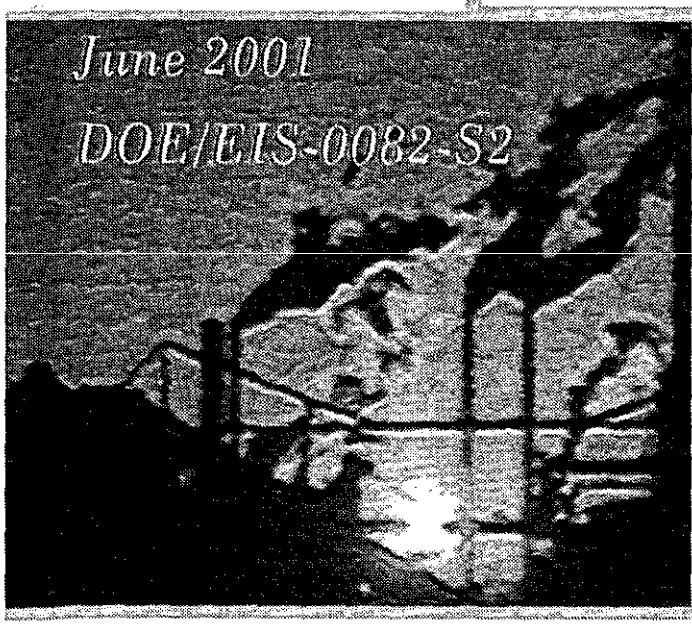
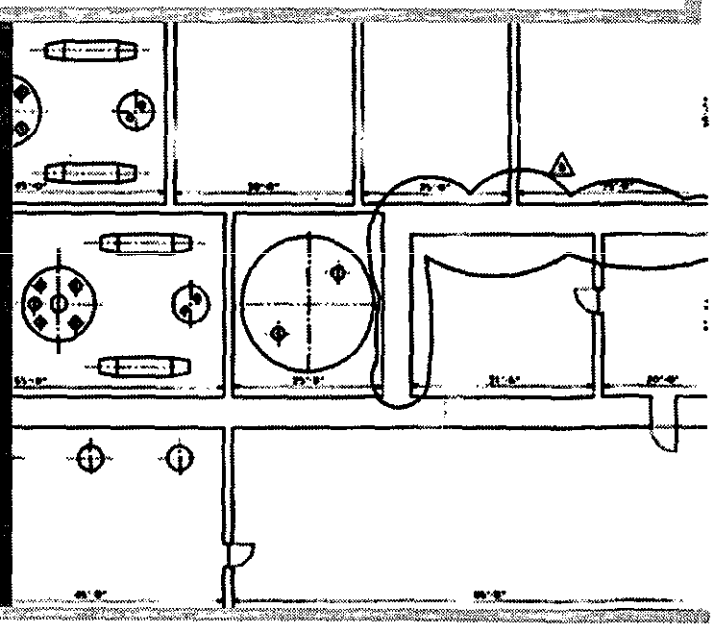
Savannah River Site

Salt Processing Alternatives

Final Supplemental Environmental Impact Statement

U.S. Department of Energy
Savannah River Operations Office
Aiken, South Carolina





COVER SHEET

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

TITLE: Savannah River Site Salt Processing Alternatives Supplemental Environmental Impact Statement (DOE/EIS-0082-S2)

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ABSTRACT: DOE prepared this SEIS on alternatives for separating the high-activity fraction from the low-activity fraction of the high-level radioactive waste salt solutions now stored in underground tanks at the Savannah River Site (SRS) near Aiken, South Carolina. The high-activity fraction of the high-level waste (HLW) salt solution would then be vitrified in the Defense Waste Processing Facility (DWPF) and stored until it could be disposed of as HLW in a geologic repository. The low-activity fraction would be disposed of as low-level waste (saltstone) in vaults at SRS.

A process to separate the high-activity and low-activity waste fractions of the HLW salt solutions is needed to replace the In-Tank Precipitation (ITP) process which, as presently configured, cannot achieve production goals and safety requirements for processing HLW. This SEIS analyzes the impacts of constructing and operating facilities for four alternative processing technologies – Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout – and the No Action Alternative. Solvent Extraction is DOE's preferred alternative. Sites for locating processing facilities within S and Z Areas at SRS are identified. TC

Because replacing the ITP process constitutes a substantial change to the HLW salt processing operation of the DWPF, as evaluated in a 1994 SEIS (DOE/SEIS-0082-S) to the 1982 DWPF EIS (DOE/EIS-0082), DOE prepared this second SEIS to evaluate the potential environmental impacts of alternatives to the ITP process.

PUBLIC INVOLVEMENT: DOE issued the Draft Salt Processing Alternatives SEIS on March 23, 2001 and held a public comment period on the Draft SEIS through May 14, 2001. In preparing the Final SEIS, DOE considered comments received via mail, fax, and electronic mail and transcribed comments made at public meetings held in North Augusta, South Carolina, on May 1, 2001, and Columbia, South Carolina, on May 3, 2001. TC

FOREWORD

The U.S. Department of Energy (DOE) published a Notice of Intent (NOI) on February 22, 1999, to prepare this supplemental environmental impact statement (SEIS). DOE prepared this SEIS on alternatives for separating the high-activity fraction from the low-activity fraction of the radioactive high-level waste (HLW) salt solution now stored in underground tanks at the Savannah River Site (SRS) near Aiken, South Carolina. The high-activity fraction of the HLW salt solution waste would then be vitrified in the Defense Waste Processing Facility and stored until it could be disposed of as high-level waste in a geologic repository. The low-activity fraction would be disposed of as low-level waste (saltstone) in vaults at SRS.

A process to separate the high-activity and low-activity waste fractions of the high-level waste salt solutions is needed to replace the In-Tank Precipitation (ITP) process which, as presently configured, cannot achieve production goals and safety requirements for processing high-level waste. This SEIS analyzes the impacts of constructing and operating four alternative processing technologies – Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout – and the No Action Alternative. The Solvent Extraction Alternative is DOE's preferred alternative. Because replacing the ITP process constitutes a substantial change to the HLW salt processing operation of the Defense Waste Processing Facility, as evaluated in a 1994 SEIS (DOE/SEIS-0082-S) to the 1982 Defense Waste Processing Facility EIS (DOE/EIS-0082), DOE prepared this second SEIS to evaluate the potential environmental impacts of alternatives to the ITP process.

A Notice of Availability for the Draft SEIS was published in the Federal Register on March 30, 2001. Public meetings to discuss and receive comments on the Draft SEIS were held at the North Augusta Community Center in North Augusta, South Carolina on May 1, 2001 and at the Holiday Inn Coliseum in Columbia, South Carolina on May 3, 2001. The public comment period ended May 14, 2001. In the public meetings nine individuals commented on the Draft SEIS. During the 45-day comment period DOE received 12 letters commenting on the Draft SEIS. A summary of the comments received during the public comment period for this SEIS, and DOE's responses are included in Appendix C.

Transcripts of public testimony, copies of comment letters, responses to those comments, and reference materials cited in the SEIS are available for review in the DOE Public Reading Room, University of South Carolina at Aiken, Gregg-Graniteville Library, University Parkway, Aiken, South Carolina.

DOE has prepared this SEIS in accordance with the National Environmental Policy Act (NEPA) regulations of the Council on Environmental Quality (40 CFR 1500-1508) and DOE NEPA Implementing Procedures (10 CFR 1021). This SEIS identifies the methods used for analyses and the scientific and other sources of information consulted. In addition, results available from ongoing studies are incorporated directly or summarized and referenced. The organization of the SEIS is as follows:

- Chapter 1 describes the background and purpose and need for DOE action regarding salt processing at SRS.
- Chapter 2 describes the proposed action and the alternatives that DOE is evaluating.
- Chapter 3 describes the SRS environment as it relates to the alternatives described in Chapter 2.
- Chapter 4 assesses the potential environmental impacts of the alternatives.

- Chapter 5 discusses the cumulative impacts of salt processing in relation to other past, present, and reasonably foreseeable future activities at SRS, and in the surrounding region.
- Chapter 6 identifies irreversible and irretrievable resource commitments.
- Chapter 7 discusses applicable statutes, state and Federal regulations, and DOE Orders, and agreements.
- Appendix A describes the facilities and processes that would be used for each of the alternatives.
- Appendix B discusses the methods used for accident analysis and the results of the analysis.
- Appendix C presents the comments received on the draft SEIS and DOE's responses to those comments. TC
- Appendix D gives the methods and the results of long-term performance modeling that was used to evaluate the impacts of salt processing alternatives.

Change Bars

Change bars beside text in this SEIS indicate a substantive change from the Draft SEIS. If the change was made in response to a comment received on the Draft SEIS, the comment number is as listed in Appendix C. If the change was a technical change made by DOE, the bar is marked "TC."

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ABBREVIATIONS, ACRONYMS, MEASUREMENT ABBREVIATIONS, USE OF SCIENTIFIC NOTATION, AND METRIC CONVERSION CHART

Abbreviations and Acronyms

ALARA	as low as reasonably achievable
AST	alpha sorption tank
CBD	chronic beryllium disease
CCME	Canadian Council of Ministries of the Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFT	caustic feed tank
CFR	Code of Federal Regulations
CIF	Consolidated Incineration Facility
CSDT	clearing solution dump tank
CSS	clarified salt solution
CST	crystalline silicotitanate
TC CWA	Clean Water Act
DCG	Derived Concentration Guide
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DOE-SR	DOE-Savannah River Operations Office
DF	decontamination factor
DNFSB	Defense Nuclear Facilities Safety Board
DSS	decontaminated salt solution
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERPG	Early Response Planning Guideline
ETF	Effluent Treatment Facility
FDM	Fugitive Dust Model
FFA	Federal Facility Agreement
FR	Federal Register

FY	fiscal year
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
IRIS	Integrated Risk Information System
ISC3	Industrial Source Complex – Short Term
ITP	In-Tank Precipitation
LCF	latent cancer fatality
LFL	lower flammability limit
LLW	low-level waste
LPDT	low point drain tank
LRHT	loaded resin hold tank
LWD	lost workdays
MCL	Maximum contaminant limit
MEI	Maximally exposed (offsite) individual
MST	monosodium titanate
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPH	Natural phenomena hazards
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OWST	organic waste storage tank
PEL	Permissible exposure limit
PHA	Precipitate Hydrolysis Aqueous
PHC	precipitate hydrolysis cell
PPT	precipitate slurry
PSD	prevention of significant deterioration
PUREX	Plutonium uranium extraction
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RPA	Radiological Performance Assessment
SCDHEC	South Carolina Department of Health and Environmental Control
SCE&G	South Carolina Electric & Gas

SEIS	Supplemental Environmental Impact Statement
SET	Systems Engineering Team
SRI	SRS National Resource Management & Research Insitute
SRS	Savannah River Site
SSRT	sludge solids receipt tank
TOA	trioctylamine
TPB	tetraphenylborate
TRC	total recordable cases
TSP	total suspended particulates
TWA	time-weighted average
VOC	volatile organic compound
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

cfm	cubic feet per minute
cfs	cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second
cm	centimeter
ci/m^3	curie per cubic meter
ft	feet
gpm	gallons per minute
hr/yr	hour per year
kg	kilogram
kW	kilowatt
L	liter = 0.2642 gallon
lb	pound = 0.4536 kilogram
msl	mean sea level
m^3	cubic meter
µCi	microcurie
µg	microgram
µm	micrometer
mg	milligram
mg/kg/day	milligram per kilogram per day
mg/L	milligram per liter
mg/m^3	milligrams per cubic meter
mg/s	milligrams per second
mrem	millirem
nCi	nanocurie
PM_{10}	particulate matter less than 10 microns in diameter
pCi	picocurie

pCi/L	picocurie per liter
rad/d	rad per day
rem	rem
sec/m^3	seconds per cubic meter
yr	year
°C	degrees Celsius = 5/9 (degrees Fahrenheit – 32)
°F	degrees Fahrenheit = 32 + 9/5 (degrees Celsius)

Use of Scientific Notation

Very small and very large numbers are sometimes written using "scientific notation" or "E-notation," rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., 10^n, or the number 10 multiplied by itself "n" times; 10^{-n}, or the reciprocal of the number 10 multiplied by itself "n" times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$
0.049 is written 4.9×10^{-2}
1,490,000 or 1.49 million is written 1.49×10^6

A positive exponent indicates a number larger than or equal to one; a negative exponent indicates a number less than one.

In some cases, a slightly different notation ("E-notation") is used, where "× 10" is replaced by "E" and the exponent is not superscripted. Using the above examples:

$4{,}900 = 4.9 \times 10^3 = 4.9\text{E+}03$
$0.049 = 4.9 \times 10^{-2} = 4.9\text{E-}02$
$1{,}490{,}000 = 1.49 \times 10^6 = 1.49\text{E+}06$

Metric Conversion Chart

To convert into metric			To convert out of metric		
If you know	**Multiply by**	**To get**	**If you know**	**Multiply by**	**To get**
Length					
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Area					
sq. inches	6.4516	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.092903	sq. meters	sq. meters	10.7639	sq. feet
sq. yards	0.8361	sq. meters	sq. meters	1.196	sq. yards
acres	0.0040469	sq. kilometers	sq. kilometers	247.1	acres
sq. miles	2.58999	sq. kilometers	sq. kilometers	0.3861	sq. miles
Volume					
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	1 000 000 000 000 000 000 = 10^{18}
peta-	P	1 000 000 000 000 000 = 10^{15}
tera-	T	1 000 000 000 000 = 10^{12}
giga-	G	1 000 000 000 = 10^{9}
mega-	M	1 000 000 = 10^{6}
kilo-	k	1 000 = 10^{3}
centi-	c	0.01 = 10^{-2}
milli-	m	0.001 = 10^{-3}
micro-	μ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}
femto-	f	0.000 000 000 000 001 = 10^{-15}
atto-	a	0.000 000 000 000 000 001 = 10^{-18}

CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

Nuclear materials production operations at the Savannah River Site (SRS) (Figure 1-1) resulted in the generation of large quantities of **high-level radioactive waste** (referred to as high-level waste or HLW). This waste has been stored onsite in large underground tanks. The U.S. Department of Energy (DOE) built the Defense Waste Processing Facility (DWPF) to convert this HLW to a stable glass form suitable for disposal in a geologic repository. The DWPF has been operating since 1996 to **vitrify** (i.e., convert to glass) one of the **HLW components**.

To assist the reader in understanding technical terms specific to the proposal action, those terms have been **bolded** the first time they are used and are discussed in Table 1-1, Primer of Technical Terms, located at the end of this chapter. Additional technical terms are located in the Glossary.

SRS HLW was generated as an acidic solution, then was chemically converted to an alkaline solution for storage. In its alkaline form, it consists of two components, soluble **salt** and insoluble **sludge**. Both components contain highly radioactive residues from nuclear materials production. **Radionuclides** found in the sludge include **fission products** (such as strontium-90) and long-lived **actinides** (such as uranium and plutonium). Radionuclides found in the salt component include **isotopes** of cesium and technetium, as well as some strontium and actinides.

Dewatering the salt solution by evaporation, a process that conserves tank space, converts the salt solution to a solid **saltcake** and a concentrated **salt supernatant**. The saltcake must be converted back to salt solution to process the salt component by any action alternative described in this SEIS. Solid saltcake would be dissolved by adding water and combined with salt supernatant to form a salt solution. An L6-10

Radionuclides

Cesium (Cs)

Cesium-137 (half-life 30 years), Cs-135 (half-life 21.3 million years), and Cs-134 (half-life 2 years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

Plutonium (Pu)

Plutonium is a man-made, radioactive element in the actinide series. Pu-238 (half-life 88 years) and -239 (half-life 24,000 years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

Strontium (Sr)

Strontium-90 (half-life 29 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Technetium (Tc)

Technetium is a man-made, radioactive element. Tc-99 (half-life 200,000 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Uranium (U)

Uranium is a long-lived radioactive element in the actinide series. U-235 (half-life 700 million years) and U-238 (half-life 4 billion years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

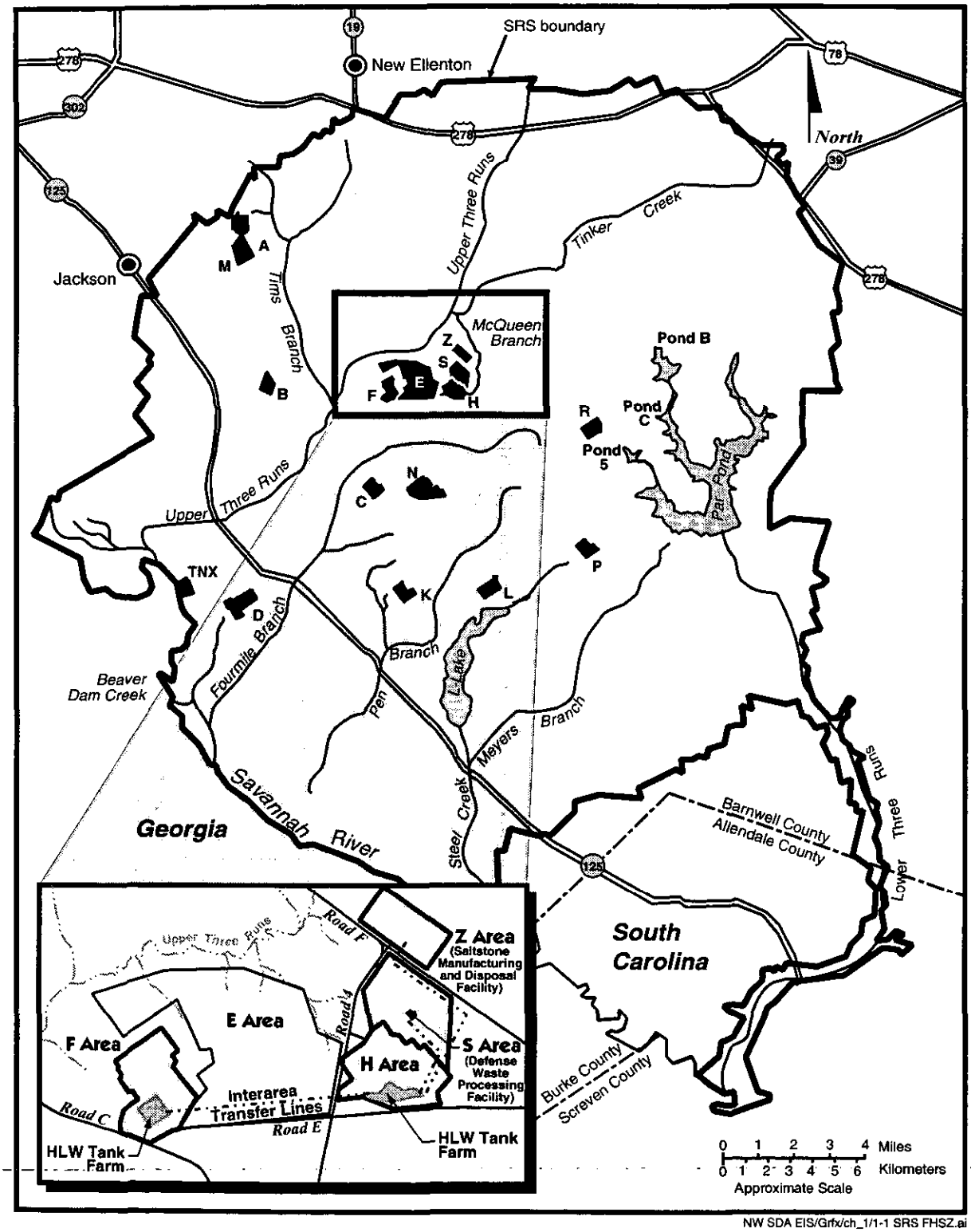

Figure 1-1. Savannah River Site map with F, H, S, and Z Areas highlighted.

important part of the system would then separate the highly radioactive constituents from the salt solution.

The high-activity fraction removed from salt solution would be vitrified in DWPF, and the less radioactive constituents, still in the salt solution, would be stabilized with grout (a cement-like mixture), to create a saltstone waste form for onsite disposal as **low-level radioactive waste (LLW)**.

DOE evaluated the potential impacts of constructing and operating DWPF in a 1982 environmental impact statement (EIS) (DOE 1982). In 1994, DOE published a Supplemental EIS (SEIS) (DOE 1994) evaluating changes in the process proposed after the 1982 EIS was issued. The Record of Decision (60 FR 18589; April 12, 1995) announced that DOE would complete the construction and startup testing of DWPF.

The process DOE selected in 1994 to separate the high-activity fraction from the salt solution is known as In-Tank Precipitation (ITP). This process was designed to be carried out primarily in one of the underground HLW storage tanks with a 1.3-million-gallon capacity. An inorganic **sorbent, monosodium titanate**, would remove actinides and radioactive strontium from the salt solution. An organic **reagent, sodium tetraphenylborate**, would precipitate radioactive cesium from the salt solution. The ITP process included washing and filtration steps to separate the resulting solids and residual sludge for vitrification in DWPF.

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The reagent used to precipitate cesium in the ITP process, tetraphenylborate, is subject to **catalytic** and **radiolytic decomposition**. This decomposition returns the cesium to the salt solution, and generates **benzene**. Benzene is a toxic, flammable, and potentially explosive organic substance that must be safely controlled.

To achieve the objectives of the ITP process, the decomposition of tetraphenylborate must be limited to minimize (1) the amount of precipitated cesium that is redissolved in the salt solution, and (2) the amount of benzene generated. The ITP process was designed to accommodate some tetraphenylborate decomposition and to limit benzene accumulation. Startup testing of the ITP facility in 1995 generated benzene in much greater quantities than had been anticipated based on calculations and laboratory experiments and ITP startup operations were suspended in order to develop a better understanding of the ITP process chemistry.

L1-2

In August 1996, the Defense Nuclear Facilities Safety Board (DNFSB), an independent oversight board chartered by Congress to review operations at DOE nuclear defense facilities and make recommendations necessary to protect public health and safety, recommended that planned large-scale testing of the ITP process not proceed further until DOE had a better understanding of how benzene was generated and released during the **precipitation** process (DNFSB 1996). In response to the DNFSB recommendation, DOE initiated an extensive chemistry program to better understand the benzene generation and releases. In January 1998, DOE determined that ITP, as designed, could not meet production goals and safety requirements, that is, the satisfactory separation of radionuclides from HLW salt solution without excessive tetraphenylborate decomposition. DOE must therefore select an alternative technology for HLW salt processing. DWPF continues to process and vitrify HLW sludge without including the high-activity fraction of the HLW salt component. About 1,100 sludge-only canisters had been processed through May 2001.

L6-12

L6-12

L6-13

L1-3

Westinghouse Savannah River Company (WSRC), the SRS operating contractor, recommended to DOE that a systematic evaluation be conducted to identify viable salt treatment technologies to replace the ITP process (DOE 1998a). This evaluation was done and, in October 1998, WSRC presented its recommendation of alternatives to DOE (WSRC 1998). WSRC recommended four technologies for further consideration: Small Tank **Tetraphenylborate Precipitation, Crystalline Silicotitanate Ion Exchange, Caustic Side Solvent Extraction,** and **Direct Disposal in Grout**. In early 1999,

The High-Level Waste Management System

The HLW management system at SRS comprises seven interconnected operations as follows:

- HLW storage (in underground storage tanks) and evaporation in the F- and H-Area Tank Farms
- Sludge processing in the Extended Sludge Processing Facility
- Salt processing using the ITP process, including the Late Wash Facilities (inactive, as described in the text)
- HLW vitrification in DWPF
- Solidification of low-activity salt solution in the Saltstone Manufacturing and Disposal Facility
- Wastewater treatment in the Effluent Treatment Facility
- Organic destruction in the Consolidated Incineration Facility (CIF) (inactive, as described in the text)

The HLW management system is currently operating, except for salt processing through ITP and the Late Wash Facility, and CIF. ITP operations are now limited to facility surveillance and maintenance. The Late Wash Facility has been tested, using nonradioactive materials, and is in standby status. The CIF was constructed to incinerate benzene generated in the ITP process and to destroy plutonium/uranium extraction (PUREX) solvent wastes from chemical separations operations, solid LLW from ongoing operations, and waste from decontamination and decommissioning projects. CIF operations were suspended in October 2000. DOE expects to make a decision on whether to resume CIF operations by April 2002. DOE is investigating alternatives to incineration and will not operate the CIF if an effective alternative disposal for PUREX solvents can be identified. TC

based upon review of the recommendation by DOE and independent reviewers, DOE decided to pursue three of the four candidate alternatives for replacement of the ITP process.

Solvent Extraction was dropped from consideration in 1999 because it was considered technically immature. DOE restored Solvent Extraction to the list of potential alternatives in February 2000 (DOE 2000a), based on recommendations from the National Academy of Sciences (NAS 1999) and new research and development results. A description of DOE's salt processing program, including results of research and development, may be found on the Internet at www.srs.gov/general/srtech/spp/randd.htm.

In parallel with development of the WSRC recommendations on alternative technologies, DOE prepared a Supplement Analysis (DOE 1998b) in accordance with the Department's National Environmental Policy Act (NEPA) regulations (10 CFR 1021). Based on the Supplement Analysis, DOE decided to prepare this second SEIS on DWPF and its supporting processes because necessary additional technical changes will significantly alter the way in which HLW salt is processed from that described in the original EIS and the 1994 SEIS. This second SEIS evaluates the potential environmental impacts of replacing the ITP process for salt processing with an alternative technology. The SEIS also considers the impacts of a No Action alternative.

1.2 Purpose and Need for Action

The ability to safely process the salt component of the HLW stored in underground storage tanks at SRS is a crucial prerequisite for completing HLW disposal. Without a suitable method for salt management, DOE would not be able to place the HLW in a configuration acceptable for safe disposal. Thus, DOE must identify and implement one or more technologies to prepare the SRS HLW salt component for disposal. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of LLW at SRS. If salt processing is delayed beyond 2010, DOE recognizes that the salt waste must be vitrified separately from the sludge component of the

HLW, and the total number of HLW canisters would be increased over that projected for concurrent sludge and salt waste vitrification.

L1-5
L6-16
L6-44

Preliminary projections indicate that, if the salt processing date of 2010 is not met, then the potential exists that up to 150 additional canisters (salt-only) per year would have to be produced for every year startup is delayed beyond 2010. The cost for additional canister production would be about $300 million per year. In the event that sludge processing was to be completed prior to the initiation of salt processing, it would take 13 years (at 150 canisters per year) to process all of the salt waste at an approximate cost of $4 billion in addition to the cost of constructing and operating the salt processing facility. (Note: These costs do not include Federal Repository costs for transportation and disposal).

HLW Tank Closure Activities

DOE, the U.S. Environmental Protection Agency (EPA), and the South Carolina Department of Health and Environmental Control (SCDHEC) have agreed to a schedule for closure of the Savannah River Site HLW tanks. DOE must close the tanks in accordance with applicable laws, regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996). Bulk waste must be removed from the tanks before closure can begin. Without a salt processing alternative, and with continued sludge-only vitrification in the DWPF, HLW storage requirements will be such that DOE may not be able to empty all tanks and, therefore, after about 2010, tank closure commitments may not be met. DOE has prepared the *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, to evaluate the impacts of the tank closure program (DOE 2000b).

1.3 SEIS Overview

1.3.1 SCOPE

In accordance with Council on Environmental Quality (CEQ) requirements, DOE is integrating the NEPA analysis early in the planning process to ensure that environmental values are considered in decision making (40 CFR 1501.2). This SEIS describes the technology alternatives that DOE is considering to replace the ITP technology for salt processing. Processes and facilities that would be needed for each alternative are presented. The SEIS also estimates the environmental impacts that could result from the construction and operations associated with each of the alternatives, based on information from **preconceptual facility designs** for the action alternatives and other information developed specifically for the SEIS. For each alternative, the impacts to the environment and human health from normal facility operation and from accidents that might occur during operation are estimated and presented in the SEIS.

In addition, the SEIS describes the potential impacts of a No Action alternative, as required by NEPA. The impacts of the No Action alternative provide a basis for comparison with the impacts of the action alternatives. The No Action alternative is defined as the continuation of actions DOE has already taken or is currently taking. As such, No Action could be defined as operation of the ITP Facility for salt processing, as projected in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility Record of Decision* (60 FR 18589 – 18594; April 12, 1995). However, because DOE has determined that the ITP process cannot achieve both safety and production requirements, it will not be operated. A comparison of the impacts of the alternatives to the operation of the ITP Facility would not, therefore, prove meaningful. Consequently, DOE has defined No Action as a continuation of current HLW management activities, including tank

space management, and vitrification of the sludge component of HLW, without operation of the ITP Facility. See Chapter 2 for a full explanation of the No Action alternative.

Decisions to be Made

DOE has completed this SEIS and related technical studies, and has selected caustic side solvent extraction as the preferred alternative. No sooner than 30 days after EPA publishes a Notice of Availability of the SEIS, DOE will select a salt processing technology and issue a Record of Decision (ROD). DOE may construct and operate a Pilot Plant for the selected technology and then produce a **final design** of the facility that would implement full-scale operation of the selected technology.

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1.3.2 ORGANIZATION

DOE has prepared this SEIS in accordance with the NEPA regulations of the CEQ (40 CFR 1500-1508) and DOE NEPA Implementing Procedures (10 CFR 1021). This SEIS identifies the methods used for analyses and the scientific and other sources of information consulted. In addition, results available from ongoing studies are incorporated directly or are summarized and referenced. The organization of the SEIS is as follows:

- Chapter 1 describes the background and purpose and need for DOE action regarding salt processing at SRS.
- Chapter 2 describes the proposed action and the alternatives that DOE is evaluating.
- Chapter 3 describes the SRS environment as it relates to the alternatives described in Chapter 2.
- Chapter 4 assesses the potential environmental impacts of the alternatives.
- Chapter 5 discusses the cumulative impacts of salt processing in relation to other past, present, and reasonably foreseeable future activities at SRS, and in the surrounding region.
- Chapter 6 identifies irreversible and irretrievable resource commitments.
- Chapter 7 discusses applicable statutes, state and Federal regulations, DOE Orders, and agreements.

The appendices provide more detailed discussions of certain topics. Appendix A describes the facilities that would be used for each of the alternatives. Appendix B describes the methods used for accident analysis and results of the analysis. Appendix C presents the public comments received on the draft SEIS, and DOE's responses to those comments. Appendix D gives the methods, concentrations, doses, and results of long-term performance modeling used to evaluate the long-term impacts of salt processing alternatives. Corresponding health effects are given in Section 4.3 of Chapter 4.

1.3.3 STAKEHOLDER PARTICIPATION

On February 22, 1999, DOE announced in the *Federal Register* its intent to prepare a *Supplemental Environmental Impact Statement for Alternatives to the In-Tank Precipitation Process* (64 FR 8558). To more accurately describe the process, DOE has since retitled this document as the Salt Processing Alternatives SEIS.

A Notice of Availability for the Draft SEIS was published in the Federal Register on March 30, 2001 (66 FR 17423). Public meetings to discuss and receive comments on the Draft SEIS were held at the North Augusta Community Center in North Augusta, South Carolina, on May 1, 2001, and at the Holiday Inn Coliseum in Columbia, South Carolina, on May 3, 2001. The public comment period ended May 14, 2001. In the public meetings nine individuals commented on the Draft SEIS. During the 45-day comment period DOE received 12 letters commenting on

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TC | the Draft SEIS. The comments addressed four broad issues:

- No Action alternative
- Direct Disposal in Grout alternative
- Waste management
- TC | Criteria for the selection of the preferred alternative

Appendix C presents the comments received on the draft SEIS and DOE's responses to those comments.

TC | The National Academy of Sciences - National Research Council Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site was given the opportunity to comment on this Final SEIS. The Committee chose not to comment on the Final SEIS, but instead to comment on separation alternatives in its report to DOE, which was submitted on June 4, 2001 (see Section 1.4.2).

1.4 Related Information

This SEIS makes use of information contained in other DOE NEPA documents related to HLW management. It is consistent with DOE's parallel EIS process on HLW tank closure at SRS, which is related to activities in the F- and H-Area Tank Farms. The NEPA documents pertaining to this Salt Processing Alternatives SEIS are briefly described below.

1.4.1 NEPA DOCUMENTS

Final Environmental Impact Statement, Defense Waste Processing Facility (DOE 1982)

DOE prepared this EIS to address the potential impacts of constructing and operating DWPF to vitrify HLW in preparation for final disposal in a monitored geologic repository. DOE announced its decision to construct and operate DWPF in a ROD published in the *Federal Register* (47 FR 23801) on June 1, 1982.

Final Environmental Impact Statement, Waste Management Activities for Groundwater Protection (DOE 1987)

DOE prepared this EIS to address the potential environmental impacts of **hazardous waste**, LLW, and **mixed waste** management activities that could affect the groundwater resources under and near SRS. On March 9, 1988, DOE decided (53 FR 7557) that LLW generated by each alternative would be disposed of in vaults on the SRS. Disposal has to meet SRS waste disposal performance assessment criteria that are imposed to protect groundwater.

Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility (DOE 1994)

DOE prepared an SEIS to examine the impacts of completing construction and operating DWPF at SRS. This document assisted the Department in deciding whether and how to proceed with the DWPF project, given the changes to processes and facilities that had occurred since 1982, when DOE issued the original DWPF EIS. The evaluation in the EIS included short- and long-term impacts associated with the construction and operation of the Saltstone Manufacturing and Disposal Facility and disposal vaults.

On April 12, 1995, the ROD (60 FR 18589) announced that DOE would complete the construction and startup testing of DWPF, and would use ITP for salt processing, after satisfactory completion of its startup testing. The ROD also announced that the low-activity salt solution resulting from salt pretreatment would be immobilized in the Saltstone Manufacturing and Disposal Facility and permanently disposed of in the Z-Area vaults. DOE has now determined that the ITP process cannot meet safety requirements and production goals and is therefore pursuing alternative technologies for HLW salt processing.

Final Environmental Impact Statement, Waste Management (DOE 1995)

DOE issued the SRS Waste Management EIS (DOE 1995) to provide a basis for the selection of a Sitewide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The SRS Waste Management EIS included the treatment of wastewater discharges in the Effluent Treatment Facility, F- and H-Area Tank Farm operations and waste removal, and construction and operation of a replacement HLW evaporator in the H-Area Tank Farm. In addition, it evaluated the CIF for the treatment of mixed waste, including incineration of benzene waste from the then-planned ITP process. The first ROD (60 FR 55249) on October 30, 1995, stated that DOE would configure its waste management system according to the moderate treatment alternative described in the EIS. The SRS Waste Management EIS is relevant to this Salt Processing Alternatives SEIS because it evaluates management alternatives for various types of waste that actions proposed in this SEIS could generate. The Waste Management EIS is also relevant to the assessment of cumulative impacts that could occur at SRS. The second ROD (62 FR 27241) was published on May 19, 1997, to ensure consistency with the *Approved Site Treatment Plan* (WSRC 1996) and also to announce DOE's decision to construct and operate additional facilities at SRS for characterization and treatment of mixed waste.

Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options (DOE 1998b)

DOE prepared a Supplement Analysis that led to a determination to prepare this SEIS. The Supplement Analysis provides a description and comparison of the impacts of the ITP facility with the proposed salt processing alternatives that DOE was considering in 1998.

Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE 2000b)

On December 29, 1998, DOE published a Notice of Intent to prepare an EIS on closure of HLW tanks at SRS (63 FR 71628). The Draft EIS, issued in November 2000, examines the impacts of closing the SRS HLW tanks in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996) approved by the South Carolina Department of Health and Environmental Control. The proposed action would begin on a tank-by-tank basis after bulk waste removal has been completed. Under each alternative, except No Action, DOE would close 49 HLW tanks and associated waste handling equipment, including evaporators, pumps, diversion boxes, and transfer lines. The preferred alternative consists of cleaning the tanks with water and filling them with grout. If necessary to meet performance requirements, additional cleaning (e.g., with oxalic acid) could be performed. The use of sand or saltstone as fill material was also considered. The EIS considers a No Action alternative that would consist of leaving the tank system in place after bulk waste removal. The comment period for the Draft EIS ended on January 23, 2001. Publication of the Final EIS is tentatively planned for Summer 2001.

1.4.2 OTHER RELEVANT DOCUMENTS

High-Level Waste Salt Disposition Systems Engineering Team Final Report (WSRC 1998)

This report describes the technology selection process that WSRC used to evaluate the final four technologies recommended to DOE for replacement of the ITP process.

Nuclear Waste – Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work (GAO 1999)

At the request of Congress, the General Accounting Office reviewed the reasons the ITP process did not work. This report describes the history of developing the ITP process and of selecting a replacement salt processing technology. The General Accounting Office concluded that the "Department and Westinghouse have taken steps that, if fully implemented, should better ensure a successful alternative."

Savannah River Site High-Level Waste Tank Space Management Team Final Report (WSRC 1999a)

This report identifies a strategy (including the potential operation of a new HLW evaporator in DWPF) for managing liquid HLW to ensure that existing SRS HLW tanks provide sufficient storage and processing capacity pending startup of a replacement process for ITP.

High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report (WSRC 1999b)

This report describes the process used to recommend a path forward for salt processing at the SRS. The report identifies programmatic risks, estimated costs, and project implementation schedules developed for the candidate technologies. The document recommended best-suited and backup technologies.

Defense Nuclear Facilities Safety Board Recommendation 96-1 to the Secretary of Energy (DNFSB 1996)

The DNFSB review of planned use of tetraphenylborate (TPB) in the ITP process to remove radioactive cesium from SRS HLW salt solutions conveyed concern over the rate of TPB decomposition and mechanisms for holdup and release of benzene encountered in large-scale tests using actual HLW. The DNFSB recommended deferral of additional tests involving large quantities of HLW pending: (1) improved understanding of the causes and mechanisms of benzene generation, retention, and release and (2) additional investigation to establish identification and role of **catalysts** involved in the TPB decomposition, and the factors controlling benzene retention and release. DNFSB concluded that such measures were necessary to ensure adequacy of existing safety requirement and to devise new safety and operational constraints.

NAS Review Committee Final Reports (NAS 2000, 2001)

In June 1999, the Under Secretary of Energy requested that the National Academy of Sciences – National Research Council provide an independent technical review of alternatives for processing the HLW salt solutions at the SRS. In response to the request, the Council appointed a "Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site" to review DOE's work to identify alternatives for separating cesium for high-level waste at the Savannah River Site. This committee conducted the review and provided an interim report in October 1999 and a final report in October 2000 (NAS 2000). In October 2000, the Council appointed a "Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site" to review DOE's efforts to evaluate and select a process for separating radionuclides for soluble high-level radioactive waste at the Savannah River Site. This second committee conducted their review and provided an interim report in March 2001 (NAS 2001a) and a Final Report in June 2001 (NAS 2001b). Summaries of the reviews conducted by these Council committees are provided in Section 2.8. TC

Defense Nuclear Facilities Safety Board Recommendation 2001-1 to the Secretary of Energy (DNFSB 2001)

A recent survey of SRS radioactive HLW management operations by the DNFSB addressed emergency problems in handling and storage of liquid wastes due to the projected shortage of HLW tank space. The survey resulted in recommendations to implement several measures to maintain adequate safety margins in HLW TC

storage, including the reassessment and vigorous acceleration of the schedule for operation of a salt processing facility. Developing an integrated plan for tank space management to maintain safe operating margins pending startup of salt waste processing was recommended. Measures proposed, analogous to those projected for the No Action alternative in the SEIS, included reducing or eliminating the DWPF low-level liquid waste stream, recovering ITP process tanks for waste storage, resolving existing HLW evaporator problems and assessing the need for additional evaporator capacity, and possibly constructing additional waste tanks. The DNFSB recognized that implementation of such measures is in progress, but urged special focus to avoid delays that could result in reduced safety.

DOE and the DNFSB are discussing the elements of an implementation plan that would be acceptable to the Board.

Table 1-1. Primer of Technical Terms (other scientific terms are defined in the glossary to this SEIS).[a]

Actinide
Any member of the group of elements with atomic numbers from 89 (actinium) to 103 (lawrencium), including uranium and plutonium. All members of this group are radioactive.

Benzene
Benzene, the simplest aromatic hydrocarbon, is widely used in industry. The chemical formula for benzene is C_6H_6. Benzene is a toxic, flammable, and potentially explosive substance that must be safely controlled. It is generated by the catalytic and radiolytic decomposition of the reagent tetraphenylborate, formerly used in the In-Tank Precipitation process and currently projected for use in the Small Tank Precipitation salt processing alternative.

Catalyst
A substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the process.

Catalytic decomposition
A chemical reaction in which a compound is broken down into simpler compounds of elements is the presence of a catalyst.

Caustic
An alkaline solution containing sodium hydroxide in other light metal oxides. SRS HLW solutions are caustic solutions.

Caustic Side Solvent Extraction
A technology alternative for processing the HLW salt solution to remove radioactive cesium by transfer to an immiscible organic stream, from which it is recovered into a secondary aqueous stream for vitrification at the Defense Waste Processing Facility. Before the cesium is removed from the salt solution, radioactive strontium and actinides are removed by sorption onto monosodium titanate and vitrified in DWPF. The remaining low-activity salt stream is immobilized in grout and disposed of as saltstone in onsite vaults.

Crystalline silicotitanate
Insoluble granular inorganic solid ($Na_4SiO_4 \cdot TiO_2$) ion exchange material developed through a cooperative research and development agreement between DOE and private industry. Provides capability for removing cesium from acid or alkaline salt solutions containing high sodium potassium concentrations. **Crystalline** refers to being, relating to, or composed of crystals.

Crystalline Silicotitanate Ion Exchange
A technology alternative for processing HLW salt solution to remove radioactive cesium by absorption onto a siliconate ion exchange resin that would be incorporated into a glass waste form by vitrification in the Defense Waste Processing Facility (see Ion Exchange).

Decomposition
The process by which a compound is broken down into simpler compounds or elements by chemical or physical reactions.

Direct Disposal in Grout
A technology alternative for processing the HLW salt solution without removal of radioactive cesium by immobilization in grout for onsite disposal as saltstone. Radioactive strontium and actinides are removed prior to disposal and vitrified in DWPF.

Table 1-1. (Continued).

Final design
In the final design phase, the emphasis has shifted almost completely from the qualitative aspects of the process to the quantitative. Major process vessels are sized and initial valve counts are often completed. By the end of this phase, a preliminary piping and instrumentation diagram typically will be complete, and broad considerations of facility site design will have been concluded. Opportunities for major process changes are few at this stage, but preliminary cost estimates (on the order of +/- 30%) and economic analyses can be produced.

Fission product
Nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by radioactive decay of the fission fragments.

High-level radioactive waste (HLW)
Based on the statutory definition in the Atomic Energy Act (which references back to the Nuclear Waste Policy Act for the definition of "high-level radioactive waste" and "spent nuclear fuel"), HLW is defined by DOE to mean the highly radioactive waste 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 is determined, consistent with existing law, to require permanent isolation. DOE has not defined "sufficient concentration" of fission products or identified "other highly radioactive material that requires permanent isolation."

HLW components
The HLW from the SRS chemical separations process consists of water soluble salts and insoluble sludges. The sludges settle to the bottom of the HLW tanks. The salt solutions are concentrated by evaporation to reduce their volume, forming a solid saltcake and a concentrated supernatant salt solution in the tanks.

Ion exchange/Ion exchange resin
The process by which salts present as charged ions in water are attached to active groups on and in an ion exchange resin and other ions are discharged into water, allowing separation of the two types of ions. **Ion exchange resins** can be formulated to remove specific chemicals and radionuclides from the salt solutions in the HLW tanks.

Isotope
See Radionuclide.

Low-level radioactive waste (LLW)
LLW is radioactive waste that does not meet the definition of high-level waste, transuranic waste, spent nuclear fuel, or by-product tailings from processing of uranium or thorium. LLW typically contains small amounts of radioactivity dispersed in large amounts of material. Some LLW requires shielding during handling and transportation to minimize personnel exposure. The SRS generates LLW in both solid and liquid forms.

Mixed waste
Waste that contains both hazardous material, as defined under RCRA, and radioactive source, special nuclear, or by-product material subject to the Atomic Energy Act.

Monosodium titanate
Water-insoluble inorganic substance ($NaTiO_5H$) used to remove fission product strontium and residual actinides (uranium, plutonium) by sorption from HLW salt solutions.

Precipitation (chemical)
Conversion of a constituent in solution into insoluble solid form by chemical or physical means.

Preconceptual Facility design
The preconceptual design phase includes the early articulation of process objectives, selection of process steps, and determination of constraints.

Table 1-1. (Continued).

Radiolytic decomposition
A physical process in which a compound is broken down into simpler compounds or elements from the absorption of sufficient radiation energy to break the molecular bonds.

Radionuclide/Isotope
A radionuclide is an unstable isotope that undergoes spontaneous transformation, emitting radiation. An isotope is any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number), but different numbers of neutrons, so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable, carbon-14 is radioactive).

Reagent
Substance used in a chemical reaction to detect, measure, examine, or produce other substances.

Resin
See Ion exchange.

Salt
Salt components of the HLW consist of water-soluble constituents that do not separate from the solutions in the HLW tanks. The salt components consist principally of sodium nitrate, with radionuclide contents being mainly isotopes of cesium and technetium.

Saltcake
Solid, crystalline phase of the salt component in HLW tanks that forms as a result of dewatering evaporation of the supernatant.

Salt supernatant
Highly concentrated solution of the salt component in HLW tanks.

Sludge
Sludge components of HLW consist of the insoluble solids that have settled to the bottom of the HLW storage tanks. Radionuclides present in the sludge include fission products (such as Sr-90) and long-lived actinides.

Small Tank Tetraphenylborate Precipitation
A technology alternative for processing HLW salt solution to remove radioactive cesium by precipitation as an insoluble tetraphenylborate salt concurrently with removal of radioactive strontium and actinides by sorption onto monosodium titanate. The process would be carried out by continuous reaction in small process vessels to limit benzene formation caused by tetraphenylborate decomposition. These solids are vitrified in the Defense Waste Processing Facility and the remaining low-activity salt solution is immobilized in grout and disposed of as saltstone in onsite vaults.

Sorbent
A material that sorbs another substance; (i.e., that has the capacity or tendency to take up the substance by either absorption or adsorption).

Sodium Tetraphenylborate
Organic reagent used in tetraphenylborate precipitation process for removal of radioactive cesium from HLW salt solution. Chemical formula for sodium tetraphenylborate is $Na(C_6H_5)_4B$.

Tetraphenylborate Precipitation
Process used to separate cesium constituents from HLW salt solution by formation of insoluble solids. The process is projected for use in the Small Tank Precipitation salt processing alternative.

Table 1-1. (Continued).

Vitrify/Vitrification
The process of converting the high-level liquid nuclear waste currently stored at the SRS into a solid glass form suitable for long-term storage and disposal. Vitrification is the preferred option for immobilizing high-level radioactive liquids into a stable, manageable form for disposal in a geologic repository.

a. See also Glossary of Terms Used in DOE NEPA Documents (DOE 1998c).

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CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

The U.S. Department of Energy (DOE) proposes to select a salt processing technology and to design, construct, and operate the facilities required to process high-level waste (HLW) salt. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of low-level waste at the Savannah River Site (SRS).

2.2 Inventory and Schedule for Processing of High-Level Waste Salt

DOE stores HLW in 49 tanks in the F-Area (20 tanks) and H-Area (29 tanks) Tank Farms. These tanks contain a total of approximately .34 million gallons of liquid waste with a radioactivity content of approximately 480 million curies. The HLW consists of a sludge component (2.8 million gallons) containing approximately 320 million curies and a salt component (31.2 million gallons) containing approximately
L6-37 | 160 million curies. Approximately 158 million of the 160 million curies is cesium-137. The salt component includes a solid phase known as saltcake (15.2 million gallons) and the salt supernatant (16 million gallons). Waste volumes and curie content are subject to change because the supernatant is evaporated to reduce its volume, and sludge is being removed for processing and vitrification.

DOE has developed a program for disposal of the wastes currently stored in the waste tanks. In this program, HLW sludge is being converted to a glass waste form by vitrification in the Defense Waste Processing Facility (DWPF). DWPF has already processed approximately 30 million curies of the original 320 million curies of the sludge component. The glass waste, in stainless steel canisters, is being stored onsite, pending shipment to a geologic repository for disposal. Processing the salt components of the wastes (saltcake and salt supernatant) for vitrification and disposal requires (1) dissolving the saltcake and combining it with the supernatant to form a salt solution and (2) separating the low-volume high-radioactivity fraction of the salt waste for incorporation, along with the sludge, into the glass waste form, leaving a high-volume low-radioactivity waste stream suitable for onsite disposal (see Figure 2-1).

Planning bases for the HLW disposal operations are presented in the periodically updated *High-Level Waste System Plan*. The latest version of the System Plan, Rev. 11, (WSRC 2000a) projects as a programmatic target case an average annual output of 200 HLW canisters for Fiscal Years (FY) 2001-2010 and 225 canisters annually for FY 2011 to program completion (FY 2023). This schedule for vitrifying HLW is critical to fulfilling planned HLW operations. Maintaining the waste removal schedule as described in the System Plan is necessary to meet mandates for removing the tanks from service.

Milestones for Salt Processing Alternatives

These milestones serve as the target basis for preconceptual design of the alternatives, and are subject to change.

Salt processing facility operations initiated	FY 2010
Waste removed from non-compliant tanks (1-24)[a]	FY 2016
Salt and sludge processing operations completed	FY 2023

Source: (WSRC 2000a).

a. Non-compliant tanks have inadequate secondary containment and leak detection capabilities as defined by the Federal Facilities Agreement (FFA). Closure of these tanks is mandated by the year 2022.

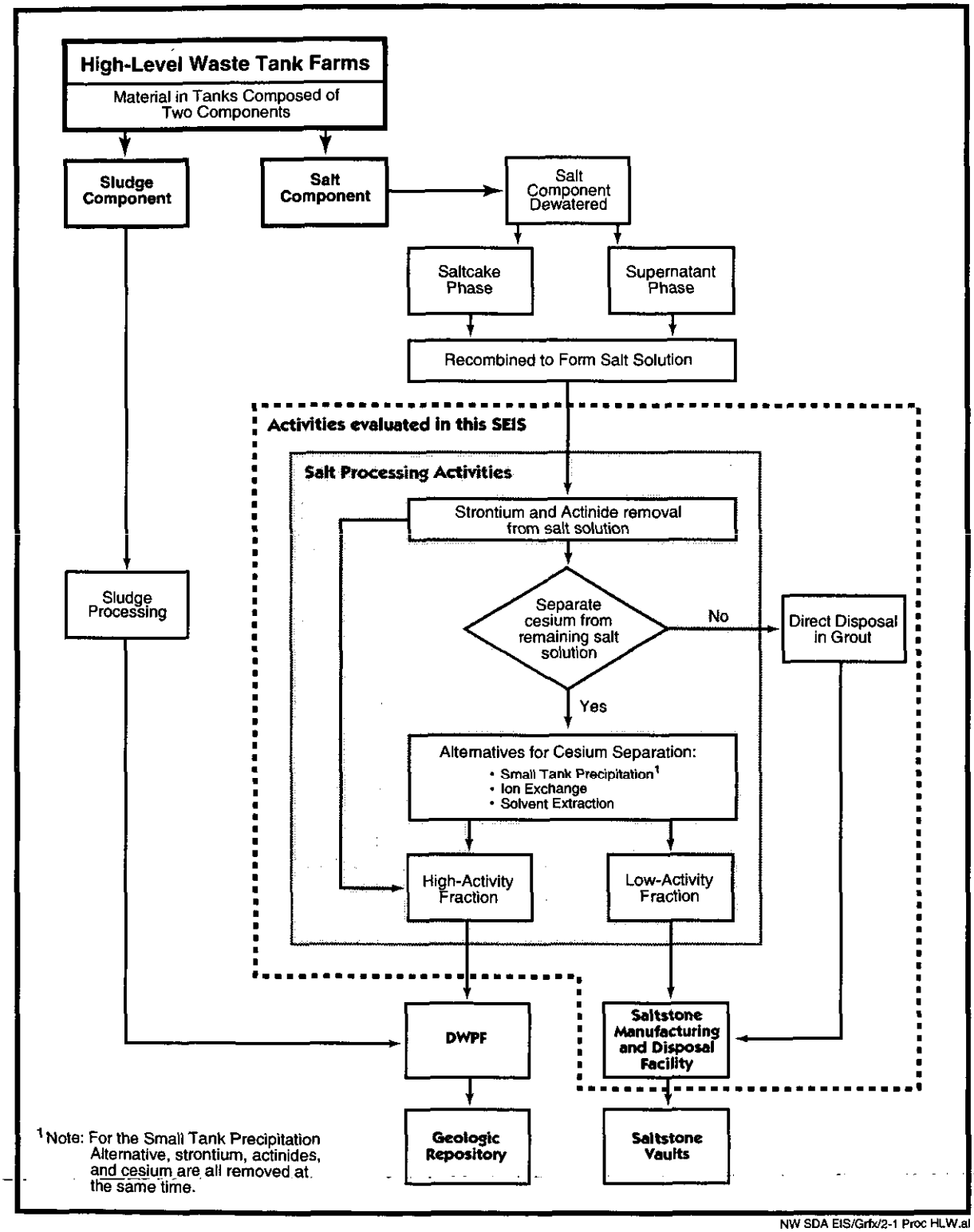

Figure 2-1. Process Flow for High-Level Waste at the Savannah River Site.

Radionuclides in HLW Salts

Antimony (Sb)

Sb-125 (half-life 2.7 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Carbon (C)

C-14 (half-life 5,700 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Cesium (Cs)

Cs-137 (half-life 30 years), Cs-135 (half-life 2.3 million years), and Cs-134 (half-life 2 years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

Iodine (I)

I-129 (half-life 16 million years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Plutonium (Pu)

Pu-238 (half-life 88 years) and Pu-239 (half-life 24,000 years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

Ruthenium (Ru)

Ru-106 (half-life 372 days) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Selenium (Se)

Se-79 (half-life 65,000 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Strontium (Sr)

Sr-90 (half-life 29 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Technetium (Tc)

Tc-99 (half-life 200,000 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Tin (Sn)

Sn-126 (half-life 100,000 years) is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Tritium (H-3)

In the HLW tanks at SRS, tritium is contained in water molecules, where it replaces one of the normal hydrogen atoms. H-3 has a half-life of 12.5 years.

Uranium (U)

U-235 (half-life 700 million years) and U-238 (half-life 4 billion years) are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

2.3 No Action Alternative

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, without a process for separating the high-activity and low-activity salt fractions. DWPF would vitrify only sludge from the HLW tanks. Saltcake and salt supernatant would be stored in the HLW tanks and monitoring activities would continue. Tank space would continue to be managed to ensure ade-

quate space to meet safety requirements and closure commitments. Current tank space management projections indicate that, after 2010, additional tank space would be needed to support continued operations (WSRC 1999a) and meet tank closure commitments under the No Action alternative.

DOE recognizes, however, that without a salt processing technology in place, current HLW storage operations cannot continue indefinitely. DWPF operations result in large volumes of waste, mostly water, that is returned to the HLW tanks. DOE uses evaporators to substantially reduce this volume but, until a salt processing alternative is on-line, DWPF operation will increase rather than decrease the volume of HLW that must be stored in the tanks.

To maintain tank space until about 2010, tank space management under the No Action alternative would include the following activities intended to enhance storage capacity in the HLW tanks (WSRC 2000a):

- Continue to evaporate water from liquid waste in the tanks
- Convert In-Tank Precipitation (ITP) processing tanks 49 and 50 to HLW storage
- Reduce the DWPF low-level liquid waste stream sent to the Tank Farms
- Implement several activities to gain small incremental storage volumes (e.g., optimize washwater use at Extended Sludge Processing)
- As 2010 approaches, reduce the available emergency space in the Tank Farms (presently 2,600,000 gallons) while maintaining the minimum emergency space required by the Authorization Basis for safe operation (1,300,000 gallons).

As soon as DOE were to determine that a salt processing facility would not be available by 2010, decisions about additional tank space would have to be made. The course of action that DOE would follow cannot be predicted at this time, but available options may include the following, either individually or in combination.

1. Identify additional ways to optimize tank farm operations
2. Reuse tanks scheduled to be closed by 2019
3. Build tanks permitted under wastewater treatment regulations
4. Build tanks permitted under RCRA regulations
5. Suspend operations at DWPF

TC

The following sections qualitatively describe the actions that DOE could take, either individually or in combination, under the No Action alternative. Attempts at quantification are very preliminary and are offered in Chapter 4 only for purposes of comparison among these potential options. Should DOE need to implement the No Action alternative, the specific actions, costs, and quantities (e.g., number of tanks required) would then be determined.

2.3.1 IDENTIFY ADDITIONAL WAYS TO OPTIMIZE TANK FARM OPERATIONS

On February 26, 1999, the HLW Salt Processing Program Manager chartered a HLW Tank Space Management Team (SM Team) to identify potential ways to maximize available tank space. Detailed study by experienced engineers and scientists led to a list of 24 ideas, each of which was capable of increasing available tank space by more than 900,000 gallons. Based on this study, the SM Team recommended a strategy to ensure sufficient storage capacity through 2009 (WSRC 1999a). The strategy included optimizing tank farm operations, bypassing the tank farms by pretreating DWPF wastewater to meet the waste acceptance criteria for the Effluent Treatment Facility or Z-Area Saltstone Manufacturing and Disposal Facility, reducing DWPF

production to reduce the amount of wastewater generated, installing evaporators at DWPF, reducing sludge washing, and using tanks outside the Tank Farms, such as in the reactor areas and offsite.

To optimize tank farm operations, DOE would need to divert funds that otherwise could support the development of the salt processing alternative. Managing leaks from the aging tanks and cleaning up resulting contamination would require additional funds. Although SRS would find it difficult to meet regulatory commitments, using some of the tank farm management strategies would enable DWPF operations to continue for some time beyond 2010.

2.3.2 REUSE TANKS SCHEDULED TO BE CLOSED BY 2019

This potential action would continue to use Tanks 4 through 8, which were built in 1953 and are to be closed by 2019. Utilization of these tanks would provide only an interim solution for management of newly generated HLW (and wastewater from DWPF) and, because of the age of the tanks, would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks. Although the use of these tanks would provide 3.75 million gallons of HLW storage (more than 4 years of inflow), this option requires the use of the older tanks, increasing risks and delaying closure of the tanks.

Implementing this option would compromise major mission goals of safety and regulatory commitment.

2.3.3 BUILD TANKS PERMITTED UNDER WASTEWATER TREATMENT REGULATIONS

About 340,000 of the 800,000-gallons-per-year tank space requirement is required to store DWPF wastewater. DWPF wastewater could be safely stored in new tanks with designs similar to those of the older (Type I) HLW tanks. These tanks have 5-foot-high secondary annulus "pans" and active cooling, but do not have the full-height secondary containment tank design used in the newest tanks (Type III). Such tanks would not be used for storage of newly generated HLW. The net capacity of each wastewater storage tank would be about 800,000 gallons. Based on scheduled completion of sludge-only processing in 2023, about six tanks would be needed to hold the DWPF wastewater. The tanks would be built in a previously disturbed area near existing waste transfer lines. DOE has estimated that about 4 years would be required to design, permit under wastewater treatment regulations, and construct six wastewater treatment tanks. This activity would be initiated about 2006. Nearly all of the resources evaluated in Section 4.1 of this SEIS would be impacted by this option. Implementing this option also would delay the regulatory commitments for tank closure and stabilization of HLW. It would increase Site restoration requirements. Further, this option could accommodate less than half (460,000) of the 800,000-gallons-per-year requirement. South Carolina Department of Health and Environmental Control (SCDHEC) would be actively involved in the design and permitting processes. L6-39 TC

2.3.4 BUILD TANKS PERMITTED UNDER RCRA REGULATIONS

Resource Conservation and Recovery Act (RCRA)-permitted tanks require double liners, leachate collection systems, and other characteristics designed to ensure tank integrity. The Type III tanks in the F- and H-Area Tank Farms are RCRA-compliant. They were constructed between 1969 and 1978. They have a full-height secondary tank, active cooling systems, and are above the water table. Each of these tanks has a net usable storage capacity of about 1,000,000 gallons. To accommodate newly generated HLW and the waste that would be generated at DWPF, approximately 10 new tanks would be required. They could be located in a previously disturbed area in or near the F- and H-Area Tank Farms (associated land use impacts are presented in Chapter 4, Section 4.1). SCDHEC would be actively involved in the design, permitting and construction of any new tanks. L6-7 L6-7 TC

As with the wastewater-permitted tanks, nearly all of the resources evaluated in Section 4.1 would be impacted by implementation of this option. This option would compromise regulatory commitments for stabilization of HLW. This option would not provide a permanent solution for management of newly generated HLW and wastewater from DWPF.

2.3.5 SUSPEND OPERATIONS AT DWPF

In the event that a salt processing technology is not available by the year 2010, DOE could suspend operation of DWPF. This would not jeopardize the environment or human health. However, if the suspension of operations at this facility was not temporary, it could result in a workforce reduction, which could have a substantial negative impact on the communities surrounding SRS. This option would seriously delay processing HLW in DWPF for eventual disposal in a geologic repository. In addition, DOE would eventually have to commit a large sum of money to restart these facilities to resume operations necessary to stabilize HLW. Finally, suspending operations could result in loss of technical expertise (core competency) and, depending on the length of time the facilities are shutdown, the ability to recapture these core competencies would diminish.

2.4 Selection of Salt Processing Technologies for Evaluation as Alternatives

A comprehensive program conducted by Westinghouse Savannah River Company (WSRC) to identify, evaluate, and recommend alternative technologies for conversion of HLW salt to acceptable final waste forms resulted in the selection of the following four options for additional development.

- Small Tank Tetraphenylborate Precipitation (Small Tank Precipitation)
- Crystalline Silicotitanate (non-elutable) Ion Exchange (Ion Exchange)
- Caustic Side Solvent Extraction (Solvent Extraction)
- Direct Disposal (of cesium) in Grout (Direct Disposal in Grout).

Following review by a WSRC Review Panel Team, WSRC recommended to DOE the Small Tank Precipitation process as the most reasonable replacement salt processing technology and the Ion Exchange technology as a backup (WSRC 1998a).

A DOE Savannah River (SR) Review Team evaluated the WSRC recommendation and concluded that the remaining technical uncertainties for both alternatives were too significant to justify selection of a preferred technology. The DOE-SR Review Team recommended that additional research and development be conducted to address the key technical uncertainties associated with the two technologies, so that one could be identified as the most reasonable. A DOE-Headquarters Independent Review Team concluded that both the Small Tank Precipitation and the Ion Exchange technologies were feasible, and recommended that further research and technology development be pursued (DOE 1998). Advances in the technology for Solvent Extraction were also noted by DOE and, coupled with recommendations from the National Academy of Sciences (NAS 1999), led to DOE's reconsideration of the potential for developing and implementing this technology in time to support waste processing needs.

DOE also considered the Direct Disposal in Grout alternative, based on demonstrated technology, safety, operational feasibility, and potential to reduce construction and operating costs. L6-3 L8-10 L11-4

2.5 Salt Processing Facility Site Identification

WSRC prepared a site selection study to identify a suitable location at the SRS for the construction and operation of a salt processing facility in

S or H Areas (WSRC 2000b). The study sought to optimize siting for engineering requirements, sensitive environmental resources, and applicable regulatory requirements. The goal of the study was to evaluate alternative siting options for site building and support facilities for either the Small Tank Precipitation technology, the Ion Exchange technology, or the Solvent Extraction technology.

Siting of the salt processing facility would be constrained by an operational requirement that it be located near the HLW processing facilities (in F, H, and S Areas, see Figure 2-2). In order to transfer the solids slurry at the proper solids concentration from the salt processing facility to the DWPF, the salt processing facility would have to be located within 2,000 feet of the DWPF or an auxiliary pumping facility. This constraint identified general areas suitable for construction and operation. Thirteen areas with sufficient acreage for the buildings, construction laydown, and support facilities were identified. Subsequent evaluation of these areas resulted in the identification of four candidate sites (A [subsequently excluded because of its potential to interfere with the expansion of an existing facility and the possible intrusion into a known waste unit], B, C, and D) in S Area (Figure 2-2). A comparative analysis of the sites provided a suitability rating, based on geologic, ecologic, human health, and engineering considerations. No notable differences were identified between the four sites on geologic, ecologic, or human health grounds. Therefore, because there were no notable differences and Site B was representative of the four candidate sites, DOE assumed for purposes of analysis and comparison that facilities for the Small Tank Precipitation, the Ion Exchange, or the Solvent Extraction technologies would be located at Site B in S Area. Floor plans of the facilities for alternatives that would be located in Site B are presented in Appendix A, Figures A-10, A-12, and A-14.

L6-20

The Direct Disposal in Grout technology was not considered in the siting study because the grout manufacturing facility would be located in Z Area, near the saltstone vaults and existing infrastructure that could support the grout production operation (Figure 2-3).

2.6 Salt Processing Alternatives

This SEIS describes and assesses the potential environmental impacts of the construction and operation of four alternatives for HLW salt processing to replace the ITP process. Each of the alternatives could accomplish the purpose and need for action described in Section 1.2, in contrast to the No Action alternative (Section 2.3), which does not include a method for salt processing.

The alternatives, as described below and detailed in Appendix A, are based on preconceptual designs (WSRC 1998b). As conceptual designs are developed, the components of the process could be modified to optimize the efficiency, safety, environmental protection, and economics of the process. For example, DOE may need to increase the capacity of process or storage vessels to ensure continuous operation of the salt processing facility, which would receive batch input from the Tank Farms and transfer its clarified waste stream and HLW products, respectively, to batch operations in the Saltstone Manufacturing and Disposal Facility and DWPF. DOE will consider whether any modification that develops during conceptual or final design requires further environmental review under the National Environmental Policy Act (NEPA).

