. Benton, Franklin, and Grant county commissioners oppose designation of the Hanford Reach under the Wild and Scenic Rivers Act and have offered an alternative proposal that would leave the Hanford Reach under local government control. Other local groups (e.g., the Lower Columbia Basin Audubon Society) and local residents support the designation. No final decisions have been made on this issue.

The Bureau of Land Management owns land on the Hanford Site that was withdrawn from the public domain for national security use. Currently, the Bureau of Land Management does not own any lands on the Central Plateau because of land exchanges with the Atomic Energy Commission in the 1960's. The Bureau of Land Management owns the land on which the potential Vernita Quarry borrow site is located.

4.7.1.2 Washington State Land Uses

Washington State has several land interests on the Hanford Site. The Washington State Department of Fish and Wildlife currently administers the area of the Hanford Site north and east of the Columbia River known as the Wahluke State Wildlife Recreation Area. This area is considered sensitive ecological upland habitat. Washington State also leases a square parcel in the south central portion of the Hanford Site between State Route 240 and the Route 2 and Route 4 junction. This property is located within the Undeveloped Area of the Site.

4.7.1.3 Tribal Nation Land Uses

The Hanford Site is located on land ceded to the United States by the Confederated Tribes and Bands of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Reservation in the treaties of 1855 (DOI 1992). The Nez Perce Tribe also has retained certain treaty rights to the Columbia River under a separate treaty with the U.S. Government.

4.7.1.4 Local Government Land Uses and Land-Use Plans

The Hanford Site is located within portions of Benton, Franklin, Grant, and Adams counties. Other surrounding local jurisdictions include the cities of Richland, West Richland, Pasco, and Kennewick. Many of the local jurisdictions' existing comprehensive plans are incomplete or outdated and updates are either in progress or recently completed. Both Benton County and the city of Richland are currently involved in land-use planning efforts for the Hanford Site, with the Richland effort focusing only on the southern portions of the Site that are within the city's urban growth boundaries (e.g., the 300 and 1100 Areas).

The majority of the Hanford Site is located within Benton County; the Site makes up 25 percent of the county land. The cities of Richland, West Richland, Kennewick, Prosser, and Benton City are located within Benton County. The unincorporated areas of the county adjacent to the Hanford Site currently have generalized land-use designations for rangeland (largely cattle grazing), undeveloped (primarily open space), and dry agriculture (almost entirely dry land wheat) (BCBCC 1985). Benton County is in the process of updating its comprehensive plan and is expected to release a recommended plan in mid-1996 and make final decisions in late 1996 or early 1997 (Stang 1995a). The plan update will include a separate Hanford Comprehensive Plan that will be consistent with the overall County plan (Walker 1995).

Franklin County, located east of the Hanford Site, includes the city of Pasco. The unincorporated area of the county adjacent to the Hanford Site is rural and sparsely developed. The land-use designation surrounding the Site, as with most of the county, is agriculture. Franklin County adopted an updated comprehensive plan in April 1995. The update does not directly impact land uses at the Hanford Site (German 1995).

Grant County contains the area of the Site north of the Columbia River. The land uses adjacent to the Site are designated as agriculture. Grant County is in the process of updating its comprehensive plan but the expected date for its completion is in 1998. No changes in the comprehensive plan would affect any areas of the Hanford Site that are south and west of the Columbia River, including any potential TWRS areas (Lambro 1995).

The city of Richland, located immediately adjacent to the Hanford Site, is currently in the process of annexing the Hanford Site's 1100 Area (Milspa 1995). The existing land uses within Richland near the Hanford Site include industrial, agricultural, and public lands. The planned land-use designation within the Richland area adjacent to the Site is identified as industrial, which is compatible with the adjacent Hanford Site use (City of Richland 1988). The city developed a set of alternatives for its updated comprehensive plan, which was released for public review in March 1996. The comprehensive plan itself is expected to be adopted by the city in early 1997. The updated plan would be expected to call for maintaining and expanding industrial and research and development activities in the area of the city adjacent to the Site (Milspa 1996).

West Richland is a developing residential community south of the Hanford Site. The West Richland land use near the Site is designated low density residential, which is consistent with the nearby existing Hanford Site land uses (Fitzner Eberhardt Arid Lands Ecology Reserve and Undeveloped Area). The West Richland comprehensive plan was released in June 1996 and is expected to be adopted by the city in September 1996. There is very little in the plan that would impact Site land-use issues (Corcoran 1996).

The cities of Pasco and Kennewick are also located near the Hanford Site. Pasco is planning major commercial, industrial, office, and residential improvements along the U.S. Interstate 182 corridor to attract businesses. Pasco adopted its updated comprehensive plan in August 1995. There is very little in the update related to Hanford Site land uses (McDonald 1995). Like Pasco, Kennewick is planning additional industrial and office areas to attract businesses. Kennewick adopted its updated comprehensive plan in April 1995. Very little in the plan is related to Site land uses (White 1995).

4.7.1.5 Natural Resources Trustee Council

The Natural Resources Trustee Council is composed of representatives from Washington State and Oregon, Federal agencies (DOE and the Department of Interior), and three affected Tribal Nations (Yakama Indian Nation, Confederated Tribes of the Umatilla Indian Reservation, and Nez Perce Tribe). The primary purpose of the Council is to facilitate the coordination and cooperation of the trustees in their efforts to restore and minimize impacts to natural resources injured as a result of or during cleanup of releases associated with DOE's activities at the Hanford Site. The Council's primary role with respect to TWRS will be to coordinate with DOE during development of the Mitigation Action Plan for impacts identified in the TWRS EIS.

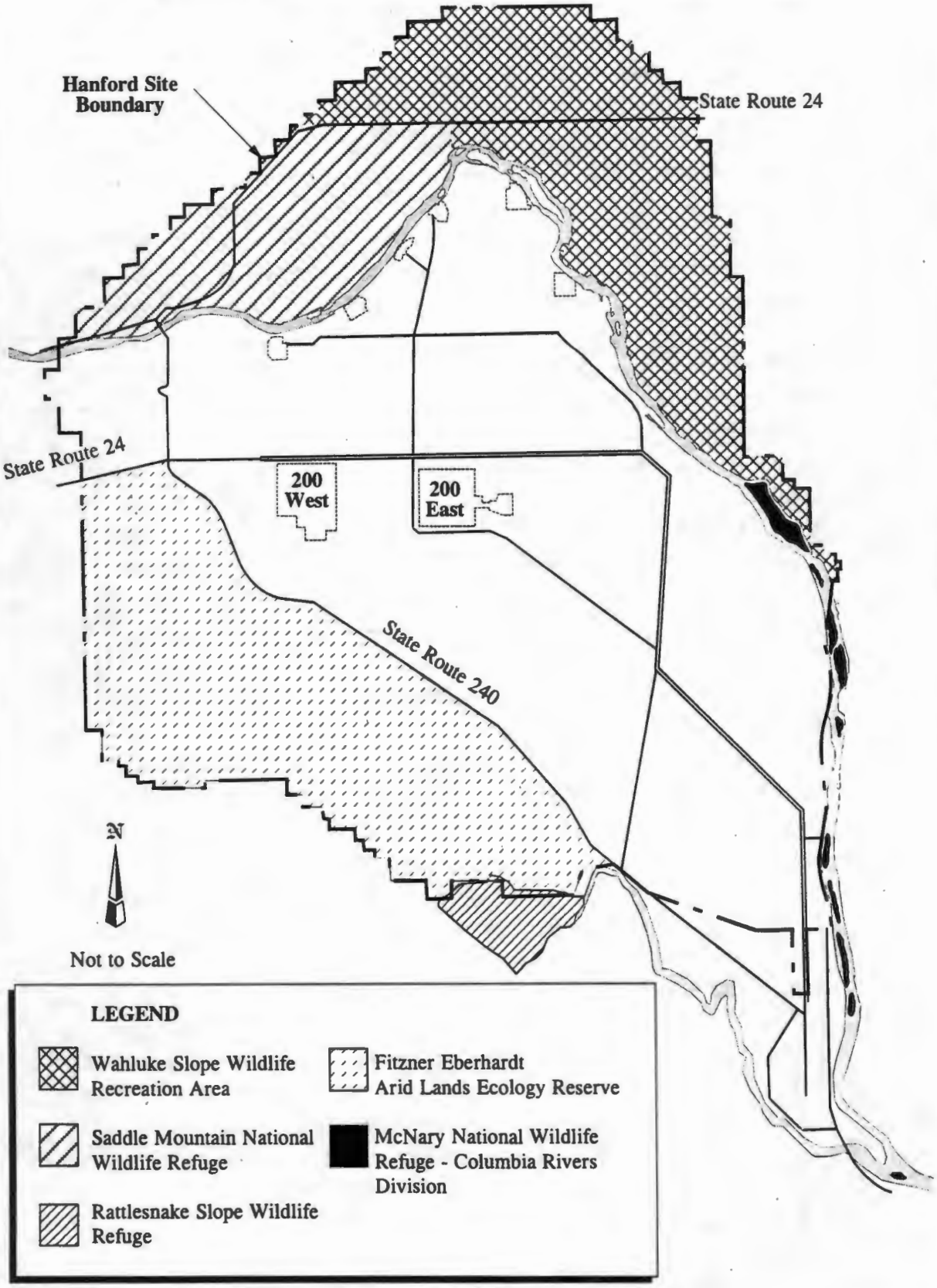
4.7.2 Prime and Unique Farmland

The Farmland Protection Policy Act requires Federal agencies to consider prime or unique farmlands when planning major projects and programs on Federal lands (7 CFR 657.4). Federal agencies are required to use prime and unique farmland criteria developed by the U.S. Department of Agriculture Soil Conservation Service. The Soil Conservation Service has determined that due to low annual precipitation in southeast Washington State, none of the soil occurring on the Hanford Site would meet prime and unique farmland criteria without irrigation (Brincken 1994).

4.7.3 Recreational Resources and the National Environmental Research Park

For the purposes of wildlife management and outdoor recreation, some portions of the Hanford Site are administered by agencies other than DOE. In 1976, the entire Hanford Site was designated by DOE as a National Environmental Research Park aimed at original research into the ecology and natural resources of the area (NPS 1994). Nearly one-half of the Hanford Site is designated for wildlife management use. These wildlife management areas buffer developed areas of the Hanford Site. The area where the Columbia River flows through the Hanford Site is identified as the Hanford Reach and has been proposed as a Recreational River. None of the recreational and wildlife areas are near the TWRS sites in the 200 Areas. They are briefly discussed in the following text and shown on Figure 4.7.3.

Figure 4.7.3 Recreation and Wildlife Areas and the Hanford Reach



- Fitzner Eberhardt Arid Lands Ecology Reserve - Located in the southwest corner of the Hanford Site, the 310-km^2 (120-mi^2) reserve is managed as an ecological research resource for DOE by Pacific Northwest National Laboratory. DOE considered a proposal from the Bureau of Land Management to exchange sections of DOE lands on the Reserve for Bureau of Land Management-owned lands elsewhere on the Hanford Site. The Yakama Indian Nation also proposed taking over the Reserve, as did Benton County (Stang 1996a). In July 1996, DOE notified the Yakama Indian Nation, other Federal Agencies, and Benton County of its decision to keep control of the Reserve (O'Leary 1996). The Reserve will continue to function as a buffer zone for on going waste management in the 200 Areas. DOE also announced its intention to negotiate an agreement with the U.S. Fish and Wildlife Service to manage the Reserve while protecting the environmentally sensitive areas and allowing greater public access (Stang 1996c.)
- McNary National Wildlife Refuge - The Refuge's 140-ha (350-ac) Hanford Islands Division contains six islands in the Columbia River (upstream of the city of Richland) which are within the boundaries of the Hanford Site.
- Saddle Mountain National Wildlife Refuge - The U.S. Fish and Wildlife Service manages the Saddle Mountain Refuge, located on the Hanford Site north and west of the Columbia River and a narrow strip of land south and west of the river. Currently, the area is closed to all public use and is dedicated to wildlife management.
- Wahluke Wildlife Recreation Area - Located on the Hanford Site north and east of the Columbia River, the area is managed by the Washington State Department of Fish and Wildlife and is open for public recreation.
- Rattlesnake Slope Wildlife Refuge - The Refuge is located adjoining the Fitzner Eberhardt Arid Lands Ecology Reserve's southern boundary. The Refuge, which is managed by the State of Washington, is outside the boundary of the Hanford Site.
- The Hanford Reach of the Columbia River - The Hanford Reach, which is the last free-flowing segment of the Columbia River in the United States, extends 80 km (50 mi) and includes those portions of the Columbia River within the boundaries of the Hanford Site. Under the National Park Service proposal to designate the Hanford Reach as a Recreational River, the least restrictive designation under the Wild and Scenic Rivers Act, the Hanford Reach boundaries would include a 0.4-km (0.25-mi) strip of land on each side of the river, the Saddle Mountain National Wildlife Refuge, and the Wahluke Wildlife Recreation Area. Under the National Park Service proposal, all public lands within the proposed boundary would be transferred to the U.S. Fish and Wildlife Service, which would be the administrating agency. Benton, Franklin, and Grant county commissioners oppose this designation and have proposed an approach that leave the Reach under local government control, although there also are local residents and groups (e.g., the Lower Columbia Basin Audubon Society) that support the designation of the Hanford Reach as a Wild and Scenic River (Stang 1996b).

The Hanford Reach and adjacent wildlife refuge and recreation areas provide a variety of recreational activities year-round for local residents and visitors. The most popular activities are sport fishing, boating, and waterfowl hunting. Other popular activities include waterskiing, upland hunting, and nature observation. The heaviest use occurs during September and October, coincident with autumn chinook salmon runs (NPS 1994).

Because of restricted use of the Hanford Site and Saddle Mountain National Wildlife Refuge lands, virtually all land-based recreation occurs on the Wahluke Wildlife Recreation Area. Total recreational use of the Hanford Reach comprises approximately 10,000 land-based visits by hunters, trappers, and nonconsumptive users and approximately 40,000 visits by water-based users (predominantly anglers) per year (NPS 1994).

4.8 VISUAL RESOURCES

The following paragraphs describe the existing visual environment that would be modified by TWRS project implementation.

4.8.1 Landscape Character

The landscape setting within the Hanford Site region is characterized by broad basins and plateaus interspersed with ridges. However, the wide open vistas throughout much of the area are interrupted by over a dozen large industrial facilities (e.g., reactors, processing facilities). Only about 6 percent of the Hanford Site has been disturbed; the remainder of the Hanford Site is undeveloped, including natural areas and abandoned agricultural lands that remain undisturbed because of restricted public access.

Visual Resources and Noise Information

Visually, the Hanford Site is characterized by wide open vistas interspersed with over a dozen large industrial facilities (e.g., reactors and processing facilities). The 200 Areas contain several large processing facilities.

Site facilities can be seen from elevated locations (e.g., Gable Mountain), a few public roadways (State Routes 24 and 240), and the Columbia River. Facilities in the 200 East Area can be seen only in the visual background from offsite locations.

Because of the size of the Hanford Site, its scattered facilities, and its largely undeveloped nature, Site activities have no offsite noise impacts.

The major landscape feature of the Hanford Site is the Columbia River, which flows through the northern part of the Hanford Site and then turning south, forms the eastern Site boundary. Yakima Ridge and Umtanum Ridge form the western boundary of the Site. Two small east-west ridges (Gable Butte and Gable Mountain) rise above the Central Plateau, the large open plateau where TWRS activities would be focused under all EIS alternatives.

The potential Vernita Quarry 0borrow site is located adjacent to the east of State Route 24 in the northwest of the Hanford Site. The potential McGee Ranch borrow site is located in slightly rolling terrain in the northwest of the Hanford Site just west of State Route 24.

4.8.2 Potential Viewing Areas

For purposes of study, viewing areas are generally divided into four distance zones: the foreground, within 0.8 km (0.5 mi); the middleground, from 0.8 to 8 km (0.5 to 5 mi); the background, from 8 to 24 km (5 to 15 mi); and seldom seen areas that are either beyond 24 km (15 mi) or are unseen because of topography (Figure 4.8.1).

Hanford Site facilities can be seen from elevated locations such as Gable Mountain, Gable Butte, Rattlesnake Mountain, and other portions of the Rattlesnake Hills along the Hanford Site's western perimeter. Gable Mountain, Gable Butte, and Rattlesnake Mountain are used by Native Americans for religious purposes. Site facilities also are visible from offsite locations including State Routes 240 and 24 and the Columbia River. Because of terrain features, distances involved, the size of the Hanford Site, and the size of individual facilities, not all facilities are visible from the highways or the Columbia River.

Facilities in the 200 East Area are in the interior of the Hanford Site and cannot be seen from the Columbia River or State Route 24. Large facilities in the 200 East Area are visible from State Route 240 only as distant background (more than 8 km [5 mi] away). Facilities in the 200 West Area can be seen by travelers on an 11-km (7-mi) segment of State Route 240 south of the Yakima Barricade. For these viewers the facilities are in the visual middleground (0.8 to 8 km [0.5 to 5 mi] away). Facilities in the 200 West Area cannot be seen from the Columbia River. Facilities throughout the 200 Areas are visible from elevated locations such as Gable Mountain and Gable Butte.

The potential Vernita Quarry borrow site is located adjacent to State Route 24 west and north of the Central Plateau. Much of the basalt resources contained in exposed basalt cliffs and past quarry operations are highly visible from the highway. The potential McGee Ranch borrow site activities would be located a short distance from the nearest public highway (State Route 24) in slightly rolling terrain. Borrow activities would be visible from the highway. The potential Pit 30 borrow site is located between the 200 East and 200 West Areas and is only visible from elevated locations.

4.9 NOISE

Noise conditions produced by current, routine operations at the Hanford Site do not violate any Federal or Washington State standards (Washington Administrative Code 173-60). Even near the operating facilities along the Columbia River, measured noise levels are lower than noise experienced in parts of the city of Richland (less than 52 decibels on the A scale (dBA) versus 61 dBA) (dBA is a noise scale used to describe sounds in the frequencies most readily detected by human hearing) (Nuclear Regulatory Commission 1982). Noise levels measured near intake structures at the Columbia River are well within the 60-dBA tolerance levels for daytime residential use. Five kilometers (3 mi) upstream of the intake structures, measured noise levels fall well within levels suited for daytime and nighttime

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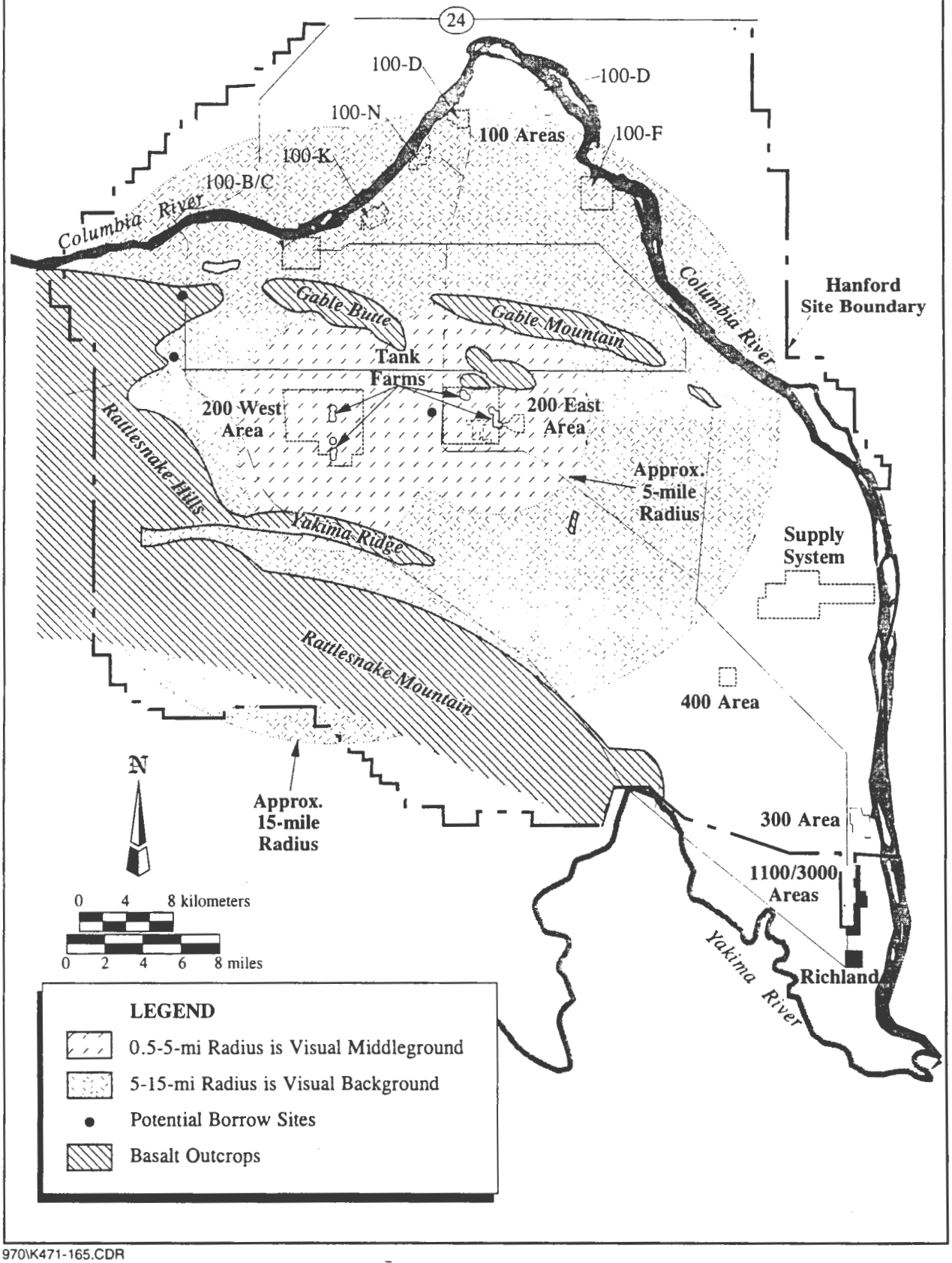
Figure 4.8.1 Potential Viewing Areas of 200 East and 200 West Areas



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residential use. Moreover, the relative remoteness of population centers from the Hanford Site as a whole (and the TWRS sites in particular) gives the Site a Class C (industrial) classification with a maximum allowable equivalent sound level of 70 dBA in compliance with Washington State and Federal standards (DOE 1991 and Cushing 1992). The equivalent sound level integrates noise levels over time and expresses them as continuous sound levels. Native Americans have expressed the concern that Hanford Site religious locations such as Gable Mountain are near enough to TWRS areas to potentially be impacted by TWRS activities (CTUIR 1996).

4.10 TRANSPORTATION

The majority of air passenger and freight services in the local area goes through the Tri-Cities Airport, located in Pasco (Cushing 1992). Both Richland and Kennewick have small airports serving general aviation. The ports of Benton, Kennewick, and Pasco use the commercial waterways of the Snake and Columbia rivers to provide access to the deep-water ports of Portland, Oregon and Vancouver, Washington.

Direct rail service is provided to the Tri-Cities area by the Burlington Northern and Union Pacific Railroads. The rail system on the Hanford Site itself consists of approximately 210 km (130 mi) of tracks. It extends from the Richland Junction (at Columbia Center in Kennewick) where it joins the Union Pacific commercial railroad track, to an abandoned commercial right-of-way near the Vernita Bridge in the northwest portion of the Site. There are currently about 1,400 railcar movements annually Sitewide, transporting a wide variety of materials including coal, fuels, hazardous process chemicals, and radioactive materials and equipment. Radioactive waste has been transported on the Site without incident for many years (DOE 1995i).

Regional road transportation is provided by a number of major highways including State Routes 24 and 240 and U.S. Interstate Highways 82 and 182 (Cushing 1992). State Routes 24 and 240 are both two-lane roads that traverse the Hanford Site. State Route 24 is an east-west highway that turns north at the Yakima Barricade in the northern portion of the Site. State Route 240 is a north-south highway that skirts the eastern edge of the Fitzner Eberhardt Arid Lands Ecology Reserve (Figure 4.10.1).

A DOE-maintained road network within the Hanford Site, mostly paved and two-lanes wide, provides access to the various work centers. The primary access roads on the Site are Routes 2, 4, 10, and 11A. Primary access to the 200 Areas is by Route 4 South from Richland. The 200 East Area is also accessed from Route 4 North off Route 11A from the north. July 1994 traffic counts on Route 4 indicated severe congestion west of the Wye Barrier (at the intersection of Routes 10 and 4 South) during Hanford Site shift changes (WHC 1994c). However, completing the State Route 240 Access Highway (Beloit Avenue) linking the 200 Areas with State Route 240 in late 1994 and declining Hanford Site employment have reduced the congestion on Route 4 (Rogers 1995).

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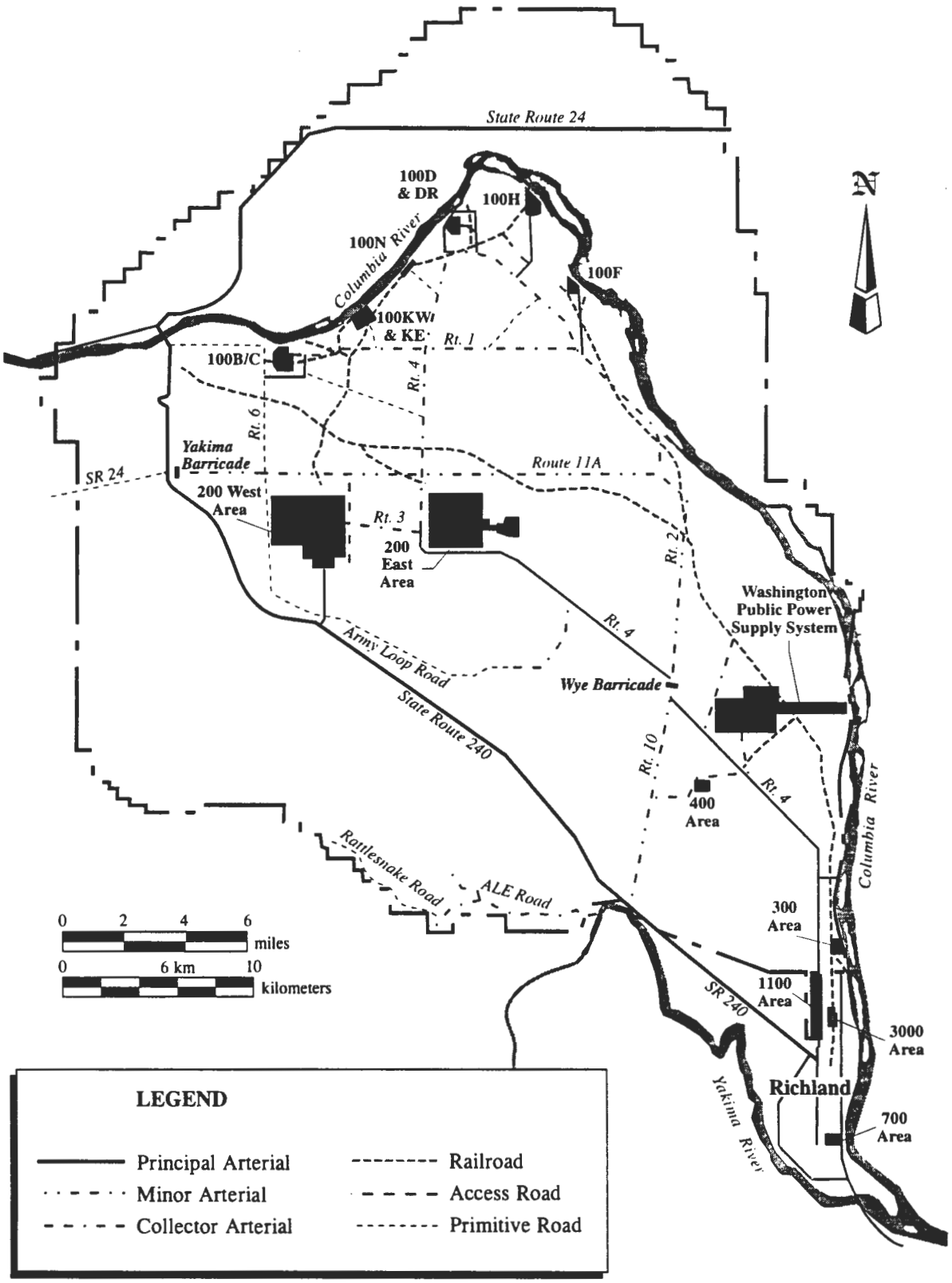
Figure 4.10.1 Hanford Site Roadway and Railroad System



SOURCE: Adapted from DOE 1994a

Stevens Road at the 1100 Area leading into the Site from Richland (Stevens Road becomes Route 4 South further north onsite) also has experienced severe congestion (BFRC 1993). The 240 Access Highway completion and reduction of Hanford Site employment have reduced this congestion somewhat, although no specific traffic count data are available to quantify this assessment (Rogers 1995).

Access to the 200 West Area is also provided from Route 11A for vehicles entering the Site through the Yakima Barricade and from Route 6 off Route 11A from the north. No congestion problems are reported on these roadways.

Public access to the 200 Areas and interior locations of the Hanford Site has been restricted by manned gates at the Wye Barricade and the Yakima Barricade (at the intersection of State Route 240 and Route 11A).

4.11 RADIOLOGICAL ENVIRONMENT: OVERVIEW AND POTENTIAL RADIATION DOSES FROM 1995 HANFORD SITE OPERATIONS

This section provides a brief introduction to the subject of radioactivity and to some of the common terms used in radiological health evaluation. It also summarizes 1995 data on radiation doses from operations at the Hanford Site and the potential future fatal cancers attributable to exposures.

4.11.1 Introduction to Radioactivity

Radioactivity is a broad term that refers to changes in the nuclei of atoms that release radiation. The radiation is an energetic ray or energetic particle. For ionizing radiation, the ray or particle has enough energy to cause changes in the chemical structure of the materials it strikes. These chemical structure changes are the mechanisms by which radiation can cause biological damage to humans. This means that a human body cell may be damaged if it comes into contact with the energy from a particle or ray released by radioactive decay.

Radiation comes from many sources, some natural and some human-made. People have always been exposed to natural or background radiation. Natural sources of radiation include the sun, and radioactive materials present in the earth's crust, in building materials and in the air, food, and water. Natural radioactivity can even be found within the human body. Some sources of ionizing radiation have been created by people for various uses or as by-products of these activities.

Radiological Information

People have always been exposed to radiation from natural sources. The average resident of the United States receives an average annual radiation dose from natural sources of about 300 mrem (0.3 rem).

Exposure to large amounts of radiation 50,000 to 600,000 mrem (50 to 600 rem) can cause serious illness or death. Exposure to small doses of radiation, such as in medical x-rays, may cause no biological damage to humans, although the probability of cancer may be slightly increased.

DOE activities at the Hanford Site have involved manmade radiation sources from nuclear processing. The DOE annual radiation dose limit for a member of the public is 100 mrem (0.1 rem).

The calculated dose from Hanford Site activities in 1995 to a hypothetical maximally-exposed individual living near the Site was 0.02 mrem.

These sources include nuclear power generation, medical diagnosis and treatment, and nuclear materials related to nuclear weapons.

Radioactive waste is a result of the use and production of radioactive materials. At the Hanford Site, DOE manages radioactive waste that was generated primarily by the production of plutonium for nuclear weapons. This waste is classified as low-activity, high-level, or transuranic. When radioactive waste is combined with hazardous chemical waste, it is referred to as mixed waste. High-level waste is the most dangerous type of radioactive waste and requires extensive shielding by materials such as lead, water, or concrete and special remote, noncontact handling. Transuranic waste is material contaminated with radioactive elements heavier than uranium. While long lasting, transuranic waste does not require the same degree of isolation as high-level waste. Low-activity waste is generally the least dangerous type of radioactive waste and requires fewer measures to isolate it from people and the environment.

Radioactive waste can be harmful and thus requires isolation for up to hundreds or even thousands of years. Plutonium-contaminated waste will be radioactive for thousands of years. Radioactive cesium, on the other hand, will be virtually gone in 300 years.

4.11.2 Common Terms in Radiological Health Evaluations

Radiation dose to individuals is usually expressed in rem or millirem (mrem), which is one-thousandth of a rem. The rem is a measure of the biological effects of ionizing radiation on people. It is estimated that the average individual in the United States receives an annual dose of about 300 mrem (0.3 rem) from all natural sources. The collective radiation dose to a population, which is calculated by adding up the radioactive dose to each member of the population, is expressed in person-rems.

Any dose of radiation potentially can cause damaging changes to body cells. However, at low levels, such as those received from a medical x-ray, the damage to cells is so slight that the cells can repair themselves or can be replaced by the regeneration of healthy cells. Radiation exposures are often classified as acute (a dose received over a short time), or chronic (a dose received over a long time). Chronic doses are usually less harmful than acute doses because the body has time to repair or replace damaged cells. Nevertheless, even chronic or low doses can have potentially harmful effects.

Impacts from radiation exposure often are expressed using the concept of risk. The most important radiation-related risk is the potential for developing cancers that may cause death in later years. This delayed effect is measured in latent (future) cancer fatalities. The risk of a latent cancer fatality is estimated by converting radiation doses into possible numbers of cancer fatalities. For an entire exposed population group, the latent cancer fatality numerical value is the chance that someone in that group would develop an additional cancer fatality in the future because of the radiation exposure, (i.e., a cancer fatality that otherwise would not occur).

Radiological risk evaluations often refer to the maximally-exposed individual. This is the hypothetical member of the public or a worker who would receive the highest possible dose in a given situation.

As a practical matter, the maximally-exposed individual likely would be a person working with radiological or hazardous materials. The Federal government has set a maximum annual exposure limit for workers of 5,000 mrem (5 rem) while DOE has an Administrative Control Limit of 2,000 mrem (2 rem) for occupational exposure. DOE's limit for annual radiological exposures to the public from DOE activities is 100 mrem (0.1 rem).

4.11.3 Potential Radiation Doses and Latent Cancer Fatalities from 1995 Hanford Site Operations

Each year the potential radiation doses to the public from Hanford Site radiation sources are calculated as part of the Hanford Site Environmental Monitoring Program. In particular, the dose to the hypothetical maximally-exposed individual is calculated as described in the Hanford Site Environmental Report for Calendar Year 1995 (PNL 1996). This hypothetical maximally-exposed individual is assumed to live at a location where the radiation dose from airborne releases would be larger than for a resident of any other offsite location. The maximally-exposed individual also is assumed to get drinking water from the Columbia River; eat food grown with Columbia River irrigation water; and use the river extensively for boating, swimming, and fishing (including eating fish from the river). The exposure calculation for this hypothetical individual is based on Hanford Site data from actual reported releases, environmental measurements, and information about operations at Hanford Site facilities.

The calculated dose in 1995 to the maximally-exposed individual near the Hanford Site was a total of 0.02 mrem compared to 0.05 mrem reported for 1994 (PNL 1996). As indicated previously, the DOE radiation dose limit for a member of the public is 100 mrem. Thus, the 1995 total dose to the maximally-exposed individual was far below the limit. The U.S. Environmental Protection Agency regulations impose a dose limit of 10 mrem to a member of the public from radioactivity released in airborne effluents. The 1995 Hanford Site airborne dose to the maximally-exposed individual of 0.006 mrem was far below the U.S. Environmental Protection Agency limit.

To estimate health effects for radiation protection purposes, it usually is assumed that a collective dose of 2,000 person-rem in the general population will cause one extra latent cancer fatality (ICRP 1991). In these calculations, it does not matter whether 20,000 people each receive an average of 0.1 rem or 2 million people each receive an average of 0.001 rem. In either case the collective dose would equal 2,000 person-mrems and thus one additional latent cancer facility would be expected. The 1995 collective dose to people surrounding the Hanford Site from Hanford Site releases was calculated to be 0.3 person-rems, which is lower than the 0.6 mrem calculated for 1994. Compared to 2,000 person-rems causing one extra latent cancer fatality, the 0.3 person-rems from the Hanford Site in 1995 is not likely to cause any latent cancer fatalities.

Environmental Consequences

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5.0 ENVIRONMENTAL CONSEQUENCES

SECTION HIGHLIGHTS

- Analyzes potential impacts on the environment for each of the alternatives
- Analyzes impacts for each component of the natural and human environment (e.g., air quality, water quality, biological resources, socioeconomics)
- Compares impacts for all alternatives
- Identifies mitigation measures

This section describes the potential impacts to the existing environment (described in Section 4.0 and discussed in further detail in Volume Five, Appendix I) of implementing each of the alternatives described in Section 3.0 and discussed in detail in Volume Two, Appendix B.

This section is divided into 20 subsections. The environmental components studied that would result in potential impacts are presented in Sections 5.1 through 5.12. The environmental components addressed include impacts of each alternative on:

- Geology and soil (Section 5.1);
- Water resources (Section 5.2);
- Air quality (Section 5.3);
- Biological and ecological resources (Section 5.4);
- Cultural resources (Section 5.5);
- Socioeconomics (Section 5.6);
- Land use and land use plans (Section 5.7);
- Visual resources (Section 5.8);
- Noise (Section 5.9);
- Transportation (Section 5.10);
- Human and ecological health effects (Section 5.11); and
- Potential accidents (Section 5.12).

This section also discusses potential cumulative impacts of each alternative when added to impacts from past, present, and reasonably foreseeable actions (Section 5.13), unavoidable adverse impacts (Section 5.14), the relationship between short-term and long-term impacts (Section 5.15), and irreversible and irretrievable commitment of resources (Section 5.16). Conflicts between land use under the alternatives and other land-use plans are discussed in Section 5.17, and pollution prevention measures are discussed in Section 5.18. An analysis of environmental impacts on minority and low-income communities is provided in Section 5.19. Section 5.20 discusses measures that, if implemented, could potentially mitigate the adverse environmental impacts of the alternatives.

Appendices to the Tank Waste Remediation System (TWRS) Environmental Impact Statement (EIS) have been prepared to support the more complex impact assessments for:

- Human and ecological health (Volume Three, Appendix D, which supports the discussion of health effects in Section 5.11);
- Potential accidents (Volume Four, Appendix E, which supports the discussion of accidents in Section 5.12);
- Groundwater quality (Volume Four, Appendix F, which supports the discussion of groundwater in Section 5.2);
- Air quality (Volume Five, Appendix G, which supports the discussion of air impacts in Section 5.3); and
- Socioeconomics (Volume Five, Appendix H, which supports the discussion of socioeconomics in Section 5.6).

These appendices are provided under separate cover in Volumes Three to Five of the EIS. Each appendix details the data sources, major assumptions, uncertainties, methodology, and results that are summarized in this section.

Also, Section 6.0 of the EIS contains an analysis of the regulatory compliance issues associated with each alternative. Section 6.0 of the EIS provides a summary of all applicable laws and regulations, identifies the environmental permits and approvals required to implement each of the alternatives, and for each alternative discusses impacts that would result in exceedances of standards (e.g., air, water) or would prevent implementation of the alternative due to a potential violation of a Federal or State law.

5.0.1 Comparability of Environmental Consequences

All of the alternatives have been evaluated using the same methods and data, allowing a comparison of all the alternatives on the same basis. For example, all of the alternatives used the common description of the alternatives provided in Section 3.0 and Volume Two, Appendix B and all used the common inventory of tank waste provided in Volume Two, Appendix A. When computer modeling was used to predict the environmental consequences, the same computer model was used for all alternatives.

Definition of Short-Term and Long-Term Impacts for use in Environmental Impact Analysis

Short-Term Impacts: Impacts associated with the 100-year period of institutional control assumed for all alternatives. Impacts would be related to routine operations, remediation activities, and post-remediation monitoring and maintenance activities (as described for each alternative).

Long-Term Impacts: Impacts associated with the 10,000-year period following the end of the 100-year period of institutional control.

5.0.2 Approach to Uncertainty and Bounding Analysis of Environmental Impacts

There were several uncertainties involved with calculating the impacts associated with the tank waste alternatives, including characteristics of the waste in the tanks and the specific performance capabilities of waste retrieval and processing technologies. Information needed to more thoroughly determine the characteristics of the

tank waste is currently being obtained through waste characterization studies. Studies of the performance of technologies and processes are conducted throughout the process of developing a design for any complex project. The results of these studies were not necessary to develop the environmental consequence analysis in this EIS, but would be necessary to refine the process design for the alternative ultimately selected by the U.S. Department of Energy (DOE). Therefore, the analyses in the following sections are based on identification of bounding waste characterization, retrieval, and processing assumptions and data to bound the impacts of actions that may be undertaken during implementation of the selected alternative. Bounding impacts represent reasonable maximum impacts that are likely to occur.

Bounding and Nominal Risks

Due to the uncertainties involved with the contents of the tank waste and some of the processes involved in remediating the waste, a **bounding** impact analysis was performed and is presented in this EIS. Bounding impacts represent the reasonable maximum impacts that are likely to occur and are developed using conservative assumptions and calculations.

Because the reasonable maximum impacts do not always occur, **nominal** impacts also are presented for those impacts that have the greatest uncertainty: impacts from operational accidents and long-term human health risks from residual waste that remains onsite and potential leaks during retrieval. Nominal impacts are developed using less conservative assumptions and calculations and represent the average impacts that are likely to occur based on currently available data.

For each environmental component, where appropriate, uncertainties regarding data, technologies, or processes are identified. Each section includes a discussion of 1) the assumptions used in the impact analysis to ensure that a bounding analysis was performed; 2) implications of the assumptions used; and 3) uncertainties. Because of the uncertainties involved in calculating impacts from operational accidents and long-term human health risks, nominal impacts are also presented. Nominal impacts are based on less conservative assumptions and represent the average impacts that are likely to occur.

5.0.3 Presentation of Remediation and Post-Remediation Analysis

The impacts provided in this section include short-term environmental impacts and the combined impacts of remediation and post-remediation activities, which provide the long-term impacts. To provide an even comparison of the long-term impacts of the alternatives, a representative closure scenario (closure as a landfill) was assumed for all tank waste alternatives. These combined impacts are presented to provide a meaningful comparison of impacts of the total project. The impacts of remediating the cesium and strontium capsules are also provided.

The environmental impacts presented in Sections 5.1 through 5.12 can be understood, in part, by whether the impacts described would be most related to the remedial or post-remedial phase of the alternative. The environmental components analyzed in the EIS that would have their peak impacts during the remedial phase (1996 to 2096, with most impacts from 1996 to 2040) include:

- Geology and soil (except post-remediation changes to topography associated with post remediation actions);
- Air quality (most impacts directly result from routine waste management or treatment emissions);
- Biological and ecological resources (impacts largely related to remediation except post-remediation impacts related to permanent commitment of land to waste disposal);
- Socioeconomics (all impacts associated with the level of remedial activities);
- Visual resources (impacts largely related to remediation except changes to topography associated with post-remediation actions);
- Noise (all impacts associated with the level of remedial activities);
- Transportation (all impacts associated with the level of remedial activities);
- Human and ecological health effects (worker health most impacted during remedial activities); and
- Potential accidents (all impacts associated with remedial activities).

Environmental components with peak impacts during the post-remediation phase (2096 to up to 10,000 years in the future) would include:

- Water resources (impacts to groundwater would influence groundwater quality for thousands of years following completion of remediation);
- Human and ecological health effects (health of the general public most impacted by post-remediation groundwater impacts and impacts associated with contact with waste remaining onsite following remediation);
- Land use and land-use plans (permanent commitment of land in the 200 Areas to waste disposal); and
- Cultural resources (impacts would be permanent).

5.0.4 Relationships Among Key Variables and the Results of the Impact Analysis

Three variables are the most important to understanding the relationship between the impacts presented in this section and the comparison of impacts among the alternatives: 1) the amount and type of waste that remained onsite under each alternative; 2) the number of labor hours for construction, operations, and other activities under each alternative; and 3) the amount of previously undisturbed habitat that would be disturbed by each alternative. An understanding of how these variables would influence the impacts presented for each alternative would help to clarify which impacts discriminate among the alternatives and which impacts are either small or do not discriminate among the alternatives.

Amount and Type of Waste That Remains Onsite

A major variable that would influence the post-remediation risks for each alternative would be the amount of waste form remaining in the tanks or on the Hanford Site following remediation. Generally, for post remediation impacts to groundwater (Section 5.2), which would be the major contributor to post-remediation routine health risks (Section 5.11), the larger the volume of waste that remained onsite the more severe the levels of groundwater contamination would be and thus, more adverse health impacts would be expected. The No Action and Long-Term Management alternatives, which would

involve no waste retrieval, would result in the highest levels of groundwater contamination and the highest levels of post- remediation health risks. On the other hand, the ex situ alternatives, which would remove an assumed 99 percent of the waste from the tanks, would have much lower levels of impacts to the groundwater and thus, much lower levels of post-remediation risk.

A related important variable would be the type of waste form that remained in the tanks or on the Hanford Site following remediation. Waste that remained onsite and was not immobilized would result in more severe levels of post-remediation groundwater contamination than would waste that was immobilized prior to disposal onsite. Thus, alternatives that would result in larger amounts of untreated waste, such as the No Action, Long-Term Management, and In Situ Fill and Cap alternatives, would result in more severe groundwater impacts and higher levels of post-remediation health risks. The In Situ Vitrification and the ex situ alternatives, which would immobilize most of the waste, would have much lower levels of post-remediation groundwater impacts and lower post-remediation health impacts. The Ex Situ/In Situ Combination 1 and 2 alternatives would have impacts that would fall between the two extremes because a larger amount of the waste by volume would be left in place without treatment, while the remainder of the waste would be retrieved and immobilized.

Impacts Influenced by the Amount and Type of Waste Form Onsite Following Remediation

The following impacts identified in this section are directly affected by the amount and type of waste form remaining onsite following remediation:

- Groundwater quality (Section 5.2);
- Post-remediation routine human health effects (impacts to future users of the Hanford Site) (Section 5.11);
- Post-remediation ecological health effects (Section 5.11);
- Humans that come into direct contract with the waste by intruding into the remediated tanks or waste disposal vaults or from unremediated waste under the No Action or Long-Term Management alternatives (Section 5.11); and
- Cumulative impacts of TWRS alternatives and other projects (Section 5.13).

Number of Labor Hours

Another variable that would influence many of the short-term impacts identified in the EIS would be the number of labor hours associated with each alternative. The number of labor hours for each alternative would directly affect the magnitude of many of the impacts discussed in this section. In other words, the more labor hours worked the higher the level of impact. This relationship would most directly affect the impacts addressed for nonradiological accidents during remediation (Section 5.12), routine worker health risks (Section 5.11), socioeconomics (Section 5.6), and transportation (Section 5.10).

Nonradiological accidents during remediation would include workplace injuries or fatalities associated with constructing or operating the facilities and injuries and fatalities to workers driving to and from work. In each of these cases, the higher the number of labor hours the higher the number of injuries or fatalities. For each of these short-term impacts of the alternatives it is important to note that the

accidents and fatalities identified would not be based upon the unique problems associated with working with tank waste. Rather, they would be products of working in a construction or industrial environment or driving to and from work. These same impacts would be associated with any similarly sized construction project or industrial facility operations. The number of fatalities associated with construction provides a good example of this relationship. The number of construction fatalities for each alternative was calculated by multiplying the historic construction fatality rate (0.0032 fatalities per 100 worker years) by the number of worker years estimated for each alternative. If an alternative required 100,000 worker years for construction, the number of expected fatalities would be approximately 3 (100,000 worker years · 0.0032 fatalities per 100 worker years = 3.2 fatalities). However, if the alternative required 700,000 worker years, the expected number of worker fatalities would be 22, or about seven times the number of fatalities for 100,000 worker years (700,000 worker years · 0.0032 fatalities per 100 worker years = 22.4 fatalities). This same relationship (the more hours worked the higher the impact) would exist for injuries associated with construction and injuries and fatalities associated with operating facilities.

For worker transportation injuries and fatalities, the number of fatalities and injuries is based on the number of kilometers (miles) driven to and from work by the employees. Based on Washington State highway accident reports, for every kilometer driven, there would be 8.98E-09 fatalities. The number of employee transportation fatalities was therefore calculated by multiplying the number of kilometers that the workers would drive to and from work by the historic fatality rate. In this case, a doubling of the number of kilometers driven would result in a doubling of the number of employee transportation fatalities and injuries.

Example Calculation of Worker Transportation Fatality Impacts

If an alternative required a total of 1,000,000,000 km of driving to and from work by employees, the number of expected fatalities would be approximately 9 (1,000,000,000 · 0.00000000898 = 8.98 fatalities).

If an alternative required a total of 2,000,000,000 km of travel, the total number of expected fatalities would be 18 (2,000,000,000 · 0.00000000898 = 18 fatalities).

Impacts that would not be directly related to the number of labor hours would tend to be associated with differences in technologies and processes unique to each alternative or the post-remediation amount of waste or waste form remaining onsite. Impacts that would be largely independent of the influence of labor hours worked would include 1) post-remediation health risks (Section 5.11); 2) remediation-phase radiological and chemical accidents (Section 5.12); and 3) the ability of an alternative to comply with environmental regulations such as air quality (Section 5.2), water quality (Section 5.3), and hazardous and radiological waste storage, treatment, and disposal (Section 6.0).

Amount of Habitat Disturbance

Another variable that would influence several of the environmental impacts addressed in this section would be the amount of habitat disturbance associated with the alternatives. The amount of impacts to

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vegetation and wildlife habitat and archeological and cultural sites would be directly related to the amount of undisturbed land required to implement each alternative. Much of the Hanford Site has been undisturbed by Site activities and the native habitat remains intact. However, in the 200 Areas, where the remediation activities addressed in this EIS would occur, a sizable portion of the land has been previously disturbed by the construction of roads, processing facilities, pipelines, and other facilities and infrastructure associated with the production of plutonium and waste management.

Alternatives such as No Action, Long-Term Management, In Situ Fill and Cap, and In Situ Vitrification, which would focus much of their activities directly at the tank farms, would disturb relatively small amounts of previously undisturbed land and consequently would have low levels of biological and ecological or archeological and cultural site impacts. The ex situ alternatives, which would require the construction of waste treatment facilities and new onsite disposal facilities, would require varying levels of disturbance to previously undisturbed habitat and consequently would have relatively larger biological and ecological and archeological and cultural site impacts. The vast majority of the habitat disturbances would occur in areas close to previously disturbed areas and within the 200 Areas, which have been identified as the area in which DOE should consolidate as much waste management and environmental restoration activities as possible to minimize potential impacts to the remainder of the Hanford Site.

For all in situ and ex situ alternatives, except No Action and Long-Term Management, the post-remediation scenario evaluated (closure of the tank farms by filling the tanks and capping the tanks and onsite disposal facilities) would result in impacts to habitat outside the 200 Areas. These impacts would be associated with securing borrow material (gravel, sand, and stones) to fill the tanks and construct the caps. While the decisions regarding closure would not be supported by this EIS, data regarding impacts associated with closure were presented to permit a balanced comparison of all known and potential impacts associated with each alternative. For all alternatives with substantial habitat impacts, the dominant impacts presented in the EIS were related to potential borrow sites. It is important to note that the final decision regarding closure of the tank farms is many years in the future and that the final closure decision could require substantially less borrow material and have less impacts to borrow sites. Also, borrow materials could be secured from alternative sites that would not involve the same level of adverse impacts to undisturbed habitat.

5.1 GEOLOGY AND SOIL

This section describes the potential impacts of the TWRS EIS alternatives on the geologic resources and soils of the Hanford Site. For both geology and soil, the potential impacts of each alternative, except the No Action alternative, would be small and similar both in nature and magnitude. The No Action alternative would not have any additional impacts on geologic resources or soils. For both geology and soil issues, the level of

Geologic and Soil Impacts

Impacts addressed in this section include:
- Mineral resources (Section 5.1.1);
- Topography (Section 5.1.2); and
- Soils (Section 5.1.3).

impacts would be linked directly to the amount of land disturbance. Generally, the more land disturbed, the higher the level of impacts to geologic resources and soils.

5.1.1 Mineral Resources

Mineral resources (i.e., silt, sand, gravel, and rip rap) would be required in varying degrees for each alternative ranging from none for the No Action alternative to 5.1E+06 cubic meters (m^3) (6.7E+06 cubic yards [yd^3]) for the Ex Situ No Separations (Vitrification) alternative. Table 5.1.1 shows the mineral resources that would be required for remediation activities and those that would be required for the total alternative activities (remediation activities plus the tank closure scenario included for comparative analysis [closure as a landfill]). During remediation, the earthen materials primarily would be used to make concrete during construction of facilities. For the In Situ Fill and Cap alternative, earthen materials would be used to fill the tanks, and for the In Situ Vitrification alternative, the earthen material would be used as a glass former during vitrification. All other earthen borrow material would be used for the construction of the Hanford Barrier over the tank farms and low-activity waste (LAW) vaults during closure activities (Volume Two, Appendix B). All of the material would be obtained from the Hanford Site as described in Section 3.6.

Because sand, gravel, and rip rap all are readily available on the Hanford Site in quantities greatly exceeding the TWRS requirements, there would be small impacts on local availability and the cost of the resources.

5.1.2 Topography

No changes in topography would result from the implementation of the No Action alternative. For the Long-Term Management alternative, only small, localized changes in topography would result during construction of replacement double-shell tanks (DSTs). The current topography at these areas is flat, and the areas around the replacement tanks would be regraded to conform with the natural terrain. Under the In Situ Fill and Cap alternative and the In Situ Vitrification alternative, the only substantive impacts during remediation would occur at the earthen borrow sites where material would be obtained to fill the tanks and for use as glass formers, respectively. Under all of the ex situ alternatives, there would be small changes to the topography where the remediation facilities would be constructed. The current topography in these areas is flat, and the area around all facilities would be regraded to conform with the natural terrain.

Only small, localized changes in topography would result from constructing Hanford Barriers over the tank farms during closure activities for all in situ and ex situ alternatives, and for constructing the LAW disposal facility associated with the Ex Situ Intermediate Separations, Ex Situ Extensive Separations, and Ex Situ/In Situ Combination 1 and 2 alternatives. The Hanford Barriers over the tank farms would cover a total of approximately 25 hectares (ha) (62 acres [ac]) with an average height of 4.5 meters (m) (15 feet [ft]). The Hanford Barrier over the LAW disposal facility would cover up to approximately 7 ha (17 ac). The Hanford Barrier would be a flat-topped, slightly abovegrade, engineered soil structure whose function would be to isolate the waste site from the environment (Volume Two, Appendix B). The Hanford Barrier would be composed of 10 layers with a combined thickness

Table 5.1.1 Key Geology and Soil Impact Parameters

Tank Waste Alternative		Mineral Resource in m^3 (yd^3)			Soil Disturbance [1] in ha (ac)	
		Sand and Gravel	Silt	Rip Rap	Temporary	Permanent
No Action	Remediation	N/R	N/R	N/R	0	0
	Total Alternative [2]	N/R	N/R	N/R	0	17 (42)
Long-Term Management	Remediation	3.8E+05 (5.0E+05)	N/R	N/R	66 (160)	8 (20)
	Total Alternative	3.8E+05 (5.0E+05)	N/R	N/R	66 (160)	25 (62)
In Situ Fill and Cap	Remediation	7.54+05 (9.88E+05)	N/R	N/R	26 (64)	17 (42)
	Total Alternative	1.2E+06 (1.57E+06)	3.80E+05 (5.00E+05)	6.40E+05 (8.40E+05)	97 (240)	25 (62)
In Situ Vitrification	Remediation	6.79E+05 (8.90E+05)	N/R	N/R	110 (270)	17 (42)
	Total Alternative	1.10E+06 (1.44E+06)	3.80E+05 (5.00E+05)	6.40E+05 (8.40E+05)	180 (440)	25 (62)
Ex Situ Intermediate Separations	Remediation	1.66E+06 (2.18E+06)	N/R	N/R	120 (300)	35 (86)
	Total Alternative	3.02E+06 (3.95E+06)	5.19E+05 (6.80E+05)	8.78E+05 (1.15E+06)	240 (590)	46 (110)
Ex Situ No Separations Vitrification	Remediation	2.90E+06 (3.80E+06)	N/R	N/R	170 (420)	20 (49)
	Total Alternative	4.10E+06 (5.37E+06)	3.80E+05 (5.00E+05)	6.40E+05 (8.40E+05)	260 (640)	28 (69)
Ex Situ Extensive Separations	Remediation	9.51E+05 (1.25E+06)	N/R	N/R	120 (300)	33 (82)
	Total Alternative	2.31E+06 (3.03E+06)	5.66E+05 (7.42E+05)	9.58E+05 (1.26E+06)	240 (590)	44 (110)
Ex Situ/In Situ Combination 1	Remediation	1.03E+06 (1.35E+06)	N/R	N/R	120 (300)	31 (77)
	Total Alternative	1.89E+06 (2.48E+06)	4.72E+05 (6.18E+05)	7.85E+05 (1.03E+06)	210 (520)	41 (100)
Ex Situ/In Situ Combination 2	Remediation	1.04E+06 (1.36E+06)	N/R	N/R	100 (250)	25 (62)
	Total Alternative	1.66E+06 (2.18E+06)	4.25E+05 (5.57E+05)	7.18E+05 (9.41E+05)	180 (440)	34 (80)
Phased Implementation (Phase 1)	Remediation	3.20E+04 (4.19E+04)	N/R	N/R	33 (82)	0
	Total Alternative	3.20E+04 (4.19E+04)	N/R	N/R	33 (82)	0
Phased Implementation (Total Alternative)	Remediation	1.20E+06 (1.57E+06)	N/R	N/R	200 (490)	38 (94)
	Total Alternative	2.56E+06 (3.35E+06)	5.66E+05 (7.42E+05)	9.58E+05 (1.26E+06)	320 (790)	49 (120)

Notes:
[1] These estimates are based on closure of the tank farms by filling tanks and covering them with a Hanford Barrier. Numbers have been rounded to two significant digits.
[2] Total Alternative estimates include remediation and closure as landfill.
N/R = None Required

of 4.5 m (15 ft), which would be placed over the top of the stabilized tanks and the LAW disposal facility. The Hanford Barriers would cover groups of tanks (tank farms), not individual tanks. Each Hanford Barrier would extend an additional 9 m (30 ft) beyond the perimeters of the tanks and vaults. All disturbed areas would be graded to conform to the surrounding topography and drainage systems.

Use of borrow sites for silt, sand and gravel, and quarry operations for rip rap would cause topographic changes at borrow sites. For purpose of analysis, three potential borrow sites were chosen as the basis for calculations: Pit 30 (located between the 200 East and West Areas); Vernita Quarry (located north and west of the 200 Areas); and the McGee Ranch (located north and west of the 200 Areas). Removing borrow materials would result in topographic depressions at the borrow sites. An excavation depth of 3 m (10 ft) was assumed for purposes of calculating the disturbed area. These sites would be recontoured to be made compatible with the surrounding terrain and drainage systems and would be revegetated, although some permanent terrain depressions would remain.

5.1.3 Soil

Soil at the tank farms, and at most of the area near the waste treatment facilities site in the 200 East Area for the Ex Situ Intermediate Separations, Ex Situ No Separations, Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1 and 2, and the Phased Implementation alternatives, previously has been disturbed so there would be only a small amount of additional soil disturbance during remediation. Each of the alternatives (except No Action) would temporarily disturb soil outside the facility footprint, primarily in the trample zone around work areas, heavy equipment traffic areas, and material laydown areas. Temporary impacts would include soil compaction and increased potential for soil erosion (Table 5.1.1).

Soil would be disturbed during closure activities at the potential locations where borrow materials would be obtained from the Pit 30, Vernita Quarry, and the McGee Ranch sites. The potential Pit 30 borrow site is an existing gravel pit and is a partly disturbed area. The potential Vernita Quarry borrow site is also an existing borrow site for basalt materials, and it is partly disturbed. The potential McGee Ranch borrow site is largely undisturbed. None of the areas that would be disturbed under any of the alternatives have prime or unique farmlands. There would be permanent loss of soil cover at the tank farms for all alternatives except for the No Action alternative. The treatment facilities proposed in the 200 East Area for the Ex Situ Intermediate Separations, Ex Situ No Separations, Ex Situ Extensive Separations, the Ex Situ/In Situ Combination 1 and 2 alternatives, and the Phased Implementation alternative also would result in long-term soil losses because the ground surface would be covered with buildings and paved areas at the facility sites (Table 5.1.1).

5.2 WATER RESOURCES

5.2.1 Groundwater

The following is a summary of the potential impacts to groundwater as described in Volume Four, Appendix F. Groundwater would be impacted by all of the EIS alternatives. Groundwater impacts were analyzed by comparing the impacts for each alternative with drinking water standards for key contaminants that have high carcinogenicity, toxicity, and mobility in the groundwater. The

environmental impacts of these and other potential groundwater contaminants also were used to analyze human and biological health risk (Section 5.11).

Water Resource Impacts

Impacts addressed in this section include:

- Source and characteristics of potential contaminants (Section 5.2.1.1);
- Groundwater quality impacts by alternative (Section 5.2.1.2);
- Discharges to surface water (Section 5.2.2.1);
- Surface water impacts including the Columbia River via groundwater (Section 5.2.2.2); and
- Surface drainage systems (Section 5.2.2.3).

The No Action and Long-Term Management alternatives would result in exceedances of drinking water standards for carbon-14, iodine-129, technetium-99, uranium-238, and nitrate in groundwater. Of all the alternatives, these alternatives would exceed the drinking water standards by the greatest magnitude. The exceedance of the standards in groundwater would occur within a period of 500 years. The In Situ Fill and Cap alternative would exceed the limits of current drinking water standards for the same contaminants with the exception of carbon-14, but most of the exceedances would be delayed for 2,500 years.

The ex situ alternatives and the In Situ Vitrification alternative would include measures to reduce the rate of release of radionuclides, which would result in lower peak concentrations at the water table. These measures would result in groundwater impacts that would occur mostly after 500 years. The ex situ alternatives and the In Situ Vitrification alternative would comply with current drinking water standards for uranium-238. Without considering contamination from the LAW vaults, alternatives that removed waste from the tanks would not meet the limits of current drinking water standards in groundwater. The calculated exceedances mostly would be attributable to the assumption that 1 percent of all tank waste would remain in the tanks after retrieval. There would be no groundwater releases during Phase 1 of the Phased Implementation alternative and hence no groundwater impacts; however, there would be groundwater releases and impacts from the Phased Implementation Total alternative.

The amount and type of waste that would remain in the tanks after retrieval is uncertain. The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology et al. 1994) set a goal of no more than 1 percent residuals, and the ex situ alternatives have been developed to attempt to achieve that goal. However, achieving this level of tank waste retrieval could require extensive effort and cost, and it may not be practicable to achieve 99 percent retrieval. Conversely, the contaminants that were not recovered would be likely to be insoluble in water, because substantial quantities of water would be used in an attempt to dissolve or suspend the waste during retrieval. Because neither of these issues can be resolved, a conservative assumption was made to bound the impacts of the residual waste. For purposes of this analysis, it was assumed that 99 percent retrieval would be achieved, but that the residual waste in the tanks would contain 1 percent of all the contaminants including the water soluble contaminants. There are a total of 177 million (1.77E+08) curies (Ci) in the tanks (Volume Two, Appendix A). Retrieval of 99 percent of the tank contents as part of the ex situ alternatives would

leave 1.77E+06 Ci remaining for potential dissolution by groundwater. Existing groundwater contamination would be in addition to these 1.77E+06 Ci, but is not in the scope of the EIS.

The groundwater assessments provided in this section required several assumptions to address uncertainties. The major assumptions and uncertainties were related to either the natural system (i.e., an understanding and ability to assign vadose zone and aquifer parameter values) or uncertainties inherent to the assessment approach.

The major assumptions and uncertainties were as follows:

- The rates of infiltration into natural ground and through a cap;
- Distribution coefficient (K_d) of contaminants;
- Uncertainty in future groundwater flow direction due to decay of groundwater mounds onsite;
- Uncertainty in future groundwater flow direction due to future land use (e.g., irrigation and groundwater withdrawal);
- Uncertainty in future groundwater flow direction and vadose zone thickness due to climate change;
- Uncertainty in future groundwater flow direction due to changes in land use;
- Uncertainty in vadose zone transport due to use of one-dimensional flow and transport simulation; and
- Uncertainty due to calculation of releases during retrieval.

DOE has a system of monitoring wells called drywells installed in the vicinity of each waste tank. The depth of these drywells varies but they do not extend to the water table of the unconfined aquifer. These drywells were installed as a way of detecting gamma emissions and serve as an indirect means of detecting or confirming waste tank leaks and mobilization of existing contamination in the vadose zone by other water sources such as potable water line leaks. Until recently, the gamma emissions that were detected were indicative of undifferentiated radioisotopes. Such emissions have been detected in many of the drywells at depths ranging from ground surface to up to 38 m (125 ft) belowground surface. Recent improvements in the borehole logging detection equipment have resulted in the identification of specific gamma-emitting radioisotopes. Thus, previously characterized gross gamma contamination is now specifically linked to several radioisotopes. The most prevalent radioisotope detected was cesium-137 while other gamma-emitting radionuclides such as carbon-60, europium-152, and europium-154 were generally found near the surface and are believed to be the result of spills (Brodeur 1996).

The transport of cesium-137 in the vadose zone sediments at the Hanford Site is believed to be greatly retarded due to adsorption. Cesium would not be expected to be found at depths of up to 38 m (125 ft) if it were being transported via interstitial flow through the sediment pore spaces and under ambient conditions that include neutral pH and infiltration rates ranging from 2 mm/yr (5.48E-06 m/day) to 10 cm/yr (2.74E-04 m/day). The detection of cesium-137 at this depth raises several questions concerning the active transport mechanisms. These questions and others are being addressed by DOE

in a RCRA Groundwater Assessment of the S and SX Tank Farms (Caggiano 1996). The improved borehole logging detection equipment provides information on the specific contaminant in the vicinity of the drywells, but there is still uncertainty on the lateral distribution of these contaminants within the vadose zone.

The most recent vadose zone characterization information is for the SX Tank Farm. Ten of the 15 tanks in the SX Tank Farm are assumed or verified as leaking as discussed in Volume Five, Appendix K. Ninety-five drywells ranging in depth from 23 to 38 m (75 to 125 ft) from ground surface were logged with the improved logging system in the SX Tank Farm. The most abundant and highest-concentration radionuclide detected was cesium-137, which was detected in virtually every borehole (Brodeur 1996). Cesium-137 was detected in several drywells at the following depths: 23 m (75 ft) in drywells 41-09-03 and 41-08-07; 32 m (105 ft) in 41-09-04; 27 m (90 ft) in 41-11-10, and 38 m (125 ft) in 41-12-02.

Other gamma-emitting radionuclides detected include cobalt-60, europium-152, and europium-154, which were generally found near the surface and are believed to be the result of spills (Brodeur 1996). Cobalt-60 was found in drywell 41-14-06 only. It was detected at a depth of 17 to 23 m (55 to 76 ft) belowground surface. The data were insufficient to conclude whether relatively immobile contaminants such as cesium-137 would be found dispersed laterally within the vadose zone (i.e., at observed concentrations laterally several meters from the drywells) at the depths of over 30 m (100 ft) based on ambient conditions and vadose zone contaminant transport via advective flow in interstitial pore spaces. Vadose zone contaminant transport mechanisms, such as discussed in Volume Five, Section K.4.1.3, in addition to interstitial transport through the pore spaces could be active. The viability of any other potential transport mechanism has not yet been demonstrated but is one of the objectives of the ongoing investigations.

A discussion of these major assumptions and uncertainties is provided in Volume Five, Sections K.4.1 and K.4.2 and results of a limited parameter sensitivity analysis are summarized in Section 5.2.1.3 and provided in Volume Five, Section K.4.2.

Vadose zone, groundwater flow, and contaminant transport were simulated for each alternative with a combined flow and transport model called VAM2D (Huyakorn et al. 1991). The groundwater impact of interest area is shown in Figure 5.2.1. The analysis approach is summarized briefly in the following text and additional details are provided in Volume Four, Appendix F.

The approach for assessing the impact to the groundwater system is illustrated in Figure 5.2.2. In the source characterization step shown in the top of Figure 5.2.2, the 177 tanks were aggregated to eight source areas, and the contaminants were placed in groups based on their mobility in the vadose zone and unconfined aquifer. The next step, vadose zone modeling shown in the center of the figure, required the development of a conceptual model for each of the source areas. Then, as described in Volume Four, Section F.2.3.1.3, the vadose zone flow field was established based on steady-state flow simulations for an ambient infiltration of 5.0 centimeters (cm)/year (2.0 inches [in.]/year).

Figure 5.2.1 Area of Interest for Groundwater Impact Assessment

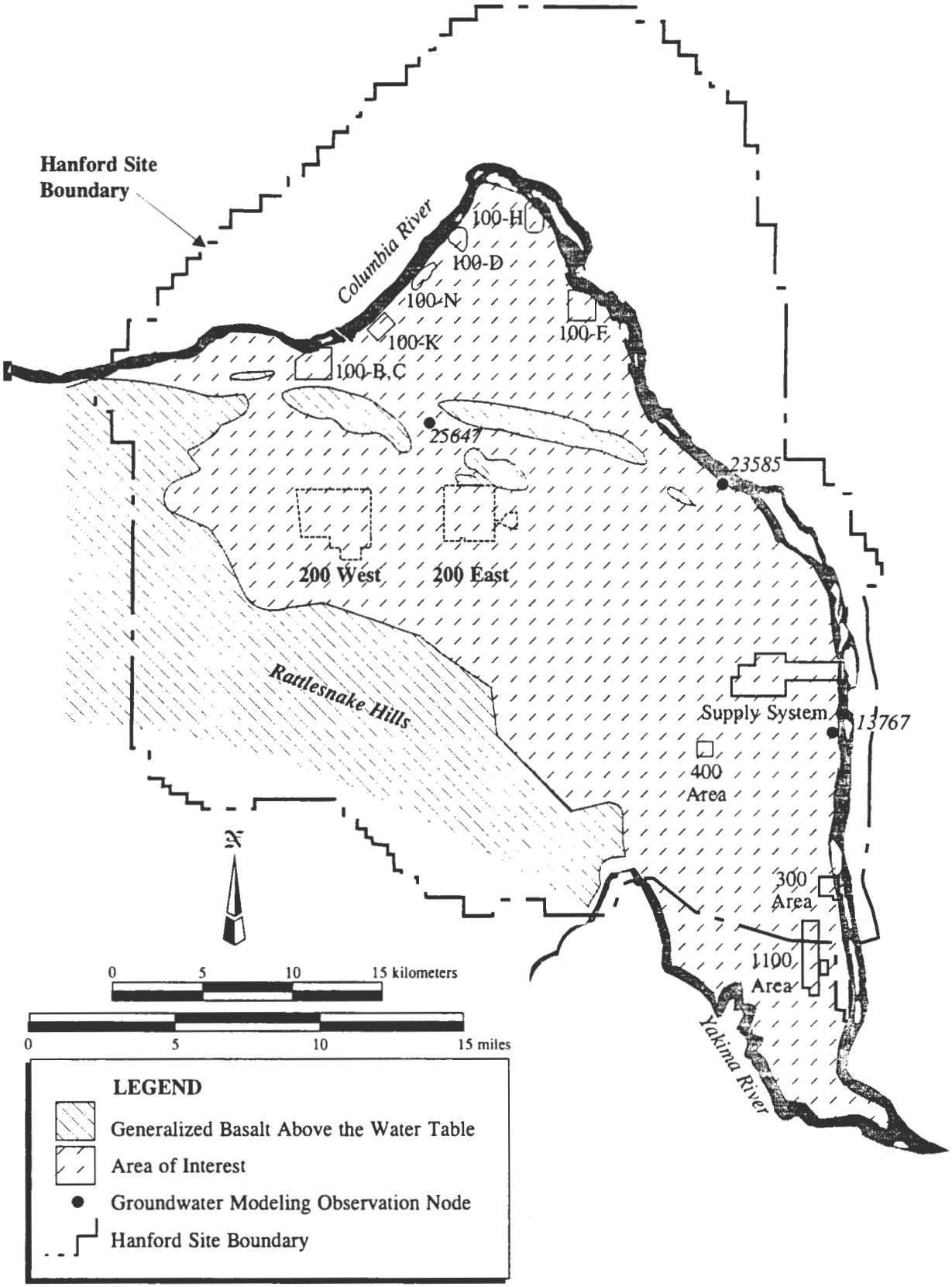
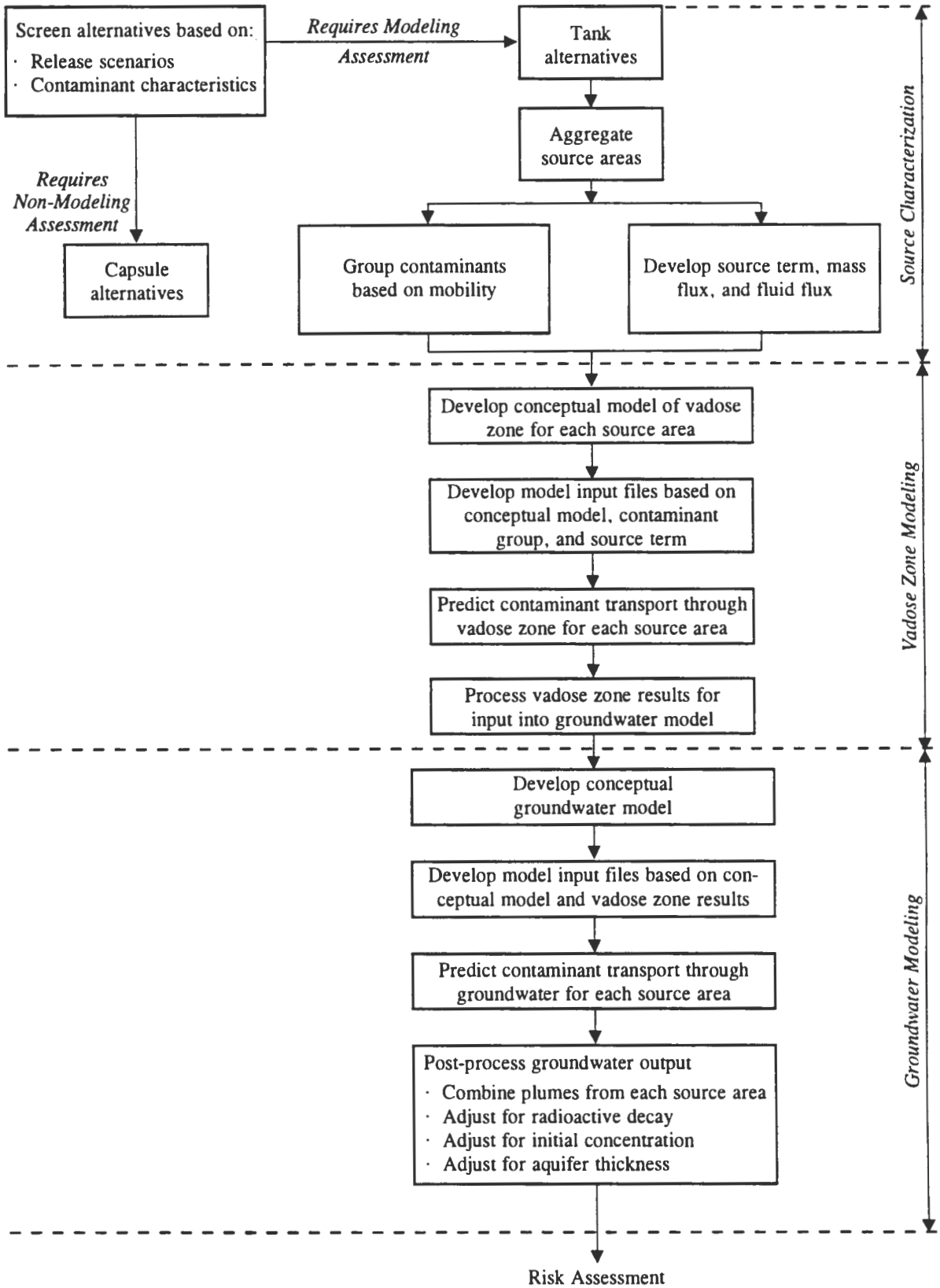


Figure 5.2.2 Groundwater Impacts Assessment Approach



Contaminant transport through the vadose zone then was simulated for each source from which results were processed for use by the groundwater model.

The groundwater modeling step, shown in the bottom of Figure 5.2.2, required the development of a conceptual model of the unconfined aquifer. Then a steady-state flow field, which is one of the principal bases for the groundwater impacts assessment, was developed using December 1979 sitewide water level measurements because it was determined (Wurstner-Devary 1993) that this data set was most representative of steady-state conditions. Using this data set also meant that the mounding from U Pond and B Pond would be evident. The mounding was recognized as a present-day condition that could dissipate over the next several decades with changes in the Site waste management practices. With the mounds in place, the vadose zone would be thinner in the 200 West and 200 East Areas and contaminant travel times would be faster to the groundwater. The travel time in the unconfined aquifer to the Columbia River would not be materially affected by the groundwater mounds compared to the vadose zone travel time. The approach based on the December 1979 water level data provides reasonable results for each alternative, especially in light of the uncertainties of land use and waste disposal practices and how these practices would affect the present groundwater mounds. Future land use such as irrigation to the west of the Site and on the Site, uncertainty in the depth of contamination in the unconfined aquifer, and climate change.

The groundwater model then was used to predict contaminant transport given the results from the vadose zone modeling as inputs. The groundwater results then were processed as appropriate for radioactive decay, initial concentration, and aquifer thickness. The final processed data then were plotted in various ways to show contaminant concentration versus time at selected points and contaminant concentration distribution on the Site for selected times in the future (e.g., 300, 500, 2,500, 5,000, and 10,000 years from present).

5.2.1.1 Source Characterization

Source characterization involved: determining the level of analysis for each alternative (screening of alternatives), aggregating the many potential sources into common source areas, grouping contaminants into categories based on their mobility, and developing the source term (i.e., mass flux and fluid flux release as a function of time) for each source area.

Screening of Alternatives and Waste Facilities

Screening was performed to exclude alternatives or waste treatment or storage facilities that had little or no potential for impacting groundwater from rigorous numerical modeling. The following sections provide the rationale for screening each alternative and for inclusion or exclusion of each from detailed groundwater modeling. Vadose zone and groundwater flow and transport simulations were used to analyze the groundwater impacts of those alternatives identified through screening as having the potential to impact groundwater.

No Action Alternative (Tank Waste)

This alternative potentially would impact the groundwater because no remediation would be performed, and all waste would remain in the tanks. During the 100-year institutional control period, tank waste management operations would continue. Waste releases to the vadose zone for both the DSTs and SSTs would occur primarily after the end of the institutional control period.

Long-Term Management Alternative

This alternative potentially would impact groundwater because no remediation would be performed and all waste would remain in the tanks. During the 100-year institutional control period, tank waste management operations would continue and the DSTs would be replaced twice during the 100-year institutional control period. Waste releases to the vadose zone would occur primarily after the end of the institutional control period for the SSTs and 100 years after the end of the institutional control period for the DSTs.

In Situ Fill and Cap Alternative

Under this alternative, the tanks would be filled with gravel, and a Hanford Barrier would be placed over the tanks. Potential releases to the groundwater system that would occur with the In Situ Fill and Cap alternative are associated with the contaminants in the waste tanks. The form of the waste and inventory are identical to the No Action alternative, and the total mass of waste entering the vadose zone and ultimately reaching the groundwater would be the same as for the No Action alternative. However, the release would occur at a slower rate because the Hanford Barrier would reduce the rate of infiltration into the tanks and the rate of migration of the waste downward into the vadose zone. While the gravel fill would structurally stabilize the tanks by supporting the tank domes, it otherwise would not help to reduce infiltration or retard contaminant transport.

In Situ Vitrification Alternative

Under this alternative, all tank waste would be vitrified in situ. A Hanford Barrier then would be placed over the tanks. Potential releases to the groundwater system from dissolution of the vitrified mass would be associated with the contaminants in the waste tanks, but the form of the waste and inventory would differ from the No Action alternative. Materials for making glass would be added to the waste, and the organic and other volatile materials present in the No Action alternative inventory would be destroyed or vaporized.

Ex Situ Intermediate Separations Alternative

Under this alternative, waste would be retrieved from the tanks, high-level waste (HLW) would be separated from the LAW, and both HLW and LAW would be vitrified. The HLW then would be shipped to a potential geologic repository and the LAW would be disposed of onsite in near-surface vaults. A Hanford Barrier would be placed over the tanks and LAW vaults. Potential releases to the groundwater would be associated with releases 1) during retrieval from the waste tanks; 2) from residuals remaining in the tanks; and 3) from the onsite LAW vaults.

Ex Situ No Separations Alternative

Under this alternative, waste would be retrieved from the tanks, vitrified or calcined, and shipped to the potential geologic repository for disposal. A Hanford Barrier would be placed over the tanks. Potential releases to the groundwater system would be associated with releases 1) during retrieval from the waste tanks; and 2) from residuals remaining in the tanks. The vitrified or calcined waste would not have a potential groundwater impact because all waste would be shipped offsite for disposal. The groundwater impacts for this alternative would be the same as those estimated for the retrieval and residual releases for the Ex Situ Intermediate Separations alternative.

Ex Situ Extensive Separations Alternative

This alternative would be similar to the Ex Situ Intermediate Separations alternative, with the difference being that a more extensive separations process would be implemented to remove a greater percentage of the HLW from the LAW waste. Under this alternative, waste would be retrieved from the tanks, HLW would be separated from the LAW, and both HLW and LAW would be vitrified. The extensive separations process would result in a smaller amount of contaminant source in the LAW vaults. A Hanford Barrier would be placed over the tanks and the LAW vaults. Potential releases to the groundwater system would be associated with releases 1) during retrieval from the waste tanks; 2) from residuals in the tanks; and 3) from the LAW vaults. Groundwater impacts associated with retrieval and residual releases would be similar to the Ex Situ Intermediate Separations alternative. However, the groundwater impacts of releases from the LAW vaults would be lower than those from the Ex Situ Intermediate Separations alternative LAW vaults because the source term is smaller.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, 107 tanks would be remediated in the manner described for the In Situ Fill and Cap alternative, and 70 tanks (60 SSTs and 10 DSTs) would be remediated in the manner described for the Ex Situ Intermediate Separations alternative. Releases to groundwater associated with the waste remediated under the In Situ Fill and Cap part of the alternative would occur as described previously. These tanks would contain disproportionately large amounts of low-mobility low-solubility contaminants. Tanks selected for waste retrieval and ex situ vitrification would contain approximately 90 percent of the high-mobility, high-solubility, high human health risk contaminants (i.e., technetium-99, carbon-14, iodine-129, and uranium-238).

Ex Situ/In Situ Combination 2 Alternative

Under this alternative, 25 tanks would be selected for retrieval and the remaining 152 tanks would be remediated in situ. The retrieved waste would be separated into LAW and HLW. The LAW would be placed into shallow subsurface LAW burial vaults in the 200 East Area and the HLW would be shipped offsite for disposal at the potential geologic repository. A Hanford Barrier would be placed over the tanks and vaults. This alternative was designed for the ex situ treatment of the largest contributors to long-term risk (i.e., technetium-99, carbon-14, iodine-129, and uranium-238) while limiting the total amount of waste to be retrieved and processed. Approximately 30 percent of the total waste volume in the tanks would be retrieved. The tank waste retrieved would contain approximately 85 percent of the

technetium-99, 80 percent of the carbon-14, 50 percent of the uranium-238, and 80 percent of the iodine-129.

Phased Implementation Alternative

Phase 1

Under the first phase of this alternative, waste from the DSTs would be retrieved, vitrified, and stored temporarily onsite. There would be no groundwater impacts under this phase because 1) releases of waste would not occur during retrieval from DSTs; and 2) the storage of the vitrified waste would be temporary and under controlled conditions so there would be no liquid releases.

Phase 2

In the second phase of this alternative, the remainder of the tank waste would be retrieved and treated in the same way as in the Ex Situ Intermediate Separations alternative. Potential releases to the groundwater for Phase 2 of the Phased Implementation alternative would be similar to those calculated for the retrieval from SSTs for the Ex Situ Intermediate Separations alternative.

Effluent Treatment Facility

This facility would be common to all of the alternatives. It potentially would impact groundwater because treated effluent from the Effluent Treatment Facility would be discharged to a State-approved land disposal site located immediately north of the 200 West Area. The Effluent Treatment Facility wastewater originates as process evaporator condensate. All tank alternatives would contribute wastewater to the State-approved land disposal site either through periodic operations of the 242-A Evaporator, DST retanking campaigns, or as liquid effluent collected from the process facility. The State-approved land disposal site consists of a piping manifold used to infiltrate treated effluent into vadose zone soil and deeper groundwater beneath the disposal site. The primary contaminant present in the treated effluent would be tritium, with other organic, inorganic, and radiologic contaminants having been removed during the treatment process (Volume Two, Appendix B). Waste releases to the vadose zone beneath the State-approved land disposal site would occur only during the operations phase of each alternative.

The effects of treated effluent disposal on groundwater were simulated as entering the uppermost aquifer beneath the State-approved land disposal site at a projected rate of 570 liters per minute (L/min) (150 gallons per minute [gal/min]) over an area of 8,350 m^2 (90,000 ft^2). Tritium concentrations in the treated effluent entering the groundwater system were assumed to be 2.1E-05 Ci/L (2.1E+07 pCi/L) with a half-life of 12.3 years. The simulation results indicated that disposal of treated effluent would have little effect on the local direction of groundwater movement beneath the State-approved land disposal site. Groundwater flow directions resume their northeasterly regional flow direction at a point approximately 300 m (980 ft) downgradient of the disposal site. It is estimated that it would take 100 years for tritium in the uppermost aquifer to travel between the disposal site and the Columbia River. Maximum tritium concentrations at the riverbank before dilution in the Columbia River were calculated to be 1.4E-08 Ci/L (1.4E+04 pCi/L), which is below the Federal drinking water standard of

2.0E-08 Ci/L (20,000 pCi/L) (Jacobs 1996). No further groundwater analysis was conducted for the effects of treated effluent disposal.

No Action Alternative (Capsules)

This alternative would not impact groundwater. Cesium and strontium capsules would be maintained and stored temporarily in the Waste Encapsulation and Storage Facility (WESF) basins for a period of approximately 10 years, until further remediation measures have been selected. Therefore, no groundwater analysis was necessary.

Onsite Disposal Alternative

Under this alternative, the capsules would be placed in 0.3-m (1.0-ft) canisters surrounded by a 0.76-m (2.5-ft)-diameter sand backfill. There would be 672 drywells on a 5-m (16-ft) center-to-center spacing with a 30-m (100-ft) buffer around the facility. The drywell depth would be 4.6 m (15 ft) belowground.

Both cesium and strontium are relatively immobile in groundwater systems at the Hanford Site. The result of this immobility would mean that no measurable amount of either cesium or strontium would reach the groundwater within the 10,000-year period of interest. In addition, cesium-137 decays to barium-137, a stable isotope that likewise is immobile in groundwater systems. Strontium-90 decays to zirconium-90, which also is stable and immobile in groundwater systems. No groundwater analysis was conducted for this alternative because no impacts would be expected from the capsule contents or their decay products.

Overpack and Ship Alternative

Under this alternative, capsules would be removed from temporary storage, overpacked, and shipped offsite. No release of liquid would occur. No groundwater assessment was necessary because there would be no release of contaminants to the vadose zone or the groundwater.

Vitrify with Tank Waste Alternative

Under this alternative, capsules would be removed from temporary storage and vitrified with the HLW. Releases of liquid would be accounted for in the ex situ alternatives. No groundwater assessment was necessary because there would be no release of contaminants to the vadose zone or groundwater in excess of those for the ex situ alternatives.

Aggregate Source Areas

The 179 potential sources (i.e., each of the 177 tanks and the proposed LAW disposal vaults) were aggregated into nine discrete source areas based on waste inventory and proximity. The criteria used for these groupings are as follows.

- The proposed LAW disposal facility was considered one source area, though there could be as many as 41 vaults. Vault spacing was assumed to be approximately 30 m (100 ft) over a continuous area of up to 9.4 ha (23 ac). The vaults would be covered with one continuous Hanford Barrier.

- The tank sources were grouped into eight source areas, three in the 200 West Area and five in the 200 East Area.

Contaminant Groups

The tanks contain more than 100 radioactive and nonradioactive contaminants that potentially could impact groundwater. The approach used for this analysis was to group the contaminants based on their mobility in the vadose zone and underlying unconfined aquifer. Contaminant groupings were used rather than the individual mobility of each contaminant primarily because of the uncertainty involved in determining the mobility of individual contaminants. The groups were selected based on relatively narrow ranges of mobility, and contaminants were placed in the more mobile group if there was uncertainty about which group they should be placed in.

Some of the contaminants, such as iodine and technetium, would move at the rate of water whether in the vadose zone or underlying groundwater. The movement of other contaminants in water, such as americium and cesium, would be slowed or retarded by interaction with soil and rock. The VAM2D flow and transport model accounted for the retardation of contaminant movement with the parameter K_d, which is the distribution coefficient (mL/g). This parameter is a measure of sorption and is the ratio of the quantity of the adsorbate adsorbed per gram of solid to the amount of adsorbate remaining in solution (Kaplan et al. 1994). Values of K_d for the contaminants range from 0 mL/g (in which the contaminant's movement in water is not retarded) to more than 100 mL/g (in which the contaminant moves much slower than water).

The waste inventory was grouped and modeled according to each contaminant's reported or assumed K_d. The contaminant groups, based on mobility and examples of common or potential constituents of concern, are described in the following text. A complete listing of tank waste constituents by K_d is provided in Volume Four, Appendix F. The waste inventory groups used for modeling included the following:

- Group 1 - Contaminants were modeled as nonsorbing (i.e., $K_d = 0$). Contaminant movement would be unretarded in water. Contaminant K_d values in this group ranged from 0 to 0.99 mL/g and included all the isotopes of carbon, iodine, technetium, uranium, and nitrate;
- Group 2 - Contaminants were modeled as slightly sorbing (i.e., $K_d = 1$). Contaminant K_d values in this group ranged from 1 to 9.9 mL/g and included all the isotopes of americium, nickel, and chromium;
- Group 3 - Contaminants were modeled as moderately sorbing (i.e., $K_d = 10$). Contaminant K_d values in this group ranged from 10 to 49.9 mL/g and included all the isotopes of lead, plutonium, strontium, and thorium; and
- Group 4 - Contaminants were modeled as strongly sorbing (i.e., $K_d = 50$). Contaminant K_d values in this group were 50 mL/g or greater and included all the isotopes cesium, rubidium, and thallium.

Source Terms

The numerical modeling used to analyze groundwater impacts required understanding and quantifying when, what, and how many (mass or activity) contaminants would be released. The quantification of this information is the source term and includes the water flux into the vadose zone, which results from precipitation infiltrating the waste and mass or activity solubilized from dissolution of waste in the tanks. A detailed description of the source term and the rates of release of contaminants into the groundwater are contained in Volume Four, Appendix F.

5.2.1.2 Results

Groundwater beneath the 200 Areas and in plumes leading from the 200 Areas toward the Columbia River currently is contaminated with hazardous chemicals and radionuclides at levels greatly exceeding Federal drinking water standards. Drinking water standards typically are applied to treated water and are used here for comparison. For radionuclides, the drinking water standard (40 Code of Federal Regulations [CFR] 141.16) is based on a calculated dose equivalent to 4 millirem (mrem)/year to an internal organ, except for uranium that has a standard of 0.02 mg/L based on total uranium (i.e., all isotopes). Hazardous chemical contaminants present at levels exceeding drinking water standards include nitrates, cyanide, fluoride, chromium, chloroform, carbon tetrachloride, trichloroethylene, and techrachloroethylene. Radiological contaminants include iodine-129, tritium, cesium-137, plutonium-239 and 240, and strontium-90.

The groundwater beneath the 200 Areas is severely contaminated at levels that substantially exceed drinking water standards for several constituents. For example, iodine-129 is present at levels that exceed standards by up to 20 times. Groundwater use restrictions have been implemented to prevent use of the contaminated groundwater. Implementing any of the TWRS alternatives would add contaminants to groundwater but in concentrations expected to be less than the current levels of contamination observed in groundwater beneath the 200 Areas. Groundwater impacts calculated for each alternative are described briefly in the following subsections.

No Action Alternative (Tank Waste)

Groundwater impacts would be essentially the same as at present for the remainder of the 100-year period of institutional control, with the exception of slightly increased contaminant levels due to additional SSTs that could develop leaks. The long-term effects of this alternative are discussed below.

Because the waste would remain in the tanks, the No Action alternative eventually would result in the long-term dissolution and release of the total waste inventory from the 177 tanks into the vadose zone. The contaminants ultimately would pass through the vadose zone and reach the groundwater in the underlying unconfined aquifer within the 10,000-year period of analysis. Once in the aquifer, the contaminants would move relatively quickly through the aquifer and discharge to the Columbia River. The calculated contaminant concentrations in the groundwater are described in the following sections.

For the K_d Group 1 (K_d = 0) contaminants (fast-moving contaminants), the vadose simulation results calculated first arrival of contaminants at the vadose zone/groundwater interface from approximately

130 to 150 years from the present for the SSTs and DSTs. Peak concentration at the vadose zone/groundwater interface would be reached approximately 210 to 260 years from the present.

For the K_d Group 2 (K_d = 1), the vadose simulation results calculated contaminant first arrival at the groundwater approximately 1,000 to 1,400 years from the present. The average time of first arrival for the three source areas in the 200 West Area would be approximately 1,300 years from the present, while the average time of first arrival for the five source areas in the 200 East Area would be approximately 1,200 years from the present. The longer average time to first arrival for source areas in the 200 West Area is consistent with the thicker vadose zone in the 200 West Area.

For the K_d Group 3 and 4 (K_d = 10 and 50), first arrival would occur late (i.e., beyond the 10,000-year period of analysis). For this reason, simulation results were not reported for these K_d groups.

Two time frames were selected to illustrate the contaminant distribution in the unconfined aquifer. The calculated nitrate distribution in the groundwater at 300 years from the present is shown in Figure 5.2.3. Nitrate has an assumed K_d equal to zero and thus would move at the same velocity as the groundwater. Figure 5.2.4 provides the calculated distribution of bismuth in the groundwater at 5,000 years from the present. Bismuth is in K_d Group 2 (K_d = 1). Bismuth would move through the groundwater system at a slower velocity than water. Maximum contaminant concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.1 with the drinking water standards for comparison.

Drinking water standards for carbon-14, iodine-129, technetium-99, nitrate, and uranium-238 all would be exceeded at the 300- and 500-year times. Contaminant concentrations would decrease by 500 years but still would exceed the drinking water standards. By 2,500 years from the present, contaminant levels would be well below applicable drinking water standards as the contaminants are flushed through the system.

Long-Term Management Alternative

Under the Long-Term Management alternative, the first retanking of the DSTs would begin 50 years from the present. As a result, there would be no short-term contaminant releases to the vadose zone and groundwater in addition to those already existing. Groundwater impacts essentially would be the same as at present for the remainder of the 100-year period of institutional control, with the possible exception of slightly increased contaminant levels due to additional SSTs that begin to develop leaks. Leaks would be very small because saltwell pumping of the SSTs would reduce the amount of liquids available for release and because leaks would not be expected from the outer tanks of the DSTs.

Long-term impacts from the Long-Term Management alternative would be similar to the No Action alternative except impacts from the DSTs would be delayed by up to 100 years. The Long-Term Management alternative would result in the release of the total waste inventory from the 177 tanks into

Figure 5.2.3 Predicted Nitrate Concentrations in Groundwater at 300 Years for the No Action Alternative

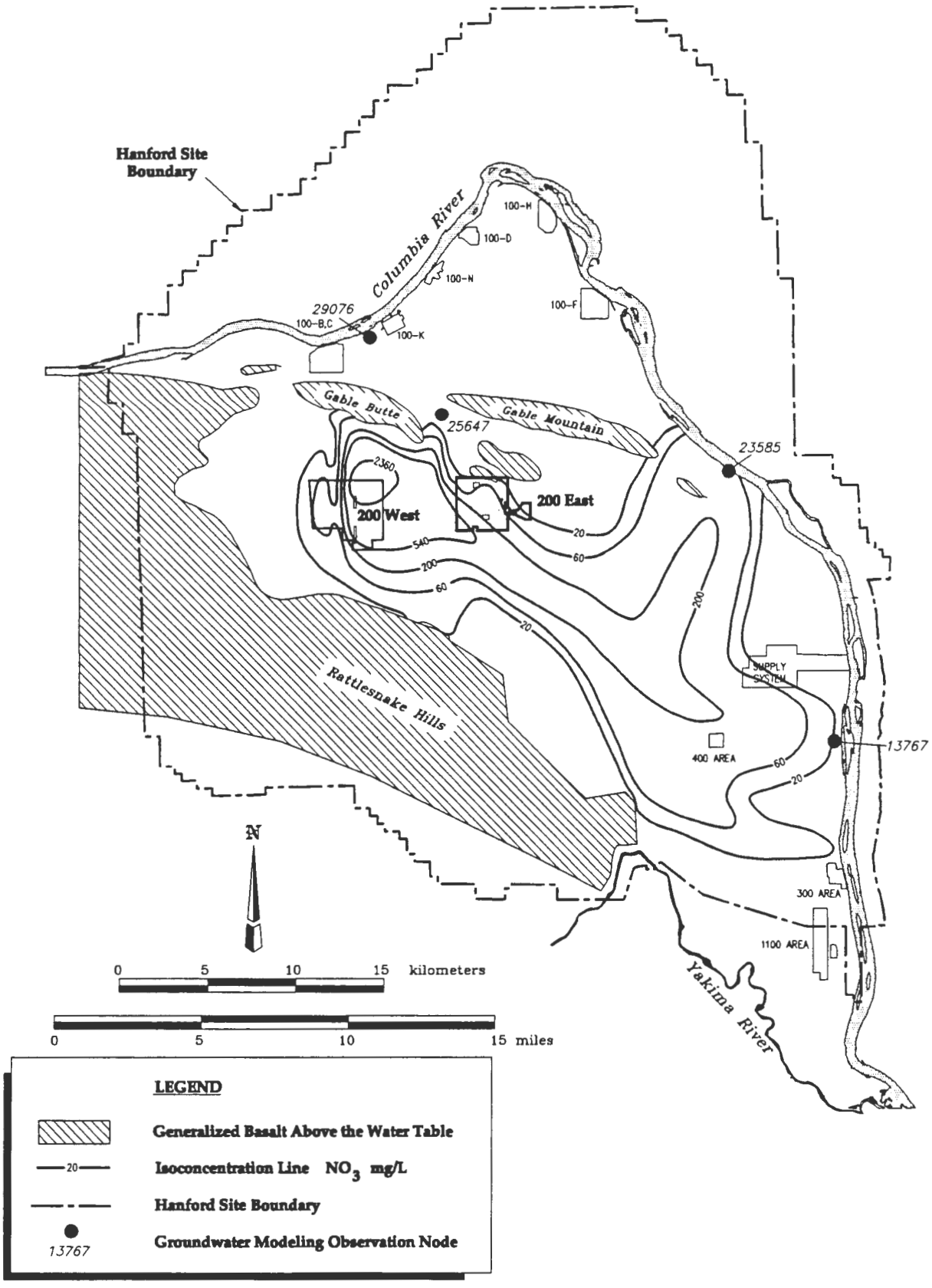


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Figure 5.2.4 Predicted Bismuth Concentrations in Groundwater at 5,000 Years for the No Action Alternative

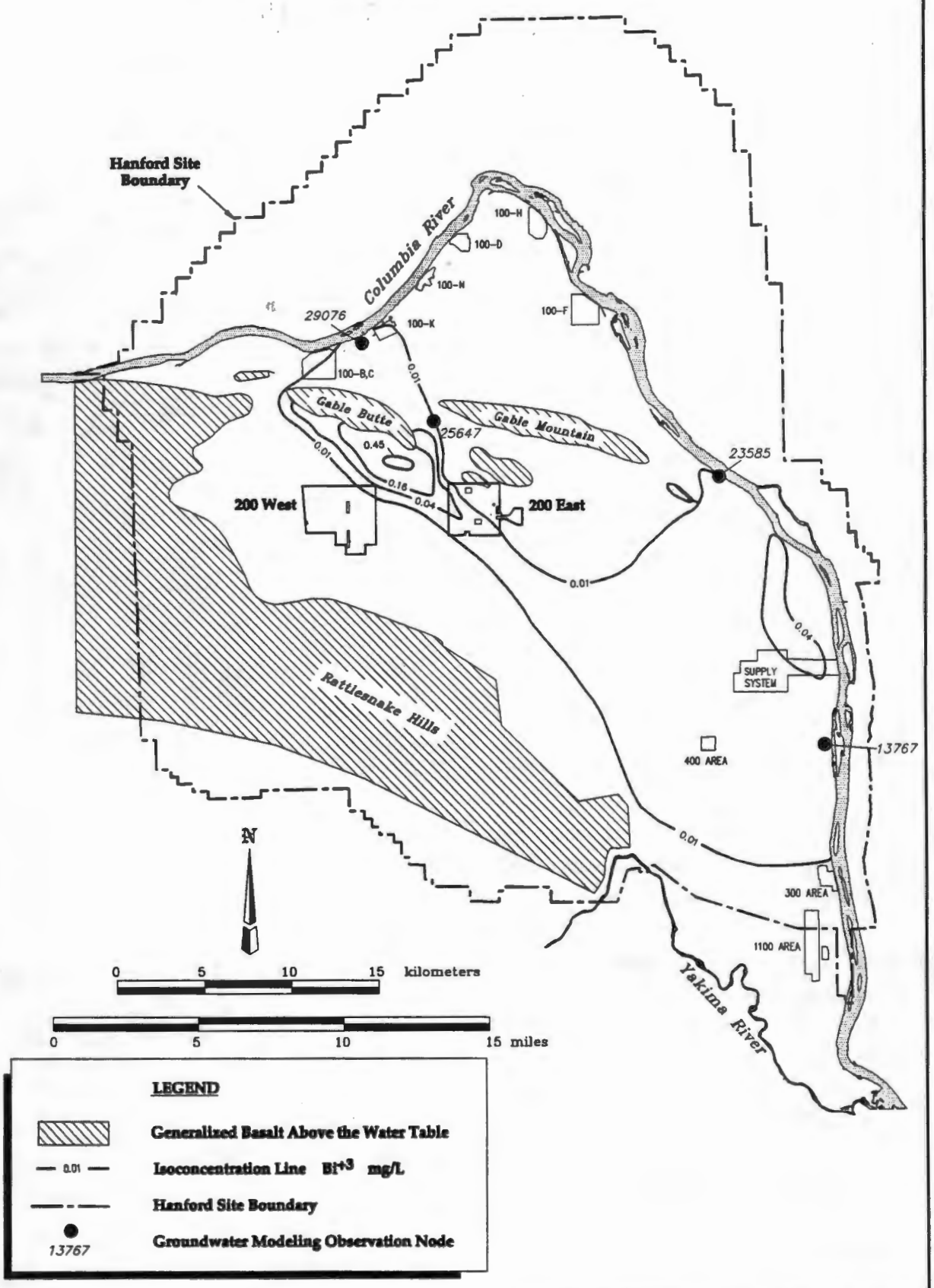

Table 5.2.1 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the No Action Alternative [1]

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	1.55E-05 [3]	6.90E+04	4.57E-06 [3]	2.03E+04	2.13E-09	9.48E+00
Iodine-129	2.50E-03 [3]	4.40E+02	3.21E-04 [3]	5.65E+01	6.51E-07	1.15E-01
Technetium-99	1.37E-02 [3]	3.16E+05	7.45E-03 [3]	1.26E+05	8.02E-06	1.36E+02
Uranium-238 [2]	1.23E+02 [3]	4.13E+04	1.42E+01 [3]	4.77E+03	5.04E-03	1.69E+00
Nitrate	6.62E+03	N/A	8.22E+02	N/A	1.21E+00	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	3.18E-11	1.42E-01	0	0	4.49E-07	2,000 pCi/L
Iodine-129	1.31E-08	2.31E-03	1.10E-12	1.94E-07	5.68E-06	1 pCi/L
Technetium-99	1.58E-07	2.67E+00	1.34E-11	2.26E-04	5.33E-05	900 pCi/L
Uranium-238 [2]	1.02E-04	3.43E-02	0	0	0.02 mg/L (Total)	
Nitrate	2.43E-02	N/A	2.09E-06	N/A	45 mg/L	

Notes:
[1] Drinking water standard exceedances are based on the combination of the alternative and the representative closure scenario presented in the EIS. Final closure actions may result in lower levels of contamination.
[2] Uranium-238 accounts for more than 99 percent of the uranium present.
[3] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

the vadose zone. The contaminants ultimately would pass through the vadose zone and reach the groundwater in the underlying unconfined aquifer within the 10,000-year period of analysis.

Once in the aquifer, the contaminants would move quickly through the aquifer and discharge to the Columbia River. The difference between this alternative and the No Action alternative is that the DSTs were assumed to last 100 years longer under the Long-Term Management alternative.

For the K_d Group 1 (K_d = 0) contaminants, the vadose zone simulation results calculated first arrival of contaminants at the vadose zone/groundwater interface approximately 140 to 250 years from present. Peak concentration at the vadose zone/groundwater interface would be reached approximately 210 to 350 years from present.

For the K_d Group 2 (K_d = 1), the vadose simulation results in calculated contaminant first arrival at the groundwater approximately 1,000 to 1,500 years from the present. The average time of first arrival for the three source areas in the 200 West Area would be approximately 1,300 years from the present, while the average time of first arrival for the five source areas in the 200 East Area would be

approximately 1,200 years. The longer average time to first arrival for source areas in the 200 West Area is consistent with the thicker vadose zone in the 200 West Area.

For the K_d Group 3 and 4 (K_d = 10 and 50), first arrival would occur late (i.e., beyond the 10,000-year period of analysis). For this reason, simulation results were not reported for these K_d groups.

Two time frames were selected to illustrate the contaminant distribution in the unconfined aquifer. The estimated nitrate distribution in the groundwater at 300 years from the present is shown in Figure 5.2.5. Nitrate has an assumed K_d equal to zero, and thus would move at the velocity of groundwater.

Figure 5.2.6 provides the calculated distribution of bismuth in the groundwater at 5,000 years from the present. Bismuth is in K_d Group 2 (K_d = 1). Bismuth would move through the groundwater system at a much slower velocity than water. Maximum contaminant concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.2 with drinking water standards for comparison.

Drinking water standards for carbon-14, iodine-129, technetium-99, nitrate, and uranium-238 all would be exceeded at the 300- and 500-year times. Contaminant concentrations would decrease by 500 years but still exceed the drinking water standards. By 2,500 years, contaminant levels would be below current drinking water standards.

In Situ Fill and Cap Alternative

There would be no contaminant losses to the vadose zone and groundwater under the In Situ Fill and Cap alternative during remediation in addition to those already existing, because retrieval of the waste would not be performed; therefore, retrieval activities would not cause increased leaks from the tanks. Groundwater impacts essentially would be the same as for the No Action alternative for the 100-year period of institutional control. The long-term effects of this alternative would commence after the 100-year period of institutional control and are discussed in the following paragraphs.

The waste that remained in the tanks under the In Situ Fill and Cap alternative eventually would result in the long-term dissolution and release of the complete inventory from the 177 tanks into the vadose zone. This complete release was considered to be a bounding condition for the EIS. However, only the most mobile contaminants, those modeled as K_d = 0, were calculated to reach the groundwater within the period of analysis. The source would be the same as for the No Action alternative.
The major difference between these alternatives is that a Hanford Barrier would be constructed over the tanks, which would result in a lower infiltration rate and lower contaminant release rate to the vadose zone compared to the No Action alternative. For the In Situ Fill and Cap and all other tank waste alternatives, except No Action, Long-Term Management, and Ex Situ/In Situ Combination 1 and 2 alternatives, only the contaminants modeled as K_d = 0 would reach the groundwater within the period

Figure 5.2.5 Predicted Nitrate Concentrations in Groundwater at 300 Years for the Long-Term Management Alternative

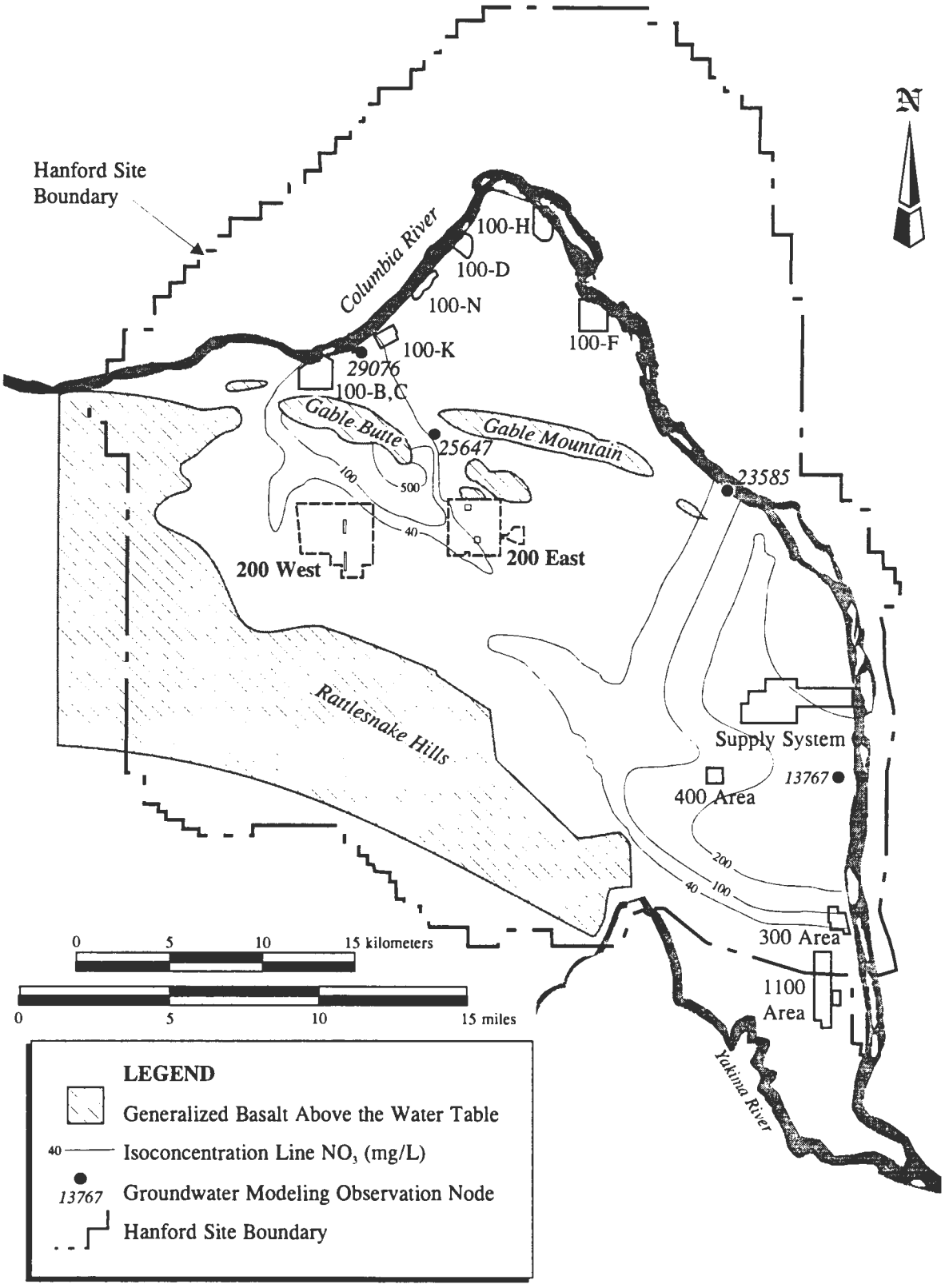

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Figure 5.2.6 Predicted Bismuth Concentrations in Groundwater at 5,000 Years for the Long-Term Management Alternative

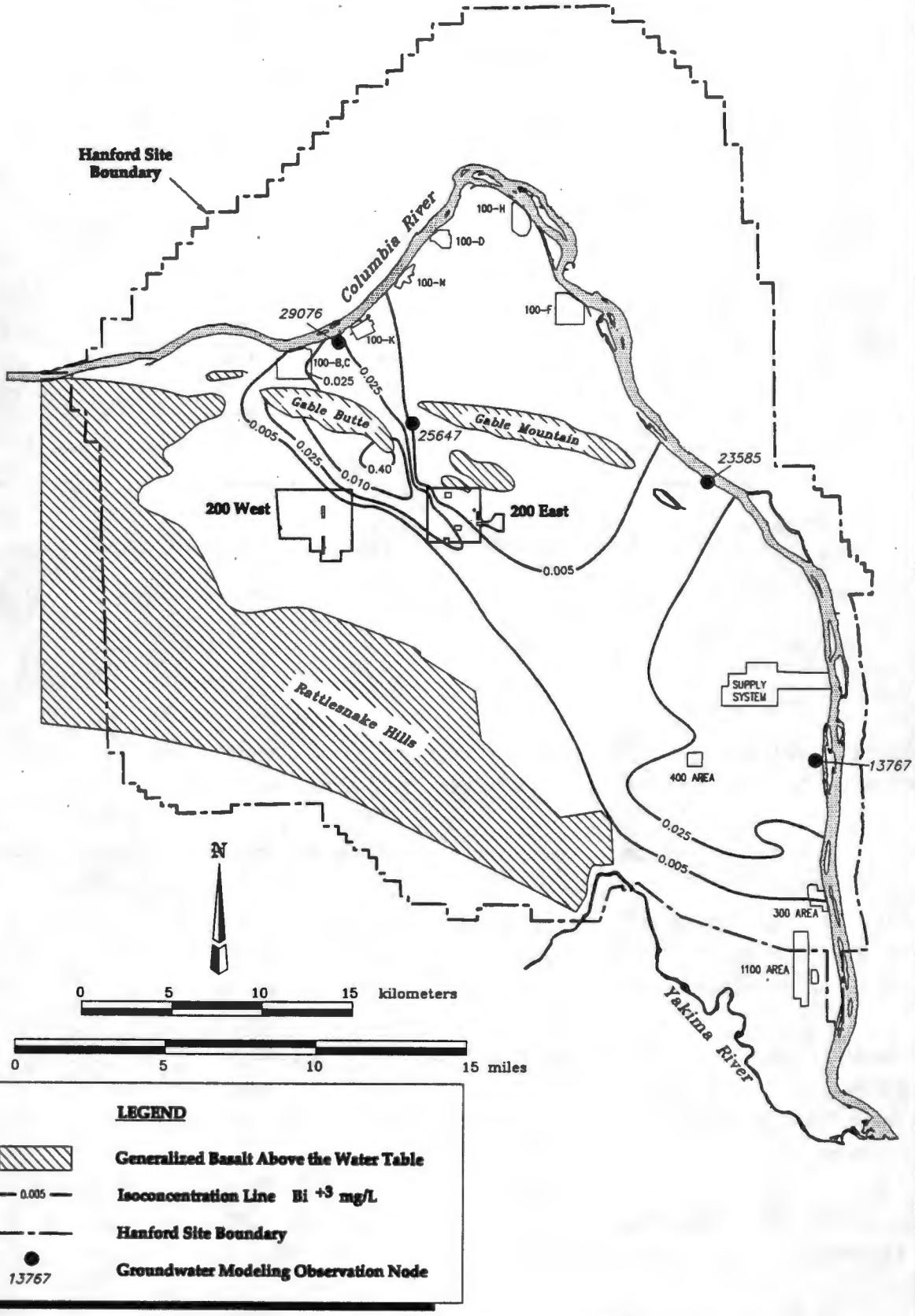


Table 5.2.2 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the Long-Term Management Alternative [3]

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	3.15E-06 [2]	1.40E+04	3.96E-06 [2]	1.76E+04	2.13E-09	9.48E+00
Iodine-129	4.09E-04 [2]	7.20E+01	3.21E-04 [2]	5.65E+01	6.51E-07	1.15E-01
Technetium-99	5.40E-03 [2]	9.13E+04	6.48E-03 [2]	1.10E+05	8.44E-06	1.43E+02
Uranium-238 [1]	1.83E+01 [2]	6.14E+03	1.42E+01 [2]	4.77E+03	7.50E-04	2.52E-01
Nitrate	1.05E+03	N/A	8.21E+02	N/A	1.21E+00	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	3.18E-11	1.42E-01	0	0	4.49E-07	2,000 pCi/L
Iodine-129	1.31E-08	2.31E-03	1.10E-12	1.94E-07	5.68E-06	1 pCi/L
Technetium-99	1.71E-07	2.89E+00	1.45E-11	2.45E-04	5.33E-05	900 pCi/L
Uranium-238 [1]	1.51E-05	5.07E-03	9.00E-09	3.02E-06	0.02 mg/L (Total)	
Nitrate	2.44E-02	N/A	2.10E-06	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ.
[3] Drinking water standard exceedances are based on the combination of the alternative and the representative closure scenario presented in the EIS. Final closure actions may result in lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

of analysis. For this reason, simulations were not reported for K_d Groups 2, 3, and 4 for the remaining alternatives except the Ex Situ/In Situ Combination 1 and 2 alternatives.

Once in the aquifer, the contaminants would move relatively quickly through the aquifer and discharge to the Columbia River. Contaminant first arrival at the vadose zone/groundwater interface was calculated to occur approximately 2,300 to 3,400 years from the present. Peak groundwater concentrations in the aquifer would be similar to those calculated for the No Action alternative but would occur approximately 4,100 to 6,300 years from present.

The average time to first arrival and peak concentration for the five source areas in the 200 East Area would be approximately 2,500 and 5,200 years, respectively. The average time to first arrival and peak concentration for the three source areas in the 200 West Area would be approximately 3,300 and 5,200 years, respectively.

The calculated peak concentrations for each of the eight areas at the vadose zone/groundwater interface were similar in magnitude to those calculated for the No Action alternative. As with the No Action

alternative, contaminant levels would reach or nearly reach steady-state conditions with maximum concentrations near 400,000 g/m^3 for all source areas except one.

The calculated nitrate distribution in the groundwater at 5,000 years from the present is shown in Figure 5.2.7. Nitrate has an assumed K_d equal to zero and thus would move at the velocity of groundwater. Nitrate concentration in the groundwater would reach steady-state conditions at approximately 5,800 years and would continue at those concentration levels for approximately 1,500 years. The nitrate concentrations shown in Figure 5.2.7 were based on an initial source concentration of 360,000 g/m^3 calculated in the upper 6 m (20 ft) of the aquifer.

Maximum contaminant concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.3 with the drinking water standards for comparison, where available.

Contaminants would not reach groundwater from the sources at earlier time periods during 300 or 500 years from present. Very low levels were calculated for the 2,500-year period. Current drinking water standards exceedances were calculated for iodine-129, uranium, and technetium-99 from 5,000 years through 10,000 years from the present. Nitrate concentrations would exceed drinking water standards at approximately 5,000 years but would decrease to below the standard before 10,000 years.

In Situ Vitrification Alternative

There would be no contaminant losses to the vadose zone and groundwater under the In Situ Vitrification alternative during remediation because the waste would be immobilized by vitrification, and the resulting glass would leach extremely slowly. The long-term effects of this alternative would commence after remediation and are discussed in the following paragraphs.

The In Situ Vitrification alternative would result in the long-term partial release of the tank inventory from the 177 tanks into the vadose zone over the period of interest (10,000 years). Only the most mobile contaminants, those modeled as K_d equal to zero, were calculated to reach the groundwater within the period of analysis. The source would be similar to the alternatives previously described but the release rates would be very low. This would result in a release of contaminants at a constant concentration for several thousand years from each vitrified tank farm.