DOE, with the help of independent experts, has performed research on each of the four process alternatives to establish the technological risk(s) involved in implementing each one. The results of the research were reviewed by independent scientists (DOE 1998). DOE has also evaluated the life-cycle cost and schedule for construction and operation for each alternative (WSRC 1998c). This Supplemental Environmental Impact Statement (SEIS) assesses the potential en-

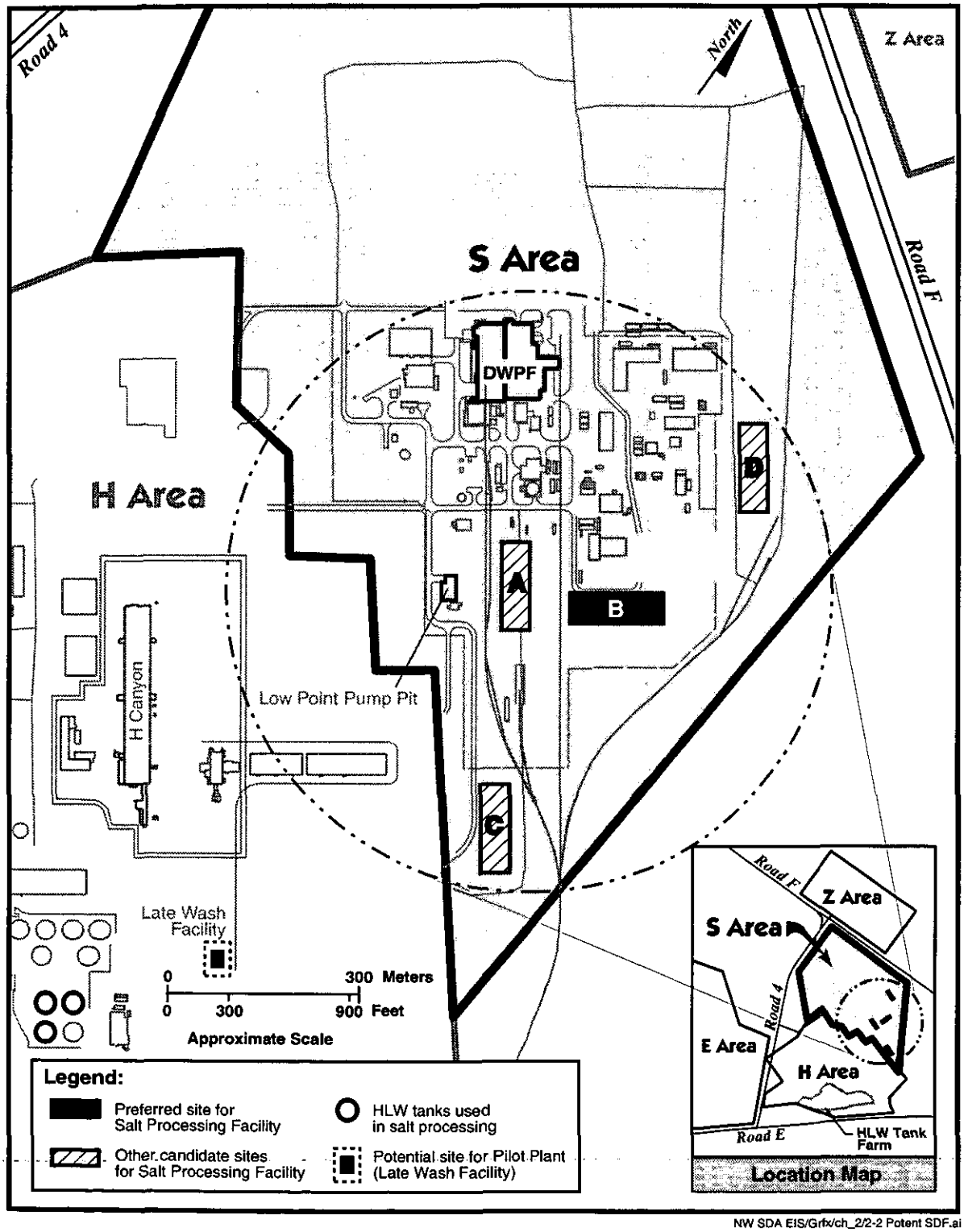

Figure 2-2. Potential salt processing facility sites in S Area.

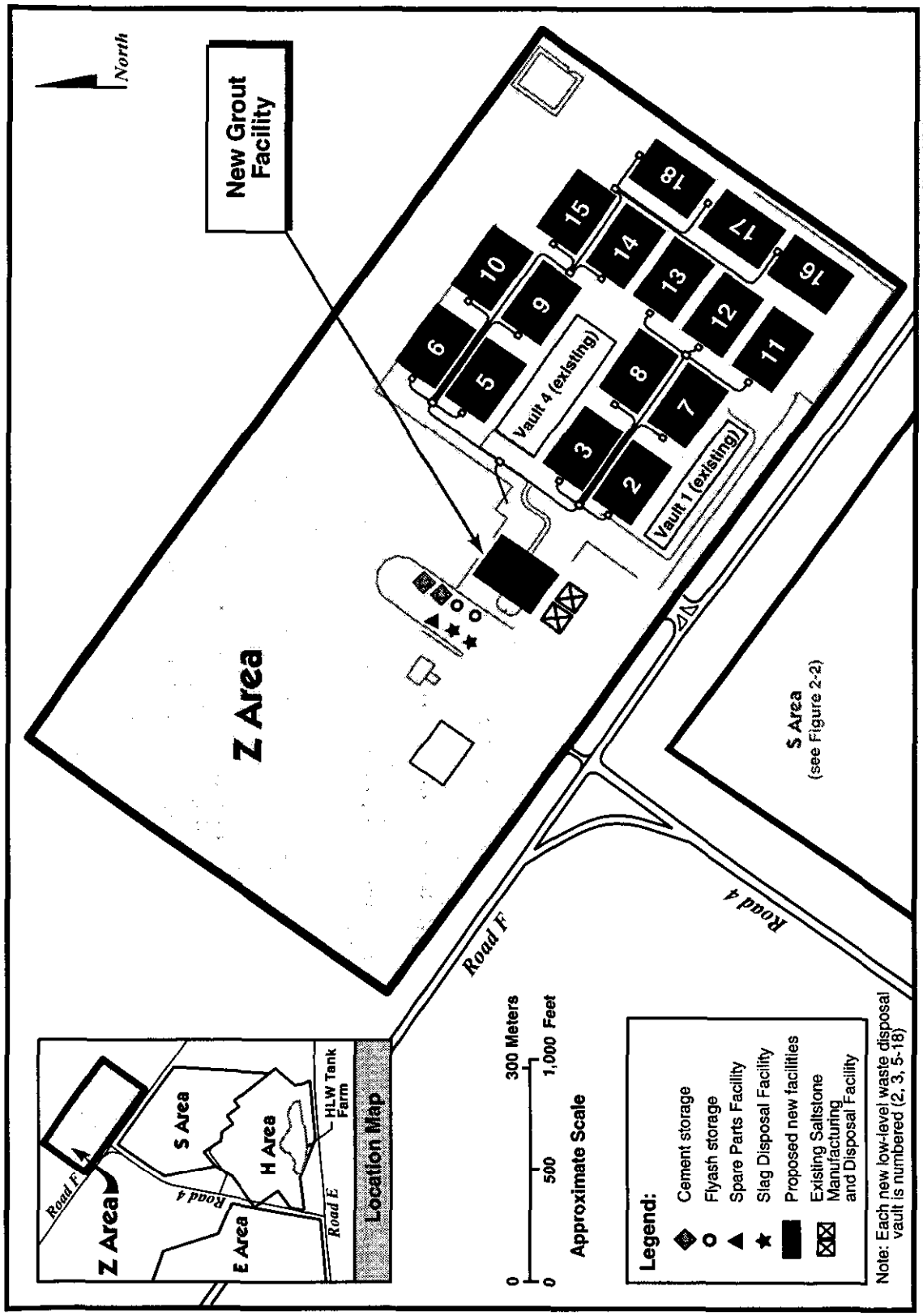

Figure 2-3. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

vironmental impacts of each alternative, which are evaluated in Chapter 4 and compared in Section 2.9.

DOE would conduct pilot scale testing of the alternative selected in a Record of Decision (ROD) before implementing the selected alternative. The Pilot Plant facility proposed for use in the testing is described in Section 2.7.6 and in Appendix A. Environmental impacts of the Pilot Plant are discussed in Chapter 4.

The following sections briefly describe each salt processing alternative, its products and waste streams, and the facilities in which the process would operate. A comparison of the process stages for the salt processing alternatives is presented in Table 2-1.

Common features of all processes include initial separation of low-concentration soluble radioactive strontium and actinides (including plutonium) by **sorption** (bolded terms are found in Table 2-2 and Table 1-1) on granular solid monosodium titanate (MST), followed by filtration. Essential differences in the alternatives are represented by technologies for removal of the relatively high concentrations of radioactive cesium, except for the Direct Disposal in Grout alternative in which cesium is not removed.

The final waste forms are similar for each alternative (except Direct Disposal in Grout) with the high-activity salt fraction extracted from the salt and incorporated into the DWPF glass waste form for eventual repository disposal, and the low-activity salt fraction immobilized as saltstone for onsite disposal. In the Direct Disposal in Grout alternative strontium and actinides are removed from one salt solution and vitrified for eventual repository disposal, but the cesium remains in the fraction immobilized as saltstone for onsite disposal. Greater detail is provided in Appendix A, Technology Descriptions.

DOE believes that it would be able to demonstrate that the low-activity salt fraction processed under any action alternative could appropriately be managed as low-level waste (LLW) under the waste incidental to reprocessing criteria of DOE Manual 435.1-1. The Manual identifies procedures for implementing DOE Order 435.1, Radioactive Waste Management, which provides a process for determining if a waste stream is waste incidental to reprocessing. The waste incidental to reprocessing determination process is described in detail in Chapter 7.

DOE has continued to perform research on each of three cesium-removal technology alternatives (PNNL 2001). Independent scientists and subject matter experts have reviewed the results of the research and assessed the potential impacts associated with each of the identified risks (WSRC 2001). These impacts were considered in the evaluation of life cycle costs and schedules for the design, construction, and operation of each alternative. In addition to, and in consideration of this research, analysis, and independent review, DOE conducted a final management review (DOE 2001) that comparatively evaluated each of the action alternatives against a list of criteria that included cost, schedule, technical maturity, technology implementability, environmental impacts, facility interfaces, process simplicity, process flexibility, and safety. On the basis of this final review, DOE has identified the solvent extraction technology as the preferred alternative.

Solvent Extraction was selected as the preferred salt processing alternative primarily because it presents the least technical risk for successfully removing cesium from radioactive waste. Although Solvent Extraction uses a complex four-component solvent system, laboratory testing has clearly shown that component concentration and process flow can be maintained to effectively remove cesium from the wastes. Other key strengths identified for the Solvent Extraction technology include: (1) maturity of and experience within the DOE Complex for processing nuclear material; (2) simplicity with which the Solvent Extraction product stream

Table 2-1. Comparison of salt processing alternatives.

Salt processing alternatives	Process stages			
			Final waste form	
	Strontium and actinide (Pu) removal from salt solution	Cesium removal from salt solution	DWPF glass (HLW)	Saltstone (LLW)
Small Tank Precipitation	MST sorption	TPB Precipitation	MST/TPB solids	Low activity salt solution
Ion Exchange	MST sorption	CST Ion Exchange	MST solids, CST resins	Low activity salt solution
Solvent Extraction	MST sorption	Organic extractant	MST solids, aqueous cesium solution	Low activity salt solution
Direct Disposal in Grout	MST sorption	None	MST solids only	Cesium salt solution

LLW = Low-level waste, MST = Monosodium Titanate, TPB = Tetraphenylborate, CST = Crystalline Silicotitanate, HLW = high-level waste.

could be incorporated into the current Defense Waste Processing Facility vitrification process; and (3) the ability to rapidly start up and shut down the Solvent Extraction **centrifugal contactors**. Solvent Extraction is comparable to the other action alternatives with regard to short-term and long-term environmental impacts.

TC

2.6.1 SMALL TANK PRECIPITATION

The Small Tank Precipitation alternative would use tetraphenylborate precipitation, the same chemical reaction as ITP, to remove the radioactive cesium from the HLW salt solution. The process would be conducted as a continuous operation using a small, temperature-controlled reaction vessel to inhibit tetraphenylborate decomposition and benzene generation. The vessel and operating conditions would be designed to minimize benzene emissions and flammability hazards by maintaining an inert gas (nitrogen) atmosphere within the reaction vessel. In contrast, the ITP process used a very large batch waste tank as a reaction vessel with limited temperature control and incomplete nitrogen gas inerting.

Radioactive cesium would be separated from the salt solution by precipitation as an insoluble tetraphenylborate solid. Radioactive strontium and actinides would be removed concurrently by sorption onto a granular solid, monosodium titanate. These solids would be separated from solution and concentrated by filtration, then treated chemically by a **precipitate hydrolysis** process to decompose the tetraphenylborate precipitate and remove the benzene formed. The solids slurry containing the separated radioactive constituents is called **Precipitate Hydrolysis Aqueous** (PHA). This slurry would be transferred to DWPF for vitrification. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

Process flows for the Small Tank Precipitation alternative are shown in Figure 2-4.

Small Tank Precipitation Features

Several important features have been incorporated into the design of the Small Tank Precipitation alternative to avoid the benzene production problems encountered in the original ITP process.

Small Tank Precipitation	ITP
Continuous, small volume process	Batch process; very large volume
Temperature-controlled process vessels	Limited temperature control
Continuous agitation	Intermittent agitation
Short processing time (hours)	Longer processing time (months)
Pressure-tight process vessels for effective nitrogen gas inerting	Incomplete nitrogen gas inerting

Table 2-2. Primer of technical terms (other scientific terms are defined in the glossary).

Back extraction
Process for transfer of constituent from organic phase to secondary aqueous phase; used to recover radioactive cesium from organic phase in solvent extraction process.

Cement
A building material made by grinding calcined limestone and clay (silica, lime, and other mineral oxides), to a fine powder, which can be mixed with water and poured to set as a solid mass or used as an ingredient in making mortar or concrete; used as an ingredient in saltstone.

Centrifugal contactor
A device used in Solvent Extraction salt processing alternative to separate cesium from HLW salt solution. Aqueous waste enters a contactor and is mixed with an organic solvent, which extracts the cesium. The two liquids are then separated by centrifugal force in a rapidly rotating inner chamber of the device. Cesium is recovered from the organic phase by back extraction into a secondary aqueous phase in another centrifugal contactor. L6-42

Extractant
A component of the solvent used in the Solvent Extraction process to facilitate the removal of a constituent from aqueous solution, as in the separation of radioactive cesium from HLW salt solution.

Flyash
Fine particulate ash produced by the combustion of a solid fuel, such as coal, and discharged as an airborne emission or recovered as a byproduct for various commercial uses; used as an ingredient in saltstone to limit water infiltration by decreasing porosity.

Hydrolysis
Decomposition of a chemical compound by reaction with water, as in the treatment of a tetraphenylborate precipitate to eliminate benzene.

Nitrate
Any member of a class of compounds derived from nitric acid. Nitrate salts are ionic compounds containing the negative nitrate ion, NO_3, and a positive ion, such as sodium (Na) in sodium nitrate ($NaNO_3$). Sodium nitrate is a major constituent of the salt component in the HLW tanks.

Precipitate Hydrolysis
A chemical process in which tetraphenylborate precipitate is catalytically decomposed to benzene and an aqueous stream of waste constituents to be fed DWPF.

Precipitate Hydrolysis Aqueous
An aqueous slurry stream, produced by the precipitate hydrolysis process, containing radioactive cesium in solution with strontium and actinides sorbed into monosodium titanate for transfer to DWPF. L6-21

Slag
The vitreous material left as a residue by the smelting of metallic ore; used as an ingredient in saltstone.

Solvent
A substance in which another substance is dissolved, forming a solution. It may also refer to the substance, usually a liquid, capable of dissolving another substance.

Solvent Extraction
Process for separation of constituent from aqueous solution by transfer to an immissible organic phase; used to separate radioactive cesium from HLW salt solution.

Sorption
Assimilation of one substance by a material of a different phase. Adsorption (sorption on a surface) and absorption (sorption into bulk material) are two types of sorption phenomena.

Strip effluent
Aqueous cesium solution resulting from the back extraction of cesium from the organic phase in the Solvent Extraction salt processing alternative.

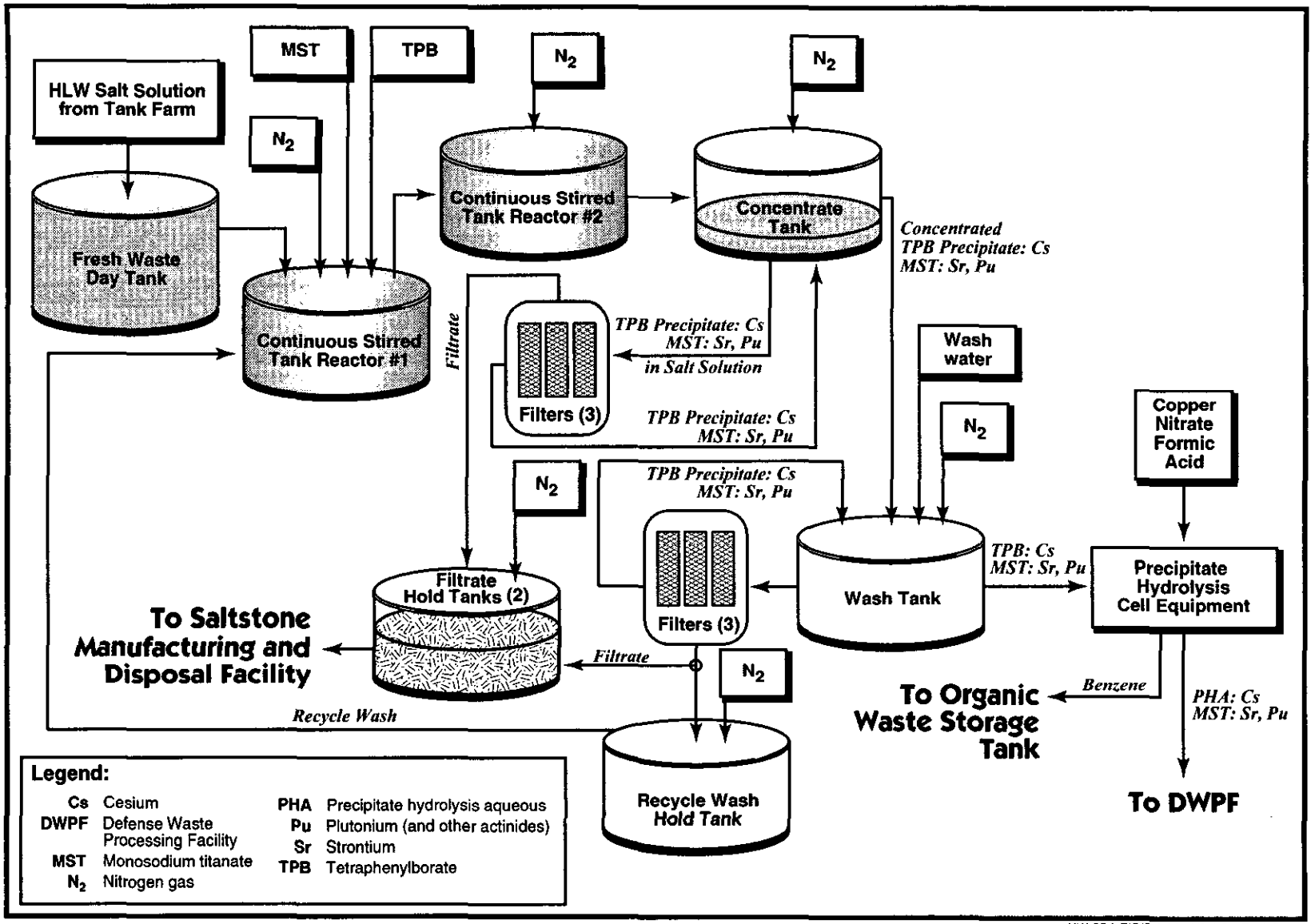

Figure 2-4. Small Tank Precipitation process flow diagram.

2.6.2 ION EXCHANGE

The Ion Exchange alternative would use crystalline silicotitanate resin in ion exchange columns to separate cesium from the salt solution. The salt solution would be passed through large stainless steel ion exchange columns filled with the ion exchange resin to react the cesium with the resin. Treatment of the solution with monosodium titanate to separate strontium and actinides, and filtration to remove the solids and residual sludge, would be necessary prior to separating the cesium to prevent plugging the ion exchange columns.

Both the monosodium titanate solids and the cesium-loaded crystalline silicotitanate resin would be transferred to DWPF for vitrification. The low activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

Process flows for the Ion Exchange alternative are shown in Figure 2-5.

The Ion Exchange process would result in the accumulation of as much as 15 million curies of radioactive cesium on the resin inventory within the process cell. This radioactive loading would necessitate stringent shielding requirements and operational controls because of high radioactivity, high heat generation, and the generation of hydrogen and other gases.

2.6.3 SOLVENT EXTRACTION

Solvent Extraction is DOE's preferred alternative. The Solvent Extraction alternative would use a highly specific organic **extractant** to separate cesium from the HLW salt solution. The cesium would be transferred from the aqueous salt solution into an insoluble organic phase, using a centrifugal contactor to provide high surface area contact, followed by centrifugal separation of the two phases. Recovery of the cesium by **back extraction** from the organic phase into a secondary aqueous phase would generate a concentrated cesium solution (**strip effluent**) for vitrification in DWPF. Prior treatment of the HLW salt solution, using monosodium titanate to separate soluble strontium and actinides and filtration to remove the solids and residual sludge, would be required to meet salt solution decontamination requirements and avoid interference in the solvent extraction process. The monosodium titanate solids would be transferred to DWPF for vitrification along with the strip effluent solution. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults. TC

Process flows for the Solvent Extraction alternative are shown in Figure 2-6.

2.6.4 DIRECT DISPOSAL IN GROUT

Under the Direct Disposal in Grout alternative, the HLW salt solution would be disposed of onsite as saltstone, without prior separation of radioactive cesium. Before solidifying the salt solution as grout, monosodium titanate would be used to remove the strontium and actinides to meet saltstone waste acceptance criteria as a low-level waste. MST processing would be the same as that used in the Ion Exchange and Solvent Extraction alternatives. Equipment required is shown in Figure 2-7 (and in Appendix A). These include the alpha sorption tank and filter unit to separate the MST-sorbed constituents. The monosodium titanate slurry would be transferred to DWPF for incorporation into HLW glass. L6-45

After the monosodium titanate treatment, the clarified salt solution would be combined with **flyash, cement** and **slag** in a grout mixer for disposal in the saltstone vaults. The resulting sandstone would have radionuclide concentrations less than Class C LLW, but would exceed Class A limits, as defined in NRC regulations at 10 CFR 61.55. These waste classifications are not generally applicable to DOE-generated LLW. However, the NRC classification system is used in this SEIS to describe differences in the waste form because DOE Manual 435.1-1 establishes a process for making waste incidental to reprocessing determinations using the NRC Classification System at 10 CFR 61.55. The current saltstone permit, which was issued by TC

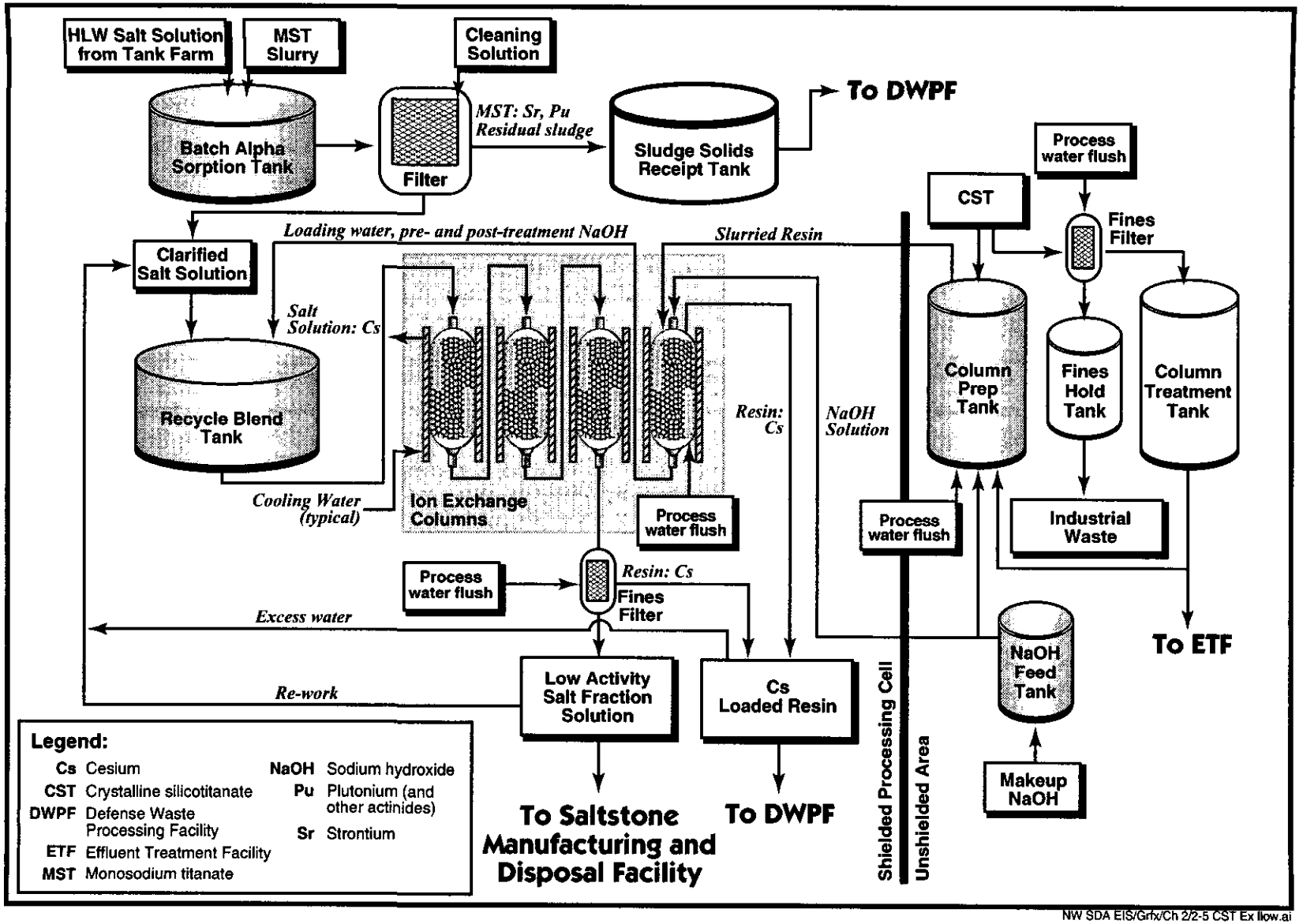

Figure 2-5. Ion Exchange process flow diagram.

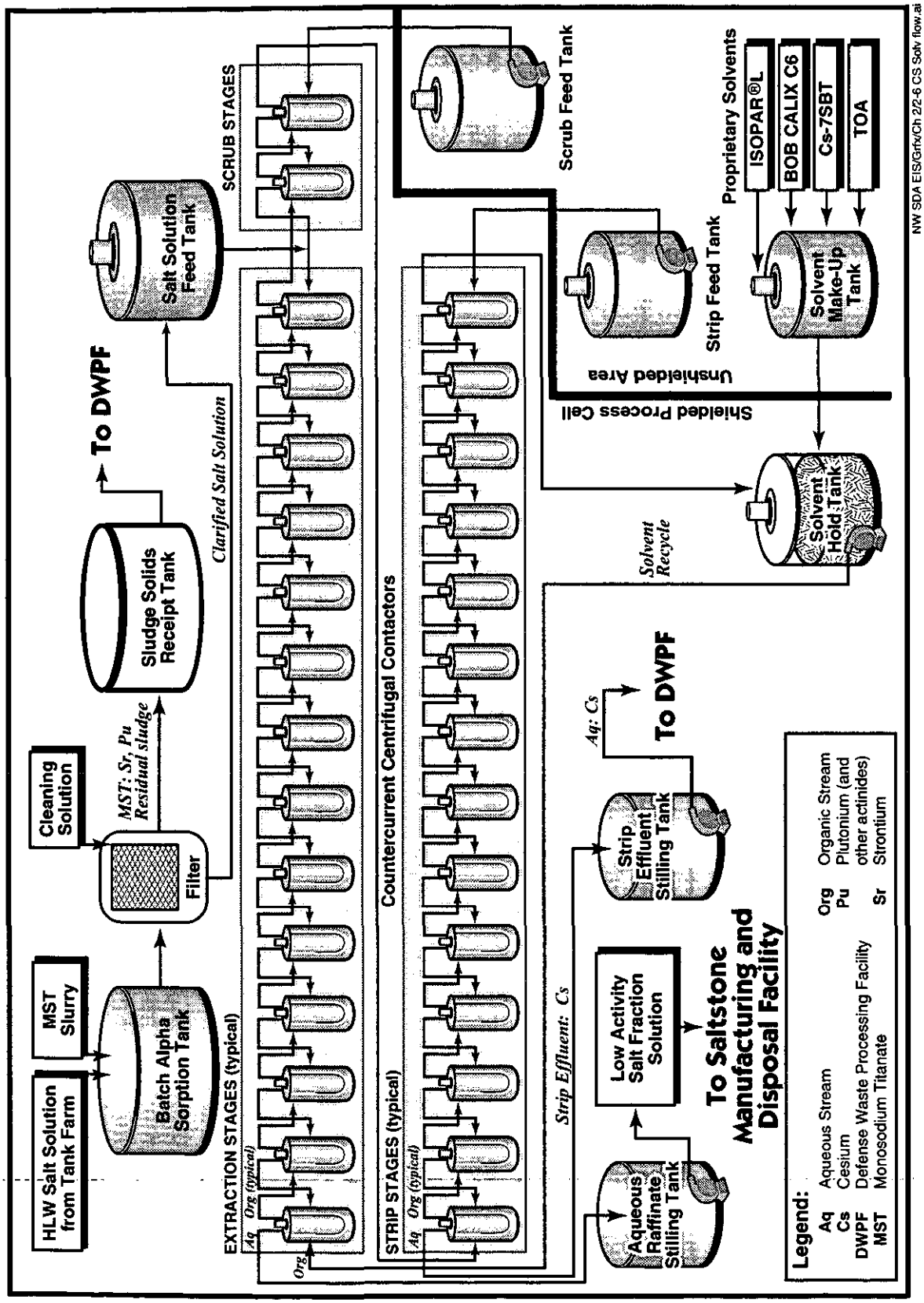

Figure 2-6. Solvent Extraction process flow diagram.

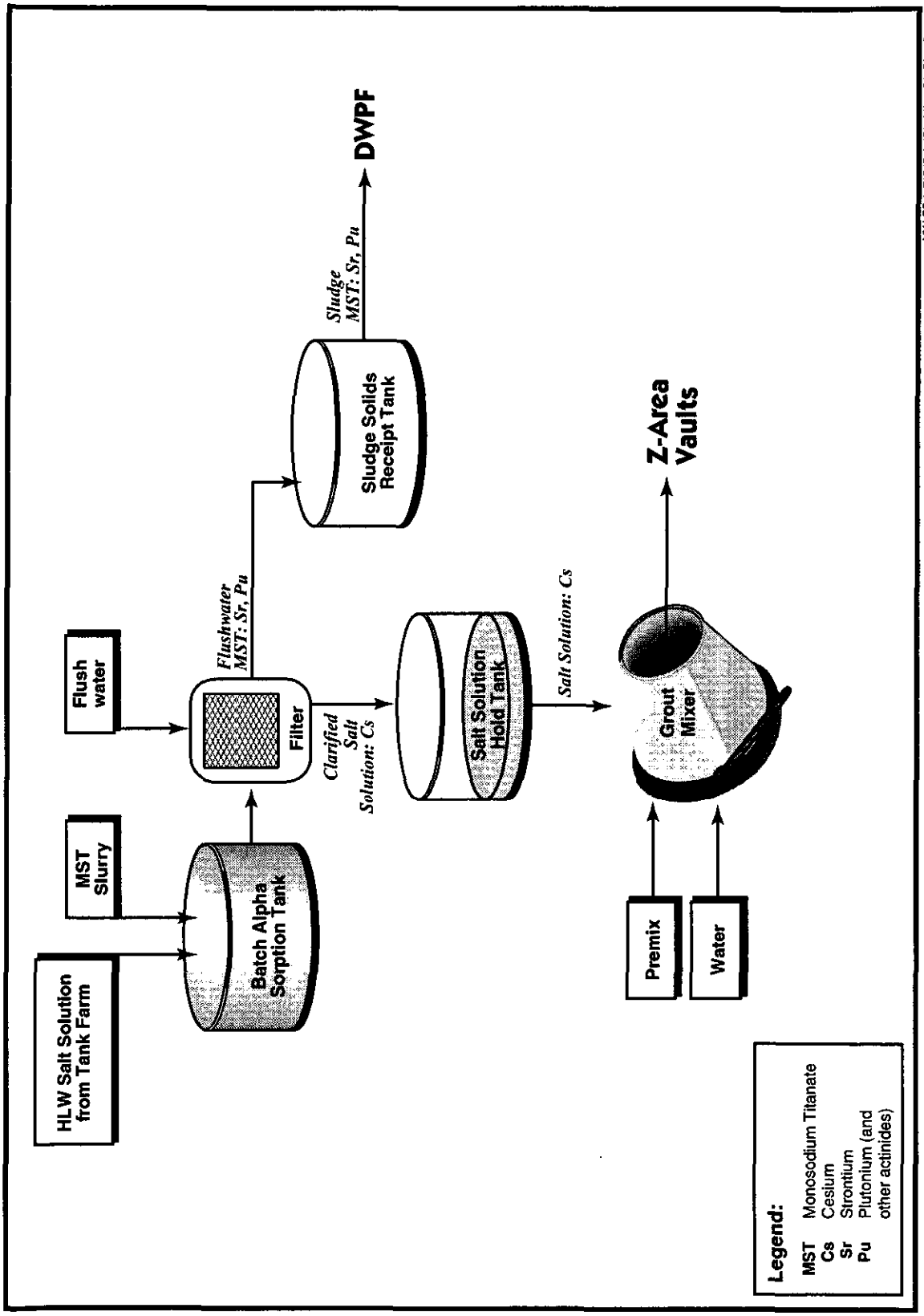

Figure 2-7. Direct Disposal in Grout process flow diagram.

SCDHEC under its State wastewater authority, authorizes disposal of wastes with radionuclide concentrations comparable to Class A LLW. Under the permit, DOE must notify SCDHEC if the characteristics of wastes in saltstone vaults would change, as would be the case with the higher level of radioactivity in the final waste form under the Direct Disposal in Grout alternative. TC

Process flows for the Direct Disposal in Grout alternative are shown in Figure 2-7.

2.7 Salt Processing Facilities

2.7.1 PROCESS INPUTS AND PROCESSING REQUIREMENTS

Design of salt processing facilities depends on specifications of processing requirements, including process input and product output. Volumes of input streams and requirements for their processing to final forms are summarized in Table 2-3. The capacities of the process facilities are specified to maintain an average processing rate of about 6 million gallons of waste salt solution per year at 75 percent attainment, allowing complete processing of about 80 million gallons total (approximate volume of salt solution when the saltcake is dissolved) within about 13 years after facility startup (WSRC 1999b). The throughput of all action alternatives is limited to 6 million gallons per year due to the physical constraints on removing waste from the waste tanks. It is important to finish processing the salt waste within this time so that the HLW sludge and the high-activity fraction of the HLW salt can be vitrified together in the DWPF. If salt processing is delayed beyond 2010 so that salt waste must be vitrified separately, the total number of HLW canisters would be increased over that projected for concurrent sludge-salt waste vitrification. Vitrification of the combined HLW sludge and salt would produce about 5,700 glass waste canisters. Preliminary projections indicate that if the salt processing initiation date of 2010 is not met, then the potential exists that up to 150 additional canisters (salt-only) per year would have to be produced for every year startup is delayed beyond 2010. The cost for additional canister production would be about $300 million per year. In the event sludge processing were to be completed prior to the initiation of salt processing, it would take 13 years (at 150 canisters per year) to process all of the salt waste at an approximate cost of $4 billion, in addition to the cost of constructing and operating the salt processing facility. (These costs do not include federal repository cost for transportation and disposal).

L6-23 TC L1-5 L6-16 L6-44 L1-5 L6-16 L6-44 L6-23

Differences in the total number of combined sludge and salt waste canisters produced from the different salt processing alternatives would be small because of the relatively minor contribution of HLW salt compared to HLW sludge in the glass waste form. As many as 16 saltstone vaults in addition to the two existing vaults would be required for final disposal of the low-activity salt solution.

2.7.2 PRODUCT OUTPUTS

The product outputs from the process facilities, including high-radioactivity solids slurry or solution to DWPF, low-activity salt solution to grout, and saltstone generated by the salt processing alternatives are compared in Table 2-4. The Solvent Extraction facility would deliver a greater volume of product to DWPF than the other facilities because of the relatively high volume of cesium solution (strip effluent) in its product output. However, the amount of sludge processed at DWPF is the primary determinant for canister production. The difference in product volume delivered to DWPF from the Solvent Extraction alternative has little effect on the number of DWPF canisters produced because of the low solids content of the strip effluent stream. The salt solution to grout and product grout produced would be about the same for each alternative, within the uncertainties on the material balance estimates.

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In addition to the principal product outputs specified in Table 2-4, the Small Tank Precipitation process would generate by-product

Table 2-3. Inputs and processing requirements for the salt processing alternatives.

	Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Required processing rate (million gallons per year)[a,b]	6.9	6.9	6.9	6.0
Long-term average throughput of salt solution at 75% attainment (million gallons per year)[a,b]	6.0	6.0	6.0	6.0
Throughput limitation[a]	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks
Number of years for construction of process facilities[c]	4.0	4.2	4.0	3.9
Number of years for startup testing	1.3	1.3	1.3	1.3
Number of years of facility operations	13[d]	13[e]	13[f]	13[g]
Planned canister production per year[h,i]	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced[h,i]	≈5,700	≈5,700	≈5,700	≈5,700
New Class A vaults[j]	16[d]	13[e]	15[k]	0[g]
New Class C vaults[j]	0[d]	0[e]	0	13[g]

a. WSRC (1998b).
b. The required processing rate for the salt processing facilities exceeds the long term average throughputs to allow for downtime when DWPF is in an outage, except for the Direct Disposal in Grout facility which can operate at the required salt removal rate even when DWPF is not operating.
c. WSRC (1998c).
d. WSRC (1998d, 2000a).
e. WSRC (1998e).
f. WSRC (1998f).
g. WSRC (1998g).
h. WSRC (2000a) target case.
i. DWPF planned glass waste canister production includes both sludge and salt wastes.
j. New saltstone vaults for onsite disposal of processed salt solution.
k. This alternative would require between 14 and 15 vaults (WSRC 1998f); for purposes of impact analysis, 15 vaults were assumed.

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benzene. About 60,000 gallons per year (200 metric tons per year) of liquid benzene would be produced by decomposition of the tetraphenylborate salt in the precipitate hydrolysis process, to be stored for incineration and disposal.

The Solvent Extraction process would generate a liquid organic solvent also requiring final processing by incineration and disposal. The total **solvent** inventory for the process would be a projected 1,000 gallons. This inventory is conservatively assumed to be replaced once per year. For a tentatively assigned operational time of 13 years, the accumulated total volume of solvent requiring storage and disposal would be 13,000 gallons.

2.7.3 PROCESS FACILITIES

DOE would construct a new shielded facility to house chemical processing equipment (tanks,

Table 2-4. Product outputs for the salt processing alternatives.

	Alternative			
	Small Tank Precipitation[a]	Ion Exchange[b]	Solvent Extraction[c]	Direct Disposal in Grout[d]
Solids Slurry (and solution) to DWPF				
Annual (million gallons)	0.22	0.20	0.68[e]	0.15
Life cycle (million gallons)	2.9	2.6[f]	8.8[e]	2.0
Salt solution to grout				
Annual (million gallons)	8	6.6	7.5	5.9
Life cycle (million gallons)	100	86	97	77
Grout produced				
Annual (million gallons)	15	12	14	11
Life cycle (million gallons)	190	160	180	140

a. WSRC (1998d, 2000a).
b. WSRC (1998e).
c. WSRC (1998f).
d. WSRC (1998g).
e. Includes 0.154 million gallons/yr solids slurry and 0.523 million gallons/yr strip effluent solution, assuming no evaporation (WSRC 1998b); analogous life-cycle outputs shown.
f. Includes 2 million gallons monosodium titanate slurry and 0.6 million gallons crystalline silicotitanate slurry (WSRC 1998b, 1998e).
Note: Material balance estimates are ± 25 percent.

pumps, filter systems) to implement any alternative. Preconceptual designs are included in this section. The facilities would be sized to contain large feed storage and product hold tanks to ensure an average daily processing rate of 25,000 gallons of salt solution. The large tanks would also enable continuous operations of salt processes by separating them from the batch processes of the Tank Farm operations. Transfer facilities required to direct the flow of process streams among the various facilities are described in Appendix A.

Because the facilities required for any of the action alternatives are very similar, this discussion is relevant to all four alternatives.

New shielded process buildings would be constructed, regardless of the salt processing alternative selected. The preferred site for the process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives is Site B in S Area. The process building for the Direct Disposal in Grout alternative would be in Z Area. Direct Disposal in Grout would require a shielded building for the MST treatment to remove strontium and actinides from the salt solution and to provide enhanced shielding and remote handling for grout operations. In each case, the process buildings would be constructed of reinforced concrete and contain shielded cells designed to handle highly radioactive materials.

L6-25

The building specifications would be similar for each of the four salt processing alternatives, requiring a somewhat smaller building with Direct Disposal in Grout. Preliminary design dimensions are provided in Table 2-5. A more detailed description of the process facilities for each alternative, including preliminary floor plans, is provided in Appendix A.

2.7.4 SUPPORT FACILITIES

Each alternative would require support facilities including a service and office building and an electrical substation. Support facilities are described in Appendix A.

2.7.5 SALTSTONE VAULTS

TC

As shown in Table 2-3, as many as 16 additional saltstone disposal vaults would be constructed in addition to the two existing vaults in Z Area to support the salt disposal for each of the

Table 2-5. Building specifications for each action alternative.[a]

	Process Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Length, ft.	310	280	300	220
Width, ft.	140	140	120	120
Height, ft.	60 (100 ft. bay)	60 (100 ft. bay)	70 (110 ft. bay)	60 (90 ft. bay)
Depth below grade, ft.	40	40	40	20
Floor Area, ft.^{2}				
including processing cells	66,000	60,000	62,000	54,000
excluding processing cells	50,000	48,000	48,000	43,000
Volume, ft.^{3}				
including processing cells	4,500,000	4,200,000	4,500,000	1,800,000
excluding processing cells	3,900,000	3,600,000	3,900,000	1,200,000
Processing cell floor area, ft.^{2}	16,000	12,000	13,000	11,000
Processing cell volume, ft.^{3}	640,000	550,000	600,000	570,000

Source: WSRC (1998c).
a. Building specifications rounded to two significant figures.

alternatives (Figure 2-2). The concrete vaults would be 300 feet long by 200 feet wide by 25 feet high. Each vault would consist of six cells, 100 feet long by 100 feet wide. Due to the heat generated during grout solidification, the cells in each vault would be filled in a rotation that would meet grout cooling requirements. All vaults would be equipped with cameras and lights to monitor filling and thermocouple assemblies to monitor heat generation during the curing process. After each batch of grout was transferred to a vault, the grout transfer lines, Saltstone Hold Tank, and Grout Feed Pumps would be flushed to the vault to remove any residual grout material. As with the original saltstone vaults, the additional vaults would be constructed at or somewhat below grade and covered over with soil after vault closure for additional shielding. Figure 2-8 illustrates how Z Area would look after vault closure. TC

For the Direct Disposal in Grout alternative, 13 additional vaults would be constructed in Z Area. Because the grout would contain large amounts of radioactive cesium, the disposal procedure for this alternative would differ from that of the other three alternatives. Each vault would have a 500-cubic-foot-per-minute ventilation system, equipped with high-efficiency particulate air filters that would operate to control contamination during the cell-filling process. Radiation monitors and dampers would be included. TC TC

2.7.6 PILOT PLANT

After DOE selects a salt processing alternative, a Pilot Plant would be designed and constructed to provide pilot-scale testing of process technology before construction and operation of the full-scale facility. DOE intends to construct and operate a Pilot Plant only for the selected alternative. However, in the event that DOE decides to demonstrate more than one technology, the Pilot Plant units would be developed and operated in series. The Pilot Plant would serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address key technical uncertainties was completed in April 2001, but some uncertainties could not be fully addressed without pilot-scale tests using actual waste from the SRS HLW system. Initial pilot-scale demonstrations would provide data required to perform preliminary and final design of the full-scale facility. Extended operation cycles, with M4-3 M4-10 M4-11 TC

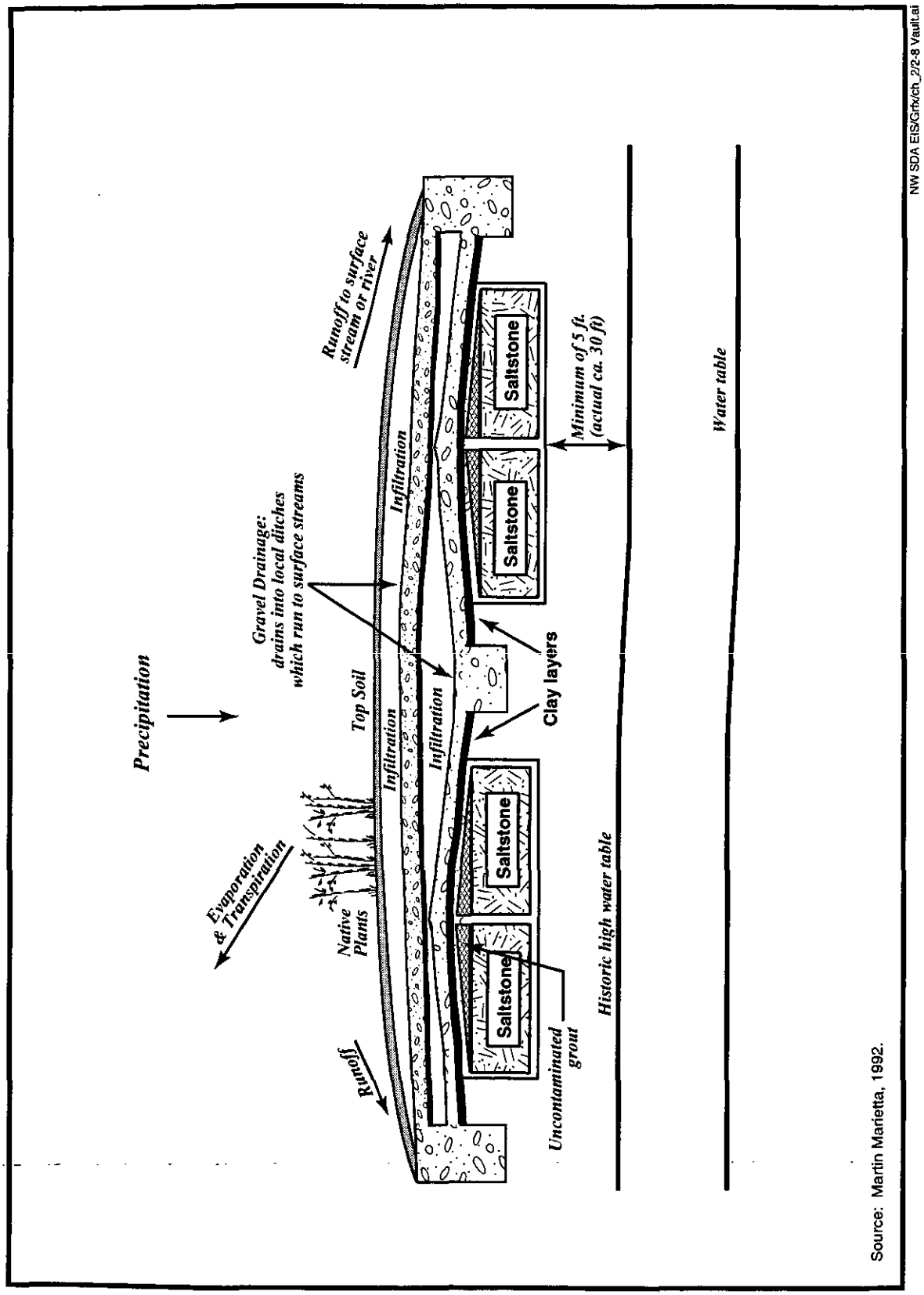

Figure 2-8. Cross-section diagram of vault closure concept.

varying operating parameters and feed blends, would provide needed process details for full-scale design and start of construction. Unit operations and their integration into a coordinated process would be demonstrated, process extremes and upset conditions would be investigated, equipment operation would be evaluated, and process streams would be qualified for full-scale operations. The Pilot Plant would also provide a facility for training engineers and operators.

The Pilot Plant components would be sized to operate on a scale from 1/100 to 1/10 of a full-sized facility.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the Late Wash Facility in H Area (see Figure 2-1), near DWPF in S Area, or in another area near the location of the proposed full-scale facility.

Detailed design and construction of the Pilot Plant would be initiated upon selection of the salt processing alternative and operation would extend through completion of final design and startup of the full-scale facility. Principal process operations would be conducted inside shielded cells. Scaled-down hardware, instrumentation, and controls appropriate to the selected process would be installed. The units would use modular designs to facilitate remote installation and modification of the process equipment.

Services that would be provided include utilities, process chemicals, ventilation systems, and personnel support. An appropriate chemical storage area would be developed, with isolation of acids, caustics, oxidizing and reducing agents, and other incompatible reactants. Ventilation systems would be operated so that airflow was from areas of low contamination to those of higher contamination potential.

Operations would be conducted in accordance with appropriate safety documentation requirements, including provisions for safe and orderly emergency shutdown. Emergency equipment and procedures would ensure that operations were maintained within constraints analogous to those of the full-size facility.

The generation and dispersion of radioactive and hazardous materials would be minimized. Process waste would be disposed of at appropriate Site locations, such as the HLW Tank Farms, DWPF, Saltstone Manufacturing and Disposal Facility, Effluent Treatment Facility, or the low-level waste vaults.

Detailed examples of proposed test objectives are given in Appendix A.

2.7.7 FACILITY DECONTAMINATION AND DECOMMISSIONING

Any new facility would be designed and constructed to limit the generation and dispersion of radioactive and hazardous materials and to facilitate ultimate decontamination and decommissioning or reuse. Areas of the facility that might become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions would incorporate design features to simplify their decontamination. Items such as service piping, conduits, and ductwork would be minimized in these areas and arranged to facilitate decontamination. Facility design would include a dedicated area for decontamination of tools and some equipment. Design features that would be incorporated into the facility include the following:

- Modular confinement would be used for radioactive and hazardous materials to preclude contamination of fixed portions of the structure

- Long runs of buried piping that would carry radioactive or hazardous materials would be minimized to the extent possible, and provisions would be included in the design that would allow testing of the integrity of joints in buried pipelines

- The facility would be designed to facilitate dismantlement, removal, and packaging of contaminated equipment
- Lifting lugs would be used on equipment to facilitate remote removal from the process cell
- The piping systems that would carry hazardous products would be fully drainable.

2.8 Other Decision-Making Factors

2.8.1 NATIONAL ACADEMY OF SCIENCES REVIEW COMMITTEES FINAL REPORTS

In June 1999 the Under Secretary of Energy requested that the National Academy of Sciences – National Research Council provide an independent technical review of alternatives for processing the HLW salt solutions at SRS. In response to the request, the Council appointed a "Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site" to review DOE's work to identify alternatives for separating cesium from high-level waste at SRS. This committee conducted the review and provided an interim report in October 1999 and a final report in October 2000. In October 2000 the Council appointed a "Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site" to review DOE's efforts to evaluate and select a process for separating radionuclides from soluble high-level radioactive waste at SRS. This second committee conducted its review and provided an interim report in March 2001 and a Final Report in June 2001. Summaries of the reviews conducted by these Council committees are provided below.

TC

2.8.1.1 Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site

The Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site was composed of experts in fields of nuclear reactor and the fuel cycle technology, nuclear chemistry and separations, environmental sciences, and nuclear waste disposal. DOE had requested that a preliminary report be provided by the end of September 1999 to identify any significant issues or problems with the alternatives that could be factored into the Draft SEIS. The committee issued an interim report in October 1999 and a final report in October 2000, prior to the issuance of the Draft SEIS. The final report (NAS 2000) endorsed in general the selection of the four candidate processes considered as alternatives for salt disposal, concluding that each of the processes was potentially appropriate and no obvious major processing options were overlooked. Recommendations for addressing the technical uncertainties associated with each of the alternative were identified, with schedule constraints and potential regulatory restrictions noted.

TC

The following describes the tasks requested by DOE, the conclusions reached by the Committee in the final report, and the subsequent actions taken by DOE:

***Task 1:* Assess identification of a comprehensive set of processes for separation of cesium from HLW salt solution.**

- *Committee Conclusions:* A comprehensive set of cesium separation processes was identified and no additional effort on process identification was recommended.
- *DOE Actions:* The Committee had no recommendations; therefore, DOE took no subsequent action.

Task 2: **Evaluate the technical soundness of the screening procedure and resultant selection of appropriate alternatives.**

- *Committee Conclusions:* Although deemed complex and based mainly on expert judgment employing qualitative factors, the screening procedure did result in four potentially appropriate processing alternatives.

- *DOE Actions:* Because the Committee determined that the screening procedure resulted in four potentially appropriate processing alternatives, DOE took no subsequent action.

Task 3: **Identify significant barriers to implementation of any alternative, taking into account state of development and potential for integration into the existing SRS HLW system.**

- *Committee Conclusions:* A carefully planned and managed research and development (R&D) program would be required for the three cesium separation alternatives (Small Tank Precipitation, Ion Exchange, and Solvent Extraction, each including monosodium titanate treatment for strontium and actinide removal), until enough information is available to make a defensible down-select decision. Good-faith discussions with regulators should be conducted to determine if the fourth alternative, Direct Disposal of cesium in Grout, would be feasible, should all other processing options prove technically or economically impractical. A more fully integrated approach involving tailoring of HLW salt processing in accord with the composition of wastes in individual tanks could prove beneficial. And lastly, the DOE should charter external expert review and oversight groups to provide needed R&D direction and support for management decisions.

- *DOE Actions:* A program plan for technology research and development (PNNL 2000) was issued in May 2000 to address the technical uncertainties associated with each of the salt processing alternatives and provide adequate information for making a down-select decision. DOE evaluated the R&D activities identified in the program plan and determined that each R&D recommendation from the Council was adequately addressed in the program plan. DOE has evaluated these R&D activities and identified those activities that would need to be completed to support a technology down-selection decision. The activities were prioritized and completed in April 2001.

Preliminary discussions with regulators (Nuclear Regulatory Commission, SCDHEC, and EPA-Region IV) indicate general acceptance of the Direct Disposal in Grout concept, provided DOE could establish that the final waste form does not require management as HLW. However, if Direct Disposal in Grout were selected as the preferred alternative, additional discussion with the regulating agencies would be necessary to address regulatory issues. Current DOE policy requires removal of "key radionuclides" from HLW to the maximum extent technically and economically practical, before permitting disposal as "waste incidental to reprocessing" in a low-level waste shallow-land disposal facility. DOE considers cesium to be a "key radionuclide" in HLW. L11-4 L6-3 L-8-10

DOE agrees with the concept of applying an integrated systems engineering approach to salt processing. The HLW System at SRS is fully integrated and managed in accord with the broad range of operational and regulatory constraints to meet acceptance criteria for the Defense Waste Processing and Saltstone facilities. This approach is reflected in the *High-Level Waste System Plan* (WSRC 2000a) and used in all HLW system planning and productions activities, including the evaluation of salt processing options. Studies undertaken to conserve tank space and optimize salt processing for final disposal have considered special tailoring of

operations for wastes of different composition. While there is variability in salt waste, a review of waste characterization data for all receipt and storage tanks indicates that saltstone grout produced from the lowest-activity tank would challenge the basis for the current saltstone operating permit. Additionally, strategies based on multiple process facilities tailored to individual tanks or groups of tanks are not considered to be viable from a cost perspective or environmentally sound when decontamination and decommissioning impacts are considered. Further evaluations of waste processing options will continue through the HLW system planning process in parallel with technology development and down-selection activities.

DOE established in March 2000 a Technical Working Group (TWG) to manage technology development of treatment alternatives. The TWG is composed of staff from DOE's Office of Project Completion, Office of Science and Technology, Office of Technical Program Integration, and the Savannah River Operations Office. The TWG is responsible for managing and overseeing the development of a Research & Development Program Plan, creating technology road maps, establishing separations technology down-selection criteria, project integration, ensuring execution, and technical oversight of technology development efforts. The TWG is supported by DOE's Tanks Focus Area for execution of R&D activities, and a Technical Advisory Team for independent review of technology implementation.

***Task 4:* Assess the adequacy of planned R&D activities to support implementation of a single preferred alternative.**

- *Committee Conclusions:* Several recommendations are made for additional R&D to address remaining scientific and technical uncertainties for each of the four salt processing options. These recommendations generally include:

  - Resolution of technical questions concerning reaction kinetics of the monosodium titanate process for removal of strontium and actinides, as advanced for all alternatives

  - Improved understanding of the tetraphenylborate decomposition process, especially catalytic reactions responsible for benzene generation

  - Evaluation of cesium desorption and resin deactivation in alkaline solutions as encountered in the Ion Exchange process

  - Continued development of the Solvent Extraction process to resolve potential solvent instability, recycle, and contaminant problems, and to establish availability of the extraction agents in quantities required for large-scale processing

  - Establishing regulatory acceptance for the Direct Disposal (of cesium) in Grout alternative.

- *DOE Actions:* R&D activities to address each of the Committee's recommendations for additional R&D work on remaining scientific and technical uncertainties were included in, and implemented in accordance with, the R&D Program Plan (PNNL 2000), issued by DOE's Tanks Focus Area in May 2000. R&D activities necessary to support a technology down-selection decision are complete. DOE has no plans to pursue regulatory acceptance of the Direct Disposal in Grout alternative. TC

2.8.1.2 Committee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site TC

In reviewing DOE's efforts to evaluate and select a process for separating radionuclides from soluble high-level radioactive waste, the Com-

mittee on Radionuclide Separation Processes for High-Level Waste at the Savannah River Site was tasked to: (1) evaluate the adequacy of the criteria that will be used to select from among the candidate processes under consideration; (2) evaluate the progress and results of the research and development work that was being undertaken on the candidate processes; and (3) assess whether the technical uncertainties have been sufficiently resolved to proceed with downsizing the list of candidate processes. The committee issued an interim report in March 2001 (NAS 2001a), which addressed only the first task. The committee's interim evaluation concluded that DOE's selection criteria were reasonable and appropriate and were developed in a transparent way, while also concluding that some criteria did not appear to be independent of others, and some criteria appeared unlikely to discriminate among the process alternatives. The committee briefed the DOE Assistant Secretary for Environmental Management in May 2001 on the final results of their evaluation. The committee's final report was submitted in June 2001. The committee concluded that solvent extraction posed the fewest technical uncertainties for removing cesium from the HLW salt (NAS 2001b).

TC

2.8.2 DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 2001-1

A recent survey of SRS radioactive high-level waste (HLW) management operations by the Defense Nuclear Facilities Safety Board (DNFSB) addressed emergency problems in handling and storage of liquid wastes due to the projected shortage of HLW tank space (DNFSB 2001). The DNFSB provides safety oversight for the DOE defense facilities operations. The survey resulted in recommendations to implement several measures to maintain adequate safety margins in HLW storage, including reassessment and vigorous acceleration of the schedule for operation of a salt processing facility. Developing an integrated plan for tank space management to maintain safe operating margins pending startup of salt waste processing was recommended. Measures proposed, analogous to those projected for the No Action scenario in the SEIS, included reducing or eliminating the DWPF liquid low-level waste stream, recovering ITP process tanks for waste storage, resolving existing HLW evaporator problems and assessing the need for additional evaporator capacity, and possibly constructing additional waste tanks. The DNFSB recognized that implementation of such measures is in progress, but urged special focus to avoid delays that could result in reduced safety. DOE and the DNFSB are discussing the elements of an implementation plan that would be acceptable to the Board.

TC

2.8.3 SELF-PROTECTING HLW CANISTERS

Direct Disposal in Grout would not be consistent with DOE's recent Record of Decision (65 FR 1608; January 11, 2000) for disposition of surplus weapons-grade plutonium, which states that some of the plutonium will be immobilized in HLW canisters for eventual geologic disposal. Implementation of this approach requires the availability of a sufficient quantity of cesium-containing HLW to vitrify around the canisters of plutonium. The Direct Disposal in Grout alternative would not produce vitrified HLW that would support this option, because the cesium would not be in the vitrified waste stream.

The U.S. Nuclear Regulatory Commission and the International Atomic Energy Agency consider material emitting more than 100 rads per hour at 1 meter to be sufficiently self-protecting to require a lower level of safeguarding. Canisters containing cesium would emit hundreds of rads per hour, and thus be self-protecting. Canisters without radioactive cesium would emit 1 to 2 rads per hour at 1 meter, which is well below the self-protecting standard. Such canisters produced using the Direct Disposal in Grout alternative would not meet the Spent Fuel Standard without the addition of another radiation source. DOE would have to evaluate alternatives to resolve this issue before selecting the Direct Disposal in Grout alternative.

2.8.4 COST

Based on the preconceptual designs prepared and used by the Salt Processing Systems Engineering Team, the cost through construction of the alternatives would range
L6-47 from $900 million to $1.4 billion (WSRC 1998a). Based on this preliminary information, the Direct Disposal in Grout alternative would be the least costly. However, as designs are refined, the projected costs are subject to change and estimates for the alternatives could be higher or lower. Because the designs are preliminary, DOE does not consider the cost estimates to be reliable enough to be a discriminating factor. Cost estimates will, however, continue to be refined and evaluated in the ultimate selection of an alternative for implementation.

2.9 Comparison of Alternatives

This comparison is based on the information in Chapter 3 (Affected Environment), and analyses in Chapter 4 (Environmental Impacts). Its purpose is to present impacts of the alternatives in comparative form to provide a clear basis for choosing among the alternatives for the decisionmaker(s) and the public.

This section compares the impacts of the four action alternatives: Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout. These action alternatives would involve very similar construction and operations activities that enable a sharply focused comparison of impacts on each environmental resource.

Because the No Action alternative is a continuation of current HLW management activities, very few changes to that baseline would occur if DOE decided to not select and implement a salt-processing alternative. However, should DOE determine that a salt processing facility would not be available by 2010, decisions about future tank space management would have to be made immediately. The course of action that DOE would follow cannot be predicted at this time, but available options may include the following, either individually or in combination:

- Identify additional ways to optimize of Tank Farm operations
- Reuse tanks scheduled to be closed by 2019
- Build tanks permitted under wastewater treatment regulations
- Build tanks permitted under RCRA regulations
- Suspend operations at DWPF.

HLW salt processing would affect the environment and human health and safety during the period of time when facilities are being constructed and are operating. For purposes of analysis in this SEIS, DOE has defined this life cycle to be from the year 2001 through about 2023, when salt processing would be complete. For the No Action alternative, short-term impacts are considered for the two periods, continuing tank space management (until 2010) and post tank space management. DOE expects the long-term impacts to be those that could result from the eventual release of residual waste from the Z-Area vaults to the environment. In this SEIS, DOE has used modeling to predict these long-term impacts.

Chapter 4 of this SEIS presents the potential short-term and long-term environmental impacts associated with each salt processing alternative and the No Action alternative.

2.9.1 SHORT-TERM IMPACTS

Section 4.1 presents the potential short-term impacts (those that would occur between the approximate years 2001 and 2023) for each of the action alternatives and No Action. Because potential impacts are presented for both the action alternatives and the No Action alternative, DOE has measured the impacts as incremental to the existing "baseline" conditions.

These potential impacts are compared among the four action alternatives in Table 2-6 for normal

Table 2-6. Summary comparison of incremental life-cycle impacts to the SRS baseline by salt processing alternative. Values in bold indicate greatest impact for a particular parameter.