Contaminant first arrival at the vadose zone/groundwater interface was calculated to occur approximately 2,400 to 3,400 years from the present. Peak concentration at the vadose zone/groundwater interface would reach steady-state conditions with a concentration of 400 mg/L between approximately 6,200 and 7,500 years and remain at that concentration for the remainder of the period of analysis. Compared to the No Action alternative, this alternative would have a much longer calculated time to first arrival and a lower peak concentration at the vadose zone/groundwater interface, primarily because of the lower infiltration rate through the Hanford Barrier and the low solubility of the vitrified waste. The calculated peak concentration for each of the eight source areas at

Figure 5.2.7 Predicted Nitrate Concentrations in Groundwater at 5,000 Years for the In Situ Fill and Cap Alternative

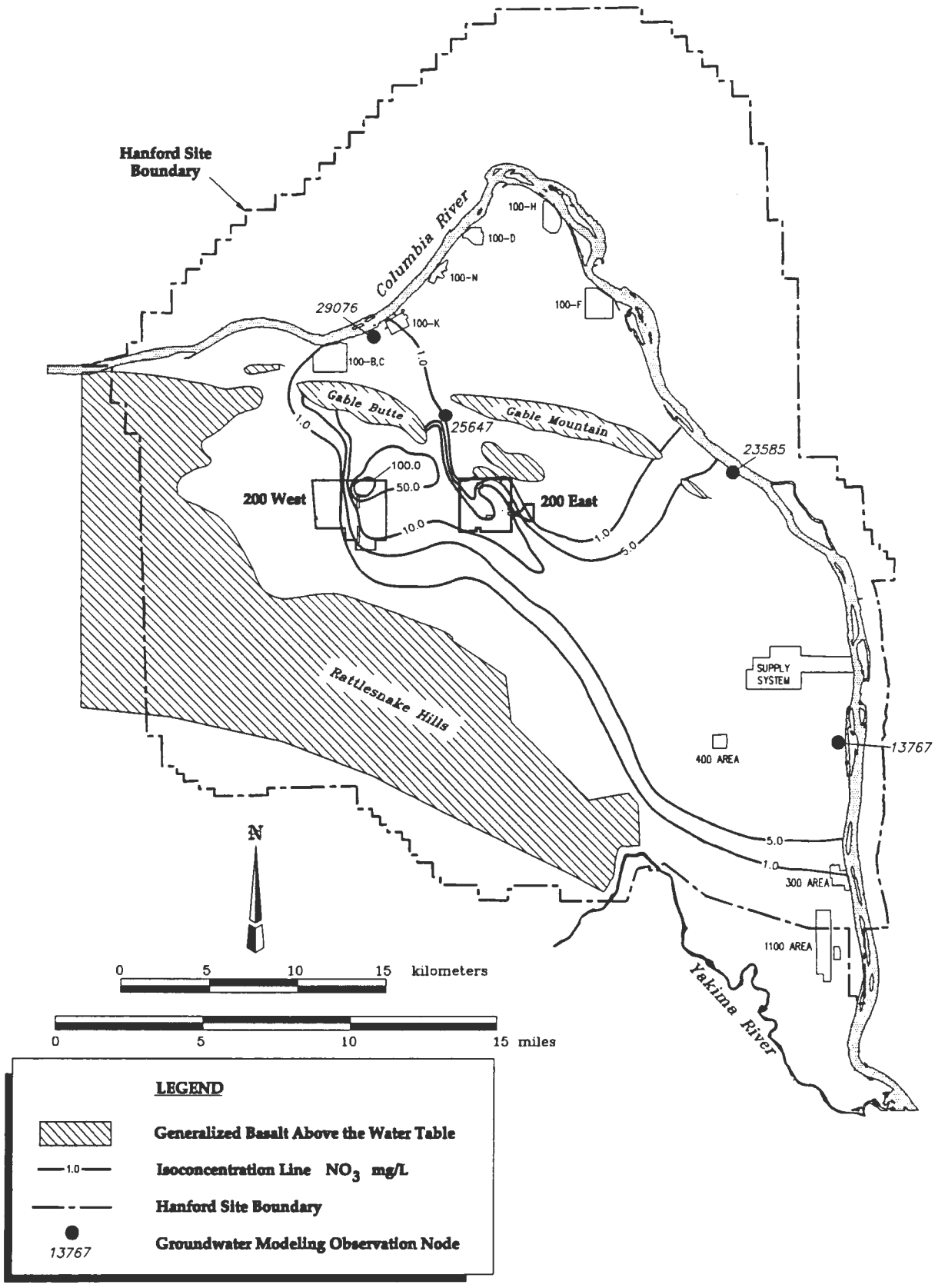


Table 5.2.3 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the In Situ Fill and Cap Alternative [3]

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	0	0	0	0	1.40E-12	6.23E-03
Iodine-129	0	0	0	0	9.82E-11	1.73E-05
Technetium-99	0	0	0	0	2.72E-09	4.60E-02
Uranium-238 [1]	0	0	0	0	3.00E-06	1.01E-03
Nitrate	0	N/A	0	N/A	3.17E-05	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	2.99E-07	1.33E+03	1.93E-08	8.59E+01	4.49 E-07	2,000 pCi/L
Iodine-129	4.74E-05 [2]	8.34E+00	1.46E-05 [2]	2.57E+00	5.68E-06	1 pCi/L
Technetium-99	8.70E-04 [2]	1.47E+04	1.03E-04 [2]	1.74E+03	5.33E-05	900 pCi/L
Uranium-238 [1]	2.40E+00 [2]	8.06E+02	2.44E-01 [2]	8.20E+01	0.02 mg/L (Total)	
Nitrate	1.27E+02	N/A	2.68E+01	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ.
[3] Drinking water standard exceedances are based on the combination of the alternative and the representative closure scenario presented in the EIS. Final closure actions may result in lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

the vadose zone/groundwater interface also would be much lower. The time of first arrival would be affected by the material properties of the strata as well as the distance of travel (vadose zone thickness).

Figure 5.2.8 presents the calculated uranium-238 distribution in the groundwater at 5,000 years from the present. Uranium-238 was assumed to have a K_d equal to zero and thus would move at the velocity of groundwater. The uranium-238 concentrations would reach steady-state conditions at approximately 5,000 years and continue at those concentration levels throughout the 10,000-year period of analysis. The uranium-238 concentrations shown in Figure 5.2.8 represent calculated concentrations in the upper 6 m (20 ft) of the aquifer. Maximum contaminant concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.4 with the drinking water standards for comparison, where available. Calculated contaminant concentrations all would be below drinking water standards for all of the times shown in Table 5.2.4. Iodine-129, nitrate, and carbon-14 were not in the source term because iodine-129 and carbon-14 would be volatilized during the vitrification process, and nitrate would be converted to volatile nitrogen oxides.

Figure 5.2.8 Predicted Uranium-238 Concentrations in Groundwater at 5,000 Years for the In Situ Vitrification Alternative

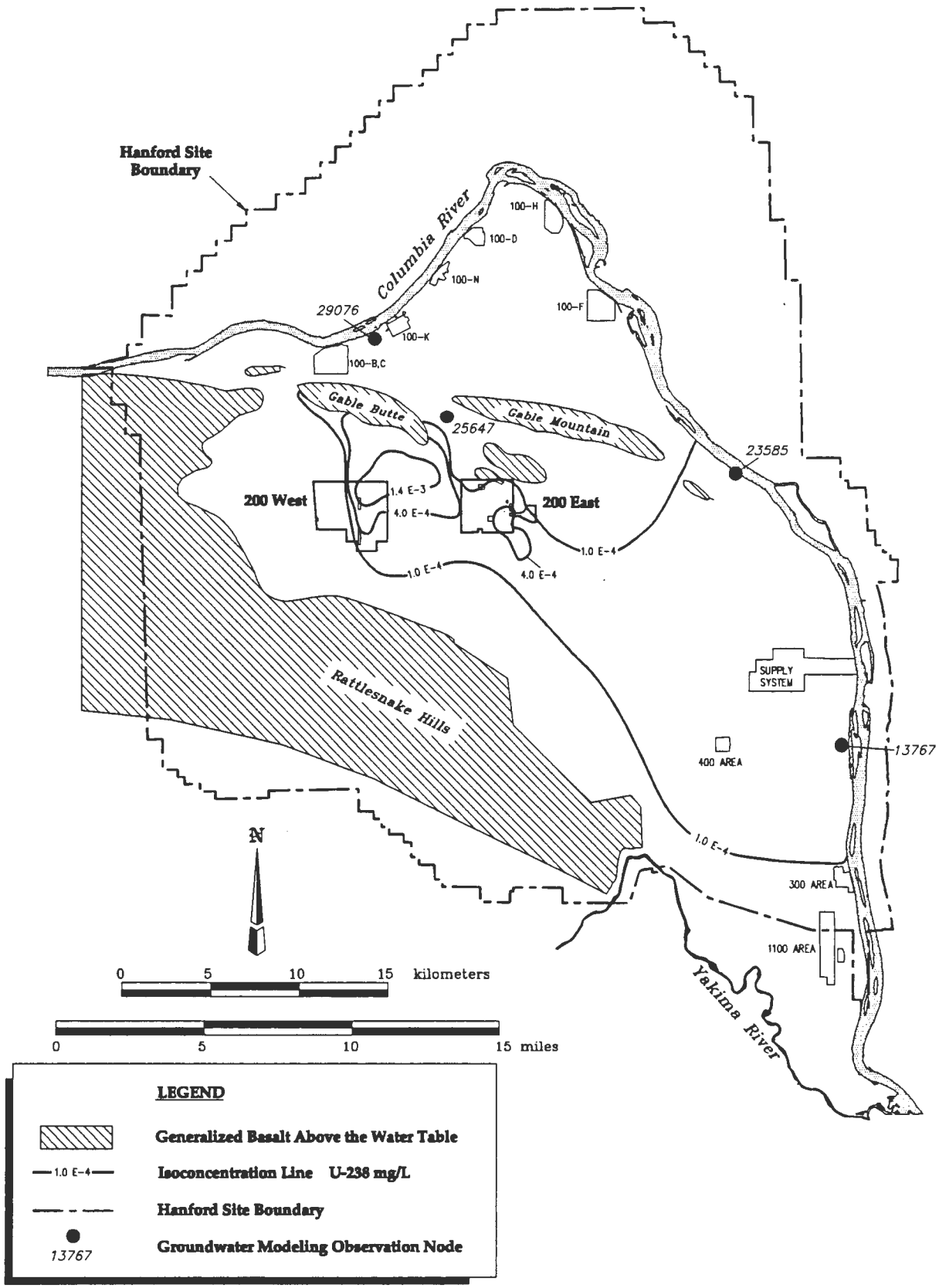


Table 5.2.4 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the In Situ Vitrification Alternative [2]

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	0	0	0	0	0	0
Iodine-129	0	0	0	0	0	0
Technetium-99	0	0	0	0	0	0
Uranium-238 [1]	0	0	0	0	0	0
Nitrate	0	N/A	0	N/A	0	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Carbon-14	0	0	0	0	4.49E-07	2,000 pCi/L
Iodine-129	0	0	0	0	5.68E-06	1 pCi/L
Technetium-99	1.72E-06	2.91E+01	2.21E-06	3.73E+01	5.33E-05	900 pCi/L
Uranium-238 [1]	1.84E-03	6.18E-01	2.37E-03	7.96E-01	0.02 mg/L (Total)	
Nitrate	0	N/A	0	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Drinking water standard exceedances are based on the combination of the alternative and the representative closure scenario presented in the EIS. Final closure actions may result in lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

Ex Situ Intermediate Separations Alternative

There would be contamination releases to the vadose zone under the Ex Situ Intermediate Separations alternative during remediation that would be caused by releases from the SSTs during retrieval. There would be no contaminant releases from the DSTs. However, the contaminants released by losses during retrieval would travel very slowly in the vadose zone, requiring approximately 1,100 years to reach the groundwater. Groundwater modeling did not distinguish between contaminants from retrieval releases and contaminants from residual waste left in the tank. The net result was that contaminants from retrieval releases would become intermingled with contaminants from residual waste left in the tanks. The modeling results shown in Volume Four, Appendix F show only the arrival of one group of contaminants at the boundary between the vadose zone and the groundwater aquifers. The long-term effects of the Ex Situ Intermediate Separations alternative are discussed in the following paragraphs.

This alternative would result in the long-term release of contaminants to the vadose zone from 1) waste from the 149 SSTs associated with retrieval operations (retrieval from DSTs do not result in releases); 2) residual waste left in the tanks (for all tanks); and 3) the LAW disposal facility.

Only the most mobile contaminants, those modeled as K_d Group 1 (K_d = 0), were calculated to reach the groundwater within the period of analysis. The contaminants modeled as K_d Group 1 (K_d = 0)

would reach the vadose zone/groundwater interface approximately 1,100 to 3,400 years from present. Compared to the No Action alternative, the mass of contaminants that would be released from the tanks would be relatively small (i.e., less than 2 percent of the mass released under the No Action alternative).

Peak contaminant concentrations at the vadose zone/groundwater interface for the tank source areas would be approximately 3,600 to 5,100 years from present. Peak contaminant concentrations at the vadose zone/groundwater interface for the LAW disposal facility would be reached at approximately 6,600 years and would remain at about that concentration for the remainder of the period of analysis. Compared to the No Action alternative, this alternative would have a much longer time to first arrival and peak contaminant concentrations at the vadose zone/groundwater interface, primarily because of the lower infiltration rate through the Hanford Barrier and the lower corrosion rate of the vitrified waste in the LAW disposal facility.

The calculated nitrate concentration in the groundwater from the tank sources at 5,000 years from the present is shown in Figure 5.2.9. The nitrate concentrations shown in Figure 5.2.9 were adjusted for an assumed initial source concentration of 360,000 g/m^3 of nitrate and represent calculated concentrations in the upper 6 m (20 ft) of the aquifer. Figure 5.2.10 presents the calculated uranium-238 concentrations in the groundwater from the tank and LAW disposal facility at 5,000 years from the present. Both nitrate and uranium-238 have an assumed K_d equal to zero and thus would move at the velocity of groundwater. Post processing of the modeling results is explained in Volume Four, Appendix F. There would be an exceedance at the current drinking water standard for uranium-238 at 5,000 years from present. No additional contaminants would exceed current groundwater standards.

Contaminants would not have reached the groundwater from the tank sources at the two earlier time periods of analysis (e.g., 300 and 500 years from the present). At 2,500 years from the present, contaminants would not have yet reached groundwater from the LAW disposal facility. Maximum concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.5 for comparison with the drinking water standards. The current drinking water standards for any of the indicator contaminants would not be exceeded by releases from the tank sources associated with waste retrieval and residuals nor the LAW disposal source, except for a slight exceedance of uranium at 5,000 years for the tank sources. Because the maximums for tank sources and LAW vaults occur at different locations, they are not additive.

Ex Situ No Separations Alternative

There would be contaminant releases to the vadose zone under the Ex Situ No Separations alternative during remediation that would be caused by releases from the SSTs during retrieval. There would be no contaminant releases from the DSTs. Because the retrieval process is the same as that for the Ex Situ Intermediate Separations alternative, the effects of these retrieval releases also would be the same. The following paragraphs discuss the long-term effects of groundwater contaminants.

9613459.0371

Figure 5.2.9 Predicted Nitrate Concentrations in Groundwater at 5,000 Years for the Ex Situ Intermediate Separations Alternative (Tank Sources Only)

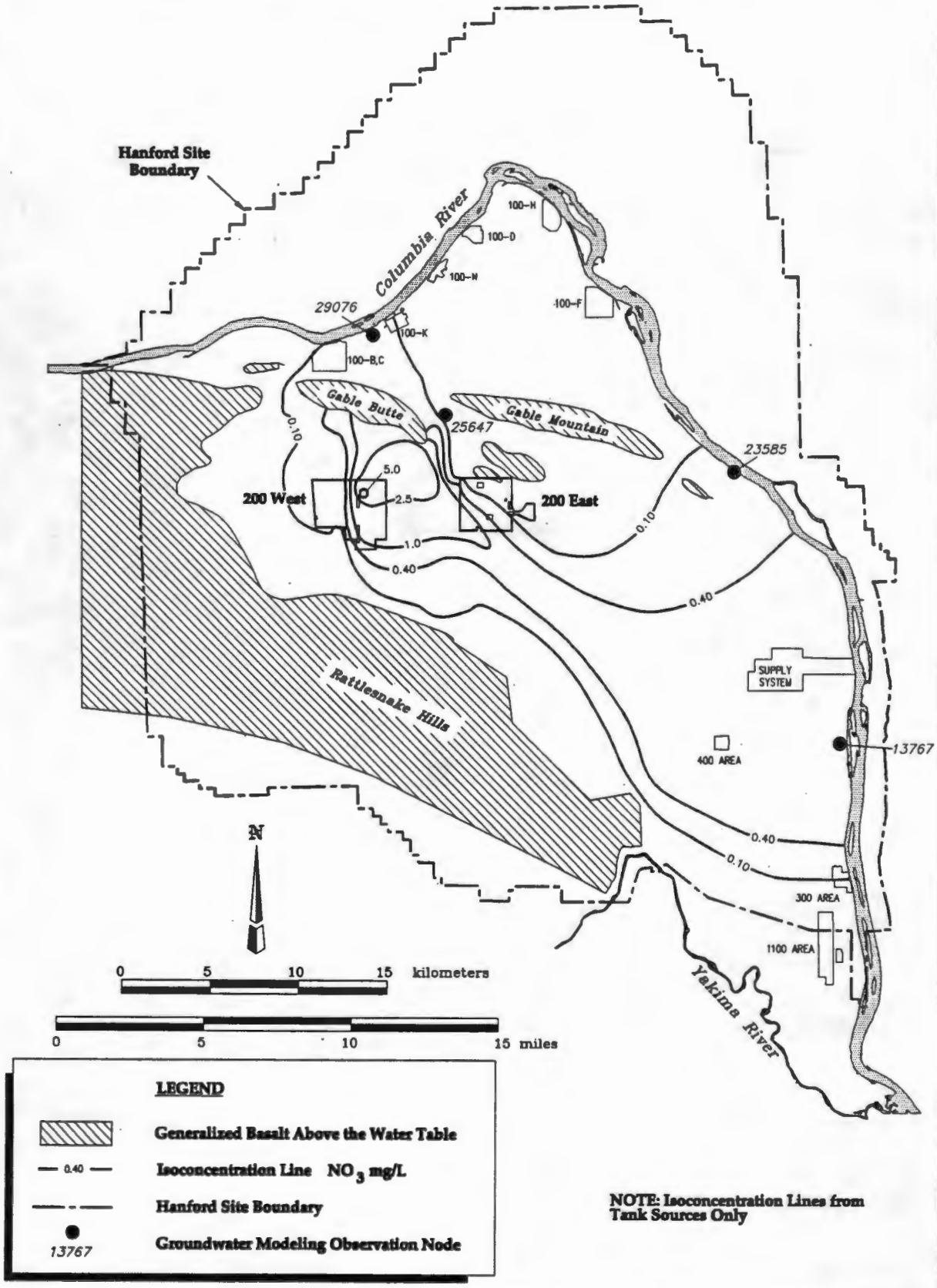


Figure 5.2.10 Predicted Uranium-238 Concentrations in Groundwater at 5,000 Years for the Ex Situ Intermediate Separations Alternative (Tank and LAW Vault Sources Combined)

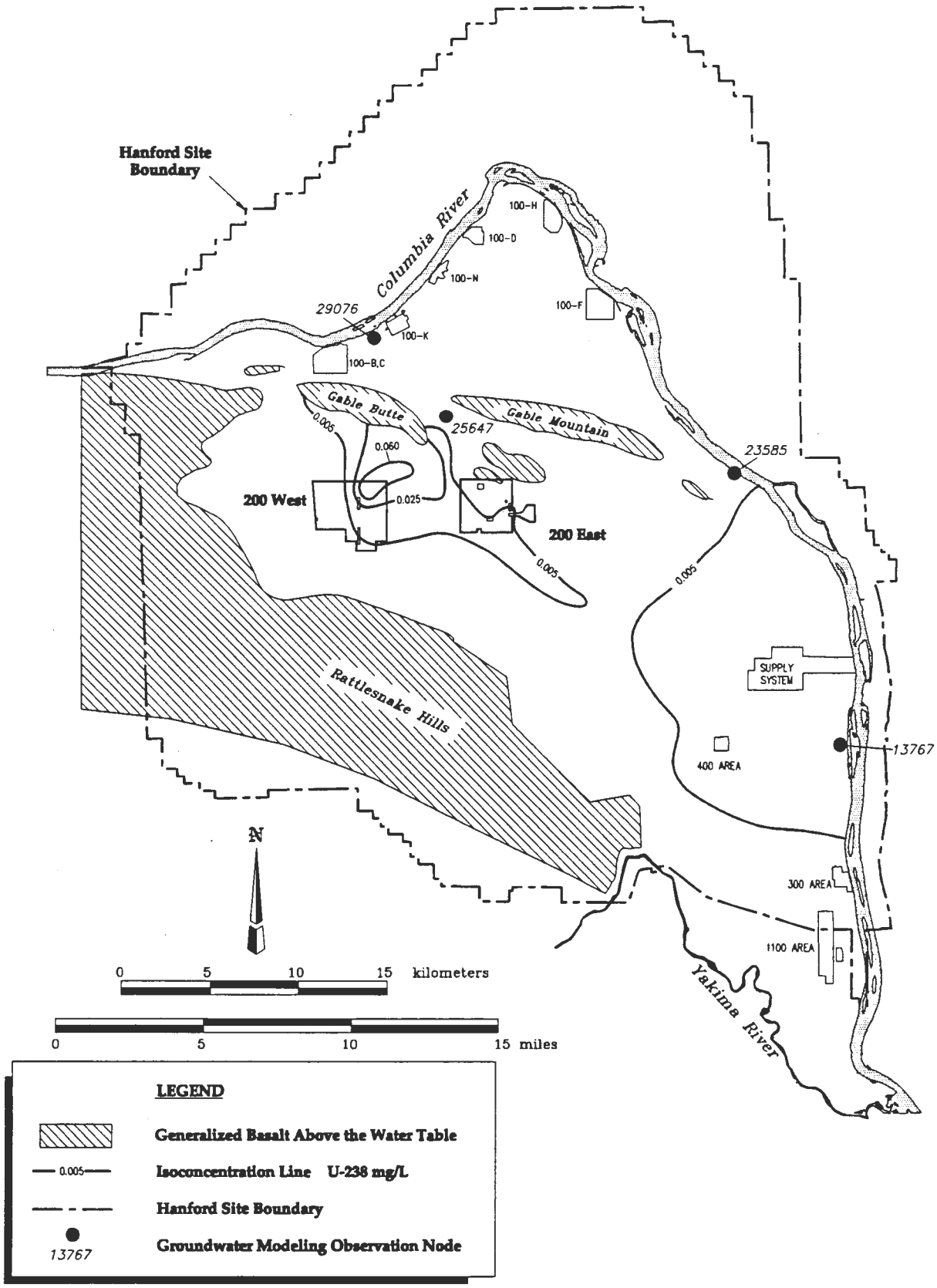


Table 5.2.5 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the Ex Situ Intermediate Separations Alternative

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	0	0	0	0	3.42E-10	1.52E+00
Iodine-129	0	0	0	0	5.32E-08	9.36E-03
Technetium-99	0	0	0	0	3.78E-07	6.39E+00
Uranium-238 [1]	0	0	0	0	1.11E-03	3.73E-01
Nitrate	0	N/A	0	N/A	2.19E-02	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	6.80E-09	3.03E+01	2.00E-13	8.90E-04	4.49E-07	2,000 pCi/L
Iodine-129	2.01E-06	3.54E-01	1.32E-10	2.32E-05	5.68E-06	1 pCi/L
Technetium-99	1.50E-05	2.54E+02	1.55E-09	2.62E-02	5.33E-05	900 pCi/L
Uranium-238 [1]	8.90E-02 [2]	2.99E+01	1.02E-06	3.43E-04	0.02 mg/L (Total)	
Nitrate	5.13E+00	N/A	2.44E-04	N/A	45 mg/L	
Constituent	**300 Years**		**500 Years**		**2,500 Years**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	0	0
Iodine-129	0	0	0	0	0	0
Technetium-99	0	0	0	0	0	0
Uranium-238 [1]	0	0	0	0	0	0
Nitrate	0	N/A	0	N/A	0	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	4.49E-07	2,000 pCi/L
Iodine-129	0	0	0	0	5.68E-06	1 pCi/L
Technetium-99	4.56E-06	7.71E+01	1.23E-05	2.08E+02	5.33E-05	900 p Ci/L
Uranium-238 [1]	3.09E-04	1.04E-01	8.35E-04	2.81E-01	0.02 mg/L (Total)	
Nitrate	0	N/A	0	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ. The LAW vaults would not exceed drinking water standards. Exceedances in the standard result from residuals in the tanks and are based on a combination of the alternative and the representative closure scenario. Final closure action addressing the residuals may lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

The long-term impact to groundwater associated with the Ex Situ No Separations alternative would be a result of waste retrieval from the SSTs and residual waste remaining in both the SSTs and DSTs. These impacts would be the same as calculated for the Ex Situ Intermediate Separations alternative for the tank sources only, as illustrated in Figures 5.2.9 and 5.2.10. All retrieved waste would be processed and transported to the potential geologic repository. Maximum calculated concentrations for the five indicator contaminants at selected time frames are provided in Table 5.2.6.

Table 5.2.6 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the Ex Situ No Separations Alternative

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	0	0	0	0	3.42E-10	1.52E+00
Iodine-129	0	0	0	0	5.32E-08	9.36E-03
Technetium-99	0	0	0	0	3.78E-07	6.39E+00
Uranium-238 [1]	0	0	0	0	1.11E-03	3.73E-01
Nitrate	0	N/A	0	N/A	2.19E-02	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	6.80E-09	3.03E+01	2.00E-13	8.90E-04	4.49E-07	2,000 pCi/L
Iodine-129	2.01E-06	3.54E-01	1.32E-10	2.32E-05	5.68E-06	1 pCi/L
Technetium-99	1.50E-05	2.54E+02	1.55E-09	2.62E-02	5.33E-05	900 pCi/L
Uranium-238 [1]	8.90E-02 [2]	2.99E+01	1.02E-06	3.43E-04	0.02 mg/L (Total)	
Nitrate	5.13E+00	N/A	2.44E-04	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ. Exceedances in the standard result from residuals in the tanks and are based on a combination of the alternative and the representative closure scenario. Final closure action addressing the residuals may lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

Contaminants would not reach the groundwater until approximately 1,100 years from the present. Levels of contaminants would remain low. There would be an exceedance of the current drinking water standard for uranium-238 at 5,000 years from the present.

Ex Situ Extensive Separations Alternative

There would be contaminant losses to the vadose zone under the Ex Situ Extensive Separations alternative during remediation that would be caused by losses from the SSTs during retrieval. There would be no contaminant losses from the DSTs. Because the retrieval process would be the

same as that for the Ex Situ Intermediate Separations alternative, the effects of these retrieval losses also would be the same. The following paragraphs discuss the long-term effects of the groundwater contaminants.

Long-term groundwater impacts for the Ex Situ Extensive Separations alternative would result from tank sources (waste retrieval releases from SSTs and residual waste releases from SSTs and DSTs) and the LAW disposal vaults. The groundwater impacts associated with the tank sources would be similar to those calculated for the Ex Situ Intermediate Separations alternative (Figures 5.2.9 and 5.2.10). The groundwater impacts associated with releases from the LAW disposal facility would be reduced from those calculated for releases from the LAW disposal vaults under the Ex Situ Intermediate Separations alternative because a greater amount of the HLW would be removed during the separations process. Maximum concentrations in groundwater of the five indicator contaminants from tank sources and of technetium-99 and uranium-238 from the LAW disposal vaults are shown at selected times in Table 5.2.7.

Contaminants would not reach the groundwater until approximately 1,100 years from the present. Levels of contaminants would remain low. There would be a slight exceedance of current drinking water standards for uranium-238 at 5,000 years from the present.

Ex Situ/In Situ Combination 1 Alternative

There would be contaminant losses to the vadose zone under the Ex Situ/In Situ Combination 1 alternative during remediation that would be caused by losses from the SSTs during retrieval. Because the retrieval process would recover waste from 60 SSTs instead of 149, the retrieval losses would be proportionately less. However, the contaminants released by losses during retrieval would travel very slowly in the vadose zone, eventually becoming indistinguishable from the contaminants caused by the residue remaining in the tanks after retrieval. There would be no contaminant losses from the DSTs during remediation. The long-term effects of groundwater contaminants are discussed in the following paragraphs.

The two major components that would result in long-term releases to the vadose zone under this alternative are 1) tank sources from retrieval losses and releases from tanks remediated in situ; and 2) releases from the LAW vault. The scenarios for these components would include all of the assumptions stated for the In Situ Fill and Cap and Ex Situ Intermediate Separations alternatives. The residual waste assumed to be 1 percent of the initial inventory, which could be left in the tanks after retrieval, was added to the inventory of tanks that would be remediated in situ. As with both the In Situ Fill and Cap and Ex Situ Intermediate Separations alternatives, only the most mobile contaminants, those modeled as K_d equal to zero, were calculated to reach groundwater within the period of analysis.

The objective of this alternative is to reduce the number of tanks in which the waste is processed ex situ and simultaneously achieve low groundwater concentrations of the high-risk contaminants technetium-99, carbon-14, iodine-129, and uranium-238. These contaminants all are mobile and are in K_d Group 1. They, along with the other contaminants in K_d Group 1, were calculated to reach the

Table 5.2.7 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the Ex Situ Extensive Separations Alternative

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	0	0	0	0	3.42E-10	1.52E+00
Iodine-129	0	0	0	0	5.32E-08	9.36E-03
Technetium-99	0	0	0	0	3.78E-07	6.39E+00
Uranium-238 [1]	0	0	0	0	1.11E-03	3.73E-01
Nitrate	0	N/A	0	N/A	2.19E-02	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	6.80E-09	3.03E+01	2.00E-13	8.90E-04	4.49E-07	2,000 pCi/L
Iodine-129	2.01E-06	3.54E-01	1.32E-10	2.32E-05	5.68E-06	1 pCi/L
Technetium-99	1.50E-05	2.54E+02	1.55E-09	2.62E-02	5.33E-05	900 pCi/L
Uranium-238 [1]	8.90E-02 [2]	2.99E+01	1.02E-06	3.43E-04	0.02 mg/L (Total)	
Nitrate	5.13E+00	N/A	2.44E-04	N/A	45 mg/L	
Constituent	**300 Years**		**500 Years**		**2,500 Years**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	0	0
Iodine-129	0	0	0	0	0	0
Technetium-99	0	0	0	0	0	0
Uranium-238 [1]	0	0	0	0	0	0
Nitrate	0	N/A	0	N/A	0	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	4.49E-07	2,000 pCi/L
Iodine-129	0	0	0	0	5.68E-06	1 pCi/L
Technetium-99	3.36E-08	5.68E-01	9.05E-08	1.53E+00	5.33E-05	900 p Ci/L
Uranium-238 [1]	1.13E-06	3.80E-04	3.06E-06	1.03E-03	0.02 mg/L (Total)	
Nitrate	0	N/A	0	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ. The LAW vaults would not exceed drinking water standards. Exceedances in the standard result from residuals in the tanks and are based on a combination of the alternative and the representative closure scenario. Final closure action addressing the residuals may lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

groundwater of the unconfined aquifer within the period of analysis. The distribution of uranium-238 in groundwater, the most abundant of the uranium isotopes in the tank waste, is presented in this section for 5,000 years from the present. Also, a tabulation of maximum concentrations of indicator contaminants in the unconfined aquifer in K_d Group 1 is provided.

Peak contaminant concentrations at the vadose zone/groundwater interface for the tank source areas would be reached approximately 3,600 to 5,100 years from the present. Peak contaminant concentrations at the vadose zone/groundwater interface for the LAW disposal facility would be reached approximately 6,600 years from the present and would remain at that concentration for the remainder of the period of analysis.

Once in the aquifer, the contaminants would discharge to the Columbia River. Contaminant concentrations in the aquifer would be approximately 10 times lower than those calculated for the No Action alternative, primarily as a result of lower contaminant inventory and a lower infiltration rate due to the Hanford Barrier, which would be constructed over the tanks remediated in situ and the LAW vault.

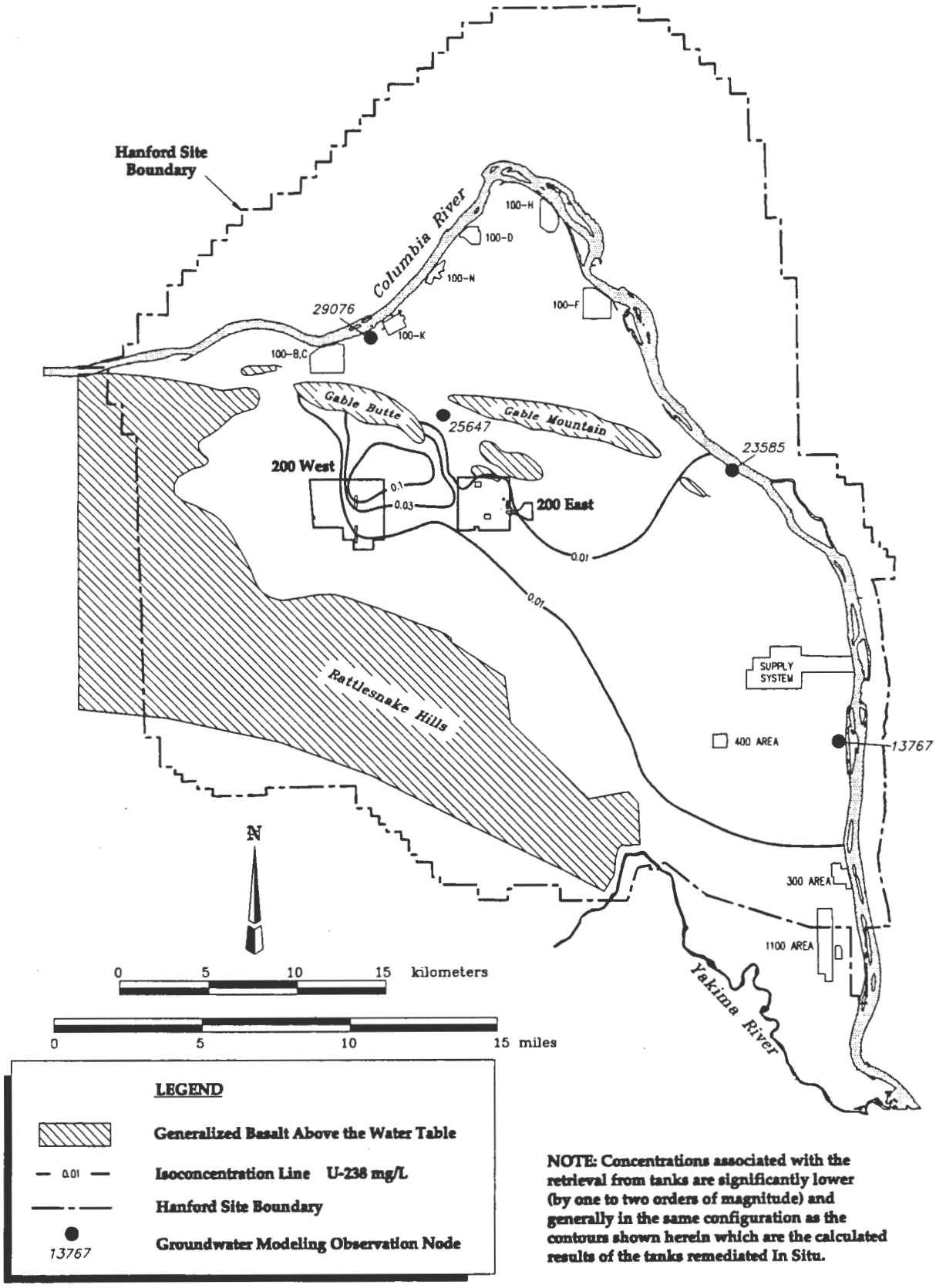
The calculated uranium-238 concentrations in the groundwater from the tank sources and from the LAW disposal facility at 5,000 years from the present are provided in Figures 5.2.11 and 5.2.12, respectively. These concentrations represent calculated concentrations in the upper 6 m (20 ft) of the aquifer. Maximum concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.8, with the drinking water standard for comparison for both the tank sources and LAW disposal source. Nitrate, iodine-129, technetium-99, and uranium-238 were calculated to exceed the current drinking water standard at 5,000 years.

Ex Situ/In Situ Combination 2 Alternative

There would be contaminant losses to the vadose zone under the Ex Situ/In Situ Combination 2 alternative from 1) retrieval losses from the 13 SSTs; 2) losses from the residual waste that would remain in the 25 tanks from which waste would be retrieved (13 SSTs and 12 DSTs); 3) releases from the 152 waste tanks that would be remediated in situ with the fill and cap technology; and 4) releases from the LAW vaults. Only the most mobile contaminants, those modeled as K_d equal to zero, were calculated to reach the groundwater within the period of interest. The long-term impacts of these releases on the groundwater are discussed in the following paragraphs.

The calculated groundwater impact from retrieval losses from the 13 SSTs would be proportionally less than the calculated impacts associated with retrieval losses for Ex Situ/In Situ Combination 1 alternative in which the waste from 60 SSTs would be retrieved. To calculate the impact from waste retrieval, the predicted contaminant concentration of each contaminant from the Ex Situ/In Situ Combination 1 alternative was multiplied by the ratio of the mass of this alternative (on a contaminant by contaminant basis) over the mass of that constituent that would be released during retrieval for the Ex Situ/In Situ Combination 1 alternative.

Figure 5.2.11 Predicted Uranium-238 Concentrations in Groundwater at 5,000 Years for the Ex Situ/In Situ Combination 1 Alternative (Tank Sources Only)



NOTE: Concentrations associated with the retrieval from tanks are significantly lower (by one to two orders of magnitude) and generally in the same configuration as the contours shown herein which are the calculated results of the tanks remediated In Situ.

9613459.0375

Figure 5.2.12 Predicted Uranium-238 Concentrations in Groundwater at 5,000 Years for the Ex Situ/In Situ Combination 1 Alternative (LAW Vault Sources Only)

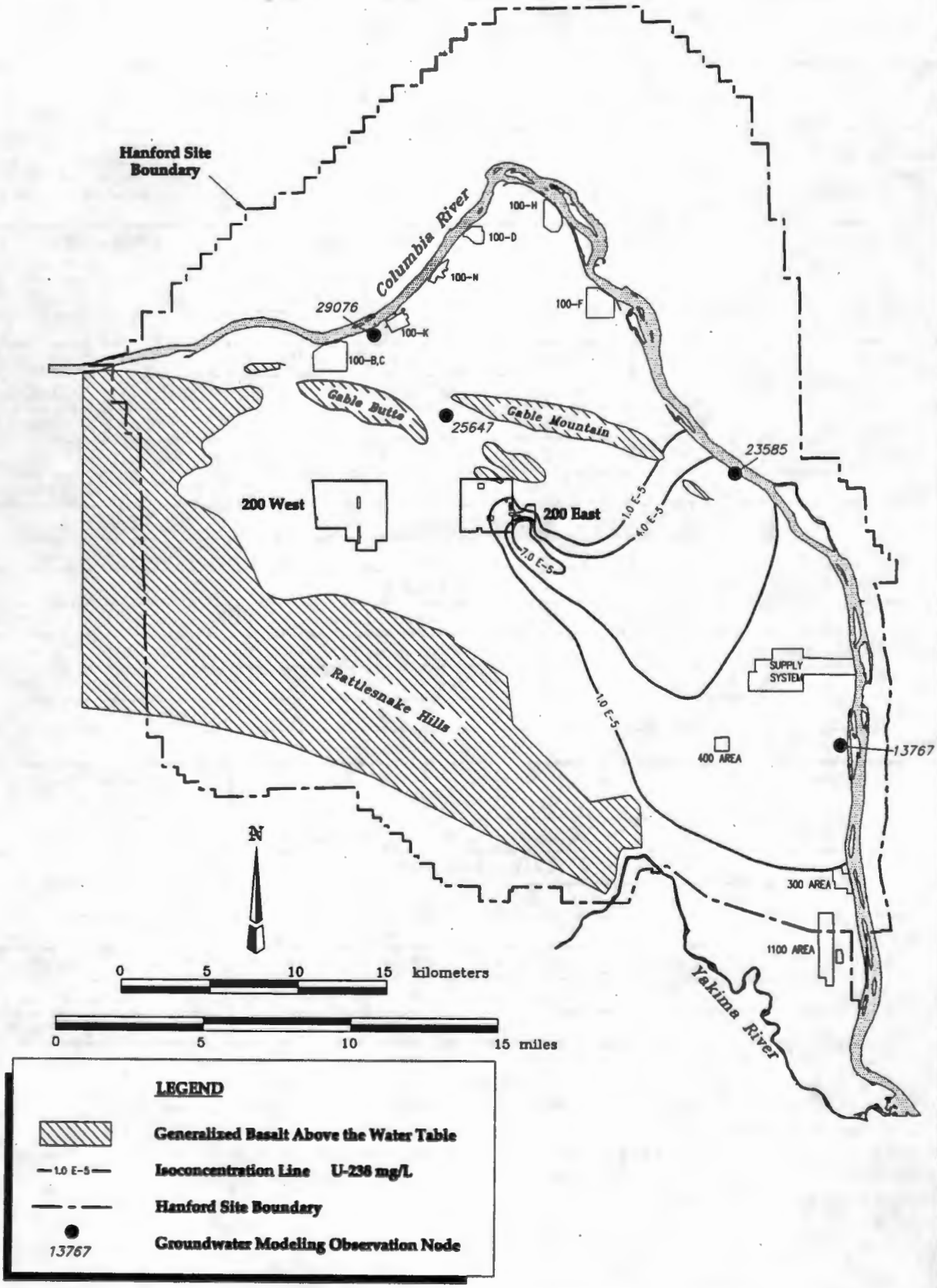


Table 5.2.8 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the Ex Situ/In Situ Combination 1 Alternative

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	0	0	0	0	2.30E-10	1.02E+00
Iodine-129	0	0	0	0	3.91E-08	6.88E-03
Technetium-99	0	0	0	0	2.78E-07	4.70E+00
Uranium-238 [1]	0	0	0	0	4.99E-04	1.68E-01
Nitrate	0	N/A	0	N/A	1.11E-02	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	5.96E-08	2.65E+02	1.45E-09	6.45E+00	4.49E-07	2,000 pCi/L
Iodine-129	2.17E-05 [2]	3.82E+00	1.07E-06	1.88E-01	5.68E-06	1 pCi/L
Technetium-99	1.65E-04 [2]	2.79E+03	7.49E-06	1.27E+02	5.33E-05	900 pCi/L
Uranium-238 [1]	3.11E-01 [2]	1.04E+02	1.99E-02	6.69E+00	0.02 mg/L (Total)	
Nitrate	7.85E+01 [2]	N/A	9.19E+00	N/A	45 mg/L	
Constituent	**300 Years**		**500 Years**		**2,500 Years**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	0	0
Iodine-129	0	0	0	0	0	0
Technetium-99	0	0	0	0	0	0
Uranium-238 [1]	0	0	0	0	0	0
Nitrate	0	N/A	0	N/A	0	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	4.49E-07	2,000 pCi/L
Iodine-129	0	0	0	0	5.68E-06	1 pCi/L
Technetium-99	2.34E-06	3.95E+01	6.30E-06	1.06E+02	5.33E-05	900 p Ci/L
Uranium-238 [1]	1.58E-04	5.31E-02	4.28E-04	1.44E-01	0.02 mg/L (Total)	
Nitrate	0	N/A	0	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ. The LAW vaults would not exceed drinking water standards. Exceedances in the standard result from residuals in the tanks and are based on a combination of the alternative and the representative closure scenario. Final closure action addressing the residuals may lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

Simulations of contaminant fate and transport as described for the In Situ Fill and Cap alternative were performed to calculate groundwater impacts from the 152 tanks remediated in situ and as with the retrieval impacts, only the most mobile contaminants would reach groundwater within the period of interest. The calculated groundwater impacts from the LAW vault would also be proportionate to the calculated impacts from the LAW vault in the Ex Situ/In Situ Combination 1 alternative. The impacts were therefore calculated by scaling the results from the Ex Situ/In Situ Combination 1 alternative as described in the previous text.

This alternative would be a variation of the Ex Situ/In Situ Combination 1 alternative. The objective of this alternative would be to reduce the quantity of the long-term risk contributors (i.e., carbon-14, iodine-129, technetium-99 and uranium-238) in tanks remediated in situ while also reducing the amount of overall tank waste that would be retrieved. The contaminants that would be long-term contributors to risk, along with the other in K_d Group 1 (K_d=0), were calculated to reach the groundwater of the unconfined aquifer within the period of interest. The calculated distribution of uranium-238 in groundwater, the most abundant of the uranium isotopes in the tank waste, is presented in this section for 5,000 years from present for both tank sources and LAW vault sources.

Peak contaminant concentrations at the vadose zone/groundwater interface for the tank releases (both from retrieval releases and releases from tanks remediated in situ) would be reached approximately 3,600 to 5,100 years from the present. Peak contaminant concentrations at the vadose zone/groundwater interface for the LAW disposal facility would be reached at approximately 6,600 years and would remain at that concentration for the remainder of the period of interest.

Once in the aquifer, the contaminants would discharge to the Columbia River. Contaminant concentrations in the aquifer would be approximately 10 times lower than those for the No Action alternative, primarily as a result of lower contaminant inventory and lower infiltration rate due to the Hanford Barrier, which would be constructed over the tanks from which waste would be retrieved, those tanks that would be remediated in situ, and the LAW vault.

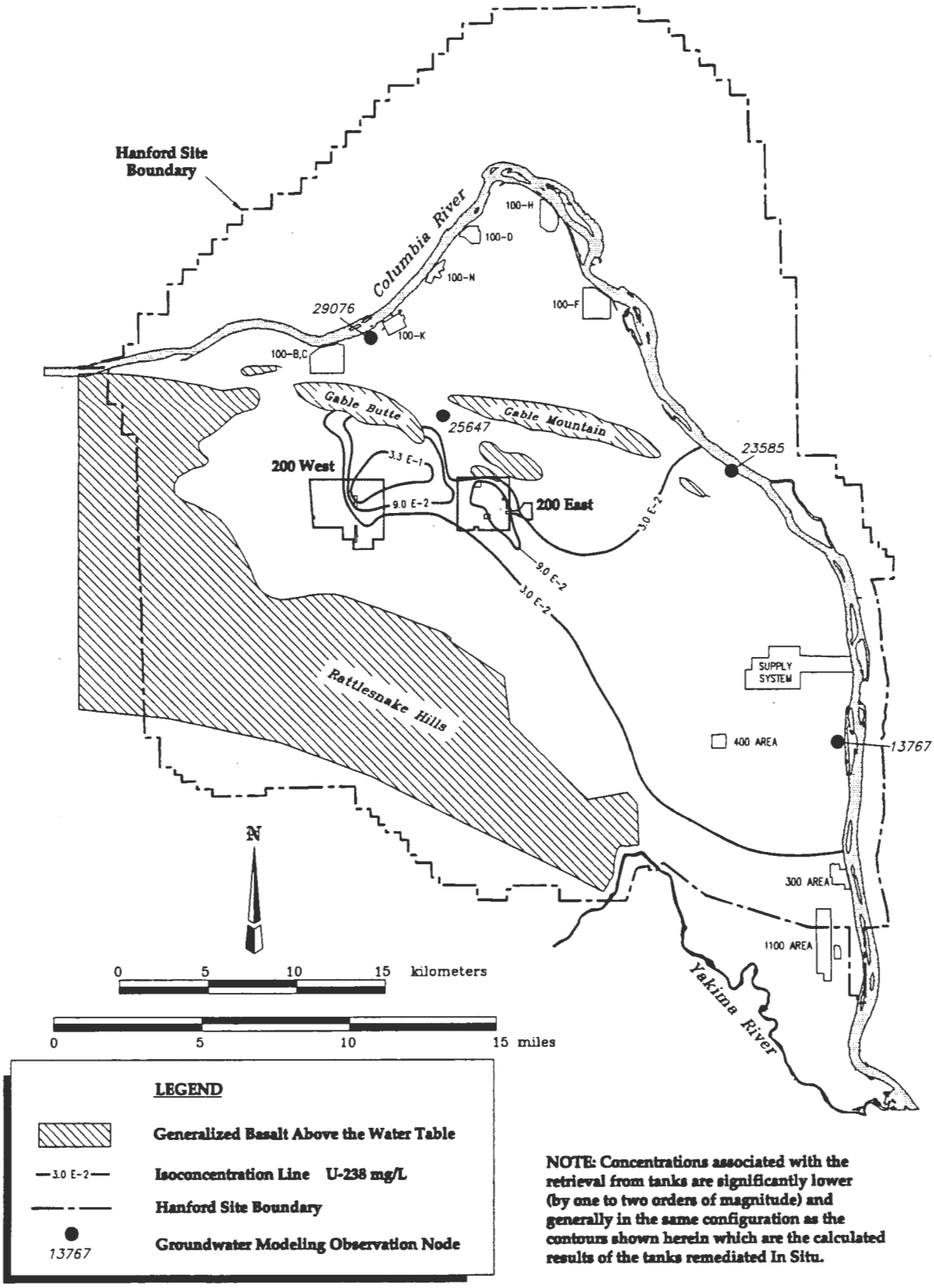
The calculated uranium-238 concentrations in the groundwater from tank sources and from the LAW disposal facility at 5,000 years from the present are provided in Figures 5.2.13 and 5.2.14, respectively. These concentrations represent calculated concentrations in the upper 6 m (20 ft) of the unconfined aquifer. Maximum concentrations for the five indicator contaminants at selected time periods are provided in Table 5.2.9, with the drinking water standard for comparison. As with the Ex Situ/In Situ Combination 1 alternative, nitrate, iodine-129, technetium-99, and uranium-238 were calculated to exceed the current drinking water standard at 5,000 years.

Phased Implementation Alternative

Phase 1

There would be no groundwater impacts from the first phase of this alternative. Nearly all of the waste would be retrieved from the DSTs, and there would be no retrieval losses.

Figure 5.2.13 Predicted Uranium-238 Concentrations in Groundwater at 5,000 Years for the Ex Situ/In Situ Combination 2 Alternative (Tank Sources Only)



NOTE: Concentrations associated with the retrieval from tanks are significantly lower (by one to two orders of magnitude) and generally in the same configuration as the contours shown herein which are the calculated results of the tanks remediated In Situ.

9613459.0377

Figure 5.2.14 Predicted Uranium-238 Concentrations in Groundwater at 5,000 Years for the Ex Situ/In Situ Combination 2 Alternative (LAW Vault Sources Only)

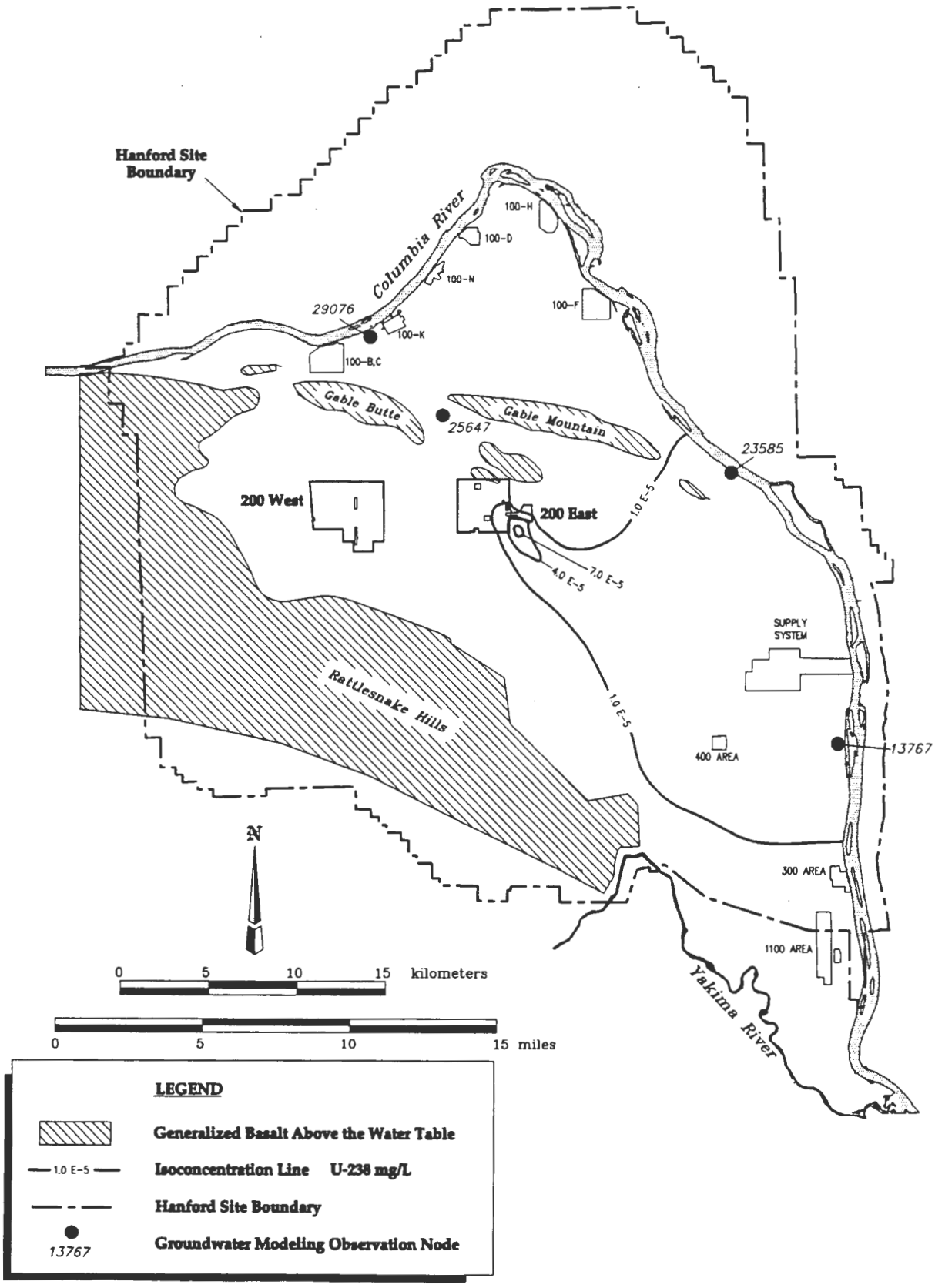


Table 5.2.9 Calculated Maximum Concentrations and Applicable Drinking Water Standards for the Ex Situ/In Situ Combination 2 Alternative

Constituent	300 Years		500 Years		2,500 Years	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	0	0	0	0	7.78E-11	3.46E-01
Iodine-129	0	0	0	0	1.26E-08	2.22E-03
Technetium-99	0	0	0	0	8.91E-08	1.51E+00
Uranium-238 [1]	0	0	0	0	9.62E-05	3.22E-02
Nitrate	0	N/A	0	N/A	2.91E-03	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
Tank Sources						
Carbon-14	5.87E-08	2.60E+02	8.10E-09	3.60E+01	4.49E-07	2,000 pCi/L
Iodine-129	2.39E-05 [2]	4.22E+00	5.57E-06	9.80E-01	5.68E-06	1 pCi/L
Technetium-99	1.70E-04 [2]	2.87E+03	3.90E-05	6.59E+02	5.33E-05	900 pCi/L
Uranium-238 [1]	8.22E-01 [2]	2.76E+02	5.53E-02	1.86E+01	0.02 mg/L (Total)	
Nitrate	8.04E+01 [2]	N/A	1.59E+01	N/A	45 mg/L	
Constituent	**300 Years**		**500 Years**		**2,500 Years**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	0	0
Iodine-129	0	0	0	0	0	0
Technetium-99	0	0	0	0	0	0
Uranium-238 [1]	0	0	0	0	0	0
Nitrate	0	N/A	0	N/A	0	N/A
Constituent	**5,000 Years**		**10,000 Years**		**Drinking Water Standard**	
	mg/L	pCi/L	mg/L	pCi/L	mg/L	pCi/L
LAW Disposal Vaults						
Carbon-14	0	0	0	0	4.49E-07	2,000 pCi/L
Iodine-129	0	0	0	0	5.68E-06	1 pCi/L
Technetium-99	2.02E-06	3.41E+01	5.45E-06	9.17E+01	5.33E-05	900 p Ci/L
Uranium-238 [1]	7.78E-05	2.61E-02	2.10E-04	7.07E-02	0.02 mg/L (Total)	
Nitrate	0	N/A	0	N/A	45 mg/L	

Notes:
[1] Uranium-238 accounts for more than 99 percent of the uranium present.
[2] Calculated value exceeds drinking water standard (40 CFR 141.16) based on a calculated dose equivalent to 4 millirem/year to an internal organ. The LAW vaults would not exceed drinking water standards. Exceedances in the standard result from residuals in the tanks and are based on a combination of the alternative and the representative closure scenario. Final closure action addressing the residuals may lower levels of contamination.
mg/L = milligrams per liter
N/A = Not applicable
pCi/L = picocuries per liter

Phase 2

The short-term and long-term groundwater impacts from the second phase of this alternative would be identical to those for the Ex Situ Intermediate Separations alternative. There would be contaminant releases to the vadose zone under the second phase of this alternative during remediation, which would be caused by losses from the SSTs during retrieval. As explained in Volume Four, Appendix F, the impacts of the losses during retrieval would be approximately half of the impacts caused by the residual waste left in the tanks after retrieval. However, the contaminants released by losses during retrieval would travel very slowly in the vadose zone, requiring approximately 1,100 years to reach the groundwater. The net result would be that contaminants from retrieval losses would become intermingled with contaminants from residual waste left in the tanks. Groundwater modeling did not distinguish between the two sources of contaminants. The long-term effects of the second phase of the Phased Implementation alternative would be the same as those discussed for the Ex Situ Intermediate Separations alternative.

Cesium and Strontium Capsules

None of the cesium and strontium capsule alternatives would result in substantive groundwater impacts, as described in Section 5.2.1.1.

5.2.1.3 Parameter Sensitivity

Parameter sensitivity was investigated for the effect of 1) higher glass surface areas for the In Situ Vitrification alternative; 2) changing the performance period of the Hanford Barrier from 1,000 years to 500 years; 3) the eventual decay of the potentiometric head resulting from groundwater mounding related to the discharge to the Hanford Site ponds; 4) the effect of variations in infiltration rate; and 5) the effect of variations in distribution coefficient (K_d). Further information concerning parameter sensitivity is presented in Volume Five, Sections K.4.5.1 and K.4.5.2.

In Situ Vitrification Surface Area

To investigate the sensitivity of the calculated results to the surface area of the glass produced by in situ vitrification, additional groundwater modeling was performed, based on the assumption that the glass surface area had increased by a factor of two. This would represent the case in which extensive cracking of the waste form had occurred. The additional modeling showed that the calculated contaminant concentrations were indistinguishable from those calculated by the base case analysis.

500-Year Versus 1,000-Year Hanford Barrier

The base case for modeling infiltration through the Hanford Barrier assumed the Barrier would not degrade for 1,000 years. Additional modeling was performed to investigate the situation in which the Hanford Barrier placed over the tanks would degrade 500 years after placement rather than 1,000 years. In the additional modeling, the water flux through the cap was assumed to increase from 0.05 cm/year to 0.1 cm/year (0.02 to 0.04 in./year) after 500 years. A comparison of the calculated nitrate concentrations for the two durations (500 versus 1,000 years) showed that the times of arrival of nitrate in the groundwater and the peak nitrate concentrations were almost identical. A comparison of calculated uranium-238 concentrations in groundwater at 10,000 years from the present indicates that

for the 500-year cap, calculated uranium-238 concentrations would be lower by a factor ranging from 5 to 10. This would be due to the higher water flux through the 500-year cap, which would allow uranium-238 to move faster and be flushed from the groundwater system. With the 500-year cap, the contaminants would have already moved through the system. The conclusion is that the maximum contaminant concentrations in groundwater would be nearly unaffected, but the time of contaminant arrival to the groundwater would be proportional to the infiltration rate through the cap.

Groundwater Mounds

To investigate the sensitivity of the calculated contaminant concentrations in the unconfined aquifer, additional modeling for this saturated system was performed, which was based on calculated future groundwater levels where the present-day groundwater mounds associated with Site waste water disposal had dissipated. The additional modeling was conducted using conditions associated with the Ex Situ Intermediate Separations alternative (e.g., source term, infiltration rate, and Hanford Barrier performance). The data indicated that contaminant transport from the waste tanks and LAW vault would be in a slightly more easterly direction compared to that calculated for the base case flow field.

Variations in Infiltration Rate

To investigate the sensitivity of the calculated results to the assumed initial infiltration rate, additional vadose zone modeling was performed based on doubling the initial infiltration to 10 cm/year (4 in./year) from 5 cm/year (2 in./year) for the In Situ Fill and Cap alternative. The additional modeling showed that the calculated contaminant concentrations at the vadose zone/groundwater interface were indistinguishable from those calculated by the base case analysis. The infiltration-limiting effects of the cap was believed to be the controlling factor. Thus, these results would apply to the other alternatives that use a cap.

Variations in K_d

Sensitivity of contaminant travel time through the vadose zone to various K_d values was evaluated by varying K_d and calculating the arrival time for the 1WSS source area and the Ex Situ Intermediate Separations alternative. The additional modeling showed that at this source area and conditions for this alternative, contaminants with K_d values equal to or greater than approximately 0.125 mL/g would not reach the groundwater within the 10,000-year period of interest.

5.2.2 Surface Water

This section describes potential impacts on surface waters from liquid effluent discharges, seeps of contaminated groundwater, and alterations of surface water drainage systems.

5.2.2.1 Water Discharges

Although each tank waste and capsule alternative would generate liquid effluent, the effluent would not be discharged to surface waters, and thus there would be no direct impacts to any surface waters. Liquid currently in the tanks, or added to the tanks for purposes such as diluting waste so it could be pumped, ultimately would be removed to the extent possible under all alternatives. This liquid would be sent to an evaporator. Condensed water from the evaporator would be sent to the Effluent

Treatment Facility in the 200 East Area. The water then would be treated in the Effluent Treatment Facility with a variety of systems, including evaporation, to meet applicable regulatory standards, and would ultimately be discharged through the Effluent Treatment Facility to the State-approved land disposal facility site, a subsurface drain field near the north-central part of the 200 West Area.

5.2.2.2 Groundwater Discharges

All of the tank waste alternatives would result in some contaminants being leached into the groundwater beginning in approximately 140 years for the No Action alternative to 3,400 years for the In Situ Vitrification alternative, as described in Section 5.2.1. Previously existing contaminants in the soils and vadose zone beneath the tanks from past tank leaks and spills also would migrate to the groundwater, but these are not in the scope of this EIS. Once contaminants reached the groundwater, they would eventually discharge into the Columbia River through seeps (springs) on the Columbia River bank or into the river through the river bed where the river intersects the unconfined aquifer. The present level of nitrate contamination in the unconfined aquifer (Volume Five, Appendix I) is approximately 20 mg/L at the river east of the 200 Areas. This concentration of nitrate in the unconfined aquifer has resulted in negligible changes in nitrate concentrations in the Columbia River and indicates that impacts to the Columbia River from any of the alternatives would be low. To verify this estimate, a mixing calculation for the water that would enter the Columbia River from the tank waste activities is described in the following text.

The analysis involved dividing the river into segments and then calculating the contaminant concentration in each segment based on inflow from the unconfined aquifer. Segments that were 1 kilometer (km) (0.6 mile [mi]) long were developed, and flow in the Columbia River was adjusted for each segment based on flux from the groundwater model at each node along the river. A water flux to or from the river then was assigned as part of the groundwater model calibration process. Contaminant mass entering the river was calculated from nitrate in groundwater at the 300-year time frame for the Long-Term Management alternative (Figure 5.2.5). This contaminant and alternative were selected because nitrate is the most abundant contaminant in the tank waste, is the contaminant most likely to impact the river, and was calculated to exceed drinking water standards in the unconfined aquifer for the No Action, Long-Term Management, and In Situ Fill and Cap alternatives. The 300-year time frame and the Long-Term Management alternative have the highest calculated nitrate concentrations in the unconfined aquifer at the river.

Columbia River Characteristics

The Columbia River flows through the northern and eastern portions of the Hanford Site for over 100 km (62 mi) and is hydraulically connected to the unconfined aquifer (Figure 5.2.1). This hydraulic connection allows river water to recharge to the unconfined aquifer along some reaches, notably in the vicinity of D Reactor. Groundwater discharges to the river at other locations, such as the reach around B Reactor and east of the Hanford Site. Both the groundwater discharge rate and nitrate concentrations vary along the approximate 105-km (65-mi) length of the Columbia River encompassed within the groundwater model. The minimum 7-day duration mean flow and the median flow rates were used in this analysis to bracket the calculated nitrate concentrations in the Columbia River.

The groundwater model, which encompasses approximately 100 km (62 mi) of the river located within the Hanford Site and a total of approximately 105 km (65 mi) of the river, calculated a net groundwater discharge to the river of approximately 0.51 m^3/sec (18 cubic feet [ft^3]/sec). This represents 0.022 percent of the median river flow.

Water quality information for the Columbia River was obtained from a U.S. Geological Survey water quality monitoring station at the Vernita Bridge, located near the western boundary of the Hanford Site where the Columbia River enters the Site. During the 1994 water year (October 1, 1993 to September 30, 1995), the combined nitrate and nitrite concentrations in the river at that location were less than the analytical detection limit (0.05 mg/L) on three occasions, 0.05 mg/L on one occasion, and 0.06 mg/L on one occasion (USGS 1994). Nitrate typically accounts for all but a small amount of the total nitrate and nitrite concentration.

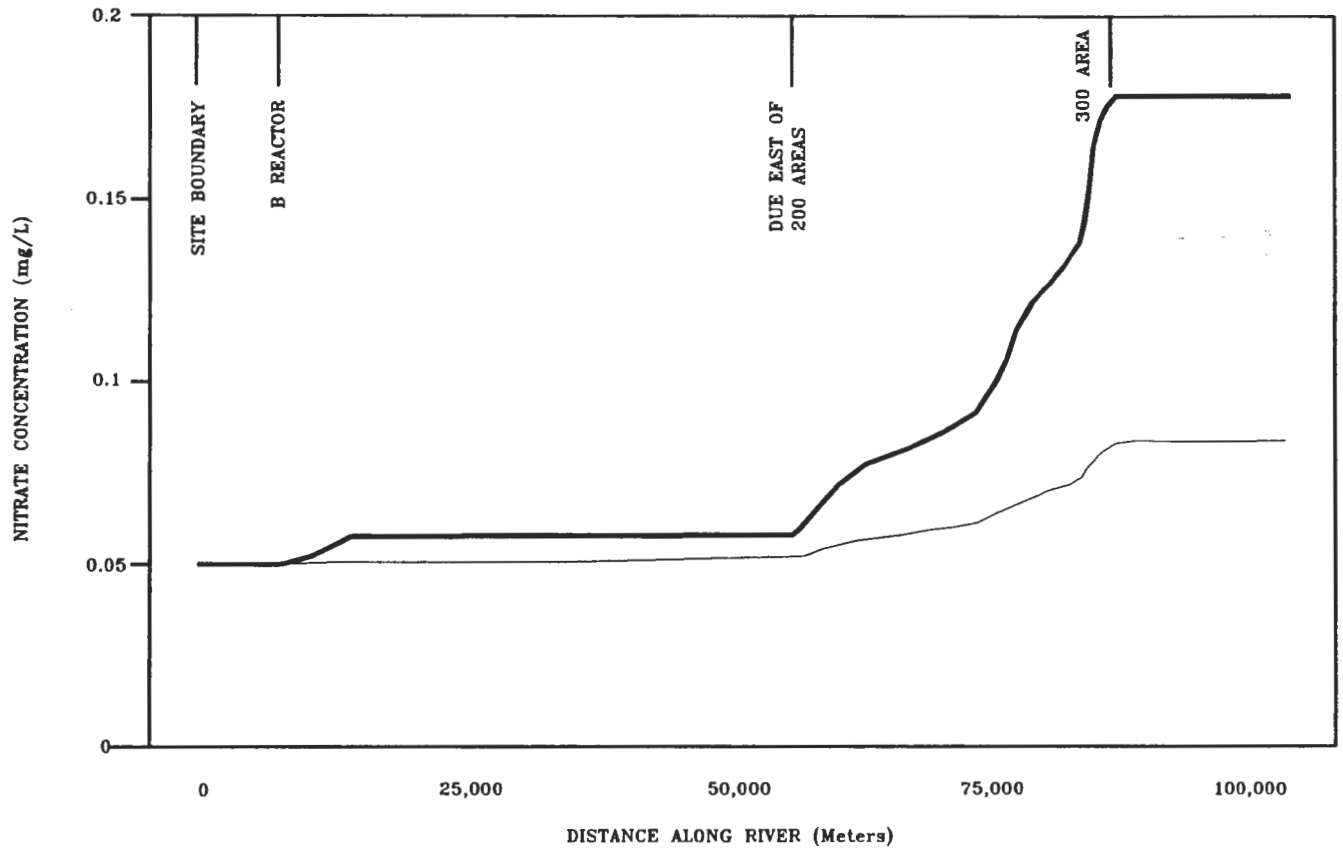
Impacts Analysis

To determine how concentrations of a contaminant such as nitrate would vary along the river, the river reach was divided into many short segments in which complete mixing of the groundwater discharge with the river flow was assumed to occur. The resultant river concentration after mixing then was assumed to be the concentration for the river influent to the next downstream segment.

For the Long-Term Management alternative, an initial analysis was performed for nitrate, the chemical pollutant identified as having the greatest potential adverse impact, with river flow rates of 594 m^3/sec (21,000 ft^3/sec) (minimum 7-day duration mean flow rate) and 2,300 m^3/sec (81,000 ft^3/sec) (median flow rate). Background nitrate concentrations at the upstream end of the Columbia River Reach through the Hanford Site were assumed to be 0.05 mg/L, which is typical of present concentrations. The results are shown in Figure 5.2.15. Groundwater calculated to be contaminated with nitrate would first enter the river near B Reactor (Figure 5.2.5), and concentrations of nitrate in the river would increase slightly to approximately 0.06 mg/L for the minimum 7-day duration mean flow rate. The nitrate levels would remain at 0.06 mg/L until additional nitrate-contaminated groundwater was calculated to enter the river east of the 200 Areas (where nitrate concentrations ultimately were calculated to reach approximately 0.177 mg/L in the river), which would be approximately 0.12 mg/L above background. Nitrate concentrations in the river were much lower for the median flow rate, reaching a maximum of approximately 0.08 mg/L, which would be 0.03 mg/L above the 0.05 mg/L background nitrate concentrations.

Nitrate is a chemical contaminant belonging to Group 1, where K_d=0. The other members of Group 1 would behave in groundwater in a similar manner, because all of them were considered nonsorbing and their movement in groundwater would be retarded. As discussed in Volume Four, Appendix F, there are other members of Group 1. The radiological constituents in Group 1 include carbon-14, iodine-129, technetium-99, and uranium-238. These radioisotopes would move with nitrate in the groundwater and enter the Columbia River at the same locations. The concentrations of the radioisotopes would be less than that of nitrate in proportion to the amount of radioisotope that is

Figure 5.2.15 Predicted Nitrate Concentration in Columbia River at 300 Years for the Long-Term Management Alternative



LEGEND

Median River Flow (2,300 Cubic Meters/Second)

Minimum Seven Day Duration Mean River Flow (594 Cubic Meters/Second)

NOTES:

1) Zero meters is at the Site Boundary where the Columbia River enters the Site.
2) See Figure F.3.3 for Nitrate concentration in unconfined aquifer.
3) Initial concentration in Columbia River 0.05 mg/L.

present in the tanks. As is discussed in Volume Four, Appendix F, the tank contents were assumed to be released in proportion to the release of the most abundant tank consistent, which is nitrate.

Therefore for the Long-Term Management alternative, the calculated concentrations of Group 1 constituents of concern would be as follows: carbon-14=3 .09E-09 g/L; iodine=2.0E-07 g/L; technetium-99=1.0E-06 g/L; and uranium-238=1.0E-03 g/L. These concentrations would be in addition to background concentrations. As explained in Volume Four, Appendix F, these calculated concentrations would be expected at approximately 500 years from the present.

Contaminants entering the Columbia River could be observed from time to time at localized higher concentrations than would be calculated by the mixing model. However, the concentration of pollutants discharged to the river rapidly would become completely mixed with the river flow from several mechanisms. The factors controlling the rate of mixing or length of mixing zone would be: turbulence of the river flow, which depends on velocity of flow; irregularities in the stream channel, including bends; and the width of the river. Secondary currents created by channel irregularities and bends also would result in rapid mixing. These mechanisms would result in the rapid mixing of groundwater discharged from the unconfined aquifer to the Columbia River. Therefore, the contaminants in the groundwater from the tank waste alternatives would be rapidly diluted on discharging into the Columbia River. There would be a slight increase in the contaminant levels, but drinking water standards would not be exceeded.

5.2.2.3 Surface Water Drainage Systems

All facilities would be constructed on relatively flat, semi-arid terrain, which slopes gently to the northeast. No major drainage features are present. While each of the tank waste alternatives would result in slightly altered localized drainage patterns, the area around all temporary structures and all permanent facilities would be designed to conform with the surrounding terrain. Small increases in surface water runoff during heavy precipitation events or rapid snow melt would occur from temporary structures, but there would be no flooding of drainage systems.

The capsule alternatives would not alter surface water drainage systems with the exception of the Onsite Disposal alternative. Under this alternative, 3.8 ha (8.4 ac) of nearly flat and level terrain would be graded almost completely flat and level for the drywell disposal facility. Only enough slope would be provided to allow for runoff during heavy precipitation or rapid snow melt. The facility would be graded to conform with the surrounding terrain. Small decreases in surface water runoff during heavy precipitation or rapid snow melt would occur.

The three potential borrow sites would be constructed on gently sloping semi-arid terrain with no major drainage features. Slightly altered localized drainage patterns would occur during borrow site operations. Small increases in surface water runoff during heavy precipitation events or rapid snow melt would occur from the altered terrain, but there would be no flooding of any drainage system.

Measures would be taken to minimize any increases in runoff during operations of the borrow sites. Following operations, the borrow sites would be recontoured to conform with the surrounding terrain.

5.3 AIR QUALITY

Air pollutant emissions estimates were developed and air dispersion modeling was performed to analyze air quality impacts from the various TWRS alternatives. A detailed description of the sources of emissions, modeling, and results is contained in Volume Five, Appendix G. The analyses were conducted to compare the calculated impacts of potential criteria pollutant releases against National Ambient Air Quality Standards and Washington State Air Quality Standards, the calculated impacts of emissions of toxic and hazardous air pollutants against applicable Washington State regulations, and the calculated impacts of emissions of radionuclides against applicable Federal and Washington State standards.

Air Quality Impacts

Impacts addressed in this section include:

- Sources of potential contaminants (Section 5.3.1);
- Construction and operations emission scenarios (Section 5.3.2);
- Emission dispersion and receptors (Section 5.3.3); and
- Comparison of modeling results to air quality standards (Section 5.3.4).

The various TWRS alternatives would have the potential to emit air pollutants from several locations and from a variety of sources. These sources were depicted in the air dispersion models as either area or point sources. Where the exact source locations were unknown or were expected to move from time to time, area sources were used to stimulate emissions. Air emissions from the vitrification processes would occur from a vertical stack and were modeled as point sources. Emissions from WESF also were modeled as a point source.

5.3.1 Emission Sources

For each alternative described in Section 3.0, emission sources were identified and analyzed. The emissions sources included tank farms, waste retrieval annexes, concrete batch plants, waste processing facilities construction, and waste processing. Figure 5.3.1 shows the source locations used in the modeling scenarios. Figure 5.3.1 contains a legend that identifies the acronyms used to designate the various point and area sources described in the following text.

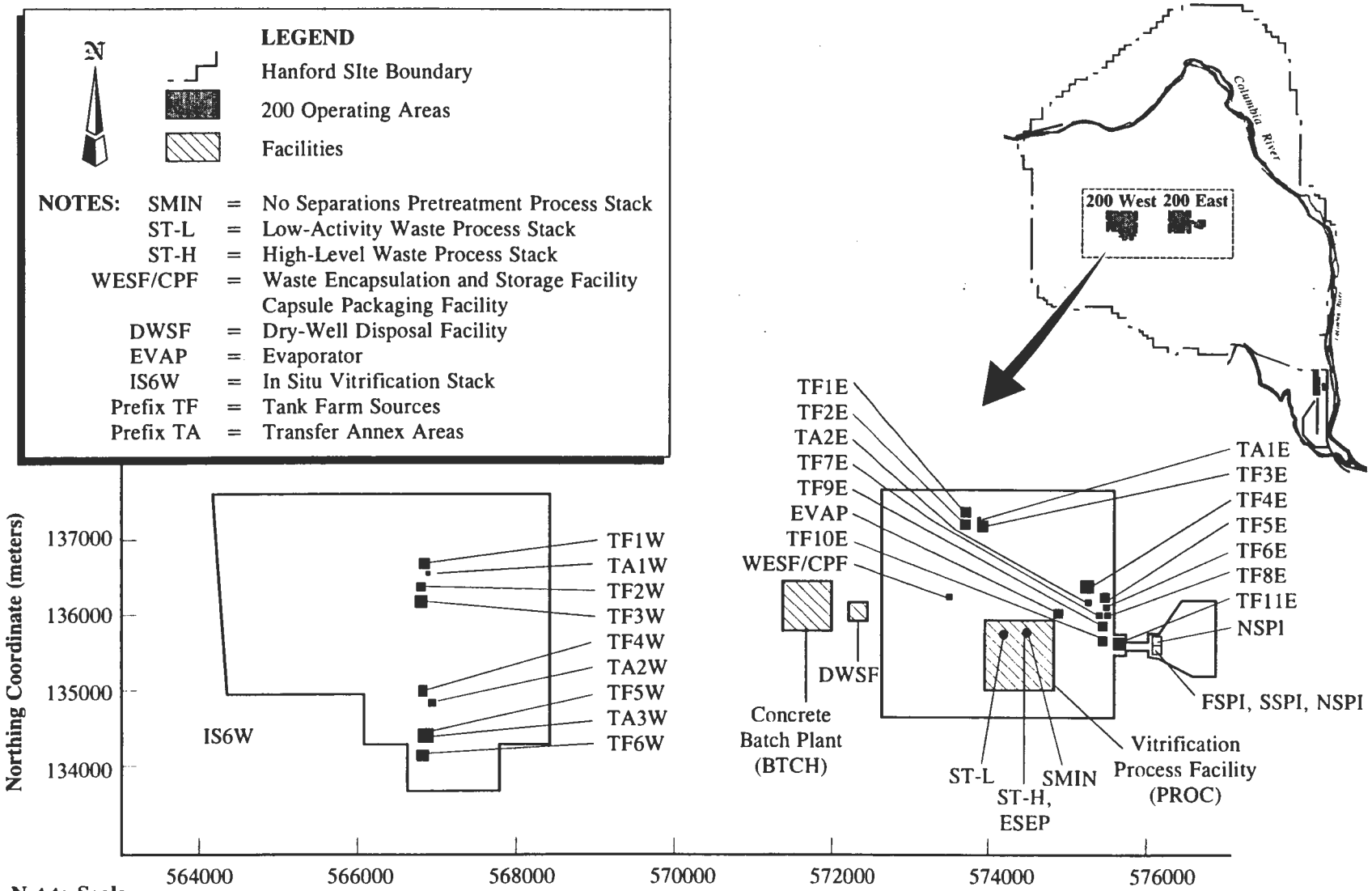
Tank Farms

Area sources identified as TF1E through TF11E and TF1W through TF6W were assigned to the tanks.

Waste Retrieval Annex Areas

Waste retrieval annexes identified as TA1E, TA2E, TA1W, TA2W, and TA3W were depicted as area sources in the dispersion models.

Figure 5.3.1 Emission Source Locations



Concrete Batch Plant

A concrete batch plant between the 200 East and 200 West Areas supporting construction activities was modeled as an area source.

In Situ Vitrification Process Stacks

During in situ vitrification operations, off-gases would be treated and released through a stack adjacent to each tank farm. A point source (IS6W) was used to model the highest impact emissions from the process stack.

Borrow Site Excavation

Particulate emissions would result from using heavy equipment to excavate and transport borrow materials from Pit 30 at the same location as the concrete batch plant.

Excavating borrow materials from the Vernita Quarry and McGee Ranch would result in similar particulate matter emissions. Specific emissions estimates and modeling were not performed because particulate matter emissions would be controlled by using wetting procedures and surfactants, resulting in compliance with Federal and State air quality standards.

Processing Facilities Construction

Emissions from constructing the processing facilities for the ex situ alternatives were assigned to an area source (vitrification facility).

Processing Facilities Operations

The majority of the emissions during the processing operation for the ex situ alternatives and the Ex Situ/In Situ Combination 1 and 2 alternatives would occur through processing facility stacks. All stacks were modeled as point sources and are located in the vitrification facility area.

Evaporator

Evaporator emissions during routine operations and waste processing operations were modeled as a point source.

W-314 Project

The anticipated emissions from the W-314 Project were not analyzed because the data available for the project indicated that construction activities would be spread out over various areas and of relatively low intensity compared to construction activities associated with the TWRS alternatives.

Drywell Disposal Facility

The emissions from constructing a drywell disposal facility (DWSF) were represented as an area source.

Capsule Packaging Facility

The emissions from the Overpack and Ship alternative were represented by an area source.

Waste Encapsulation and Storage Facility

Emissions from WESF would occur through a stack and were modeled as a point source.

5.3.2 Emissions Scenarios

The various alternatives would involve emissions from one or more of the emission sources described in Section 5.3.1. Implementing the alternatives would involve an initial period of facility construction, followed by an operating period during which the treatment, transfer, or repackaging processes would occur. Consequently, alternatives would have different phases in which the emissions and calculated impacts were distinctly different. For each alternative, the emissions and calculated impacts from each phase were reported separately. The following sections describe the potential sources of air emissions for each remediation alternative.

5.3.2.1 Tank Waste Alternatives

No Action Alternative (Tank Waste)

The No Action alternative would involve routine radiological and nonradiological emissions from continued operations of the storage tanks and routine operations of the evaporator. Because no remediation or closure activities would occur under this alternative, no change in emissions would occur.

Long-Term Management Alternative

The Long-Term Management alternative would involve routine emissions from the tanks plus emissions from transferring the waste to newly constructed DSTs 50 and 100 years in the future. Because no remediation activities and no closure activities would occur under this alternative, no short-term changes in emissions would occur. Fifty years from the present, new tanks would be constructed in the same location as the area reserved for the process facility for the ex situ alternatives. Construction emissions for new DSTs were modeled by assigning them to the source PROC. Increased emissions from tanks undergoing retrieval were analyzed by assigning the highest emission rate for each pollutant to the TF6W Tank Farm.

In Situ Fill and Cap Alternative

Implementing the In Situ Fill and Cap alternative would involve construction and gravel-filling operations at the tank farm locations and removing gravel from Pit 30. Construction activities were assumed to simultaneously occur with filling operations and routine emissions from the continued operations of the tank farms. The following summarizes the pollutant emitting activities and sources for this alternative.

- Particulate matter emissions were assigned for Pit 30 (BTCH) (an assumed potential borrow site).
- Construction equipment emissions were assigned to the most conservative location (TF6W).
- Gravel handling operations were assigned to TF5W.
- Increased tank emissions during filling operations were assigned to TF6W for retrieval operations.

No substantial additional emissions would occur under this alternative as a result of closure activities. As explained previously, heavy equipment operating at the borrow sites would have particulate emissions; however, wetting procedures and surfactants used at the borrow sites would result in compliance with Federal and State air quality standards.

In Situ Vitrification Alternative

Implementing this alternative would involve constructing a tank farm confinement facility and an off-gas treatment facility at each tank farm. Constructing one confinement facility would occur while vitrification processes were occurring at another tank farm. For potential air quality impacts, the highest emission location for construction would be TF6W, and impacts were calculated using this location.

Operating this alternative would release a treated gas stream from a vertical stack. The location for this operation producing the highest impacts was shown to be adjacent to TF6W. Although construction and operation activities would not occur at the same time and at the same location, operational emissions were assigned to this location (IS6W) to provide a conservative analysis.

No substantial additional emissions would occur under the In Situ Vitrification alternative as a result of closure activities. As explained previously, emission control measures would result in compliance with Federal and State air quality standards.

Ex Situ Intermediate Separations Alternative

The construction phase would involve emissions from constructing five waste transfer annexes and two waste processing facilities, and constructing and operating a concrete batch plant to support these operations. Additionally, emissions associated with constructing tank waste retrieval equipment at the tank farms would occur simultaneously.

An analysis was conducted that identified the TF5W and TF6W areas as having the highest combined impacts when construction activities occurred simultaneously. This analysis identified the TF5W and TF6W areas as having the highest combined impacts. Accordingly, construction impacts were assessed by assuming simultaneous construction operations at the process facilities, concrete batch plant, five transfer annexes (TA1W, TA2W, TA3W, TA1E, TA2E); and two tank farm locations (TF5W and TF6W).

Operating the Ex Situ Intermediate Separations alternative would include separating the waste into HLW and LAW streams and processing the streams at separate facilities. Additionally, retrieval equipment would operate at various tank farm locations during the course of processing. Therefore, the impacts of the operation phase of the alternative were analyzed by evaluating the simultaneous operations of both processing facilities (ST-L and ST-H) and the two tank farm locations producing the highest impacts (TF5W and TF6W).

For all of the ex situ alternatives (Intermediate Separations, No Separations, and Extensive Separations), no substantial additional emissions would occur as a result of future closure activities. As explained previously, emission control measures used with heavy equipment and at the borrow sites would result in compliance with Federal and State air quality standards.

Ex Situ No Separations Alternative

The emissions for the Ex Situ No Separations alternative would differ from the Ex Situ Intermediate Separations alternative because the tank waste would not be separated into LAW and HLW components, and only one processing plant with one process stack would be operated. Two options, vitrification and calcination, were analyzed for this alternative. With the exception of the emission rates of nitrogen oxides and carbon-14, the sources and emission rates associated with the calcination option would be nearly identical to those of the vitrification alternative.

The construction phase would involve emissions from constructing five waste transfer annexes and process facilities, and constructing and operating a concrete batch plant. Emissions from erecting the retrieval equipment at the tank farms would occur simultaneously. These emissions were assessed in the same manner as those for the construction phase of the Ex Situ Intermediate Separations alternative.

Operating emissions would occur at the main process stack at the vitrification facility. Installing and operating retrieval equipment would occur at two tank farm locations at a time during processing. Therefore, the impacts of the operation phase of this alternative were analyzed by evaluating the simultaneous operations of the process facility and the two tank farm locations producing the highest combined impacts (TF5W and TF6W).

No substantial additional emissions would occur as a result of future closure activities under this ex situ alternative.

Ex Situ Extensive Separations Alternative

The construction phase would involve emissions from constructing five waste transfer annexes, the process facilities, and from constructing and operating a concrete batch plant. Emissions from erecting the retrieval equipment at the tank farms would occur simultaneously. These emissions were assessed in the same manner as those for the construction phase of the Ex Situ Intermediate Separations alternative.

Operating this alternative would include separating the tank waste into HLW and LAW streams and processing the streams at separate facilities. Off-gas emissions from these two processes would be combined in a common stack. Retrieval equipment would be operated at various tank farm locations during processing. Therefore, the impacts of the operation phase of this alternative were analyzed by evaluating the simultaneous operations of the process facilities and the two tank farm locations producing the highest combined impacts (TF5W and TF6W).

No substantial additional emissions would occur as a result of future closure activities under this ex situ alternative.

Ex Situ/In Situ Combination 1 and 2 Alternatives

The in situ portion of these alternatives would involve the same source locations and emissions as described for the In Situ Fill and Cap alternative. These emissions would occur simultaneously with those from the operation phase of the ex situ portion of these alternatives.

The construction phases would involve emissions from constructing waste transfer annexes and process facilities, and from constructing and operating a concrete batch plant. Emissions from erecting the retrieval equipment at the tank farms would occur simultaneously. These emissions were analyzed in the same manner as described for the Ex Situ Intermediate Separations alternative.

Operating the ex situ vitrification portion of these alternatives would include separating the HLW and LAW streams and processing the waste at separate facilities. Retrieval equipment would be expected to operate at various tank farm locations during processing. Therefore, the impacts of the operation phase of these alternatives were analyzed by evaluating the simultaneous operations of both process facilities (ST-L and ST-H) and the two tank farm locations producing the highest impacts (TF5W and TF6W).

These alternatives are a combination of two remediation methods, neither of which would produce substantial additional emissions as a result of future closure activities.

Phased Implementation Alternative

Phase 1

The first phase of the Phased Implementation alternative would involve a period during which two vitrification facilities would be built. Construction on both facilities would occur simultaneously, so construction emissions were assigned to a single source (FCPI).

After the first phase of construction was completed, the two facilities would begin operating. Emissions from the vitrification processes would be released through two stacks. The impacts from operations were analyzed by using peak hourly emission rates from all processes simultaneously.

Phase 2

In the second phase of this alternative, a facility would be constructed to treat the remainder of the tank waste. Emissions would come from constructing the five waste transfer annexes, process facilities, and a concrete batch plant. Emissions from erecting retrieval equipment at the tank farms would occur simultaneously. These emissions were assessed in the same manner as described for the Ex Situ Intermediate Separations alternative.

Impacts from operating the second phase of this alternative were assessed in the same manner as for the Ex Situ Intermediate Separations alternative. This involved the simultaneous operation of two facilities and the two tank farm locations producing the highest impacts.

Total Alternative

For the Phased Implementation alternatives, the total impacts would be the result of operating the first phase simultaneously with the second phase. The emissions would occur from operating the combined LAW and HLW plant and the LAW plant from the first phase; plus the emissions from operating the second phase process facilities, the concrete batch plant, the five transfer annexes, and the two tank farm locations producing the highest impacts.

No substantial additional emissions would occur as a result of future closure activities under this alternative.

5.3.2.2 Capsule Alternatives

No Action Alternative (Capsules)

Routine radiological emissions from maintaining the capsules at WESF were analyzed for this alternative and included in the analysis of all other alternatives. These emissions were modeled as a point source.

Onsite Disposal Alternative

Constructing the drywell disposal facility would cause pollutant emissions from construction equipment; therefore, these emissions were modeled as an area source.

Overpack and Ship Alternative

Construction and operation emissions from a repacking facility were modeled as an area source (CPF).

Vitrify with Tank Waste Alternative

No appreciable emissions above those calculated for the Ex Situ Intermediate Separations alternative would occur, so no additional air quality impacts were included in this alternative.

5.3.3 Air Dispersion Models

Version two of the U.S. Environmental Protection Agency (EPA) Industrial Source Complex Model (ISC2) (EPA 1992a) was used for the air dispersion modeling. ISC2 is capable of simulating emissions from diverse source types. ISC2 is a guideline air quality model (accepted by EPA for regulatory applications) and routinely is recommended for performing screening and refined analyses for remedial actions at Resource Conservation and Recovery Act (RCRA) and Superfund sites. The model requires input of source data, meteorological data, and receptor data.

The short-term version of ISC2 (ISCST2) was used to calculate concentrations with averaging periods ranging from 1 to 24 hours. Annual average concentrations and dose values were calculated with the long-term version of the model (ISCLT2).

Source Data

The primary sources of data used for the emission rates were the Engineering Data Packages for the various TWRS EIS alternatives, which were prepared by the Site Management and Operations contractor (WHC 1995a, b, c, d, e, f, g, h, i, n) and the TWRS EIS contractor (Jacobs 1996). The emission rates for each alternative are provided in tables presented in Volume Five, Appendix G.

Long-Term Meteorological Data

The meteorological data used for the ISCLT2 model consists of wind speed, wind direction, and stability class for individual years 1989 to 1993. The data, provided by the Pacific Northwest National Laboratory, were based on measurements collected at the Hanford Meteorological Station (PNL 1994g).

Short-Term Meteorological Data

For short-term averaging periods, the ISCST2 model was run in a screening mode because it adequately calculates the overall impacts and the differences in air quality among the alternatives. A range of meteorological conditions was applied to the model in a manner consistent with EPA guidance (EPA 1992a).

Receptor Data

A receptor is a location where the model calculates specific air quality impacts. The locations of receptors used in the ISC2 model corresponded to areas where workers and the general public could be exposed.

Compliance with Federal and State ambient air quality standards and levels was analyzed using a total of 614 receptors located along the Columbia River, State Route 240, and the Hanford Site boundaries. Receptors were placed at 500-m (1,650-ft) intervals along sections of State Route 240. Other offsite receptors were placed 2 km (1.2 mi) apart.

Compliance with the Federal standard for radionuclide releases (40 CFR 60) was determined by analyzing the effective dose equivalent at the nearest residence (DOE 1994d). No residences are located within 24 km (15 mi) of the 200 West Area or within 16 km (10 mi) of the 200 East Area. Consequently, a circular set of 72 receptors, centered on the 200 West Area and with a 24-km (15-mi) radius, was established. A rectangular grid of 834 receptors that encompasses the Hanford Site was used to generate isopleths of radionuclide impacts.

5.3.4 Results of Air Emission Modeling

The model output consists of calculated ground-level average concentrations. The ISCST2 model was run to determine the maximum 1-hour average concentrations that could result from a range of meteorological conditions. The 1-hour averages were multiplied by correction factors to calculate longer (3-, 8-, and 24-hour) averaging times. Annual average concentrations were produced with the ISCLT2 model.

The results of the modeling were compared with Washington State air quality standards or emission levels. Washington State standards are listed in the Washington Administrative Code (WAC) and include the following:

- Acceptable Source Impact Levels for toxic air pollutants (WAC 173-460);
- Ambient Air Quality Standards for particulate matter (WAC 173-470);
- Ambient Air Quality Standards for sulfur oxides (WAC 173-474);
- Ambient Air Quality Standards for carbon monoxide, ozone, and nitrogen dioxide (WAC 173-475);
- Ambient Air Quality Standards for radionuclides (WAC 173-480); and
- Ambient Air Quality Standards for fluorides (WAC 173-481).

The results also were compared with national primary and secondary Ambient Air Quality Standards listed in 40 CFR 50. The Washington Ambient Air Quality Standards are equal to or more stringent than the National Ambient Air Quality Standards, and thus compliance with the Washington Ambient Air Quality Standards results in compliance with the National Ambient Air Quality Standards.

The modeling results for select pollutants including sulfur oxides, carbon monoxide, nitrogen dioxide, particulates, and total radionuclides are presented in Table 5.3.1. Complete modeling results and comparison to the National Ambient Air Quality Standards and the Washington Ambient Air Quality Standards are presented in Volume Five, Appendix G. The modeling results for all alternatives show no exceedances of Federal or State air quality standards for criteria pollutants, hazardous air pollutants, or radionuclides. The following pollutants would result in the highest levels of emission compared to Federal or State standards.

Carbon Monoxide	Impacts, as a percentage of the Federal and State 8-hour standard, would occur during the construction phases of the Ex Situ Extensive Separations, Ex Situ Intermediate Separations, and Ex Situ No Separations alternatives (25 percent, 21 percent, and 17 percent, respectively).
Sulfur Oxides	Impacts, as a percentage of the State 1-hour standard, would occur during the In Situ Vitrification alternative (10 percent of the standard).
Radionuclides	Impacts, as a percentage of the State annual standard, would occur during the In Situ Vitrification alternative (75 percent of standard, with primary contributors being carbon-14 and iodine-129).
	Impacts, as a percentage of the Federal annual standard, would occur during the In Situ Vitrification alternative (24 percent of standard, with primary contributors being carbon-14 and iodine-129).

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Table 5.3.1 Major Pollutant Impacts

Pollutant-Averaging Period	Calculated Maximum Concentration for Each Alternative $\mu g/m^3$						Standard $\mu g/m^3$	
	No Action	Long-Term Management (Phase 1 and 2)	In Situ Fill and Cap	In Situ Vitrification	Ex Situ Intermediate Separations			
					Construction	Operation	Federal	State
Sulfur Oxides								
1 Hour	--	0.13	24	68	7.3	4.9	N/A	655
3 Hours	--	0.11	21	6.1	6.5	4.4	1,300	N/A
24 Hours	--	5.0E-02	9.5	27	2.9	2.0	365	260
Annual	--	7.2E-04	9.6E-02	2.8E-01	2.7E-02	2.1E-02	80	60
Carbon Monoxide								
1 Hour	2.4E-02	2.5	49	980	2,900	60	40,000	40,000
8 Hours	1.6E-02	1.8	35	690	2,050	42	10,000	10,000
Nitrogen Oxides								
Annual	1.1E-05	2.2E-03	4.5E-03	1.5	1.9	0.12	100	100
PM-10								
24 Hours	--	1.4	4.0	96	93	0.75	150	150
Annual	--	2.0E-02	0.29	1.0	1.0	7.8E-03	50	50
Total Radionuclide	1.1E-03 [4]	1.1E-03	1.1E-03	2.3	1.1E-03	0.95	10 [2]	--
mrem/yr	1.6E-03 [4]	1.7E-03	1.7E-03	18.6	1.6E-03	1.1	--	25 [3]

Pollutant-Averaging Period	Calculated Maximum Concentration for Each Alternative $\mu g/m^3$							Standard $\mu g/m^3$	
	Ex Situ No Separations (Vitrification)		Ex Situ Extensive Separations		Ex Situ/In Situ Combinations				
	Construction	Operation	Construction	Operation	Construction [6]	Operation Combination 1	Operation Combination 2	Federal	State
Sulfur Oxides									
1 Hour	6.6	8.6	8.0	14	27	2.5	1.6	N/A	655
3 Hours	6.0	7.7	7.2	13	24	2.2	1.5	1,300	N/A
24 Hours	2.7	3.4	3.2	5.6	11	0.98	0.66	365	260
Annual	3.0E-02	3.0E-02	3.1E-02	6.0E-02	0.11	1.0E-02	7.0E-03	80	60
Carbon Monoxide									
1 Hour	2,500	85	3,500	27	1,100	32	19	40,000	40,000
8 Hours	1,700	60	2,500	19	800	22	14	10,000	10,000
Nitrogen Oxides									
Annual	1.6	0.12 0.13 [1]	2.2	1.7	1.1	5.9E-02	2.4E-02	100	100
PM-10									
24 Hours	85	0.75	95	1.4	51	1.4	0.67	150	150
Annual	0.88	7.9E-03	1.0	2.0E-02	0.6	1.4E-02	6.8E-03	50	50
Total Radionuclide	1.1E-03	0.9	1.1E-03	1.0	1.1E-03	0.8	1.2	10 [2]	--
mrem/yr	1.6E-03	1.16	1.6E-03	1.2	1.6E-03	1.0	1.5	--	25 [3]

Table 5.3.1 Major Pollutant Impacts (cont'd)

Pollutant-Averaging Period	Calculated Maximum Concentration for Each Alternative $\mu g/m^3$						Standard $\mu g/m^3$	
	Phased Implementation (Phase 1)		Phased Implementation (Phase 2)		Onsite Disposal	Overpack and Ship		
	Construction	Operation	Construction	Operation	Construction [5]	Construction [5]	Federal	State
Sulfur Oxides								
1 Hour	4.8	2.4	7.6	4.0	5.0	--	N/A	655
3 Hours	4.3	2.1	6.9	3.6	4.5	--	1,300	N/A
24 Hours	3.2	0.9	3.1	1.6	2.0	--	365	260
Annual	2.9E-02	1.4E-02	2.9E-02	2.0E-02	1.0E-02	--	80	60
Carbon Monoxide								
1 Hour	1100	39	3,200	48	83	39	40,000	40,000
8 Hours	800	27	2,300	34	58	27	10,000	10,000
Nitrogen Oxides								
Annual	1.3	6.9E-03	2.1	0.12	0.40	0.15	100	100
PM-10								
24 Hours	87	5.0E-02	98	0.75	18	1.8	150	150
Annual	1.2	7.1E-04	1.1	7.9E-03	0.11	0.02	50	50
Total Radionuclide	1.1E-03	0.4	1.1E-03	0.4	1.1E-03	1.1E-03	10 [2]	--
mrem/yr	1.6E-03	0.4	1.6E-03	0.5	1.6E-03	1.6E-03	--	25 [3]

Notes:
[1] For Ex Situ No Separations (Calcination). All other pollutant concentrations are the same as for Ex Situ No Separations (Vitrification).
[2] Maximum at nearest residence, 40 CFR 61.
[3] Maximum at any offsite receptor, WAC 17-480.
[4] Includes No Action alternative (Capsules).
[5] No operational emissions for these alternatives.
[6] Construction emissions for both ex situ/in situ combination alternatives are identical.
-- = No available data

5.4 BIOLOGICAL AND ECOLOGICAL RESOURCES

This section describes the impacts of the TWRS EIS alternatives on biological and ecological resources. The impact assessment focused on the biological resources of the specific land areas where activities are proposed under the various EIS alternatives. All of the alternatives would have varying impacts on vegetation and wildlife habitat, especially shrub-steppe habitat. In all cases, the impacts would be less than 1 percent of the total remaining shrub-steppe habitat on the Central Plateau and a fraction of 1 percent of the Hanford Site's remaining shrub-steppe habitat. When considering only the area that would be designated for future waste management uses, the TWRS alternatives would impact up to 6 percent of the undisturbed shrub-steppe within the designated waste management area. For remediation activities impacts would range from 10 ha (25 ac) for the Long-Term Management

Biological and Ecological Impacts

Impacts addressed in this section include:
- Vegetation (Section 5.4.1);
- Wildlife (Section 5.4.2);
- Aquatic, wetland, and riparian (Section 5.4.3);
- Species of concern and critical habitats (Section 5.4.4);
- Biodiversity (Section 5.4.5); and
- Radiological and chemical impacts to biological and ecological resources (Section 5.4.6).

alternative to 81 ha (200 ac) for the Phased Implementation alternative. Total alternative impacts (remediation and post-remediation closure actions) would add from 40 ha (100 ac) to 80 ha (200 ac) to the impacts from remediation. Most remediation impacts would occur in the 200 Areas, while post-remediation impacts would more heavily impact potential borrow sites, two of which are located outside the Central Plateau of the Hanford Site. All of the alternatives, expect No Action, Long-Term Management, and In Situ Fill and Cap, would result in noise and transportation impacts that would impact wildlife. None of the alternatives would adversely impact Hanford Site aquatic, wetland, or riparian habitats and none would impact Federal or State threatened or endangered species. Potential impacts to other species of concern would be limited to a relatively small portion of the overall habitat.

Following the end of the remedial phase of each alternative, exposure to waste under the No Action and Long-Term Management alternatives likely would be fatal for wildlife. Direct exposure to waste would pose a fatal risk under the In Situ Fill and Cap, In Situ Vitrification, and Ex Situ/In Situ Combination 1 and 2 alternatives; however, the likelihood of exposure would be minimal. Direct exposure under the remaining ex situ alternatives, though considered unlikely, would pose a risk to wildlife. No other exposure scenario (e.g., contaminated groundwater at seeps along the Columbia River) under any of the alternatives would pose a substantial risk to wildlife.

For this analysis, the key issues are 1) whether the land areas proposed for use currently are undisturbed or whether they have been disturbed by past activities; 2) the extent of potential impacts on sensitive shrub-steppe habitat, which is considered a priority habitat by Washington State; and 3) potential impacts on plant and animal species of concern (those listed or candidates for listing by the Federal government or Washington State as threatened, endangered, and sensitive). The section also describes impacts to three potential borrow sites that would be associated with the tank closure scenario included for the comparative analysis of the alternatives.

Activities for all tank waste alternatives except No Action would occur at locations that contain both undisturbed and disturbed land. For example, the tank farms and their immediate surrounding areas currently are heavily disturbed and thus have minimal native vegetative or wildlife habitat. The vitrification facility sites in the 200 East Area associated with the various ex situ alternatives and the Phased Implementation alternative contain currently disturbed land that is of minimal habitat value and undisturbed shrub-steppe that is considered valuable as vegetative and wildlife habitat. The amount and location of the land areas required by each alternative are described in Section 3.0 and Volume Two, Appendix B. The analysis of potential impacts on species of concern focused on plant and animal species found in the Hanford Site's shrub-steppe habitat.

Where TWRS alternatives' activities are proposed in areas that are partly disturbed and partly undisturbed habitat, the alternatives' vegetation and wildlife habitat impacts were calculated proportional to the current percentage of disturbed versus undisturbed land at the particular site. For example, if 30 ha (70 ac) were required at a site that currently is 50 percent disturbed, the habitat impact was calculated to be 15 ha (30 ac) (30 ha [70 ac] times 50 percent). No attempt was made to lay out or configure facilities to either maximize or minimize habitat impacts. Final design,

configuration, and layout of facilities for alternatives selected for implementation would incorporate habitat impact avoidance and minimization as part of the development process. However, none of the alternatives are far enough along in the design process for this to have occurred.

5.4.1 Impacts to Vegetation

Virtually all proposed TWRS activities under all EIS alternatives would occur on the Hanford Site's Central Plateau within or between the 200 East and 200 West Areas. All TWRS sites are within shrub-steppe habitat. There are approximately 8,500 ha (21,000 ac) of shrub-steppe on the Central Plateau. This area is approximately 15 percent of the total remaining shrub-steppe habitat of the Hanford Site. All alternatives except No Action would have varying degrees of impact on vegetative habitat (Figure 5.4.1 and Table 5.4.1). In all cases, the affected shrub-steppe area would be less than 1 percent of the total remaining shrub-steppe on the Central Plateau and a small fraction of 1 percent of the Hanford Site's total shrub-steppe habitat.

Table 5.4.1 summarizes the potential shrub-steppe habitat impacts of the TWRS alternatives and identifies the plant species of concern that potentially would be affected. Table 5.4.1 provides a comparison of the potential impacts of each alternative based on where the impacts would occur (200 Areas or at potential borrow sites) and the impacts of the remedial phase of the project compared to impacts of the total alternative (remediation and the post-remediation closure scenario activities). The table also summarizes the total impacts of the alternatives and lists the species (vegetation and wildlife that potentially could be impacted by the alternatives).

Under all alternatives except No Action, approximately 13,000 m (33,000 ft) of replacement underground pipelines would be constructed at various locations in the 200 Areas. All pipelines would be placed in currently disturbed areas adjacent to the existing pipelines. Therefore, there would be no impact on shrub-steppe habitat.

5.4.1.1 Tank Waste Alternatives

No Action Alternative (Tank Waste)

The No Action alternative would involve no additional construction and thus no additional land disturbance. Consequently, there would be no impacts to shrub-steppe habitat.

Long-Term Management Alternative

As shown in Table 5.4.1, the Long-Term Management alternative would impact approximately 10 ha (25 ac) of undisturbed area in the 200 East Area. The undisturbed area that would be affected is shrub-steppe habitat characterized by big sagebrush or gray rabbitbrush, both native plant species typical of the shrub-steppe community. This area would be used for constructing replacement DSTs for existing storage tanks that have reached the end of their design lives, as well as for power lines to

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Figure 5.4.1 Habitat Impacts of Tank Waste and Capsule Alternatives

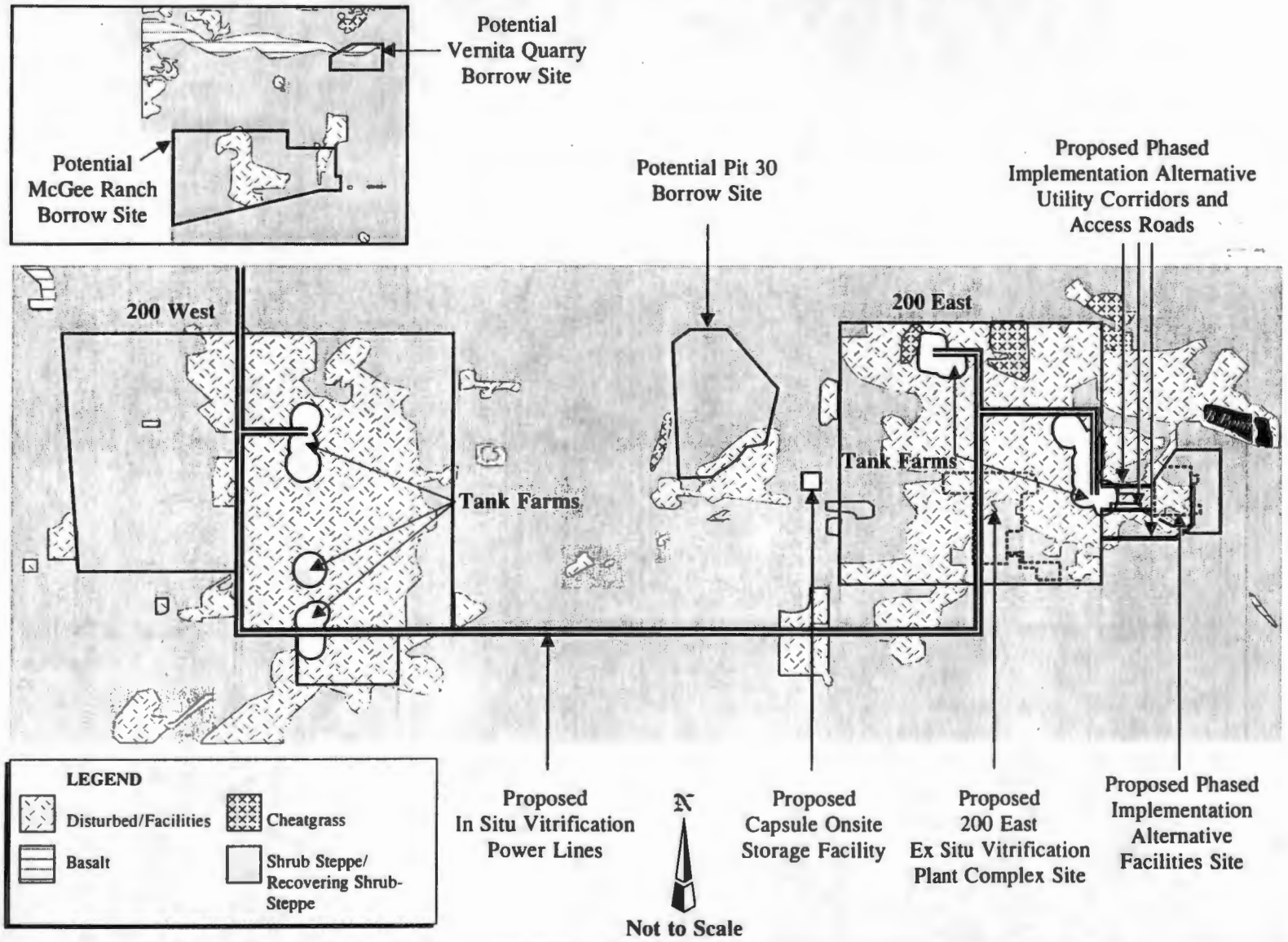

Table 5.4.1 Shrub-Steppe Habitat and Associated Potential Impacts on Plant and Wildlife Species of Concern of TWRS Alternatives

Alternative [2]	Total Shrub-Steppe Disturbed ha (ac)						Potentially Affected Species of Concern [1]
	200 Areas		Potential Borrow Sites		Total [3]		
	Remediation	Total Alternative	Remediation	Total Alternative	Remediation	Total Alternative	
No Action	0	0	0	0	0	0	**Plant Species** crouching milkvetch scilla onion stalked-pod milkvetch Pipers daisy **Bird Species** loggerhead shrike ferruginous hawk sage sparrow swainsons hawk sage thrasher prairie falcon long-billed curlew golden eagle burrowing owl **Mammal Species** pygmy rabbit **Reptile Species** striped whipsnake desert night snake northern sagebrush lizard
Long-Term Management	10 (25)	10 (25)	14 (35)	14 (35)	24 (59)	24 (59)	
In Situ Fill and Cap	0	0	23 (57)	65 (160)	23 (57)	65 (160)	
In Situ Vitrification	23 (57)	23 (57)	21 (52)	63 (160)	44 (110)	86 (210)	
Ex Situ Intermediate Separations	57 (140)	57 (140)	33 (82)	110 (270)	90(220)	170 (420)	
Ex Situ No Separations	44 (110)	44 (110)	89 (220)	153 (380)	130 (320)	200 (490)	
Ex Situ Extensive Separations	57 (140)	57 (140)	32 (79)	110 (270)	86 (210)	170 (420)	
Ex Situ/In Situ Combination 1	56 (140)	56 (140)	32 (79)	90 (220)	88 (220)	150 (379)	
Ex Situ/In Situ Combination 2	40 (100)	40 (100)	30 (74)	79 (200)	71 (180)	120 (300)	
Phased Implementation (Phase 1)	20 (49)	20 (49)	1 (2)	1 (2)	21 (52)	21 (52)	
Phased Implementation (Total Alternative)	99 (240)	99 (240)	37 (91)	120 (300)	136 (340)	220 (540)	
Capsules (All Alternatives)	<2 (<5)	<2 (<5)	0	0	<2 (<5)	<2 (<5)	

Notes:
[1] Species of concern are species that are identified by the Federal government or Washington State as listed, candidate, monitor, or sensitive species.
[2] All of these alternatives, except No Action, potentially would affect all species, with the level of impact related to the amount of shrub-steppe disturbed.
[3] Differences in total values reflect rounding.

provide electrical power to the new tank farms and for a new evaporator. Plant species potentially impacted include the crouching milkvetch, stalked-pod milkvetch, and scilla onion, all Washington State Class 3 monitor species, and Pipers daisy, a species that is listed as sensitive by Washington State.

This alternative also would impact approximately 14 ha (35 ac) of shrub-steppe habitat at the potential Pit 30 borrow site. No Federally listed plant species would be affected, but the stalked-pod milkvetch, a Washington State Class 3 monitor species, and Pipers daisy, a State sensitive species, have been observed there and would be affected (Duranceau 1995).

In Situ Fill and Cap Alternative

The In Situ Fill and Cap alternative would affect no undisturbed vegetative habitat in the 200 Areas. However, because remediation would involve filling all 177 tanks with gravel from the potential Pit 30 borrow site, 23 ha (57 ac) of vegetation would be disturbed at Pit 30 (located on the Central Plateau between the 200 East Area and the 200 West Area).

During closure activities, approximately 17 ha (42 ac) of shrub-steppe would be disturbed at the potential Vernita Quarry borrow site. The area that would be affected is undisturbed shrub-steppe habitat with varying degrees of shrub coverage, primarily big sagebrush, rigid sagebrush, and some spiny hopsage, as well as grasses such as Sandbergs bluegrass and bluebunch wheatgrass.
No Federally-listed threatened or endangered species would be affected. Two plant species classified as Class 3 monitor species by Washington State were observed in 1993 biological surveys and would be affected. These are the stalked-pod milkvetch and crouching milkvetch (Duranceau 1995).

This alternative also would disturb approximately 12 ha (30 ac) of shrub-steppe at the potential McGee Ranch borrow site and 13 ha (32 ac) at the potential Pit 30 borrow site during closure activities.
No Federally-listed threatened or endangered species would be affected at McGee Ranch, although the crouching milkvetch and the scilla onion, two Washington State Class 3 monitor species, were identified there in 1993 biological surveys and would be impacted (Landeen et al. 1994).
No Federally-listed threatened or endangered plant species would be impacted at Pit 30, although the stalked-pod milkvetch, a Washington State Class 3 monitor species, and Pipers daisy, a State sensitive species, have been observed there (Duranceau 1995).

In Situ Vitrification Alternative

The In Situ Vitrification alternative would disturb 23 ha (57 ac) of undisturbed shrub-steppe habitat by constructing 115-kilovolt (kV) transmission lines to the tank farms in the 200 Areas where the in situ vitrification activities would occur (Figure 5.4.1). The acreage at and around the tank farms where the vitrification facilities would be developed currently is disturbed. An additional 18 ha (44 ac) would be disturbed at the potential Pit 30 borrow site during remediation activities.

During closure activities, the In Situ Vitrification alternative also would disturb approximately 42 ha (100 ac) of shrub-steppe at the three potential borrow sites (17 ha [42 ac] at Vernita Quarry, 12 ha [30 ac] at McGee Ranch, and 13 ha [32 ac] at Pit 30). Impacts would be similar to the In Situ Fill and Cap alternative.

Ex Situ Intermediate Separations Alternative

During tank waste remediation, this alternative would impact about 59 ha (150 ac) of shrub-steppe habitat in the 200 East Area and 33 ha (82 ac) at the potential Pit 30 borrow site. During closure activities, this alternative would impact an additional 77 ha (220 ac) of shrub-steppe at the three potential borrow sites (23 ha [62 ac] at Vernita Quarry, 13 ha [47 ac] at McGee Ranch, and 41 ha [110 ac] at Pit 30). The same impacts described for the Long-Term Management and In Situ Fill and Cap alternatives would be impacted under this alternative.

Ex Situ No Separations Alternative

This alternative would have similar vegetation impacts to the Ex Situ Intermediate Separations alternative. However, during remediation, the Ex Situ No Separations alternative would impact more shrub-steppe in the 200 Area (approximately 89 ha [220 ac]) than the Ex Situ Intermediate Separations alternative (approximately 33 ha [82 ac]) because of the need for interim storage of large quantities of vitrified waste before offsite shipment to the potential geologic repository. During closure, less borrow material, and therefore less habitat disturbance, would be required at the potential borrow sites for this alternative than for the Ex Situ Intermediate Separations alternative (Table 5.4.1).

Ex Situ Extensive Separations Alternative

During remediation, similar activities would take place at the same proposed waste processing site and for closure at the same potential borrow sites, as discussed for the other ex situ alternatives. The Ex Situ Extensive Separations alternative would disturb the same amount of shrub-steppe habitat as the Ex Situ Intermediate Separations alternative (Table 5.4.1).

Ex Situ/In Situ Combination 1 Alternative

During remediation, this alternative would impact about 56 ha (140 ac) of shrub-steppe habitat in the 200 East Area and 32 ha (79 ac) at Pit 30. For closure activities, a total of 58 ha (140 ac) of additional shrub-steppe habitat would be impacted at the three potential borrow sites; (21 ha [52 ac] at Vernita Quarry, 12 ha [30 ac] at McGee Ranch, and 25 ha [62 ac] at Pit 30).

Ex Situ/In Situ Combination 2 Alternative

This alternative would impact 40 ha (100 ac) of shrub-steppe habitat in the 200 Areas during remediation as well as 30 ha (75 ac) at Pit 30. For closure activities, an additional 48 ha (120 ac) of shrub-steppe would be affected at the three potential borrow sites; 19 ha (47 ac) at Vernita Quarry, 11 ha (27 ac) at McGee Ranch, and 18 ha (44 ac) at Pit 30.

Phased Implementation Alternative

Phase 1

Phase 1 of the Phased Implementation alternative would disturb about 21 ha (52 ac) of shrub-steppe vegetation in the easternmost section of the 200 East Area. Approximately 1 ha (2 ac) of shrub-steppe would also be disturbed at the potential Pit 30 borrow site to support remediation activities. The same kind of plant species identified for the other alternatives would be impacted by this alternative.

Total Alternative

The Phased Implementation alternative, when fully implemented, would result in a total disturbance that would include the impacts identified for Phase 1, as well as impacts associated with implementing Phase 2 construction, retrieval, operations, and post remediation for the entire alternative. The total impacts would include 99 ha (240 ac) of shrub-steppe habitat in the 200 Areas and 37 ha (49 ac) in the potential Pit 30 borrow site associated with remediation activities. An additional 81 ha (200 ac) of shrub-steppe habitat would be disturbed at the three potential borrow sites resulting from closure activities. The same kind of plant species impacted under the other alternatives would be impacted by this alternative.

5.4.1.2 Capsule Alternatives

The No Action alternative essentially would have no vegetation impacts because no new land disturbance would occur. All other cesium and strontium capsule alternatives would have minor impacts on vegetation. The Onsite Disposal alternative would involve constructing a disposal facility on the Central Plateau just west of the 200 East Area, which would impact approximately 1.5 ha (3.7 ac) of shrub-steppe. The Overpack and Ship and the Vitrify with Tank Waste alternatives would involve additional minor facility development within areas that would be disturbed by the vitrification complex proposed in the 200 East Area for the Ex Situ Intermediate Separations alternative. Thus, no additional vegetation disturbance would be associated with these capsule alternatives.

5.4.2 Wildlife

Under all tank waste alternatives except No Action, some loss of individual members of wildlife species would occur. However, when considering the total Hanford Site population of the affected species, the number of individual members lost is not expected to be large enough to have substantial impact on any species as a whole. As described previously, activities in currently undisturbed areas would affect wildlife habitat, while activities in currently disturbed areas would not affect wildlife habitat. The impact analysis focused on impacts in undisturbed wildlife habitat areas.

The EIS alternatives would impact wildlife by directly disturbing habitat areas at proposed facility sites. Rodent and rabbit populations of the disturbed areas would be destroyed or displaced. This would impact raptor species (birds of prey such as harriers, kestrels, hawks, and owls) and mammals (such as coyotes, badgers, mule deer) of the Central Plateau and vicinity. Predator food supplies would decrease, which would in turn increase competition and decrease predator species productivity. Eventually, this would result in a local reduction in the predator population of the Central Plateau as individual species members died or were displaced. Common bird species (e.g., larks and finches)

would be displaced and ground nesting birds such as the killdeer and mourning dove could be affected by the destruction of nests. Impacts would affect only individual members of the species; they would not be of a scale to affect the Sitewide populations of either the predator species or nonpredator species.

In addition to direct impacts from habitat loss, the increased levels of human activity and associated noise for all tank waste alternatives (except No Action) would displace wildlife species, particularly raptors and predatory mammals. The noise impacts would occur primarily from using heavy equipment during facilities construction and at borrow sites, although the general disturbance caused by increased human presence would continue throughout facility operations. Predators would likely move out of the immediate area, which would further contribute to competition for food and living space in adjacent areas. Construction noise levels would approach background levels at distances greater than 600 m (2,000 ft), and the zone of indirect impact would vary by species. However, the overall zone of impact for some species could extend to a radius of up to 800 m (2,700 ft) from the construction site (Section 5.9).

Increased vehicular traffic associated with the various alternatives also could lead to occasional collisions between vehicles and wildlife. This could lead to a slight increase in mortality of various wildlife species, including large mammals such as mule deer. The levels of increased mortality would be directly proportional to the employment levels and associated traffic volumes for each alternative (Section 5.10).

The nesting period is a critical time period for most bird species. Disturbances, including noise, could result in nest abandonment and declines in productivity. Nesting disturbances of raptors such as the ferruginous hawk, swainsons hawk, red-tailed hawk, and prairie falcon could occur at distances greater than 800 m (2,700 ft). For example, the Pacific Northwest National Laboratory recommends confining human activity to the nonnesting season or avoiding alteration or disturbance within 1.0 km (0.6 mi) of red-tailed hawk nests, 1.6 km (1.0 mi) of ferruginous hawk nests, and 1.5 km (0.9 mi) of swainsons hawk nests (PNL 1994e). The only likely potential raptor nesting site in the 200 Areas would be on power transmission facilities. Construction of new power lines for the alternatives could provide additional raptor nesting sites. Passerine (songbird) species such as the sage sparrow also could be adversely affected by disturbance during the breeding season. Avoiding activities such as Site clearing during breeding or avoiding disturbance near songbird nesting areas would reduce these impacts.

Under all tank waste alternatives except No Action, there would be approximately 13,000 m (33,000 ft) of replacement underground pipelines placed in currently disturbed portions of the 200 Areas. As these pipelines would be placed in currently disturbed areas adjacent to the existing pipelines, no wildlife impacts would be expected.

Impacts associated with the closure phase of the alternatives would 1) include habitat loss at the potential McGee Ranch borrow site, which would be used under all tank waste alternatives except No Action and Long-Term Management; and 2) adversely affect an important wildlife corridor between

the Hanford Site and the Yakima Training Center, which are the two largest remaining shrub-steppe habitat areas in Washington State. Disturbing this corridor would contribute to fragmenting the region's shrub-steppe habitat. The corridor potentially is of importance to medium-to-large mammals, such as coyote, deer, and elk, and to other species using relatively undisturbed shrub-steppe. The corridor is generally important from the standpoint of species proliferation and maintaining genetic diversity. The corridor also has the potential for serving as a conduit for the reintroduction to the Hanford Site of sage grouse, a State and Federal candidate species. Sage grouse were displaced from the Site by a major wildfire in 1984. The nearest population of sage grouse is at the Yakima Training Center, and the McGee Ranch provides the most direct, relatively undisturbed corridor between the Site and the Yakima Training Center.

Table 5.4.1 summarizes the shrub-steppe habitat impacts of the TWRS alternatives and identifies wildlife species of concern that potentially may be affected.

5.4.2.1 Tank Waste Alternatives

No Action Alternative (Tank Waste)

The No Action alternative would involve no additional land disturbance and thus would have no impacts on wildlife resources.

Long-Term Management Alternative

The Long-Term Management alternative would disturb approximately 10 ha (25 ac) of shrub-steppe wildlife habitat in the 200 East Area from retanking the DSTs. An additional 14 ha (35 ac) of shrub-steppe habitat would be affected at the potential Pit 30 borrow site. Potentially affected species would include the horned lark, western meadowlark, common raven, red-tailed hawk, ferruginous hawk, violet green swallow, great basin pocket mouse, and northern pocket gopher. Impacts, which would be limited to individual members of species, would be small when considering the Hanford Site as a whole.

Two species of concern are found at the potential Pit 30 borrow site in addition to the species identified in the 200 East Area. These are the loggerhead shrike (Federal and State candidate species) and the sage sparrow (State candidate species). Both species nest and raise their young in shrub-steppe, and the habitat disturbance would adversely impact both the shrike and sparrow.

In Situ Fill and Cap Alternative

During remediation, the In Situ Fill and Cap alternative would affect only currently disturbed lands in the 200 Areas (Table 5.4.1). These areas at and near the tank farms are of little wildlife habitat value. During remediation, there would be 23 ha (57 ac) impacted at the potential Pit 30 borrow site.

During closure, activities at the potential Vernita Quarry borrow site would affect wildlife by disturbing about 17 ha (42 ac) of shrub-steppe habitat. Potentially affected species and impacts would be those identified for the Long-Term Management alternative, as well as mule deer, coyote, and badger, which all are found in the vicinity. A pair of red-tailed hawks was observed nesting on the basalt cliff face at

Vernita Quarry during a 1994 biological survey. Such nesting activity would be disrupted if the hawks were present during the post-remediation Hanford Barrier construction phase of the project (Duranceau 1995).

Similar bird and mammal species would be affected at the potential McGee Ranch borrow site where 12 ha (30 ac) of shrub-steppe wildlife habitat would be disturbed. Individual species members would be lost or replaced, but only small impacts would occur on the species as a whole. However, the McGee Ranch area is an important corridor between the Hanford Site and the Yakima Training Center. Two species of concern found at McGee Ranch would be affected: the loggerhead shrike (Federal and State candidate species) and the sage sparrow (State candidate species). Moreover, the reintroduction to the Hanford Site of the sage grouse, a Federal and State candidate species, could be adversely affected.

During closure activities, wildlife impacts would be similar at the potential Pit 30 borrow site to those at the potential McGee Ranch and Vernita Quarry borrow sites. This is because essentially the same bird and mammal species are found in the shrub-steppe at Pit 30, although Pit 30 does not have the same importance as a wildlife corridor as McGee Ranch. However, the same adverse impacts on the sage sparrow and loggerhead shrike (Federal and State candidate species) would occur at Pit 30 as at McGee Ranch. Approximately 13 ha (32 ac) of additional shrub-steppe wildlife habitat would be impacted at Pit 30 during closure activities.

In Situ Vitrification Alternative

During remediation activities, this alternative would disturb approximately 23 ha (57 ac) of shrub-steppe habitat by constructing power lines to the tank farms in the 200 Areas and 21 ha (52 ac) of shrub-steppe habitat at the potential Pit 30 borrow site (Table 5.4.1). During closure, an additional 42 ha (100 ac) of shrub-steppe habitat would be disturbed at all three potential borrow sites (Table 5.4.1). Wildlife impacts at the potential borrow sites would be the same as described for the In Situ Fill and Cap alternative.

Ex Situ Intermediate Separations Alternative

During remediation, this alternative would disturb 57 ha (150 ac) of shrub-steppe wildlife habitat in the 200 East Area and 33 ha (59 ac) of shrub-steppe habitat in the potential Pit 30 borrow site. For closure activities, an additional 77 ha (220 ac) would be disturbed at the three potential borrow sites. Impacts would be the same as described for the In Situ Fill and Cap alternative.

Ex Situ No Separations Alternative

This alternative would involve wildlife impacts similar to the Ex Situ Intermediate Separations alternative. There would be more shrub-steppe wildlife habitat (96 ha [240 ac]) disturbed than for the Ex Situ Intermediate Separations alternative in the 200 Areas and at Pit 30 during remediation, with 89 ha (220 ac) of the disturbance occurring at Pit 30 (Table 5.4.1). There would be less disturbance at potential borrow sites during closure for this alternative than for the Ex Situ Intermediate Separations alternative because there would be no LAW vaults (64 ha [160 ac]).

Ex Situ Extensive Separations Alternative

This alternative would have impacts similar to the Ex Situ Intermediate Separations alternative because the same activities would occur at the same sites. The wildlife habitat acreage impacted would be less than for the Ex Situ Intermediate Separations alternative (Table 5.4.1).

Ex Situ/In Situ Combination 1 Alternative

During remediation activities, this alternative would disturb approximately 56 ha (140 ac) of shrub-steppe wildlife habitat in the 200 East Area and 32 ha (77 ac) of shrub-steppe habitat at the potential Pit 30 borrow site. An additional 58 ha (160 ac) of shrub-steppe habitat would be disturbed at the three potential borrow sites (21 ha [52 ac] at Vernita Quarry, 12 ha [30 ac] at McGee Ranch, and 25 ha [64 ac] at Pit 30) to support closure of the tank farms and LAW vaults. Impacts would be similar to those described for the Ex Situ Intermediate Separations alternative.

Ex Situ/In Situ Combination 2 Alternative

During remediation, this alternative would disturb 40 ha (99 ac) of shrub-steppe habitat in the 200 East Area and 30 ha (74 ac) at the potential Pit 30 borrow site. During closure, an additional 48 ha (120 ac) would be disturbed at the three potential borrow sites; 19 ha (47 ac) at Vernita Quarry, 11 ha (27 ac) at McGee Ranch, and 18 ha (44 ac) at Pit 30. Impacts would be similar to those described for the Ex Situ Intermediate Separations alternative.

Phased Implementation Alternative

Phase 1

Phase 1 of the Phased Implementation alternative would disturb approximately 21 ha (49 ac) of shrub-steppe wildlife habitat, all but 1 ha (2.5 ac) of which would be in the 200 East Area. Impacts similar to those described for the Ex Situ Intermediate Separations alternative would be expected.

Total Alternative

The Phased Implementation alternative, when fully implemented, would result in a total disturbance that would include the disturbances identified for Phase 1, as well as disturbances associated with implementing Phase 2. The total disturbances would include 79 ha (150 ac) of shrub-steppe habitat in the 200 Areas and 37 ha (91 ac) at the potential Pit 30 borrow site would be associated with remediation activities. An additional 81 ha (200 ac) at the three potential borrow sites would be associated with closure activities. Impacts to wildlife similar to those described for the Ex Situ Intermediate Separations alternative would be expected.

5.4.2.2 Capsule Alternatives

Wildlife impacts from all capsule alternatives would be negligible. The No Action (Capsules) alternative would disturb no additional wildlife habitat. The Onsite Disposal alternative would involve an area currently partly disturbed, and only 1.5 ha (3.5 ac) of wildlife habitat would be affected. Both of the other capsule alternatives would involve developing small facilities within the proposed complex for vitrifying tank waste. Thus, no additional wildlife habitat areas would be disturbed, and no incremental impacts would occur.

5.4.3 Aquatic, Wetlands, and Riparian Habitats

The aquatic habitats on the Hanford Site include the Columbia River, two small spring-fed streams on the Fitzner Eberhardt Arid Lands Ecology Reserve, and artificial ponds and ditches located in or near the 200 Areas. The primary wetlands on the Hanford Site are the riparian areas along the Columbia River. There also are human-made wetlands near the 200 East Area. None of the aquatic habitats, riparian areas, or wetlands would be directly or indirectly adversely affected by any EIS alternative.

5.4.4 Species of Concern and Critical Habitats

Impacts of all EIS alternatives on plant and animal species of concern were directly related to the amount of disturbance of shrub-steppe habitat associated with each alternative (Table 5.4.1). Species of concern are defined as those species 1) listed as threatened or endangered by the Federal government or Washington State; 2) identified as candidates for listing by the Federal government; or 3) identified as candidate, monitor, or sensitive species by Washington State. Critical habitats are habitat types that are of high value to wildlife, declining in abundance, or both.

No Federal- or State-listed species would be impacted by any EIS alternative. The following Federal candidate species or Washington State candidate, monitor, or sensitive species either were observed in TWRS EIS biological surveys or are known to exist in shrub-steppe habitat, and thus should be considered potentially impacted:

- Plant species - Crouching milkvetch, stalked-pod milkvetch, scilla onion, and Pipers daisy;
- Bird species - Loggerhead shrike, sage sparrow, ferruginous hawk, swainsons hawk, sage thrasher, long-billed curlew, prairie falcon, golden eagle, and burrowing owl;
- Mammal species - Pygmy rabbit; and
- Reptile species - Northern sagebrush lizard, striped whipsnake, and desert night snake.

Washington State considers shrub-steppe a priority habitat because of its value to many wildlife species and because it is a diminishing resource that is relatively scarce in the state. It is DOE policy at the Hanford Site to mitigate losses of mature sagebrush in shrub-steppe habitat areas. Section 5.20 contains additional details on mitigation of impacts to shrub-steppe habitat.

The western sage grouse, a Federal and State-listed threatened species, was found on the Site until the local population was displaced by a major wildfire in 1984. The bald eagle, also listed as threatened by the Federal government and Washington State, winters along the Hanford Reach. The bald eagle forages on fish and wildlife along the river. Eagles are not known to use the Central Plateau of the Site, which is 10 km (6 mi) or more from the river. Although the bald eagle potentially could consume fish from areas of the river that received groundwater contaminated under TWRS EIS alternatives, contaminant exposures to the bald eagle would be expected to be below levels of concern (Section 5.4.6). Thus, no direct or indirect impacts would be expected under any TWRS EIS alternative.

5.4.5 Biodiversity

The destruction or degradation of the shrub-steppe habitat on the Hanford Site would impact the area's unique biodiversity. None of the EIS alternatives would affect more than a fraction of 1 percent of the Hanford Site's total shrub-steppe area. However, impacts on the McGee Ranch area, a potential borrow site under all tank waste alternatives except No Action and Long-Term Management, would impact a wildlife corridor that is important for species migration, proliferation, and genetic diversity. Historic evidence at the Hanford Site indicates that disturbing shrub-steppe habitat leads to the incursion of exotic species that replace or compete with the native species. These new species tend to simplify the ecosystem, thereby reducing diversity and changing the ecological character of the Hanford Site. The impacts of EIS alternatives would be directly related to the amount of shrub-steppe they would disturb. Table 5.4.1 lists the differences in impacts among alternatives.

There are a variety of other ecosystems on the Hanford Site such as wetlands, riparian areas, and bluffs. These support unique plant and animal communities and contribute to the Hanford Site's biodiversity. None of the EIS alternatives would adversely affect any of the other Hanford Site ecosystems.

5.4.6 Radiological and Chemical Impacts to Biological and Ecological Resources

This section describes risk to plant and animal species from possible exposures to radionuclides and hazardous chemicals under the various EIS alternatives. Radiation doses and chemical hazards were assessed for a generic plant, several mammals (great basin pocket mouse, coyote, and mule deer), and two bird species (red-tailed hawk and loggerhead shrike). The methodology for this assessment is described in Volume Three, Appendix D. Calculation methods used were for the analysis similar to those described in the Hanford Baseline Risk Assessment Methodology (DOE 1995c). The equations were modified to follow the unit risk factor approach used for the human health assessment (Section 5.11).

Radioactive and Chemical Impact Analysis

The analysis included:

- Potential radiological risk from direct contact with the waste;
- Radiological risk from consuming contaminated groundwater that reaches the Columbia River;
- Radiological risk from exposures to airborne releases during routine operations; and
- Chemical hazards from consuming contaminated groundwater that reaches the Columbia River.

5.4.6.1 Tank Waste Alternatives

No Action Alternative (Tank Waste) and Long-Term Management Alternative

Direct contact with stored waste is unlikely as long as institutional controls are present, but would be possible after the 100-year institutional control period. If direct contact with the waste occurred under the No Action and Long-Term Management alternatives, that exposure would be estimated to lead to potential radiation doses ranging from 16 to several million radiation absorbed doses (rad)/day, which most likely would be lethal to wildlife in a short time. The chemical hazards of direct exposure would range as high as several hundreds of times higher than the 1.0 hazard index that is the benchmark for

potential adverse ecological impacts (e.g., a hazard index greater than 1.0 indicates adverse effects in ecological receptors of concern). The mechanism by which direct contact could occur many years in the future (after institutional control has been lost) would involve the eventual collapse of the top of an underground tank. This would allow species to fall into the exposed tank and suffer trauma from the fall as well as radioactive and chemical exposures. Birds would be the most likely animal to be impacted.

Exposure to routine air emissions under this alternative is estimated to result in radiation exposures of less than 1.0E-06 rad/day. Routine air emissions would occur only during the period of institutional control. This exposure level is far below background levels and would be expected to have no detectable effects on exposed species.

Exposure to contaminated groundwater reaching the Columbia River would result in low radiological exposure levels. Radiation doses would not approach the International Atomic Energy Agency 0.1-rad/day benchmark for terrestrial organisms or the National Council on Radiation Protection and Measurement 1.0-rad/day benchmark for aquatic organisms (IAEA 1992 and NCRP 1991).

The No Action and Long-Term Management alternatives are the most conservative of the alternatives evaluated and represent the greatest potential impact to groundwater and the Columbia River. This is because no remediation would be performed, and all the waste would remain in the tanks and be available for migration to groundwater following tank failure.

Under these alternatives, maximum chemical concentrations calculated to reach the Columbia River 300, 500, 2,500, 5,000, or 10,000 years in the future would result in maximum hazard indices well below the hazard index criterion of 1.0 for the indicator species (coyote, mule deer, red-tailed hawk, and loggerhead shrike). The ecological hazards were based on a conservative scenario involving consumption of groundwater contaminants at the point where groundwater reaches the surface on the Columbia River bank (e.g., springs or seeps) and assume no dilution of the groundwater contaminants by the river before access by the receptors. This scenario conservatively assumes that a terrestrial receptor would obtain all its water from a spring where maximum contaminant concentrations are calculated to occur. Further, this receptor is assumed to spend its entire lifetime drinking water from this single, maximum exposure location and nowhere else. In reality, all indicator species used to evaluate potential groundwater consumption are highly mobile and have relatively large home ranges, such that they would drink water at numerous locations both onsite and offsite. Based on the conservative nature of the exposure scenarios, the estimated hazards for the representative species indicate that no adverse effects would be expected for any terrestrial or aquatic receptor consuming groundwater in the future.

In Situ Fill and Cap Alternative

Under the In Situ Fill and Cap alternative, all of the tank waste would remain in place. As long as institutional controls were present, it is unlikely that ecological receptors would have direct contact with the tank waste. Following the loss of institutional controls, if direct contact with the waste occurred,

that exposure would lead to potential radiation doses that most likely would be lethal to ecological receptors. Doses would be similar to those calculated for the No Action and Long-Term Management alternatives. The chemical hazards of direct exposure would range as high as several hundred times above the 1.0 benchmark for potential adverse ecological impacts.

For the In Situ Fill and Cap alternative, closure would entail placing a multi-layered Hanford Barrier over each tank farm. This 4.5-m (15-ft)-thick barrier would be designed to inhibit intrusion by burrowing animals. Consequently, direct contact with tank waste would be unlikely following closure.

Potential radiation doses as a result of radiological releases to air from routine operations would be below the 0.1-rad/day benchmark. Radiation doses from contaminated groundwater also would be below the 0.1-rad/day and 1.0-rad/day benchmarks for terrestrial and aquatic organisms, respectively. The maximum chemical concentrations calculated to reach the Columbia River under the No Action alternative represent the highest potential concentrations of groundwater contaminants for any of the alternatives. As described previously for the No Action alternative, maximum calculated contaminant concentrations in groundwater would result in hazard indices well below the hazard index criterion of 1.0 for all indicator species (coyote, mule deer, red-tailed hawk, and loggerhead shrike). Because chemical concentrations that would reach the Columbia River would be approximately 10 times lower under the In Situ Fill and Cap alternative than under the No Action alternative, potential chemical exposures would not pose a threat to terrestrial or aquatic receptors under the In Situ Fill and Cap alternative.

In Situ Vitrification Alternative

Under the In Situ Vitrification alternative, direct contact with the stabilized waste-containing material would result in radiation doses that most likely would produce lethal effects in ecological receptors. Following closure and construction of a Hanford Barrier over each tank farm, direct contact with the stabilized waste would be unlikely because this barrier is intended to prevent penetration by burrowing animals.

Estimated radiation doses resulting from routine air emissions would not exceed the 0.1-rad/day benchmark of concern (IAEA 1992). Exposure to contaminated groundwater reaching the Columbia River would be well below the 0.1-rad/day and 1.0-rad/day benchmarks for terrestrial and aquatic species, respectively. As described previously, maximum chemical concentrations calculated to reach the Columbia River under the No Action alternative would represent the highest potential concentrations of groundwater contaminants for any of the alternatives. Because the maximum hazard indices under the No Action alternative would be below the hazard index benchmark value of 1.0, chemical concentrations that would reach the Columbia River under the In Situ Vitrification alternative would not pose a threat to terrestrial or aquatic receptors.

Ex Situ Intermediate Separations Alternative

Under the Ex Situ Intermediate Separations alternative, 1 percent of the tank waste would remain as residual contamination. Direct contact with this residual tank waste would result in radiation doses that

would pose a threat to ecological receptors, including potential lethal effects. Following closure and construction of a Hanford Barrier, direct contact with the 1 percent residual waste would be unlikely because this barrier is intended to prevent penetration of burrowing animals.

The maximum estimated radiation exposure from air releases during routine operations would exceed the 0.1-rad/day benchmark of concern under conservative assumptions. Exposures would range from 1.0 rad/day for the mule deer to 48 rad/day for the pocket mouse, primarily due to releases of carbon-14, cesium-137, and strontium-90. However, this estimate assumes year-long exposure at the location of maximum radionuclide concentrations. At other locations, radionuclide concentrations would be lower, and thus exposures would be lower. Species exposure to harmful levels of airborne radiation from routine releases would be unlikely unless an animal spent its entire life at the point of maximum exposure.

As described previously, maximum contaminant concentrations calculated to reach the Columbia River under the No Action alternative would represent the highest potential concentrations of groundwater contaminants of any of the alternatives. Because the maximum hazard indices and radiation doses under the No Action alternative were below their respective benchmark values (e.g., a hazard index of 1.0, 0.1 rad/day for terrestrial species, and 1.0 rad/day for aquatic species), groundwater contaminant concentrations that would reach the Columbia River under the Ex Situ Intermediate Separations alternative would not pose a threat to terrestrial or aquatic receptors.

Ex Situ No Separations Alternative

Radiological and chemical hazards to animal species for this alternative would be similar to those described for the Ex Situ Intermediate Separations alternative. However, direct contact radiological risk would be lower than for the Ex Situ Intermediate Separations alternative because there would be no long-term onsite storage of LAW. Maximum estimated radiation doses resulting from routine releases would be expected to exceed the 0.1-rad/day benchmark for terrestrial receptors. Given the conservative nature of this exposure scenario (i.e., year-long exposure at the point of maximum radionuclide concentration), it is unlikely that ecological receptors would be exposed to harmful levels of airborne radiation from routine releases under the Ex Situ No Separations alternative.

As described previously, maximum contaminant concentrations calculated to reach the Columbia River under the No Action alternative would represent the highest potential concentrations of groundwater contaminants of any of the alternatives. Because the maximum hazard indices and radiation doses under the No Action alternative would be below their respective benchmark values (a hazard index of 1.0, 0.1 rad/day for terrestrial species, and 1.0 rad/day for aquatic species), groundwater contaminant concentrations that would reach the Columbia River under the Ex Situ No Separations alternative would not pose a threat to terrestrial or aquatic receptors.

Ex Situ Extensive Separations Alternative

Radiological and chemical risk to animal species would be similar to those described for the Ex Situ Intermediate Separations alternative. Exposure mechanisms would be similar to the Ex Situ

Intermediate Separations alternative but there would be less risk from LAW vaults because the concentration of radionuclides would be less in the LAW disposed of onsite. Maximum estimated radiation doses resulting from routine releases would be expected to exceed the 0.1-rad/day benchmark for terrestrial receptors. Given the conservative nature of this exposure scenario (i.e., year-long exposure at the point of maximum radionuclide concentration), it is unlikely that ecological receptors would be exposed to harmful levels of airborne radiation from routine releases under the Ex Situ Extensive Separations alternative.

As described previously, maximum contaminant concentrations calculated to reach the Columbia River under the No Action alternative would represent the highest potential concentrations of groundwater contaminants for any of the alternatives. Because the maximum hazard indices and radiation doses under the No Action alternative would be below their respective benchmark values (a hazard index of 1.0, 0.1 rad/day for terrestrial species, and 1.0 rad/day for aquatic species), groundwater contaminant concentrations that would reach the Columbia River under the Ex Situ Extensive Separations alternative would not pose a threat to terrestrial or aquatic receptors.

Ex Situ/In Situ Combination 1 and 2 Alternatives

These alternatives would be combinations of the In Situ Fill and Cap alternative for those tanks left in place and the Ex Situ Intermediate Separations alternative for the tank waste retrieved. The radiological and chemical constituents and concentrations released during operations would be similar to the In Situ Fill and Cap and the Ex Situ Intermediate Separations alternatives.

Under the conservative maximum exposure scenario, the maximum estimated radiation doses from air releases during routine operations would not exceed the 0.1-rad/day benchmark for terrestrial receptors.

As described previously, maximum contaminant concentrations calculated to reach the Columbia River under the No Action alternative would represent the highest potential concentrations of groundwater contaminants of any of the alternatives. Because the maximum hazard indices and radiation doses under the No Action alternative would be below their respective benchmark values (a hazard index of 1.0, 0.1 rad/day for terrestrial species, and 1.0 rad/day for aquatic species), groundwater contaminant concentrations that would reach the Columbia River under the Ex Situ/In Situ Combination 1 and 2 alternatives are not expected to pose a threat to terrestrial or aquatic receptors.

Phased Implementation Alternative

Phase 1

Phase 1 of the Phased Implementation alternative would include constructing one LAW processing plant and one combined LAW and HLW facility to process a portion of the tank waste. The chemical and radiological constituents and concentrations released during operations of this alternative would be similar to the Ex Situ Intermediate Separations alternative, and the associated impacts would be similar to operations. This phase of the alternative would not include disposal, so no post-remediation impacts would occur.

Total Alternative

The Phased Implementation alternative would result in chemical and radiological releases during operation, as described previously for Phase 1, and during operations associated with implementing Phase 2. The total chemical and radiological releases during operations and post remediation would be similar to those of the Ex Situ Intermediate Separations alternative.

5.4.6.2 Capsules Alternatives

Radiological and chemical risk to animal species would be small for all capsule alternatives. Neither the No Action alternative nor the Onsite Disposal alternative would involve waste treatment activities, and thus no radiological or chemical hazards would occur. Furthermore, no airborne releases would be expected from routine operations. Groundwater risk would be small because of the radioactive decay of the cesium and strontium capsule contents. By the time any releases could reach groundwater, only stable progeny isotopes (i.e., barium-137 and zirconium-90) would remain. The concentrations of these progeny in the groundwater would result in doses below the levels that would cause toxic effects in animal species.

It is conceivable that burrowing animals could be affected under the Onsite Disposal alternative after institutional controls were lost in the future. For example, pocket mice and burrowing owls could be stressed as a result of the heat generated from the capsules. Direct contact with the capsule contents also could occur following failure of the capsules. However, some radioactive decay of the cesium and strontium capsules likely would have occurred by the time of possible direct contact. Potential heat stress or direct contact impacts would affect a small number of individual species members and would have no impact on the total species population of the Site as a whole.

The Overpack and Ship alternative would involve no waste treatment and no long-term onsite storage of the capsules. No chemical or radiological risk to species would be expected.

The Vitrify with Tank Waste alternative would involve low risk to species. Capsule contents would be processed together with the tank waste in the same manner and at the same facility as described for the Ex Situ Intermediate Separations alternative. The vitrified capsule contents would be shipped offsite for disposal as HLW, and thus there would be no long-term onsite capsule waste storage.

5.5 CULTURAL RESOURCES

This section describes the impacts of the EIS alternatives on prehistoric and historic sites. The approach used was to 1) define specific land areas that would be disturbed by construction and operation; and 2) identify any prehistoric or historic materials or sites at those locations that might be adversely impacted. Table 5.5.1 summarizes these impacts and identifies the areas that potentially would be impacted. Issues of potential concern to

Cultural Resource Impacts

Impacts addressed in this section include:
- Prehistoric sites (Section 5.5.1);
- Historic sites (Section 5.5.2); and
- Issues of concern to Native Americans (Section 5.5.3).

Native Americans, such as land use and access, are presented in Section 5.5.3 and also are discussed in Section 5.19 (Environmental Justice).

Table 5.5.1 Prehistoric and Historic Impacts of TWRS Alternatives

Alternative	Prehistoric Resources	Historic Resources [1]
No Action	Minimal Potential Impacts	Minimal Potential Impacts
Long-Term Management	Minimal Potential Impacts	Minimal Potential Impacts
In Situ Fill and Cap	High Potential at Potential McGee Ranch and Vernita Quarry Sites.	High Potential at Potential McGee Ranch and Vernita Quarry Sites. Potential impacts to historically important waste storage tanks.
In Situ Vitrification [2]		
Ex Situ Intermediate Separations		
Ex Situ No Separations		
Ex Situ Extensive Separations		
Ex Situ/In Situ Combination		
Phased Implementation (Phase 1)	Minimal Potential Impacts	Minimal Potential Impacts
Phased Implementation (Total Alternative)	High potential at potential McGee Ranch and Vernita Quarry sites.	High potential at potential McGee Ranch and Vernita Quarry sites. Potential impacts to historically significant waste storage tanks.
Capsule Alternatives (all)	Minimal Potential Impacts	Minimal Potential Impacts

Notes:
[1] Historic sites include sites and artifacts from the pre-Hanford Site homestead and farming era, and from the Manhattan Project and Cold War era.
[2] New transmission historic lines for the In Situ Vitrification alternative would cross relatively unimportant portions of the National Register-nominated White Bluffs Freight Road.

Cultural resources surveys conducted in 1994 for this EIS and previous cultural resources surveys indicated existing ground disturbance at portions of the sites proposed for TWRS facilities in the 200 East Area proposed under the various ex situ alternatives and the Ex Situ/In Situ Combination 1 and 2 alternatives (PNL 1994a, b, c). This disturbance has resulted from past and ongoing Hanford Site activities. However, it is possible that the disturbed areas may contain cultural resources that were not identified in past surveys. Thus, additional cultural resource surveys would be conducted and TWRS construction would include procedures and monitoring activities to protect cultural resources encountered during construction.

Survey work in the 200 East Area has recorded two historic isolated artifacts within the proposed TWRS sites. These items, a flat-bottomed, crimped tin can and a double-soldered tin can, are considered of little importance as they probably do not meet National Register of Historic Places eligibility criteria because they lack physical integrity. Surveys of the proposed Phased Implementation (Phase 1) alternative site in the 200 East Area identified no archaeological sites (Cadoret 1995). Surveys of the 200 West Area also have identified very few archaeological sites (Section 4.5).

Under all tank waste alternatives except No Action, approximately 13,000 m (33,000 ft) of replacement underground pipelines would be placed at various locations in the 200 East and 200 West Areas. These pipelines would be placed adjacent to and replace the existing pipelines. Thus, no currently undisturbed land would be impacted, and no prehistoric or historic sites would be impacted by the activities under any EIS alternative.

Archaeological surveys of the three potential borrow sites have identified a variety of prehistoric or historic artifacts and sites at the Vernita Quarry and McGee Ranch. The likelihood of disturbing additional archaeological sites in these areas is considered high. The McGee Ranch site is part of the proposed McGee Ranch/Cold Creek Archaeological District, which has been deemed eligible for nomination to the National Register of Historic Places. The potential of disturbing archaeological sites at Pit 30 is considered low because of its location between the 200 West and 200 East Areas, a vicinity where few prehistoric or historic sites have been identified (Duranceau 1995).

5.5.1 Prehistoric Sites Impacts

5.5.1.1 Tank Waste Alternatives

No Action Alternative

The No Action alternative would involve no new construction, and thus no impacts to prehistoric archaeological sites would occur.

Long-Term Management Alternative

This alternative would disturb 50 ha (124 ac) in the 200 East Area and 16 ha (40 ac) at the potential Pit 30 borrow site for the construction of two new tank farms. This disturbance in the 200 East Area would occur in the same area proposed for the waste treatment facilities under the various ex situ alternatives. Because no important prehistoric sites were found in surveys of this area, no impacts would be expected. It is unlikely that activities at the potential Pit 30 borrow site would encounter any prehistoric sites.

In Situ Fill and Cap Alternative

During remediation activities, there would be minimal new disturbances (0.1 ha [0.5 ac]) in the 200 Areas near the tank farms. There would be approximately 25 ha (62 ac) disturbed at the potential Pit 30 borrow site where it is unlikely that activities would encounter prehistoric sites.

The remediation and closure activities under the In Situ Fill and Cap alternative would involve disturbing areas within and adjacent to the tank farms and at the potential borrow sites. Activities at and near the tank farms would have low impact potential. Disturbance of about 37 ha (91 ac) by construction activities at the potential Vernita Quarry and McGee Ranch borrow sites would have a high likelihood of impacting prehistoric sites because past surveys have found prehistoric materials in both areas. However, it is unlikely that activities at the potential Pit 30 borrow site would encounter any prehistoric sites.

In Situ Vitrification Alternative

During remediation, the in situ vitrification activities would occur in disturbed areas within and immediately adjacent to the various tank farms in the 200 Areas, and thus impacts to archaeological sites were considered unlikely. The In Situ Vitrification alternative would involve constructing a new substation and new power transmission lines in the 200 Areas to bring power to the in situ vitrification activities at the tank farms. The new substation would be located in currently disturbed areas, and it is likely that no impacts to prehistoric archaeological sites would occur. Constructing the new power lines would affect approximately 70 ha (170 ac) of land in approximately 17,000-m (57,000-ft) by 15-m (50-ft)-wide corridors. The bulk of this area, about 47 ha (115 ac), is currently disturbed, and thus it is unlikely that any new impacts to archaeological sites would occur. The remaining 23 ha (57 ac) are undisturbed. A cultural resources field survey of these power line routes would be performed before any final power line alignment would be selected. During remediation, 23 ha (57 ac) of currently undisturbed land would be impacted at the potential Pit 30 borrow site. However, activities would not likely encounter prehistoric sites.

During closure activities, this alternative would disturb land at the potential Vernita Quarry, McGee Ranch, and Pit 30 borrow sites. The likelihood of impacting prehistoric archaeological sites would be high at Vernita Quarry and McGee Ranch because prehistoric materials have been recorded there in past cultural resource surveys. Approximately 37 ha (91 ac) would be disturbed at these two potential borrow sites. Impact potential is considered low at the potential Pit 30 borrow site because prehistoric sites are scarce in and around the arid 200 Areas.

Ex Situ Intermediate Separations Alternative

As indicated previously, field investigations have indicated no important archaeological sites at the proposed 200 East Area site for the remediation activities under the Ex Situ Intermediate Separations alternative. Thus, no impacts on prehistoric sites would be expected.

During closure activities, the alternative would disturb land at all three potential borrow sites. The potential for impacts on prehistoric archaeological sites would be similar to those described previously, (i.e., high at the potential Vernita Quarry and McGee Ranch borrow sites and low at the potential Pit 30 borrow site).

Ex Situ No Separations Alternative

The prehistoric archaeological site impact potential during remediation activities would be very low at the proposed 200 East Area waste treatment site and the potential Pit 30 borrow site. During closure activities, there would be a high potential for impacts at the Vernita Quarry and McGee Ranch borrow sites.

Ex Situ Extensive Separations Alternative

The prehistoric archaeological site impact potential during remediation activities would be the same as described for the Ex Situ Intermediate Separations alternative. During closure activities, the same

amount of land disturbance would occur at the primary areas of potential impact (the potential McGee Ranch and Vernita Quarry borrow sites).

Ex Situ/In Situ Combination 1 Alternative

During remediation, this alternative would involve activities at the proposed waste processing site in the 200 East Area and in currently disturbed areas in and around the tank farms. Impact potential would be the same as for the Ex Situ Intermediate Separations alternative. During closure activities, a total of 42 ha (100 ac) of land would be disturbed at the potential McGee Ranch and Vernita Quarry borrow sites.

Ex Situ/In Situ Combination 2 Alternative

During remediation, this alternative would involve activities at the same locations as for the Ex Situ/ In Situ Combination 1 alternative, but would disturb a somewhat smaller total area. Impact potential would be the same as for the Ex Situ Intermediate Separations alternative. During closure activities, a total of 38 ha (94 ac) would be disturbed at the potential McGee Ranch and Vernita Quarry borrow sites.

Phased Implementation Alternative

Phase 1

Past surveys of the proposed Phased Implementation alternative facility sites that would be used during Phase 1 in the 200 East Area revealed no prehistoric materials or sites (Cadoret 1995). Thus, no impacts would be expected. Borrow material used during remediation activities would be obtained from the potential Pit 30 borrow site so there would be a low probability of impacting archaeological sites.

Total Alternative

The Phased Implementation alternative would have the same potential impacts on prehistoric sites as were described for the Ex Situ Intermediate Separations alternative.

5.5.1.2 Capsule Alternatives

The capsule No Action alternative would involve no additional ground disturbance, and therefore no impacts to prehistoric archaeological sites would occur. The Onsite Disposal alternative would involve ground disturbance at a site adjacent to the 200 East Area that is mostly disturbed, and thus no new impacts to archaeological sites are likely. The Overpack and Ship and Vitrify with Tank Waste alternatives would involve using small amounts of land at the waste treatment site in the 200 East Area proposed under the various ex situ alternatives. As described previously, because site surveys revealed no important archaeological sites, no impacts would be expected from these capsule alternatives.

5.5.2 Historic Site Impacts

Except for within the tank farms, there would be no facilities constructed in areas that contained historic structures (i.e., structures that were occupied or used after written records became available) under all tank waste and capsule alternatives. In addition, no new construction activities would occur

adjacent to existing historic buildings or structures. No existing buildings or structures would be modified other than possibly the waste storage tanks and other structures at the tank farms (WHC 1995a, c, e, f, g, h, j, n). Under the In Situ Vitrification and the various ex situ alternatives, facilities within the tank farms (e.g., buildings and water tanks) could be modified or destroyed.

The waste storage tanks could be considered of potential historical importance because they represent activities of the World War II and Cold War periods. Under all alternatives involving ex situ treatment, the waste contents of the tanks would be retrieved by hydraulic or mechanical means or both. Waste retrieval might require modifications to the existing tank structures to allow waste content removal. Under the In Situ Vitrification alternative, the waste tanks would be melted into glass with their waste contents. Typically, contaminated structures of historical value would have their history and use documented but would not be preserved intact. DOE has received an exemption that would allow documenting of only one SST, one DST, and one inactive miscellaneous underground storage tank, rather than documenting each tank individually (DOE 1996e).

The former White Bluffs Freight Road crosses diagonally through the 200 West Area from the northeast to the southwest and would be intersected in two places by the new power transmission corridors under the In Situ Vitrification alternative. What is now known as the White Bluffs Freight Road has been in continuous use since prehistoric times. It has played a role in Euro-American immigration in the nineteenth century, in agriculture, and in Hanford Site operations (Cushing 1994). Nomination of this property to the National Register of Historic Places is pending, and a 100-m (330-ft) easement exists to protect the road from uncontrolled disturbance. However, the road segment that passes through the 200 West Area is not an important element in the National Register nomination largely because it has been disturbed in places by past Hanford Site activities (Cadoret 1995). Affected Tribal Nations indicate that although the White Bluffs Freight Road has been fragmented by past contemporary activities, it remains just as important to the affected Tribes as any other cultural site within the Pasco Basin (CTUIR 1996).

Historic sites have been recorded at the potential McGee Ranch and Vernita Quarry borrow sites. These sites are representative of Euro-American settlement activities from the turn of the century to the 1940's. One structure from the pre-Hanford Site homesteading period is known to exist at the potential Pit 30 borrow site. Impact potential is considered high for historic sites at both the potential McGee Ranch and Vernita Quarry borrow sites. At McGee Ranch, the historic sites are the primary basis for its being judged eligible for nomination to the National Register of Historic Places (Cadoret 1995). The historic structure at the potential Pit 30 borrow site has not yet been evaluated for its historic importance, but the overall historic site impact potential is considered low.

5.5.3 Issues of Potential Concern to Native Americans

As described in Section 4.5, the Hanford Site as a whole has special importance for Native Americans. By treaty, the Hanford Site was ceded by the Confederated Tribes and Bands of the Yakama Indian Nation and Confederated Tribes of the Umatilla Indian Reservation to the United States. There are Native American remains and other specific sites of religious and cultural importance at various

locations around the Hanford Site, approximately 94 percent of which has not been disturbed by past activities and currently is unused. The Native American perspective on resources is different in many ways from the perspective of Euro-Americans (Harper 1995).

Development of the Hanford Site has altered substantially the natural landscape. Buildings have been erected, soil and water has been disturbed, and the distribution of plants and animals has been altered. Environmental cleanup and restoration activities will further alter the visual landscape, disrupt wildlife, and alter plant communities, leaving the Site less natural than it once was. Such changes affect the relationship between the Native Americans and the native lands.

Access to the Hanford Site by Native Americans, as well as all members of the public, has been restricted since the Hanford Site was established as a national defense facility in 1943. However, Tribal Nations have continued to express the desire to access and use Hanford Site areas. The various alternatives would have different long-term impacts on Native American land access and use. However, access to and use of the 200 Areas would be restricted regardless of which EIS alternative is selected because of environmental contamination of areas surrounding the tank farms (e.g., the existing processing facilities).

For remediation activities, the tank waste No Action and Long-Term Management alternatives would leave the tank waste intact in its current location and form indefinitely, thereby restricting access and use of land associated with the tank farms. All other tank waste alternatives also would leave various amounts of residual waste in the tanks but with less potential health hazard than No Action or Long-Term Management. For post-remediation activities associated with the closure scenario, all the alternatives except No Action and Long-Term Management would result in areas covered by the Hanford Barriers that would be restricted from alternative uses and access. To support closure activities, all tank waste alternatives except No Action and Long-Term Management would change the land forms and land uses at the three potential borrow sites (i.e., Vernita Quarry, McGee Ranch, and Pit 30).

During remediation, the In Situ Vitrification alternative would involve additional power transmission corridor development that would limit uses of the corridor during the alternative's construction and operation phases. The Ex Situ Intermediate Separations, Ex Situ Extensive Separations, Phased Implementation (total alternative), and the Ex Situ/In Situ Combination 1 and 2 alternatives would involve permanent onsite disposal of LAW, which would require restricting future use of this area. The Ex Situ No Separations alternative would involve no onsite LAW storage.

The cesium and strontium capsule Onsite Disposal alternative would maintain access restrictions for 100 years for the drywell disposal location. Alternative uses and access would be precluded at least for that time frame. The Overpack and Ship alternative would remove all waste from the Hanford Site, as would the capsule Vitrify with Tank Waste alternative. Consequently, these alternatives would have no impact on future Native American land use or access.

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5.6 SOCIOECONOMICS

The following is a summary of the potential impacts to the socioeconomic environment associated with each of the alternatives. To support a comparison of the relative impacts of each alternative, the impact analysis focused on key indicators of the potentially impacted area including Hanford Site employment and the effects of Site employment levels on employment, population, taxable retail sales, and housing prices in the surrounding area. These impacts are addressed in more detail in Volume Five, Appendix H. Based on the results of the socioeconomic modeling of the key indicators of socioeconomic impacts, analyses of potential impacts to public services and facilities (schools, police and fire protection, medical services, sanitary and solid waste disposal, and electricity, natural gas, and fuel oil) were completed. The socioeconomic analysis did not address the possible economic impacts of TWRS accidents. Impacts resulting from accidents are presented in Section 5.12 and Volume Four, Appendix E. Impacts to the transportation system are addressed separate from this section (Section 5.10).

Socioeconomic Impacts

Impacts addressed in this section include:

- Hanford Site employment (Section 5.6.1.1);
- Tri-Cities area employment (Section 5.6.1.2);
- Taxable retail sales (Section 5.6.1.3);
- Tri-Cities area population (Section 5.6.2.1);
- Tri-Cities area housing prices (Section 5.6.2.2); and
- Impacts on public facilities and services (schools, public safety, etc.) (Section 5.6.3).

All of the tank waste alternatives, except No Action, would create new jobs at the Hanford Site and in the surrounding community. Peak year new employment typically would occur during the construction phase for each alternative with peak construction ranging from 150 jobs under the In Situ Fill and Cap alternative to approximately 6,700 jobs under the Ex Situ Intermediate Separations and Phased Implementation alternatives. For capsule alternatives, peak year employment would range from none under the No Action alternative to 47 under the Overpack and Ship and Vitrify with Tank Waste alternatives. New jobs created under each alternative would have impacts on the Tri-Cities economy based on the number of jobs created. These impacts would include increased total population, retail sales, housing prices, and increased demands for housing and public facilities and services. The level of impacts would be directly related to the level of new jobs created, and in each case, the impacts would be greatest in the years closest to the year of peak employment. A large number of jobs would be created over a short period of time under some of the alternatives, resulting in the Tri-Cities economy experiencing a boom-bust cycle that could adversely impact the local economy.

This socioeconomic analysis was limited to the Richland-Kennewick- Pasco Metropolitan Statistical Area, also known as the Tri-Cities area, which encompasses all of Benton and Franklin counties. The analysis did not address impacts on other areas in the region because there are too few Hanford Site employees in surrounding counties for changes in Hanford Site employment to cause any measurable economic impacts. Historically, Hanford Site employees that live outside Benton and Franklin counties constitute approximately 7 percent of the total Hanford Site labor force (Cushing 1995). Most of these employees live in Yakima County, which has a total nonfarm employment of over 65,000

(WSDES 1993b). Hanford Site employees represent approximately 1 percent of the total Yakima County nonfarm employment. Thus, outside of Benton and Franklin counties, the economic impacts of EIS alternatives would be too small to warrant detailed analysis (Serot 1995a).

The socioeconomic modeling summarized in this section focused on total numbers of jobs and did not address the possible economic effects of differences in wage and salary levels (and thus total Tri-Cities gross income) of new jobs created compared to wages and salaries of jobs lost as Hanford Site employment declines over time. Historically, Hanford Site-related jobs have been higher paying than non-Site jobs in the area, and new jobs created in the Tri-Cities might not match the total income generated by jobs that previously existed at the Hanford Site. The projections of nonfarm employment and population were used to assess the impacts of each alternative on public services and facilities (e.g., schools, police and fire services, and public utilities). Development of the calculational baseline projection and use of the economic forecasting model are described in more detail in Volume Five, Appendix H.

Economic forecasts that attempt to calculate conditions many years into the future are inherently limited in their accuracy. Because of the uncertainties in calculating Federal funding, and thus future employment levels, the economic forecasting model may provide optimistic calculations of several economic indicators. This socioeconomic impact analysis is not a definitive description of the future of the Tri-Cities area. Rather, the information is presented to identify the differences in socioeconomic impacts among the various EIS alternatives. To use the analysis for any other purpose assumes a validity and usefulness not intended.

Employment and Economic Analysis

The analysis addresses for each EIS alternative:

- Hanford Site employment under that alternative;
- The impacts on total nonfarm employment in the Tri-Cities area; and
- The taxable retail sales as a measure of total economic activity.

It concludes with a description of employment impacts by ethnic group.

Currently, the Tri-Cities area is in a transitional period as the Hanford Site, historically the dominant local employer, downsizes. There is as yet limited evidence of how the area's economy will adapt to this change. For example, it is not yet known how successful the ongoing attempts will be to diversify the economy by using the Site's technology and skilled employee base. The Tri-Cities economy of the mid-1990's is considerably larger and more diversified than it was during Site downturns in past decades. This would tend to lessen the overall effect on the Tri-Cities of changes in employment and spending at the Site.

Emerging data indicate that the negative effect to the Tri-Cities economy of the recent declines in Hanford Site employment have been less severe than commonly assumed. For example, average Hanford Site employment in 1995 declined from 18,388 in 1994 to 15,767, a reduction of over 2,600 jobs. Over the same time frame, total nonfarm employment in the Tri-Cities area declined from

73,800 to 72,200, a reduction of 1,600 jobs (Table 4.6.1). Analyses of the Tri-Cities economy based on historical data indicate that each additional job created at the Hanford Site would in turn lead to the creation of more than one additional job locally (i.e., a multiplier effect of more than 2). If this same multiplier worked in reverse, each job lost at the Site should lead to a reduction in total nonfarm employment of two jobs or more. However, the data indicate that this has not occurred, or at least has not yet occurred.

It is too early to determine why Site job losses have not led to greater immediate declines in total Tri-Cities employment, and it would be inappropriate to suggest that the data mean that total Tri-Cities employment is unaffected by Hanford Site job reductions. Future data on total nonfarm employment may show a sharper decline, which could indicate that there is a time lag between Site job reductions and the time when these reductions would be reflected in the data about the Tri-Cities area's economy as a whole. However, it also is possible that because of the increasing diversification of the area's economy, the effects of changes in Site employment on the area's economy may not be as great as in the past, particularly when Site employment declines (i.e., as in 1995), compared to when it increases (i.e., as it did in the early 1990's) (Serot 1996).

If future data indicate that changes in Hanford Site employment have a smaller impact on total nonfarm employment and other socioeconomic aspects of the Tri-Cities area than would result from the 2.4 employment multiplier for Site employment used in this EIS, then the impacts of the TWRS alternatives on total Tri-Cities nonfarm employment, population, taxable retail sales, housing prices, and public services and facilities would be less than estimated in this EIS.

5.6.1 Economy and Employment

The socioeconomic impacts of each TWRS alternative were measured in terms of changes from a baseline projection of economic activity, population, and housing in the Tri-Cities area. The projection assumed the successful completion of the scheduled milestones for Hanford Site cleanup and environmental restoration under the Tri-Party Agreement (Ecology et al. 1994). This baseline projection was developed for impact analysis purposes only and should be considered a calculational baseline. Developing this calculational baseline began with the most current available projection of long-term overall Hanford Site employment including DOE employees, contractors, and major subcontractors (Daly 1995). The overall Hanford Site employment projection included the proposed TWRS activities as defined in the Tri-Party Agreement (Ecology et al. 1994).

The calculational baseline for the EIS socioeconomic impact analysis removed the proposed TWRS component from the overall Hanford Site employment projection. This provided a consistent base from which to add the estimated labor requirements for each TWRS alternative (WHC 1995a, c, e, f, g, h, j, n and Jacobs 1996). Figure 5.6.1 shows the projection of Hanford Site employment including the TWRS program as defined in the Tri-Party Agreement and the calculational baseline used for this socioeconomic analysis. An economic forecasting model then was used to project the effects of the calculational baseline of Hanford Site employment under each alternative on the Tri-Cities area nonfarm employment, taxable retail sales, population, and housing prices.

The current projection of long-term, overall Hanford Site employment showed a decline from a peak of about 19,000 in 1994 to 15,000 in 1996 (Daly 1995). From 1996 to 2001, the current projection showed staffing at 15,000. From 2001 to 2030, the projection showed a steady decline in employment, reaching a level of 8,000 by 2030. For this analysis, the same rate of decline was continued through 2040, which was the end of the forecast period for the EIS socioeconomic impact analysis.
Figure 5.6.2 shows the current Hanford Site employment projection and a projection of Tri-Cities area nonfarm employment based on that forecast of Hanford Site employment.

Recent data show that the Site employment in mid-1996 was 14,100, which was lower than the 15,000 that was used in the EIS baseline forecast for this year. However, because the same future baseline forecast was used to assess the impacts of all TWRS alternatives on Tri-Cites total nonfarm employment, population, taxable retail sales, and housing prices, the comparison of impacts among the TWRS alternatives would yield the same relative results. This means that the alternatives with the largest impacts on Site employment, total nonfarm employment, and population would still have the largest impacts even if a new baseline Site employment forecast were used. Likewise, the alternatives with the smallest impacts on local socioeconomic conditions under the previous baseline forecast would have the smallest impacts under a new baseline forecast.

Revisions in the descriptions and schedules of the TWRS alternatives have occurred since the Draft EIS was published. However, for all alternatives except Phase 2 of Phased Implementation, the changes would have less than a 5 percent effect on the alternative's employment levels. The modeling analysis of the Phased Implementation (Total alternative) has been revised to reflect the revised employment estimates. No additional modeling has been performed for the other alternatives for the Final EIS.

The Final EIS also includes the Ex Situ/In Situ Combination 2 alternative, which was not analyzed in detail in the Draft EIS. Although estimates of peak employment were developed for this alternative, detailed year-by-year employment data were not available, and thus no socioeconomic impact modeling was performed. The discussions in Section 5.6 of the Ex Situ/In Situ Combination 2 alternative's impacts on Tri-Cities total nonfarm employment, population, taxable retail sales, housing prices, and public services and facilities were scaled from the impact analyses of other TWRS alternatives with similar employment levels.

The projection of Tri-Cities nonfarm employment showed a decline from 1994 to 1996, then an increasing trend. The increase in regional employment at the same time as Hanford Site employment declines reflects the experience in the Tri-Cities following the shut-down of Hanford Site plutonium production operations in 1988 (Section 4.6). The projection showed an approximately 33 percent increase in nonfarm employment between its lowest point in 1996 and the year 2040. Agriculture and food processing would remain important factors in the local economy, as would the role of the Tri-Cities as a regional retail center and transportation hub.

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Figure 5.6.1 Current Hanford Site Employment and Calculation Baseline, 1994 to 2040

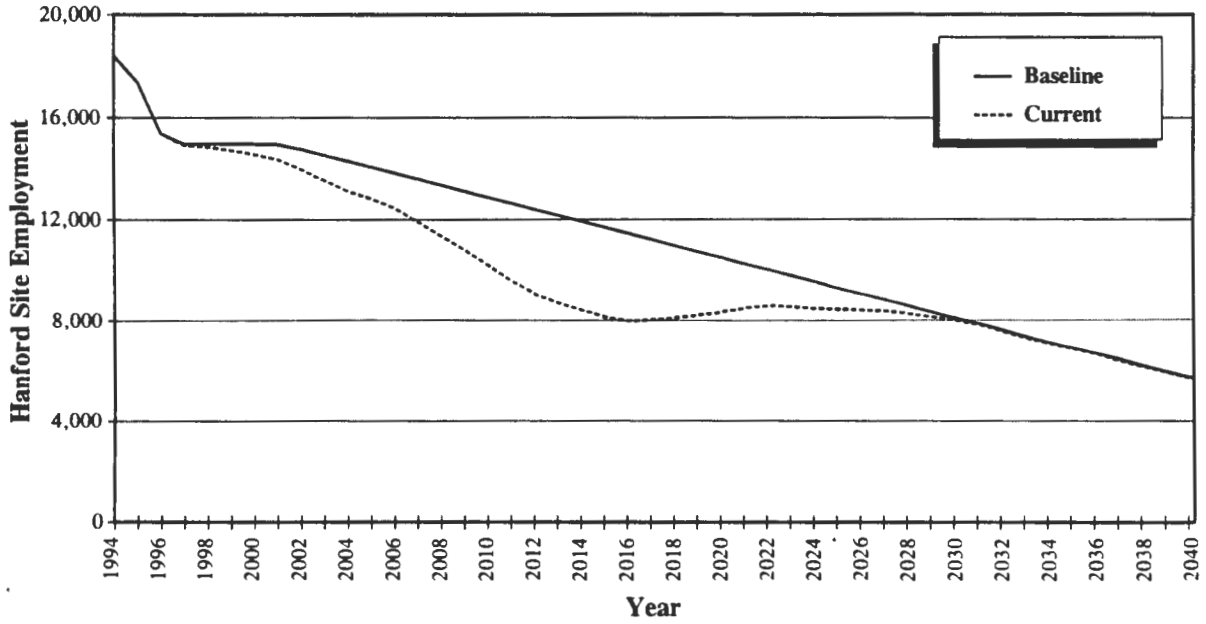
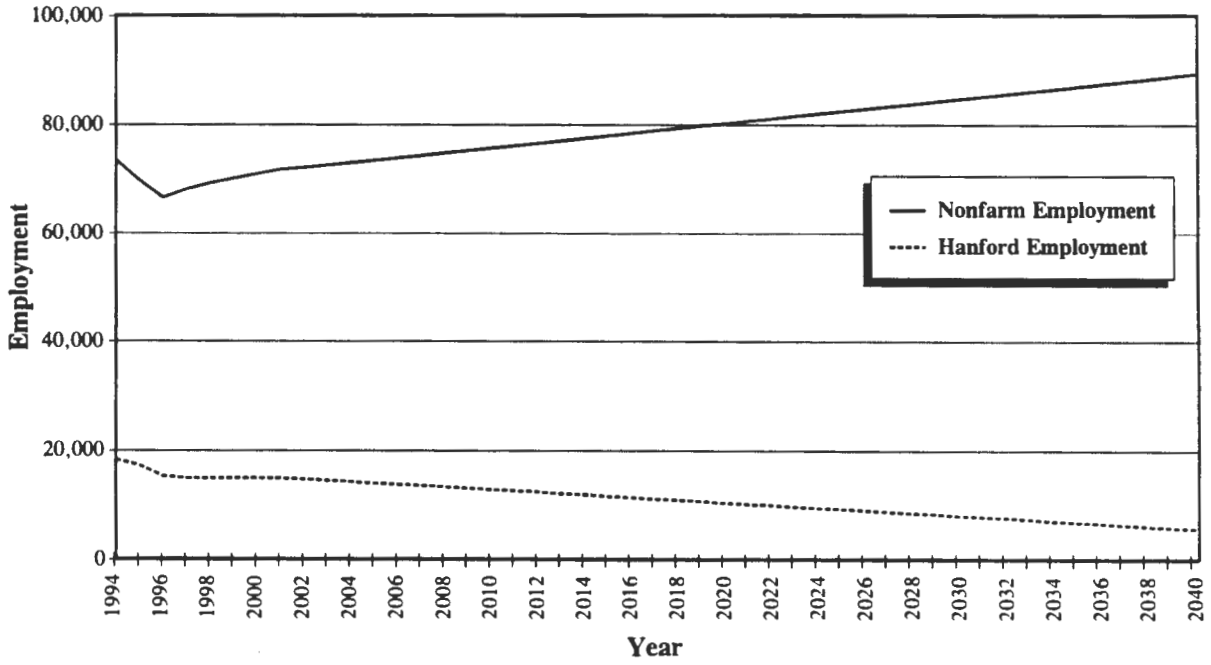


Figure 5.6.2 Current Hanford Site Employment Projection and Current Nonfarm Employment Projection for the Tri-Cities Metropolitan Statistical Area, 1994-2040



The current projection of long-term, overall Hanford Site employment showed a decline from a peak of about 19,000 in 1994 to 15,000 in 1996 (Daly 1995). From 1996 to 2001, the current projection showed staffing at 15,000. From 2001 to 2030, the projection showed a steady decline in employment, reaching a level of 8,000 by 2030. For this analysis, the same rate of decline was continued through 2040, which was the end of the forecast period for the EIS socioeconomic impact analysis. Figure 5.6.2 shows the current Hanford Site employment projection and a projection of Tri-Cities area nonfarm employment based on that forecast of Hanford Site employment.

As described previously, the calculational baseline used to analyze and compare the socioeconomic impacts of the TWRS EIS alternatives reflects these same underlying trends except that the baseline excludes TWRS remediation. As a result, the economy showed slower growth for the period 1997 to 2030, which would be the primary period of TWRS activities. After 2030, however, the calculational baseline projection for the Tri-Cities area employment merged into the current projection.

The four capsule alternatives, No Action, Onsite Disposal, Overpack and Ship, and Vitrify with Tank Waste, are not described in detail because their potential socioeconomic impacts would be small. The capsules No Action alternative showed a peak labor requirement of 10 full-time equivalent employees per year. The Onsite Disposal alternative showed a peak labor requirement of 28 full-time equivalent employees per year. The Overpack and Ship and Vitrify with Tank Waste alternatives both showed a peak labor requirement of 47 full-time equivalent employees per year (WHC 1995n). These staffing levels were too small to have any measurable effect on economic conditions in the Tri-Cities and are not described further in this section.

5.6.1.1 Hanford Site Employment

Figures 5.6.3, 5.6.4, and 5.6.5 and Tables 5.6.1, 5.6.2, and 5.6.3 present total Hanford Site employment for the calculational baseline projection and each of the tank waste alternatives. All of the tank waste alternatives, except No Action and Long-Term Management, included employment estimates associated with the closure scenario. In all cases, closure-related employment would represent a small fraction of the total Hanford Site employment (less than 2 percent). Typically, closure activities would begin during the final phases of remediation activities. For all alternatives involving closure, peak employment impacts would occur during the construction and remediation phases of the alternative, and therefore closure employment would not appreciably affect the impacts described in the remainder of this section. The following text summarizes the impacts of each tank waste alternative on Hanford Site employment.

No Action Alternative (Tank Waste)

Under the No Action alternative, routine operations would be maintained at approximately their current level with approximately 1,000 employees during the 100-year institutional control period. Hanford Site employment under this alternative would begin to diverge from and exceed the baseline in 2006 because routine tank farm operations would begin to decline at that time in the calculational baseline. By 2030, when routine operations were fully phased out in the baseline, the No Action alternative would have about 1,000 employees more than the baseline.

Figure 5.6.3 Hanford Site Employment Baseline, No Action, Long-Term Management, and In Situ Fill and Cap Alternatives for Selected Years

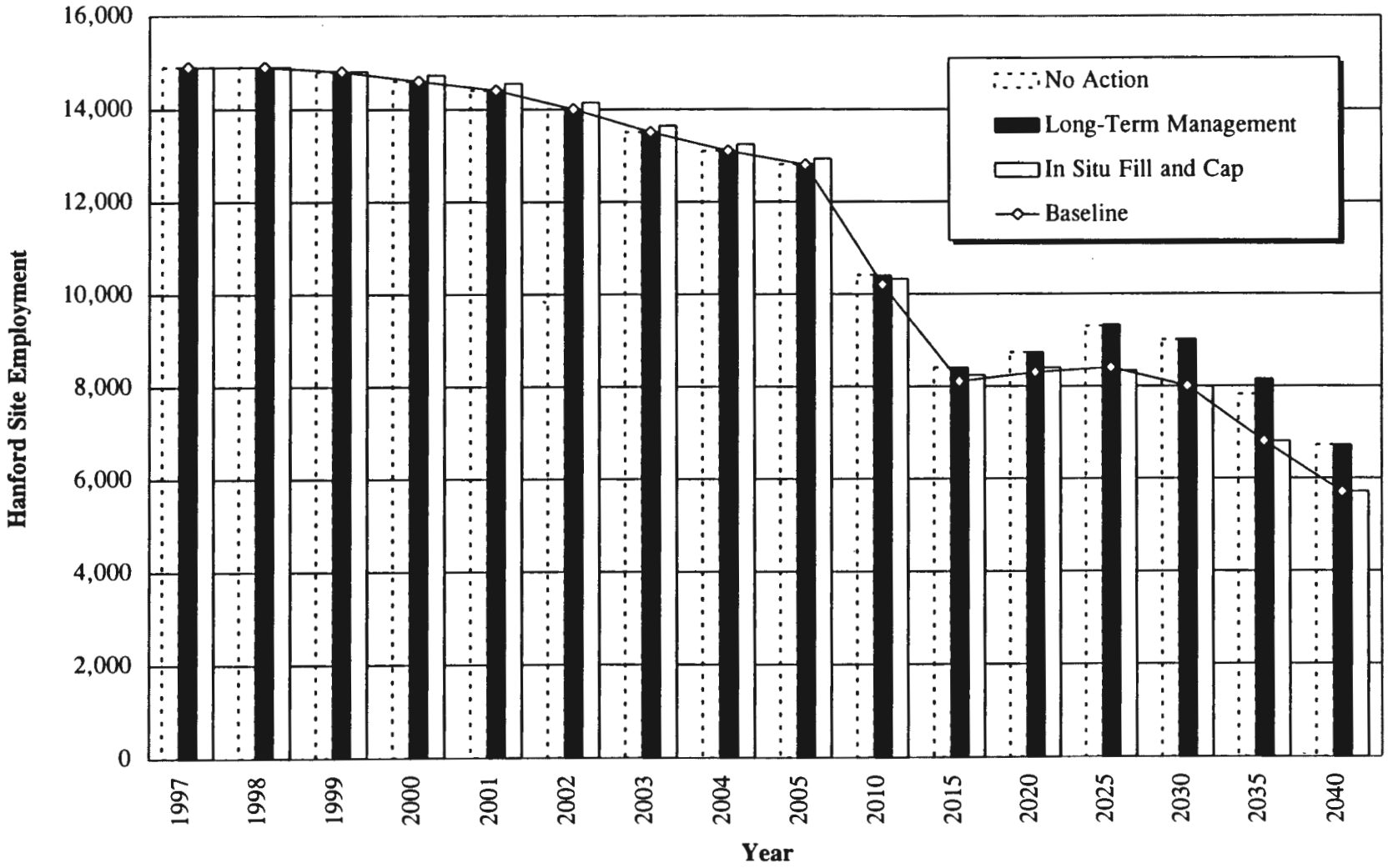


Figure 5.6.4 Hanford Site Employment Baseline, In Situ Vitrification, Ex Situ Intermediate Separations, and Ex Situ No Separations Alternatives for Selected Years

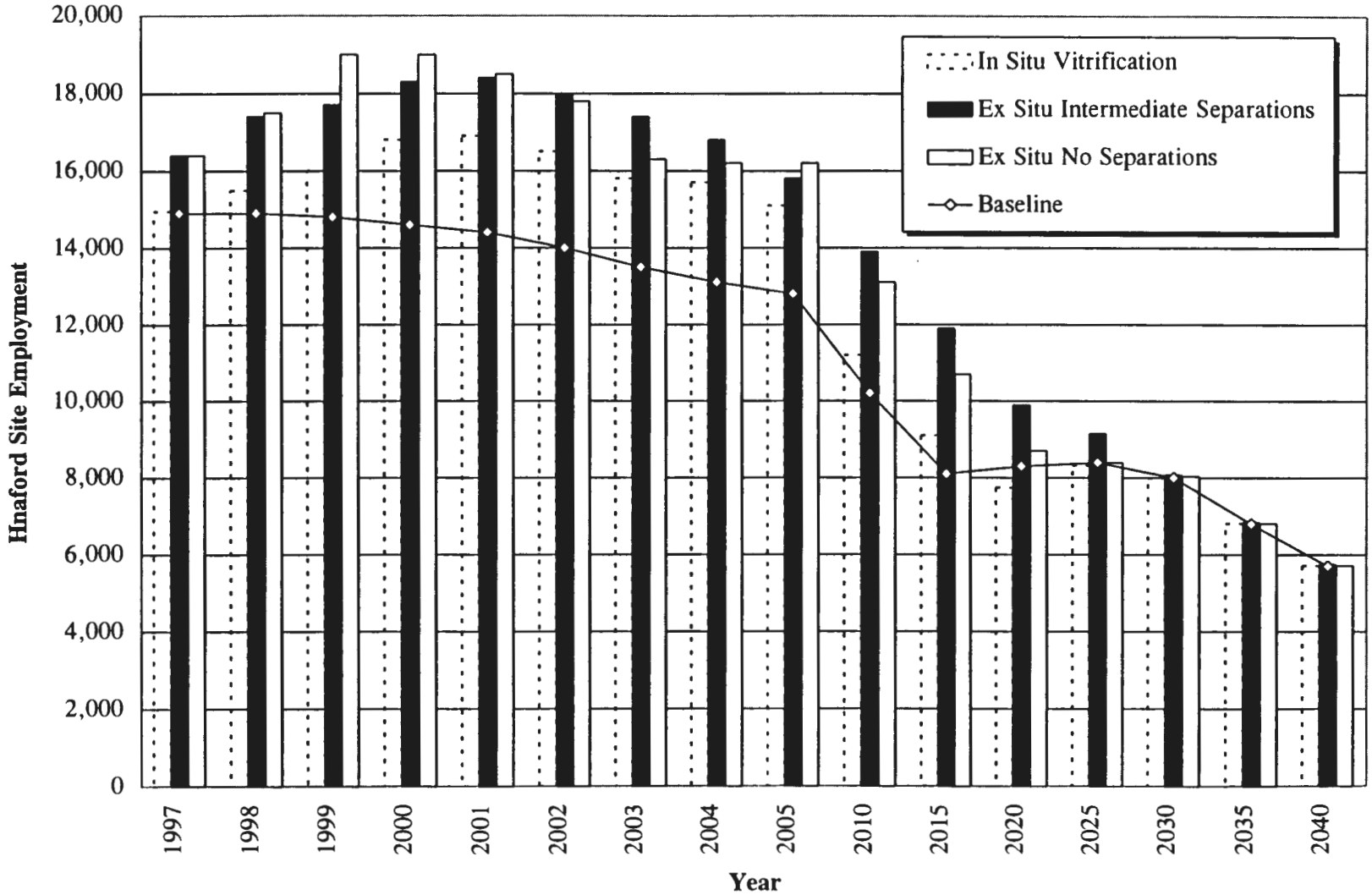
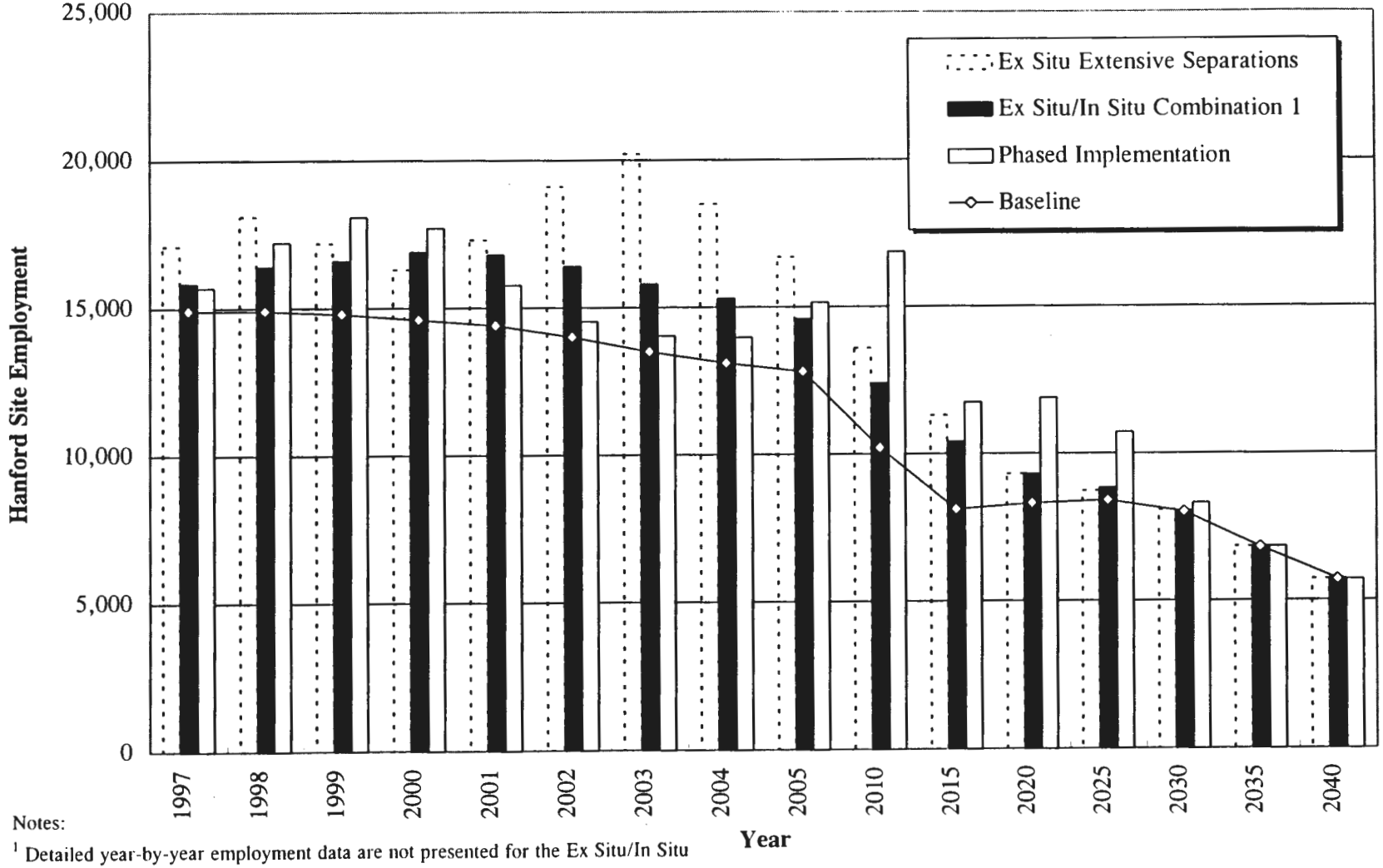


Figure 5.6.5 Hanford Site Employment Baseline, Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1, and Phased Implementation Alternatives for Selected Years [1]



Notes:

[1] Detailed year-by-year employment data are not presented for the Ex Situ/In Situ Combination 2 alternative in figures and tables. However, the text presents peak impacts calculated for the alternative.

Table 5.6.1 Hanford Site Employment Changes from the Baseline for Selected Years with No Action, Long-Term Management, and In Situ and Fill and Cap Alternatives

Year	Baseline Level	No Action [1,2]		Long-Term Management [3]		In Situ Fill and Cap [4]	
		Change	% Change	Change	% Change	Change	% Change
1997	14,900	0	0.0	0	0.0	0	0.0
1998	14,900	0	0.0	0	0.0	0	0.0
1999	14,800	0	0.0	0	0.0	10	0.1
2000	14,600	0	0.0	0	0.0	130	0.9
2001	14,400	0	0.0	0	0.0	150	1.0
2002	14,000	0	0.0	0	0.0	140	1.0
2003	13,500	0	0.0	0	0.0	140	1.0
2004	13,100	0	0.0	0	0.0	140	1.0
2005	12,800	10	0.0	10	0.0	130	1.0
2010	10,200	210	2.1	200	2.1	130	1.2
2015	8,100	300	3.7	300	3.7	140	1.7
2020	8,300	430	5.1	430	5.1	100	1.2
2025	8,400	930	11.1	930	11.1	-60	-0.7
2030	8,000	1,000	12.6	1,010	12.7	-10	-0.1
2035	6,800	1,020	14.8	1,350	19.8	10	0.1
2040	5,700	1,020	18.0	1,020	18.0	10	0.1

Notes:
[1] Under the No Action and Long-Term Management alternatives, employment would be expected to continue at their year 2040 levels until approximately 2095.
[2] Under the No Action and Long-Term Management alternatives, employment increases for routine operations are included because under the Tri-Party Agreement TWRS estimate, routine operations begin to phase out from 2005 through 2029. The new employees included would maintain routine operations employment at approximately 1,000.
[3] In the 2080's there would be another retanking campaign under the Long-Term Management alternative that would increase employment by about 350 jobs for a several-year period.
[4] Negative employment results from an earlier phase out of routine tanks from operations than was planned in the Tri-Party Agreement-based estimates of Site employment.

Long-Term Management Alternative

In terms of Site employment, the Long-Term Management alternative would be the same as the No Action alternative, except that replacement DSTs would be constructed between the years 2031 and 2037. Constructing the new tanks would add approximately 350 additional employees to the level of employment shown for the No Action alternative. This would be about 1,350 more employees than in the baseline during the 2030's.

In Situ Fill and Cap Alternative

Employment under this alternative would peak at 150 workers in 2001 during remediation activities and continue at nearly that level until 2012 when the remediation phase would end. For closure activities under the In Situ Fill and Cap alternative, employment would never exceed 150 jobs in any single year and would have a maximum impact on Hanford Site employment of less than 2 percent.

Table 5.6.2 Hanford Site Employment Changes from the Baseline for Selected Years with In Situ Vitrification, Ex Situ Intermediate Separations, and Ex Situ No Separations Alternatives

Year	Baseline Level	In Situ Vitrification		Ex Situ Intermediate Separations		Ex Situ No Separations	
		Change [1]	% Change	Change	% Change	Change	% Change
1997	14,900	50	0.3	1,500	10.2	1,500	9.7
1998	14,900	590	4.0	2,500	17.1	2,600	17.8
1999	14,800	1,200	8.3	2,900	19.7	4,200	28.2
2000	14,600	2,200	15.0	3,700	25.7	4,400	30.3
2001	14,400	2,500	17.2	4,000	28.1	4,100	28.7
2002	14,000	2,500	17.7	4,000	29.0	3,800	27.1
2003	13,500	2,300	17.1	3,900	28.8	2,800	21.0
2004	13,100	2,600	19.4	3,700	28.1	3,100	23.8
2005	12,800	2,300	17.8	3,000	23.3	3,400	26.6
2010	10,200	1,000	10.3	3,700	36.4	2,900	28.6
2015	8,100	1,000	11.9	3,800	47.2	2,600	32.4
2020	8,300	-560	-6.7	1,600	19.5	410	5.0
2025	8,400	-80	-0.9	760	9.1	0	0.0
2030	8,000	-10	-0.1	70	0.9	40	0.5
2035	6,800	10	0.1	40	0.6	10	0.1
2040	5,700	10	0.1	50	0.8	10	0.2

Notes:
[1] Negative employment results from an earlier phase out of routine tank farm operations than was planned in the Tri-Party Agreement-based estimate of Hanford Site employment.

In Situ Vitrification Alternative

Under the In Situ Vitrification alternative, the greatest onsite employment impact would occur during remediation in 2004, when there would be 2,600 more workers employed at the Hanford Site or about 19 percent more workers above the baseline level. When the remediation phase ended in 2016, employment under this alternative would be below 1,000 workers. Closure activities would begin in 2016 and end in 2020. The year 2020 shows a reduction in Hanford Site employment that would be below the baseline level. This would be caused by the faster phase-out of routine tank farm operations compared to the baseline because routine operations would cease when all waste in a given tank farm was vitrified. The in situ vitrification activities, including closure, would be completed by 2033 except for monitoring and maintenance.

Ex Situ Intermediate Separations Alternative

The Ex Situ Intermediate Separations alternative would have its greatest impact on Hanford Site employment during the remediation phase of the alternative in 2002, when total Site employment was estimated to be about 4,000 above the calculational baseline; a 29 percent increase. These initial increases would result from construction employment. There would be a second increase in employment in 2009 when full waste processing would begin.

Table 5.6.3 Hanford Site Employment Changes from the Baseline for Selected Years with Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1, and Phased Implementation Alternatives [1]

Year	Baseline Level	Ex Situ Extensive Separations		Ex Situ/In Situ Combination 1		Phased Implementation (Total Alternative)	
		Change	% Change	Change	% Change	Change	% Change
1997	14,900	2,200	15.0	930	6.2	790	5.3
1998	14,900	3,200	21.5	1,500	10.4	2,300	15.6
1999	14,800	2,400	16.2	1,800	12.0	3,300	22.1
2000	14,600	1,700	11.3	2,300	15.6	3,100	21.3
2001	14,400	2,900	20.1	2,500	17.0	1,400	9.5
2002	14,000	5,100	36.3	2,400	17.5	540	3.9
2003	13,500	6,700	49.5	2,300	17.3	540	4.0
2004	13,100	5,400	41.3	2,200	16.9	870	6.6
2005	12,800	3,900	30.8	1,800	13.9	2,400	18.4
2010	10,200	3,400	33.2	2,200	21.4	6,700	65.4
2015	8,100	3,500	43.3	2,300	27.8	3,700	45.6
2020	8,300	1,200	14.3	1,000	11.5	3,600	43.1
2025	8,400	350	4.2	420	5.0	2,300	27.6
2030	8,000	70	0.9	40	0.5	310	3.9
2035	6,800	20	0.2	30	0.4	20	0.3
2040	5,700	10	0.2	30	0.5	10	0.2

Notes:
[1] Detailed year-by-year employment data are not presented for the Ex Situ/In Situ Combination 2 alternative. However, the text presents peak impacts for the alternative.

The greatest percentage change would occur in 2015, where the percentage change would be 47 percent and when the alternative's total employment would be about 3,800. The greater percentage change in 2015 would be caused by the decline in overall Hanford Site employment in the calculational baseline scenario, which would make the smaller number of TWRS employees a larger percentage of the baseline. This same paradox of large percentage would impact in later years, because TWRS employment would impact a smaller base of total Hanford Site employment, which would apply to the Ex Situ No Separations and Ex Situ Extensive Separations alternatives as well.

Overall employment under the alternative would decline substantially from 2015 to 2024 as remedial construction and waste processing began to phase out. Remediation would end in 2028. Closure activities would begin in 2010 and end in 2034. During the early phase of closure, less than 5 percent of the workers would result from closure activities, and the highest level of employment would reach 90 workers in 2031.

Ex Situ No Separations Alternative

Analysis of the Ex Situ No Separations alternative showed a substantial increase in Hanford Site employment compared to the calculational baseline between 1996 and about 2018. There would be an employment spike (a short-term increase that dropped off rapidly after the peak year) between 1996 and 2003 because of construction employment. The largest impact under this alternative would occur during construction in 2000, when there would be over 4,400 more Hanford Site employees than in the baseline, a difference of approximately 30 percent. Remediation would end in 2017. Closure activities would have a peak employment of 510 in 2018.

Ex Situ Extensive Separations Alternative

The Ex Situ Extensive Separations alternative shows an initial spike in Hanford Site employment in 1998, then a second, larger spike that would peak in 2003. Both of these spikes would be attributable to construction employment. The largest percentage impact of the alternative would occur in 2003 during construction, when Hanford Site employment would be almost 50 percent above the calculational baseline, a difference of approximately 6,700 jobs. The 1998 and 2003 spikes in the projections of Hanford Site employment under this alternative would result in a boom-bust pattern that could have adverse impacts on the local economy and public services. Remedial activities would end in 2024, with closure activities beginning in 2010, and would end in 2030. Peak closure-related employment would be 370 jobs in 2023.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, Hanford Site employment would peak at about 16,800 employees in 2001, which would be 17.0 percent higher than the calculational baseline. Employment would remain at about 17 percent (more than 2,200 employees) above the baseline through 2004. Activities under this alternative would contribute approximately 2,000 employees to the total Hanford Site workforce until 2018. Remediation activities would end in 2023 with closure beginning in 2010 and ending in 2034. Peak employment during closure would reach 390 employees in 2024.

Ex Situ/In Situ Combination 2 Alternative

Employment under this alternative would peak in 2001 with total Hanford Site employment of approximately 16,600, which would be 15.3 percent higher than the calculational baseline. From the years 2009 to 2018, during the alternative's peak operations phase, the Ex Situ/In Situ Combination 2 alternative would add approximately 750 workers to the Site's workforce.

Phased Implementation Alternative

Phase 1

The Phased Implementation alternative was analyzed in two parts. Part one analyzed Phase 1 of the Phased Implementation alternative and part two analyzed the total Phased Implementation alternative.

The Phased Implementation alternative would cause a large increase in Hanford Site employment compared to the calculational baseline between 1997 and 2001. This increase would result from constructing the waste treatment facilities associated with the alternative. During the alternative's

operation phase, Site employment would exceed the baseline by approximately 4 to 5 percent or about 550 workers. There would be no impacts after 2013 because all activities, including decommissioning and decontamination, would have been completed.

Total Alternative

Hanford Site employment for the Phased Implementation alternative would include the employment discussed for Phase 1 of the alternative through 2003 and Phase 2, which would start in 2004. Construction of the Phase 2 treatment facilities would begin in 2005. The additional Hanford Site employment in the Phased Implementation total alternative would peak in 2010, with about 6,700 additional workers, which would be an approximate 65 percent increase over the calculational baseline. Site employment would remain over 40 percent above the baseline during the period of full-scale operations. Operations would begin to decline in 2024, followed by a period of decommissioning and decontamination activities ending about 2030. Closure and management and maintenance activities would continue through 2040, accounting for a small continued increase in employment above the baseline. Employment associated with closure would peak in 2023 at about 1,600 jobs.

5.6.1.2 Tri-Cities Area Employment

Changes in Hanford Site employment would be the primary source of socioeconomic impacts on the Tri-Cities for all the tank waste alternatives. These impacts would be driven by the changes in the area's nonfarm employment caused by changes in Site employment. Nonfarm employment included all employment in the Tri-Cities except for permanent and migratory farm workers. Nonfarm employment included food processing, which is classified in government statistics as a type of manufacturing. Farm workers were excluded from the impact analysis because farm employment would not be affected by Hanford Site employment.

Tables 5.6.4, 5.6.5, and 5.6.6 show Tri-Cities nonfarm employment for each tank waste alternative for the years 1994 through 2040. The following text summarizes the potential impacts of each tank waste alternative on Tri-Cities nonfarm employment.

No Action Alternative (Tank Waste)

Under the No Action alternative, Tri-Cities area nonfarm employment would track the baseline through 2005, then increase through the end of the forecast period in 2040. This reflects the continuation of routine operations at the tank farms under the No Action alternative. By 2040, Hanford Site employment would be about 1,000 employees above the baseline, which would translate to a 2 percent increase (1,600 jobs) in nonfarm employment in the local economy.

Long-Term Management Alternative

Under this alternative, Hanford Site employment would be the same as the No Action alternative until 2031, when replacement DSTs tanks would be constructed. The new tank construction would increase Site employment, which would result in an increase of about 2.5 percent (2,200 jobs) in local employment during the tank construction period. By the year 2040, however, when the retanking was

Table 5.6.4 Nonfarm Employment in the Tri-Cities - Changes from the Baseline for Selected Years with No Action, Long-Term Management, and In Situ Fill and Cap Alternatives

Year	Baseline Level [2]	No Action [1]		Long-Term Management [1]		In Situ Fill and Cap	
		Change	% Change	Change	% Change	Change	% Change
1997	68,000	0	0.0	0	0.0	0	0.0
1998	69,100	0	0.0	0	0.0	0	0.0
1999	69,700	0	0.0	0	0.0	30	0.0
2000	70,200	0	0.0	0	0.0	320	0.5
2001	70,700	0	0.0	0	0.0	250	0.3
2002	70,700	0	0.0	0	0.0	220	0.3
2003	70,800	0	0.0	0	0.0	220	0.3
2004	71,000	0	0.0	0	0.0	220	0.3
2005	71,400	10	0.0	10	0.0	220	0.3
2010	71,200	350	0.5	350	0.5	220	0.3
2015	72,300	510	0.7	510	0.7	240	0.3
2020	77,200	710	0.9	710	0.9	150	0.2
2025	81,400	1,600	2.0	1,600	2.0	-160 [3]	-0.2
2030	84,700	1,700	1.9	1,700	2.0	20	0.0
2035	87,000	1,600	1.9	2,200	2.5	10	0.0
2040	89,300	1,600	1.8	1,600	1.8	10	0.0

Notes:
[1] Both the No Action and Long-Term Management alternatives would have nonfarm employment impacts that would last beyond the year 2040. Routine operations of the tank farms would continue at approximately their 2040 levels until approximately 2095.
[2] For each alternative, a flat (no growth) baseline employment projection would substantially alter the impacts of the alternatives on Hanford Site and Tri-Cities Area employment, as well as taxable retail sales, area population, housing prices, and demand for local services and facilities.
[3] Negative employment results from an earlier phase out of routine tank farm operations than was planned in the Tri-Party Agreement-based estimate of Hanford Site employment.

completed, Tri-Cities nonfarm employment would fall back to the same level as in the No Action alternative.

In Situ Fill and Cap Alternative

Under the In Situ Fill and Cap alternative, nonfarm employment impacts would peak in the year 2000 at approximately 320 jobs over the baseline, a difference of 0.5 percent. Nonfarm employment would stay slightly over the baseline until 2020.

Ex Situ No Separations Alternative

The impacts of the No Separations alternative on area nonfarm employment would peak in 1999 and 2000, when employment would be 10 to over 11 percent higher (over 7,400 jobs) than the calculational baseline. The higher employment would fall off by 2003, then peak again in 2005 at 8 percent (5,700 jobs) above the baseline. By 2020, nonfarm employment impacts of the alternative would correspond to the baseline.

Table 5.6.5 Nonfarm Employment in the Tri-Cities - Changes from the Baseline for Selected Years with In Situ Vitrification, Ex Situ Intermediate Separations, and Ex Situ No Separations Alternatives

Year	Baseline Level	In Situ Vitrification		Ex Situ Intermediate Separations		Ex Situ No Separations	
		Change [1]	% Change	Change	% Change	Change	% Change
1997	68,000	120	0.2	3,000	4.5	3,400	5.0
1998	69,100	1,400	2.0	4,900	7.1	5,300	7.6
1999	69,700	2,500	3.6	5,000	7.2	8,000	11.5
2000	70,200	4,300	6.2	6,700	9.6	7,400	10.5
2001	70,700	4,200	6.0	6,800	9.6	6,400	9.1
2002	70,700	4,000	5.7	6,600	9.3	5,800	8.3
2003	70,800	3,600	5.1	6,200	8.7	3,800	5.4
2004	71,000	4,300	6.1	5,800	8.2	5,300	7.4
2005	71,400	3,400	4.8	4,200	6.0	5,700	8.0
2010	71,200	1,500	2.2	6,300	8.8	4,700	6.6
2015	72,300	1,600	2.2	6,100	8.5	4,200	5.8
2020	77,200	-1,100	-1.4	2,300	3.0	530	0.7
2025	81,400	-40	-0.1	1,000	1.2	-10	0.0
2030	84,700	20	0.0	130	0.2	110	0.1
2035	87,000	10	0.0	80	0.1	10	0.0
2040	89,300	10	0.0	70	0.1	10	0.0

Notes:
[1] Negative employment results from an earlier phase out of routine tank farm operations than was planned in the Tri-Party Agreement-based estimate of Hanford Site employment.

In Situ Vitrification Alternative

For the In Situ Vitrification alternative, a large increase in area nonfarm employment would occur from 2000 to 2007. Employment then would decline relative to the calculational baseline. By 2017, nonfarm employment with this alternative would fall below the baseline and remain below the baseline through 2029. This would reflect lower Hanford Site employment under the In Situ Vitrification alternative caused by the faster phase-out of routine tank farm operations compared to the baseline. In the peak impact year (2000), there would be over 4,300 more nonfarm jobs compared to the calculational baseline, an increase of approximately 6.2 percent.

Ex Situ Intermediate Separations Alternative

The Ex Situ Intermediate Separations alternative would result in nonfarm employment above the calculational baseline from 1996 through 2030. Implementing this alternative would result in two large increases in employment compared to the baseline. The first, with a peak in 2000, would occur when the alternative's employment peaked during the construction of the waste retrieval and treatment facilities. At this peak, there would be about 6,700 more jobs, an increase of 9.6 percent over the baseline. The second increase, beginning about 2009, would occur during the peak of the alternative's operation phase when employment would be about 6,300, or 8.8 percent over the baseline.

Table 5.6.6 Nonfarm Employment in the Tri-Cities - Changes from the Baseline for Selected Years with Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1, and Phased Implementation Alternatives

Year	Baseline Level	Ex Situ Extensive Separations		Ex Situ/In Situ Combination 1		Phased Implementation (Total Alternative)	
		Change	% Change	Change	% Change	Change	% Change
1997	68,000	4,800	7.1	1,900	2.7	2,000	3.0
1998	69,100	5,900	8.6	3,000	4.3	4,800	7.0
1999	69,700	3,200	4.6	3,000	4.4	5,900	8.4
2000	70,200	2,100	2.9	4,100	5.8	4,600	6.6
2001	70,700	5,700	8.1	4,100	5.8	1,100	1.5
2002	70,700	10,000	14.1	3,900	5.6	300	0.4
2003	70,800	12,200	17.2	3,700	5.2	900	1.2
2004	71,000	7,700	10.9	3,500	4.9	1,900	2.7
2005	71,400	5,200	7.2	2,500	3.5	4,900	6.9
2010	71,200	5,800	8.2	3,700	5.2	11,000	15.4
2015	72,300	5,600	7.8	3,600	5.0	5,900	8.1
2020	77,200	1,700	2.2	1,400	1.8	5,700	7.4
2025	81,400	240	0.3	490	0.6	3,200	3.9
2030	84,700	130	0.1	90	0.1	200	0.3
2035	87,000	10	0.0	50	0.1	0	0.0
2040	89,300	20	0.0	50	0.1	0	0.0

Ex Situ Extensive Separations Alternative

Analysis of the Ex Situ Extensive Separations alternative showed a spike in nonfarm employment compared to the calculational baseline in 1997 and 1998. In 1998, there would be 8.6 percent (5,900 jobs) more nonfarm jobs in the area than would exist for the baseline conditions. By 2000, the level of increase in nonfarm jobs would fall to 2.9 percent over the baseline. Nonfarm employment then would spike again compared to the baseline, peaking at 17.2 (12,200 jobs) percent above the baseline in 2003. Employment then would begin to fall back to the baseline, and by 2020 would be only 2.2 percent higher than the baseline.

Ex Situ/In Situ Combination 1 Alternative

This alternative would have its greatest impacts on Tri-Cities nonfarm employment in 2000 and 2001, when nonfarm employment would be 5.8 percent (4,100 jobs) above the calculational baseline. Tri-Cities nonfarm employment under this alternative would remain above the baseline through 2030.

Ex Situ/In Situ Combination 2 Alternative

This alternative would be expected to have its peak impacts on total nonfarm employment in approximately 2001. In that year, nonfarm employment would be about 5.1 percent (3,600 jobs) higher than the calculational baseline. Tri-Cities nonfarm employment would remain above the baseline until about 2030.

Phased Implementation Alternative

Phase 1

The peak impact on Tri-Cities employment under this alternative would occur in 1999, when area employment would be 8.4 percent (5,900 jobs) above the calculational baseline. There would be a dip in employment in 2002 after the completion of the construction phase, caused by the loss of several thousand construction jobs.

Total Alternative

The employment impacts on the Tri-Cities showed two peaks for the total Phased Implementation alternative. Employment under the total alternative tracked the impacts of Phase 1 through 2003, with a peak of more than 8 percent in 1999. Beginning in 2004, the increased Hanford Site employment under the Phased Implementation total alternative would result in a second increase in area employment. The maximum impact would occur in 2010, with a 15.4 percent increase in employment over the calculational baseline, or about 11,000 additional jobs. Employment would remain well above the baseline through 2025, then converge to the calculational baseline over the next 5 years as the Phased Implementation alternative was completed and decommissioning and decontamination and closure activities was finished.

5.6.1.3 Taxable Retail Sales

Taxable retail sales are an important indicator of economic impacts. The data on taxable retail sales used in this analysis, as reported by Washington State, included services, building contracting, manufacturing, wholesaling, and other industries in addition to sales by retail stores. These data are representative of aggregate economic activity in the Tri-Cities area.

Table 5.6.7 shows the taxable retail sales impacts of the various alternatives. For all tank waste alternatives except No Action, Long-Term Management, and In Situ Fill and Cap, there would be a large increase in taxable retail sales from current levels between 1999 and 2040. This result would be consistent with the experience in the Tri-Cities during the economic downturn of 1988 and 1989, when retail sales continued to increase despite employment reductions at the Hanford Site (Section 4.5). The projected retail sales growth would be equivalent to an approximate 3.5 percent average annual rate of growth from current levels. However, the data used to estimate the forecasting equation for retail sales were not corrected for inflation so that much of the apparent growth in retail sales could be accounted for by inflation.

One important implication of the increase in taxable retail sales would be that cities and counties would receive increased revenues from their share of sales taxes. Increases in sales tax revenues from higher employment would help finance the increased services needed for the increased population that would follow increased employment. Population impacts are described in Section 5.6.1.2.

The maximum impact under the tank waste No Action alternative would occur between 2025 and 2035 when taxable sales would be approximately 0.6 percent above the baseline. The largest impact under the Long-Term Management alternative would occur in 2035, when sales would be approximately

Table 5.6.7 Taxable Retail Sales in the Tri-Cities - Changes from the Baseline for Selected Years

Year	Baseline Level	No Action	Long-Term Management	In Situ Fill and Cap	In Situ Vitrification	Ex Situ Intermediate Separations	Ex Situ No Separations	Ex Situ Extensive Separations	Ex Situ/ In Situ Combination 1	Phased Implementation (Total Alternative)
		Percentage Change								
1997	750	0.0	0.0	0.0	0.0	2.3	0.3	2.1	1.4	0.2
2000	980	0.0	0.0	0.0	2.6	6.1	8.7	5.0	3.7	6.7
2002	1,100	0.0	0.0	0.3	4.5	7.3	7.5	5.2	4.4	2.6
2004	1,300	0.0	0.0	0.2 [1]	3.7	6.3	4.6	10.8	3.8	0.9
2005	1,400	0.0	0.0	0.2 [1]	3.9	5.6	4.7	8.2	3.4	1.5
2010	1,700	0.2 [1]	0.2 [1]	0.1 [1]	1.5	4.0	3.5	3.6	2.4	7.4
2015	2,100	0.3	0.3	0.1 [1]	1.0	3.9	2.7	3.6	2.3	3.6
2020	2,500	0.3	0.3	0.1 [1]	-0.3	1.6	0.5	1.3	1.0	3.0
2025	2,900	0.6	0.6	0.0	-0.1 [1]	0.8	0.0 [1]	0.5	0.5	2.0
2030	3,300	0.6	0.6	0.0	0.0 [1]	0.0 [1]	0.0 [1]	0.0 [1]	0.0	0.4
2035	3,700	0.6	0.8	0.0	0.0	0.0 [1]	0.0 [1]	0.0 [1]	0.0 [1]	0.0 [1]
2040	4,100	0.5	0.5	0.0	0.0	0.0 [1]	0.0 [1]	0.0 [1]	0.0 [1]	0.0 [1]

Notes:
[1] Change in retail sales would be less than $5 million.

0.8 percent above the calculational baseline. The taxable retail sales impacts of the In Situ Fill and Cap alternative would be small, peaking at approximately $3 million in 2022. The maximum impact under the In Situ Vitrification alternative would occur in 2002, with retail sales 4.5 percent higher than the baseline.

In 2002, retail sales in the Ex Situ Intermediate Separations alternative would be 7.3 percent above the baseline. The Ex Situ No Separations alternative would have its peak impact on retail sales in 2000, when sales would be 8.7 percent above the baseline. The Ex Situ Extensive Separations alternative's retail sales impacts would peak in 2004, when sales would be 10.8 percent above the baseline. The Ex Situ/In Situ Combination 1 alternative's impacts would peak in 2001 at 4.4 percent above the baseline, while the Ex Situ/In Situ Combination 2 alternative's impacts would peak in the same year at about the same level. Under the Phased Implementation alternative, the maximum impact would be 6.6 percent in 2000 during Phase 1, with another peak in 2011 of 7.6 percent.

For all tank waste alternatives, the pattern of the impacts closely followed the impacts on nonfarm employment, especially with respect to the timing of the divergence from the baseline. Taxable retail sales would exceed those of the baseline when nonfarm employment under the alternative exceeded baseline employment. The main difference is that the impacts of the alternative on taxable retail sales would be smaller (in terms of percent changes) than their impacts on nonfarm employment.

5.6.1.4 Employment Impacts by Ethnic Group

The analysis of employment impacts by ethnic group focused on Hanford Site employment. The breakdown of Hanford Site Management and Operations contractor employment by occupational category and minority group as of November 1994 showed that African Americans, Asians, and Native Americans account for the same or higher percentage of the Management and Operations contractor workforce than the group's proportion to the total labor force in the Tri-Cities area (Pitcher 1994). Hispanics, however, accounted for about 4 percent of the Site work force, compared to 11.4 percent of the total labor force in the Tri-Cities. Therefore, the analysis of employment impacts of the EIS alternatives by ethnic group focused on Hispanic employment. Assuming that the proportions of Hispanic workers in the different occupational categories at the Site Management and Operations contractor remained constant, it would be possible to estimate the employment impact of different EIS alternatives on the Hanford Site's Hispanic labor force.

Hispanics currently are underrepresented in the Tri-Cities construction labor force. Data show that Hispanics account for about 2.5 percent of the construction workers in Benton and Franklin Counties, while the Hispanic origin category in the 1990 census represents about 13 percent of the two counties' population. The estimates of the Hispanic construction workers under the EIS alternatives assumed that Hispanics' participation in the local construction trades remained at current levels. Table 5.6.8 shows estimated Hispanic employment under the various EIS alternatives during both construction and operation phases.

Table 5.6.8 Estimated Employment Impacts on the Tri-Cities Hispanic Labor Force of EIS Alternatives [1]

Alternative	Construction Phase (Number of Hispanic Workers) (Peak Year)	Operation Phase (Number of Hispanic Workers) (Typical Year) [2]
No Action	Not applicable	See Note 3
Long-Term Management	10	See Note 3
In Situ Fill and Cap	5	5
In Situ Vitrification	50	20
Ex Situ Intermediate Separations	90	140
Ex Situ No Separations	110	100
Ex Situ Extensive Separations	140	140
Ex Situ/In Situ Combination 1	60	90
Ex Situ/In Situ Combination 2	60	60
Phased Implementation (Phase 1)	80	25
Phased Implementation (Total Alternative)	110	140

Notes:
[1] Assumes that current proportions of Hispanic workers of the Hanford Site Management and Operations contractor remain the same and that the current proportions of Hispanics in the Tri-Cities construction labor force remain the same.
[2] Operations phase employees include managerial, professional, craft, and operative workers.
[3] There would be no new operation phase workers under No Action and Long-Term Management, but there would be Hispanics in the continuing tank farm routine operations work force.

5.6.2 Population and Housing

Changes in employment and economic activity would cause changes in population, which in turn would have impacts on housing and the demand for public facilities and services. This section describes population and housing. Public facilities and services impacts are described in Section 5.6.3.

5.6.2.1 Population

Table 5.6.9 provides population projections for the Tri-Cities for the calculational baseline and population projections based on implementing the tank waste alternatives. While the time paths of the population projections closely track the time paths of the corresponding nonfarm employment projections, there are two differences. First, the population projections lag behind employment projections by one year. For example, employment impacts would peak under the Ex Situ Intermediate Separations alternative in the year 2000, while the population impacts would peak in 2001. Based on the historical experience of the Tri-Cities (Section 4.6), population changes lag behind changes in employment. This tendency was reflected in the forecasting model used for this analysis. Second, the impacts of each EIS alternative in terms of percentage changes from the calculational baseline would be smaller for population changes than for employment changes. The following text summarizes the potential impacts on the Tri-Cities population under each tank waste alternative.

Table 5.6.9 Population Changes in the Tri-Cities from the Baseline for Selected Years

Year	Baseline Level	No Action	Long-Term Management	In Situ Fill and Cap	In Situ Vitrification	Ex Situ Intermediate Separations	Ex Situ No Separations	Ex Situ Extensive Separations	Ex Situ/ In Situ Combination 1	Phased Implementation (Total Alternative)[1]
		Percentage Change								
1997	162,000	0.0	0.0	0.0	0.0	1.8	0.3	1.7	1.1	0.1
2000	167,000	0.0	0.0	0.0	2.2	4.4	7.0	2.8	2.7	5.2
2002	170,000	0.0	0.0	0.2	3.7	5.9	5.5	4.9	3.5	0.9
2004	170,000	0.0	0.0	0.2	3.1	5.3	3.3	10.5	3.2	0.8
2005	171,000	0.0	0.0	0.2	3.7	5.0	4.5	6.6	3.0	1.6
2010	173,000	0.3	0.3	0.1	1.3	5.4	3.8	5.0	3.2	8.7
2015	176,000	0.4	0.4	0.2	1.2	5.2	3.6	4.8	3.1	4.9
2020	184,000	0.6	0.6	0.2	-0.6	1.6	0.2	1.1	1.0	4.6
2025	192,000	1.2	1.2	0.1	0.0	1.2	0.0	0.9	0.8	2.6
2030	199,000	1.2	1.2	0.0	0.0	0.0	0.0	0.1	0.0	0.6
2035	205,000	1.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2040	210,000	1.1	1.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0

Notes:
[1] Peak impact year is 2011 (not shown) with population change of 6.7 percent.

No Action Alternative (Tank Waste)
Under the No Action alternative, population would exceed the baseline by about 2,400 persons or 1.2 percent by 2035.

Long-Term Management Alternative
Under the Long-Term Management alternative, population change would peak at 1.6 percent in 2035. The population difference between this alternative and the calculational baseline projection in 2035 would be approximately 3,200.

In Situ Fill and Cap Alternative
Under this alternative, peak impacts on Tri-Cities population would occur in 2001 at approximately 460 people (0.3 percent) over the calculational baseline.

In Situ Vitrification Alternative
The In Situ Vitrification alternative would have its peak population impact in 2001, with approximately 6,300 more people than in the baseline projection. This would represent a 3.8 percent change from the baseline.

Ex Situ Intermediate Separations Alternative
For the Ex Situ Intermediate Separations alternative, the maximum change in population would occur in 2001, when population would be 9,900 above the calculational baseline, a difference of 5.9 percent. By 2020, the population changes compared to the baseline would be 2,900 (1.6 percent).

Ex Situ No Separations Alternative
The Ex Situ No Separations alternative would result in a population increase over the calculational baseline beginning in 1997. The maximum impact under this alternative would occur in 2000, when population would be 11,700 over the baseline, an increase of 7 percent. By 2020, the population impact would be approximately 380 (0.2 percent).

Ex Situ Extensive Separations Alternative
The Extensive Separations alternative would result in a spike in population peaking in 1999 and a second spike peaking in 2004. Each spike in population would be followed by a large drop in population, especially the spike in 2004. The peak impact in 2004 would result in a population 17,800 (10.5 percent) above the baseline. However, by 2005 the increase would be down to 11,300 or 6.6 percent. Population impacts would continue until 2025 when they would be approximately 1,700 people (0.9 percent) over the baseline. The population spikes with the Ex Situ Extensive Separations alternative could result in potential adverse socioeconomic impacts on the Tri-Cities because of the short-term demands on housing and public facilities caused by large numbers of construction workers moving into the area for a limited time.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, peak impacts on Tri-Cities population would occur in 2001, when population would be 6,000 people (3.6 percent) above the calculational baseline. Population would remain between 3 and 3.5 percent above the baseline until 2015.

Ex Situ/In Situ Combination 2 Alternative

Under this alternative, peak impacts on Tri-Cities population would occur in 2001 or 2002 when population would be about 5,300 (3.2 percent) above the baseline. From approximately 2010 to 2019, population levels in the Tri-Cities would be about 2,000 (slightly over 1 percent) above the baseline.

Phased Implementation Alternative

Phase 1

The peak impact under Phase 1 of the Phased Implementation alternative on population would occur in 2000, with an increase of 8,600 people (5.1 percent) above the calculational baseline. After construction was completed in 2001, employment would decline and population growth would begin to decline in 2003. After Phase 1 was completed in 2013, employment and population would decline.

Total Alternative

Population under the Phased Implementation alternative would follow the changes resulting from Phase 1 through 2003, with a peak of 5.1 percent above the calculational baseline in 2000, followed by a decline through 2003. However, from 2004 the higher levels of employment resulting from Phase 2 implementation would cause higher population levels. The peak impact would occur in 2011, with 16,100 additional persons, or about 9.3 percent more than the calculational baseline. This would result in a boom-bust pattern, which could have impacts on housing and public facilities.

5.6.2.2 Housing Prices

Table 5.6.10 shows projected average home prices for the calculational baseline and prices that would result from the various alternatives. These projections closely matched the projections of nonfarm employment in timing and direction. However, while population projections for the tank waste alternatives showed smaller impacts than in the projections of nonfarm employment, the projections for average home prices showed larger impacts.

The baseline projection showed housing prices in the Tri-Cities rising steadily from 1997 through 2040. All tank waste alternatives would result in consistent increases in housing prices, although there would be fluctuations in prices with all tank waste alternatives except for No Action and Long-Term Management. These housing price fluctuations reflected the fluctuations in Tri-Cities area nonfarm employment that would be caused by implementing these alternatives.

In some years under the In Situ Vitrification alternative and the various ex situ alternatives, average housing prices would decline at the same time as total Hanford Site employment and total Tri-Cities nonfarm employment declines. However, these declines would be from projected average prices the

Table 5.6.10 Average Home Price Changes ($ Thousands) in the Tri-Cities from the Baseline for Selected Years

Year	Baseline Level	No Action	Long-Term Management	In Situ Fill and Cap	In Situ Vitrification	Ex Situ Intermediate Separations	Ex Situ No Separations	Ex Situ Extensive Separations	Ex Situ/ In Situ Combination 1	Phased Implementation (Total Alternative) [1]
		Percentage Change								
1997	100	0.0	0.0	0.0	0.0	4.8	0.7	4.5	2.9	0.4
2001	100	0.0	0.0	0.7	9.3	14.5	15.8	4.4	8.8	10.0
2002	100	0.0	0.0	0.5	8.9	14.2	13.5	12.0	8.6	2.3
2004	100	0.0	0.0	0.5	7.4	12.7	7.9	25.1	7.6	1.8
2005	100	0.0	0.0	0.4	8.8	11.8	10.7	15.7	7.1	3.9
2010	100	0.6	0.6	0.3	3.0	12.4	8.7	11.4	7.2	19.9
2015	100	0.8	0.8	0.3	2.7	11.4	8.0	10.5	6.7	10.8
2020	100	1.1	1.1	0.3	-1.2	3.3	0.4	2.2	2.0	9.5
2025	200	2.4	2.4	0.2	0.0	2.4	-0.1	1.7	1.5	5.1
2030	200	2.2	2.2	-0.1	-0.1	0.0	0.0	0.2	0.0	1.2
2035	200	2.1	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2040	200	2.0	2.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0

Notes:
[1] Peak impact year is 2011 (not shown) with housing price change of 15.3 percent.

proceeding year. In all cases, housing prices would be higher than they would be in that year under the baseline scenario. The following text summarizes the potential impacts on housing prices in the Tri-Cities under each tank waste alternative.

No Action Alternative (Tank Waste)

The No Action alternative would have no impact on housing prices until approximately 2010. The impacts would peak in 2025 and for the following decade when average housing prices would be $4,000 over the calculational baseline, a difference of over 2 percent.

Long-Term Management Alternative

Housing prices under this alternative would be the same as under the No Action alternative, except for slightly higher prices in the 2030's, when replacement tanks would be constructed. In those years, housing prices would be approximately $5,000 over the baseline, a difference of almost 3 percent.

In Situ Fill and Cap Alternative

The In Situ Fill and Cap alternative would have minor impacts on housing prices because of its small impact on employment and population.

In Situ Vitrification Alternative

Under the In Situ Vitrification alternative, housing prices would increase above the baseline levels from 1999 until nearly 2010. Impacts would peak in 2001 when average prices would be $11,000 (9.3 percent) over the calculational baseline. There then would be several years of modest declines in housing prices from the preceding year, although prices still would exceed the baseline.

Ex Situ Intermediate Separations Alternative

The Ex Situ Intermediate Separations alternative would lead to increases in the average housing prices from 1997 through 2020. The peak impact year would be 2001, when average prices would be $16,000 (14.5 percent) above the calculational baseline. There would be housing price declines from the proceeding year between 2005 and 2008 and again in 2020, reflecting declines in Hanford Site and Tri-Cities total employment.

Ex Situ No Separations Alternative

The Ex Situ No Separations alternative would have impacts on housing prices between approximately 1998 and 2020. The maximum impact would be in the year 2000, with average home prices exceeding the baseline by $19,000 (17.5 percent). There would be a decline in housing prices (compared to the previous year, not compared to the baseline) in 2004, followed by a resumption in housing price growth in 2005.

Ex Situ Extensive Separations Alternative

The Ex Situ Extensive Separations alternative would show a peak in housing prices in 1999 with average housing prices exceeding the baseline by $14,000 (13.3 percent), then dropping and peaking again to reach an even higher peak in 2004, with prices $30,000 (25.1 percent) above the baseline.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, housing prices would exceed the calculational baseline from 1996 until 2030. In the 2001 peak year, housing prices would be $10,000 (8.8 percent) above the baseline.

Ex Situ/In Situ Combination 2 Alternative

Under this alternative, housing prices would show a peak increase over baseline levels in 2001 or 2002. In the peak year, housing prices would be approximately 8 percent higher than the baseline.

Phased Implementation Alternative

Phase 1

Housing prices would reflect changes in employment under Phase 1 of the Phased Implementation alternative. The peak impact would occur in 2000, when the average home price would be $14,000 above the calculational baseline, a difference of 12.9 percent.

Total Alternative

Housing prices reflected the pattern in employment under the Phased Implementation alternative, with prices tracking prices in Phase 1 and peaking in 2000 at 13 percent above the calculational baseline,

then falling through 2003. Prices would start rising again in 2004 with the implementation of Phase 2, with a second higher peak in 2010, when the average price would be $22,000 (19.9 percent) above the baseline.

5.6.2.3 Impacts of Higher Housing Prices

Higher housing prices that would be related to the various ex situ alternatives, the Ex Situ/In Situ Combination 1 and 2 alternatives, and the In Situ Vitrification alternative could have a negative impact on home buyers in the Tri-Cities area. Young families, low-income families, and first-time home buyers could be adversely affected by the higher prices and might find it difficult to buy a house. This could also affect families moving into the Tri-Cities area to work. Higher housing prices could make it harder for employers to attract new workers to the region.

The Ex Situ Extensive Separations alternative and, to a lesser extent, the Ex Situ No Separations alternative would have impacts that reflect the boom-bust pattern in Hanford Site and total Tri-Cities nonfarm employment that could cause adverse impacts on the housing market. The potential problems would be caused not so much by the size of the price increases, but by the fact that the price increases would result from the large number of construction workers involved in relatively short-term but labor-intensive projects. The Ex Situ Intermediate Separations alternative also would lead to considerable housing price increases, but would not have the same level of boom-bust impacts as the other two ex situ alternatives.

The sharp increases in housing prices in some years under the Ex Situ Extensive Separations and Ex Situ No Separations alternatives would make it more difficult for lower-income residents to purchase homes, while the sharp declines in housing prices might adversely affect existing home owners. Permanent residents moving into the area at the peak of one of these spikes may have to pay higher prices for housing, and then see the prices of their homes drop after the peak. This could be a serious loss for many families for whom their home is their major asset. Over time, average home prices would rise, as in the baseline, but stable housing prices would make it easier for families to plan their future and reduce the potential for loss if the family needed to sell its home on short notice.

At the same time, the higher housing prices would be caused by higher levels of employment associated with the tank waste alternatives. Therefore, while higher prices could adversely affect young families and low-income families, the greater employment opportunities would benefit these same families. In addition, higher housing prices would benefit current homeowners, especially if they were selling their homes.

5.6.2.4 Rental Housing Prices (All Alternatives)

Rental housing would show price increases consistent with single-family home prices. Higher employment levels would increase the demand for rental units, thus raising rates. Unless new rental construction was sufficient to keep prices down, rents would increase. Because many renters are young or lower-income families or individuals, they would be adversely affected. Although in many cases, these adverse impacts could be offset by increased employment opportunities. While this is a common

situation in any growing economy, the impacts could be more severe in an area like the Tri-Cities where the total supply of rental housing is smaller than in a large, metropolitan area.

5.6.2.5 Housing Starts

The projected increases in housing prices for the various alternatives might stimulate new housing construction in the Tri-Cities. The level and timing of any additional housing construction would depend in part on the size, timing, and expected duration of the employment and population growth associated with individual alternatives. The Ex Situ Extensive Separations, Ex Situ No Separations, Ex Situ Intermediate Separations, and the Phased Implementation alternatives could have the largest impact on housing starts because of their associated levels of employment and population growth.

5.6.3 Public Facilities and Services

This section describes the impacts of the various EIS alternatives on public facilities and services in the Tri-Cities area. The most important driving forces for impacts on public facilities and services were 1) changes in population, which create changed levels of demand on the agencies and facilities providing these services; and 2) changes in the local economy, which cause population changes and generate the local tax revenues that fund public services.

Sharp upturns or downturns in a local economy, coupled with fluctuations in the population base, can strain the ability of agencies to meet service requirements in a timely manner. The Tri-Cities area has faced such problems in the past, in large part because of cycles of growth and decline at the Hanford Site. The rapid growth at the Hanford Site from the late 1980's to 1994 led to population growth that strained public services, particularly local school districts. The ongoing and expected reductions in budgets and employment at the Hanford Site likely will ease some of the problems related to continuing rapid growth in the area. However, losses to the local economic base from Hanford Site cutbacks also will impact the vitality of the local economy and public service systems. In addition, not all workers who may be drawn to the Tri-Cities to work on the relatively short-term TWRS construction activities would bring their families to the area, thus reducing the demand on public services and facilities. Table 5.6.11 summarizes the EIS alternatives' impacts on local public facilities and services.

Current baseline population forecasts for the Tri-Cities area (without implementing any of the EIS alternatives) showed relatively slow growth through 2040 (Section 5.6.2). This projected population growth rate was well below recent levels of increase and reflected the expected long-term decline in Hanford Site employment.

5.6.3.1 Public Safety

Increases in population that would result from the alternatives would place additional demands on public safety services provided by local jurisdictions.

Table 5.6.11 Impacts on Public Facilities and Services in the Tri-Cities Area

Alternative	Peak Year	Peak Population Increase Number and (Percent)	Police (Additional Officers)	Fire (Additional Personnel)	Peak School Enrollment Increase Number and (Percent)	Medical, Sewer, Solid Waste, and Electrical Power
Tank Waste						
No Action	2025	2,400 (1.2)	4	0	670 (1.2)	Within Expected Capacity
Long-Term Management	2035	3,200 (1.6)	4	0	900 (1.6)	Within Expected Capacity
In Situ Fill and Cap	2001	460 (0.3)	0	0	140 (0.3)	Within Expected Capacity
In Situ Vitrification	2001	6,300 (3.8)	8 to 12	4 to 8	1,800 (3.8)	Within Expected Capacity
Ex Situ Intermediate Separations	2002	9,900 (5.9)	12 to 16	8 to 12	2,800 (5.9)	Within Expected Capacity
Ex Situ No Separations	2000	11,700 (7.0)	12 to 16	8 to 12	3,300 (7.0)	Within Expected Capacity
Ex Situ Extensive Separations	2004	17,800 (10.5)	16 to 20	8 to 12	5,100 (10.5)	Within Expected Capacity
Ex Situ/In Situ Combination 1	2001	6,000 (3.6)	8 to 12	4 to 8	1,700 (3.6)	Within Expected Capacity
Ex Situ/In Situ Combination 2	2001 or 2002	5,300 (3.2)	8 to 12	4 to 8	1,500 (3.2)	Within Expected Capacity
Phased Implementation (Phase 1)	2000	8,600 (5.1)	12 to 16	8 to 12	2,400 (5.1)	Within Expected Capacity
Phased Implementation (Total Alternative)	2011	16,100 (9.3)	12 to 16	12 to 16	4,600 (9.3)	Within Expected Capacity
Capsule Alternatives (All)	N/A	Minimal	0	0	Minimal	Within Expected Capacity

Long-Term Management Alternative

Impacts under the Long-Term Management alternative would be the same as under the No Action alternative. Local police departments each would require one additional officer in Pasco, Richland, Kennewick, and Benton County. Local fire departments would not require additional staff.

No Action Alternative

Under the No Action alternative, to maintain existing service levels (based on officers per population of 1,000), the police departments of Pasco, Richland, and Kennewick, and the Benton County Sheriff's Department each would require one additional officer during the 2025 to 2040 period compared to baseline levels (Table 5.6.11). Local fire departments would not require any additional staffing under this alternative. The alternative would not result in the need for new public safety facilities (e.g., police or fire stations).

In Situ Fill and Cap Alternative

The In Situ Fill and Cap alternative would involve little population growth, and thus no additional police or fire department personnel or facilities would be required.

In Situ Vitrification Alternative

Under the In Situ Vitrification alternative, for local agencies to maintain existing service levels (officers per population of 1,000), an additional two to three officers each over baseline levels would be required by the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department in the peak year (2001). Local fire departments also could require one to two additional personnel each. No new public safety facility requirements would be expected.

Ex Situ Intermediate Separations Alternative

Under the Ex Situ Intermediate Separations alternative, to maintain existing service levels, the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department would require an additional three to four officers each over baseline levels during the 1999 to 2019 time frame. Local fire departments in Richland, Kennewick, Pasco and the Benton County Fire Department also could require two to three additional personnel each. It is unlikely that new public safety facilities (e.g., police or fire stations) would be needed, assuming that TWRS population growth was centered within established residential areas or in newly developed areas in close proximity to established areas.

Ex Situ No Separations Alternative

The Ex Situ No Separations alternative would require an additional three to four officers over baseline levels by each of the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department to maintain existing service levels from 1999 to 2003. Local fire departments in Richland, Kennewick, Pasco, and the Benton County Fire Department also might require two to three additional personnel each. No new public safety facilities would be required.

Ex Situ Extensive Separations Alternative

To maintain existing ratios of officers per population of 1,000, the Ex Situ Extensive Separations alternative would require as many as four to five additional police officers by each of the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department in the single peak year of 2004, and three to four additional officers between 2003 and 2008. Fire departments in Richland, Kennewick, Pasco and the Benton County Fire Department would need two to three additional personnel each in the 2003 to 2008 time period. No new public safety facilities would be required.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department would each need an additional two to three officers over baseline levels to maintain current service levels in the year 2001. Local fire departments could each require one to two additional personnel. No new public safety facilities would be required.

Ex Situ/In Situ Combination 2 Alternative

Under this alternative, the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department would be expected to need two or three additional officers each to maintain current service levels in the peak year, which would be 2001 or 2002. Local fire departments could each require an additional one to two personnel. No new public safety facilities would be required.

Phased Implementation Alternative

Phase 1

This alternative would have impacts similar to the Ex Situ Intermediate Separations alternative in terms of additional public safety services needs. To maintain current services levels, the Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department would require an additional three to four officers each over baseline levels. The peak requirement would occur from 1999 to 2001, with a smaller requirement of perhaps one additional officer in each jurisdiction from 2002 to 2013. Local fire departments also could require two to three additional personnel each.

Total Alternative

The Phased Implementation alternative, when fully implemented, would involve the impacts detailed for Phase 1 as well as impacts associated with the second phase of the alternative. Peak requirements for police and fire services under Phase 2 would occur in 2011 when Richland, Kennewick, and Pasco police departments and the Benton County Sheriff's Department would require four to five officers over baseline levels. The local fire departments would also require four to five additional personnel.

Capsule Alternatives

None of the cesium and strontium capsule alternatives would require new public safety personnel or facilities. This is because employment and resulting population growth for the capsule alternatives would be small.

5.6.3.2 Medical Services

The projected population increase associated with the various EIS alternatives (as much as 10.5 percent over baseline levels in the peak year) would create additional demands on the facilities and services provided by the area's three major hospitals. However, these hospitals currently are operating at between 35 and 50 percent capacity (Cushing 1995). Although some additional staffing might be required to handle the potential increase in admissions, the existing facilities should be able to accommodate the impacts associated with all alternatives -- given current use rates and the moderate expected baseline growth. The supply of medical personnel (e.g., physicians) currently is adequate, and no major problems would be expected in accommodating growth as a result of implementing any of the EIS alternatives.

5.6.3.3 Schools

Local schools in the Kennewick, Richland, Pasco, and Kiona-Benton school districts all are operating at or near their capacities in 1995 (Section 4.6). Although the pace of enrollment growth over the next few years could slow somewhat as Hanford Site employment declines and associated population growth

rates decline (particularly in the Richland school district), current capacity problems need to be addressed. School district enrollment grew by an average of 1.2 percent in the 1995 to 1996 school year even though Hanford Site employment declined in 1995. In all cases, the severity of impacts related to increased school enrollment would be partially dependent on the various school districts resolving existing capacity issues. Table 5.6.11 provides data on estimated school enrollment impacts of the EIS alternatives.

No Action Alternative

Under the No Action alternative, population increases compared to baseline levels would be relatively minor up to the year 2025. In 2025, increases in enrollments would be approximately 1.2 percent over projected baseline enrollments. Because of the long planning horizon and the relatively minor enrollment increases (670 students), these additional students should be accommodated fairly easily.

Long-Term Management Alternative

Under the Long-Term Management alternative, impacts on school enrollment would be similar to the No Action alternative. By the year 2035, enrollment would be approximately 1.6 percent over projected baseline enrollments. Because of the relatively minor increases (900 students), the impacts should be accommodated fairly easily.

In Situ Vitrification Alternative

The In Situ Vitrification alternative would have its most substantial school enrollment increase compared to baseline levels between 2000 and 2008, with the peak year occurring in 2001. In 2001, assuming that the school growth was distributed proportionally among the school districts, area school enrollment would increase over calculational baseline levels by the following amounts: Kennewick 760; Richland 500; Pasco 450; and Kiona-Benton 90. These would represent enrollment increases of 3.8 percent over calculational baseline levels.

In Situ Fill and Cap Alternative

The In Situ Fill and Cap alternative would involve additional school enrollments of less than one-half of 1 percent (140 students) over baseline levels. This increase should be accommodated fairly easily.