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
		Geologic Resources				
	Continuation of tank space management activities would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks.	The reuse of existing HLW tanks would increase the risk of tank failure resulting in the release of HLW to soils. Any new HLW storage tanks would be built in previously disturbed industrial areas. Best management practices would be used to stabilize soils and control erosion during construction. The operation of any new HLW storage tanks would not disturb any landforms or surface soils.	Minimal	Minimal	Minimal	Minimal
		Water Resources				
Surface Water	No Change	Construction of any new HLW tanks would be confined to previously disturbed industrial areas with established stormwater controls. Therefore, impacts would be minimal.	Minimal	Minimal	Minimal	Minimal
Groundwater	Continuation of tank space management activities would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks.	The reuse of existing HLW tanks would increase the risk of tank failure resulting in the release of HLW to ground-water. Any release of HLW to groundwater would have a substantial adverse impact on the quality of the surficial aquifer. Construction of any new HLW tanks would be confined to previously disturbed industrial areas with a deep water table. The operation of any new HLW storage tanks would not involve discharges to groundwater.	Minimal	Minimal	Minimal	Minimal

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Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Air Resources						
Nonradiological air emissions (tons/yr.):						
Sulfur dioxide (as SO_2) (PSD Standard - 40)	No Change	Minimal[b]	0.33	0.33	0.33	0.33
Total suspended particulates (PSD Standard - 25)	No Change	Minimal[b]	0.95	0.95	0.95	0.80
Particulate matter (≤10 µm) (PSD Standard - 15)	No Change	Minimal[b]	0.40	0.40	0.40	0.30
Carbon monoxide (PSD Standard - 100)	No Change	Minimal[b]	5.4	5.4	5.4	4.9
Volatile organic compounds (PSD Standard - 40)	No Change	Minimal[b]	**70**	1.6	40	1.5
Oxides of nitrogen (NO_x) (PSD Standard - 40)	No Change	Minimal[b]	21	21	21	19
Lead (PSD Standard - 0.6)	No Change	Minimal[b]	4.0×10^{-4}	4.0×10^{-4}	4.0×10^{-4}	3.5×10^{-4}
Beryllium (PSD Standard - 4.0×10^{-4})	No Change	Minimal[b]	1.0×10^{-4}	1.0×10^{-4}	1.0×10^{-4}	5.0×10^{-5}
Mercury (PSD Standard - 0.1)	No Change	Minimal[b]	0.0026	0.0026	0.0026	0.0025
Formic Acid (PSD Standard - NA)	No Change	Minimal[b]	**1.6**[c]	None	None	None
Benzene (PSD Standard - NA)	No Change	Minimal[b]	**53**	0.0085	0.0085	0.0085
Biphenyl (PSD Standard - NA)	No Change	Minimal[b]	**1.1**	None	None	None
Methanol (PSD Standard - NA)	No Change	Minimal[b]	0.42	0.42	0.42	0.42
n-Propanol (PSD Standard - NA)	No Change	Minimal[b]	0.42	0.42	0.42	0.42
Isopar®L (PSD Standard - NA)	None	None	None	None	**38**	None
Air pollutants at the SRS boundary (maximum concentrations-µg/m³):						
Sulfur dioxide (as SO_2) - 3 hr. (Standard - 1,300)	1240[d]	Minimal[b]	0.30	0.30	0.30	**0.40**
Total suspended particulates - annual (Standard - 75)	67[d]	Minimal[b]	0.0010	0.0010	0.0010	0.0010
Particulate matter (≤10 µm) - 24 hr. (Standard - 150)	130[d]	Minimal[b]	0.070	0.070	0.070	0.070

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Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank *Precipitation*	Ion *Exchange*	Solvent *Extraction*	Direct Disposal *in Grout*
	Continue Tank Space *Management*	Post Tank Space *Management Scenarios*				
Carbon monoxide - 1 hr. (Standard - 40,000)	10,350[d]	Minimal[b]	15	15	15	18
Ozone - 1 hr. (Standard - 235)	216[d]	Minimal[b]	ND	ND	ND	ND
Nitrogen dioxide (NO_2) - annual (Standard -100)	26[d]	Minimal[b]	0.030	0.030	0.030	0.030
Lead - max. quarterly (Standard - 1.5)	0.03[d]	Minimal[b]	4.0×10^{-7}	4.0×10^{-7}	4.0×10^{-7}	4.0×10^{-7}
Beryllium - 24 hr. (Standard - 0.01)	0.0090[d]	Minimal[b]	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Mercury - 24 hr. (Standard - 0.25)	0.03[d]	Minimal[b]	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Benzene - 24 hr. (Standard - 150)	5[d]	Minimal[b]	**4.0**	0.0010	0.0010	0.0010
Biphenyl - 24 hr. (Standard - 6)	0.02[d]	Minimal[b]	**0.45**	None	None	None
Methanol - 24 hr. (Standard - 1,310)	0.9[d]	Minimal[b]	0.32	0.32	0.32	0.53
Annual radionuclide emissions (curies/year): (Doses are reported in Worker and Public Health Section.)	No Change[e]	Minimal[b]	5.3	18.2	**25.4**	9.3[f]
Worker and Public Health						
Radiological dose and health impacts to the public:						
Maximally-exposed individual (mrem/yr.)	No Change[g]	Minimal[h]	0.20	0.049	**0.31**	0.086
MEI project-phase latent cancer fatality	No Change[g]	Minimal[h]	1.3×10^{-6}	3.2×10^{-7}	**2.0×10^{-6}**	5.6×10^{-7}
Offsite population dose (person-rem/yr.)	No Change[g]	Minimal[h]	12.0	2.9	**18.1**	4.0
Offsite population project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	0.078	0.019	**0.12**	0.026

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Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Nonradiological health impacts to the public:						
Maximally exposed offsite individual						
Latent cancer fatality from benzene	No Change[g]	Minimal[h]	**1.7×10^{-5}**	(c)	(c)	(c)
Latent cancer fatality from beryllium	No Change[g]	Minimal[h]	2.4×10^{-8}	2.4×10^{-8}	2.4×10^{-8}	2.4×10^{-8}
Radiological dose and health impacts to noninvolved workers:						
Noninvolved worker dose (mrem/yr.)	No Change[g]	Minimal[h]	3.3	0.8	**4.8**	1.7
Project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	1.7×10^{-5}	4.2×10^{-6}	**2.5×10^{-5}**	8.6×10^{-6}
Nonradiological health impacts to noninvolved workers:						
Latent cancer fatality from benzene	No Change[g]	Minimal[h]	**0.0066**	(i)	(i)	(i)
Latent cancer fatality from beryllium	No Change[g]	Minimal[h]	7.2×10^{-5}	7.2×10^{-5}	7.2×10^{-5}	7.2×10^{-5}
Radiological dose and health impacts to involved workers:						
Involved worker dose (mrem/yr)	No Change[g]	Minimal[h]	16	3.9	**23**	10
Project-phase dose to population of involved workers (total person-rem)	No Change[g]	Minimal[h]	29	5.0	**47**	14
Project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	0.012	0.0020	**0.019**	0.0056
OSHA-regulated nonradiological air pollutants at noninvolved worker location (max conc. in mg/m^3)[n]						
Sulfur dioxide (as SO_2) - 8 hr. (OSHA Standard -13)[j]	No Change[g]	Minimal[h]	0.01	0.01	0.01	0.01
Total suspended particulates - 8 hr (OSHA Standard -15)	No Change[g]	Minimal[h]	0.02	0.02	0.02	0.01

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Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Particulate matter (≤10 μm) - 8 hr. (OSHA Standard - 5)	No Change[g]	Minimal[h]	0.02	0.02	0.02	0.01
Carbon monoxide - 8 hr. (OSHA Standard - 55)	No Change[g]	Minimal[h]	0.2	0.2	0.2	0.2
Oxides of nitrogen (as NO_x) - ceiling (OSHA Standard - 9)	No Change[g]	Minimal[h]	7.0	7.0	7.0	7.0
Lead - 8 hr. (OSHA Standard - 0.5)	No Change[g]	Minimal[h]	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Beryllium - 8 hr. (OSHA Standard - 0.002)	No Change[g]	Minimal[h]	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}
Beryllium - ceiling (OSHA Standard - 0.005)	No Change[g]	Minimal[h]	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Mercury - ceiling (OSHA Standard - 0.1)	No Change[g]	Minimal[h]	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Benzene - 8 hr. (OSHA Standard - 3.1)	No Change[g]	Minimal[h]	**0.1**	3.0×10^{-4}	3.0×10^{-4}	3.0×10^{-4}
Benzene - ceiling (OSHA Standard - 15.5 m^3)	No Change[g]	Minimal[h]	**0.8**	0.004	0.004	0.004
Formic Acid - 8 hr. (OSHA Standard - 9 m^3)	No Change[g]	Minimal[h]	**2.2×10^{-4}[c]**	None	None	None
Methyl alcohol - 8 hr. (OSHA Standard - 260)	No Change[g]	Minimal[h]	0.08	0.08	0.08	0.08
n-Propyl alcohol - 8 hr. (OSHA Standard - 500)	No Change[g]	Minimal[h]	0.08	0.08	0.08	0.08
Occupational Health and Safety						
Total recordable accidents per year	No Change	0.80[k]	2.2	1.7	**2.7**	1.8
Lost workdays per year	No Change	0.35[k]	1.0	0.72	1.2	0.77
Environmental Justice						
	None	None	None	None	None	None
Ecological Resources						
	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife.	Activity and noise could displace small numbers of wildlife.	Activity and noise could displace small numbers of wildlife.	Activity and noise could displace small numbers of wildlife.

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Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Land Use						
	Zoned heavy industrial-no change in land use patterns. Land dedicated to HLW tanks could not be used for other purposes.	Zoned heavy industrial-no change in land use patterns. Land dedicated to HLW tanks could not be used for other purposes.	Zoned heavy industrial-no change in SRS land use patterns.	Zoned heavy industrial-no change in SRS land use patterns.	Zoned heavy industrial-no change in SRS land use patterns.	Zoned heavy industrial-no change in SRS land use patterns.
			Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.	Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.	Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.	Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.
Socioeconomics (employment - full time equivalents)						
Annual construction employment	None	500	500	500	500	500
Annual operational employment	No Change	65[j]	180	135	220	145
Cultural Resources						
	None	None	None	None	None	None
Transportation						
Construction:						
Material shipments	None	(k)	3,000	3,000	3,000	3,400
Accidents from material shipments	None	(k)	0.04	0.04	0.04	0.05
Construction worker accidents	None	(k)	95	**98**	95	91
Construction worker injuries	None	(k)	42	**43**	42	40
Construction worker fatalities	None	(k)	0.4	0.4	0.4	0.4
Operations:						
Material shipments	No Change	No Change	**26,000**	21,000	24,000	19,000
Accidents from material shipments	No Change	No Change	0.4	0.3	0.3	0.3
Operations worker accidents	No Change	39[l]	122	91	**148**	97
Operations worker injuries	No Change	17[l]	53	40	**65**	42
Operations worker fatalities	No Change	0.2[l]	0.5	0.4	**0.6**	0.4

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Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Waste Generation						
Maximum annual waste generation:						
Radioactive liquid waste (gallons)	No Change	No Change	300,000	250,000	**900,000**	150,000
Nonradioactive liquid waste (million gallons)	No Change	No Change	Minimal	**34,000**	Minimal	Minimal
Transuranic waste (m^3)	No Change	No Change	Minimal	Minimal	Minimal	Minimal
Low-level waste (m^3)	No Change	No Change	71	71	71	71
Hazardous waste (m^3)	No Change	No Change	Startup - 23 Operations - 1	Startup - 23 Operations - 1	Startup - 23 Operations - 1	Startup - 23 Operations - 1
Mixed low-level waste (m^3)	No Change	No Change	1	1	1	1
Mixed low-level liquid waste (gallons)	No Change	No Change	**60,000**	None	1,000	None
Industrial waste (metric tons)	No Change	No Change	Startup - 30 Operations - 20	Startup - 30 Operations - 20	Startup - 30 Operations - 20	Startup - 30 Operations - 20
Sanitary waste (metric tons)	No Change	No Change	Startup - 62 Operations - 41	Startup - 62 Operations - 41	Startup - 62 Operations - 41	Startup - 62 Operations - 41
Total waste generation:						
Radioactive liquid waste (million gallons)	No Change	No Change	3.9	3.3	**12.0**	2.0
Nonradioactive liquid waste (million gallons)	No Change	No Change	Minimal	**0.49**	Minimal	Minimal
Transuranic waste (m^3)	No Change	No Change	Minimal	Minimal	Minimal	Minimal
Low-level waste (m^3)	No Change	No Change	920	920	920	920
Hazardous waste (m^3)	No Change	No Change	43	43	43	43
Mixed low-level waste (m^3)	No Change	No Change	13	13	13	13
Mixed low-level liquid waste (gallons)	No Change	No Change	**780,000**	None	13,000	None
Industrial waste (metric tons)	No Change	No Change	299	299	299	299
Sanitary waste (metric tons)	No Change	No Change	611	611	611	611
Utilities (total life cycle)						
Water (million gallons)			**435**	403	380	289
Construction	None	(m)	35	37	35	33
Operations	No Change	No Change	400	366	345	256

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Table 2-6. (Continued).

Parameter	No Action[a] Continue Tank Space Management	No Action[a] Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Electricity (gigawatt-hours)			319	365	**391**	245
Construction	None	(m)	76	79	76	73
Operations	No Change	No Change	243	286	315	172
Steam (million pounds)			**2,548**	2,300	1,915	1,536
Construction	None	(m)	0	0	0	0
Operations	No Change	No Change	2,548	2,300	1,915	1,536
Fuel (million gallons)			8.7	**9.3**	8.7	8.2
Construction	None	(m)	8.4	9	8.4	8
Operations	No Change	No Change	0.3	0.3	0.3	0.2

L6-28

a. Under the No Action alternative, DOE would continue tank space management activities until approximately 2010, when the existing HLW tanks would reach capacity. Because the course of action that DOE would pursue after the initial period of tank space management has not been determined. For each resource evaluated, only those post tank management scenarios that would be expected to have an impact are included.

b. Air emissions under the No Action alternative would be similar to those from the existing HLW Tank Farm operations for all scenarios. Therefore, the No Action alternative is represented by slight increases above the baseline.

c. Formic acid emissions would shift from DWPF to the Small Tank Precipitation facility, resulting in no net increase in emissions.

d. SRS baseline concentration at the site boundary. Emissions from ongoing tank space management activities are included in this value.

e. Radionuclide emissions from ongoing tank space management activities are included in the site baseline. SRS baseline emissions are shown in Table 3-12.

f. Includes building stack and ground level vault emissions. Vaults for the other three action alternatives would have no measurable emissions because the saltstone produced by these action alternatives would have a much lower activity level and the vaults would not be ventilated.

g. Under No Action, air emissions during tank space management activities would remain at current levels; therefore, no change in worker and public health impacts would be expected.

h. For all scenarios under No Action, impacts to worker and pubic health would be expected to increase slightly above the current baseline.

i. Latent cancer fatalities from benzene from the other alternatives would be substantially less than that from Small Tank Precipitation.

j. Up to 65 new employees would be required for operation of any new HLW tanks constructed under No Action. Alternatively, DOE could suspend operations at the DWPF which, if prolonged, could result in a workforce reduction.

k. Material shipments and associated accident and injury rates for construction transportation of up to 10 new HLW tanks would be similar to those identified under the action alternatives. L6-7

l. Based on employment of 65 additional workers for operation of any new HLW tanks built under the No Action alternative.

m. DOE could build as many as 10 new HLW storage tanks under the No Action alternative. Utility and energy use during the construction period would be similar to usage rates under the action alternatives. L6-7

n. Under normal operating conditions, involved workers would not be exposed to any OSHA-regulated nonradiological air pollutants; therefore, impacts to involved worker health would be minimal for all alternatives, including No Action.

ND = Not Determined.

operations (bolded values in the table indicate the alternative that would have the greatest impact on selected parameters). Because the specific activities that would be pursued under the No Action alternative have not been determined, only those potential activities that would be expected to have an impact on a given resource area are discussed in this section.

Geologic and water resources – The sites proposed for salt processing facilities lie within areas of the SRS that are committed to industrial use and have been previously disturbed. Therefore, none of the salt processing action alternatives would have short-term impacts to the geology or groundwater, regardless of which alternative was selected. DOE anticipates small sedimentation impacts to McQueen Branch from construction activities, but these impacts would cease once construction was completed.

Under the No Action alternative reuse of old tanks would increase the risk for the release of radiological and nonradiological hazardous liquids with potential for substantial negative impact on soils and the quality of the surficial aquifer.

Nonradiological air quality – Construction activities and routine operations associated with salt processing activities would result in the re-lease of regulated nonradiological pollutants to the surrounding air. For any of the four action alternatives, the increases in pollutant concentrations resulting from construction activities would be small and would not exceed regulatory limits.

Nonradiological emissions from routine operations (with the exception of volatile organic compounds [VOCs]) would be below regulatory limits. The Small Tank Precipitation alternative would require additional permit review, whereas emissions from the other alternatives are either covered by the existing permit(s) or are below the threshold values.

All options under the No Action alternative would result in emissions similar to those at the existing HLW Tank Farms. Therefore, incremental increases in air emissions as a result of the No Action alternative would be minimal.

For all alternatives, air concentrations at the SRS boundary of the emitted pollutants would be well below South Carolina Department of Health and Environmental Control (SCDHEC) or Clean Air Act regulatory limits. Occupational Safety and Health Administration (OSHA) -regulated pollutant levels would be below regulatory limits at both the noninvolved and the involved worker locations.

Radiological air quality – Radiation dose to the maximally exposed individual (MEI) from air emissions associated with the salt processing alternatives would be highest (0.31 millirem per year) for the Solvent Extraction alternative, due to the higher emissions of radioactive cesium, which would account for 90 percent of the total dose to the MEI. Dose to the MEI from other alternatives would be lower: 0.20 millirem per year for the Small Tank Precipitation alternative, 0.049 millirem per year for the Ion Exchange alternative, and 0.086 millirem per year for the Direct Disposal in Grout alternative. Estimated dose to the offsite population would also be highest for the Solvent Extraction alternative (18.1 person-rem per year). For the Small Tank Precipitation alternative, the offsite population dose would be 12.0 person-rem per year; for the Ion Exchange alternative, the offsite population dose would be 2.9 person-rem per year; and for the Direct Disposal in Grout alternative, the offsite population dose would be 4.0 person-rem per year.

For doses to the noninvolved (onsite) worker, the involved worker, and the collective onsite population from the estimated annual radioactive emissions. The highest estimated dose would occur under the Solvent Extraction alternative, with the Small Tank Precipitation having similar results and the Ion Exchange and the Direct Disposal in Grout alternatives having lower doses. The maximum dose to the noninvolved and in

volved worker would be 4.8 millirem per year and 22.8 millirem per year, respectively, with radioactive cesium emissions contributing about 98 percent of the total dose. The maximum estimated dose to the onsite population would be 6.5 person-rem per year, with 94 percent of this total dose due to radioactive cesium emissions. Under the No Action alternative, air emissions from all potential scenarios would be similar to those from ongoing operations at the HLW Tank Farms.

Impacts on radiological air quality are measured in terms of effects on occupational and public health and are reported in the *Worker and Public Health* section of Table 2-6.

Nonradiological pollutant concentrations at noninvolved worker locations would be well below the regulatory limits, except for oxides of nitrogen. Facility workers would be exposed to minimum levels of nonradiological air pollutants under all four alternatives. Worker exposure to chemicals in the workplace would be monitored in accordance with OSHA regulatory guidance.

Radiation Dose and Cancer Fatalities

Worker and public health impacts are expressed in terms of latent cancer fatalities. The primary health effect of radiation is an increased risk of cancer. A radiation dose to a population is believed to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The National Council on Radiation Protection and Measurement has established dose-to-risk conversion factors of 0.0005 per person-rem for the general population and 0.0004 per person-rem for workers. The difference is due to the presence of children, who are believed to be more susceptible to radiation, in the general population.

DOE estimates the doses to the population and uses the conversion factor to estimate the number of cancer fatalities that might result from those doses. In most cases the result is a small fraction of one. For these cases, DOE concludes that no additional cancers would be expected in the exposed population.

Worker and public health impacts – Radiological air doses for the Solvent Extraction alternative translate into 0.12 additional project-phase latent cancer fatalities in the offsite population of approximately 620,000 people. Additional project-phase latent cancer fatalities in the offsite population from Small Tank Precipitation, Ion Exchange, and Direct Disposal in Grout radiological doses would be 0.078, 0.019, and 0.026, respectively. For the collective worker population at SRS, additional project phase latent cancer fatalities would be 0.022, 0.0055, 0.034, and 0.012 for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives, respectively. Under all action alternatives, the potential for any cancer death as a result of salt processing activities is minimal. Air emissions from all potential scenarios under the No Action alternative are similar to those at the existing HLW Tank Farms and would result in slight increases above the baseline cancer risk.

Occupational Health and Safety – Based on historic SRS injury rates over a four-year period (1995 through 1999), estimated total recordable cases (TRCs) and lost workdays (LWDs) would be greatest for the Solvent Extraction alternative, with 2.7 TRCs and 1.2 LWDs on an annual basis. The Small Tank Precipitation, Ion Exchange, and Direct Disposal in Grout alternatives would generate fewer TRCs (2.2, 1.7, and 1.8, respectively) and LWDs (1.0, 0.72 and 0.77, respectively) because fewer employees are required for these alternatives. Under the No Action alternative, TRCs and LWCs would be expected to remain at current levels during ongoing tank space management activities. In the event that DOE would build new HLW tanks, the number of TRCs and LWCs would increase by approximately 0.80 and 0.35, respectively.

Environmental Justice – Because short-term impacts from salt processing activities would not significantly affect the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the salt processing alternatives.

Ecological resources – Construction-related disturbances under all alternatives, including No Action, would result in impacts to wildlife that are small, intermittent, and localized. Some individual animals could be displaced by construction noise and activity, but populations would not be affected. Operational impacts would be minimal.

Land use – Each of the four action alternatives would be constructed in areas (S and Z) that are zoned as heavy industrial. Under the No Action alternative, continuation of tank space management activities would have no impact on existing land use plans. Any tanks built under the No Action alternative would also be constructed in industrial areas. SRS land use patterns are not expected to change over the short term due to proposed salt processing activities.

Socioeconomics – Each of the salt processing alternatives, including No Action, would require approximately 500 construction workers annually. During operations, the number of workers for the action alternatives would range from 135 to 220, depending on the alternative chosen. None of the action alternatives is expected to have a measurable effect on regional employment or population trends.

Under the No Action alternative, DOE could suspend operations at DWPF. If the suspension of operations at these facilities is not temporary, it would result in a sizeable workforce reduction, which would have a substantial negative impact on the communities surrounding SRS. Alternatively, DOE could construct as many as 10 new HLW tanks. Operation of new HLW tanks would require up to 65 new employees. This small increase is not expected to have a measurable effect on regional employment or population trends.

Cultural resources – No impacts to cultural resources would occur under any of the alternatives, including No Action. The sites proposed for salt processing facilities and any tanks built under No Action all lie within areas of SRS that are committed to industrial use and have been previously disturbed by construction activities. There are no known archeological or historic resources on the proposed construction sites. Therefore, there are no expected cultural impacts.

Traffic and Transportation – Transportation by truck of materials to construct and operate the salt processing facilities over the duration of the project would require from 22,000 shipments (400,000 miles) for the Direct Disposal in Grout alternative to 29,000 shipments (525,000 miles) for the Small Tank Precipitation alternative. Construction of any tanks built under the No Action alternative would require a similar number of material shipments as the action alternatives. No vehicle accidents, occupant injuries, or fatalities would be expected for these miles driven.

Construction worker commutes to the site during the construction phase of the salt processing action alternatives would vary from 24 million miles for the Direct Disposal in Grout alternative to 26 million miles for the Ion Exchange alternative. Up to 98 accidents, 43 occupant injuries, and no fatalities would be expected for these total commuter miles. Commuter miles and impacts would be similar for construction of any tanks under the No Action alternative.

The increased traffic resulting from facility operations for any of the alternatives, including No Action, would be minimal.

Waste generation – Salt processing activities under the action alternatives would generate 150,000 to 900,000 gallons of radioactive liquid waste annually. This radioactive liquid waste consists of wastewater recycled from the treatment of the high-activity portion of the salt solutions at DWPF. Small amounts of waste (low-level radioactive, mixed low-level, hazardous, industrial, and sanitary) would be produced under each of the action alternatives and could be handled within the existing site capacity. The No Action alternative would not generate any waste beyond that which is included in the SRS baseline.

Utilities and energy consumption – Water use over the duration of the project would range from 290 million gallons for the Direct Disposal in Grout alternative to 435 million gallons for the Small Tank Precipitation alternative. Construction and operation phase water usages would be from 33 to 37 million gallons and 260 to 400 million gallons, respectively. At its highest average daily use, the water required would be 1.5 percent of the lowest estimated production capacity of the aquifer.

Electricity use over the duration of the project would range from 245 gigawatt-hours (with a peak power demand of 18 megawatts) for the Direct Disposal in Grout alternative to 391 gigawatt-hours (with a peak power demand of 32 megawatts) for the Solvent Extraction alternative. During the construction and operation phases, electricity use would be from 73 to 79 gigawatt-hours and 172 to 315 gigawatt-hours, respectively. This electricity use and peak power demand could be supported by the current power generation and distribution systems serving SRS.

Steam use over the duration of the project would range from 1.5 billion pounds for the Direct Disposal in Grout alternative to 2.5 billion pounds for the Small Tank Precipitation alternative. No steam would be used during the construction phase of the project.

Liquid fuel use over the duration of the project would range from 8.2 million gallons for the Direct Disposal in Grout alternative to 9.3 million gallons for the Ion Exchange alternative. Fuel use during the operation phase would not exceed 300,000 gallons under any alternative. This fuel use is well within the current regional fuel supply capacity.

Under the No Action alternative, utility and energy use would be similar to consumption rates at the existing tank farm and is therefore included in the SRS baseline.

Accidents – DOE evaluated the impacts of potential accidents related to each of the action alternatives (Table 2-7). Because the No Action alternative includes primarily current operations that have been evaluated in approved safety analysis reports (WSRC 1998h), only the radiological and nonradiological hazards associated with accidents under the four action alternatives were evaluated. For each action alternative, the accidents considered were: loss of confinement; earthquakes; fire in a process cell; loss of cooling; external events, such as aircraft and helicopter crashes; and explosions from benzene and radiation-generated hydrogen. Accidents for which the probability was calculated at less than 1 in 10,000,000 years were not considered credible and were dropped from further consideration.

For each remaining accident scenario involving radioactive materials, the radiation dose to the involved worker, the noninvolved worker, the onsite and offsite MEI, and the collective radiation dose to the onsite and offsite populations were calculated. The impacts of the alternatives, expressed as latent cancer fatalities to these receptors, were also calculated. A beyond-extremely-unlikely aircraft impact at the Ion Exchange facility would result in the highest potential dose to each of the receptor groups and the highest potential increase in latent cancer fatalities. On a latent cancer fatality per year basis (i.e., latent cancer fatality per accident times accident frequency), the beyond design-basis earthquake at the Small Tank Precipitation facility would result in the highest impact on each of the five receptors. In general, severe accident potential was highest for the Small Tank Precipitation alternative and lowest for the Direct Disposal in Grout alternative.

In general, accidents involving nonradiological hazardous materials would result in minimal impacts to onsite and offsite receptors. However, noninvolved workers exposed to atmospheric releases of benzene from two of the accidents evaluated under the Small Tank Precipitation alternative could experience serious or life-threatening health effects. Workers exposed to airborne benzene concentrations (950 mg/m^3)

Table 2-7. Comparison of accident impacts among alternatives.[a]

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Accidents Involving Radioactive Materials				
Loss of Confinement	Once in 30 years				L6-28
Maximally Exposed Offsite Individual					
Dose (rem)		0.0016	8.3×10^{-4}	8.3×10^{-4}	2.4×10^{-4}
LCF per accident[b]		8.2×10^{-7}	4.2×10^{-7}	4.2×10^{-7}	1.2×10^{-7}
LCF per year		2.8×10^{-8}	1.4×10^{-8}	1.4×10^{-8}	4.1×10^{-9}
Offsite population					
Dose (person-rem)		88	45	45	14
LCF per accident		0.044	0.022	0.022	0.0072
LCF per year		0.0015	7.6×10^{-4}	7.6×10^{-4}	2.4×10^{-4}
Involved Worker (100 m)					
Dose (rem)		3.2×10^{-6}	6.4×10^{-8}	6.4×10^{-8}	7.3×10^{-8}
LCF per accident[b]		1.3×10^{-9}	2.6×10^{-11}	2.6×10^{-11}	2.9×10^{-11}
LCF per year[b]		4.3×10^{-11}	8.7×10^{-13}	8.7×10^{-13}	9.8×10^{-13}
Noninvolved Worker (640 m)					
Dose (rem)		0.024	0.012	0.012	0.0036
LCF per accident[b]		9.5×10^{-6}	4.9×10^{-6}	4.9×10^{-6}	1.5×10^{-6}
LCF per year[b]		3.2×10^{-7}	1.6×10^{-7}	1.6×10^{-7}	4.9×10^{-8}
Onsite population					
Dose (person-rem)		39	20	20	4.2
LCF per accident		0.016	0.0080	0.0080	0.0017
LCF per year		5.3×10^{-4}	2.7×10^{-4}	2.7×10^{-4}	5.7×10^{-5}
Beyond Design Basis Earthquake	*Less than once in* 2,000 years				L6-28
Maximally Exposed Offsite Individual					
Dose (rem)		0.31	0.12	0.12	0.042
LCF per accident[b]		1.5×10^{-4}	5.9×10^{-5}	5.8×10^{-5}	2.1×10^{-5}
LCF per year[b]		7.6×10^{-8}	2.9×10^{-8}	2.9×10^{-8}	1.0×10^{-8}
Offsite population					
Dose (person-rem)		16,000	6,200	6,100	2,300
LCF per accident		8.0	3.1	3.0	1.1
LCF per year		0.0040	0.0016	0.0015	5.7×10^{-4}
Involved Worker (100 m)					
Dose (rem)		310[c]	120	120	42
LCF per accident[b]		0.12	0.047	0.046	0.017
LCF per year		6.1×10^{-5}	2.4×10^{-5}	2.3×10^{-5}	8.4×10^{-6}
Noninvolved Worker (640 m)					
Dose (rem)		9.6	3.7	3.6	1.3
LCF per accident[b]		0.0038	0.0015	0.0015	5.3×10^{-4}
LCF per year[b]		1.9×10^{-6}	7.4×10^{-7}	7.3×10^{-7}	2.6×10^{-7}
Onsite population					
Dose (person-rem)		9,000	3,500	3,400	1,000
LCF per accident		3.6	1.4	1.4	0.41
LCF per year		0.0018	6.9×10^{-4}	6.8×10^{-4}	2.1×10^{-4}

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	
Loss of Cooling to Loaded Resin Hold Tanks	Once in 5,300 years					L6-28
Maximally Exposed Offsite Individual						
Dose (rem)		NA	9.4×10^{-7}	NA	NA	
LCF per accident[b]		NA	4.7×10^{-10}	NA	NA	
LCF per year[b]		NA	8.9×10^{-14}	NA	NA	
Offsite population						
Dose (person-rem)		NA	0.052	NA	NA	
LCF per accident		NA	2.6×10^{-5}	NA	NA	
LCF per year		NA	5.0×10^{-9}	NA	NA	
Involved Worker (100 m)						
Dose (rem)		NA	8.8×10^{-8}	NA	NA	
LCF per accident[b]		NA	3.5×10^{-11}	NA	NA	
LCF per year[b]		NA	6.7×10^{-15}	NA	NA	
Noninvolved Worker (640 m)						
Dose (rem)		NA	1.4×10^{-5}	NA	NA	
LCF per accident[b]		NA	5.7×10^{-9}	NA	NA	
LCF per year[b]		NA	1.1×10^{-12}	NA	NA	
Onsite population						
Dose (person-rem)		NA	0.023	NA	NA	
LCF per accident		NA	9.0×10^{-6}	NA	NA	
LCF per year		NA	1.7×10^{-9}	NA	NA	
Fire in Process Cell	Once in 10,000 years					L6-28
Maximally Exposed Offsite Individual						
Dose (rem)		0.014	0.0094	0.0094	0.0027	
LCF per accident[b]		7.2×10^{-6}	4.7×10^{-6}	4.7×10^{-6}	1.4×10^{-6}	
LCF per year[b]		7.2×10^{-10}	4.7×10^{-10}	4.7×10^{-10}	1.4×10^{-10}	
Offsite population						
Dose (person-rem)		780	500	500	160	
LCF per accident		0.39	0.25	0.25	0.0081	
LCF per year		3.9×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	8.1×10^{-6}	
Involved Worker (100 m)						
Dose (rem)		2.8×10^{-5}	9.1×10^{-7}	7.2×10^{-7}	8.2×10^{-7}	
LCF per accident[b]		1.1×10^{-8}	3.6×10^{-10}	2.9×10^{-10}	3.3×10^{-10}	
LCF per year[b]		1.1×10^{-12}	3.6×10^{-14}	2.9×10^{-14}	3.3×10^{-14}	
Noninvolved Worker (640 m)						
Dose (rem)		0.21	0.14	0.14	0.041	
LCF per accident[b]		8.5×10^{-5}	5.5×10^{-5}	5.5×10^{-5}	1.6×10^{-5}	
LCF per year[b]		8.5×10^{-9}	5.5×10^{-9}	5.5×10^{-9}	1.6×10^{-9}	
Onsite population						
Dose (person-rem)		340	220	220	48	
LCF per accident		0.14	0.089	0.089	0.019	
LCF per year		1.4×10^{-5}	8.9×10^{-6}	8.9×10^{-6}	1.9×10^{-6}	

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	
Benzene Explosion in PHC[d]	Once in 99,000 years					L6-28
Maximally Exposed Offsite Individual						
Dose (rem)		0.70	NA	NA	NA	
LCF per accident[b]		3.5×10^{-4}	NA	NA	NA	
LCF per year[b]		3.5×10^{-9}	NA	NA	NA	
Offsite population						
Dose (person-rem)		38,000	NA	NA	NA	
LCF per accident		19	NA	NA	NA	
LCF per year		1.9×10^{-4}	NA	NA	NA	
Involved Worker (100 m)						
Dose (rem)		0.0014	NA	NA	NA	
LCF per accident[b]		5.5×10^{-7}	NA	NA	NA	
LCF per year[b]		5.6×10^{-12}	NA	NA	NA	
Noninvolved Worker (640 m)						
Dose (rem)		10	NA	NA	NA	
LCF per accident[b]		0.0041	NA	NA	NA	
LCF per year[b]		4.1×10^{-8}	NA	NA	NA	
Onsite population						
Dose (person-rem)		17,000	NA	NA	NA	
LCF per accident		6.7	NA	NA	NA	
LCF per year		6.8×10^{-5}	NA	NA	NA	
Hydrogen Explosion in Extraction Cell	Once in 1,300,000 years					L6-28
Maximally Exposed Offsite Individual						
Dose (rem)		NA	NA	0.0029	NA	
LCF per accident[b]		NA	NA	1.4×10^{-6}	NA	
LCF per year[b]		NA	NA	1.1×10^{-12}	NA	
Offsite population						
Dose (person-rem)		NA	NA	160	NA	
LCF per accident		NA	NA	0.081	NA	
LCF per year		NA	NA	6.1×10^{-8}	NA	
Involved Worker (100 m)						
Dose (rem)		NA	NA	2.7×10^{-4}	NA	
LCF per accident[b]		NA	NA	1.1×10^{-7}	NA	
LCF per year[b]		NA	NA	8.1×10^{-14}	NA	
Noninvolved Worker (640 m)						
Dose (rem)		NA	NA	0.044	NA	
LCF per accident[b]		NA	NA	1.8×10^{-5}	NA	
LCF per year[b]		NA	NA	1.3×10^{-11}	NA	
Onsite population						
Dose (person-rem)		NA	NA	70	NA	
LCF per accident		NA	NA	0.028	NA	
LCF per year		NA	NA	2.1×10^{-8}	NA	

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Helicopter Impact	Once in 2,100,000 years				L6-28
Maximally Exposed Offsite Individual					
Dose (rem)		3.3	1.7	1.7	0.53
LCF per accident[b]		0.0016	8.5×10^{-4}	8.5×10^{-4}	2.7×10^{-4}
LCF per year		7.9×10^{-10}	4.1×10^{-10}	4.1×10^{-10}	1.3×10^{-10}
Offsite population					
Dose (person-rem)		170,000	89,000	89,000	29,000
LCF per accident		87	45	45	14
LCF per year		4.2×10^{-5}	2.1×10^{-5}	2.1×10^{-5}	6.9×10^{-6}
Involved Worker (100 m)					
Dose (rem)		3,300[c]	1,700[c]	1,700[c]	53
LCF per accident[b]		1.3	0.68	0.68	0.21
LCF per year[b]		6.3×10^{-7}	3.2×10^{-7}	3.3×10^{-7}	1.0×10^{-7}
Noninvolved Worker (640 m)					
Dose (rem)		100	53	53	17
LCF per accident[b]		0.041	0.021	0.021	0.0067
LCF per year[b]		2.0×10^{-8}	1.0×10^{-8}	1.0×10^{-8}	3.2×10^{-9}
Onsite population					
Dose (person-rem)		97,000	50,000	50,000	13,000
LCF per accident		39	20	20	5.3
LCF per year		1.9×10^{-5}	9.5×10^{-6}	9.6×10^{-6}	2.5×10^{-6}
Aircraft Impact	Once in 2,700,000 years				L6-28
Maximally Exposed Offsite Individual					
Dose (rem)		5.4	2.0	2.0	0.74
LCF per accident[b]		0.0027	0.0010	0.0010	3.7×10^{-4}
LCF per year[b]		1.0×10^{-9}	3.7×10^{-10}	3.8×10^{-10}	1.4×10^{-10}
Offsite population					
Dose (person-rem)		280,000	110,000	110,000	40,000
LCF per accident		140	53	54	20
LCF per year		5.3×10^{-5}	2.0×10^{-5}	2.0×10^{-5}	7.4×10^{-6}
Involved Worker (100 m)					
Dose (rem)		5,400[c]	2,000[c]	2,000[c]	740[c]
LCF per accident[b]		2.1	0.81	0.81	0.30
LCF per year[b]		8.0×10^{-7}	3.0×10^{-7}	3.0×10^{-7}	1.1×10^{-7}
Noninvolved Worker (640 m)					
Dose (rem)		170	63	64	23
LCF per accident[b]		0.067	0.025	0.026	0.0093
LCF per year[b]		2.5×10^{-8}	9.4×10^{-9}	9.5×10^{-9}	3.4×10^{-9}
Onsite population					
Dose (person-rem)		160,000	59,000	60,000	18,000
LCF per accident		63	24	24	7.3
LCF per year		2.3×10^{-5}	8.8×10^{-6}	8.9×10^{-6}	2.7×10^{-6}

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Nonradioactive Hazardous Materials					
Accidents Involving Sodium Hydroxide Releases					
Caustic Feed Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}
Noninvolved Worker (640 m) Dose (mg/m^3)		0.18	0.18	0.18	0.18
Caustic Dilution Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		NA	NA	NA	0.0031
Noninvolved Worker (640 m) Dose (mg/m^3)		NA	NA	NA	0.93[e]
Accidents Involving Nitric Acid Releases					
Nitric Acid Feed Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		NA	NA	8.8×10^{-5}	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		NA	NA	0.026	NA
Accidents Involving Benzene Releases					
PHA Surge Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		7.4×10^{-10}	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		2.2×10^{-8}	NA	NA	NA
TPB Tank Spill	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.060	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		18.7	NA	NA	NA
Organic Evaporator Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.45	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		130	NA	NA	NA
Beyond Design Basis Earthquake	Less than once in 2,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.0026	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		0.78	NA	NA	NA

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
OWST Loss of Confinement	Once in 140,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		3.2	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		950[f]	NA	NA	NA
Loss of Cooling	Once in 170,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.0015	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		0.44	NA	NA	NA
Benzene Explosion in the OWST	Once in 770,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		30	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		8,840[g]	NA	NA	NA

L6-28

NA = not applicable.
a. Accident impacts based on bounding case.
b. Probability of latent cancer fatality (LCF) to the exposed individual.
c. An acute dose to an individual over 300 rem would likely result in death.
d. PHC = precipitate hydrolysis cell.
e. Individuals exposed to sodium hydroxide concentrations above 0.5 mg/m^3 could experience mild transient health effects (headache, nausea, rash) or perception of a clearly defined objectionable odor.
f. Individuals exposed to benzene concentrations above 480 mg/m^3 could experience or develop irreversible kidney damage or other serious health effects (dizziness, confusion, impaired vision).
g. Individuals exposed to benzene concentrations above 3,190 mg/m^3 could experience or develop life-threatening health effects (loss of consciousness, cardiac dysrhythmia, respiratory arrest).

resulting from an Organic Waste Storage Tank (OWST) loss of confinement accident could develop irreversible (e.g., kidney damage) or other serious health effects that may impair their ability to take protective action (e.g., dizziness, confusion, impaired vision). Workers exposed to airborne benzene concentrations (8,840 mg/m^3) resulting from an explosion in the OWST could experience life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory arrest). Both of these accidents would occur less than once in 100,000 years and are in the extremely unlikely category.

Pilot Plant – Under the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives, DOE would design, construct, and operate 1/100 to 1/10 scale pilot plant to demonstrate the salt processing technology. No Pilot Plant is needed for the Direct Disposal in Grout alternative because the technology has already been demonstrated in the existing Saltstone Manufacturing and Disposal Facility. Because the Pilot Plant would be a scaled-down version of the salt processing facility, impact would typically be no more than 10 percent of that for the full-sized facility.

2.9.2 LONG-TERM IMPACTS

Section 4.2 of the Draft SEIS discusses the long-term impacts associated with disposing of fractions of the salt solutions as a saltstone grout in Z-Area vaults. DOE estimated long-term impacts by doing a performance assessment that included fate and transport modeling

to determine when certain impacts (e.g., radiation dose) could reach a maximum value. DOE used the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (Martin Marietta 1992) as the basis for analysis of the long-term water resource and human health impacts. This performance assessment was based on the original saltstone that would have resulted from the ITP process.

Analytical results, particularly those attempting to predict impacts over a long period of time, always have some uncertainties. Uncertainties could be associated with assumptions used, the complexity and variability of the process being analyzed, or incomplete or unavailable information. The uncertainties involved in estimating the long-term impacts analyzed in this SEIS are described in Appendix D.

This section presents estimates of long-term impacts of the four salt processing action alternatives and the No Action alternatives. For all the action alternatives, the major source of long-term impacts would be the saltstone that would result from each of the four alternatives. As discussed in Chapter 2, the saltstone vaults would be located in Z Area, regardless of the selected alternative. Therefore, this SEIS analyzes impacts only from the placement of saltstone in Z Area. Short-term impacts of manufacturing the saltstone are included in Section 4.1.

L3-2
L6-4
L7-3
L8-5
L8-6

For NEPA analysis of long-term impacts of the action alternatives, DOE assumed that institutional control would be maintained for 100 years post-closure, during which the land encompassing the saltstone vaults would be managed to prevent erosion or other conditions that would lead to early degradation of the vaults. DOE also assumed that the public would not have access to Z Area during this time to set up residence. DOE estimated long-term impacts by doing a performance evaluation that included fate and transport modeling to determine when certain impacts (e.g., radiation dose) could peak. DOE used the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (WSRC 1992) (RPA) as the basis for the water resources and human health analyses. This performance assessment was done for the original saltstone that would have resulted from the In-Tank Precipitation process. For this SEIS, DOE modified the source terms for each of the action alternatives. See Appendix D for details of the analysis.

For NEPA analysis of long-term impacts of the No Action alternative, DOE assumes that the sludge in the HLW tanks would be processed to the extent practicable so that only salt waste would be left in the tanks, and the tanks would be nearly full. It is also assumed that DOE would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves but would maintain institutional control and would maintain the tanks for 100 years. Following this 100-year period of institutional control, the HLW tanks would begin to fail. Failed tanks could create physical hazards to humans and wildlife in the area. Waste contaminants could be released from tanks into groundwater and the contaminants would eventually migrate to surface water. Precipitation could infiltrate into failed tanks, causing them to overflow and spill dissolved salt onto the ground surface. Salt solutions spilled onto the ground surface could contaminante the soil, vegetation, and groundwater, and could flow overland to surface streams (Upper Three Runs, Fourmile Branch, and the Savannah River). People who intruded into the site vicinity could receive radiation exposure by external exposure to contaminated soil or by consuming contaminated surface water, groundwater, or vegetation, or eating meat or dairy products from animals that had consumed such water or vegetation.

L3-2
L6-4
L7-3
L8-5
L8-6

In the Draft SEIS, DOE did not model the eventual release of salt waste to the environment under the No Action alternative. Instead, DOE provided a comparison to the modeling results from the No Action alternative in the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000). In the Tank Closure Draft EIS No Action scenario, most of the waste would be removed

from the HLW tanks (i.e., approximately 10,000 gallons would remain as residual waste in a 1.3-million-gallon tank). After a period of several hundred years, the remaining waste, 200 curies of long half-life isotopes and 9,900 curies of cesium-137 (which has a relatively short half-life of 30 years), would be released to groundwater and eventually migrate to surface water. The Tank Closure Draft EIS modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime dose of 430 millirem (primarily from groundwater) and incur an incremental risk of 0.0022 of contracting a fatal cancer. For comparison, in the No Action alternative in the Salt Processing Alternatives Draft SEIS, DOE assumed that HLW would be left in the tanks and the tanks would be nearly full and that 160,000,000 curies (primarily cesium-137) in the salt component and 290,000,000 curies (primarily long half-life isotopes) in the sludge component of the HLW in the storage tanks would be released to groundwater and eventually enter surface water. This analysis did not take credit for any decay of the short half-life radionuclides, particularly cesium-137. Because the activity under this scenario (450,000,000 curies) would be much greater than the activity (10,000 curies) modeled in the Tank Closure Draft EIS, the Salt Processing Alternatives Draft SEIS stated that long-term impacts to human health resulting from the radiation dose under the No Action alternatives would be catastrophic.

L3-2
L6-4
L7-3
L8-5
L8-6

During the public comment period, DOE received several comments from the public (See Appendix C, Letters L3, L6, L7, and L8) questioning the description of the No Action alternative and its impacts. The commenters generally expressed the opinion that the long-term impacts of No Action would be more severe than portrayed qualitatively in the Salt Processing Alternatives Draft SEIS and requested that the No Action alternative be modified and the long-term impacts analyzed quantitatively. One commenter suggested that, to be consistent with the short-term No Action scenario described in Section 2.3, the long-term No Action scenario should contain the consequences of removing all the sludge and leaving the salt waste containing 160,000,000 curies of activity (primarily cesium-137) in the tanks. In addition, several commenters suggested that, by assuming all radionuclides would reach the public through groundwater, the Salt Processing Alternatives Draft SEIS missed the largest long-term risk to the public and that DOE should consider the release of HLW to surface run-off.

In response to these comments, for this Final Salt Processing Alternatives SEIS, DOE modeled the potential impacts of a scenario in which precipitation leaks into the tanks, causing them to overflow and spill their contents onto the ground surface, from which contaminants migrate to surface streams.

DOE estimated that the salt waste in the HLW tanks now contains about 160,000,000 curies, approximately 500 curies of long half-life isotopes (e.g., technetium-99, iodine-129, and plutonium-239), and the balance short half-life isotopes, primarily cesium-137, which has a half-life of 30 years. Radioactive decay during the 100-year period of institutional control would reduce the activity level to around 16,000,000 curies.

L6-5

To conservatively estimate the consequences of this scenario for water users, DOE modeled the eventual release of the salt waste to surface water at SRS, assuming no loss of contaminants during overland flow. The modeling showed that an individual consuming 2 liters per day of water from Fourmile Branch would receive a dose of 640 millirem per year. This dose is more than 160 times the drinking water regulatory limit of 4 millirem per year and would result in a 2.2 percent increase in the probability of contracting a latent cancer fatality from a 70-year lifetime exposure. While a 2.2 percent increase is low, the probability of contracting a latent cancer fatality under the No Action alternative is about 13,000 times greater than that of any of the action alternatives. Similarly, an individual consuming the same amount of water from Upper Three Runs would receive a dose of 295 millirem per year, and an individual consuming the same amount of water from the Savannah River would re-

ceive a dose of 14.5 millirem per year. These doses also exceed the drinking water limit and would incrementally increase the probability of contracting a latent cancer fatality from a 70-year lifetime exposure by 1.0 percent and 0.051 percent, respectively.

For the No Action alternative, DOE also considered potential external radiation exposure from the tank overflow scenario described above for a resident in the tank farm area conservatively assuming that all contamination is
L6-5 deposited on the ground surface rather than flowing to streams or entering the underlying soil. The modeling showed that an individual living in the tank farm would receive an external dose of about 2,320 rem in the first year following the event, which would result in a prompt fatality.

DOE expects that those two scenarios bound the potential impacts of the No Action alternative. This is consistent with results of a multipathway exposure analysis for the Z-Area vaults which showed that the external radiation dose an individual would receive from cesium-137 is considerably greater than doses an individual would receive from other exposure pathways (e.g., drinking water).

Because of the assumption that, in the long term, DOE would not be active at the Site, there would be no long-term impacts to socioeconomics, utilities and energy, worker health, traffic and transportation, or waste generation. Air and accident impacts would be very small and would not differ substantially among alternatives. Section 4.2 does not analyze or discuss long-term impacts to these resources. The following impact areas are analyzed: geologic resources, water resources (groundwater and surface water), ecological resources, land use, and public health. Table 2-8 summarizes the long-term impacts to these resources.

Geologic resources – No detrimental effect on topography or on the structural or load-bearing properties of the geologic deposits would occur as a result of saltstone manufactured by any of the analyzed action alternatives.

Under the No Action alternative, DOE assumed that only salt waste would be left in the HLW tanks. Failure of the HLW tanks would allow precipitation to collect in the tanks and eventually salt solution could overflow and contaminate surface soils. No detrimental effect on topography or load-bearing properties of geologic deposits would result from release of contaminants from the HLW tanks. The contaminants would contaminate nearby soils, but would not alter their physical structure.

Surface water – Based on modeling results, the saltstone manufactured under all action alternatives would be effective in limiting the long-term movement of residual contaminants from Z Area to nearby streams via groundwater. Radiological doses at the seeplines of Upper Three Runs and McQueen Branch would be orders of magnitude below the drinking water standard of 4 millirem per year. Concentrations of nonradiological contaminants (primarily **nitrate**) moving to Upper Three Runs via McQueen Branch or the Upper Three Runs seepline would be very low; in most cases, they would be several times below applicable standards. For all action alternatives, predicted long-term concentrations of nonradiological contaminants would be well below applicable water quality standards.

Under the No Action alternative, after failure of the HLW tanks, salt solution could overflow and run off to onsite streams (Upper Three Runs, Fourmile Branch, and the Savannah River). The runoff would mix with the stream flow. Assuming that the upstream concentration of all contaminants would be zero and no groundwater infiltration occurred, the radioactivity in Fourmile Branch would be 4.95×10^{-6} curies per liter resulting in a drinking water dose to an individual of 640 millirem per year. Similarly, Upper Three Runs radioactivity would be 2.28×10^{-6} curies per liter and Savannah River radioactivity would be 1.12×10^{-7} curies per liter, respectively.

L6-5
L6-51

Table 2-8. Summary comparison of long-term impacts by salt processing alternative. Bolded values indicate greatest impacts for a particular parameter.

Parameter	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Geologic Resources					
	After tank failure soils could become contaminated.	After saltstone degradation, soil could become contaminated.	After saltstone degradation, soil could become contaminated.	After saltstone degradation, soil could become contaminated.	After saltstone degradation, soil could become contaminated.
Surface Water					
	Contaminants could be transported overland to surface water.	Contaminants in groundwater could be transported to downgradient surface waters, but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters but concentrations would be very low.	Contaminants in groundwater could be transported to down-gradient surface waters but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters, but concentrations would be very low.
Groundwater					
Maximum radiation dose (mrem/yr) 1 meter downgradient of vaults	NA	0.49	**0.58**	0.45	0.57
Maximum radiation dose (mrem/yr) 100 meters downgradient of vaults	**640**[a]	0.042	0.044	0.038	0.048
Maximum radiation dose (mrem/yr) at seepline	NA	0.0029	0.0028	0.0025	**0.0032**
Maximum nitrate concentration (mg/L) 1 meter downgradient of vaults	NA	338	**395**	307	394

L6-28

Table 2-8. (Continued).

Parameter	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	
Maximum nitrate concentration (mg/L) 100 meters downgradient of vaults	NA	29	31	26	**33**	L6-28
Maximum nitrate concentration at seepline (mg/L)	NA	2.2	2.1	1.9	**2.4**	
Ecological Resources						
	Ecological receptors could encounter severe adverse impacts.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	
Land Use						
	The area around the tank farms would be too contaminated to support human or ecological habitats.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	
Radiation dose from Agricultural Scenario *(mrem/yr)*	NA	110	130	110	**140**	
Latent Cancer Fatalities from Agricultural Scenario[b]	NA	0.0018	0 0.0046	0.0039	**0.0049**	L6-28 L6-32
Radiation dose from Residential Scenario at 100 years post-closure (mrem/yr)[d]	**2,320,000**[b,c]	0.11	0.13	0.1	1,200	

Table 2-8. (Continued).

Parameter	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	
Latent Cancer Fatalities from Residential Scenario at 100 years post-closure[b,d]	**1.16**[e]	3.9×10^{-6}	4.6×10^{-6}	3.5×10^{-6}	0.042	L6-28
Radiation dose from Residential Scenario at 1,000 years post-closure (mrem/yr)[d]	NA	69	80	65	**85**	L6-32
Latent Cancer Fatalities from Residential Scenario at 1,000 years post-closure[b,d]	NA	0.0024	0.0028	0.0023	**0.0030**	L6-33

a. Based on consumption of contaminated surface water in Fourmile Branch.
b. Health effects are expressed as lifetime (70-year) individual probability of an LCF.
c. Based on external radiation in the area of the tank farm.
d. External radiation doses and latent cancer fatalities at 1,000 years post-closure are higher than doses 100 years post-closure because a layer of soil to provide adequate shielding is assumed to be present in the 100-year scenario, but is assumed to be absent in the 1,000-year scenario.
e. Probability of an LCF provided for comparison. The external radiation dose from the No Action alternative would result in prompt fatalities.

L4-10

mrem/yr = millirem per year.
mg/L = milligram per liter.
LCF = latent cancer fatalities.

Groundwater – Long-term impacts to the groundwater of the Upper Three Runs Aquifer and the Gordon Aquifer could occur as the saltstone degrades and releases additional contaminants to the aquifers. Based on groundwater modeling, no constituents would occur in concentrations that exceed drinking water standards in wells 100 meters from the vaults. However, for all alternatives, maximum nitrate concentrations in a well 1 meter downgradient from the vaults would exceed the established maximum contaminant level in both aquifers.

Ecological resources – The potential risk is very low to biota in Upper Three Runs or McQueen Branch from long-term effects of saltstone.

TC | The No Action alternative would have severe adverse impacts on the ecological resources in the area of the tank farms.

Land use – Long-term impacts to land use at Z Area would occur. The placement of 13 to 16 additional vaults that will contain radioactive cementitious grout for up to 10,000 years would limit other uses of the land in Z Area.

L6-60 | Because of the contamination under the No Action alternative, future land use at SRS tank farms would not support human or ecological habitats.

Public health – Although the vaults would contain radioactive cementitious grout for up to 10,000 years, DOE evaluated the long-term impacts to public health, using the methods developed in the original radiological performance assessment prepared for the Z-Area Saltstone Manufacturing and Disposal Facility. This included determining concentrations in groundwater and radiological doses from those concentrations, radiological doses from crops grown on the vaults, doses from living in a home constructed on the vaults 100 years after closure, and doses from living in a home on the vault site 1,000 years after closure.

The differences in calculated concentrations and doses among the alternatives are a function primarily of the differences in composition of the saltstone by alternative. The Small Tank Precipitation alternative would produce a saltstone that is very similar to that originally planned for the ITP process. The Ion Exchange alternative would result in a saltstone with slightly more concentrated contaminants, thus causing greater impacts. The Solvent Extraction alternative would produce a saltstone with slightly lower contaminant concentrations, resulting in smaller impacts. The Direct Disposal in Grout alternative would produce saltstone with radioactive cesium concentrations many times higher than the other alternatives, but with only slightly higher concentrations of other contaminants.

As shown in Table 2-8, the Direct Disposal in Grout alternative results in higher doses and greater health effects over the long term than the other action alternatives. However, for all action alternatives the projected number of latent cancer fatalities is very much less than one and DOE does not therefore expect any alternative to result in adverse health effects over the long term.

As discussed above for the No Action alternative, an individual consuming 2 liters per day of water from Fourmile Branch would receive a dose of 640 millirem per year. This dose is more than 160 times the drinking water regulatory limit of 4 millirem per year and would result in a 2.2 percent increase in the probability of contracting a latent cancer fatality from a 70-year lifetime exposure. While a 2.2 percent increase is low, the probability of contracting a latent cancer fatality under the No Action alternative is about 13,000 times greater than that of any of the action alternatives. L6-5 L6-51

For the No Action alternative, an individual living in the tank farm area would receive an external dose of about 2,320,000 millirem in the first year following the event, which would result in a prompt fatality. L6-5 L6-51

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CHAPTER 3. AFFECTED ENVIRONMENT

The affected environment is the baseline for assessing potential impacts of the alternatives considered in this Draft Supplemental Environmental Impact Statement (SEIS). The information in this chapter comes primarily from the comprehensive environmental monitoring and surveillance programs that the U.S. Department of Energy (DOE) maintains at the Savannah River Site (SRS). DOE performs effluent monitoring and environmental surveillance within a 31,000-square-mile area surrounding the SRS (out to a distance of 100 miles from the Site boundary) that includes cities, towns, and counties in Georgia and South Carolina.

This chapter describes the following:

- Land use, biota, geology and soils, and cultural features of locations on the SRS that could host salt processing activities
- Site and regional ambient conditions for air, surface water, and groundwater
- Socioeconomic conditions of the counties and communities that compose the SRS region of influence, information on the location of minority and low-income populations, and projections of regional growth and related socioeconomic indicators.

In addition, this chapter presents information on existing facilities and the SRS infrastructure to provide a basis for an examination of the capacity of existing systems to handle projected waste streams, power and water requirements, and inter-area transportation.

As mentioned in Chapter 2, Section 2.5, DOE proposes to locate salt processing activities in either S Area or Z Area of SRS. S Area is approximately 270 acres and Z Area is about 180 acres. Both sites are within existing heavily industrialized zones. Regardless of where salt processing activities occur, grout disposal would be in vaults in Z Area.

Westinghouse Savannah River Company (WSRC) uses a formal, documented facility site selection process. Criteria include: proximity to existing, related facilities; sufficient acreage; and ecological, human health, geoscience and engineering considerations. Applying this process to the requirements for a salt processing facility identified four potential sites (Sites A – D; Figures 2-2 and 3-1) for Small Tank Precipitation, Ion Exchange, or Solvent Extraction facilities. Selection of the primary site was based on subsequent geotechnical characterization. The site in Z Area selected for the Direct Disposal in Grout facility was chosen because a grout-production facility that would be modified is located there. Z Area was selected as the saltstone disposal site prior to construction of the Defense Waste Processing Facility (DWPF) (DOE 1982).

The primary site (Site B in S Area; see Figure 2-2) for a Small Tank Precipitation, Ion Exchange, or Solvent Extraction facility is approximately 25 acres. It is 950 feet east-southeast of the DWPF and approximately 650 feet east of the Low Point Pump Pit between H Area and DWPF. The site was used as a laydown area during construction of DWPF, and is situated along an eastward slope of a previously existing topographic high point. The land surface is flat, gently sloping, and covered with grass and gravel. The surface elevation is about 280 feet above mean sea level (msl) (Figure 3-1) (WSRC 2000a).

Z Area is partially developed and contains the Saltstone Manufacturing and Disposal Facility, two vaults, a paved parking area, a rail spur, and perimeter road. Surface elevation ranges from about 270 to 300 feet above msl (Figure 3-2). The land at the site for a Direct Disposal in Grout facility is presently mounded with excavated soils and covered with grass (Shedrow and Wike 1999). The site covers approximately 15 acres.

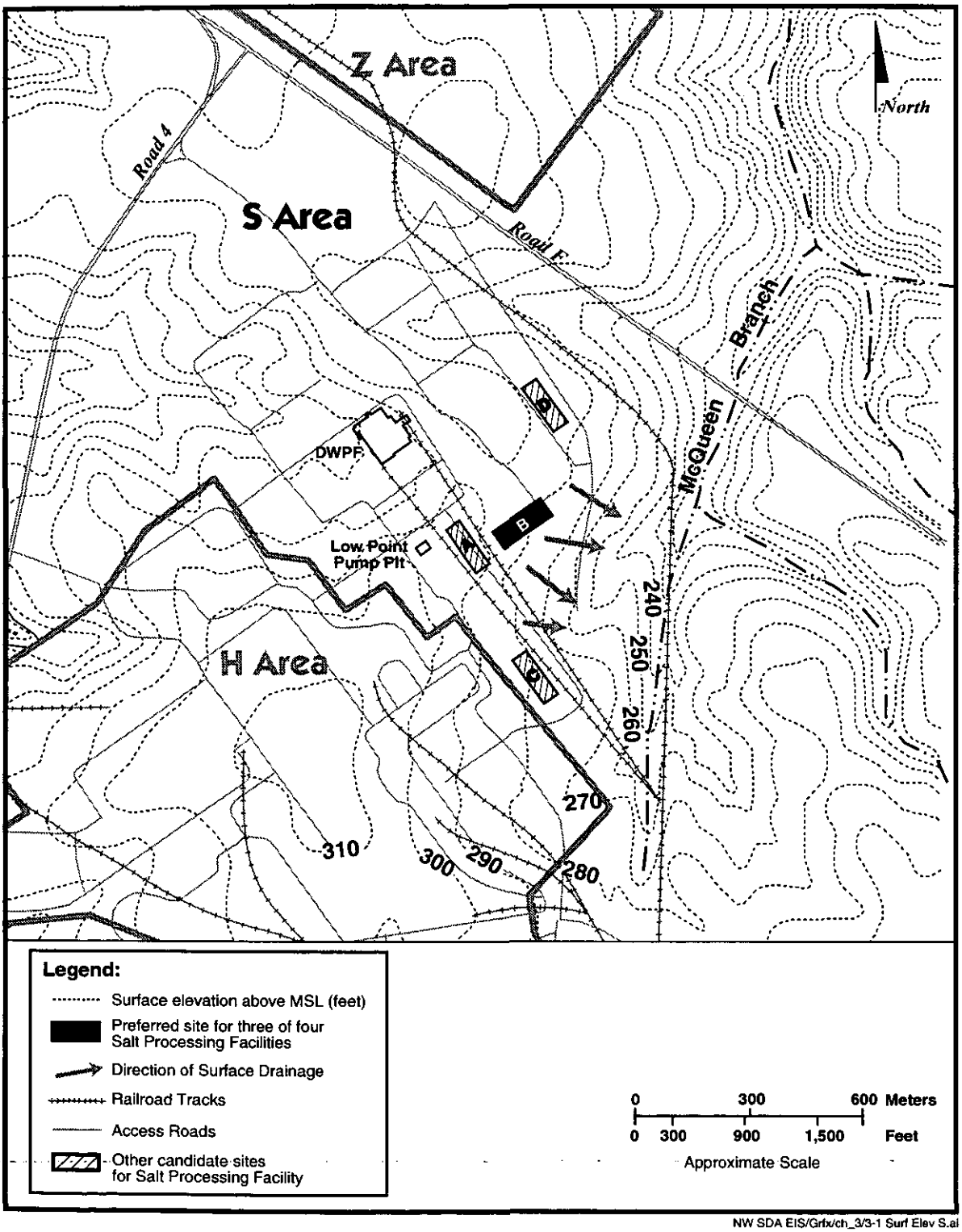


Figure 3-1. Surface elevation and direction of surface drainage in the vicinity of S Area.

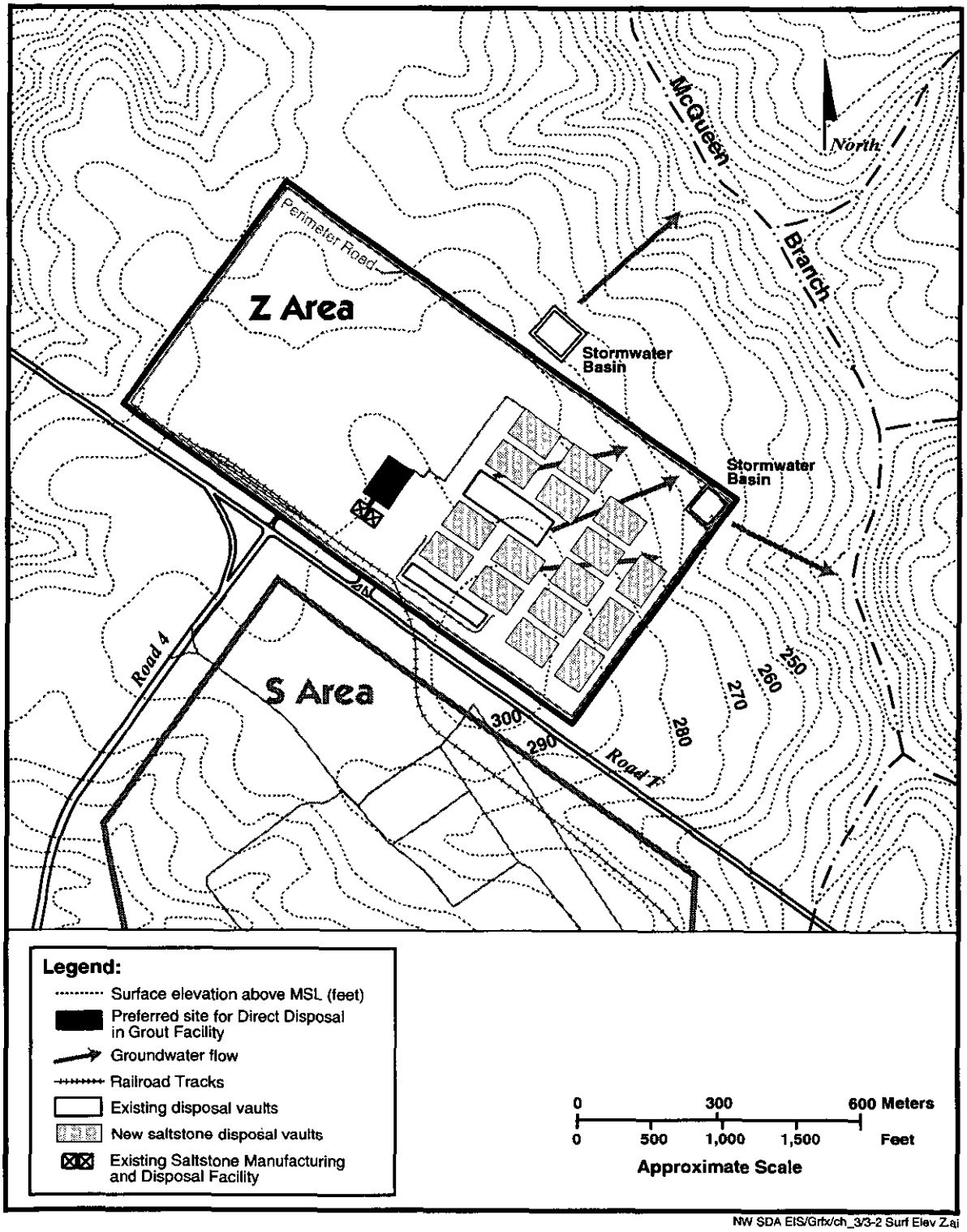


Figure 3-2. Surface elevation and direction of surface drainage in the vicinity of Z Area.

The remaining sections of this chapter characterize the SRS and its environs, as well as pertinent information on Site B in S Area and the Z-Area site. Chapter 4 describes potential impacts of the No-Action alternative and the different alternatives for processing salt, including the impacts of constructing and operating processing facilities.