Ex Situ Intermediate Separations Alternative

With the Ex Situ Intermediate Separations alternative, substantial school enrollment increases would occur between 1999 and 2019, with the peak year occurring in 2002. In the peak year, area school enrollment would increase over calculational baseline levels by the following amounts: Kennewick 1,200; Richland 780; Pasco 700; and Kiona-Benton 140. This would represent an increase of 5.9 percent over baseline levels.

Ex Situ No Separations Alternative

The Ex Situ No Separations alternative would involve substantial school enrollment increases in the 1999 to 2003 time frame, peaking in 2000. In 2000, area school enrollment would increase over calculational baseline levels by the following amounts: Kennewick 1,400; Richland 920; Pasco 830;

and Kiona-Benton 160. This would represent increases of 7 percent over calculational baseline levels. Annual growth would continue at more moderate rates (3 to 4 percent per year higher than the baseline) until 2015.

Ex Situ Extensive Separations Alternative

The Ex Situ Extensive Separations alternative would result in an increase over the baseline of 10.5 percent and would lead to the largest school enrollment increases of all the EIS alternatives. Enrollment would increase considerably between 2003 and 2008, peaking in 2004. In that year, area school enrollment would increase over calculational baseline levels by the following amounts: Kennewick 2,100; Richland 1,400; Pasco 1,300; and Kiona-Benton 250. The severity of these impacts would depend in part on the district's ability to solve current capacity problems. Annual growth would remain at over 4 percent per year higher than the calculational baseline until 2015.

Ex Situ/In Situ Combination 1 Alternative

This alternative would have a peak impact on school enrollments in 2001. In that year, assuming that the school growth is distributed proportionally among the school districts, area school enrollment would increase over calculational baseline levels by the following amounts: Kennewick 720; Richland 470; Pasco 430; and Kiona-Benton 80. This growth would represent a 3.6 percent increase over calculational baseline levels.

Ex Situ/In Situ Combination 2 Alternative

Peak impacts on school population under this alternative would occur in 2001 or 2002 when there would be approximately 1,500 more students than under baseline conditions. Assuming that the growth was distributed proportionately among the area school districts, school enrollments would be over calculational baseline levels by approximately the following amounts: Kennewick 640, Richland 410, Pasco 380, and Kiona-Benton 70.

Phased Implementation Alternative

Phase 1

Phase 1 impacts on school enrollment would peak in 1999. In that year, area school enrollment would increase over calculational baseline levels by the following amounts: Kennewick 1,000; Richland 680; Pasco 610; and Kiona-Benton 120. This would represent a 5.1 percent increase over calculational baseline levels.

Total Alternative

The Phased Implementation alternative, when fully implemented, would involve the impacts detailed for Phase 1 as well as impacts associated with the second phase of the alternative. Peak impact on school enrollments would occur in 2011 when 4,600 new students would be enrolled in the four school districts. This growth would represent a 9.3 percent increase over baseline levels distributed as follows: Kennewick 1,900; Richland 1,300; Pasco 1,200; and Kiona-Benton 230.

5.6.3.4 Electricity, Natural Gas, and Fuel Oil

For all TWRS alternatives, construction, operation, and project-related population growth would result in an increased demand for electricity. Domestic electrical demand would be expected to directly reflect the population growth associated with each alternative, which could peak at over 10 percent above baseline levels in 2001 to 2002 under the Ex Situ Extensive Separations alternative. For all alternatives that involved waste vitrification, operation phase electrical demands would be more substantial than the population growth incremental demand, but would peak later than the population demand. This is because waste vitrification is an electrical power-intensive operation.

The incremental electrical demand of all the vitrification alternatives (up to over 320 megawatts [MW]) would be a substantial increase over the 1994 estimated Hanford Site electrical requirement of approximately 57 MW. However, this demand still would be less than Site electrical usage in the late 1980's, when average Site requirements were approximately 550 MW (Cushing 1994). The Site has the electrical power infrastructure required by the TWRS alternatives' without major modifications other than new powerlines (mostly for the In Situ Vitrification alternative) and an additional electrical substation in the 200 Areas.

The incremental demand under all EIS alternatives would be no more than 1.5 percent of the Pacific Northwest electrical generation system's guaranteed energy supply capacity. Additional hydroelectric generating capacity, which is the primary electrical power source in the region, is being constructed in the region, and there are proposals being considered by various utilities in the region to construct natural gas-fired power plants. Currently, the Pacific Northwest has a surplus of electrical generating capacity.

Natural gas is a minor energy source in the Tri-Cities area, and incremental consumption related to population growth under any alternative would have negligible impacts. The operation phase of the EIS alternatives also would require up to 38,000 L/day (10,000 gal/day) of fuel oil. No substantial impacts on local supply or distribution systems would be expected from this level of demand.

5.6.3.5 Sanitary Waste Disposal

Under all EIS alternatives, project-induced population growth would increase demands on local municipal wastewater systems. The treatment systems of Richland, Kennewick, and Pasco would be expected to be able to accommodate these increased demands because they all are currently operating at 50 to 60 percent capacity (Cushing 1994). The current sanitary waste disposal system in the 200 Areas, however, would not be able to accommodate the additional personnel and tank waste treatment activities required under any of the EIS alternatives except the No Action, Long-Term Management, and In Situ Fill and Cap alternatives (Harvey 1995).

5.6.3.6 Solid Waste

The Hanford Site's solid waste landfill is expected to reach capacity by 1996. In October 1995, an agreement was announced between DOE and the city of Richland under which nonregulated, nonhazardous solid waste generated at the Hanford Site would be accepted by the city of Richland's

sanitary landfill (DOE 1995k). The first shipments of Site solid waste to the Richland landfill occurred in November 1995.

The solid waste landfills that serve the Tri-Cities area (including the city of Richland-owned landfill and landfills in Arlington, Oregon and Roosevelt, Washington, which are operated by firms that contract with Kennewick, Pasco, and West Richland) all have current capacity life expectancies of 40 to 50 years. Thus, no TWRS alternatives would be expected to cause any difficulties in terms of municipal solid waste disposal.

5.7 LAND USE

This section describes the land-use impacts of the various EIS alternatives. Land-use impacts were addressed in terms of the compatibility of temporary and permanent land-use commitments under each alternative with past, present, and planned and potential future uses of the land and the surrounding area. Also addressed were potential conflicts with uses of land adjacent to the land that would be impacted under each alternative and unique land uses in proximity to the proposed TWRS sites, including the Hanford Reach of the Columbia River and the Fitzner Eberhardt Arid Land Ecology Reserve. Conflicts between EIS alternatives and Federal, State, local, and Tribal Nation land-use policies, plans, and controls are described in Section 5.17.

Land Use Impacts

Impacts addressed in this section include:

- Temporary and permanent land use commitments (Section 5.7.1);
- Impacts on surrounding Central Plateau and Site land uses (Section 5.7.2); and
- Impacts on recreational resources and ecological and environmental research land uses (Section 5.7.2.1).

Temporary and permanent proposed land-use commitments for remedial activities under all TWRS EIS alternatives would be consistent with past and existing land uses for the 200 Areas, as well as with proposed use of the area as an exclusive-use waste management area for Hanford Site waste disposal and environmental restoration programs. Potential land-use commitments do not conflict with land uses in the area of the Hanford Site immediately surrounding the 200 Areas, recreational resources such as the Hanford Reach of the Columbia River, or the Fitzner Eberhardt Arid Land Ecology Reserve. For some of the alternatives, temporary land-use commitments associated with use of potential borrow sites outside of the 200 Areas may conflict with future Site land-use plans. However, borrow sites identified in this EIS were used only to compare potential impacts associated with one closure scenario. When a final closure plan is selected, borrow material needs may be much lower, and different onsite or offsite sources of borrow material may be selected to support closure activities. In August 1996, the Hanford Site published the Draft Hanford Remedial Action EIS and Comprehensive Land Use Plan (DOE 1996), which addresses future Site uses and the cleanup levels required to facilitate the uses identified for various areas of the Hanford Site, including the 200 Areas and the Central Plateau.

5.7.1 Land-Use Commitments

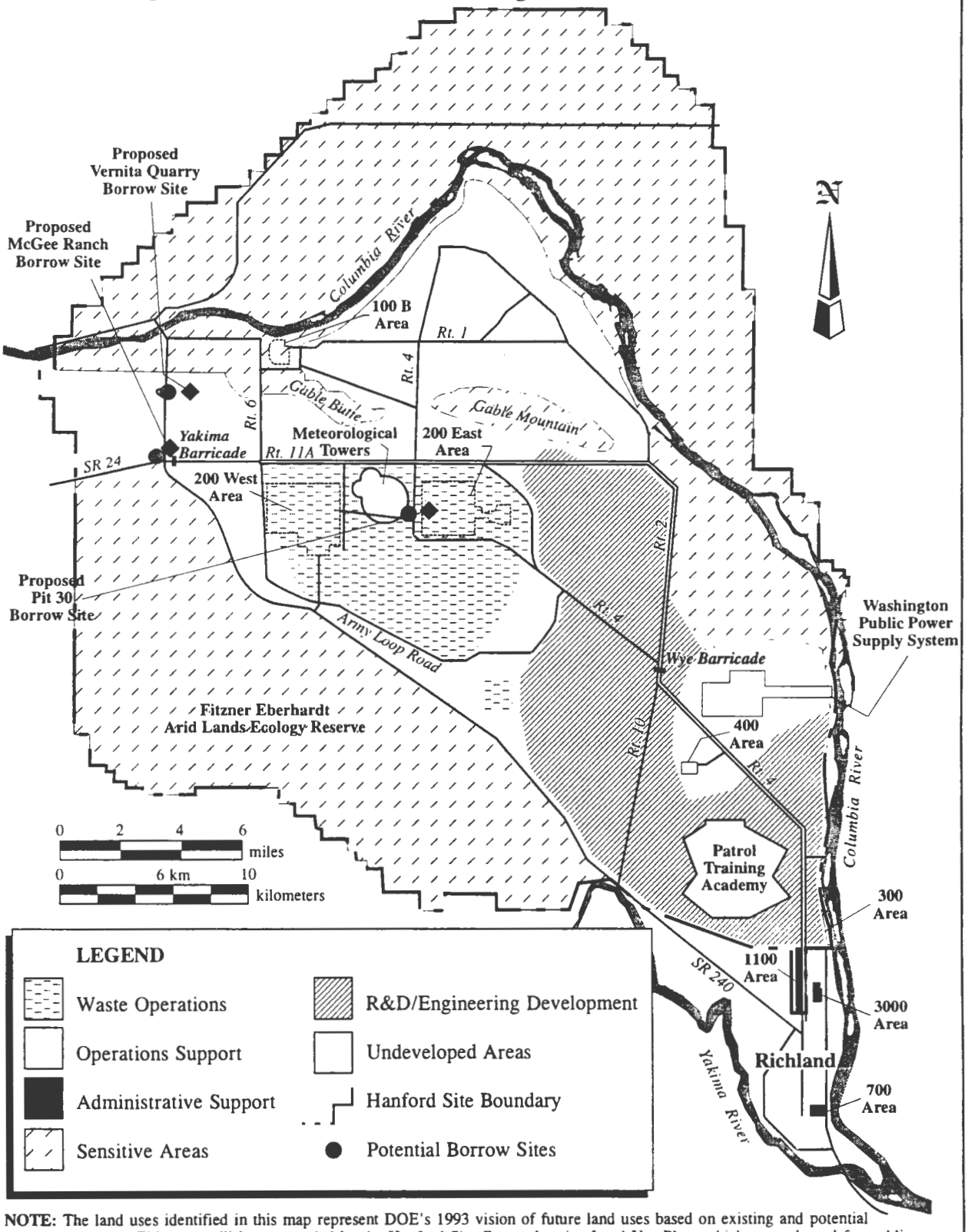
All major remediation activities associated with the EIS alternatives would occur within the current boundaries of the 200 Areas. However, the closure scenario used to compare impacts would result in activities at two potential borrow sites (Vernita Quarry and McGee Ranch), which lie to the north and west of the 200 Areas, and at the potential Pit 30 borrow site, which is located between the 200 East and 200 West Areas (Figure 5.7.1). For more than 40 years, the 200 Areas have been used for industrial and waste management activities associated with the Hanford Site's past national defense mission and current waste management and environmental restoration cleanup mission. The 200 Areas consist of approximately 2,600 ha (6,400 ac). The tank farms where the tank waste currently is stored would be the location of the in situ remediation activities under the In Situ Vitrification and In Situ Fill and Cap alternatives. The tank farms currently are being used for waste management purposes.

All proposed permanent land-use commitments would consist of changes from existing waste management uses to waste disposal uses, which is consistent with the exclusive use for waste management designation for the Central Plateau including the 200 Areas. All EIS alternatives would result in temporary and permanent land-use commitments. Temporary land-use commitments would include currently undisturbed areas used for constructing and operating the alternatives, and construction activities associated with closure. Temporary land-use commitments would include facility footprints, parking lots, construction laydown areas, materials storage areas, facility assembly areas, new power line corridors, and areas used at the three potential borrow sites. Permanent land-use commitments would include areas that would be permanently committed to waste disposal as a result of an EIS alternative. This would include the areas committed through the remedial phase of the alternatives, such as the tank farms and the LAW vaults associated with all the ex situ alternatives (except Ex Situ No Separations) and with the Ex Situ/In Situ Combination 1 and 2 alternatives. Permanent land use commitments associated with the closure scenario would include the areas that would be covered by the Hanford Barriers under all alternatives except No Action and Long-Term Management.

It is likely that there would be some land exclusion zones or restricted use zones around areas that were permanently committed to waste disposal. No exclusion or restricted use zones have been defined, but this type of land-use issue has been addressed in the land-use planning process for the Hanford Site that is currently underway (DOE 1996c).

Groundwater use at the Hanford Site is controlled at present because of existing groundwater contamination. Groundwater contamination has land-use implications. While some land uses might not be precluded because of underlying groundwater contamination, the value of land for potential future uses such as agriculture could be diminished or restricted because the underlying groundwater could not be used. Under all EIS alternatives, TWRS activities would contribute to future Site groundwater contamination.

Figure 5.7.1 Future Land Uses Showing Potential TWRS Borrow Sites



NOTE: The land uses identified in this map represent DOE's 1993 vision of future land uses based on existing and potential Hanford missions. This map will be superseded by the Hanford Site Comprehensive Land Use Plan, which was released for public comment in August 1996 (DOE 1996c).

SOURCE: Adapted from DOE 1993e

At some point in the future, from a few hundred to several thousand years from now depending on the alternative, contaminants from TWRS tanks would reach the groundwater and begin migrating with the underlying groundwater flow patterns toward the Columbia River (Sections 5.2 and 5.11). The size (areal extent) as well as the timing of the TWRS-related groundwater contamination would differ for each alternative. The nature, extent, and timing of TWRS groundwater contamination, and thus the potential implications for future land uses, would depend on TWRS closure decisions that have not yet been made, as well as on the future Sitewide land-use planning decisions. Likewise, many relevant decisions related to non-TWRS-related groundwater contamination and overall Hanford Site groundwater cleanup have not yet been made.

The EIS analyzes use of three potential borrow sites. Final selection of borrow sites for TWRS uses will be made in the future after the Site land-use planning process is completed.

Temporary and permanent land-use commitments for the various alternatives are summarized in Table 5.7.1. None of the alternatives would require temporary or permanent land-use commitments that would exceed the available land for waste management within the 200 Areas. All land-use commitments would constitute a small fraction of the 200 Areas' 2,600 ha (6,400 ac). The greatest impact on land use would result from the Phased Implementation alternative. This alternative would require approximately 320 ha (790 ac) for temporary construction-related uses and 49 ha (120 ac) for permanent land uses. Approximately 40 percent of the temporary land use would be outside the 200 Areas at the potential borrow sites. Thus, the alternative would use about 6 percent of the total 200 Areas temporarily and 2 percent of the total 200 Areas for permanent land uses.

All of the ex situ alternatives and the Ex Situ/In Situ Combination 1 and 2 alternatives would involve the temporary storage of vitrified HLW onsite until a potential geologic repository was able to accept the waste for permanent disposal.

The Hanford Site has no designated prime or unique farmlands (Section 4.7). There are no known plans for agricultural use of the 200 Areas, although such future uses cannot be precluded given possible DOE or other agency land-use decisions.

No Action Alternative (Tank Waste)

The No Action alternative would involve no incremental land-use commitment, as no new construction would occur. The 17 ha (42 ac) currently used for the 18 existing tank farms would be permanently committed to waste disposal. As stated previously, and as is true for all the other alternatives described in the following text, the permanent land-use commitment areas described in this section do not include any exclusion or restricted-use zones that may be designated around the tank farms.

Long-Term Management Alternative

The Long-Term Management alternative would involve temporarily committing 50 ha (120 ac) of land for two new tank farms in the 200 East Area and 16 ha (40 ac) of land at the potential Pit 30 borrow site. Only 25 ha (62 ac) would be permanently committed to waste disposal; 8 ha (20 ac) at the new

Table 5.7.1 TWRS Alternatives Land-Use Commitments

Alternative	Temporary Land Commitments [1] ha (ac)		Permanent Land Commitments [2] ha (ac)	
Tank Waste	**Remediation**	**Total**	**Remediation**	**Total**
No Action	0	0	0	17 (42)
Long-Term Management	66 (160)	66 (160)	8 (20)	25 (62)
In Situ Fill and Cap	26 (64)	97 (240)	17 (42)	25 (62)
In Situ Vitrification	110 (270)	190 (470)	17 (42)	25 (62)
Ex Situ Intermediate Separations	120 (300)	240 (590)	35 (86)	46 (110)
Ex Situ No Separations	170 (420)	260 (650)	20 (49)	28 (69)
Ex Situ Extensive Separations	120 (300)	240 (590)	33 (82)	44 (110)
Ex Situ/In Situ Combination 1	120 (300)	210 (520)	31 (77)	41 (100)
Ex Situ/In Situ Combination 2	100 (250)	180 (440)	25 (62)	34 (80)
Phased Implementation (Phase 1)	33 (82)	33 (82)	0	0
Phased Implementation (Total Alternative)	200 (490)	320 (790)	38 (94)	49 (120)
Capsules				
No Action	0	0	0.6 (1.5)	0.6 (1.5)
Onsite Disposal	4 (10)	4 (10)	1.8 (4.4)	1.8 (4.4)
Overpack and Ship	2 (5)	2 (5)	0	0
Vitrify with Tank Waste	1 (2)	1 (2)	0	0

Notes:
[1] Temporary land-use commitments include the construction and operation phases, land used for facilities, construction laydown areas, and materials storage areas, plus land used at the three potential borrow sites.
[2] Permanent land-use commitments include areas that would be covered by Hanford Barriers, LAW disposal vaults, and the contaminated portions of processing facilities.

tank farms and 17 ha (42 ac) at the existing tank farms. Under this alternative, no other land commitments would occur.

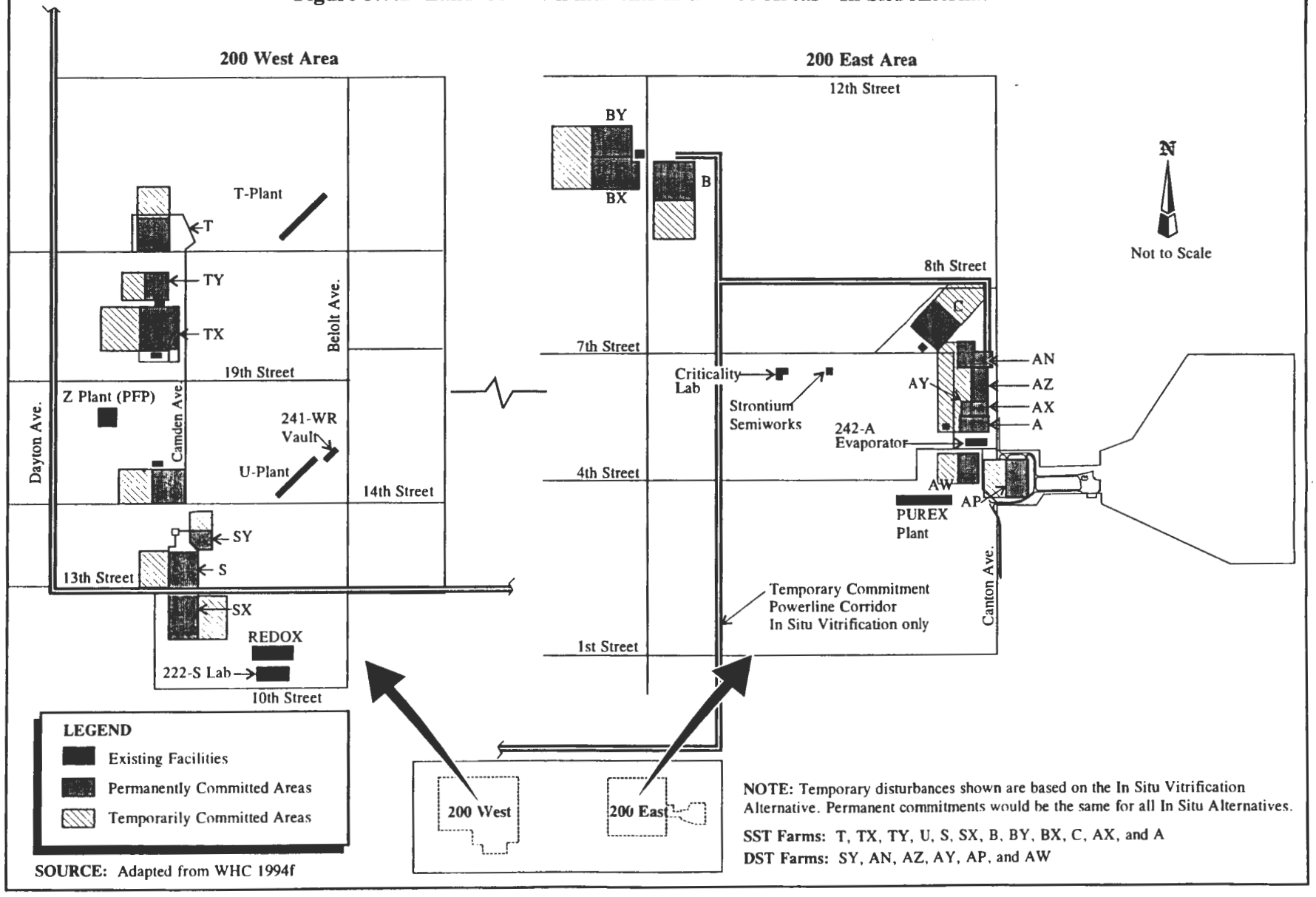
In Situ Fill and Cap Alternative

For the remediation phase of the project, 26 ha (64 ac) would be temporarily committed and 17 ha (42 ac) of land would be permanently committed (Figure 5.7.2). For the total In Situ Fill and Cap alternative, temporary commitments would total 97 ha (240 ac) of land. Of this total, 76 ha (190 ac) would be at the three potential borrow sites with virtually all of the remaining committed land being used during construction of the Hanford Barriers. The only permanent land-use commitment would be 25 ha (62 ac) for the tank farms and Hanford Barriers over the tank farms.

In Situ Vitrification Alternative

The remediation activities would temporarily commit 110 ha (270 ac) and permanently commit 17 ha (42 ac) of land (Figure 5.7.2). For the total In Situ Vitrification alternative, temporary commitments would total 190 ha (470 ac) for project use, including 70 ha (170 ac) for the potential new power transmission corridors, a total of 74 ha (190 ac) at the three potential borrow sites, and 21 ha (52 ac)

Figure 5.7.2 Land-Use Commitments in the 200 Areas - In Situ Alternatives



SOURCE: Adapted from WHC 1994f

for constructing the tank farm confinement structures for use during remedial operations. Because there would be no new waste processing facilities, the only additional land permanently committed to waste disposal would be 25 ha (62 ac) for the tank farms and Hanford Barriers.

Ex Situ Intermediate Separations Alternative

Remediation activities would temporarily commit 120 ha (300 ac) and permanently commit 35 ha (86 ac) of land (Figure 5.7.3). For the total Ex Situ Intermediate Separations alternative, temporary commitments would total 240 ha (590 ac) of land. This would include 89 ha (220 ac) for constructing and operating waste retrieval, transfer, and processing facilities; 24 ha (59 ac) used during Hanford Barrier construction; and 130 ha (320 ac) at the three potential borrow sites (Figure 5.7.4). Permanent land-use commitments for waste disposal would total 46 ha (110 ac) for tank farms and LAW disposal vaults, Hanford Barriers over the tank farms and LAW vaults, and contaminated portions of the waste treatment facility site.

Ex Situ No Separations Alternative

Remediation activities would temporarily commit 170 ha (420 ac) and permanently commit 20 ha (49 ac) of land (Figure 5.7.3). For the total Ex Situ No Separations alternative, temporary commitments would total 260 ha (650 ac) of land, 70 ha (170 ac) for constructing and operating new waste retrieval, transfer, and processing facilities; 20 ha (49 ac) for constructing Hanford Barriers at the tank farms; and 170 ha (420 ac) at the potential borrow sites. A total of 28 ha (69 ac) would be permanently committed to the tank farms and Hanford Barriers over the tank farms and at contaminated portions of the waste treatment facility site.

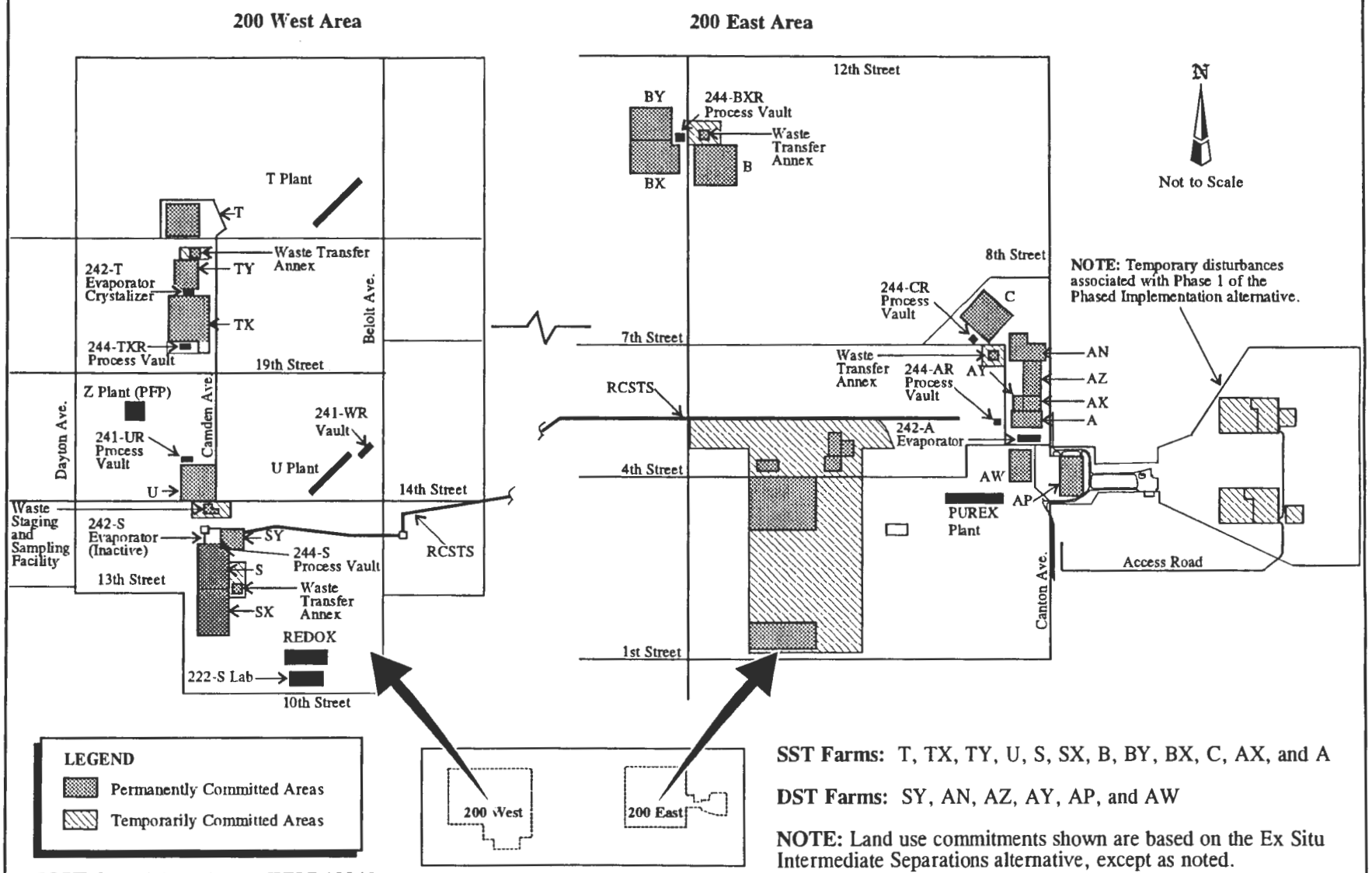
Ex Situ Extensive Separations Alternative

The remediation phase activities would temporarily commit 120 ha (300 ac) and permanently commit 33 ha (82 ac) of land (Figure 5.7.3). For the total Ex Situ Extensive Separations alternative, temporary land commitments would total 240 ha (590 ac). This would include 88 ha (220 ac) for constructing and operating waste retrieval, transfer, and processing facilities; 24 ha (59 ac) disturbed during Hanford Barrier construction at the tank farms and LAW disposal vaults; and 130 ha (320 ac) at the three potential borrow sites. Permanent land-use commitments would total 44 ha (110 ac) for the tank farms, the Hanford Barriers over the tank farms, the LAW vaults, and the contaminated portions of the waste treatment facility site.

Ex Situ/In Situ Combination 1 Alternative

For the remediation activities, 120 ha (300 ac) of land would be temporarily committed and 31 ha (77 ac) of land would be permanently committed (Figures 5.7.2 and 5.7.3). For the total Ex Situ/In Situ Combination 1 alternative, temporary commitment would total 210 ha (520 ac) of land. This would include 85 ha (210 ac) for constructing and operating new waste retrieval, transfer, and processing facilities; 22 ha (54 ac) during Hanford Barrier construction; and 100 ha (250 ac) at the three potential borrow sites. A total of 41 ha (100 ac) would be permanently committed to waste disposal.

Figure 5.7.3 Land-Use Commitments in the 200 Areas



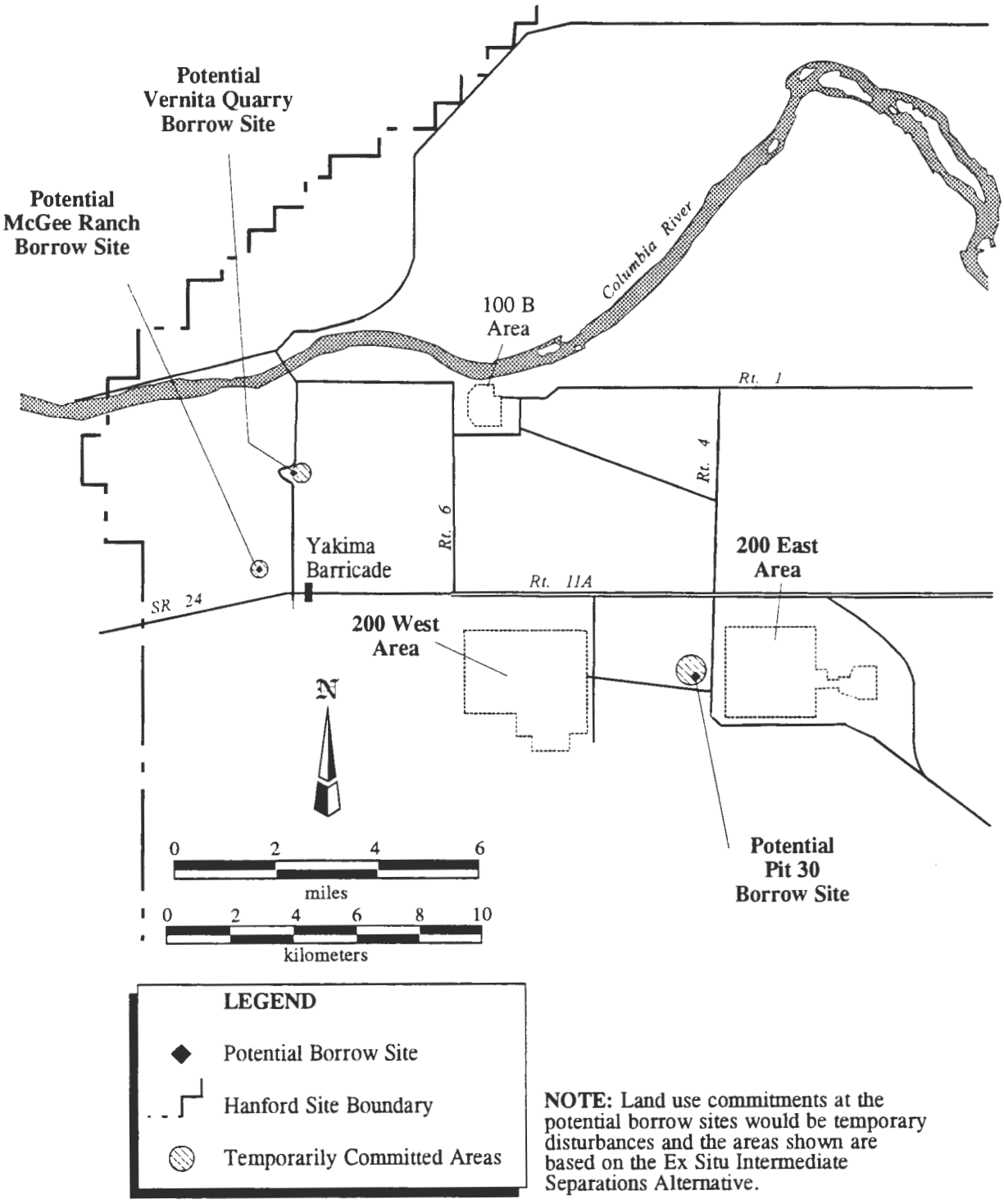
SST Farms: T, TX, TY, U, S, SX, B, BY, BX, C, AX, and A

DST Farms: SY, AN, AZ, AY, AP, and AW

NOTE: Land use commitments shown are based on the Ex Situ Intermediate Separations alternative, except as noted.

SOURCE: Adapted from WHC 1994f

Figure 5.7.4 Land-Use Commitments at Potential Borrow Sites



NOTE: Land use commitments at the potential borrow sites would be temporary disturbances and the areas shown are based on the Ex Situ Intermediate Separations Alternative.

SOURCE: Adapted from DOE 1993

Ex Situ/In Situ Combination 2 Alternative

During remediation activities, 100 ha (250 ac) of land would be temporarily committed and 25 ha (62 ac) would be permanently committed. For the total Ex Situ/In Situ Combination 2 alternative, temporary land commitments would total 180 ha (440 ac). This would include 63 ha (160 ac) for constructing and operating new waste retrieval, transfer, and processing facilities; 22 ha (54 ac) during Hanford Barrier construction; and 92 ha (230 ac) at the three potential borrow sites. A total of 34 ha (80 ac) would be permanently committed to waste disposal.

Phased Implementation Alternative

Phase 1

Phase 1 of the Phased Implementation alternative would involve disturbing a total of 33 ha (82 ac) of land during construction and operation. This would include about 32 ha (79 ac) for new waste processing facilities at the facility site in the easternmost portion of the 200 East Area, and 1 ha (2 ac) at the potential Pit 30 borrow site to obtain sand and gravel for construction phase concrete needs. There would be no permanent land-use commitments resulting from this phase.

Total Alternative

The Phased Implementation alternative, when fully implemented, would include the impacts detailed for Phase 1 as well as impacts associated with Phase 2 of the alternative. During remediation activities alone, 200 ha (490 ac) of land would be temporarily committed and 38 ha (94 ac) of land would be permanently committed (Figure 5.7.3). The total alternative land-use commitments would temporarily commit 320 ha (790 ac) of land: 150 ha (380 ac) for constructing and operating new facilities; 24 ha (60 ac) for Hanford Barrier construction at the tank farms; and 140 ha (350 ac) at the potential borrow sites. A total of 49 ha (120 ac) would be permanently committed to surface barriers over the tank farms, the LAW vaults, and at contaminated portions of the vitrification facility sites.

Capsules Alternatives

The cesium and strontium capsule alternatives all would involve relatively few land-use commitments. The capsules No Action alternative would involve no incremental land-use commitment because all activities would take place within the current footprint of the existing WESF site. Permanent land-use commitment at this site would total 0.6 ha (1.5 ac). The Onsite Disposal alternative would temporarily commit 4 ha (10 ac) and permanently commit 1.8 ha (4.4 ac) of land for the disposal facility.
The Overpack and Ship and Vitrify with Tank Waste alternatives temporarily would commit approximately 2 ha (5 ac) for the handling and processing facilities. The Overpack and Ship and Vitrify with Tank Waste alternative would have minimal permanent land-use commitments. These land areas are included within the areas that would be committed for the ex situ alternatives because the facilities for these alternatives would be located within the proposed tank waste treatment facility complex.

5.7.2 Impacts on Surrounding Land Uses

As designated by the Hanford Site Development Plan (DOE 1993e), current and planned land uses that surround the 200 Areas would include research and development, engineering areas, and a buffer zone

(undeveloped areas) (Figure 5.7.1). Research and development and engineering areas include developing scientific and engineering technology and managing waste. The waste management use of the 200 Areas would be within the overall Central Plateau use as a waste management area. Under the Hanford Site Development Plan, the Central Plateau waste management area would consist of approximately 11,700 ha (28,800 ac). Waste management would take place on 4,900 ha (12,200 ac) of the area while the remaining 6,700 ha (16,600 ac) would be designated for use as a buffer zone. The 200 Areas constitute approximately 2,600 ha (6,400 ac) of the waste management area (53 percent).

The buffer undeveloped areas would provide a land-use transition between the waste operations of the 200 Areas and other more sensitive use areas. Similar uses have occurred in these locations for over 40 years without land-use conflicts. Thus, the EIS alternatives' activities in the 200 Areas would be consistent with existing and currently planned land uses in surrounding Hanford Site areas. None of the alternatives would directly or indirectly impact current or planned land uses in surrounding areas. The Hanford Comprehensive Land-Use Plan, which was released for public comment in August 1996, designates future land-use plans for the Site under various alternatives.

5.7.2.1 Recreational Resources and the National Environmental Research Park

Although the Hanford Site is designated as a National Environmental Research Park (Section 4.7), the 200 Areas do not contain any designated or protected wildlife areas, wildlife refuges, or recreational areas. However, the 200 Areas do contain shrub-steppe habitat of ecological value. The 200 Areas have been used for more than 40 years for defense production and waste management purposes. All EIS alternatives would continue past and current land uses and would not conflict with the goals of the National Environmental Research Park.

The Fitzner Eberhardt Arid Land Ecology Reserve is located approximately 3 km (2 mi) southwest of the 200 Areas. The Saddle Mountain National Wildlife Refuge is located approximately 8 km (5 mi) north of the 200 Areas. The Wahluke Slope Wildlife Recreation Area is located approximately 8 km (5 mi) northeast of the 200 Areas. The McNary National Wildlife Refuge is located approximately 20 km (13 mi) southeast of the 200 Areas. The Hanford Reach of the Columbia River, which is proposed for designation as a Recreational River under the Wild and Scenic Rivers Act, is located approximately 11 km (7 mi) from the 200 Areas. Implementing any of the EIS alternatives would not preclude or adversely affect the current or planned use of any of these sensitive wildlife or recreational areas.

5.8 VISUAL RESOURCES

This section describes the impacts of the TWRS alternatives on the visual resources of the Hanford Site and vicinity, focusing primarily on potential impacts from offsite locations.
The visual impacts of all TWRS alternatives would result from developing the facilities associated with waste retrieval, processing, and storage activities, and from borrow site activities associated with implementing the alternatives.

Visual Resource Impacts

Impacts addressed in this section include:
- Visual impacts from tank waste remediation facilities; and
- Visual impacts from capsule remediation facilities.

As described in Section 4.8, the Hanford Site landscape is characterized primarily by its broad plateau (Section 4.8). This visual setting provides for sweeping vistas of the area broken up by more than a dozen large Hanford Site facilities (e.g., processing plants and nuclear reactors) located around the Hanford Site. Only 6 percent of the Hanford Site's total area has been used for industrial activities. The 200 Areas, where virtually all proposed TWRS activities except for borrow site use would occur under all alternatives, currently contain three large processing facilities (the Plutonium-Uranium Extraction [PUREX] Plant in the 200 East Area and B Plant and U Plant in the 200 West Area) as well as the 18 tank farms that contain the tank waste and numerous multi-story support facilities.

The potential Pit 30 borrow site, which would provide sand and gravel as part of implementing all EIS tank waste alternatives except No Action and Long-Term Management, is located between the 200 East and 200 West Areas. The potential Vernita Quarry and McGee Ranch borrow sites, which would be used (if selected and approved) under all tank waste alternatives except No Action and Long-Term Management for closure-related activities, are located in undeveloped areas approximately 6 km (4 mi) north and west of the 200 West Area.

The following text summarizes the potential impacts to visual resources under each of the EIS alternatives.

No Action Alternative (Tank Waste)

Under the No Action alternative, impacts would be largely limited to continuing existing visual disturbance from ongoing use of the tank farms. No additional facilities would be constructed, and routine tank farm operations would continue in their current form.

Long-Term Management Alternative

This alternative would have the same visual impacts as the No Action (Tank Waste) alternative (continuation of existing visual disturbance) until new replacement storage tanks were developed to replace the existing DSTs. In the 2030's and again in the 2080's, 26 additional underground tanks would be built to replace the existing tanks that would reach the end of their design lives. The new tanks would be constructed in a previously disturbed area of the 200 East Area about 180 by 150 m (600 by 500 ft). The new tank farms would not be visible from any offsite locations because they would be in the interior of the Hanford Site, and most of the facilities would be underground. The new tank farms would, however, be visible from elevated locations on the Site (Gable Mountain, Gable Butte, and Rattlesnake Mountain) that are used by Native Americans for religious purposes. The Confederated Tribes of the Umatilla Indian Reservation have expressed the concern that visibility of new TWRS facilities under this and virtually all other alternatives except No Action would represent an adverse impact on these religious sites (CTUIR 1996).

In Situ Fill and Cap Alternative

The In Situ Fill and Cap alternative would not develop any new treatment facilities in the 200 Areas. However, Hanford Barriers would be developed over each of the tank farm sites. Visually, the Hanford Barriers, which would be associated with the closure scenario, would resemble a 4.5-m (15-ft)

soil mound with sloping sides covered with soil and vegetation. Because of this low visual profile, impacts would be minor. There would be no visual impacts from any offsite locations, including the Columbia River.

Borrow site activities would leave a topographic depression at each of the three potential borrow sites for this alternative, as well as for all other tank waste alternatives except No Action and Long-Term Management. While such topographic changes would be visually inconsistent with the surrounding landforms, there would be limited viewing opportunities from offsite. The potential Pit 30 borrow site is in the interior of the Hanford Site and could not be seen from offsite except from elevated locations. Borrow site impacts associated with closure are described to provide a basis for comparing the impacts of this EIS. The potential Vernita Quarry borrow site would be expanded to support TWRS project closure activities. The past quarry operations site is highly visible from State Route 24, and the expansion area also would be highly visible from the highway. The potential McGee Ranch borrow site would be located near State Route 24. The borrow activities would be visible to travelers on State Route 24 traveling east-west just west of the Yakima Barricade, and travelers on State Route 24 after it turns north-south at the Yakima Barricade.

In Situ Vitrification Alternative

The primary visual feature of the In Situ Vitrification alternative would be the large confinement structures that would be erected over each tank farm during operations (Figure 3.4.5). A tank farm confinement structure would enclose an entire tank farm, reaching a maximum abovegrade height of 30 to 45 m (100 to 150 ft). There would be one tank farm confinement structure in operation and two tank farm confinement structures under construction at any one time over the 18-year period between 1998 and 2016.

The number of tank farm confinement structures would increase steadily as activities proceeded under this alternative, eventually reaching a total of 18 such structures (one for each tank farm). Decontamination and decommissioning of all tank farm confinement structures would occur when vitrification was completed at the last tank farm. After 2016, the structures would be removed and their visual impact would be eliminated.

Each in situ vitrification facility would have one 30-m (100-ft)-high stack and a number of support facilities, none of which would be more than one to two stories high. There also would be power line segments installed to provide electrical power to the in situ vitrification operations at each tank farm. After the waste vitrification activities at the tank farms were complete, each tank farm would be covered with a Hanford Barrier.

Figure 5.8.1 illustrates the alternative's potential visual impacts. The tank farm confinement structures would be visible from several kilometers away and each would resemble a large industrial building with an exposed steel arch roof structure. They would be visible along an approximately 11-km (7-mi) segment of State Route 240 to the south and east of the 200 Areas. Travelers on State Route 240 would see the confinement structures in the 200 West Area tank farms as part of the visual middleground, defined as 0.8 to 8 km (0.5 to 5 mi) away. Offsite viewing would be of moderate visual

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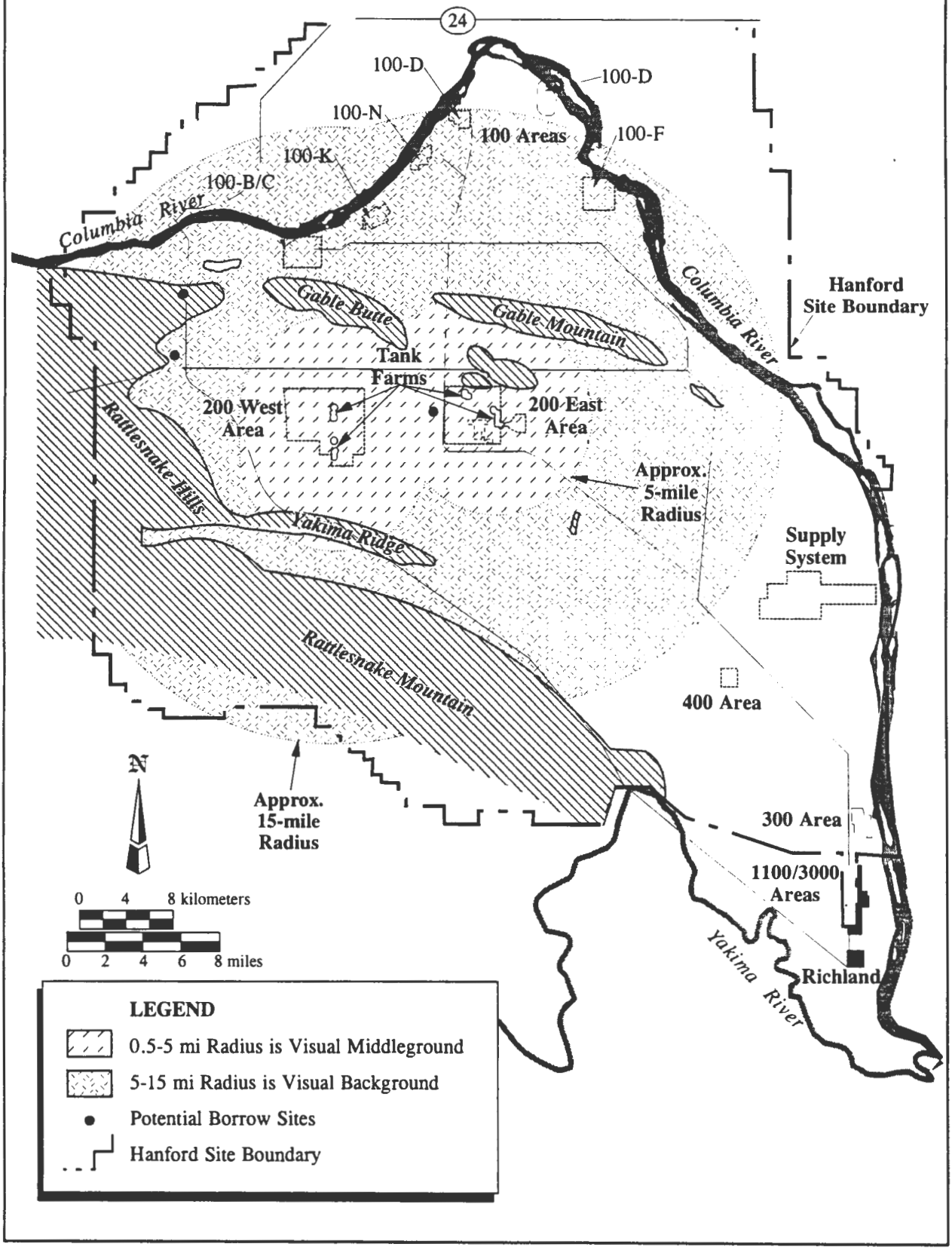
Figure 5.8.1 Potential Visual Impacts of TWRS Alternatives



intrusiveness because the TWRS sites would be relatively similar to other industrial facilities currently existing at the Hanford Site. Tank farm confinement structures in the 200 East Area would be visible in the visual background (more than 8 km [5 mi] away). Vitrification operations would not be expected to produce any stack plumes that would be visible from offsite locations.

Post-remediation Hanford Barriers would have minimal visual impacts from any offsite locations because of their low visual profiles and the distances involved. None of the facilities (including the tank farm confinement structures) would be expected to be visible from offsite locations other than State Route 240. The facilities would be visible from elevated locations such as Gable Mountain, Gable Butte, and Rattlesnake Mountain, but would not be visible from the Columbia River.

Borrow site impacts essentially would be the same as for the In Situ Fill and Cap alternative: borrow activities and the resulting land form changes would be highly visible at the potential Vernita Quarry borrow site from State Route 24, visible at the potential McGee Ranch borrow site from State Route 24, and not visible from public roadways at the potential Pit 30 borrow site. All activities at the potential borrow sites would be visible from elevated locations such as Gable Mountain, Gable Butte, and Rattlesnake Mountain.

Ex Situ Intermediate Separations Alternative

This alternative would require two large facilities, both located in the same portion of the 200 East Area. These would be a HLW vitrification facility reaching 30 m (100 ft) abovegrade, and a LAW vitrification facility reaching 19 m (63 ft) abovegrade. Each plant would have two 55-m (180-ft)-high stacks. The two large vitrification facilities with their 55-m (180-ft)-high stacks occasionally might be visible in the visual background from State Route 240 (Figure 5.8.1). Because of the distance involved, visual impacts would be minor and similar to the impacts that currently exist. Plumes from the vitrification facility stacks might be visible occasionally from locations near the Site boundaries under certain atmospheric conditions (e.g., high humidity and no wind). The LAW vaults and tank farms would not be visible from State Route 240 because of their size (no more than the equivalent of one to two stories high) and the distances involved. None of the TWRS sites would be expected to be visible from any other offsite locations, including the Columbia River. However, the facilities would be visible from elevated locations such as Gable Mountain, Gable Butte, and Rattlesnake Mountain.

As part of the closure scenario, there also would be Hanford Barriers over the tank farms and LAW disposal vaults. Borrow site impacts would be the same as described for the In Situ Vitrification alternative, high at the potential Vernita Quarry and McGee Ranch borrow sites, and low at the potential Pit 30 borrow site.

Ex Situ No Separations Alternative

The remedial activities of the Ex Situ No Separations alternative would result in similar impacts to the Ex Situ Intermediate Separations alternative. There would be only one large stack because there would be only one vitrification facility. This stack would be briefly visible in the visual background by travelers on State Route 240 and facilities would be visible from elevated locations. Plumes from the

vitrification facility stack might be visible from locations near Site boundaries under certain atmospheric conditions. Because there would be no onsite LAW disposal vaults, closure would require fewer Hanford Barriers. Visual impacts at the potential borrow sites resulting from their use to support closure would be the same as described for the other tank waste alternatives.

Ex Situ Extensive Separations Alternative

The remediation actions under this alternative would result in essentially the same visual impacts as described earlier for the Ex Situ Intermediate Separations alternative. Visual impacts would result from two large vitrification facilities of the same height as described previously, both with 55-m (180-ft)-high stacks. Closure impacts would include the Hanford Barriers over the tank farms and LAW disposal vaults, and land form changes at the potential borrow sites and disposal vaults.

The two vitrification facilities occasionally would be visible in the visual background from State Route 240, and all facilities would be visible from elevated locations. No facilities would be visible from the Columbia River. Plumes from the vitrification facility stacks could be visible occasionally near the Hanford Site boundaries on days with certain atmospheric conditions (e.g., high humidity and no wind).

Ex Situ/In Situ Combination 1 and 2 Alternatives

These alternatives would have essentially the same visual impacts as described for the Ex Situ Intermediate Separations alternative. Changes to the visual environment would occur at facility sites during remediation and at Hanford Barriers and the potential borrow sites during closure.

Phased Implementation Alternative

Phase 1

Phase 1 of the Phased Implementation alternative would have similar visual impacts to the other ex situ alternatives. The primary visual impact would be from 46-m (150-ft)-high stacks on each vitrification facility, although the overall complex would be smaller than the other ex situ alternatives.

The vitrification facility stacks occasionally would be visible from State Route 240, and under certain atmospheric conditions, plumes from the stack might be visible from near Site boundaries. The Phased Implementation facilities would be visible from elevated locations. No facilities would be visible from the Columbia River. Phase 1 of Phased Implementation would involve no onsite LAW disposal vaults. The only borrow site visual impacts would be from the disturbance of 0.4 ha (1 ac) at the potential Pit 30 borrow site.

Total Alternative

The Phased Implementation alternative, when fully implemented, would include the impacts detailed for Phase 1 as well as impacts associated with the second phase of the alternative. The additional visual impacts would include two large vitrification tactics with their stacks. All other impacts would be similar to those of the Ex Situ Intermediate Separations alternative.

Capsule Alternatives

All cesium and strontium capsule alternatives except Onsite Disposal would have negligible visual impacts because no activities would be visible from offsite locations. The No Action alternative would involve continued use of the current WESF site. The Onsite Disposal alternative would involve using a disturbed site adjacent to the 200 East Area and facilities but would have 672 1.2-m (4-ft)-high cement caps over each of the drywells, which would be visible from elevated locations. The Overpack and Ship and Vitrify with Tank Waste alternatives would require small facilities that would be sited within the large TWRS sites proposed for the 200 East Area under the various ex situ alternatives. These capsule facilities would not be noticeable within the complex.

5.9 NOISE

The following text summarizes potential noise impacts to onsite workers, the public, and wildlife from the construction and operations phase of each alternative. Potential construction noise impacts were compared with the General Service Administration construction noise specifications, and a bounding case scenario was evaluated to estimate the probable distance from construction activities that would be impacted. For operations phase noise, noise impacts of activities within facilities and exterior to facilities were addressed.

Noise Impacts

Impacts addressed in this section include:

- Noise impacts during construction activities to humans and wildlife under the tank waste and capsule alternatives (Section 5.9.1); and
- Noise impacts during operation of facilities to humans and wildlife under the tank waste and capsule alternatives (Section 5.9.2).

Potential noise impacts of all alternatives would be minor. All tank waste alternatives except the No Action alternative would involve noise generation associated with construction and operation phase activities. However, all proposed sites are a considerable distance from sensitive receptors such as residences, hospitals, and schools. None of the alternatives would have noise impacts on offsite locations, nor would any violations of Federal or State noise standards occur. The only potential onsite noise impact on human beings would be occupational noise effects on project workers from exposure to construction equipment noise and the noise of waste treatment facility operations. Noise protection measures would be used to ensure that no occupational noise standards would be violated. Noise emissions during construction activities and noise associated with borrow site activities could cause minor disturbance to sensitive wildlife species (particularly birds of prey) in the vicinity of the construction and potential borrow sites (Section 5.4.2). The affected Tribal Nations have expressed the concern that noise emissions, which would be highest during construction, could adversely impact Gable Mountain, which is used by Native Americans for religious purposes (CTUIR 1996). However, because Gable Mountain is approximately 3 km (2 mi) from TWRS areas, TWRS noise emissions would have only very minor impacts on noise levels at Gable Mountain or at Gable Butte.

During both construction and operation phases of all tank waste alternatives, there would be some increases in noise levels offsite from vehicular travel (worker vehicles and trucks) along existing

roadways near the Hanford Site. The noise impacts of these incremental noise emissions would be minor because they would occur on existing roadways that currently are used extensively.

5.9.1 Construction Phase Noise Impacts

Construction phase noise impacts would result largely from noise generated by mechanized equipment such as loaders, bulldozers, cranes, and trucks. Borrow site activities would involve similar heavy equipment. The noise emissions of various alternatives likely would differ somewhat depending on the types and number of pieces of mechanized equipment in use at a given time and location and on the duration of construction and borrow site activities. Noise emission levels from all mechanized equipment used during construction and borrow site activities for all alternatives would be within the General Services Administration construction noise specifications or other similar noise standards. Table 5.9.1 lists noise specifications for some of the types of construction equipment likely to be used.

Table 5.9.1 General Services Administration Construction - Noise Specifications [1]

Equipment Type	dBA at 15 m (50 ft)	dBA at 150 m (500 ft)
Earthmoving		
Front loader	75	79
Backhoes	75	85
Dozers	75	80
Scrapers	80	88
Graders	75	85
Trucks	75	91
Materials Handling		
Cranes	75	83
Stationary		
Pumps	75	76
Generators	75	78
Compressors	75	81

Notes:
[1] Effective date: May 1987
dBA is decibels on the A scale, which adjusts noise levels to account for human hearing capabilities.

Because of the remoteness and natural setting of much of the Hanford Site, potential noise impacts to resident wildlife species were of concern. Table 5.9.2 presents the results of this analysis, in which a scraper, bulldozer, and grader were assumed to operate concurrently at the same location. Because these pieces of equipment likely all would be in relatively constant motion, it is likely that three such pieces of equipment would be operating in close proximately to each other only for short periods of time. At a distance of 15 m (50 ft), the cumulative noise level would be 90 decibels on the A scale (dBA). The noise level would reduce to less than 74 dBA at 100 m (330 ft) and 62 dBA at 400 m (1,300 ft). To place these noise levels in perspective, 90 dBA is approximately the noise level of a food blender at a distance of 1 m (3 ft). Riding inside an automobile at 65 km (40 mi) per hour

produces approximately 75 dBA. Normal speech is 60 dBA. Consequently, there would be some short-term disturbance of noise-sensitive wildlife species near the TWRS activity sites during construction and borrow site activities (Section 5.4). Construction noise levels would approach background levels at distances greater than 600 m (2,000 ft), although some species could be disturbed up to a distance of up to 800 m (2,700 ft) from the construction sites.

Table 5.9.2 Probable Bounding Case Cumulative Noise Impact During the Construction Phase (All Alternatives)

Equipment Type	Noise Level 15 m (dBA)	Cumulative Noise Level (dBA)		
		15 m (50 ft)	100 m (330 ft)	400 m (1,300 ft)
Scraper	88	90	74	62
Dozer	80			
Grader	85			

Notes:
dBA is decibels on the A scale, which adjusts noise levels to account for human hearing capabilities.

No Action Alternative (Tank Waste)

Because the No Action alternative would involve no new construction, there would be no construction phase noise impacts. Noise emissions from routine maintenance activities would be monitored, and appropriate noise protection measures would be taken under routine Hanford Site occupational health and safety procedures.

Long-Term Management Alternative

This alternative would have no construction phase noise impacts until the 2030's and again in the 2080's, when new underground storage tanks would be constructed to replace existing DSTs at the end of their design lives. Noise impacts would be the same as described in Table 5.9.2.

In Situ Fill and Cap Alternative

The In Situ Fill and Cap alternative would involve minimal construction activities (i.e., only those associated with preparing to place the fill material in the tanks). This alternative would involve borrow site activities and associated noise emissions at the potential Vernita Quarry, McGee Ranch, and Pit 30 borrow sites, as well as noise emissions associated with constructing Hanford Barriers at the tank farms (during closure). Noise impacts would be as described in Table 5.9.2.

In Situ Vitrification Alternative

The In Situ Vitrification alternative would involve construction activities for constructing tank farm confinement facilities and installing vitrification equipment throughout the 200 Areas at the 18 tank farms, and along the transmission line corridors in the 200 Areas where new powerlines would be installed to supply power to the vitrification activities. Borrow site activities and noise emissions would occur at the potential Pit 30 borrow site. Noise emissions also would occur during closure at the

potential Vernita Quarry and McGee Ranch borrow sites and while constructing Hanford Barriers at the tank farms. Noise impacts would be as described in Table 5.9.2.

Ex Situ Intermediate Separations Alternative

The Ex Situ Intermediate Separations alternative would involve noise emissions from waste retrieval and waste processing facility construction during remediation. During closure, noise emissions would include Hanford Barrier construction at the tank farms and LAW vaults and heavy equipment activities at borrow sites. Impacts would be as described in Table 5.9.2.

Ex Situ No Separations Alternative

The Ex Situ No Separations alternative would involve construction noise emissions from all of the same activities at the same locations as the Ex Situ Intermediate Separations alternative, except that no vault construction or Hanford Barriers would be required for LAW vaults during closure. The Ex Situ No Separations alternative would involve no long-term LAW storage on the Hanford Site.

Ex Situ Extensive Separations Alternative

The Ex Situ Extensive Separations alternative would involve noise emissions similar to the Ex Situ Intermediate Separations alternative. This alternative would involve similar activities at the same locations (i.e., tank farms, waste processing facilities, borrow sites, and LAW vaults).

Ex Situ/In Situ Combination 1 and 2 Alternatives

These alternatives would involve noise emissions from waste retrieval construction and fill and cap activities at the tank farms and from constructing the proposed TWRS sites in the 200 East Area during remediation. They also would result in impacts from constructing Hanford Barriers at the tank farms as part of the closure process and from constructing Hanford Barriers at the LAW vaults following emplacement of the stabilized LAW. Noise emissions also would be generated at the potential Vernita Quarry, McGee Ranch, and Pit 30 borrow sites during closure.

Phased Implementation Alternative

Phase 1

This phase of the alternative would involve noise emissions from constructing the two demonstration separations and vitrification facilities.

Total Alternative

The Phased Implementation alternative, when fully implemented, would include the impacts for Phase 1 as well as impacts associated with the second phase of the alternative. The total alternative noise impacts would involve construction emissions from all of the same activities at the same locations as the Ex Situ Intermediate Separations alternative.

Capsule Alternatives

All cesium and strontium capsule alternatives would have minor noise impacts during construction. The No Action alternative would involve no construction activities. The Onsite Disposal alternative

would involve construction noise at a site adjacent to the western edge of the 200 East Area. The Overpack and Ship and Vitrify with Tank Waste alternatives would involve minimal construction, all of which would occur as part of developing the proposed TWRS sites in the 200 East Area associated with the various ex situ alternatives.

5.9.2 Operation Phase Noise Impacts

For all tank waste alternatives except the No Action and Long-Term Management alternatives, operation phase noise emissions would be largely related to operating process equipment (e.g., evaporator, mixer pumps, and melter and quencher). The No Action alternative would involve only the continuation of noise from ongoing, routine tank farm operations. The Long-Term Management alternative would involve operating two new tank farms, but there would be noise emissions from the existing 18 tank farms. Because the waste treatment process equipment for the various vitrification alternatives would be operating inside enclosed structures, exterior noise levels would not be substantially increased. There would be some exterior noise emissions from the emplacement of fill material in the tanks under the In Situ Fill and Cap alternative.

All facilities and working conditions would comply with the Occupational Safety and Health Administration occupational noise requirements contained in 29 CFR 1910.95. Pursuant to these occupational noise requirements, noise exposures for an 8-hour duration would not exceed 85 dBA. In cases where the workers would be exposed to noise levels exceeding this value, administrative controls, engineering controls, or personal protective equipment use would be required to reduce the noise exposures below the allowable maximum.

5.10 TRANSPORTATION

This section describes the impacts of the vehicular traffic associated with the various TWRS alternatives on the roadway system of the Hanford Site and vicinity. As described in Section 4.10, the roadways of primary concern would be 1) the segment of Stevens Road at the 1100 Area, which is the primary Site entrance from the city of Richland; and 2) the segment of Route 4, which is a continuation of Stevens Road northward into the Hanford Site, west of the Wye Barricade. Stevens Road and Route 4 are by far the Hanford Site's most heavily traveled north-south route, and both of the road segments experienced heavy peak hour congestion in the recent past, although congestion has declined in 1995 as Site employment levels declined. The standard traffic Level of Service hierarchy ranges from Level of Service A (least congested) to Level of Service F (most congested). Conditions worse than Level of

Transportation Impacts

Impacts addressed in this section include:

- Traffic impacts on road capacity to and from the Hanford Site under tank waste alternatives (Section 5.10.1);
- Traffic impacts on road capacity to and from the Hanford Site under capsule alternatives (Section 5.10.2);
- Offsite rail shipment impacts on the rail system capacity (Section 5.10.3); and
- Impacts of transportation accidents are addressed in Section 5.12.

Service D are considered unacceptable. Prior to mid-1995, morning peak hour congestion on Stevens Road frequently reached Level of Service F, while on Route 4, it frequently reached Level of Service E.

To estimate vehicular traffic impacts, expected incremental traffic volumes (approximately 98 percent personal vehicles and 2 percent trucks for all EIS alternatives) were added to estimated future baseline Hanford Site traffic volumes. The analysis focused on the peak year of activity for each EIS alternative, which differed based on the alternative-specific schedule for construction and operation. The approximate time frames before and after the peak year when increased traffic congestion also would be expected were identified as well. Because Hanford Site traffic volumes typically reach their daily peaks during the morning shift change, this analysis focused on the morning peak hour, the time period of expected greatest impact.

For the tank waste No Action, Long-Term Management, and In Situ Fill and Cap alternatives and all capsule alternatives, there would be negligible impacts on traffic conditions on the two roadways of primary concern. All of the remaining tank waste alternatives would contribute to level of service conditions, which are considered unacceptable (Level of Service E and F). The impacts of these alternatives generally would build prior to the peak year and decline in the years following the peak year. The peak year for the various EIS alternatives except Phased Implementation would be from 2001 to 2004 depending on the alternative. For the Phased Implementation (Total) alternative, the peak year of traffic impacts would be in 2010.

Impacts of TWRS alternatives' rail transport to and from the Hanford Site are described in Section 5.10.3. Transportation accident risks are described in Section 5.12 (Accidents).

There are a number of key assumptions that underlie the EIS traffic impact analysis, which include the following.

- Approximately 12 percent of the future total average daily traffic on Stevens Road would occur during the morning peak hour, while about 25 percent of the average daily traffic on Route 4 west of the Wye Barricade would occur during the morning peak. This assumption was based on traffic data from the last few years (BFRC 1993 and WHC 1994c).
- All TWRS day shift employee vehicular traffic would occur during the Hanford Site's morning peak hour, with an assumed average of 1.35 persons/vehicle to account for carpooling and vanpooling.
- There would be heavy use by TWRS employees of both the new State Route 240 Access Road (Beloit Avenue), which avoids Stevens Road and Route 4 entirely, and of the Route 2/11A route to the 200 Areas from the Wye Barricade, which avoids the critical segment of Route 4 west of the Wye Barricade.
- It is assumed that approximately 11 percent of TWRS employees would commute from areas west of the Hanford Site (e.g., Benton City and Prosser) and that about 6 percent would commute from West Richland. This was the distribution of Hanford Site employee points of origin in 1992 (BFRC 1993). These TWRS commuters were

assumed largely to use alternatives to Stevens Road and Route 4, i.e., the Yakima Barricade Site entrance (commuters from the west), or Route 10 (West Richland commuters).

The transportation of borrow material from the potential Vernita Quarry and McGee Ranch borrow sites during closure, which would occur under all alternatives except No Action and Long-Term Management, would increase truck traffic on State Route 24 and on Route 11A leading to the 200 Areas. This traffic increase would take place during the construction of Hanford Barriers after waste treatment was completed. Hanford Barrier construction would occur almost entirely in the 2020's under all alternatives. No quantitative analysis has been performed, but given the projected long-term declines in overall Hanford Site employment, no substantial traffic congestion would be expected at this future date.

The onsite transport of waste from the inactive miscellaneous underground storage tanks would occur by a specially designed truck. There could be occasional interference with normal traffic flow onsite during these waste transport activities to ensure safety during the waste transport operations; however, the impact of these disruptions to peak community employee traffic could be mitigated by scheduling truck traffic during nonpeak hours.

5.10.1 Tank Waste Alternatives

The traffic impacts of each EIS alternative are described in the following text and summarized in Table 5.10.1.

No Action Alternative (Tank Waste)

Traffic impacts under the No Action alternative would be lowest of all the tank waste alternatives because this alternative would have the lowest employment levels (routine tank farm operations only). On Stevens Road, total morning peak hour traffic volumes would be approximately 3,100 (Table 5.10.1), which is about 6 percent lower than the 1992 levels that were evaluated as Level of Service F (highly congested). Thus, a Level of Service in the D to E range would be expected, which represents congestion approaching unacceptable conditions. On Route 4 west of the Wye Barricade, morning peak hour volumes would exceed 1,900, which is nearly 20 percent below the congested (Level of Service E) conditions observed in mid-1994. Thus, acceptable traffic conditions would be expected.

Long-Term Management Alternative

This alternative would have the same traffic volumes and impacts as the No Action alternative until the 2030's when there would be construction of new underground tanks. Because projecting future traffic levels 35 years in the future has large uncertainties, the traffic impacts of the Long-Term Management alternative were assumed to be the same as for No Action. Thus in 2001, it was assumed that traffic congestion would be approaching unacceptable levels on Stevens Road and acceptable levels on Route 4 west of the Wye Barricade.

Table 5.10.1 Peak Year Traffic Impacts

Alternative and Roadway Segment	Peak Year	AM Peak Hour Traffic Volumes			Expected Traffic Conditions [1]
		Baseline (Without TWRS)	TWRS Increment	Total	
No Action - Stevens Road at 1100 Area	2001	2,900	200	3,100 [2]	Level of Service D to Level of Service E
No Action - Route 4 West of Wye Barricade	2001	1,900	100	2,000 [3]	Level of Service C to Level of Service D
Long-Term Management - Stevens Road at 1100 Area	2001	2,900	200	3,100 [2]	Level of Service D to the level of Service E
Long-Term Management - Route 4 West of Wye Barricade	2001	1,900	100	2,000 [3]	Level of Service C to Level of Service D
In Situ Vitrification - Stevens Road at 1100 Area	2004	2,700	900	3,600 [2]	Level of Service F
In Situ Vitrification - Route 4 West of Wye Barricade	2004	1,700	400	2,100 [3]	Level of Service D
In Situ Fill and Cap	N/A	N/A	<50	N/A	Negligible Impacts
Ex Situ Intermediate Separations - Stevens Road at 1100 Area	2002	2,900	1,800	4,700 [2]	Level of Service F
Ex Situ Intermediate Separations - Route 4 West of Wye Barricade	2002	1,800	1,300	3,100 [3]	Level of Service F
Ex Situ No Separations - Stevens Road at 1100 Area	2000	3,000	1,800	4,800 [2]	Level of Service F
Ex Situ No Separations - Route 4 West of Wye	2000	1,900	1,300	3,200 [3]	Level of Service F
Ex Situ Extensive Separations - Stevens Road at 1100 Area	2003	2,800	3,400	6,200 [2]	Level of Service F
Ex Situ Extensive Separations - Route 4 West of Wye Barricade	2003	1,800	2,900	4,700 [3]	Level of Service F
Ex Situ/In Situ Combination 1 - Stevens Road at 1100 Area	2001	2,900	800	3,700 [2]	Level of Service F
Ex Situ/In Situ Combination 1 - Route 4 West of Wye Barricade	2001	1,800	400	2,200 [3]	Level of Service E
Ex Situ/In Situ Combination 2 - Stevens Road at 1100 Area	2001	2,900	700	3,600	Level of Service F
Ex Situ/In Situ Combination 2 - Route 4 West of Wye Barricade	2001	1,800	350	2,200	Level of Service E

Table 5.10.1 Peak Year Traffic Impacts (cont'd)

Alternative and Roadway Segment	Peak Year	AM Peak Hour Traffic Volumes			Expected Traffic Conditions [1]
		Baseline (Without TWRS)	TWRS Increment	Total	
Phased Implementation (Phase 1) - Stevens Road 1100 Area	1999	3,000	1,300	4,300 [2]	Level of Service F
Phased Implementation (Phase 1) - Route 4 West of Wye Barricade	1999	1,900	800	2,700 [3]	Level of Service E to Level of Service F
Phased Implementation (Total Alternative) - Stevens Road 1100 Area	2010	2,100	3,500	5,600 [2]	Level of Service F
Phased Implementation (Total Alternative) - Route 4 West Wye Barricade	2010	1,300	2,900	4,200 [3]	Level of Service F
Capsule Alternatives (All)	N/A	N/A	<50 [4]	N/A	Negligible Impact

Notes:
[1] Traffic Levels of Service range from Level of Service A (least congested) to Level of Service F (most congested). Level of Service E and Level of Service F are considered unacceptable traffic conditions.
[2] Recorded morning peak hour traffic volume in 1992 was 3,362 vehicles, which produced Level of Service F conditions.
[3] Recorded morning peak hour traffic volume in 1994 was 2,368 vehicles, which produced Level of Service E conditions.
[4] The In Situ Fill and Cap alternative and all capsule alternatives would have low traffic volumes and would have negligible impacts.
N/A = Not applicable

In Situ Fill and Cap Alternative

Under the In Situ Fill and Cap alternative, incremental traffic volumes in all years would be small because of the small workforce associated with the alternative (less than 150 in any year). Incremental traffic on the roadways of concern would not exceed 50 vehicles in the morning peak hour, which would have a negligible impact on traffic conditions.

In Situ Vitrification Alternative

Under the In Situ Vitrification alternative, during the peak year of 2004, morning peak hour volumes would reach 3,600 vehicles on Stevens Road at the 1100 Area. Additionally, traffic would be congested on the State Route 240 Bypass Highway approaching the intersection with Stevens Road. The TWRS traffic on Stevens Road would represent an increase of 33 percent above baseline levels in that year. Traffic congestion would be extremely heavy (Level of Service F). On Route 4 west of the Wye Barricade, morning peak hour volumes would be 2,100 vehicles, with TWRS vehicles representing an increase of about 25 percent above baseline traffic volumes. Traffic conditions would be somewhat congested (Level of Service D), as the volumes would be approximately 10 percent lower than the volumes that produced Level of Service E on the same road in 1994. Congestion on both roads would begin to build up in 2001 and would remain steady until 2007.

Ex Situ Intermediate Separations Alternative

Under the Ex Situ Intermediate Separations alternative, peak traffic flows would occur in the year 2002 and would result in extreme peak hour congestion (Level of Service F) on both roadways of

interest. On Stevens Road, the morning peak hour volume would be about 4,700 vehicles. This would be well over the volumes that produced Level of Service F conditions in 1994. Additionally, traffic would be congested on the State Route 240 Bypass Highway approaching the intersection with Stevens Road. The TWRS traffic would increase peak hour volumes on Stevens Road by over 60 percent above the baseline. On Route 4, TWRS traffic volumes (3,100 vehicles) would be 70 percent above the baseline, which would produce total peak hour volume about 30 percent higher than the Level of Service E conditions observed in 1994. Congestion would begin to build up in 1999 and would continue at high levels until 2004.

Ex Situ No Separations Alternative

With the Ex Situ No Separations alternative, morning peak hour conditions in the year 2000 would be extremely congested (Level of Service F) on both roadways of concern. On Stevens Road in the 1100 Area, traffic volumes would be about 4,800 vehicles, with the alternative's traffic representing an increase of 60 percent over the baseline. Additionally, traffic would be congested on the State Route 240 Bypass approaching the intersection with Stevens Road. On Route 4 west of the Wye Barricade, traffic volumes would be approximately 3,200, an increase of 70 percent over baseline levels. Severely congested conditions would begin in 1999 and last through 2001.

In Situ Vitrification Alternative

Under the In Situ Vitrification alternative, during the peak year of 2004, morning peak hour volumes would reach 3,600 vehicles on Stevens Road at the 1100 Area. Additionally, traffic would be congested on the State Route 240 Bypass Highway approaching the intersection with Stevens Road. The TWRS traffic on Stevens Road would represent an increase of 33 percent above baseline levels in that year. Traffic congestion would be extremely heavy (Level of Service F). On Route 4 west of the Wye Barricade, morning peak hour volumes would be 2,100 vehicles, with TWRS vehicles representing an increase of about 25 percent above baseline traffic volumes. Traffic conditions would be somewhat congested (Level of Service D), as the volumes would be approximately 10 percent lower than the volumes that produced Level of Service E on the same road in 1994. Congestion on both roads would begin to build up in 2001 and would remain steady until 2007.

Ex Situ Intermediate Separations Alternative

Under the Ex Situ Intermediate Separations alternative, peak traffic flows would occur in the year 2002 and would result in extreme peak hour congestion (Level of Service F) on both roadways of interest. On Stevens Road, the morning peak hour volume would be about 4,700 vehicles. This would be well over the volumes that produced Level of Service F conditions in the recent past. Additionally, traffic would be congested on the State Route 240 Bypass Highway approaching the intersection with Stevens Road. The TWRS traffic would increase peak hour volumes on Stevens Road by over 60 percent above the baseline. On Route 4, TWRS traffic volumes (3,100 vehicles) would be 70 percent above the baseline, which would produce total peak hour volume about 30 percent higher than the Level of Service E conditions observed in 1994. Congestion would begin to build up in 1999 and would continue at high levels until 2004.

Ex Situ No Separations Alternative

With the Ex Situ No Separations alternative, morning peak hour conditions in the year 2000 would be extremely congested (Level of Service F) on both roadways of concern. On Stevens Road in the 1100 Area, traffic volumes would be about 4,800 vehicles, with the alternative's traffic representing an increase of 60 percent over the baseline. Additionally, traffic would be congested on the State Route 240 Bypass approaching the intersection with Stevens Road. On Route 4 west of the Wye Barricade, traffic volumes would be approximately 3,200, an increase of 70 percent over baseline levels. Severely congested conditions would begin in 1999 and last through 2001.

Ex Situ Extensive Separations Alternative

The Ex Situ Extensive Separations alternative would have the most intense traffic impacts of the EIS alternatives. In the peak year of 2003, extremely severe congestion (Level of Service F) would occur during the morning peak hour on both Stevens Road at the 1100 Area and on Route 4 west of the Wye Barricade. On Stevens Road, peak hour volumes would be approximately 6,200 vehicles, which would be a 130 percent increase over baseline conditions. This volume also would be 2,800 more vehicles than caused extreme congestion (Level of Service F) conditions on Stevens Road in 1992. Additionally, traffic would be congested on the State Route 240 Bypass approaching the intersection of Stevens Road. On Route 4 west of the Wye Barricade, traffic volumes would be approximately 4,700 vehicles, an increase of approximately 150 percent over the expected baseline volume. Severe congestion would begin in the year 2002 and continue through 2004.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, morning peak hour traffic volumes would occur in 2001 and would result in severe congestion (Level of Service F) on Stevens Road at the 1100 Area and slightly less severe but still unacceptable (Level of Service E) congestion on Route 4 west of the Wye Barricade. Additionally, traffic would be congested on the State Route 240 Bypass Highway approaching the intersection with Stevens Road. On Stevens Road, morning peak hour volumes would be about 3,700 vehicles. This would be about 350 vehicles (10 percent) more than the volumes that created Level of Service F in 1992. On Route 4 west of the Wye Barricade, morning peak hour volume would be approximately 2,200 vehicles, slightly less than the volumes that created Level of Service E in 1994. Congestion would begin to build up in 1999 and continue through 2004.

Ex Situ/In Situ Combination 2 Alternative

This alternative would have similar peak traffic volumes and resulting traffic impacts as the Ex Situ/ In Situ Combination 1 alternative. In the peak year of 2001, severe congestion (Level of Service F) would occur on Stevens Road at the 1100 Area, and slightly less severe but still unacceptable congestion (Level of Service E) would occur on Route 4, west of the Wye Barricade. Traffic on the 240 Bypass Highway approaching the intersection with Stevens Road also would occur. Morning peak hour volumes on Stevens Road would be about 3,600 vehicles. This would be about the same as the volumes that created Level of Service F in 1992. On Route 4 west of the Wye Barricade, morning peak hour volumes would be about 2,200 vehicles, which is almost the same as the volumes that created Level of Service E in 1994.

Phased Implementation Alternative

Phase 1

The greatest morning peak hour traffic volumes under Phase 1 of Phased Implementation would occur in 1999. These volumes would lead to severe congestion (Level of Service F) on Stevens Road at the 1100 Area and severe congestion (Level of Service E to Level of Service F) on Route 4 west of Wye Barricade. There also would be congestion on State Route 240 Bypass Highway approaching the intersection with Stevens Road. On Stevens Road, morning peak hour volumes would be approximately 4,300 vehicles, which would be about 30 percent more vehicles than the volume that produced Level of Service F conditions in 1992. On Route 4 west of Wye Barricade, morning peak hour volumes would be about 2,700 vehicles. This would be nearly 15 percent more vehicles than the volume that created Level of Service E conditions in 1994. This phase of the alternative's impacts would begin to build up in 1998 and would continue until 2000.

Total Alternative

The Phased Implementation alternative, when fully implemented, would involve the impacts detailed for Phase 1 as well as impacts associated with Phase 2 of the alternative. The peak traffic flows would occur in the year 2010 and would result in extreme peak hour congestion (Level of Service F) on both roadways of interest. On Stevens Road, the morning peak hour volume would be approximately 5,600 vehicles. On Route 4, the incremental TWRS traffic volumes of 2,900 vehicles would produce peak hour traffic that would result in Level of Service F conditions. Congestion would begin to build in 2007 and would continue at high levels and continue for several years after the 2010 peak.

5.10.2 Capsule Alternatives

Because employment under the cesium and strontium capsule alternatives would be less than 50 employees in the peak year, traffic volumes would be small. The capsule alternatives' incremental traffic volumes would have negligible impacts on traffic conditions at the Hanford Site.

5.10.3 Rail Traffic

Rail traffic volume would be relatively small for all EIS alternatives, and small impacts on the rail systems would be expected (Table 5.10.2). The No Action (Tank Waste) alternative would involve no rail traffic. The Long-Term Management alternative would involve approximately 65 rail trips per year during new tank construction in the 2030's and 2080's. The In Situ Fill and Cap alternative would involve three rail trips per year to deliver materials to the Site during construction and operations. The In Situ Vitrification alternative would involve 16 rail trips per year for transporting construction materials and chemicals used during operations to the Site.

The Ex Situ Intermediate Separations alternative would involve an average of 25 rail trips per year to deliver materials to the Site during construction and operations phases, and 17 rail trips per year to transport HLW to the potential geologic repository. In the year 2020, when both waste processing operations and HLW shipments are ongoing, total rail traffic would be 42 trips per year (more than 3 trips per month).

Table 5.10.2 Rail Traffic Volumes

Alternative	Construction/Operations Phases [1]		HLW Shipments to Repository [2]	
	Average Trips/Year	Time Frame	Average Trips/Year	Time Frame
Tank Waste				
No Action	0	--	0	--
Long-Term Management	65	2030 - 2080	0	--
In Situ Fill and Cap	3	1999 - 2013	0	--
In Situ Vitrification	16	1998 - 2016	0	--
Ex Situ Intermediate Separations	25	1998 - 2022	17	2022 - 2040
Ex Situ No Separations:				
Vitrification	38	1998 - 2020	145	2020 - 2040
Calcination	18	1998 - 2020	51	2020 - 2040
Ex Situ Extensive Separations	30	1999 - 2023	5	2022 - 2025
Ex Situ/In Situ Combination 1	14	1998 - 2023	12	2022 - 2040
Ex Situ/In Situ Combination 2	9	1998 - 2022	7	2022 - 2040
Phased Implementation (Phase 1)	11	1997 - 2012	0	--
Phased Implementation (Total)	26	1997 - 2028	17	2022 - 2040
Capsules				
No Action	0	--	0	--
Onsite Disposal	0	--	0	--
Overpack and Ship	0	2002 - 2028	6	2028 - 2029
Vitrify with Tank Waste [3]	--	--	--	--

Notes:
[1] All rail trips during construction and operations phases would be trips to the Site for deliveries such as construction materials and chemicals used during waste processing. Estimate based on 20 rail cars per trip.
[2] Estimate for average trips per year based on 10 rail cars per trip.
[3] The Vitrify with Tank Waste alternative rail trips are included in total trips shown for the ex situ alternatives.

The Ex Situ No Separations alternative (Vitrification) would require 38 rail trips per year during construction and operations and 145 rail trips per year for HLW transport to the potential geologic repository. During the year 2020, when operation and HLW shipments overlap, a total of 50 rail trips per year (approximately 4 rail trips per month) would be expected. The calcination option for the No Separations alternative would involve 18 trips per year during construction and operations, 51 HLW shipments per year to the potential geologic repository, and a combined peak (in 2020) of 69 rail trips per year (up to 6 trips per month).

The Ex Situ Extensive Separations alternative would require 30 rail trips per year to the Site during construction and operations phases and 5 trips per year of HLW shipments to the potential geologic repository. From 2022 to 2023, when both operations and HLW shipments would be ongoing, rail trips would average 35 per year (3 per month). The Ex Situ/In Situ Combination 1 alternative would require 14 rail trips to the Site during construction and operations and 12 HLW rail shipments per year to the potential geologic repository. From 2022 to 2023, when both operations and HLW shipments

would be ongoing, rail trips would average 26 per year (2 per month). The Ex Situ/In Situ Combination 2 alternative would involve 9 trips per year during construction and operations, 7 HLW rail shipments per year, and 16 rail trips per year during 2020 when both operations and HLW shipments would be ongoing.

Phased Implementation (Phase 1) would involve 11 rail shipments per year to bring materials onto the Site, but no offsite shipments of HLW. The total Phased Implementation alternative would require 26 rail shipments per year during construction and operations, 17 rail shipments per year to the potential geologic repository. This results in 43 rail trips per year (3 to 4 rail trips per month) from 2022 to 2028 when both operations activities and HLW shipments would be ongoing.

Rail traffic volumes associated with the capsule alternatives would be minimal, as discussed in the following text. The No Action and Onsite Disposal alternatives would involve no rail traffic. The Overpack and Ship alternative would involve six rail shipments of HLW per year to the potential geologic repository in 2028 and 2029 only. Rail trips associated with the Vitrify with Tank Waste alternative were included in the rail trips estimated for each of the tank waste ex situ alternatives.

5.11 ANTICIPATED HEALTH EFFECTS

This section describes the anticipated risk to human health for each of the EIS alternatives.
The categories of anticipated risk presented were 1) remediation risk resulting from routine remediation activities, such as retrieving waste from tanks and waste treatment operations; 2) post-remediation risk, such as the risk resulting from residual contamination remaining after the completion of remediation activities; and 3) post-remediation risk resulting from human intrusion directly into the residual tank waste remaining after remediation.

Carcinogenic and noncarcinogenic adverse health effects on humans from exposure to radioactive and toxicological contaminants associated with each of these categories of risk were evaluated for each alternative. Health effects from accidents are described in Section 5.12 and ecological risk effects are described in
Section 5.4.6.

Health Effects Impacts

Impacts addressed in this section include the following:

- Employee and public health effects from radiological exposure during remediation (Section 5.11.1.1);
- Employee and public health effects from chemical exposure during remediation (Section 5.11.1.2);
- Public health effects from radiological and chemical exposure after remediation is completed (Section 5.11.2.2); and
- Health risk to a human intruder from waste disposed of onsite (Section 5.11.3).

Radiological and chemical impacts on biological resources were discussed previously (Section 5.4.6).

The No Action, Long-Term Management, In Situ Fill and Cap, and In Situ Vitrification tank waste alternatives each would result in less than one occupational latent cancer fatality, and cancer risk from

chemical exposures for workers would range from 9.84E-07 to 1.95E-07. During tank waste remediation activities, all of the alternatives involving waste retrieval would result in a similar number of latent cancer fatalities to involved and noninvolved workers (two to four according to the alternative) and similar levels of cancer risk from chemical exposure from 2.52E-06 to 8.22E-07. These health effects would be the result of the large number of tank waste remediation workers for the ex situ alternatives and retrieval, treatment, and handling of the waste. All of the capsule alternatives would result in less than one occupational latent cancer fatality from radiological exposures during remediation. All of the tank waste or capsule alternatives would result in less than one latent cancer fatality and cancer risk of less than 3.35E-06 to the general public during remedial activities.

After remediation was completed, there would be no potential for occupational health risk; however, migration of residual tank waste and contaminants disposed of onsite in LAW vaults could pose risk to future Hanford Site users. The greatest health risk to future Site users would result from alternatives that would leave all of the waste untreated in the tanks (No Action, Long-Term Management, and In Situ Fill and Cap alternatives) or large amounts of untreated waste in the tanks (Ex Situ/In Situ Combination 1 and 2 alternatives). All of these alternatives would pose similar risk with peak years of risk occurring from 300 to 2,500 years in the future. All of the ex situ alternatives would pose similar lower incremental lifetime cancer risk and hazard indices. Peak years of risk would occur from 5,000 to 10,000 years in the future. Future Site users that intruded into the waste remaining in the tanks would be exposed to substantial risk of a latent cancer fatality under all alternatives that leave more than 1 percent of the waste in the tanks (a probability of 1 in 100 and 3,000) compared to all of the ex situ alternatives (a probability of 1 in 11,700).

Radiation Effects

The effects of radiation emitted during disintegration (decay) of a radioactive substance depend on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. This absorbed energy is referred to as the absorbed dose. The absorbed dose, when multiplied by certain quality factors that take into account different sensitivities of various tissues, is referred to as the effective dose equivalent, or simply dose. The common unit of effective dose equivalent is the rem (1 rem equals 1,000 mrem). The total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 0.3 rem (300 mrem), the collective dose would be 1,000 persons · 0.3 rem (300 mrem) = 300 person-rem. Alternatively, the same collective dose (300 person-rem) would result from 10,000 people, each of whom received a dose of 0.03 rem (30 mrem) (10,000 · 0.03 = 300 person-rem).

An individual could be exposed to ionizing radiation externally (from a radioactive source outside the body) and internally (from ingesting or inhaling radioactive material). The external dose is different from the internal dose. It is estimated that the average individual in the United States receives a dose of about 0.3 rem (300 mrem) per year from natural sources of radiation. For perspective, a modern chest x-ray results in an approximate dose of 0.008 rem (8 mrem), while a diagnostic hip x-ray results in an approximate dose of 0.083 rem (83 mrem). A person must receive an acute (short-term) dose of approximately 600 rem (600,000 mrem) before there is a high probability of near-term death.

Radiation also can cause a variety of ill-health effects in people. The consequence of environmental and occupational radiation exposure is the induction of latent cancer fatalities. This effect is referred to as latent cancer fatalities because the cancer may take many years to develop and for death to occur.

The factor that this EIS used to relate a dose to its effect was 0.0004 latent cancer fatalities per person-rem for a Site worker and 0.0005 latent cancer fatalities per person-rem for individuals among the general population. The general population latent cancer fatalities factor is slightly higher due to the presence of individuals in the general public that may be more sensitive to radiation than workers (e.g., infants). The concept of calculating latent cancer fatalities can be demonstrated by estimating the effects of natural radiation exposure on an individual. For example, the number of cancer fatalities corresponding to an individual's exposure over a (presumed) 70-year lifetime with a natural radiation dose of 0.3 rem (300 mrem) per year is as follows:

> 1 person · 0.3 rem (300 mrem)/year · 70 years · 0.0005 latent cancer fatalities/person-rem = 0.0105 latent cancer fatalities.

This should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure on an exposed individual would produce a 1.05 percent chance that the individual might incur a latent cancer caused by the exposure. In other words, about 1.05 percent of the population is estimated to die of cancer induced by the radiation background.

Uncertainty in Risk Assessments

Human health risk assessment results are conditional estimates dependent on the assumptions that must be made to account for uncertainties of biological processes or a lack of information on source data, transport, or receptor behavior. Therefore, in evaluating risk estimates, it is important to recognize the uncertainties involved in the analysis to place the risk estimates in proper perspective. The uncertainties associated with the TWRS EIS risk estimates are quantitative where many parameters are involved in the models used in the analysis and qualitative for certain risk, such as worker risk based on the historical statistics or actuarial data. Volume Three, Appendix D presents some parameter uncertainties associated with remediation risk (Section D.4.16), anticipated post-remediation risk (Section D.5.17), ecological risk (Section D.6.5), and intruder risk (Section D.7.5), which are briefly discussed as follows. A detailed discussion of the uncertainties associated with the risk assessment is presented in Volume Five, Appendix K.

To estimate risk, information must be available on dose-response relationships, which defines the biological response from exposure to a contaminant. Although human epidemiological data are used for developing radiation and nonradiological chemical dose-response models, this information also is developed in laboratory tests using animals exposed to relatively high doses. Therefore, uncertainty is inherent in dose-response relationships, including extrapolating from effects in animals at high doses to potential effects in humans that most often are exposed at much lower doses.

Another important component of risk assessment is estimating exposure concentration. Uncertainties associated with this component of the analysis included estimating releases of contaminants from emission sources to different environmental media such as the groundwater, soil, air, and surface water, the transport and transformation of contaminants in these media, and the pathway, frequency, and duration by which humans contact the contaminants.

The risk associated with the potential release of radionuclides or chemicals to ambient environmental media during routine operations was estimated using models. The risk estimates determined by these models have a greater uncertainty than those based on the historical or actual data. However, it is reasonable to assume that potential releases would occur on a routine basis over the operational lifetime of the facility. The risk estimates for post-remediation and intruder scenarios were associated with more uncertainty than facility routine operation risk and involved uncertainties associated with the hypothetical land use and intrusion in addition to modeling. Finally, the maximally-exposed individual risk estimates generally involved a greater level of uncertainty than population risk estimates.

5.11.1 Remediation Risk

Radiological and chemical risk from remediation activities for each alternative was evaluated for Hanford Site workers involved in remediation activities; Hanford Site workers not involved in remediation activities (noninvolved workers); the general public; and a maximally-exposed individual from the workers, noninvolved workers, and general public. A maximally-exposed individual is an individual who is assumed to receive the highest possible exposure.

Health Effects Terms

Carcinogenic: A radionuclide or nonradiological chemical that has been proven or is suspected to be either a promoter or initiator of cancer in humans or animals.

Hazard Index: A measure of the noncarcinogenic health effects of human exposure to chemicals. Health effects are assumed to be additive for exposure to multiple chemicals. A hazard index of greater than 1.0 is indicative of potential adverse health effects. Health effects could be minor temporary effects or fatal, depending on the chemical and amount of exposure.

Incremental Lifetime Cancer Risk: A measure of the potential of developing cancer based on exposure to individual or multiple radionuclides or known or suspected carcinogenic chemicals. It reports the level of risk of contracting cancer in terms of one individual's risk of contracting cancer among the entire exposed population (e.g., 1 in 10, 1 in 10,000, 1 in 1 million).

Latent Cancer Fatality: A fatality resulting from cancer caused by an exposure to a radionuclide or known or suspected carcinogenic chemical.

Maximally-Exposed Individual: A hypothetical member of the public or worker who by virtue of location or living habits could receive the highest dose from an exposure to radionuclides or carcinogenic chemicals.

Population: For risk assessment purposes, population consists of the total potential members of the public or workforce who could be exposed to a possible radiation or chemical dose from an exposure to radionuclides or carcinogenic chemicals.

A more detailed description of the methodology and assumptions used in the assessment of human health risk is contained in Volume Three, Appendix D.

5.11.1.1 Comparison of Radiological Consequences from Remediation Operations

Table 5.11.1 summarizes latent cancer fatality risk for each alternative. Details of the risk calculation methodology are presented in Volume Three, Appendix D. Factors that were incorporated into the analysis included differences in the dose-to-risk conversion factor between workers and noninvolved workers and the general population; extent of exposure in each category; and the number of workers involved in each alternative.

The worker dose would result from occupational exposure to radiation. The historical dose to a Hanford Site tank farm worker has been 14 mrem/year. This same dose was assumed for radiation workers during construction of the transfer lines, retrieval system tie-ins, and tank farm confinement facilities, and during tank farm operations, monitoring, maintenance, and closure activities. A dose of 200 mrem/year was assumed for personnel operating evaporators, retrieval facilities, separation and treatment facilities (both in situ and ex situ), and for processing the capsules. The dose of 200 mrem/year was the average whole body deep exposure to operational personnel at the PUREX Plant facility in 1986 (WHC 1995g and Jacobs 1996). An average dose of 200 mrem/year was assumed for the capsule alternatives.

The maximally-exposed individual worker dose is based on a Hanford Site maintenance and operations contractor administrative control level of 500 mrem/year (HSRCM 1994). Because each alternative consists of several operations, the duration of exposure for the maximally-exposed individual was assumed to be equivalent to the duration of the operation requiring the greatest amount of time.

The potential exposure to the noninvolved worker was based on inhaling respirable radiological contaminants, which would be released to the atmosphere (at ground level or through an elevated stack) from remediation activities during each year of operation. The noninvolved worker population was assumed to occupy the area from the Hanford Site boundary to within 100 m (330 ft) of the point of release. The maximally-exposed individual was also assumed to be within 100 m (330 ft) from the point of release for ground releases and between 200 and 800 m (600 and 2,600 ft) from the point of release for elevated releases.

The potential exposure to the general public would result from exposure from air emissions released to the environment during remediation activities, and transported offsite by atmospheric dispersion during each year of operation. Routes of exposure would be from inhaling gaseous and particulate emissions; ingesting vegetables, meats, and milk products contaminated by airborne deposition; and receiving external exposure from submersion in contaminated airborne plumes. The general public population was assumed to occupy the area extending from the Hanford Site boundary (Volume Three, Section D.2.2.3) to an 80-km (50-mi) radius from the release point, centered in the 200 Areas. A reduced Site boundary was assumed for risk assessment and excluded areas that are likely to be released by DOE in

Table 5.11.1 Comparison of Radiological Consequences from Remediation Operations Under Normal Conditions

Alternative	Latent Cancer Fatalities					
	Workers		Noninvolved Workers		General Public	
	Population	MEI	Population	MEI	Population	MEI
Tank Waste						
No Action	3.31E-01	6.00E-03	1.00E-06	1.56E-07	8.00E-05	2.30E-09
Long-Term Management						
Remediation	4.92E-01	6.00E-03	3.30E-05	3.51E-07	2.45E-04	6.45E-09
In Situ Fill and Cap						
Remediation	2.09E-01	3.80E-03	1.66E-05	1.00E-07	1.20E-04	2.05E-09
Total Alternative [1]	2.13E-01	6.00E-03	1.66E-05	1.00E-07	1.20E-04	2.05E-09
In Situ Vitrification						
Remediation	6.24E-01	3.80E-02	5.40E-04	6.48E-08	3.29E-01	1.10E-06
Total Alternative [1]	6.28E-01	6.00E-03	5.40E-04	6.48E-08	3.29E-01	1.10E-06
Ex Situ Intermediate Separations						
Remediation	3.12E+00	5.80E-03	7.92E-04	9.84E-07	1.56E-01	3.35E-06
Total Alternative [1]	3.13E+00	6.00E-03	7.92E-04	9.84E-07	1.56E-01	3.35E-06
Ex Situ No Separations						
Vitrification - Remediation	1.50E+00	4.80E-03	8.28E-04	6.80E-07	1.56E-01	3.35E-06
Total Alternative [1]	1.96E+00	6.00E-03	8.28E-04	6.80E-07	1.56E-01	3.35E-06
Calcination - Remediation	1.95E+00	6.00E-03	7.88E-04	6.80E-07	1.11E-01	2.40E-06
Total Alternative [1]	1.96E+00	6.00E-03	7.88E-04	6.80E-07	1.11E-01	2.40E-06
Ex Situ Extensive Separations						
Remediation	3.19E+00	6.00E-03	7.24E-04	8.40E-07	1.26E-01	2.75E-06
Total Alternative [1]	3.20E+00	6.00E-03	7.24E-04	8.40E-07	1.26E-01	2.75E-06
Ex Situ/In Situ Combination 1						
Remediation	2.02E+00	6.00E-03	3.89E-04	8.40E-07	1.31E-01	3.00E-06
Total Alternative [1]	2.02E+00	6.00E-03	3.89E-04	8.40E-07	1.31E-01	3.00E-06
Ex Situ/In Situ Combination 2						
Remediation	2.02E+00	6.00E-03	2.54E-04	8.40E-07	1.09E-01	1.26E-06
Total Alternative [1]	2.02E+00	6.00E-03	2.54E-04	8.40E-07	1.09E-01	1.26E.06
Phased Implementation						
Remediation	3.27E+00	6.00E-03	9.04E-04	9.60E-07	1.94E-01	2.43E-06
Total Alternative [1]	3.27E+00	6.00E-03	9.04E-04	9.60E-07	1.94E-01	2.43E-06
Capsules						
No Action	6.10E-02	2.00E-03	5.20E-08	7.60E-11	3.20E-07	6.50E-12
Onsite Disposal						
Remediation	6.96E-02	3.80E-03	2.20E-05	1.44E-10	8.75E-06	1.25E-11
Overpack and Ship						
Remediation	1.12E-02	3.80E-03	1.76E-02	1.44E-10	1.07E-03	1.25E-11
Vitrify with Tank Waste						
Remediation	1.12E-02	3.80E-03	7.92E-03	1.44E-10	4.82E-04	1.25E-11

Notes:
[1] Includes remediation and closure.
MEI = Maximally-exposed individual

the near future. Volume Three, Section D.2.2.3 defines the adjusted Site boundary. The maximally-exposed individual was assumed to live on the Hanford Site boundary and raise and consume all of their own food.

In the case of an exposed population, risk is expressed as the expected increase in latent cancer fatalities in the population at risk over the duration of the proposed alternative. For the maximally-exposed individual, it is expressed as the increased probability of dying from cancer as a result of the exposure over the duration of the alternative.

The results of the health risk calculations for the tank waste alternatives are presented in Table 5.11.1. The greatest risk to workers would result from the Phased Implementation alternative (3.27 latent cancer fatalities to the worker population as a result of remediation). Risk to the worker population was of similar magnitude for all ex situ alternatives (e.g., 1.96 latent cancer fatalities for Ex Situ No Separations, 2.02 latent cancer fatalities for the Ex Situ/In Situ Combination 1 and 2 alternatives, and 3.12 latent cancer fatalities for Ex Situ Intermediate Separations). This is a result of the large number of tank farm radiation workers that would be involved with these alternatives (e.g., 53,500 person-years for Ex Situ Extensive Separations; 58,500 person-years for Ex Situ Intermediate Separations; 45,000 person-years for Ex Situ/In Situ Combination 1 and 2; 36,700 person-years for Ex Situ No Separations; and 58,500 person-years for Phased Implementation).

For the noninvolved worker population, the greatest risk would be from the Phased Implementation alternative (e.g., 9.04E-04 latent cancer fatalities). The risk from other ex situ alternatives are essentially the same but slightly lower than the Phased Implementation alternative. The risks from Ex Situ Intermediate Separations, Ex Situ No Separations, and Ex Situ Extensive Separations alternatives are 7.92E-04, 8.28E-04, and 7.24E-04 latent cancer fatalities, respectively. All of these risks are extremely low. These risks result primarily from onsite transportation of waste and separation and treatment operations.

For the general public population, no latent cancer fatalities would be expected under any of the tank waste alternatives. The calculations for the cesium and strontium capsule alternatives show there would be no expected latent cancer fatalities under any of the alternatives for remediation workers, noninvolved Hanford Site workers, or the general public population.

5.11.1.2 Comparison of Nonradiological Chemical Consequences from Remediation Operations

The chemical hazard evaluation estimated inhalation intakes for identified chemical emissions and evaluated potential Incremental Lifetime Cancer Risk (ILCR) and noncarcinogenic health hazards using chemical-specific cancer slope factors and reference doses, respectively. Although the cesium and strontium capsules contain chloride, fluoride, and the decay products barium-137 and zirconium-90, no emissions of these chemicals would be associated with any of the capsule alternatives. Consequently, chemical risks were not evaluated for the capsule alternatives. The detailed methodology for estimating chemical intakes and subsequent cancer risk and noncancerous hazards are presented in Volume Three,

Appendix D. The key assumptions, methodology overview, and risk assessment results are summarized in the following text.

During remediation activities, routine chemical emissions from the tank farm were based on calculations using tank farm emissions data (Jacobs 1996). Operational emissions from the tank farms, such as would occur while retrieving waste from tanks and gravel-filling the tanks, were based on the tank farm emissions data and appropriate scaling for potential increased emission rates.

The hazard index approach conservatively assumed that the noncarcinogenic health effects would be additive for all chemicals (i.e., all chemicals would have the same mechanism of action and affect the same target organ). The hazard index represents the summation of hazards evaluated. A hazard index greater than or equal to 1.0 (unity) would be indicative of potential adverse health effects in the population of concern from exposure to multiple chemicals. Conversely, a hazard index less than 1.0 would suggest that no adverse health effects would be expected.

All carcinogenic risks were assumed to be additive. Consequently, the total ILCR would represent the summation of individual chemical cancer risks, from each emission source, for each alternative analyzed. Regulatory agencies have defined an acceptable level of risk to be between 1 in 10,000 (1.0E-04) and 1 in 1,000,000 (1.0E-06), with 1.0E-06 being the point of departure and referred to as de minimis (below which there is no concern) risk. For the purpose of this EIS, a risk below 1.0E-06 was considered low, and a risk greater than 1.0E-04 was considered high.

Tables 5.11.2 and 5.11.3 summarize the noncarcinogenic health hazards and carcinogenic risks associated with air emissions for each alternative. As shown by the results in Table 5.11.2, the hazard indices for the maximally-exposed individual worker, maximally-exposed individual noninvolved worker, and maximally-exposed individual general public were well below the benchmark value of 1.0 for all alternatives. Therefore, none of the proposed remediation alternatives would be expected to result in adverse health effects from air emissions.

As shown by the results in Table 5.11.3, ILCR for the maximally-exposed individual general public would be well below 1.0E-06 for all remediation alternatives. For the maximally-exposed individual non-involved worker, estimated ILCRs were slightly greater than 1.0E-06 for the Ex Situ Intermediate Separations (1.09E-06), Ex Situ/In Situ Extensive Separations (1.01E-06), Ex Situ/In Situ Combination 1 and 2 (1.09E-06), and Phased Implementation (1.09E-06) alternatives. For these alternatives, the majority of the overall risk (approximately 73 percent of the overall risk) was attributable to emissions released during tank waste retrieval operations. For the maximally-exposed individual involved worker, estimated ILCRs were just above 1.0E-06 for the Ex Situ Intermediate Separations (2.51E-06), Ex Situ No Separations (1.90E-06), Ex Situ Extensive Separations (2.33E-06), Ex Situ/In Situ Combination 1 and 2 (2.52E-06), and Phased Implementation (2.51E-06) alternatives. For these alternatives, the majority of the overall cancer risk (between 70 and 73 percent of the overall risk) was attributable to emissions released during tank waste retrieval operations.

Table 5.11.2 Comparison of Nonradiological Chemical Hazards from Remediation Operations

Alternative	Nonradiological Health Hazards		
	MEI Involved Worker Hazard Index	MEI Noninvolved Worker Hazard Index	MEI General Public Hazard Index
No Action	7.70E-02	3.33E-02	1.82E-05
Long-Term Management	1.12E-01	4.86E-02	3.51E-05
In Situ Fill and Cap	7.89E-02	3.43E-02	2.75E-05
In Situ Vitrification	7.89E-02	3.48E-02	2.04E-04
Ex Situ Intermediate Separations	3.08E-01	1.33E-01	7.29E-05
Ex Situ No Separations	3.08E-01	1.33E-01	7.34E-05
Ex Situ Extensive Separations	3.08E-01	1.33E-01	7.29E-05
Ex Situ/In Situ Combination 1	3.10E-01	1.34E-01	8.22E-05
Ex Situ/In Situ Combination 2	3.10E-01	1.34E-01	8.22E-05
Phased Implementation	3.08E-01	1.33E-01	7.50E-05

Notes:
MEI = Maximally-exposed individual

Table 5.11.3 Comparison of Nonradiological Chemical Cancer Risks from Remediation Operations

Alternative	Chemical Incremental Lifetime Cancer Risks		
	MEI Involved Worker Cancer Risk	MEI Noninvolved Worker Cancer Risk	MEI General Public Cancer Risk
No Action	7.05E-07	3.05E-07	9.08E-11
Long-Term Management	9.84E-07	4.26E-07	1.27E-10
In Situ Fill and Cap	4.50E-07	1.95E-07	5.80E-11
In Situ Vitrification	4.51E-07	1.95E-07	5.81E-11
Ex Situ Intermediate Separations	2.51E-06	1.09E-06	5.43E-10
Ex Situ No Separations	1.90E-06	8.22E-07	4.29E-10
Ex Situ Extensive Separations	2.33E-06	1.01E-06	4.92E-10
Ex Situ/In Situ Combination 1	2.52E-06	1.09E-06	5.43E-10
Ex Situ/In Situ Combination 2	2.52E-06	1.09E-06	5.43E-10
Phased Implementation	2.51E-06	1.09E-06	6.34E-10

Notes:
MEI = Maximally-exposed individual

5.11.2 Post-Remediation Risk

5.11.2.1 Methodology

This section describes the potential risks to human health after all remediation activities were completed. Post-remediation human health risks were calculated for two types of health effects: the potential for ILCR and toxic effects. The ILCR was expressed as the increased probability of an individual developing cancer from exposure to radioactive or nonradioactive carcinogenic chemicals. The ILCR rate was approximately one and one-half times higher than the latent cancer fatality risk discussed in Section 5.11.1. There is no universally accepted standard for the level of risk that is considered acceptable. For known or suspected carcinogens, acceptable exposure levels suggested by Federal (55 FR 8666 and 40 CFR 300) and State (WAC 173-340) standards generally are those that represent an ILCR in the range between 1.0E-04 and 1.0E-06, which indicates a probability of 1 in

10,000 to 1 in 1,000,000, respectively. An ILCR of 1.0 means that an individual's lifetime probability of developing cancer approaches 100 percent. For the purposes of this EIS, a risk of less than 1.0E-06 (1 in 1,000,000) was considered low. A risk greater than 1.0E-04 (1 in 10,000) was considered high.

Noncarcinogenic chemicals were evaluated in terms of a hazard index, which is the ratio of chemical intake to a reference dose below which no adverse health effects would be expected. For a hazard index less than 1.0, no adverse health effects would be expected. For a hazard index greater than 1.0, adverse health effects would be expected. A health effect could be fatal or it could be a minor temporary effect on the human body, depending on the specific chemical and amount of exposure involved.

Three key factors were involved in calculating potential risks: the source term, transport, and exposure. The source term is the amount and type of contaminant that may be released to the environment. For example, under the No Action (Tank Waste) alternative the source term would be the entire contents of the tanks that could be released over time into the groundwater. The source terms of the alternatives would vary because of the differences in the quantity, form, or manner of containment of the waste left onsite. The source term for each alternative is described in Volume Three, Appendix D and summarized in Section 5.11.2.2.

Transport refers to movement of the contaminants in the environment from the source (e.g., tanks) to the receptor, which is the person who might be exposed to the contaminant. Following loss of institutional controls (assumed to be 100 years), the tank contents would be released to the subsurface soils and be available for transport to groundwater from infiltration of rainwater and percolation through the soil column. Based on the existing depth of the tanks, resulting soil contamination would be below the maximum depth of soil likely to be contacted by all potential receptors, with the exception of the intruder scenario. Consequently, the soil medium was not evaluated as a post-remediation transport mechanism for any of the alternatives. Because tank waste would be released to the subsurface, no contaminants would be transported into the air, and this medium was not evaluated for any of the alternatives. Also, for this EIS, post remediation impacts for all tank waste alternatives except No Action and Long-Term Management included a closure scenario (closure as a landfill) that included covering the tank farms and LAW vaults with a Hanford Barrier. Therefore, groundwater would be the only post-remediation transport mechanism for all the alternatives.

Under all of the alternatives, any waste that would be disposed of offsite would not be of concern for exposure at the Hanford Site. Any waste that remained on the Hanford Site would have a potential to cause exposure to people in the surrounding community. Onsite waste, under all of the alternatives, would be in a waste tank, a LAW vault, or drywells (cesium and strontium capsules). The potential transport of waste from the tanks or the vaults could result from leaks that might occur during retrieval. Another mechanism would be precipitation filtering through the Hanford Barriers placed over the tanks and vaults, into the underlying vadose zone, and then into the groundwater aquifer. This process can be extremely slow because of the low precipitation rates for the Hanford Site, the ability of the Hanford Barrier to retard water movement, the slow rate that some contaminants would be leached by water,

and the slow rate that the contaminated water would move through the vadose zone into the groundwater aquifer. Once in the groundwater, the contaminants would move relatively quickly to the Columbia River, where they would discharge as springs along the river bank or seep directly into the river. Once in the surface water, contaminants would be rapidly diluted by mixing with the river flow. The total process can be extremely slow, taking hundreds or thousands of years from the initiation of the leak, depending on the alternative. Groundwater migration with subsequent discharge to the Columbia River would be the only pathway for migration of contaminants that would occur after remediation was complete for any of the alternatives. A detailed description and computer modeling of the groundwater transport pathway for each alternative is contained in Volume Four, Appendix F and summarized in Section 5.2.

Because the groundwater pathway can take hundreds or thousands of years to result in exposures, and because contaminants in the waste are persistent (i.e., remain in the environment for a long time), risk must be calculated for a number of extended time periods. This shows how potential risk may increase or decrease over time as contaminants move through the groundwater and as radioactive decay changes the characteristics of the contaminants. To show these changes, risks were calculated for five time periods: 300, 500, 2,500, 5,000, and 10,000 years from the present.

The risks described in this section are the incremental risks for the TWRS alternatives only, and do not take into account soil and groundwater below the tank farms and other portions of the Hanford Site that currently are contaminated with a wide variety of radiological and chemical contaminants.

Exposure was the third factor involved in calculating potential risk. Exposure involves the pathway, duration, and intensity of potential exposure from contaminants that have been transported into and through the groundwater. The type and amount of exposure would be dependent on future potential land uses. Five exposure scenarios were modeled: Native American, residential farmer, industrial worker, recreational land user, and recreational shoreline user of the Hanford Reach along the Columbia River. These exposure scenarios were considered likely post-remediation future uses of the land on and adjacent to the Hanford Site and represented a range of land uses that aided in comparison of the impacts of alternatives. The potential risk for each of these future uses would be different because each scenario would involve different levels of consumption and contact with contaminated groundwater or surface water contaminated by discharge of groundwater. Future Site uses will be the subject of analysis in the Hanford Remedial Action EIS, which is being prepared by DOE.

The Native American scenario represented exposures to a Native American who engaged in both traditional lifestyle activities (e.g., hunting, fishing, and using a sweat lodge) and contemporary lifestyle activities (e.g., irrigated farming). Exposure pathways included those defined for the residential farmer scenario plus additional pathways unique to the Native American subsistence lifestyle (such as sweat lodge use). The exposures were assumed to be continuous for 365 days per year over a 70-year lifetime. The scenario used native food ingestion rates. By incorporating subsistence lifestyle activities and native food ingestion rates, this scenario resulted in exposures that would be approximately five times higher than the exposures for the residential farmer scenario.

The residential farmer scenario represented use of the land for residential and agricultural production. This scenario involved a person living on the Hanford Site, drinking water pumped from the groundwater, and producing and consuming animal, vegetable, and fruit products irrigated with groundwater. The exposures were assumed to be continuous and included occasional surface water recreational activities and surface water sediment contact.

The industrial worker scenario involved exposures to workers who lived outside of the Hanford Site but worked in a commercial or industrial setting on the Hanford Site for 20 years. The scenario involved consuming water pumped from the groundwater and indoor activities, although some outdoor activities also were included. These exposures would not be continuous because the worker was assumed to go to a home outside the Hanford Site at the end of the 8-hour work day. The scenario was intended to represent nonremediation workers who would wear no protective clothing.

The recreational land user was a random Sitewide land user. This scenario involved exposure to contamination from recreational camping, hiking, and other land-based recreational activities. These exposures would not be continuous, but rather were assumed to occur for 14 days per year for 30 years. There would be no groundwater or surface water pathway for the recreational land user, thus there were no risks for this exposure scenario under any of the TWRS alternatives. This scenario is not described further in this analysis.

The recreational shoreline user scenario involved exposure to contamination in the groundwater and Columbia River and along its shoreline from recreational swimming, boating, and other shoreline activities. The scenario involved mainly outdoor activities. These exposures would not be continuous, but rather were assumed to occur for 14 days per year for 30 years.

The exposure parameters (e.g., amount of water consumed) for each of these exposure scenarios are shown in Volume Three, Appendix D. The residential farmer, industrial worker, and recreational user exposure scenarios were consistent with the Hanford Site Risk Assessment Methodology, which is the Site-approved method for calculating risks (DOE 1995c). For the first time, DOE has included a Native American exposure scenario in an analysis of potential long-term health effects. This scenario was developed from the Columbia River Comprehensive Impact Assessment (Napier et al. 1996), which was modified at the request of and in consultation with the potentially affected Tribes. This scenario is in its initial stages of development and has not received a complete review by the scientific community, nor has it been approved by the potentially affected Tribes. Therefore, this scenario should be considered preliminary and may have more uncertainty associated with it than the other scenarios. However, the scenario does provide a bounding assessment of the potential health effects to a Native American who might inhabit the Site in the future and engage in both subsistence lifestyle activities (e.g., hunting, fishing, and using sweat lodges) and contemporary lifestyle activities (e.g., irrigated farming). Volume Three, Appendix D contains a detailed description of the methodology and assumptions used to develop the risk calculations.

5.11.2.2 Risk Assessment Results

Summary

Table 5.11.4 shows the maximum calculated potential ILCR from both radiological and carcinogenic chemicals and the noncarcinogenic chemical hazard for each tank waste alternative. The ILCR data shown in Table 5.11.4 are plotted graphically for the Native American, residential farmer, industrial worker, and recreational shoreline user scenarios in Figures 5.11.1 through 5.11.4. Risk distribution contour maps for the residential farmer at the time of maximum risk for each alternative are shown in Figures 5.11.5 through 5.11.14. Similar figures showing risk distributions for the other exposure scenarios are presented in Volume Three, Appendix D.

Potential risks were not shown for the recreational land user because this exposure would involve no consumption of groundwater and no contact with the Columbia River. Therefore, there would be no pathway for potential exposure, and there would be no post-remediation risks associated with this scenario.

In general, the results showed the following ranking of the tank waste alternatives from greatest risk to lowest risk, although the order would change somewhat over the 10,000-year period addressed in this analysis:

- No Action;
- Long-Term Management;
- In Situ Fill and Cap;
- Ex Situ/In Situ Combination 2;
- Ex Situ/In Situ Combination 1;
- Ex Situ Intermediate Separations;
- Phased Implementation;
- Ex Situ Extensive Separations;
- Ex Situ No Separations; and
- In Situ Vitrification.

All of the ex situ alternatives, except the Ex Situ/In Situ Combination 1 and 2 alternatives, would result in similar risk levels. This is because most of the risk would result from contaminants leached from the 1 percent residual waste that would be left in the tanks after waste retrieval under these alternatives. The risk from the 1 percent residuals in the tanks generally would be 100 or more times greater than the risk from contaminants leached from the LAW vaults although this would vary somewhat at different time periods.

An assessment was prepared of the total latent cancer incidence and fatalities that could occur over 10,000 years for each of the exposure scenarios: Native American, residential farmer, industrial worker, and recreational shoreline use. Table 5.11.5 presents the potential total cancer incidence and fatalities for each alternative over the entire 10,000-year period. The methodology and detailed analysis are presented in Volume Three, Appendix D, Section D.5.15.1. The uncertainties associated with these calculations are high; however, these calculations provide an estimate of possible impacts

Figure 5.11.1 Post-Remediation Risk to the Native American for all Tank Waste Alternatives

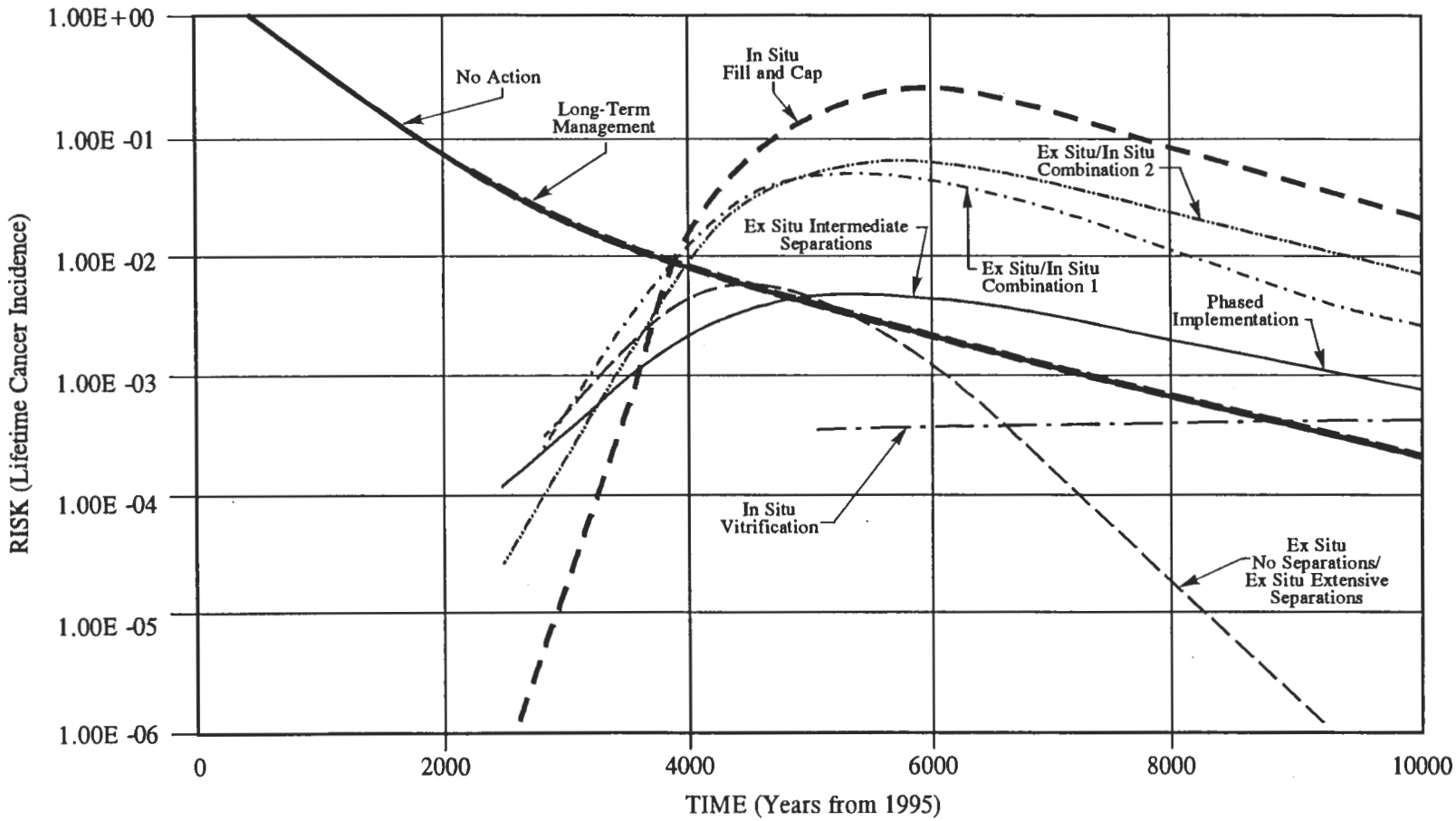


Figure 5.11.2 Post-Remediation Risk to the Residential Farmer for all Tank Waste Alternatives

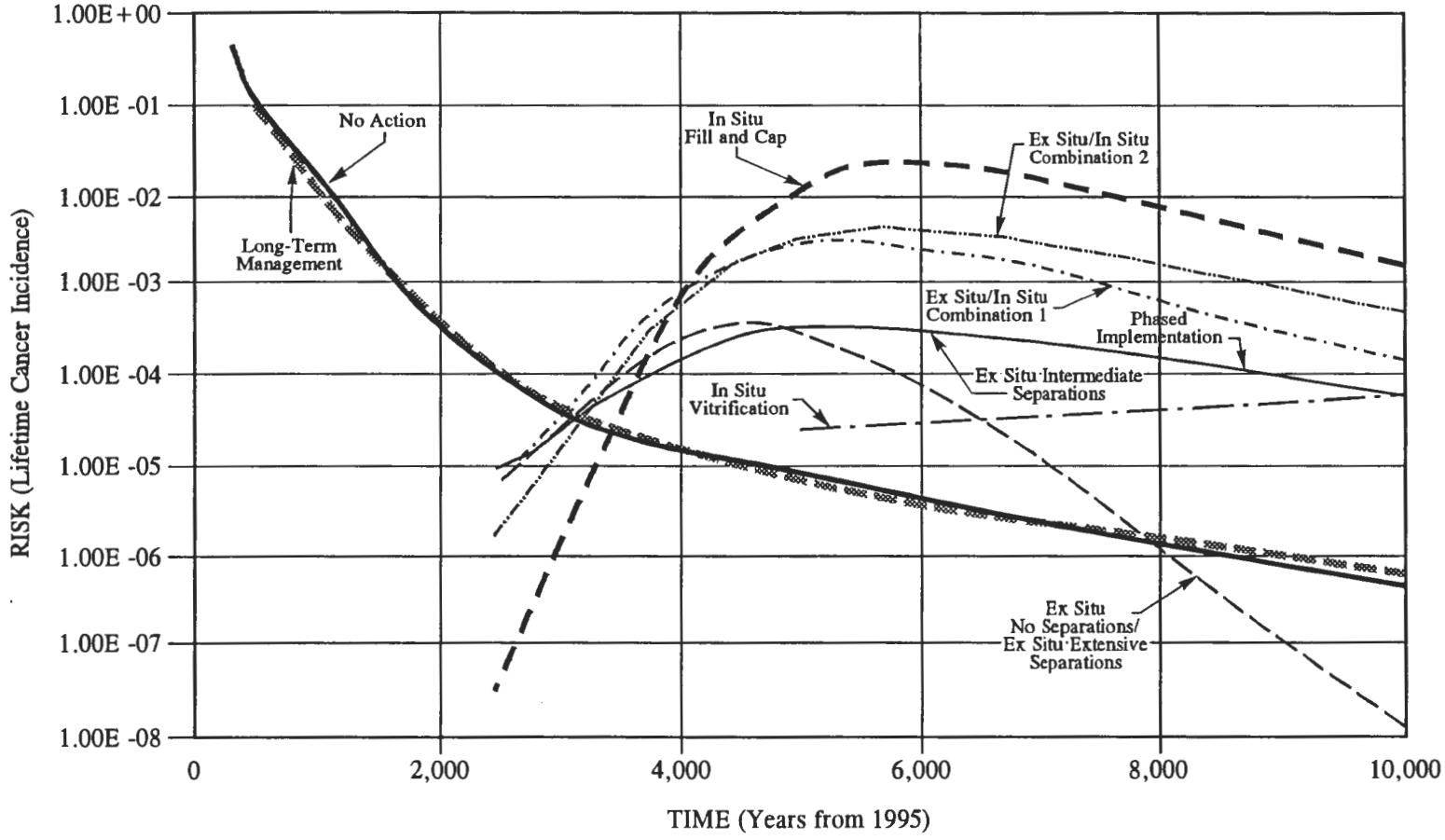


Figure 5.11.3 Post-Remediation Risk to the Industrial Worker for all Tank Waste Alternatives

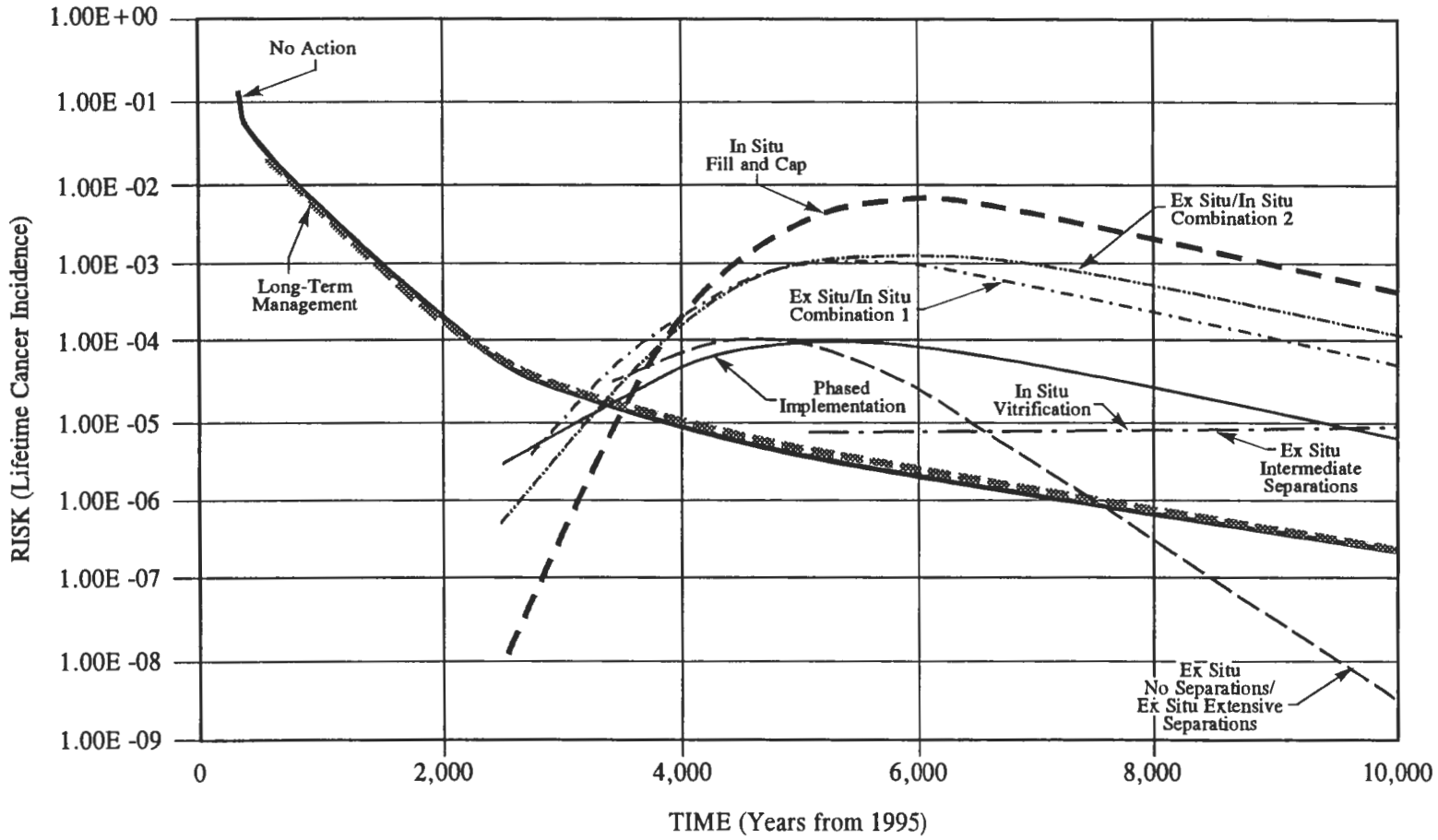


Figure 5.11.4 Post-Remediation Risk to the Recreational Shoreline User for all Tank Waste Alternatives

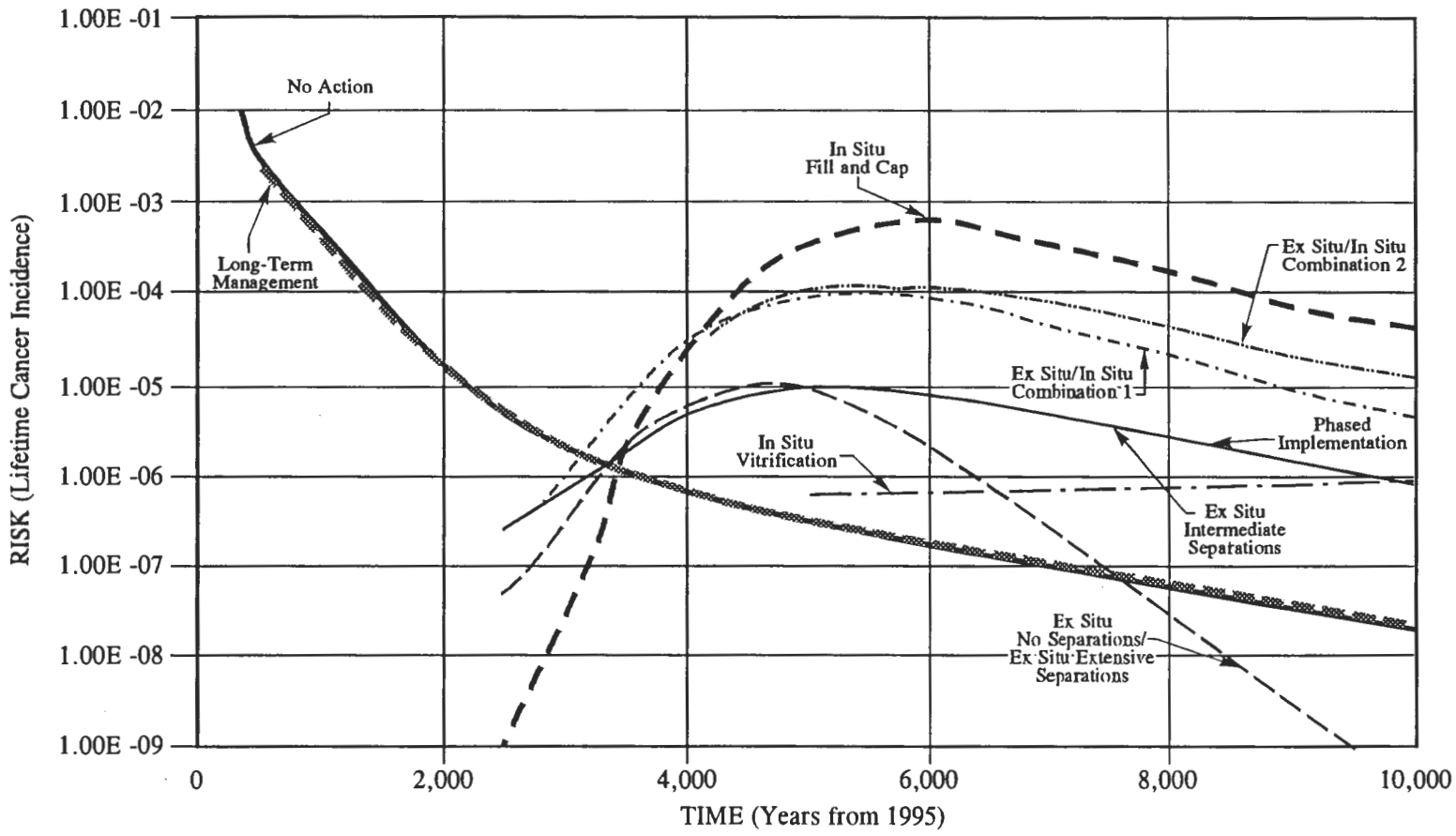
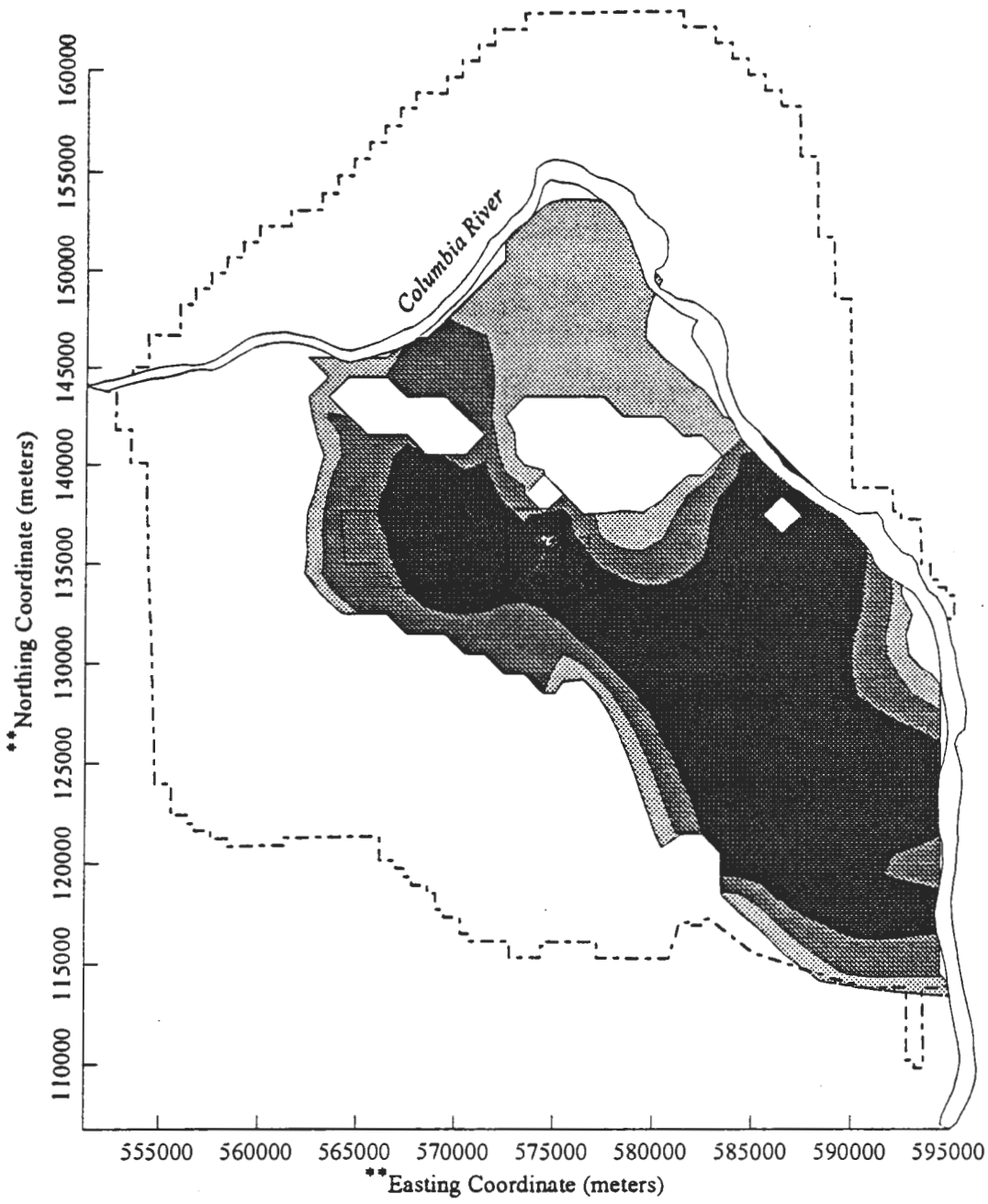


Figure 5.11.5 No Action Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals at 300 Years from Present



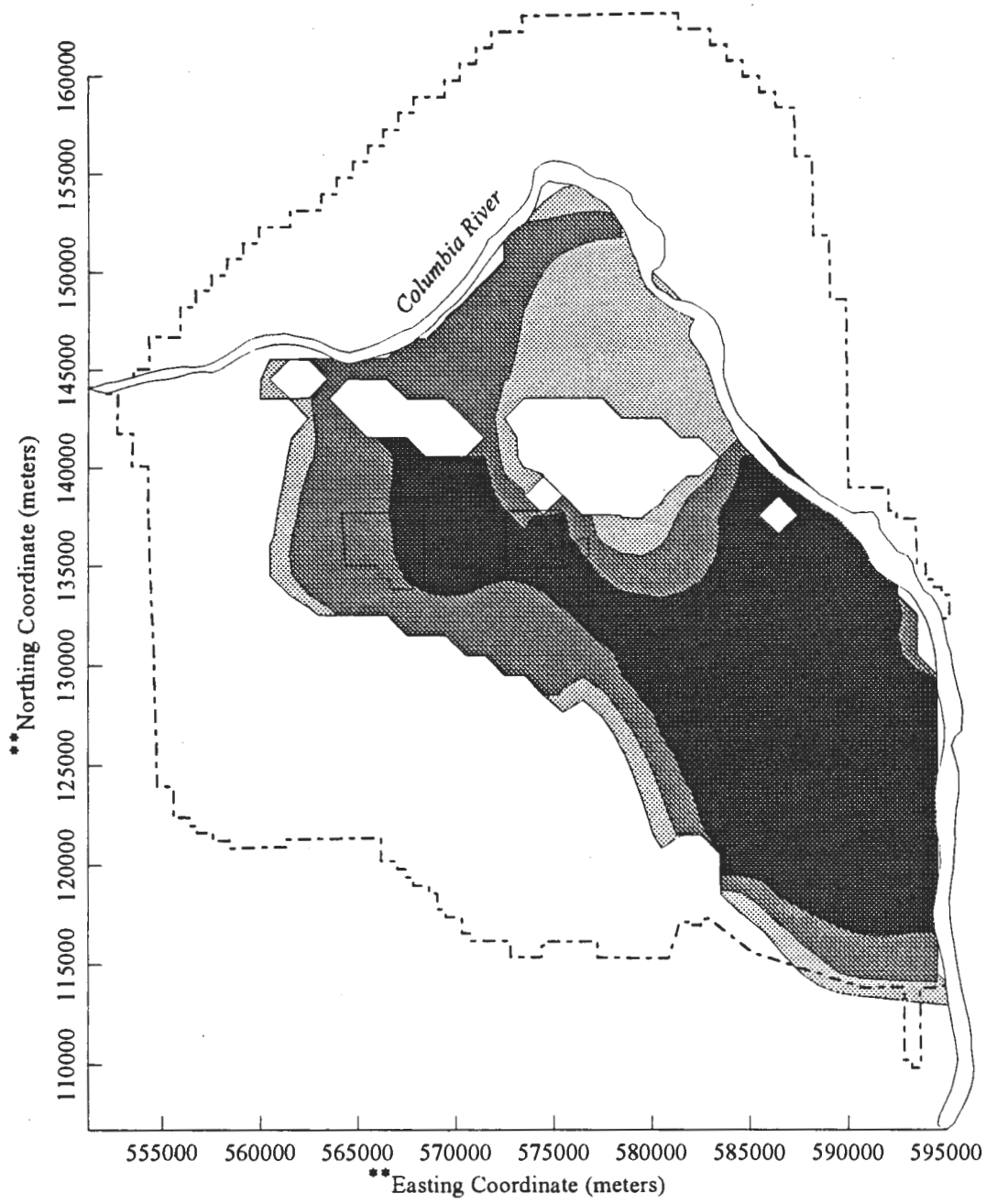
LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- - - Hanford Site Boundary
- — 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

9613459.0439

Figure 5.11.6 Long-Term Management Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals at 300 Years from Present

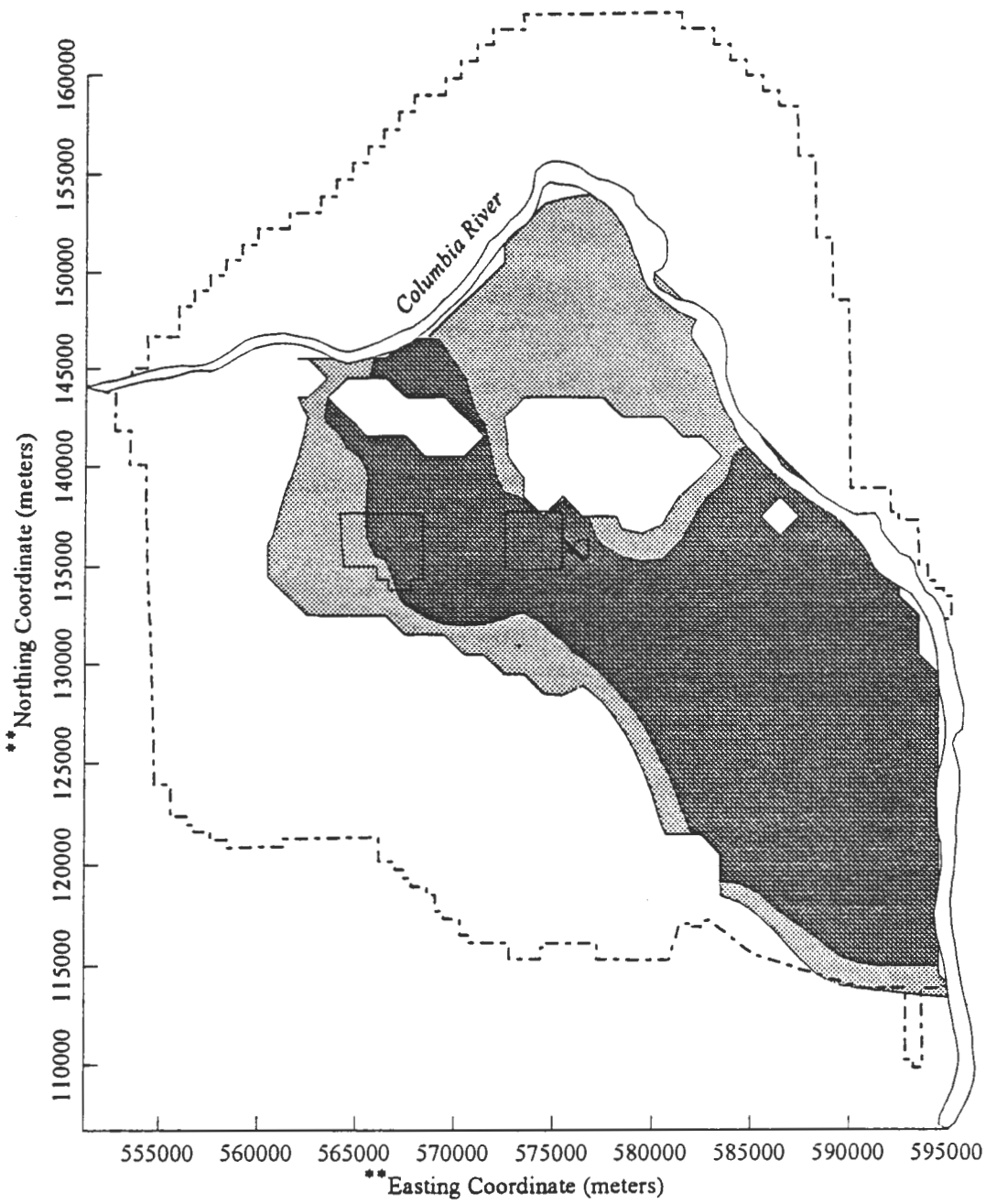


LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- Hanford Site Boundary
- 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

Figure 5.11.7 In Situ Fill and Cap Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals at 5,000 Years from Present



LEGEND

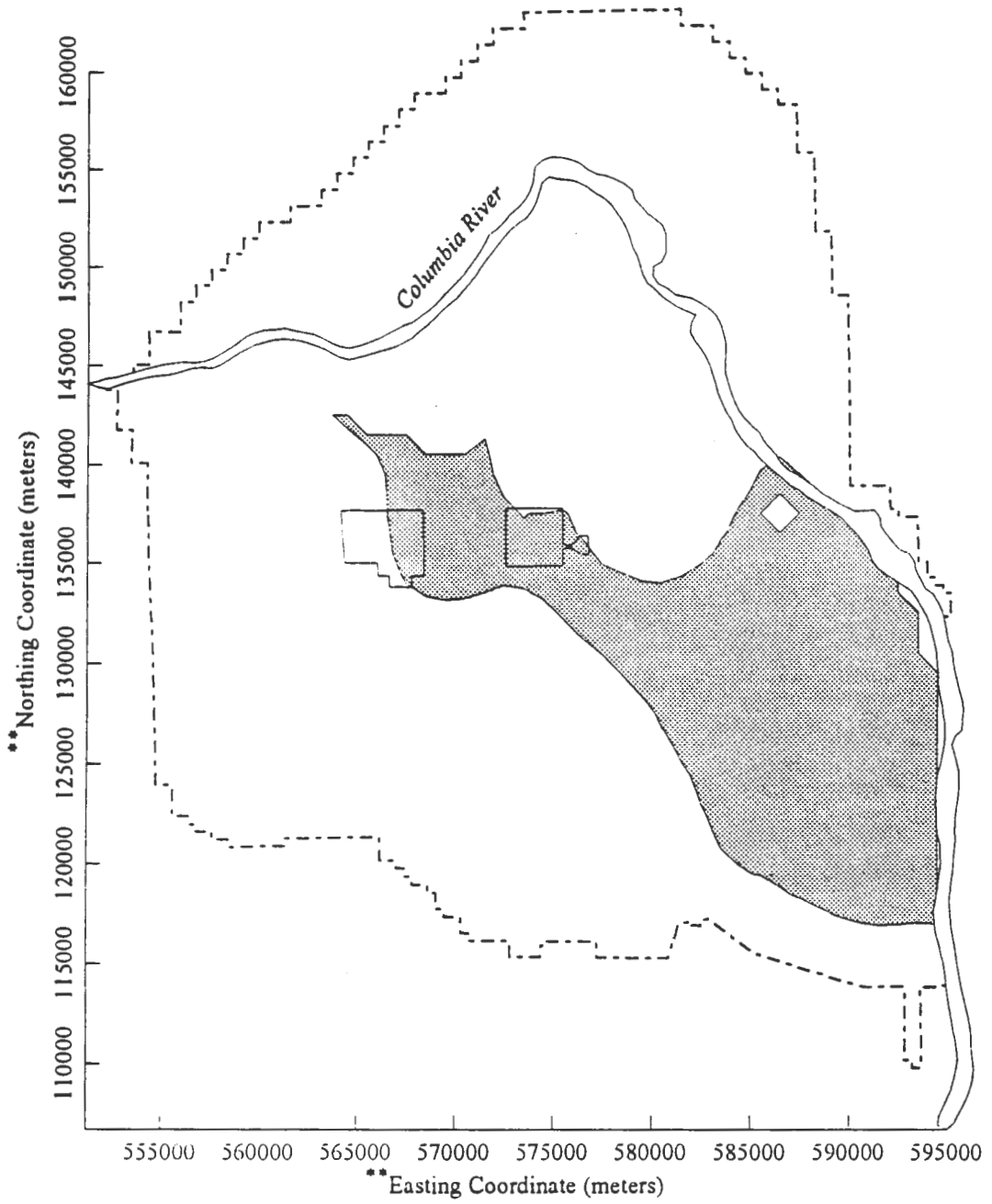
N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06

- - - Hanford Site Boundary
— 200 East and West Areas
* Incremental Lifetime Cancer Risk
** Washington State Plane Coordinates

9613459.0440

Figure 5.11.8 In Situ Vitrification Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals at 10,000 Years from Present

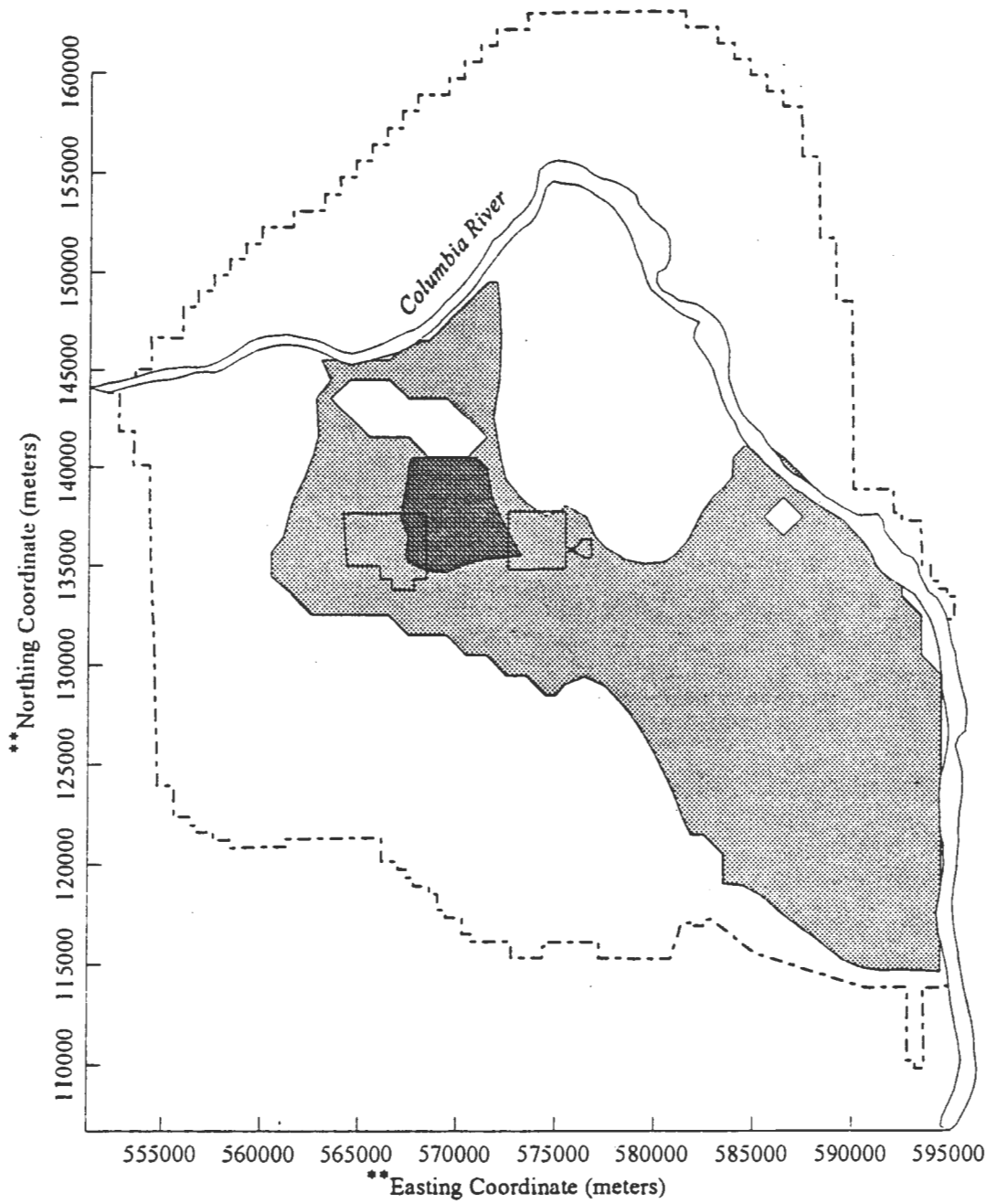


LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- --- Hanford Site Boundary
- — 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

Figure 5.11.9 Ex Situ Intermediate Separations Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals & LAW Vaults at 5,000 Years from Present



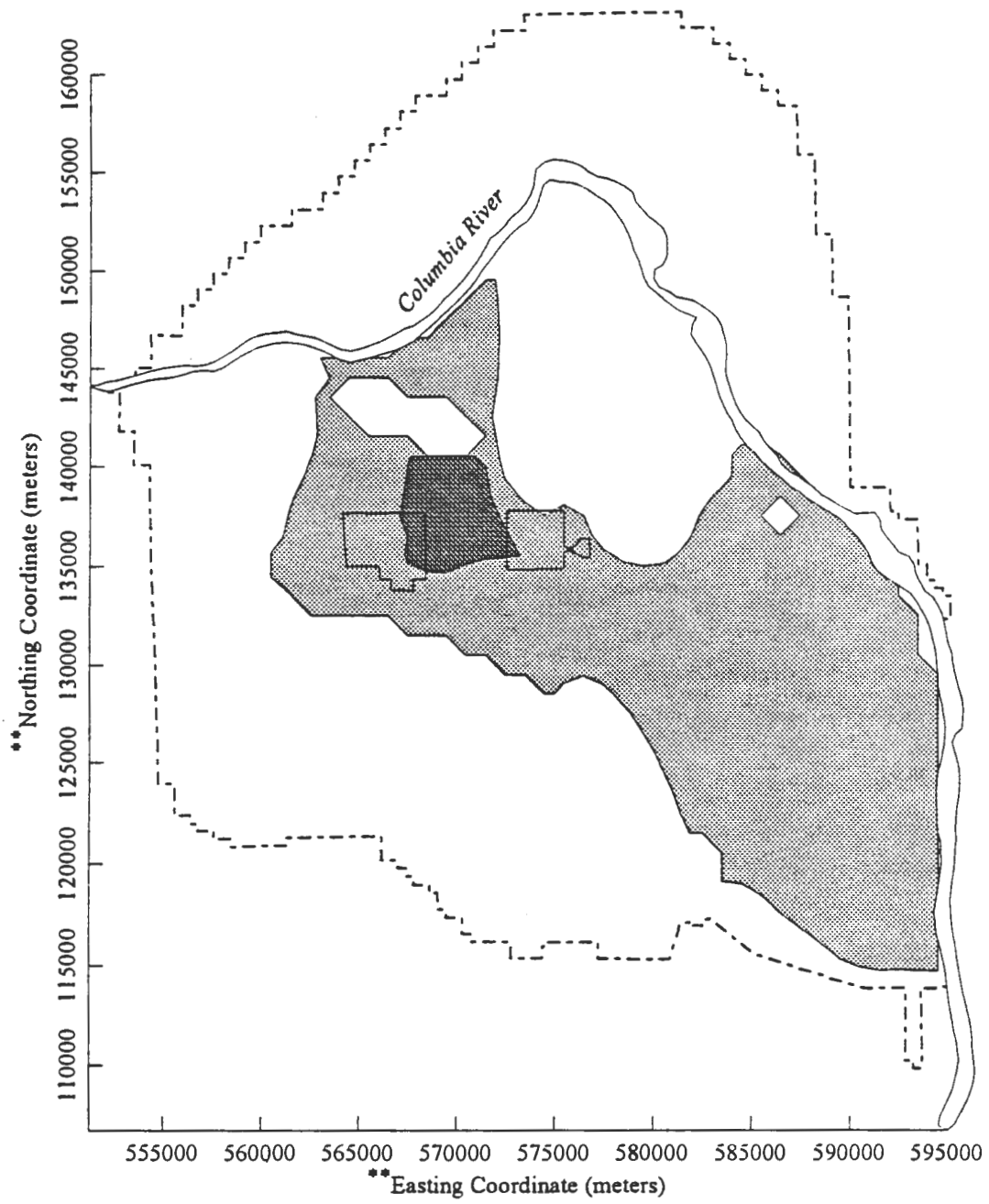
LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- Hanford Site Boundary
- 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

9613459.0441

Figure 5.11.10 Ex Situ No Separations Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals at 5,000 Years from Present

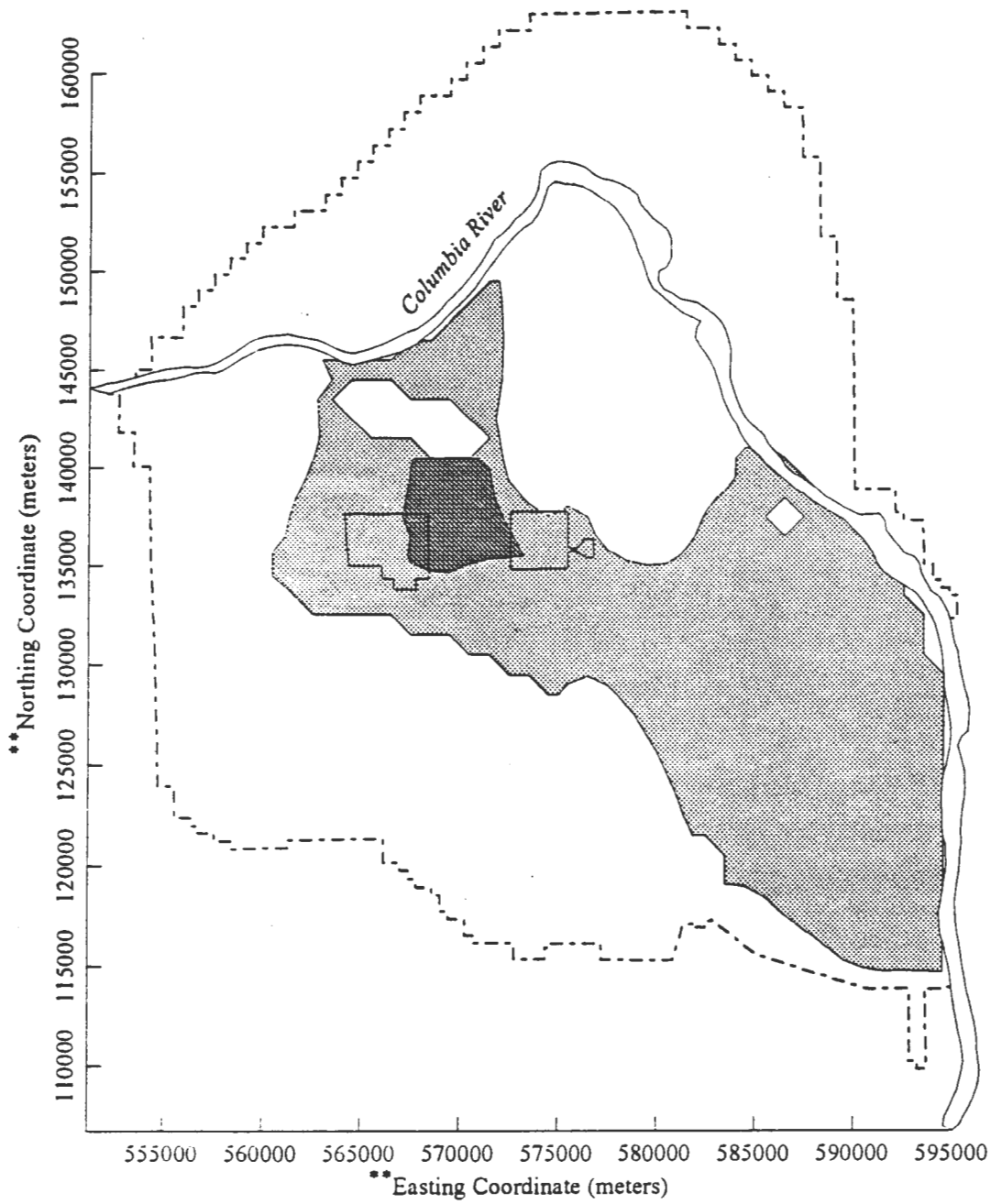


LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- --- Hanford Site Boundary
- — 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

Figure 5.11.11 Ex Situ Extensive Separations Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals & LAW Vaults at 5,000 Years from Present



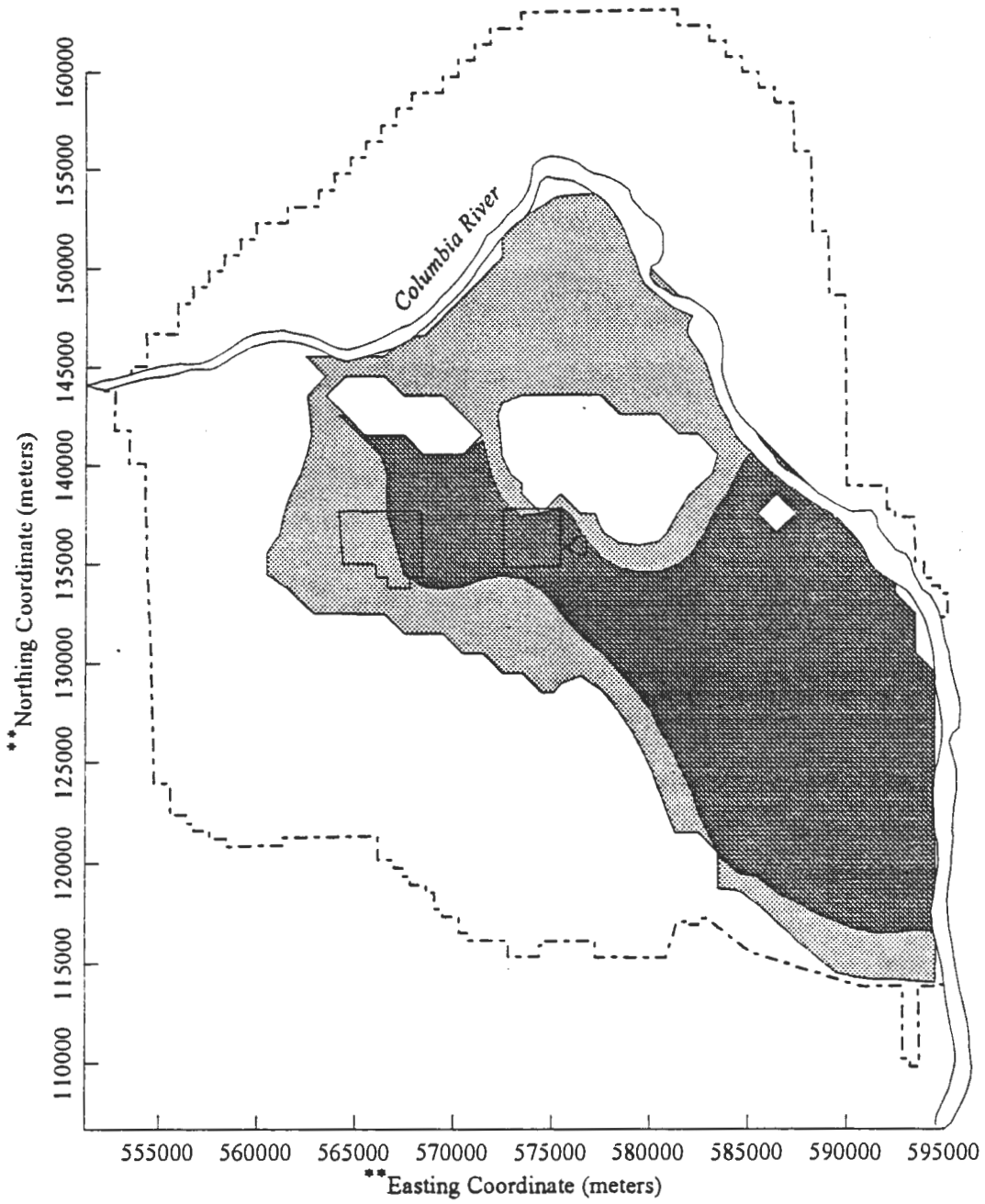
LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- Hanford Site Boundary
- 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

9613459.0442

Figure 5.11.12 Ex Situ/In Situ Combination 1 Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals & LAW Vaults at 5,000 Years from Present



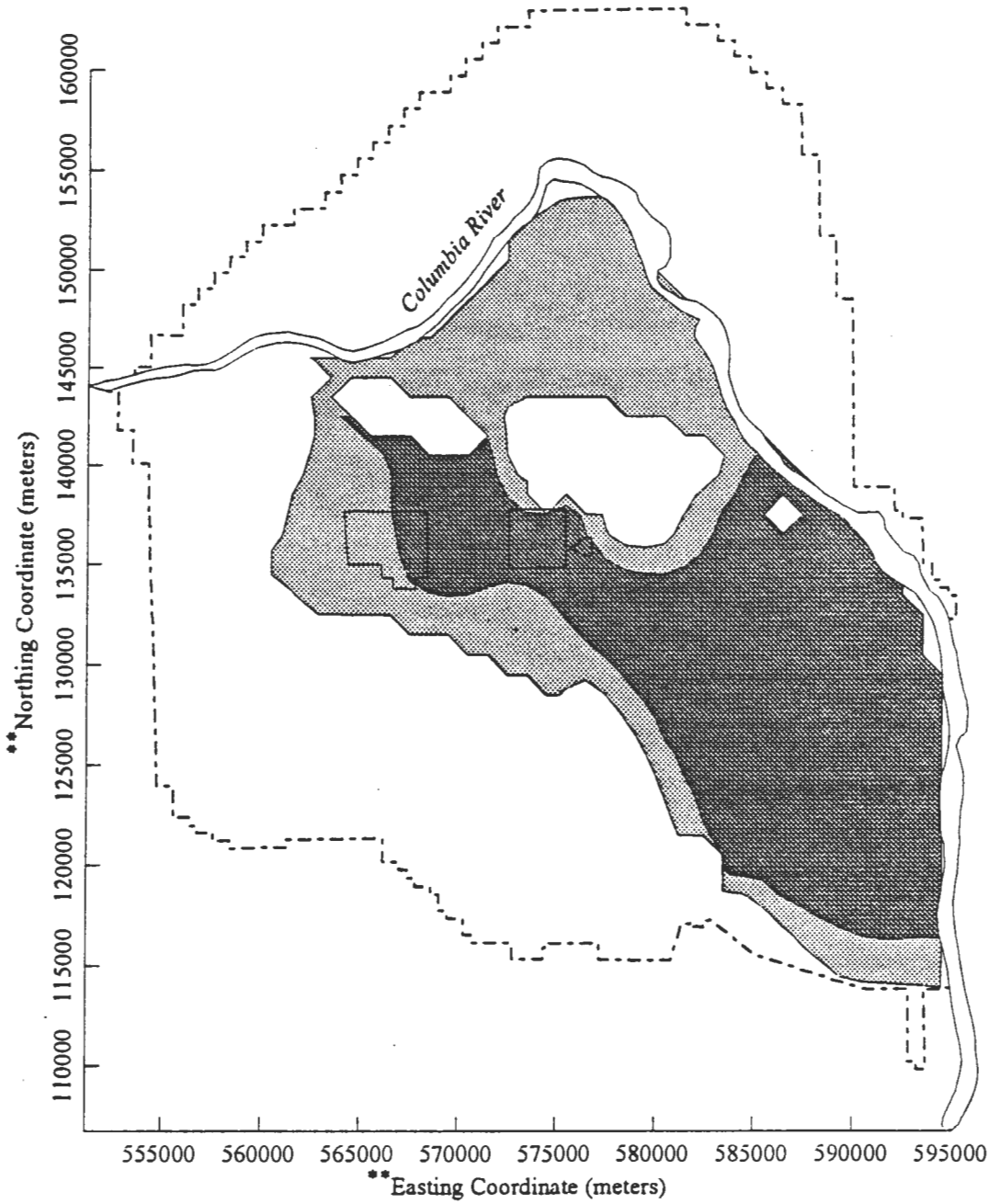
LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06

- --- Hanford Site Boundary
- — 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

Figure 5.11.13 Ex Situ/In Situ Combination 2 Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals & LAW Vaults at 5,000 Years from Present



LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06

- --- Hanford Site Boundary
- — 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

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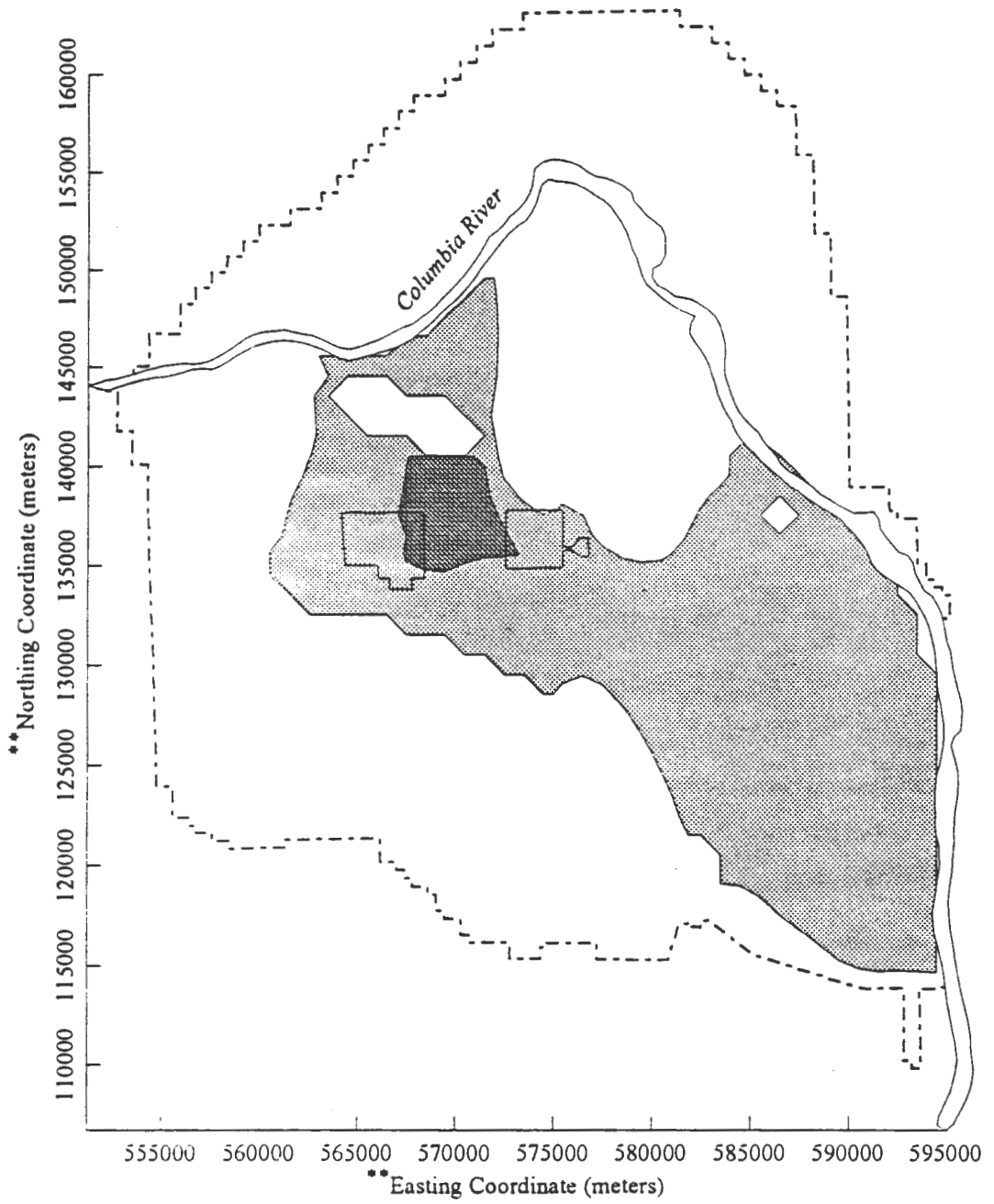
Figure 5.11.14 Phased Implementation Alternative, Residential Farmer Scenario, Post Remediation Risk from Tank Residuals & LAW Vaults at 5,000 Years from Present



LEGEND

N

- 1.0E+00 ≥ ILCR* ≥ 1.0E-02
- 1.0E-02 > ILCR* ≥ 1.0E-04
- 1.0E-04 > ILCR* ≥ 1.0E-06
- --- Hanford Site Boundary
- — 200 East and West Areas
- * Incremental Lifetime Cancer Risk
- ** Washington State Plane Coordinates

Table 5.11.4 Summary of Bounding Case Incremental Lifetime Cancer Risks and Hazard Indices

Alternative	300 Years from 1995 Incremental Lifetime Cancer Risks			
	Native American	Residential Farmer	Industrial Worker	Recreational User
No Action	1.00E+00	4.58E-01	1.34E-01	1.26E-02
Long-Term Management	1.00E+00	2.65E-01	1.18E-01	1.02E-02
In Situ Fill and Cap	No Risk	No Risk	No Risk	No Risk
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk
Ex Situ Intermediate Separations	No Risk	No Risk	No Risk	No Risk
Ex Situ No Separations	No Risk	No Risk	No Risk	No Risk
Ex Situ Extensive Separations	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 1	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 2	No Risk	No Risk	No Risk	No Risk
Phased Implementation	No Risk	No Risk	No Risk	No Risk
	Hazard Index			
No Action	2.77E+05	5.04E+04	5.37E+01	7.33E+00
Long-Term Management	4.42E+04	7.99E+03	8.24E+00	1.12E+00
In Situ Fill and Cap	No Hazard	No Hazard	No Hazard	No Hazard
In Situ Vitrification	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Intermediate Separations	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ No Separations	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Extensive Separations	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 1	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 2	No Hazard	No Hazard	No Hazard	No Hazard
Phased Implementation	No Hazard	No Hazard	No Hazard	No Hazard

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Table 5.11.4 Summary of Bounding Case Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

Alternative	500 Years from 1995 Incremental Lifetime Cancer Risks			
	Native American	Residential Farmer	Industrial Worker	Recreational User
No Action	1.00E+00	1.13E-01	2.82E-02	2.63E-03
Long-Term Management	1.00E+00	9.55E-02	2.75E-02	2.51E-03
In Situ Fill and Cap	No Risk	No Risk	No Risk	No Risk
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk
Ex Situ Intermediate Separations	No Risk	No Risk	No Risk	No Risk
Ex Situ No Separations	No Risk	No Risk	No Risk	No Risk
Ex Situ Extensive Separations	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 1	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 2	No Risk	No Risk	No Risk	No Risk
Phased Implementation	No Risk	No Risk	No Risk	No Risk
	Hazard Index			
No Action	3.47E+04	6.25E+03	6.69E+00	9.10E-01
Long-Term Management	3.46E+04	6.24E+03	6.44E+00	8.78E-01
In Situ Fill and Cap	No Hazard	No Hazard	No Hazard	No Hazard
In Situ Vitrification	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Intermediate Separations	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ No Separations	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Extensive Separations	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 1	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 2	No Hazard	No Hazard	No Hazard	No Hazard
Phased Implementation	No Hazard	No Hazard	No Hazard	No Hazard

Table 5.11.4 Summary of Bounding Case Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

Alternative	2,500 Years from 1995 Incremental Lifetime Cancer Risks			
	Native American	Residential Farmer	Industrial Worker	Recreational User
No Action	3.09E-02	1.17E-04	5.37E-05	4.47E-06
Long-Term Management	3.09E-02	1.17E-04	5.37E-05	4.47E-06
In Situ Fill and Cap	3.98E-07	3.47E-08	8.71E-09	7.94E-10
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk
Ex Situ Intermediate Separations	1.17E-04	9.55E-06	3.02E-06	2.69E-07
Ex Situ No Separations	1.17E-04	9.55E-06	3.02E-06	2.69E-07
Ex Situ Extensive Separations	1.17E-04	9.55E-06	3.02E-06	2.69E-07
Ex Situ/In Situ Combination 1	8.51E-05	6.92E-06	2.19E-06	2.00E-07
Ex Situ/In Situ Combination 2	2.24E-05	1.86E-06	5.50E-07	4.90E-08
Phased Implementation	1.17E-04	9.55-06	3.02E-06	2.69E-07
	Hazardous Index			
No Action	5.16E+01	9.18+00	8.91E-01	1.19E-01
Long-Term Management	5.17E+01	9.20E+00	8.91E-01	1.19E-01
In Situ Fill and Cap	2.00E-03	3.37E-04	4.79E-07	6.49E-08
In Situ Vitrification	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Intermediate Separations	7.24E-01	1.23E-01	1.14E-04	1.57E-05
Ex Situ No Separations	7.24E-01	1.16E-01	1.14E-04	1.57E-05
Ex Situ Extensive Separations	7.24E-01	1.23E-01	1.14E-04	1.57E-05
Ex Situ/In Situ Combination 1	4.69E-01	8.48E-02	1.84E-04	1.57E-05
Ex Situ/In Situ Combination 2	1.20E-01	2.21E-01	1.14E-04	1.57E-05
Phased Implementation	7.24E-01	1.23E-01	1.14E-04	1.57E-05

Table 5.11.4 Summary of Bounding Case Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

Alternative	5,000 Years from 1995 Incremental Lifetime Cancer Risks			
	Native American	Residential Farmer	Industrial Worker	Recreational User
No Action	3.16E-03	8.13E-06	3.72E-06	3.09E-07
Long-Term Management	3.16E-03	8.13E-06	3.72E-06	3.09E-07
In Situ Fill and Cap	1.30E-01	1.10E-02	2.88E-03	2.63E-04
In Situ Vitrification	3.02E-04	2.34E-05	6.92E-06	6.31E-07
Ex Situ Intermediate Separations	4.27E-03	3.39E-04	1.02E-04	9.55E-06
Ex Situ No Separations	4.27E-03	3.39E-04	1.02E-04	9.55E-06
Ex Situ Extensive Separations	4.27E-03	3.39E-04	1.02E-04	9.55E-06
Ex Situ/In Situ Combination 1	4.27E-02	3.31E-03	1.07E-03	9.55E-05
Ex Situ/In Situ Combination 2	4.57E-02	3.63E-03	1.10E-03	1.02E-04
Phased Implementation	4.27E-03	3.39E-04	1.02E-04	9.55E-06
	Hazard Index			
No Action	2.17E+00	5.76E-01	1.16E-01	1.56E-02
Long-Term Management	2.69E+00	5.76E-01	1.16E-01	1.56E-02
In Situ Fill and Cap	3.01E+03	5.32E+02	4.21E-01	7.13E-02
In Situ Vitrification	1.00E-03	3.15E-04	6.68E-05	9.03E-06
Ex Situ Intermediate Separations	1.22E+02	2.11E+01	2.23E-02	3.00E-03
Ex Situ No Separations	1.22E+02	2.11E+01	2.21E-02	3.00E-03
Ex Situ Extensive Separations	1.22E+02	2.11E+01	2.23E-02	3.00E-03
Ex Situ/In Situ Combination 1	3.31E+03	5.97E+02	6.26E-01	8.50E-02
Ex Situ/In Situ Combination 2	3.37E+03	6.09E+02	6.54E-01	8.89E-02
Phased Implementation	1.22E+02	2.11E+01	2.23E-02	3.00E-03

Table 5.11.4 Summary of Bounding Case Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

Alternative	10,000 Years from 1995 Incremental Lifetime Cancer Risks			
	Native American	Residential Farmer	Industrial Worker	Recreational User
No Action	1.82E-04	5.37E-07	2.45E-07	2.09E-08
Long-Term Management	1.82E-04	5.37E-07	2.45E-07	2.09E-08
In Situ Fill and Cap	1.78E-02	1.48E-03	3.98E-04	3.72E-05
In Situ Vitrification	3.89E-04	3.02E-05	9.12E-06	8.13E-05
Ex Situ Intermediate Separations	6.92E-04	6.76E-05	7.41E-06	7.76E-07
Ex Situ No Separations	1.91E-07	1.62E-08	3.72E-09	3.47E-10
Ex Situ Extensive Separations	1.91E-07	1.62E-08	3.72E-09	3.47E-10
Ex Situ/In Situ Combination 1	2.24E-03	1.66E-04	5.50E-05	4.90E-06
Ex Situ/In Situ Combination 2	6.92E-03	5.62E-04	1.55E-04	1.41E-05
Phased Implementation	6.92E-04	6.76E-05	7.41E-06	7.76E-07
	Hazard Index			
No Action	1.07E-01	2.79E-02	5.62E-03	7.51E-04
Long-Term Management	1.99E-01	2.79E-02	5.62E-03	7.51E-04
In Situ Fill and Cap	1.29E+02	1.86E+02	6.21E+00	5.73E-01
In Situ Vitrification	1.30E-03	4.06E-04	8.62E-05	1.16E-05
Ex Situ Intermediate Separations	7.68E-03	1.60E-03	3.65E-04	4.94E-05
Ex Situ No Separations	7.68E-03	8.99E-04	1.76E-06	2.10E-07
Ex Situ Extensive Separations	9.12E-01	1.35E-03	2.83E-04	3.72E-05
Ex Situ/In Situ Combination 1	4.28E+02	6.98E+01	7.49E-02	9.76E-03
Ex Situ/In Situ Combination 2	7.54E+02	1.21E+02	1.39E-01	1.80E-02
Phased Implementation	7.68E-03	1.60E-03	3.65E-04	4.94E-05

Notes:
No Risk and No Hazard = No exposure in any of the pathways examined.

under one set of future use assumptions and help to compare the long-term risks among the alternatives. These calculations were based on assumptions and represent one set among many possible sets of scenarios representing long-term risk.

The integrated post-remediation health effects over 10,000 years from the present for the downriver population on the Columbia River for an estimated population of 500,000 were calculated for each alternative. Table 5.11.6 presents the total fatalities, population dose, and maximum incremental dose for each alternative.

As discussed earlier in this section, the post-remediation risk calculations contained a number of conservative assumptions designed to ensure that the results would provide an upper bound of the long-term risk associated with the TWRS alternatives. For comparison purposes, a nominal case was also evaluated. The nominal case was based on average rather than conservative assumptions. Evaluation methods for the nominal case were identical to the bounding case. Tables 5.11.7 and 5.11.8 present

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Table 5.11.5 Bounding Case Post-Remediation Total Cancer Incidence and Cancer Fatalities for 10,000 Years from the Present for all Alternatives

Alternatives	Native American		Residential Farmer		Industrial Worker		Recreational User	
	Cancer Incidence [1]	Cancer Fatality [2]	Cancer Incidence [1]	Cancer Fatality [2]	Cancer Incidence [1]	Cancer Fatality [2]	Cancer Incidence [1]	Cancer Fatality [2]
No Action	2,597	2,164	759	632	441	367	52	43
Long-Term Management	2,720	2,260	681	567	441	367	50	41
In Situ Fill and Cap	1,261	1,051	400	333	459	383	29	24
In Situ Vitrification	3	2	1	1	2	1	0	0
Ex Situ Intermediate Separations	40	33	12	10	18	15	0	0
Ex Situ No Separations	40	33	12	10	18	15	0	0
Ex Situ Extensive Separations	40	33	12	10	18	15	0	0
Ex Situ/In Situ Combination 1	200	166	72	60	183	153	1	0
Ex Situ/In Situ Combination 2	225	204	77	64	183	153	4	3
Phased Implementation	40	33	12	10	18	15	0	0
Population Density (number of individuals/ km^2)	1.91		4.97		N/A		18.75	
Population per Generation (number of individuals)	1,500		3,900		2,200		1,950	
Total population in 10,000 yr (number of individuals)	214,286		557,143		733,333		650,000	
Area of Land Use (km^2)	785		785		Maximum Risk		104	

Notes:
[1] Dose to risk conversion factor for cancer incidence used is 6.0E-04 (ICRP 1991).
[2] Dose to risk conversion factor for cancer fatality used is 5.0E-04 (ICRP 1991).
N/A = Not applicable

Table 5.11.6 Estimated Fatality, Population Dose (person-rem), and Maximum Incremental Dose (mrem) for the Columbia River User (500,000 persons) for 10,000 Years for all Alternatives

Alternative	Total Fatalities	Population Dose [1] (Person-rem)	Average Individual Dose (mrem/10,000 yr)
No Action	2.8	5,580	0.84 (2,900)
Long-Term Management	2.3	4,520	0.77 (2,830)
In Situ Fill and Cap	25.7	51,400	0.15 (12,000)
In Situ Vitrification	1.00E-06	0.002	0
Ex Situ Intermediate Separations	0.5	907	0.005 (9,060)
Ex Situ No Separations	0.5	907	0.005 (9,060)
Ex Situ Extensive Separations	0.5	907	0.005 (9,060)
Ex Situ/In Situ Combination 1	2.6	5,150	0.014 (12,000)
Ex Situ/In Situ Combination 2	5.6	11,200	0.03 (12,000)
Phased Implementation	0.5	907	0.005 (9,060)

Notes:
[1] The dose to risk conversion factor is 5.0E-04 cancer fatality per rem.

the risk range for the bounding and nominal cases. Risk range refers to the difference between the risk values for the bounding case and the corresponding values for the nominal case.

Table 5.11.7 shows the maximum calculated values for ILCR and noncarcinogenic chemical hazard for the bounding and nominal cases. Values shown are the highest values calculated for each exposure scenario and time period under each alternative. The risk range can be determined by comparing values for the bounding case with the corresponding values for the nominal case. For example, under the bounding case for the No Action (Tank Waste) alternative, the post-remediation risk to the residential farmer at 300 years was calculated to be 4.58E-01; the corresponding risk for the nominal case was calculated to be 1.92E-01 (Table 5.11.7).

Table 5.11.8 shows the total post-remediation cancer incidence calculated over a 10,000 year period for the bounding and nominal cases. The risk range can be determined in the same manner as for the maximum risk range. For example, under the bounding case for the No Action (Tank Waste) alternative, the total cancer incidence for the residential farmer over 10,000 years was calculated to be 759; the corresponding cancer incidence for the nominal case was calculated to be 626 (Table 5.11.8).

No Action Alternative (Tank Waste)

The source term under this alternative would be the entire inventory of the tank waste. After the 100-year administrative control period, the tank tops would collapse, and without a Hanford Barrier, precipitation would move through the waste relatively fast, leaching contaminants into the underlying vadose zone and groundwater. The groundwater would rapidly transport contaminants to the Columbia River. The fastest moving contaminants would reach the groundwater aquifer in approximately 140 years after 100 years of administrative control. Within 300 years the ILCR for the Native American, residential farmer, and industrial worker scenarios would be greater than 1.0E-01 (high

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Table 5.11.7 Risk Range for the Bounding and Nominal Cases, Maximum Incremental Lifetime Cancer Risks and Hazard Indices

300 Years from 1995								
Alternative	**Native American**		**Residential Farmer**		**Industrial Worker**		**Recreational User**	
Incremental Lifetime Cancer Risks								
	Bounding Case	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**
No Action	1.00E+00	1.00E+00	4.58E-01	1.92E-01	1.34E-01	1.62E-02	1.26E-02	2.45E-03
Long-Term Management	1.00E+00	9.93E-01	2.65E-01	3.63E-02	1.18E-01	2.45E-03	1.02E-02	3.80E-04
In Situ Fill and Cap	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ Intermediate Separations	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ No Separations	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ Extensive Separations	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 1	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 2	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Phased Implementation	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Hazard Index								
No Action	2.77E+05	2.77E+05	5.04E+04	5.04E+04	5.37E+01	5.37E+01	7.33E+00	7.33E+00
Long-Term Management	4.42E+04	4.42E+04	7.99E+03	7.99E+03	8.24E+00	8.24E+00	1.12E+00	1.12E+00
In Situ Fill and Cap	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
In Situ Vitrification	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Intermediate Separations	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ No Separations	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Extensive Separations	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 1	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 2	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Phased Implementation	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard

Table 5.11.7 Risk Range for the Bounding and Nominal Cases, Maximum Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

500 Years from 1995								
Alternative	**Native American**		**Residential Farmer**		**Industrial Worker**		**Recreational User**	
Incremental Lifetime Cancer Risks								
	Bounding Case	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**
No Action	1.00E+00	7.69E-01	1.13E-01	5.50E-02	2.82E-02	2.19E-03	2.63E-03	3.63E-04
Long-Term Management	1.00E+00	7.73E-01	9.55E-02	4.57E-02	2.75E-02	1.95E-03	2.51E-03	3.09E-04
In Situ Fill and Cap	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ Intermediate Separations	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ No Separations	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ Extensive Separations	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 1	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ/In Situ Combination 2	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Phased Implementation	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Hazard Index								
No Action	3.47E+04	3.47E+04	6.25E+03	6.25E+03	6.69E+00	6.69E+00	9.10E-01	5.97E-01
Long-Term Management	3.46E+04	3.46E+04	6.24E+03	6.24E+03	6.44E+00	6.44E+00	8.78E-01	5.84E-01
In Situ Fill and Cap	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
In Situ Vitrification	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Intermediate Separations	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ No Separations	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Extensive Separations	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 1	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ/In Situ Combination 2	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Phased Implementation	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard

Table 5.11.7 Risk Range for the Bounding and Nominal Cases, Maximum Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

2,500 Years from 1995								
Alternative	**Native American**		**Residential Farmer**		**Industrial Worker**		**Recreational User**	
Incremental Lifetime Cancer Risks								
	Bounding Case	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**
No Action	3.09E-02	1.00E+00	1.17E-04	4.68E-02	5.37E-05	2.04E-02	4.47E-06	1.78E-03
Long-Term Management	3.09E-02	1.00E+00	1.17E-04	4.68E-02	5.37E-05	2.04E-02	4.47E-06	1.78E-03
In Situ Fill and Cap	3.98E-07	3.39E-07	3.47E-08	5.50E-08	8.71E-09	3.55E-09	7.94E-10	5.75E-10
In Situ Vitrification	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk	No Risk
Ex Situ Intermediate Separations	1.17E-04	2.57E-05	9.55E-06	1.91E-06	3.02E-06	7.24E-08	2.69E-07	1.15E-08
Ex Situ No Separations	1.17E-04	2.57E-05	9.55E-06	1.91E-06	3.02E-06	7.24E-08	2.69E-07	1.15E-08
Ex Situ Extensive Separations	1.17E-04	2.57E-05	9.55E-06	1.91E-06	3.02E-06	7.24E-08	2.69E-07	1.15E-08
Ex Situ/In Situ Combination 1	8.51E-05	3.24E-05	6.92E-06	2.19E-06	2.19E-06	9.33E-08	2.00E-07	1.48E-08
Ex Situ/In Situ Combination 2	2.24E-05	7.76E-06	1.86E-06	6.92E-07	5.50E-07	2.57E-08	4.90E-08	4.07E-09
Phased Implementation	1.17E-04	2.57E-05	9.55E-06	1.91E-06	3.02E-06	7.24E-08	2.69E-07	1.15E-08
Hazard Index								
No Action	5.16E+01	6.41E+01	9.18E+00	9.18E+00	8.91E-01	5.90E-01	1.19E-01	1.12E-01
Long-Term Management	5.17E+01	6.53E+01	9.20E+00	9.20E+00	8.91E-01	5.90E-01	1.19E-01	1.12E-01
In Situ Fill and Cap	2.00E-03	1.33E-03	3.37E-04	2.41E-04	4.79E-07	4.70E-07	6.49E-08	6.15E-08
In Situ Vitrification	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Ex Situ Intermediate Separations	7.24E-01	5.99E-01	1.23E-01	1.11E-01	1.14E-04	9.05E-05	1.57E-05	1.24E-05
Ex Situ No Separations	7.24E-01	4.51E-01	1.16E-01	1.05E-01	1.14E-04	9.05E-05	1.57E-05	1.24E-05
Ex Situ Extensive Separations	7.24E-01	5.99E-01	1.23E-01	1.11E-01	1.14E-04	9.05E-05	1.57E-05	1.24E-05
Ex Situ/In Situ Combination 1	4.69E-01	4.69E-01	8.48E-02	8.48E-02	1.84E-04	1.84E-04	2.51E-05	2.51E-05
Ex Situ/In Situ Combination 2	1.20E-01	1.20E-01	2.21E-02	2.21E-02	1.92E-05	1.92E-05	2.64E-06	2.64E-06
Phased Implementation	7.24E-01	5.99E-01	1.23E-01	1.11E-01	1.14E-04	9.05E-05	1.57E-05	1.24E-05

Table 5.11.7 Risk Range for the Bounding and Nominal Cases, Maximum Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

5,000 Years from 1995								
Alternative	**Native American**		**Residential Farmer**		**Industrial Worker**		**Recreational User**	
Incremental Lifetime Cancer Risks								
	Bounding Case	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**
No Action	3.16E-03	1.75E-01	8.13E-06	6.03E-03	3.72E-06	2.63E-03	3.09E-07	2.29E-04
Long-Term Management	3.16E-03	1.77E-01	8.13E-06	6.03E-03	3.72E-06	2.69E-03	3.09E-07	2.34E-04
In Situ Fill and Cap	1.30E-01	1.25E-01	1.10E-02	4.79E-03	2.88E-03	3.09E-04	2.63E-04	4.68E-05
In Situ Vitrification	3.02E-04	3.02E-04	2.34E-05	1.70E-05	6.92E-06	7.94E-07	6.31E-07	1.26E-07
Ex Situ Intermediate Separations	4.27E-03	7.08E-04	3.39E-04	2.04E-05	1.02E-04	2.57E-06	9.55E-06	2.63E-07
Ex Situ No Separations	4.27E-03	7.08E-04	3.39E-04	2.04E-05	1.02E-04	1.70E-06	9.55E-06	2.57E-07
Ex Situ Extensive Separations	4.27E-03	7.08E-04	3.39E-04	2.04E-05	1.02E-04	2.04E-06	9.55E-06	2.57E-07
Ex Situ/In Situ Combination 1	4.27E-02	2.19E-02	3.31E-03	1.10E-03	1.07E-03	6.17E-05	9.55E-05	9.55E-06
Ex Situ/In Situ Combination 2	4.27E-02	4.57E-02	3.63E-03	1.38E-03	1.10E-03	1.15E-04	1.02E-04	1.74E-05
Phased Implementation	4.27E-03	7.08E-04	3.39E-04	2.04E-05	1.02E-04	2.57E-06	9.55E-06	2.63E-07
Hazard Index								
No Action	2.17E+00	2.17E+00	5.76E-01	4.38E-01	1.16E-01	1.10E-01	1.56E-02	1.55E-02
Long-Term Management	2.69E+00	2.69E+00	5.76E-01	4.38E-01	1.16E-01	1.10E-01	1.56E-02	1.55E-02
In Situ Fill and Cap	3.01E+03	5.35E+03	5.32E+02	9.66E+02	4.21E-01	5.98E-01	7.13E-02	1.17E-01
In Situ Vitrification	1.00E-03	2.01E-03	3.15E-04	6.30E-04	6.68E-05	1.34E-04	9.03E-06	1.81E-05
Ex Situ Intermediate Separations	1.22E+02	3.41E+01	2.11E+01	6.30E+00	2.23E-02	5.15E-03	3.00E-03	7.08E-04
Ex Situ No Separations	1.22E+02	3.41E+01	2.11E+01	6.30E+00	2.21E-02	5.15E-03	3.00E-03	7.08E-04
Ex Situ Extensive Separations	1.22E+02	3.41E+01	2.11E+01	6.30E+00	2.23E-02	5.15E-03	3.00E-03	7.08E-04
Ex Situ/In Situ Combination 1	3.31E+03	3.31E+03	5.97E+02	5.97E+02	6.26E-01	6.26E-01	8.50E-02	8.50E-02
Ex Situ/In Situ Combination 2	3.37E+03	3.37E+03	6.09E+02	6.09E+02	6.54E-01	6.54E-01	8.89E-02	8.89E-02

Table 5.11.7 Risk Range for the Bounding and Nominal Cases, Maximum Incremental Lifetime Cancer Risks and Hazard Indices (cont'd)

10,000 Years from 1995								
Alternative	**Native American**		**Residential Farmer**		**Industrial Worker**		**Recreational User**	
Incremental Lifetime Cancer Risks								
	Bounding Case	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**	**Bounding Case**	**Nominal Case**
No Action	1.82E-04	7.94E-03	5.37E-07	2.69E-04	2.45E-07	1.17E-04	2.09E-08	1.02E-05
Long-Term Management	1.82E-04	7.94E-03	5.37E-07	2.69E-04	2.45E-07	1.17E-04	2.09E-08	1.02E-05
In Situ Fill and Cap	1.78E-02	1.41E-02	1.48E-03	5.89E-04	3.98E-04	3.47E-05	3.72E-05	5.25E-06
In Situ Vitrification	3.89E-04	3.89E-04	3.02E-05	2.19E-05	9.12E-06	1.02E-06	8.13E-07	1.62E-07
Ex Situ Intermediate Separations	6.92E-04	6.17E-04	6.76E-05	3.98E-05	7.41E-06	6.17E-06	7.76E-07	6.03E-07
Ex Situ No Separations	1.91E-07	1.51E-04	1.62E-08	5.37E-06	3.72E-09	2.34E-06	3.47E-10	2.04E-07
Ex Situ Extensive Separations	1.91E-07	3.09E-04	1.62E-08	1.10E-05	3.72E-09	4.68E-06	3.47E-10	4.07E-07
Ex Situ/In Situ Combination 1	2.24E-03	2.29E-03	1.66E-04	5.13E-05	5.50E-05	3.89E-06	4.90E-06	5.25E-07
Ex Situ/In Situ Combination 2	6.92E-03	6.31E-03	5.62E-04	2.45E-04	1.55E-04	1.29E-05	1.41E-05	2.00E-06
Phased Implementation	6.92E-04	6.17E-04	6.76E-05	3.98E-05	7.41E-06	6.17E-06	7.76E-07	6.03E-07
Hazard Index								
No Action	1.07E-01	1.01E-01	2.79E-02	2.75E-02	5.62E-03	5.62E-03	7.51E-04	7.51E-04
Long-Term Management	1.99E-01	1.80E-01	2.79E-02	2.75E-02	5.62E-03	5.62E-03	7.51E-04	7.51E-04
In Situ Fill and Cap	1.29E+02	1.23E+03	1.86E+02	3.90E+02	6.21E+00	9.98E-01	5.73E-01	5.83E-01
In Situ Vitrification	1.30E-03	2.59E-03	4.06E-04	8.13E-04	8.62E-05	1.73E-04	1.16E-05	2.33E-05
Ex Situ Intermediate Separations	7.68E-03	1.40E+00	1.60E-03	2.17E-03	3.65E-04	4.70E-04	4.94E-05	6.25E-05
Ex Situ No Separations	7.68E-03	5.98E-01	8.99E-04	1.35E-03	1.76E-06	2.83E-04	2.10E-07	3.72E-05
Ex Situ Extensive Separations	9.12E-01	1.82E+00	1.35E-03	2.70E-03	2.83E-04	5.66E-04	3.72E-05	7.44E-05
Ex Situ/In Situ Combination 1	4.28E+02	4.28E+02	6.98E+01	6.98E+01	7.49E-02	7.49E-02	9.76E-03	9.76E-03
Ex Situ/In Situ Combination 2	7.54E+02	7.54E+02	1.21E+02	1.21E+02	1.39E-01	1.39E-01	1.80E-02	1.80E-02
Phased Implementation	7.68E-03	1.40E+00	1.60E-03	2.17E-03	3.65E-04	4.70E-04	4.94E-05	6.25E-05

Notes:
No Risk and No Hazard = No exposure in any of the pathways examined.

Table 5.11.8 Risk Range for the Bounding and Nominal Cases, Post-Remediation Total Cancer Incidence for 10,000 Years from the Present for All Alternatives

Alternatives	Native American		Residential Farmer		Industrial Worker		Recreational User	
	Bounding	Nominal	Bounding	Nominal	Bounding	Nominal	Bounding	Nominal
No Action	2,597	2,178	759	626	441	438	52	30
Long-Term Management	2,720	2,476	681	625	441	423	50	33
In Situ Fill and Cap	1,261	307	400	276	459	18	29	3
In Situ Vitrification	3	2	1	0	2	0	0	0
Ex Situ Intermediate Separations	40	7	12	2	18	0	0	0
Ex Situ No Separations	40	7	12	2	18	0	0	0
Ex Situ/Extensive Separations	40	7	12	2	18	0	0	0
Ex Situ/In Situ Combination 1	200	82	72	55	183	10	1	0
Ex Situ In Situ Combination 2	225	98	77	58	183	18	4	0
Phased Implementation	40	7	12	2	18	0	0	0
Population Density (number of individual/km^2)	1.91		4.97		N/A		18.75	
Population per Generation (number of individual)	1,500		3,900		2,200		1,950	
Total population in 10,000 yr (number of individual)	214,286		557,143		733,333		650,000	
Area of Land Use (km^2)	785		785		Maximum Risk		104	

Notes:
N/A = Not applicable

risk), and the hazard indices would be greater than 1.0 for all the scenarios, indicating that toxic effects would occur. Within 300 years, the ILCR for the recreational shoreline user would be greater than 1.0E-02 (high risk). The ILCR slowly would decrease over time but would be high for at least 10,000 years for the Native American scenario and at least 2,500 years for the residential farmer scenario.

Long-Term Management Alternative

Under this alternative, the source of contamination would be the entire inventory of the tank waste. This would be the same source as under the No Action (Tank Waste) alternative; however, 1 percent of the current DST inventory would remain in the original DSTs as residual waste and the other 99 percent would be contained in replacement DSTs. As in the No Action alternative, the tank tops would collapse after the administrative control period; however, this collapse would take longer to occur because of the replacement DSTs. As previously described, without a Hanford Barrier, contamination

would rapidly leach from the tanks and would reach the groundwater in approximately 140 years after 100 years of administrative control.

Within 300 years, the ILCR would exceed 1.0E-01 (high risk) for the Native American, residential farmer, and industrial worker scenarios and 1.0E-02 (high risk) for the recreational shoreline user. The hazard indices would be greater than 1.0 for all the scenarios, indicating that toxic effects would occur. The ILCR would decrease over time at a somewhat more rapid rate than for the No Action alternative but would remain high for at least 10,000 years for the Native American scenario and at least 2,500 years for the residential farmer scenario.

In Situ Fill and Cap Alternative

The source for contamination under this alternative would be the entire inventory of the tank waste. This would be the same source as under the Long-Term Management alternative; however, there would be a Hanford Barrier over the tanks to retard infiltration under this alternative. Water from precipitation would move slowly through the Hanford Barrier and leach contaminants from the unstabilized waste. Contaminants would not reach the groundwater until approximately 2,300 years from the present. The ILCR would be less than 1.0E-06 (low risk) for all receptors until after 2,500 years. At 5,000 years, potential risks would exceed 1.0E-01 (high risk) for the Native American, 1.0E-02 (high risk) for the residential farmer, 1.0E-03 (high risk) for the industrial worker, and 1.0E-04 (high risk) for the recreational shoreline user. The hazard indices would approach or reach 1.0, indicating that toxic effects would be expected.

In Situ Vitrification Alternative

The source term under this alternative would be the entire inventory of the tank waste. This would be the same waste inventory as under the No Action (Tank Waste) alternative; however, the waste would be in an immobilized (vitrified) form, and there would be a low-permeability Hanford Barrier over the tanks to retard infiltration of precipitation. Water from precipitation would move slowly through the Hanford Barrier and leach contaminants from the vitrified waste. Contaminants would not reach the groundwater aquifer for approximately 2,350 years, and the ILCR would be less than 1.00-06 (low risk) for all receptors until after 2,500 years.

At 5,000 and 10,000 years, the ILCR would exceed 1.0E-04 (high risk) for the Native American scenario and be between 1.0E-06 (low risk) and 1.0E-04 for the residential farmer, industrial worker, and recreational shoreline user scenarios. The hazard indices would be less than 1.0 for all exposure scenarios and all time periods, indicating that no toxic effects would occur.

Ex Situ Intermediate Separations Alternative

There would be two sources for contamination under this alternative. One source term would be the 1 percent of the current tank waste that would remain in the tanks as residual waste. The other source would be the vitrified waste in the LAW vaults. Both sources would be covered with a Hanford Barrier. While water from precipitation would move slowly through the Hanford Barrier and through the tanks as previously described, the volume of contaminants available to be leached would be only

1 percent of the current tank volume; therefore, the levels of contamination in the groundwater would be reduced substantially. Water from precipitation also would move slowly through the Hanford Barrier and through the LAW vaults, slowly leaching contaminants in the vitrified waste into the groundwater aquifer. The groundwater contamination from the 1 percent residual waste in the tanks would be approximately 100 times or more greater than the contaminants from the LAW vaults, although this would vary somewhat at different time periods. Contaminants would not reach the groundwater until approximately 1,100 years from the present.

The ILCR would be less than or near 1.0E-06 (low risk) until after 2,500 years for all but the Native American scenario. Potential risks for the Native American scenario would exceed 1.0E-04 (high risk) at 2,500 years and would remain above 1.0E-04 through the 10,000-year time period. At 5,000 years, the hazard index would exceed 1.0 for the Native American, indicating that toxic effects would be expected. For the residential farmer and industrial worker scenarios, the ILCR would exceed 1.0E-04 at 5,000 years and be between 1.0E-06 and 1.0E-04 at 10,000 years. The hazards index for the residential farmer would exceed 1.0 at 5,000 years, indicating that toxic effects would be expected. The hazard index for the industrial worker would not exceed 1.0 for any time period. For the recreational shoreline user scenario, the ILCR would only exceed 1.0E-06 (but be below 1.0E-04) at the 5,000-year time period, and the hazard index would be below 1.0. The ILCR from the 1 percent residuals in the tanks would be approximately 100 times greater than the ILCR from the LAW vaults.

Ex Situ No Separations Alternative

Under this alternative, the source would be the same as under the Ex Situ Intermediate Separations alternative except there would be no LAW vaults because all waste retrieved would be disposed of at the potential geologic repository. The source for this alternative would be the 1 percent of the current tank waste that would remain in the tanks as residual waste. As described previously, water from precipitation would move slowly through the Hanford Barrier and leach the residuals into the aquifer within approximately 1,100 years from the present. The risks and hazards associated with this alternative would be nearly identical to the Ex Situ Intermediate Separations alternative because the risks from the 1 percent residuals would be 100 times greater than from the LAW vaults, and they overshadow the ILCR from the LAW vaults. The absence of LAW vaults under this alternative would have little impact on risks. Hazard indices would approach or reach 1.0 at 5,000 years for the Native American and residential farmer, indicating that toxic effects would be expected.

Ex Situ Extensive Separations Alternative

Under this alternative, the sources would be the same as under the Ex Situ Intermediate Separations alternative except that the LAW vaults would contain approximately 100 to 1,000 times lower concentrations of technetium-99 and uranium (total). However, because the ILCR from the 1 percent residuals would be 100 times greater than the LAW vaults in the Ex Situ Intermediate Separations alternative, the reduction in the technetium-99 and uranium (total) would have little effect on overall ILCR. Therefore, the ILCR and hazard indices for this alternative essentially would be the same as the Ex Situ Intermediate Separations and Ex Situ No Separations alternatives.

Ex Situ/In Situ Combination 1 Alternative

Under this alternative, approximately one-half of the tank waste by volume would be remediated using the In Situ Fill and Cap alternative and the other half would be remediated under the Ex Situ Intermediate Separations alternative. By selecting the appropriate tanks for retrieval, approximately 90 percent of the largest contributors to groundwater risk (technetium-99, iodine-129, carbon-14, and uranium) would be retrieved, vitrified, and disposed of in the HLW, which would be sent to the potential geologic repository. Both the tanks and the LAW vaults would be covered with a Hanford Barrier, and water from precipitation would leach the contaminants as previously described. Contaminants would not reach the groundwater for approximately 500 years. At 2,500 years, the ILCR would exceed 1.0E-04 (high risk) for the Native American scenario but would be less than or near 1.0E-06 (low risk) for the other scenarios. At 5,000 years, the ILCR would exceed 1.0E-03 for the Native American, residential farmer, and industrial worker, and be between 1.0E-06 and 1.0E-04 for the recreational shoreline user. Potential risks would decrease over time but would remain above 1.0E-04 for the native American and residential farmer at the 10,000-year period, and between 1.0E-06 and 1.0E-04 for the industrial worker and recreational shoreline user. Hazard indices would exceed 1.0 only for the Native American and residential farmer at 5,000 and 10,000 years, indicating that toxic effects would be expected at these time periods.

Ex Situ/In Situ Combination 2 Alternative

The Ex Situ/In Situ Combination 2 alternative would use modified tank selection criteria to provide for ex situ treatment of the largest contributors to groundwater risk while limiting the volume of waste to be processed. Under this variation, approximately 25 tanks instead of 177 tanks would be retrieved and remediated using the Ex Situ Intermediate Separations alternative, while the remaining tanks would be remediated under the In Situ Fill and Cap alternative. As for the Ex Situ/In Situ Combination 1 alternative, the tanks and LAW vaults would be covered with a Hanford Barrier and contaminants would not reach groundwater for approximately 500 years. The ILCR would be less than or near 1.0E-06 (low risk) until after 2,500 years. Potential risks at 5,000 and 10,000 years would be higher than for Ex Situ/In Situ Combination 1 alternative because a greater volume of unstabilized tank waste would be available to leach into the groundwater. The ILCR would exceed 1.0E-04 for all scenarios at 5,000 years and remain above 1.0E-04 for all but the recreational shoreline user through the 10,000-year period. Hazard indices would exceed 1.0 only for the Native American and residential farmer at 5,000 and 10,000 years, indicating that toxic effects would be expected at these time periods.

Phased Implementation Alternative

There would be two sources for contamination under this alternative. One source term would be the 1 percent of the current tank waste that would remain in the tanks as residual waste. The other source would be the vitrified waste in the LAW vaults. Both sources would be covered with a Hanford Barrier. While water from precipitation would move slowly through the Hanford Barrier and through the tanks as previously described, the volume of contaminants available to be leached would be only 1 percent of the current tank volume; therefore, the levels of contamination in the groundwater would be reduced substantially. Water from precipitation also would move slowly through the Hanford Barrier and through the LAW vaults, slowly leaching contaminants in the vitrified waste into the

groundwater aquifer. The groundwater contamination from the 1 percent residual waste in the tanks would be approximately 100 times or more greater than the contaminants from the LAW vaults, although this would vary somewhat at different time periods. Contaminants would not reach the groundwater until approximately 1,100 years from the present. At 2,500 years, the ILCR would exceed 1.0E-04 (high risk) for the Native American scenario but would be less than or near 1.E-06 (low risk) for the other scenarios. At 5,000 years, the ILCR would exceed 1.0E-04 for the Native American, residential farmer, and industrial worker, and be between 1.0E-06 and 1.0E-04 for the recreational shoreline user. Potential risks would decrease over time but would remain above 1.0E-04 for the Native American at the 10,000-year period and between 1.0E-06 and 1.0E-04 for the residential farmer and the industrial worker. Hazard indices would exceed 1.0 only for the Native American and residential farmer at 5,000 years, indicating that toxic effects would be expected. The ILCR from the 1 percent residuals in the tanks would be approximately 100 times greater than the ILCR from the LAW vaults.

Hypothetical Intruder

The **hypothetical driller** is an individual who works for a drilling company. This individual would drill a 30-cm (76.2-in.)-diameter well through the tank waste. It would take 40 hours to complete the operation. The individual's exposure pathways would include inhalation of contaminated dust while drilling through waste and external exposure to penetrating radiation from waste brought to the surface.

The **hypothetical post-drilling resident** is an adult who, as a result of drilling, would be exposed to contaminated soil from within the waste that would be brought to the surface and spread over 2,500 m^2 (0.62 ac). This individual would have three exposure pathways: exposure to airborne contamination via inhalation, external exposure to penetrating radiation, and consumption of contaminated produce (25 percent of the individual's diet of fruit and vegetables).

Capsule Alternatives

All of the cesium and strontium capsule alternatives, except Onsite Disposal, would involve removing all of the cesium and strontium from the Hanford Site, and therefore would not result in any post-remediation risks. Under the Onsite Disposal alternative, the cesium and strontium would decay into their stable progeny before the steel canisters corroded and allowed the release of cesium and strontium, which could move through the vadose zone (Section 5.2). Cesium and strontium, with half-lives of only 30.2 and 28.6 years, respectively, would decay into their stable progeny, barium-137 and zirconium-90. As described in Volume Four, Appendix F, it would take approximately 600 years to transport the cesium and strontium to the groundwater. After this time period, there would be small amounts of cesium and strontium remaining, and no measurable amount would reach the groundwater. Barium and zirconium, the progeny, eventually would reach the groundwater in concentrations so low that they would represent a negligible risk. Therefore, none of the capsule alternatives would result in any substantial post-remediation risks.

5.11.3 Post-Remediation Intruder Scenario

An intruder scenario analysis is presented in Volume Three, Appendix D. The increased cancer incidence risk and increased latent cancer fatality risk for the alternatives are calculated in Volume Three, Appendix D, Section D.7.0, Tables D.7.4.1 and D.7.4.2. The intrusion was a postulated well drilling scenario on the Hanford Site after the assumed loss of institutional control 100 years from the present. The exposure to the well driller who would drive a 30-cm (0.98-ft)-diameter well through the onsite waste and would bring the waste to the surface was calculated. Exposure to a post-drilling resident also was calculated. The post-drilling resident was assumed to have a vegetable garden in the exhumed waste that supplied 25 percent of this individual's vegetable intake.

The greatest risk would come from the No Action, Long-Term Management and In Situ Fill and Cap tank waste alternatives, in which the entire nonimmobilized inventory of waste would remain in the tanks. For each of these three alternatives, the probability of a cancer incidence was calculated to be 1.02E-02 (1 in 100) for the driller and 5.07E-02 (1 in 20) for the post-drilling resident. The probability of a latent cancer fatality was calculated to be 8.52E-03 (1 in 100) for the driller and 4.23E-02 (1 in 24) for the post-drilling resident.

The Ex Situ/In Situ Combination 1 alternative would have the next highest risk with a probability of a cancer incidence of 1.47E-03 (1 in 700) for the driller and 7.94E-03 (1 in 125) for the post-drilling resident. The probability of a latent cancer fatality was calculated to be 1.23E-03 (1 in 800) for the driller and 6.62E-03 (1 in 150) for the post-drilling resident. The Ex Situ/In Situ Combination 2 alternative would have the next highest risk with a cancer incidence probability of 7.26E-04 (1 in 4,000) for the driller and 3.04E-03 (1 in 328) for the post-drilling resident. The probability of a latent cancer fatality was calculated to be 6.05E-04 (1 in 1,500) for the driller and 2.53E-03 (1 in 400) for the post-drilling resident. These risks would be lower than the risks for the Ex Situ/In Situ Combination 1 alternative because waste would be retrieved from a greater number of DSTs. The Ex Situ/In Situ Combination 2 alternative would be similar to the In Situ Vitrification alternative, which would have a probability of a cancer incidence of 3.79E-04 (1 in 2,600) for the driller and 2.54E-03 (1 in 400) for the post-drilling resident. The probability of a latent cancer fatality was calculated to be 3.16E-04 (1 in 3,000) for the driller and 2.04E-03 (1 in 500) for the post-drilling resident.

The lowest risk would come from the Ex Situ Intermediate Separations, Ex Situ No Separations, Ex Situ Extensive Separations, and Phased Implementation alternatives in which 99 percent of the inventory of waste would be removed from the tanks. For each of these four alternatives, the probability of a cancer incidence was calculated to be 1.02E-04 (1 in 10,000) for the driller and 5.07E-04 (1 in 2,000) for the post-drilling resident. The probability of a latent cancer fatality was calculated to be 8.52E-05 (1 in 11,700) for the driller and 4.23E-04 (1 in 2,400) for the post-drilling resident.

The only increased risk from the capsule alternatives would come from the Onsite Disposal alternative. Under the other alternatives, cesium and strontium would be removed from the Hanford Site.

The probability of a cancer incidence and latent cancer fatality for both the driller and the post-drilling resident was calculated to be 1.0.

5.12 ACCIDENTS

This section compares the risks resulting from potential accidents associated with the alternatives. Accidents are unplanned events or a sequence of events that would cause undesirable consequences. This analysis addresses the following:

- Occupational risks, including the nonradiological/nontoxicological injuries, illnesses, and fatalities from construction, operation, or transportation accidents common to the workplace such as falls, cuts, and operator-machine impacts. The risk associated with an accident was defined as the product of the probability of an accident occurring and the consequence of the accident; and
- Radiological and toxicological risks associated with transportation and operations. The risks associated with a toxicological or radiological release were expressed as the probability or the number of latent cancer fatalities given the occurrence and consequences of an accident.

Accident Impacts

Impacts addressed in this section include:

- Injuries, illnesses, and fatalities to workers from nonradiological accidents during construction and operations (Section 5.12.1);
- Injuries and fatalities to workers resulting from workplace and commuting traffic accidents (Section 5.12.1);
- Latent cancer fatalities among workers and the public resulting from transportation of HLW (Section 5.12.2);
- Health effects among workers and the public from chemical exposure from remediation and transportation accidents (Section 5.12.3); and
- Latent cancer fatalities among workers and the public resulting from waste remediation facility operations accidents (Section 5.12.4).

The results of the analyses are summarized in the following sections. More detailed information concerning the methodology, supporting data, and assumptions for the basis of the analysis is contained in Volume Four, Appendix E. Appendix E also contains a latent cancer fatality point estimate risk evaluation. The point estimate risk accounted for the probability of the accident occurring. The probability was factored into the latent cancer fatality risk.

Nonradiological occupational and transportation accidents would largely be a function of the number of person-years of labor required to complete the total activities for each alternative. The more person-years of labor, the more injuries, illnesses, and fatalities. For the tank waste alternatives, the alternative that was estimated to have the greatest number of injuries, illnesses, and fatalities was Long-Term Management, and the alternative with the least number was In Situ Fill and Cap. Onsite Disposal would have the highest number of injuries, illnesses, and fatalities among the capsule alternatives, with the Overpack and Ship and Vitrify with Tank Waste alternatives having the lowest.

For radiological and chemical exposures resulting from accidents during remediation, the greatest risk to workers and the public would be associated with a flammable gas deflagration in a waste storage tank. The alternative that would allow the waste to remain unstabilized over the longest period of time would pose the greatest risk. Therefore, the No Action (Tank Waste) and Long-Term Management alternatives would have the highest risk. The lowest risk would come from In Situ Fill and Cap.

For radiological and chemical exposure resulting from accidents after remediation, the greatest risk to the general population would be associated with the No Action and Long-Term Management tank waste alternatives in which the tanks would not have been stabilized with gravel.

In Volume Five, Appendix K an analysis is presented regarding uncertainties associated with the accident analyses for the tank waste alternatives. For the operation accidents, uncertainties were associated with the inventory of waste in the tanks and the atmospheric conditions that would transport the waste released as a result of an accident. Because of this uncertainty, a 100-percent composite inventory was developed for tank farm accidents. This composite incorporated estimates of the historical tank contents, the results from prior individual tank analyses, and the results of recent tank characterization programs. This composite provided a bounding tank waste inventory for the accident analysis. A less conservative approach was to estimate the inventory of radioactive materials contained in the fuel from the single-pass reactors and N Reactor and sent to the tank farms. Reduction factors were applied to account for extracted plutonium, uranium, cesium, and strontium. This nominal radiological inventory is shown in Volume Four, Section E.1.0. Because the tank waste inventory has not yet been well characterized, bounding and nominal radiological and toxicological consequences were presented in the analysis to provide a risk range.

Atmospheric conditions would influence the dispersion in air of contaminants to potential receptors. To provide a bounding case for analysis in the EIS, very unlikely atmospheric conditions were used (99.5 percentile). To assess the effect of using the bounding atmospheric conditions, the uncertainties analysis compared the results of bounding case atmospheric conditions to typical atmospheric conditions (50th percentile).

There would also be uncertainties associated with the analysis of consequences of an accident involving the transportation of vitrified HLW to the potential geologic repository under certain tank waste alternatives. The potential consequences would be influenced by the percent for the HLW by weight that would be mixed in the glass. The baseline analysis in the EIS assumed a 20 percent waste loading; however, a waste loading of as little as 15 percent and as much as 40 percent could occur. Uncertainties associated with waste loading are discussed further in Volume Two, Section B.8.0. To address this uncertainty, the impacts from a transportation accident involving the baseline waste loading were compared to an accident involving vitrified glass with a 15 percent waste loading and with a 40 percent waste loading (see Volume Four, Section E.16).

In addition to the uncertainties associated with the accident analysis, a number of important assumptions influenced the results presented in this section. These assumptions included the following:

- The offsite general public population for operation accidents was based on census data from the 1990 census. While it is unlikely that the general public population would be constant throughout the operation phase of each alternative, the use of the 1990 census provided a uniform basis for comparison of impact among the alternatives.
- The onsite worker population for operation accidents was based on the Hanford Site work force in 1995. In the future, the Site work force would likely decline, resulting in proportionately lesser impacts than are presented in the EIS. However, use of the existing worker population provided a bounding impact analysis in terms of total impacts and also provided a basis for uniform comparison of impacts among the alternatives.
- For nonradiological occupational construction, operation, and transportation accidents, it was assumed that injuries, illnesses, and fatalities would occur at rates similar to historical rates for each activity.
- It was assumed that there would be no evacuation of Hanford Site personnel in the event of an accident. Emergency planning and evacuation programs are in place at the Hanford Site to mitigate potential consequences resulting from an accident.
- For transportation of HLW to a potential geologic repository the accident scenarios were based on transportation of the waste from the Hanford Site to Yucca Mountain, Nevada by rail.

Accident Terms

Beyond Design Basis Accident: An accident with an annual frequency of occurring between 1 in 1,000,000 and 1 in 10,000,000 (1.0E-06 and 1.0E-07) or below the site-specific designated return frequency for natural events.

Bounding Accident: The most conservative parameters (e.g., source terms, meteorology) applied to a conservative accident resulting in a bounding accident analysis.

Corrosive or Irritant Health Effect: Following exposure to corrosive hydroxides (e.g., sodium, ammonium, potassium), effects could range from simple, reversible irritation to irreversible tissue destruction especially to skin, eyes, mucous membranes, and deep fatty tissue.

Lethal Dose: A radiological dose that would result in death shortly after the exposure.

Lost Workday Case: A workplace injury or illness that would result in an employee missing work.

Point Estimate Risk: The product of the probability (likelihood) of an accident occurring and the consequences of the accident (latent cancer fatalities).

Total Recordable Case: A workplace injury or illness that would require medical care.

Toxicological Health Effect: Reversible or irreversible effects in specific target organs from acute exposure to nonradiological chemicals. Adverse effects most often are observed in the central nervous system.

5.12.1 Comparison of Consequences from Nonradiological Occupational and Transportation Accidents

The number of total recordable cases (injuries and illnesses requiring medical care), lost workday cases (an injury or illness resulting in an employee missing work), and fatalities

resulting from construction and operations for each alternative was based on the projected number of employees associated with the activity, multiplied by historical incidence rates. The incidence rates for total recordable and lost workday cases were based on Hanford Site construction statistics. Fatality incidence rates for all DOE sites were used. A comparison of the accident consequences is presented in Table 5.12.1.

Table 5.12.1 also presents consequences of transportation accidents, based on a comparison of the number of injuries and fatalities resulting from the direct impact of traffic accidents. The traffic scenarios analyzed included employee traffic to and from work, and transportation of building materials and other miscellaneous materials to support the alternatives. The incidence rates for injuries and fatalities were based on U.S. Department of Transportation statistics, Washington State Highway accident reports, and Hanford Site statistics.

The calculations for the tank waste alternatives showed the greatest nonradiological and nontoxicological risk would result from the Long-Term Management alternative. This is because of the large number of person-years that would be required to support 100 years of operations and the two retanking campaigns. The In Situ Fill and Cap alternative would have the lowest risk due to the reduced number of person-years required to support 12 years of construction and operation.

The calculations for the capsule alternatives showed the greatest nonradiological and nontoxicological risk would result from the Onsite Disposal alternative because it would require the greatest number of person-years among all of the capsule alternatives. The Overpack and Ship and the Vitrify with Tank Waste alternatives would have the lowest risk.

5.12.2 Comparison of Potential Consequences from Radiological Accidents

Risk is the product of the chance, or probability, of an accident occurring during an operation and the consequences of the accident if it were to occur. An event that was certain to occur would have a probability of 1 (a 100 percent certainty). If an accident was expected to happen once every 100 years, the frequency of occurrence would be 0.01 per year (1 occurrence divided by 100 years = 0.01 occurrences per year). If the operation was scheduled to continue for 20 years, the probability of the accident would be 0.2 (0.01 occurrences per year multiplied by 20 years of operation).

Example Calculation of Accident Risk

If the frequency of an accident were 0.01 occurrences per year, the number of latent cancer fatalities resulting from the accident were 0.05, and the operation was scheduled to continue for 20 years, the probability of the accident would be 0.2.

$$(0.01/\text{yr} \cdot 20\ \text{yr} = 0.2)$$

The total risk from the operation would be determined by multiplying the consequences of the accident (0.05 latent cancer fatalities) by the probability of the accident (0.2) resulting in a total risk of 0.01 latent cancer fatalities.

Table 5.12.1 Comparison of Potential Nonradiological/Nontoxicological Accident Consequences

Alternative	Total Recordable Cases				Lost Workday Cases		Fatalities			
	Occupational		Transportation		Occupational		Occupational		Transportation	
	Con-struction	Operation	Truck/ Rail	Com-muter [1]	Con-struction	Operation	Con-struction	Operation	Truck/ Rail	Com-muter [1]
Tank Waste										
No Action	0.00E+00	2.3E+03	1.6E-01	2.0E+03	0.00E+00	1.1E+03	0.00E+00	3.3E+00	9.5E-03	2.5E+01
Long-Term Management Remediation	3.7E+02	2.3E+03	2.9E+00	2.1E+03	9.2E+01	1.1E+03	1.2E-01	3.3E+00	1.5E-01	2.6E+01
In Situ Fill and Cap Remediation	2.5E+01	5.6E+02	4.8E-01	4.9E+02	6.3E+00	2.8E+02	8.3E-03	8.1E-01	2.2E-02	6.2E+00
Total Alternative	7.1E+01	5.6E+02	2.5E+00	5.0E+02	1.8E+01	2.8E+02	2.3E-02	8.1E-01	1.1E-01	6.3E+00
In Situ Vitrification Remediation	2.2E+03	5.8E+02	1.6E+00	9.3E+02	5.4E+02	2.9E+02	7.1E-01	8.4E-01	9.5E-02	1.2E+01
Total Alternative	2.2E+03	5.8E+02	3.5E+00	9.4E+02	5.5E+02	2.9E+02	7.2E-01	8.4E-01	1.9E-01	1.2E+01
Ex Situ Intermediate Separations Remediation	3.0E+03	1.2E+03	7.3E+00	1.6E+03	7.5E+02	6.0E+02	9.8E-01	1.8E+00	4.0E-01	2.1E+01
Total Alternative	3.0E+03	1.2E+03	1.0E+01	1.7E+03	7.6E+02	6.0E+02	9.9E-01	1.8E+00	5.3E-01	2.1E+01
Ex Situ No Separations Vitrification - Remediation	2.5E+03	9.1E+02	5.6E+00	1.3E+03	6.3E+02	4.5E+02	8.2E-01	1.3E+00	2.9E-01	1.6E+01
Total Alternative	2.5E+03	9.1E+02	7.8E+00	1.3E+03	6.4E+02	4.5E+02	8.3E-01	1.3E+00	3.9E-01	1.6E+01.
Calcination - Remediation	2.5E+03	9.1E+02	3.5E+00	1.3E+03	6.3E+02	4.5E+02	8.2E-01	1.3E+00	1.9E-01	1.6E+01
Total Alternative	2.5E+03	9.1E+02	5.7E+00	1.3E+03	6.4E+02	4.5E+02	8.3E-01	1.3E+00	2.9E-01	1.6E+01
Ex Situ Extensive Separations Remediation										
Total Alternative	3.6E+03	9.8E+02	2.3E+01	1.6E+03	9.0E+02	4.9E+02	1.2E+00	1.4E+00	1.4E+00	2.0E+01
	3.6E+03	9.8E+02	2.6E+01	1.6E+03	9.1E+02	4.9E+02	1.2E+00	1.4E+00	1.6E+00	2.0E+01
Ex Situ/In Situ Combination 1 Remediation	2.0E+03	1.2E+03	4.4E+00	1.4E+03	5.0E+02	5.8E+02	6.5E-01	1.7E+00	2.4E-01	1.8E+01
Total Alternative	2.0E+03	1.2E+03	7.0E+00	1.4E+03	5.1E+02	5.8E+02	6.6E-01	1.7E+00	3.7E-01	1.8E+01
Ex Situ/In Situ Combination 2 Remediation	1.7E+03	7.9E+02	2.9E+00	1.0E+03	4.3E+02	3.9E+02	5.6E-01	1.1E+00	1.6E-01	1.3E+01
Total Alternative	1.7E+03	7.9E+02	5.3E+00	1.0E+03	4.4E+02	3.9E+02	5.7E-01	1.1E+00	2.7E-01	1.3E+01

Table 5.12.1 Comparison of Potential Nonradiological/Nontoxicological Accident Consequences (cont'd)

Alternative	Total Recordable Cases				Lost Workday Cases		Fatalities			
	Occupational		Transportation		Occupational		Occupational		Transportation	
	Construction	Operation	Truck/ Rail	Commuter [1]	Construction	Operation	Construction	Operation	Truck/ Rail	Commuter [1]
Phased Implementation Remediation	4.1E+03	1.9E+03	7.4E+00	2.5E+03	1.0E+03	9.4E+02	1.4E+00	2.7E+00	4.0E-01	3.1E+01
Total Alternative	4.2E+03	1.9E+03	1.1E+01	2.5E+03	1.1E+03	9.4E+02	1.4E+00	2.7E+00	5.4E-01	3.1E+01
Capsules										
No Action	0.0E+00	2.2E+01	0.0E+00	1.9E+01	0.0E+00	1.1E+01	0.0E+00	3.2E-02	0.0E+00	2.4E-01
Onsite Disposal Remediation	2.1E+01	2.4E+01	3.2E-02	2.5E+01	5.2E+00	1.2E+01	6.7E-03	3.5E-02	2.0E-03	3.1E-01
Overpack and Ship Remediation	9.8E+00	3.1E+00	2.2E-02	4.6E+00	2.5E+00	1.6E+00	3.2E-03	4.5E-03	1.6E-03	5.8E-02
Vitrify with Tank Waste Remediation	9.8E+00	3.1E+00	2.1E-02	4.6E+00	2.5E+00	1.6E+00	3.2E-03	4.5E-03	1.4E-03	5.8E-02

Notes:
[1] Commuter accidents and potential fatalities are indirect impacts dependent on the number of project employees. All other impacts shown in the table are direct impacts of the alternatives.

Once the probability and the consequences (for radiation effects, measured in terms of the number of latent cancer fatalities caused by the radiation exposure) of an accident are known, the risk can be determined. The risk is the product of the probability of occurrence times the number of latent cancer fatalities or, in this scenario, a risk of 0.01 latent cancer fatalities. This risk expresses the expected number of latent cancer fatalities, taking account of both the chance that an accident might occur and the estimated consequences if it does occur.

Each phase of the various operations associated with the alternatives was assessed for potential accidents. The spectrum of accidents associated with each alternative is identified in Volume Four, Appendix E, from which dominant accident scenarios were selected for further analysis to determine the latent cancer fatality risk. Dominant accidents were selected through a screening process that involved multiplying the consequence of each accident by the probability of the accident.

5.12.2.1 Tank Waste Alternatives Accident Scenarios

Table 5.12.2 presents the accident scenarios postulated for each tank waste alternative. Table 5.12.3 presents the accident scenarios postulated for each capsule alternative.

5.12.2.2 Summary of Results

Table 5.12.4 compares the latent cancer fatality risk resulting from bounding accident scenarios of each alternative. Details of the risk calculation methodology are presented in Volume Four, Appendix E.

Table 5.12.2 Tank Waste Alternatives Accident Scenarios

Tank Waste Alternatives								
No Action	**Long-Term Management**	**In Situ Fill and Cap**	**In Situ Vitrification**	**Ex Situ Intermediate Separations**	**Ex Situ No Separations**	**Ex Situ Extensive Separations**	**Ex Situ/ In Situ Combinations 1 and 2**	**Phased Implementation**
Continued operations - Tank waste transfers - Postulated that a jumper was mispositioned and pinhole leaks develop at both ends of the jumper resulting in a pressurized spray release of tank waste. [1]								
X	X	X	X	X	X	X	X	X
Continued operations - Waste storage tanks - Postulated that a hydrogen deflagration occurs because of hydrogen gas generating in the tank, rising into the tank headspace, and reaching concentrations exceeding the lower flammability limit. Rapid combustion suspends waste as aerosols and release particulate.								
X	X	X	X	X	X	X	X	X
Retrieval - Postulated that a ventilation heater failure could occur due to an electrical fault resulting in humid air plugging the HEPA filter and filter blow out.								
				X	X	X	X	X
Pretreatment - Postulated that a line break could occur within a ventilated vault because of an earthquake, resulting in a pressurized spray release.								
				X		X	X	X
Treatment - Postulated that a double-ended break occurs in the off-gas line between the off-gas hood and the off-gas facility. The initiating event was postulated to be an earthquake.								
			X					
Treatment - Postulated that a canister of vitrified HLW was dropped because of mechanical failure or human error in the HLW vitrification facility.								
				X	X	X	X	X
Stabilization - Postulated that a deflagration occurs while filling the tank with gravel using a rock slinger. A spark from the gravel ignites a hydrogen gas plume, subsequently overpressurizing the tank. An airborne release results because of either a HEPA filter blowout or dome collapse.								
		X					X	
Beyond Design Basis Accident - Postulated that a tank dome collapses as a result of an earthquake.								
X	X	X	X	X	X	X	X	X

Notes:
[1] This accident would result in a pressurized spray release due to a mispositioned jumper. A jumper is a short connection pipe used in a jumper pit to route tank waste transfers from one line to another line in sending tank waste to a specific location.
HEPA = High-efficiency particulate air.
HLW = High-level waste
X = Accidents postulated to occur

Table 5.12.3 Capsule Alternatives Accident Scenarios

Capsule Alternatives			
No Action	**Onsite Disposal**	**Overpack and Ship**	**Vitrify with Tank Waste**
Pool Storage - Postulated that water was drained from the pool cell storage and capsules were crushed at the Waste Encapsulation Storage Facility resulting from structural failure because of an earthquake.			
X	X	X	X
Drywell Disposal - Postulated that a strontium capsule in drywell disposal was breached when a cell coverblock was inadvertently dropped on the capsule.			
	X		
Capsule Overpacking at the Waste Encapsulation Storage Facility - Postulated that a strontium capsule in temporary dry storage was breached when a heavy object was inadvertently dropped on the capsule.			
	X	X	X
Vitrification - Postulated that a cesium ion-exchange column overpressurizes and explodes.			
			X

Notes:
X = Accidents postulated to occur

The values presented in Table 5.12.4 for the population receptors showed the total number of cancer fatalities resulting from radiological exposure. For the maximally-exposed individual, the table value is the probability that the individual would die as a result of the exposure assuming that the accident occurred.

The calculations for the tank waste alternatives showed the greatest radiological impact during remediation would result from an accident associated with the In Situ Vitrification alternative, in which all 10 workers potentially could die from a lethal radiological dose. From the same accident, 36 noninvolved workers and 5 individuals from the general public potentially could die from latent cancers. The accident could occur during in situ vitrification, if a double-ended break occurred in the off-gas line between the off-gas hood and the off-gas facility, resulting in an unfiltered release directly to the environment. The initiating event was postulated to be an earthquake.

The other alternatives would have the same radiological impact resulting from a flammable gas deflagration in a waste storage tank. The overall risk (factoring in the probability of occurrence) would be lowest for In Situ Fill and Cap, which would require the least amount of time to stabilize the waste.

Table 5.12.4 Comparison of Radiological Consequences Resulting from Potential Operations and Transportation Accidents

Alternative	Activity	Prob-ability	Latent Cancer Fatalities					
			Operations					
			Worker		Noninvolved Worker		General Public	
			MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding
Tank Waste								
No Action	Continued operations (transfer)	1.1E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	7.2E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Post Remediation	8.0E-04	N/A	N/A	2.8E+00	4.2E+01	3.1E-03	3.7E+00
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	1.4E-02	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00
Long-Term Management	Continued operations (transfer)	2.2E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	7.2E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Post Remediation	8.0E-04	N/A	N/A	2.8E+00	4.2E+01	3.1E-03	3.7E+00
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	1.4E-02	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00
In Situ Fill and Cap	Continued operations (transfer)	1.3E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	8.6E-02	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Treatment	1.0E-04	9.8E-02	9.8E-01	2.3E-02	1.6E-01	3.6E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.4E-03	2.1E+00
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	1.7E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00

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Table 5.12.4 Comparison of Radiological Consequences Resulting from Potential Operations and Transportation Accidents (cont'd)

Alternative	Activity	Prob-ability	Latent Cancer Fatalities					
			Operations					
			Worker		Noninvolved Worker		General Public	
			MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding
In Situ Vitrification	Continued operations (transfer)	1.8E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.2E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Treatment	1.6E-02	7.9E-03	7.9E-02	2.6E-03	9.7E-02	1.4E-05	3.0E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	3.6E+01	2.6E-03	5.5E+00
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	2.2E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00
Ex Situ Intermediate Separation	Continued operations (transfer)	2.8E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.8E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.2E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Pretreatment	1.6E-02	7.4E-04	7.4E-03	1.1E-05	4.1E-04	6.0E-08	1.3E-04
			2.8E-03	2.8E-02	4.2E-05	1.6E-03	2.3E-07	4.8E-04
	Treatment	1.0E+00	1.8E-11	1.8E-10	2.7E-13	1.0E-11	5.0E-16	1.1E-12
			1.1E-08	1.1E-07	1.6E-10	6.1E-09	3.0E-13	6.7E-10
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	3.5E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00

Table 5.12.4 Comparison of Radiological Consequences Resulting from Potential Operations and Transportation Accidents (cont'd)

Alternative	Activity	Prob-ability	Latent Cancer Fatalities					
			Operations					
			Worker		Noninvolved Worker		General Public	
			MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding
Ex Situ No Separations - Vitrification	Continued operations (transfer)	2.5E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.7E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.0E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Treatment	1.0E+00	3.6E-11	3.6E-10	5.4E-13	2.0E-11	1.0E-15	2.2E-12
			2.2E-08	2.2E-07	3.3E-10	1.2E-08	6.0E-13	1.3E-09
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	3.2E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00
- Calcination	Continued operations (transfer)	2.5E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.7E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.0E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Treatment	1.0E+00	3.6E-11	3.6E-10	5.4E-13	2.0E-11	1.0E-15	2.2E-12
			2.2E-08	2.2E-07	3.3E-10	1.2E-08	6.0E-13	1.3E-09
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	3.2E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00

Table 5.12.4 Comparison of Radiological Consequences Resulting from Potential Operations and Transportation Accidents (cont'd)

Alternative	Activity	Prob-ability	Latent Cancer Fatalities					
			Operations					
			Worker		Noninvolved Worker		General Public	
			MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding
Ex Situ Extensive Separations	Continued operations (transfer)	2.9E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.9E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.3E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Pretreatment	1.7E-02	7.4E-04	7.4E-03	1.1E-05	4.1E-04	6.0E-08	1.3E-04
			2.8E-03	2.8E-02	4.2E-05	1.6E-03	2.3E-07	4.8E-04
	Treatment	1.0E+00	1.8E-11	1.8E-10	2.7E-13	1.0E-11	5.0E-16	1.1E-12
			1.1E-08	1.1E-07	1.6E-10	6.1E-09	3.0E-13	6.7E-10
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	3.6E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00
Ex Situ/In Situ Combination 1	Continued operations (transfer)	2.0E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.9E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	9.6E-03
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.3E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Pretreatment	1.7E-02	7.4E-04	7.4E-03	1.1E-05	4.1E-04	6.0E-08	1.3E-04
			2.8E-03	2.8E-02	4.2E-05	1.6E-03	2.3E-07	4.8E-04
	Treatment (Ex Situ)	1.0E+00	1.8E-11	1.8E-10	2.7E-13	1.0E-11	5.0E-16	1.1E-12
			1.1E-08	1.1E-07	1.6E-10	6.1E-09	3.0E-13	6.7E-10
	Treatment (Fill and Cap)	1.0E-04	9.8E-02	9.8E-01	2.3E-02	1.6E-01	3.6E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.4E-03	2.1E+00
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	3.6E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00

Table 5.12.4 Comparison of Radiological Consequences Resulting from Potential Operations and Transportation Accidents (cont'd)

Alternative	Activity	Prob-ability	Latent Cancer Fatalities					
			Operations					
			Worker		Noninvolved Worker		General Public	
			MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding
Ex Situ/In Situ Combination 2	Continued operations (transfer)	1.8E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.0E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	1.8E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.2E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Pretreatment	1.6E-02	7.4E-04	7.4E-03	1.1E-05	4.1E-04	6.0E-08	1.3E-04
			2.8E-03	2.8E-02	4.2E-05	1.6E-03	2.3E-07	4.8E-04
	Treatment (Ex Situ)	1.0E+00	1.8E-11	1.8E-10	2.7E-13	1.0E-11	5.0E-16	1.1E-12
			1.1E-08	1.1E-07	1.6E-10	6.1E-09	3.0E-13	6.7E-10
	Treatment (Fill and Cap)	1.0E-04	9.8E-02	9.8E-01	2.3E-02	1.6E-01	3.6E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.4E-03	2.1E+00
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	3.5E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00
Phased Implementation	Continued operations (transfer)	3.0E-01	4.7E-02	4.7E-01	7.7E-03	2.9E-01	4.2E-05	8.9E-02
			1.0E+00	1.0E+01	1.00E+00	6.6E+00	9.6E-04	2.0E+00
	Continued operations (storage)	2.2E-01	3.1E-02	3.1E-01	3.8E-03	5.3E-02	1.1E-05	1.0E-02
			1.0E+00	1.0E+01	1.0E+00	9.9E+00	2.1E-03	1.9E+00
	Retrieval	2.7E-04	3.9E-02	3.9E-01	1.3E-04	5.5E-03	6.9E-07	1.0E-03
			1.0E+00 [2]	1.0E+01 [2]	1.7E-02	3.7E-01	4.6E-05	6.9E-02
	Pretreatment	2.0E-02	7.4E-04	7.4E-03	1.1E-05	4.1E-04	6.0E-08	1.3E-04
			2.8E-03	2.8E-02	4.2E-05	1.6E-03	2.3E-07	4.8E-04
	Treatment	1.0E+00	1.8E-11	1.8E-10	2.7E-13	1.0E-11	5.0E-16	1.1E-12
			1.1E-08	1.1E-07	1.6E-10	6.1E-09	3.0E-13	6.7E-10
	Post Remediation	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
	BDBA	4.3E-03	9.7E-02	9.7E-01	2.3E-02	1.6E-01	3.5E-05	3.1E-02
			1.0E+00 [2]	1.0E+01 [2]	1.0E+00 [2]	1.1E+01	2.3E-03	2.1E+00

Table 5.12.4 Comparison of Radiological Consequences Resulting from Potential Operations and Transportation Accidents (cont'd)

Alternative	Activity	Prob-ability	Latent Cancer Fatalities					
			Operations					
			Worker		Noninvolved Worker		General Public	
			MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding	MEI Nominal Bounding	Population Nominal Bounding
Capsules								
No Action	Pool Storage	2.5E-03	1.0E+00 [3]	1.0E+01 [3]	1.3E-02	6.4E-01	3.1E-07	3.9E-06
Onsite Disposal	Pool storage	4.8E-03	1.0E+00 [3]	1.0E+01 [3]	1.3E-02	6.4E-01	3.0E-07	3.9E-06
	Overpacking or drywell disposal	1.9E-01	6.8E-05	6.8E-04	1.4E-08	4.8E-07	2.1E-11	1.1E-07
	BDBA	<1.0E-06	1.0E+00 [2]	1.0E+01 [2]	3.7E-02	4.8E-01	3.1E-05	1.0E-01
	Capsule transport	N/A [4]	3.6E-04	I/P	I/P	I/P	2.1E-06	I/P
Overpack and Ship	Pool storage	4.8E-03	1.0E+00 [3]	1.0E+01 [3]	1.3E-02	6.4E-01	3.0E-07	3.9E-06
	Overpacking	1.9E-01	6.8E-05	6.8E-04	1.4E-08	4.8E-07	2.1E-11	1.1E-07
	BDBA	<1.0E-06	1.0E+00 [2]	1.0E+01 [2]	3.7E-02	4.8E-01	3.1E-05	1.0E-01
	Capsule Transport	N/A [4]	5.2E-04	I/P	I/P	I/P	2.8E-06	I/P
Vitrify with Tank Waste	Pool storage	4.8E-03	1.0E+00 [3]	1.0E+01 [3]	1.3E-02	6.4E-01	3.0E-07	3.9E-06
	Overpacking	1.9E-01	6.8E-05	6.8E-04	1.4E-08	4.8E-07	2.1E-11	1.1E-07
	Vitrification	1.9E-01	ND	ND	3.5E-04	4.4E-03	2.9E-07	5.0E-04
	BDBA	<1.0E-06	1.0E+00 [2]	1.0E+01 [2]	3.7E-02	4.8E-01	3.1E-05	1.0E-01
	Transport vitrified capsules with tank HLW	N/A [4]	2.8E-03	I/P	I/P	I/P	1.5E-05	I/P

Notes:
[1] Integrated population includes worker, nonworker, and general public.
[2] Death results from a lethal dose, not from latent cancer.
[3] Death results from earthquake, not from latent cancer.
[4] Probabilities are factored into latent cancer fatalities for integrated population and urban population transportation accidents of vitrified HLW.
BDBA = Beyond design basis accident.
I/P = Integrated population. The number of latent cancer fatalities was not calculated for each specific receptor.
MEI = Maximally-exposed individual. The quantified risk shown in the column is the probability that the maximally-exposed individual will die from cancer because of the radiological exposure from the accident.
Population = The quantified risk shown in the column is the number of increased cancer deaths resulting from the radiological exposure of the accident.
N/A = Not applicable
ND = No dose to the worker because the accident takes place in a canyon, resulting in a stack release.