3.1 Geologic Setting and Seismicity

The SRS is in west-central South Carolina, approximately 100 miles from the Atlantic coast (Figure 3-3). It is on the Aiken Plateau of the Upper Atlantic Coastal Plain, about 25 miles southeast of the Fall Line that separates the Atlantic Coastal Plain from the Piedmont.

3.1.1 GENERAL GEOLOGY

In South Carolina, the Atlantic Coastal Plain province consists of a wedge of seaward-dipping and thickening unconsolidated and semiconsolidated sediments that extend from the Fall Line to the Continental Shelf. The Aiken Plateau is the subdivision of the Coastal Plain that includes SRS. Coastal Plain sediments underlying SRS consist of sandy clays and clayey sands, although occasional beds of clean sand, gravel, clay, or carbonate occur (DOE 1995a). The formations that must be considered in evaluating potential groundwater transport from S and Z Areas are part of the shallow (Floridan) aquifer system (Figure 3-4).

Surface soils at both Site B in S Area and the Z Area site are classified as Udorthents. The generic term Udorthents describes natural soil weathering horizons that have been disturbed or removed, usually by erosion or construction activities. These soils are generally well-drained and range from sandy to clayey, depending upon their origin. Dominant soil types in the undisturbed western portion of Z Area include Fuquay and Blanton soils, respectively, as shown on Figure 3-5 (USDA 1990).

3.1.2 SUBSURFACE FEATURES

A benchmark study of geophysical evidence (summarized by Wike et al. 1996) and an earlier study (Stephenson and Stieve 1992) identified the onsite geologic faults. Since these studies were published, new seismic reflection data have been acquired specifically for refinement of the fault map or in support of other characterization projects. In addition, several other relevant geologic studies relating to SRS basement geology have been completed. These studies resulted in the current map of subsurface faults shown on Figure 3-6. The lines on Figure 3-6 represent the location of the faults on the basement surface. The actual faults do not reach the surface, but stop several hundred feet below it.

Based on available information, none of the faults discussed in this section are capable, which means that none of the faults have moved at or near the ground surface within the past 35,000 years or are associated with another fault that has moved in the past 35,000 years. Appendix A of 10 CFR 100 contains a more detailed definition of a capable fault.

Rock strata under some areas of SRS include layers of pockets of carbonate rock that are subject to dissolution. Sites underlain by these "soft zones" are considered unsuitable for structural formations unless extensive soil stabilization is done. There are no carbonate soft zones underlying structures that would be built within the Site B footprint (WSRC 2000a). Of the three candidate sites, Sites B and D have equal hardness and Site C is softer. The difference would have minimal effect on the total site suitability score. In 1986, DOE conducted a geologic investigation in support of the new vaults in Z Area. Of the 23 borings extended through the calcareous layer, one major soft zone was encountered. Within the Z-Area footprint, there is sufficient area to avoid building a vault over this soft zone if soil stabilization is not successful (WSRC 1999a). TC TC

3.1.3 SEISMICITY

Two major earthquakes have occurred within 186 miles of SRS.

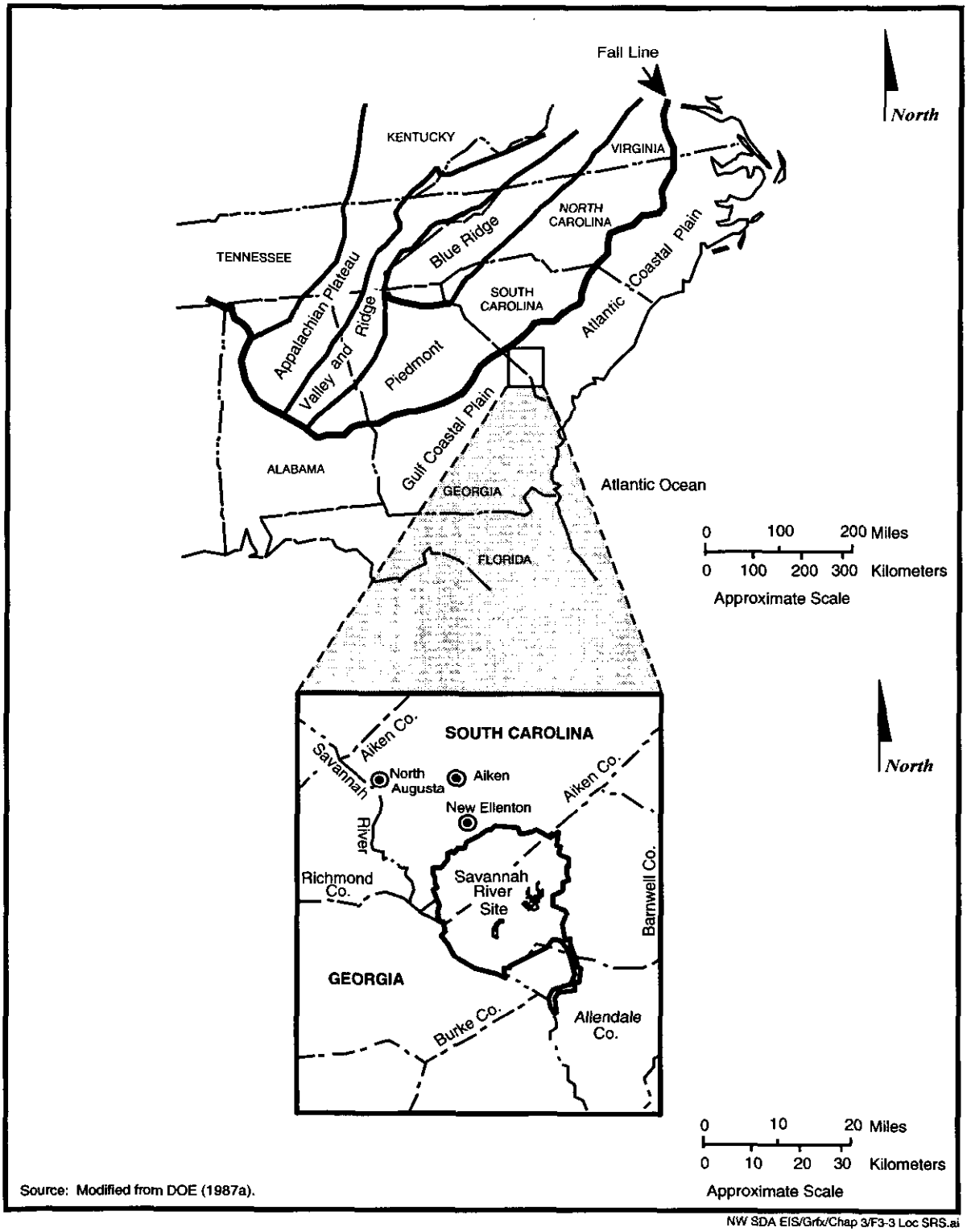
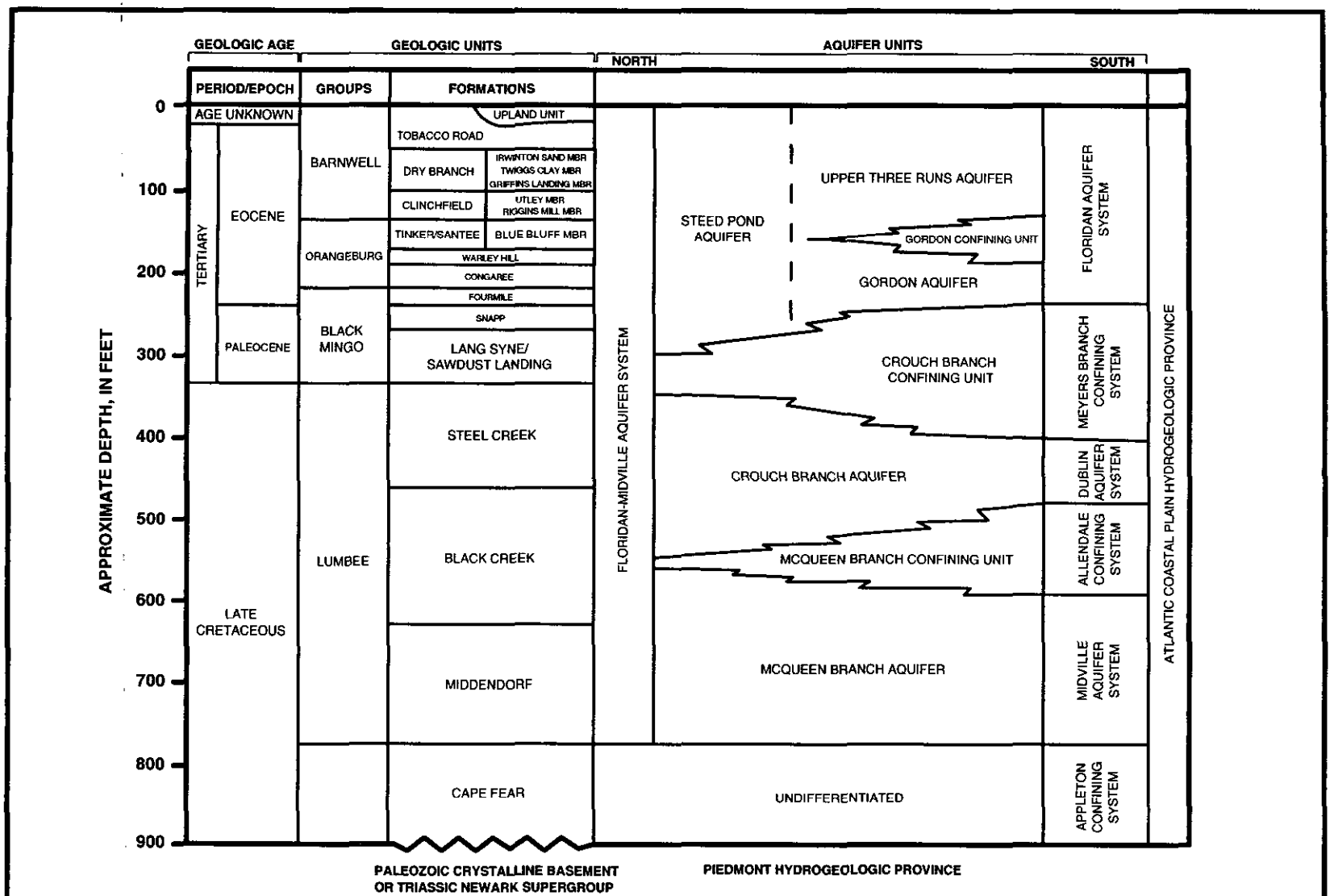


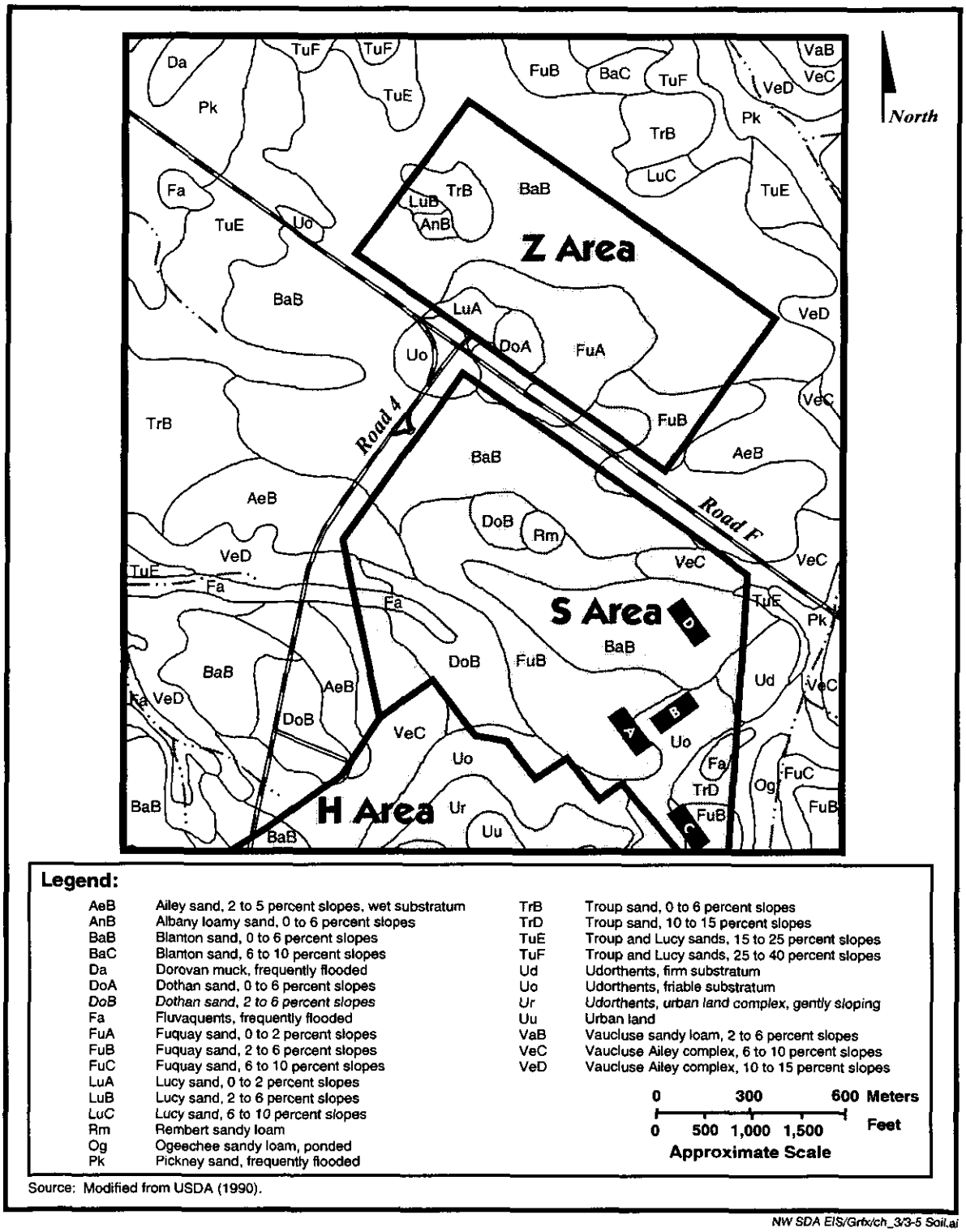
Figure 3-3. Generalized location of Savannah River Site and its relationship to physiographic provinces of southeastern United States.



Source: Aadland, Gellici, and Thayer (1995).

NW SDA EIS/Grfx/Chap 3/3-4 geo & aqu.ai

Figure 3-4. Generalized geologic and aquifer units in SRS region.



Legend:

AeB	Ailey sand, 2 to 5 percent slopes, wet substratum	TrB	Troup sand, 0 to 6 percent slopes
AnB	Albany loamy sand, 0 to 6 percent slopes	TrD	Troup sand, 10 to 15 percent slopes
BaB	Blanton sand, 0 to 6 percent slopes	TuE	Troup and Lucy sands, 15 to 25 percent slopes
BaC	Blanton sand, 6 to 10 percent slopes	TuF	Troup and Lucy sands, 25 to 40 percent slopes
Da	Dorovan muck, frequently flooded	Ud	Udorthents, firm substratum
DoA	Dothan sand, 0 to 6 percent slopes	Uo	Udorthents, friable substratum
DoB	*Dothan sand, 2 to 6 percent slopes*	Ur	*Udorthents, urban land complex, gently sloping*
Fa	Fluvaquents, frequently flooded	Uu	Urban land
FuA	Fuquay sand, 0 to 2 percent slopes	VaB	Vaucluse sandy loam, 2 to 6 percent slopes
FuB	Fuquay sand, 2 to 6 percent slopes	VeC	Vaucluse Ailey complex, 6 to 10 percent slopes
FuC	Fuquay sand, 6 to 10 percent slopes	VeD	Vaucluse Ailey complex, 10 to 15 percent slopes
LuA	Lucy sand, 0 to 2 percent slopes		
LuB	Lucy sand, 2 to 6 percent slopes		
LuC	Lucy sand, 6 to 10 percent slopes		
Rm	Rembert sandy loam		
Og	Ogeechee sandy loam, ponded		
Pk	Pickney sand, frequently flooded		

Source: Modified from USDA (1990).

NW SDA EIS/Grfx/ch_3/3-5 Soil.ai

Figure 3-5. Soil series in H, S, and Z areas.

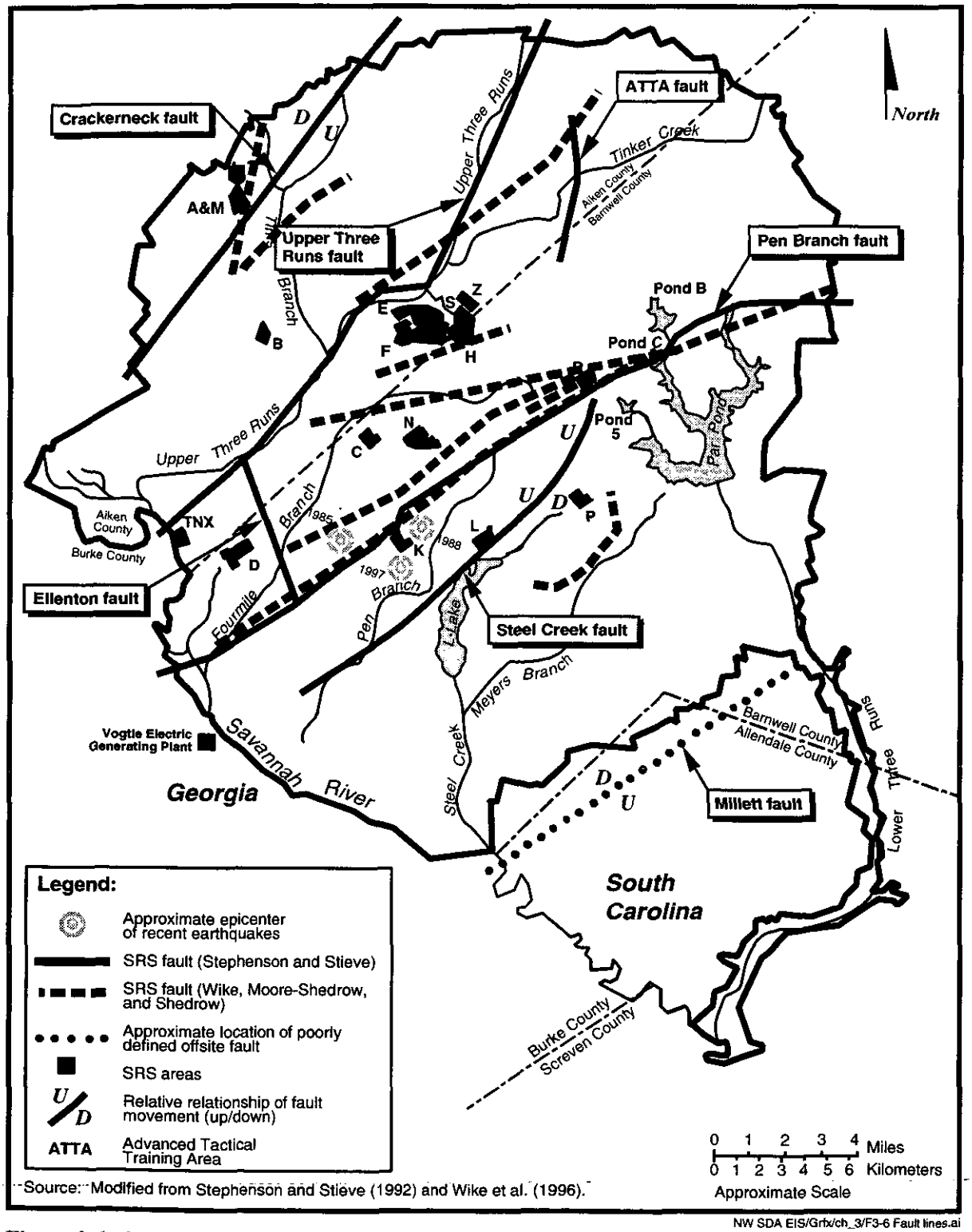


Figure 3-6. Savannah River Site, showing fault lines and locations of onsite earthquakes and their year of occurrence.

- The Charleston, South Carolina, earthquake of 1886 had an estimated Richter magnitude of 6.6; it occurred approximately 90 miles from the SRS area, which experienced an estimated peak horizontal acceleration of 8 percent of gravity (0.08g) (Lee, Maryak, and McHood 1997). Lee, Maryak, and McHood (1997) re-evaluated historical data for the 1886 event and for other earthquakes in the Charleston area and determined that the Charleston epicentral zone could produce a magnitude 7.5 earthquake.

- As summarized by Geomatrix (1991), the Union County, South Carolina, earthquake of 1913 had an estimated magnitude of 4.5 and occurred 90 to 100 miles from SRS. The Union County earthquake is included in a group of historical epicenters that form a diffuse northwesterly trending zone from the Charleston region to the Appalachian tectonic province. Within that zone, Geomatrix (1991) concluded that an earthquake of up to magnitude 6.0 could theoretically occur.

In recent years, the following three earthquakes occurred inside the SRS boundary, as reported by local print media and cited in DOE (2000a):

- On May 17, 1997, with a Richter magnitude of 2.3 and a focal depth of 3.38 miles; its epicenter was southeast of K Area

- On August 5, 1988, with a Richter magnitude of 2.0 and a focal depth of 1.6 miles; its epicenter was northeast of K Area

- On June 8, 1985, with a Richter magnitude of 2.6 and a focal depth of 3.7 miles; its epicenter was south of C Area and west of K Area.

Existing information does not relate these earthquakes conclusively with known faults under the Site. In addition, the focal depth of these earthquakes is currently being reevaluated. Figure 3-6 shows the locations of the epicenters of these earthquakes.

Outside the SRS boundary, an earthquake with a Richter scale magnitude of 3.2 occurred on August 8, 1993, approximately 10 miles east of the City of Aiken near Couchton, South Carolina. People reported feeling this earthquake in Aiken, New Ellenton (immediately north of SRS), North Augusta (approximately 25 miles northwest of the SRS), and on the Site (Aiken Standard 1993).

3.2 Water Resources

This section describes surface and subsurface water in the area potentially affected by the proposed action. Surface water and groundwater are characterized in terms of flow and quality (physical properties and concentrations of chemicals and contaminants).

3.2.1 SURFACE WATER

The Savannah River bounds SRS on its southwestern border for about 20 miles, approximately 160 river miles from the Atlantic Ocean. Five upstream reservoirs – Jocassee, Keowee, Hartwell, Richard B. Russell, and Strom Thurmond – minimize the effects of droughts and the impacts of low flow on downstream water quality and fish and wildlife resources in the river. River flow averages about 10,000 cubic feet per second at SRS (DOE 1995b).

Approximately 130 river miles downstream of SRS, the river supplies domestic and industrial water for Savannah, Georgia, and Beaufort and Jasper Counties in South Carolina through intakes at about River Mile 29 and River Mile 39, respectively (DOE 1995b).

The SRS streams that could be affected by the alternatives are blackwater streams, which means that the water has a dark coloration due to the dissolution of natural organic matter from soils and decaying vegetation. Three SRS streams potentially could be affected by salt processing alternatives: McQueen Branch, Upper Three Runs, and Fourmile Branch

(Figure 3-7). Of the three, only Fourmile Branch ever received the high flows and elevated temperatures associated with thermal discharges from nuclear reactors. McQueen Branch, which lies east of the proposed facilities, receives surface runoff from both proposed sites (Figures 3-1 and 3-2) and potentially could be affected by land-disturbing construction activities. Process wastewater from salt processing operations would be treated in the Effluent Treatment Facility (ETF) and discharged to Upper Three Runs via National Pollutant Discharge Elimination System (NPDES) outfall H-16. Sanitary wastewater from salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES outfall G-10 (WSRC 1999b).

McQueen Branch flows approximately 3 miles from its headwaters east of H Area to its confluence with Tinker Creek (see Figure 3-7). Tinker Creek flows west for several hundred feet before entering Upper Three Runs, approximately 1 mile north of Z Area. McQueen Branch is a shallow blackwater stream with an average width of approximately 6 feet. For most of its length, it lies in a bottomland hardwood forest.

Upper Three Runs, the longest of the SRS streams, is a large blackwater stream in the northern part of SRS that discharges to the Savannah River. It drains an area of over 195 square miles and is approximately 25 miles long, with its lower 17 miles within SRS boundaries. This creek receives more water from underground sources than other SRS streams and is the only stream with headwaters arising outside the Site. It is the only major tributary on SRS that has not received thermal discharges from nuclear reactors; however, it does receive NPDES-permitted wastewater discharges from other SRS facilities (Halverson et al. 1997).

Fourmile Branch is a blackwater stream that originates near the center of SRS and flows southwest for 15 miles before emptying into the Savannah River (Halverson et al. 1997). It drains an area of about 22 square miles, including much of F, H, and C Areas. In its lower reaches, Fourmile Branch broadens and flows via braided channels through a delta formed by the disposition of sediments eroded form upstream during high flows associated with reactor operations. Downstream from the delta, the channels rejoin into one main channel. Most of the flow discharges into the Savannah River, while a small portion flows west and enters Beaver Dam Creek (DOE 1995b).

From 1974 to 1995, the mean flow of Upper Three Runs at Road A was 245 cubic feet per second, and the 7Q10 (minimum 7-day average flow rate that occurs with an average frequency of once in 10 years) was 100 cubic feet per second (Halverson et al. 1997). The *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a) contain detailed information on flow rates and water quality of the Savannah River and SRS streams.

The South Carolina Department of Health and Environmental Control (SCDHEC) regulates the physical properties and concentrations of chemicals and metals in SRS effluents under the NPDES program. A comparison of 1997 Savannah River water quality analyses showed no significant differences between stations up- and down-stream of SRS (Arnett and Mamatey 1998a). Table 3-1 summarizes the water quality of Fourmile Branch and Upper Three Runs for 1997. Occasionally, reported concentrations in Table 3-1 exceed water quality criterion (see, for example, aluminum). An exceedance suggests the potential for adverse effects to aquatic biota, but should not be construed as an actual risk. Water quality criteria are based on laboratory studies that do not take into account site-specific ameliorative or mediating factors in the environment that reduce or limit the bioavailability of a chemical. Concentrations that exceed water quality criteria may have natural or anthropogenic origins.

In 1997, major releases of radionuclides from the SRS to surface waters amounted to 8,950

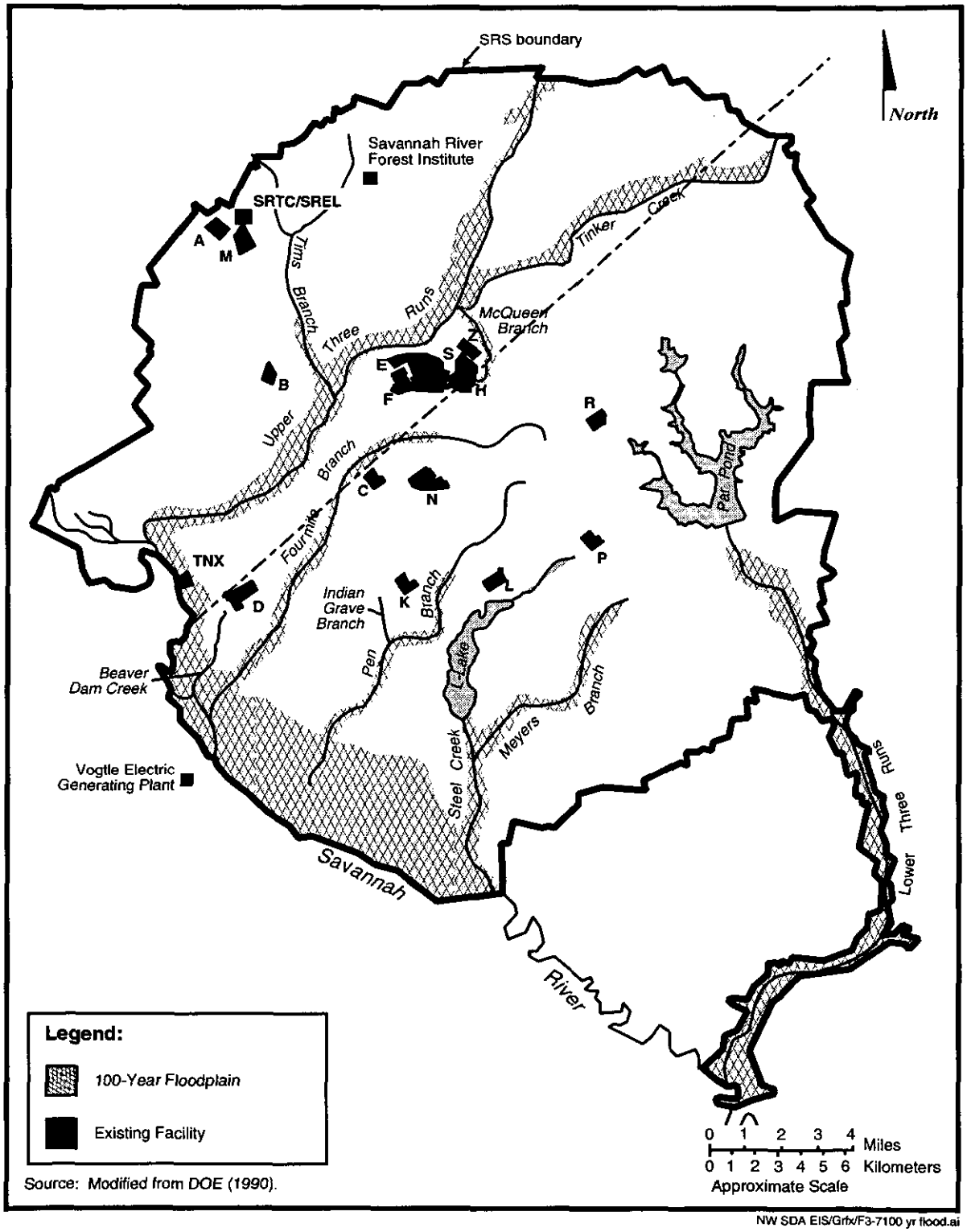


Figure 3-7. Savannah River Site, showing 100-year floodplain and major stream systems.

Table 3-1. SRS stream water quality (onsite downstream locations).

Parameter[a]	Units	Upper Three Runs (U3R-4) (average)	Water Quality Standard[b]
Aluminum	mg/L	0.274[c]	0.087
Cadmium	mg/L	ND[d]	0.00066
Calcium	mg/L	1.62	NA[e]
Cesium-137	pCi/L	0.67	120[f]
Chromium	mg/L	ND	0.011
Copper	mg/L	0.036[c]	0.0065
Dissolved oxygen	mg/L	8.2	≥5
Iron	mg/L	0.586	1
Lead	mg/L	ND	0.0013
Magnesium	mg/L	0.385[c]	0.3
Manganese	mg/L	0.026	1
Mercury	mg/L	ND	0.000012
Nickel	mg/L	0.012	0.088
Nitrate	mg/L	0.24	10[g]
pH	pH	6.3	6-8.5
Plutonium-238	pCi/L	ND	1.6[f]
Plutonium-239	pCi/L	0.0005	1.2[f]
Sodium	mg/L	1.58	NA
Strontium-89,90	pCi/L	0.061	8[g]
Suspended solids	mg/L	14.1	NA
Temperature[h]	°C	17.3	32.2
Total dissolved solids	mg/L	36	500[i]
Tritium	pCi/L	4.260	20,000[g]
Uranium-234	pCi/L	0.093	20[f,j]
Uranium-235	pCi/L	0.046	24[f,j]
Uranium-238	pCi/L	0.110	24[f,j]
Zinc	mg/L	0.028	0.059

L4-5

Source: Arnett and Mamatey (1998a).

a. Parameters DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.
b. Water Quality Criteria for aquatic life unless otherwise indicated.
c. Concentration exceeded WQC; however, these criteria are for comparison only. WQCs are not legally enforceable.
d. ND = Not detected.
e. NA = Not applicable.
f. MCL = Maximum Contaminant Level; State Primary Drinking Water Regulations.
g. DCG = DOE Derived Concentration Guides for Water (DOE Order 5400.5). DCG values are based on committed effective dose of 100 millirem per year; however, because drinking water MCL is based on 4 millirem per year, value listed is 4 percent of DCG.
h. Shall not be increased more than 2.8°C (5°F) above natural temperature conditions or exceed a maximum of 32.2°C (90°F) as a result of the discharge of heated liquids, unless appropriate temperature criterion mixing zone has been established.
i. Secondary MCL; State Drinking Water Regulations.
j. EPA MCL for uranium is 30 µg/L, which is equivalent to 27 pCi/L. Because the DCG is a lower concentration, DOE uses it for the uranium standard.

L4-5
L4-6
L8-9
L11-7

curies of tritium, 0.262 curie of strontium-89 and -90, and 0.177 curie of cesium-137 (Arnett and Mamatey 1998b). Table 3-2 lists radioactive liquid releases by source for 1997; Table 3-3 lists radioactive liquid releases by outfall or facility and compares annual average radionuclide concentrations to DOE concentration guides. Figure 3-8 shows outfall and facility locations for radioactive surveillance. The resulting dose to a downriver consumer of river water from radionuclides released from the Site was less than 2 percent of the U.S. Environmental Protection Agency (EPA) and DOE standards for public water supplies (40 CFR Part 141 and DOE Order 5400.5, respectively) and less than 0.1 percent of the DOE dose standard from all pathways (DOE 1990; Arnett and Mamatey 1998b). Table 3-4 lists potential contributors of contamination to Upper Three Runs and Fourmile Branch.

3.2.2 GROUNDWATER RESOURCES

3.2.2.1 Groundwater Features

In the SRS region, the subsurface contains two hydrogeologic provinces. The uppermost, consisting of a wedge of unconsolidated Coastal Plain sediments of Late Cretaceous and Tertiary age, is the Atlantic Coastal Plain hydrogeologic province. Beneath the sediments of the Atlantic Coastal Plain hydrogeologic province are rocks of the Piedmont hydrogeologic province. These rocks consist of Paleozoic igneous and metamorphic basement rocks and Upper Triassic Age lithified mudstone, sandstone, and conglomerates of the Upper Triassic Dunbarton basin. Sediments of the Atlantic Coastal Plain hydro

Table 3-2. Annual liquid releases by source for 1997 (including direct and seepage basin migration releases).

		Curies					
Radionuclide[a]	Half-life (years)	Reactors	Separations[b]	Reactor materials	TNX	SRTC	Total
H-3 (oxide)	12.3	2.91×10^{3}	5.24×10^{3}		4.02×10^{2}	1.82	8.55×10^{3}
Sr-89,90[c]	29.1	6.46×10^{-2}	1.40×10^{-1}		5.09×10^{-3}	4.10×10^{-3}	2.14×10^{-1}
I-129[d]	1.6×10^{7}		7.82×10^{-2}				7.82×10^{-2}
Cs-137	30.2	2.86×10^{-3}	4.49×10^{-2}				4.78×10^{-2}
U-234	2.46×10^{5}	4.45×10^{-3}	2.30×10^{-2}	2.68×10^{-5}	1.52×10^{-6}	1.06×10^{-4}	2.76×10^{-2}
U-235	7.04×10^{8}	4.91×10^{-5}	7.23×10^{-4}		1.37×10^{-7}	3.44×10^{-6}	7.76×10^{-4}
U-238	4.47×10^{9}	3.83×10^{-3}	2.57×10^{-2}	5.71×10^{-5}	9.19×10^{-6}	1.11×10^{-4}	2.97×10^{-2}
38	87.7	4.24×10^{-5}	9.57×10^{-4}		7.68×10^{-7}	1.78×10^{-6}	1.00×10^{-3}
Pu-239[d]	24,100	1.10×10^{-2}	3.39×10^{-2}	1.14×10^{-3}	1.12×10^{-3}	3.38×10^{-3}	5.05×10^{-2}
Am-241	432.7		7.81×10^{-6}	2.11×10^{-6}			9.92×10^{-6}
Cm-244	18.1		2.93×10^{-6}	4.14×10^{-7}			3.34×10^{-6}

Notes: Blank spaces indicate no quantifiable activity.
Source: Arnett and Mamatey (1998a).
a. H = hydrogen (H-3 = tritium), Sr = strontium, I = iodine, Cs = cesium, U = uranium, Pu = plutonium, Am = americium, Cm = curium.
b. Includes separations, waste management, and tritium facilities.
c. Includes unidentified beta.
d. Includes unidentified alpha.
TNX = a technology development facility adjacent to the Savannah River.
SRTC = Savannah River Technology Center.

Table 3-3. Liquid radioactive releases by outfall/facility and comparison of annual average radionuclide concentrations to DOE derived concentration guides.[b]

Outfall or Facility	Radionuclide[a]	Quantity of Radionuclides Released during 1997 (curies)	Average Effluent Concentration during 1997 (microcuries per milliliter)	DOE DCGs[b] (microcuries per milliliter)
F Area (Separations and Waste Management)				
F-01	H-3	5.03×10^{-2}	2.54×10^{-7}	2.00×10^{-3}
	Sr-89,90	Below MDL[d]	1.02×10^{-11}	1.00×10^{-6}
	Cs-137	Below MDL	1.32×10^{-9}	3.00×10^{-6}
F-012 (281-8F Retention Basin)	H-3	7.6710^{-1}	9.83×10^{-6}	2.00×10^{-3}
	Sr-89,90	Below MDL	3.01×10^{-9}	1.00×10^{-6}
	Cs-137	1.58×10^{-3}	2.07×10^{-8}	3.00×10^{-6}
F-013 (200-F Cooling Basin)	H-3	1.73×10^{-2}	1.63×10^{-6}	2.00×10^{-3}
	Sr-89,90	3.13×10^{-5}	4.39×10^{-9}	1.00×10^{-6}
	Cs-137	5.92×10^{-4}	2.30×10^{-8}	3.00×10^{-6}
Fourmile Branch-3 (F-Area Effluent)	H-3	1.32	7.80×10^{-7}	2.00×10^{-3}
	Sr-89,90	Below MDL	4.16×10^{-10}	1.00×10^{-6}
	Cs-137	Below MDL	8.97×10^{-10}	3.00×10^{-6}
Upper Three Runs-2 (F Storm Sewer)	H-3	1.66×10^{-1}	8.78×10^{-7}	2.00×10^{-3}
	Sr-89,90	Below MDL	8.56×10^{-11}	1.00×10^{-6}
	Cs-137	Below MDL	5.13×10^{-10}	3.00×10^{-6}
	U-234	6.86×10^{-5}	3.48×10^{-10}	6.00×10^{-7}
	U-235	5.15×10^{-6}	3.02×10^{-11}	6.00×10^{-7}
	U-238	1.90×10^{-4}	9.15×10^{-10}	6.00×10^{-7}
	Pu-238	1.54×10^{-5}	9.10×10^{-11}	4.00×10^{-8}
	Pu-239	7.73×10^{-6}	4.66×10^{-11}	3.00×10^{-8}
	Am-241	7.77×10^{-6}	3.98×10^{-11}	3.00×10^{-8}
	Cm-244	2.92×10^{-6}	1.74×10^{-11}	6.00×10^{-8}
Upper Three Runs F-3 (Naval Fuel Effluent)	H-3	3.45×10^{-2}	1.46×10^{-6}	2.00×10^{-3}
	Sr-89,90	Below MDL	1.16×10^{-10}	1.00×10^{-6}
	Cs-137	Below MDL	2.47×10^{-10}	3.00×10^{-6}
	U-234	1.62×10^{-5}	8.95×10^{-10}	6.00×10^{-7}
	U-235	5.86×10^{-6}	2.30×10^{-9}	6.00×10^{-7}
	U-238	3.04×10^{-6}	1.76×10^{-10}	6.00×10^{-7}
	Pu-238	1.61×10^{-7}	6.23×10^{-12}	4.00×10^{-8}
	Pu-239	2.60×10^{-8}	5.04×10^{-12}	3.00×10^{-8}
	Am-241	4.49×10^{-8}	7.07×10^{-13}	3.00×10^{-8}
	Cm-244	9.54×10^{-9}	-6.84×10^{-11}	6.00×10^{-8}
H Area (Separations and Waste Management)				
Fourmile Branch-1C (H-Area Effluent)	H-3	3.85	9.22×10^{-6}	2.00×10^{-3}
	Sr-89,90	7.93×10^{-5}	7.05×10^{-10}	1.00×10^{-6}
	Cs-137	6.77×10^{-4}	3.27×10^{-9}	3.00×10^{-6}
H-017 (281-8H Retention Basin)	H-3	7.17×10^{-1}	1.02×10^{-5}	2.00×10^{-3}
	Sr-89,90	5.21×10^{-4}	7.91×10^{-9}	1.00×10^{-6}
	Cs-137	1.04×10^{-2}	1.11×10^{-7}	3.00×10^{-6}

Table 3-3. (Continued).

Outfall or Facility	Radionuclide[a]	Quantity of Radionuclides Released during 1997 (curies)	Average Effluent Concentration during 1997 (microcuries per milliliter)	DOE DCGs[b] (microcuries per milliliter)
H-018 (200-H Cooling Basin)	H-3	1.44×10^{-1}	2.27×10^{-5}	2.00×10^{-3}
	Sr-89,90	2.75×10^{-4}	4.58×10^{-8}	1.00×10^{-6}
	Cs-137	2.21×10^{-4}	3.71×10^{-7}	3.00×10^{-6}
HP-15 (Tritium Facility Outfall)	H-3	1.74	1.55×10^{-5}	2.00×10^{-3}
	Cs-137	Below MDL	7.75×10^{-11}	3.00×10^{-6}
HP-52 (H-Area Tank Farm)	H-3	2.43	1.30×10^{-6}	2.00×10^{-3}
	SR-89,90	Below MDL	7.67×10^{-11}	1.00×10^{-6}
	Cs-137	1.58×10^{-4}	1.92×10^{-9}	3.00×10^{-6}
McQueen Branch at Road F	H-3	1.20×10^{1}	1.05×10^{-5}	2.00×10^{-3}
	Cs-137	Below MDL	4.85×10^{-10}	3.00×10^{-6}
Upper Three Runs – 2A (Effluent Treatment Facility Outfall at Rd C)	H-3	3.82×10^{2}	4.72×10^{-3}	2.00×10^{-3}
	Sr-89,90	1.28×10^{-5}	2.24×10^{-9}	1.00×10^{-6}
	Cs-137	1.79×10^{-2}	2.16×10^{-7}	3.00×10^{-6}
S Area	H-3	9.18×10^{-1}	1.57×10^{-5}	2.0×10^{-3}
S-004 (Defense Waste Processing Facility)	Sr-89,90	2.98×10^{-6}	1.43×10^{-10}	1.00×10^{-6}
	Cs-137	Below MDL	6.30×10^{-10}	3.00×10^{-6}
	U-234	2.63×10^{-7}	1.74×10^{-11}	6.00×10^{-7}
	U-238	7.80×10^{-7}	3.13×10^{-11}	6.00×10^{-7}
	Pu-238	1.17×10^{-7}	7.08×10^{-13}	4.00×10^{-8}
	Pu-239	6.15×10^{-8}	2.79×10^{-12}	3.0×10^{-8}

Notes: MDL denotes "minimum detectable level."
Source: Arnett and Mamatey (1998a).

a. H = hydrogen (H-3 = tritium), Sr = strontium, I = iodine, Cs = cesium, U = uranium, Pu = plutonium, Am = americium, Cm = curium.

b. DCG = Derived Concentration Guide. Source: DOE Order 5400.5. In cases where different chemical forms have different DCGs, the lowest DCG for the radionuclide is given. DCGs are defined as the concentration of that radionuclide that will give a 50-year committed effective dose equivalent of 100 mrem under conditions of continuous exposure for one year. DCGs are reference values only and are not considered release limits or standards.

geologic province are divided into three aquifer systems: the Floridan Aquifer System, the Dublin Aquifer System, and the Midville Aquifer System as shown in Figure 3-4 (Aadland, Gellici, and Thayer 1995). The Meyers Branch Confining System and/or the Allendale Confining System, as shown in Figure 3-4, separate the aquifer systems.

Groundwater within the Floridan System (the shallow aquifer beneath the Site) flows slowly toward SRS streams and swamps and into the Savannah River. The depth to which onsite streams cut into soils, the lithology of the soils, and the orientation of the soil formations control the horizontal and vertical movement of the groundwater. The valleys of smaller perennial streams allow discharge from the shallow saturated geologic formations. The valleys of major tributaries of the Savannah River (e.g., Upper Three Runs) drain formations of intermediate depth, and the river valley drains deep formations.

Groundwater flow in the shallow (Floridan) aquifer system is generally horizontal, but does have a vertical component. In divide areas between surface-water drainages, the vertical component of the hydraulic gradient typically is downward. In the lower reaches of streams, groundwater again moves generally in a horizontal direction, but may have an upward vertical component.

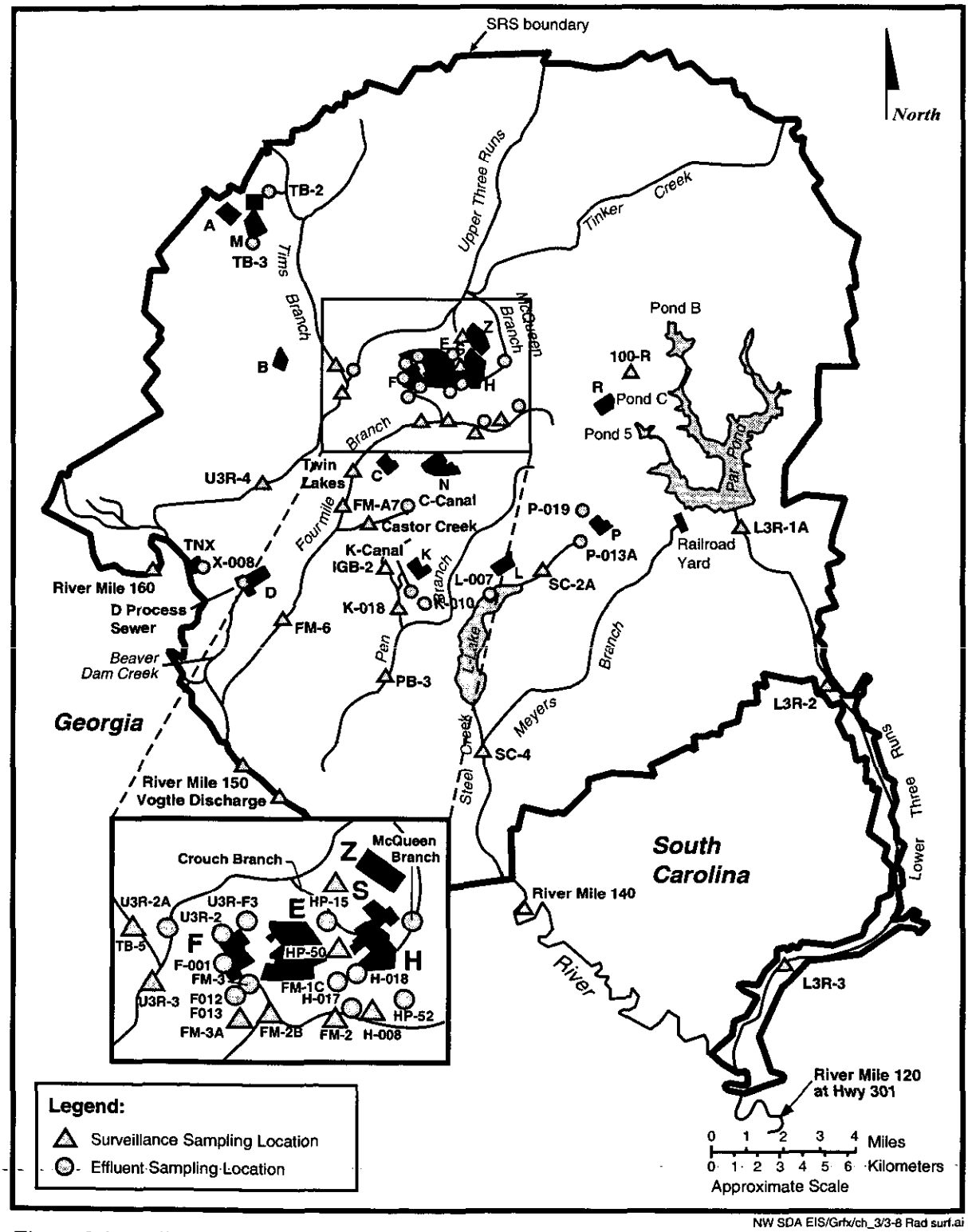


Figure 3-8. Radiological surface water sampling locations.

Table 3-4. Potential F and H Area contributors of contamination to Upper Three Runs and Fourmile Branch.

Fourmile Branch Watershed	Upper Three Runs Watershed
Burial Ground Complex Groundwater[a]	Burial Ground Complex Groundwater[a]
Burial Ground Complex: the Old Radioactive Waste Burial Ground (643-E) and Solvent Tanks S01-S22 portions	*Burial Ground Complex: the Low-Level Radioactive* Waste Disposal Facility (643-7E) portion
F-Area Coal Pile Runoff Basin, 289-F	Burma Road Rubble Pit, 231-4F
F-Area Hazardous Waste Management Facility, 904-41G, -42G, -43G	F-Area Burning/Rubble Pits, 231-F, -1F, -2F
F-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-1F	F-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-1F
F-Area Retention Basin, 281-3F	
F-Area Seepage Basin Groundwater Operable Unit	H-Area Coal Pile Runoff Basin, 289-H
H-Area Hazardous Waste Management Facility, 904-44G, -45G, -46G, -56G	
H-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-H	H-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-H
H-Area Retention Basin, 281-3H	Old F-Area Seepage Basin, 904-49G
H-Area Seepage Basin Groundwater Operable Unit	211-FB Plutonium-239 Release, 081-F
H-Area Tank Farm Groundwater	
Mixed Waste Management Facility, 643-28E	
Warner's Pond, 685-23G	

Source: WSRC (1996)
a. Units located in more than one watershed.

With the release of water to the streams, the hydraulic head of the aquifer unit releasing the water can become less than that of the underlying unit. If this occurs, groundwater has the potential to migrate upward from the lower unit to the overlying unit. For example, to the south of H Area, Fourmile Branch cuts into the Upper Three Runs Aquifer, but does not cut into the Gordon Aquifer; the hydraulic head is greater in the Gordon Aquifer than in the overlying Upper Three Runs Aquifer. At such a location, contaminants in the overlying aquifer system would be prevented from migrating into deeper aquifers by the upward hydraulic gradient.

Shallow groundwater flow in S and Z Areas is to the southwest toward Crouch Branch, to the northeast toward McQueen Branch, and to the northwest toward Upper Three Runs. Northwest-flowing Crouch and McQueen Branches are tributaries to Upper Three Runs, which flows southwest to the Savannah River. Groundwater flow in deeper aquifers (e.g., Crouch Branch and McQueen Branch Aquifers) is generally to the southwest. Thus, at some depth there is a reversal of flow from that of the shallow aquifers.

Based on data in the SRS groundwater geochemical database, no groundwater plumes are mapped as emanating from S- or Z-Area sources. However, a preliminary review of groundwater monitoring data for S Area indicates tritium contamination in one monitoring well. The contamination is likely from the tritium facility in H Area. This well is located just south of Site B. No tritium contamination was noted in groundwater monitoring data for Z Area. Within the immediate vicinity of Site

B in S Area, depth to the water table averages approximately 45 feet below grade. Groundwater flow in the area is to the northeast to McQueen Branch (Figure 3-9). At the Z-Area site, average depth to the water table ranges from 70 to 60 feet. Groundwater flow below the subject site is to the northeast toward McQueen Branch (Figure 3-10).

3.2.2.2 Groundwater Use

At SRS, most groundwater production for domestic and process water comes from the intermediate/deep aquifers (i.e., the Crouch Branch and McQueen Branch Aquifers). A few lower-capacity domestic water wells pump from the shallower Gordon (Congaree) Aquifer and the lower zone of the Upper Three Runs (Barnwell-McBean) Aquifer. These wells are located in outlying areas, away from the main operations areas including guard barricades and operations offices/laboratories (DOE 1998a).

Domestic water requirements for the General Separations Area (an area that includes S and Z Areas) are supplied from groundwater wells located in A Area (Arnett and Mamatey 1998b).

From January to December 1998, the total groundwater withdrawal rate in the General Separations Area for industrial use, including groundwater from process production wells and former domestic wells (now used as process wells in F, H, and S Areas), was approximately 2.086 million gallons per day. These wells are installed in the deeper Cretaceous aquifers. During 1998, wells in H and S Areas produced approximately 1.02 million gallons per day and 49,000 gallons per day, respectively. H Area has two former domestic wells and three process production wells (Wells 1997; WSRC 1999b). S Area's groundwater production is three process/former domestic wells (WSRC 1995a).

3.2.2.3 Hydrogeology

The aquifers of primary interest for H, S, and Z Areas are the Upper Three Runs and Gordon Aquifers. The Upper Three Runs Aquifer includes the Tinker/Santee Formation, the Dry Branch Formation, and the Tobacco Road Formation. Table 3-5 provides descriptions of the lithologic and hydrologic characteristics of these formations. The Twiggs Clay Member of the Dry Branch Formation locally acts as a confining unit (colloquially known as the "tan clay") that separates the Upper Three Runs Aquifer into an upper and a lower zone. Averages of various types of field tests for horizontal hydraulic conductivity of the upper zone of the Upper Three Runs Aquifer ranges from 0.7 to 13 feet per day. Comparable ranges of horizontal hydraulic conductivity of the lower zone of the Upper Three Runs Aquifer are approximately 0.9 to 33.3 feet per day, although the overall average is about one-half that of the upper zone (Aadland, Gellici, and Thayer 1995). The vertical hydraulic conductivity of the Upper Three Runs Aquifer (upper and lower zones) is understood to be less than the horizontal.

The Gordon Confining unit (colloquially the "green clay") that separates the Upper Three Runs and Gordon Aquifers consists of the Warley Hill Formation and the Blue Bluff Member of the Santee Limestone. It is not a continuous unit, but consists of overlapping lenses of clay that thicken, thin, and pinch out. Beds of calcareous mud (Blue Bluff Member of the Santee Formation) locally add to the thickness of the unit (Aadland, Gellici, and Thayer 1995).

The Gordon Aquifer consists of the Congaree, Fourmile, and Snapp Formations. Table 3-5 provides lithologic and hydrologic soil descriptions of these formations. The Gordon Aquifer is partly eroded near the Savannah River and along Upper Three Runs. This aquifer is recharged directly by precipitation in outcrop areas, at inter-stream divides in and near outcrop areas, and by leakage from overlying and underlying aquifers. Average field tests for horizontal hydraulic conductivity range between approximately 5 and 35 feet per day (Aadland, Gellici, and Thayer 1995). The vertical hydraulic conductivity is less than the horizontal.

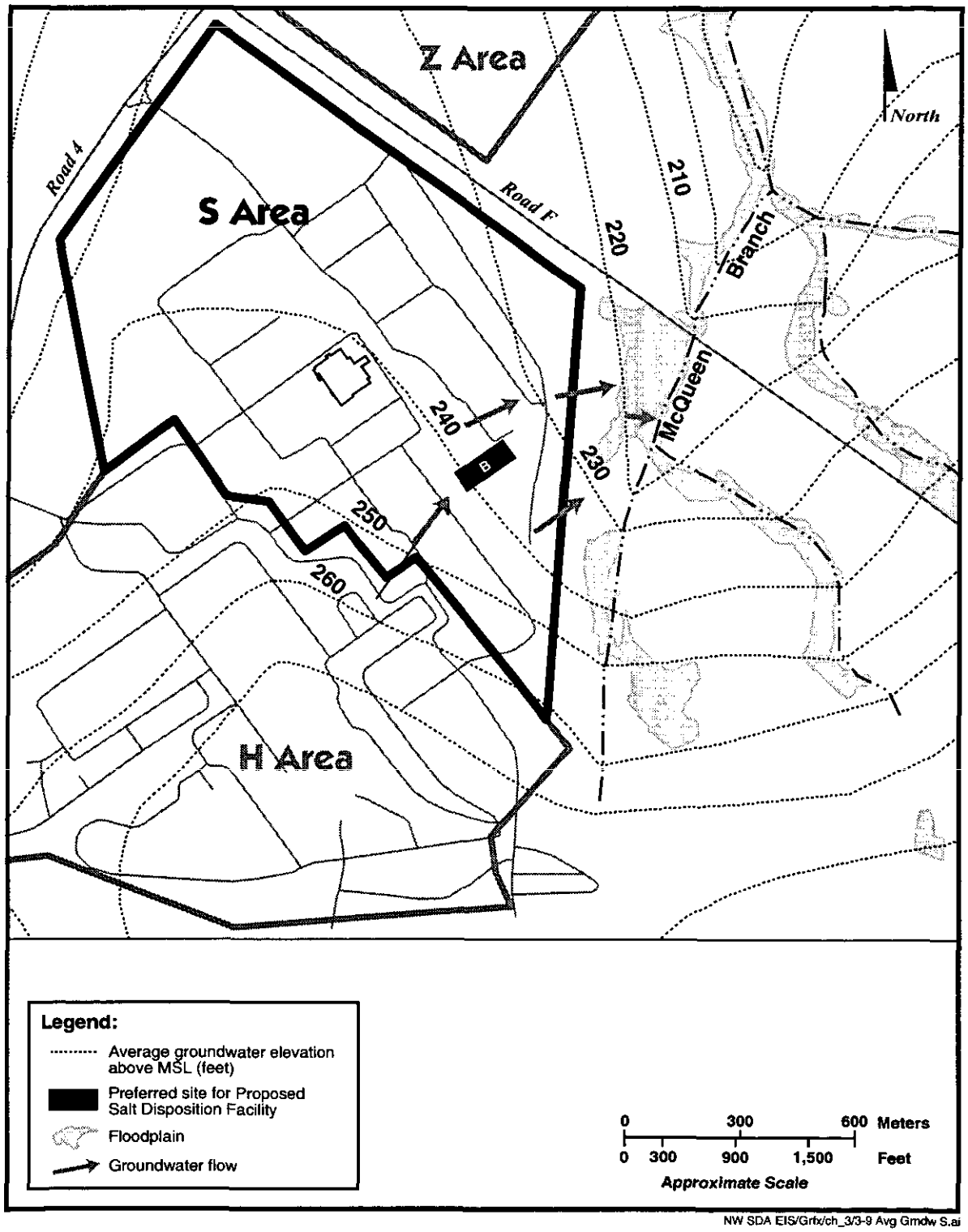


Figure 3-9. Average groundwater elevation and direction of flow in the vicinity of S Area.

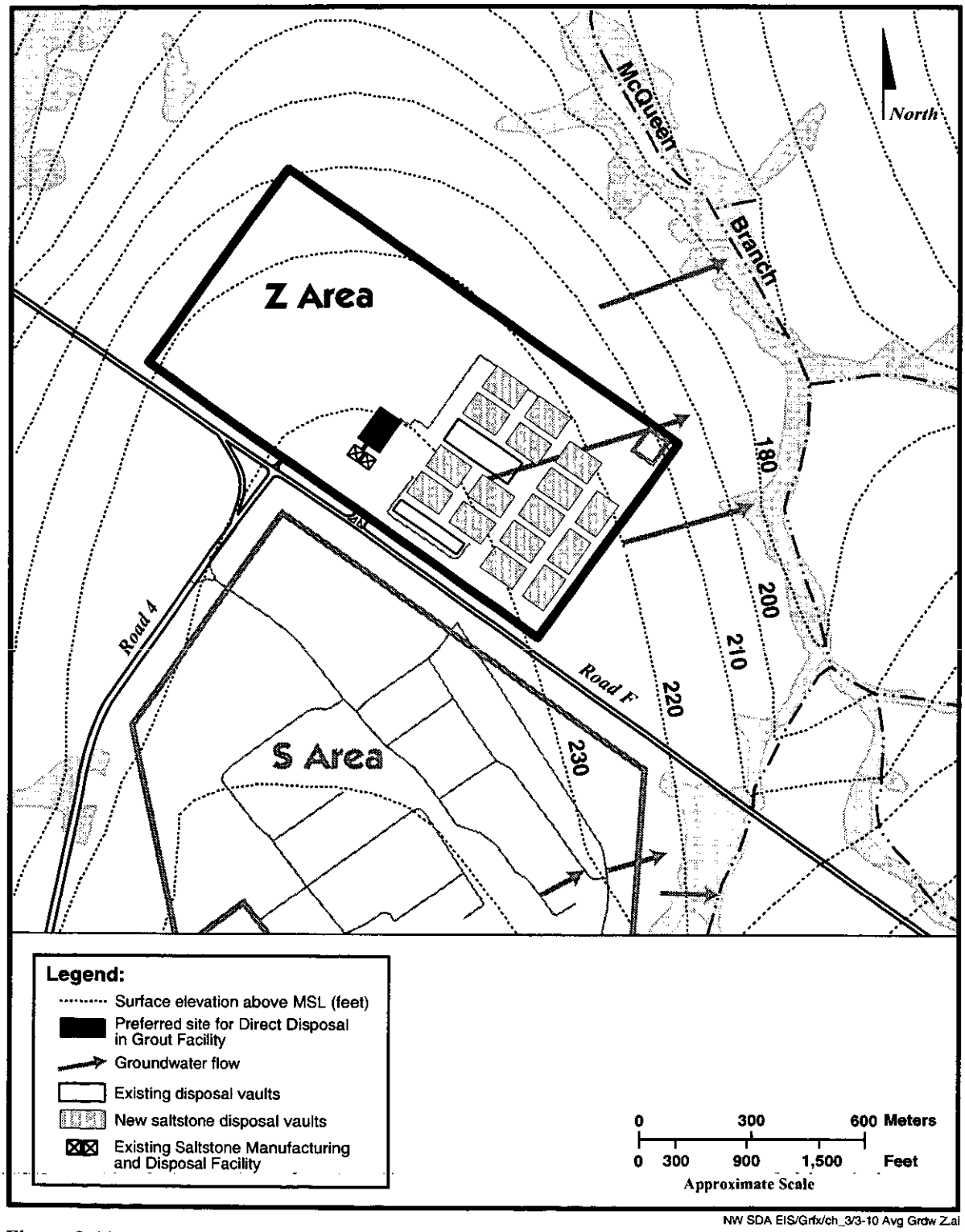


Figure 3-10. Average groundwater elevation and direction of groundwater flow in vicinity of Z Area.

Table 3-5. Soil formations of the Floridan aquifer system in F and H Areas.

Aquifer Unit	Formation	Description
Upper Three Runs Aquifer (formerly Water Table and Barnwell/McBean Aquifers)	"Upland Unit"	Poorly sorted, clayey-to-silty sands, with lenses and layers of conglomerates, pebbly sands, and clays. Clay clasts are abundant, and cross-bedding and flecks of weathered feldspar are locally common.
	Tobacco Road Formation	Moderately to poorly sorted, variably colored, fine-to-coarse grained sand, pebbly sand, and minor clay beds
	Dry Branch Formation	Variably colored, poorly sorted to well-sorted sand with interbedded tan to gray clay
	Clinchfield Formation	Light colored basal quartz sand and glauconitic, biomoldic limestone, calcareous sand and clay. Sand beds of the formation constitute Riggins Mill Member and consist of medium-to-coarse, poorly to well-sorted, loose and slightly indurated, tan, gray, and green quartz. The carbonate sequence of the Clinchfield consists of Utley Member -- sandy, glauconitic limestone and calcareous sand with indurated biomoldic facies.
	Tinker/Santee Formation	Unconsolidated, moderately sorted, subangular, lower coarse-to-medium grained, slightly gravely, immature yellow and tan quartz sand and clayey sand; calcareous sands and clays and limestone also occur in F and H Areas.
Gordon Confining Unit (green clay)	Blue Bluff Member of Santee Limestone	Micritic limestone
	Warley Hill Formation	Fine-grained, glauconitic, clayey sand, and clay that thicken, thin, and pinch out abruptly
Gordon Aquifer	Congaree Formation	Yellow, orange, tan, gray, and greenish gray, well-sorted, fine-to-coarse-grained quartz sands. Thin clay laminae occur throughout the section, with pebbly layers, clay clasts, and glauconite in places. In some places on SRS, the upper part of Congaree Formation is cemented with silica; in other places it is slightly calcareous. Glauconitic clay, encountered in some borings on SRS near the base of this formation, indicates that basal contact is unconformable
	Fourmile Formation	Tan, yellow-orange, brown, and white, moderately to well-sorted sand, with clay beds near middle and top of unit. The sand is very coarse-to-fine-grained, with pebbly zones common. Glauconite and dinoflagellate fossils occur.
	Snapp Formation	Silty, medium-to-coarse-grained quartz sand interbedded with clay. Dark, micaceous, lignitic sand also occurs. In northwestern part of SRS, this Formation is less silty and better sorted, with thinner clay interbeds.

Source: Aadland, Gellici, and Thayer (1995).

3.2.2.4 Groundwater Quality

Most contaminated groundwater at SRS occurs beneath a few facilities; the contaminants reflect the operations and chemical processes performed at those facilities. In the H, S, and Z Areas, contaminants above regulatory and DOE guidelines include tritium and other radionuclides, metals, nitrates, sulfates, and chlorinated and volatile organics.

Tables 3-6 through 3-8 list concentrations of individual analytes above regulatory or SRS guidelines for the period from fourth quarter 1997 through third quarter 1998 for H, S, and Z Areas, respectively (WSRC 1997a; WSRC 1998a,b,c).

3.3 Air Resources

3.3.1 METEOROLOGY

The southeastern United States has a humid subtropical climate characterized by relatively short, mild winters and long, warm, humid summers. Summer-like weather typically lasts from May through September, when the area is subject to the persistent presence of the Atlantic subtropical anticyclone (i.e., the "Bermuda" high). The humid conditions often result in scattered afternoon and evening thunderstorms.

The influence of the Bermuda high starts to diminish during the fall, resulting in lower humidity and more moderate temperatures. Average seasonal rainfall is usually lowest during the fall.

During the winter months, weather conditions frequently tend to alternate between warm, moist, subtropical air from the Gulf of Mexico region and cool, dry polar air. Measurable snowfall is rare.