The post-remediation accidents with the greatest radiological and chemical risk would result from an accident associated with the No Action (Tank Waste) and Long-Term Management alternatives, in which 42 fatalities could be expected within the population living at that time (beyond the institutional control period) on the Hanford Site and 4 latent cancer fatalities could be expected within the population living off the Hanford Site. The accident could occur after the 100 years of institutional control, when the tanks have exceeded the design life and could collapse. The initiating event was postulated to be an earthquake. The tanks would be stabilized for all the other alternatives and there would be no airborne releases of waste from an earthquake.

A common accident to all capsule alternatives would be crushed capsules caused by an earthquake. It was postulated that the water could be drained from the pool cell storage and capsules crushed at WESF from structural failure because of an earthquake. The workers were assumed to have died as a direct result of the building collapsing on them. Latent cancer fatalities resulting from the exposure to the nonworkers and general public would be unlikely. No other accidents were identified that could result in radiological latent-cancer fatalities for the capsule alternatives.

Understanding Estimates of Latent Cancer Fatalities

Effects of accidents are reported in terms of the number of latent cancer fatalities per rem for a population. For example, a general population of 100,000 people exposed to 0.3 rem would result in an estimated 15 latent cancer fatalities. However, sometimes calculations of latent cancer fatalities do not yield whole numbers and may yield numbers less than 1.0. A number of less than 1.0 (e.g., 0.05) should be interpreted as the result of a statistical estimate. That is, 0.05 would be the average number of deaths that would be expected if the same exposure situation were applied to many different groups of 100,000 people. For most groups, no one (0 people) would incur a latent cancer fatality. In a small number of groups, 1 latent fatal cancer would result; and in even fewer groups, 2 or more latent cancers would occur. The average number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is 1/4, or 0.25). The most likely outcome is 0 latent cancer fatalities.

The same concept applies for an individual. The risk to a single individual of incurring a latent cancer fatality would be 100 percent if the risk were 1.0. A risk of less than 1.0 (0.011 for example) would mean that the individual would have a 1.1 percent chance (probability) of incurring a latent fatal cancer caused by the accident.

Beyond design basis accidents (accidents with an annual frequency of happening between 1.0E-06 and 1.0E-07 or below the site-specific designated return frequency for natural events) were also analyzed in Volume Four, Appendix E for radiological and chemical consequences. The bounding beyond design basis accident, common to all tank waste alternatives, was a seismic event resulting in tank dome collapse. Exposure from this accident potentially could result in all the workers receiving a lethal dose and 11 noninvolved workers and 2 individuals from the general public dying from potential latent cancers.

5.12.3 Comparison of Consequences from Potential Toxicological Accidents

The chemical exposures for the accidents listed in Table 5.12.2 were calculated for each alternative. The chemical exposures to the maximally-exposed individual in each of the worker, noninvolved worker, and general public receptor groups were compared to the following guidelines.

The American Industrial Hygiene Agency Emergency Response Planning Guidelines (ERPGs) were used as the primary criteria. For those chemicals lacking published American Industrial Hygiene Agency ERPGs, Hanford Site-specific ERPGs were used as published in the Toxicological Evaluation of Tank Waste Chemicals, Hanford Environmental Health Foundation Industrial Hygiene Assessments (Dentler 1995). These tank farm-specific ERPGs were developed by the Hanford Environmental Health Foundation for the purpose of evaluating health hazards associated with chemicals in the tank farms for accidental releases.

Cumulative hazard indices were calculated for each maximally-exposed individual receptor and for each ERPG screening level (i.e., ERPG-1, ERPG-2, and ERPG-3). A cumulative (concentrations of chemicals with similar hazard effects were added) hazard index greater than 1.0 indicated that the acute hazard guidelines for a group of chemicals would be exceeded and the chemical group could pose a potential acute health impact. Chemicals were subdivided based on acute health impacts into toxic chemicals or corrosive/irritant chemicals.

Emergency Response Planning Guidelines

Emergency Response Planning Guidelines (ERPG): Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing the listed effects.	**ERPG 1:** Mild transient adverse health effects or perceiving a clearly defined objectionable odor.
	ERPG 2: Irreversible or other serious health effects, or symptoms that could impair ability to take protective action.
	ERPG 3: Irreversible or life-threatening health effects could result from exposures exceeding one hour.

Table 5.12.5 summarizes the comparison of chemical exposures to their respective ERPGs for operational activities. The same methodology was applied to transportation accidents involving the transport of chemicals to the Hanford Site as summarized in Table 5.12.5 . An integrated worker/public population was used as the receptor for the transportation accident scenarios that included both onsite and offsite receptors.

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Tank Waste Alternatives					
No Action					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 1.1E-01	Worker population	$1.3E+02_{C/I}$	$6.8E+00_{C/I}$	$2.7E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 7.2E-01	Worker population	$8.2E+00_{Tox}$ $1.9E+02_{C/I}$	$1.6E+00_{Tox}$ $9.6E+00_{C/I}$	$3.8E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$1.7E+02_{Tox}$ 3.8E+03C/I	$3.2E+01_{Tox}$ $2.0E+02_{C/I}$	$9.4E+00_{Tox}$ $7.9E+01_{C/I}$
			$1.2E+04_{Tox}$ $9.3E+03_{C/I}$	$2.3E+03_{Tox}$ $4.8E+02_{C/I}$	$4.5E+02_{Tox}$ $1.9E+02_{C/I}$
		Noninvolved worker population at 290 m	$1.4E+01_{C/I}$	<1.0	<1.0
			$4.5E+01_{Tox}$ $3.4E+01_{C/I}$	$8.4E+00_{Tox}$ $1.7E+00_{C/I}$	$1.7E+0_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 1.4E-02	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780 m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Post Remediation Accident	Seismic event resulting in dome collapse of 177 storage tanks. Probability of accident is 8.0E-04	Onsite population at 100 m	6.6E+03$_{Tox}$ 3.0E+06$_{C/I}$	1.7E+03$_{Tox}$ 1.6E+05$_{C/I}$	3.1E+02$_{Tox}$ 6.2E+04$_{C/I}$
		Onsite population at 290 m	2.4E+01$_{Tox}$ 1.1E+04$_{C/I}$	6.3E+00$_{Tox}$ 5.7E+02$_{C/I}$	1.1E+00$_{Tox}$ 2.3E+02$_{C/I}$
		Onsite population at 1,780 m	1.5E+02$_{C/I}$	7.6E+00$_{C/I}$	3.0E+00$_{C/I}$
		Offsite population at 16,100 m	1.1E+01$_{C/I}$	<1.0	<1.0
Long-Term Management Alternative					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 2.2E-01	Worker population	1.3E+02$_{C/I}$	6.8E+00$_{C/I}$	2.7E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	3.0E+00$_{C/I}$	<1.0	<1.0
			1.0E+01$_{Tox}$ 4.4E+00$_{C/I}$	5.4E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 7.2E-01	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 1.4E-02	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780 m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0
Post-Remediation Accident	Seismic event resulting in dome collapse of 177 storage tanks. Probability of accident is 8.0E-04	Onsite population at 100 m	$6.6E+03_{Tox}$ $3.0E+06_{C/I}$	$1.7E+03_{Tox}$ $1.6E+05_{C/I}$	$3.1E+02_{Tox}$ $6.2E+04_{C/I}$
		Onsite population at 290 m	$2.4E+01_{Tox}$ $1.1E+04_{C/I}$	$6.3E+00_{Tox}$ $5.7E+02_{C/I}$	$1.1E+00_{Tox}$ $2.3E+02_{C/I}$
		Onsite population at 1,780 m	$1.5E+02_{C/I}$	$7.6E+00_{C/I}$	$3.0E+00_{C/I}$
		Offsite population at 16,100 m	$1.1E+01_{C/I}$	<1.0	<1.0
In Situ Fill and Cap					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 1.3E-01	Worker population	$1.3E+02_{C/I}$	$6.8E+00_{C/I}$	$2.7E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

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Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 8.6E-02	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - fill and cap	Flammable gas deflagration in tank resulting in dome collapse. Probability of accident is 1.0E-04	Worker population	2.6E+00$_{Tox}$ 1.2E+03$_{C/I}$	6.2E+01$_{C/I}$	2.5E+01$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	5.5E+01$_{Tox}$ 2.5E+04$_{C/I}$	1.4E+01$_{Tox}$ 1.3E+03$_{C/I}$	2.6E+00$_{Tox}$ 5.1E+02$_{C/I}$
			8.5E+04$_{Tox}$ 3.6E+04$_{C/I}$	4.4E+04$_{Tox}$ 1.8E+03$_{C/I}$	2.2E+03$_{Tox}$ 7.3E+02$_{C/I}$
		Noninvolved worker population at 290 m	9.0E+01$_{C/I}$	4.7E+00$_{C/I}$	1.9E+00$_{C/I}$
			3.1E+02$_{Tox}$ 1.3E+02$_{C/I}$	1.6E+02$_{Tox}$ 6.7R+00$_{C/I}$	7.8E+00$_{Tox}$ 2.7E+00$_{C/I}$
		Noninvolved worker population at 1,780 m	1.2E+00$_{C/I}$	<1.0	<1.0
			4.1E+00$_{Tox}$ 1.7E+00$_{C/I}$	2.2E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			3.4E+00$_{Tox}$ 1.4E+00$_{C/I}$	1.8E+00$_{Tox}$	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 1.7E-03	Worker population	2.6E+00$_{Tox}$ 1.2E+03$_{C/I}$	6.2E+01$_{C/I}$	2.5E+01$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	5.5E+01$_{Tox}$ 2.5E+04$_{C/I}$	1.4E+01$_{Tox}$ 1.3E+03$_{C/I}$	2.6E+00$_{Tox}$ 5.1E+02$_{C/I}$
			8.5E+04$_{Tox}$ 3.6E+04$_{C/I}$	4.4E+04$_{Tox}$ 1.8E+03$_{C/I}$	2.2E+03$_{Tox}$ 7.3E+02$_{C/I}$
		Noninvolved worker population at 290 m	9.0E+01$_{C/I}$	4.7E+00$_{C/I}$	1.9E+00$_{C/I}$
			3.1E+02$_{Tox}$ 1.3E+02$_{C/I}$	1.6E+02$_{Tox}$ 6.7R+00$_{C/I}$	7.8E+00$_{Tox}$ 2.7E+00$_{C/I}$
		Noninvolved worker population at 1,780 m	1.2E+00$_{C/I}$	<1.0	<1.0
			4.1E+00$_{Tox}$ 1.7E+00$_{C/I}$	2.2E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			3.4E+00$_{Tox}$ 1.4E+00$_{C/I}$	1.8E+00$_{Tox}$	<1.0
In Situ Vitrification					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 1.8E-01	Worker population	1.3E+02$_{C/I}$	6.8E+00$_{C/I}$	2.7E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	3.0E+00$_{C/I}$	<1.0	<1.0
			1.0E+01$_{Tox}$ 4.4E+00$_{C/I}$	5.4E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 1.2E-01	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Treatment - In situ vitrification	Off gas duct rupture. Probability of accident is 1.6E-02	Worker population	$2.1E+01_{C/I}$	$1.1E+00_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	<1.0	<1.0	<1.0
			$1.5E+00_{Tox}$ $1.2E+00_{C/I}$	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 2.2E-03	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780 m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0
Ex Situ Intermediate Separations					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 2.8E-01	Worker population	$1.3E+02_{C/I}$	$6.8E+00_{C/I}$	$2.7E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 1.8E-01	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Retrieval	Loss of ventilation due to HEPA filter blow out. Probability of accident is 2.2E-04	Worker population	4.0E+01$_{C/I}$	2.1E+00$_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	1.8E+00$_{Tox}$ 8.3E+02$_{C/I}$	4.4E+01$_{C/I}$	1.7E+01$_{C/I}$
			2.9E+03$_{Tox}$ 1.2E+03$_{C/I}$	1.5E+03$_{Tox}$ 6.2E+01$_{C/I}$	7.3E+01$_{Tox}$ 2.5E+01$_{C/I}$
		Noninvolved worker population at 290 m	3.0E+00$_{C/I}$	<1.0	<1.0
			1.0E+01$_{Tox}$ 4.4E+00$_{C/I}$	5.4E+00$_{Tox}$	<1.0
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Pretreatment	Line break in ventilated vault. Probability of accident is 1.6E-02	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - Ex situ vitrification	Canister of vitrified HLW inadvertently dropped. Probability of accident is 1.0E+00	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 3.5E-03	Worker population	2.6E+00$_{Tox}$ 1.2E+03$_{C/I}$	6.2E+01$_{C/I}$	2.5E+01$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	5.5E+01$_{Tox}$ 2.5E+04$_{C/I}$	1.4E+01$_{Tox}$ 1.3E+03$_{C/I}$	2.6E+00$_{Tox}$ 5.1E+02$_{C/I}$
			8.5E+04$_{Tox}$ 3.6E+04$_{C/I}$	4.4E+04$_{Tox}$ 1.8E+03$_{C/I}$	2.2E+03$_{Tox}$ 7.3E+02$_{C/I}$
		Noninvolved worker population at 290 m	9.0E+01$_{C/I}$	4.7E+00$_{C/I}$	1.9E+00$_{C/I}$
			3.1E+02$_{Tox}$ 1.3E+02$_{C/I}$	1.6E+02$_{Tox}$ 6.7R+00$_{C/I}$	7.8E+00$_{Tox}$ 2.7E+00$_{C/I}$
		Noninvolved worker population at 1,780 m	1.2E+00$_{C/I}$	<1.0	<1.0
			4.1E+00$_{Tox}$ 1.7E+00$_{C/I}$	2.2E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			3.4E+00$_{Tox}$ 1.4E+00$_{C/I}$	1.8E+00$_{Tox}$	<1.0
Chemical Transport Accident	Transportation of process chemicals to the Site (2.0E-07)	Integrated population	5.0E+02$_{C/I}$	6.2E+01$_{C/I}$	1.2E+01$_{C/I}$
Ex Situ No Separations					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 2.5E-01	Worker population	1.3E+02$_{C/I}$	6.8E+00$_{C/I}$	2.7E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	3.0E+00$_{C/I}$	<1.0	<1.0
			1.0E+01$_{Tox}$ 4.4E+00$_{C/I}$	5.4E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 1.7E-01	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Retrieval	Loss of ventilation due to HEPA filter blow out. Probability of accident is 2.0E-04	Worker population	$4.0E+01_{C/I}$	$2.1E+00_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	$1.8E+00_{Tox}$ $8.3E+02_{C/I}$	$4.4E+01_{C/I}$	$1.7E+01_{C/I}$
			$2.9E+03_{Tox}$ $1.2E+03_{C/I}$	$1.5E+03_{Tox}$ $6.2E+01_{C/I}$	$7.3E+01_{Tox}$ $2.5E+01_{C/I}$
		Noninvolved worker population at 290 m	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - Ex situ vitrification	Canister of vitrified HLW inadvertently dropped. Probability of accident is 1.0E+00	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 3.2E-03	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780 m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0
Chemical Transport Accident	Transportation of process chemicals to the Site (2.0E-07)	Integrated population	$5.0E+02_{C/I}$	$6.2E+01_{C/I}$	$1.2E+01_{C/I}$

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Ex Situ Extensive Separations					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 2.8E-01	Worker population	$1.3E+02_{C/I}$	$6.8E+00_{C/I}$	$2.7E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 1.9E-01	Worker population	$8.2E+00_{Tox}$ $1.9E+02_{C/I}$	$1.6E+00_{Tox}$ $9.6E+00_{C/I}$	$3.8E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$1.7E+02_{Tox}$ $3.8E+03_{C/I}$	$3.2E+01_{Tox}$ $2.0E+02_{C/I}$	$9.4E+00_{Tox}$ $7.9E+01_{C/I}$
			$1.2E+04_{Tox}$ $9.3E+03_{C/I}$	$2.3E+03_{Tox}$ $4.8E+02_{C/I}$	$4.5E+02_{Tox}$ $1.9E+02_{C/I}$
		Noninvolved worker population at 290 m	$1.4E+01_{C/I}$	<1.0	<1.0
			$4.5E+01_{Tox}$ $3.4E+01_{C/I}$	$8.4E+00_{Tox}$ $1.7E+00_{C/I}$	$1.7E+0_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Retrieval	Loss of ventilation due to HEPA filter blow out. Probability of accident is 2.3E-04	Worker population	$4.0E+01_{C/I}$	$2.1E+00_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	$1.8E+00_{Tox}$ $8.3E+02_{C/I}$	$4.4E+01_{C/I}$	$1.7E+01_{C/I}$
			$2.9E+03_{Tox}$ $1.2E+03_{C/I}$	$1.5E+03_{Tox}$ $6.2E+01_{C/I}$	$7.3E+01_{Tox}$ $2.5E+01_{C/I}$
		Noninvolved worker population at 290 m	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Pretreatment	Line break in ventilated vault. Probability of accident is 1.7E-02	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - Ex situ vitrification	Canister of vitrified HLW inadvertently dropped. Probability of accident is 1.0E+00	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 3.6E-03	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0
Chemical Transport Accident	Transportation of process chemicals to the Site (2.0E-07)	Integrated population	$5.0E+02_{C/I}$	$6.2E+01_{C/I}$	$1.2E+01_{C/I}$
Ex Situ/In Situ Combination 1					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 2.0E-01	Worker population	$1.3E+02_{C/I}$	$6.8E+00_{C/I}$	$2.7E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 1.9E-01	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Retrieval	Loss of ventilation due to HEPA filter blow out. Probability of accident is 2.3E-04	Worker population	4.0E+01$_{C/I}$	2.1E+00$_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	1.8E+00$_{Tox}$ 8.3E+02$_{C/I}$	4.4E+01$_{C/I}$	1.7E+01$_{C/I}$
			2.9E+03$_{Tox}$ 1.2E+03$_{C/I}$	1.5E+03$_{Tox}$ 6.2E+01$_{C/I}$	7.3E+01$_{Tox}$ 2.5E+01$_{C/I}$
		Noninvolved worker population at 290 m	3.0E+00$_{C/I}$	<1.0	<1.0
			1.0E+01$_{Tox}$ 4.4E+00$_{C/I}$	5.4E+00$_{Tox}$	<1.0
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Pretreatment	Line break in ventilated vault. Probability of accident is 1.7E-02	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - Ex situ vitrification	Canister of vitrified HLW inadvertently dropped. Probability of accident is 1.0E+00	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Treatment - fill and cap	Flammable gas deflagration results in tank dome collapse. Probability of the accident is 1.0E-04	Worker population	2.6E+00$_{Tox}$ 1.2E+03$_{C/I}$	6.2E+01$_{C/I}$	2.5E+01$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	5.5E+01$_{Tox}$ 2.5E+04$_{C/I}$	1.4E+01$_{Tox}$ 1.3E+03$_{C/I}$	2.6E+00$_{Tox}$ 5.1E+02$_{C/I}$
			8.5E+04$_{Tox}$ 3.6E+04$_{C/I}$	4.4E+04$_{Tox}$ 1.8E+03$_{C/I}$	2.2E+03$_{Tox}$ 7.3E+02$_{C/I}$
		Noninvolved worker population at 290 m	9.0E+01$_{C/I}$	4.7E+00$_{C/I}$	1.9E+00$_{C/I}$
			3.1E+02$_{Tox}$ 1.3E+02$_{C/I}$	1.6E+02$_{Tox}$ 6.7R+00$_{C/I}$	7.8E+00$_{Tox}$ 2.7E+00$_{C/I}$
		Noninvolved worker population at 1,780 m	1.2E+00$_{C/I}$	<1.0	<1.0
			4.1E+00$_{Tox}$ 1.7E+00$_{C/I}$	2.2E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			3.4E+00$_{Tox}$ 1.4E+00$_{C/I}$	1.8E+00$_{Tox}$	<1.0
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 3.6E-03	Worker population	2.6E+00$_{Tox}$ 1.2E+03$_{C/I}$	6.2E+01$_{C/I}$	2.5E+01$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	5.5E+01$_{Tox}$ 2.5E+04$_{C/I}$	1.4E+01$_{Tox}$ 1.3E+03$_{C/I}$	2.6E+00$_{Tox}$ 5.1E+02$_{C/I}$
			8.5E+04$_{Tox}$ 3.6E+04$_{C/I}$	4.4E+04$_{Tox}$ 1.8E+03$_{C/I}$	2.2E+03$_{Tox}$ 7.3E+02$_{C/I}$
		Noninvolved worker population at 290 m	9.0E+01$_{C/I}$	4.7E+00$_{C/I}$	1.9E+00$_{C/I}$
			3.1E+02$_{Tox}$ 1.3E+02$_{C/I}$	1.6E+02$_{Tox}$ 6.7R+00$_{C/I}$	7.8E+00$_{Tox}$ 2.7E+00$_{C/I}$
		Noninvolved worker population at 1,780 m	1.2E+00$_{C/I}$	<1.0	<1.0
			4.1E+00$_{Tox}$ 1.7E+00$_{C/I}$	2.2E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			3.4E+00$_{Tox}$ 1.4E+00$_{C/I}$	1.8E+00$_{Tox}$	<1.0
Chemical Transport Accident	Transportation of process chemicals to the Site (2.0E-07)	Integrated population	5.0E+02$_{C/I}$	6.2E+01$_{C/I}$	1.2E+01$_{C/I}$

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Ex Situ/In Situ Combination 2					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 1.8E-01	Worker population	$1.3E+02_{C/I}$	$6.8E+00_{C/I}$	$2.7E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 1.8E-01	Worker population	$8.2E+00_{Tox}$ $1.9E+02_{C/I}$	$1.6E+00_{Tox}$ $9.6E+00_{C/I}$	$3.8E+00_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$1.7E+02_{Tox}$ $3.8E+03_{C/I}$	$3.2E+01_{Tox}$ $2.0E+02_{C/I}$	$9.4E+00_{Tox}$ $7.9E+01_{C/I}$
			$1.2E+04_{Tox}$ $9.3E+03_{C/I}$	$2.3E+03_{Tox}$ $4.8E+02_{C/I}$	$4.5E+02_{Tox}$ $1.9E+02_{C/I}$
		Noninvolved worker population at 290 m	$1.4E+01_{C/I}$	<1.0	<1.0
			$4.5E+01_{Tox}$ $3.4E+01_{C/I}$	$8.4E+00_{Tox}$ $1.7E+00_{C/I}$	$1.7E+0_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Retrieval	Loss of ventilation due to HEPA filter blow out. Probability of accident is 2.2E-04	Worker population	$4.0E+01_{C/I}$	$2.1E+00_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	$1.8E+00_{Tox}$ $8.3E+02_{C/I}$	$4.4E+01_{C/I}$	$1.7E+01_{C/I}$
			$2.9E+03_{Tox}$ $1.2E+03_{C/I}$	$1.5E+03_{Tox}$ $6.2E+01_{C/I}$	$7.3E+01_{Tox}$ $2.5E+01_{C/I}$
		Noninvolved worker population at 290 m	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Pretreatment	Line break in ventilated vault. Probability of accident is 1.6E-02	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - Ex situ vitrification	Canister of vitrified HLW inadvertently dropped. Probability of accident is 1.0E+00	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - fill and cap	Flammable gas deflagration results in tank dome collapse. Probability of the accident is 1.0E-04	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780 m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 3.5E-03	Worker population	2.6E+00$_{Tox}$ 1.2E+03$_{C/I}$	6.2E+01$_{C/I}$	2.5E+01$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	5.5E+01$_{Tox}$ 2.5E+04$_{C/I}$	1.4E+01$_{Tox}$ 1.3E+03$_{C/I}$	2.6E+00$_{Tox}$ 5.1E+02$_{C/I}$
			8.5E+04$_{Tox}$ 3.6E+04$_{C/I}$	4.4E+04$_{Tox}$ 1.8E+03$_{C/I}$	2.2E+03$_{Tox}$ 7.3E+02$_{C/I}$
		Noninvolved worker population at 290 m	9.0E+01$_{C/I}$	4.7E+00$_{C/I}$	1.9E+00$_{C/I}$
			3.1E+02$_{Tox}$ 1.3E+02$_{C/I}$	1.6E+02$_{Tox}$ 6.7R+00$_{C/I}$	7.8E+00$_{Tox}$ 2.7E+00$_{C/I}$
		Noninvolved worker population at 1,780 m	1.2E+00$_{C/I}$	<1.0	<1.0
			4.1E+00$_{Tox}$ 1.7E+00$_{C/I}$	2.2E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			3.4E+00$_{Tox}$ 1.4E+00$_{C/I}$	1.8E+00$_{Tox}$	<1.0
Chemical Transport Accident	Transportation of process chemicals to the Site (2.0E-07)	Integrated population	5.0E+02$_{C/I}$	6.2E+01$_{C/I}$	1.2E+01$_{C/I}$
Phased Implementation					
Continued Operations - waste transfer	Mispositioned jumper resulting in spray release. Probability of accident is 3.0E-01	Worker population	1.3E+02$_{C/I}$	6.8E+00$_{C/I}$	2.7E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	3.0E+00$_{C/I}$	<1.0	<1.0
			1.0E+01$_{Tox}$ 4.4E+00$_{C/I}$	5.4E+00$_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Continued Operations - waste tank storage	Hydrogen deflagration in storage tank. Probability of accident is 2.2E-01	Worker population	8.2E+00$_{Tox}$ 1.9E+02$_{C/I}$	1.6E+00$_{Tox}$ 9.6E+00$_{C/I}$	3.8E+00$_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	1.7E+02$_{Tox}$ 3.8E+03$_{C/I}$	3.2E+01$_{Tox}$ 2.0E+02$_{C/I}$	9.4E+00$_{Tox}$ 7.9E+01$_{C/I}$
			1.2E+04$_{Tox}$ 9.3E+03$_{C/I}$	2.3E+03$_{Tox}$ 4.8E+02$_{C/I}$	4.5E+02$_{Tox}$ 1.9E+02$_{C/I}$
		Noninvolved worker population at 290 m	1.4E+01$_{C/I}$	<1.0	<1.0
			4.5E+01$_{Tox}$ 3.4E+01$_{C/I}$	8.4E+00$_{Tox}$ 1.7E+00$_{C/I}$	1.7E+0$_{Tox}$
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1) Nominal Bounding	Acute Hazard (ERPG-2) Nominal Bounding	Acute Hazard (ERPG-3) Nominal Bounding
Retrieval	Loss of ventilation due to HEPA filter blow out. Probability of accident is 2.7E-04	Worker population	$4.0E+01_{C/I}$	$2.1E+00_{C/I}$	<1.0
			LD	LD	LD
		MEI noninvolved worker	$1.8E+00_{Tox}$ $8.3E+02_{C/I}$	$4.4E+01_{C/I}$	$1.7E+01_{C/I}$
			$2.9E+03_{Tox}$ $1.2E+03_{C/I}$	$1.5E+03_{Tox}$ $6.2E+01_{C/I}$	$7.3E+01_{Tox}$ $2.5E+01_{C/I}$
		Noninvolved worker population at 290 m	$3.0E+00_{C/I}$	<1.0	<1.0
			$1.0E+01_{Tox}$ $4.4E+00_{C/I}$	$5.4E+00_{Tox}$	<1.0
		Noninvolved worker population at 1,780 m	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Pretreatment	Line break in ventilated vault. Probability of accident is 2.0E-02	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Treatment - Ex situ vitrification	Canister of vitrified HLW inadvertently dropped. Probability of accident is 1.0E+00	Worker population	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI noninvolved worker	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
			<1.0	<1.0	<1.0
Beyond Design Basis Accident	Seismic event resulting in dome collapse of a storage tank. Probability of accident is 4.3E-03	Worker population	$2.6E+00_{Tox}$ $1.2E+03_{C/I}$	$6.2E+01_{C/I}$	$2.5E+01_{C/I}$
			LD	LD	LD
		MEI noninvolved worker	$5.5E+01_{Tox}$ $2.5E+04_{C/I}$	$1.4E+01_{Tox}$ $1.3E+03_{C/I}$	$2.6E+00_{Tox}$ $5.1E+02_{C/I}$
			$8.5E+04_{Tox}$ $3.6E+04_{C/I}$	$4.4E+04_{Tox}$ $1.8E+03_{C/I}$	$2.2E+03_{Tox}$ $7.3E+02_{C/I}$
		Noninvolved worker population at 290 m	$9.0E+01_{C/I}$	$4.7E+00_{C/I}$	$1.9E+00_{C/I}$
			$3.1E+02_{Tox}$ $1.3E+02_{C/I}$	$1.6E+02_{Tox}$ $6.7R+00_{C/I}$	$7.8E+00_{Tox}$ $2.7E+00_{C/I}$
		Noninvolved worker population at 1,780 m	$1.2E+00_{C/I}$	<1.0	<1.0
			$4.1E+00_{Tox}$ $1.7E+00_{C/I}$	$2.2E+00_{Tox}$	<1.0
		MEI general public	<1.0	<1.0	<1.0
			$3.4E+00_{Tox}$ $1.4E+00_{C/I}$	$1.8E+00_{Tox}$	<1.0

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Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident and (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1)	Acute Hazard (ERPG-2)	Acute Hazard (ERPG-3)
Chemical Transport Accident	Transportation of process chemicals to the Site (2.0E-07)	Integrated population	5.0E+02$_{CA}$	6.2E+01$_{CA}$	1.2E+01$_{CA}$
Capsule Alternative					
No Action	Pool storage "Canisters are breached and water drained from cell due to earthquake" (2.5E-03)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
Onsite Disposal	Pool storage "Canisters are breached and water drained from cell due to earthquake" (4.8E-03)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Overpacking "Crushed canister" (1.9E-01)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Beyond design basis accident "Crushed canister unmitigated release" (<1.0E-06)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
Overpack and Ship	Pool Storage "Canisters are breached and water drained from cell due to earthquake" (4.8E-03)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Overpacking "Crushed canister" (1.9E-01)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Beyond design basis accident "Crushed canister unmitigated release" (<1.0E-06)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0

Table 5.12.5 Comparison of Chemical Exposures Resulting From Potential Operations and Transportation Accidents (cont'd)

Alternative	Accident and (Probability)	Receptor	Chemical Exposure		
			Acute Hazard (ERPG-1)	Acute Hazard (ERPG-2)	Acute Hazard (ERPG-3)
Vitrify with Tank Waste	Pool storage "Canisters are breached and water drained from cell due to earthquake" (4.8E-03)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Overpacking "Crushed canister" (1.9E-01)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Vitrification "Cesium ion-exchange column explosion" (1.9E-01)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0
	Beyond design basis accident "Crushed canister unmitigated release" (<1.0E-06)	Worker population	<1.0	<1.0	<1.0
		Noninvolved MEI worker	<1.0	<1.0	<1.0
		MEI general public	<1.0	<1.0	<1.0

Notes:
C/I = Corrosive or irritant effects
ERPG-1 = The maximum airborne concentration below what it is believed nearly all individuals could be exposed to for up to 1 hour without experiencing other than mild transient adverse effects or perceiving a clearly defined objectionable odor.
ERPG-2 = The maximum airborne concentration below what it is believed nearly all individuals could be exposed to for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their ability to take protective action.
ERPG-3 = The maximum airborne concentration below what it is believed nearly all individuals could be exposed to for up to 1 hour without experiencing or developing life-threatening health effects.
LD = Lethal dose of radiation
MEI = Maximally-exposed individual
Tox = Toxicological health effects

The general public and nominal worker population exposure to toxic or corrosive/irritant chemicals resulting from potential accidents during operations would not exceed the cumulative ratio of exposure to ERPG-3 concentration value for any of the tank waste alternatives. The only such exposure potentially could occur as a result of a transportation accident when chemicals are being transported to the Hanford Site in support of the Ex Situ Intermediate Separations, Ex Situ No Separations, Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1 and 2, and Phased Implementation alternatives.

A flammable gas deflagration in a waste storage tank would have the highest chemical impacts for all the alternatives. In the event of this accident, emergency planning and evacuation plans are in place at the Hanford Site to mitigate potential consequences. Consequently, these noninvolved workers would not likely be exposed to air concentrations that would result in significant health effects. Failure to evacuate could result in noninvolved worker exposure downwind from the plume source that could exceed the cumulative ratio of exposure to ERPG-3 concentration value. The potential exists for

workers to exceed ERPG-3; however, the workers would have received a potentially lethal radiological dose from the accident. There would be no irreversible health effects to the general public.

The cesium and strontium capsule alternatives would not exceed the cumulative ratio of exposure to any ERPG concentration values for the general public, noninvolved worker, or worker.

5.12.4 Vitrified HLW Transport to the Potential Geologic Repository

Under the ex situ tank waste treatment alternatives the HLW streams would be vitrified or calcined and eventually shipped to a geologic repository assumed to be located 2,140 km (1,330 mi) offsite by a dedicated train of 10 railcars per train. The nonradiological and radiological transportation impacts associated with this activity are evaluated in this section.

The expected injuries and fatalities resulting from transportation accidents associated with each ex situ stabilization alternative are summarized in Table 5.12.6. Fatalities resulting from trauma caused by transportation accidents would be directly proportional to the number of miles driven. The Ex Situ No Separations alternative would have the highest number of shipments and therefore the most fatalities. The Ex Situ Extensive Separations alternative would have the least fatalities.

Table 5.12.6 Injuries and Fatalities from Rail Transportation Accidents

Alternative	Impact	Urban	Suburban	Rural	Total
Ex Situ Intermediate Separations	Fatality	2.2E-04	1.10E-03	2.07E+00	2.07E+00
	Injury	4.28E-04	2.14E-03	4.02E+00	4.03E+00
Ex Situ No Separations:					
Vitrification	Fatality	2.12E-03	1.06E-02	1.99E+01	1.99E+01
	Injury	4.11E-03	2.06E-02	3.86E+01	3.87E+01
Calcination	Fatality	7.49E-04	3.75E-03	7.04E+00	7.05E+00
	Injury	1.45E-03	7.27E-03	1.37E+01	1.37E+01
Ex Situ Extensive Separations	Fatality	1.09E-05	5.46E-05	1.03E-01	1.03E-01
	Injury	2.12E-05	1.06E-04	1.99E-01	1.99E-01
Ex Situ/In Situ Combination 1	Fatality	1.56E-04	7.79E-04	1.46E+00	1.46E+00
	Injury	3.02E-04	1.51E-03	2.84E+00	2.84E+00
Ex Situ/In Situ Combination 2	Fatality	9.02E-05	4.51E-04	8.48E-01	8.49E-01
	Injury	1.75E-04	8.76E-04	1.65E+00	1.65E+00
Phased Alternative	Fatality	2.22E-04	1.11E-03	2.09E+00	2.09E+00
	Injury	4.31E-04	2.15E-03	4.05E+00	4.05E+00

Radiological exposures resulting from routine exposures and accidents while the waste is in transit were analyzed using RADTRAN 4 (Neuhauser-Kanipe 1992). For routine risk, the key variable in the code was the dose rate from the vehicle package. The radioactive shipments in this analysis were assumed to be less than the regulatory maximum dose rate of 10 mrem per hour at 1 m (Jacobs 1996). For accidents, the population doses calculated by RADTRAN 4 were dependent on the accident probability, release quantities, atmospheric dispersion parameters, population distribution parameters, human uptake, and dosimetry models (Jacobs 1996).

The routine exposures were addressed as onsite population latent cancer fatality risk and offsite population latent cancer fatality risk. The analysis addressed radiological accident impacts as both integrated population latent cancer risk (i.e., accident frequencies time consequences integrated over the entire shipping campaign) and urban population latent cancer fatality risk. The routine and accident latent cancer fatality risks resulting from transporting vitrified or calcined HLW to a potential geologic repository are presented in Table 5.12.7 for each of the ex situ treatment alternatives. The radiological impacts from both routine exposure and accidents would be directly proportional to the number of trips made to the repository. The Ex Situ No Separations alternative would have the highest number of trips made to the repository. The Ex Situ No Separations alternative would have the highest number of shipments and therefore the highest latent cancer fatality risk. The Ex Situ Extensive Separations alternative would have the lowest latent cancer fatality risk.

Table 5.12.7 Latent Cancer Fatality Risk from Routine and Accident Radiological Exposures While Shipping Vitrified or Calcined High-Level Waste By Rail to a Proposed Geologic Repository

Alternative	Routine Exposure				Accident Exposure			
	Onsite Population		Offsite Population		Integrated Population		Urban Population	
	Dose	LCF Risk	Dose	LCF Risk	Dose	LCF Risk	Dose	LCF Risk
Ex Situ Intermediate Separations	7.65E-01	3.06E-04	6.41E+00	3.21E-03	6.26E-02	3.13E-05	1.69E-03	8.45E-07
Ex Situ No Separations								
Vitrification	7.30E+00	2.92E-03	6.11E+01	3.06E-02	8.33E-02	4.17E-05	2.31E-02	1.16E-05
Calcination	2.58E+00	1.03E-03	2.17E+01	1.09E-02	2.17E-01	1.09E-04	2.29E-03	1.14E-06
Ex Situ Extensive Separations	3.76E-02	1.50E-05	3.15E-01	1.58E-04	1.15E-02	5.75E-06	7.04E-04	3.52E-07
Ex Situ/In Situ Combination 1	5.37E-01	2.15E-04	4.50E+00	2.25E-03	5.26E-02	2.63E-05	1.46E-03	7.28E-07
Ex Situ/In Situ Combination 2	3.11E-01	1.24E-04	2.61E+00	1.31E-03	4.34E-02	2.17E-05	1.33E-03	6.63E-07
Phased Implementation	7.65E-01	3.06E-04	6.41E+00	3.21E-03	6.28E-02	3.14E-05	1.69E-03	8.45E-07

Notes:
LCF = Latent cancer fatality

A main uncertainty associated with calculating the radiological doses resulting from transporting HLW to a potential geologic repository would be the location of the repository. The analysis was based on the assumption that the waste would be transported to Yucca Mountain should that site be shown to be acceptable and approved as a potential geologic repository. If Yucca Mountain should not be approved the latent cancer fatality risks could increase or decrease depending on the distance and population pathways of the alternative site.

5.13 CUMULATIVE IMPACTS

This section describes potential cumulative impacts associated with implementing the TWRS alternatives and other actions at the Hanford Site. The TWRS impacts described in this section include the impacts of both remediation of the tank waste and subsequent closure of the tank farms. The section identifies other actions that could impact the Hanford Site and, when possible, provides a qualitative or quantitative discussion of the potential cumulative impacts of the TWRS alternatives and the other actions.

Cumulative Impacts

Cumulative impacts addressed in this section include:

- Actions at other DOE sites or programmatic actions (Section 5.13.1), actions adjacent to the Hanford Site (Section 5.13.2), and other Hanford Site actions (Section 5.13.3);
- Impacts on land use and biological resources (Section 5.13.4);
- Health effects related to radiological exposure (Section 5.13.4);
- Impacts to air quality (Section 5.13.4);
- Impacts to groundwater quality (Section 5.13.4); and
- Impacts to Hanford Site and Tri-Cities employment and housing prices (Section 5.13.4).

The impacts of the tank waste and capsule alternatives described in previous sections would occur in the context of other past, present, and reasonably foreseeable activities at the Hanford Site. The National Environmental Policy Act (NEPA) implementation regulations define a cumulative impact as the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes other such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7).

As discussed in Section 5.0.4, post-remediation risk of TWRS EIS alternatives would be strongly influenced by the type and form of waste remaining in the tanks or on the Hanford Site following remediation, the amount of time and labor that would be needed to accomplish the alternative, and the environmental disturbance that would take place during the work, including permanent disturbance or long-term resource commitment. These factors were comprehensively analyzed and discussed throughout Section 5.0 for each resource for each of the TWRS alternatives. For purposes of discussing the potential cumulative impacts in this section, the TWRS alternative having the highest potential cumulative impacts was drawn from the comprehensive discussion and presented in combination with the other past, present, and reasonably foreseeable sources of impact. Thus the upper bound of the reasonably foreseeable potential cumulative impacts is presented.

Actions at the Hanford Site that would have quantifiable environmental impacts that would be cumulative with TWRS actions include the Hanford Site waste management and remedial action programs, the Environmental Restoration and Disposal Facility, the management of spent nuclear fuel stored in the K Basins, the US Ecology Site, and the replacement cross-site transfer system. While these activities would occur in the same general time frame as the EIS alternatives, little quantifiable cumulative impacts of the TWRS alternatives and other projects would be expected. Among the

cumulative impacts that would occur would be impacts to land use and biological resources, human health, air quality, groundwater quality, and socioeconomics.

5.13.1 Actions at Other DOE Sites or Facilities and Programmatic Actions that Could Potentially Impact the Hanford Site

Programs or actions at other DOE sites and DOE programmatic evaluations that could impact the Hanford Site are described in this section.

Waste Management Programmatic EIS

DOE will determine what type, size, and number of waste storage, treatment, and disposal facilities will be needed for DOE waste and where to build them. This would include determining the transportation network; i.e., deciding what sites would ship to other sites for treatment, storage, and disposal.

Under the Waste Management Programmatic EIS, the Hanford Site is an alternative site for centralized or regionalized management of DOE waste (DOE 1995e). The Hanford Site would manage its own waste (decentralized alternative), receive waste from offsite (regional or centralized alternatives), or ship waste to another DOE or commercial waste management facility (regional or centralized alternatives).

In the EIS, DOE considered a broad spectrum of hazardous and radioactive waste management issues at the Hanford Site. The highest level of adverse impacts at the Hanford Site and the surrounding region would result from alternatives in which treatment and disposal facilities would be constructed for the Hanford Site to manage its own waste, in addition to accepting waste from offsite DOE facilities for treatment, disposal, or storage. Offsite waste received would include LAW and low-level mixed waste for treatment and disposal, transuranic waste for treatment, and HLW canisters for storage. The lowest level of adverse impacts of the waste management alternatives would be those in which the Hanford Site would package and ship its waste for offsite disposal, or would receive only small quantities of waste for treatment and disposal from other sites.

The Hanford Site-specific impacts under the DOE Waste Management Program alternatives would be primarily confined to the Central Plateau, the same area where proposed TWRS activities analyzed in the TWRS EIS would occur. Potential cumulative impacts of conducting waste management activities on the Central Plateau would involve increased land use, habitat, health effects, air quality, water quality, transportation, and socioeconomic impacts.

Disposal of Decommissioned, Defueled Cruiser, Los Angeles Class, and Ohio Class Naval Reactor Plants

The final EIS, prepared by the U.S. Navy, evaluates the potential impacts of disposing of defueled reactor plants from decommissioned naval vessels (Navy 1996). The preferred alternative is land burial at the low-level waste burial grounds at the Hanford Site. DOE is a cooperating agency in the preparation of this EIS.

5.13.2 Actions Adjacent to the Hanford Site

In addition to DOE waste management activities, there are other nuclear facilities at or near the Hanford Site that could contribute to radioactive releases. These facilities include a commercial radioactive waste burial site, a commercial nuclear power plant, a nuclear fuel production plant, a commercial low-level radioactive waste compacting facility, and a commercial decontamination facility. The ongoing operations of these facilities would have cumulative impacts with the proposed TWRS activities in areas such as socioeconomics, air and water emissions, transportation, and land use.

DOE actions near the Columbia River could be affected by the U.S. Department of Interior's proposal to designate the Hanford Reach of the Columbia River as a Recreational River under the Wild and Scenic Rivers Act. DOE was a cooperating agency with the U.S. Department of Interior in preparing the Hanford Reach of the Columbia River Final River Conservation Strategy EIS (NPS 1994). The U.S. Department of Interior published its Record of Decision and made its recommendation to Congress. Designation of the Hanford Reach as a Recreational River awaits congressional action.

5.13.3 Currently Planned or Reasonably Foreseeable DOE Actions at the Hanford Site

This section describes the currently planned and reasonably foreseeable actions originating at the Hanford Site with potential cumulative impacts. Actions are identified in the context of the existing, ongoing, or planned activities. The activities are grouped into actions on the Central Plateau and actions in other Hanford Site areas. A number of proposed actions at the Hanford Site are being evaluated in environmental assessments, as detailed in the Draft 1995 Hanford Mission Plan (DOE 1994g). At present, it is not possible to include a quantitative analysis of all the impacts from these projects in this analysis because evaluation of many of these projects is not complete. However, these projects may contribute to cumulative future impacts from proposed remedial actions in the geographic areas considered in this EIS.

5.13.3.1 Central Plateau

The major impacts from the proposed TWRS alternatives would occur on the Central Plateau in the 200 Areas from 1997 to 2028, although tank farm closure actions would occur later.

Closure

Closure of the SSTs and DSTs is beyond the scope of this EIS. However, closure options could be interrelated with the TWRS alternative that is selected for implementation and the long-term impacts of the alternatives would be influenced by closure actions. Due to a lack of information, decisions on the appropriate type of tank farm closure cannot be made at this time. However, the long-term impacts of closure are reasonably foreseeable, and therefore are discussed in this section. Closure options range from clean closure, in which the tanks and all associated waste would be removed from the tank farm areas and disposed of onsite or offsite, to leaving the tanks and most of the tank waste in-place as described in the In Situ Vitrification and the In Situ Fill and Cap alternatives. Tank farm closure methods would be determined when the overall long-term land-use policies were established at the Hanford Site. The impacts of closing existing TWRS sites are also related to other major waste disposal facility closure issues on the Central Plateau. For purposes of calculating the reasonably

foreseeable long-term impacts of the TWRS alternatives it has been assumed that closure would consist of emplacement of engineered barriers over waste left or placed in the near surface soils. Ultimate closure decisions would affect long-term land use of the Hanford Site. Long-term land use and ongoing Hanford Site operational issues will be addressed in the Hanford Remedial Action EIS and the Site's Comprehensive Land Use Plan, both of which are being prepared, and the planned Hanford Sitewide EIS.

Environmental Restoration Disposal Facility

The Environmental Restoration Disposal Facility, which has been constructed adjacent to the 200 Areas, provides for the safe storage and disposal of waste generated during environmental restoration activities at the Hanford Site (DOE 1994h). The Environmental Restoration Disposal Facility, a large double-lined subsurface trench, serves as the disposal facility for most of the waste excavated during remediation of waste management units at the Hanford Site. Waste generated from remediating Comprehensive Environmental Response, Compensation, and Liability Act past practice units and RCRA closure and corrective action activities will be placed in the Environmental Restoration Disposal Facility. Only waste that originates within the Hanford Site will be placed in the facility. The waste is expected to consist of hazardous, radioactive, and mixed waste. The Environmental Restoration Disposal Facility site will cover as much as 4.1 km^2 (1.6 mi^2) on the Central Plateau, approximately in the center of the Hanford Site, southeast of the 200 West Area and southwest of the 200 East Area.

Under current climate conditions, none of the contaminants that would be placed in the Environmental Restoration Disposal Facility are expected to reach groundwater within 10,000 years. The shrub-steppe habitat at the Environmental Restoration Disposal Facility site is considered priority habitat by Washington State. The disturbed area includes the Environmental Restoration Disposal Facility site itself (including the trench, stockpiling areas, roads, and supporting facilities), a borrow area, and a rail line right-of-way. Environmental Restoration Disposal Facility impacts that might be cumulative with TWRS alternatives include land use, habitat, air quality, transportation, and socioeconomic impacts.

Safe Interim Storage of Hanford Tank Waste

As described in Section 3.2.1.6, DOE decided to implement most of the actions of the preferred alternative, which were evaluated in the Safe Interim Storage of Hanford Tank Waste EIS (DOE 1995i). The actions will involve the continued operation of the existing cross-site transfer system between 200 West and 200 East Area tank farms until replaced by construction and operation of a new replacement cross-site transfer system and the continued operation of the mixer pump installed in tank 241-SY-101 to mitigate the unacceptable accumulation of hydrogen and other flammable gases. In the interim period prior to making and implementing decisions based on the TWRS EIS, the replacement cross-site transfer system would be used to transfer liquid waste from interim stabilization of SSTs and waste generated by 200 West Area facilities. Construction of the replacement cross-site transfer system began in late 1995 and is to be completed in 1998. Safe interim storage impacts identified in the Safe Interim Storage of Hanford Tank Waste EIS that might be cumulative with TWRS alternatives include land use and habitat.

Hanford Site Plutonium Finishing Plant Stabilization

DOE evaluated alternatives to convert plutonium-bearing materials at the Plutonium Finishing Plant Facility into a more stable, safer form and to reduce potential environmental and worker safety risks.

The Plutonium Finishing Plant Stabilization Final EIS was published in May 1996 (DOE 1996d) and a Record of Decision was issued in July 1996 (DOE 1996c). DOE decided to initiate removal of plutonium-bearing material in hold-up at the Plutonium Finishing Plant Facility and to initiate the stabilization of this and other plutonium-bearing material at the facility. Impacts that may be cumulative with TWRS alternatives include health effects and socioeconomics.

Waste Receiving and Processing Facility

During 1994, construction was started on the first major solid waste processing facility associated with Hanford Site cleanup. Scheduled to begin operations in March 1997, the Waste Receiving and Processing Facility Module 1 will be used to analyze and prepare for disposal, drums, and boxes of waste resulting from plutonium operations at the Hanford Site. Some of the materials processed will qualify as LAW suitable for disposal directly at the Hanford Site. The remaining waste will be certified as transuranic waste and packaged for eventual shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico. Materials requiring further processing to meet disposal criteria will be retained at the Hanford Site pending treatment.

The 4,800-m^2 (52,000-ft^2) facility will begin operations in 1997 near the Central Waste Complex in the 200 West Area. The facility is designed to process 6,800 drums of waste annually for 30 years. No potentially cumulative impacts have been identified at this time for this action.

Effluent Treatment Facility and Liquid Effluent Retention Facility

These facilities will provide for collection, retention, and treatment if necessary, of liquid waste before it is discharged to the soil column through a Washington State-approved land disposal site north of the 200 West Area. An evaluation of the Effluent Treatment Facility indicated that no significant impacts would result (DOE 1992c). Therefore, no potentially cumulative impacts have been identified at this time for this action.

US Ecology Low-Level Radioactive Waste Disposal Facility

The US Ecology Low-Level Radioactive Waste Disposal Facility occupies 40 ha (100 ac) of land leased by DOE to Washington State. US Ecology subleases the land from the State. The facility is located just southwest of the 200 East Area and receives low-level waste from commercial organizations. US Ecology began operating in 1965 and since that time has received a total of approximately 3.4E+05 m^3 (1.3E+07 ft^3) of commercial low-level waste through December 1994. This waste consists of solid or solidified material, contaminated equipment, cleaning waste, tools, protective clothing, gloves, laboratory waste, and naturally occurring or accelerator- produced radioactive material containing about 2.2 million curies. All waste and waste containers have been emplaced in trenches excavated into the surficial sediments. When completely filled, each trench is covered with at least 2.4 m (8 ft) of soil and capped with a layer of gravel (Ledoux 1995). US Ecology is assumed to

continue to receive and emplace commercial low-level waste through the year 2063 (Jacobs 1996). Impacts that might be cumulative with TWRS alternatives include land use, groundwater, and transportation.

5.13.3.2 Other Hanford Site Areas

Hanford Remedial Action Program

The Hanford Remedial Action Program encompasses remediating contaminated soil and groundwater, decommissioning and decontaminating structures, and closing treatment, storage, and disposal facilities. Much of the waste to be generated by environmental restoration activities at the Hanford Site would be placed in the Environmental Restoration Disposal Facility. The Hanford Remedial Action EIS (DOE 1996c) examines these needs primarily in the context of DOE's responsibilities under RCRA, the Comprehensive Environmental Response, Compensation, and Liability Act, and the Tri-Party Agreement (Ecology et al. 1994).

The Hanford Remedial Action EIS compares alternatives for land use including no action, unrestricted use, restricted use, and exclusive-use scenarios for various areas of the Hanford Site. The EIS analysis divides the Hanford Site into four geographic areas and evaluates the land-use alternatives for each of those areas. The Hanford Remedial Action Draft EIS has been published for public review.

Waste generated by the Hanford Remedial Action Program would be disposed of in the Environmental Restoration Disposal Facility on the Central Plateau. Impacts that might be cumulative with TWRS alternatives include land use, habitat, groundwater, traffic, and socioeconomics.

Decommissioning Eight Surplus Production Reactors

Present and foreseeable actions in the 100 Areas consist primarily of decommissioning the eight surplus production reactors along the Columbia River. DOE has decided on safe storage for 75 years or less, followed by one-piece removal of each reactor block and transport intact on a tractor-transporter from its present location in the 100 Areas to the 200 West Area for disposal. Contaminated materials associated with the fuel storage basins would also be disposed of in the 200 West Area, along with contaminated equipment and components associated with the reactors. Uncontaminated portions of the fuel storage basins would be removed to provide access for the tractor-transporter. Other uncontaminated structures and equipment would be demolished and placed in landfills in the vicinity of the reactor sites (DOE 1992b and DOE 1993j). Impacts that might be cumulative with TWRS alternatives include land use and habitat.

Management of Spent Nuclear Fuel Currently Stored in the K Basins

DOE evaluated alternatives to reduce risks associated with spent nuclear fuel and sludge currently stored in the water-filled K East and K West Storage Basins (K Basins). A Final EIS was issued in January 1996 and a Record of Decision was issued in March 1996. DOE decided to implement the preferred alternative, which consists of removing the spent nuclear fuel from the storage basins, drying, conditioning, and sealing the fuel in canisters, and storing the canisters in a new dry storage facility for up to 50 years pending decisions on ultimate disposition. The storage facility will be located

in the 200 East Area on the Central Plateau. Impacts that might be cumulative with TWRS alternatives include land use, habitat, transportation, and socioeconomics.

5.13.4 Summary of Cumulative Impacts

Although many of the activities described previously would occur in the same general time frame as the TWRS EIS alternatives, little quantifiable cumulative impacts of the TWRS alternatives and other projects would be expected because of differences in the nature of the activities and their physical separation.

From certain broader environmental perspectives, cumulative impacts of the TWRS alternatives and other projects can be expected. For example, multiple projects each impacting a small amount of sensitive shrub-steppe habitat eventually could have a more substantial impact by fragmenting the habitat and reducing the total amount of shrub-steppe remaining on the Hanford Site. Cumulative impacts from groundwater would consist of a combination of 1) the existing groundwater contamination; 2) potential additional contamination from waste currently in the soils above the groundwater; and 3) potential additions from waste left in place or placed in the ground by future activities including TWRS alternatives.

Another area in which cumulative impacts could occur is on the socioeconomic environment. For example, if decisions are made that lead to constructing and operating facilities at the Hanford Site that currently are not foreseen, there would be additional employment and other economic benefits for the Tri-Cities area. However, there also could be additional population growth and the resulting burdens on public services and facilities such as schools, and impacts on the price and availability of housing. Table 5.13.1 presents a matrix of Hanford Site activities that overlap the proposed TWRS alternatives in time and location and could have cumulative impacts.

The proposed TWRS activities would be carried out against the baseline of overall Hanford Site operations. The TWRS alternatives and ongoing operations would have cumulative socioeconomic, land use, risk, and ecological impacts. The range of operational alternatives would be quantified in the planned Hanford Sitewide EIS. At this time, the magnitude of the additive impacts cannot be quantified. Assuming that the Hanford Site's environmental restoration and waste management mission does not change, it is likely that the future range of operational impacts would not be greater than the current impacts associated with Hanford Site waste and operations.

Land Use and Biological Resources

The Hanford Site covers 145,000 ha (358,000 ac). Approximately 6 percent of the site has been disturbed and actively used (Cushing 1995). An assessment of future land uses at the Hanford Site was conducted as part of the scoping for the Hanford Remedial Action EIS and was published as the Final Report of the Hanford Future Site Uses Working Group (HFSUWG 1992). The Central Plateau of the Hanford Site, which encompasses the 200 East and 200 West Areas, is suggested for waste storage and disposal in support of Site cleanup. The area identified in the Central Plateau for cleanup consists of a buffer zone and an exclusive waste management use area.

Table 5.13.1 Cumulative Impacts of Other Projects and TWRS Alternatives

	Impact Category				
Project	**Land Use and Habitat**	**Health Risks**	**Air Quality**	**Groundwater Quality**	**Socioeconomics**
Hanford Remedial Action	yes	yes	yes	yes	yes
Environmental Restoration and Disposal Facility	yes	yes	yes	no	yes
K Basin	yes	no	no	no	yes
Safe Interim Storage of Tank Waste	yes	no	no	no	no
Waste Management Program	yes	yes	yes	yes	yes

Notes:
no = Impact not cumulative with TWRS alternatives.
yes = Potential cumulative impact with TWRS alternatives.

According to the report of the Hanford Future Site Uses Working Group, all future waste from cleanup activities would be placed in the exclusive waste management use area. The buffer zone is to reduce risks that could result from waste management in the exclusive use area. The report of the Hanford Future Site Uses Working Group does not constitute official DOE policy or guidance; however, DOE initiated the study as a part of the scoping for the Hanford Remediation Action EIS to help establish cleanup levels.

A comprehensive land-use plan is being coordinated with the Hanford Remedial Action EIS to further define the preferred alternative and is expected to be finalized in 1996. Therefore, pending availability of the plan, the Final Report of the Hanford Future Site Uses Working Group will be used as the baseline for purposes of analysis in the TWRS EIS.

The proposed Central Plateau exclusive waste management use area would consist of approximately 11,700 ha (28,800 ac), including about 6,700 ha (16,600 ac) for the buffer zone and about 4,900 ha (12,200 ac) for the exclusive waste management use area. About 2,300 ha (5,800 ac) of the proposed 4,900 ha (12,200 ac) exclusive waste management use area is relatively undisturbed land, which represents the maximum area of potential impact for the TWRS alternatives and the other proposed actions described in this section.

Virtually all proposed TWRS activities under the alternatives in this EIS would occur within the Central Plateau's exclusive waste management area or at two potential borrow sites to the west of the Central Plateau. All TWRS sites would impact some shrub-steppe habitat areas, some of which are currently disturbed. There are approximately 8,500 ha (21,000 ac) of shrub-steppe habitat on the Central Plateau. This area constitutes approximately 15 percent of the total remaining Hanford Site shrub-steppe habitat. Activities under all alternatives would occur largely in areas that are currently partially disturbed, except at the two potential borrow sites, where activities would occur in currently

undisturbed areas. A third potential borrow site is located on partly disturbed land between the 200 East and West Areas.

Other major projects that would be substantial contributors to cumulative land use and habitat impacts on the Central Plateau include the Hanford Remediation Program, the Environmental Restoration Disposal Facility, and the replacement cross-site transfer system. Estimates for the Hanford Remedial Action Program indicate that about 2,150 ha (5,300 ac), including about 480 ha (1,200 ac) of shrub-steppe habitat, could be disturbed by the highest impact alternatives (Jacobs 1996). Much of the waste to be generated by the Hanford Remedial Action Program would be disposed of in the Environmental Restoration Disposal Facility. Remedial action waste would result from soil and groundwater cleanup, decommissioning and decontamination of structures, and closing treatment, storage, and disposal facilities. The Environmental Restoration Disposal Facility site would cover 495 ha (1,240 ac) on the Central Plateau. In addition, approximately 55 ha (135 ac) of habitat impacts would occur as a result of borrow site activities and 40 ha (100 ac) for a rail line right of way (DOE 1994h). The replacement cross-site transfer system (addressed in the Safe Interim Storage Record of Decision [60 FR 61687]) would remove 9 ha (22 ac) of shrub-steppe habitat, with a total land commitment of 30 ha (74 ac). Approximately 6 ha (15 ac) on the Central Plateau would be disturbed to accommodate disposal of waste from decommissioning the surplus reactors. The preferred alternative for the K Basins spent nuclear fuel could disturb an additional 3.5 ha (9 ac), all of which could be shrub-steppe habitat (DOE 1995j). Regionalized or centralized alternatives under the Waste Management Programmatic EIS would use an additional 72 ha (179 ac) of Hanford Site land.

The TWRS alternative with the greatest land-use impact would be the Phased Implementation alternative, which would impact about 6 percent (269 ha [664 ac]) of the exclusive waste management use area. While TWRS impacts to land use and biological resources may not by themselves be substantial, fragmentation of the Central Plateau's habitats by TWRS alternatives, other waste management actions, and remedial actions could have a cumulative impact greater than the sum of the individual impacts. Cumulative land-use impacts for the TWRS EIS Phased Implementation alternative and other major activities on the Central Plateau are shown in Table 5.13.2.

Radiation Dose and Health Effects

The cumulative population dose due to past Hanford Site operations from startup in 1944 through 1994 has been estimated to be 100,000 person-rem (estimated to one significant figure). Using the conversion factor of 2,000 person-rem per latent cancer fatality, the number of inferred cumulative latent cancer fatalities since startup would total about 50. In the same 50 years since startup, the population of interest (assuming a constant population of 380,000 and an average individual dose from naturally-occurring radiation of 0.3 rem per year) would have received about 5,000,000 person-rem from naturally-occurring radiation sources (natural radiation), which would result in about 2,500 latent cancer fatalities. In the same 50 years, about 27,000 cancer fatalities from all causes would have been expected in that population (DOE 1995j).

Table 5.13.2 Cumulative Land-Use and Habitat Impacts

Source of Impact	Total Land Use ha (ac)	Habitat [1] ha (ac)
Hanford Remedial Action Program [2]	1,138 (2,812)	462 (1,153)
Environmental Restoration Disposal Facility [2]	590 (1,475)	314 (773)
Decommissioning Eight Surplus Reactors	6 (15)	6 [3] (15)
Management of Spent Nuclear Fuel from K Basins	3.5 (9)	3.5 (9)
Safe Interim Storage of Hanford Tank Waste	30 (74)	9 (22)
Tank Waste Remediation System alternatives [2]	320 (790)	220 (540)
Programmatic Waste Management	72 (180)	7 (18)
Subtotal of Potential Future Impacts	2,154 (5,340)	1,016 (2,515)
Baseline - Previously Disturbed	8,700 (21,500)	No Data
Cumulative Total (previously and potentially disturbed)	10,854 (26,840)	1,016 (2,575)

Notes:
[1] Shrub-steppe unless otherwise noted.
[2] Highest impact alternative.
[3] Not specified as shrub-steppe in data source.

The TWRS preferred tank waste alternative is the Phased Implementation alternative, which would take about 27 years to complete. The cumulative offsite population dose from this TWRS alternative would be about 388 person-rem, which infers that about 0.2 latent cancer fatalities would result. Other planned activities that could take place in that same 27-year time period include managing spent nuclear fuel stored at the K Basins, stabilization activities at the Plutonium Finishing Plant, and programmatic waste management actions. The spent nuclear fuel management preferred alternative was identified as the Drying/Passivation with Dry Storage alternative, which would take about two years to complete (DOE 1995j). Cumulative population dose from implementing the preferred alternative would be about 2 person-rem, which infers that no latent cancer fatalities would result. Cumulative population dose from the Plutonium Finishing Plant stabilization and removal activities would be approximately 14 person-rem (DOE 1996b). No latent cancer fatalities would be expected to result from that dose. The maximum cumulative population dose in the Hanford Site region from programmatic waste management alternatives would be approximately 220 person-rem (DOE 1995m). No latent cancer fatalities would be expected to result from that dose. Continued operations of the Washington Public Power Supply System's Plant-2 for the next 27 years (0.7 person-rem per year) (DOE 1995j) would result in an additional cumulative population dose of about 19 person-rem, which infers that no latent cancer fatalities would result. Assuming that other Hanford Site activities would continue for the next 27 years at a level about equal to the present (0.6 person-rem per year) results in an additional cumulative population dose of about 16 person-rem, which infers that no additional latent cancer fatalities would result. Thus, the long-term cumulative total population dose from the reasonably foreseeable activities on the Hanford Site would be about 659 person-rem. Less than one latent cancer fatality would be expected to result from that dose.

For perspective, over the next 27 years the population (380,000 people) would have received about 2,700,000 person-rem from natural background radiation. That dose would result in about 1,350 latent

cancer fatalities. In the same 27 years, about 14,000 cancer fatalities from all causes would be expected among the population in the region of analysis (within 80 km [50 mi]). The long-term cumulative population doses and health effects are presented in Table 5.13.3.

Table 5.13.3 Cumulative Radiation Population Dose and Health Effects [1]

Source of Impact	Dose (person-rem)	Latent Cancer Fatality [2]
Hanford Past Operations [3]	100,000	50
Ongoing Hanford Operations (1997 - 2024) [4]	16	0 [5]
Washington Public Power Supply System Plant-2 (1997 - 2024)	19	0 [5]
Programmatic Waste Management at Hanford	220	0.1
Plutonium Finishing Plant Stabilization	14	0 [5]
K Basin Fuel [3]	2	0 [5]
TWRS Phased Implementation Alternative	388	0.2
Cumulative Hanford Site Total	100,659	50
Cumulative Total Natural Background (past and future) [6, 7]	7,700,000	3,850

Notes:
[1] Assume constant population of about 380,000.
[2] Each 2,000 person-rem assumed to result in one latent cancer fatality.
[3] Data from DOE 1995j.
[4] Assumed to continue at the 1994 population dose rate.
[5] Values of less than 0.1 were rounded to 0.
[6] Cumulative doses and assumed latent cancer fatalities from natural background are provided for perspective only.
[7] Natural background included only from 1944 through 2024, the end of the TWRS operational period.

The maximally-exposed individuals would receive a cumulative annual average dose of about 0.7 mrem/yr, less than 1 percent of the 100 mrem/yr offsite dose limit (DOE 1996b).

Air Quality

Air emissions from constructing and operating facilities under the TWRS alternatives would overlap with those from ongoing Site operations and other activities on the Central Plateau including Environmental Restoration Disposal Facility operations and some Hanford Remedial Action program activities. These activities would result in cumulative air emissions.

The principal air quality impacts associated with the Environmental Restoration Disposal Facility would be from excavating disposal trenches, vehicle emissions, and fugitive dust from placing two truck loads of waste and clean fill in the trenches. The Environmental Restoration Disposal Facility would use appropriate dust suppression techniques to comply with air quality standards. Air quality impacts from Hanford Remedial Action program activities would be from excavating waste sites and transporting waste to the disposal facility.

Operating powerhouses on the Hanford Site are the primary source of criteria pollutants (particulates, nitrogen oxides, sulfur oxides, and carbon monoxide) in the Hanford Site baseline. The baseline criteria pollutant concentrations are available from estimates derived by modeling the Hanford Site

operational emissions (PNL 1995). Table 5.13.4 presents the modeled baseline results along with the TWRS, Environmental Restoration Disposal Facility, and the Hanford Remedial Action program criteria pollutant impacts. The TWRS impacts are not for a single alternative but rather are the maximum values selected from among all the TWRS alternatives.

Table 5.13.4 Cumulative Air Quality Impacts

Sources	Maximum Average Concentration ($\mu g/m^3$)			
	Particulate (PM-10)	Nitrogen Oxides (NO_x)	Sulfur Oxides (SO_x)	Carbon Monoxide (CO)
Hanford Site Baseline	3	3	19	3
Hanford Remedial Action	43	40	5	26
Environmental Restoration Disposal Facility	33	Negligible	Negligible	Negligible
Tank Waste Remediation System alternative	98	2.2	27	2,500
Total	177	45	51	2,529
Standard [1]	150 (24 hour)	100 (Annual)	365 (24 hour)	10,000 (8 hour)

Notes:
[1] Washington State standards

Groundwater Quality

Cumulative groundwater impacts need to be examined in the context of existing sources of contamination in the soil, vadose zone, and groundwater. The following contaminants were consistently detectable in soil on the Hanford Site: cobalt-60, strontium-90, cesium-137, plutonium-239, plutonium-240, and uranium. Soil concentrations for these radionuclides were higher near and within the Hanford Site boundaries compared to offsite concentrations (PNL 1993a). Contaminants in the vadose zone in the 200 Areas are primarily associated with past waste disposal practices using engineered structures such as cribs, drains, septic tanks and associated drain fields, and reverse wells (wells that do not penetrate to groundwater); percolation from ponds, ditches, and trenches such as B Pond and U Pond; solid waste burial in backfilled trenches; and unplanned releases such as leaks from SSTs. Contaminants include both radioactive materials (transuranic isotopes, uranium, and fission products) and nonradioactive materials (metals, volatile organics, semivolatile organics, and inorganics). In addition, the US Ecology Low-Level Radioactive Waste Disposal Facility located southwest of the 200 East Area is estimated to contain about 2.2 million curies of radioactive waste in backfilled trenches (Ledoux 1995). Reasonably foreseeable additions to contaminants in the vadose zone include future waste disposal at the 200 Area and US Ecology solid waste burial grounds and the placement of remediation waste in the Environmental Restoration Disposal Facility.

Groundwater beneath the 200 Areas and in plumes leading from the 200 Areas toward the Columbia River is contaminated with hazardous chemicals and radionuclides from past liquid disposal practices at levels that would exceed Federal drinking water standards if the groundwater was a source of drinking water as defined in the standards. Hazardous chemical contaminants present at levels that exceed drinking water standards include nitrates, cyanide, fluoride, chromium, carbon tetrachloride,

trichloroethylene, and tetrachloroethylene. Radiological contaminants include iodine-129, tritium, cesium, plutonium, and strontium. Iodine-129 is present in the groundwater beneath the 200 Areas at levels that exceed standards up to 20 times. Other groundwater plumes from the 200 Areas tend to have lower levels than the iodine-129 levels; however, many of these contaminants would exceed drinking water standards if they were applicable.

Post-remediation health risks to the public from TWRS alternatives would result from contaminants in the groundwater. The first arrival of any contaminant at the interface between the vadose zone and groundwater would occur at times varying between 140 and 250 years following remediation for impacts associated with the No Action and Long-Term Management tank waste alternatives. The tank inventory would be released faster for these alternatives than for any of the other alternatives because it was assumed that there would be no engineered barriers to reduce infiltration or any attempt to remove or stabilize the tank waste. The first arrival time for contaminants from the other alternatives would occur about 2,000 years in the future and the peak concentrations would occur about 5,000 years in the future.

Cumulative radionuclide concentrations that could occur in the groundwater from a potential combination of contamination from past disposal practices, currently anticipated future waste disposal, and the contamination from the TWRS alternatives are discussed in Volume Four, Section F.4.5. Peak groundwater concentrations from the various potential sources could occur at different times and different locations. However, to maximize the potential cumulative impacts, the peak concentrations of the past and reasonably foreseeable future sources were assumed to combine with the peak concentrations from the TWRS alternatives. This resulted in a conservative bounding of the maximum potential cumulative groundwater impact for each TWRS alternative. A more detailed modeling of the potential cumulative impacts will be done in a future Hanford Site EIS. The results of the future analysis would probably indicate lower cumulative groundwater impacts than presented in this bounding analysis.

The highest cumulative groundwater concentrations occur for the No Action and Long-Term Management tank waste alternatives and the tank waste would be the dominant contributor to the predicted cumulative concentrations. The other alternatives would result in much lower cumulative radionuclides concentrations in the groundwater, and the dominant contributors would be contamination from past disposal practices and tank leaks. The radiation dose and risk to the potential future user of the contaminated groundwater, the time at which it could occur, and the percent attributable to TWRS waste are presented in Table 5.13.5 for each alternative. The table is based on a hypothetical onsite farmer who is assumed to use the groundwater at the maximum cumulative point concentration for each alternative. The groundwater was assumed to be used for all purposes including drinking, washing, and gardening for 30 years. Future solid waste disposal at the 200 West Area solid waste burial ground and the Environmental Restoration Disposal Facility collectively would contribute about 5 rem of the hypothetical 30-year resident farmer doses presented. Less than 10 mrem of the hypothetical 30-year resident farmer dose was attributed to past and future solid waste disposal at the US Ecology solid waste burial ground.

Table 5.13.5 Cumulative Groundwater Radiation Dose and Health Effects

Tank Waste Alternative	30 Year Dose (rem)	Percent from TWRS	ILCR	Time (years)
No Action	790	93	4.9E-01	300
Long-Term Management	480	89	3.0E-01	300
In Situ Fill and Cap	68	26	4.2E-02	5,000
In Situ Vitrification	52	3	3.2E-02	10,000
Ex Situ Intermediate Separations	51	1	3.2E-02	5,000
Ex Situ No Separations	51	1	3.2E-02	5,000
Ex Situ Extensive Separations	51	1	3.2E-02	5,000
Ex Situ/In Situ Combination 1	56	10	3.5E-02	5,000
Ex Situ/In Situ Combination 2	57	10	3.5E-02	5,000
Phased Implementation	51	1	3.2E-02	5,000

Notes:
ILCR = Incremental Lifetime Cancer Risk

Cumulative radiation doses ranged from about 790 rem for the No Action (Tank Waste) alternative to about 51 rem for the ex situ alternatives. The in situ alternatives were somewhat higher than the ex situ alternatives. The groundwater impacts of the Ex Situ/In Situ Combination 1 and 2 alternatives were for the specific combinations of waste retrieval for disposal and waste disposed of in place chosen for detailed analysis. Other variations of the Ex Situ/In Situ Combination 1 and 2 alternatives could present higher or lower groundwater impacts ranging between the ex situ alternatives (51 rem) and the In Situ Fill and Cap alternative (68 rem). The cumulative radiation dose under the Long-Term Management alternative after administrative control was assumed to end would be about 480 rem. At 10,000 years after disposal, the potential dose from the cumulative contamination in groundwater would be about 3 rem for any alternative except for In Situ Fill and Cap, which would be about 6 rem.

Nitrate concentrations measured in the 200 Area wells in 1994 ranged up to 1,700 mg/L. In addition, nitrate remains in the vadose zone from past disposal practices and will migrate to groundwater over the next several decades. Because of its relatively high mobility, most of the nitrate associated with past liquid disposal practices has probably already entered the groundwater and the maximum concentrations from past disposal practices would have already occurred. This is supported by the fact that nitrate concentrations in the 200 Area groundwater are generally decreasing. Further, it is assumed that the groundwater will transport much of the nitrate from past disposal practices from the 200 Area before arrival of any potential contamination from the TWRS alternatives. Therefore, the nitrate from past disposal practices and from the TWRS alternatives was not expected to combine to give higher concentrations but will extend the time period over which nitrate will be present in the groundwater at potentially high concentrations. Detailed discussion of nitrate contamination from TWRS alternatives is presented in Section 5.2.1.

The maximum nitrate concentrations and the time at which they will be present in the groundwater are presented in Table 5.13.6. The potential nitrate concentrations ranged from 6,600 mg/L for the No Action (Tank Waste) alternative to about 5 mg/L for the Phased Implementation alternative. All other ex situ alternatives would also result in nitrate contamination of the groundwater of about 5 mg/L.

The in situ alternatives ranged from about 130 mg/L for the In Situ Fill and Cap alternative to about 0 mg/L for the In Situ Vitrification alternative. Nitrate concentration under the Long-Term Management alternative after administrative control was assumed to end would be about 1,050 mg/L.

Socioeconomics

The socioeconomic impact analysis described in Section 5.6 assessed the impacts of the TWRS EIS alternatives on the Tri-Cities area. The socioeconomic impacts of the TWRS alternatives were measured against a baseline projection of economic activity and population growth that assumed the successful completion of scheduled milestones for Hanford Site cleanup and environmental restoration under the Tri-Party Agreement. Cumulative impacts from TWRS alternatives were analyzed against the baseline of steadily declining Hanford Site employment, which was projected to drop from approximately 15,000 in 1997 to approximately 5,600 in 2040. In that same time frame, nonfarm employment in the Tri-Cities area was projected to increase from approximately 68,000 to 89,000. The peak year impact of each TWRS EIS alternative on Hanford Site employment, Tri-Cities nonfarm employment, and housing prices is presented in Table 5.13.7.

Table 5.13.6 Cumulative Groundwater Nitrate Concentrations

Tank Waste Alternative	Nitrate Concentration (mg/L)	Time (years)
No Action	6,600	300
Long-Term Management	1,050	500
In Situ Fill and Cap	130	5,000
In Situ Vitrification	0	N/A
Ex Situ Intermediate Separations	5	5,000
Ex Situ No Separations	5	5,000
Ex Situ Extensive Separations	5	5,000
Ex Situ/In Situ Combination 1	80	5,000
Ex Situ/In Situ Combination 2	80	5,000
Phased Implementation	5	5,000

Note:
N/A = Not applicable

If decisions were made that led to constructing and operating facilities at the Hanford Site not currently foreseen and reflected in the baseline, there would be additional employment, transportation, and infrastructure impacts to the Tri-Cities area.

5.14 UNAVOIDABLE ADVERSE IMPACTS

This section summarizes the potential unavoidable adverse impacts associated with the EIS alternatives. Identified are those unavoidable adverse impacts that would remain after incorporating all mitigation measures that were incorporated in the development of the EIS alternatives. Potentially adverse impacts for

Unavoidable Adverse Impacts

Impacts addressed in this section include:
- Tank waste alternatives impacts on the natural and human environment (Section 5.14.1); and
- Capsule alternatives impacts on the natural and human environment (Section 5.14.2).

Table 5.13.7 TWRS-Induced Peak Year Changes in Employment and Home Prices

Tank Waste Alternative [1]	Percent Change from Baseline in Hanford Site Employment (Peak Year)	Percent Change from Baseline in Tri-Cities Nonfarm Employment (Peak Year)	Percent Change from Baseline in Tri-Cities Average Home Prices (Peak Year)
No Action	18.0 (2040)	2.0 (2025)	2.4 (2025)
Long-Term Management	19.8 (2035)	2.5 (2035)	2.8 (2035)
In Situ Fill and Cap	1.7 (2015)	0.5 (2000)	0.7 (2001)
In Situ Vitrification	19.4 (2004)	6.2 (2000)	9.3 (2001)
Ex Situ Intermediate Separations	47.2 (2015)	9.6 (2001)	14.5 (2001)
Ex Situ No Separations	32.4 (2015)	11.5 (1999)	17.5 (2000)
Ex Situ Extensive Separations	49.5 (2003)	17.2 (2003)	25.1 (2004)
Ex Situ/In Situ Combination 1	17.0 (2015)	5.8 (2000)	8.8 (2001)
Ex Situ/In Situ Combination 2	15.3 (2001)	5.1 (2002)	8.0 (2001)
Phased Implementation (Phase 1)	20.3 (2000)	8.4 (1999)	12.9 (2000)
Phased Implementation (Total Alternative)	6.56 (2010)	15.4 (2010)	19.9 (2011)

Note:
[1] Capsule alternatives would have no measurable socioeconomic impact.

each of the alternatives are described in other portions of Section 5.0. In Section 5.20, additional practicable mitigation measures are identified that could further reduce the impacts described in this section.

5.14.1 Impact Summary

Table 5.14.1 summarizes the impacts for each tank waste alternative presented in this EIS. Impacts for each capsule alternative are summarized in Table 5.14.2. For detailed information regarding the remediation activity impacts, refer to the relevant sections of the EIS where impacts are discussed in detail. The tables identify the various areas of potential impacts (water resources, air quality, socioeconomics) for each alternative.

5.14.2 Unavoidable Adverse Impacts for Tank Waste Alternatives

The potential unavoidable adverse impacts identified in Table 5.14.1 are summarized in the following text.

Geology and Soil

Total soil disturbance because of remediation would range from none for the No Action (Tank Waste) alternative to 66 ha (160 ac) for the Long-Term Management alternative and 200 ha (490 ac) for the Phased Implementation alternative. Permanent soil disturbance because of remediation activities would range from none for the No Action alternative to 38 ha (94 ac) for the Phased Implementation alternative.

All tank waste alternatives, except No Action and Long-Term Management, would involve excavating large volumes of borrow material at three potential borrow sites as part of the closure scenario.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives

Type of Impact	No Action Alternative (Tank Waste)	Long-Term Management Alternative
Geology and Soil	No disturbances would occur.	Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resource availability. Construction associated with retanking temporarily would disturb 50 ha (120 ac) in the 200 Areas.
Air Quality	No exceedances of Federal or State air quality standards would occur during construction or operation.	No exceedances of Federal or State air quality standards would occur during construction or operation. Additional fugitive dust emissions and exhaust gases from vehicles and construction equipment would result from retanking construction activities.
Water Resources - Surface Water	No effluent discharges to surface water bodies.	No effluent discharges to surface water bodies. Small changes to minor surface drainage patterns.
Water Resources - Groundwater [1]	Water from precipitation would slowly leach contaminants from the tank waste into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of carbon-14, iodine-129, technetium-99, uranium-238, and nitrate would exceed current water quality standards at the 300- and 500- year periods.	Water from precipitation would slowly leach contaminants from the tank waste into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of carbon-14, iodine-129, technetium-99, and uranium-238, and nitrate would exceed current water quality standards at the 300- and 500- year periods.
Land Use	Would be consistent with plan for waste management in 200 Areas.	Would be consistent with plans for waste management and disposal in 200 Areas. Would commit 50 ha (120 ac) temporarily for construction and operation and 25 ha (62 ac) permanently to waste management in the 200 Areas. Would commit 16 ha (40 ac) temporarily at potential borrow sites.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	In Situ Fill and Cap Alternative	In Situ Vitrification Alternative
Geology and Soil	A Hanford Barrier would be constructed over each of the 18 tank farms and would cover a 25 ha (62 ac) area and be 4.5 m (15 ft) high. It would be graded to conform to the surrounding topography. Borrow site excavation would cause surface depressions up to 3 m (10 ft). All disturbance of topography and soil, except at borrow sites would occur in previously disturbed areas. Would not impact mineral resources availability.	Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over each of the 18 tank farms and would cover a 25 ha (62 ac) area and be 4.5 m (15 ft) high. It would be graded to conform to the surrounding topography.
Air Quality	No exceedances of Federal or State air quality standards would occur during construction or operation. Construction emissions would include fugitive dust and exhaust gases from vehicle and construction equipment. In addition, some radionuclide emissions including plutonium-239, plutonium-240, iodine-129, and cesium-137 would result from tank filling operations.	Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. No exceedances of Federal or State air quality standards would occur during construction or operation. Emissions from operations would include particulate matter, nitrogen dioxide, and radionuclides, including carbon-14, iodine-129, and cesium-137.
Water Resources - Surface Water	No effluent discharges to surface water bodies. Small changes to minor surface drainage patterns.	No effluent discharges to surface water bodies. Small changes to minor surface drainage patterns.
Water Resources - Groundwater [1]	Water from precipitation would slowly leach contaminants from the tank waste into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of iodine-129, technetium-99, uranium-238, and nitrate would exceed current water quality standards at the 5,000-year period.	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults (for the Ex Situ Intermediate Separations alternative) into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater controls would continue during the 100-year period of institutional control.
Land Use	Would be consistent with plans for waste management and disposal in 200 Areas. Would commit 21 ha (52 ac) temporarily for construction and operation and 25 ha (62 ac) permanently to waste management in the 200 Areas. Would commit 76 ha (190 ac) temporarily at potential borrow sites.	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 110 ha (270 ac) temporarily to construction and operation and 25 ha (62 ac) permanently to waste management in the 200 Areas. Would commit 74 ha (180 ac) temporarily at potential borrow sites.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Intermediate Separations Alternative	Ex Situ No Separations Alternative
Geology and Soil	Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over each of the 18 tank farms and low-activity vaults and would cover a 39 ha (96 ac) area and be 4.5 m (15 ft) high. It would be graded to conform to the surrounding topography.	Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over each of the 18 tank farms and would cover a 25 ha (62 ac) area and be 4.5 m (15 ft) high. It would be graded to conform to the surrounding topography.
Air Quality	Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. No exceedances of Federal or State air quality standards would occur during construction or operation. Emissions from operations would include sulfur oxides, carbon monoxides, nitrogen dioxide, and particulate matter. Hazardous chemicals such as chlorine, fluorine, and ammonia, as well as radionuclides such as americium-241, plutonium-239, plutonium-240, carbon-14, iodine-129, and cesium-137 also would be emitted.	Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. No exceedances of Federal or State air quality standards would occur during construction or operation. Emissions from operations would include sulfur oxides, carbon monoxides, nitrogen dioxide, and particulate matter. Hazardous chemicals such as chlorine, fluorine, and ammonia, as well as radionuclides such as americium-241, plutonium-239, plutonium-240, carbon-14, iodine-129, and cesium-137 also would be emitted.
Water Resources - Surface Water	No effluent discharges to surface water bodies. Small changes to minor surface drainage patterns.	No effluent discharges to surface water bodies. Small changes to minor surface drainage patterns.
Water Resources - Groundwater [1]	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults (for the Ex Situ Intermediate Separations alternative) into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater controls would continue during the 100-year period of institutional control. Concentrations of uranium-238 would exceed current water quality standards at the 5,000-year period.	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults (for the Ex Situ Intermediate Separations alternative) into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater controls would continue during the 100-year period of institutional control. Concentrations of uranium-238 would exceed current water quality standards at the 5,000-year period.
Land Use	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 110 ha (270 ac) temporarily to construction and operation and 46 ha (110 ac) permanently to waste management in the 200 Areas. Would commit 130 ha (320 ac) temporarily at potential borrow sites.	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 90 ha (220 ac) temporarily to construction and operation and 28 ha (69 ac) permanently to waste management in the 200 Areas. Would commit 180 ha (440 ac) temporarily at potential borrow sites.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Extensive Separations Alternative	Ex Situ/In Situ Combination 1 Alternative
Geology and Soil	Hanford Barriers constructed over each of the 18 tank farms would cover a 25 ha (62 ac) area, be 4.5 m (15 ft) high, and graded to conform to the surrounding topography. Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over low-activity vaults and would cover a 12 ha (30 ac) area and be 4.5 m (15 ft) high.	Hanford Barriers constructed over each of the 18 tank farms would cover a 25 ha (62 ac) area, be 4.5 m (15 ft) high, and graded to conform to the surrounding topography. Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over low-activity vaults and would cover a 9 ha (22 ac) area and be 4.5 m (15 ft) high.
Air Quality	No exceedances of Federal or State air quality standards would occur during construction or operation. Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. Emissions from operations include sulfur oxides, carbon monoxides, nitrogen dioxide, and particulate matter. Hazardous chemicals such as chlorine, fluorine, and ammonia, as well as radionuclides such as americium-241, plutonium-239, plutonium-240, carbon-14, iodine-129, and cesium-137 would also be emitted.	No exceedances of Federal or State air quality standards would occur during construction or operation. Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. Emissions from operations include sulfur oxides, carbon monoxides, nitrogen dioxide, and particulate matter. Hazardous chemicals such as chlorine, fluorine, and ammonia, as well as radionuclides such as americium-241, plutonium-239, plutonium-240, carbon-14, iodine-129, and cesium-137 would also be emitted.
Water Resources - Surface Water	No effluent discharges to surface water bodies. Small changes to minor surface drainage pattern.	No effluent discharges to surface water bodies. Small changes to minor surface drainage pattern.
Water Resources - Groundwater [1]	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of uranium-238 would exceed current water quality standards at the 5,000-year period.	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of iodine-129, technetium-99, uranium-238, and nitrate would exceed current water quality standards at the 5,000-year period.
Land Use	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 110 ha (270 ac) temporarily to construction and operation and 44 ha (110 ac) permanently to waste management in the 200 Areas. Would commit 130 ha (320 ac) temporarily at potential borrow sites.	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 110 ha (270 ac) temporarily to construction and operation and 41 ha (100 ac) permanently to waste management in the 200 Areas. Would commit 110 ha (270 ac) temporarily at potential borrow sites.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ/In Situ Combination 2 Alternative	Phased Implementation Alternative
Geology and Soil	Hanford Barriers constructed over each of the 18 tank farms would cover a 25 ha (62 ac) area, be 4.5 m (15 ft) high, and graded to conform to the surrounding topography. Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over low-acting vaults and would cover a 5 ha (12 ac) area and be 4.5 (15 ft) high.	Hanford Barriers constructed over each of the 18 tank farms would cover a 25 ha (62 ac) area, be 4.5 m (15 ft) high, and graded to conform to the surrounding topography. Borrow site excavation would cause surface depressions up to 3 m (10 ft). Would not impact mineral resources availability. Hanford Barrier would be constructed over low-activity vaults and would cover a 17 ha (42 ac) area and be 4.5 m (15 ft) high.
Air Quality	No exceedances of Federal or State air quality standards would occur during construction or operation. Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. Emissions from operations include sulfur oxides, carbon monoxides, nitrogen dioxide, and particulate matter. Hazardous chemicals such as chlorine, fluorine, and ammonia, as well as radionuclides such as americium-241, plutonium-239, plutonium-240, carbon-14, iodine-129, and cesium-137 would also be emitted.	No exceedances of Federal or State air quality standards would occur during construction or operation. Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. Emissions from operations include sulfur oxides, carbon monoxides, nitrogen dioxide, and particulate matter. Hazardous chemicals such as chlorine, fluorine, and ammonia, as well as radionuclides such as americium-241, plutonium-239, plutonium-240, carbon-14, iodine-129, and cesium-137 would also be emitted.
Water Resources - Surface Water	No effluent discharges to surface water bodies. Small changes to minor surface drainage pattern.	No effluent discharges to surface water bodies. Small changes to minor surface drainage pattern.
Water Resources - Groundwater [1]	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of iodine-129, technetium-99, uranium-238, and nitrate would exceed current water quality standards at the 5,000-year period.	Water from precipitation would slowly leach contaminants from the residual tank waste and the low-activity vaults into currently contaminated groundwater below the Site, which would discharge to the Columbia River. Current groundwater use controls would continue during the 100-year period of institutional control. Concentrations of uranium-238 would exceed current water quality standards at the 5,000-year period.
Land Use	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 80 ha (200 ac) temporarily to construction and operations and 34 ha (80 ac) permanently to waste management in the 200 Areas. Would commit 91 ha (220 ac) temporarily at potential borrow sites.	Would be consistent with plans for waste management and disposal in the 200 Areas. Would commit 180 ha (440 ac) temporarily to construction and operations and 49 ha (120 ac) permanently to waste management in the 200 Areas. Would commit 140 ha (350 ac) temporarily at potential borrow sites.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	No Action Alternative (Tank Waste)	Long-Term Management Alternative
Biological Resources	No disturbances to biological resources.	Shrub-steppe habitat loss potentially would impact related candidate, monitor, or sensitive plants and wildlife. Loss of shrub-steppe habitat would total 10 ha (25 ac) in the 200 Areas and 14 ha (35 ac) at potential borrow sites.
Cultural Resources	No disturbances to prehistoric or historic sites.	Low impact potential to currently disturbed 200 Areas. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.
Transportation	No new traffic beyond existing traffic associated with routine tank farm operations.	Additional a.m. daily vehicles on Stevens Road and Route 4 would be minimal.
Noise	No new noise beyond existing noise associated with routine tank farm operations.	No onsite or offsite impacts during construction or operation exceeding Federal or State noise standards. Small impacts to onsite wildlife near construction areas during new tank construction in 2030's.
Visual Resources	No new visual impacts.	No offsite impacts from non-elevated locations.
Socioeconomics - Economy - Employment - Low-Income - Minority	Would involve 1,000 Site jobs over baseline conditions in 2030 and 1,700 area jobs in 2030 (peak year).[1] Peak housing price increase above baseline of 2.4 percent in 2025.	Long-term continuation of routine tank farm operations jobs, plus new tank farm construction jobs in 2030s. Total of 1,350 Site jobs over baseline conditions and 2,200 area jobs over baseline in 2035 (peak year).[1] Peak housing price increase of 2.8 percent above baseline in 2035.

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Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	In Situ Fill and Cap Alternative	In Situ Vitrification Alternative
Biological Resources	Shrub-steppe habitat loss potentially would impact related candidate, monitor, or sensitive plants and wildlife. Loss of shrub-steppe habitat would total 65 ha (160 ac) at the proposed borrow sites.	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Loss of shrub-steppe habitat would total 23 ha (57 ac) in the 200 Areas and 63 ha (160 ac) at potential borrow sites.
Cultural Resources	Low impact potential to currently disturbed 200 Areas. Small potential impact to potentially important borrow site prehistoric sites. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.	Low impacts potential to currently disturbed 200 Areas. Small potential impacts to potentially substantial borrow site prehistoric resources. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.
Transportation	Additional a.m. daily vehicles on Stevens Road and Route 4 would peak at 50 in 2002. No impact on traffic congestion.	Stevens Road, access to Stevens Road from State Route 240, and Route 4 West of the Wye Barricade would experience extremely heavy a.m. congestion. Peak year (2004) additional a.m. daily vehicles of 900 on Stevens Road and 400 on Route 4. Congestion would begin in 2001 and remain high until 2007.
Noise	No onsite or offsite impacts during construction or operation exceeding Federal or State noise standards. Small impacts to onsite wildlife near construction areas from 1997 to 2007. No operation phase impacts to wildlife.	No offsite impacts during construction or operation. No operation phase impacts to wildlife. All noise levels within Federal and State standards. Small onsite impacts to wildlife near construction areas from 1998 to 2016.
Visual Resources	No construction phase or permanent impacts offsite from non-elevated locations. The Hanford Barriers, which would conform to existing land forms, would be permanently visible in background from elevated locations.	The Hanford Barriers would be permanently visible in background from elevated locations. However, the Barriers would conform to existing land forms. Minor stack vapor plume visible only onsite. Tank farm confinement structures visible in middle ground from State Route 240 from 1998 to 2016 and from elevated locations.
Socioeconomics - Economy - Employment - Low-Income - Minority	Increase of 150 Site jobs in 2000 (peak year), 320 area jobs in 2000 (peak year), and 460 in new population in 2001 (peak year). Housing prices would reach 0.7 percent above baseline conditions in 2001.	An added 2,600 Site jobs in 2004 (peak year), 4,300 area jobs in 2004 (peak year), and 6,300 in new population in 2005 (peak year). Housing price increases would peak at 9.3 percent above baseline conditions in 2001. High housing prices would create adverse housing access conditions for low-income populations.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Intermediate Separations Alternative	Ex Situ No Separations Alternative
Biological Resources	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Loss of shrub-steppe habitat would total 57 ha (140 ac) in the 200 Areas and 110 ha (270 ac) at potential borrow sites.	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Loss of shrub-steppe habitat would total 44 ha (110 ac) in the 200 Areas and 150 ha (370 ac) at potential borrow sites.
Cultural Resources	Low impacts potential to currently disturbed 200 Areas. Small potential impacts to potentially substantial borrow site prehistoric resources. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.	Low impacts potential to currently disturbed 200 Areas. Small potential impacts to potentially substantial borrow site prehistoric resources. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.
Transportation	Stevens Road, access to Stevens Road from State Route 240, and Route 4 West of the Wye Barricade would experience extremely heavy a.m. congestion. Peak year (2002) additional a.m. daily vehicles of 1,800 on Stevens Road and 1,300 on Route 4. Congestion would build beginning in 1999 and remain high until 2004.	Stevens Road, access to Stevens Road from State Route 240, and Route 4 West of the Wye Barricade would experience extremely heavy a.m. congestion. Peak year (2000) additional a.m. daily vehicles of 1,800 on Stevens Road and 1,300 on Route 4. Congestion would build beginning in 1999 and remain high until 2001.
Noise	No offsite impacts during construction or operation. No operation phase impacts to wildlife. All noise levels within Federal and State standards. Small onsite impacts to wildlife near construction areas from 1997 to 2007.	No offsite impacts during construction or operation. No operation phase impacts to wildlife. All noise levels within Federal and State standards. Small onsite impacts to wildlife near construction areas from 1997 to 2007.
Visual Resources	The Hanford Barriers would be permanently visible in background from elevated locations. However, the Barriers would conform to existing land forms. Minor stack vapor plume visible only onsite. Waste treatment facility visible in background from State Route 240 and from elevated locations. Stack vapor plume visible onsite and in close proximity offsite under certain conditions.	The Hanford Barriers would be permanently visible in background from elevated locations. However, the Barriers would conform to existing land forms. Minor stack vapor plume visible only onsite. Waste treatment facility visible in background from State Route 240 and from elevated locations. Stack vapor plume visible onsite and in close proximity offsite under certain conditions.
Socioeconomics - Economy - Employment - Low-Income - Minority	An added 4,000 Site jobs in 2002 (peak year), 6,800 area jobs in peak year, and 9,900 in new population in 2002 (peak year). Housing price increases would peak at 14.5 percent above baseline conditions in 2001. High housing prices would create adverse housing access conditions for low-income populations.	An added 4,400 Site jobs in 2000 (peak year), 8,000 area jobs in peak year, and 11,700 in new population in 2000 (peak year). Housing price increases would peak at 17.5 percent above baseline conditions in 2000. High housing prices would create adverse housing access conditions for low-income populations.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Extensive Separations Alternative	Ex Situ/In Situ Combination 1 Alternative
Biological Resources	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Most areas impacted are currently disturbed. Loss of shrub-steppe habitat would total 57 ha (140 ac); borrow site loss would total 110 ha (270 ac).	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Most areas impacted are currently disturbed. Loss of shrub-steppe habitat would total 56 ha (140 ac); borrow site loss would total 90 ha (220 ac).
Cultural Resources	Low impacts potential to currently disturbed 200 Areas. Small potential impact to potentially substantial borrow site prehistoric sites. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.	Low impacts potential to currently disturbed 200 Areas. Small potential impact to potentially substantial borrow site prehistoric sites. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.
Transportation	Stevens Road, access to Stevens Road from State Route 240, and Route 4 would experience extremely heavy a.m. congestion. Peak year (2003) additional a.m. daily vehicles of 3,400 on Stevens Road and 2,900 on Route 4. Congestion would build beginning in 2002 and remain high until 2004.	Stevens Road access from State Route 240 Bypass, and Route 4 would experience heavy a.m. congestion. Peak year (2001) additional a.m. daily vehicles of 800 on Stevens Road and 400 on Route 4. Congestion would build beginning in 1999 and remain high until 2007.
Noise	No offsite impacts during construction or operation. No operation phase impacts to wildlife. All noise levels within Federal and State standards. Small onsite impacts to wildlife near construction areas from 1997 to 2007.	No offsite impacts during construction or operation. No operation phase impacts to wildlife. All noise levels within Federal and State standards. Small onsite impacts to wildlife near construction areas from 1997 to 2017.
Visual Resources	The Hanford Barrier would be permanently visible in background from elevated locations. However, the Hanford Barrier would conform to existing land forms. Stack vapor plume visible onsite and in close proximity offsite under certain conditions. Waste treatment facility visible in background from State Route 240 and from elevated locations.	The Hanford Barrier would be permanently visible in background from elevated locations. However, the Hanford Barrier would conform to existing land forms. Stack vapor plume visible onsite and in close proximity offsite under certain conditions. Waste treatment facility visible in background from State Route 240 and from elevated locations.
Socioeconomics - Economy - Employment - Low-Income - Minority	An added 6,700 Site jobs in 2003 (peak year), 12,200 area jobs in 2003 (peak year), and 17,800 in new population in 2004 (peak year). Housing price increases would peak at 25.1 percent above baseline conditions in 2004. High housing prices would create adverse housing access conditions for low-income populations.	An added 2,500 Site jobs in 2001 (peak year), 4,100 area jobs in 2002 (peak year), and 6,000 in new population in 2002 (peak year). Housing price increases would peak at 8.8 percent above baseline conditions in 2001. High housing prices would create adverse housing access conditions for low-income populations.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ/In Situ Combination 2 Alternative	Phased Implementation Alternative
Biological Resources	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Most areas impacted are currently disturbed. Loss of shrub-steppe habitat would total 20 ha (49 ac); borrow site loss would total 78 ha (200 ac)	Shrub-steppe habitat loss would potentially impact related candidate, monitor, or sensitive plants and wildlife. Phase 1: Loss of 200 Area shrub-steppe habitat would total 20 ha (49 ac). Total Alternative: Loss of 200 Area shrub-steppe habitat would total 99 ha (240 ac); borrow site losses would total 120 ha (300 ac).
Cultural Resources	Low impact potential to currently disturbed 200 Areas. Small potential impact to potentially substantial borrow site prehistoric resources. However, changes to land forms and natural resources considered impacts to cultural resources by affected Tribal Nations.	Low impacts potential to currently disturbed 200 Areas. Small potential impact to potentially substantial borrow site prehistoric sites. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.
Transportation	Stevens Road access from State Route 240 Bypass, and Route 4 would experience heavy congestion. Peak year (2001) additional a.m. daily vehicles of 700 on Stevens Road and 350 on Route 4. Congestion would build beginning in 1999 and remain high for several years after peak year.	Phase 1: Stevens Road access from State Route 240 Bypass, and Route 4 would experience heavy a.m. congestion. Phase 1: Peak year (1999) additional a.m. daily vehicles of 1,300 on Stevens Road and 800 on Route 4. Congestion from 1998 to 2000. Total Alternative: Peak year (2010) 3,500 additional a.m. daily vehicles on Stevens Road and 2,900 vehicles on Route 4. Congestion would build beginning in 1998 to 2000 and again from 2007 to 2020.
Noise	No offsite impacts during construction or operation. No operations phase impact to wildlife. All noise levels below Federal and State standards.	No offsite impacts during construction or operation. No operation phase impacts to wildlife. All noise levels within Federal and State standards. Small onsite impacts to wildlife near construction in 200 East Area from 1997 to 2003 and again from 2005 to 2011.
Visual Resources	The Hanford Barrier would be permanently visible in background from elevated locations. However, the Hanford Barrier would conform to existing land forms. Stack vapor plume visible onsite and in close proximity offsite under certain conditions. Waste treatment facility visible in background from State Route 240. Facility also visible from elevated locations (e.g. Gable Mountain) used by Native Americans for religious purposes.	The Hanford Barrier would be permanently visible in background from elevated locations. However, the Hanford Barrier would conform to existing land forms. Stack vapor plume visible onsite and in close proximity offsite under certain conditions. Waste treatment facility visible in background from State Route 240 and from elevated locations.
Socioeconomics - Economy - Employment - Low-Income - Minority	An added 2,200 Site jobs in 2001 (peak year), about 3,600 area jobs in 2002 (peak year) and 5,300 in new population in 2001 or 2002 (peak year). Housing prices would peak at approximately 8 percent above baseline conditions in 2001 or 2002. High housing prices would create adverse housing access conditions for low-income populations.	An added 6,700 jobs in 2010 (peak year), 11,000 area jobs in 2010 (peak year), and 16,100 in new population in 2011 (peak year). Housing price increases would peak at 19.9 percent above baseline conditions in 2011 (peak year). High housing prices would create adverse housing access conditions for low-income populations.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	No Action Alternative (Tank Waste)	Long-Term Management Alternative
Socioeconomics - Facilities and Services	No impacts on Tri-Cities area public facilities and services.	All increase in demands for local facilities and services would be within projected capacity. School population increase would peak at 900 new students in 2035.
Health Effects[2] - Routine - Post Remediation Native American and Farmer - Intruder - Integrated 10,000 years	No cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 1 and 1 in 2 probability of developing cancer, respectively. Hazard indices of 2.7E+05 and 5.0E+04 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 24 probability of a cancer fatality. Over 10,000 years, there would be 2,200 and 630 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 3 fatalities within the 500,000 population of Columbia River users over the 10,000 years.	No cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 1 and 1 in 3 probability of developing cancer, respectively. Hazard indices of 4.4E+04 and 7.9E+03 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 24 probability of a cancer fatality. Over 10,000 years, there would be 2,300 and 570 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 2 fatalities for the Columbia River users over the 10,000 years.
Health Effects[3] - Accidents	There would be 2,290 injuries and 3 fatalities from occupational accidents and 2,000 injuries and 25 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 16. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft). There would be 184 fatalities resulting from radiological and chemical exposure from the tank dome collapsing beyond the 100 years of institutional control.	There would be 2,650 injuries and 3 fatalities from occupational accidents and 2,080 injuries and 26 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 16. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft). There would be 184 fatalities resulting from radiological and chemical exposure from the tank dome collapsing beyond the 100 years of institutional control.

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	In Situ Fill and Cap Alternative	In Situ Vitrification Alternative
Socioeconomics - Facilities and Services	All increase in demands for local facilities and services would be within projected capacity. School population increase would peak at 140 new students in 2001.	All increase in demands for local facilities and services except local fire and police and possibly school personnel would be within projected capacity. Additional staff needed would include 8 to 12 police and 4 to 8 fire personnel in 2001. School population increase would peak at 1,800 new students in 2001.
Health Effects[2] - Routine - Post Remediation Native American and Farmer - Intruder - Integrated 10,000 years	No cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 8 and 1 in 90 probability of developing cancer, respectively. Hazard indices of 3.0E+03 and 5.3E+02 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 24 probability of a cancer fatality. Over 10,000 years, there would be 1,000 and 330 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 26 fatalities for the Columbia River users over the 10,000 years.	No cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 2,600 and 1 in 18,000 probability of developing cancer, respectively. Hazard indices less than 1.0 indicate that future Native American and residential farmer Site users would not have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 490 probability of a cancer fatality. Over 10,000 years, there would be 2 and 1 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 0 fatalities for the Columbia River users over the 10,000 years.
Health Effects[3] - Accidents	There would be 630 injuries and 1 fatality from occupational accidents and 506 injuries and 6 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 2. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).	There would be 2,770 injuries and 2 fatalities from occupational accidents and 944 injuries and 12 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 3. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Intermediate Separations Alternative	Ex Situ No Separations Alternative
Socioeconomics - Facilities and Services	All increase in demands for local facilities and services except local fire and police and possibly school personnel would be within projected capacity. Additional staff needed would include 12 to 16 police and 8 to 12 fire personnel in 2002. School population increase would peak at 2,800 new students in 2002.	All increase in demands for local facilities and services except local fire and police and possibly school personnel would be within projected capacity. Additional staff needed would include 12 to 16 police and 8 to 12 fire personnel in 2000. School population increase would peak at 3,300 new students in 2000.
Health Effects[2] - Routine - Post Remediation Native American and Farmer - Intruder - Integrated 10,000 years	A calculated 3 cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 230 and 1 in 3,000 probability of developing cancer, respectively. Hazard indices of 1.2E+02 and 2.1E+01 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 2,400 probability of a cancer fatality. Over 10,000 years, there would be 33 and 10 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 1 fatality for the Columbia River users over the 10,000 years.	A calculated 2 cancer fatalities would result from routine operations for vitrification. For calcination, a calculated 2 cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 230 and 1 in 3,000 probability of developing cancer, respectively. Hazard indices of 1.2E+02 and 2.1E+01 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 2,400 probability of a cancer fatality. Over 10,000 years, there would be 33 and 10 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 1 fatality for the Columbia River users over the 10,000 years.
Health Effects[3] - Accidents	There would be 4,230 injuries and 3 fatalities from occupational accidents and 1,670 injuries and 26 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 4. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).	Vitrification: There would be 3,450 injuries and 2 fatalities from occupational accidents and 1,300 injuries and 17 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 4. Calcination: There would be 3,450 injuries and 2 fatalities from occupational accidents and 1,300 injuries and 17 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 4. Vitrification and Calcination: Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Extensive Separations Alternative	Ex Situ/In Situ Combination 1 Alternative
Socioeconomics - Facilities and Services	All increase in demands for local facilities and services except local fire and police and possibly school personnel would be within projected capacity. Additional staff needed would include 16 to 20 police and 8 to 12 fire personnel in 2000. School population increase would peak at 5,100 new students in 2004.	All increase in demands for local facilities and services except local fire and police and possibly school personnel would be within projected capacity. Additional staff needed would include 12 to 16 police and 8 to 12 fire personnel in 2001. School population increase would peak at 1,700 new students in 2001.
Health Effects[2] - Routine - Post Remediation Native American and Farmer - Intruder - Integrated 10,000 years	A calculated 3 cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 230 and 1 in 3,000 probability of developing cancer, respectively. Hazard indices of 1.2E+02 and 2.1E+01 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 2,400 probability of a cancer fatality. Over 10,000 years, there would be 33 and 10 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 1 fatality for the Columbia River users over the 10,000 years.	A calculated 2 cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 23 and 1 in 300 probability of developing cancer, respectively. Hazard indices of 3.3E+03 and 6.0E+02 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 150 probability of a cancer fatality. Over 10,000 years, there would be 166 and 60 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 3 fatalities for the Columbia River users over the 10,000 years.
Health Effects[3] - Accidents	There would be 4,590 injuries and 3 fatalities from occupational accidents and 1,590 injuries and 21 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 4. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).	There would be 3,180 injuries and 2 fatalities from occupational accidents and 1,420 injuries and 18 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 4. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).

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Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ/In Situ Combination 2 Alternative	Phased Implementation Alternative
Socioeconomics - Facilities and Services	All increase in demands for local facilities and services except local police and fire, and possibly school personnel would be within projected capacity. Additional staff need would include 2 to 3 police personnel and 1 to 2 fire personnel in 2001 or 2002. School enrollment increases would peak at about 2,000 in peak year (2001 or 2002).	All increase in demands for local facilities and services except local fire and police and possibly school personnel would be within projected capacity. Phase 1: Additional staff needed would include 16 to 20 police personnel and 8 to 20 fire personnel in 2000. School enrollment increase would peak at 4,600 in 2001. Total Alternative: Additional staff needed would include 16 to 20 police personnel and 8 to 20 fire personnel in 2010. School enrollment increase would peak at 4,600 in 2011.
Health Effects[2] - Routine - Post Remediation Native American and Farmer - Intruder - Integrated 10,000 years	A calculated 2 cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 22 and 1 in 275 probability of developing cancer, respectively. Hazard indices of 3.4E+03 and 6.1E+02 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 400 probability of a cancer fatality. Over 10,000 years, there would be 204 and 64 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 6 fatalities for the Columbia River users over the 10,000 years.	A calculated 3 cancer fatalities would result from routine operations. A Native American and residential farmer using the Site in the future would have a 1 in 230 and 1 in 3,000 probability of developing cancer, respectively. Hazard indices of 1.2E+02 and 2.1E+01 indicate that future Native American and residential farmer Site users would have a strong probability of developing noncarcinogenic health effects. A post-remediation intruder would have a 1 in 2,400 probability of a cancer fatality. Over 10,000 years, there would be 33 and 10 potential fatalities to Native Americans and residential farmers using the Site, respectively. There would be 1 fatality for the Columbia River users over the 10,000 years.
Health Effects[3] - Accidents	There would be 2,530 injuries and 2 fatalities from occupational accidents and 1,040 injuries and 13 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 4. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).	There would be 6,060 injuries and 4 fatalities from occupational accidents and 2,480 injuries and 32 fatalities from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be 5. Chemical exposure potentially would be fatal to the 10 workers (these same 10 workers also would receive a lethal radiological exposure). There would be no irreversible effects to populations beyond 100 m (330 ft).

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	No Action Alternative (Tank Waste)	Long-Term Management Alternative
Cost	$12.6 to 16.1 billion	$19.0 to 23.2 billion
Commitments of Resources	No new impacts on any resource beyond existing demands associated with continued tank farm operations. The alternative would use 1.0E+03 mt of steel, 1.5E+06 m^3 of water, 1.1E+03 GWh of electricity, and 2.2E+04 m^3 of fuel. [4]	All resource requirements would be within regional resource capacity and would cause no resource impacts. The alternative would use 1.3E+04 mt of steel, 1.5E+06 m^3 of water, 3.5E+05 m^3 of concrete, 1.1E+03 GWh of electricity, 4.65E+05 m^3 of borrow material, and 1.7E+05 m^3 of fuel.[4]
Type of Impact	**In Situ Fill and Cap Alternative**	**In Situ Vitrification Alternative**
Cost	$7.0 to 8.8 billion	$15.9 to 27.4 billion
Commitments of Resources	All resource requirements would be within regional resource capacity and would cause no resource impacts. The alternative would use 2.2E+06 m^3 of borrow material. It would also use 2.4E+06 m^3 of water, 1.9E+04 m^3 of concrete, 9.5E+02 GWh electricity, and 6.0E+04 m^3 of fuel. [4]	All resources are within existing capacity within the region and would cause no resource limitations. The alternative would use 2.0E+06 m^3 of borrow material, 2.6E+05 mt of steel, 1.8E+04 mt of process chemicals, 1.7E+08 m^3 of water, 1.3E+05 m^3 of concrete, 4.5E+03 GWh of electricity, and 8.6E+04 m^3 of fuel. [4]
Type of Impact	**Ex Situ Intermediate Separations Alternative**	**Ex Situ No Separations Alternative**
Cost	$29.0 to 35.1 billion. This cost range includes $5.3 billion for HLW disposal at a geologic repository.	Vitrification: $59.2 to 74.5 billion. This cost range includes $38.9 billion for HLW disposal at a geologic repository. Calcination: $35.2 to 42.5 billion. This cost range includes $14.6 billion for HLW disposal at a geologic repository.
Commitments of Resources	All resources are within existing capacity within the region and would cause no resource limitations. The alternative would use 3.8E+06 m^3 of borrow material, 2.7E+05 mt of steel, 1.0E+06 mt of process chemicals, 1.9E+07 m^3 of water, 1.1E+06 m^3 of concrete, 1.1E+04 GWh of electricity, 3.3E+04 mt of stainless steel, 1.8E+05 m^3 of fuel, and 6.6E+04 m^3 of kerosene. [4]	All resources are within existing capacity within the region and would cause no resource limitations. The alternative would use 5.2E+06 m^3 of borrow material, 2.6E+05 mt of steel, 7.2E+05 mt of process chemicals, 4.1E+06 m^3 of water, 2.8E+06 m^3 of concrete, 7.1E+03 GWh of electricity, 7.1E+04 m^3 of fuel, 1.8E+05 mt of stainless steel, and 8.5E+04 m^3 of kerosene for the vitrification option[4]. For calcination the alternative would use 3.1E+05 mt of process chemicals, 1.3E+06 m^3 of concrete, 1.3E+05 mt of steel, 2.5E+06 m^3 of water, 4.7E+03 GWh of electricity, 7.1E+04 m^3 of fuel, 7.1E+04 mt of stainless steel, 1.1E+04 m^3 of kerosene, and 3.6E+06 m^3 of borrow material. [4]

Table 5.14.1 Summary of Environmental Impacts of the Tank Waste Alternatives (cont'd)

Type of Impact	Ex Situ Extensive Separations Alternative	Ex Situ/In Situ Combination 1 Alternative
Cost	$27.2 to 37.7 billion. This cost range includes $0.27 billion for HLW disposal at a geologic repository.	$22.1 to 27.0 billion. This cost range includes $3.7 billion for HLW disposal at a geologic repository.
Commitments of Resources	All resources are within existing capacity within the region and would cause no resource limitations. The alternative would use 3.8E+06 m^3 of borrow material, 3.1E+05 mt of steel, and 1.9E+06 mt of process chemicals. It would also use 6.7E+07 m^3 of water, 9.1E+05 m^3 of concrete, 3.3E+04 GWh of electricity, 1.5E+05 m^3 of fuel, 2.2E+04 mt of stainless steel, and 1.9E+05 m^3 kerosene. [4]	All resources are within existing capacity within the region and would cause no resource limitations. The alternative would use 3.2E+06 m^3 of borrow material, 1.5E+05 mt of steel, and 6.0E+05 mt of process chemicals. It would also use 1.3E+07 m^3 of water, 5.8E+05 m^3 of concrete, 1.04E+04 GWh of electricity, 1.9E+04 mt of stainless steel, 4.0E+04 m^3 of kerosene, and 1.1E+05 m^3 of fuel. [4]
Type of Impact	**Ex Situ/In Situ Combination 2 Alternative**	**Phased Implementation Alternative**
Cost	$16.6 to 19.9 billion. This cost range includes $2.2 billion for HLW disposal at a geologic repository.	$30.4 to 38.1 billion. This cost range includes $5.3 billion for HLW disposal at a geologic repository.
Commitments of Resources	The alternative would use 2.8E+06 m^3 of borrow material, 9.7E+04 mt of steel, and 3.5E+05 mt of process chemicals. It would also use 7.4E+06 m^3 of water, 3.8E+05 m^3 of concrete, 7.6E+03 GWh of electricity, 8.9E+04 m^3 of fuel, 1.2E+04 mt of stainless steel, and 2.3E+04 m^3 of kerosene.[4]	All resources are within existing capacity within the region and would cause no resource limitations. Would use 4.1E+06 m^3 of borrow material, 3.0E+05 mt of steel, and 9.8E+05 mt of process chemicals. It would use 1.9E+07 m^3 of water, 1.1E+06 m^3 of concrete, 1.1E+04 GWh of electricity, 1.2E+05 m^3 of fuel, 3.8E+04 mt of stainless steel, and 6.5E+04 m^3 of kerosene.[4]

Notes:
[1] For all alternatives, groundwater contaminants would be the primary contributor to long-term health effects. This table summarizes health effects during and after remediation elsewhere.
[2] Cancer fatalities are rounded to two significant digits.
[3] Occupational accidents were based on DOE and Hanford Site statistics. Transportation accidents were based on U.S. Department of Transportation statistics, Washington State Highway Accident Reports, and Hanford Site statistics. Operation accidents resulting in latent cancer fatalities were based on maximum foreseeable accidents. The probabilities of the accidents are presented in Table 5.12.4.
[4] Fuel includes gasoline and diesel fuel.
ac = acres
ft = feet
GWh = gigawatt-hour
ha = hectares
m = meters
m^3 = cubic meters
mt= metric tons

Table 5.14.2 Summary of the Environmental Impacts of the Capsule Alternatives

Type of Impact	No Action Alternative (Capsules)	Onsite Disposal Alternative
Geology and Soil	No impacts anticipated.	During construction 4 ha (10 ac) of soil would be temporarily disturbed and 1.8 ha (4.4 ac) would be permanently disturbed by the disposal facility. The facility would conform to surrounding area land forms.
Air Quality	There would be no operational emissions for this alternative. No exceedances of Federal or State air quality standards would occur	Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. There would be no operational emissions for this alternative. No exceedances of Federal or State air quality standards would occur during construction or operation.
Water Resources - Surface Water	No impacts anticipated.	No impacts anticipated.
Water Resources - Groundwater	No impacts anticipated.	Cesium and strontium would decay to stable and non-hazardous daughter products prior to entering the groundwater. No impacts anticipated.
Land Use	None beyond existing levels.	Would conform to plans for use of the 200 Areas for waste management. During construction and operation 4 ha (10 ac) of soil would be temporarily committed and 1.8 ha (4.4 ac) would be permanently committed by the Onsite Disposal Facility.
Transportation (peak year)	None beyond existing levels.	Less than 50 additional vehicles per day during a.m. commute. No impact on traffic congestion.
Noise	No impacts anticipated.	No incremental wildlife impacts near construction areas above Ex Situ Intermediate Separations alternative impacts. No offsite impacts. Noise levels would not exceed standards.
Visual Resources	No impacts anticipated.	No offsite impacts.
Biological Resources	No impacts anticipated.	Most areas to be impacted currently are disturbed. Loss of shrub-steppe habitat would total 1.5 ha (3.7 ac).

Table 5.14.2 Summary of the Environmental Impacts of the Capsule Alternatives (cont'd)

Type of Impact	Overpack and Ship Alternative	Vitrify with Tank Waste Alternative
Geology and Soil	During construction 2 ha (5 ac) would be temporarily disturbed. There would be no permanent disturbances.	During construction 1 ha (2 ac) would be temporarily disturbed. There would be no permanent disturbances.
Air Quality	Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. No exceedances of Federal or State air quality standards would occur during construction or operation.	Construction emissions would include fugitive dust and exhaust gases from vehicles and construction equipment. No exceedances of Federal or State air quality standards would occur during construction or operation.
Water Resources - Surface Water	No impacts anticipated.	No impacts anticipated.
Water Resources - Groundwater	No releases to the groundwater would occur. No impacts anticipated.	No releases to the groundwater would occur. No impacts anticipated.
Land Use	No land beyond the land committed to waste treatment for the Ex Situ Intermediate Separations alternative would be used.	No land beyond the land committed to waste treatment for the Ex Situ Intermediate Separations alternative would be used.
Transportation (peak year)	Less than 50 additional vehicles per day during a.m. commute. No impact on traffic congestion.	Less than 50 additional vehicles per day during a.m. commute. No impact on traffic congestion.
Noise	No incremental wildlife impacts near construction areas above Ex Situ Intermediate Separations alternative impacts. No offsite impacts. Noise levels would not exceed standards.	No incremental wildlife impacts near construction areas above Ex Situ Intermediate Separations alternative impacts. No offsite impacts. Noise levels would not exceed standards.
Visual Resources	No offsite impacts.	No offsite impacts.
Biological Resources	Most areas to be impacted currently are disturbed. Additional loss of shrub-steppe habitat would total 0.5 ha (1.2 ac).	Most areas to be impacted currently are disturbed. Additional loss of shrub-steppe habitat would total 0.5 ha (1.2 ac).

Table 5.14.2 Summary of the Environmental Impacts of the Capsule Alternatives (cont'd)

Type of Impact	No Action Alternative (Capsules)	Onsite Disposal Alternative
Cultural Resources	No impacts anticipated.	Low potential to impact cultural resources. However, changes to land forms and natural resources are considered impacts to cultural resources by affected Tribal Nations.
Socioeconomic - Economy - Employment - Low-Income - Minority	No impacts anticipated.	Minor employment impacts (28 Site jobs and less than 100 Areas jobs in peak year). No other impacts.
Socioeconomic - Facilities and Services	No impacts anticipated.	No impacts anticipated.
Health Effects - Routine	No impacts anticipated to onsite workers or present or future offsite population.	No impacts anticipated to onsite workers or present or future offsite population.
Health Effects - Accidents	There would be 22 injuries and less than 1 (0.3) fatality from occupational accidents and 19 injuries and less than 1 (0.2) fatality from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be less than 1.0 (4.1E-03). The risk is based in 10 years of routine operations after which it is assumed that remedial action will be taken.	There would be 44 injuries and less than 1 (0.4) fatalities from occupational accidents and 25 injuries and less than 1 (0.3) fatality from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be less than 1.0 (5.1E-02).
Cost	$112 million	$697 million
Commitments of Resources	No new resources beyond existing demands associated with tank farm operations.	This alternative would be 530 m^3 of borrow material, 1,000 mt of steel, 6,400 m^3 of water, 4,100 m^3 of concrete and 130 GWh of electricity. All resources are within the existing capacity of the region.

Table 5.14.2 Summary of the Environmental Impacts of the Capsule Alternatives (cont'd)

Type of Impact	Overpack and Ship Alternative	Vitrify with Tank Waste Alternative
Cultural Resources	No impacts anticipated.	No impacts anticipated.
Socioeconomic - Economy - Employment - Low-Income - Minority	Minor employment impacts (28 Site jobs and less than 100 Areas jobs in peak year). No other impacts.	Minor employment impacts (47 Site jobs and 100 Areas jobs in peak year). No other impacts.
Socioeconomic - Facilities and Services	No impacts anticipated.	No impacts anticipated.
Health Effects - Routine	No impacts anticipated to onsite workers or present or future Site users or offsite population.	No impacts anticipated to onsite workers or present or future Site users or offsite population.
Health Effects - Accidents	There would be 13 injuries and less than 1 (0.008) fatality from occupational accidents and 5 injuries and less than 1 (0.06) fatality from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be less than 1.0 (5.1E-02).	There would be 13 injuries and less than 1 (0.008) fatality from occupational accidents and 5 injuries and less than 1 (0.06) fatality from transportation accidents. The number of cancer fatalities (factoring in the probability of the accident) resulting from a radiological accident during operations would be less than 1.0 (5.1E-02) and less than 1.0 (1.0E-04) from vitrified HLW transport accident (capsules are vitrified with high-level tank waste).
Cost	$587 million. This cost includes $124 million for disposal at a geologic repository.	$511 million. This cost includes $111 million for disposal at a geologic repository.
Commitments of Resources	This alternative would use 400 mt of steel, 2,300 m^3 of concrete and 0.4 GWh of electricity. All resources are within the existing capacity of the region.	This alternative would use 620 mt of steel, 23,000 m^3 of water, 3,500 m^3 of concrete and 0.7 GWh of electricity. All resources are within the existing capacity of the region.

Notes:
GWh = gigawatt-hour
m^3 = cubic meters
mt = metric tons

Borrow material excavation would leave shallow terrain depressions at the excavation sites and other land form changes such as removing portions of the exposed basalt cliffs at the potential Vernita Quarry borrow site (Section 5.1). There also would be permanent soil disturbance (loss of soil cover) at areas that would be covered with Hanford Barriers (tank farms and LAW vaults in the 200 Areas). Placing a Hanford Barrier over each of the 18 tank farms would occur under all tank waste alternatives, except for the No Action and Long-Term Management alternatives, and would cover 25 ha (62 ac). Barriers that would be placed over the LAW vaults under the Ex Situ Intermediate Separations, Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1 and 2, and Phased Implementation alternatives would cover 5 to 14 ha (12 to 35 ac).

Air Quality

Even with the implementation of additional practicable mitigation measures, all TWRS EIS alternatives would result in substantial air emissions, although no applicable air quality standards would be exceeded. Construction and operation activities of all alternatives would result in increased levels of air emissions (Section 5.3).. Construction activities would produce fugitive dust (particulates) and combustion emissions from the use of heavy equipment and motor vehicles. Operation activities would produce radionuclide emissions, combustion emissions, and hazardous air pollutants. Radionuclide emissions would include carbon-14, iodine-129, and cesium-137.

Water Resources

The vadose zone and groundwater aquifer beneath portions of the Hanford Site, including the 200 Areas, currently are contaminated at levels that exceed drinking water standards. Controls on the use of Hanford Site groundwater currently are in place and are expected to continue well into the future.

All tank waste alternatives would involve some release of waste into the currently contaminated vadose zone beneath the 200 Areas, and eventually into the underlying groundwater aquifer (Section 5.2). Under the No Action (Tank Waste) and Long-Term Management alternatives, potential contaminants released to the groundwater would result in water quality standards being exceeded for all four indicator contaminants (iodine-129, technetium-99, nitrite, and uranium-238) at 300 and 500 years into the future, but would be well within the standards at 2,500 years. This analysis assumed that the current drinking water standards would be applicable beyond 1,000 years.

All other tank waste alternatives would result in contaminant releases to the currently contaminated groundwater, although the releases would be at substantially lower levels than for the No Action and Long-Term Management alternatives. The No Action, Long-Term Management, In Situ Fill and In Situ Vitrification and Cap, Ex Situ/In Situ Combination 1 and Ex Situ/In Situ Combination 2 alternatives would exceed water quality requirements. The LAW vaults would meet water quality requirements. Residuals left in the tanks under the ex situ alternatives would not meet water quality requirements; however, the residuals would be a addressed in a future closure plan.

Land Use

Remediation activities would result in permanent land-use commitments that would range from zero for the No Action (Tank Waste) alternative to 38 ha (94 ac) for the Phased Implementation alternative. All alternatives could result in the permanent commitment of land in the 200 Areas to waste disposal uses (Section 5.7). While the TWRS alternatives' land use would be compatible with current land use and current plans for future land use of the 200 Areas, the committed areas would be inaccessible for alternative land use. The amount of land involved would be small compared to the total Central Plateau waste management area of the Hanford Site.

Transportation

All of the EIS alternatives would involve additional motor vehicle traffic, mostly from employees commuting to and from TWRS sites. For all tank waste alternatives except No Action, Long-Term Management, and In Situ Fill and Cap, there would be increased traffic congestion during daytime peak hours on Stevens Road north of Richland and on Route 4 west of the Wye Barricade (Section 5.10). This congestion would occur during the peak employment periods (2001 to 2004 for most alternatives), largely associated with construction activities, and would last for several years (Section 5.10). The various ex situ alternatives would involve the largest traffic volumes and thus would have the greatest potential adverse impacts.

Noise

Because the TWRS sites would be located in the interior of the Hanford Site and would be a long distance from populated offsite areas, the only unavoidable adverse noise impact would be temporary wildlife disturbances near construction sites from heavy equipment use (Section 5.9).

Visual Resources

As described in Section 5.8, constructing facilities and performing borrow site excavation activities under all tank waste alternatives, except No Action and Long-Term Management, would affect the visual environment, particularly from elevated locations onsite (e.g., Gable Mountain, Gable Butte, and Rattlesnake Mountain that are used by Native Americans for religious purposes) and from State Route 24 near the potential Vernita Quarry and McGee Ranch borrow sites. From ground level, the In Situ Vitrification alternative would involve constructing large tank farm confinement structures that would be somewhat visually intrusive for travelers on State Route 240. Facilities developed in the 200 East Area under all alternatives would be visible in the distant background from State Route 240 and from offsite elevated locations.

Biological and Ecological Resources

All tank waste alternatives, except No Action, would affect shrub-steppe habitat in the 200 Areas and at least one of the three potential borrow sites (Vernita Quarry, McGee Ranch, and Pit 30) (Section 5.4). Shrub-steppe is a habitat that is defined as a priority habitat by Washington State. In the affected shrub-steppe habitat areas, there would be a loss of plants, loss or displacement of wildlife species (e.g., birds, small mammals), and a resulting loss of food supplies for birds of prey and predatory mammals.

A small percentage (less than one-half of 1 percent) of the Hanford Site's total shrub-steppe area would be affected, and only individual species members potentially would be impacted, rather than the species as a whole. However, a number of plant and wildlife species of concern (species that are classified as candidates for listing as threatened or endangered, or as State monitor or sensitive species) potentially would be affected.

Cultural Resources

Prehistoric and historic materials and sites in the 200 Areas are scarce and the TWRS sites currently are heavily disturbed (the 18 tank farms) or partly disturbed (the proposed waste treatment facility sites). The potential Vernita Quarry and McGee Ranch borrow sites are considered potentially sensitive for both prehistoric and historic sites (Section 5.5). Important prehistoric sites may be encountered at Vernita Quarry and McGee Ranch, both of which potentially would be used during closure activities for all tank waste alternatives except the No Action and Long-Term Management alternatives.

Socioeconomics

All of the tank waste alternatives, except No Action, Long-Term Management, and In Situ Fill and Cap, would involve short-term socioeconomic impacts that would stem largely from rapid fluctuations in employment during construction (Section 5.6). These short-term impacts would be greatest for the Ex Situ Extensive Separations, Ex Situ No Separations, and Phased Implementation alternatives. For example, increased housing prices stemming from rapid increases in local population could have particularly adverse impacts on the access to affordable housing by low-income populations in the Tri-Cities. The increases in local population also would require hiring additional local police and fire department personnel and also would lead to increased enrollment in local schools.

Health Effects

The No Action (Tank Waste) alternative followed closely by the Long-Term Management alternative, would pose the highest post-remediation cancer risk of all the tank waste alternatives. For the No Action (Tank Waste) alternative, maximum cancer risks would be 1 in 1 for the Native American and the residential farmer respectively, at 300 years after 1995, resulting in 3,300 and 600 fatalities over 10,000 years. The In Situ Vitrification alternative would result in the lowest cancer risk of the various alternatives, with a 1 in 1,700 and 1 in 40,000 risk for the Native American and the residential farmer respectively, at 5,000 years from 1995 resulting in 3 and 1 fatalities over 10,000 years.

All alternatives would pose some risks of adverse health effects. The risks during remediation would be limited mainly to workers, with the greatest risk associated with onsite transportation of waste and separations and treatment operations. The Ex Situ No Separations, Ex Situ Intermediate Separations, and Phased Implementation alternatives would have the highest fatal cancer risk to onsite remediation workers. The other ex situ alternatives would have similar lower risks to workers, while the in situ alternatives would have the lowest risk of all alternatives (Section 5.11). These higher risks would be largely the product of the substantially higher number of person-years of labor required for retrieval, treatment, and disposal of an assumed 99 percent of the tank waste.

Accidents

All alternatives would involve potential accidents. This would include occupational and transportation accidents, both onsite and offsite, that could cause injuries, illness, and a small number of fatalities (mostly from traffic accidents). These types of injuries, illnesses, and fatalities would be directly dependent on the number of person-years of labor required to complete the alternative. Thus, the more

person-years of labor the more injuries, illnesses, and fatalities. As described in Section 5.12, the Long-Term Management alternative would result in the largest and the In Situ Fill and Cap alternative the fewest total number of occupational injuries and illnesses (Section 5.12).

For all of the tank waste alternatives the number of cancer fatalities (factoring in the probability of the accident occurring) resulting from a radiological accident during operations would range from 2 (In Fill and Cap alternative) to 16 (No Action and Long-Term Management alternatives).

There also could be accidents resulting in exposure to hazardous chemicals. The various ex situ alternatives and the Ex Situ/In Situ Combination 1 and 2 alternatives would have higher hazardous chemical risks onsite and offsite than would the In Situ Vitrification, No Action, or Long-Term Management alternatives. The higher risk would be because of the greater extent of waste retrieval and treatment under these alternatives.

Cost

Financial resource commitments would range from a low of $7.0 to 8.8 billion for the In Situ Fill and Cap alternative to a maximum of $59.2 to 74.5 billion for the Ex Situ No Separations alternative.

Commitment of Resources

All of the tank waste alternatives would consume water, concrete (except No Action), and electricity; all except No Action would use borrow materials; all would use steel (except In Situ Fill and Cap); all ex situ alternatives and the In Situ Vitrification alternative would consume process chemicals. The No Action, Long-Term Management, and In Situ Fill and Cap alternatives would not use any process chemicals. The largest consumption of earthen borrow materials would occur under the Ex Situ No Separations (Vitrification) alternative; the greatest water consumption would be under the In Situ Vitrification alternative; and the greatest consumption of electricity would be under the Ex Situ Extensive Separations alternative. Although all of these resource consumption impacts would be within existing capacity, the resources would be unavailable for alternative uses.

5.14.3 Unavoidable Adverse Impacts for Capsule Alternatives

The unavoidable adverse impacts of the capsule alternatives identified in Table 5.14.2 are summarized in the following text.

Geology and Soil

A small area of soil would be permanently disturbed by the Onsite Disposal alternative. Other capsule alternatives would have no permanent impacts on .

Air Quality

Low levels of emissions of particulates, sulfur oxides, carbon monoxide, and nitrogen dioxides would occur during construction of facilities associated with all capsule alternatives except the No Action (Capsules) alternative. All construction phase and operations phase emissions would be within air quality standards.

Water Resources
No surface water or groundwater impacts would be expected for any of the capsule alternatives. Onsite Disposal would be the only alternative with potential to impact groundwater, but cesium and strontium would decay to nonhazardous progeny before any potential groundwater impacts could occur.

Land Use
Only the No Action and Onsite Disposal capsule alternatives would result in permanent commitment of land. The areas disturbed would be small, less than 2 ha (5 ac). The area impacted in both cases, however, would be within the 200 Areas and presently is designated for waste management.

Transportation
An increase in vehicular traffic of less than 50 vehicles per day during the morning commute would be expected for all capsule alternatives. These traffic volumes would not adversely impact traffic conditions on any transportation route.

Noise
None of the capsule alternatives would produce substantial onsite or offsite noise impacts. Noise levels would not exceed standards for any of the capsule alternatives.

Biological and Ecological Resources
Virtually all capsule alternative's activities would occur in currently disturbed areas. Minimal impacts would be expected from all alternatives except Onsite Disposal. Onsite Disposal would lead to a maximum loss of 1.8 ha (4.5 ac) of shrub-steppe habitat.

Cultural Resources
There would be a small potential to impact cultural sites during construction of the Onsite Disposal alternative's storage facility. Because the storage facility would be located in an currently disturbed area, the potential impacts would be small.

Socioeconomics
Small employment impacts would result from implementation of any capsule alternative. The greatest impact would be from the Vitrify with Tank Waste alternative, with peak year employment of less than 50 Site jobs and 100 total nonfarm jobs in the Tri-Cities. No adverse socioeconomics impacts would be expected for any capsules alternative.

Visual Resources
No offsite impacts to visual resources are anticipated for any capsule alternative.

Health Effects
No adverse health effects are anticipated for any of the capsule alternatives.

Accidents

For all alternatives, a relatively small number of occupational and transportation accidents would result in injury or illness. The Onsite Disposal alternative would have the highest potential for accidents among capsule alternatives. Injuries and illnesses resulting from occupational and transportation accidents would range from 18 for the Overpack and Ship and Vitrify with Tank Waste alternatives to 69 for the Onsite Disposal alternative.

Cost

Financial resource commitment would range from a low of $112 million for the No Action (Capsules) alternative to a high of $697 million for the Onsite Disposal alternative.

Commitment of Resources

The Onsite Disposal and Overpack and Ship alternatives would result in the consumption of water, concrete, and electricity. The Onsite Disposal alternative would result in the greatest consumption of electricity while the Overpack and Ship alternative would result in the greatest consumption of water. None of the alternatives would result in demands for resources that would adversely impact resource availability or cost.

5.15 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

For this EIS, short-term was considered the period of the EIS alternatives' construction and operation phases (scheduled to be completed by 2028) and the monitoring and maintenance phase that would continue throughout the 100-year institutional control period. Most short-term environmental impacts would occur during the construction and operations phases of each alternative. Under the No Action and Long-Term Management tank waste alternatives, the tank waste in their current form would be managed for 100 years. For this EIS, long-term referred to the period after the end of the 100-year institutional control period. This section describes both the natural environment (e.g., air, water, and biological resources) and the human environment (e.g., employment, population, public facilities, and services issues).

Short-Term Versus Long-Term Impacts

Impacts addressed in this section include:

- Short-term impacts to the natural and human environment (Section 5.15.1); and
- Long-term impacts to the natural and human environment (Section 5.15.2).

5.15.1 Short-Term Impacts

For all tank waste alternatives except No Action, there would be increased air emissions and noise, solid and liquid waste generation, and increased risks of accidents and illness, primarily to workers involved in implementing the alternatives. The ex situ alternatives, including the Ex Situ/In Situ Combination 1 and Ex Situ/In Situ Combination 2 alternatives would involve more accidents than the in situ alternatives, mostly industrial and transportation accidents. The No Action and Long-Term Management alternatives would involve nearly the same number of accidents as the ex situ alternatives

because their operations would last 100 years, by far the longest of all the tank waste alternatives. The No Action and Long-Term Management alternatives would be expected to lead to the highest number of latent cancer fatalities of 16 (factoring in the probability of the accident); Phased Implementation would have 5; Ex Situ Intermediate Separations, Ex Situ No Separations, Ex Situ Extensive Separations, Ex Situ/In Situ Combination 1 and Ex Situ/In Situ Combination 2 alternatives would have 4 latent cancer fatalities; In Situ Vitrification alternative would have 3 latent cancer fatalities; and In Situ Fill and Cap alternative would have 2 latent cancer fatalities. All alternatives would consume both natural and human-made resources (e.g., fuels, concrete, steel, and chemicals), but none of the alternatives would be expected to cause shortages or price increases as a result of their resource consumption.

Over the short-term, land areas would be committed to EIS alternatives' activities. This would affect biological resources under all tank waste alternatives except No Action, because shrub-steppe habitat would be disturbed. A portion of the areas that would be affected by the EIS alternatives currently is disturbed (e.g., the tank farms and parts of the proposed waste treatment facilities sites for the various ex situ alternatives and the Phased Implementation alternative). Access and uses for other purposes would be restricted, while these areas are being used for the EIS alternatives' construction and operation. Access to these areas has been restricted since the early 1940's.

The various ex situ alternatives, Phased Implementation, and Ex Situ/In Situ Combination 1 and 2 alternatives would have relatively similar short-term land requirements and biological resources impacts in the same areas of the Hanford Site. The in situ alternatives would have smaller land requirements because no large TWRS waste processing facility sites would be required. However, the In Situ Vitrification alternative would require a new power line transmission corridor development dispersed through the 200 Areas, and thus land-use impacts would be more dispersed.

With respect to effluents, emissions, and land requirements, the No Action (Tank Waste) and Long-Term Management alternatives would have the fewest short-term natural environment impacts of any of the tank waste alternatives because they would involve the lowest activity levels during both construction and operation. Effluents, emissions, biological impacts, and health effects of the various action alternatives would be fairly similar to each other.

In terms of the human environment, all of the EIS alternatives would involve the expenditure of Federal funds in the Tri-Cities. There would be increased employment and economic activity associated with these expenditures. This would result in increased population and population growth impacts such as increased traffic, impacts on the price and availability of housing, and impacts on public facilities such as schools. For all tank waste alternatives except No Action, Long-Term Management and Phased Implementation, the largest impacts would occur in the early period of the project, before 2010.

The impacts on the human environment of the EIS alternatives would be driven largely by their levels of employment. Because they would involve the least number of jobs, the In Situ Fill and Cap, No Action, and Long-Term Management tank waste alternatives would have the least short-term

impacts. The No Action and Long-Term Management alternatives would have the longest lasting and most stable employment and related impacts because they would last for 100 years, whereas the other alternatives would be complete in approximately 30 years.

The Phased Implementation, Ex Situ Extensive Separations and Ex Situ No Separations alternatives would have the most intense short-term impacts on the human environment because they would have the sharpest short-term fluctuations in employment, population, and associated impacts on public services. Rapid growth in employment and population that drops off sharply, such as would be the case with these alternatives' construction phases particularly, can cause socioeconomic disruption as well as economic benefits. The Ex Situ Intermediate Separations, Ex Situ/In Situ Combination 1, Ex Situ/In Situ Combination 2, and In Situ Vitrification alternatives would have somewhat less intense construction phases, which would allow for better planning to accommodate the impacts of both increases and subsequent decreases in employment construction and operation. Effluents, emissions, and risks of the various action alternatives would be similar to each other.

5.15.2 Long-Term Impacts

The long-term impacts on the natural environment of the EIS alternatives would be related in large part to how much waste remained on the Hanford Site after the alternatives were fully implemented, and how much of the remaining waste had been treated (vitrified) or left untreated. Future decisions on the ultimate closure of the tank farms that are beyond the scope of this EIS would have an effect on long-term impact issues. The long-term impacts of the EIS alternatives also must be considered in the context of decisions to be made concerning other contamination in the 200 Areas that is unrelated to the waste tanks or capsules, such as from the large 200 Areas processing facilities. Regardless of which EIS alternative is selected, the vicinity of the tank farms and proposed tank waste treatment facilities still would be contaminated. This would affect long-term health risks and future land uses of the 200 Areas, which would be the primary areas of long-term impacts associated with the EIS alternatives.

The tank waste No Action and Long-Term Management alternatives would leave the waste totally unremediated. The capsules No Action alternative would have the same effect. The No Action, Long-Term Management and In Situ Fill and Cap alternatives would have the largest long-term health risk impacts of any of the EIS alternatives because contaminants would be released from the tanks into the groundwater at levels that would exceed drinking water standards and pose substantial health risks to future Site users. The tank farms would be permanently committed to waste management use, preventing use of the land for alternative purposes. Future users of the Hanford Site lands (Native Americans, residential farmers, workers, or recreational users) potentially would experience increased health risks over a time period extending thousands of years into the future.

All of the other EIS alternatives also would permanently commit small amounts of land to waste disposal use at the tank farms, and in some cases at waste treatment facility sites or onsite LAW vaults. The maximum permanent land commitment for remediation activities would be 38 ha (94 ac) for the Phased Implementation alternative. The permanently committed lands would be unavailable for alternative uses.

The alternatives also would have potential small long-term health effects on future Hanford Site users because of eventual contaminant release to the groundwater. However, these impacts would be fewer and further in the future than under the No Action, Long-Term Management, and In Situ Fill and Cap alternatives. Impacts would be fewer because less contamination would remain onsite and untreated. The Ex Situ/In Situ Combination 1 and Ex Situ/In Situ Combination 2 alternatives would leave the tank waste onsite and untreated. These two alternatives would have higher long-term health risks than the ex situ, Phased Implementation, or In Situ Vitrification alternatives, although risks would be lower than for the No Action or Long-Term Management. The In Situ Vitrification alternative would have the lowest long-term health effect potential of any of the EIS alternatives. The ranking of tank waste alternatives from greatest to lowest total health effect for the entire 10,000 years for the residential farmer scenario would be: No Action, Long-Term Management, In Situ Fill and Cap, Ex Situ/In Situ Combination 1, Ex Situ/In Situ Combination 2, Ex Situ Intermediate Separations, Phased Implementation, Ex Situ Extensive Separations, Ex Situ No Separations, and In Situ Vitrification. Only the No Action, Long-Term Management, and In Situ Fill and Cap alternatives would have long-term health effects for the future downriver user of the Columbia River.

In terms of long-term human environment impacts, all of the tank waste alternatives except No Action and Long-Term Management would have similar and negligible impacts because there would be no long-term employment following the loss of institutional control in 100 years. For No Action and Long-Term Management, a post-remediation accident would result in fatalities. Also, under all disposal alternatives, post-remediation intrusion into waste remaining onsite would be highest for all alternatives that dispose of all or portions of the HLW onsite.

5.16 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The alternatives for managing, treating, and disposing of the Hanford Site tank waste and cesium and strontium capsules would involve the irreversible and irretrievable commitment of land, energy, materials, and financial resources. Table 5.16.1 presents a summary of resource commitments for the tank waste and capsule alternatives. More detailed comparisons of resource commitments are provided in Volume Two, Appendix B.

Depending on the alternative, managing, treating, and disposing of the Hanford Site tank waste could result in the permanent commitment of up to 49 ha (120 ac) of land, 3.3E+04 gigawatts-hours (GWh) of electric energy consumption, 1.2E+07 m^3 (1.7E+07 yd^3) of borrow materials, 1.7E+11 L (4.5E+10 gal) of water, and 4.4E+05 metric tons (mt) (4.8E+05 tons) of steel. Although large quantities of resources would be required, the quantities used would not cause substantial impacts to the availability or cost of these resources to other potential users. The cost of implementing the tank waste alternatives could be from $7.9 to 62.5 billion, which would represent an irretrievable commitment of financial resources. The $62.5 billion cost would be for the Ex Situ No Separations alternative and would include $38.9 billion for HLW disposal at a geologic repository.

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Resources that would be committed for the capsule alternatives would constitute only a small fraction of the resources required for tank waste alternatives. For example, land commitments would not exceed 2 ha (5 ac) and cost would not exceed $697 million.

Table 5.16.1 Irreversible and Irretrievable Commitment of Resources

	Land Permanently Committed (hectares)		Sand, Gravel, Silt, and Rip Rap (cubic meters)		Steel (metric tons)	Stainless and Alloy Steel (metric tons)	Concrete (cubic meters)
Tank Waste	**Remediation**	**Total**	**Remediation**	**Total**			
No Action	0	17	N/A	N/A	1.0E+03	NA	N/A
Long-Term Management	8	25	3.8E+05	3.8E+05	1.4E+04	2.2E+01	3.5E+05
In Situ Fill and Cap	17	25	7.5E+05	2.2E+06	N/A	NA	1.9E+04
In Situ Vitrification	17	25	6.8E+05	2.1E+06	2.6E+05	NA	1.3E+05
Ex Situ Intermediate Separations	35	46	1.7E+06	3.9E+06	2.7E+05	3.5E+04	1.04E+06
Ex Situ No Separations:							
Vitrification	20	28	2.9E+06	5.2E+06	2.6E+05	1.8E+05	2.8E+06
Calcination	20	28	1.3E+06	3.6E+06	1.3E+05	7.3E+04	1.3E+06
Ex Situ Extensive Separations	33	44	9.5E+05	1.2E+07	3.0E+05	2.3E+04	9.1E+05
Ex Situ/In Situ Combination 1	31	41	1.0E+06	3.2E+06	1.5E+05	2.0E+04	5.8E+05
Ex Situ/In Situ Combination 2	25	34	1.0E+06	2.8E+06	9.7E+04	1.3E+04	3.8E+05
Phased Implementation (Phase 1)	0	0	3.2E+04	3.2E+04	8.6E+04	1.6E+04	3.0E+04
Phased Implementation (Total Alternative)	38	49	1.2E+06	4.1E+06	3.0E+05	4.1E+04	1.1E+06
Capsules							
No Action	1	1	N/A	N/A	N/A	N/A	N/A
Onsite Disposal	2	2	530	530	1,000	23	4,100
Overpack and Ship	N/A	N/A	N/A	N/A	380	20	2,300
Vitrify with Tank Waste	N/A	N/A	N/A	N/A	600	20	3,500

Table 5.16.1 Irreversible and Irretrievable Commitment of Resources (cont'd)

	Total Water Usage (cubic meters)	Electric Power (GWh)	Gasoline (cubic meters)	Diesel (cubic meters)	Kerosene (cubic meters)	Process Chemicals (metric tons)	Cost [1] Range (Billions of 1995 Dollars)
Tank Waste							
No Action	1.5E+06	1.1E+03	N/A	2.2E+04	NA	NA	12.6 - 16.1
Long-Term Management	1.5E+06	1.1E+03	8.6E+04	8.5E+04	NA	NA	19.0 - 23.2
In Situ Fill and Cap	2.4E+06	9.5E+02	4.0E+02	6.0E+04	NA	NA	7.0 - 8.8
In Situ Vitrification	1.7E+08	4.5E+03	1.5E+04	7.1E+04	NA	1.8E+04	15.9-27.4
Ex Situ Intermediate Separations	1.9E+07	1.1E+04	8.1E+03	9.6E+04	6.6E+04	9.9E+05	29.0 - 35.1
Ex Situ No Separations: Vitrification	4.1E+06	7.1E+03	5.4E+03	6.6E+04	8.5E+04	7.2E+05	59.2 - 74.5
calcination	2.5E+06	4.7E+03	5.4E+03	6.5E+04	1.1E+04	3.1E+06	35.2 - 42.5
Ex Situ Extensive Separations	6.7E+07	3.3E+04	1.0E+04	1.1E+05	1.9E+05	1.9E+06	27.2 - 37.7
Ex Situ/In Situ Combination 1	1.3E+07	1.0E+04	5.3E+03	9.9E+04	4.0E+04	6.0E+05	22.1 - 27.0
Ex Situ/In Situ Combination 2	7.4E+06	7.6E+03	3.6E+03	7.8E+04	2.3E+04	3.5E+05	16.6 - 19.9
Phased Implementation (Phase 1)	2.8E+06	1.7E+03	6.5E+03	1.8E+04	9.8E+02	1.8E+05	7.3 - 9.6
Phased Implementation (Total Alternative)	1.9E+07	1.1E+04	1.1E+04	1.1E+05	6.5E+04	9.8E+05	30.4 - 38.1
Capsules							
No Action	6.0E+03	0.4	N/A	N/A	N/A	N/A	112
Onsite Disposal	6.4E+03	130	200	2.6	N/A	N/A	697
Overpack and Ship	1.5E+04	0.4	50	2.6	N/A	N/A	587
Vitrify with Tank Waste	2.3E+04	0.7	50	2.6	N/A	N/A	511

Notes:
[1] Total estimated cost range including repository fee where applicable. Section 3.4 and 3.7 contains additional information and estimated cost ranges for the alternatives.
GWh = Gigawatt-hours
N/A = Not applicable
N/R = Not reported

5.17 CONFLICTS BETWEEN THE PROPOSED ACTION AND THE OBJECTIVES OF FEDERAL, REGIONAL, STATE, LOCAL, AND TRIBAL LAND-USE PLANS, POLICIES OR CONTROLS

This section describes the possible conflicts between the various EIS alternatives and Federal, State, local, government, and Tribal plans and policies. Additional analyses of land-use issues are included in Sections 4.7 and 5.7.

All EIS alternatives would include a combination of land uses including waste management; processing; and treatment, storage, and disposal. The Hanford Site Development Plan is the only currently available land-use planning document until the Comprehensive Land-Use Plan is finalized in 1997 (Section 5.7). The Hanford Site Development Plan identifies Waste Operations and Research and Development as the only allowable uses within and between the 200 East and 200 West Areas (DOE 1993e). The EIS alternatives are thus consistent with the planned land uses for the 200 Areas, based on the available Hanford Site land-use planning documents.

The current and planned land uses designated by the Hanford Site Development Plan for areas surrounding the 200 Areas include the categories of Research and Development and Undeveloped Area. The Research and Development land-use category includes scientific and engineering technology development for irradiated waste, while the Undeveloped Area provides a transitional land use and buffer between the Waste Operations and other more sensitive use areas. Industrial and waste management uses have occurred in the 200 Areas and surrounding areas for over 40 years without land-use conflicts. Thus, all proposed EIS alternatives' activities in the 200 Areas would be compatible with the currently available Federal land-use plans for the Hanford Site.

The potential Vernita Quarry and McGee Ranch borrow sites are in areas identified as Undeveloped on the Hanford Site Development Plan's Future Land-Use Map (Figure 5.7.1). Use of the Vernita Quarry for the EIS alternatives would involve expanding an existing quarry, while McGee Ranch essentially would be newly developed as a borrow site (although one small, old borrow area exists at the McGee Ranch). The Washington State Department of Fish and Wildlife has asked DOE to preserve the McGee Ranch area as a wildlife corridor (Baker 1996). Planning for possible borrow sites for the TWRS program is still in its early stages, and will be addressed in future NEPA analysis.

As described in Section 4.7 and 5.7, there are various wildlife and recreational land uses that exist and are planned or proposed on and near the Hanford Site (e.g., the Fitzner Eberhardt Arid Lands Ecology Reserve and the proposed Wild and Scenic River designation for the Hanford Reach of the Columbia River). None of the EIS alternatives would impact proposed uses of those wildlife and recreational areas, and thus the alternatives are consistent with the land-use plans and policies that apply to the wildlife and recreational use areas.

5.17.1 State and Local Plans and Policies

The two local jurisdictions most directly concerned with Hanford Site land uses are Benton County, which contains the majority of the Hanford Site, and the city of Richland, which is located immediately adjacent to the Hanford Site and is in the process of annexing portions of the Hanford Site's 1100 Area.

Benton County is in the process of updating its comprehensive plan. This update will include a separate Hanford Comprehensive Plan that is expected to be compatible with the overall county plan, although this cannot be certain until the plan is released. Although all EIS alternatives involve uses compatible with the current DOE land uses of the 200 Areas, and with DOE's currently available land-use planning documents, it is not possible to evaluate compatibility with Benton County's land-use plans until the county's Hanford Comprehensive Plan is adopted. Adoption of the plan by Benton County Commissioners is expected by the end of 1996 (Fyall 1996).

The county's Draft Hanford Comprehensive Plan classifies the potential Vernita Quarry borrow site as Area Three (preservation area), where essentially no development activity would be allowed. The McGee Ranch is classified as Area Two (multiple-use, onsite mitigation), where development activity would be allowed only with mitigation of environmental (mainly habitat) effects on the site. The Washington State Department of Fish and Wildlife has asked Benton County to designate McGee Ranch as a critical area (preservation area) (McConnaughey 1996, a). The 200 Areas, where most TWRS activities would occur under all alternatives, is classified as Area One (multiple-use, offsite mitigation), where development would be allowed with mitigation offsite (Fyall 1996)

The city of Richland also is currently updating its comprehensive plan. Richland's planning encompasses only the southern areas of the Site that are within the city's 20-year growth boundary. The plan is expected to call for expanding industrial and research and development uses in areas adjacent to the Hanford Site. There would be no conflict between this planned land use and the activities of any EIS alternatives. No other local jurisdiction's land-use plans or policies would be affected by any of the EIS alternatives.

5.17.2 Tribal Nation Plans and Policies

Land-use conflict issues related to Tribal Nation concerns are described in Sections 5.5 and 5.19.

5.18 POLLUTION PREVENTION

Consistent with overall national policy (e.g., the Pollution Prevention Act of 1990), and specific DOE guidance (DOE Order 5400.1), Hanford Site programs are directed to incorporate pollution prevention into their planning and implementation activities. This includes reducing the quantity and toxicity of hazardous, radioactive, mixed, and sanitary waste generated at the Hanford Site; incorporating waste recycle and reuse into program planning and implementation; and conserving resources and energy. Guidelines are contained in the Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan (WHC 1995c). The major elements of the program are 1) establishing management support; 2) identifying and implementing pollution-prevention opportunities through a systematic assessment process; 3) setting and measuring the progress of waste reduction goals; 4) developing

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waste generation baseline and tracking systems; 5) creating employee awareness, training, and incentives programs; 6) championing Sitewide pollution prevention initiatives; and 7) supporting technology transfer, information exchange, and public outreach.

The TWRS alternatives are still in the early conceptual stages of the engineering and design process. To comply with the pollution prevention requirements outlined in the previous paragraphs, opportunities to reduce waste generation at the source, as well as for materials recycle and reuse, will be sought and incorporated into the engineering and design process for the selected alternative. Examples of pollution prevention and waste minimization concepts that have been incorporated into the EIS alternatives include the following.

- For solvent extraction operations included in the Ex Situ Extensive Separations alternative, evaporation steps downstream of the process would recover solvents from aqueous streams that came in with contact organic solvents. When evaporator condensate contained solvent, the condensate would be sent to a decanter and the recovered solvent would be recycled to the solvent extraction system.
- The ex situ alternatives' melter off-gas treatment system would recycle excess condensate to the LAW feed evaporator for re-evaporation. Scrubbed melter off-gases then would be processed to recover sulfur dioxide, which would be converted to elemental sulfur and returned to the process.
- The Ex Situ Extensive Separations alternative would use a calcination process to allow the recovery and recycle of sodium hydroxide. Nitric acid would be recovered from the HLW denitrification processes and during various evaporation steps.
- Minimizing the use of water in retrieving waste from SSTs would prevent additional leakage of contaminants and reduce the volume of material sent to the TWRS evaporators. The retrieval system would be designed to use the absolute minimum liquid necessary to remove tank solids.
- All ex situ alternatives would use metal high-efficiency particulate air filters that would be recyclable rather than filters that were not reusable.

Energy conservation for each of the alternatives would be achieved primarily in three areas: process configuration, mechanical design, and electrical design. Energy conservation would be maximized by incorporating it into the process and facility design from the outset. Where possible, the process would be configured to conserve energy by using heat exchangers so the hot exit streams could heat cool incoming streams, which would conserve heating energy. Where cooling of process streams would be required, maximum use of cooling water would be employed, which would minimize the amount of refrigeration cooling to be used. Mechanical design would employ energy efficient compressors, pumps, and fans. Ducting would be designed for minimum pressure drop. Facilities would employ energy-efficient insulation and reflective panels where appropriate. Air conditioning systems would make efficient use of outside air. Electrical design would employ energy efficient electrical motors and actuators. The electrical power factor for the system would be maintained in balance, and capacitors would be used where required. Accurate electrical power metering of each system would indicate the

major power consumers and give warning of unusually high energy consumption. This would allow corrective measures to be taken promptly.

5.19 ENVIRONMENTAL JUSTICE

Based on the 1990 census, the 80-km (50-mi) area surrounding the Hanford Site had a total 1990 minority population of 86,400 and a low-income population of 77,700. Hispanics residing predominantly in Franklin, Yakima, Grant, and Adams counties are the area's principal minority group. Native Americans reside principally on the Yakama Indian Reservation. The area's low-income population is dispersed throughout the 80-km (50-mi) region with the highest concentrations occurring in Franklin, Yakima, Grant, and Adams counties. Section 4.6.1 describes minority and Native American populations and low-income populations residing in the 80-km (50-mi) radius of the Hanford Site. Additional information regarding minority and Native American populations and low-income populations is provided in Volume Five, Appendix I.

For each of the areas of technical analysis presented in the EIS, a review of impacts to the human and natural environment was conducted to determine if any potentially disproportionate and adverse impacts on minority populations or low-income populations would occur. The review included potential impacts on land use, socioeconomics (e.g., employment, housing prices, public facilities, and services), water quality, air quality, health effects, accidents, and biological and cultural resources. For each of the areas of analysis, impacts were reviewed to determine if there were any potential disproportionate and adverse impacts to the surrounding population that would occur due to construction, routine operations, or accident conditions. If an adverse impact was identified, a determination was made as to whether minority populations or low-income populations would be disproportionately affected. The results of the review are presented in Table 5.19.1.

For the purposes of this EIS, disproportionate impacts are defined as impacts that would affect minority and Native American populations or low-income populations at levels appreciably greater than their effects on nonminority populations or non-low-income populations. Adverse impacts are defined as negative changes to the existing conditions in the natural environment (e.g., land, air, water, wildlife, vegetation) or in the human environment (e.g., employment, health, land use).

During consultation with affected Tribal Nations, representatives of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation expressed the view that impacts associated with all of the in situ and ex situ alternatives may adversely impact the cultural values of affected Tribal Nations to the extent that they involve disturbance or destruction of ecological and biological resources, alter land forms, or pose a noise or visual impact to sacred sites. The level of impact to cultural values associated with natural resources would be proportional to the amount of land disturbed under each of the alternatives.

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Table 5.19.1 Environmental Justice Impact Analysis

Area of Analysis	Potential Disproportionate and Adverse Impact Identified	Alternative(s) for Which a Potentially Disproportionate and Adverse Impact was Identified
Land Use (Section 5.7 and Cultural Resources in this table)	None identified.	All alternatives are consistent with existing Federal, State, and local government land-use plans for use of the Central Plateau as a waste management area.
Socioeconomics - Employment - Housing - Public Services (Section 5.6)	Potential increases in housing prices could adversely impact access to affordable housing by low-income populations.	All alternatives, except No Action, Long-Term Management, and the In Situ Fill and Cap could have a disproportionate, significant, or adverse impact. Low-income populations in Benton and Franklin counties potentially would be impacted.
Water Quality (Section 5.2)	None identified.	None of the alternatives would have groundwater quality or surface water quality impacts that would disproportionately impact low-income communities or minority communities.
Air Quality (Section 5.3)	None identified.	None of the alternatives would have air quality impacts that would disproportionately impact low-income communities or minority communities.
Health Effects (Section 5.11)	None identified.	All of the alternatives would have small offsite health impacts; however, the impacts would not disproportionately impact low-income communities or minority communities.
Potential Accidents (Section 5.12)	None identified.	All alternatives would have no accident impacts associated with routine operations, remediation, or post-remediation that would disproportionately impact low-income communities or minority communities.
Cultural Resources (Section 5.5)	Tribal Nation member access to relatively small portions of the Hanford Site would continue to be restricted.	All alternatives would require continuing access restrictions to portions of the 200 Areas.
Biological and Ecological Resources (Section 5.4)	None identified.	All alternatives would have no biological or ecological impacts that would affect offsite populations, and hence would not disproportionately impact low-income communities or minority communities.
Visual and Noise (Sections 5.8 and 5.9)	Tribal Nation cultural use of Gable Mountain and Rattlesnake Mountain would be diminished by changes to landforms and construction of facilities.	Impacts would be adverse but would not be disproportionately high because impacts would occur in areas already visually disturbed.

Changes to land forms would result from the construction of barriers over the tank farms and LAW vaults. However, barriers would be constructed only under closure of the tank farms, which is outside the scope of this EIS. These disturbances would largely occur in areas already disturbed and would only be visible from locations such as Gable Mountain, Gable Butte, and Rattlesnake Mountain, which are sacred sites of the affected Tribal Nations. Additionally, facilities constructed under most of the alternatives would also be visible from these sacred sites. The facilities would be constructed in areas that already include several facilities of similar size and general configuration. Noise associated with construction and operation of the TWRS facilities would likely have very minor, if any, potential to impact Gable Mountain.

Under all of the alternatives, there would be no disproportionately high and adverse impacts to human health during routine operations or under accident scenarios, with the exception of a potential impact to Gable Mountain resulting from deposition of contaminants under certain accident scenarios. Such an accident is very unlikely to occur but could result in a limitation of cultural and religious practices on Gable Mountain until mitigation actions could be implemented to remediate any potential risks to human health. Under all other scenarios, there would be no risks to human health to existing populations from continued access to sacred sites and hence no disproportionately high or adverse impacts to minority, Native American, or low-income populations. However, the EIS does analyze potential post-remediation risks under various land-use scenarios. This assessment of risk indicates that under the closure scenario analyzed in the EIS for purpose of comparison of alternatives, post-remediation risks would exist under all land-use scenarios and that risks would be highest under the Native American scenario. Because closure is outside the scope of the TWRS EIS, future NEPA documentation will address risks associated with various closure alternatives. This analysis would be required to determine if any particular closure alternative would represent a disproportionately high and adverse impact on minority, Native American, or low-income populations. However, implementation of the No Action, Long-Term Management, In Situ Fill and Cap, In Situ Vitrification, and the In Situ portions of the Ex Situ/In Situ Combination 1 and 2 alternatives would preclude clean closure or modified clean closure of some or all of the tanks. For these alternatives, except for In Situ Vitrification, post-remediation health risks under the Native American scenario would be disproportionately high for Native American users of the site. Risk would be three to four times higher than under the future Site land uses analyzed. For the In Situ Vitrification alternative, risks would not be disproportionately high compared to risks under other land-use scenarios. For the alternatives involving extensive waste retrieval, the ex situ alternatives closure options that would reduce risks beyond those presented in the EIS would not be precluded. Therefore, future NEPA analysis of closure alternatives would address risks associated with various closure alternatives and potential disproportionate and adverse impacts.

Under all tank waste alternatives except the No Action and Long-Term Management alternatives, the result of implementing the alternative would be to lessen overall potential impacts to the human and natural environment resulting from future releases of tank waste into the environment. If tank waste is not stabilized and isolated (the in situ alternatives) or retrieved, immobilized, and disposed of (the ex situ alternatives), releases to the environment would pose long-term risks to biological and ecological

resources and human health based on the analysis provided in Sections 5.4, 5.11, and 5.12 and Appendices D (Volume Three) and E (Volume Four). Therefore, actions to manage and dispose of tank waste would result in an overall beneficial impact to the environment compared to existing conditions or conditions that would exist in the future should no action be implemented.

Two areas of potentially disproportionate and adverse impacts on minority and Native American populations or low-income populations were identified. These impacts include 1) potential increases in housing prices that could adversely impact access to affordable housing by low-income populations; and 2) continued restrictions on access to portions of the 200 Areas that could restrict access to the 200 Areas by all individuals. Access restrictions also would apply to the Confederated Tribes and Bands of the Yakama Indian Nations and the Confederated Tribes of the Umatilla Indian Reservation, who have expressed an interest in access to and unrestricted use of the Hanford Site.

Housing Cost Impacts on Low-Income Populations

Housing prices in the Tri-Cities are projected to increase steadily from 1997 through 2040 under baseline conditions. All of the tank waste alternatives, except No Action, would result in additional increases in housing prices (Section 5.6.2.2). The levels of increase would vary substantially and housing prices would fluctuate depending on the levels of employment for each TWRS alternative as well as non-TWRS related fluctuations in Hanford Site and area employment. For example, the EIS analysis did not address the reduction of Hanford Site employment by 4,500 jobs that occurred in 1995, and future projections of baseline conditions were based on funding of the Hanford Site waste management and environmental restoration program as defined in the Tri-Party Agreement.

Additional reductions in Site employment resulting from funding reductions could minimize the potential adverse impacts on housing prices resulting from proposed TWRS activities. The No Action, Long-Term Management, and the In Situ Fill and Cap alternatives would have minor impacts on housing prices and hence would not adversely impact the access of low-income populations to affordable housing. The alternatives with the greatest potential impacts on housing prices include the following:

- In Situ Vitrification alternative - 9.3 percent increase in the average purchase price of a home above baseline conditions in 2001 (the peak year of impacts);
- Ex Situ Intermediate Separations alternative - 14.5 percent increase in the average purchase price of a home above baseline conditions in 2001 (peak year);
- Ex Situ No Separations alternative - 17.5 percent increase in the average purchase price of a home above baseline conditions in 2000 (peak year);
- Ex Situ Extensive Separations alternative - 25.1 percent increase in the average purchase price of a home above baseline conditions in 2004 (peak year);
- Ex Situ/In Situ Combination 1 alternative - 8.8 percent increase in the average purchase price of a home above baseline conditions in 2001 (peak year);
- Ex Situ/In Situ Combination 2 alternative - 8 percent increase in the average purchase price of a home above baseline conditions in 2001 or 2002 (peak year);

- Phased Implementation alternative (Phase 1) - 12.9 percent increase in the average purchase price of a home above baseline conditions in 2000 (peak year); and
- Phased Implementation alternative (total alternative) - 19.9 percent increase in the average purchase price of a home above baseline conditions in 2011 (peak year).

For each of these alternatives, housing price increases would exceed baseline conditions for a number of years depending on employment levels and construction and operation schedules.

Higher housing prices related to the alternatives would have a negative impact on low-income home buyers and renters in the Tri-Cities. Historically, rental prices increase consistent with the price of single-family homes. Low-income families would be adversely and disproportionately impacted in their ability to purchase affordable housing or rent housing at affordable prices.

The baseline conditions used in the impact analysis of the alternatives on the housing market in the Tri-Cities assumed Hanford Site employment at levels projected in the Tri-Party Agreement and did not assume any increase in low-income housing or rental units or housing cost subsidies or assistance by Federal, State, or local low-income housing agencies or programs. Changes from these baseline conditions or other substantial changes in the Tri-Cities economy could substantially modify the net impact of the alternatives on the housing market. If the housing market in the Tri-Cities does not experience the levels of price increases shown in the EIS, the disproportionate impact on low-income communities would be reduced.

Continued Restrictions on Access to Portions of the 200 Areas

Access to the Hanford Site has been restricted since the Hanford Site was established in 1943. However, the Confederated Tribes and Bands of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation have expressed a desire to have access and use of the Central Plateau of the Hanford Site in the future. The Tribal Nations have also expressed an interest in long-term ownership of lands on the Hanford Site. All of the EIS alternatives would have long-term land-use impacts that would continue restrictions on access by all individuals, including Tribal Nation members, to portions of the 200 Areas permanently committed to waste management and disposal.

Approximately two-thirds of the land that would be restricted from future access is land that has previously been disturbed by Hanford Site activities, including the tank farms. Table 5.19.2 summarizes the extent of the land that would be subject to long-term land-use restrictions. The total land that would continue to be subject to access restrictions as a result of EIS alternatives represents less than 1 percent of the total Hanford Site and less than 2 percent of the 200 Areas (Section 5.7). The relatively small amount of land that would be subject to continued restrictions could result in small disproportionate impacts to Tribal Nation land use and ownership interests.

The amount of land that would be restricted from future access is based on land-use restrictions that would result from implementing the TWRS alternatives. Additional land-use restrictions and potential groundwater-use restrictions might be required based on the ultimate closure action implemented for

Table 5.19.2 Comparison of Land Area Requiring Continued Access Restrictions

Alternative	Continued Access Restrictions ha (ac)	
Tank Waste	**Remediation**	**Total**
No Action	0 (0)	17 (42)
Long-Term Management	8 (20)	25 (62)
In Situ Fill and Cap	17 (42)	25 (62)
In Situ Vitrification	17 (42)	25 (62)
Ex Situ Intermediate Separations	35 (86)	46 (110)
Ex Situ No Separations	20 (49)	28 (69)
Ex Situ Extensive Separations	33 (82)	44 (110)
Ex Situ/In Situ Combination 1	31 (77)	41 (101)
Ex Situ/In Situ Combination 2	25 (62)	38 (84)
Phased Implementation (Phase 1)	0	0
Phased Implementation (Total Alternative)	38 (94)	49 (120)
Capsules		
No Action	0.6 (1.5)	0.6 (1.5)
Onsite Disposal	1.8 (4.4)	1.8 (4.4)
Overpack and Ship	0	0
Vitrify with Tank Waste	0	0

the tank farms. However, future NEPA documentation will be prepared to address the closure action. That document will address various closure alternatives and analyze the associated impacts including land use and groundwater restrictions. The analysis would also address the extent to which any of the alternatives would pose a disproportionately high and adverse impact on minority, Native American, or low-income populations.

The No Action and Long-Term Management alternatives would leave all tank waste intact in their current location and form indefinitely, thereby restricting land access and use indefinitely. All of the other tank waste alternatives would leave the tank farms in place following remediation. Under the closure scenario, the tanks would be covered with Hanford Barriers with varying amounts of waste remaining in the tanks. All of the alternatives would require long-term land-use restrictions. The In Situ Fill and Cap and In Situ Vitrification alternatives would leave essentially all waste in the tanks, requiring long-term land-use restrictions because all of the waste would be permanently disposed of onsite. The least amount of waste would remain onsite under the Ex Situ No Separations alternative because there would be no LAW disposed of onsite, as all waste retrieved from the tanks would be disposed of offsite. For the capsule alternatives, only the Onsite Disposal alternative would require future land access and use restrictions. However, because all of the tank waste alternatives would require future closure decisions, the final nature and extent of the land-use restrictions cannot be determined at this time.

The overall issue of access to the tank farm portions of the Central Plateau is linked to the ultimate land-use plan for the 200 Areas. Access to the tank farm areas would be limited by the level of cleanup accomplished for the surrounding area. The tank farms are in an area that currently is designated as a waste management area by DOE. DOE is preparing a Comprehensive Land-Use Plan for the Hanford Site, and final decisions regarding the level of cleanup required to support the land-use plan for the Central Plateau will impact the final decisions regarding the closure of the tank farms and future access to the 200 Areas.

5.20 MITIGATION MEASURES

This section describes measures to mitigate potential impacts of the alternatives in two areas. Section 5.20.1 summarizes measures that currently are included in the alternatives to prevent or mitigate environmental impacts. Section 5.20.2 summarizes additional measures that could be included in the alternatives to further reduce or mitigate potential environmental impacts described previously in other portions of Section 5.0 if deemed necessary. The section focuses on measures to mitigate potential impacts during remediation. Future NEPA documentation will specifically address in detail impacts and mitigation of post-remediation tank closure where, for example, most of the impacts of borrow site activities would occur.

5.20.1 Measures Included in the Alternatives

A large number of measures have been incorporated into all of the alternatives to ensure safe implementation, reduce environmental impacts, and meet all regulatory requirements (except as described in Section 6.0). The following measures apply to all of the alternatives for the tank waste and capsules except as indicated.

- All nuclear facilities would be designed, constructed, and operated in compliance with the comprehensive set of DOE or commercial requirements that have been established to protect public and worker health and the environment. These requirements encompass a wide variety of topics, including radiation protection, design criteria for nuclear facilities, fire protection, emergency preparedness and response, seismic events, and operations safety requirements.
- Measures would be taken to protect construction and operations personnel from occupational hazards. These measures include the following:
  - Emphasis on safety awareness;
  - Radiation and hazardous waste training;
  - Use of appropriate personal protective equipment (e.g., gloves, eye protection, and respirators);
  - Personal and environmental radiation monitoring and the application of administrative limits to restrict exposures to within regulatory limits and as low as reasonably achievable;
  - Administrative controls for potentially hazardous areas;
  - Use of hearing protection and monitoring exposure to occupational noise;
  - Good housekeeping of work areas; and
  - Preparing and implementing safety plans for all field work activities.

- Emergency response plans would be developed to rapidly respond to potentially dangerous unplanned events.
- Water and surfactants would be used to control dust emissions especially at borrow sites, gravel or dirt haul roads, and during construction earthwork.
- Areas for new facilities would be selected to minimize environmental impacts to the extent practicable, such as avoidance of undisturbed shrub-steppe habitat.
- Pollution control or treatment would be used to reduce or eliminate releases of contaminants to the environment and to meet regulatory standards. Among the measures included are the following:
  - Treating liquid through a variety of processes, including evaporation, prior to discharging the water into the subsurface;
  - Treating air emissions through the use of high-efficiency particulate air filters and scrubbers to reduce levels of air emissions to within regulatory standards;
  - Incorporating appropriate metal and concrete shielding to control exposures to workers from gamma radiation; and
  - Use of double liners, double-wall piping, and other double containment and backup systems to control leaks that might occur. Double containment is not included for the existing SSTs.
- Extensive environmental monitoring systems would be implemented to continually monitor potential releases to the environment including the following:
  - Air monitoring within buildings, certain tanks, and the ambient atmosphere;
  - Groundwater and vadose zone monitoring around the tank farms;
  - Comprehensive radiation monitoring during all construction and operation; and
  - Post-remediation monitoring and maintenance for up to 100 years for any radioactive and hazardous materials that remain onsite.
- All newly disturbed areas would be recontoured to conform with the surrounding terrain and would be revegetated with locally derived native plant species consistent with Sitewide biological mitigation plans.
- All shipments of radioactive or hazardous materials on public roads would be performed in compliance with all regulatory requirements including requirements for the following:
  - Maintaining manifests;
  - Using appropriate shipping containers;
  - Using trained and licensed transporters;
  - Using appropriate signs on vehicles;
  - Providing appropriate notices to potentially involved organizations; and
  - Using specially designed containers for shipment of HLW to reduce the possibility of public exposure in the extremely unlikely event of a release.
- Although much of the area proposed for the remedial activities is in areas currently disturbed, activities in some areas have the potential to impact historic, prehistoric, or cultural sites. These areas have not been fully surveyed because they are potential borrow sites subject to change during final design. The final selection of borrow sites

would be made through future NEPA analysis. Historic, prehistoric, and cultural resource surveys would be performed for any undisturbed areas to be impacted and the following measures could be implemented.

- Prior to any ground disturbance activities, consultations would be conducted with the DOE Richland Operations Office Historic Preservation Officer, the Hanford Cultural Resource Laboratory, Washington State Historic Preservation Officer, and concerned Native American Tribal groups and governments.
  - Avoidance of prehistoric and historic site areas identified would be the primary form of mitigation whenever practicable.
  - An archaeological monitor would be onsite during ground disturbing activities of highly sensitive areas to ensure that construction impacts were limited to the remediation area only whenever practicable.
  - If prehistoric or historic materials sites were encountered, construction activities would be stopped or diverted to other areas until the site was evaluated and appropriate consultations were conducted.
- Consultation with Tribal Nations groups and governments would be performed early in the planning process to determine areas or topics of importance to these groups such as religious areas and potential resources of medicinal plants.

5.20.2 Potential Mitigation Measures

The following mitigation measures could be incorporated into one or more of the alternatives as indicated. A decision on which, if any, of these measures to incorporate would be made by DOE and the Washington State Department of Ecology (Ecology).. The decisions would follow the public comment period and would be incorporated into the Mitigation Action Plan and the Record of Decision. The TWRS Mitigation Action Plan, which will be published with the Record of Decision, will describe the plan for implementing mitigation commitments made in the Record of Decision for the alternative selected for implementation.

Tank Waste

Under all tank waste alternatives except In Situ Vitrification, contaminant levels in the groundwater potentially would exceed safe levels. Potential health effects (incidences of cancer) could occur to anyone routinely consuming this water. This impact could be mitigated by placing restrictions on the use of the groundwater such as prohibiting the installation of wells for drinking water or irrigating crops. Potential impacts would last for more than 10,000 years, and the effectiveness of administrative controls in preventing or limiting the installation of wells over this length of time is uncertain. However, it should be noted that the area that would require administrative controls due to TWRS remediation contains groundwater that currently is contaminated at levels far above safe levels. Therefore, unless this existing contamination is remediated in the future, administrative controls would be necessary with or without the additional TWRS impacts to groundwater.

All of the tank waste alternatives, except the No Action and Long-Term Management alternatives, would include the placement of a Hanford Barrier over the tanks and the LAW vaults (when applicable)

to reduce the amount of precipitation that would infiltrate the waste and leach contaminants into the groundwater. For the analysis performed in this EIS, a Hanford Barrier was used to bound impacts. A Hanford Barrier would be a 4.5-m (15-ft)-thick, earthen cap constructed primarily of 10 layers of soil, rock, and synthetic materials. It would be designed to inhibit the infiltration of precipitation, limit intrusion by plant roots and burrowing animals that could penetrate the Hanford Barrier, and inhibit inadvertent human intrusion into the waste. The Hanford Barrier would be expensive to construct and would require using a large volume of earthen materials from borrow sites. Using borrow sites would require disturbing shrub-steppe habitat. These impacts could be partially mitigated by substituting a different type of surface barrier for the Hanford Barrier, such as the type of barrier required for hazardous waste sites under RCRA. These barriers may be somewhat less effective than the Hanford Barrier but they may be adequate for some or all of the alternatives to protect the groundwater. Selection of a specific barrier design is a decision that will be made in the future when final decisions are made on closure of the tank farms. At that time, alternate barrier designs that may be less consumptive of resources could be examined. This mitigation measure could be especially applicable to the In Situ Vitrification alternative because the barrier would be needed to prevent human and wildlife intrusion and would not be needed to protect the groundwater from contamination.

All of the tank waste alternatives except No Action and Long-Term Management would include filling the tank void spaces with soil or rock. This would require the extensive use of earthen borrow sites, which would potentially disturb areas of shrub-steppe habitat. The tanks could be filled with contaminated soils excavated during closure activities or during the implementation of other Hanford Site remediation projects, which would reduce the amount of shrub-steppe habitat disturbed. Because a Hanford Barrier would be constructed over the tanks during closure (if closure as a landfill was selected), additional landfills would not need to be constructed for closure or the other soil remediation projects. Contaminated soil could also be used as the glass former for the In Situ Vitrification alternative, which would provide greater protection of the groundwater because the contaminants in the soil would be immobilized in the vitrified tank waste.

Subsurface barriers could be used with any of the alternatives to contain leakage and minimize the migration of waste away from the tank in the event of a leak. Subsurface barriers are impermeable layers that would be installed in the soil surrounding a tank to contain any leakage that might occur. Subsurface barriers could be used with any of the tank waste alternatives but would be most suitable for SSTs that would be retrieved under the ex situ alternatives. The SST waste retrieval primarily would be performed using hydraulic sluicing, which has a high potential for leakage. The possibility of using subsurface barriers resulted from the concern about the potential for leaks from the tanks during hydraulic sluicing for retrieval. Subsurface barriers would not prevent tank leakage but they would function to prevent leakage from migrating beyond the barrier and into the vadose zone. This would minimize the volume of soil contaminated by a leak, and result in easier cleanup of contaminated soils.

A number of subsurface barrier technologies exist that could be used during waste retrieval operations to minimize the potential for release of contaminants to the vadose zone (see Volume Two, Section B.9). Close-coupled subsurface barriers could be installed directly adjacent to the outer tank

sides and bottom or offset from the tank. The close-coupled barriers would minimize the contamination of soils if a leak were to occur, and the offset barriers could be used to contain existing soil contamination and could have features to collect and recover tank leaks. Subsurface barrier technologies that have been investigated for use at the Hanford Site include: close-coupled injected chemical barriers, box-shaped chemical walls, v-shaped chemical barriers, freeze walls, and circulating air barriers (Treat et al. 1995). Some technologies such as freeze walls are active and would require continuous equipment operation to maintain the barrier integrity. Other technologies such as chemical barriers are passive and once installed would only require monitoring. The functional requirements potentially could be satisfied by any of the subsurface barrier technologies evaluated. Mitigation of waste leakage during retrieval would be evaluated as information is developed in support of tank closure and retrieval-based leakage criteria.

All of the alternatives that would retrieve tank waste assumed that a heel of waste equal to 1 percent of the tank contents would be left in the tank. This heel would not be immobilized and over a period of time would be dissolved by infiltrating water and transported to the groundwater. Mitigating the impacts from the tank residuals would involve immobilizing the residual waste to slow the release of contaminants from the residual waste. Broadcasting a dry grout mixture on the tank floor following retrieval would combine with any liquids remaining in the tanks and partially immobilize the contaminants. The grout would maintain the remaining solids at a high pH to further inhibit solid dissolution and would recrystallize over time to further stabilize the solids.

In situ vitrification is another technology that could be used as a mitigative measure to immobilize tank residuals and contaminated soils. In situ vitrification of residual waste and contaminated soil would immobilize contaminants in a waste form that would substantially reduce the long-term release of contaminants to the vadose zone.

Under the In Situ Fill and Cap alternative and the fill and cap portion of the Ex Situ/In Situ Combination 1 and 2 alternatives, there would be the potential for flammable gases (primarily hydrogen) to collect within the top of the tank and possibly under the asphalt layer of the Hanford Barrier. If this buildup occurred, and an ignition source such as sparks or heat from friction during an earthquake occurred, there would be a possibility that the gases could ignite or explode. This event could be mitigated by providing a mechanism for the gases to vent to the atmosphere. One way to accomplish this would be to include risers that extended from the tanks through the Hanford Barrier to the surface. These risers would allow the gases to vent to the surface. Because the generation of hydrogen gas and other flammable gases is decreasing over time, these risers could be plugged at the end of the administrative control period. In addition, when the tank was filled a hole could be cut in the top of the tank dome to provide adequate venting into the Hanford Barrier and a hole would be left in the asphalt layer of the Hanford Barrier, which would allow gas to vent to the surface. On reaching the surface, hydrogen would diffuse upward (it is less dense than air) and be dispersed into the atmosphere. Should an ignition source occur at the surface such as lightning, the ignition would not propagate downward through the soil into the tank. Flames would not propagate through small pore

spaces such as those that would be in the soil at the top of the earthen barriers. Extensive tank waste characterization and engineering would be necessary to implement this mitigation measure.

An additional mitigative measure could be the engineered placement of catalytic recombiners in and near the tanks. The catalytic recombiners would promote the low-temperature reaction of hydrogen and oxygen to form water. The continual reaction of the hydrogen as it was formed could prevent its concentration from reaching flammable or explosive limits. The rate of generation of flammable gas has been decreasing over time and may be decreasing by one-half every 15 years as the heat-producing radionuclides decay and volatile organics are depleted.

A pressurized spray release resulting from a mispositioned jumper during a tank waste transfer is an accident that would be common to all tank waste alternatives. The LCF point estimate risk ranged from 2.0E+00 to 5.6E+00 among the alternatives for the bounding scenario and from 9.3E-02 to 2.6E-01 for the nominal scenario. A mitigative measure that could reduce the risk of a spray release would be to ensure that cover blocks were in place at all times when the jumper was in service during tank waste transfers. Ensuring that the cover blocks were in place would not prevent the accident from occurring, but it could mitigate the consequences of the accident by over five orders of magnitude.

A hydrogen deflagration in a DST or SST prior to or during remediation is an accident that would be common to all tank waste alternatives. The LCF point estimate risk ranged from 1.9E+00 to 1.6E+01 among the alternatives for the bounding scenario and from 3.2E-02 to 2.7E-01 for the nominal scenario. A mitigative measure that could reduce the risk of a hydrogen deflagration would be to install active ventilation systems and mixer pumps in those tanks that pose the risk. This mitigative measure could reduce the probability of the accident occurring and reduce the potential energy of the deflagration if the accident did occur, resulting in a direct reduction of the consequences.

For the In Situ Vitrification alternative, it was postulated that a double-ended break would occur in the off-gas line between the off-gas hood and the off-gas facility as a result of an earthquake. The LCF point estimate risk was 8.3E-01 for the bounding scenario and 3.3E-03 for the nominal scenario. Mitigative measures that could reduce the risk of this accident would be to install a seismic qualified off-gas duct system and seismic shut-off switches that could remove the power to the electrodes and to the off-gas exhaust system and reduce the consequences.

The retrieval accident in which a ventilation heater failed due to an electrical fault resulting from humid air plugging the HEPA filter and filter blow-out would be common to all the ex situ alternatives and the ex situ component of the Ex Situ/In Situ Combination 1 and 2 alternatives. The LCF point estimate risk was approximately 2.3E-03 for the bounding scenario and 8.8E-05 for the nominal scenario. A mitigative measure that could reduce the risk of this accident would be to install a pressure differential shut-off switch that would measure the pressure differential over the HEPA filters. This action could reduce the probability of the accident occurring.

For the In Situ Fill and Cap alternative and the fill and cap remediation portion of the Ex Situ/In Situ Combination 1 and 2 alternatives, it was postulated that a deflagration could occur while the tank was filled with gravel using a rock slinger. A spark from the gravel could ignite a hydrogen gas plume, subsequently overpressurizing the tank. The LCF point estimate risk for a hydrogen deflagration during the fill and cap operation was approximately 2.3E-03 for the bounding scenario and 1.2E-04 for the nominal scenario. A mitigative measure that could reduce the risk of this accident would be to use wet sand or grout as fill. This action could reduce the probability of the hydrogen ignition and therefore reduce the probability of the accident occurring.

These accidents will be evaluated in more detail in Final Safety Analysis Reports, which will provide the basis for safe operations.

With the exception of the No Action, Long-Term Management, and In Situ Fill and Cap alternatives, the schedule of activities for the tank waste alternatives would cause one or more boom-bust cycles in the local economy. These cycles would place a strain on the availability of housing and cause large upward and downward swings in housing prices. These cycles also could cause strains on local school districts. The careful scheduling of activities, primarily construction, could reduce the severity of the boom-bust cycle. It would be possible to build certain facilities in sequence rather than concurrently although this could cause small delays in the initiation or completion of the project and increases in project cost.

The calculation of impacts in this EIS is based on a representative location for process facilities. The representative location was chosen from three similar locations that were considered in a preliminary site selection process. However, this EIS does not support a decision on the final selection of a site for any facilities that would be constructed during remediation. The selection of the precise location of remediation facilities would be the subject of future NEPA analyses when more detailed information is available on the number, size, and configuration of the required facilities. The potential impacts to sensitive habitats would be one of the evaluation criteria used to select sites for required facilities.

All of the alternatives except the No Action alternative would disrupt shrub-steppe habitat. These impacts would be mitigated to the extent appropriate by implementing the following hierarchy of measures.

- Avoid shrub-steppe areas to the extent feasible by choosing alternative locations or configurations for project elements such as new power lines.
- Minimize impacts to the extent feasible, possibly by modifying facility layouts, design elements, altering construction timing, or by salvaging (transplanting) some resources.
- Restore temporarily disturbed areas, possibly by replanting indigenous species taken from other disturbed areas.

Mitigation of impacts to habitats of special importance to the ecological health of the region is most effective when planned and implemented on a Sitewide basis. Recognizing this, DOE is preparing a

Sitewide biological management plan to protect these resources. Under this Sitewide approach, the potential impacts of all projects would be evaluated and appropriate mitigation would be developed based on the cumulative impacts to the ecosystem. Mitigation to reduce the ecological impacts from TWRS remediation would be performed in compliance with the Sitewide biological management plan. Mitigation would focus on disturbance of contiguous, mature sagebrush-dominated shrub-steppe habitat. Compensation (habitat replacement) would occur where deemed appropriate. Specific mitigation ratios, sites, and planting strategies (e.g., plant size, number, and density) would be defined in the Mitigation Action Plan, which would be prepared for specific facility siting decisions. The Mitigation Action Plan would be prepared in consultation with the Washington State Department of Fish and Wildlife and the U.S. Fish and Wildlife Service, with input from the Hanford Site's Natural Resources Trustees Council.

All facilities could be constructed using colors that conformed with surrounding visual resources. This would involve using earth tones such as sandstone and sage colors on all facilities practicable. This would reduce the background visual impacts from the air emission stacks, middle ground impacts from the large facilities, and all impacts from all facilities from elevated locations such as Gable Mountain.

All of the alternatives currently assume 16-m^3 (20-yd^3) trucks would be used to haul earthen material from the borrow sites to the TWRS sites. This would involve increased traffic congestion and high haulage cost. If a dedicated haul road was constructed, 30- to 60-m^3 (35- to 70-yd^3) trucks could be used to reduce these impacts.

Under all of the tank waste alternatives, except No Action, Long-Term Management, and In Situ Fill and Cap, there would be extremely heavy traffic congestion on the State Route 240 Bypass Highway near the intersection with Stevens Road on Route 4 west of the Wye Barricade and on Stevens Road north of Richland. The congestion would last for several years. These impacts could be partially mitigated by providing bus service to the 200 Areas, providing incentives to vanpool and carpool, or by staggering work start times to the extent practicable. Other mitigation measures could include modifications to Stevens Road such as adding turn lanes, sequencing traffic signals to improve traffic flow, modifying access approaches to certain facilities, or by widening Route 4 west of the Wye Barricade.

Two areas of potentially disproportionate, significant, and adverse impacts on minority populations or low-income populations were identified. These impacts include 1) increases in housing prices that could adversely impact access to affordable housing by low-income populations; and 2) continued restrictions on access to portions of the 200 Areas that could impede the ability Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation to exercise access, certain land-use treaty rights, and interest in future land ownership.

To mitigate the increased housing prices to low-income populations, the Federal or State government could provide grants for constructing additional low-income housing. Having additional low-income

housing available would affect market conditions and tend to keep prices at lower levels. The Federal or State government could also provide grants for constructing low-income housing with guaranteed purchase and rental rates, which could issue low-interest rate home loans with qualifying requirements to low-income applicants.

To mitigate the impacts that continued access restrictions could have on the ability of Native Americans to exercise certain treaty rights, DOE could provide increased protection from disturbance for areas of special importance to the Native Americans, and allow and encourage Native American participation in the planning and mitigation phases of the project. DOE also could purchase and transfer title to lands outside of the 200 Area as compensation for continued access restrictions in the 200 Area.

All of the alternatives would involve traffic accidents and fatalities (six or more fatalities) because of the large number of employees and the long distance traveled by employees to reach the 200 Areas each work day. Although the accident and fatality rates would not be higher than the State-wide averages, the number of fatalities could be reduced by widening Route 4 west of the Wye Barricade, or by reducing the speed limits on Route 4.

All of the mitigative measures would have cost associated with them, and DOE and Ecology would consider the benefits of performing these measures against this cost, and the effect this additional cost might have on the availability of funding for other projects.

Cesium and Strontium Capsules

None of the capsule alternatives, except the Onsite Disposal alternative, would involve substantial environmental impacts so no mitigative measures specific to these alternatives were developed. The Onsite Disposal alternative would involve the disruption of shrub-steppe habitat and the same potential mitigation measures described for the tank waste alternatives could also be used to mitigate impacts on the shrub-steppe habitat for the Onsite Disposal alternative.

Statutory and Regulatory Requirements

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6.0 STATUTORY AND REGULATORY REQUIREMENTS

SECTION HIGHLIGHTS

- Describes Federal and Washington State regulations potentially applicable to TWRS EIS alternatives
- Describes regulatory issues affecting the ability to implement the alternatives
- Describes the ability of the alternatives to enable DOE to comply with applicable regulations

In response to the continued nationwide accumulation of spent nuclear fuel, high-level radioactive waste, other hazardous wastes, and a growing public awareness and concern for public health and safety, Congress has passed numerous laws including the Nuclear Waste Policy Act. The purpose of these laws was to establish a national policy and program that would provide reasonable assurance that the public and the environment would be adequately protected from the hazards posed by these wastes. The action by Congress was influenced by a national consensus that the potential hazards of spent nuclear fuel and high-level waste (HLW) needed to be permanently isolated from the human environment with minimal reliance on institutional controls. Permanent isolation consists of containing the waste within engineered and natural barriers that would be likely to contain the material for a very long time. Minimal reliance on institutional controls means the isolation would not be dependent on ongoing maintenance of facilities, human attention, or commitment by government or other institutions. The national consensus has been reflected in the Northwest by strong support from the U.S. Department of Energy (DOE), Federal and State agencies, Tribal Nations, and citizens and stakeholders to clean up the Hanford Site.

It is DOE's policy to conduct its operations in an environmentally safe and sound manner in compliance with applicable environmental statutes, regulations, and standards. Statutory, regulatory, and permit requirements potentially applicable to the management and disposal of Tank Waste Remediation System (TWRS) tank waste and cesium and strontium capsules are described in this section.

6.1 RELEVANT ENVIRONMENTAL REQUIREMENTS

In 1994 DOE committed to a standards-based management program for "protecting the environment and the safety and health of the public and workers" and for "demonstrating good stewardship of resources" (DOE 1994k). This new program included the "necessary and sufficient" approach in which DOE and its contractor(s) would determine the set of standards appropriate for a facility, a site, or an activity. Applicable requirements contained in Federal, State, and local laws and regulations must be part of the set of standards. The DOE and its contractor(s) would have considerable latitude to agree on other standards that are needed. Current and new DOE Orders would not automatically be invoked. This program is an effort by DOE to appropriately apply human health and environmental standards to specific projects rather than applying all requirements to all projects without considering whether or not the requirement adds any value. However, DOE and its contractor(s) cannot use the necessary and sufficient process to set aside requirements from other agencies. Applicable

requirements contained in Federal, State, and local laws and regulations must be part of the necessary and sufficient set.

This section describes the Federal, Washington State, and DOE regulations and requirements that may apply to the proposed action and alternatives considered in this Environmental Impact Statement (EIS). Table 6.1.1 summarizes these requirements.

Table 6.1.1 Relevant Federal Environmental Statutes and Regulations

Statutes and Regulations	Relevance
National Environmental Policy Act	Dictates need for the TWRS EIS
Atomic Energy Act	Establishes standards for managing and disposing of HLW
Clean Air Act	Regulates air pollutants from construction and radioactive waste processing
Safe Drinking Water Act	Establishes contaminant limits for drinking water
Clean Water Act	Regulates pollutants in groundwater and Columbia River
Resource Conservation and Recovery Act (RCRA)	Establishes standards for treatment, storage, and disposal of hazardous waste
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	Provides emergency response, reporting, and cleanup requirements for uncontrolled release of contaminants
Federal Facility Compliance Act	Pertains to RCRA Compliance at DOE sites
Occupational Safety and Health Act	Regulates safe and healthful working conditions
Noise Control Act	Regulates noise impact on personnel
Emergency Planning and Community Right-to-Know Act	Provides community information for emergency response planning
Nuclear Waste Policy Act	Provides for development of repositories for disposal of HLW and spent nuclear fuel
Pollution Prevention Act	Encourages waste minimization
National Historic Preservation Act	Requires review of potentially important sites
Archaeological Resource Protection Act	Requires excavation permits
American Indian Religious Freedom Act	Requires coordination on excavations
Native American Graves Protection and Repatriation Act	Requires coordination on excavations
Endangered Species Act	Requires consultation with U.S. Fish and Wildlife for work in critical habitats
Migratory Bird Treaty Act	Requires consultation with U.S. Fish and Wildlife for work in critical habitats
Bald and Golden Eagle Protection Act	Requires permit to relocate nests
Wild and Scenic Rivers Act	Protects Columbia River

6.1.1 Federal Environmental Statutes and Regulations

National Environmental Policy Act of 1969, as amended (42 United States Code [USC] §4321 et seq.)

The National Environmental Policy Act (NEPA) establishes a national policy to promote awareness of the consequences of human activities on the environment and analysis of potential environmental impacts during the planning and decision-making stages of proposed Federal actions. NEPA requires all Federal agencies to prepare a detailed statement on the potential environmental effects that a major proposed Federal action may have on the quality of the human environment.

Federal Requirements for Siting or Operation of DOE Nuclear Facilities

- National Environmental Policy Act
- Atomic Energy Act
- Clean Air Act
- Safe Drinking Water Act
- Clean Water Act
- Resource Conservation and Recovery Act
- Comprehensive Environmental Response, Compensation, and Liability Act
- Federal Facility Compliance Act
- Occupational Safety and Health Act
- Noise Control Act
- Emergency Planning and Community Right-to-Know Act
- Nuclear Waste Policy Act
- Pollution Prevention Act

This EIS has been prepared in response to those NEPA requirements and policies. It identifies reasonable alternatives for the proposed action and the potential environmental consequences of each alternative. The EIS has been prepared according to the Council on Environmental Quality regulations for implementing the procedural provisions of NEPA as listed in Title 40 Code of Federal Regulations (CFR) 1500 through 1508, and DOE NEPA Implementing Procedures (10 CFR 1021).

Atomic Energy Act of 1954, as amended (42 USC §2011 et seq.)

The Atomic Energy Act authorizes DOE to establish standards to protect health or minimize dangers to life or property for activities under DOE's jurisdiction. Through a series of DOE Orders, an extensive system of standards and requirements has been established to ensure safe operation of facilities. The Nuclear Regulatory Commission (NRC), which also has regulatory responsibilities under the Atomic Energy Act for establishing standards for the commercial disposal of radioactive waste, has established regulations for radioactive waste that can be disposed of in near-surface disposal sites (10 CFR 61) and for radioactive waste requiring geologic disposal (10 CFR 60). Under authority of the Atomic Energy Act, the U.S. Environmental Protection Agency (EPA) has implemented standards for managing and disposing of spent nuclear fuel, HLW, and transuranic waste (40 CFR 191). 40 CFR 191 would apply if HLW is disposed of on the Hanford Site.

Clean Air Act, as amended (42 USC §7401 et seq.)

The Clean Air Act is intended to protect and enhance the quality of the nation's air resources and to promote public health and welfare and the productive capacity of its population. Section 118 of the Clean Air Act requires that each Federal agency, with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with all Federal, State, interstate, and local requirements regarding the control and abatement of air pollution.

The Clean Air Act requires the EPA to establish National Ambient Air Quality Standards to protect public health, with an adequate margin of safety, from any known or anticipated adverse health effects of a regulated pollutant (42 USC §7409). The Clean Air Act also requires establishing national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC §7411), and permitting of specific emission increases to prevent a deterioration in air quality (42 USC §7470). Hazardous air pollutants, including radionuclides, are regulated separately (42 USC §7412). Air emissions are regulated by the EPA in 40 CFR 50 through 99. In particular, radionuclide emissions are regulated by the EPA under the National Emissions Standard for Hazardous Air Pollutants Program (40 CFR 61).

The Clean Air Act Amendments of 1990, which amended the Federal Clean Air Act of 1977, require that the EPA develop a national Air Operating Permit Program, which would require each state to develop an Air Operating Permit Program to identify all sources of regulated pollutants. Regulated pollutants include criteria pollutants (oxides of nitrogen, sulfur oxides, total suspended particulates, carbon monoxide, particulate matter less than 10 microns in size, and lead) plus 189 other hazardous air pollutants. In July 1992, the EPA responded to this directive by promulgating 40 CFR 70.

In November 1994, the EPA approved the Washington State Air Operating Permit Regulation, promulgated as Washington Administrative Code (WAC), Chapter 173-401. This permit became effective December 1994. DOE has applied for a Sitewide Air Operating Permit.

Safe Drinking Water Act, as amended (42 USC §300 [F] et seq.)

The primary objective of the Safe Drinking Water Act is to protect the quality of the public water supplies and all sources of drinking water. The implementing regulations, which are administered by the EPA unless delegated to the states, establish standards applicable to public water systems. Public water systems are defined as water systems that serve at least 15 service connections used by year-round residents, or regularly serve at least 25 year-round residents. These regulations establish maximum contaminant levels (including those for radionuclides) in public water systems. The Safe Drinking Water Act requirements have been implemented by the EPA in 40 CFR 100 through 149. Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

Clean Water Act, as amended (33 USC §1251 et seq.)

The Clean Water Act, which amended the Federal Water Pollution Control Act, was enacted to restore and maintain the chemical, physical, and biological integrity of the nation's water. The Clean Water Act regulates the discharge of pollutants to navigable waters of the United States. Section 313 of the Clean Water Act requires all branches of the Federal Government, engaged in any activity that might result in a discharge or runoff of pollutants to surface waters, to comply with Federal, State, interstate, and local requirements.

The Clean Water Act establishes guidelines and limitations for effluents from point-source discharges and authorizes the EPA to implement the National Pollutant Discharge Elimination System Permitting Program. The National Pollutant Discharge Elimination System Permitting Program is administered by the Water Management Division of the EPA pursuant to regulations in 40 CFR 122 et seq.

Resource Conservation and Recovery Act, as amended (42 USC §6901 et seq.)
The treatment, storage, and disposal of hazardous and nonhazardous waste are regulated under the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments of 1984, and the Federal Facility Compliance Act, which are described separately from RCRA in this section. RCRA sets forth requirements for generators and transporters of hazardous waste and also establishes a specific permit program for treatment, storage, and disposal of hazardous waste. The EPA regulations implementing RCRA are found in 40 CFR 260 through 280. Washington State regulations implementing the Washington State Department of Ecology's (Ecology) hazardous waste program are described in Section 6.1.2.

Comprehensive Environmental Response, Compensation, and Liability Act, as amended (42 USC 9601 et seq.)
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides a statutory framework for the cleanup of waste sites containing hazardous substances and, as amended by the Superfund Amendments and Reauthorization Act, provides an emergency response program in the event of a release or threat of release of a hazardous substance to the environment. Using the Hazard Ranking System, Federal and private sites are ranked and may be included on the National Priorities List. CERCLA requires Federal facilities having such sites to undertake investigations and remediation as necessary. CERCLA also includes requirements for reporting releases of certain hazardous substances in excess of specified amounts to Federal and State agencies. CERCLA could be applicable in the event of a release of hazardous substances to the environment. The implementing regulations for CERCLA are found in 40 CFR 300.

Federal Facility Compliance Act (42 USC §6921 et seq.)
The Federal Facility Compliance Act waives sovereign immunity for RCRA violations at Federal facilities. However, provisions in the act postpone compliance with RCRA mixed waste storage regulations at DOE sites. Instead DOE is required to prepare Site Treatment Plans for developing required treatment capacity for mixed waste stored or generated at each facility unless a State-enforceable agreement for RCRA compliance is put into effect. The Federal Facility Compliance Act provides that DOE will not be subject to fines and penalties for violating prohibitions on land disposal of mixed waste as long as it is in compliance with an approved Site Treatment Plan and meets all other applicable regulations. The Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (Ecology et al. 1994), among Ecology, EPA, and DOE constitutes a State-enforceable agreement that meets the Federal Facility Compliance Act requirements.

Occupational Safety and Health Act of 1970, as amended (29 USC §651 et seq.)
The Occupational Safety and Health Act establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration and the U.S. Department of Labor. While the Occupational Safety and Health Administration and EPA both have mandates to reduce exposures to toxic substances, the Occupational Safety and Health Administration's jurisdiction is limited to safety and health conditions in the workplace environment. DOE implements these standards at the Hanford Site through DOE Orders 3790.1B, 5483.1A, and 5480.1B.

Noise Control Act of 1972, as amended (42 USC §4901 et seq.)
Section 4 of the Noise Control Act of 1972 directs all Federal agencies to carry out, to the fullest extent within their authority, programs within their jurisdictions in a manner that furthers the national policy of promoting an environment free from noise that may jeopardize health and welfare.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC §11001 et seq.)
(Also known as Superfund Amendments and Reauthorization Act [SARA] Title III)
Under Subtitle A of this Act, Federal facilities, including those owned by DOE, provide information, such as specific chemical inventories used or stored and accidental releases that occur from these facilities to the State Emergency Response Commission and the Local Emergency Planning Committee to ensure that emergency plans sufficiently respond to unplanned releases of hazardous substances.

Nuclear Waste Policy Act of 1982 (42 USC §10101 et seq.)
The Nuclear Waste Policy Act established a national policy for disposal of HLW and spent nuclear fuel in a geologic repository, and directed DOE to characterize the Yucca Mountain site in Nevada for suitability as the site of a first United States repository. The Act authorizes disposal of HLW and spent nuclear fuel, in the first repository, subject to a limit on repository capacity and the payment of appropriate fees. The Act specifically instructs the NRC to limit the potential first geologic repository to 70,000 metric tons (mt) (77,000 tons) of heavy metal or a quantity of solidified HLW resulting from the reprocessing of such a quantity of spent nuclear fuel until such time as a second geologic repository is in operation. For planning purposes, DOE assumes that some or all of the Hanford Site HLW that satisfies the repository's acceptance criteria could be placed in the potential geologic repositories developed under the Nuclear Waste Policy Act.

Sufficient information is not available to determine at this time whether the Yucca Mountain site is a suitable candidate for geologic disposal of spent nuclear fuel and high-level radioactive waste. DOE, however, is in the early planning stages for a repository EIS, which will be prepared pursuant to the Nuclear Waste Policy Act. DOE has issued a formal notice of its intent to prepare this analysis. The repository EIS would evaluate potential environmental impacts, based on the best available information and data, that would be associated with the repository's development and operation, and to support the Secretary of Energy's final recommendation to the President, as required by the Nuclear Waste Policy Act. The repository EIS would examine the site-specific environmental impacts from construction, operation, and eventual closure of the repository, including potential post-closure

radiological effects to the environment and would assess the impacts of transporting spent nuclear fuel and HLW to a repository.

The Nuclear Waste Policy Act provides that any repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only shall be subject to licensing under Section 202 of the Energy Reorganization Act of 1974 (42 USC 5842). Further, Section 202 of the Energy Reorganization Act authorizes NRC licensing of facilities authorized for the express purpose of long-term storage of high-level radioactive waste that are not used for, or are not a part of, research and development activities. Therefore, to the extent that any decision based on this EIS requires defense HLW to be placed in a repository constructed under the Nuclear Waste Policy Act or a facility subject to licensing under Section 202 of the Energy Reorganization Act, such a repository or facility would be subject to licensing by the NRC. NRC regulations governing the licensing of a geologic repository are contained in 10 CFR 60.

The Nuclear Waste Policy Act of 1982 directed EPA to promulgate waste standards pursuant to the Atomic Energy Act. EPA responded on September 19, 1985, by issuing the Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Wastes (final rule) in 40 CFR 191. Over a period of years, 40 CFR 191 was vacated and remanded by the court in response to petitions for review. Certain sections of 40 CFR 191 were reinstated and on December 20, 1993, EPA promulgated the current final rule including a revised Section 191.15, Individual Protection Requirements and a new Subpart C, Environmental Standards for Ground-Water Protection. The final rule announcement (58 FR 66398) notes that 40 CFR 191 does not apply to the candidate Yucca Mountain site.

The final 40 CFR 191 rule consists of three subparts. Subpart A established dose limits for members of the public including doses resulting from management and storage of spent nuclear fuel and high-level or transuranic waste at any disposal facility operated by DOE that is not regulated by NRC or by agreement States. Subpart B establishes containment requirements, assurance requirements, and individual protection requirements for disposal systems for spent nuclear fuel, HLW, and transuranic waste. This part specifies a 10,000-year design objective, discusses requirements for institutional controls, monitoring performance of the disposal system, designation by records, markers, and passive controls, avoidance of resource areas, and finally retrievability of wastes. Subpart C establishes groundwater protection standards for underground sources of drinking water for disposal systems for spent nuclear fuel, HLW, and transuranic waste.

The rule was developed primarily for mined geologic repositories. However, EPA states that "Although developed primarily through consideration of mined geologic repositories, 40 CFR 191 ... applies to disposal of the subject wastes by any method with three exceptions." The standards do not apply to ocean disposal or disposal that occurred before the 1985 standards. The groundwater protection requirements of Subpart C may not apply to disposal systems located within a quarter mile of an underground source of drinking water.

40 CFR 191 could apply to some waste that would be disposed of onsite under the TWRS alternatives. If the waste that is disposed of onsite is classified as high-level or transuranic radioactive waste, 40 CFR 191 would apply. It would not apply to waste classified as incidental or low-activity waste (LAW). It would not apply to TWRS HLW assumed to be disposed of at the potential geologic repository at Yucca Mountain, Nevada. Much of the DST waste is considered HLW and onsite disposal would be subject to the requirements of 40 CFR 191. The NRC has not determined the classification of SST waste or residual waste that cannot be recovered from the tanks (see Section 6.2.1, Tank Waste Classification). Depending on how these wastes are classified, 40 CFR 191 may or may not apply to in situ disposal of these wastes. In support of the repository program, waste acceptance system requirements are being developed (DOE 1995q) that would be applicable to any HLW emplaced in the repository. These include requirements for waste form, waste characteristics, waste composition, waste container specifications, and records.

Pollution Prevention Act of 1990 (42 USC §13101 et seq.)

The Pollution Prevention Act establishes a national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal. Disposal or releases to the environment should only occur as a last resort. DOE requires each site to establish site-specific goals to reduce generation of all waste types.

National Historic Preservation Act, as amended (16 USC §470 et seq.)

The National Historic Preservation Act requires that sites with national historic value be placed on the National Register of Historic Places. There are no permits or certifications required under the National Historic Preservation Act. However, if a Federal activity may impact a historic property resource, consultation is required with the President's Advisory Council on Historic Preservation. The consultation will normally result in the generation of a Memorandum of Agreement, including stipulations that must be followed to minimize adverse impacts. Coordination with the State Historic Preservation Officer is also part of the consultation process undertaken to ensure that potentially important sites are properly identified and appropriate mitigative actions are implemented.

Federal Requirements for Cultural and Historical Protection

- National Historic Preservation Act
- Archaeological Resource Protection Act
- American Indian Religious Freedom Act
- Native American Graves Protection and Repatriation Act

Archaeological Resource Protection Act, as amended (16 USC §470 aa et seq.)

The Archaeological Resource Protection Act provides for the preservation of historical and archaeological data (including relics and specimens) that might otherwise be irreparably lost or destroyed as a result of actions by any Federal agency or its contractors. If a Federal agency finds that its activities may cause irreparable loss or destruction of important scientific, prehistorical, historical, or archaeological data, the agency must notify the U.S. Department of Interior and may request the Department undertake the recovery, protection, and preservation of such data. This Act requires a permit for excavating or removing archaeological resources from public or Tribal lands. Excavations

must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed remain the property of the United States.

American Indian Religious Freedom Act of 1978 (42 USC §1996)

The American Indian Religious Freedom Act was enacted to protect and preserve the rights of Native Americans to believe, express, and exercise their traditional religions. The Act also requires that Federal actions avoid interfering with access of Native Americans to sacred locations and traditional resources that are integral to the practice of traditional religions.

Native American Graves Protection and Repatriation Act of 1990 (25 USC § 3001)

The Native American Graves Protection and Repatriation Act established Federal agency responsibility for inventories and summaries of cultural items, including associated funerary objects, unassociated funerary objects, sacred objects, and cultural patrimony items, in Federal collections. Agencies are given procedural directions for planned excavation when cultural items may be present or discovered.

Endangered Species Act, as amended (16 USC §1531 et seq.)

The Endangered Species Act is intended to prevent the further decline of endangered and threatened species and restore these species and their habitats. The Endangered Species Act is jointly administered by the U.S. Department of Commerce and the U.S. Department of Interior. Section 7 of the Endangered Species Act requires Federal agencies proposing action to consult with the U.S. Fish and Wildlife Service to determine whether endangered and threatened species or their critical habitats are known to be in the vicinity of the proposed action.

Federal Requirements for Species and Ecology Protection

- Endangered Species Act
- Migratory Bird Treaty Act
- Bald and Golden Eagle Protection Act
- Wild and Scenic Rivers Act

Migratory Bird Treaty Act, as amended (16 USC §703 et seq.)

The Migratory Bird Treaty Act is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. This Act regulates the harvest of migratory birds by specifying things such as the mode of harvest, hunting seasons, and bag limits. Federal agencies proposing action are required to consult with the U.S. Fish and Wildlife Service regarding impacts to migratory birds and to evaluate ways to avoid or minimize impacts in accordance with the U.S. Fish and Wildlife Service Mitigation Policy.

Bald and Golden Eagle Protection Act, as amended (16 USC §668-668d)

The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Section 668, 668c). A permit must be obtained from the U.S. Department of Interior to relocate a nest that interferes with resource development or recovery operations.

Wild and Scenic Rivers Act, as amended (16 USC §1271 et seq. §71:8301 et seq.)
The Wild and Scenic River Act was enacted to protect selected rivers that possess outstanding scenic, recreational, geological, fish and wildlife, historical, cultural, or other similar values. These rivers are to be preserved in free-flowing condition to protect water quality and promote other conservation activities. The Act authorizes creating a national wild and scenic rivers system, designating rivers that are initially a part of that system, and developing standards for adding new rivers to the system.

6.1.2 Washington State Environmental Statutes and Regulations

Washington State environmental requirements applicable to the proposed action and alternatives evaluated in this EIS are administered by Ecology and the Washington State Department of Health. These requirements are described in the following sections.

Washington State Requirements

- Washington State Environmental Policy Act
- Hazardous Waste Management Act
- Washington Clean Air Act
- Water Pollution Control Act

Washington State Environmental Policy Act (Chapter 43.21C Revised Code of Washington)
The Washington State Environmental Policy Act (SEPA) and its implementing regulations (WAC 197-11) require any Washington State or local agency to analyze all reasonable alternatives and their potential environmental impacts prior to taking an action that may significantly impact the environment. The SEPA action necessitating this EIS is the issuance of State permits required for this proposal. Because SEPA and NEPA (Section 6.1.1) are very comparable in their purpose, intent, and procedures, Ecology and DOE are co-preparing this EIS in compliance with the requirements of SEPA and NEPA.

Hazardous Waste Management Act (Chapter 70.105 Revised Code of Washington)
The Hazardous Waste Management Act and its implementing regulations (WAC 173-303) apply to the management of all dangerous and mixed waste at the Hanford Site. The EPA has delegated the RCRA base program to Ecology, which gives Ecology the authority to regulate mixed waste in Washington State (Section 6.1.1). The Tri-Party Agreement provides the framework for applying the State's requirements for dangerous waste treatment, storage, and disposal units at the Hanford Site. WAC 173-303 specifies requirements for design, permitting, operation, and closure of dangerous and mixed waste management sites.

Washington Clean Air Act (Chapter 70.94 Revised Code of Washington)
Ecology regulates releases of nonradioactive pollutants while the Washington State Department of Health regulates radioactive pollutants to the air under the WAC 173-400 and 173-460. These regulations require that new sources of toxic air pollutants comply with requirements for measurement of emissions and best available control technologies for potential toxic releases to the environment.

Water Pollution Control Act (Chapter 90.48 Revised Code of Washington)
The Water Pollution Control Act and its implementing regulations (WAC 173-200 and 173-216) require

that a permit be obtained for any discharge to the soil column, and the quality of the groundwater in the vicinity be protected and not degraded. Protecting groundwater quality involves applying all known, available, and reasonable methods of prevention, control, and treatment. Both toxic pollutants and radionuclides are included in the groundwater quality standards for the State. WAC 173-201A establishes surface water quality standards for Washington State and requires that toxic substances that have the potential to adversely affect water uses not be introduced into surface waters of the State above natural background levels. EPA retains regulatory authority over the National Pollutant Discharge Elimination System program for the Hanford Site under 40 CFR 122-136. WAC 173-226 provides the basis for a general waste discharge permit program for the State. The WAC 173-226-100 prohibits the discharge of any high-level radioactive waste into State waters.

6.1.3 DOE Regulations and Directives

Through the authority of the Atomic Energy Act, DOE is responsible for establishing comprehensive programs at its facilities to protect health, safety, and the environment. Formerly, DOE carried out this responsibility by directing the activities of its employees and contractors with a series of DOE Orders. Since August 1994, DOE has begun shifting to a system of regulations and directives, in a standards-based management approach, to ensure the excellence in performance that DOE expects of its employees and contractors (DOE 1994k). Directives include orders, policy statements, contractor requirements documents, and manuals to give advice on how to implement requirements. A necessary and sufficient process will be used by DOE and its contractor to decide what directives apply to a particular facility, activity, or site.

DOE regulations are generally found in Title 10 CFR. For purposes of this EIS, relevant regulations include 10 CFR 820, Procedural Rules for DOE Nuclear Activities; 10 CFR 830, Nuclear Safety Management; 10 CFR 834, Radiation Protection of the Public and the Environment (Draft); 10 CFR 835, Occupational Radiation Protection; 10 CFR 1021, Compliance with the National Environmental Policy Act; and 10 CFR 1022, Compliance with Floodplains/Wetlands Environmental Review Requirements. As DOE issues formal regulations, and as the standards-based management approach continues to be implemented, some DOE Orders are no longer needed, while others need to be consolidated. Thus, the new directives are in transition. In September 1995, DOE canceled 58 orders. Nevertheless, the remaining directives give DOE expectations for the environment, safety, and health, These are DOE Policy 450.2, Identification, Implementation, and Compliance with Environment, Safety, and Health Requirements (DOE 1995n) and DOE Order 231.1, Safety and Health Reporting Requirements (DOE 1995o).

DOE Policy 450.2 is a policy statement that sets forth the framework for identifying, implementing, and complying with environment, safety, and health requirements so that work is performed in the DOE complex in a manner that ensures adequate protection of workers, the public, and the environment. This framework is an integral part of DOE's commitment to a standards-based management system. This policy statement reaffirms the commitments in the DOE Nuclear Safety Policy Statement (September 9, 1991) and the DOE Environment, Safety, and Health Policy Statement (July 20, 1993), including the commitments to excellence and continuous improvement in all DOE

operations. DOE Order 460.1 establishes onsite packaging and transportation safety requirements (DOE 1995p). DOE Order 231.1 directs the collection and reporting of information on the environment, safety, and health that is required by law or regulation to be collected, or that is essential for evaluating DOE operations and identifying opportunities for improvement needed for planning purposes within DOE (DOE 1995o).

DOE Order 5820.2A establishes policies, guidelines, and minimum requirements for managing radioactive or mixed waste facilities (DOE 1988). Specific requirement limits include 1) external exposure to waste and concentrations of radioactive material that may be released into surface water, groundwater, soil, plants, or animals and is limited to an effective dose equivalent not to exceed 25 millirems/year to any member of the public; and 2) atmospheric releases that are required to comply with the limits specified in 40 CFR 61. Limits are imposed on the cumulative effective dose received by an individual intruder at any time after 100 years, when there is an assumed loss of active institutional control. DOE's historic planning strategy has been to dispose of the majority of their HLW in a national repository. However, DOE does not view disposal in a national repository as being legally required, and DOE intends to determine the appropriate disposition of HLW on a case-by-case basis. For purposes of disposal, DOE Order 5820.2A differentiates between new and readily retrievable existing HLW and HLW that is not readily retrievable. The order provides for new and readily retrievable existing waste to be processed and the HLW fraction disposed of in a geologic repository. For HLW that is not readily retrievable, the order provides for evaluation of such methods as in-place stabilization as well as possible retrieval and processing as stated for new and readily retrievable HLW.

DOE Order 1230.2, American Indian Tribal Government Policy (DOE 1992d), issued April 8, 1992, commits to consult with tribal governments to ensure that tribal rights and concerns are considered before DOE takes actions that may affect tribes. DOE also commits to avoid unnecessary interference with traditional tribal religious practices.

6.1.4 Federal Transportation Regulations

In addition to the packaging and transportation requirements in DOE Orders, offsite shipping of radioactive materials on public right-of-ways is regulated by the NRC and the U.S. Department of Transportation. Table 6.1.2 summarizes applicable Federal regulations for transporting nuclear material.

Table 6.1.2 Summary of Major Federal Transportation Requirements

Agency	Regulation	Topic
Nuclear Regulatory Commission	10 CFR 71	Packaging of radioactive material for transport and transportation of radioactive material under certain conditions
U.S. Department of Transportation	49 CFR 171 to 178	General information, regulations, definitions, communications, shipping and packaging requirements, and container specifications
U.S. Department of Transportation	49 CFR 350 to 399	Establishes requirements for motor carrier safety

6.1.5 Tri-Party Agreement

The Tri-Party Agreement, signed by DOE, Ecology, and EPA on May 14, 1989, is an agreement to clean up radioactive and hazardous waste at the Hanford Site over a 30-year period. The Tri-Party Agreement establishes an action plan for clean up that addresses priority actions, methods for resolving problems, and milestones. The Tri-Party Agreement sets milestones to achieve coordinated cleanup of the Hanford Site and provides for the enforcement of these milestones to keep the program on schedule. In addition, the Tri-Party Agreement establishes the applicability of RCRA and CERCLA and their amendments to the Hanford Site.

In January 1994, the Tri-Party Agreement was amended to incorporate the revised TWRS program technical strategy, which includes remediation of single-shell tank (SST) and double-shell tank (DST) waste. The requirements in the Tri-Party Agreement reflect the plan for remediating the tank waste for purposes of analysis in this EIS. DOE has committed to comply with requirements of the Tri-Party Agreement related to managing tank waste at the Hanford Site. These tank-farm specific requirements are being assessed in the TWRS EIS and compared to other alternatives for tank waste remediation as well as to the No Action alternative. The Tri-Party Agreement does not address the encapsulated cesium and strontium. The major requirements of the Tri-Party Agreement schedule related to TWRS are shown in Table 6.1.3. DOE, Ecology, and EPA negotiated additional amendments to the agreement in 1996. The primary changes to the agreement are to 1) incorporate DOE's proposed approach for contracting with private companies to perform certain aspects of the TWRS activities; and 2) combine the LAW pretreatment and LAW vitrification milestones.

Table 6.1.3 Tri-Party Agreement Schedule of Tank Waste Milestones

Milestone	Date
Begin construction of replacement cross-site transfer system	1995
Begin construction of LAW pretreatment and immobilization facility	TBD
Complete construction of replacement cross-site transfer system	1998
Complete characterization of tank waste	1999
Complete interim stabilization of SSTs by removing all pumpable liquid	2000
Resolve tank safety issues	2001
Initiate hot operations of LAW pretreatment and immobilization facility	2002
Start construction of HLW vitrification facility	2002
Complete tank farm upgrades	2005
Complete construction of HLW vitrification facility	2007
Complete retrieval of waste from SSTs	2018
Complete closure of all SSTs	2024
Complete LAW tank waste remediation	2024
Complete HLW tank waste remediation	2028

Notes:
TBD = To be determined
Source: Ecology et al. 1996

6.2 ABILITY OF TANK WASTE ALTERNATIVES TO COMPLY WITH REGULATORY REQUIREMENTS

Section 6.1 describes relevant Federal and State laws and regulations, permits, compliance agreements, and DOE Orders that may be applicable to the alternatives addressed in the EIS. Review of the requirements has raised a number of regulatory issues that could affect the regulatory compliance status of certain alternatives. Section 6.2.1 describes the regulatory issues. The list of permits and approvals that may be required to implement the alternatives is provided in Table 6.2.1. In many cases, specific operating requirements or pollution control equipment would be required to ensure compliance with air and water quality regulations.

However, certain alternatives may not be fully compliant with existing regulations or may require regulatory relief (modification or waiver of regulations) to be compliant. Specific items of compliance or noncompliance are described in Section 6.2.2 for each of the tank waste alternatives. The key requirements that may affect the compliant implementation of alternatives include the following:

- DOE, NRC, and EPA disposal requirements for LAW, HLW, and mixed waste;
- RCRA and State of Washington Hazardous Waste Management Act requirements for the treatment, storage, and disposal of hazardous waste; and
- HLW capacity limitations and waste acceptance criteria of the potential national geologic repository.

These are key regulatory requirements that govern remediation of the tank waste. The ability of the alternatives to meet these requirements is an important factor in the evaluation and comparison of the alternatives.

6.2.1 Waste Disposal Regulatory Issues

A number of regulatory issues have been identified that, depending upon how they are resolved, could affect the ability to implement one or more of the tank waste alternatives. Some issues, such as classification of tank waste, are the subject of ongoing discussions with regulatory authorities.

Tank Farm Closure

Under the Tri-Party Agreement, both SSTs and DSTs are RCRA hazardous waste management units that will be eventually closed under State Dangerous Waste regulations (WAC 173-303). The three existing options for closure in accordance with the Hanford Site Dangerous Waste Permit (No. WA7890008967) are 1) clean closure, involving removal of all waste and waste constituents, including tanks, debris, contaminated equipment, and contaminated soil and groundwater; 2) modified closure, which permits closure to a specified level to be determined in consultation with the regulatory authority, a period of institutional controls, and periodic assessments to determine the effectiveness of the closure; and 3) closure as a landfill with waste remaining in-place and corrective action taken for contaminated media under post-closure requirements. All options would require the submittal to and approval of closure plans by Ecology. Although closure is not within the scope of this EIS, the decisions made on how to treat and dispose of the tank waste may impact the choice of closure activities. Implementing one of the in situ alternatives precludes clean closure options for the

Table 6.2.1 Potential Permits and Approvals Needed for Tank Waste and Capsule Alternatives

Activity and Waste Type	Regulatory Action Required	Regulation	Regulatory Agency
Air emissions	Radiation Air Emissions Program (Approval)	WAC 246-247	Washington State Department of Health
Air emissions	Controls for New Sources of Toxic Air Pollutants (Approval)	WAC 173-460, 40 CFR 61	Ecology and EPA
Air emissions	Notice of Construction (Approval) and possible Sitewide Air Operating Permit modification (Permit)	WAC 173-400 and 173-460	Ecology and Benton County Clean Air Authority
Air emissions	Ambient Air Quality Standards and Emissions Limits for Radionuclides (Approvals)	WAC 173-480	Ecology
Soil column wastewater disposal	State Waste Discharge Permit (Permit)	WAC 173-216	Ecology
Effluents, spills	Groundwater Quality Standards (Approval and possible permit)	WAC 173-200	Ecology
Effluents	Water Quality Standards for Surface Waters (Permit)	WAC 173-201A	Ecology
Effluents	National Pollutant Discharge Elimination System Permit Program (Permit)	40 CFR 122-136	EPA
Dangerous (including mixed) waste generation, storage, treatment, and disposal	Dangerous Waste Permit, RCRA Permit (Permit)	WAC 173-303, 40 CFR 260-270	Ecology EPA
All media	Cultural Resource Review Clearance	36 CFR 800	DOE and State Historic Preservation Officer
All media	Endangered Species Review	50 CFR 402.6	U.S. Fish and Wildlife Service
Onsite management and disposal of high-level and transuranic waste	Waste Disposal Review and Standards (Approval)	40 CFR 191	EPA

treatment, storage, and disposal unit, and post-closure monitoring and maintenance would be required. Implementing one of the ex situ alternatives does not preclude any closure option.

RCRA Permit Modification

Facilities used to treat tank waste would be RCRA-permitted treatment units that may generate radioactive or hazardous emissions. Effluent treatment systems would be included in these units where required to ensure that any airborne emissions and liquid effluents would meet air and water quality standards. The Hanford Site Dangerous Waste Permit requires all air emissions from treatment, storage, or disposal units to comply with all applicable Federal and State regulations pertaining to air

emission controls, including but not limited to WACs 173-400, 173-460, and 173-480. In addition, the Dangerous Waste Permit requires that the permittee obtain all other necessary permits for work performed under the Dangerous Waste Permit. This is interpreted to mean that the requirements of WACs 173-216, 173-226, and 173-201A also apply to any wastewater or other liquid discharges from treatment facilities. Therefore, before any technologies could be implemented, the Hanford Site Dangerous Waste Permit would need to be modified with the approval of Ecology.

Hanford Site Air Operating Permit Modification

DOE has applied for a Sitewide Air Operating Permit under the Washington State Air Operating Permit Regulation. WAC 173-401-650(1) allows the facility to identify reasonably anticipated operating scenarios. Operating scenarios included in the permit can be implemented without a permit revision. These operating scenarios must comply with all applicable requirements and any terms or conditions of the permit. Once DOE has determined what TWRS alternative will be implemented, the activities will be examined for new source review applicability, and Notices of Construction will be prepared as needed. Specific Notice of Construction requirements may require a permit modification.

National Pollutant Discharge Elimination System Permit Modification

The Clean Water Act applies to all discharges to waters of the United States. At the Hanford Site, the regulations are applied through a National Pollutant Discharge Elimination System Permit governing effluent discharges to the Columbia River. The Hanford Site currently has two of these permits, which specify discharge points (called outfalls), effluent limitations, and monitoring requirements. One permit (No. WA000374-3) is for eight outfalls and the other permit (No. WA002591-7) is for one outfall associated with the 300 Area Treated Effluent Disposal Facility. Any actions that would result in a new or increased discharge to waters of the United States would require a permit modification or a new permit.

Tank Radioactive Waste Classification

The disposal or storage of radioactive waste is regulated by DOE and the NRC pursuant to the Atomic Energy Act and the Energy Reorganization Act. DOE's guidance for classifying waste is contained in DOE Order 5820.2A, Radioactive Waste Management (DOE 1988). The order classifies waste into HLW, low-level waste (LLW), transuranic waste, hazardous waste, and mixed waste. WAC 173-303-040 defines mixed waste. Waste designation procedures under WAC 173-303-070 are also applicable. NRC guidance on waste classification is contained in 10 CFR 60 (Disposal of High-Level Radioactive Wastes in Geologic Repositories) and in 10 CFR 61 (Licensing Requirements for Land Disposal of Radioactive Waste). HLW is defined in 10 CFR 60 as 1) irradiated reactor fuel, 2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and 3) solids into which such liquid wastes have been converted. LLW is classified as A, B, C, and greater-than-Class C in 10 CFR 61.55. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides whose potential hazard will persist long after such precautions such as institutional controls, waste form, and deep disposal have ceased to be effective. Second, consideration

must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective. DOE LLW disposal is not regulated by the NRC; however, NRC rulings regarding waste treatment and waste feed limitations will affect classifying waste that is subject to HLW disposal requirements.

Proper classification of waste from each tank is required to determine what regulations or DOE Orders are applicable to the waste streams. It is also necessary to determine the disposal requirement to be applied to residual waste left in tanks after retrieval. Tank waste remaining after the removal of the practicable amount of HLW does not fit the DOE definition of LLW (DOE 1988) because this waste was initially derived from spent nuclear fuel. Therefore, to preserve the distinction and the origin of this waste, the DOE (Hanford Site) terminology for this waste is LAW. Design specifications for HLW and LAW treatment will require that waste forms meet applicable criteria (DOE 1995q) for disposal in the potential geologic repository, or as LAW for onsite disposal.

Section 202 of the Energy Reorganization Act of 1974 requires NRC to regulate and license facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste, generated by DOE, which is not used for, or part of, research and development activities. Thus, it is important to determine which tank waste is HLW and must be disposed of at a licensed facility. The Nuclear Waste Policy Act defines HLW as:

- The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and
- Other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

The Hanford Site underground storage tanks contain HLW, transuranic waste, and mixed waste. In the current storage mode they are managed as HLW and are listed as HLW in the Integrated Data Base Inventory. Criteria must be formalized as to the extent to which the HLW in the tanks must be separated for the residual waste to be determined to be LAW by the NRC. DOE disposal of LAW is not regulated by the NRC.

DOE and the NRC have had formal discussions on the way tank waste is classified and how the LAW portion might be regulated. These consultations were carried out in the context of the previously planned grouted LAW, but the logic may be applied to vitrified LAW as well (although DOE would need to solicit an opinion from the NRC). The NRC's likely position on classifying Hanford Site tank waste may be inferred from the Denial of Petition (58 Federal Register [FR] 12344, March 4, 1993), which documents DOE and NRC consultations. In the Denial of Petition, NRC cites and summarizes documents that discuss principles derived from the U.S. Atomic Energy Commission's overall regulatory objectives that led to the promulgation of 10 CFR 50, Appendix F in 1970. Among other things, these principles state that "a high degree of decontamination capability" will be achieved, implying that the facility should separate for disposal as much of the radioactivity as possible using

processes that are technically and economically practical. Residual radioactive contamination also must be sufficiently low as to not endanger public health and safety.

In 58 FR 12344, the NRC cited a previous finding that DOE's former plans for handling DST waste (as presented in the Hanford Defense Waste EIS [DOE 1987]) were consistent with the NRC's principles of waste decontamination and protection of the public. As such, NRC stated that the waste materials resulting from the process described by DOE for the treatment of DST waste would be incidental waste, provided that the largest practical amount of total radioactivity attributable to first cycle solvent extraction waste be segregated for disposal as HLW. The residual waste after processing, to be disposed of as incidental waste, would not exceed the applicable concentration limits for Class C low-level waste, as defined in 10 CFR 61.

In 58 FR 12344, the NRC did not provide a view on the waste classification of SST waste. NRC indicated that "the appropriate classification of some Hanford waste remains to be determined--specifically, any SST waste...A case-by-case determination of the appropriate waste classification might be necessary." As such, some consideration may be required for the regulation of SST waste by the NRC. The NRC did not address the classification of residual waste that could not be recovered from the tanks or the contaminated equipment used for waste management or remediation and disposal. These are closure issues that require further discussion among DOE, Ecology, and NRC.

Therefore, classification of some tank waste is subject to the results of ongoing waste characterization studies and regulatory decision making. The current planning basis for the applicability of NRC regulations to the alternatives has several components depending on the alternative. For the in situ alternatives and the in situ component of the combination alternative the planning basis includes the following.

- Most DST waste is currently designated HLW. In situ disposal of this waste would be subject to NRC licensing.
- SSTs contain HLW, which may be classified on a case-by-case basis as LAW or incidental waste. The NRC would make the classification determination. In situ disposal of this incidental waste would not be subject to NRC regulation or licensing.

For the ex situ alternatives and the ex situ component of the combination alternative, the planning basis includes the following.

- HLW components would be separated out and disposed of in a geologic repository. The repository would be subject to NRC regulations including licensing.
- HLW processing facilities and immobilized HLW storage facilities at the Hanford Site would not be regulated or licensed by the NRC unless the facilities are owned by a private entity such as is proposed under the privatization initiative.
- It is assumed that residual waste remaining in the tanks after retrieval of as much of the waste as practicable would be classified as incidental waste (not HLW) and would be disposed of in-place as LLW. The NRC would make the classification determination. Disposal of incidental waste would not be subject to NRC regulation or licensing.

- LAW remaining after processing the high-level tank waste to remove as much of the high-level radioactivity as practicable could be classified as incidental waste as previously indicated by the NRC (58 FR 12344). It is assumed that this waste will not be greater than Class C LLW. Onsite disposal facilities (vaults) for this waste would not be subject to NRC regulation or licensing.
- Waste disposed of under the Ex Situ/In Situ Combination 1 and 2 alternatives would follow the combined planning basis described earlier for the various components.

In summary, the tank waste alternatives that involve a separations process for Hanford Site tank waste would be designed to produce HLW and LAW streams. Current design assumptions are that at least 90 percent of the activity would be in the high-level stream. The concentrated activity stream would be classified as HLW and could be disposed of in the potential geologic repository. The LAW stream, based on the NRC's published opinion, could be classified as incidental waste and subject to less stringent disposal requirements for LAW, if it does not exceed the Class C LLW requirements.

Onsite Disposal of Low-Activity Waste

Onsite disposal of LAW would be consistent with DOE's policies and requirements for low-level radioactive waste management and disposal activities. LAW disposal vaults would be regulated under DOE Order 5820.2A. DOE Order 5820.2A establishes performance objectives for LAW disposal as well as radiological performance assessment requirements. The DOE Order provides guidance on waste characterization, waste acceptance criteria, disposal site selection, facility design, operations and closure/post closure. EPA is considering the need for additional regulation of DOE LAW facilities. At this time, however, DOE LAW facilities are not subject to regulation either by EPA or the NRC. The LAW could be disposed onsite in compliance with Tri-Party Agreement and DOE requirements.

Onsite Storage of High-Level Waste

DOE requirements for storage of HLW are defined in DOE Order 5820.2A. This order specifies that all HLW shall be considered to be radioactive mixed waste and subject to both the Atomic Energy Act and RCRA. Thus, in addition to meeting all applicable DOE radiation protection standards, HLW storage facilities must be RCRA compliant. With respect to mixed waste, DOE retains authority over the radiological components while EPA retains authority over the hazardous components. Designs for HLW storage facilities must meet the requirements of DOE Order 6430.1 (General Design Criteria) and 40 CFR 264 (requirement for RCRA treatment, storage, and disposal facilities).

Disposal of High-Level Waste

The Nuclear Waste Policy Act of 1982 provided for the development of repositories for disposal of HLW and commercial spent nuclear fuel and required the President to evaluate the use of commercial repository capacity for the disposal of defense high-level nuclear waste. In February 1985, the then Secretary of Energy submitted a memorandum to the President recommending "that the Department proceed with plans and actions to dispose of defense waste in a commercial repository." In an April 1985 Presidential Memorandum, the President approved proceeding on the basis of the recommendation. Subsequently, in September 1988, DOE issued DOE Order 5820.2A, which stated

requirements to process and dispose of DOE's new and readily retrievable HLW in a geologic repository and to consider options such as in-place stabilization or retrieval, processing and disposal in a geologic repository for permanent disposal of a singly contained tank waste.

The Nuclear Waste Policy Act Amendments of 1987 ordered termination of activities at all geologic repository candidate sites other than the Yucca Mountain site and required that the Secretary of Energy report to the President and Congress between January 1, 2007 and January 1, 2010 on the need for a second repository. Therefore, the current planning basis for disposal of DOE's new or readily retrievable HLW is for disposal at a geologic repository, which may be Yucca Mountain should that site be shown to be acceptable and approved as a geologic repository.