Spring is characterized by a higher frequency of tornadoes and severe thunderstorms than the other seasons. Spring weather is somewhat windy, with mild temperatures and relatively low humidity.

3.3.1.1 Local Climatology

Data collection sources used to characterize the climatology of SRS consist of a standard instrument shelter in A Area (temperature, humidity, and precipitation for 1961 to 1994), the Central Climatology Meteorological Facility near N Area (temperature, humidity, and precipitation), and seven meteorological towers (winds and atmospheric stability).

The average annual temperature at SRS is 64.7°F. July is the warmest month of the year, with an average daily maximum of 92°F and an average daily minimum near 72°F. January is the coldest month, with an average daily high around 56°F and an average daily low of 36°F. Temperature extremes recorded at SRS since 1961 range from a maximum of 107°F in July 1986 to -3°F in January 1985.

Annual precipitation at SRS averages 49.5 inches. Summer is the wettest season of the year with an average monthly rainfall of 5.2 inches. Fall is the driest season with a monthly average rainfall of 3.3 inches. Relative humidity averages 70 percent annually, with an average daily maximum of 91 percent and an average daily minimum of 45 percent.

The observed wind at SRS indicates no prevailing wind direction, which is typical for the lower Midlands of South Carolina. According to wind data collected from 1992 through 1996, winds are most frequently from the northeast sector (9.7 percent) followed by winds from the north-northeast sector (9.4 percent) (Arnett and Mamatey 1998b). Measurements of air turbulence are used to determine whether the atmosphere has relatively high, moderate, or low potential to disperse airborne pollutants (commonly identified as unstable, neutral, or stable atmospheric conditions, respectively). Generally, SRS atmospheric conditions were categorized as unstable 56 percent of the time (DOE 1999a).

Table 3-6. H Area maximum reported groundwater parameters in excess of regulatory and SRS limits.

Analyte	Concentration	Regulatory limit	
Aluminum[a]	13,000 µg/L[b]	50 µg/L[c]	
Bis (2-ethylhexyl) phthalate	142 µg/L	6 µg/L[d]	
Dichloromethane	8.45 µg/L	5 µg/L[d]	
Gross alpha	9.74×10^{-8} µCi/mL[b]	1.5×10^{-8} µCi/mL[e]	
Iodine-129	1.09×10^{-7} µCi/mL	1.0×10^{-9} µCi/mL[e]	
Iron[a]	17,100 µg/L	300 µg/L[c]	
Lead[a]	417 µg/L	50 µg/L[f]	
Manganese[a]	1,650 µg/L	50 µg/L[c]	
Mercury[a]	18.5 µg/L	2.0 µg/L[d]	
Nickel-63	4.79×10^{-7} µCi/mL	5.0×10^{-8} µCi/mL[e]	
Nitrate-nitrite as nitrogen	52,800 µg/L	10,000 µg/L[d,g]	
Nonvolatile beta	3.37×10^{-6} µCi/mL	5.0×10^{-8} µCi/mL[e]	
Phosphate	2.28 µg/L	1.7 µg/L[h]	
Radium-226	6.52×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[e,i]	
Radium-228	6.98×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[e,i]	
Radium, total alpha emitting	6.70×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[e]	
Ruthenium-106	3.81×10^{-8} µCi/mL	3.0×10^{-8} µCi/mL[e]	
Strontium-89,90	1.01×10^{-8} µCi/mL	8.0×10^{-9} µCi/mL[d]	
Strontium-90	1.24×10^{-6} µCi/mL	8.0×10^{-9} µCi/mL[d]	
Thallium[a]	1,060 µg/L	2 µg/L[d]	
Trichloroethylene	14.7 µg/L	5 µg/L[d]	
Tetrachloroethylene	12.6 µg/L	5 µg/L[d]	
Tritium	1.02×10^{-2} µCi/mL	2.0×10^{-5} µCi/mL[d]	
Uranium-233,234	4.28×10^{-8} µCi/mL	2.7×10^{-8} µCi/mL[j]	L4-5 L4-6
Uranium-238	4.20×10^{-8} µCi/mL	2.7×10^{-8} µCi/mL[j]	
Vanadium[a]	139 µg/L	133 µg/L[i]	

a. Total recoverable.
b. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
c. EPA National Secondary Drinking Water Standards (WSRC 1997a; 1998a,b,c).
d. EPA Final Primary Drinking Water Standards (WSRC 1997a; 1998a,b,c). TC
e. *EPA Final Primary Drinking Water Standards; Radionuclides (65 FR 76708).*
f. SCDHEC Final Primary Drinking Water Standards (WSRC 1997a; 1998a,b,c).
g. Nitrate Maximum Contaminant Level (MCL) = 10,000 µg/L; Nitrite MCL = 1,000 µg/L.
h. Drinking Water Standards do not apply. Criterion 10 × a recently published 90th percentile detection limit was used (WSRC 1997a; 1998a,b,c). L4-5 L4-6
i. Radium-226, 228 combined MCL of 5.0×10^{-8} microcuries per milliliter.
j. Uranium combined MCL of 30 µg/L is equivalent to 2.7×10^{-8} µCi/mL (65 FR 76708). L11-8

Table 3-7. S Area maximum reported groundwater parameters in excess of regulatory and SRS limits.

Analyte	Concentration	Regulatory limit
Trichloroethylene	49.2 µg/L[a]	5 µg/L[b]

a. µg/L = micrograms per liter.
b. EPA Final Primary Drinking Water Standards (WSRC 1997a; 1998a,b,c).

Table 3-8. Z Area maximum reported groundwater parameters in excess of regulatory and SRS limits.

Analyte	Concentration	Regulatory limit
Gross alpha	9.77×10^{-8} µCi/mL[a]	1.5×10^{-8} µCi/mL[b]
Nonvolatile beta	5.26×10^{-8} µCi/mL	5.0×10^{-8} µCi/mL[c]
Radium-226	7.78×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[c,d]
Radium-228	8.09×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[c,d]
Radium, total alpha emitting	5.55×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[c]
Ruthenium-106	3.08×10^{-8} µCi/mL	3.0×10^{-8} µCi/mL[c]

a. µCi/mL = microcuries per milliliter.
b. EPA Final Primary Drinking Water Standards (WSRC 1997a; 1998a,b,c).
c. EPA Interim Final Primary Drinking Water Standard (WSRC 1997a; 1998a,b,c).
d. Radium-226, 228 combined proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.

3.3.1.2 Severe Weather

An average of 54 thunderstorm days per year were recorded by the National Weather Service in Augusta, Georgia, between 1950 and 1996. About half of the annual thunderstorms occurred during the summer.

Since operations began at SRS, 10 confirmed tornadoes have occurred on or in close proximity to the Site. Several of these tornadoes, one of which was estimated to have winds up to 150 miles per hour, did considerable damage to forested areas of SRS. None caused damage to structures. Tornado statistics indicate that the average frequency of a low-intensity tornado striking SRS is 2×10^{-4} times per year or about once every 5,000 years (WSRC 1998d). A tornado of this frequency would have a maximum wind speed (three-second gust) of 45 miles per hour. Similarly a tornado with a maximum wind speed of 120 miles per hour would occur approximately once every 25,000 years.

The highest sustained wind recorded by the Augusta National Weather Service Office is 82 miles per hour. Hurricanes struck South Carolina 36 times during the period from 1700 to 1992, which equates to an average recurrence frequency of once every 8 years. A hurricane-force wind of 74 miles per hour or greater has been observed at SRS only once, during Hurricane Gracie in 1959.

3.3.2 AIR QUALITY

3.3.2.1 Nonradiological Air Quality

The SRS is located in the Augusta-Aiken Interstate Air Quality Control Region (AQCR). All areas within this region are classified as achieving attainment with the National Ambient Air Quality Standards (NAAQS). Ambient air is defined as that portion of the atmosphere, external to buildings, to which the general public has access. The NAAQS define ambient concentration criteria or limits for sulfur dioxide (SO_2), particulate matter equal to or less than 10 micrometers in aerodynamic diameter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb). These pollutants are generally referred to as "criteria pollutants". The nearest area

not in attainment with the NAAQS is Atlanta, Georgia, which is approximately 150 miles west of SRS.

All of the Aiken-Augusta AQCR is designated a Class II area with respect to the Clean Air Act's Prevention of Significant Deterioration (PSD) regulations. The PSD regulations provide a framework for managing existing clean air resources in areas that meet the NAAQS. Areas designated PSD Class II have sufficient air resources available to support moderate industrial growth. A Class I PSD designation is assigned to areas that are to remain pristine, such as national parks and wildlife refuges. Little additional impact to the existing air quality is allowed with a Class I PSD designation. There are no Class I areas within 62 miles of SRS.

SCDHEC has been delegated the authority to implement and enforce requirements of the Clean Air Act for the State of South Carolina. SCDHEC Air Pollution Regulation 62.5, Standard 2, enforces the NAAQS and sets ambient limits for two additional pollutants: total suspended particulates (TSP) and gaseous fluorides (as hydrogen fluoride, HF). SCDHEC Standard 7 implements the PSD limits. In addition, SCDHEC Standard 8 establishes ambient standards for 256 toxic air pollutants. The ambient limits found under Standards 2 and 8 are enforceable at or beyond the Site boundary.

The EPA promulgated new standards for ground-level ozone and particulate matter, that became effective on September 16, 1997 (62 FR 138). However, on May 14, 1999, in response to challenges filed by industry and others, a three-judge panel from the U.S. Court of Appeals for the District of Columbia Circuit issued a split opinion (2 to 1) directing EPA to develop a new particulate matter standard (meanwhile reverting back to the previous PM_{10} standard) and ruling that the new ozone standard "cannot be enforced" (EPA 1999). The full (11-member) Court revised the decision of the panel somewhat, but did not take action to render the proposed new standards enforceable. The EPA has asked the U.S. Department of Justice to appeal this decision and the U.S. Supreme Court has decided the case and upheld the decision. Therefore, it is uncertain at this time when new ozone and particulate matter standards will become enforceable.

Prior to 1991, ambient monitoring of SO_2, NO_2, TSP, CO, and O_3 was conducted at five sites across SRS. Because there is no regulatory requirement to conduct air quality monitoring at SRS, all of these stations have been decommissioned. Ambient air quality data collected during 1997 from monitoring stations operated by SCDHEC in Aiken County and Barnwell County, South Carolina, are summarized in Table 3-9. These data indicate that ambient concentrations of the measured criteria pollutants are generally much less than the standard.

Significant sources of criteria and toxic air pollutants at SRS include coal-fired boilers for power and steam production, diesel generators, chemical storage tanks, DWPF, groundwater air strippers, and various other process facilities. Another source of criteria pollutant emissions at SRS is the prescribed burning of forested areas across the Site by the U.S. Forest Service (Arnett and Mamatey 1998a). Table 3-10 shows the actual atmospheric emissions from all SRS sources in 1997.

SCDHEC also requires dispersion modeling as a means of evaluating local air quality. Periodically, all permitted sources of regulated air emissions at SRS must be modeled to determine estimates of ambient air pollution concentrations at the SRS boundary. The results are used to demonstrate compliance with ambient standards and to define a baseline from which to assess the impacts of any new or modified sources. Table 3-11 provides a summary of the most recent regulatory compliance modeling for SRS emissions. These calculations were performed with EPA's Industrial Source Complex air dispersion model and site-wide maximum potential emissions data from the 1998 air emissions inventory. Model estimates of ambient SRS boundary

Table 3-9. SCDHEC ambient air monitoring data for 1997.

Pollutant	Averaging time	SC Standard ($\mu g/m^3$)	Aiken Co. ($\mu g/m^3$)	Barnwell Co. ($\mu g/m^3$)
Sulfur dioxide	3-hr[a]	1,300	60	44
	24[a]	365	21	10
	Annual[b]	80	5	3
Total suspended particulates	Annual	75	36	--
Particulate matter (≤10 μm)	24-hr[a]	150	45	44
	Annual[b]	50	21	19
Carbon monoxide	1-hr[a]	40,000	5,100[c]	--
	8-hr[a]	10,000	3,300[c]	--
Ozone	1-hr	235	200	210
Nitrogen dioxide	Annual	100	9	8
Lead	Max. quarter	1.5	0.01	--

Source: SCDHEC (1998).
a. Second highest maximum concentration observed.
b. Arithmetic mean of observed concentrations.
c. Columbia, Richland County, South Carolina (nearest monitoring station to SRS).

Table 3-10. Criteria and toxic/hazardous air pollutant emissions from SRS (1997).

Pollutant	Actual tons/year
Criteria pollutants[a]	
Sulfur dioxide	490
Total suspended particulates	2,000
Particulate matter (≤10 μm)	1,500
Carbon monoxide	5,200
VOCs[b]	290
Oxides of nitrogen	430
Lead	0.019
Toxic/hazardous air pollutants[c]	
Benzene	13
Beryllium	0.0013
Biphenyl	0.013
Mercury	0.039
Methyl alcohol (methanol)	0.73

Source: Mamatey (1999). Includes actual emissions from all SRS sources (permitted and unpermitted).
a. Includes an additional pollutant, PM-10, regulated under SCDHEC, Standard 2. Note: gaseous fluoride is also regulated under Standard 2, but is not expected to be emitted as a result of salt processing activities.
b. VOCs are not criteria pollutants, but they are reported here because they are precursors to ozone, which is regulated.
c. Pollutants listed include only air toxics of interest to salt processing activities. A complete list of air toxic emissions from SRS can be found in Mamatey (1999).
VOCs = volatile organic compounds

Table 3-11. SRS baseline air quality for maximum potential emissions and observed ambient concentrations.

Pollutant	Averaging time	SCDHEC ambient standard ($\mu g/m^3$)[a]	Estimated SRS baseline concentration ($\mu g/m^3$)[b]
Criteria pollutants			
Sulfur dioxide[c]	3-hr	1,300	1,200[c]
	24-hr	365	350
	Annual	80	34
Total suspended particulates	Annual	75	67
Particulate matter (≤10 μm)[d]	24-hr	150	130
	Annual	50	25
Carbon monoxide	1-hr	40,000	10,000
	8-hr	10,000	6,900
Nitrogen dioxides[e]	Annual	100	26[e]
Lead	Calendar Quarterly mean	1.5	0.03
Ozone[f]	1-hr	235	220
Toxic/hazardous air pollutants			
Benzene	24-hr	150	4.6
Beryllium	24-hr	0.01	0.009
Biphenyl	24-hr	6	0.02
Mercury	24-hr	0.25	0.03
Methyl alcohol (methanol)	24-hr	1,310	0.9
Formic acid	24-hr	225	0.15

a. Source: SCDHEC Standard 2, "Ambient Air Quality Standards," and Standard 8, "Toxic Air Pollutants" (SCDHEC 1976).
b. Source: Hunter (2000). Concentration is the sum of modeled air concentrations using the permitted maximum potential emissions from the 1998 air emissions inventory for all SRS sources not exempted by Clean Air Act Title V requirements and observed concentrations from nearby ambient air monitoring stations.
c. Based partly on dispersion modeling of emissions for all oxides of sulfur (SO_x).
d. New NAAQS for particulate matter ≤2.5 microns (24-hour limit of 65 $\mu g/m^3$ and an annual average limit of 15 $\mu g/m^3$) will become enforceable during the life of this project.
e. Based partly on dispersion modeling of emissions for all oxides of nitrogen (NO_x).
f. New NAAQS for ozone (8 hours limit of 0.08 parts per million) will become enforceable during the life of this project.

concentrations for all air pollutants emitted at SRS are less than their respective ambient standards.

3.3.2.2 Radiological Air Quality

In the SRS region, airborne radionuclides originate from natural sources (i.e., terrestrial and cosmic), worldwide fallout, and SRS operations. DOE maintains a network of 23 air sampling stations on and around SRS to determine concentrations of radioactive particulates and aerosols in the air (Arnett and Mamatey 1998b).

DOE provides detailed summaries of radiological releases to the atmosphere from SRS operations, along with resulting concentrations and doses, in a series of annual environmental data reports. Table 3-12 lists 1997 radionuclide releases from each major operational group of SRS facilities. All radiological impacts are within regulatory requirements.

Atmospheric emissions of radionuclides from DOE facilities are limited under the EPA regulation "National Emission Standards for Hazardous Air Pollutants (NESHAP)," 40 CFR Part 61, Subpart H. The EPA annual effective dose

Table 3-12. Radiological atmospheric releases by operational group for 1997.

Radionuclide[a]	Half-life	Reactors	Separations[b]	Reactor materials	Heavy water	SRTC[c]	Diffuse and fugitive[d]	Total
		Curies released						
Gases and Vapors								
H-3 (oxide)	12.3 years	5.2×10^{3}	3.3×10^{4}		350		150	3.9×10^{4}
H-3 (elem)	12.3 years		1.9×10^{4}					1.9×10^{4}
H-3 Total	12.3 years	5.2×10^{3}	5.2×10^{4}		350		150	5.8×10^{4}
C-14	5.73×10^{3} years		3.1×10^{-2}				1.9×10^{-8}	3.1×10^{-2}
Kr-85	10.73 years		9.6×10^{3}					9.6×10^{3}
I-129	1.57×10^{7} years		7.1×10^{-3}				1.2×10^{-7}	7.1×10^{-3}
I-131	8.040 days		2.9×10^{-5}			2.98×10^{-5}		5.9×10^{-5}
I-133	20.8 hours					4.92×10^{-4}		4.9×10^{-4}
Particulates								
Na-22	2.605 years						1.1×10^{-9}	1.1×10^{-9}
Mn-54	312.2 days						4.8×10^{-12}	4.8×10^{-12}
Co-57	271.8 days		2.2×10^{-7}				1.0×10^{-9}	2.1×10^{-7}
Co-58	70.88 days						1.7×10^{-12}	1.7×10^{-12}
Co-60	5.271 years		3.5×10^{-7}				9.1×10^{-7}	1.3×10^{-6}
Ni-59	7.6×10^{4} years						3.2×10^{-10}	3.2×10^{-10}
Ni-63	100 years						2.3×10^{-9}	2.3×10^{-9}
Zn-65	243.8 days						3.7×10^{-12}	3.7×10^{-12}
Se-79	6.5×10^{4} years						2.2×10^{-10}	2.2×10^{-10}
Sr-89,90[e]	29.1 years	1.8×10^{-3}	2.2×10^{-4}	4.2×10^{-5}	1.8×10^{-4}		8.2×10^{-5}	2.3×10^{-3}
Zr-95	64.02 days						2.1×10^{-5}	2.1×10^{-5}
Nb-95	34.97 days						1.6×10^{-15}	1.6×10^{-15}
Tc-99	2.13×10^{5} years						3.6×10^{-8}	3.6×10^{-8}
Ru-106	1.020 years						0.070	0.070
Sn-126	1×10^{5} years						3.4×10^{-15}	3.4×10^{-15}
Sb-124	60.2 days						3.4×10^{-12}	3.4×10^{-12}
Sb-125	2.758 years						5.9×10^{-7}	5.9×10^{-7}
Cs-134	2.065 years		1.4×10^{-6}				1.2×10^{-9}	1.4×10^{-6}
Cs-137	30.17 years	2.5×10^{-4}	4.2×10^{-4}		2.9×10^{-6}		4.2×10^{-3}	4.9×10^{-3}
Ba-133	10.53 years						3.0×10^{-12}	3.0×10^{-12}
Ce-144	284.6 days		4.2×10^{-6}				6.1×10^{-6}	1.0×10^{-5}
Pm-144	360 days						1.3×10^{-12}	1.3×10^{-12}

Table 3-12. (Continued).

Radionuclide[a]	Half-life	Reactors	Separations[b]	Reactor materials	Heavy water	SRTC[c]	Diffuse and fugitive[d]	Total
		Curies released						
Particulates (continued)								
Pm-147	2.6234 years						1.0×10^{-8}	1.0×10^{-8}
Eu-152	13.48 years						5.3×10^{-9}	5.3×10^{-9}
Eu-154	8.59 years		1.5×10^{-7}				6.4×10^{-6}	6.6×10^{-6}
Eu-155	4.71 years		4.9×10^{-6}				1.7×10^{-6}	6.6×10^{-6}
Ra-226	1.6×10^{3} years						1.2×10^{-8}	1.2×10^{-8}
Ra-228	5.76 years						1.8×10^{-10}	1.8×10^{-10}
Th-228	1.913 years						2.2×10^{-10}	2.2×10^{-10}
Th-230	7.54×10^{4} years						2.0×10^{-10}	2.0×10^{-10}
Th-232	1.40×10^{10} years						1.4×10^{-10}	1.4×10^{-10}
Th-234	24.10 days						2.3×10^{-10}	2.3×10^{-10}
Pa-231	3.28×10^{4} years						1.0×10^{-9}	1.0×10^{-9}
Pa-234	6.69 hours						2.3×10^{-10}	2.3×10^{-10}
U-233	1.592×10^{5} years						2.1×10^{-8}	2.1×10^{-8}
U-234	2.46×10^{5} years		8.0×10^{-6}	4.0×10^{-6}			1.5×10^{-5}	2.7×10^{-5}
U-235	7.04×10^{8} years		6.3×10^{-7}	6.4×10^{-7}			4.8×10^{-7}	1.8×10^{-6}
U-236	2.342×10^{7} years						4.8×10^{-7}	4.8×10^{-7}
U-238	4.47×10^{9} years		1.9×10^{-5}	1.7×10^{-6}			3.5×10^{-5}	5.6×10^{-5}
Np-237	2.14×10^{6} years						1.4×10^{-9}	1.4×10^{-9}
Np-239	2.35 days						2.2×10^{-7}	2.2×10^{-7}
Pu-238	87.7 years		3.3×10^{-5}	4.4×10^{-9}			3.6×10^{-4}	3.9×10^{-4}
Pu-239[f]	2.410×10^{4} years	2.9×10^{-4}	5.1×10^{-5}	6.9×10^{-6}	2.3×10^{-5}	2.5×10^{-6}	6.9×10^{-6}	3.8×10^{-4}
Pu-240	6.56×10^{3} years						1.1×10^{-6}	1.1×10^{-6}
Pu-241	14.4 years						5.2×10^{-5}	5.2×10^{-5}
Pu-242	3.75×10^{5} years						3.7×10^{-11}	3.7×10^{-11}
Am-241	432.7 years		1.4×10^{-5}	1.2×10^{-8}			8.7×10^{-7}	1.5×10^{-5}
Am-243	7.37×10^{3} years						1.8×10^{-5}	1.8×10^{-5}

Table 3-12. (Continued).

Radionuclide[a]	Half-life	Reactors	Separations[b]	Reactor materials	Heavy water	SRTC[c]	Diffuse and fugitive[d]	Total
		Curies released						
Particulates (continued)								
Cm-242	162.8 days						8.2×10^{-12}	8.2×10^{-12}
Cm-244	18.1 years		2.5×10^{-5}	2.0×10^{-10}			1.3×10^{-4}	1.5×10^{-4}
Cm-245	8.5×10^{3} years						1.9×10^{-12}	1.9×10^{-12}

Source: Arnett and Mamatey (1998a).

a. H = hydrogen (H-3 = tritium), C = carbon, Kr = krypton, I = iodine, Na = sodium, Mn = manganese, Co = cobalt, Ni = nickel, Zn = zinc, Se = selenium, Sr = strontium, Zr = zirconium, Nb = niobium, Tc = technetium, Ru = ruthenium, Sn = tin, Sb = antimony, Cs = cesium, Ba = barium, Ce = cerium, Pm = promethium, Eu = europium, Ra = radium, Th = thorium, Pa = protactinium, U = uranium, Np = neptunium, Pu = plutonium, Am = americium, Cm = curium.

b. Includes F- and H-Area releases.

c. SRTC = Savannah River Technology Center.

d. Estimated releases from minor unmonitored diffuse and fugitive sources.

e. Includes unidentified beta emissions.

f. Includes unidentified alpha emissions.

equivalent limit of 10 millirem (mrem) per year to members of the public for the atmospheric pathway is also incorporated in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." To demonstrate compliance with the NESHAP regulations, DOE annually calculates maximally exposed offsite individual (MEI) and collective doses and a percentage of dose contribution from each radionuclide, using the CAP88 computer code. The dose to the MEI from 1997 SRS emissions was estimated at 0.05 mrem which is 0.5 percent of the 10 mrem-per-year EPA standard. The CAP88 collective dose was estimated at 5.5 person-rem. Tritium oxide accounts for 94 percent of both the MEI and the population dose (Arnett and Mamatey 1998b). The contributions to dose from other radionuclides can be found in *SRS Environmental Data for 1997* (Arnett and Mamatey 1998a). Table 3-13 lists average and maximum atmospheric concentrations of radioactivity at the SRS boundary and at background monitoring locations (100-mile radius) during 1997. SRS-specific computer dispersion models, such as MAXIGASP and POPGASP, were used to calculate radiological doses to members of the public from the 1997 releases, based on the amounts released and the estimated concentration in the environment. Whereas the CAP88 code assumes that all releases occur from one point (for SRS, at the center of the site), MAXIGASP models multiple release locations, which is more representative of actual conditions.

3.4 Ecological Resources

3.4.1 NATURAL COMMUNITIES OF THE SAVANNAH RIVER SITE

The SRS comprises a variety of diverse habitat types that support terrestrial, aquatic, and semi-aquatic wildlife species. These habitat types include upland pine forests, mixed hardwood forests, bottomland hardwood forests, swamp forests, and Carolina bays. Since the early 1950s, the site has changed from 60 percent forest and 40 percent agriculture to 90 percent forest, with the remainder in aquatic habitats and developed (facility) areas (Halverson et al. 1997). The wildlife correspondingly shifted from forest-farm edge species to a predominance of forest-dwelling species. The SRS now supports 44 species of amphibians, 59 species of reptiles, 255 species of birds, and 54 species of mammals (Halverson et al. 1997). Comprehensive descriptions of the SRS's ecological re-sources and wildlife can be found in documents such as *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a).

SRS has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks, or impoundments. In addition, approximately 200 Carolina bays occur on SRS (DOE 1995b).

Table 3-13. Radioactivity in air at the SRS boundary and at a 100-mile radius during 1997 (picocuries per cubic meter).

Location	Tritium	Gross alpha	Gross beta	Cobalt-60	Cesium-137	Strontium-89,90	Plutonium -238	Plutonium -239
Site boundary								
Average[a]	11	9.8×10^{-4}	0.015	5.7×10^{-4}	1.5×10^{-4}	8.0×10^{-5}	(b)	(b)
Maximum[c]	65	0.0033	0.032	0.024	0.0073	3.6×10^{-4}	4.1×10^{-6}	7.0×10^{-6}
Background (100-mile radius)								
Average	3.2	0.0011	0.011	(b)	(b)	8.9×10^{-4}	6.9×10^{-6}	(b)
Maximum	5.4	0.0030	0.018	0.0073	0.0055	0.0019	4.2×10^{-5}	2.6×10^{-5}

Source: Arnett and Mamatey (1998a).
a. The average value is the average value of the arithmetic means reported for the Site perimeter sampling locations.
b. Below background levels.
c. The maximum value is the highest value of the maximums reported for the Site perimeter sampling locations.

The Savannah River bounds SRS to the southwest for approximately 20 miles. The river floodplain supports an extensive swamp, covering about 15 square miles of SRS; a natural levee separates the swamp from the river (Halverson et al. 1997).

The aquatic resources of SRS have been the subject of intensive study for more than 30 years. Several monographs (Britton and Fuller 1979; Bennett and McFarlane 1983), the eight-volume comprehensive cooling water study (du Pont 1987), and a number of environmental impact statements (EISs) (DOE 1987, 1990, 1997a) describe the aquatic biota (fish and macroinvertebrates) and aquatic systems of SRS. The *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a) review ecological research and monitoring studies conducted in SRS streams and impoundments over several decades.

Under the Endangered Species Act of 1973, the Federal government provides protection to six species that occur on the SRS: American alligator (*Alligator mississippiensis*, threatened due to similarity of appearance to the endangered American crocodile); shortnose sturgeon (*Acipenser brevirostrum*, endangered); bald eagle (*Haliaeetus leucocephalus*, threatened); wood stork (*Mycteria americana*, endangered); red-cockaded woodpecker (*Picoides borealis*, endangered); and smooth purple coneflower (*Echinacea laevigata*, endangered) (SRFS 1994; Halverson et al. 1997). None of these species is known to occur on or near the proposed sites in S and Z Areas, which are surrounded by roads, parking lots, construction shops, and construction laydown areas and are continually exposed to high levels of human disturbance (SRFS 1996).

S and Z Areas

Site B, the identified site for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction technologies, is in S Area, approximately one-quarter mile south of DWPF. This open grassy area, which is currently being used as an equipment laydown and storage area, lies in a transitional zone between the heavily-developed central portion of S Area and the relatively undeveloped woodlands to the east (see Figure 2-1). The wildlife of these open, grassy habitats of the SRS that are adjacent to heavy-industrial areas include ground-foraging birds (e.g., American robin, killdeer, mourning dove), small mammals (e.g., cotton mouse, cotton rat, and Eastern cottontail), and reptiles, (e.g., Eastern hognose snake, rat snake, black racer) (Mayer and Wike 1997). East of Site B, the terrestrial habitat grades from pine plantation into a riparian bottomland hardwood community along McQueen Branch.

The site for the Direct Disposal in Grout facilities occupies the eastern half of Z Area, a 180-acre area dedicated in the mid-1980s for the Saltstone Manufacturing and Disposal and support facilities (see Figure 2-2). The western part of Z Area encompasses approximately 70 acres of planted pines. This community is dominated by 35-foot and taller slash pine, with a dense mid-story hardwood component. Dominant tree and shrub species in the mid-story and understory include southern red oak (*Quercus rubra*), water oak (*Q. nigra*), willow oak (*Q. phellos*), hickory (*Carya* spp.), sassafras (*Sassafras albidum*), cherry (*Prunus* spp.), wild plum (*Prunus* spp.), and smooth sumac (*Rhus glabra*) (WSRC 2000a). The developed portion of Z Area consists of the Saltstone Manufacturing and Disposal Facility, vaults, and parking areas. The eastern portion of Z Area consists of old fields and early successional wooded habitats (herbaceous vegetation, small slash pine, and small hardwoods). A few scattered mature southern red oaks are also present (WSRC 2000a). Wildlife of SRS old fields and open woodlands includes upland game birds (e.g., bobwhite quail, Eastern wild turkey), songbirds (e.g., Eastern meadowlark, field sparrow, song sparrow), small mammals (e.g., cotton mouse, cotton rat, and Eastern cottontail), reptiles (e.g., fence lizard, pine snake, scarlet snake, black racer), and amphibians (e.g., southern toad, eastern narrow-mouthed toad) (Sprunt and Cham-

berlain 1970; Cothran et al. 1991; Gibbons and Semlitsch 1991; Halverson et al. 1997). The terrestrial habitat adjacent to Z Area consists primarily of pine plantations that grade into a riparian hardwood community along the McQueen Branch stream corridor.

There are no jurisdictional wetlands (wetlands protected by law) within or immediately adjacent to either of the proposed salt processing sites. However, there are jurisdictional wetlands along McQueen Branch in the general vicinity of Z Area. There are no threatened or endangered species or critical habitats on the sites proposed for development (WSRC 2000a).

3.4.2 ECOLOGICAL COMMUNITIES POTENTIALLY AFFECTED BY DEVELOPMENT AND OPERATION OF SALT PROCESSING FACILITIES

Aquatic Communities Downstream of S and Z Areas

Upper Three Runs

According to summaries of studies on Upper Three Runs documented in the *SRS Ecology Environmental Information Document* (Halverson et al. 1997), the macroinvertebrate communities of Upper Three Runs are characterized by unusually high measures of taxa richness and diversity. Upper Three Runs is a spring-fed stream and is colder and generally clearer than most streams in the upper Coastal Plain. As a result, species normally found in the Northern U.S. and southern Appalachians are found here, along with endemic lowland (Atlantic Coastal Plain) species (Halverson et al. 1997).

A study conducted from 1976 to 1977 identified 551 species of aquatic insects within this stream system, including a number of species and genera new to science (Halverson et al. 1997). A 1993 study found more than 650 species in Upper Three Runs, including more than 100 caddisfly species. Although no threatened or endangered species have been found in Upper Three Runs, there are several environmentally sensitive species. Davis and Mulvey (Halverson et al. 1997) identified a rare clam species (*Elliptio hepatica*) in this drainage. Also, the American sand-burrowing mayfly (*Dolania americana*), a mayfly relatively common in Upper Three Runs, was until 1996 listed by the U.S. Fish and Wildlife Service as a Category 2 candidate species for listing under the Endangered Species Act. Between 1987 and 1991, the density and variety of insects collected from Upper Three Runs decreased for unknown reasons. More recent data, however, indicate that insect communities are recovering (Halverson et al. 1997).

The fish community of Upper Three Runs is typical of third- and higher-order streams in the southeast that have not been greatly affected by industrial operations, with shiners and sunfish dominating collections. The smaller tributaries to Upper Three Runs are dominated by shiners and other small-bodied species (i.e., pirate perch, madtoms, and darters) indicative of unimpacted streams in the Atlantic Coastal Plain (Halverson et al. 1997). In the 1970s, the U.S. Geological Service designated Upper Three Runs as a National Hydrological Benchmark Stream, due to its high water quality and rich fauna. However, this designation was rescinded in 1992, due to increased residential development of the Upper Three Runs watershed north of SRS (Halverson et al. 1997).

Fourmile Branch

Until C Reactor was shut down in 1985, the distribution and abundance of aquatic biota in Fourmile Branch were strongly influenced by reactor operations (high water temperatures and flows downstream of the reactor discharge). Following the shutdown of C Reactor, macroinvertebrate communities began to recover and, in some reaches of the stream, began to resemble those in nonthermal and unimpacted streams of the SRS (Halverson et al. 1997). Surveys of macroinvertebrates in more recent years showed that some reaches of Fourmile Branch had healthy macroinvertebrate communities (high measures of taxa richness), while others had depauperate macroinvertebrate communities (low measures of diversity or communities dominated by pollution-tolerant forms). Differ-

ences appeared to be related to variations in dissolved oxygen levels in different portions of the stream. In general, macroinvertebrate communities of Fourmile Branch show more diversity (taxa richness) in downstream reaches than upstream reaches (Halverson et al. 1997). Recent fish sampling (Specht and Paller 1998) indicates that fish diversity is greater at downstream locations than at upstream locations. This is probably related to factors other than NPDES discharges (Specht and Paller 1998).

To assess potential impacts of groundwater outcropping to Fourmile Branch, WSRC in 1990 surveyed fish populations in Fourmile Branch up- and downstream of F- and H-Area seepage basins (Halverson et al. 1997). Upstream stations were dominated by pirate perch, creek chubsucker, yellow bullhead, and several sunfish species (redbreast sunfish, dollar sunfish, and spotted sunfish). Downstream stations were dominated by shiners (yellowfin shiner, dusky shiner, and taillight shiner) and sunfish (redbreast sunfish and spotted sunfish), with pirate perch and creek chubsucker present, but in lower numbers. Differences in species composition were believed to be due to habitat differences, rather than to the effect of contaminants entering the stream in groundwater.

Savannah River

An extensive information base is available regarding the aquatic ecology of the Savannah River in the vicinity of SRS. The most recent water quality data available from environmental monitoring conducted on the river in the vicinity of SRS and its downstream reaches can be found in *Savannah River Site Environmental Data for 1997* (Arnett and Mamatey 1998a). These data demonstrate that the Savannah River is not adversely impacted by SRS wastewater discharges to its tributary streams. A full description of the ecology of the Savannah River in the vicinity of SRS can be found in the *SRS Ecology Environmental Information Document* (Halverson et al. 1997), the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a), and the EIS for *Accelerator Production of Tritium at the Savannah River Site* (DOE 1999a).

3.5 Land Use

The SRS is in west-central South Carolina (Figure 3-3), approximately 100 miles from the Atlantic Coast. The major physical feature at SRS is the Savannah River, which is the southwestern boundary of the Site and is also the South Carolina-Georgia border. The SRS includes portions of Aiken, Barnwell, and Allendale counties in South Carolina.

The SRS occupies an almost circular area of approximately 300 square miles (or 192,000 acres) and contains production, service, and research and development areas (Figure 3-7). The production facilities occupy less than 10 percent of the SRS; the remainder of the site is undeveloped forest or wetlands (DOE 1997b) (see Section 3.4).

S and Z Areas are in the north-central portion of the SRS, bounded by Upper Three Runs to the north and Fourmile Branch to the south. Land within a 5-mile radius of these areas lies entirely within the SRS boundaries and is either industrial or forested (DOE 1997b).

In March 1998, the *Savannah River Site Future Use Plan* (DOE 1998b) was formally issued. It was developed in partnership with all major site contractors, support agencies, and DOE Headquarters counterparts and with the input of stakeholders; it defines the future use for the Site. The plan states as policy the following important points: (1) SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government, consistent with the Site's designation as a National Environmental Research Park; (2) residential uses of all SRS land shall be prohibited; and (3) an Integral Site Model that incorporates three planning zones (industrial, industrial support, and restricted public uses) will be utilized. The land around the industrial areas (i.e., between Upper Three Runs and Fourmile Branch) will be con-

sidered in the industrial use category (DOE 1998b). Consequently, DOE's plan is to continue active institutional control for those areas as long as is necessary to protect the public and the environment (DOE 1998b).

3.6 Socioeconomics and Environmental Justice

3.6.1 SOCIOECONOMICS

The socioeconomic region of influence (ROI) for the proposed action is a six-county area around the SRS, where the majority of Site workers reside and where socioeconomic impacts are most likely to occur. The six counties are Aiken, Allendale, Barnwell, and Bamberg in South Carolina, and Columbia and Richmond in Georgia. *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site* (HNUS 1997) contains details on the ROI, as well as most of the information discussed in this section. The study includes full discussions of regional fiscal conditions, housing, community services and infrastructure, social services and institutions, and educational services. This section will, however, focus on population and employment estimates that have been updated to reflect the most recently available data.

Population

Based on state and Federal agency surveys and trends, the estimated 1998 population in the ROI was 466,222. About 90 percent lived in Aiken (29 percent), Columbia (20 percent), and Richmond (41 percent) Counties. The population in the region grew at an annual rate of about 6.5 percent between 1990 and 1998 (Bureau of the Census 1999). Columbia County and, to a lesser extent, Aiken County, contributed to most of the growth due to in-migration from other ROI counties and other states. Over the same period, Bamberg and Barnwell Counties experienced net out-migration.

Population projections indicate that the overall population in the region should continue to grow at less than 1 percent per year until about 2040, except Columbia County, which could experience 2 to 3 percent annual growth. Table 3-14 presents projections by county through 2040.

Based on the most recent information available (1992), the estimated median age of the population in the region was 31.8 years. Median ages in the region are generally lower than those of the nation and the two states. The region had slightly higher percentages of persons in younger age groups (under 5 and 5 to 19) than the U.S. while, for all other age groups, the region was comparable to U.S. percentages. The only exception to this was Columbia County, with only 6 percent of its population 65 years or older, while the other counties and the U.S. had 10 percent or greater in this age group. The proportion of persons younger than 20 is expected to decrease, while the proportion of persons older than 64 is expected to increase (DOE 1999a).

Employment

In 1994, the latest year consistently developed information is available for all counties in the ROI, the total civilian labor force for the region was 206,518, with 6.9 percent unemployment. The unemployment rate for the U.S. for the same period was 6.1 percent. For the Augusta-Aiken Metropolitan Statistical Area, which does not exactly coincide with the counties in the ROI, the 1996 labor force totaled 202,400, with an unemployment rate of 6.7 percent. The most recent unemployment rate for the Augusta-Aiken Metropolitan Statistical Area (issued for February 1999) was 5.0 percent.

In 1994, total employment according to Standard Industrial Code sectors ranged from 479 workers in the mining sector (e.g., clay and gravel pits) to 58,415 workers in the services sector (e.g., health care and education). Average per capita personal income in 1993 (adjusted to 1995 dollars) was $18,867, in comparison to the U.S. figure of $21,937.

Table 3-14. Population projections and percent of region of influence.

Jurisdiction	2000 Population	2000 % ROI	2010 Population	2010 % ROI	2020 Population	2020 % ROI
South Carolina						
Aiken County	135,126	28.7	143,774	27.9	152,975	26.9
Allendale County	11,255	2.4	11,514	2.2	11,778	2.1
Bamberg County	16,366	3.5	17,528	3.4	18,773	3.3
Barnwell County	21,897	4.6	23,517	4.6	25,257	4.5
Georgia						
Columbia County	97,608	20.7	120,448	23.3	148,633	26.9
Richmond County	189,040	40.1	199,059	38.6	209,609	37.0
Six-county total	471,292	100	515,840	100	567,025	100

Jurisdiction	2030 Population	2030 % ROI	2040 Population	2040 % ROI
South Carolina				
Aiken County	162,766	26.0	173,182	24.9
Allendale County	12,049	1.9	12,326	1.8
Bamberg County	20,106	3.2	21,533	3.1
Barnwell County	27,126	4.5	29,134	4.2
Georgia				
Columbia County	184,413	29.4	226,332	32.6
Richmond County	220,718	35.2	232,417	33.4
Six-county total	627,178	100	694,924	100

Source: HNUS (1997), scaled from HNUS (1997) and Bureau of the Census (1999).
ROI = region of influence.

Based on a detailed workforce survey completed in the fall of 1995, the SRS had 16,625 workers (including contractors, permanent and temporary workers, and persons affiliated with Federal agencies and universities who work on the Site) with a total payroll of slightly over $634 million. By September 1997, DOE had reduced the total workforce to 14,379 (DOE 1998c).

3.6.2 ENVIRONMENTAL JUSTICE

In 1995, DOE completed an analysis of the economic and racial characteristics of the population in areas affected by SRS operations for the *Interim Management of Nuclear Materials Environmental Impact Statement* (DOE 1995c). That EIS evaluated whether minority or low-income communities could receive disproportionately high and adverse human health and environmental impacts from the alternatives included in that EIS. The EIS examined the population within a 50-mile radius of the SRS boundary, plus areas downstream of the Site that withdraw drinking water from the Savannah River. The area encompasses a total of 147 census tracts, (if any portion of a census tract fell within the 50-mile radius, the entire tract was included for purposes of analysis), with a total affected population of 993,667. Of that population, 618,000 (62 percent) are Caucasian. In the minority population, approximately 94 percent are African-American; the remainder consists of small percentages of Asian, Hispanic, and Native American (Table 3-15).

Table 3-15. General racial characteristics of population in the Savannah River Site region of influence.

State	Total population	Caucasian	Total Minority	African American	Hispanic	Asian	Native American	Other	Percent minorities[a]
South Carolina ROI	418,685	267,639	151,046	144,147	3,899	1,734	911	355	36.1%
Georgia ROI	574,982	350,233	224,749	208,017	7,245	7,463	1,546	478	39.1%
Total	993,667	617,872	375,795	352,164	11,144	9,197	2,457	833	37.8%

a. Minority population divided by total population.
ROI = region of influence.

The *Interim Management of Nuclear Materials EIS* used data on minority and low-income populations from the 1990 census. Although the Bureau of Census publishes county- and state-level population estimates and projects in odd (inter-census) years, census-tract-level statistics on minority and low-income populations are only collected for decennial censuses. Updated census tract information is expected to be published by the Bureau of Census in 2001.

Of the 147 census tracts in the combined region, 80 contain populations of 50 percent or more minorities. An additional 50 tracts contain between 35 and 50 percent minorities. These tracts are well distributed throughout the region, although there are more of them toward the south and in the immediate vicinities of Augusta and Savannah (Figure 3-11).

Low-income communities (25 percent or more of the population living in poverty [i.e., annual income of $10,915 for a family of two]) occur in 72 census tracts distributed throughout the ROI, but primarily to the south and west of SRS (Figure 3-12). This represents more than 169,000 persons or about 17 percent of the total population (Table 3-16).

3.7 Cultural Resources

Through a cooperative agreement, DOE and the South Carolina Institute of Archaeology and Anthropology of the University of South Carolina conduct the Savannah River Archaeological Research Program to provide services re-required by Federal law for the protection and management of archaeological resources. Ongoing research programs work in conjunction with the South Carolina State Historic Preservation Office.

Savannah River archaeologists have examined 60 percent of the 300-square-mile area and recorded more than 1,200 archaeological sites (HNUS 1997). Most (approximately 75 percent) of these sites are prehistoric. To facilitate the management of these resources, SRS is divided into three archaeological zones, based on an area's potential for containing sites of historical or archaeological significance (DOE 1995b). Zone 1 represents areas with the greatest potential for having significant resources; Zone 2 areas possess sites with moderate potential; and Zone 3 has areas of low archaeological significance.

Studies of S and Z Areas prior to construction of DWPF found no evidence of historic or cultural resources (DOE 1982). Because S and Z Areas are in industrialized sections of the SRS, it is likely that any resources that may have been present were destroyed during initial construction activities in the 1950s.

3.8 Public and Worker Health

Radiological and nonradiological hazardous materials released from SRS reach the workers and public through various environmental transport pathways. The primary transport pathways include inhalation, ingestion, or direct contact exposure pathways from air and drinking water. This SEIS evaluates the collective impacts to workers and the public from radiological and nonradiological pollutant transport pathways.

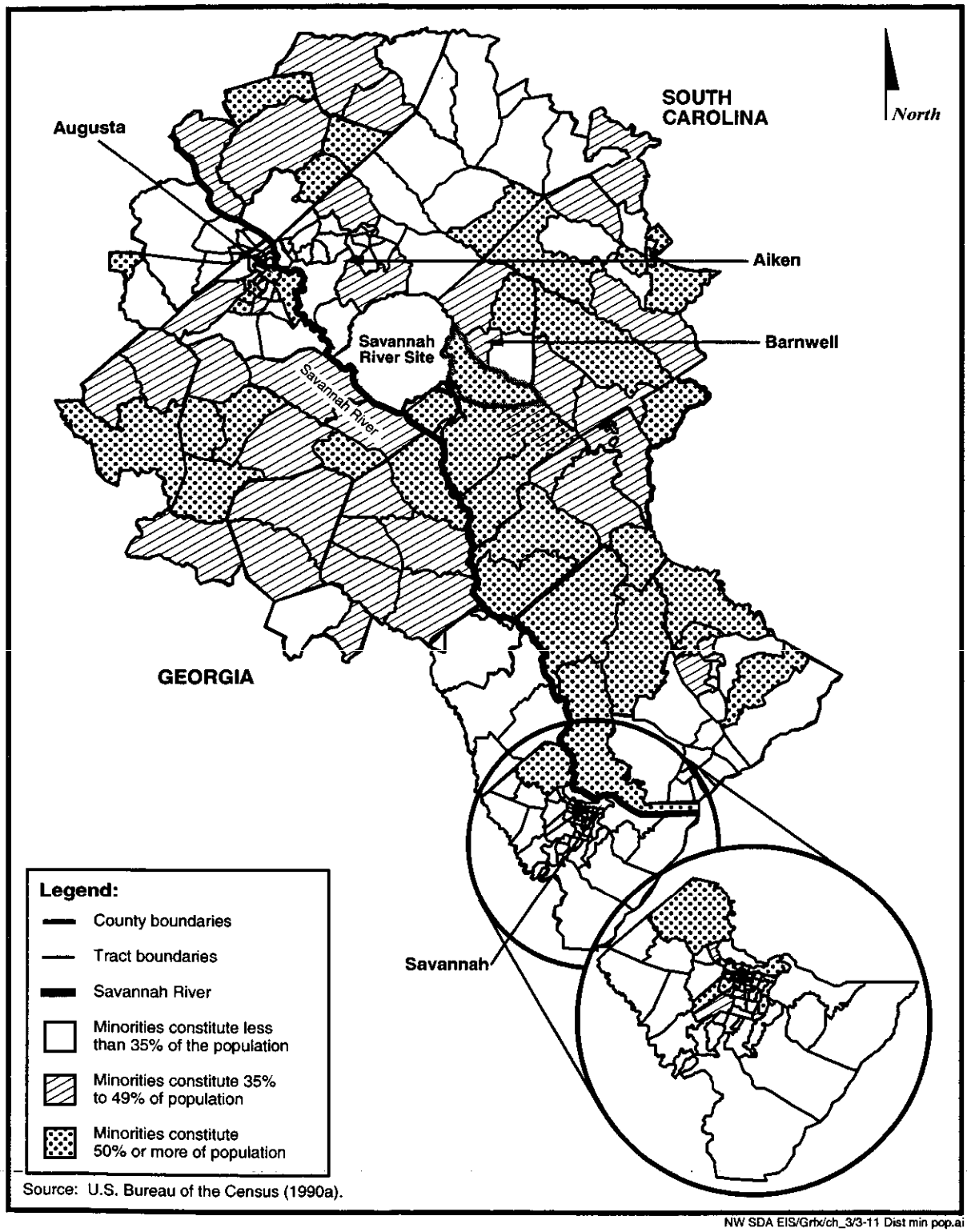


Figure 3-11. Distribution of minority population by census tracts in the SRS region of analysis.

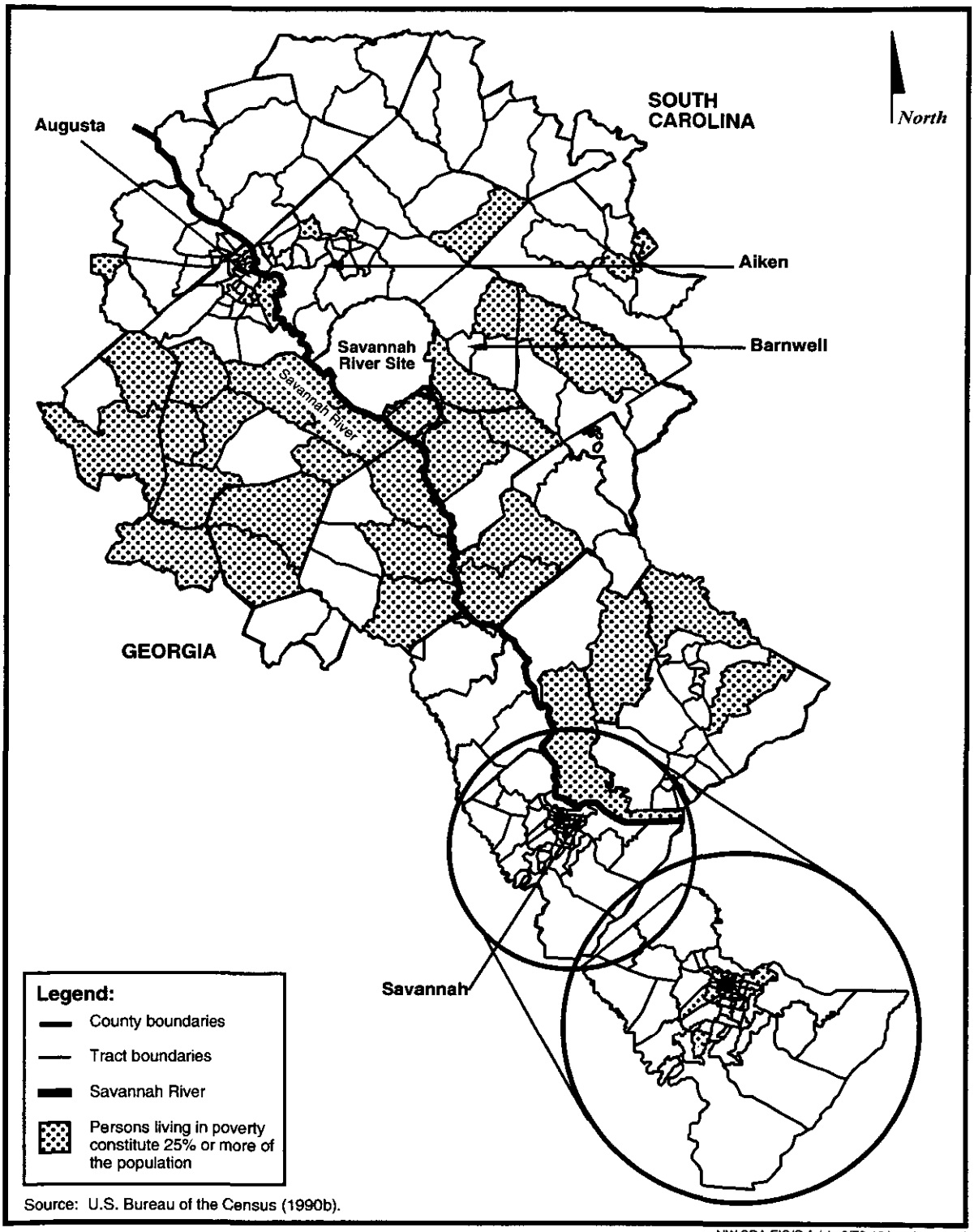


Figure 3-12. Low income census tracts in the SRS region of analysis.

Table 3-16. General poverty characteristics of populations in the Savannah River Site region of influence.

Area	Total population	Persons living in poverty[a]	Percent living in poverty
South Carolina	418,685	72,345	17.3%
Georgia	574,982	96,672	16.8%
Total	993,667	169,017	17.0%

a. Families with income less than the statistical poverty threshold, which in 1998 was an annual income of $10,915 for a family of two.

3.8.1 PUBLIC RADIOLOGICAL HEALTH

Because there are many sources of radiation in the human environment, evaluations of radioactive releases from nuclear facilities must consider all ionizing radiation to which people are routinely exposed.

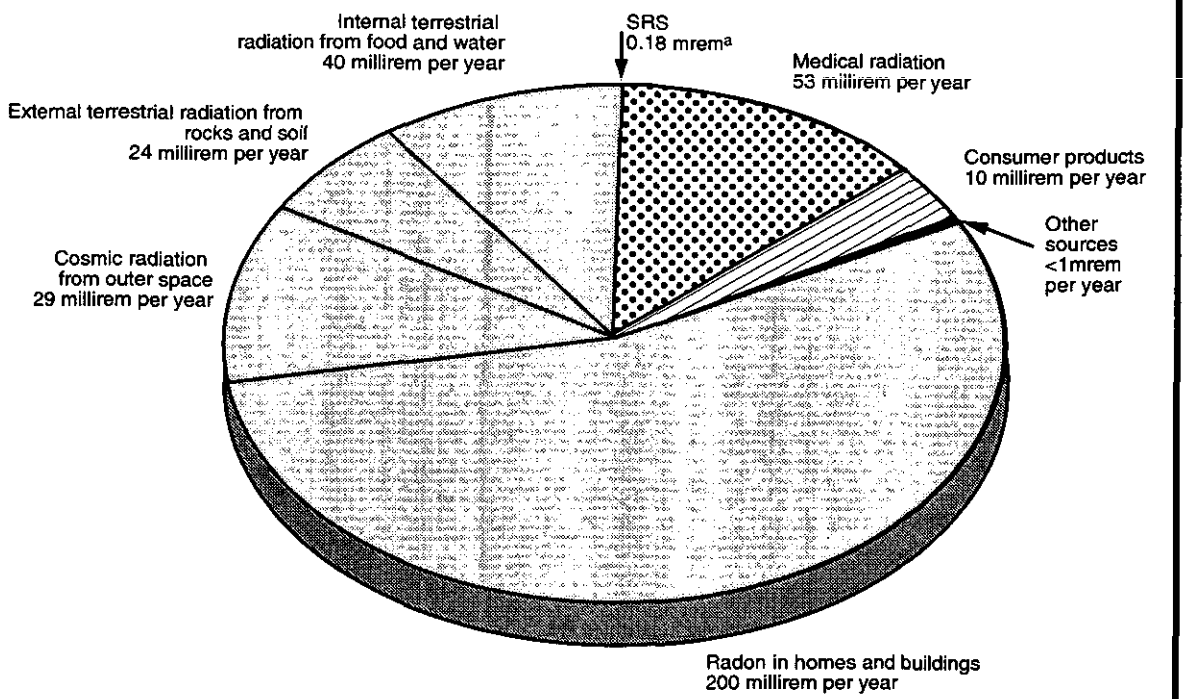
Doses of radiation are expressed as millirem (mrem), rem (1,000 mrem), and person-rem (sum of dose to all individuals in population). An individual's radiation exposure in the vicinity of SRS is estimated to be approximately 357 mrem per year, which is comprised of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; weapons test fallout; consumer and industrial products; and nuclear facilities. Figure 3-13 shows the relative contribution of each of these sources to the dose that would be received by an individual living near SRS. All radiation doses mentioned in this SEIS are committed effective dose equivalents, which include both the dose from internal deposition of radionuclides and the dose attributable to sources external to the body.

Releases of radioactivity from SRS to the environment account for less than 0.1 percent of the total annual average environmental radiation dose to individuals within 50 miles of the Site. Natural background radiation contributes about 293 mrem per year, or 82 percent of the annual dose of the estimated 357 mrem received by an average member of the population within 50 miles of the Site. Based on national averages, medical exposure accounts for an additional 14.8 percent of the annual dose and combined doses from weapons test fallout, consumer and industrial products, and air travel account for about 3 percent (NCRP 1987).

Other nuclear facilities within 50 miles of SRS include a low-level waste disposal site operated by Chem-Nuclear Systems, Inc., near the eastern Site boundary and approximately 11 miles from S Area and Georgia Power Company's Vogtle Electric Generating Plant, directly across the Savannah River from SRS and approximately 13 miles from S Area. In addition, Starmet CMI (formerly Carolina Metals), Inc., which is northwest of Boiling Springs in Barnwell County, approximately 15 miles from S Area, processes depleted uranium.

The SCDHEC *South Carolina Nuclear Facility Monitoring Annual Report 1995* (SCDHEC 1995) indicates that the Chem-Nuclear and Starmet CMI facilities do not influence radioactivity levels in the air, precipitation, groundwater, soil, or vegetation. Plant Vogtle began commercial operation in 1987: 1992 releases produced an annual dose of 0.54 mrem to the MEI at the plant boundary and a total population dose within a 50-mile radius of 0.045 person-rem (NRC 1996).

In 1997, releases of radioactive material to the environment from SRS operations resulted in an estimated MEI air pathway dose of 0.05 mrem at the Site boundary in the west-southwest sector of the Site, and an estimated maximum dose from water of 0.13 mrem, for an estimated maximum total annual dose at the boundary of 0.18 mrem.

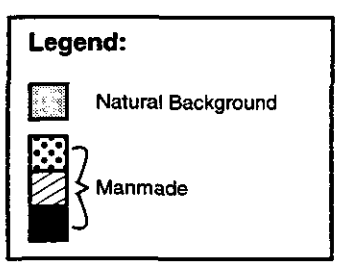


L1-15

Notes:
1. Values are effective dose equivalents from NCRP (1987a) unless noted otherwise.
2. Cosmic: NCRP (1987a) reports 26 millirem per year for sea level. Multiplying value by a factor of 1.1 to correct for the altitude of 300 meters above sea level gives 29 millirem per year.
3. External terrestrial: NCRP (1987b) reports an absorbed dose rate for Augusta, Georgia of 4 microrad per hour, which is 35 millirad per year. NCRP (1987b) uses a factor of 0.7 to convert absorbed dose in air to effective dose equivalent, so 35 x 0.7 = 24 millirem per year.
4. Value for SRS contribution is from Arnett and Mamatey (1998b).
5. Other sources include commercial nuclear facilities (nationwide), occupational exposure, air travel, and fallout.

a. The SRS dose of 0.18 mrem is too small to be depicted on the graph

L1-15



NW SDA EIS/Grfx/ch_3/3-13 Major rad expo.ai

Figure 3-13. Major sources of radiation exposure in the vicinity of the Savannah River Site.

The estimated maximum dose from water pathways to downstream consumers of Savannah River water – 0.07 mrem – occurred to users of the Port Wentworth and the Beaufort-Jasper public water supplies (Arnett and Mamatey 1998b).

In 1990, the population within 50 miles of the Site was approximately 620,100. The estimated collective effective dose equivalent to that population in 1997 was 2.2 person-rem from atmospheric releases. The 1997 population of 70,000 people using water from the Port Wentworth, Georgia, public water supply and 60,000 people using water from the Beaufort-Jasper Water Treatment Plant near Beaufort, South Carolina, received an estimated collective dose equivalent of 2.4 person-rem in 1997 (Arnett and Mamatey 1998b).

Population statistics indicate that cancer caused 23.3 percent of the deaths in the United States in 1997 (CDC 1999). If this percentage of deaths from cancer continues, 23.3 percent of the U.S. population would contract a fatal cancer from all causes. Thus, in the 1990 population of 620,100 within 50 miles of SRS, approximately 144,000 persons would be likely to contract fatal cancers from all causes. The total calculated population dose from SRS of 4.6 person-rem (2.2 person-rem from atmospheric pathways plus 2.4 person-rem from water pathways) could result in 0.0023 additional latent cancer death in the same population [based on 0.0005 cancer death per person-rem]) (NCRP 1993).

3.8.2 PUBLIC NONRADIOLOGICAL HEALTH

The hazards associated with the alternatives described in this SEIS include exposure to nonradiological chemicals in the form of water and air pollution (see Sections 3.2 and 3.3). Nonradiological chemical air pollutants are released from SRS facilities that involve chemical processes, such as separations and high-level waste (HLW) treatment and storage. Due to dilution and dispersion, lower levels of these air pollutants would occur at locations near the Site boundary, offsite, and farther away from the sources. Table 3-11 lists ambient air quality standards and estimated SRS baseline concentrations for selected criteria and toxic pollutants. The purpose of these standards is to protect public health. As discussed in Section 3.3, all estimated SRS baseline concentrations are below the ambient standards for all air pollutants emitted at SRS (Table 3-11).

Nonradiological pollutants from past SRS operations have been identified in other environmental pathways (such as groundwater, surface water, and soils). Environmental sampling programs for these resources indicate that the public is not exposed to these pollutants at concentrations that would impact its health. Groundwater monitoring results in recent years have indicated that ongoing remediation efforts at A and M Areas have diminished the spread of contamination (primarily organics and metals) and reduced the groundwater impact of operations in those areas. Each SRS stream receives varying amounts of treated wastewater and rainwater runoff from site facilities. Stream water quality is sampled monthly and quarterly. In addition, river sampling sites are located upriver of, adjacent to, and downriver of the Site in order to compare the SRS contribution of pollutants to background levels of chemicals from natural sources and upriver non-SRS industrial sources. Analysis of the data for samples collected in 1997 indicates that SRS discharges are not adversely affecting the water quality of the site streams or the river. Table 3-1 lists selected water quality standards, guidelines, and measured concentrations at the Upper Three Runs sampling location downstream of McQueen's Branch. SRS's sediment surveillance program also indicates that inorganic contaminant results were within the expected range (Arnett and Mamatey 1998b).

3.8.3 WORKER RADIOLOGICAL HEALTH

One of the major goals of the SRS Health Protection Program is to keep worker exposures to radiation and radioactive material as low as reasonably achievable. Such a program must

evaluate both external and internal exposures, with the goal being to minimize the total effective dose equivalent. An effective program to keep doses as low as reasonably achievable must also balance minimizing individual worker doses with minimizing the collective dose of workers in a group. For example, using many workers to perform small portions of a task would reduce the individual worker dose to low levels. However, frequent worker changes would make the work inefficient, resulting in a significantly higher collective dose to all the workers than if fewer had received slightly higher individual doses.

SRS worker doses have typically been well below Federal worker exposure limits. DOE sets administrative exposure guidelines at a fraction of the exposure limits to help enforce doses that are as low as reasonably achievable. For example, the current DOE worker exposure limit is 5,000 mrem per year, and the 1998 SRS as-low-as-reasonably-achievable administrative control level for the whole body was 500 mrem per year. Every year, DOE evaluates the SRS as-low-as-reasonably-achievable administrative control levels and adjusts them as needed.

Table 3-17 lists average individual doses and SRS collective doses from 1989 to 1998.

3.8.4 WORKER NONRADIOLOGICAL HEALTH

Industrial hygiene and occupational health programs at SRS deal with all aspects of worker health and the relationship of the worker to the work environment. The objective of an effective occupational health program is to protect employees from hazards in their work environments. To evaluate these hazards, DOE uses routine monitoring to determine employee exposure levels to hazardous chemicals.

Exposure limit values are the basis of most occupational health codes and standards. If an overexposure to a harmful agent does not exist, that agent generally does not create a health problem.

The Occupational Safety and Health Administration (OSHA) has established Permissible Exposure Limits to regulate worker exposure to hazardous chemicals. These limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could receive repeated exposures day after day without adverse health effects.

Table 3-18 lists OSHA-regulated workplace pollutants likely to be generated by salt processing activities and the applicable OSHA limits.

A well-defined worker protection program is in place at SRS to protect the occupational health of DOE and contractor employees. To prevent occupational illnesses and injuries and to preserve the health of the SRS workforce, contractors involved in the construction and operations programs have implemented DOE-approved health and safety programs. Tables 3-19 and 3-20 display the results of these health and safety programs, which have resulted in lower incidences of injury and illness than in the general industry construction and manufacturing workforces.

3.9 Waste and Hazardous Materials Management

This section describes the waste generation baseline that DOE uses in Chapter 4 to gauge the relative impact of each salt processing alternative on the overall waste generation at SRS and on DOE's capability to manage such waste. In 1995, DOE prepared an EIS on the management of wastes projected to be generated by SRS for the next 30 years (DOE 1995b).

DOE generates six basic types of waste – HLW, low-level radioactive (LLW), hazardous, mixed (low-level radioactive and hazardous),

Table 3-17. SRS annual individual and collective radiation doses.

Year	Employees with measurable dose	Average individual worker dose (rem)[a]	Site worker collective dose (person-rem)
1989	12,363	0.070	863
1990	11,659	0.065	753
1991	8,391	0.055	459
1992	6,510	0.054	352
1993	5,202	0.051	264
1994	6,284	0.050	315
1995	4,846	0.053	256
1996	4,736	0.053	252
1997	3,327	0.050	165
1998	3,163	0.052	166

Sources: duPont (1989), Petty (1993), WSRC (1991, 1992, 1993, 1994, 1995b, 1996, 1997b, 1998e, 1999c).
a. The average dose includes only workers who received a measurable dose during the year.

Table 3-18. Potential occupational safety and health hazards and associated exposure limits.