Waste Acceptance System Requirements

Of the many waste acceptance requirements that are being developed, a few are of particular relevance to implementation of the alternatives for disposal of tank waste or encapsulated cesium and strontium presented in this EIS. They include the following requirements (DOE 1995q):

Waste Form

Particulate waste forms shall be consolidated (e.g., by incorporation into an encapsulating matrix) to limit the availability and generation of particulates. This requirement affects the acceptability of the encapsulated strontium fluoride and calcined HLW, both of which are compacted powders. The waste form shall not contain explosive, pyrophoric, or chemically reactive materials in an amount that could compromise the repository's ability for waste isolation or the ability to satisfy the performance objectives. This requirement affects the acceptability of the encapsulated cesium chloride and strontium fluoride, which are potentially corrosive.

The standard canistered HLW form shall be borosilicate glass sealed inside stainless steel canister(s) with a concentric neck and lifting flange. A footnote to this requirement states that other standard HLW forms will be defined in subsequent revisions of the waste acceptance requirements. Waste forms such as soda-lime glass or calcined HLW waste forms produced under the Ex Situ No Separations alternative could be considered if they can be fully qualified for licensing but may be subject to delayed acceptance. Delayed acceptance would occur after a license is granted.

Repository Capacity

The repository shall not accept in excess of 70,000 mt (77,000 tons) uranium or equivalent in the first repository prior to operation of a second repository. Within this capacity ten percent, or 7,000 mt (7,700 tons) heavy metal, has been set aside for disposal of HLW and DOE spent nuclear fuel. How DOE intends to allocate the 7,000 mt (7,700 tons) heavy metal capacity has not been decided (i.e., spent nuclear fuel first with the balance from HLW; Savannah River waste before Hanford Site waste). However, for purposes of analysis in the EIS, it is assumed that 2,465 (approximately equal to 7,000 mt [7,770 tons]) waste packages from the Hanford Site could be disposed of in the potential geologic repository.

Repository Availability

The repository shall have the capability to accept spent nuclear fuel beginning in 2010 and HLW beginning in 2015 for disposal at the geologic repository at a specified receipt rate. The current repository program planning assumption is that any DOE material (vitrified HLW or spent nuclear fuel) qualified and selected for emplacement in the first repository would be disposed beginning in 2015. The disposition of remaining DOE spent nuclear fuel and vitrified HLW not emplaced in the first repository would not be decided until DOE makes a recommendation on the need for a second repository. This decision would consider such factors as the physical and statutory limits of the first repository.

Mixed Waste

DOE Order 5820.2A states that unless demonstrated to the contrary, all HLW shall be considered to be radioactive mixed waste and subject to the requirements of the Atomic Energy Act and RCRA. DOE has determined that HLW that contains hazardous characteristics or RCRA listed waste may not be disposed of in the potential first geologic repository.

Hanford Site high-level radioactive waste and cesium and strontium capsules contain hazardous, characteristic, and/or listed wastes. Hanford Site tank waste is both characteristic waste and listed waste under RCRA, and the encapsulated cesium and strontium are characteristic waste (the characteristic of corrosivity) under RCRA (once they are determined to be waste). Any alternative that includes disposal offsite must include all necessary requirements to treat, and/or delist, the waste prior to shipment. The DOE generator of HLW, and DOE as a whole, will continue to examine every technical and regulatory option for the disposal of high-level radioactive waste and cesium and strontium capsules. Such options may include pursuing treatability variances and/or delisting options in the appropriate regulatory agencies, working to ensure the safe management of radioactive mixed waste through current modifications to the Hazardous Waste Identification Rule promulgated by EPA (60 FR 66344), or through changes in statute. In any case, appropriate Federal and State agencies (including the receiving state for ex situ options) will be consulted. Treatment standards and delisting must be approved by the receiving state, in addition to Washington State.

6.2.2 Regulatory Compliance

This section describes the ability of each tank waste alternative to enable DOE to comply with Federal and State regulations. The permits and approvals that are potentially required for the alternatives are listed in Table 6.2.1. Implementation of the alternatives would in some cases require regulatory relief. Regulatory relief includes amendment of existing permits, renegotiation of the Tri-Party Agreement, or changes in Federal or State laws or regulations. A summary of potential regulatory relief that might be required to implement each of the tank waste alternatives is presented in Table 6.2.2.

6.2.2.1 No Action Alternative (Tank Waste)

Under the No Action alternative the waste would continue to be stored in underground tanks. No action would be taken to remediate the waste.

Table 6.2.2 Regulatory Relief Requirements - Tank Waste Alternatives

Area of Regulatory Relief					
Alternative	**Disposal of HLW**	**Disposal of RCRA Waste**	**National Waste Repository WASRD**	**Other**	
No Action	Near surface disposal of readily retrievable HLW does not meet DOE requirements to dispose of HLW in a geologic repository.	Does not meet land disposal requirement for hazardous waste components. Would need amendment to the Hanford Dangerous Waste Permit.	N/A	Does not meet water protection requirements.	A new source review to evaluate the need for a Prevention of Significant Deterioration Permit.
Long-Term Management					
In Situ Fill and Cap					
In Situ Vitrification		Compliance dependent on vitrification effectiveness.			
Ex Situ Intermediate Separations	Meets requirements.	Amendment would be needed to the Hanford Dangerous Waste Permit.	Exceeds assumed waste package limitation.	Disposal of incidental waste in vaults meets water protection requirements. Residuals left in tanks would need to be addressed further in a future closure plan.	
Ex Situ No Separations			Exceeds assumed waste package limitation. Soda-lime glass or calcine not WASRD defined standard waste form. Calcine would not meet WASRD particulate immobilization requirements.		
Ex Situ Extensive Separations			Meets requirements.		
Ex Situ/In Situ Combination 1	Ex situ portion meets DOE requirements to dispose of readily retrievable HLW in a geologic repository. In situ portion may not meet DOE policy to dispose of readily retrievable HLW in a geologic repository	Does not meet land disposal requirement. Would need amendment to the Hanford Dangerous Waste Permit.		Ex situ portion meets water protection requirements (see ex situ above). In situ portion does not meet water protection requirements (see in situ above).	
Ex Situ/In Situ Combination 2					
Phased Implementation	Meets requirements.	Amendment would be needed to the Hanford Dangerous Waste Permit.	Exceeds assumed waste package limitation.	Meets water protection requirements (see ex situ alternatives above).	

Notes:
HLW = High-level waste
N/A = Not applicable to the alternative
WASRD = Waste Acceptance System Requirements Document (these criteria have not been finalized).

Hazardous Waste Management and Disposal

The SSTs do not meet RCRA or State Hazardous Waste Management Act requirements for storing hazardous waste. While the DSTs meet these requirements, parts of the tank waste transfer system do not. The RCRA land disposal restrictions require that established treatment requirements be met prior to land disposal of hazardous waste. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and possibly modification of the Washington Administrative Code.

Radioactive Waste Management and Disposal

Implementing this alternative would not comply with the requirements of DOE Order 5820.2A and would be inconsistent with the planned disposal of other HLW in a potential geologic repository. In addition, this alternative may require changes to the requirements for disposal of high-level radioactive waste if no closure action is taken.

Air Quality Standards

Implementing this alternative would not result in violation of air quality standards.

Water Protection Standards

Implementing this alternative would not meet the water protection requirements of 40 CFR 191 (without treating the water) in the future when the tanks are assumed to degrade resulting in migration of the waste if no closure action is taken. Final closure action would be addressed in a closure plan and may result in lower levels of water contamination.

6.2.2.2 Long-Term Management Alternative

Under the Long-Term Management alternative, the tank waste would continue to be stored in underground tanks. The SST waste would have minimal free liquids and would be left in place and monitored. Ultimate decisions on the treatment and disposal of the tank waste, as well as decisions regarding tank closure, would be deferred until some future date. DST waste would be monitored, retrieved, and placed into new DSTs at 50-year intervals.

Hazardous Waste Management and Disposal

The SSTs do not meet RCRA or State Hazardous Waste Management Act requirements for storing hazardous waste. The DSTs do meet these requirements but parts of the tank waste transfer system do not. The RCRA land disposal restrictions require that established treatment requirements be met prior to land disposal of hazardous waste. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and may require modification of the Washington Administrative Code.

Radioactive Waste Management and Disposal

This alternative would be implemented so as to comply with DOE, NRC, and State Hazardous Waste Management Act requirements for the storage of HLW. This alternative would not comply with the requirements of DOE Order 5820.2A and would be inconsistent with the planned disposal of other HLW in a potential geologic repository. Implementation of this alternative may require changes to the requirements for disposal of HLW if no closure action is taken.

Air Quality Standards
Implementing this alternative would not result in violation of air quality standards.

Water Protection Standards
Implementing this alternative would not meet the water protection requirements of 40 CFR 191 (without treating the water) in the future when the tanks are assumed to degrade resulting in migration of the waste. This alternative would require changes to the groundwater protection requirements if no closure action is taken. Final closure action would be addressed in a closure plan and may result in lower levels of water contamination.

6.2.2.3 In Situ Fill and Cap Alternative
Under this alternative waste would be disposed of in place, no treatment would be performed, the tanks would be filled with gravel, and the tank farm would be capped with a Hanford Barrier.

Hazardous Waste Management and Disposal
Implementing this alternative would not meet the land disposal restrictions of the State Dangerous Waste Regulations (including the requirements of RCRA) because the hazardous characteristics of the waste would be retained. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and may require modification of the Washington Administrative Code. This alternative would preclude clean closure of the tanks under RCRA.

Radioactive Waste Management and Disposal
Near-surface disposal of any readily retrievable HLW would not meet the requirements of DOE Order 5820.2A and would be inconsistent with the planned disposal of other HLW in a potential geologic repository. Implementation of this alternative would require changes to the requirements for disposal of HLW if additional closure action is not taken.

Air Quality Standards
Implementing this alternative would not result in violation of air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards
Implementing this alternative would not meet the water protection requirements of 40 CFR 191 (without treating the water). Water quality requirement exceedances are based on the combination of the alternative and the representative closure scenario included in the analysis. Final closure actions would be addressed in a closure plan and may result in lower levels of water contamination.

6.2.2.4 In Situ Vitrification Alternative
Under this alternative all waste would be immobilized with in situ vitrification and disposed of in place.

Hazardous Waste Management and Disposal

This alternative is designed to stabilize the tank waste in a manner that would remove its hazardous characteristics. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and may require modification of the Washington Administrative Code. This alternative would preclude clean closure of the tanks under RCRA.

Radioactive Waste Management and Disposal

Near-surface disposal of any readily retrievable HLW would not meet the requirements of DOE Order 5820.2A and would be inconsistent with the planned disposal of other HLW in a geologic repository. In addition, this alternative would require changes to the requirements for the disposal of HLW.

Air Quality Standards

Implementing this alternative would meet the air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards

Implementing this alternative would not meet the requirements of 40 CFR 191 (without treating the water). Water quality requirement exceedances are based on the combination of the alternative and the representative closure scenario included in the analysis. Final closure actions would be addressed in a closure plan and may result in lower levels of water contamination.

6.2.2.5 Ex Situ Intermediate Separations Alternative

Under this alternative, all of the waste that could be practicably removed (assumed to be 99 percent) would be recovered and separated into HLW and LAW fractions and vitrified. The LAW would be disposed in an onsite near-surface disposal facility and the HLW would be shipped offsite to a potential geologic repository.

Hazardous Waste Management and Disposal

Implementation would require an amendment to the Hanford Site Dangerous Waste Permit.

Radioactive Waste Management and Disposal

This alternative would meet the requirements for the disposal of HLW and LLW. The EPA is considering a rule to further regulate LLW disposal facilities; the final design of the onsite LAW disposal facility may be impacted by the EPA rule (40 CFR 193). The Waste Acceptance System Requirements Document (DOE 1995q) for the potential first geologic repository limits the total quantity of defense HLW for all of DOE activities. The 3,050 waste packages that would be produced under this alternative would exceed the assumed Hanford Site portion of the limit.

Air Quality Standards

Implementing this alternative would not result in violation of air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards

Implementing this alternative would not meet the dose limit requirements of 40 CFR 141 (without treating the water) due to conservative assumptions regarding release of residuals remaining in the tanks after retrieval. Incidental waste disposed of in vaults would meet water protection requirements. Residuals left in tanks would not meet the water protection requirements if additional closure action is not taken. However, tanks and residuals would be addressed in a future closure plan.

6.2.2.6 Ex Situ No Separations Alternative

Under this alternative, all waste that could be practicably removed (assumed to be 99 percent) would be recovered and vitrified. The HLW would be shipped offsite to a potential geologic repository.

Hazardous Waste Management and Disposal

The calcine waste form may not qualify as the Best Demonstrated Available Technology for treatment under RCRA. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit.

Radioactive Waste Management and Disposal

This alternative would meet the requirements for the disposal of HLW and LLW. The EPA is considering a rule to further regulate LLW disposal facilities; the final design of the onsite LAW disposal facility may be impacted by the EPA rule (40 CFR 193). The 10,300 to 29,100 waste packages that would be produced under the Ex Situ No Separations alternative would exceed the assumed Hanford Site portion of the potential first geologic repository limit. The compacted particulate waste form of the calcination option under this alternative would not meet the current waste acceptance system requirements for the potential first geologic repository, which requires incorporating particulate waste into an encapsulating matrix. Neither soda-lime glass or calcine are currently an approved standard waste form.

Air Quality Standards

Implementing this alternative would not result in violation of air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards

Implementing this alternative would not meet the dose limit requirements of 40 CFR 141 (without treating the water) due to conservative assumptions regarding release of residuals remaining in the tanks after retrieval. Incidental waste disposed of in vaults would meet water protection requirements. Residuals left in tanks would not meet the water protection requirements if additional closure action is not taken. However, tanks and residuals would be addressed in a future closure plan.

6.2.2.7 Ex Situ Extensive Separations Alternative

Under this alternative, all waste that could be practicably removed (assumed to be 99 percent) would be recovered and separated into HLW and LAW fractions and vitrified. The LAW would be disposed of

in an onsite near-surface disposal facility and the HLW would be shipped offsite to a potential geologic repository.

Hazardous Waste Management and Disposal
Implementation would require an amendment to the Hanford Site Dangerous Waste Permit.

Radioactive Waste Management and Disposal
This alternative would meet the requirements for disposal of HLW and LLW. The EPA is considering a rule to further regulate LLW disposal facilities; the final design of the onsite LAW disposal facility may be impacted by the EPA rule (40 CFR 193). The 143 waste packages that would be produced under the Ex Situ Extensive Separations alternative is well within the assumed Hanford Site portion of the potential first geologic repository limit.

Air Quality Standards
Implementing this alternative would not result in violation of air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards
Implementing this alternative would not meet the dose limit requirements of 40 CFR 141 (without treating the water) due to conservative assumptions regarding release of residuals remaining in the tanks after retrieval. Incidental waste disposed of in vaults would meet water protection requirements. Residuals left in tanks would not meet the water protection requirements if additional closure action is not taken. However, tanks and residuals would be addressed in a future closure plan.

6.2.2.8 Ex Situ/In Situ Combination Alternative 1
Under this alternative approximately one-half of the waste by volume would be recovered and treated, consistent with the Ex Situ Intermediate Separations alternative. Approximately 90 percent of the waste constituents that contribute to risk would be contained within this material. The other half of the waste would be disposed of in situ, consistent with the In Situ Fill and Cap alternative.

Hazardous Waste Management and Disposal
Implementing the in situ portion of this alternative would not meet the land disposal restrictions of RCRA because the hazardous characteristics of the waste remaining in the tanks would be retained. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and may require modification of the Washington Administrative Code.

Radioactive Waste Management and Disposal
Near-surface disposal of any readily retrievable HLW would not meet the requirements of DOE Order 5820.2A (DOE 1988). Implementing this alternative would be inconsistent with the planned disposal of other HLW in a potential geologic repository. In addition, this alternative would require changes to the requirements for disposal of HLW if additional closure action is not taken. The ex situ portion of the

alternative would meet the requirements for the disposal of HLW and LLW. The approximately 2,130 waste packages that would be produced under the Ex Situ/In Situ Combination 1 alternative would be within the assumed Hanford portion of the potential first geologic repository limit.

Air Quality Standards

Implementing this alternative would meet the air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards

Implementing this alternative would not meet the dose limit requirements of 40 CFR 141 or 40 CFR 191 (without treating the water). The ex situ portion would follow the discussion for the ex situ alternatives and the in situ portion would follow the discussion for the in situ alternatives.

6.2.2.9 Ex Situ/In Situ Combination Alternative 2

Under this alternative, approximately one-third of the waste by volume would be recovered and treated, consistent with the Ex Situ Intermediate Separations alternative. Approximately 85 percent of the waste constituents that contribute to risk would be contained within this material. The other two-thirds of the waste would be disposed of in situ, consistent with the In Situ Fill and Cap alternative.

Hazardous Waste Management and Disposal

Implementing the in situ portion of this alternative would not meet the land disposal restrictions of RCRA because the hazardous characteristics of the waste remaining in the tanks would be retained. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and may require modification of the Washington Administrative Code.

Radioactive Waste Management and Disposal

Near-surface disposal of any readily retrievable HLW would not meet the requirements of DOE Order 5820.2A (DOE 1988). Implementing this alternative would be inconsistent with the planned disposal of other HLW in a potential geologic repository. In addition, this alternative would require changes to the requirements for disposal of HLW if additional closure action is not taken. The ex situ portion of the alternative would meet the requirements for the disposal of HLW and LLW. The approximately 1,230 waste packages that would be produced under the Ex Situ/In Situ Combination 2 alternative are within the assumed Hanford portion of the potential first geologic repository limit.

Air Quality Standards

Implementing this alternative would meet the air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards

Implementing this alternative would not meet the dose limit requirements of 40 CFR 141 or 40 CFR 191 (without treating the water). The ex situ portion would follow the discussion for the ex situ alternatives and the in situ portion would follow the discussion for the in situ alternatives.

6.2.2.10 Phased Implementation Alternative

Under this alternative, all of the waste that could be practicably removed (assumed to be 99 percent) would be recovered and separated into HLW and LAW fractions and vitrified. The LAW would be disposed of in an onsite near-surface disposal facility, and the HLW would be shipped offsite to a potential geologic repository. One separations and demonstration-scale LAW vitrification facility, and one separations, LAW vitrification, and HLW vitrification facility would be constructed to test the process. Following completion of Phase 1, a full-scale separations, LAW, and HLW vitrification facility would be constructed to remediate the remaining tank waste.

Hazardous Waste Management and Disposal

Implementation would require an amendment to the Hanford Site Dangerous Waste Permit.

Radioactive Waste Management and Disposal

This alternative would meet the requirements for the disposal of HLW and LLW. The EPA is considering a rule to further regulate LLW disposal facilities; the final design of the onsite LAW disposal facility may be impacted by the EPA rule (40 CFR 193). The 3,050 waste packages that would be produced under the Phased Implementation alternative would exceed the assumed Hanford portion of the potential first geologic repository limit.

Air Quality Standards

Implementing this alternative would meet the air quality standards. A new source review would need to be conducted to determine if a Prevention of Significant Deterioration Permit would be required.

Water Protection Standards

Implementing this alternative would not meet the dose limit requirements of 40 CFR 141 (without treating the water) due to conservative assumptions regarding release of residuals remaining in the tanks after retrieval. Incidental waste disposed of in vaults would meet water protection requirements. Residuals left in tanks would not meet the water protection requirements if additional closure action is not taken. However, tanks and residuals would be addressed in a future closure plan.

6.3 ABILITY OF CESIUM AND STRONTIUM CAPSULE ALTERNATIVES TO COMPLY WITH REGULATORY REQUIREMENTS

6.3.1 Regulatory Issues

Presently, the encapsulated cesium and strontium are in storage and may have a beneficial value as irradiation or heat sources. This discussion of the disposal of the capsules includes the underlying assumption that these by-products remain HLW for purposes of permanent disposal once they have been determined to have no beneficial value. The final classification of the cesium and strontium will be made in consultation with the NRC when and if they are determined to be waste.

These radionuclides were originally removed from the tank HLW to reduce the generation of heat which was a potential threat to the integrity of the tanks. They therefore meet part (A) of the Nuclear Waste Policy Act HLW definition that refers to any solid material derived from liquid waste produced

from reprocessing that contains fission products in sufficient concentrations [Section 2.(12)(A)]. Also, because of the highly concentrated form of the encapsulated cesium and strontium, they could also be candidates for disposal in a geologic repository under Part (B) of the Nuclear Waste Policy Act HLW definition relating to "other highly radioactive that the commission . . . determines by rule requires permanent isolation [Section 2.(12)(B)]." At this time no such ruling has been made for the encapsulated cesium and strontium.

They are subject to the radioactive waste management requirements of DOE Order 5820.2A and the Safety Requirements for the Packaging and Transportation of Hazardous Wastes (DOE Order 5480.3), as well as the relevant requirements listed in Tables 6.1.1 and Table 6.1.2. In addition to these requirements, the encapsulated cesium and strontium, if overpacked or vitrified, would have to meet the waste acceptance criteria for the potential geologic repository including treatment and/or delisting if they are determined to be mixed waste under RCRA.

6.3.2 Regulatory Compliance

This section describes the ability of each capsule alternative to enable DOE to comply with Federal and State regulations. The permits and approvals that are potentially required for the alternatives are listed in Table 6.2.1. Implementation of the alternatives would in some cases, require regulatory relief. Regulatory relief includes amendment of existing permits or changes in Federal or State laws or regulations. A summary of potential regulatory relief that might be required to implement each of the capsule alternatives is presented in Table 6.3.1.

6.3.2.1 No Action Alternative (Capsules)

Under this alternative, the capsules would remain in storage at the Waste Encapsulation and Storage Facility for a period of ten years, at which time disposal alternatives would be considered and a disposal method selected.

Hazardous Waste Management and Disposal

Ongoing storage would comply with applicable regulations. Implementing this alternative would defer compliance issues related to disposal of hazardous waste until such time as the capsules are designated for disposal.

Radioactive Waste Management and Disposal

Ongoing storage would comply with applicable regulations. Implementing this alternative would defer compliance issues related to disposal of HLW until such time as the capsules are designated for disposal.

Air Quality and Water Protection Standards

This alternative would not result in a violation of any air quality or water protection standards.

6.3.2.2 Onsite Disposal Alternative

Under this alternative, the capsules would be disposed in an onsite subsurface drywell facility.

Table 6.3.1 Regulatory Relief Requirements - Capsule Alternatives

Alternative	Area of Regulatory Relief		
	Disposal of HLW	Disposal of RCRA Waste	National Waste Repository WASRD
No Action	N/A	N/A	N/A
Onsite Disposal	Near-surface disposal would not meet DOE requirements to dispose of readily retrievable HLW in a geologic repository.	Capsules would not meet land disposal requirements due to characteristic (corrosivity) and hazardous waste components. Would need amendment to the Dangerous Waste Permit.	N/A
Overpack and Ship	Meets requirements	Would not meet DOE restriction on mixed waste in the potential first geologic repository. May require relief from RCRA land disposal requirement	May not be acceptable due to corrosivity and powder (strontium fluoride) waste form. May require processing.
Vitrify with Tank Waste	Meets requirements	Meets requirements	Meets requirements

Notes:
HLW = High-level waste
N/A = Not applicable to the alternative
WASRD = Waste Acceptance System Requirements Document (these criteria have not been finalized).

Hazardous Waste Management and Disposal

Implementing this alternative would not meet the land disposal restrictions of RCRA because the hazardous characteristics of the capsules would be retained and land disposal of untreated hazardous waste is not allowed under RCRA. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit and may require modification of the Washington Administrative Code.

Radioactive Waste Management and Disposal

Implementing this alternative would constitute disposal of HLW in a near-surface facility, which would not meet the requirements of DOE Order 5820.2A for disposal of readily retrievable HLW in a geologic repository.

Air Quality and Water Protection Standards

This alternative would not result in a violation of any air quality or water protection standards.

6.3.2.3 Overpack and Ship Alternative

Under this alternative the capsules would be removed, overpacked into canisters, temporarily stored onsite aboveground, and shipped to the potential geologic repository for disposal.

Hazardous Waste Management and Disposal

Implementing this alternative may not enable DOE to meet the land disposal restrictions of RCRA because the characteristic corrosivity of the waste would be retained. Also, the overpacked capsules

may not meet DOE's restriction against disposal of mixed waste in the potential first geologic repository because of the potential corrosive characteristic.

Radioactive Waste Management and Disposal

This waste form may not meet the waste acceptance system requirement of the potential geologic repository because the strontium fluoride is a compacted powder. The requirement specifies that particulate waste forms must be consolidated (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates. However, it might be considered for acceptance under the HLW nonconforming form requirements.

Air Quality and Water Protection Standards

This alternative would not result in a violation of any air quality or water protection standards.

6.3.2.4 Vitrify with Tank Waste Alternative

Hazardous Waste Management and Disposal

Implementing this alternative would enable DOE to comply with RCRA. Implementation would require an amendment to the Hanford Site Dangerous Waste Permit.

Radioactive Waste Management and Disposal

Implementing this alternative would comply with the applicable requirements. Vitrification is assumed, for purposes of this analysis, to eliminate mixed waste concerns. This would have to be confirmed with appropriate waste form testing.

Air Quality and Water Protection Standards

This alternative would not result in a violation of any air quality or water protection standards.

Scoping, Public Participation and Consultations

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7.0 SCOPING, PUBLIC PARTICIPATION, AND CONSULTATIONS

SECTION HIGHLIGHTS

- Public participation in the EIS process
- Public comment opportunities
- Consultations with Tribal Nations and agencies
- Draft EIS public comment period

The Tank Waste Remediation System (TWRS) scoping process provided interested Federal and State agencies, Tribes, and members of the public an opportunity to identify issues or concerns to be analyzed in the TWRS Environmental Impact Statement (EIS). The Council on Environmental Quality (CEQ) and Washington Administrative Code (WAC) regulations require an early and open process to determine the scope of an EIS (10 Code of Federal Regulations [CFR] Parts 1500 through 1508 and WAC 197-11). The purpose of the scoping process was to determine the scope and issues to be analyzed in the Safe Interim Storage of Hanford Tank Waste EIS (DOE 1995i) and the TWRS EIS. The scoping process also identified and eliminated from detailed study areas of potential impacts that were identified as less important and narrowed the discussion of such potential impacts to a brief presentation of why they were not included. The scoping process for the TWRS EIS is described in Section 7.1.1.

Federal agencies, Washington State, and local agencies are required by the National Environmental Policy Act (NEPA), CEQ, and Washington State Environmental Policy Act (SEPA) regulations to involve the public in the decision making process associated with proposed actions that have potentially significant impacts on the human environment. Public participation activities give the public both access to information and the opportunity to participate meaningfully in the decision making process throughout the EIS preparation and at key EIS milestones. The public participation program for the TWRS EIS is described in Section 7.2.

Federal agencies as part of the NEPA process and State agencies as part of the SEPA process also consult with appropriate Tribal Nations and Federal, State, and local agencies. Various Federal and State agencies have responsibilities for certain geographic areas, natural resources, or environmental regulations that may be impacted by the proposed action. Federal and State laws regarding cultural, historical, and archaeological sites as well as treaties and intergovernmental agreements require consultation with Tribal Nations that may be impacted by the proposed action. Section 7.3 describes U.S. Department of Energy (DOE) and Washington State Department of Ecology (Ecology) consultations with applicable agencies and Tribal Nations. Volume Five, Appendix J contains formal consultation letters from DOE and Ecology, and the associated response received.

Section 7.4 describes the public comment process for the Draft EIS and information about how comments were submitted and then considered by DOE and Ecology when preparing the Final EIS.

Section 7.4 describes how public comments provide issue-specific information to the decision makers and how to follow comments through the decision process.

7.1 SCOPING SUMMARY

On January 28, 1994, DOE published a Notice of Intent in the Federal Register announcing its intent to prepare the TWRS EIS and the Safe Interim Storage EIS (59 FR 4052). The Safe Interim Storage EIS has been completed (DOE 1995i). The Notice of Intent also announced DOE's intent to conduct a series of public scoping meetings on the proposed actions in accordance with CEQ regulations and DOE Implementing Procedures (10 CFR 1021). After publishing the Notice of Intent, DOE and Ecology agreed to co-prepare the two EISs (MOU 1994).

7.1.1 The Public Scoping Process

During the 45-day scoping period, which ended on March 15, 1994, DOE and Ecology invited all interested parties to submit comments or suggestions concerning the scope of the issues, alternatives, and environmental impacts to be analyzed within each EIS. The public was also invited to attend scoping meetings, at which both oral and written comments were accepted on each proposed EIS. The agencies placed advertisements in local newspapers to announce the public scoping meetings. The newspapers and advertisement dates are included in the Implementation Plan for the TWRS EIS (DOE 1995b).

The purpose of the scoping meetings was to inform the public about the proposed action and the nature and content of the decision-documents to be prepared. These meetings also allowed the public an opportunity to identify, for the record, areas of potential impacts that should be considered by DOE and Ecology in preparing the EIS. The public scoping meetings dates and locations are included in the Implementation Plan for the TWRS EIS.

A verbatim transcript was made by a court reporter of all oral comments from each meeting. Written comments were accepted at the meetings and throughout the comment period. Copies of all transcripts and comment letters are available in the DOE Reading Rooms and Information Repositories listed in Table 7.1.1.

The initial scope of the TWRS EIS was provided in the Notice of Intent and at each public scoping meeting. The scope called for consideration of impacts associated with the following actions:

- Continue tank waste and encapsulated cesium and strontium management;
- Retrieve single-shell tank (SST) and double-shell tank (DST) waste;
- Process the waste into high-level waste (HLW) and low-activity waste (LAW) streams;
- Immobilize the HLW stream and store the treated material until a potential geologic repository is available; and
- Immobilize the LAW stream and dispose of it or put it into retrievable onsite storage.

The analysis of impacts for implementing the No Action alternative was also included in the scope of the EIS.

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Table 7.1.1 DOE Reading Rooms and Information Repositories

Location	Type of Facility	Address
Suzzallo Library	Information Repository	University of Washington Suzzallo Library Government Publications Room Mail Stop FM-25 Seattle, WA 98195 (206) 543-4664
Foley Center	Information Repository	Gonzaga University E. 502 Boone Spokane, WA 99258 (509) 328-4220, Ext. 3125
DOE Reading Room	Reading Room and Information Repository	Washington State University, Tri-Cities 100 Sprout Road, Room 130 Richland, WA 99352 (509) 376-8583
Bradford Price Miller Library	Information Repository	Portland State University Science and Engineering Floor SW Harrison and Park P.O. Box 1151 Portland, OR 97207 (503) 725-3690
DOE Freedom of Information Reading Room	Reading Room	Forrestal Building 1000 Independence Avenue, SW Washington, D.C. 20585 (202) 586-5000

7.1.2 Public Scoping Process Results

The EIS scoping process provided an opportunity for interested parties to address both the TWRS EIS and the Safe Interim Storage EIS. The scoping process resulted in comments that were relevant only to the TWRS EIS, relevant only to the Safe Interim Storage EIS, or relevant to both of the EISs. The Implementation Plan for the TWRS EIS summarizes and responds to those scoping comments relevant only to the TWRS EIS as well as those scoping comments applicable to both EISs (DOE 1995b).

DOE and Ecology's responses to scoping comments are summarized in the Implementation Plan for the TWRS EIS, which is available at the DOE Reading Rooms and Information Repositories listed in Table 7.1.1. These documents are also available upon request by calling 1-800-321-2008 or writing to Carolyn Haass, DOE TWRS EIS NEPA Document Manager, U.S. Department of Energy, P.O. Box 1249, Richland, Washington 99352, or Geoff Tallent, Ecology TWRS EIS Project Lead, Washington State Department of Ecology, P.O. Box 47600, Olympia, Washington 98504-7600.

Those issues raised during the public scoping process and analyzed in the TWRS EIS are listed in Table 7.1.2. All the topics originally identified in the Notice of Intent have been addressed in this EIS.

Table 7.1.2 Issues Identified During Public Scoping and Analyzed in the TWRS EIS

Topic	Issue
EIS Scope and Content	Identify long-term disposal method.
	Include all tank waste in the EIS scope.
	Analyze additive impacts associated with storage and disposal of Hanford Site waste.
	Address decontamination and decommissioning and closure of existing TWRS sites.
	Address siting of all TWRS sites (including storage and disposal).
	Compare short-term environmental impacts associated with waste retrieval to impacts related to in-tank disposal.
	Assess interim storage of HLW at the Hanford Site.
	Analyze impacts associated with new tanks and tank farm infrastructure improvements.
	Limit duplication of analysis contained in the Technical Options Report (Boomer et al. 1993).
TWRS EIS Alternatives	Address in-tank stabilization and disposal of tank waste.
	Address options to use grout for waste stabilization and storage.
	Address Resource Conservation and Recovery Act compliance issues.
	Address Hanford Site storage of vitrified LAW.
	Provide cost and environmental impacts comparisons for waste separation and vitrification.
	Provide analysis of interim storage and transportation of tank waste in rail cars.
	Address waste disposal for future retrieval.
	Large-cask repository disposal of minimized waste should be compared to vitrification alternatives.
Closure and Land-Use Restrictions	Address the history of past land disturbances.
	Determine future land-use restrictions.
	Address tank farm closure and decontamination and decommissioning of existing facilities and facilities constructed to implement the TWRS alternatives.
	Minimize the area set aside for long-term disposal.
Vitrification	Analyze vitrification technology options.
	Address shielding and encasement options for vitrified materials using cask for canister construction materials (e.g., lead, stainless steel, and contaminated steel and cement materials currently onsite).
	Provide analysis on the vitrification of the encapsulated cesium and strontium.
	Analyze the in-tank vitrification of all tank waste.
	Analyze cost and environmental impacts associated with storage of unvitrified waste.
	Address feed materials for the vitrification process (e.g., borosilicate, sodium nitrate, and sodium carbonate).
	Determine the need for an interstitial filler.
Grout	Analyze the use of grout for LAW stabilization.
Waste Characterization	Address neptunium contamination.
	Analyze the cost and environmental impacts of combining SST and DST waste.
	Address the quality and sufficiency of existing waste characterization data.

Table 7.1.2 Issues Identified During Public Scoping and Analyzed in the TWRS EIS (cont'd)

Topic	Issue
Waste Storage and Retrieval	Address freeze barrier isolation of tank waste during clean-out operations or in-tank processing.
	Address waste retrieval options and tank integrity.
	Address environmentally benign barrier or containment options.
	Minimize the level of retrieval of sludges and solids.
Waste Treatment	Analyze the use of solvent extraction to remove transuranics.
	Address options to process the waste into HLW and LAW.
Resource Recovery and Waste Minimization	Address the use of ion exchange to concentrate radionuclides and reduce waste volume.
	Determine the use of sugar denitrification as a waste minimization option.
	Address all options for minimization of waste (especially iodine-129, carbon-14, and tritium).
	Determine the possibilities of resource recovery from tank waste.
	Analyze waste volume reduction options including use of an evaporator to minimize liquid waste.
Health and Safety	Determine tank explosion potentials.
	Provide an independent assessment of threats.
	Determine options for safe disposition of ferrocyanide compounds and tritium.
	Assess the emergency response requirements of alternatives.
Emissions, Effluents, and Monitoring	Address potential releases to air, water, and groundwater for each alternative.
	Analyze operational tank leak detection and monitoring program options.
	Consider technologies such as filters or treatment options to minimize the releases of gases to the atmosphere.
	Trap, treat, and store long-term radioactive and hazardous gases.
Natural Resource Preservation and Mitigation	Analyze the impacts on State- and Federal-listed species.
	Analyze the impacts on shrub-steppe habitat present at the Hanford Site.
	Determine habitat variables assessed so alternatives within a site can be considered to minimize impacts to higher quality habitat areas.
	Minimize construction impacts and consider post-construction mitigation.
	Address use of native plants and seeds and transplanting to restore impacted land.
	Analyze impacts on the Columbia River ecosystem and associated natural and cultural resources.

7.2 EIS PUBLIC PARTICIPATION PROCESS

A Notice of Availability of the Draft EIS was published in the Federal Register and advertisements were placed in local newspapers (61 FR 16248). These notifications also informed the public of the comment period for the Draft EIS and the schedule for public hearings. Copies of the Draft EIS were distributed to interested individuals, public interest groups, agencies, and Tribes. The public comment period extended from April 12 to May 28, during which time the public and others had the opportunity to submit written comments on the Draft EIS. Additionally, DOE and Ecology conducted a series of

five public comment hearings and meetings at which the public had the opportunity to submit oral and written comments. During and after the comment period, DOE and Ecology held consultation meetings with Tribal Nations and agencies to address issues associated with the Draft EIS. DOE and Ecology considered comments on the Draft EIS prior to completing the Final EIS. The Final EIS includes a list of public comments and the responses to comments from DOE and Ecology (Volume Six, Appendix L). The Final EIS has been distributed to the public and others and placed for public inspection in DOE Reading Rooms and Information Repositories, as listed in Table 7.1.1.

The decision regarding the proposed action will not be made until at least 30 days following the publication of the Final EIS Notice of Availability. DOE and Ecology will prepare a Record of Decision, which will be published in the Federal Register and be available for public inspection in DOE Reading Rooms and Information Repositories. A Mitigation Action Plan will be prepared to analyze any commitments to mitigate environmental impacts contained in the Record of Decision. Copies of the Mitigation Action Plan will also be available for public inspection at the locations listed in Table 7.1.1.

The goal of the TWRS EIS public participation program is to create an open and accessible decision making process that results in TWRS decisions that are technically feasible, environmentally sound, health and safety-conscious, and that address public concerns and values. Provisions for meaningful and informed public involvement within the TWRS decision making process will help achieve this goal. A detailed discussion of the goal and objectives is presented in the Implementation Plan for the TWRS EIS (DOE 1995b).

The following documents, activities, and avenues of communication for the TWRS EIS have and will continue to encourage direct two-way communication between the agencies and those stakeholders, Tribal Nations, and Federal, State, and local agencies interested in the TWRS EIS and the decisions to be made.

Notice of Availability

In addition to the Notice of Availability that was published in the Federal Register for the Draft EIS and Final EIS.

Public Notification

Public notices (advertisements in local newspapers, broadcasts via radio or television stations, and mailings) are used to announce DOE and Ecology activities and plans and to encourage public involvement in the TWRS EIS decision making process.

Stakeholders, Agencies, Tribal Nations, and Media

Direct notification via phone calls, facsimile, press releases, Notices of Availability, or mailings are used to announce DOE and Ecology decisions and major project milestones (e.g., the public comment period for the Draft EIS, availability of the Final EIS. Copies of the Record of Decision will be provided to agencies, Tribal Nations, and interested stakeholders.

Briefing of DOE Headquarters, DOE Richland Operations Office, and Ecology Advisory Boards and Committees

DOE Headquarters, DOE Richland Operations Office, and Ecology have established communication channels with advisory boards and committees to provide public input into agency policies, programs, and decisions. These boards and committees, including the Hanford Advisory Board, the Environmental Management Advisory Board, and the Defense Nuclear Facility Safety Board, have provided input into the TWRS EIS.

Public Comment Period

The public comment period provided an opportunity for interested Tribal Nations, agencies, public interest groups, and the public to provide their input on the proposed action and environmental impact analysis contained in the EIS. The public comment period for the Draft EIS began on April 12, 1996 and ended on May 28, 1996.

Public Hearings

Public hearings and meetings were held in conjunction with the public comment period for the Draft EIS. Public hearings were announced a minimum of 15 days prior to any hearing and diverse channels of communication were used to reach the broadest possible audience.

Administrative Record and DOE Reading Rooms and Information Repositories

The Administrative Record for the TWRS EIS is maintained under the direction of DOE Richland Operations. The Administrative Record contains an index of all documents in the record, guidance documents, final reports, technical information, comments by the public and agencies, DOE and Ecology's responses to comments, decision documents, and other documents used as a basis for analysis during the development of the EIS. These documents, including an index of the Administration Record files, may be found in the DOE Reading Rooms and Information Repositories listed in Table 7.1.1.

Toll-Free Telephone Line, Hanford Cleanup at 1-800-321-2008 (Hanford Hotline)

A toll-free telephone number is available to provide stakeholders with an opportunity to ask questions and obtain information about the TWRS EIS.

Hanford Home Page

TWRS EIS documents have been and will continue to be made available on the Internet via the Hanford Home Page (www.Hanford.gov). Documents placed or to be placed on the Hanford Home Page include the Draft EIS, Final EIS, Record of Decision, meeting notices, fact sheets, and press releases.

7.3 CONSULTATIONS WITH TRIBAL NATIONS AND FEDERAL, STATE, LOCAL, AND REGIONAL AGENCIES

To ensure full compliance with NEPA and SEPA regulations and to help keep concerned agencies informed of DOE actions, the consultations listed in Table 7.3.1 were conducted. Consultations consisted of written correspondence regarding the proposed action, alternatives, environmental impacts,

regulatory requirements, issues of concern, and information available from Federal, State, and local agencies and Tribal Nations. Copies of formal consultation letters are contained in Volume Five, Appendix J.

Table 7.3.1 Agency and Tribal Nation Consultations

Subject Area	Basis of the Requirement	Agency
Endangered Species	Endangered Species Act	U.S. Fish and Wildlife Service Washington State Department of Fish and Wildlife
Migratory Birds	Migratory Bird Treaty Act	U.S. Fish and Wildlife Service
Archaeological, Historical, and Cultural Sites	National Historic Preservation Act Archeological Resources Protection Act Antiquities Act American Indian Religious Freedom Act Native American Graves and Repatriation Act Federal Cave Protection Act	National Park Service U.S. Bureau of Land Management Washington State Historic Preservation Officer U.S. Advisory Council on Historic Preservation Bureau of Indian Affairs
Air Pollution	Clean Air Act Washington Clean Air Act	U.S. Environmental Protection Agency Washington State Department of Health Washington State Department of Ecology
Water Resources Hanford Reach Water Pollution	Wild and Scenic Rivers Act Hanford Reach Study Act Waste Pollution Control Act	National Park Service Washington State Department of Ecology
Floodplains and Wetlands	Floodplain and Wetlands Regulations	U.S. Army Corps of Engineers
Hazardous, Dangerous, and Mixed Waste Management and Transportation	Resource Conservation and Recovery Act Hazardous and Solid Waste Amendments Comprehensive Environmental Response, Compensation, and Liability Act	U.S. Environmental Protection Agency Washington State Department of Ecology Oregon Department of Energy Washington State Department of Transportation Natural Resources Trustee Council
Tribal Nation Concerns	U.S. Department of Energy Policy	Confederated Tribes and Bands of the Yakama Indian Nation Confederated Tribes of the Umatilla Indian Reservation Nez Perce Tribe Federal Government Washington State Department of Ecology
Socioeconomics and Planning	National Environmental Policy Act	Benton and Franklin Counties and Municipal Agencies for Richland, Kennewick and Pasco (Planning and Economic Development)
Environmental Justice	Executive Order 12898	U.S. Department of Energy Washington State Department of Ecology Confederated Tribes and Bands of the Yakama Indian Nation Confederated Tribes of the Umatilla Indian Reservation Nez Perce Tribe Wanapum People

In addition to written consultation, and when appropriate, DOE and Ecology consulted agencies and Tribal Nations to clarify areas of potential impacts, attain an understanding of concerns, and receive information provided by the agencies and Tribal Nations. Meetings or other consultations were held with the following Tribal Nations, organizations, and agencies:

- Benton County, Washington;
- Community Council, Benton and Franklin Counties, Washington;
- Confederated Tribes and Bands of the Yakama Indian Nation;
- Confederated Tribes of the Umatilla Indian Reservation;
- Defense Nuclear Facility Safety Board;
- Environmental Management Advisory Board;
- Hanford Advisory Board;
- Hanford Natural Resources Trustee Council;
- National Academy of Sciences;
- Nez Perce Tribe;
- U.S. Environmental Protection Agency;
- Washington State Department of Fish and Wildlife; and
- Washington State Department of Health.

In addition to consultations conducted prior to and following the release of the Draft EIS and Final EIS, DOE and Ecology provided consulting agencies and Tribes with copies of the documents for review. The Record of Decision will also be provided to Tribal Nations and agencies.

7.4 PUBLIC COMMENT PROCESS FOR THE TWRS DRAFT EIS

Distribution of the Draft EIS

Beginning on April 4, 1996 and continuing through the end of the comment period on May 28, 1996, DOE and Ecology distributed in excess of 850 copies of all or portions of the Draft EIS. Distribution included copies sent to local, State, and Federal agencies and elected officials; Tribal Nations; and interested stakeholders. A copy of the EIS and supporting documents was made available at five DOE Reading Rooms and Information Repositories (Seattle, Spokane and Richland, Washington; Portland, Oregon; and Washington, D.C.). The Draft EIS was posted on the Hanford Home Page.

Notice of Availability

On April 12, 1996, a Notice of Availability for the Draft EIS was published in the Federal Register (61 FR 16248).

Public Notification

The public was notified of the availability of the Draft EIS for review, the public comment period, and the dates and locations of public meetings through a variety of channels of communication.

- On April 8, 1996, officials from DOE and Ecology held a press conference for regional and national media to announce the start of the comment period and the availability of the Draft EIS for review and public comment. The press conference generated extensive coverage in the local and regional newspapers.

- The press release announcing the start of the public comment period was placed on the Hanford Home Page.
- An EIS fact sheet was mailed on April 12, 1996 to more than 1,200 individuals on the Hanford Tri-Party Agreement mailing list. The fact sheet summarized the EIS, listed the locations of information repositories where the document was available for public review, informed readers of the dates and locations of public hearings and meetings, and informed readers how a copy of the EIS could be obtained.
- On April 12, 1996, copies of the EIS and supporting documents were made available for public review in five DOE Reading Rooms and Information Repositories.
- On April 12, 1996, public notification advertisements on the start of comment period and meeting dates and locations were published in newspapers in Seattle, Spokane, and Richland, Washington; Portland and Hood River, Oregon; and Washington, D.C.
- On April 12, 1996, information on the Draft EIS and comment period was posted on the Hanford Calendar (revised and distributed weekly throughout the comment period).

Hearings and Meetings

DOE and Ecology sponsored five public hearings and meetings on the Draft EIS. Meetings were held in Seattle on May 22, 1996, Spokane on May 15, 1996, and Pasco, Washington on May 2, 1996; Portland, Oregon on May 9, 1996; and Arlington, Virginia on May 7, 1996. At the public meetings, information was provided to attendees regarding the Draft EIS, representatives from DOE and Ecology responded to questions from attendees, and oral and written comments were submitted by attendees. Comments were recorded and a transcript of each comment is available for review at DOE Reading Rooms and Information Repositories.

In addition to notifications regarding the meetings that were included in information disseminated on the start of the comment period and notification of the availability of the Draft EIS for review, the following activities were completed:

- Display advertisements were placed in general circulation newspapers in the region near the hearing or meeting sites the week prior to the hearing or meeting.
- Post cards were mailed to individuals living in the region surrounding the hearing or meeting locations.
- A press release was issued to the media in the region surrounding the hearing or meeting to announce the meeting time, date, and location.
- Hearing or meeting times, dates, locations, and formats were coordinated with public interest groups (Heart of America Northwest, Hanford Energy Action League, and Government Accountability Project), State agencies (Oregon Department of Energy), and the Hanford Advisory Board to maximize attendance.
- Meeting times, dates, and locations were included in Hanford Happenings and Hanford Update.

Consultation Meetings

Meetings, formal and informal, were held during and following the comment period with the following agencies, Tribal Nations and advisory groups to receive input on the Draft EIS:

- Hanford Advisory Board, Waste Management Committee Meeting, Seattle, Washington;
- Yakama Indian Nation, Richland, Washington;
- Nez Perce Tribe, Lapwai, Idaho;
- Hanford Advisory Board, Richland, Washington;
- Community Council, Richland, Washington;
- Washington and Oregon Congressional Delegation, Washington, D.C.;
- Environmental Management Advisory Board, Arlington, Virginia;
- U.S. Environmental Protection Agency, Seattle, Washington;
- Confederated Tribes of the Umatilla Indian Reservation, Mission, Oregon;
- Defense Nuclear Facility Safety Board, Richland, Washington; and
- National Academy of Sciences, Washington, D.C.

In addition to the above meetings, other communication or meetings were held with the technical staff of the following organizations, agencies, or Tribal Nations to support submission of comments and review of the EIS and to receive additional technical information for inclusion in the Final EIS:

- Yakama Indian Nation, Richland, Washington;
- Nez Perce Tribe, Lapwai, Idaho;
- Confederated Tribes of the Umatilla Indian Reservation, Mission, Oregon;
- Benton County, Washington;
- National Academy of Sciences, Washington, D.C.;
- Heart of America Northwest; and
- Hanford Energy Action League.

DOE also requested that the National Academy of Science review the Draft EIS to determine its adequacy to support decision making for the TWRS program. DOE has consulted with the National Academy of Science review committee since the publication of the Draft EIS and responded to initial comments and questions during preparation of the Final EIS. DOE intends to consider final comments by the National Academy of Science in the Record of Decision for the TWRS program.

7.5 COMMENTS ON THE DRAFT EIS

The Draft EIS was provided for public comment from April 12 to May 28, 1996. During this time, 5 public hearings and workshops were held and approximately 750 written and oral comments were received from more than 350 individuals, agencies, stakeholders, Tribal Nations, and organizations provided comments. In response to these comments and emerging technical information that was not available when the Draft EIS was published, a number of changes have been incorporated into the Final EIS.

DOE and Ecology prepared Appendix L, Draft EIS Comments and Agency Responses, to address and respond to public comments on the Draft EIS. In addition, DOE considered comments from the public, agencies, and Tribal Nations, along with other factors such as programmatic need, short- and long-term impacts, technical feasibility, and cost, in arriving at DOE's preferred alternative. Appendix L contains the comments on the EIS received during the public comment period and DOE and Ecology responses to those comments. In compliance with the provisions of the NEPA and CEQ regulations [40 CFR 1502.14(e)], public comments on the Draft EIS were assessed and considered both individually and collectively by DOE and Ecology. Some comments resulted in modifications to the EIS. Other responses contained an explanation of the reasons that the comments did not warrant any further response or modification to the EIS.

As required in the CEQ regulations, the Final EIS identifies DOE's and Ecology's preferred alternatives. The preferred alternatives were identified based on consideration of environmental impacts, regulatory compliance, DOE and Waste Management programmatic missions, public comments, and DOE policy. Public, agency, and Tribal Nation input considered in DOE's and Ecology's identification of preferred alternatives included concerns, preferences, and opinions regarding the activities addressed in the EIS, as well as expectations of DOE in making the decisions on environmental restoration and waste management programs at the Hanford Site.

A major purpose of NEPA is to promote efforts that will prevent or eliminate damage to the environment by ensuring informed decision making on major Federal actions that significantly affect the quality of the human environment. This EIS has been revised, as appropriate, in response to comments. Comments were received on a wide variety of issues including:

- General and specific preferences for one or more of the alternatives;
- The cost estimates presented in the Draft EIS;
- The characterization and modeling of vadose zone and groundwater contamination;
- How repository fees were calculated and the assumption that HLW would be disposed of at an offsite repository;
- The sufficiency of characterization data to support retrieval and treatment of the waste;
- Calculation of post-remediation risk to a Native American Site user;
- Calculation of potential accident risks;
- The extent of waste retrieval from the tanks;
- Consideration of closure in the scope of the EIS;
- Consideration of impacts to cultural and natural resources; and
- Consideration of alternatives that would not comply with Federal and State laws and regulations.

Based on review of public comments along with consultations held with commenting agencies and State and Tribal governments, primary EIS enhancements include the following.

- Discussion and analysis associated with the disposal of HLW at the potential national geologic repository were reviewed, clarified by separating the discussion and analysis from other components of the alternatives, and current data and formulas for

calculating costs were added to Volumes One and Two, as appropriate. DOE has refined the cost estimates for disposal of HLW at the offsite geologic repository. Changes were made in the number of canisters as well as the cost-estimating methodology, which impacted the HLW disposal fees. The size of the HLW canisters was increased to reduce the number of HLW packages requiring disposal. Repository disposal fee estimates were performed using the current disposal fee methodology along with revised canister projections. This approach to estimating disposal fees is a refinement over the estimates presented in the Draft EIS, which were based on a fixed cost per canister for all alternatives.

- The option of longer interim onsite storage of immobilized HLW pending availability of an offsite geologic repository was included in the Final EIS.
- In Volume One, Section 5.11 and Volume Three, DOE revised the risk analysis to include a Native American subsistence user scenario. This exposure scenario was developed at the request of and in consultation with the Yakama Indian Nation, Nez Perce Tribe, and Confederated Tribes of the Umatilla Indian Reservation. This scenario represents a Native American who might engage in both a traditional Native American lifestyle and contemporary lifestyle activities such as irrigated farming.
- Additional consultation with the affected Tribal Nations is reflected in the environmental justice analysis and throughout the EIS, as appropriate.

As committed to in the Draft EIS and in response to comments on the Draft EIS, a discussion of emerging data regarding vadose zone contamination beneath the tanks resulting from past leaks has been added to the Final EIS in Volume One, Sections 4.2 and 5.2, Appendix F, and Appendix K. The data were unavailable for inclusion in the EIS at the time the Draft EIS was published. Much of the data presented in the Final EIS are based on preliminary analysis of the vadose zone contamination, and thus the EIS presents several scenarios that are currently under review by DOE and Ecology regarding the cause, nature, and extent of the contamination. Cesium-137 and other radioactive contaminants from past leaks from the tanks have recently been found at greater depths below the tanks than previously known. This means that some of the contaminants that were expected to move very slowly towards the groundwater have moved more quickly than previously anticipated. The mechanisms for how these contaminants have moved more quickly than anticipated are not fully understood, and DOE has implemented a program to determine the mechanism(s) for this transport. The Final EIS presents a discussion of the data collected to date, potential mechanisms for the transport of the contaminants, and how each mechanism might affect the impacts presented in the Final EIS. Potentially this issue could affect closure of the tank farms and the measures taken to control leaks during retrieval.

Other enhancements to the EIS included modifying the Phased Implementation alternative. The Draft EIS included one full-scale separations and immobilization facility during Phase 2 (full-scale production). This was modified for the Final EIS to include two smaller facilities that together would process the same volume of waste as the large facility shown in the Draft EIS. This change was made to ensure that the EIS bounded the impacts associated with the phased approach for the implementing extensive retrieval alternatives. Accident discussions and analysis were reviewed and emerging data

were added to Volume One, Section 5.12 and Appendix E. The EIS was also revised to reflect 1995 Site environmental monitoring and reporting (PNL 1996).

Additional analysis was performed to assess the volume of HLW that would be expected for the ex situ alternatives. This analysis provided an improved planning basis for the volume of HLW that would require interim onsite storage and offsite disposal at a geologic repository. Refinements in the alternatives and revised tank waste inventory were also made. These refinements included 1) adding provisions for 50 years of onsite storage of HLW for those alternatives that included the disposal of HLW in a geologic repository; 2) using dedicated trains to ship HLW to a geologic repository; 3) increasing the amount of contaminants that could potentially be released during certain accidents; 4) adding 22 curies of iodine-129 to the tank waste inventory; and 5) refinements in the amount and source of construction materials and other resource requirements. Also, the Draft EIS contained an analysis of uncertainties for each relevant component of the environment (e.g., risk, waste inventory, groundwater migration) in the applicable section of the EIS. For the Final EIS, the evaluation and discussion of uncertainties was expanded and presented together in Volume Six, Appendix K.

Finally, DOE expanded the EIS analysis of a variation to the Ex Situ/In Situ Combination alternative (known as Ex Situ/In Situ Combination 1 alternative in the Final EIS) presented in the Draft EIS. This alternative was described in the Draft EIS in the cover letter and preface to Volume One and is called the Ex Situ/In Situ Combination 2 in the Final EIS. The Ex Situ/In Situ Combination 2 alternative is similar to the Ex Situ/In Situ Combination 1 alternative that was fully assessed in the Draft EIS, except that the waste would be retrieved from 25 tanks rather than 70 tanks. Both of these alternatives are based on the retrieval of the wastes that would provide the greatest contribution to long-term health risk. The discussion and analysis for this alternative are presented in Volume One and Appendix B.

The changes and refinements described previously resulted in relatively small adjustments in the resource commitments and the calculated environmental and human health impacts. The only large change in impacts resulted from the reevaluation of an energetic fire in a hydrogen generating tank for all of the alternatives and the costs associated with the disposal of the HLW for the ex situ alternatives. Overall, the relative relationship of the impacts between alternatives did not substantially change except that the potential operational accidents for the No Action and Long-Term Management Alternatives would be substantially higher than the other alternatives.

List of Preparers

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8.0 LIST OF PREPARERS

SECTION HIGHLIGHTS

- Identifies the agencies and parties responsible for the TWRS EIS preparation and review
- Provides qualifications of EIS authors and areas of responsibility

This section describes the persons responsible for preparing and reviewing the Tank Waste Remediation System (TWRS) Environmental Impact Statement (EIS). Support for preparing the EIS was provided to the U.S. Department of Energy (DOE) Richland Operations Office. The EIS was prepared with assistance from Jacobs Engineering Group Inc. and its subcontractors, Advanced Science, Inc. and Environmental Sciences and Engineering, Inc. The environmental analyses were based largely on engineering data prepared by the Hanford Site Management and Operations contractor and Jacobs Engineering Group Inc. and reviewed by DOE. The DOE, Washington State Department of Ecology (Ecology), and Jacobs Engineering Group Inc. staff and its subcontractor staff who contributed to preparing the EIS are listed in Table 8.1.1. Table 8.1.2 provides brief biographic sketches of preparers from DOE, Ecology, and Jacobs Engineering Group Inc. and its subcontractors.

Table 8.1.1 List of EIS Preparers

Volume and Section	Preparers
EIS NEPA Document Manager	Carolyn Haass (DOE)
EIS Ecology Project Manager	Geoff Tallent (Ecology)
EIS Project Manager	Marc Nelson
EIS Summary	Dave Nichols and Marc Nelson
Volume One	
1.0 Introduction	Dave Nichols
2.0 Purpose and Need for Action	Carolyn Haass (DOE) and Geoff Tallent (Ecology)
3.0 Description and Comparison of Alternatives	David Murray, Colin Henderson, Marc Nelson, and Larry Selby
4.0 Affected Environment	Arrie Bachrach
Geology	Phillip Rogers
Water Resources	Phillip Rogers, Charlene Regenhardt, Keith Fuchser, and Eileen Poeter
Meteorology and Air Quality	John Shrock and John Kuhn
Biological and Ecological Resources	Larry Dean and Clifford Duke
Cultural Resources	Tirzo Gonzales
Socioeconomics	David Serot, Keith Lusk, Arrie Bachrach, and Dave Nichols
Land Use	Ray Hrenko
Visual Resources	Keith Lusk and Arrie Bachrach
Noise	William Elzinga
Transportation	Keith Lusk and Arrie Bachrach
5.0 Environmental Consequences	Marc Nelson and Arrie Bachrach
Geology	Phillip Rogers
Water Resources	Phillip Rogers, Charlene Regenhardt, Keith Fuchser, Eileen Poeter, and Marc Nelson
Meteorology and Air Quality	John Shrock, John Kuhn, and William Glover
Biological and Ecological Resources	Larry Dean, Bill Bosan, and Clifford Duke
Cultural Resources	Tirzo Gonzales

Table 8.1.1 List of EIS Preparers (cont'd)

Volume and Section	Preparers
5.0 Socioeconomics	David Serot, Arrie Bachrach, and Keith Lusk
Land Use	Ray Hrenko and Arrie Bachrach
Visual Resources	Keith Lusk and Arrie Bachrach
Noise	William Elzinga
Transportation	Arrie Bachrach
Anticipated Health Effects	Alex Nazarali, Michael Harker, Bill Bosan, Doug Evans, and Andy Stanley
Accidents	Michael Harker and Bill Bosan
Cumulative Impacts	Phil Bramson and William Glover
Unavoidable Adverse Environmental Impacts	Arrie Bachrach and Dave Nichols
Relationship Between Short-term Uses of the Environmental and Long-term Productivity	Arrie Bachrach
Irreversible and Irretrievable Commitments of Resources	Arrie Bachrach, William Glover, and Colin Henderson
Conflicts Between the Proposed Plan and Land-Use Plans or Controls	Ray Hrenko
Pollution Prevention	Arrie Bachrach and David Murray
Environmental Justice	Dave Nichols
Mitigation Measures	Marc Nelson
6.0 Statutory and Regulatory Requirements	Phil Bramson, Marc Nelson, William Glover, and Barbara Morson
7.0 Scoping, Public Participation, and Consultations	Dave Nichols and Doug Brown
8.0 List of Preparers	Maura Oldfield
Volume Two	
A. TWRS EIS Waste Inventory Data	Colin Henderson and David Murray
B. Description of Alternatives	David Murray, Jim Goodwin, Colin Henderson, Dave Stein, Joseph Scott, Ronald Weed, and Larry Selby
C. Alternatives Considered but Rejected from Further Evaluation	David Murray
Volume Three	
D. Anticipated Risks	Alex Nazarali, Clifford Duke, Andy Stanley, Mitch Pelton, Joan Young, Doug Evans, Bill Bosan, and Loretta Crow
Volume Four	
E. Risk from Accidents	Michael Harker
F. Groundwater Modeling	Phillip Rogers, Charlene Regenhardt, Greg Wroblicky, Keith Fuchser, Eileen Poeter, and Kent Bostick
Volume Five	
G. Air Modeling	John Shrock and John Kuhn
H. Socioeconomic Impact Modeling	David Serot
I. Affected Environment	Arrie Bachrach (with supporting principals identified for Section 4.0)
J. Consultation Letters	Dave Nichols
K. Uncertainties Analysis	Alex Nazarali, David Duran, Clifford Duke, Phil Bramson, Colin Henderson, Phillip Rogers, Michael Harker, and Marc Nelson
Volume Six	
L. Draft EIS Comments and Agency Responses	Marc Nelson, Colin Henderson, Alex Nazarali, Phillip Rogers, David Murray, Michael Harker, Loretta Crow, Mamie Brouwer, Doug Evans, Ronald Weed, Arrie Bachrach, and Dave Nichols
EIS Document Production, Editing, and Graphics	Maura Oldfield, Norma Sanchez, Mig Owens, Michelle Johnson, Marie Marquis-Anderson, Claudia Holguin, John Lawrence, Geri Bertelson, Loretta Crow, Mitch Pelton, Ron Allingham, and Carrie Meyer

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Table 8.1.2 Biographical Sketches of EIS Preparers

Name	Degree(s), Registrations, and Experience	Years Experience
Bachrach, Arrie	MS, BA, Political Science	22
Managed and prepared over 50 EIRs for Federal, State, and local governments and private industry. Prepared environmental documents for DOE Office of Civilian Radioactive Waste Management and Uranium Mill Tailings Remedial Action Project.		
Bosan, Bill	PhD, Pharmacology and Toxicology; BS, Biological Sciences; BA, Chemistry.	12
Managed/prepared human health and environmental risk assessments at CERCLA/RCRA sites for DOD and private clients.		
Bostick, Kent	PHg, CGWP; MS, Groundwater Hydrology; BS, Soil Science	20
Managed Hydrology Group on Uranium Mill Tailings Remedial Action Project preparing NEPA documents for 24 sites. Experience in unsaturated, saturated flow, and contaminant transport modeling; emphasis on waste isolation. Contributed to mixed-waste disposal cell designs for Los Alamos National Laboratory and Parks Shallow Land Disposal Facility.		
Bramson, Phil	BA, Engineering Physics	36
Managed preparation of NEPA documents including EISs for Hanford Site's TWRS and Defense Waste projects, and DOE Headquarters' New Production Reactor EIS. Managed Battelle's Environmental Protection Department at Pantex Plant.		
Brouwer, Mamie	BA, Botany	16
Managed environmental information and quality assurance tasks for 25 DOD installations and DOE sites nationwide. Program Manager for environmental information management systems supporting the Navy and Air Force.		
Brown, Doug	BA, Computer Information Systems	3
Supported stakeholder development, public hearings, and comment period for the Spent Nuclear Fuels Programmatic EIS. Supported development of the data management plan for the public comment period for the Waste Management Plan at INEL.		
Callahan, Mike	BS, Chemical Engineering; BA, Chemistry; PE	16
Performed air emission analysis and assessed oil and gas production facilities for 5 EIR/EIS projects. Specialist in industrial operations, waste generation, air emission control, off-gas treatment and wastewater associated with remediation activities.		
Crow, Loretta	BA, Biology	10
Technical editor and document production coordinator for engineering studies, remedial investigations, feasibility studies, and work plans including documents for DOD Navy sites.		
Dean, Larry	BS, Wildlife Management	23
Managed multidisciplinary team preparing NEPA documents including the Preliminary Draft Hanford Remedial Action EIS. Prepared environmental documents for DOE's Hanford and Fernald sites.		
Duke, Clifford	PhD, Botany; MA, Public Policy; BA, Biology and Environmental Sciences	15
Provided ecological risk assessment support for an RI/FS and an EIS at the DOE Fernald Site. Developed the framework and analytical methodology for the baseline ecological risk and impacts section of the Hanford Remedial Action EIS.		
Duran, David	PhD, MS, BS, Chemistry	10
Senior toxicologist in support of CERCLA/RCRA RI/FSs. Managed and authored four human health and ecological risk assessments under the NAVY CLEAN for DOD. Performed Monte Carlo uncertainty analysis at the Hanford Site.		
Elzinga, Bill	MS, BS, Biology	15
Performed EAs and EISs for EPA, U.S. Fish and Wildlife Service, and Army Corp of Engineers, including required NEPA elements (i.e., natural resources, air, noise, socioeconomics). Manager of aquatic surveillance program at Weldon Springs.		
Evans, Doug	MS, BS, Geology	9
Analyzed impacts to geologic and water resources for the Hanford Remedial Action EIS. Conducted field investigations and prepared environmental documents for Environmental Restoration programs at DOE's Hanford and Fernald sites.		
Fromm, Carl	BS, Chemical Engineering	23
Performed engineering/economic evaluations for pollution prevention and environmental controls for DOE, DOD, and private clients. Developed computer model for estimating effects of changing capacity on capital cost for alternative technologies.		
Fuchser, Keith	BS, Aerospace Engineering	7
Supported environmental monitoring, impact assessment, disaster planning and response, land parcel mapping, and facilities management projects. Experience includes vadose zone and groundwater model applications and geographic analysis.		

Table 8.1.2 Biographical Sketches of EIS Preparers (cont'd)

Name	Degree(s), Registrations, and Experience	Years Experience
Glover, William A.	MS, Nuclear Engineering; BS, Astrophysics; PE	19
Directed multidisciplinary staffs for NEPA assessments for DOE's Uranium Mill Tailings Remedial Action Project. Participated in license review of a low-level radioactive waste disposal site and requirements review at DOE's Fernald Site.		
Gonzalez, Tirzo	MA, Candidate, Historic Preservation; BA, Visual Arts	12
Conducted archaeological studies at the DOE Kaui Test Facility in Hawaii, coordinated field studies for a proposed missile launch facility, and contributed to the establishment of a cultural resources Geographical System database for the Hanford Site.		
Goodwin, Jim	BS, Metallurgical Engineering	36
Project Manager for engineering and construction of process plants for industry and the project manager for $150 million upgrades project at DOE's Fernald Site.		
Haass, Carolyn	BS, Mineral Engineering Chemistry/Metallurgical Engineering	13
TWRS Environmental Program Manager for DOE Richland Operations Office. Responsible for TWRS NEPA compliance, permitting (RCRA, Clean Air Act, and Clean Water Act), environmental compliance, closure, waste minimization, Tri-Party Agreement, and development of the TWRS environmental strategy.		
Harker, Michael R.	BS, Zoology	14
Provided accident and risk analyses for various DOE Safety Analysis Reports, including the Hanford Site Plutonium Finishing Plant Safety Analysis Reports. Lead risk analyst for the Hanford Site Solid Waste Burial Ground Safety Analysis Reports.		
Henderson, Colin	BS, Mechanical Engineering; PE	9
Developed engineering design changes and documentation for facility upgrades and resolution of non-compliance issues as a Systems Engineer at DOE's Hanford Site.		
Hrenko, Ray	BS, Environmental Sciences	14
Prepared over 50 land-use plans and contributed to 35 EISs and 50 EAs. Managed the land use and recreation sections of the White Sands Missile Range EIS and supported the land use sections of DOD Nuclear Electric Propulsion Space Test EIS.		
Kuhn, John	BS, Environmental Engineering Sciences; EIT	3
Conducted dispersion modeling in support of two EISs and various permit applications. Conducted dispersion modeling and impact assessment of hypothetical accidental releases in support of a RCRA Part B Permit for a hazardous waste facility.		
Lober, Robert	MS, Environmental Soil Science; BS, Soil Science	17
Developed soil quality indicators for environmental and agronomic assessments, evaluated reclamation strategies for disturbed lands, and researched solute movement within the vadose zone of disturbed soils and groundwater transport modeling. Supported the TWRS Environmental Compliance program.		
Lusk, Keith	MA, BA, Economics	8
Supported the land use sections of the DOD Nuclear Electric Propulsion Space Test EIS and Draft Hanford Remedial Action EIS for DOE's Hanford Site. Technical reviewer for DOE's Draft New Production Reactor EIS.		
Meyer, Carrie	BA, English	5
Provided technical editing and publication support for various scientific and technical documents, including Safety Analysis Reports, Engineering Studies, Environmental Assessments, and Facility Effluent Monitoring Plans for DOE's Hanford Site.		
Morson, Barbara	BS, Wildlife Management	17
Manager for RCRA facility permitting, compliance and corrective action, pollution prevention projects, and supported emergency response and preparedness planning for oil and chemical releases, site rankings, and CERCLA investigations.		
Murray, David	DSc, MS, BS, Metallurgical Engineering; PE	22
Manager for process and environmental projects at DOE's Savannah River Site. Supervised analysis of waste management data for DOE's Pantex Plant. Developed feasibility studies for treatment of radioactive waste at DOE's Weldon Spring Site.		
Nazarali, Alex	MS, Radiological Science-Health Physics; MS, Nuclear Engineering	8
Author of 3 EIS risk sections for DOE (Hanford Site and Waste Isolation Pilot Project) and 4 EAs and Safety Assessments. Member of DOE's Radiological Assistance Team and Massachusetts Nuclear Incident Advisory Emergency Response Team.		
Nelson, Marc	BS, Geology	20
Project manager for 4 EISs and 14 Environmental Assessments. Managed Regulatory Compliance and Waste Management Departments for 3 DOE projects including the Fernald Site, Uranium Mill Tailings Remedial Action Project, and the Weldon Spring Remedial Action Project. Project and Site Manager for 5 DOE projects and 1industrial remediation project.		

Table 8.1.2 Biographical Sketches of EIS Preparers (cont'd)

Name	Degree(s), Registrations, and Experience	Years Experience
Nichols, Dave	BA, Political Science and Communications	13
Managed public involvement tasks for DOE, EPA, DOD, and industry (air, water, and wetlands) projects. Supported DOE's New Production Reactors Draft EIS hearing plan and the Fernald Site's public involvement Requirements Identification Document and revised Community Relations Plan.		
Oldfield, Maura	BA, English	7
Provided technical editing and publications support for DOE Hanford Site scientific, technical, programmatic, and environmental restoration documents including Tank Characterization Reports, Data Quality Objective Documents, Multi-Year Program Plans, Facility Effluent Monitoring Plans, and Environmental Reports.		
Pelton, Mitch	BS, Computer Science, Software Engineer	3
Managed data compilation and integrated geographic, textual, and risk information, for the Hanford Remedial Action EIS. Supported the development and testing for the Multimedia Environmental Pollutant Assessment System.		
Poeter, Eileen	PhD, Engineering; MS, Engineering Science; BS, Geology; PE	20
Associate Professor at Colorado School of Mines. Previously an Assistant Professor at Colorado School of Mines and at Washington State University. Conducted research projects for DOE, DOD, other Federal agencies, and private firms.		
Regenhardt, Charlene	BS, Geology; BS, Math and Computer Science	13
Project manager for several Environmental Assessments and supported site characterizations and investigations at numerous CERCLA sites. Experienced with groundwater and vadose zone models, computer programming, and statistical applications.		
Rogers, Phillip	MS, Water Resources; BA, Civil Engineering; PE	18
Managed environmental projects including the 100-BC-5 Groundwater RI/FS Work Plan for the B Reactor and Basalt Waste Isolation Project at the Hanford Site. Supported groundwater projects at DOE's Hanford, Pantex, and Rocky Flats sites.		
Scott, Joseph	PhD, BS, Chemical Engineering; PE	11
Manager of lead technical resource divisions for feasibility studies, remedial action plans, and remedial designs for projects for DOE, Army Corp of Engineers, and DOD, including radiological, metal, and chemical contaminated soil and groundwater.		
Selby, Larry	BA, General Science; BS, Geologic Engineering	30
Thirty years cost estimating experience. Forty years of civil engineering and construction industry experience.		
Serot, David	PhD, MA, BA, Economics	17
Conducted review of Hanford Site area economy for the Tri-Cities Industrial Development Council and feasibility study for the Tri-Cities Enterprise Association. Developed scenarios describing potential economic trends & energy requirements for DOE.		
Shrock, John	MSES, Environmental Impact Assessment; BS, Physics	19
Performed air dispersion modeling for a variety of sources and pollutants for regulatory development, permitting, model validation, accident release studies, and risk assessments. Supported the Illinois Department of Nuclear Safety.		
Stein, David	BS, MS, Chemical Engineering; MBA	29
Performed engineering evaluations for a CERCLA investigation at the DOE Weldon Spring Site involving remediation of radiologically and chemically contaminated media and completed several engineering studies for DOD and commercial clients. Evaluated vitrification and calcination processes for remediation of tank waste at the Hanford Site.		
Tallent, Geoff	BS, Environmental Studies	6
Managed two State Environmental Policy Act/NEPA EISs for Hanford Site projects. Coordinated interdisciplinary team reviews and approvals of the TWRS EIS. Representative for Ecology on the Hanford Natural Resources Trustee Council.		
Weed, Ronald	BS, MS, PhD Candidate, Chemical Engineering; PE	39
Developed resource summary for TWRS EIS. Performed safety analysis and licensing at commercial nuclear facilities. Supported the waste tank ventilation program and restart of the 242-A Evaporator and PUREX Plant for the Hanford Site. Performed restart analysis for systems at Rocky Flats. Holder of nuclear decontamination solutions and process patents.		
Wroblicky, Greg	MS, BA, Earth and Planning Sciences; BA, Biology	4
Wrote environmental reports on landfill options and performance of the DOE Pantex Plant. Performed manual modeling for groundwater containment flow and remedial options for CERCLA investigation of a DOD Navy Base.		
Young, Joan	MS, Engineering Management; BS, Chemical Engineering	17
Task manager for Hanford Mission TWRS Integrated Technology Planning. Supported the risk assessment for the Hanford Remedial Action EIS. Over 17 years of DOE Hanford Site experience in risk and technical project support.		

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GLOSSARY

These words are defined within the context used in this Environmental Impact Statement.

242-A Evaporator: A facility in the 200 East Area that concentrates dilute liquid waste from the double-shell tanks to reduce the volume of waste in the tanks. It uses a forced-circulation vacuum evaporation system.

Active Institutional Control: Continued Federal control of the Hanford Site along with maintenance and surveillance of facilities and waste.

Activity: The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the Becquerel (Bq).

Acute: Happening over a short period of time, usually refers to accidents.

Acute Exposure: The absorption of a relatively large amount of hazardous material (or intake of hazardous material) over a short period of time.

Acute Release: A release of radioactive or other hazardous material to the environment that occurs over a relatively short period of time (e.g., minutes or hours versus years).

Air Submersion Dose: Radiation dose received from external exposure to radioactive materials present in the surrounding atmosphere.

Airborne Release Fraction (ARF): The fraction of spilled or leaked material that is caused to be airborne by an event at the point of origin.

Airborne Release Rate (ARR): The airborne release fraction (ARF) over the leak time duration.

Alluvial: Sediment deposited by flowing water, as in a riverbed or delta.

Alpha Particle: A positively charged particle, consisting of two protons and two neutrons, that is emitted during radioactive decay from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

Alternative: A major choice or strategy as opposed to the engineering options available to achieve the goal of an alternative.

Ambient Air: The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.

Americium: A transuranic element of the actinide series, having isotopes with mass numbers from 232 to 248 and half-lives from 55 seconds to 7,380 years. The longest-lived isotopes (241 and 243) are alpha-ray emitters used as radiation sources in research.

Ampere: The unit of steady electric current.

Annulus: A vessel space in the form of a ring (i.e., the space between concentric walls).

Anticline: An arch of stratified rock in which the layers bend downward in opposite directions from the crest.

Aquifer: A body of permeable rock, rock fragments, or soil through which groundwater moves.

Arid Lands Ecology Reserve: The western part of the Hanford Site, a (124 square-mile) area that has been relatively undisturbed for almost 50 years, to which access is limited for scientific purposes. The boundaries of this reserve are the crest of Rattlesnake Ridge to the west, Highway 240 to the east, and Highway 24 to the north.

As Low as Reasonably Achievable (ALARA): An approach to radiological or hazardous material control whereby individual and collective exposures to the work force and to the general public are managed and controlled to be at levels as low as reasonably achievable. This takes into account the social, technical, economic, practical, and public policy considerations. This is not a dose limit but a process that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable.

Assumed Leaker: A waste storage tank for which past surveillance data have indicated a loss of liquid attributed to a breach of integrity.

B Plant (222-B): A facility built in 1943 and located in the 200 East Area used to recover plutonium for nuclear weapons until 1956. After modifications, B Plant restarted in 1967 to remove strontium and cesium from stored liquid wastes.

Back-Filling: An act or process by which the Hanford Site's waste tanks would be filled with gravel or other earthen materials to prevent the potential collapse of the tanks over time.

Basalt: Dark to medium-dark colored rocks, volcanic in origin.

Beyond Design Basis Accident (BDBA): An accident with an annual frequency of occurring between 1 in 1,000,000 and 1 in 10,000,000 (1.0E-06 and 1.0E-07).

Bismuth Phosphate Process: One of the earliest separation techniques used at the Hanford Site to separate plutonium from irradiated uranium fuels.

Biodiversity: Pertains to the variety of life (e.g. plants, animals, and other organisms) that inhabit a particular area or region.

Borosilicate: A form of glass with silica sand, boric oxide, and soda ash.

Borrow Site: An area from which material is removed for use somewhere else (e.g., a gravel pit).

Bottoms (Tank): Material remaining in waste tanks after most of the contents have been pumped out for solidification or transfer to other storage tanks. This term can also refer to specific tanks used to collect such bottom waste from several other tanks.

Bounding Accident: A postulated accident that is defined to encompass the range of anticipated accidents and used to evaluate the consequences of accidents at facilities. The most conservative parameters (e.g., source terms, meteorology) applied to a conservative accident resulting in a bounding accident analysis.

Buffer: A term used to refer to a part of the site that surrounds an exclusive area. It would be treated like an exclusive area because of the risk emanating from the area it abuts. Environmental restoration activities would occur in buffers, but waste management activities would not. A buffer area would not be expected to remain a buffer area forever.

Burial Ground: Land area specifically designated to receive contaminated waste packages and equipment, usually in trenches covered with overburden.

Calcination: The act or process by which a substance is heated to a high temperature that is below the melting or fusing point. Calcination results in the loss of moisture, organic destruction, and high temperature chemical reactions. The final waste form is a dense powder.

Calcine: To heat a substance to a high temperature, but below its melting point, causing loss of volatile constituents such as moisture. This term is also used to refer to the material produced by this process.

Caliche: An accumulation of calcareous (i.e., calcium carbonate containing) material formed in soil or sediments in arid regions.

Cancer: The name given to a group of diseases characterized by uncontrolled cellular growth.

Canister: A container for high-level waste such as cesium or strontium capsules or vitrified wastes.

Canyon: A heavily shielded, partially below-grade concrete structure used for remote chemical processing of radioactive fuels or wastes.

Capsule: Stainless-steel, double-walled container containing either cesium chloride or strontium fluoride recovered from Hanford Site high-level waste.

Carbon Tetrachloride: A solvent used in the plutonium extraction process at the Plutonium Finishing Plant. Carbon tetrachloride is a known human carcinogen via inhalation and ingestion. Other toxic effects include damage to the central nervous system.

Carbon-14: A radioactive isotope of carbon with a mass number of 14 and half-life of 5,730 years (plus or minus 40 years). It occurs naturally as a result of reactions between atmospheric nitrogen and neutrons resulting from cosmic-ray collisions.

Carcinogen: A radionuclide or nonradiological chemical that has been proven or suspected to be either a promoter or initiator of cancer in humans or animals.

Carbonate: A salt of carbonic acid. Calcite, aragonite, and dolomite are examples of carbonate minerals.

Cascade: Tanks connected in series and placed at different elevations creating a downhill gradient for liquids to flow from one tank to another.

Cask: A specially designed container used for shipping, storage, and disposal of radioactive material that affords protection from accidents and provides shielding for radioactive material. The design includes special shielding, handling, and sealing features to provide positive containment and minimize personnel exposure.

Ceramic: Materials made from non-metallic minerals such as clays at high temperatures through firing.

Cesium-137 (Cs-137): A gamma emitting radioisotope with a half-life of 30 years. Cesium-137 is generated during fission of uranium-235.

Cladding: The outer jacket (i.e., metal sheath or coating) of nuclear fuel elements used to prevent corrosion and the release of fission products into reactor coolants.

Cladding Removal Waste: Chemical wastes resulting from dissolving the metal sheath or coating surrounding fuel elements. These chemical wastes usually are contaminated with activation products, fission products, and some transuranic elements.

Class C Waste: Radioactive waste that is suitable for near surface disposal but due to its radionuclide concentrations must meet vigorous requirements for waste form stability and also requires additional measures at the disposal facility to protect against inadvertent intrusion.

Cobalt-60 (Co-60): A radioactive isotope of a hard, brittle metallic element found associated with nickel, silver, lead, copper, and iron ores and resembling nickel and iron in appearance. This isotope has a mass number 60 and a half-life of 5.27 years. It is an intense gamma-ray emitter, used in radiotherapy, metallurgy, and materials testing.

Code of Federal Regulations (CFR): A document containing the regulations of Federal executive departments and agencies.

Collective Effective Dose Equivalent: Sum of the effective dose equivalents for individuals composing a defined population. The units for this are person-rem or person-siervert.

Comingle: To mix or cause to be mixed together.

Committed Dose Equivalent: Total dose equivalent accumulated in an organ or tissue in the 50 years following a single intake of radioactive materials into the body.

Committed Effective Dose Equivalent (CEDE): The sum of committed radiological dose equivalents to various tissues in the body, each multiplied by the appropriate weighing factor and expressed units of rem. A 70-year dose commitment period was assumed for the EIS.

Complexants: Organics chemicals, that assist in chelating (a type of chemical bonding) metallic atoms. Examples include citrates, ethylenediaminetetracetic acid (EDTA), and hydroxyethylene-diaminetriacetic acid (HEDTA).

Concentrated Complexant: Material containing high concentrations of complexants and stored in double-shell tanks; usually resulting from strontium recovery. This material can be also referred to as complex concentrates.

Condensate: Liquid that results from condensing a gas.

Confined Aquifer: A subsurface water-bearing region that has defined, relatively impermeable upper and lower boundaries. The impermeable boundary is referred to as a confining layer.

Conservative: Conservative choices of parameters or assumptions are those that would tend to result in reasonable maximum impacts.

Contact-handled: Radioactive materials, usually packaged in some form, that emit low enough radiation (a surface dose rate not exceeding 200 millirem per hour) to permit close and unshielded manipulation by workers.

Contact-maintained: Having a configuration and radioactive exposure rate so that equipment can be repaired or replaced by hands-on contact.

Contaminant: Any gaseous, chemical or organic material that contaminates (pollutes) air, soil, or water. This term also refers to any hazardous substance that does not occur naturally or that occurs at levels greater than those naturally occurring in the surrounding environment (background).

Corrosion: The destruction of metal by chemical or electrochemical processes.

Corrosive or Irritant Health Effect: Following exposure to corrosive hydroxides (e.g., sodium, ammonium, potassium), effects may range from simple, reversible irritation to irreversible tissue destruction especially to skin, eyes, mucous membranes, and deep fatty tissue.

Coulomb: The unit of electrical charge.

Credible Accident: An accident that has a probability of occurrence greater than or equal to one in a million per year.

Crib: An underground structure designed to receive liquid waste that can percolate into the soil directly or after traveling through a connected tile field. This is similar in concept to a septic tank system.

Critical: A condition where in uranium, plutonium or tritium is capable of sustaining a nuclear chain reaction.

Criteria: General guidelines or principles from which more quantitative or definitive standards are prepared to regulate activities.

Criticality: State of being critical. Refers to a self-sustaining nuclear chain reaction in which there is an exact balance between the production of neutrons and the losses of neutrons in the absence of extraneous neutron sources.

Cullet: Small pieces of glass (similar in size to pea-gravel) formed when hot molten glass is quenched in a water bath.

Curie (Ci): A unit of measurement of radioactivity or the quantity of a radionuclide, equal to 37 billion (3.7E+10) disintegrations or nuclear transformations per second.

Current Acid Waste: The high-level waste stream from the Plutonium Uranium Extraction (PUREX) Plant that contains most of the fission products from the dissolved fuel.

Damage Ratio (DR): The fraction of the material at risk (MAR) that is impacted by an event. Unless specifically defined in the accompanying analysis, the value is assumed to be 1.00.

Dangerous Waste: Waste designated by Washington State as posing a substantial or potential hazard to human health or the environment when improperly managed. In general, these include wastes classified as hazardous under the Federal Resource Conservation and Recovery Act (RCRA). Dangerous waste is ignitable, corrosive, reactive, carcinogenic, persistent, or toxic.

Decommissioning: Removing facilities contaminated with radiation (e.g., processing plants, waste tanks, and burial grounds) from service and reducing or stabilizing radioactive contamination.

Decontamination: Those activities employed to reduce the levels of contamination in or on structures, equipment, materials, and personnel.

Decontamination and Decommissioning: The process of removing contamination from facilities or equipment by washing, chemical action, mechanical cleaning, or other techniques; removing the facility from operation; and entombing, dismantling, and removing, or converting the facility for another use.

Decontamination Factor: The factor by which the concentration of radioactive contaminants is reduced. This is measured by the ratio of the radioactivity initially present to that present after decontamination.

Design Basis Accident (DBA): For nuclear facilities, a postulated abnormal event that is used to establish the performance requirements of structures, systems, and components that are necessary to maintain them in a safe shutdown condition indefinitely or to prevent or mitigate the consequences so that the general public and operating staff are not exposed to radiation in excess of appropriate guideline values.

Design Basis Earthquake: The maximum intensity earthquake that might occur along the nearest fault to a structure. Structures are built to withstand a design basis earthquake.

Diffusion Barrier: A molecular-level physical barrier to prevent contaminants from leaving a vault.

Dispersion: Process whereby effluents are spread through the environment as they are transported by groundwater or air.

Disposal: Emplacement of radioactive material in a repository or other suitable confinement with no foreseeable intent of recovery, regardless of whether or not emplacement permits recovery. Most wastes are not currently considered disposed of, but are considered temporarily stored.

Disposal Site: The area dedicated to waste disposal and related activities.

Diversion Box: A belowgrade concrete enclosure containing the remotely maintained jumpers and spare nozzles for the routing of waste solution to storage tank farms.

Dome Fill: Material used for backfilling the open space above wastes in single- and double-shell tanks.

Dose (radiation dose): In radiation science, the energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, which is equal to 100 ergs (i.e., a unit of work and energy) per gram of irradiated material in any medium.

Dose Equivalent: Product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem. A millirem is one one-thousandth of a rem.

Double-Shell Slurry: Concentrated wastes in the double-shell tanks that resulted from evaporating off liquids in the double-shell tank wastes and the liquids that are pumped from the single-shell tanks.

Double-Shell Slurry Feed: Non-organic, evaporator concentrate that is high in sodium aluminate.

Double-Shell Tank (DST): A large reinforced concrete underground container with two steel liners to provide containment and backup containment of liquid wastes. The space between the liners has instruments to detect leaks from the inner liner.

Down-Gradient: In hydrologic terms, this is used to designate downstream (e.g., direction of underground water flow).

Drainable Liquor: Liquid in waste storage tanks that can migrate by gravity through the saltcake or sludge and possibly leak out of an impaired tank liner (if the tank were to be breached below the liquid level).

Drywell: A drainage receptacle constructed by digging a hole and refilling with coarse gravel. Also refers to a watertight well casing used for inserting monitoring equipment into the ground.

Drywell (in tank): A sealed casing within a tank that is attached to a riser. It is used to insert experimental equipment, such as neutron or acoustical probes, to determine the drainage level of interstitial liquor.

Dry-Well Storage: An act or process by which cesium or strontium capsules are placed in a non-liquid containing facility or container for storage.

Earthen Barrier: A multi-layer cover consisting primarily of soil, sand, and rock up to 4.6 meters (15 feet) thick. The cover could be placed over waste that would remain onsite. The purpose of the cover is to inhibit infiltration of water and human intrusion into the waste. Commonly referred to as the Hanford Barrier.

Effective Dose Equivalent: A value used for estimating the total risk of potential health effects from radiation exposure. This estimate is the sum of the committed effective dose equivalent from internal deposition of radionuclides in the body and the effective dose equivalent from external radiation received during a year.

Effluent: Liquid or gaseous waste streams released from a facility.

Effluent Monitoring: Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

Effluent Treatment Facility: A processing facility on the Hanford Site that receives low-level liquid effluents and removes organic, hazardous, and radioactive contaminants. The final product of this plant is water that is discharged to a State-approved land disposal site in the 200 West Area.

Element: A chemical substance that cannot be divided into simpler substances by chemical means. A substance whose atoms all have the same atomic number.

Encapsulated Waste: Cesium chloride stored in stainless steel capsules, and strontium fluoride stored in Hastelloy capsules in the Waste Encapsulation and Storage Facility water basins.

Energy: The capacity for action or accomplishment. In physics, the term is defined as the work that a physical system is capable of doing in changing from its actual state to a specified reference state, the total including contributions of potential energy, kinetic energy, and rest energy.

Engineered Barrier: An addition to a disposal site that is designed to retard or preclude radionuclide transport, and to preserve the integrity of the disposal site.

Entrainment: The involuntary capture and inclusion of organisms in streams of flowing water. The term often applies to the cooling water systems of power plants and reactors. The organisms involved depend on the intake screen mesh size: they may include phyto- and zooplankton, fish eggs and larvae (ichthyoplankton), shell fish larvae, and other forms of aquatic life.

Ephemeral: Lasting briefly.

Equilibrium: A condition in which the level of material in a particular environmental compartment remains constant over time because the loss of the material from the compartment equals the input.

Erosional Windows: The absence of a sequence of geologic strata or layers due to erosion or weathering.

Ethonobotanical: Pertaining to the role of plants spaces in various human cultures.

Ethnography: A branch of anthropology dealing with the study of human culture.

Evaporator: A facility that mechanically reduces the water content in tank waste to concentrate the waste and reduce storage space needs.

Evaporator-Crystallizer: Equipment used to reduce the moisture content in high-level waste, which minimizes the danger of potential tank liner failures and reduces storage space needs.

Evaporator Feed: Any waste liquid that can be concentrated to form saltcake (e.g., low heat, dilute interstitial liquor, aged waste, and other radioactive waste solutions).

Ex Situ: In the context of the Tank Waste Remediation System (TWRS) Environmental Impact Statement (EIS), the word ex situ is used to describe out-of-tank (place) operations for the Hanford Site's tank wastes. The Latin word *ex* means out, while *situ* is taken from the Latin word *situs*, meaning place.

Exposure: The condition of being subjected to radiation or some form of chemical contamination.

Extraction: The mass transfer of an element or compound from one phase to another.

Fast Flux Test Facility: An experimental nuclear reactor at the Hanford Site. It is used for testing fuels, materials, and designs related to breeder reactor technology.

Feed: Waste that is sent to a facility for processing.

Ferrocyanide: A chemical previously added to waste storage tanks to scavenge or settle out other chemicals. This was used primarily for cesium. It is now a source of single-shell tank safety problems because of potential explosion concerns.

Force: Capacity to do work or cause change (i.e., strength or power).

Frit: Chemical additives mixed with waste that create a glass when heated. Examples include fusible ceramic oxides and silicates.

Geologic Repository: A deep (on the order of 600-meter [1,928-feet] or more) underground mined array of tunnels used for permanent disposal of radioactive waste.

Geomorphology: The scientific discipline that studies and analyzes the surface features of the earth. This includes both the surface forms on land and under the ocean plus the chemical, physical, and biological factors that act on these forms.

Gigawatt Hour (Gwh): A unit of energy equal to one billion (1.0E+09) watts.

Glass: A homogeneous or heterogeneous solid, without crystalline or structure.

Glass Additives: Components used to make glass. Examples are sand, soda ash, borax, and lime.

Glass Matrix: The mixture of ingredients that form the glass that immobilizes radioactive and hazardous wastes.

Groundwater: Water occurring beneath the earth's surface in the intervals between soil grains, in fractures, and in porous formations.

Groundwater Gradient: The slope of the water table that, together with permeability of the rock and soil material, determines the direction and rate of groundwater movement. Groundwater gradients include both a horizontal and vertical dimension.

Grout: A fluid mixture of cement-like materials and liquid waste that sets up as a solid mass and is used for waste fixation and immobilization.

Gross Alpha: The total alpha radiation from all sources (e.g., radioactive materials) reported in one measurement.

Gross Beta: The total beta radiation from all sources (e.g., radioactive materials) reported in one measurement.

Habitat: The sum of environmental conditions in a specific place occupied by animals, plants, and other organisms.

Half-Life: Length of time in which a radioactive substance will lose one-half of its radioactivity by decay. Half-lives range from a fraction of a second to billions of years, and each radionuclide has a unique half-life.

Hanford Barrier: An aboveground, multi-component barrier that prevents the entry of rainfall, plant roots, or burrowing animals into the area covered by the barrier.

Hastelloy: A trade name for a special nickel-based alloy with corrosion-resistant properties that is used for encapsulating strontium fluoride.

Hazard Index: A measure of the noncarcinogenic health effects of human exposure to chemicals. Health effects are assumed to be additive for exposure to multiple chemicals. A hazard index of greater than 1.0 is indicative of potential adverse health effects. Health effects could be minor temporary effects or fatal, depending on the chemical and amount of exposure.

Hazardous Waste: A solid waste or combination of solid wastes that, because of its quantity, concentration, or physical, chemical or infectious characteristics, may cause or significantly contribute to an increase in deaths or serious illness. It may pose a present or future risk to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous waste is regulated under the Resource Conservation and Recovery Act.

Heat Content: In tank wastes or capsules, refers to the amount of fission products generating heat through radioactive decay.

High-Efficiency Metal Filter: A filter that performs the same functions as a high-efficiency particulate air (HEPA) filter. Contamination can be washed from the metal filter, allowing its reuse.

High-Efficiency Particulate Air (HEPA) Filter: Material, such as paper or a fiber sheet that is pleated to increase the surface area. The filter captures entrained particles from an air stream, usually with efficiencies of 99.95 percent or higher.

High-Heat Waste: Radioactive waste which generates sufficient fission product decay heat to cause self-boiling and concentration.

High-Level Waste (HLW): Highly radioactive waste that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in the reprocessing and any solid waste derived from the liquid that contains fission products in sufficient concentration. May include other highly radioactive material that requires permanent isolation in a deep geologic repository.

Holocene: A geologic term, describing the period in time (epoch) since the last ice age in North America, and those sediments deposited during that epoch.

Hydraulic Sluicing: A method for removing slurry from double-shell tanks by dissolving and suspending the slurry in water and then pumping the mixture out. This is usually followed by concentrating the mixture in an evaporator and crystallizer.

Hydraulic Conductivity: A measurement that indicates the ease with which a porous medium permits fluids (e.g., water) to flow and the ease with which the fluid flows given its physical characteristics.

Immobilization: A process (e.g., grouting or vitrification) used to stabilized waste. Stabilizing the waste inhibits the release of waste to the environment.

In Situ: A Latin term meaning in place.

In Situ Immobilization: An in-place technique such as pressure grouting or electrical resistance glassification that consolidates wastes to inhibit nuclide and chemical mobility.

In Situ Vitrification: A process that turns soil (and whatever is in it) into glass by inserting electrodes into the soil and heating it until it melts. The soil then solidifies in a glass-like material resembling obsidian. The process destroys organic materials and immobilizes inorganic materials. This process is used to safely isolate wastes.

Incidental Waste: Wastes that are not defined as high-level waste (i.e., originating from nuclear fuel processing).

Incremental Lifetime Cancer Risk (ILCR): A measure of the potential of developing cancer based on exposure to individual or multiple radionuclides or known or suspected carcinogenic chemicals. It reports the level of risk of contracting cancer in terms of one individual's risk of contracting cancer among the entire exposed population (e.g., 1 in 10, 1 in 10,000, 1 in 1 million).

Institutional Control: Period of time when a site is under active control. Controls includes site access, restrictions, monitoring, and maintenance. For the purposes of this analysis, a period of 100 years is assumed.

Interim Stabilization: Removing the liquids that can be readily pumped from single-shell tank wastes and transferring these liquids to double-shell tanks.

Interim Stabilized: A tank which contains less than 190,000 liters (50,000 gallons) of drainable interstitial liquid and has less than 19,000 liters (5,000 gallons) of supernatant liquid is said to be interim stabilized. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow must also have been at or below 0.19 liters (0.05 gallons) per minute before interim stabilization is complete.

Interim Storage: A management policy of controlling waste until an ultimate disposal plan is approved and implemented.

Interstitial: Referring to the volume within a solid matrix contained in crevices, cracks, and void spaces.

Interstitial Liquor: The liquid within the pores of saltcake and sludge in the double- and single-shell tanks. Some of the liquid is capable of gravity drainage while the rest is held by capillary action.

Iodine-129 (I-129): Beta emitting radioisotope with a half-life of 15,700,000 years. It is generated during the fission of uranium-235.

Ion-Exchange: A process for selectively removing a constituent from a waste stream by reversibly transferring ions between an insoluble solid and the waste stream. The exchange medium (usually a column of resin or soil) can be washed to collect the waste or taken directly to disposal.

Irradiation: Exposure to radiation resulting from being placed near a radioactive source. For example, materials are irradiated by being placed in an operating nuclear reactor.

Irretrievable Resource Commitments: Actions or processes that may render an area, parcel, or material of value (i.e., resources) to a state or condition that is of lesser or no value without the possibility of returning the resources to a valuable state or condition.

Isolate: In the context of prehistoric or historic resources, it is an isolated cultural artifact not found as part of an assemblage or grouping of cultural artifacts.

Isotope(s): Different forms of the same chemical element that are distinguished by different numbers of neutrons in the nucleus. A single element may have many isotopes: some may be radioactive and some may be nonradioactive (stable). For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

Jet Pump: A modified commercially-available, low-capacity jet pump used as a salt-well pump.

Jet Pumping: A technique for removing interstitial liquid from single-shell tanks.

Joule: A unit of work or energy.

Joule Heated Melter: A thermal treatment technology in which electrodes are placed in the glass melt and an electric current provides the source of heat.

Joule Heating: Method of applying energy to a crucible of solid material to melt the material. Joule heating involves placing electrodes into the material and applying electrical potential. This results in a current flow and resistance heating.

Jumper Pit: A pit that contains the valves, pipes, and other equipment to connect processing equipment that may contain highly-radioactive materials.

Lag Storage: Space required to temporarily hold solutions or solids so that processes are not upset by variations in throughput.

Landfill: A solid waste facility or part of a facility for the permanent disposal of solid wastes in or on the land. This includes a sanitary landfill, balefill, landspreading disposal facility; or a hazardous waste, problem waste, limited purpose, inert, or demolition waste landfill.

Latent Cancer Fatality: A fatality resulting from cancer caused by an exposure to a known or suspected radionuclide or carcinogenic chemical.

Leach: To dissolve soluble constituents from a solid material by contact with water or another solvent.

Leachate: Any liquid, including suspended components in the liquid, that has percolated through or drained from hazardous or solid waste. Also refers to liquid that percolates out of a solution.

Leak Detection Pit: Collection point for any leaking tanks from the Hanford Site AX Tank Farm. The pits are equipped with radiation and liquid detection instruments.

Leak Path Factor (LPF): The fraction of material at risk (MAR) that is permitted to escape the confinement boundary either by design, by natural causes, or by degradation caused by the accident. This pathway could take the form of a filter, a crack caused by weathering and wear, or damage by accident. Unless specifically defined in the accompanying analysis the value is assumed to be 1.00.

Lethal Dose: A radiological dose that would result in death shortly after the exposure.

Liquefaction: In seismology, a process or event that causes a body of cohensionless particles (e.g., sand) to change its physical state from solid to liquid.

Liquid Effluent Retention Facility: A Hanford Site facility being built to temporarily store 242-A Evaporator process condensate containing certain regulated chemicals (e.g., ammonia) that have been classified as listed waste or dangerous waste. This waste would then be treated at the Effluent Treatment Facility.

Lithic: Pertaining to stone or a stone tool.

Lost Workday Case: A workplace injury or illness resulting in an employee missing work.

Low-Activity Waste (LAW): The waste that remains after separating from high-level waste as much of the radioactivity as is practicable that when solidified may be disposed of as low-level waste in a near surface facility according to Nuclear Regulatory Commission regulations. In its final form it would meet Class C radioisotope limits.

Low-Level Waste (LLW): Waste that contains radioactivity and is not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or by-product material (as defined in Section IIc(2) of the Atomic Energy At of 1954 [42 USC 2014(e)(2)]).

LR-56H: A specially designed truck with radiation shielding to transport HLW onsite.

Manipulator: Mechanical grippers or some other device for performing work behind a barrier or in a cave.

Material at Risk (MAR): That inventory of concern of what in a definable, separate space that is measured in terms of radiological hazard (liters) or toxicological hazard (liters) and that is at risk of being released by the event.

Maximally-Exposed Individual (MEI): A hypothetical member of the public residing near an activity who, by virtue of location and living habits, could receive the highest dose from exposure to radionuclides or carcinogenic chemicals.

Mechanical Recovery of Tanks: A means of removing wastes from an underground storage tank, usually a single-shell tank, without using water because of the risk of possible leakage.

Megawatt: A unit of power equal to 1 million watts.

Metal: An opaque, fusible, ductile, and typically lustrous substance that is a good conductor of electricity and heat.

Metal Waste: Waste from the plutonium processing plants containing all the uranium, approximately 90 percent of the original fission product activity, and approximately 1 percent of the plutonium product. This waste was brought just to the neutral point with 50 percent caustic and then treated with an excess of sodium carbonate. This procedure yielded almost completely soluble waste at a minimum total volume. The exact composition of the carbonate compounds was not known but was assumed to be an uranium phosphate carbonate mixture.

Methyl Isobutyl Ketone (Hexone) (MIBK): A solvent used at the reduction-oxidation (REDOX) separations plant.

Miscellaneous Underground Storage Tank (MUST): Relatively small steel or concrete containers. These tanks range in capacity from 3,400 liters to 189,000 liters (900 gallons to 50,000 gallons) and were used for solids settling prior to decanting liquids to cribs, neutralizing acidic process wastes, uranium recovery operations, collecting waste-transfer leakage, and waste handling and experimentation. Inactive miscellaneous underground storage tanks are tanks that are out of service and no longer used, however, they may still contain waste. Active miscellaneous underground storage tanks are tanks that are still operational and are being used to facilitate waste transfers within the tank farms.

Mitigation: A series of actions implemented to ensure that project impacts will result in no net loss of habitat value or wildlife populations. The purpose of these actions is to avoid, minimize, rectify, or compensate for any adverse environmental impact.

Mixed Waste: Waste with both hazardous waste under the Resource Conservation and Recovery Act and radioactive wastes regulated by the Atomic Energy Act.

Mole: The amount of a substance equal to the molecular weight. For example, when the mass is in grams, it is referred to as a gram mole.

Monitored Retrievable Storage: A concept for interim storage of waste or spent fuel. The waste would be continuously monitored and would be stored in such a way that it could be retrieved at a later date.

Monitoring: Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and pollutant levels in various media or in humans, animals, and other living things. This term also refers to actions intended to detect and evaluate radiological conditions.

Monitoring Wells: Holes sunk in the ground to various depths where instruments are lowered or water samples are taken to determine what is present.

Monocline: An oblique geologic fold, meaning that the fold is neither parallel or perpendicular.

Neptunium: A silvery, metallic, naturally radioactive element with the atomic number 93. It is the first of the transuranium elements and has 13 isotopes with mass numbers from 228 to 243 and half-lives ranging from one minute to 2.14 million years. Neptunium is found in trace quantities in uranium ores and is produced synthetically by nuclear reactions.

Neutralization: The reaction of acidic liquids with an alkali such as sodium hydroxide, calcium hydroxide or potassium hydroxide.

Neutralized Current Acid Stream: The highly radioactive liquid waste after plutonium is removed from dissolved irradiated fuel during reprocessing. It is the most radioactive of the waste streams from reprocessing operations.

Neutralized Cladding Removal Waste: Waste that results from dissolving and removing the zirconium cladding from irradiated N Reactor fuel in the plutonium-uranium extraction (PUREX) process . This waste has been neutralized to permit low-corrosive storage in carbon steel tanks. This waste stream has transuranic contamination.

Nitrogen Oxides (NO_x): A mixture of nitrogen-oxygen containing compounds primarily formed as gaseous waste effluents in the combustion of fuels.

Non-complexed: General waste term applied to all Hanford Site liquors not identified as containing organics (i.e., complexed).

Noncombustible: Items such as concrete rubble and steel tools that will not support combustion under ordinary circumstances.

Nuclear Criticality: A self-sustaining nuclear chain reaction.

Off-gas: Gas evolved or generated during a thermal treatment process such as incineration or vitrification.

Off-gas Treatment: Generic name for equipment designed to cleanup gases being vented off of processes. May consist of absorbers, sand beds, gas flares, and high-efficiency particulate air (HEPA) filters.

Offsite: Away from the project site.

Operations: All aspects involved in the operation of a plant or facility. These activities include engineering, maintenance, safety, and process operations.

Order of Magnitude: A range of magnitude (i.e., largeness in size or numbers) extending some value to ten times that value.

Organic Destruction: Pertains to destroying organic compounds to their elemental or non-organic state.

Organic Solvent Layer: A strata (layer) within Hanford Site waste tanks composed of organics from processing operations.

Organics: Compounds that contain carbon.

Overburden: Soil used to backfill an excavation containing solid waste or a liquid waste disposal structure. This term can also be used to refer to material that is overlying a deposit of useful geologic materials.

Overpack: A thick steel canister designed to dissipate heat and shield and contain radioactive waste.

Packaging: Assembly of radioactive material in one or more containers.

Parameter: In statistics, a numerical quantity (such as the mean) that characterizes the distribution of a random variable or a population.

Particulate: Pertains to minute, separate particles. An example of dry particulate is dust.

Perched Water Table: An underground water body that occupies a basin in impermeable material (such as clay), and is located in a position higher than the water table.

Permeability: The property or capacity of a porous rock, sediment, or soil for transmitting a fluid such as water.

Person-Rem: A unit used to measure the radiation exposure to an entire group and to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average dose equivalent (measured in rems) to a given organ or tissue by the number of persons in the population of interest.

pH: A measure of the relative acidity or alkalinity of a solution. A neutral solution has a pH of 7, acids have a pH of less than 7, and bases have a pH of greater than 7.

Plasma: A hot ionized gas composed of nearly equal numbers of electrons and positive ions.

Plume: The distribution of contaminants a distance away from a point source in a medium like groundwater or air. It is a defined area of contamination.

Plutonium: A heavy, radioactive, anthropogenic metallic element consisting of several isotopes. One important isotope is plutonium-239, which is produced by irradiating uranium-238 with neutrons.

Plutonium-Uranium Extraction (PUREX) Plant: A plant located in the 200 East Area used to separate plutonium from irradiated fuel and uranium from 1956 to 1972 and 1983 to 1989.

Point Estimate Risk: The product of the probability (likelihood) of an accident occurring and the consequences of the accident (latent cancer fatalities).

Population: For risk assessment purposes, population consists of the total potential members of the public or workforce who could be exposed to a possible radiation or chemical dose from an exposure to radionuclides or carcinogenic chemicals.

Portland Cement: A hydraulic cement made by finely pulverizing the clinker produced by calcining a mixture of clay and limestone or similar materials.

Prefilter: A filter that provides first-stage air filtration to remove larger particulates and prolong the efficient use of a high-efficiency particulate air (HEPA) filter.

Pretreatment: The processing of waste stored in tanks to separate it into high-level and low-level waste.

Privatization: Use of the commercial sector for services usually performed by the government or its contractors.

Process Condensate: Liquid that is boiled off from an aqueous solution, then condensed back into a liquid.

Protective Barrier: A structure designed to prevent as many waste migration pathways as possible and as necessary, depending on waste mobility, hazard, and lifetime. These migration pathways can include animal burrows, plant roots, erosion, and water infiltration.

Public Comment: A written or verbal remark or statement of fact or opinion made in response to a position proposed by a government agency.

Radiofrequency Drying: A laboratory-tested process for in-place drying of moist wastes. It is similar to microwave heating.

Radionuclides: Nuclides that are radioactive. A nuclide is a species of atom with a specific mass, atomic number, and nuclear energy state. Standard practice for naming radionuclides is to use the name or atomic symbol of an element followed by its atomic weight (e.g., cobalt-60 or Co-60).

Raffinate: That portion of a treated liquid mixture remaining after chemical processing.

Recharge: The process of restoring or replenishing water to an aquifer through percolation downward through the soil. Recharge can be natural (e.g., precipitation) or artificial (intentional discharge of water to the ground).

Reduction-Oxidation (REDOX) Plant: A facility in the 200 West Area for separating plutonium from irradiated fuels by using successive steps of chemical reduction and oxidation together with solvent extraction.

Rem: A unit of radiation dose that reflects the ability of different types of radiation to damage human tissues and the susceptibility of different tissues to the damage. Rems are a measure of effective dose equivalent.

Repository: An offsite land-based deep disposal site for long-term isolation of high-level waste. These disposal sites are often located in salt, granite, or basalt.

Residual Liquid: The liquid that remains after steps have been taken to decrease moisture in a waste tank.

Residual Waste: The waste that remains after a major reprocessing step.

Respirable Fraction (RF): That fraction of airborne droplets or particulate matter (aerosol) with individual particle aerodynamic equivalent diameter (AED) less than 10 μm. This is assumed to be important for inhalation consequences. Non-condensable gases and vapors have a respirable fraction equal to 1.00.

Retrievable Disposal: Disposing or getting rid of low-activity waste in a manner that it can be retrieved or recovered at a later time.

Retrieval: Removal of liquid and solid wastes from storage tanks.

Riparian: Living or located on a riverbank.

Riprap: Irregular chunks of rock used as fence, dike, and barrier construction material. This term also can be used for a loose assemblage of stones used in water or silt ground as a foundation.

Risk: The probability that a detrimental health effect will occur given the consequences of an accident. Specifically, it is a quantitative or qualitative expression of possible loss that considers both the probability that a hazard will cause harm and the consequences of that event. Risk is the product of the consequences of an event multiplied by the probability of that event.

Roughing Filter: A prefilter used to remove the majority of the larger particles in an air exhaust stream, after which high-efficiency particulate air filters then remove the small particulates.

S Plant: The reduction-oxidation facility at the Hanford Site used to recover plutonium and uranium. It is located in the 200 West Area.

Saltwell: A hole drilled or sluiced into a saltcake and lined with a cylindrical screen to permit drainage and jet pumping of interstitial liquor.

Saltcake: Crystallized nitrate and other salts deposited in waste tanks, usually after active measures are taken to remove moisture.

Scope: The range of actions, alternatives, and impacts to be considered in a document prepared pursuant to the National Environmental Policy Act.

Sediment: Solid material that has settled from a state of suspension in a liquid (e.g., material that has settled at the bottom of a pond or estuary).

Seismicity: The relative geographic distribution and frequency of earthquakes.

Seismology: The scientific study of earthquakes and tremors. This includes the origin, propagation, and energy manifestations of earthquakes; and the structure of the earth and possible methods of prediction.

Separated Waste: Waste that has been sorted or separated according to its suitability for recycling, incineration, use in landfills, or other types of treatment or disposal.

Separations: Processes to divide tank waste into different portions, such as transuranic-nontransuranic and radioactive-nonradioactive, and to remove components such as cesium.

Shielding: Bulkheads, walls, or other constructions used to absorb radiation to protect personnel or equipment.

Shipping Container: A specially-designed, large, stainless steel or lead-lined, steel-shelled cask that is transported in a vertical position on a well-type or depressed center railcar. The container is certified by the U.S. Department of Energy and the U.S. Department of Transportation for use in shipping naval spent nuclear fuel.

Shrub-Steppe: An important habitat type found at the Hanford Site. Shrub-steppe is characterized by vegetation requiring little moisture and occurs on arid land and in areas of an extreme temperature range. It is considered a critical habitat by Washington State.

Single-Shell Tank (SST): Underground reinforced concrete containers with one carbon-steel liner, which are covered with 2 to 3 meters of earth. Capacity ranges from 208,175 liters to 3.79 million liters (55,000 gallons to 1 million gallons). The tanks have been used to store high-level radioactive wastes.

Slag: A scum or impurity layer that forms on the surface of a molten metal during thermal processing. Slag usually consists of various inorganic materials that may take either gaseous, crystalline, metallic, or mixed forms.

Sludge: The precipitate resulting from the chemical coagulation, flocculation, and sedimentation of water or wastewater. This term also can refer to the insoluble metal hydroxides and oxides precipitated from neutralized current acid waste and neutralized cladding removal waste.

Sludge Dissolution: A pretreatment process using water or chemicals to dissolve sludge.

Sludge Washing: Sludge cleanup with water or chemical solutions to remove soluble impurities.

Sluicing: Removing solids from tanks by mixing them with water and pumping out the resulting mixture.

Slurry: Insoluble material suspended in water or aqueous solution.

Solidification: In a liquid the change from liquid to solid caused by cooling below the melting temperature or by adding solid-forming materials such as Portland cement. This term also can refer to removing waste from wastewater.

Solvent: Substance (usually liquid) capable of dissolving one or more other substances.

Sorption: A general term used to encompass the processes of absorption, adsorption, ion exchange, ion retardation, chemisorption, and dialysis.

Sorptive Capacity: The measure of the ability of a material to sorb specific constituents from a liquid if it passes through the material.

Source Term (Q): The quantity of radioactive material released by an accident or operation that causes exposure after transmission or deposition. Specifically, it is that fraction of respirable material at risk (MAR) that is released to the atmosphere from a specific location. The source term defines the initial condition for subsequent dispersion and consequence evaluations. Q = material at risk (MAR) x damage ratio (DR) x airborne release fraction (ARF) x respirable fraction (RF) x leak path factor (LPF). The units of Q are quantity at risk averaged over the specified time duration.

Specific Gravity (SpG): Ratio of density of a substance to that of water.

Stabilization: Treatment of waste to protect the environment from contamination. This includes rendering a waste immobile or safe for handling and disposal.

Stabilize: As applied to wastes for disposal in place at the Hanford Site, the application of processes or actions that would increase the resistance of waste to chemical change or physical disintegration.

Stack: A vertical pipe or flue designed to exhaust gases and suspended particulates.

Stakeholder: An individual or group that could affect or be affected by decisions.

Steam Condensate: Liquid that is condensed after being boiled off as steam. Although it is typically nearly pure water, impurities with boiling points near or below that of water can be included.

Strata: Defined layers of sedimentary rock that are usually separated from other layers above and below. Strata is the plural form of stratum.

Stratigraphy: The origin, composition, distribution, and succession of different layers or strata of rock or earth.

Strontium-90 (Sr-90): A heavy radioactive isotope of strontium that is hazardous because it can be assimilated by and deposited much like calcium in the bones of organisms. It is a beta emitter with a half-life of 28.6 years.

Subsurface Barriers: A structure such as a dike or wall that is placed below ground level to restrict liquid flow or movement.

Sulfur Oxide (SO_2, SO_3): Compounds formed as waste effluents in the burning of some fossil fuels.

Sump: A below-grade tank often used to clarify wastes, permit addition of chemicals to waste, and to provide an integrated sample reservoir prior to subsequent disposal. It is usually associated with other liquid waste disposal facilities.

Supernatant (Liquor): The liquid that floats on the surface of heavier material deposited by settling, precipitation, or centrifugation. In waste storage tanks, the liquid quantity is defined by the difference between the measured liquid level and the measured average solids level in a tank.

Surveillance: Those activities that ensure the site waste remains safe. These include inspecting and monitoring of the site, maintaining access barriers to radioactive materials left on the site, and preventing activities on the site that might impair these barriers.

Syncline: A trough of stratified rock in which the beds dip toward each other from either side.

T Plant (222-T): One of the original processing plants built in 1943 to separate plutonium for use in nuclear warheads. Now the facility is used to decontaminate and decommission equipment.

Tank: A large steel-lined concrete container that is located underground for storage of liquid waste.

Tank Farm: An installation of multiple adjacent tanks, usually interconnected, for storage of liquid radioactive waste. Major tank farms at the Hanford Site are underground and located in the 200 Areas.

Technetium-99 (Tc-99): A pure beta emitting radioisotope with a half-life of 212,000 years. Technetium-99 is generated during the fission of uranium-235.

Topography: The general configuration of a land surface including its relief and its natural and man-made features.

Total Recordable Case: A workplace injury or illness that requires medical care.

Toxicological Health Effect: Reversible or irreversible effects in specific target organs from acute exposure to nonradiological chemicals. Adverse effects most often are observed in the central nervous system.

Tracking Radioactive Components: A computer model (also referred to as TRAC) used for estimating waste tank inventories based on initial fuel irradiation data, partitioning coefficients, tank waste transfers, and waste treatment.

Transuranic Elements: Those having an atomic number greater than that of uranium (92).

Transuranic Wastes: Waste containing more than 100 nanocuries per gram of alpha emitting transuranic isotopes with half-lives of greater than 20 years. This does not include high-level waste, waste that DOE, with EPA agreement, determines does not need the degree of isolation required for high-level waste, or waste that the Nuclear Regulatory Commission has approved for disposal in a near-surface disposal facility.

Treated Effluent: Wastewater that has undergone any combination of treatment processes to reduce suspended solids, pathogens, and inorganic solids, and subsequently to reduce the biochemical oxygen demand.

Treatment: Any activity that alters the chemical or physical nature of a hazardous waste to reduce its toxicity, volume, mobililty or to render it amenable for transport, storage or disposal.

Tri-Party Agreement: The Hanford Federal Facility Agreement and Consent Order. It is an agreement signed in 1989 and amended in 1994 by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology that identifies milestones for key environmental restoration and waste management actions.

Tributyl Phosphate (TOP): A solvent used in the plutonium-uranium extraction PUREX process.

Tritium: A radioactive isotope of hydrogen with one proton and two neutrons. This isotope has a half-life of 12.3 years.

Unconfined Aquifer: A subsurface water-bearing region that does not have impermeable confining boundary layers to restrict water movement. In an unconfined aquifer the water table forms the upper boundary.

Uranium: A naturally-occurring radioactive element found in natural ores with the atomic number 92 and an average atomic weight of approximately 238. The two principal natural isotopes are uranium-238 (99.3 percent of natural uranium) and uranium-235 (0.7 percent of natural uranium). Natural uranium also includes a minute amount of uranium-234.

Uranium-Oxide Plant: A processing facility that converted liquid uranyl (uranium) nitrate hexahydrate from the plutonium-uranium extraction (PUREX) process into a uranium trioxide powder that was recycled into reactor fuel. The plant was built in 1943 to 1944 and operated from 1951 to 1972 and from 1984 to 1989.

Vadose Zone: The region of soil and rock between the ground surface and the top of the water table in which pore spaces are only partially filled with water. Over time, contaminants in the vadose zone often migrate downward to the underlying aquifer.

Vault: A type of structure constructed out of concrete to store a variety of nuclear materials (similar to a caisson).

Vessel Vent System: In a processing facility the vents from process tanks and their vessels are piped through a common system that vents through a treatment system to remove pollutants and contaminants.

Vitrification: A method of immobilizing waste (e.g., radioactive, hazardous, and mixed). This involves adding frit and waste to a joule-heated vessel and melting the mixture into a glass. The purpose of this process is to permanently immobilize the waste and to isolate it from the environment.

Void: An air space either above waste in a caisson, burial trench, or tank or within pores or the small spaces contained in a bulk material such as gravel.

Volatile Organic Compounds: Compounds that readily evaporate and vaporize at normal temperatures and pressures.

Waste Concentration: Removal of excess water from liquid wastes or slurries.

Waste Encapsulation and Storage Facility (WESF): A facility located next to B Plant in which radioactive cesium and strontium were doubly encapsulated in stainless steel and stored underwater.

Waste Isolation Pilot Plant: A facility located near Carlsbad, New Mexico. The purpose of this facility is to demonstrate the safe disposal of military transuranic wastes buried in a repository in a salt layer 655 meters (2,150 feet) underground.

Watchlist: A list of the Hanford Site's single- and double-shell underground waste storage tanks that have identified safety issues. This list is required by Public Law 101-50, Section 3137(a), which requires the identification and aggressive management of those tanks that pose a serious risk of explosion. Tanks on the Watchlist have safety issues regarding flammable gas generation, high-heat loads, organic compounds, and ferrocyanide contents.

Watchlist Tank: An underground storage tank containing waste that requires special safety precautions because it may have a serious potential for release of high-level radioactive waste because of uncontrolled increases in temperature or pressure. Special restrictions have been placed on these tanks by Safety Measures for Waste Tanks at Hanford Nuclear Reservation, Section 3137 of the National Defense Authorization Act for Fiscal Year 1991, November 5, 1990, Public Law 101-501 (also known as the Wyden Amendment).

Wetland(s): Those areas that are covered by water with a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mudflats, and natural ponds.

Wind Rose: A star-shaped diagram showing how often winds of various speeds blow from different directions. This is usually based on yearly average.

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