Pollutant	OSHA PEL[a] (mg/m^3)	Time period
Benzene	3.1	8 hours
Carbon monoxide	55	8 hours
Nitrogen dioxide	9	Ceiling limit
Sulfur dioxide	13	8 hours
Particulate matter (<10 microns)	150	24 hours
	50	annual
Total particulates	15	8 hours

a. PEL = Permissible Exposure Limits. The OSHA PEL listed in Table Z-1-A or Z-2 of the OSHA General Industry Air Contaminants Standard (29 CFR 1910.1000) provided if appropriate. These limits, unless otherwise noted (e.g., ceiling), must not be exceeded during any 8-hour work shift of a 40-hour work week.

Table 3-19. Comparison of injury and illness incident rates for SRS construction to general industry construction.

Incident rate	SRS construction department[a]	Construction industry[b]
Total recordable cases per 200,000 hours worked[c]	5.11	9.70
Total lost workday cases per 200,000 hours worked[c]	2.41	4.45

a. Source: DOE (2000b). Data includes direct-hire and subcontract construction hours worked for the years 1995 through 1999.
b. Source: Bureau of Labor Statistics (2000). Industry average for the years 1995 through 1998. No data available for 1999.
c. 200,000 hours is the standard base for incidence rates, and represents the equivalent of 100 employees working 40 hours per week for 50 weeks.

Table 3-20. *Comparison of injury and illness incident rates for SRS operations to private industry and manufacturing.*

Incident rate	SRS operations[a]	Private industry[b]	Manufacturing[b]
Total recordable cases per 200,000 hours worked[c]	1.24	7.33	10.55
Total lost workday cases per 200,000 hours worked[c]	0.54	3.35	4.93

a. Source: DOE (2000b). Data includes direct-hire and subcontract operations hours worked for the years 1995 through 1999.
b. Source: Bureau of Labor Statistics (2000). Industry average for the years 1995 through 1998. No data available for 1999.
c. 200,000 hours is the standard base for incidence rates, and represents the equivalent of 100 employees working 40 hours per week for 50 weeks.

transuranic (including alpha-contaminated), and sanitary (nonhazardous, nonradioactive) – which this SEIS considers because they are possible byproducts of the SRS salt processing activities. The following sections describe the waste types. Table 3-21 lists projected total waste generation volumes for a 30-year period that encompasses the expected duration of the salt processing activities addressed in this SEIS. The assumptions and uncertainties applicable to SRS waste management plans and waste generation estimates are described in Halverson (1999). These estimates do not include wastes that would be generated as a result of SRS salt processing activities evaluated in this SEIS.

Tables 3-22 through 3-24 provide an overview of the existing and planned facilities that DOE expects to use in the storage, treatment, and disposal of the various waste classes.

3.9.1 LOW-LEVEL RADIOACTIVE WASTE

DOE (1999b) defines LLW as radioactive waste that cannot be classified as HLW, spent nuclear fuel, transuranic waste, byproduct material, or naturally occurring radioactive material.

At present, DOE uses a number of methods for treating and disposing of LLW at SRS, depending on the waste form and radioactivity level. DOE volume-reduces these wastes by incineration, compaction, supercompaction, smelting, or repackaging (DOE 1995b). After volume reduction, DOE packages the remaining low-activity waste and places it in either shallow land disposal or vault disposal in E Area.

DOE places LLW of intermediate activity and some tritiated LLW in E Area intermediate activity vaults, and will store long-lived LLW (e.g., spent deionizer resins) in the long-lived waste storage buildings in E Area, where they will remain until DOE determines their final disposition.

3.9.2 MIXED LOW-LEVEL WASTE

Mixed LLW is radioactive waste that contains material that is listed as hazardous waste under the Resource Conservation and Recovery Act (RCRA) or that exhibits one or more of the following hazardous waste characteristics: ignitability, corrosivity, reactivity, or toxicity. It includes such materials as tritiated mercury, tritiated oil contaminated with mercury, other mercury-contaminated compounds, radioactively-contaminated lead shielding, equipment from the tritium facilities in H Area, and filter paper takeup rolls from the M-Area Liquid ETF.

Table 3-21. Total waste generation forecast for SRS (cubic meters).[a]

	Waste class				
Inclusive dates	Low-level	HLW	Hazardous	Mixed low-level	Transuranic and alpha
1998 to 2029	180,299	14,129	6,315	3,720	6,012

a. Derived from Halverson (1999). Projected quantities for hazardous and mixed low-level waste derived using ratio of expected waste forecasts for these waste types in DOE (1995b).

3.9.2 MIXED LOW-LEVEL WASTE

Mixed LLW is radioactive waste that contains material that is listed as hazardous waste under the Resource Conservation and Recovery Act (RCRA) or that exhibits one or more of the following hazardous waste characteristics: ignitability, corrosivity, reactivity, or toxicity. It includes such materials as tritiated mercury, tritiated oil contaminated with mercury, other mercury-contaminated compounds, radioactively-contaminated lead shielding, equipment from the tritium facilities in H Area, and filter paper takeup rolls from the M-Area Liquid ETF.

As described in the *Approved Site Treatment Plan* (WSRC 1999d), storage facilities for mixed low-level waste are in several different SRS areas. These facilities are dedicated to solid, containerized, or bulk liquid waste and all are approved for this storage under RCRA as interim status or permitted facilities or under the Clean Water Act as permitted tank systems. Several treatment processes described in WSRC (1999d) could be used for mixed LLW. These facilities, which are listed in Table 3-23, include the Consolidated Incineration Facility (CIF), the M-Area Vendor Treatment Facility, and the Hazardous Waste/Mixed Waste Containment Building.

CIF operations were suspended in October 2000. It was constructed primarily to incinerate benzene generated in the In-Tank Precipitation process. Additionally, it was scheduled to destroy plutonium uranium extraction (PUREX) wastes from Canyon operations, some solid LLW from ongoing operations, and waste from decontamination and decommissioning (D&D) projects. The benzene stream and the D&D projects did not materialize, and LLW could be more cost-effectively compacted. If an effective alternative to PUREX disposal can be identified, CIF will not be necessary. DOE is expected to make a decision on CIF by April 2002. L4-7

Depending on the nature of the waste residues remaining after treatment, DOE plans to use either shallow land disposal or RCRA-permitted hazardous waste/mixed waste vaults for disposal.

3.9.3 HIGH-LEVEL WASTE

HLW is highly radioactive material resulting from the reprocessing of spent nuclear fuel that contains fission products in concentrations requiring permanent isolation. It includes both liquid waste produced by reprocessing and any solid waste derived from that liquid (DOE 1999b).

At present, DOE stores HLW in carbon steel and reinforced concrete underground tanks in the F- and H-Area Tank Farms. The HLW in the tanks consists of three physical forms: sludge, saltcake, and supernatant. The sludge is solid material that precipitates or settles to the bottom of a tank. The saltcake is comprised of salt com-pounds that have crystallized as a result of concentrating the salt component of HLW by evaporation. The salt supernatant is a highly concentrated liquid.

Table 3-22. Planned and existing waste storage facilities.

Storage facility	Location	Capacity	Original waste stream[a]						Status
			Low-level	HLW	Transuranic	Alpha[b]	Hazardous	Mixed Low-level	
Long-lived waste storage buildings	E Area	140 m^3/bldg	X						One exists; DOE plans to construct additional buildings, as necessary.
Containerized mixed waste storage	Buildings 645-2N, 643-29E, 643-43E, 316-M, and Pad 315-4M	4,237 m^3						X	DOE plans to construct additional storage buildings, similar to 643-43E, as necessary.
Liquid mixed waste storage	DWPF Organic Waste Storage Tank (S Area) SRTC Mixed Waste Tanks Liquid Waste Solvent Tanks (H Area) Process Waste Interim Treatment/Storage Facility Tanks (M Area)	9,586 m^3						X	The Process Waste Interim Treatment/Storage Facility ceased operation under RCRA in March 1996 and now operates under the Clean Water Act.
HLW Tank Farms	F and H Areas	(c)		X					51 underground tanks; one (16H) has been removed from service and two (17F, 20F) have been closed.[d]
Failed equipment storage vaults	Defense Waste Processing Facility (S Area)	300 m^3		X					Two exist; DOE plans approximately 12 additional vaults.
Glass waste storage buildings	Defense Waste Processing Facility (S Area)	2,286 canisters[e]		X					One exists and is expected to reach capacity in 2005; a second is planned to accommodate canister production from 2005 to 2015.
Hazardous waste storage facility	Building 710-B Building 645-N Building 645-4N Waste Pad 1 (between 645-2N and 645-4N) Waste Pad 2 (between 645-4N and 645-N) Waste Pad 3 (east of 645-N)	4,557 m^3					X		Currently in use. No additional facilities are planned, as existing space is expected to adequately support the short-term storage of hazardous wastes awaiting treatment and disposal.
Transuranic waste storage pads	E Area	(f)			X	X		X	19 pads exist; additional pads will be constructed as necessary.

Sources: DOE (1994; 1995b), WSRC (1999d).

a. Sanitary waste is not stored at SRS; therefore, it is not addressed in this table.
b. Currently, alpha waste is handled and stored as transuranic waste. After it is surveyed and separated, most will be treated and disposed of as low-level or mixed low-level waste.
c. As of April 1998, there were approximately 660,000 gallons of space available in each of the HLW Tank Farms.
d. Twenty-four of these tanks do not meet secondary containment requirements and have been scheduled for closure.
e. Usable storage capacity of 2,159 canisters due to floor plug problems.
f. Transuranic waste storage capacities depend on the packaging of the waste and the configuration of packages on the pads.

m^3 = cubic meters, SRTC = Savannah River Technology Center.

Table 3-23. Planned and existing waste treatment processes and facilities.

Waste Treatment Facility	Waste Treatment Process	Waste type							Status
		Low-level	High-level	Transuranic	Alpha[a]	Hazardous	Mixed Low-level	Sanitary	
Consolidated Incineration Facility	Incineration	X				X	X		Operations suspended in 2000
Offsite facility	Incineration	X				X	X		Not currently operating
Offsite facility	Compaction	X							Not currently operating
Onsite facility	Supercompaction	X							Operating
Offsite facility	Smelting	X							Not currently operating
Onsite facility	Repackaging	X							Operating
Defense Waste Processing Facility	Vitrification		X						Operating (sludge only)
Saltstone Manufacturing and Disposal	Stabilization						X		Not currently operating
Replacement High-Level Waste Evaporator[c]	Volume Reduction		X						Began treating waste in December 1999
M-Area Vendor Treatment Facility	Vitrification						X		Treatment of design basis wastes completed in February 1999
Hazardous Waste/Mixed Waste Containment Building	Macroencapsulation Decontamination					X	X		Plan to begin operations in 2006
Treatment at point of waste stream origin	Macroencapsulation						X		As feasible, based on waste and location
Non-Alpha Vitrification Facility	Vitrification	X				X	X		Under evaluation as a potential process
DOE Broad Spectrum Contractor[b]	Amalgamation/Stabilization/Macroencapsulation						X		DOE is considering use of the Broad Spectrum Contract
Offsite facility	Offsite Treatment and Disposal					X			Currently operational
Offsite facility	Decontamination						X		Began treating waste onsite in December 1998. Plan to pursue treatment offsite in 2000, if necessary.
High-activity mixed transuranic waste facility	Repackaging/size reduction			X	X				Planned to begin operations in 2012
Low-activity mixed transuranic waste facility	Repackaging/size reduction/super compaction			X	X				Planned to begin operations in 2002
Various onsite and offsite facilities[d]	Recycle/Reuse	X				X	X	X	Currently operational
Existing DOE facilities	Repackaging/Treatment			X					Transuranic waste strategies are still being finalized
F- and H-Area Effluent Treatment Facility	Wastewater Treatment	X					X		Currently operational

Sources: DOE (1994, 1995b); WSRC (1999d,e; 2000b).

a. Currently, alpha waste is handled as transuranic waste. After it is surveyed and separated, most will be treated and disposed of as low-level or mixed low-level waste.

b. Evaporation precedes treatment at the DWPF and is used to maximize HLW storage capacity.

c. Various waste streams have components (e.g., silver, lead, freon, paper) that might be recycled or reused. Some recycling activities might occur onsite, while other waste streams are directed offsite for recycling. Some of the recycled products are released for public sale, while others are reused onsite.

Table 3-24. Planned and existing waste disposal facilities.

Disposal facility	Location	Capacity (m^3)	Original waste stream[a]						Status
			Low-level	High-level	Transuranic	Hazardous	Mixed Low-level	Sanitary	
Shallow land disposal trenches	E Area	*(b)*	X						*Four have been filled; up to 58 more may be constructed.*
Low-activity vaults	E Area	30,500/vault	X						One vault exists and one additional is planned.
Intermediate-activity vaults	E Area	5,300/vault	X						Two vaults exist and five more may be constructed.
Hazardous waste/mixed waste vaults	NE of F Area	2,300/vault				X	X		RCRA permit application submitted for *10 vaults. At least 11* additional vaults may be needed.
Saltstone Manufacturing and Disposal	Z Area	80,000/vault[c]	X						Two vaults exist; future vault needs to be determined by SRS salt processing alternatives.
Three Rivers Landfill	Intersection of SC 125 and SRS Road 2	NA						X	Current destination for SRS sanitary waste.
Burma Road Cellulosic and Construction Waste Landfill	SRS Intersection of C Road and Burma Road	NA						X	Current destination for demolition/construction debris. DOE expects to reach permit capacity in 2008.
Waste Isolation Pilot Plant (WIPP)	New Mexico	175,600			X				Current destination for some SRS transuranic waste.[d]
Federal repository	See Status	NA		X					Proposed Yucca Mountain, Nevada, site is currently under investigation.

Sources: DOE (1994, 1995b, 1997c); WSRC (1999d,f; 2000b).

a. After alpha waste is assayed and separated from the transuranic waste, DOE plans to dispose of it as low-level or mixed low-level waste, so it is not addressed separately here.

b. Various types of trenches exist including engineered low-level trenches, greater confinement disposal boreholes and engineered trenches, and slit trenches. The different trenches are designed for different waste types, are constructed differently, and have different capacities.

c. *This is the approximate capacity of a double vault. One single vault and one double vault have been constructed. Future vault design would be based on the selected salt processing alternative.*

d. SRS received WIPP certification in April 2001 and shipped waste to WIPP in May 2001.

NA = not available, WIPP = Waste Isolation Pilot Plant.

The sludge portion of the HLW is currently being transferred to DWPF for immobilization in borosilicate glass. The treatment processes at DWPF are described in the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994). The salt portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before ultimate treatment. Alternatives for processing the salt portion of the SRS HLW is the subject of this SEIS.

DOE has committed to complete closure by 2022 of the 24 HLW tank systems that do not meet the secondary containment requirements in the Federal Facility Agreement (WSRC 2000b). During waste removal, DOE will retrieve as much of the stored HLW as can be removed using the existing waste transfer equipment. The sludge portion of the retrieved waste will be treated in treatment facilities and vitrified at DWPF, as discussed in the 1999 SEIS. Processing of the salt portion of the retrieved waste is the subject of this SEIS.

3.9.4 SANITARY WASTE

Sanitary waste is solid waste that is neither hazardous, as defined by RCRA, nor radioactive. It consists of salvageable material and material that is suitable for disposal in a municipal sanitary landfill. Sanitary wastes include such items as paper, glass, discarded office material, and construction debris (DOE 1994).

Sanitary waste volumes have declined due to recycling and the decreasing SRS workforce. DOE sends sanitary waste that is not recycled or reused to the Three Rivers Landfill on SRS. DOE also continues to operate the Burma Road Cellulosic and Construction Waste Landfill to dispose of demolition and construction debris.

3.9.5 HAZARDOUS WASTE

Hazardous waste is nonradioactive waste that SCDHEC regulates under RCRA and corresponding state regulations. Waste is hazardous if the EPA lists it as such or if it exhibits any of the characteristic(s) of ignitability, corrosivity, reactivity, or toxicity. SRS hazardous waste streams consist of a variety of materials, including mercury, chromate, lead, paint solvents, and various laboratory chemicals.

At present, DOE stores hazardous wastes in three buildings and on three solid waste storage pads that have RCRA permits. Hazardous waste is sent to offsite treatment and disposal facilities. DOE also plans to continue to recycle, reuse, or recover certain hazardous wastes, including metals, excess chemicals, solvents, and chlorofluorocarbons. Wastes remaining after treatment might be suitable for either shallow land disposal or disposal in the Hazardous/Mixed Waste Disposal Vaults (DOE 1995b).

3.9.6 TRANSURANIC AND ALPHA WASTE

Transuranic waste contains alpha-emitting transuranic radionuclides (those with atomic numbers greater than 92) that have half-lives greater than 20 years at activities exceeding 100 nanocuries per gram (DOE 1999b). At present, DOE manages low-level alpha-emitting waste with activities between 10 and 100 nanocuries per gram (referred to as alpha waste) as transuranic waste at SRS. L4-8

Current SRS efforts for transuranic and alpha waste consist primarily of providing continued safe storage. After alpha waste is assayed and separated from the transuranic waste, DOE plans to dispose of the alpha waste onsite as low-level or mixed low-level waste. Eventually, DOE plans to ship the SRS transuranic and mixed transuranic waste to the Waste Isolation Pilot Plant in New Mexico for disposal.

3.9.7 HAZARDOUS CHEMICALS

The *Savannah River Site Tier II Emergency and Hazardous Chemical Inventory Report* for 1998 (WSRC 1999g) lists more than 79 hazardous chemicals that were present at SRS at some time during the year in amounts that exceeded the minimum reporting thresholds (generally 10,000

pounds for hazardous chemicals and 500 pounds for extremely hazardous substances). Four of the 79 hazardous chemicals are considered extremely hazardous substances under the Emergency Planning and Community Right-to-Know Act of 1986. The actual number and quantity of hazardous chemicals present on and at individual facilities changes daily as a function of use and demand.

3.10 Energy and Utilities

Electricity. The South Carolina Electric and Gas Company (SCE&G) supplies SRS electric power needs via one 160-kilovolt and two 115-kilovolt-capacity transmission lines, with a combined available power of about 390 megawatts. The SRS D-Area Powerhouse, which was once operated by DOE to provide a portion of the Site's electricity needs, is now under lease to SCE&G, which in turn sells electricity to DOE. Current Site power demand is about 70 megawatts, with 30 percent of that total (about 22 megawatts) being delivered to H-Area facilities. The capacity of the H-Area power distribution network is 64 megawatts. A substation in H Area distributes electricity to S and Z Areas.

Steam. Steam production facilities at SRS include coal-fired powerhouses at A, D, and H Areas, and two package boilers, which use number 2 fuel oil, in K Area. DOE has privatized the D-Area Powerhouse, which provides most of the steam for SRS. SCE&G produces and sells steam to DOE. At present, steam generation occurs continuously at the A- and D-Area facilities (the H-Area powerhouse is maintained in a standby condition). The combined capacity of these steam production facilities is about 1.7 million pounds per hour, with the D-Area powerhouse representing 75 percent of that capacity (1.3 million pounds per hour). Average daily steam use is about 150,000 pounds per hour (excluding 30,000 pounds per hour use during winter).

Domestic and Process Water. During 1998, groundwater withdrawals at SRS for domestic and process uses totaled 5,345 billion gallons, or a daily average of 14,634 million gallons (10,162 gallons per minute). This demand represents about 91 percent of the lowest estimated production capacity (16 million gallons per day) of the aquifer. The 1998 average consumption of water in H- and S-Area facilities was about 1.023 and 0.049 million gallons per day, respectively. This water demand represents almost 7 percent of the total Site demand. The average demand for water is about 960 gallons per minute; the water supply capacity is about 3,450 gallons per minute, which is about 30 percent of the lowest estimated production capacity (16 million gallons per day) of the aquifer. The water demand imposed by the operation of S- and Z-Area facilities averages 50 gallons per minute (about 5 percent of the total Site demand); the associated system capacity is 200 gallons per minute.

Originally built to supply water from the Savannah River to the five SRS production reactors, the River Water System includes three pumphouses, two (1G and 3G) on the Savannah River, and one (6G) on Par Pond. Pumphouse 5G is also on the Savannah River, but has a separate piping system that supplies cooling water to the D-Area Powerhouse. Pumphouses 1G and 6G are no longer operating, but DOE has maintained the 1G pumphouse and system. The total design capacity of the 1G and 3G pumphouses is 400,000 gallons per minute. In 1997, DOE installed a 5,000-gallon-per-minute pump in Pumphouse 3G to save energy and costs. At present, only Pumphouse 3G is in use, withdrawing 5,000 gallons per minute from the Savannah River to supply small cooling loads in K and L Areas.

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CHAPTER 4. ENVIRONMENTAL IMPACTS

Chapter 4 describes the impacts to the Savannah River Site (SRS) and the surrounding region of implementing each of the alternatives described in Chapter 2. As discussed in Chapter 2, in addition to the No Action alternative, the U.S. Department of Energy (DOE) has identified four *action* alternatives that would meet the purpose and need for action: *to identify and implement one or more technologies to prepare the SRS high-level waste (HLW) salt component for disposal.* The five alternatives are as follows:

- No Action
- Small Tank Precipitation
- Ion Exchange
- Solvent Extraction (DOE's preferred alternative)
- Direct Disposal in Grout

Environmental impacts could include direct physical disturbance of resources, consumption of resources, or degradation of resources caused by effluents and emissions. Resources include air, water, soils, plants, animals, cultural artifacts, and people, including SRS workers and people in nearby communities. Impacts may be detrimental (e.g., increased airborne emissions of hazardous chemicals) or beneficial (e.g., improvements to the environmental baseline of the SRS HLW System).

Section 4.1 describes the short-term impacts associated with construction and operation of each alternative, including No Action. For purposes of the analyses in this Supplemental Environmental Impact Statement (SEIS), the short-term impacts span from the year 2001 until completion of salt processing operations (approximately 2023). As indicated in Chapter 2, the time of completion varies slightly with the selected technology. Section 4.2 describes for each action alternative the long-term impacts of the radioactive and non-radioactive constituents solidified in saltstone and disposed of in the saltstone disposal vaults. Long-term assessment of the action alternatives involves a performance evaluation beginning with a 100-year period of institutional control and continuing through an extended period, during which it is assumed that residential and/or agricultural uses could occur. For the No Action alternative, Section 4.2 describes the long-term impacts of the radioactive constituents if salt waste were left in the HLW tanks. The long-term assessment of the No Action alternative involves a 100-year period of institutional control after which the HLW tanks would fail, allowing salt solution to overflow to the ground and run off to surface streams that could serve as sources of drinking water.

The assessments in this SEIS have generally been performed so that the estimated magnitude and intensity of impacts would not be exceeded by the actual facility. Predictions of the impacts of routine operations are based on monitoring of similar operations and are, therefore, considered realistic estimates. For accidents, there is more uncertainty because the impacts are based on events that have not occurred. In this SEIS, DOE selected hypothetical accidents that would produce impacts as severe or more severe than any reasonably foreseeable accidents, which ensures that DOE has bounded all potential accidents for each alternative.

To ensure that small potential impacts are not over-analyzed and large potential impacts are not under-analyzed, analysts have focused efforts on significant environmental issues and have discussed impacts in proportion to their significance. This methodology follows the recommendation for the use of a "sliding scale" approach to analysis described in *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993).

4.1 Short-Term Impacts

This section describes the short-term impacts associated with construction and operation of each action alternative (i.e., Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout). Construction includes those actions necessary to prepare land and erect facilities for the alternatives evaluated in this SEIS. Routine operations would include normal use of those facilities. For the No Action alternative, this section describes the short-term impacts associated with continuing tank space management activities through approximately 2010. Because the specific activities that DOE would pursue after the initial period of tank space management have not been determined, only those No Action activities that would be expected to have an impact on a given resource are addressed in this section. For purposes of the analyses, the short-term impacts span from the year 2001 until completion of salt processing operations (approximately 2023). As indicated in Chapter 2, the time of completion varies slightly with the selected technology.

The structure of Section 4.1 closely parallels that of Chapter 3, Affected Environment, with the addition of sections on traffic and transportation, accidents, and a Pilot Plant. The sections discuss methodology and present the potential impacts of each alternative evaluated. More details on the methodology for accident analysis are provided in Appendix B.

4.1.1 GEOLOGIC RESOURCES

This section describes impacts to geologic resources from activities associated with construction and operation of each salt processing action alternative. For the No Action alternative, this section describes impacts to geological resources from ongoing tank space optimization activities, the construction of new HLW tanks, and reuse of existing HLW tanks.

The sites under consideration for the salt processing facilities are located in existing industrial areas (S and Z Areas), where landforms and surface soils have already been disturbed. The No Action alternative would also occur in previously disturbed areas near S and Z Areas. Geologic deposits of economic value are not known to exist in these areas.

Construction

As shown in Table 4-1, the footprints for proposed facilities under the four salt processing action alternatives are similar and would range from about 26,000 square feet for the Direct Disposal in Grout facility to 42,000 square feet for the Small Tank Precipitation facility. The footprints for the Ion Exchange and Solvent Extraction facilities would be approximately 38,000 square feet each. Between 23,000 cubic yards of soil (Direct Disposal in Grout) and 82,000 cubic yards of soil (Solvent Extraction) would be excavated during construction of the process facility. The total land area that would be cleared in S Area for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative is about 23 acres or 0.12 percent of SRS land dedicated to industrial use. Approximately 15 acres or 0.078 percent of SRS land dedicated to industrial use would be cleared for the Direct Disposal in Grout facility in Z Area. The use of best management practices at existing industrial areas would minimize the impact to the area during construction. Soils excavated during construction would be used as backfill or transported to an appropriate site within 2,500 feet of the facility for disposal (WSRC 1999a). Best management practices would consist of the use of silt fences at the construction site and also at the excavated soil disposal areas. In addition, exposed soils would be stabilized by seeding with grasses or legumes to control erosion. By doing this, DOE would substantially limit the possibility of the soils being eroded and transported to nearby surface waters. Therefore, impacts to geologic resources during construction would be minimal.

Table 4-1. Impact to SRS land from each of the proposed action alternatives.[a]

	Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Facility footprint[b] (square feet)	42,000	38,000	38,000	26,000
Material excavated (cubic yards)	77,000	78,000	82,000	23,000
Total land area cleared for process facility (acres)[b]	23	23	23	15
Land cleared as percentage of SRS industrial area	0.12	0.12	0.12	0.078
Land cleared as percentage of total SRS Area	0.012	0.012	0.012	0.0078
Number of new saltstone vaults[c]	16	13	15	13
Land set aside for vaults (Acres)	180	180	180	180
Land set aside as percentage of SRS industrial area	0.94	0.94	0.94	0.94
Land set aside as percentage of total SRS Area	0.094	0.094	0.094	0.094

Total SRS area = 300 square miles (192,000 acres) (DOE 1997b).
Total Industrial area = 30 square miles (19,200 acres) (DOE 1997b).

a. As many as 18 tanks could be constructed under the No Action alternative. The footprint for each tank constructed under the No Action alternative would be about 5,000 square feet. Approximately 43,000 cubic yards of soil would be excavated for each tank built.
b. (WSRC 1998a).
c. (WSRC 1998b).

Saltstone disposal vaults would be constructed as needed throughout the period of salt processing. Construction of new saltstone disposal vaults in Z Area over the period from 2010 to 2023 (Small Tank Precipitation), 2011 to 2023 (Ion Exchange), 2010 to 2023 (Solvent Extraction), or 2010 to 2023 (Direct Disposal in Grout) would require minimal soil excavation. Thirteen to 16 vaults (see Table 4-1), each 300 feet long by 200 feet wide by 25 feet high, would be constructed at or slightly below grade. In accordance with best management practices, DOE would stabilize exposed soils by seeding with grasses or legumes to stabilize disturbed areas and control erosion.

Because of the phased nature – construction of process facilities for all action alternatives followed by construction of vaults over a 13-year period as additional saltstone disposal capacity is required – some excavation of soils would continue for nearly 20 years.

Under the No Action alternative, DOE would use approved siting procedures to ensure that any new HLW storage tanks would be built in previously disturbed industrial areas. Each new tank would require excavation of approximately 43,000 cubic yards of soil. About 28,000 cubic yards would be used for backfill (DOE 1980). The remaining 15,000 cubic yards of soil would be transported to an appropriate site for disposal. Best management practices would be used to stabilize soils and control erosion. Up to 18 new tanks would be necessary to store the waste generated from sludge-only processing at DWPF.

Operation

Facility operations would not disturb landforms or surface soils under any action alternative. Therefore, regardless of the salt processing action alternative chosen, operation of the selected alternative would have no short-term impact on the geology of the identified sites.

Under the No Action alternative, continuation of tank space optimization activities through approximately 2010 would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks. The reuse of existing HLW tanks (after 2010) would also increase the risk of tank leaks and spills, resulting in the release of HLW to soils. The operation of any new HLW storage tanks constructed under the No Action alternative would not disturb any landforms or surface soils and, therefore, would have no short-term impact on geological resources.

TC

4.1.2 WATER RESOURCES

This section describes incremental impacts to surface water and groundwater quality from activities associated with each salt processing alternative. For the No Action alternative, this section addresses impacts from ongoing tank space optimization activities, reuse of existing HLW storage tanks, and construction and operation of new HLW storage tanks. Water use is discussed in Section 4.1.12.1.

4.1.2.1 Surface Water

McQueen Branch, a first-order tributary of Upper Three Runs, is the closest surface water body to the proposed construction sites in S and Z Areas (see Figure 3-7). McQueen Branch lies approximately 1,000 feet east of the identified process facility site in S Area (Site B) for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives, and approximately one mile (5,000 feet) east of the process facility site in the center of Z Area for the Direct Disposal in Grout alternative (see Figures 3-1 and 3-2). The identified locations for new saltstone vaults, in the eastern portion of Z Area, range from 1,500 to 5,000 feet from McQueen Branch.

Overland runoff from the process facility construction site in S Area (Site B) for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives generally flows east in the direction of the stream (see Figure 3-1), but is interrupted by a drainage ditch along the eastern perimeter of the site (WSRC 1999b). Runoff moves from the drainage ditch to four culverts that channel water under a roadway and railroad embankment and, once through the culverts, overland by sheet flow to a ravine or ditch that was stabilized with netting and riprap in the past and appears to have received little or no flow in recent years. This lined channel was designed to convey storm water to McQueen Branch during construction of the DWPF, but has grown up in grasses and weeds.

Surface drainage is to the east and northeast from the construction sites for the saltstone disposal vaults and the Direct Disposal in Grout process facility in Z Area (see Figure 3-2). Drainage ditches in the area intercept stormwater flow and direct it to stormwater retention basins on the periphery of the area (WSRC 1999b). Discharge from these basins moves to McQueen Branch via an engineered ditch.

Construction

As discussed in Section 4.1.1 for the action alternatives, up to 23 acres of land would be cleared and 23,000 to 82,000 cubic yards of soil would be excavated for construction of the salt processing facility. A slight increase in suspended solids and particulates in stormwater runoff could occur as soils are disturbed during the four-year period when process and support facilities are being built, but would be expected only during periods of unusually high rainfall. Soil excavated for building foundations would be used as backfill or trucked to suitable disposal sites on SRS, greatly reducing the likelihood that loose or stockpiled soil would be transported to streams along with stormwater.

In accordance with best management practices, DOE would stabilize exposed soils by seeding with grasses or legumes (e.g., clovers) in a water medium that includes mulch and fertilizer. Hydroseeding is often used at SRS to stabilize disturbed areas and control erosion.

As discussed in Section 2.3.4, DOE could build as many as 18 new HLW storage tanks under the No Action alternative; DOE would use approved siting procedures to ensure that any new tanks would be built in previously disturbed industrial areas with a water table well below ground surface. Each new tank would require excavation of approximately 43,000 cubic yards of soil. Excavated soil would be used as backfill or trucked to suitable disposal sites on SRS. Best management practices would be used to stabilize soils and prevent runoff, reducing the likelihood that loose or stockpiled soil would be transported to streams along with stormwater.

Construction at SRS must comply with the requirements of the South Carolina stormwater management and sediment control regulations, which became effective in 1992 as part of the Clean Water Act. The regulations and associated permits require DOE to prepare erosion and sedimentation control plans for all land-disturbing projects, regardless of the size of the area affected, to minimize potential discharges of silts, solids, and other contaminants to surface waters. Effective January 2, 1997, the South Carolina Department of Health and Environmental Control (SCDHEC) approved a General Permit for stormwater management and sediment reduction at SRS (SCDHEC 1996). Although the General Permit does not exempt any land-disturbing and construction activities from the requirement of state stormwater management and sediment control regulations, it does not require SCDHEC approval of individual erosion and sediment control plans for construction activities at SRS.

Before beginning construction, DOE would develop site-specific erosion and sediment control plans for the proposed facilities. After construction, and depending on the location of the site, it may be necessary to include applicable mitigation measures in the SRS *Storm Water Pollution Prevention Plan* (WSRC 1993), which is a requirement of the General Permit covering industrial activities (Permit No. SCR000000). If the facility to be constructed is in the drainage area of a stormwater collection system permitted as part of National Pollutant Discharge Elimination System (NPDES) Permit No. SC0000175, it would not be necessary to include mitigation measures in the Plan.

DOE anticipates that impacts to McQueen Branch water quality from processing facility construction activities in S Area or Z Area would be small and would cease once construction was completed. Depending on the alternative selected, as many as 16 saltstone vaults (see Table 4-1) would be constructed in Z Area. These vaults would be built as needed during the 13 years required to process the salt solutions. DOE anticipates that impacts to surface water from this construction would be small due to implementation of best management practices and an approved site-specific erosion and sediment control plan.

Under all alternatives, including No Action, construction activities would be confined to established facility areas with established stormwater controls. Discharges from construction sites would be in compliance with SRS's site-wide stormwater permit and mitigated by best construction management practices and engineering controls. Because erosion and sedimentation from land-disturbing activities in S and Z Areas are not expected to degrade water quality in McQueen Branch, downstream impacts to Upper Three Runs would be unlikely.

Operations

Sanitary wastewater from salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES Outfall G-10.

Process wastewater from salt processing facilities would be treated at the F/H Effluent Treatment Facility (ETF) and discharged to Upper Three Runs via NPDES Outfall H-16. As can be seen in Table 4-2, the volume of sanitary and process wastewater generated by each of the action alternatives is similar and low. The Solvent Extraction alternative would generate the highest volume of both wastewater streams, but would only constitute 2.2 percent of the SRS sanitary wastewater treatment capacity and 0.57 percent of the ETF capacity. In both instances, current treatment capacity would be more than adequate to handle the additional demand from salt processing facilities. Current NPDES discharge limitations would remain in effect, meaning that no degradation of water quality in Fourmile Branch, Upper Three Runs, or the Savannah River would be expected. Under the No Action alternative, sanitary and process wastewater generation rates would continue at current levels.

4.1.2.2 Groundwater Resources

Construction

Elements of the processing facility would be constructed below grade. The depth below grade for the Small Tank Precipitation and Ion Exchange process buildings would be about 45 feet, while the process building for Solvent Extraction would be about 40 feet below grade (WSRC 1998a). Because the surficial water table (Upper Three Runs Aquifer) is about 45 feet below ground surface (see Section 3.2.2.1) at the preferred site in S Area (see Figure 3-9), excavation for the deeper elements of the processing buildings and associated structures would approach groundwater. Therefore, dewatering could be necessary during construction. The dewatering would be performed for a short period of time and impact to the surficial aquifer would be minimal.

The process building in Z Area for Direct Disposal in Grout would be about 25 feet below grade (WSRC 1998a). The saltstone disposal vaults for all action alternatives would be at or slightly below grade. Depth to groundwater in Z Area is about 60 to 70 feet (see Figure 3-10, Section 3.2.2.1). Dewatering at this site would not be required. The potential at Z Area for impacts to groundwater during excavation and construction would be minimal because best management practices would be used, in compliance with Federal and state regulations.

DOE would use the approved siting process to ensure that any new HLW storage tanks built under the No Action alternative would be constructed in a previously disturbed area and not within the groundwater table. Therefore, groundwater impacts from construction of new tanks would be minimal.

Operations

Facility operations would not discharge to groundwater under any action alternative. Therefore, regardless of the salt processing alternative chosen, operation of the selected alternative would create no short-term impact to the groundwater. Groundwater use is discussed in Section 4.1.12, Utilities and Energy.

Under the No Action alternative, continuation of tank space optimization activities through approximately 2010 would increase the potential for tank failure and the resulting release of HLW to groundwater. The reuse of existing HLW tanks (after 2010) would also increase the risk of tank leaks and spills resulting in the release of HLW to groundwater. DOE would increase maintenance, monitoring and surveillances to minimize the potential for leaks and spills. The operation of any new HLW storage tanks constructed under the No Action alternative would not involve discharges to groundwater. Therefore, operation of any new HLW storage tanks would have no short-term impact to the groundwater.

Table 4-2. Total annual wastewater generation and as a percentage of available treatment capacity for all salt processing action alternatives.

	Baseline[a]	Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
	Percent utilization	Total (million gallons)	Percentage of treatment capacity	Total (million gallons)	Percentage of treatment capacity	Total (million gallons)	Percentage of treatment capacity	Total (million gallons)	Percentage of treatment capacity
Sanitary Wastewater	18[b]	6.9[c]	1.8[b]	6.6[c]	1.7[b]	8.4[c]	2.2[b]	5.2[c]	1.4[b]
Process Wastewater	2.67[d,e]	0.30[f]	0.19[e]	0.25[f]	0.16[e]	0.90[f]	0.57[e]	0.15[f]	0.09[e]

a. For all scenarios under the No Action alternative, volume of wastewater generated would be similar to the wastewater generation at the existing HLW Tank Farms. Therefore, wastewater generation under No Action would be included in the SRS baseline.
b. SRS Centralized Sanitary Waste Treatment Facility capacity = 1.05 million gallons per day (Schafner 2001).
c. Adapted from WSRC (1999e). Sanitary wastewater based on estimated potable water use.
d. F/H ETF design capacity = 433,000 gallons per day (DOE 1995).
e. ETF percent utilization based on 1994 data (DOE 1995).
f. Total process wastewater (radioactive liquid waste) annually (WSRC 1999b, 2000b).

4.1.3 AIR RESOURCES

To determine impacts on air quality, DOE estimated the nonradiological and radiological emission rates associated with processes and equipment used in each action alternative. This included identifying potential emission sources and any methods by which air would be filtered before being released to the environment. These emissions were entered into air dispersion models to determine potential maximum concentrations at onsite and offsite locations. Air emissions under the No Action alternative would be similar to those from the existing HLW Tank Farm operations for all scenarios. Therefore, the No Action alternative is represented by slight increases above the baseline. The estimated emissions and air concentrations of nonradiological and radiological pollutants are discussed and compared to the pertinent SCDHEC and Federal regulatory limits in the following two sections. Impacts resulting from incremental increases of air pollutant concentrations are measured in terms of human health effects and are discussed in Section 4.1.4, Worker and Public Health.

4.1.3.1 Nonradiological Emissions

Construction

Construction (excluding vaults) would occur over approximately four years for each action alternative. As discussed in Section 4.1.1, 13 to 16 saltstone vaults would be constructed over the 13-year period between 2010 and 2023. Building new tanks under the No Action alternative would require four or more years of construction, depending on the number of tanks needed. Construction activities would involve the use of heavy equipment such as bulldozers, cranes, dump trucks, and backhoes to clear the land, construct buildings, and develop the infrastructure to support the facilities (e.g., paved roads, sewer/potable water and feed lines). Table 4-3 lists the expected construction-related air emission sources for all alternatives, including No Action. Table 4-4 shows the annual air emission rates from all construction-related sources (Hunter 2000). The type and rate of construction emissions for all alternatives would be the same.

During construction, the excavation and transfer of soils and the disturbance of surface dust by heavy equipment all result in particulate matter emissions. These emissions of particulate matter caused by wind or man's activities, or both, are known as fugitive dust. In accordance with good dust control practices required by South Carolina regulations, measures would be implemented to control fugitive particulate matter. Best management practices would be used during land clearing, road grading, and construction to minimize airborne dust. Dust control measures could include seeding, wind speed reduction (e.g., wind barriers), wet or chemical suppression, or early paving. The U.S. Environmental Protection Agency's (EPA's) Fugitive Dust Model (FDM) (EPA 1992) computer program was used to model all fugitive emissions from construction activities.

Heavy-duty construction equipment (i.e., trucks, bulldozers, and other diesel-powered support equipment) would be used for excavation and grading, hauling soil and debris for disposal, and other routine construction activities. Exhaust emissions from these diesel engines would result in releases of sulfur dioxide (SO_2), oxides of nitrogen (NO_x), particulate matter (PM_{10}), carbon monoxide (CO), and total suspended particulate (TSP) matter. A detailed listing of the construction equipment that would be used is documented in WSRC (1999b).

Facility construction (including new tanks under the No Action alternative) would necessitate a concrete batch plant at the building site. Particulate matter, consisting primarily of cement dust, would be the only regulated pollutant emitted in the concrete mixing process. Emissions would occur at the point of transfer of cement to the silo. However, DOE would use filter bags, which have control efficiencies as high as 99 percent, or a similar technology to remove particulate emissions. Particulate emission limits for the operation of a concrete batch plant would be established in a construction permit

Table 4-3. Expected sources of air emissions from construction activities for all alternatives.

Alternative	Source of air emissions
All alternatives, including No Action	Excavation/soil transfers
	Dust from vehicle traffic on unpaved surfaces
	Vehicle exhaust
	Concrete batch plant emissions

Table 4-4. Estimated nonradiological air emissions (tons per year) from construction activities associated with all alternatives.

Air pollutant	Vehicle exhaust (tons per year)	Fugitive Dust (tons per year)[a]	Concrete Batch Plant (tons per year)
SO_2	13	–	–
TSP	16	100	14
PM_{10}	NA[b]	25	NA
CO	60	–	–
NO_x	150	–	–

Source: Hunter (2000).

a. Includes fugitive dust caused from excavation/soil transfers and dust disturbed by moving vehicles used for site preparation and facility construction.

b. NA = Not available. No method for estimating PM_{10} emissions from this type of emission source is available.

SO_2 = sulfur dioxide, TSP = total suspended particles, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 micrometers, CO = carbon monoxide, NO_x = oxides of nitrogen .

granted by SCDHEC. Any fugitive dust emissions from sand and aggregate piles around the batch plant would be controlled by water suppression, chemical dust suppressants, or other approved methods. Using the emission rates from construction vehicles and the concrete batch plant (Table 4-4), maximum concentrations of regulated pollutants were determined, using Release 3 of the Industrial Source Complex – Short Term (ISC3) air dispersion model (EPA 1995).

Meteorological data input into the models (ISC3 and FDM) included sequential hourly averages of wind speed, wind direction, turbulence intensity (stability), and temperature (from SRS meteorological tower network), and twice-daily mixing height (rural) data (for Atlanta, Georgia). A one-year data set (1996) was used.

Using ISC3 and FDM, the maximum concentrations at the SRS boundary were estimated because that is the closest location where members of the public potentially would be exposed. At the Site boundary, concentrations are estimated at ground level because, at this distance from the emission point(s), the vertical distribution of the contaminants would be relatively uniform. The resulting incremental increases to background concentrations (in micrograms per cubic meter) at the SRS boundary are listed in Table 4-5. Particulate matter (TSP and PM_{10}) concentrations would be slightly increased (1 percent and 2 percent, respectively), with fugitive dust emissions accounting for most of the particulate matter emissions. All other regulated pollutant concentrations estimated at the Site boundary increase less than 1 percent of the standard. Because the increases in concentration listed in Table 4-5 would be associated only with construction, they would be temporary, lasting only until construction ended. Also, all the construction emission sources would not be in operation at the same time or throughout the entire construction period.

Table 4-5. Estimated maximum incremental increases of air concentrations (micrograms per cubic meter) of SCDHEC-regulated nonradiological air pollutants at the SRS boundary from construction activities associated with all salt processing alternatives.

Air pollutant	Averaging time	SCDHEC standard ($\mu g/m^3$)[a]	SRS baseline concentration ($\mu g/m^3$)[b]	SRS baseline concentration (% of standard)	Maximum concentration ($\mu g/m^3$)[c]	SRS baseline + concentration (% of standard)
SO_2	3-hr	1,300	1,240	96	5.0	96
	24-hr	365	350	96	0.7	96
	Annual	80	34	42	0.009	42
TSP	Annual geometric mean	75	67	89	0.04	90
PM_{10}[d]	24-hr	150	130	88	2	90
	Annual	50	25	51	0.03	51
CO	1-hr	40,000	10,350	26	70	26
	8-hr	10,000	6,870	69	10	69
NO_2	Annual	100	26	26	01	26

Source: Hunter (2000).
a. SCDHEC Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards".
b. Sum of (1) an estimated maximum Site boundary concentration from modeling all SRS sources of the indicated pollutant not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations (Hunter 2000).
c. Maximum concentrations would be the same for all alternatives including construction of new tanks under No Action.
d. New standards for particulate matter will come into effect during the construction of this project.
SO_2 = sulfur dioxide, TSP = total suspended particles, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 pm, CO = carbon monoxide, NO_2 = nitrogen dioxide.

Operations

Salt processing activities would result in the release of regulated nonradiological pollutants to the surrounding air. Table 4-6 lists, by alternative, the expected air emission sources during the operation of each action alternative. For all scenarios under the No Action alternative, the only air emission source would be the ventilation exhaust from each utilized tank. As presented in the following tables, the baseline is representative of the No Action alternative. The estimated emission rates (tons per year) for nonradiological pollutants emitted under each action alternative are presented in Table 4-7 (Hunter 2000). These emission rates can be compared against emission rates defined in SCDHEC Standard 7, "Prevention of Significant Deterioration (PSD)," to determine if the emission would exceed this standard or cause a significant pollutant emission increase.

As part of its evaluation of the impact of air emissions, DOE consulted the Guidance on Clean Air Act General Conformity requirements (DOE 2000a). DOE determined that the General Conformity rule does not apply because the area where the DOE action would take place is an attainment area for all criteria pollutants. Therefore, although each alternative would emit criteria pollutants, a conformity review is not necessary.

As can be seen in Table 4-7, sulfur dioxide (SO_2), TSP, PM_{10}, CO, NO_x, lead, beryllium, and mercury emissions are similar for all action alternatives and would be well below their corresponding PSD limits.[1] The estimated emission rates for these air pollutants range from 53 percent of the PSD limit (for NO_x under the Small Tank Precipitation, Ion Exchange, and Solvent

[1] PSD limit refers to the threshold emissons rates that trigger the need for a PSD review.

Table 4-6. Expected sources of air emissions during salt processing for the four action alternatives[a].

Alternative	Source of air emissions
All action alternatives	Minimal new emission sources (S Area)
Small Tank Precipitation, Ion Exchange, Solvent Extraction	Exhaust stack for the Process Facility (S Area) Ventilation exhaust from the Cold Chemical Feed Area (S Area) Exhaust stack for existing saltstone facility (Z Area) Exhaust from two emergency diesel generators (S Area) Exhaust from one emergency diesel generator (Z Area)
Direct Disposal in Grout	Exhaust stack for the Direct Disposal in Grout Process Facility (Z Area) Ventilation exhaust from the Cold Chemical Feed Area (Z Area) Ventilation exhaust from the Vaults (Z Area)[b] Exhaust from two emergency diesel generators (Z Area)

a. For all scenarios under the No Action alternative, the expected source of emissions would be the ventilation exhaust from each tank.
b. Vaults for the other three action alternatives would have minimal emissions because the saltstone produced by these action alternatives would have a lower activity level and the vaults would not be ventilated.

Extraction alternatives) to less than 1 percent of the limit for SO_2, lead, and mercury.

The estimated volatile organic compounds (VOC) emissions rate of 70 tons per year for the Small Tank Precipitation alternative would exceed the threshold value established by SCDHEC for PSD permit review, whereas estimated emissions from the other alternatives are either estimated below the PSD limit or covered by existing air permit levels. Implementation of the Small Tank Precipitation alternative would result in small increases in offsite concentrations of benzene and ozone, with minimal impacts to public health. The other alternatives would have lower impacts.

VOC emissions are subject to a PSD limit because they contribute to the formation of ozone. Ozone is a photochemical oxidant and the major component of smog. Ozone is not emitted directly into the air, but is formed through complex chemical reactions between emissions of VOCs and NO_x in the presence of sunlight. Both VOCs and NO_x are emitted by industrial and transportation sources.

Prevention of Significant Deterioration Review

Facilities, such as SRS, that are located in attainment areas for air quality and are classified as major facilities may trigger a PSD review under the new source review requirements of the Clean Air Act when they construct a major stationary source or make a major modification to a major source. (A major source is defined as a source with the potential to emit any air pollutant regulated under the Clean Air Act in amounts equal to or exceeding specified thresholds). The SCDHEC uses a two-step process to determine whether a new source results in a significant emissions increase of a regulated pollutant. First, the potential emissions from the new source are compared to their corresponding PSD significant emission limits. If the emission increase is by itself (without considering any contemporaneous decreases) less than the PSD limit, no further analysis is required. If, however, the emission increase is equal to or greater than the PSD limit, then all contemporaneous emissions increases and decreases must be summed and the net increase is compared to the PSD limit. A PSD permit review is required if that modification or addition to the major facility results in a net increase of any regulated pollutant over the level established in the current permit that is greater than the corresponding PSD limit.

Table 4-7. Estimated nonradiological air emissions (tons per year) from routine operations for salt processing alternatives.[a]

Air pollutant	SRS Permit Allowance (tons/yr)[b]	PSD New Source Emission Limit (tons/yr)[c]	Small Tank Precipitation (tons/yr)	Small Tank Precipitation (% of PSD limit)	Ion Exchange (tons/yr)	Ion Exchange % of PSD limit	Solvent Extraction (tons/yr)	Solvent Extraction % of PSD limit	Direct Disposal in Grout (tons/yr)	Direct Disposal in Grout % of PSD limit
SO_2	3.32	40	0.33	0.81	0.33	0.81	0.33	0.81	0.30	0.75
TSP	5.51	25	0.95	3.8	0.95	3.8	0.95	3.8	0.80	3.2
PM_{10}	2.4	15	0.4	2.7	0.4	2.7	0.4	2.7	0.30	2.0
CO	86.9	100	5.4	5.4	5.4	5.4	5.4	5.4	4.9	4.9
VOCs[d]	70.23[e]	40	70	175	1.6	4.1	40	100	1.5	3.6
NO_x	232.8	40	21	53	21	53	21	53	19	48
Lead	NA[f]	0.6	4.0×10^{-4}	0.067	4.0×10^{-4}	0.067	4.0×10^{-4}	0.067	3.5×10^{-4}	0.058
Beryllium	NA[f]	4.0×10^{-4}	1.0×10^{-4}	25	1.0×10^{-4}	25	1.0×10^{-4}	25	5.0×10^{-5}	13
Mercury	0.88	0.1	0.0026	2.6	0.0026	2.6	0.0026	2.6	0.0025	2.5
Formic Acid[g]	1.6	NA[h]	1.6	-	None	-	None	-	None	-
Benzene	50.48	NA[h]	53	-	0.0085	-	0.0085	-	0.0080	-
Biphenyl[i]	NA[j]	NA[h]	1.1	-	None	-	None	-	None	-
Methanol[k]	NA[j]	NA[h]	0.42	-	0.42	-	0.42	-	0.42	-
n-Propanol[l]	NA[j]	NA[h]	0.42	-	0.42	-	0.42	-	0.42	-
Isopar®L[m]	NA[j]	NA[h]	0.0	-	0.0	-	38	-	0.0	-

Source: Hunter (2000).

a. For all scenarios under the No Action alternative, air emissions would be similar to those from the existing HLW Tank Farm operations. Therefore, No Action is represented by slight increases above the SRS baseline.
b. SCDHEC Bureau of Air Quality Control Operating Permits for HLW management facilities.
c. SCDHEC Regulation 61-62.5, Standard 7, "Prevention of Significant Deterioration".
d. VOCs are subject to a PSD limit because they are a precursor to ozone. VOCs that may be emitted as a result of the proposed action include benzene, biphenyl, methanol, n-Propanol, and Isopar®L. NO_x also contributes to ozone formation.
e. Value includes 50.48 tons per year of benzene and 19.75 tons per year of other VOCs.
f. SRS lead and beryllium emissions originate from permit-exempted units, so no allowance has been established.
g. Formic acid emissions would shift from DWPF to the Small Tank Precipitation facility, resulting in no net change in emissions.
h. No PSD limit is defined for this pollutant.
i. Also known as diphenyl.
j. This pollutant is a VOC and the SRS air permits do not have a specific permit allowance for this pollutant.
k. Also known as methyl alcohol.
l. Also known as n-Propyl alcohol; OSHA-regulated pollutant.
m. Isopar®L is a proprietary chemical; regulated as a VOC only.

NA = not applicable, SO_2 = sulfur dioxide, TSP = total suspended particulates, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 µm, CO = carbon monoxide, NO_x = oxides of nitrogen, PSD = prevention of significant deterioration, VOC = volatile organic compound.

According to EPA AIRS databases (EPA 2001), Aiken and Barnwell Counties combined produced a total of more than 10,000 tons per year of NO_x in 1998 and anthropogenic VOC emissions were over 10,000 tons per year. According to the EPA TRENDS reports (EPA 2000), the biogenic VOC contribution for the Aiken-Barnwell region is around 9,000 tons per year. Estimated emissions from the alternative with the highest VOC emissions (i.e., Small Tank Precipitation) are 21 tons per year NO_x and 70 tons per year VOCs. Therefore, regional emissions of ozone precursors would be expected to increase by less than one percent for this alternative. From modeling results such as those presented in Carter (1994), percentage increases in ozone precursers are generally greater than the resulting changes in ozone. Therefore, ozone concentrations would be expected to increase by no more than one percent. The background level of ozone is 216 micrograms per cubic meter, and the ambient air quality standard for ozone is 235 micrograms per cubic meter. Therefore, a one percent increase in ozone, to about 218 micrograms per cubic meter, at the point of maximum impact would not exceed the ambient air quality standard.

As shown in Table 4-6, nonradionuclide emissions from routine salt processing operations would come from several sources. Using the emission rates from Table 4-7 for the listed sources, maximum concentrations of released regulated pollutants were determined using the ISC3 air dispersion model. Because the proposed sites for salt processing facilities in S and Z Areas are located in close proximity to DWPF and would be subject to the same meteorological conditions as DWPF, the stack for each process facility was assumed to be the same height as the DWPF stack (i.e., 46 meters). Emissions from the cold chemical feed area (see Section 2.7.4, Support Facilities) and from the emergency generators were assumed to occur at ground level. The process facilities and the cold chemical feed areas were assumed to emit pollutants continuously. The emergency generators were assumed to operate 250 hours per year, primarily for testing.

The ICS3 short-term modeling results provided estimated maximum concentrations at the SRS boundary, where members of the public potentially would be exposed, and at the location of a hypothetical noninvolved site worker. For the location of the noninvolved worker, the analysis used a generic location 640 meters from the release point in the direction of the greatest concentration. This location is the distance for assessing consequences from facility accidents and, for consistency, is used here for normal operations. Concentrations at the noninvolved worker location were calculated at an elevation of 1.8 meters above ground to simulate the breathing height of a typical adult.

The maximum air concentrations (micrograms per cubic meter) at the SRS boundary that would be associated with the release of regulated nonradiological pollutants are presented in Table 4-8. For the action alternatives, the incremental increase in concentrations of SO_2, TSP, PM_{10}, CO, nitrogen dioxide (NO_2), and lead (SCDHEC Ambient Air Quality Standards [Standard 2] regulated pollutants) would be less than 1 percent of the baseline (i.e., No Action alternative). Incremental concentration increases of air toxic pollutants (NO_2, lead, beryllium, mercury, benzene, biphenyl, methanol, and formic acid) would be small under all alternatives; for most pollutants, there would be an incremental increase of less than 1 percent of the baseline (i.e., No Action alternative). The greatest increase (7.5 percent) would occur for biphenyl under the Small Tank Precipitation alternative, but ambient concentrations would remain far below the SCDHEC Toxic Air Pollutants (Standard 8) limit. Therefore, no salt processing alternative would exceed SCDHEC standards at the SRS boundary.

The air quality impacts at the location of a hypothetical noninvolved worker in the vicinity of the processing facilities are presented in

Table 4-8. Estimated maximum increases in air concentrations (micrograms per cubic meter) and percent of standard of SCDHEC-regulated non-radiological air pollutants at the SRS boundary from salt processing alternatives.

					Maximum concentration							
					Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Air pollutant	Averaging time	SCDHEC standard ($\mu g/m^3$)[a]	SRS baseline concentration ($\mu g/m^3$)[b]	SRS baseline concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)
Ambient air pollutants												
SO_2	3-hr	1,300	1,240	96	0.30	96	0.30	96	0.30	96	0.40	96
	24-hr	365	350	96	0.040	96	0.040	96	0.040	96	0.050	96
	Annual	80	34	42	4.0×10^{-4}	42	4.0×10^{-4}	42	4.0×10^{-4}	42	5.0×10^{-4}	42
TSP	Annual geo-metric mean	75	67	89	0.0010	89	0.0010	89	0.0010	89	0.0010	89
PM_{10}[c]	24-hr	150	130	88	0.070	89	0.070	89	0.070	89	0.070	89
	Annual	50	25	51	0.0010	51	0.0010	51	0.0010	51	0.0010	51
CO	1-hr	40,000	10,350	26	15	26	15	26	15	26	18	26
	8-hr	10,000	6,870	69	1.9	69	1.9	69	1.9	69	2.3	69
Ozone[c]	1-hr	235	216	92	ND	ND	ND	ND	ND	ND	ND	ND
NO_2	Annual	100	26	26	0.030	26	0.030	26	0.030	26	0.030	26
Lead	Max. calendar quarter	1.5	0.03	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0
Air toxic pollutants[e]												
Benzene	24-hr	150	5	3.1	4.0	5.7	0.0010	26	0.0010	26	0.0010	26
Mercury	24-hr	0.25	0.03	12	3.0×10^{-5}	12	3.0×10^{-5}	12	3.0×10^{-5}	12	3.0×10^{-5}	12
Biphenyl[f]	24-hr	6	0.02	0.33	0.45	7.8	None	0.33	None	0.33	None	0.33
Methanol[g]	24-hr	1,310	0.9	0.069	0.32	0.093	0.32	0.090	0.32	0.090	0.53	0.11
Beryllium	24-hr	0.01	0.0090	90	1.0×10^{-5}	90	1.0×10^{-5}	90	1.0×10^{-5}	90	1.0×10^{-5}	90
Formic Acid[h]	24-hr	225	0.15	0.067	0.01	0.067	None	0.067	None	0.067	None	0.067

Source: Hunter (2000). Concentrations are based on maximum potential emissions.

a. SCDHEC Air Pollution Regulation 61-62 5, Standard 2, "Ambient Air Quality Standards", and Standard 8, "Toxic Air Pollutants".

b. Sum of (1) estimated maximum site boundary concentration from modeling all SRS sources of the indicated pollutant not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations (Hunter 2000). For all scenarios under the No Action alternative, emissions would be similar to those from existing HLW Tank Farm operations and would be represented by slight increases over the SRS baseline.

c. New standards for this pollutant may come into effect during the lifetime of this project.

d. Source: SCDHEC (1998). Observed concentration of ozone at SCDHEC ambient monitoring station for Aiken County.

e. n-Propanol is not included on this table because it is an OSHA-regulated pollutant, not an SCDHEC-regulated pollutant.

f. Also known as diphenyl.

g. Also known as methyl alcohol.

h. Formic acid emissions would shift from DWPF to the Small Tank Precipitation Facility, resulting in no net change in emissions.

ND = Not determined, SO_2 = sulfur dioxide, TSP = total suspended particulates, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 μm, CO = carbon monoxide, NO_2 = nitrogen dioxide.

the Worker and Public Health section (Section 4.1.4.1 – Nonradiological Health Effects). For all processing alternatives, ambient concentrations of NO_2 would reach 78 percent of the Occupational Safety and Health Administration (OSHA) ceiling limit of 9 milligrams per cubic meter (mg/m^3). These NO_2 emissions would result from the periodic operation of the emergency generators. Since the estimated emissions are based on maximum potential emissions and all the emergency generators likely would not operate at the same time, the estimated emissions and resulting concentrations are conservative. All concentrations of OSHA-regulated pollutants would be below the established limits.

4.1.3.2 Radiological Emissions

Construction

No known radiological contamination exists at the proposed construction sites in S and Z Areas. DOE would use the approved siting process to ensure that any new HLW tanks constructed under the No Action alternative would be constructed in an area where no radiological contamination is known to exist. Therefore, regardless of the alternative chosen, no radiological air emissions are expected as a result of construction activities.

Operations

DOE estimated routine radionuclide air emissions for each salt alternative. Under each processing alternative, radionuclides would be emitted to the air via a stack. As discussed in Section 4.1.3.1, the stack for each process facility was assumed to be 46 meters high, the same height as the DWPF stack. For all the salt processing alternatives, the ventilation exhaust would be filtered through high-efficiency particulate air filters. The Direct Disposal in Grout alternative would have an additional emission point at each vault in operation because radioactive cesium would not be removed before grouting, requiring the vaults to have a forced air ventilation system for temperature control while the saltstone cures. Because the other three action alternatives would remove more radionuclides (including radioactive cesium) from the low-activity salt fraction, the grout would have much lower activity levels and the vaults would not need to be ventilated. Therefore, the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives would have no measurable emissions from the associated saltstone vaults. Emissions from the vaults for Direct Disposal in Grout alternative were assumed to be at ground level. The estimated total radiological air emissions for each action alternative are shown in Table 4-9 (Pike 2000). Because there are no equivalent facilities at SRS, DOE's method for estimating emission rates from the alternative salt processing facilities is conservative and ensures that total emissions are not underestimated. All action alternatives are all treated with the same conservative basis. The Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes all produce highly concentrated cesium-bearing process streams. The engineered systems designed for each facility would ensure that the cesium emissions are as low as reasonably achievable.

Air emissions under the No Action alternative would be similar to those from existing HLW Tank Farms operations for ongoing tank space management activities and all subsequent scenarios. Therefore, the No Action alternative is represented by slight increases above the baseline.

After determining routine emission rates for the action alternatives, DOE used the MAXIGASP and POPGASP computer codes to estimate radiological doses to the maximally exposed (offsite) individual (MEI), the hypothetical noninvolved worker, and the offsite population surrounding SRS. Both codes utilize the GASPAR (Eckerman et al. 1980) and XOQDOQ (Sagendorf et al. 1976, 1982) modules; GASPAR and XOQDOQ are based on U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides 1.111 and 1.109 (NRC1977), respectively. Both GASPAR and XOQDOQ have

Table 4-9. Annual radionuclide emissions (curies/year) resulting from operations.[a]

	Annual emission rate			
	Small Tank Precipitation (Ci/yr)	Ion Exchange (Ci/yr)	Solvent Extraction (Ci/yr)	Direct Disposal in Grout[b] (Ci/yr)
Tritium	4.3	18	24	9.2
Strontium-90	8.3×10^{-4}	4.9×10^{-5}	0.0019	0.0036
Technetium-99	1.6×10^{-5}	1.6×10^{-6}	8.4×10^{-5}	3.4×10^{-5}
Ruthenium-106	5.2×10^{-6}	4.9×10^{-7}	2.6×10^{-5}	1.0×10^{-5}
Antimony-125	1.5×10^{-6}	1.6×10^{-7}	9.0×10^{-6}	3.5×10^{-6}
Iodine-129	1.5×10^{-8}	1.7×10^{-9}	6.9×10^{-7}	3.7×10^{-8}
Cesium-134	0.0035	0.0024	0.014	8.5×10^{-4}
Cesium-137	0.98	0.24	1.4	0.085
Total Alpha[c]	0.0010	1.5×10^{-4}	0.0060	0.011
Total	5.3	18.2	25.4	9.3

Source: Pike (2000).

a. Air emissions under the No Action alternative would be similar to those from existing HLW Tank Farm operations for continuing tank space management activities and all subsequent scenarios. Therefore, the No Action alternative is represented by slight increases over the SRS baseline. SRS baseline emissions are shown in Table 3-12.

b. Includes emissions from vaults. Vaults for the other three action alternatives would have no measurable emissions because the saltstone produced by these action alternatives would have a much lower activity level and the vaults would not be ventilated.

c. Assumed to be plutonium-239.

been adapted and verified for use at SRS (Hamby 1992 and Bauer 1991, respectively). MAXIGASP and POPGASP are both Site-specific computer programs that have SRS-specific meteorological parameters (e.g., wind speeds and directions) and population distribution parameters (e.g., number of people in sectors around the Site). The 1990 census population database was used to represent the population living within a 50-mile radius of the center of SRS.

Table 4-10 presents the calculated maximum radiological doses (as 50-year committed effective dose equivalents) associated with salt processing activities for all the analyzed alternatives. Based on the dispersion modeling for stack emissions from processing facilities for each alternative, the MEI (public) was identified as being located north-northeast at the SRS boundary. For ground-level releases (vault emission under the Direct Disposal in Grout alternative), the MEI would be located at the north SRS boundary (Simpkins 1999, 2000a,b). The maximum committed effective dose equivalent for the MEI would be 0.31 millirem per year for the Solvent Extraction alternative, which is higher than the other alternatives, due to higher estimated radioactive cesium emissions. Ninety percent of the dose to the MEI is associated with the radio active cesium emissions and 9.5 percent of the dose would result from the total alpha emissions. The Small Tank Precipitation alternative has a maximum committed effective dose equivalent of 0.20 millirem per year, while the Ion Exchange and Direct Disposal alternatives have a lower maximum committed effective dose equivalent for the MEI of 0.049 and 0.086, respectively. The annual MEI dose under all the alternatives would still be well below the established annual dose limit of 10 millirem for SRS atmospheric releases (40 CFR 61.92).

The maximum estimated dose to the offsite population residing within a 50-mile (80-kilometer) radius (approximately 620,000 people) would be 18.1 person-rem per year, also as a result of the Solvent Extraction alternative. As with the MEI dose, offsite concentrations of radioactive cesium would compose most (93 percent) of the total population dose. The Small Tank Precipitation alternative has an offsite population dose of 12.0 person-rem per year. The Ion Exchange and Direct Disposal in Grout

Table 4-10. Annual doses from radiological air emissions from salt processing activities presented as 50-year committed effective dose equivalents.

	Maximum dose[a]			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout[b]
Maximally exposed offsite individual dose (millirem/year)	0.20	0.049	0.31	0.086
Offsite population dose (person-rem/year)	12.0	2.9	18.1	4.0
Noninvolved worker dose (millirem/year)	3.3	0.8	4.8	1.7
Involved worker dose (millirem/year)	15.7	3.9	22.8	10.1
Onsite population dose (person-rem/year)	4.3	1.1	6.5	2.3

Source: Based on emission values listed in Table 4-7 and Simpkins (1999 and 2000a,b).

a. For all scenarios under the No Action alternative, radiological air emissions would be similar to those from existing HLW Tank Farm operations, and would be represented by slight increases above the baseline. Therefore, under the No Action alternative, doses to all receptors would be minimal.

b. Includes building stack and ground-level vault doses.

alternatives have values that are similar to each other, but lower than the previous alternatives (2.9 and 4.0 person-rem per year, respectively). For all scenarios, the total offsite population dose is low.

Table 4-10 also reports doses to the noninvolved (onsite) worker, the involved worker, and the collective onsite population from the estimated annual radiological emissions. For each case, the highest estimated dose would occur under the Solvent Extraction alternative, with the Small Tank Precipitation alternative having similar results and the Ion Exchange and the Direct Disposal in Grout alternatives having lower doses. The maximum dose to the noninvolved and involved worker would be 4.8 millirem per year and 22.8 millirem per year, respectively, with radioactive cesium emissions contributing about 98 percent of the total dose. The maximum estimated dose to the onsite population would be 6.5 person-rem per year, with 94 percent of this total dose due to radioactive cesium emissions. In all cases these doses are low.

For ongoing tank space management activities and all subsequent scenarios under the No Action alternative, radiological air emissions would be similar to those from existing HLW Tank Farm operations, and would be represented by slight increases above the baseline. Therefore, under the No Action alternative, doses to all receptors would be minimal.

4.1.4 WORKER AND PUBLIC HEALTH

This section discusses potential radiological and nonradiological health effects to SRS workers and the surrounding public from construction and routine operation of the salt processing alternatives; it does not include impacts of potential accidents, which are discussed in Section 4.1.13. DOE based its calculations of health effects from radiological releases to air as doses with the corresponding impacts expressed as latent cancer fatalities (LCFs) to (1) the MEI; (2) the collective population within a 50-mile (80-kilometer) radius around SRS (approximately 620,000 people); (3) the maximally exposed noninvolved worker (i.e., an SRS employee who may work in the vicinity of the salt processing facilities, but is not directly involved with the work); (4) the involved worker; (5) the onsite population of involved workers (i.e., the workers directly involved in salt processing activities); and (6) the population of SRS workers

(includes both involved and noninvolved workers). All radiation doses in this SEIS are committed effective dose equivalents. This section presents total impacts for the entire length of time necessary to implement each technology. The annual impacts attributable to each phase were multiplied by the duration of that phase. The impacts from all phases were summed to calculate the total impact for the technology. This discussion characterizes health effects to populations as additional lifetime LCFs likely to occur in the general population around SRS, the population of onsite workers, and the population of workers who would be associated with implementing the alternatives. Health effects to the MEI and the noninvolved and involved worker are characterized by the additional probability of an LCF to the exposed individual.

Nonradiological health effects discussed in this section include effects from nonradiological emissions to air of toxic and criteria pollutants. In addition to radiological and nonradiological health effects, common occupational health impacts are presented in terms of estimated work-related illness and injury events associated with each of the salt processing alternatives. There are no radiological or nonradiological releases to water from any of the action alternatives.

4.1.4.1 Nonradiological Health Effects

The Occupational Health and Industrial Hygiene programs at SRS deal with all aspects of worker health and the workers' relationships with their work environment. The objective of an effective Occupational Health program is to enable employees to work safely and to recognize unsafe work practices or conditions before an accident occurs.

The objective of an Industrial Hygiene program is to evaluate toxic or hazardous chemicals in the work environment and use established procedures and routine monitoring to prevent or minimize employee exposures to these chemicals. Exposure limit values are the basis of most occupational health codes and standards and are used to regulate worker exposure to hazardous chemicals.

OSHA permissible exposure limits (PELs) (29 CFR 1910.1000) are established limits that ensure the safety of the worker population. PELs are time-weighted average concentrations that a facility cannot exceed in any 8-hour work shift of a 40-hour work week. OSHA ceiling limits are concentrations of substances that cannot be exceeded during any part of the workday. Both of these exposure limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could be exposed day after day without adverse health effects. However, because of the wide variation in individual susceptibility, a small percentage of workers could experience discomfort from some substances at concentrations at or below the permissible limits. The OSHA PEL standards for identified pollutants of concern during salt processing activities are listed in Table 3-18.

DOE evaluated the range of chemicals in facility air emissions to which the public and workers would be exposed due to salt processing activities and expects minimal health impacts from nonradiological exposures. Section 4.1.3 discusses onsite and offsite chemical concentrations from air emissions. DOE estimated noninvolved worker impacts and Site boundary concentrations to which a maximally exposed member of the public could be exposed. Site boundary concentrations were compared to the SCDHEC standards for ambient concentrations and DOE concluded that all air emission concentrations would be below the applicable standard. See Section 4.1.3 for comparison of estimated concentrations at the Site boundary with SCDHEC standards.

The noninvolved worker concentrations were compared to OSHA PELs or ceiling limits for protecting worker health, and the comparisons indicated that all criteria pollutant concentrations would be negligible compared to the OSHA standards.

Beryllium is a pollutant of concern for salt processing activities. A naturally occurring metal,

beryllium is used primarily in electronic components and cellular network communication systems. It is also used in aerospace and defense applications. Most of the beryllium emissions in the United States are a result of beryllium-copper alloy production and burning of fossil fuels (e.g., coal and oil) to produce electricity. Beryllium is also a constituent of cigarette smoke (ATSDR 1988). The beryllium that would be emitted by the salt processing alternatives is primarily a constituent of the exhaust from the emergency generators (Hunter 2000), which were assumed to operate 250 hours per year for testing. Health concerns from beryllium exposure include excess lifetime cancer risk and chronic beryllium disease (CBD), which can be seriously debilitating and lead to premature death. The maximum excess lifetime cancer risks to the noninvolved worker and to the MEI from exposure to beryllium emissions were estimated to be 7.2×10^{-5} and 2.4×10^{-8}, respectively, based on the EPA's Integrated Risk Information System (IRIS) database (EPA 1998) unit risk factor for beryllium of 2.4×10^{-3} excess cancer risk per microgram per cubic meter. This excess cancer risk from beryllium emissions is the same for all given alternatives.

Exposure to respirable beryllium fumes, dusts, or powder can also cause CBD in individuals who are sensitized (allergic) to beryllium. One to six percent of workers engaged in operations producing or using beryllium and its compounds develop CBD over their lifetimes (National Jewish Medical and Research Center 2001). While some cases of CBD have been reported in individuals with no occupational exposure to beryllium, only one case has been reported since 1973. No cases of CBD have been associated with low atmospheric concentrations of beryllium, such as those observed in the vicinity of SRS (NIOSH 1986). Therefore, DOE believes that the excess CBD risk to workers and the public as a result of salt processing operations would be minimal for all salt processing alternatives.

Benzene is the pollutant of most concern for salt processing activities. The maximum excess lifetime cancer risks to the noninvolved worker and MEI from exposure to benzene emissions were estimated to be 6.6×10^{-3} and 1.7×10^{-5}, respectively, based on the EPA's IRIS database (EPA 1998) unit risk factor for benzene of 8.3×10^{-6} excess cancer risk per microgram per cubic meter. This excess cancer risk from benzene emissions is associated with the Small Tank Precipitation alternative. Because benzene emissions (primarily from the emergency generators) from the other salt processing alternatives are similar and would be much lower than the emissions from the Small Tank Precipitation alternative, they are expected to have considerably lower excess lifetime cancer risks. See Table 4-11 for additional nonradiological pollutant concentrations. Under the No Action alternative, air emissions from ongoing tank space management activities and all subsequent scenarios would be similar to air emissions from the HLW operations included in the SRS baseline. Therefore, incremental health affects would be minimal.

Engineered systems designed for the process facilities and tanks under the No Action alternative would ensure that there would be little possibility of involved workers in the proposed facilities being exposed to anything other than very small concentrations of airborne nonradiological materials that would be similar among all alternatives. Therefore, health effects from exposure to nonradiological material inside the facilities would be minimal for all alternatives.

4.1.4.2 Radiological Health Effects

Radiation can cause a variety of health effects in people. The major effect of environmental and occupational radiation exposures is a delayed cancer fatality, which is called an LCF, because the cancer can take many years to develop and cause death.

Table 4-11. Estimated maximum concentration in milligrams per cubic meter (mg/m^3) of air pollutants to the noninvolved worker from facility air emissions.[a,b]

	Averaging time[c]	OSHA Standard[c]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Sulfur dioxide	8-hr TWA[d]	13	0.01	0.01	0.01	0.01
Total particulates	8-hr TWA	15	0.02	0.02	0.02	0.01
Particulates <10 microns	8-hr TWA	5	0.02	0.02	0.02	0.01
Carbon monoxide	8-hr TWA	55	0.2	0.2	0.2	0.2
Nitrogen dioxide	Ceiling[e]	9	7.0	7.0	7.0	7.0
Lead	8-hr TWA	0.5	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Beryllium	8-hr	0.002	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}
	Ceiling	0.005	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Methyl alcohol	8-hr TWA	260	0.08	0.08	0.08	0.08
n-Propyl alcohol	8-hr TWA	500	0.08	0.08	0.08	0.08
Mercury	Ceiling	0.1	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Benzene	8-hr	3.1	0.1	3.0×10^{-4}	3.0×10^{-4}	3.0×10^{-4}
	Ceiling	15.5	0.8	0.004	0.004	0.004
Formic Acid[f]	8-hr	9	2.2×10^{-4}	None	None	None

Source: Hunter (2000).

a. For a noninvolved onsite worker at a distance of 640 meters from the process building stack and a 1.8-meter breathing height.

b. Under the No Action alternative, air emissions from all scenarios would be similar to air emissions from the HLW operations included in the SRS baseline. Therefore, incremental health effects would be minimal.

c. From 29 CFR 1910.1000.

d. TWA – Time-weighted average.

e. Ceiling limits are permissible exposure limits that a facility cannot exceed at any time.

f. Formic acid emissions would be shifted from DWPF to the Small Tank Precipitation facility, resulting in no net change.

To relate a dose to its effect, DOE has adopted a dose-to-risk conversion factor of 0.0004 LCFs per person-rem for workers and 0.0005 LCFs per person-rem for the general population (NCRP 1993) to estimate the number of LCFs that could result from the calculated exposure. The factor for the general population is slightly higher because infants and children are more sensitive to radiation than the adult worker population.

These dose-to-risk factors are consistent with the factors used by the NRC in its rulemaking *Standards for Protection Against Radiation* (10 CFR 20). The factors apply if the dose to an individual is less than 20 rem and the dose rate is less than 10 rem per hour. At doses greater than 20 rem, the factors used to relate radiation doses to LCFs are doubled. At much higher dose rates, prompt effects, rather than LCFs, would be the primary concern.

DOE expects minimal worker and public health impacts from the radiological consequences of salt processing activities under any of the technology alternatives. All alternatives are expected to result in similar radiological release levels. Public radiation doses would occur from airborne releases only (Section 4.1.3). Table 4-12 lists estimated radiation doses and corresponding incremental LCFs for the noninvolved worker (a worker not directly involved with implementing the alternative, but located 2,100 feet [640 meters] from the salt processing facility), the involved worker (a worker located 328 feet [100 meters] from the salt processing facility), the collective population of involved workers, the collective onsite (SRS) population, and the public (MEI and the collective offsite population) for each technology alternative.

Table 4-12. Estimated public and occupational radiological doses and health impacts from atmospheric emissions during operations.[a,b,c]

Receptor[d,e]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout[f]
MEI dose (millirem/year)	0.20	0.049	0.31	0.086
Probability of an LCF from MEI dose[g]	1.3×10^{-6}	3.2×10^{-7}	2.0×10^{-6}	5.6×10^{-7}
Dose to population within 50 miles of SRS (person-rem/year)	12.0	2.9	18.1	4.0
Estimated number of project-phase LCFs in the population within 50 miles of SRS[g]	0.078	0.019	0.12	0.026
Noninvolved worker dose (millirem/year)	3.3	0.8	4.8	1.7
Probability of an LCF from noninvolved worker dose[g]	1.7×10^{-5}	4.2×10^{-6}	2.5×10^{-5}	8.6×10^{-6}
Annual number of radiological workers[h]	140	100	160	110
Involved worker dose (millirem/year)	16	3.9	23	10
Probability of an LCF from involved worker dose[g]	8.2×10^{-5}	2.0×10^{-5}	1.2×10^{-4}	5.3×10^{-5}
Annual dose to the population of involved workers (person-rem per year)	2.2	0.39	3.6	1.1
Project-phase dose to involved workers (person-rem)	29	5.0	47	14
Estimated number of project-phase LCFs to involved workers[g]	0.012	0.0020	0.019	0.0056
Annual dose to the population of SRS workers (person rem/year)	4.3	1.1	6.5	2.3
Estimated number of project-phase LCFs in the worker population at SRS[g]	0.022	0.0055	0.034	0.012

a. Source term is based on data from Pike (2000).
b. Doses represent increment above baseline values from existing SRS activities.
c. Under the No Action alternative, air emissions from all scenarios would be similar to emissions from the HLW operations included in the SRS baseline. Therefore, incremental health effects would be minimal.
d. The MEI is 11,800 meters from the facility stack(s). The noninvolved worker is located 640 meters from the facility stack(s). The involved worker is located 100 meters from the facility stack(s).
e. Doses presented here are based on emissions from a 46-meter stack elevation.
f. Includes dose from operations and vaults.
g. LCFs are calculated for the project duration only. (When facility operations cease, residual contaminant levels would be negligible.) Each of the four action alternatives would operate for 13 years.
h. Assumes 75 percent of operations staff are radiological workers (WSRC 1999c).

As shown in Table 4-12, the highest radiological impacts to both involved and noninvolved workers and to the public would be associated with the Solvent Extraction alternative. The Small Tank Precipitation alternative would have impacts similar to Solvent Extraction, and the Ion Exchange and Direct Disposal in Grout alternatives would result in slightly lower impacts. The radiological doses from the Solvent Extraction alternative airborne emissions are higher than those for the other alternatives, and would result in an estimated additional 0.12 LCF for the general population surrounding SRS (50-mile radius) over the period of operation. Emissions from the Solvent Extraction alternative would also result in the highest impact to workers at SRS, an estimated 0.034 LCF for the collective SRS worker population (includes both involved and noninvolved workers) over the 13-year life of the project.

As expected, the collective involved worker doses and total project-phase doses shown in Table 4-12 are similar for all four action alternatives. The Solvent Extraction project-phase collective worker dose is the highest of the alternatives at 47 person-rem over the life of the project, and would result in 0.019 LCF. All doses are well within the administrative control limits for SRS workers (500 millirem per year).

The estimated number of LCFs in the public (Table 4-12) due to airborne emissions from each action alternative can be compared to the projected number of fatal cancers (approximately 140,000) in the public around the SRS from all causes (as discussed in Section 3.8.1). Similarly, the estimated number of fatal cancers in the involved worker population can be compared to the percent of the general population that succumbs from cancer regardless of cause (approximately 23.3 percent; see Section 3.8.1). In all cases, the incremental impacts from the alternatives would be minimal.

4.1.4.3 Occupational Health and Safety

The established method of determining a company or facility's safety record is by using its historic number of total recordable cases (TRCs) and lost workday cases (LWCs). Table 4-13 provides estimates of the number of TRCs and LWCs that would occur during a year and during the facility life cycle for the estimated number of involved workers for each alternative. The projected injury rates are based on historic SRS injury rates over a four-year period (1995 through 1999) multiplied by the employment levels and years for each alternative and the appropriate TRC and LWC rates.

The TRC rate includes work-related deaths, illnesses, or injuries that resulted in loss of consciousness, restriction from work or motion, transfer to another job, or required medical treatment beyond first aid. The LWC rate represents the number of workdays, beyond the day of injury or onset of illness, the employee was away from work or limited to restricted work activity because of an occupational injury or illness.

The results in Table 4-13 indicate that each action alternative has similar TRCs and LWCs, but the Solvent Extraction alternative would have the highest TRCs and LWCs. The higher number of injuries for this alternative is due to the larger number of workers needed to operate the facility. The number of TRCs and LWCs would remain at current levels during continuation of tank space management activities under the No Action alternative. Up to 65 new workers would be employed for operation of any new tanks built under No Action. This small increase in employment levels would result in 11 TRCs and 5 LWCs over the 13-year operations phase of the new tanks.

Tables 3-19 and 3-20 demonstrate that the SRS health and safety program has resulted in lower incidences of injury and illness than those in the general industry and manufacturing workforces.

These lower injury and illness rates for a proposed workforce ranged between 135 and 220 workers annually and for a period of 14.3 years are represented in Table 4-13. Considering the improvements the SRS safety program has made and continues to make in lowering the TRC and LWC rates, the numbers presented in Table 4-13 are conservative and future safety rates are expected to be much lower than the rates currently presented.

4.1.5 ENVIRONMENTAL JUSTICE

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs each Federal agency to "make...achieving environmental justice part of its mission" and to identify and address "...disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations." The Presidential Memorandum that accompanied Executive Order 12898 emphasized the importance of using existing laws, including the

Table 4-13. Estimated total recordable cases and lost workdays annually and for the life cycle of each alternative.[a]

Incident rate	No Action[b]	Small Tank Precipitation[c]	Ion Exchange[c]	Solvent Extraction[c]	Direct Disposal in Grout[c]
Total recordable cases (annual)	0.8	2.2	1.7	2.7	1.8
Total lost workday cases (annual)	0.35	1.0	0.72	1.2	0.77
Total recordable cases (facility life cycle)	11	32	24	39	25
Total lost workday cases (facility life cycle)	5	14	10	17	11

Source: WSRC (1998b, 1999d), DOE (2000b).
a. Based on working 8 hours per day, 250 days per year.
b. Based on 65 new workers for a period of 13 years to operate any new tanks built under the No Action alternative.
c. Facility life cycle includes 1.3 years for startup and 13 years of full operations.

National Environmental Policy Act (NEPA), to identify and address environmental justice concerns, "including human health, economic, and social effects, of Federal actions."

The Council on Environmental Quality (CEQ), which oversees the Federal government's compliance with Executive Order 12898 and NEPA, subsequently developed guidelines to assist Federal agencies in incorporating the goals of Executive Order 12898 in the NEPA process. This guidance, published in 1997, was intended to "...assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed."

As part of this process, DOE identified (in Section 3.6.2) minority and low-income populations within a 50-mile radius of the SRS (plus areas downstream of the Site that withdraw drinking water from the Savannah River), which was defined as the region of influence for the environmental justice analysis. The following section discusses whether implementing the alternatives described in Chapter 2 would result in disproportionately high and adverse impacts to minority or low-income populations.

DOE referred to the Draft Guidance on Environmental Justice and NEPA (DOE 2000c) in preparing this section.

4.1.5.1 Background

The CEQ issued guidance on assessing potential environmental justice impacts. No standard formula has been issued on how environmental justice issues should be identified or addressed. However, the following six principles provide general guidance (CEQ 1997):

- The composition of the area should be considered to determine whether minority populations, low-income populations, or Indian tribes are present in the area affected by the proposed action and, if so, whether there may be disproportionately high and adverse human health or environmental effects on those populations.

- Relevant public health data and industry data concerning the potential for multiple or cumulative exposures to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards should be considered.

- The interrelated cultural, social, occupational, historical, and economic factors that may amplify the natural and physical environmental effects of the proposed action should be recognized.

- Effective public participation strategies should be developed.

- Meaningful community representation in the process should be ensured.

- Tribal representation in the process should be sought in a manner that is consistent with the government-to-government relationship between the United States and tribal governments.

Environmental justice guidance developed by CEQ defines "minority" as individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic (CEQ 1997). The Council identifies these groups as minority populations when either (1) the minority population of the affected area exceeds 50 percent or (2) the minority population percentage in the affected area is meaningfully greater than the minority population percentage in the general population or appropriate unit of geographical analysis.

Low-income populations are identified using statistical poverty thresholds from the Bureau of Census Current Population Reports, Series P-60 on Income and Poverty. In identifying low-income populations, a community may be considered either as a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effects.

Environmental justice impacts can result if the proposed activities cause disproportionately high and adverse human health or environmental effects to minority or low-income populations. DOE assesses three factors to the extent practicable to identify disproportionately high and adverse human health effects:

- Whether the health effects are significant (as used by NEPA) or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death.

- Whether the risk or rate of exposure by a minority or low-income population to an environmental hazard is significant (within the meaning of NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group.

- Whether health effects occur in a minority or low-income population affected by cumulative or multiple adverse exposures from environmental hazards.

4.1.5.2 Methodology

First, DOE assessed the impacts of the proposed action and alternatives to the general population which, near the SRS, includes minority and low-income populations. No special considerations, such as unique exposure pathways or cultural practices, contribute to any discernible disproportionate impacts. The only identified cultural practice (or unusual pathway) potentially associated with minority and low-income populations is use of the Savannah River for subsistence fishing. For the Final *Accelerator Production of Tritium for the Savannah River Site Environmental Impact Statement* (EIS) (issued in 1999), DOE reviewed the limited body of literature available on subsistence activities in the region.

DOE concluded that, because the identified minority or low-income communities are widely distributed, and the potential impact to the general population is not discernible, there would be no potential for disproportionate impacts among minority or low-income populations. Second, having concluded that the potential offsite consequences to the general public of the proposed action and the alternatives would be small, DOE concluded that there would be no disproportion-

ately high and adverse impacts to minority or low-income populations.

These conclusions are based on the comparison of salt processing actions to past actions for which environmental justice issues were evaluated in detail. In 1995, DOE conducted an analysis of economic and racial characteristics of the population potentially affected by SRS operations within a 50-mile radius of the Site (DOE 1995). In addition, DOE examined the population downstream of the Site that withdraws drinking water from the Savannah River. The economic and racial characterization was based on 1990 census tract data from the U.S. Census Bureau. More recent census tract data are not available. The nearest minority and low-income populations to SRS are south of Augusta, Georgia, northwest of the Site.

This environmental justice analysis was based on the assessment of potential impacts associated with the various HLW salt processing alternatives to determine if there would be high and adverse human health or environmental impacts. In this assessment, DOE reviewed potential impacts arising under the major disciplines and resource areas, including: socioeconomics; cultural, air, water, and ecological resources; and public and worker health over the short term (approximately the years 2001 to 2023) and long term (approximately 10,000 years after saltstone was placed in vaults). Regarding health effects, both normal facility operations and postulated accident conditions were analyzed, with accident scenarios evaluated in terms of risk to workers and the public.

Although no high and adverse impacts were predicted for the activities analyzed in this SEIS, DOE nevertheless considered whether there were any means for minority or low-income populations to experience disproportionately high and adverse impacts. The basis for making this determination would be a comparison of areas predicted to experience human health or environmental impacts with areas in the region of influence known to contain high percentages of minority or low-income populations.

The environmental justice analysis for the HLW salt processing alternatives was assessed for a 50-mile area surrounding SRS (plus downstream areas), as discussed in Section 3.6.2.

Short-Term Impacts

For environmental justice concerns to be initiated, high and adverse human health or environmental impacts must disproportionately affect minority or low-income populations.

None of the proposed alternatives would produce appreciable short-term impacts to surface water (see Section 4.1.2.1) or groundwater (see Section 4.1.2.2). With the exception of VOCs, emissions of nonradiological and radiological air pollutants from HLW salt processing activities would be below regulatory limits (see Section 4.1.3) and would result in minimal impacts to workers and the public (see Section 4.1.4.2). The estimated radiological doses and health impacts to the noninvolved worker and the public are small (highest dose is 4.8 millirem per year to the noninvolved worker, under the Solvent Extraction alternative).

Because all salt processing activities would take place in an area that has been dedicated to industrial use for more than 40 years, no short-term impacts to ecological resources (see Section 4.1.6), existing land uses (see Section 4.1.7), or cultural resources (see Section 4.1.9) are expected.

Relatively small numbers of workers would be required to carry out salt processing activities, regardless of the alternative selected (see Section 4.1.8); as a result, none of the alternatives would affect socioeconomic trends (i.e., unemployment, wages, housing) in the region of influence.

As noted in Section 4.2, no long-term environmental justice impacts are anticipated.

Because short-term impacts would not substantially affect the surrounding population, and no

means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the alternatives.

Subsistence Consumption of Fish, Wildlife, and Game

Section 4-4 of Executive Order 12898 directs Federal agencies "whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence and that Federal governments communicate to the public the risks of these consumption patterns." There is no evidence to suggest that minority or low-income populations in the SRS region of influence are dependent on subsistence fishing, hunting, or gathering. DOE nevertheless considered whether there were any means for minority or low-income populations to be disproportionately affected by examining levels for contaminants in vegetables, fruit, livestock, and game animals collected from the SRS or adjacent lands. In addition, DOE assessed concentrations of contaminants in fish collected from SRS waterbodies and from the Savannah River up- and downstream of the Site.

Based on recent monitoring results, concentrations of radiological and nonradiological contaminants in vegetables, fruit, livestock, game animals, and fish from the SRS and surrounding areas are generally low, in virtually all instances below applicable DOE standards (Arnett and Mamatey 1998a,b). Consequently, no disproportionately high and adverse human health impacts would be expected in minority or low-income populations in the region that rely on subsistence consumption of fish, wildlife, or native plants.

It should be noted that mercury, which is present in relatively high concentrations in fish collected from SRS and the middle reaches of the Savannah River, could pose a potential threat to individuals and populations that rely on subsistence fishing. This mercury in fish has been attributed to upstream (non-DOE) industrial sources and natural sources (DOE 1997a). The salt processing alternatives under consideration would not affect mercury concentrations in SRS waterbodies or the Savannah River.

4.1.6 ECOLOGICAL RESOURCES

Construction

Depending on the salt processing alternative selected by DOE, construction of several new facilities would be required in either S or Z Area. Process buildings for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives would be built in S Area, while the process building for the Direct Disposal in Grout alternative would be built in Z Area. Regardless of the salt processing alternative (thus, process facility configuration) chosen, support facilities, including a service building, office building, and an electrical substation would be constructed in close proximity to the main process building (see Chapter 2 and Appendix A for details). New salt disposal vaults would be built in Z Area under all of the salt processing action alternatives.

As shown in Table 4-1, construction of process facilities for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives would require the excavation of approximately 77,000, 78,000, 82,000 and 23,000 cubic yards of soil, respectively. The total land area that would be cleared in S area (see Figure 3-1) for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative is 23 acres or 0.12 percent of SRS land dedicated to industrial use. Approximately 15 acres or 0.078 percent of SRS land dedicated to industrial use would be cleared for the Direct Disposal in Grout facility in Z Area (see Figure 3-2). Land in Z Area would also be required for construction of new saltstone vaults. All land-disturbing activity would be within the fenced boundaries of S and Z Areas, areas currently devoted to industrial use (waste management facilities).

As noted in Section 3.4.1, the preferred site (Site B) for salt processing facilities in S Area is approximately one-quarter mile south of DWPF (an active industrial facility) and, as a result, is within an area with relatively high levels of noise and activity. Because the Saltstone Manufacturing and Disposal Facility has not operated since 1998, the preferred site in Z Area has lower levels than S Area of noise and activity, limited for the most part to security patrols and an occasional tour.

There is the potential to disturb wildlife in both S and Z Areas and in adjacent woodlands during the construction phase of the project (approximately four years for site preparation and facility construction). Construction would involve the movement of workers and construction equipment and would be associated with relatively loud noises from earth-moving equipment (including backhoes, bulldozers, and graders), portable generators, and air compressors. Although noise levels in construction areas could be as high as 110 decibels (dBA), these high local noise levels would not extend far beyond the boundaries of the proposed project sites.

Table 4-14 shows the attenuation of construction noise over relatively short distances. At 400 feet from the construction sites, construction noises would range from approximately 55 to 85 dBA. Golden et al. (1980) suggest that noise levels higher than 80 to 85 dBA are sufficient to startle or frighten birds and small mammals. Thus, there would be little potential for disturbing birds and small mammals outside a 400-foot radius of the construction sites.

Although noise levels would be relatively low outside the immediate construction areas, the combination of construction noise and human activity probably would displace small numbers of animals (e.g., songbirds and small mammals) that forage, feed, nest, rest, or den in the woodlands to the east of S Area and to the south and east of Z Area. An access road and a railroad spur (Z Line) separate Site B in S Area from woodlands to the east (see Figure 3-1), reducing the value of Site B and adjacent woodlands as wildlife habitat. The identified site in Z Area (see Figure 3-2) is farther removed from roads and the railroad spur (and heavy industrial facilities in H and S Areas) and is presumed to have marginally higher value as wildlife habitat. Construction-related disturbances in both areas are likely to create impacts to wildlife that would be small, intermittent, and localized. Some animals could be driven from the area permanently, while others could become accustomed to the increased noise and activity and return to the area. Species likely to be affected (e.g., gray squirrel, opossum, white-tailed deer) are common to ubiquitous on SRS.

Under the No Action alternative, DOE would use approved siting procedures to ensure that any new tanks would be built in a previously disturbed industrial area. Studies and continued monitoring would also be performed to determine the presence of any threatened or endangered species and ensure that critical habitats would not be affected.

Operations

Operation of salt processing facilities would be less disruptive to wildlife than construction activities, but would entail movement of workers and equipment and noise from public address systems (e.g., testing of radiation and fire alarms), air compressors, pumps, and HVAC-related equipment. These activities would be similar under all alternatives, including No Action. With the possible exception of the public address systems, noise levels generated by these kinds of sources are not expected to disturb wildlife outside of facility boundaries.

As noted in Section 3.4, no threatened or endangered species or critical habitats occur in or near S or Z Areas, which are industrial sites surrounded by roads, parking lots, construction shops, and construction lay-down areas that are continually exposed to high levels of human disturbance. Proposed salt processing activities(and Tank Farm operations under No Action) would not disturb any threatened or endangered

Table 4-14. Peak and attenuated noise (in dBA) levels expected from operation of construction equipment.

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

Source: Golden et al. (1980).

species, would not degrade any critical or sensitive habitat, and would not affect any wetlands. DOE would continue to monitor the areas around S and Z Areas for the presence of threatened or endangered species. If a listed species were found, DOE would determine if salt processing activities would affect that species. If DOE were to determine that adverse impacts could occur, DOE would initiate consultation with the U.S. Fish and Wildlife Service, as required by Section 7 of the Endangered Species Act.

4.1.7 LAND USE

The *Savannah River Site Future Use Plan* (DOE 1998) provides an Integral Site Model that lays out intended future land use policies. DOE determined that this model most realistically accommodates development during the next 50 years. The model divides the SRS into three zones: industrial, industrial support, and restricted public use. The future use plan does not contemplate DOE relinquishing ownership of or institutional control over any portion of the SRS. The industrial zone surrounds facilities that: process or store radioactive liquid or solid waste, fissionable materials, or tritium; conduct separations operations; or conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations. The new salt processing facility would be constructed in areas (S or Z) designated as industrial. As shown in Table 4-1, approximately 23 acres (0.12 percent of SRS land dedicated to industrial use) would be cleared and graded for salt processing facilities at the selected site in S Area (see Figure 3-1), should the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative be selected. Approximately 15 acres (0.078 percent of SRS land dedicated to industrial use) would be cleared and graded for salt processing facilities in Z Area (see Figure 3-2), should the Direct Disposal in Grout alternative be selected. All land-disturbing activity would be within the fenced boundaries of S and Z Areas, areas currently devoted to industrial use (waste management facilities).

DOE would use the approved siting process to ensure that any new tanks under the No Action alternative would be constructed in a previously disturbed industrial area with a deep groundwater table. Due to the speculative nature of the No Action alternative, DOE has not determined how much land would be cleared for construction of any new HLW storage tanks. However, a

Type III HLW tank and associated equipment would occupy about one acre. Construction and operation of the proposed salt processing facility, including ongoing tank space management activities and building new tanks under the No Action alternative, would be consistent with the current SRS land use plans (DOE 1998).

4.1.8 SOCIOECONOMICS

Socioeconomic impact assessments are performed to determine the effects changes in local economic variables (e.g., number of jobs in a particular industry, wage rates, or increases in capital investment) may have on other economic measures (total regional employment, population, and total personal income).

New economic information was not developed for this SEIS. However, in 1999, DOE issued its *Accelerator Production of Tritium for the Savannah River Site Final Environmental Impact Statement* (DOE 1999). This EIS proposed a large accelerator for the SRS, and a full array of socioeconomic impact assessments was performed for the EIS. Based on these assessments, DOE concluded that the potential impacts attributed to construction and operation of the accelerator were relatively small in comparison with historical economic trends in the region and were not expected to stress existing regional infrastructures or result in an economic "boom."

Construction

During the construction phase of this project, based on preliminary design information, each salt processing alternative would employ approximately 500 construction workers annually, or about 50 percent fewer than the accelerator in its peak year of construction. Additionally, the estimated construction phase for the salt processing alternatives would be about 4 years, rather than 11 years for the accelerator, so potential construction impacts would be shorter in duration than those for the accelerator would have been.

Table 4-15 presents the estimated employment levels for each salt processing action alternative. The construction workforce is assumed to be constant over the life of the construction phase. The construction phase, expected to last approximately 4 years for each action alternative, would require less than 3.6 percent of the existing SRS workforce.

Under the No Action alternative, up to 500 construction workers may be employed to construct new HLW tanks. Tank construction would be expected to last 4 or more years (DOE 1980).

Operations

The Small Tank Precipitation alternative would require approximately 180 operations employees. The Ion Exchange alternative would require approximately 135 operations employees.

Table 4-15. Estimated salt processing employment by alternative.

Project phase	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction	500[a]	500	500	500	500
Operations	65[b]	180	135	220	145

Source: (WSRC 1998a, 2000a)

a. Up to 500 construction workers could be employed if new HLW tanks were built under the No Action alternative.

b. Up to 65 operations workers could be employed if new HLW tanks were built under the No Action alternative. However, a workforce reduction could occur if operations at the DWPF were suspended under No Action.

The Solvent Extraction alternative would require approximately 220 operations employees, and the Direct Disposal in Grout alternative would require approximately 145 operations employees, (WSRC 1998a, 2000a). During the operations phase, the Solvent Extraction alternative would require the most workers, but would still require less than 1.5 percent of the existing SRS workforce.

DOE believes staffing requirements for construction and operations of any salt processing action alternative could be filled with existing SRS employees. Given the size of the local economy, any supplemental workforce requirements could be met without measurable impacts or the influx of large workforces. Therefore, DOE does not expect any salt processing action alternative to have measurable socioeconomic impacts.

Under the No Action alternative, DOE would continue tank space management activities for a period of approximately 10 years and employment would remain at the current level. Subsequent activities under No Action could impact employment levels. DOE could suspend operations at DWPF. Suspension of operations at these facilities could result in a workforce reduction, which would have a negative impact on the communities surrounding SRS. Alternatively, up to 65 new employees would be needed for the operation of any new HLW tanks constructed under No Action (DOE 1980).

4.1.9 CULTURAL RESOURCES

Depending on the salt processing alternative selected by DOE, construction of new facilities would be required in either S (Site B) or Z Area. Process buildings for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives would be built in S Area, while the process building for the Direct Disposal in Grout alternative would be built in Z Area. Regardless of the salt processing alternative (thus, facility configuration) chosen, support facilities including a service building, office building, and an electrical substation would also be constructed in close proximity to the main process building (see Chapter 2 and Appendix A for details). New salt disposal vaults would be built in Z Area under any of the salt processing alternatives.

Because no important archaeological resources were discovered during the S Area surveys conducted in support of the *Final Environmental Impact Statement Defense Waste Processing Facility Savannah River Plant* (DOE 1982), DOE believes additional construction within this area would not adversely impact cultural resources. Most of Z Area also has been surveyed in the past, and no important cultural resources were discovered (DOE 1994). Both areas have been disturbed repeatedly by construction activity over the last 15 to 20 years, and the likelihood of undiscovered cultural or historic resources is small.

DOE would use the approved siting process to ensure that any new tanks for the No Action alternative would be constructed in a previously disturbed industrial area. DOE would ensure that any tank construction would not impact cultural or historic resources.

If any archaeological or cultural resources were discovered in the course of developing the previously described facilities in S and Z Areas or new tanks for the No Action alternative, DOE would contact the Savannah River Archaeological Research Program and the State Historic Preservation Officer in compliance with Section 106 of the National Historic Preservation Act for guidance on mitigating potential impacts to these resources.

4.1.10 TRAFFIC AND TRANSPORTATION

SRS is served by more than 199 miles of primary roads and more than 995 miles of unpaved secondary roads. The primary highways used by SRS commuters are State Routes 19, 64, and 125; 40, 10, and 50 percent of the workers, respectively, use these routes. Traffic congestion can occur during peak periods onsite on SRS Road 1-A, State Routes 19 and 125, and U.S. Route 278 at SRS access points. Vehicles asso-

ciated with this project would use these same routes and access points. None of the routes would require additional traffic controls or highway modifications, as explained below.

Construction

As shown in Table 4-16, concrete premix would be required during construction of the facilities under all action alternatives. Assuming that these materials are supplied by vendor facilities in Jackson and New Ellenton (for a round-trip distance of 18 miles), implementation of the alternatives would result in 55,000 to 61,000 freight miles traveled. Using Federal Highway Administration roadway composite statistics for South Carolina for the 1994 to 1996 period of record (Saricks and Tompkins 1999), these shipments would result in a maximum occurrence of 0.05 accidents, no fatalities, and 0.03 injuries as a result of material transport activities during construction. These projections are similar for all action alternatives. Therefore, it is highly unlikely that material transport activities during construction would lead to any accidents, fatalities, or injuries, regardless of the alternative selected.

As shown in Table 4-17, approximately 500 workers would travel to the Site 5 days a week (250 round trips per year for each worker) for 45 to 50 months during the construction phase of the project. Assuming no ride sharing and a round-trip commute distance of 50 miles, up to 26 million commuter miles would be traveled during the construction phase. Using 1998 national transportation statistics (BTS 1998), as many as 98 vehicle accidents could occur with this mileage, resulting in a maximum of 0.4 fatalities and 43 injuries. These projections are similar for all action alternatives.

Building new HLW tanks under the No Action alternative would require a similar number of material shipments as that required for construction of the action alternatives. DOE anticipates that the construction workforce under the No Action alternative would also be similar to the number of workers employed for construction of the action alternatives.

Operations

As shown in Table 4-16, saltstone premix and process reagents would be required during operation of the facilities under all action alternatives. Assuming that these materials are supplied by vendor facilities in Jackson and New Ellenton (for a round-trip distance of 18 miles), implementation of the alternatives would result in 340,000 to 470,000 miles traveled. Using Federal Highway Administration roadway composite statistics for South Carolina for the 1994 to 1996 period of record (Saricks and Tompkins 1999), these shipments would result in a maximum occurrence of 0.4 accidents, 0.02 fatalities, and 0.3 injuries as a result of material transport activities during construction. These projections are similar for all action alternatives. Therefore, it is very unlikely that material transport activities during construction would lead to any accidents, fatalities, or injuries, regardless of the alternative selected.

As shown in Table 4-17, between approximately 135 and 220 workers, depending on the alternative selected, would travel to the Site 5 days a week (250 round trips per year for each worker) for the 14.3-year startup and operation phase of the project. Assuming no ride sharing and a round-trip commute distance of 50 miles, up to 39 million commuter miles would be traveled during the operations phase. Using 1998 national transportation statistics (BTS 1998), as many as 148 vehicle accidents could occur with this mileage, resulting in a maximum of 0.6 fatalities and 65 injuries. The projections are similar for all action alternatives.

For the No Action alternative, up to 65 new employees would be needed for the 13-year operation phase (2010-2023) for any tanks constructed (DOE 1980). Therefore, approximately 39 vehicle accidents could occur under the No Action alternative, resulting in a maximum occurrence of 0.2 fatalities and 17 injuries.

Table 4-16. Material shipments (totals for the construction and operation phases) and transportation impacts associated with the salt processing alternatives.

Material use impact categories		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction					
Structural concrete premix shipments[a,b]		3,000	3,000	3,000	3,400
Total round-trip shipment distance (miles)		55,000	55,000	55,000	61,000
Number of	Accidents	0.04	0.04	0.04	0.05
	Fatalities	0	0	0	0
	Injuries	0.03	0.03	0.03	0.03
Operations[c]					
Saltstone premix[d]		25,500	21,100	23,800	19,000
Sodium hydroxide[d]		6	56	416	4
Oxalic acid[d]		1	1	1	1
Tetraphenylborate[d]		710	NA	NA	NA
Monosodium titanate[d]		1	1	1	1
Crystalline Silicotitanate[d]		NA	11	NA	NA
90% Formic acid[d,e]		66	NA	NA	NA
15% Cupric nitrate[d,e]		45	NA	NA	NA
Nitric Acid[d]		NA	NA	9	NA
Isopar®L[d]		NA	NA	40	NA
Trioctylamine[d]		NA	NA	1	NA
Calixarene[d]		NA	NA	1	NA
Cs-7SBT[d]		NA	NA	1	NA
Total number of shipments		26,000	21,000	24,000	19,000
Total round-trip shipment distance (miles)		470,000	380,000	440,000	340,000
Number of	Accidents	0.4	0.3	0.3	0.3
	Fatalities	0.02	0.02	0.02	0.01
	Injuries	0.3	0.2	0.2	0.2

a. Data for structural concrete use adapted from Attachments 9.2, 9.3, 9.4, and 9.5 of the life cycle cost estimate report (WSRC 1998a) using an assumed blended concrete premix density of 3,934 lb/yd^3 and a truck load capacity of 50,000 pounds.
b. Concrete requirements for construction of any new tanks under the No Action alternative would be similar to those required for the action alternatives.
c. For operations under the No Action alternative, material shipments would remain at current levels.
d. Number of shipments.
e. Corresponding decrease at DWPF.
NA = not applicable. The chemical would not be used in that particular alternative.

Table 4-17. Worker transportation impacts associated with the salt processing alternatives.

Worker travel impact categories		No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction worker travel						
Number of workers		500[a]	500	500	500	500
Total number of Site trips		500,000[a]	500,000	520,000	500,000	480,000
Total round-trip distance (million miles)		25[a]	25	26	25	24
Number of	Accidents	95[a]	95	98	95	91
	Fatalities	0.4[a]	0.4	0.4	0.4	0.4
	Injuries	42[a]	42	43	42	40
Operations worker travel						
Number of workers		65[b]	180	135	220	145
Total number of Site trips		210,000[b]	640,000	480,000	780,000	510,000
Total round-trip distance (million miles)		11[b]	32	24	39	26
Number of	Accidents	39[b]	122	91	148	97
	Fatalities	0.2[b]	0.5	0.4	0.6	0.4
	Injuries	17[b]	53	40	65	42

a. Based on 500 construction workers over a 4-year construction period. The construction period could be longer, depending on the number of tanks built.
b. Up to 65 workers would be required for operation of any new tanks built under No Action.

The surrounding area already has a certain volume of truck and car traffic associated with SRS logging, agriculture, and industrial activity. The amount of traffic associated with any of the alternatives (including No Action) is not expected to substantially increase traffic volume.

4.1.11 WASTE GENERATION

4.1.11.1 Wastes From Salt Processing

Each of the action alternatives would produce a low-activity salt waste stream that would be grouted for disposal in vaults in Z Area. The characteristics and volumes of grout produced from the low-activity salt solutions would vary among the alternatives. In addition, the high-activity materials separated from the salt solution would be transferred to DWPF for processing to borosilicate glass. Details of the wastes from salt processing under each of the action alternatives are discussed below.

Under the Small Tank Precipitation alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. New cement silos would be built to accommodate saltstone production. Sixteen new vaults would be needed to accommodate the expected grout volume (188 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55 (see Appendix A for Class A limits). Approximately 2.9 million gallons of slurry, containing monosodium titanate (MST) solids and precipitate hydrolysis aqueous (PHA) product, would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository. Processing the precipitate in the Small Tank Precipitation Facility would create a benzene waste stream that is unique to this salt processing alternative. The management of this benzene waste is described in Section 4.1.11.2.

Under the Ion Exchange alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. No modifications to the existing grouting process would be required. Thirteen new vaults would be needed to accommodate the expected grout volume (156 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55. Approximately 2 million gallons of slurry containing MST solids and 600,000 gallons of cesium-loaded crystalline silicotitanate (CST) resin would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository.

Under the Solvent Extraction alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. No modifications to the existing grouting process would be required. Fifteen new vaults would be needed to accommodate the expected grout volume (175 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55. Approximately 2 million gallons of slurry containing MST solids and 6.8 million gallons of cesium-loaded strip solution would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository. The Solvent Extraction process would also generate a liquid organic solvent. Management of this solvent waste is described in Section 4.1.11.2.

Under the Direct Disposal in Grout alternative, radioactive cesium would not be separated from salt solutions. Because of the shielding requirements for handling the cesium-containing salt solution, this material could not be processed in the existing Z Area Saltstone Manufacturing and Disposal Facility. After treatment with MST and filtration to remove strontium, uranium, plutonium, and entrained sludge, the clarified salt solution would be transferred to a new grouting facility located in Z Area. Thirteen new vaults would be needed to accommodate the expected grout disposal volume (141 million gallons). Because of its cesium content, the grout would be equivalent to Class C LLW, as defined in 10 CFR 61.55 (see Appendix A for Class C limits). Approximately 2 million gallons of slurry containing MST solids would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository.

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, without a process for separating the high-activity and low-activity salt fractions. DWPF would vitrify only sludge from the HLW tanks. HLW salt would be stored in existing tanks and monitoring activities would continue. Current tank space management projections indicate that, after 2010, additional tank space would be needed to support continued operations (WSRC 1999d). The course of action that DOE would follow cannot be predicted at this time but, regardless of which option DOE would pursue, waste generation rates under No Action would not be expected to increase from current levels.

4.1.11.2 Secondary Waste

This section presents the secondary waste generation estimates for each salt processing alternative that DOE considers in this SEIS. Unlike wastes from salt processing that are the direct result of processing the salt solutions, secondary wastes are those wastes generated as a result of construction, operation, and maintenance of the salt processing facilities under the action alternatives. Impacts are assessed in terms of the amount of secondary waste projected for each of the alternatives, relative to the quantity of waste that would otherwise be managed at SRS during the period of analysis. Table 4-18 provides es-

timates of the maximum annual waste generation. Table 4-19 provides the total waste volumes that would be generated over the life cycle of each of the salt processing alternatives.

Waste generation under the No Action alternative would be similar to waste generation rates at the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline. Baseline forecasts are provided in Table 5-4.

Liquid Waste

The radioactive wastewater that would be generated as a result of salt processing activities is produced during the DWPF vitrification process. The incremental increase in DWPF radioactive liquid waste would be associated with processing the high-activity waste (e.g., MST slurry, PHA product, loaded CST resin, cesium strip solution) from the various salt processing action alternatives, and would vary from about 150,000 gallons per year for the Direct Disposal in Grout alternative to 900,000 gallons per year for the Solvent Extraction alternative. The Small Tank Precipitation and the Ion Exchange alternatives would generate 300,000 and 250,000 gallons per year, respectively. The DWPF radioactive wastewater would be returned to the Tank Farm to be processed in the waste evaporators. Evaporator overheads would be treated in the ETF and discharged to Upper Three Runs via NPDES outfall H-16. DOE currently is examining options to ensure sufficient capacity in the Tank Farms to accommodate the DWPF radioactive liquid waste stream and other projected influents to the SRS HLW management system (WSRC 1999d).

Transuranic waste

DOE would not expect to generate transuranic wastes as a result of the proposed salt processing activities.

LLW

Under each of the action alternatives, DOE would expect to generate approximately 71 cubic meters per year of LLW. The projected volume represents about 0.5 percent of the forecasted SRS LLW generation through 2029 (Halverson 1999). Compactible LLW would be segregated from non-compactible LLW and processed in a volume reduction facility before disposal. Currently all LLW is disposed of onsite, but DOE is investigating the possibility of sending some LLW offsite for commercial treatment and disposal (DOE 2000d).

Hazardous waste

Under each of the action alternatives, DOE would expect to generate approximately 23 cubic meters per year of hazardous waste as a result of startup activities. This waste would consist of nonradioactive chemicals used to test the new facilities prior to actual waste processing. An additional 1 cubic meter per year of hazardous waste is expected during operations. The projected volume represents about 0.7 percent of the forecasted SRS hazardous waste generation through 2029 (Halverson 1999). This waste would be shipped offsite to commercial facilities for treatment and disposal (DOE 2000d).

Mixed LLW

Under each of the action alternatives, DOE would expect to generate small amounts (about 1 cubic meter per year) of mixed waste. These projected volumes represent about 0.4 percent of the forecasted SRS mixed LLW generation through 2029 (Halverson 1999). This waste would be treated onsite or at other DOE sites. Disposal would be at offsite facilities (DOE 2000d).

Table 4-18. Maximum annual waste generation for the salt processing action alternatives[a].

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	300,000	250,000	900,000	150,000
Nonradioactive liquid waste (gallons)	Negligible[b]	34,000[b,c]	Negligible[b]	Negligible[b]
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
LLW (m^3)	71	71	71	71
Hazardous waste (m^3)	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1
Mixed LLW (m^3)	1	1	1	1
Mixed low-level liquid waste (gallons)	60,000	None	1,000	None
Industrial waste (metric tons)	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20
Sanitary waste (metric tons)	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41

Source: WSRC (1999b, 2000b).

a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.
b. Assumes continuous operation.
c. CST resin pretreatment generates a spent 1 M NaOH solution and CST fines slurry.
d. Assumes a 1.3-year duration for startup activities under each action alternative.

Table 4-19. Total estimated waste generation for the salt processing action alternatives[a].

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (million gallons)	3.9	3.3	12	2.0
Nonradioactive liquid waste (million gallons)	negligible	0.49	negligible	negligible
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
LLW (m^3)	920	920	920	920
Hazardous waste (m^3)	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13
Mixed LLW (m^3)	13	13	13	13
Mixed low-level liquid waste (gallons)	780,000	None	13,000	None
Industrial waste (metric tons)	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260
Sanitary waste (metric tons)	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530

a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.
b. Assumes a 1.3-year duration for startup activities and 13 years of operation for each of the action alternatives.

Under the Small Tank Precipitation alternative, additional mixed LLW would be produced as a result of processing the precipitate. In a section of the Small Tank Precipitation facility, the precipitate slurry would undergo acid hydrolysis to separate it into a low-radioactivity organic portion (benzene) and a high-radioactivity aqueous portion. The organic portion would then be separated from the aqueous portion, washed to reduce the level of cesium, and transferred to the Organic Waste Storage Tank in S Area, which has a storage capacity of 150,000 gallons. A maximum of 60,000 gallons per year of benzene waste could be produced. DOE is investigating treatment and disposal options for this waste stream. This waste would be treated by incineration in the Consolidated Incineration Facility, in a portable vendor-operated incinerator or in a suitable offsite incineration facility, followed by disposal in a permitted facility. DOE analyzed the impacts of incineration in the Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility (DOE 1994).

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Under the Solvent Extraction alternative, additional mixed LLW would be produced as a result of solvent replacement. The total solvent inventory for the process, consisting primarily of the diluent Isopar®L, is a projected 1,000 gallons. Using the conservative assumption that the solvent inventory is replaced once per year, a total of 13,000 gallons of organic solvent could be accumulated over the 13-year operating life. DOE is investigating treatment and disposal options for this waste stream similar to those discussed in the previous paragraph for benzene.

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Industrial waste

Under each of the action alternatives, DOE would expect to generate approximately 30 metric tons per year of industrial (nonhazardous, nonradioactive) waste as a result of startup activities and an additional 20 metric tons per year during operations. The projected volume represents less than 1 percent of the forecasted SRS industrial waste generation through 2029 (Halverson 1999). This waste would be recovered for recycling or disposed of onsite at the Three Rivers Landfill (DOE 2000d).

Sanitary waste

Sanitary wastewater from the salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES outfall G-10. These discharges would be expected to comply with current NPDES permit limitations.

Under each of the action alternatives, DOE would expect to generate approximately 62 metric tons per year of solid sanitary wastes as a result of startup activities and an additional 41 metric tons per year during operations. The projected volume represents about 5 percent of the forecasted SRS sanitary waste generation through 2029 (Halverson 1999). This waste would be disposed of onsite at the Three Rivers landfill (DOE 2000d).

4.1.12 UTILITIES AND ENERGY

This section discusses potential utility and energy impacts from construction and operation under each of the salt processing alternatives. The scope of the analysis includes electric power, fuel (diesel and gasoline) consumption, process water consumption, and steam use. DOE used applicable past SRS operations or engineering to estimate the energy and utility requirements of the alternatives. Estimates of water use include: process additions, cooling, and flushing; product washes; and grout production. Steam is used primarily to operate the ventilation systems and to heat waste solutions during processing. Fuel consumption is based on use of diesel-powered equipment during construction activities and diesel emergency power generators. The analysis compared the use of electricity, water, and steam to the available capacities discussed in Section 3.10.

DOE would obtain utilities and energy from existing sources and suppliers. Water would come from existing site wells; and electricity and fuel

would come from existing on- and offsite suppliers. Steam would be produced onsite.

Table 4-20 lists electric energy, fuel, steam, and water use during the construction and operation phases of each action alternative. Overall, DOE does not expect substantial increases in water use or energy consumption with implementation of any of the alternatives, including No Action.

Table 4-20. Estimated project total energy and utilities use for the salt processing alternatives.

Phase[a]	SRS Baseline[b]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Potable water use (million gallons)					
Construction	NA	19	20	19	18
Operation	NA	99	95	120	75
Project subtotal use	NA	118	115	139	93
Process water use (million gallons)					
Construction	NA	16	17	16	15
Operation	23,000[c]	301	271	225	181
Project subtotal use	NA	317	288	241	196
Project total water use (million gallons)	NA	435	403	380	289
Peak electrical power demand (megawatts)					
Construction	NA	1.66	1.66	1.66	1.66
Operation	130[c]	24	24	32	18
Electricity use (gigawatt-hours)					
Construction	NA	76	79	76	73
Operation	410[c]	243	286	315	172
Project total use	NA	319	365	391	245
Steam use (million pounds)					
Construction	NA	0	0	0	0
Operation	NA	2,548	2,300	1,915	1,536
Project total use	NA	2,548	2,300	1,915	1,536
Fuel use (million gallons)					
Construction	NA	8.4	9	8.4	8
Operation	8.75[d]	0.3	0.3	0.3	0.2
Project total use	NA	8.7	9.3	8.7	8.2

Adapted from WSRC (1999e).

a. From Table 2-1, the construction and operation duration of each alternative are as follows: Small Tank Precipitation – 48 months and 13 years; Ion Exchange – 50 months and 13 years; Solvent Extraction – 48 months and 13 years; and Direct Disposal in Grout – 46 months and 13 years. The total project duration includes a startup duration of 1.3 years for each alternative (Sessions 1999).

b. Construction of any new tanks would require approximately 660,000 gallons of water and 45,000 gallons of fuel per tank. Utility and energy use under the No Action alternative would be similar to use at the existing HLW Tank Farms, and is included in the baseline.

c. Halverson (1999).

d. DOE (1995).

NA = Not Available.

4.1.12.1 Water Use

During the approximately 4-year construction phase, the estimated demand for water would range from 33 to 37 million gallons, depending on the processing alternative selected. On a daily average basis, the highest use would represent about 2.3 percent of water used in H-, S-, and Z-Area facilities in 1998 (SCDHEC 1999a) and 0.2 percent of the lowest estimated production capacity of the aquifer (16 million gallons per day) (WSRC 1998b).

Under the No Action alternative, construction of any new tanks would require approximately 660,000 gallons of water per tank (DOE 1980), which is less than 0.1 percent of the aquifer production capacity.

During the 13-year operational phase, total water use for the action alternatives would be similar and would vary between 256 and 400 million gallons, depending on the processing alternative selected. On a daily average use basis, the highest use would be about 22.6 percent of the volume used in H-, S-, and Z-Area facilities during 1998 (SCDHEC 1999a), and 1.5 percent of the lowest estimated production capacity of the aquifer (WSRC 1998b).

Water use for the entire duration of the project would be similar for all action alternatives and would be between 289 and 435 million gallons, for the Direct Disposal in Grout and Small Tank Precipitation alternatives, respectively.

For the No Action alternative, water use during operation under any scenario would be slightly higher than the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline.

4.1.12.2 Electricity Use

During construction, the estimated peak electrical power demand would be 1.7 megawatts for each alternative, with use varying between about 73 and 79 gigawatt-hours, depending on the processing alternative selected. The peak power demand would be a small fraction of the H-Area power distribution network's capacity (64 megawatts) (WSRC 1996). Power for S and Z Areas would be supplied through the H-Area network.

Electric power demand during construction of any tanks under the No Action alternative would be similar to that of the action alternatives.

During operations, the peak electric power demand would be very similar for each action alternative and would vary between 18 and 32 megawatts, depending on the processing alternative selected. In combination with the 22-megawatt demand for power from H-Area facilities, a total demand of 54 megawatts is possible, which represents 84 percent of the H-Area power distribution network's capacity (WSRC 1996). The highest peak power demands and electricity use would occur under the Solvent Extraction alternative. Electricity use during operations would be similar for each action alternative and would vary between 172 and 315 gigawatt-hours, depending on the alternative selected.

Electricity use for the entire duration of the project would be between 245 and 391 gigawatt-hours, for the Direct Disposal in Grout and Solvent Extraction alternatives, respectively.

For the No Action alternative, electric power demand during operation of any scenario would be slightly higher than the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline.

4.1.12.3 Steam Use

No steam would be used during the construction phase for any of the alternatives, including No Action. The main uses for steam during the operation phase would be operation of building ventilation systems and waste solution heating. Operation of the ventilation systems would account for most of the steam used. Total steam use during the operations phase would be similar under each alternative and would range from 1.5 to 2.5 billion pounds for the Direct Disposal in

Grout and Small Tank Precipitation alternatives, respectively. On a daily average use basis, the highest use would be about 18.3 percent of the steam used in H-, S-, and Z-Area facilities, and 1.5 percent of the steam production capacity for H-, S-, and Z-Area facilities (WSRC 1996).

Steam use under the No Action alternative would be slightly higher than current use rates at the existing HLW Tank Farms. Therefore, the No Action alternative would constitute a slight increase over the baseline.

4.1.12.4 Fuel Use

Diesel and gasoline fuels would be used during the construction and operation phases of the project, primarily for the operation of mobile heavy equipment and stationary support equipment. Fuel consumption would be similar under all the action alternatives. The highest consumption of liquid fuels, about 9 million gallons, would be during the construction phase of the Ion Exchange alternative (2.1 million gallons per year). Liquid fuel use during the operations phase of any alternative is low, at less than 300,000 gallons total. As a comparison, operations at SRS used approximately 8.75 million gallons of liquid fuels in 1994 (DOE 1995).

Under the No Action alternative, a total of approximately 45,000 gallons of diesel fuel and gasoline would be required per tank during construction (DOE 1980). Liquid fuel use during the operation phase would be similar to the existing Tank Farm and is included in the baseline.

4.1.13 ACCIDENT ANALYSIS

This section summarizes risks to the public and workers from potential accidents associated with the various salt processing action alternatives at SRS.

Detailed descriptions of each accident, including the scenario description, probability of occurring, radiological source terms, nonradiological hazardous chemical release rates, and consequences are provided in Appendix B.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

- *Internal initiators* normally originate in and around the facility, but are always a result of facility operations. Examples include equipment or structural failures and human errors.

- *External initiators* are independent of facility operations and normally originate outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.

- *Natural phenomena initiators* are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

Because current operations are the basis from which each of the proposed alternatives begins, the hazards associated with each of the action alternatives are in addition to those of current operations. However, after the period of opera-

tion, the hazards associated with salt processing are eliminated and those associated with the storage of salt solutions would be substantially reduced. Because the No Action alternative includes primarily current operations that have been evaluated under the NEPA process and in approved safety analysis reports, accidents associated with current tank space management operations are not evaluated here. Failure of a Salt Solution Hold Tank is addressed in the High-Level Waste Tank Closure Draft EIS (DOE 2000e). The radiological and nonradiological hazards associated with the four action alternatives were evaluated in this section and Appendix B.

Nonradiological

The long-term health consequences of human exposure to nonradiological hazardous materials are not as well understood as those related to radiation exposure. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

Table 4-21 summarizes the impacts of accidents involving the release of nonradiological hazardous materials to the MEI and noninvolved workers. In general, impacts to these receptors resulting from accidents involving nonradiological hazardous materials are minimal. However, noninvolved workers exposed to atmospheric releases of benzene from two of the accidents evaluated under the Small Tank Precipitation alternative could develop serious or life-threatening health effects. Workers exposed to airborne benzene concentrations (950 mg/m^3) resulting from an Organic Waste Storage Tank (OWST) loss of confinement accident could experience serious health effects that may impair their ability to take protective action (e.g., dizziness, confusion, impaired vision). Workers exposed to airborne benzene concentrations (8,840 mg/m^3) resulting from an explosion in the OWST, could experience life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory failure). Both of these accidents would occur less than once in 100,000 years and are in the extremely unlikely category.

Radiological

Tables 4-22 through 4-25 summarize for each salt processing alternative the estimated impacts to onsite workers and the public from potential accidents involving the release of radiological materials. These tables list potential accident consequences for all receptors as LCFs per accident and LCFs per year. The LCF per accident values are an estimate of the consequences without accounting for the probability of the accident occurring. The LCF per year values do take the accident's probability into consideration and provide a common basis for comparison of accident consequences.

DOE estimated impacts to five receptors: (1) the MEI at the SRS boundary; (2) the offsite population in an area within 50 miles (80 kilometers); (3) an involved worker 328 feet (100 meters) from the accident; (4) a noninvolved worker 2,100 feet (640 meters) from the accident location, as discussed in DOE (1994); and (5) the onsite population (includes both involved and noninvolved workers).

For all of the accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. In some cases, the impacts to the involved worker would be greater than to the noninvolved worker. DOE estimated the increased probability of an LCF to an involved and a noninvolved worker from radiation exposure during each of the accident scenarios.

However, prediction of latent potential health effects becomes increasingly difficult to quantify with any certainty as the distance between the accident location and the receptor decreases, because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The involved worker may be acutely injured or killed by physical effects of the accident itself. DOE identified potential accidents in Cappucci et al.

Table 4-21. Estimated consequences of accidents involving nonradioactive hazardous materials.

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Sodium Hydroxide Releases				
Caustic Feed Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}
Noninvolved Worker (640 m) Dose (mg/m^3)	0.18	0.18	0.18	0.18
Caustic Dilution Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	NA	NA	NA	0.0031
Noninvolved Worker (640 m) Dose (mg/m^3)	NA	NA	NA	0.93[a]
Accidents Involving Nitric Acid Releases				
Nitric Acid Feed Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	NA	NA	8.8×10^{-5}	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	NA	NA	0.026	NA
Accidents Involving Benzene Releases				
PHA Surge Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	7.4×10^{-10}	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	2.2×10^{-8}	NA	NA	NA
TPB Tank Spill – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	0.060	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	18.7	NA	NA	NA
Organic Evaporator Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	0.45	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	130	NA	NA	NA
Beyond Design Basis Earthquake – Frequency: Less than once in 2,000 years				
MEI Dose (mg/m^3)	0.0026	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	0.78	NA	NA	NA
OWST Loss of Confinement – Frequency: Once in 140,000 years				
MEI Dose (mg/m^3)	3.2	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	950[b]	NA	NA	NA
Loss of Cooling – Frequency: Once in 170,000 years				
MEI Dose (mg/m^3)	0.0015	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	0.44	NA	NA	NA
Benzene Explosion in the OWST – Frequency: Once in 770,000 years				
MEI Dose (mg/m^3)	30	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	8,840[c]	NA	NA	NA

a. Individuals exposed to sodium hydroxide concentrations above 0.5 mg/m^3 could experience mild transient health effects (e.g., rash, headache, nausea) or perception of a clearly defined objectionable odor.
b. Individuals exposed to benzene concentrations above 480 mg/m^3 could experience or develop irreversible or other serious health effects (e.g., dizziness, confusion, impaired vision).
c. Individuals exposed to benzene concentrations above 3,190 mg/m^3 could experience or develop life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory failure).

NA = Not Applicable, MEI - maximally exposed (offsite) individual, PHA = precipitate hydrolysis aqueous, OWST = Organic Waste Storage Tank, TPB = tetraphenylborate.

Table 4-22. Estimated accident consequences for the Small Tank Precipitation process.

	Loss of Confinement - PHA surge tank[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell-PHA Surge tank[a]	Benzene explosion	Helicopter Impact - PHA Surge Tank[a]	Aircraft Impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 99,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI dose (rem)	0.0016	0.31	0.014	0.70	3.3	5.4
MEI LCF per accident[c]	8.2×10^{-7}	1.5×10^{-4}	7.2×10^{-6}	3.5×10^{-4}	0.0016	0.0027
MEI LCF per year[c]	2.8×10^{-8}	7.6×10^{-8}	7.2×10^{-10}	3.5×10^{-9}	7.9×10^{-10}	1.0×10^{-9}
Offsite population dose (person-rem)	88	16,000	780	38,000	170,000	280,000
Offsite population LCF per accident	0.044	8.0	0.39	19	87	140
Offsite population LCF per year	0.0015	0.0040	3.9×10^{-5}	1.9×10^{-4}	4.2×10^{-5}	5.3×10^{-5}
Noninvolved worker Dose (rem)	0.024	9.6	0.21	10	100	170
Noninvolved worker LCF per accident[c]	9.5×10^{-6}	0.0038	8.5×10^{-5}	0.0041	0.041	0.067
Noninvolved worker LCF per year[c]	3.2×10^{-7}	1.9×10^{-6}	8.5×10^{-9}	4.1×10^{-8}	2.0×10^{-8}	2.5×10^{-8}
Involved worker dose (rem)	3.2×10^{-6}	310[d]	2.8×10^{-5}	0.0014	3,300[d]	5,400[d]
Involved worker LCF per accident[c]	1.3×10^{-9}	0.12	1.1×10^{-8}	5.5×10^{-7}	1.3	2.1
Involved worker LCF per year[c]	4.3×10^{-11}	6.1×10^{-5}	1.1×10^{-12}	5.6×10^{-12}	6.3×10^{-7}	8.0×10^{-7}
Onsite population dose (person-rem)	39	9,000	340	17,000	97,000	160,000
Onsite population LCF per accident	0.016	3.6	0.14	6.7	39	63
Onsite population LCF per year	5.3×10^{-4}	0.0018	1.4×10^{-5}	6.8×10^{-5}	1.9×10^{-5}	2.3×10^{-5}

a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
PHA = precipitate hydrolysis aqueous; PHC = precipitate hydrolysis cell; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-23. Estimated accident consequences for the Ion Exchange process.

	Loss of Confinement - Alpha Filter Cell[a]	Beyond Design-Basis Earthquake[b]	Loss of Cooling-Loaded Resin Hold Tank[a]	Fire in a Process Cell - Alpha Filter Cell[a]	Helicopter Impact - Alpha Filter Cell[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 5,300 years	Once in 10,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	8.3×10^{-4}	0.12	9.4×10^{-7}	0.0094	1.7	2.0
MEI LCF per accident[c]	4.2×10^{-7}	5.9×10^{-5}	4.7×10^{-10}	4.7×10^{-6}	8.5×10^{-4}	0.0010
MEI LCF per year[c]	1.4×10^{-8}	2.9×10^{-8}	8.9×10^{-14}	4.7×10^{-10}	4.1×10^{-10}	3.7×10^{-10}
Offsite population Dose (person-rem)	45	6,200	0.052	500	89,000	110,000
Offsite population LCF per accident	0.022	3.1	2.6×10^{-5}	0.25	45	53
Offsite population LCF per year	7.6×10^{-4}	0.0016	5.0×10^{-9}	2.5×10^{-5}	2.1×10^{-5}	2.0×10^{-5}
Noninvolved Worker Dose (rem)	0.012	3.7	1.4×10^{-5}	0.14	53	63
Noninvolved Worker LCF per accident[c]	4.9×10^{-6}	0.0015	5.7×10^{-9}	5.5×10^{-5}	0.021	0.025
Noninvolved Worker LCF per year[c]	1.6×10^{-7}	7.4×10^{-7}	1.1×10^{-12}	5.5×10^{-9}	1.0×10^{-8}	9.4×10^{-9}
Involved Worker Dose (rem)	6.4×10^{-8}	120	8.8×10^{-8}	9.1×10^{-7}	1,700[d]	2,000[d]
Involved Worker LCF per accident[c]	2.6×10^{-11}	0.047	3.5×10^{-11}	3.6×10^{-10}	0.68	0.81
Involved Worker LCF per year[c]	8.7×10^{-13}	2.4×10^{-5}	6.7×10^{-15}	3.6×10^{-14}	3.2×10^{-7}	3.0×10^{-7}
Onsite population Dose (person-rem)	20	3,500	0.023	220	50,000	59,000
Onsite population LCF per accident	0.0080	1.4	9.0×10^{-6}	0.089	20	24
Onsite population LCF per year	2.7×10^{-4}	6.9×10^{-4}	1.7×10^{-9}	8.9×10^{-6}	9.5×10^{-6}	8.8×10^{-6}

a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-24. Estimated accident consequences for the Solvent Extraction process.

Frequency	Loss of Confinement - SSRT[a] Once in 30 years	Beyond Design-Basis Earthquake[b] Less than once in 2,000 years	Fire in a Process Cell - Alpha Filter Cell[a] Once in 10,000 years	Hydrogen Explosion-Extraction Cell[a] Once in 1,300,000 years	Helicopter Impact - Alpha Filter Cell[a] Once in 2,100,000 years	Aircraft impact[b] Once in 2,700,000 years
MEI Dose (rem)	8.3×10^{-4}	0.12	0.0094	0.0029	1.7	2.0
MEI LCF per accident[c]	4.2×10^{-7}	5.8×10^{-5}	4.7×10^{-6}	1.4×10^{-6}	8.5×10^{-4}	0.0010
MEI LCF per year[c]	1.4×10^{-8}	2.9×10^{-8}	4.7×10^{-10}	1.1×10^{-12}	4.1×10^{-10}	3.8×10^{-10}
Offsite population Dose (person-rem)	45	6,100	500	160	89,000	110,000
Offsite population LCF per accident	0.022	3.0	0.25	0.081	45	54
Offsite population LCF per year	7.6×10^{-4}	0.0015	2.5×10^{-5}	6.1×10^{-8}	2.1×10^{-5}	2.0×10^{-5}
Noninvolved Worker Dose (rem)	0.012	3.6	0.14	0.044	53	64
Noninvolved Worker LCF per accident[c]	4.9×10^{-6}	0.0015	5.5×10^{-5}	1.8×10^{-5}	0.021	0.026
Noninvolved Worker LCF per year[c]	1.6×10^{-7}	7.3×10^{-7}	5.5×10^{-9}	1.3×10^{-11}	1.0×10^{-8}	9.5×10^{-9}
Involved Worker Dose (rem)	6.4×10^{-8}	120	7.2×10^{-7}	2.7×10^{-4}	1,700[d]	2,000[d]
Involved Worker LCF per accident[c]	2.6×10^{-11}	0.046	2.9×10^{-10}	1.1×10^{-7}	0.68	0.81
Involved Worker LCF per year[c]	8.7×10^{-13}	2.3×10^{-5}	2.9×10^{-14}	8.1×10^{-14}	3.3×10^{-7}	3.0×10^{-7}
Onsite population Dose (person-rem)	20	3,400	220	70	50,000	60,000
Onsite population LCF per accident	0.0080	1.4	0.089	0.028	20	24
Onsite population LCF per year	2.7×10^{-4}	6.8×10^{-4}	8.9×10^{-6}	2.1×10^{-8}	9.6×10^{-6}	8.9×10^{-6}

a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
SSRT = sludge solids receipt tank; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-25. Estimated accident consequences for the Direct Disposal in Grout process.

	Loss of Confinement - SSRT[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell - SSRT[a]	Helicopter Impact - SSRT[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	2.4×10^{-4}	0.042	0.0027	0.53	0.74
MEI LCF per accident[c]	1.2×10^{-7}	2.1×10^{-5}	1.4×10^{-6}	2.7×10^{-4}	3.7×10^{-4}
MEI LCF per year[c]	4.1×10^{-9}	1.0×10^{-8}	1.4×10^{-10}	1.3×10^{-10}	1.4×10^{-10}
Offsite population Dose (person-rem)	14	2,300	160	29,000	40,000
Offsite population LCF per accident	0.0072	1.1	0.081	14	19
Offsite population LCF per year	2.4×10^{-4}	5.7×10^{-4}	8.1×10^{-6}	6.9×10^{-6}	7.4×10^{-6}
Noninvolved Worker Dose (rem)	0.0036	1.3	0.041	17	23
Noninvolved Worker LCF per accident[c]	1.5×10^{-6}	5.3×10^{-4}	1.6×10^{-5}	0.0067	0.0093
Noninvolved Worker LCF per year[c]	4.9×10^{-8}	2.6×10^{-7}	1.6×10^{-9}	3.2×10^{-9}	3.4×10^{-9}
Involved Worker Dose (rem)	7.3×10^{-8}	42	8.2×10^{-7}	53	740[d]
Involved Worker LCF per accident[c]	2.9×10^{-11}	0.017	3.3×10^{-10}	0.21	0.30
Involved Worker LCF per year[c]	9.8×10^{-13}	8.4×10^{-6}	3.3×10^{-14}	1.0×10^{-7}	1.1×10^{-7}
Onsite population Dose (person-rem)	42	1,000	48	13,000	18,000
Onsite population LCF per accident	0.0017	0.41	0.19	5.3	7.3
Onsite population LCF per year	5.7×10^{-5}	2.1×10^{-4}	1.9×10^{-6}	2.5×10^{-6}	2.7×10^{-6}

a. Tank/cell listed is bounding case (e.g., results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
SSRT = sludge solids receipt tank; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

(1999) and estimated impacts using the AXAIRQ computer model (Simpkins 1995a,b), as discussed in Appendix B.

4.1.14 PILOT PLANT

As discussed in Section 2.7.6, a Pilot Plant would be designed and constructed to demonstrate the overall process objectives of the salt processing alternative that DOE will select. Details of the proposed demonstration objectives are provided in Appendix A. Detailed design and construction of the Pilot Plant would be initiated upon selection of the salt processing alternative and operation would extend through completion of final design and potentially

through startup of the full-scale facility. This section discusses potential impacts from construction and operation of the Pilot Plant for each salt processing action alternative.

For the purposes of this SEIS, DOE assumes that the Pilot Plant components would be sized to operate on a scale of approximately 1/100 to 1/10 that of the full-size facility, and would utilize a modular design to facilitate remote installation and modification of the process equipment. A Pilot Plant for the Direct Disposal in Grout alternative is not planned because this technology is better developed than the other action alternatives, and has been demonstrated at full scale in the Saltstone Manufacturing and Disposal Facility. Therefore, this SEIS does not include a demonstration of the Direct Disposal in Grout alternative.

DOE intends to construct and operate a Pilot Plant only for the selected alternative. Knowledge gained from the demonstration could lead to a decision to demonstrate more than one salt processing alternative technology. In the event that DOE decides to demonstrate more than one technology, the Pilot Plant units would be developed and operated in series. Therefore, impacts associated with more than one Pilot Plant would not occur at the same time, but would extend over a longer period.

The Pilot Plant would be designed to demonstrate the processing of real radioactive wastes. Principal process operations would be conducted inside shielded cells.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the Late Wash Facility in H Area (see Figure 2-3), which was designed and built to handle radiological operations and is located near DWPF, in S Area or in another area similar to the location of the proposed full-scale facility.

Services to support operations would be provided, including utilities, process chemicals, ventilation systems, and habitability services. An appropriate chemical storage area would be developed, with isolation of acids, caustics, oxidizing and reducing agents, and other incompatible reactants. Ventilation systems would be operated such that airflow is from regions of low contamination to areas of higher contamination.

The generation and dispersion of radioactive and hazardous materials would be minimized. Process waste would be managed at appropriate site locations, such as DWPF, Saltstone Manufacturing and Disposal Facility, HLW Tank Farms and the LLW vaults.

All Pilot Plants are at the pre-conceptional stage, therefore, the analysis in this section is qualitative.

4.1.14.1 Geologic Resources

The Pilot Plant would be constructed in an existing facility in a previously disturbed area. Therefore, no additional impact to geologic resources would occur.

4.1.14.2 Water Resources

The Pilot Plant would be constructed in an existing facility. No additional land would be disturbed therefore the water table would not be disturbed and no increase in suspended solids in stormwater runoff would be expected. Therefore, no impact to surface water or groundwater resources would occur during construction.

The Pilot Plant would generate less than 10 percent of the sanitary and process wastewater of the full size salt processing facility on an annual basis. DOE concluded in Section 4.1.2 that regardless of the alternative selected, impacts to surface water as a result of salt processing facility activities would be minimal and there would be no impact to groundwater quality. The quantity of sanitary and process wastewater generated by the Pilot Plant would be much smaller than the amount generated by the salt processing

facility, therefore surface water impacts from operation of the Pilot Plant would be minimal and there would be no impact to groundwater quality.

4.1.14.3 Air Resources

The Pilot Plant would use skid-mounted equipment and be constructed in an existing facility. No land would be disturbed during construction, therefore the use of heavy-duty construction equipment (i.e., trucks, bulldozers, and other diesel-powered support equipment) would be minimized. Therefore, impacts to air quality during construction would be minimal.

As shown in Table 4-7, with the exception of VOCs, the nonradiological air emissions from the full-scale salt processing facility for each alternative are similar and would be well below the SCDHEC PSD limit. The estimated VOC emissions for the full-scale Ion Exchange facility would not be greater than 5 percent of the PSD limit of 40 tons per year. The estimated VOC emissions for the full-scale Small Tank Precipitation facility would be 70 tons per year, while the emissions from the full-scale Solvent Extraction facility would be 40 tons per year. VOC emissions from both full-scale facilities would exceed the PSD limit of 40 tons per year. Because air emissions from the Pilot Plant would not be greater than 10 percent of the emissions from the full-size facility, all nonradiological emissions from the Pilot Plant would be much lower than their corresponding PSD limits. Similarly, incremental increases in air concentrations at the SRS boundary would also be much lower than those projected for the full-scale facility.

As shown in Table 4-8, all radiological air emissions from the full-scale facility for each alternative would be similar and low. Because air emissions from the Pilot Plant would not be greater than 10 percent of the emissions from the full-size facility, incremental impacts of radiological emissions from the Pilot Plant would be minimal.

4.1.14.4 Worker and Public Health

In Section 4.1.4 DOE concluded the overall occupational and health impacts (radiological, nonradiological, and occupational safety) would be minimal for the full-scale Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout facilities. Doses to the noninvolved worker would be well below Federal limits and SRS administrative guides and would not result in adverse impacts. Exposures to the MEI would result in an annual dose that is below the Federal exposure limits. The Pilot Plant would not be greater than 1/10 the size of the preferred salt processing alternative and would be operated in a manner that minimizes the generation and dispersion of radioactive and hazardous materials. Therefore, the overall occupational and health impacts (radiological, nonradiological, and occupational safety) would be similar and minimal.

4.1.14.5 Environmental Justice

In Section 4.1.5, DOE concluded that the potential offsite consequences to the general public of the proposed action and the alternatives would be small, and there would be no disproportionately high and adverse impacts to minority or low-income populations. The Pilot Plant would not be greater than 1/10 the size of the preferred salt processing alternative and would be operated in a manner that minimizes the generation and dispersion of radioactive and hazardous materials. Therefore, by similarity, the Pilot Plant would have no disproportionately high and adverse impacts to minority or low-income populations.

4.1.14.6 Ecological Resources

The Pilot Plant would be constructed in an existing facility located in a heavily industrialized area that has marginal value as wildlife habitat. Construction would involve the movement of workers and construction equipment, but no earth-moving equipment would be anticipated, so noise levels would be somewhat lower than the levels that would be experienced during construction of the full-scale facility. Construction-

related disturbances are likely to create impacts to wildlife that would be small, intermittent, and localized.

Operation of the Pilot Plant would entail movement of workers and equipment and noise from public address systems (e.g., testing of radiation and fire alarms), air compressors, pumps, and HVAC-related equipment. With the possible exception of the public address systems, noise levels generated by these kinds of sources are not expected to disturb wildlife outside of facility boundaries.

4.1.14.7 Land Use

The Pilot Plant would be constructed in an existing facility located in an area designated for industrial use. Therefore, no change in land use patterns would occur.

4.1.14.8 Socioeconomics

The Pilot Plant would be constructed in an existing facility. During construction of the Pilot Plant, the number of workers would be restricted by space constraints inside the proposed facility. In addition, the Pilot Plant would have a modular design that maximizes the use of skid-mounted equipment, which would facilitate remote installation and further limit the number of workers required for construction. Therefore, the number of workers involved in the construction of the Pilot Plant would be much lower than the number of workers required for construction of the salt processing facility.

The Small Tank Precipitation process facility would require approximately 180 operations employees. The Ion Exchange process facility would require approximately 135 operations employees. The Solvent Extraction process facility would require approximately 220 operations employees, (WSRC 1998a, 2000a). These same employees would be trained in and would operate the Pilot Plant.

4.1.14.9 Cultural Resources

The Pilot Plant would be constructed in an existing facility and would, therefore, not disturb any cultural or historic resources. Therefore, no impact to cultural resources would occur.

4.1.14.10 Traffic and Transportation

In Section 4.1.10, DOE estimated that material shipments required for implementation of the alternatives would result in 403,000 to 529,000 miles traveled over the 13 year life of the facility and no accidents involving injuries or fatalities would be expected during those material shipments. The Pilot Plant would operate potentially for a period of approximately 5.5 years and the number of material shipments would be substantially lower, so no accidents involving injuries or fatalities would be expected during material shipments to the Pilot Plant.

During the life of the Pilot Plant, workers would make between 184,250 and 292,000 Site trips. Under the Small Tank Precipitation Pilot Plant, workers would make approximately 240,000 Site trips; 45 accidents, 20 injuries and no fatalities would be expected. Under the Ion Exchange Pilot Plant, workers would make approximately 184,250 Site trips; 35 accidents, 15 injuries and no fatalities would be expected. Under the Solvent Extraction Pilot Plant, workers would make approximately 292,000 Site trips; 55 accidents, 24 injuries and no fatalities would be expected.

4.1.14.11 Waste Generation

The Pilot Plant would generate no greater than 10 percent of the waste of the full-size salt processing facility on an annual basis. Waste generation under the Solvent Extraction Pilot Plant would be slightly higher than the other Pilot Plant units, due to the inclusion of a 1/5-scale centrifugal contactor.

As with the full-scale salt processing facility, the Pilot Plant would generate minimal quantities of low-level, transuranic, hazardous, industrial, and sanitary waste under all scenarios. All opera-

tions would generate a small amount of radioactive liquid waste, but the quantity generated by the Solvent Extraction Pilot Plant would be somewhat higher than that generated by the other three Pilot Plants. The Ion Exchange Pilot Plant would generate a small amount of nonradioactive liquid waste, while the Pilot Plants for the other two action alternatives would generate minute quantities of nonradioactive liquid waste. All Pilot Plant operations would generate a small amount of mixed LLW, but the quantity generated by the Solvent Extraction Pilot Plant would be higher than that generated by the Small Tank Precipitation and Ion Exchange Pilot Plants. Because it produces a comparatively large amount of benzene, the Small Tank Precipitation Pilot Plant would generate considerably more mixed low-level liquid waste than the other two Pilot Plants.

4.1.14.12 Utilities and Energy

Utility and energy use during construction of the Pilot Plant would be minimal. No steam would be used, and the use of skid-mounted equipment and the fact that the Pilot Plant would be constructed in an existing facility would limit water, electricity, and fuel requirements.

Utility and energy use during operation of the Pilot Plant would not be greater than 10 percent of the amount used in the full-size salt processing facility on an annual basis. Utility and energy demand for the Solvent Extraction Pilot Plant would be slightly higher than the other Pilot Plants due to the inclusion of a 1/5-scale centrifugal contactor. The impact to SRS utility and energy supplies would be minimal during operation of the Pilot Plant.

4.2 Long-Term Impacts

This section presents estimates of long-term impacts of the four salt processing action alternatives and the No Action alternatives. For all the action alternatives, the major source of long-term impacts would be the saltstone that would result from each of the four alternatives. As discussed in Chapter 2, the saltstone vaults would be located in Z Area, regardless of the selected alternative. Therefore, this SEIS analyzes impacts only from the placement of saltstone in Z Area. Short-term impacts of manufacturing the saltstone are included in Section 4.1.

For NEPA analysis of long-term impacts of the action alternatives, DOE assumed that institutional control would be maintained for 100 years post-closure, during which the land encompassing the saltstone vaults would be managed to prevent erosion or other conditions that would lead to early degradation of the vaults. DOE also assumed that the public would not have access to Z Area during this time to set up residence. DOE estimated long-term impacts by doing a performance evaluation that included fate and transport modeling to determine when certain impacts (e.g., radiation dose) could peak. DOE used the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (WSRC 1992) (RPA) as the basis for the water resources and human health analyses. This performance assessment was done for the original saltstone that would have resulted from the In-Tank Precipitation process. For this SEIS, DOE modified the source terms for each of the action alternatives. See Appendix D for details of the analysis.

For NEPA analysis of long-term impacts of the No Action alternative, DOE assumes that the sludge in the HLW tanks would be processed to the extent practicable so that only salt waste would be left in the tanks, and the tanks would be nearly full. It is also assumed that DOE would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves, but would maintain institutional control and would maintain the tanks for 100 years. Following this 100-year period of institutional control, the HLW tanks would begin to fail. Failed tanks could create physical hazards to humans and wildlife in the area. Waste contaminants could be released from tanks into groundwater and the contaminants would eventually migrate to surface water. Precipitation could infiltrate into failed tanks, causing them to overflow and spill dissolved salt

L3-1
L6-4
L7-3
L8-5
L8-6

onto the ground surface. Salt solutions spilled onto the ground surface could contaminante the soil, vegetation, and groundwater, and could flow overland to surface streams (Upper Three Runs, Fourmile Branch, and the Savannah River). People who intruded into the site vicinity could receive radiation exposure by external exposure to contaminated soil or by consuming contaminated surface water, groundwater, or vegetation, or eating meat or dairy products from animals that had consumed such water or vegetation.

In the Draft SEIS, DOE did not model the eventual release of salt waste to the environment under the No Action alternative. Instead, DOE provided a comparison to the modeling results from the No Action alternative in the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000). In the Tank Closure Draft EIS No Action scenario, most of the waste would be removed from the HLW tanks (i.e., approximately 10,000 gallons would remain as residual waste in a 1.3-million-gallon tank). After a period of several hundred years, the remaining waste, 200 curies of long half-life isotopes and 9,900 curies of cesium-137 (which has a relatively short half-life of 30 years), would be released to groundwater and eventually migrate to surface water. The Tank Closure Draft EIS modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime dose of 430 millirem (primarily from groundwater) and incur an incremental risk of 0.0022 of contracting a fatal cancer. For comparison, in the No Action alternative in the Salt Processing Alternatives Draft SEIS, DOE assumed that HLW would be left in the tanks and the tanks would be nearly full and that 160,000,000 curies (primarily cesium-137) in the salt component and 290,000,000 curies (primarily long half-life isotopes) in the sludge component of the HLW in the storage tanks would be released to groundwater and eventually enter surface water. This analysis did not take credit for any decay of the short half-life radionuclides, particularly cesium-137. Because the activity under this scenario (450,000,000 curies) would be much greater than the activity (10,000 curies) modeled in the Tank Closure Draft EIS, the Salt Processing Alternatives Draft SEIS stated that long-term impacts to human health resulting from the radiation dose under the No Action alternative would be catastrophic.

L3-2
L6-4
L7-3
L8-5
L8-6

During the public comment period, DOE received several comments from the public (See Appendix C, Letters L3, L6, L7, and L8) questioning the description of the No Action alternative and its impacts. The commenters generally expressed the opinion that the long-term impacts of No Action would be more severe than portrayed qualitatively in the Salt Processing Alternatives Draft SEIS and requested that the No Action alternative be modified and the long-term impacts analyzed quantitatively. One commenter suggested that, to be consistent with the short-term No Action scenario described in Section 2.3, the long-term No Action scenario should contain the consequences of removing all the sludge and leaving the salt waste containing 160,000,000 curies of activity (primarily cesium-137) in the tanks. In addition, several commenters suggested that, by assuming all radionuclides would reach the public through groundwater, the Salt Processing Alternatives Draft SEIS missed the largest long-term risk to the public and that DOE should consider the release of HLW to surface run-off.

In response to these comments, for this Final Salt Processing Alternatives SEIS, DOE modeled the potential impacts of a scenario in which precipitation leaks into the tanks, causing them to overflow and spill their contents onto the ground surface, from which contaminants migrate to surface streams.

L6-3
L6-5

DOE estimated that the salt waste in the HLW tanks now contains about 160,000,000 curies, approximately 500 curies of long half-life isotopes (e.g., technetium-99, iodine-129, and plutonium-239), and the balance short half-life isotopes, primarily cesium-137, which has a half-life of 30 years. Radioactive decay during the 100-year period of institutional control would reduce the activity level to around 16,000,000 curies.

To conservatively estimate the consequences of this scenario for water users, DOE modeled the eventual release of the salt waste to surface water at SRS, assuming no loss of contaminants during overland flow. The modeling showed that an individual consuming 2 liters per day of water from Fourmile Branch would receive a dose of 640 millirem per year. This dose is more than 160 times the drinking water regulatory limit of 4 millirem per year and would result in a 2.2 percent increase in the probability of contracting a latent cancer fatality from a 70-year lifetime exposure. When a 2.2 percent increase is low, the probability of contracting a latent cancer fatality under the No Action alternative is about 13,000 times greater than that of any of the action alternatives. Similarly, an individual consuming the same amount of water from Upper Three Runs would receive a dose of 295 millirem per year, and an individual consuming the same amount of water from the Savannah River would receive a dose of 14.5 millirem per year. These doses also exceed the drinking water limit and would incrementally increase the probability of contracting a latent cancer fatality from a 70-year lifetime exposure by 1.0 percent and 0.051 percent, respectively.

L6-3
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For the No Action alternative, DOE also considered potential external radiation exposure from the tank overflow scenario described above for a resident in the tank farm area, conservatively assuming that all contamination is deposited on the ground surface rather than flowing to streams or entering the underlying soil. The modeling showed that an individual living in the tank farm would receive an external dose of about 2,320 rem in the first year following the event, which would result in a prompt fatality.

DOE expects that those two scenarios bound the potential impacts of the No Action alternative. This is consistent with results of a multipathway exposure analysis for the Z-Area vaults, which showed that the external radiation dose an individual would receive from cesium-137 is considerably greater than doses an individual would receive from other exposure pathways (e.g., drinking water).

Because of the assumption that, in the long term, DOE would not be active at the Site, there would be no long-term impacts to socioeconomics, utilities and energy, worker health, traffic and transportation, or waste generation. Air and accident impacts would be very small and would not differ substantially among alternatives. Section 4.2 does not analyze or discuss long-term impacts to these resources. The following impact areas are analyzed: geologic resources, water resources (groundwater and surface water), ecological resources, land use, and public health.

4.2.1 GEOLOGIC RESOURCES

The Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives include disposal of radioactive waste in vaults in Z Area. Failure of the vaults at some time in the future would have the potential to contaminate the surrounding soils. If the integrity of a vault were breached, infiltration of water could result in contaminants leaching to groundwater. The water-borne contaminants would contaminate nearby soils, but would not alter their physical structure. No detrimental effect on surface soils, topography, or on the structural or load-bearing properties of geologic deposits would occur because of release of contaminants from the vaults.

Under the No Action alternative, DOE assumed that only salt waste would be left in the HLW tanks. Failure of the HLW tanks would allow precipitation to collect in the tanks and eventually salt solution could overflow and contaminate surface soils. No detrimental effect on topography or load-bearing properties of geologic deposits would result from release of contaminants from the HLW tanks.

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4.2.2 WATER RESOURCES

4.2.2.1 Surface Water

For the action alternatives surface water impacts would only occur by discharge of contaminated groundwater. Because the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives would result in radioactive waste being disposed in the Z Area vaults, the potential exists for long-term impacts to groundwater (see Section 4.2.2.2). Contaminants in groundwater could then be transported through the Upper Three Runs Aquifer and the underlying Gordon Aquifer to the seeplines along McQueen Branch and Upper Three Runs, respectively (see Section 4.2.2.2 for a more detailed discussion). The factors that govern the movement of contaminants through groundwater (i.e., the hydraulic conductivity, hydraulic gradient, effective porosity, and dispersion of aquifers in the area) and the processes resulting in attenuation of radiological and nonradiological contaminants (i.e., radioactive decay, ion exchange in the soil, and adsorption to soil particles) would be expected to reduce or mitigate impacts to surface water resources.

As described in Appendix D, DOE used an analysis based on the PORFLOW-3D computer code to model the fate and transport of contaminants in groundwater and subsequent flux (i.e., groundwater discharge at the seepline) to surface waters. The groundwater discharge at the seepline would naturally mix with the stream flow. Assuming that the upstream concentration of all contaminants in surface water is zero, and that no storm runoff is present, the resulting concentration of contaminants in surface water would be the result of the seepline groundwater mixing with uncontaminated surface water. The resulting concentrations in surface water would thus always be less than the groundwater seepline concentrations, due to dilution. The average flows in McQueen Branch and Upper Three Runs at the point of mixing with the groundwater discharge along the seeplines would be on the order of 2 to 3 cubic feet per second and 135 to 150 cubic feet per second, respectively (Parizek and Root 1986).

EPA periodically publishes water quality criteria as concentrations of substances that are known to affect "diversity, productivity, and stability" of aquatic communities including "plankton, fish, shellfish, and wildlife" (EPA 1986, 1999). These recommended criteria provide guidance for state regulatory agencies developing location-specific water quality standards to protect aquatic life (SCDHEC 1999b). Such standards are used in a number of environmental protection programs, including setting discharge limits in NPDES permits. Water quality criteria and standards are generally not legally enforceable; however, NPDES discharge limits based on these criteria and standards are legally binding and are enforced by SCDHEC.

The fate and transport modeling indicates that movement of radiological contaminants from failed vaults to nearby surface waters via groundwater discharge would be minimal. Based on the previous radiological performance assessment (RPA) contaminant screening (WSRC 1992), the radiological contaminants of concern would be carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135. Table 4-26 shows maximum radiation doses from all contaminants to humans and corresponding impacts expressed as LCFs from groundwater at the seeplines of McQueen Branch and Upper Three Runs before dilution with surface water. Doses would be low under each action alternative and would be below the drinking water standard of 4 millirem per year (40 CFR 141.16) in all cases. As discussed above, the in-stream concentrations resulting from the mixing of groundwater discharge at the seepline with the upstream flow would result in lower downstream concentrations than shown in Table 4-26. These data represent that point in time.

The 4-millirem-per-year standard applies only to beta-emitting radionuclides but, because the total dose would be less than 4 millirem per year, the standard would be met.

Table 4-26. Maximum dose and health effects from concentrations of radionuclides in groundwater 1 meter and 100 meters downgradient of Z Area vaults and at the seepline.

	Maximum dose							
	Upper Three Runs Aquifer				Gordon Aquifer			
Exposure point	Small Tank Precipitation	Ion Exchange	Solvent Exchange	Direct Disposal in Grout	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
1 meter downgradient								
Total dose (millirem/year)	0.080	0.095	0.074	0.096	0.49	0.58	0.45	0.57
Lifetime LCF[a]	2.8×10^{-6}	3.3×10^{-6}	2.6×10^{-6}	3.4×10^{-6}	1.7×10^{-8}	2.0×10^{-5}	1.6×10^{-5}	2.0×10^{-5}
100 meters downgradient								
Total dose (millirem/year)	0.0068	0.0073	0.0062	0.0079	0.042	0.044	0.038	0.048
Lifetime LCF[a]	2.4×10^{-7}	2.6×10^{-7}	2.2×10^{-7}	2.8×10^{-7}	1.5×10^{-6}	1.5×10^{-1}	1.3×10^{-6}	1.7×10^{-6}
Seepline								
McQueen Branch								
Maximum dose (millirem/year)	0.0019	0.0020	0.0017	0.0022	NA	NA	NA	NA
Lifetime LCF[a]	6.7×10^{-8}	7.0×10^{-8}	6.0×10^{-8}	7.7×10^{-8}	NA	NA	NA	NA
Upper Three Runs								
Maximum dose (millirem/year)	NA	NA	NA	NA	0.0029	0.0028	0.0025	0.0032
Lifetime LCF[a]	NA	NA	NA	NA	1.0×10^{-7}	6.3×10^{-8}	8.8×10^{-8}	1.1×10^{-7}
Regulatory limit (millirem /year)	4	4	4	4	4	4	4	4

a. Increased probability of an LCF to the exposed individual over a 70-year period.
b. The discharge point for the Upper Three Runs aquifer is the McQueen Branch seepline, and the discharge point for the Gordon aquifer is the Upper Three Runs seepline.
c. Maximum impacts would not occur at the same time due to the different radionuclide transport times to the potential exposure locations.
LCF = latent cancer fatality.

The results of the fate and transport modeling of nonradiological contaminant migration from failed vaults to nearby surface water via groundwater discharge are presented in Table 4-27. Based on the previous RPA contaminant screening (WSRC 1992), the only nonradiological contaminant of concern would be nitrate. The recent modeling results indicate that there would be little difference between the alternatives and that none of the four action alternatives would result in an exceedance of the drinking water criteria for nitrate in the groundwater discharge at the seeplines of McQueen Branch or Upper Three Runs. Concentrations of nitrate at the seeplines would be small (less than 3 milligrams per liter [mg/L]) in all cases. Taking into account the dilution effect of the groundwater discharge mixing with the in-stream flow (assumed to be contaminant-free), the predicted concentrations of nonradiological contaminants would be even lower than those in Table 4-27. Therefore, no health impacts are anticipated from nitrates discharged to surface waters.

Table 4-27. Maximum nonradiological contaminant concentrations (mg/L) in groundwater 1 meter and 100 meters downgradient and at the seepline.

	Maximum concentration							
	Upper Three Runs Aquifer[a]				Gordon Aquifer[b]			
Exposure point/ contaminant	Small Tank Precipitation	Ion Exchange	Solvent Exchange	Direct Disposal in Grout	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
1 meter downgradient								
Nitrate (mg/L)	56	66	51	66	338	395	307	394
100 meters downgradient								
Nitrate (mg/L)	4.8	5.1	4.4	5.6	29	31	26	33
Seepline								
Nitrate (mg/L)	1.4	1.5	1.3	1.6	2.2	2.1	1.9	2.4
EPA MCL (mg/L)	44	44	44	44	44	44	44	44

a. Surfaces at McQueen Branch seepline.
b. Surfaces at Upper Three Runs seepline.
c. Nitrate as total nitrogen.
MCL = maximum contaminant level.

Under the No Action alternative, DOE assumed that only salt waste would be left in the HLW tanks. Failure of the HLW tanks would allow precipitation to collect in the tanks and eventually salt solution could overflow and run off to onsite streams (Upper Three Runs, Fourmile Branch and the Savannah River). The runoff would mix with the stream flow. Assuming that the upstream concentration of all contaminants would be zero and no groundwater infiltration occurred, the concentration of contaminants in Fourmile Branch would be 4.95×10^{-6} curies/liter resulting in a drinking water dose to an individual of 640 millirem per year. Similarly, Upper Three Runs concentrations would be 2.28×10^{-6} curies per liter and the Savannah River concentrations would be 1.12×10^{-7} curies per liter, respectively.

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4.2.2.2 Groundwater

Each of the action alternatives proposed in Chapter 2 includes actions that could result in potential long-term impacts to groundwater beneath the Z-Area vaults. Because groundwater is in a state of constant flux, impacts that occur directly below the vaults could propagate to areas hydraulically downgradient of Z Area.

The primary action that would result in long-term impacts to groundwater is failure of the vaults and the generation of contaminated leachate that would enter the vadose zone soils. The contamination has the potential to contaminate groundwater at some point in the future, due to leaching and water-borne transport of contaminants. As described in detail in Appendix D, shallow groundwater beneath the vaults flows to ward McQueen Branch, but also includes a vertical flow component toward deeper aquifers. In the analyzed alternatives, the mobile contaminants that leached from the vault would gradually migrate downward through unsaturated soil to the hydrogeologic units comprising the shallow aquifers underlying the vaults. As described in Section 4.1.2.1, because the vaults will be constructed above the typical elevation of the water table, contaminants released from the vaults would be released into the vadose zone and not directly into the shallow groundwater.

The shallowest hydrogeologic unit affected would be the upper zone of the Upper Three Runs Aquifer, formally known as the Water Ta-

ble Aquifer (Aadland, Gellici, and Thayer 1995). Hydrogeologic studies and modeling (Flach and Harris 1996) conducted for the area of SRS where S and Z Areas are located, suggest however that flow in the upper zone of the Upper Three Runs Aquifer that originates in the proposed vault disposal area does not outcrop to McQueen Branch. Rather, water in the upper zone would migrate downward into the lower zone of the Upper Three Runs Aquifer (formally known as the Barnwell-McBean Aquifer). Some contaminants would be transported subsequently to the northeast by groundwater flow through the lower zone of the Upper Three Runs Aquifer and discharge at the seepline along McQueen Branch.

The previous modeling results for the General Separations Area (the location of S and Z Areas) (Flach and Harris 1996), also suggested that a portion of the contaminant mass released to the Upper Three Runs Aquifer would migrate downward and then laterally through the Gordon Aquifer to a point of discharge at the seepline along Upper Three Runs. The groundwater flow direction in the Gordon Aquifer is toward the north-northwest.

Summary of Predicted Concentrations

The results of the groundwater fate and transport modeling for radiological and nonradiological contaminants entering the Upper Three Runs and Gordon Aquifers are presented in Tables 4-26 and 4-27. The modeling calculated impacts to each aquifer layer. The results are presented for each alternative for groundwater wells 1 meter and 100 meters downgradient of the vaults and for the seeplines. The specific concentrations for each radiological and nonradiological contaminant for each aquifer layer and each exposure point are presented in Appendix D.

For radiological contaminants, the doses in millirem per year from all radionuclides are considered additive for any given aquifer layer at any exposure point. The concentrations in groundwater from the various aquifers are, however, not additive. The maximum radiation dose (millirem per year), regardless of the aquifer layer is therefore presented in the tables for each exposure point. These data represent the increment in time when the sum of all beta-gamma emitters would be greatest, but not necessarily when all radionuclides are at their maximum concentrations. This method of data presentation shows the overall maximum dose or concentration that could occur at each exposure point. Based on the previous RPA contaminant screening (WSRC 1992), the radiological contaminants of concern in groundwater would be carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135.

Based on the previous RPA contaminant screening (WSRC 1992), the only nonradiological contaminant of concern would be nitrate; therefore, only nitrate was modeled. The maximum concentration of nitrate, regardless of time, was determined for each aquifer layer and for each exposure point.

Comparison of Alternatives

The groundwater radiological concentrations (Table 4-26) consistently show that the greatest long-term impacts for beta-gamma emitters at the 100-meter well would occur under the Direct Disposal in Grout or the Ion Exchange alternative, although the differences among alternatives are small. The results also indicate that none of the alternatives would result in an exceedance of the regulatory limit for dose to humans in drinking water (i.e., 4 millirem per year), either at the wells or at the seeplines (i.e., groundwater discharge points). Public health effects are discussed in Section 4.2.5.

The nonradiological results presented in Table 4-27 identify a consistent trend for nitrate at all points of exposure; the highest concentration occurs under the Ion Exchange and Direct Disposal in Grout alternatives, but there are only small differences among alternatives. The data show that nitrate would exceed the maximum contaminant level (MCL) for drinking water 1 meter downgradient of the facility for all alternatives, but would not exceed the 100 meters

downgradient of the vaults for any alternatives. The MCL would not be exceeded at the seepline for either aquifer layer.

4.2.3 ECOLOGICAL RESOURCES

This section presents an evaluation of the potential long-term impacts of salt processing alternatives to ecological receptors. DOE assessed the potential risks to ecological receptors at the seeplines of McQueen Branch (a tributary of Upper Three Runs near Z Area) and Upper Three Runs.

Groundwater-to-surface water discharge of contaminants was the only long-term migration pathway evaluated because the disposal vaults will be several meters underground, precluding overland runoff of contaminants and associated terrestrial risks. The vaults would have concrete roofs and be capped with clay and gravel. This would provide an impervious layer for deep plant roots. As a result, only risks to aquatic or semi-aquatic biota were considered possible. The habitat in the vicinity of the seeplines is bottomland (riparian) hardwood forest along the channels of McQueen Branch and Upper Three Runs. Upslope of the floodplain, the forest is a mixture of pine and hardwood.

The Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives were assessed for their potential long-term ecological impacts. Modeling of groundwater-to-surface water migration of contaminants from the disposal vaults indicated that nitrate was the only nonradiological chemical that would reach McQueen Branch and Upper Three Runs, and that carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135 were the radionuclides that would reach the two streams. The model generated concentrations of these contaminants in the groundwater at the seeplines.

4.2.3.1 Radiological Contaminants

The Oak Ridge National Laboratory (ORNL) has developed screening guidelines for the protection of aquatic organisms from radiological chemicals in surface water (Bechtel Jacobs Company 1998). These guidelines were developed by back-calculating the DOE Order 5400.5 dose rate limit for aquatic biota of 1.0 rad per day (rad/d) to obtain corresponding concentrations of radionuclides in surface water. These guidelines can then be compared to ambient concentrations to assess potential risks to aquatic biota. The guidelines are in picocuries per liter (pCi/L) and were developed separately for small fish and large fish. All guidelines include exposures from parent isotopes and all short-lived daughter products. They also include exposures from all major alpha, beta, and gamma emissions for each isotope. It should be noted that ORNL developed its guidelines for radionuclides of concern at the Oak Ridge Reservation. No similar values have been calculated for SRS. However, the ORNL values were derived using generic data and are based on types of fish that could occur on SRS. The groundwater chemical data for this SEIS were modeled for thousands of years after disposal and, therefore, the isotopes that comprise the data are not generally in agreement with ORNL's (i.e., in this analysis, credit was taken for radioactive decay). Only a guideline for technetium-99 was available.

The predicted radiological concentrations in groundwater at the McQueen Branch and Upper Three Runs seeplines are presented in Table 4-28 for each of the four action alternatives. The concentrations of technetium-99 were orders of magnitude lower than the ORNL guideline. Again, no ORNL guidelines were available for the other elements (their particular isotopes). However, a cesium-137 surrogate value of 6.19×10^3 pCi/L can be used to assess risks from the elements other than technetium-99. This value generates an acceptable dose of 1 rad/day. Cesium-137 has a higher energy emitted per day than the other radionuclides in the seepwater. Because the surrogate guideline concentration is orders of magnitude higher than all those of the detected radionuclides in the seepwater, it can be inferred that the risks from those elements would be much lower. Because the maximum radiological concentrations predicted for McQueen Branch and Upper Three Runs are all far below

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Table 4-28. Maximum concentrations of radiological contaminants in seepline groundwater compared to ORNL screening guidelines (pCi/L).

		Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Contaminant	ORNL guideline Small/Large Fish[a]	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)
Carbon-14	NA[b]	1.9×10^{-6}	2.0×10^{-6}	2.1×10^{-6}	1.9×10^{-6}	1.8×10^{-6}	1.7×10^{-6}	2.2×10^{-6}	2.1×10^{-6}
Selenium-79	NA[b]	0.16	0.23	0.17	0.23	0.15	0.20	0.19	0.25
Technetium-99	1.94×10^{6}/ 1.94×10^{6}	0.42	0.66	0.44	0.64	0.38	0.58	0.48	0.72
Tin-126	NA[b]	5.7×10^{-5}	3.9×10^{-5}	6.1×10^{-5}	3.9×10^{-5}	5.2×10^{-4}	3.5×10^{-5}	6.6×10^{-5}	4.3×10^{-5}
Iodine-129	NA[b]	0.0028	0.0045	0.0029	0.0044	0.0025	0.0039	0.0032	0.0049
Cesium-135	7,720/6,190	9.8×10^{-7}	1.5×10^{-6}	1.0×10^{-6}	1.5×10^{-6}	8.9×10^{-7}	1.3×10^{-6}	0.012	0.017

a. Cesium-137 is used as a surrogate value for cesium-135. Cesium-137 has a higher decay energy than cesium-135. Therefore, this is a conservative estimate of the guideline for cesium-135.
b. Specific guidelines for these radionuclides are not available. However, because cesium accumulates in biological tissues and because cesium-137 has a higher decay energy than any of the other radionuclides listed, guidelines for these radionuclides are unlikely to be smaller than the guideline for cesium-137.

this surrogate guideline, it can be concluded that potential risks to aquatic biota in McQueen Branch and Upper Three Runs from radionuclides in seepwater would be very low.

4.2.3.2 Nonradiological Contaminants

Nitrate is considered to be essentially nontoxic to fish and wildlife, and is important as a plant nutrient in aquatic systems (Wetzel 1983).

Nitrates are generally considered to be a potential human health hazard at high concentrations in drinking water because they are reduced to nitrites in the digestive system (EPA 1986). Nitrites are capable of oxidizing hemoglobin to produce methemoglobin, which is incapable of transporting oxygen (EPA 1986). However, in well-oxygenated aquatic systems, nitrite is typically oxidized to nitrate.

The relatively low ecotoxicity from nitrates is reflected in the lack of surface water screening levels and criteria. EPA (1986) points out that concentrations of nitrate or nitrite with toxic effects on fish could "rarely occur in nature" and, therefore, "restrictive criteria are not recommended". No Federal ambient water quality criteria based on protection of aquatic organisms are available for nitrates (or nitrites) (EPA 1999). Nevertheless, some guidelines for nitrate/nitrite toxicity are available. EPA (1986) concludes that (1) concentrations of nitrate at or below 90 mg/L will have no adverse effects on warmwater fishes, (2) nitrite at or below 5 mg/L would be protective of most warmwater fishes, and (3) nitrite at or below 0.06 mg/L should be protective of salmonid fishes (no salmonid fishes are present on SRS). The Canadian Council of Ministers of the Environment (CCME) presents a surface water guideline protective of aquatic organisms of 0.06 mg/L (Environment Canada 1998). In the past, DOE has used an MCL of 10 mg/L as a surrogate protective concentration for semi-aquatic wildlife, such as mink (DOE 1997b).

Generally speaking, the only effects of elevated nitrate concentrations in streams and reservoirs are the fertilization of algae and macrophytes and the hastening of eutrophication. This occurs mainly when significantly increased nitrate inputs and inputs of other nutrients, mainly phosphorous, continue over a long period of time (Wetzel 1983). The concentrations of nitrate in groundwater at the McQueen Branch and Upper Three Runs seeplines are presented in Table 4-29 for each of the four action alternatives. On the whole, the predicted concentrations in seepwater for all four action alternatives exceeded the EPA nitrite guideline for protection of coldwater fishes and the CCME nitrite guideline for protection of aquatic biota. The concentrations were comparable to the EPA nitrite guideline for protection of warmwater fishes and were an order of magnitude or more lower than the EPA nitrate no-adverse-effects guideline for warmwater fishes. They also were less than the human health nitrate MCL. It should be noted that guidelines for coldwater fishes are conservative because they are usually based on toxicity data for salmonids, which are generally more sensitive to contaminants than warmwater fishes (Mayer and Ellersieck 1986).

If the ratio of nitrates to nitrites introduced from the alternatives was lower, or the introduced nitrate was transformed to nitrite in appreciable quantities, substantive risks could potentially be present. However, EPA (1986) states that, in oxygenated natural water systems, nitrite is rapidly oxidized to nitrate. Upper Three Runs tends to be well oxygenated (Halverson et al. 1997).

More importantly, the assessment of risk to ecological receptors was performed on groundwater at the seepline and, hence, did not account for dilution by stream volumes. After dilution, the concentration of nitrate (and nitrite) would likely be much lower, probably by orders of magnitude.

Toxicity data for semi-aquatic receptors (e.g., mink) are scarce for nitrate, reflecting its relatively low ecotoxicity. Only one study of the effects of nitrate on mammals that applied to ecological risk considerations could be located.

Table 4-29. Maximum concentrations of nitrate in seepline groundwater compared to ecotoxicity guidelines (mg/L).

	Alternative (mg/L)				Ecotoxicity guideline (mg/L)				
Aquifer	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	No-adverse-effects on warmwater fishes (nitrate as nitrogen)[a]	Protection of warmwater fishes (nitrite as nitrogen)[a]	Protection of cold-water fishes (nitrite as nitrogen)[a]	CCME guideline for protection of aquatic biota (nitrite as nitrogen)[b]	MCL (nitrate as nitrogen)[c]
McQueen Branch (Upper Three Runs Aquifer)	1.4	1.5	1.3	1.6	90	5	0.06	0.06	10
Upper Three Runs (Gordon Aquifer)	2.2	2.1	1.9	2.4	90	5	0.06	0.06	10

a. EPA (1986).
b. Environment Canada (1998).
c. Maximum Contaminant Level (MCL) for drinking water (EPA 1999).

The study involved the effects of potassium nitrate on guinea pigs, using oral ingestion of water as the exposure medium (ORNL 1996). No adverse effects were observed at a dose of 507 milligrams per kilogram (mg/kg) of body weight per day (mg/kg/day). A reduction in the number of live births was observed at 1,130 mg/ kg/day. ORNL (1996) extrapolated toxicity and dose concentration data from this study to determine potentially toxic concentrations in various media to wildlife species. Based on the ORNL study, nitrate concentrations of at least 6,341 and 4,932 mg/L in surface water would be necessary to produce toxic effects for the short-tailed shrew and mink, respectively. The con-centrations are several orders of magnitude higher than the maximum modeled concentrations presented in Table 4-29. EPA (1986) does not indicate that nitrate bioaccumulates and, therefore, concentrations in the prey or forage of semi-aquatic wildlife would likely be low.

For these reasons, the potential risks to aquatic and semi-aquatic biota in McQueen Branch and Upper Three Runs from nitrate would be low for all alternatives.

TC The No Action alternative would have severe adverse impacts on the ecological resources in one area of the tank farms.

4.2.4 LAND USE

Long-term impacts from saltstone disposal vaults would not affect proposed SRS future land use. However, the presence of 13 to 16 low-level radioactive vaults in Z Area (see Table 4-1) would limit any other use for as long as the vaults remained, a period of time modeled to 10,000 years in this analysis.

L6-60 The tank farm areas are already designated to remain an industrialized zone. In principle, industrial zones are ones in which the facilities pose either a potentially significant nuclear or non-nuclear hazard to employees or the general public. Because of the contamination under the No Action alternative, future land use at SRS tank farms would not support human or ecological habitats under this scenario.

4.2.5 PUBLIC HEALTH

This section presents the potential impacts on human health from contaminants in the saltstone at some point after the period of institutional control of Z Area. To determine the long-term impacts, DOE evaluated data for Z Area, including the following:

- Expected source inventory that would be present in the saltstone
- Existing technical information on geological and hydrogeological parameters in the vicinity of Z Area
- Arrangement of the saltstone vaults within the stratigraphy
- Actions to be completed under each of the alternatives.

In its evaluation, DOE reviewed the methodology and conclusions contained in the *Radiological Performance Assessment for the Z-Area Saltstone Facility* (WSRC 1992) to determine what changes in the RPA analysis, if any, would result from implementing any of the salt processing alternatives. (The RPA was done for saltstone that would have resulted from the In-Tank Precipitation process.) Based on its review, DOE believes the exposure pathway methodology in the RPA is technically valid. DOE has modified certain input parameters to represent the alternatives. Therefore, DOE believes this modeling is valid for evaluating long term impacts. See Appendix D for additional details.

The RPA considers multiple routes of exposure for humans in the future. Z Area is zoned as an industrial area, and DOE does not expect that any public access to Z Area would be allowed. However, for purposes of analysis, DOE assumed that people would have access to the land beginning 100 years after the last vault was closed. The RPA considered multiple routes of exposure for humans following a 100-year period of institutional control and determined that two scenarios, an agricultural

scenario and a residential scenario, would have the greatest potential for exposing a hypothetical individual to saltstone contaminants. Impacts on trespassers were not considered for the action alternatives because the impacts on trespassers would be small due to much shorter exposure times relative to the agricultural scenario. The assumptions of the two scenarios are described below:

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- An agricultural scenario, in which the individual unknowingly farms and constructs a home on the soil above the saltstone vaults. In this scenario, the individual is assumed to derive half of his vegetable consumption from a garden planted in contaminated soil located over the vaults. The time spent gardening is assumed to be short compared to the amount of time spent indoors or farming. Only potential impacts from external radiation, inhalation, incidental soil ingestion, and vegetable ingestion are calculated for indoor residence and outdoor gardening activities. Since the farming activities would occur over a widespread area that would include uncontaminated and undisturbed soil not subject to irrigation with contaminated water, the meat and milk pathways would not contribute significantly to the individual's dose. Because of DOE's expectation that the saltstone would remain relatively intact for an extended period of time, DOE does not believe this scenario could be reasonable until approximately 10,000 years post-closure because, at least until that time, the individual could identify that he was digging through a cementitious material. However, for conservatism, DOE has calculated the impacts of the agricultural scenario at 1,000 years post-closure. This scenario includes the 1,000-year residential scenario described below.

- A residential scenario, in which the individual constructs and lives in a permanent residence on the vaults. This scenario analyzes two options: construction at 100 years and at 1,000 years. Under the first option, a sufficient layer of soil would cover the still-intact vaults so that the individual would not know that the residence was constructed on the vaults. Under the second option, the saltstone is assumed to have been exposed and weathered sufficiently so that a person could build a home directly on a degraded vault without being aware of the saltstone.

Radiological Contaminants

In addition to these scenarios and options, the RPA also determined the impacts from consuming water from a well drilled 100 meters from the saltstone vaults after the period of institutional control. The original analysis considered the two uppermost aquifers underneath the saltstone facility and determined the concentrations downgradient of the vaults.

Using this information from the RPA, DOE calculated new results for the groundwater concentrations and the exposure scenarios. First, DOE used the engineering data developed during the alternative development process to determine how the saltstone composition would differ for the alternatives analyzed in this SEIS, as compared to the composition of the saltstone analyzed in the original RPA. Second, DOE determined how the new saltstone compositions (including concentrations of contaminants) affected the results in the original RPA and used that information as the basis to determine results for the analyzed alternatives in this SEIS. For those issues that the RPA did not address (such as direct disposal of cesium in grout), DOE performed the necessary original calculations to account for the newer information. A detailed discussion of DOE's methodology is contained in Appendix D.

Table 4-30 shows the calculated groundwater concentrations and radiation doses from the exposure scenarios. DOE compared groundwater results to the regulatory limits for drinking water specified in 40 CFR 141. The applicable drinking water standards for radionuclides are 4 millirem per year for beta/gamma-emitting radionuclides and

Table 4-30. Summary comparison of long-term human exposure scenarios and health effects.

Parameter	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Nitrate concentration at 100-meter well (mg/L)[a]	NA	29	31	26	33
Radiation dose (millirem per year) from 100-meter well	640[b]	0.042	0.044	0.038	0.048
LCF from 100-meter well[c]	0.022^{b}	1.5×10^{-6}	1.5×10^{-6}	1.3×10^{-6}	1.7×10^{-6}
Radiation dose from Agricultural Scenario (millirem per year)	NA	110	130	110	140
LCF from Agricultural Scenario[c]	NA	3.9×10^{-3}	4.6×10^{-3}	3.9×10^{-3}	4.9×10^{-3}
Radiation dose from Residential Scenario at 100 years post-closure (millirem per year)[c]	2,320,000[d]	0.11	0.13	0.1	1,200[e]
LCF from Residential Scenario at 100 years post-closure[c]	1.16^{f}	3.9×10^{-6}	4.6×10^{-6}	3.5×10^{-6}	4.2×10^{-2}
Radiation dose from Residential Scenario at 1,000 years post-closure[g] (millirem per year)[g]	NA	69	80	65	85
LCF from Residential Scenario at 1,000 years post-closure[c]	NA	2.4×10^{-3}	2.8×10^{-3}	2.3×10^{-3}	3.0×10^{-3}

L6-32

a. Nitrate MCL is 10 mg/L (EPA 1999).
b. Based on consumption of contaminated surface water in Fourmile Branch.
c. Health effects are expressed as lifetime (70-year) individual probability of an LCF.
d. Based on external radiation in the area of the tank farm.
e. The external dose for direct disposal in grout alternative in the 100-year scenario is primarily due to cesium-137 (half-life 30 years). For all other action alternatives and scenarios, the external dose is primarily due to the isotopes with long half-lives.
f. Probability of an LCF provided for comparison. The external radiation dose from No Action would result in prompt fatalities.
g. External radiation doses at 1,000 years post-closure are higher than doses at 100 years post-closure because a layer of soil that provides shielding is assumed to be present in the 100 year scenario, but is assumed to be absent in the 1,000 year scenario.

L4-10

NA = not applicable.

15 pCi/L for alpha-emitting radionuclides. The RPA analyses indicated that alpha-emitting radionuclides would not be transported from the saltstone vaults except in minute quantities, and DOE therefore excluded them from the impacts analysis. For nonradiological constituents (primarily nitrate), DOE compared the water concentrations directly to the concentrations listed as MCLs in 40 CFR 141.

The differences in calculated concentrations and doses among the action alternatives are primarily a function of the differences in composition of the saltstones. The Small Tank Precipitation alternative would produce a saltstone very similar to that analyzed in the RPA, and the results for this alternative (in Table 4-30) are therefore consistent with the results in the RPA. The Ion Exchange alternative would result in a salt solution with slightly higher contaminant concentrations, resulting in higher contaminant concentrations in saltstone and associated greater impacts. Similarly, the Solvent Extraction salt solution has slightly lower concentrations.

The Direct Disposal in Grout alternative would result in a salt solution with slightly higher concentrations for most constituents than the other alternatives, but with essentially all of the cesium. Cesium-137 has a relatively short half-life

(approximately 30 years), so the cesium-137 concentration at the end of 100 years would be decreased by a factor of about 10, with subsequent decreases as time elapses. Therefore, for most of the scenarios in Table 4-30, the impacts of Direct Disposal in Grout are comparable to those of the other alternatives. However, for the residential scenario that assumes construction at 100 years directly on top of the saltstone facility, radioactive cesium would still be present in quantities sufficient to produce a dose noticeably higher than the other alternatives. Because the second residential scenario assumes construction at 1,000 years, the radioactive cesium would have undergone approximately 30 half-lives, resulting in a greatly decreased dose contribution from that radionuclide (however, the longer-lived cesium-135 isotope would still be present).

The maximum doses from the drinking water, agricultural, and 100-year residential scenarios are not expected to occur concurrently, although the agricultural scenario values in the table include the 1,000-year residential scenario contribution, as discussed above. Therefore, it is not appropriate to add the doses from these scenarios.

As shown in Table 4-30, the 1,000-year residential scenario doses for all four action alternatives are similar and would be below the 100-millirem-per-year public dose limit. They range from as low as approximately 65 millirem per year to as high as 85 millirem per year. Doses for the agricultural scenario are similar, but exceed the 100-millirem-per-year public dose limit. Doses for the agricultural scenario would range from 110 to 140 millirem per year. For the 100-year residential scenario, the dose would be highest for the Direct Disposal in Grout alternative (1,200 millirem per year) and would exceed the 100-millirem-per-year public dose limit. The 100-year residential scenario doses for the other three action alternatives would be much smaller and would not exceed 0.13 millirem per year.

As discussed in Section 4.1.4.1, DOE adopted a dose-to-risk conversion factor of 0.0005 LCFs per person-rem to estimate the probability of an individual developing a fatal cancer from the calculated radiation exposure. Because estimation of future populations is very speculative, DOE based the analysis of each scenario on an individual with a 70-year life span. As shown in Table 4-30, under the action alternatives, the probability of an LCF resulting from the long-term exposure scenarios is low. Therefore, DOE expects no adverse health impacts due to these radiation exposures.

As discussed above for the No Action alternative, an individual consuming 2 liters per day of water from Fourmile Branch would receive a dose of 640 millirem per year. This dose is more than 160 times the drinking water regulatory limit of 4 millirem per year and would result in a 2.2 percent incremental increase in the probability of contracting a latent cancer fatality from a 70-year lifetime exposure. While a 2.2 percent increase is low, the probability of contracting an LCF under the No Action alternative is about 13,000 times greater than that of any of the action alternatives. L6-5 L6-51

For the No Action alternative, an individual living in the tank farm area would receive an external dose of about 2,320,000 millirem in the first year following the event, which would result in a prompt fatality.

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CHAPTER 5. CUMULATIVE IMPACTS

The Council on Environmental Quality (CEQ) regulations that implement the procedural provisions of the National Environmental Policy Act (NEPA) define cumulative impacts as impacts on the environment that result 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 such other actions (40 CFR 1508.7).

Based on an examination of the environmental impacts resulting from salt processing, coupled with those from U.S. Department of Energy (DOE) and other agency actions and some private actions, it was determined that cumulative impacts for the following areas need to be presented: (1) air resources; (2) water resources; (3) public and worker health; (4) waste generation; and (5) utilities and energy consumption. Discussion of cumulative impacts for the following subject areas is omitted because impacts to these topics from the proposed salt processing alternatives would be so small that their potential contribution to cumulative impacts would be minimal: geologic resources, ecological resources, aesthetic and scenic resources, cultural resources, traffic, and socioeconomics.

The baseline represents current conditions at Savannah River Site (SRS), as detailed in Chapter 3. In this chapter, DOE considers the baseline to represent the No Action alternative because the No Action alternative would continue current high-level waste (HLW) management activities through 2010. Any incremental impacts under the No Action alternative would occur after that. DOE provides a mostly qualitative assessment of the No Action alternative in Chapter 4.

Impacts that vary among the salt processing alternatives

The cumulative impacts analysis presented in this section is based on the actions associated with the SRS salt processing alternative with the greatest impact for each resource, other onsite activities, reasonably foreseeable future actions, and offsite activities with a potential for related environmental impacts. In certain cases, the magnitude of an impact to a particular resource varies among the salt processing alternatives. To be conservative, DOE based this analysis of cumulative impacts on the alternative with the highest impact for a particular resource category, but not on the same alternative for all resource areas (see data tables in this chapter).

As an overview, the resource categories that varied among the alternatives and the salt processing alternatives with the highest and lowest impacts are presented below:

Carbon monoxide and sulfur dioxide ground-level concentrations

- Highest – Direct Disposal in Grout
- Lowest – Small Tank Precipitation, Ion Exchange, and Solvent Extraction would be equal and have 83 percent of the Direct Disposal in Grout concentration for carbon monoxide, 75 percent of the highest 3-hour and annual sulfur dioxide concentrations, and 80 percent of the highest concentration for 24-hour sulfur dioxide.
- Conclusion – The addition to baseline concentrations is very small (less than 0.5 percent) for all action alternatives.

Ozone ground-level concentrations

- Highest – Small Tank Precipitation would not be expected to contribute more than 1 percent of observed background levels.
- Lowest – Concentration under Direct Disposal in Grout would be substantially lower than that for Small Tank Precipitation.

- Conclusion – The effect of any salt processing alternative is minimal on ozone concentration.

Project phase radiological dose and health effects

- Highest – Solvent Extraction would result in essentially no increased probability of latent cancer fatalities from exposure during the 13 years of operation (1.6×10^{-7}) for the maximally exposed offsite individual (MEI), and 0.009 and 0.12, respectively, for the offsite population and involved worker populations.

- Lowest – Ion Exchange would have 16 percent of Solvent Extraction's offsite population health impacts and 11 percent of the Solvent Extraction impacts to involved workers.

- Conclusion – Health effects from the salt processing alternatives are well below levels of concern.

Liquid High-Level Waste generation

- Highest – Solvent Extraction would be a major contributor (24 percent) to cumulative HLW generation.

- Lowest – Direct Disposal in Grout would contribute 16 percent of the Solvent Extraction contribution.

- Conclusion – If an HLW salt processing alternative is implemented, current and future liquid HLW generation would be managed effectively and safely.

Electric energy consumption

- Highest – Solvent Extraction would consume a minor portion (4 percent) of the cumulative energy consumption at SRS.

- Lowest – Direct Disposal in Grout would use 55 percent of the Solvent Extraction energy consumption rate.

- Conclusion – Existing electrical capacity is adequate to supply these very small increases in electrical energy consumption.

Water usage

- Highest – Small Tank Precipitation would consume a minute fraction of the production capacity of the aquifer.

- Lowest – Direct Disposal in Grout would use 67 percent of Small Tank Precipitation water requirements.

- Conclusion – The increment of water usage from salt processing is very small and would not be noticeable.

DOE has examined impacts of the construction and operation of SRS over its 50-year history. It has analyzed trends in the environmental characteristics of the Site and nearby resources to establish a baseline for measurement of the incremental impact of salt processing activities.

SRS History

In 1950, the U.S. Government selected a large rural area in southwestern South Carolina for construction and operation of facilities required to produce nuclear fuels (primarily defense-grade plutonium and tritium) for the Nation's defense. Then called the Savannah River Plant, the facility had full production capability, including fuel and target fabrication, irradiation of the fuel in five production reactors, product recovery in two chemical separations plants, and waste management facilities, including the HLW Tank Farms (DOE 1980). In 1988, DOE placed the active SRS reactors in standby, and the end of the Cold War in the early 1990s prompted their permanent shutdown.

Construction impacts included land clearing, excavation, air emissions from construction vehicles, relocation of about 6,000 persons, and the formation of mobile home communities to house workers and families during con-

struction. Peak construction employment totaled 38,500 in 1952 (DOE 1980).

Early impacts to surrounding communities stabilized quickly. The largest community on the Site, Ellenton, was relocated immediately north of the Site boundary and was renamed New Ellenton.

The SRS has had a beneficial effect on employment in the region. The operations workforce has varied from 7,500 (DOE 1980) to almost 26,000 (HNUS 1992), and presently numbers approximately 14,000 (DOE 2000a).

Currently, the SRS is approximately 90 percent natural areas, with 10 percent devoted to industrial facilities and infrastructure. The Savannah River Site Natural Resource Management and Research Institute (SRI), formerly the Savannah River Forest Station, manages natural resources at SRS. The SRI supports forest research projects, erosion control projects, and native plants and animals (through maintenance and improvements to their habitats). SRI sells timber, manages control-burns, plants seedlings, and maintains secondary roads and exterior boundaries (Arnett and Mamatey 1998a).

Normal SRS operations produced nonradioactive and radioactive emissions of pollutants to the surrounding air and discharges of pollutants to onsite streams. Impacts of these releases to the environment were minimal. In addition, large withdrawals of cooling water from the Savannah River caused minimal entrainment and impingement of aquatic biota from the river and severe thermal impacts to onsite streams, due to the discharge of high volumes of heated cooling water. The discharges stripped the vegetation along stream channels and adjacent banks and destroyed cypress-tupelo forests in the Savannah River Swamp. In 1991, DOE committed to reforest the Pen Branch delta in the Savannah River Swamp, using appropriate wetland species, and to manage it until successful reforestation had been achieved (56 FR 5584-5587; February 11, 1991). Groundwater contamination occurred in areas of hazardous, radioactive, and mixed waste sites and seepage basins.

Because of the large buffer area between the center of operations and the Site boundary, offsite effects were minimal. Thermal effects from surface water discharges did not extend beyond the Site boundary. Groundwater contamination plumes did not move offsite, and onsite surface water contamination had minimal effects offsite because SRS streams discharge to the Savannah River and the large volume of river water, compared to the small volumes of onsite creek water, reduced the concentrations of pollutants to well below concentrations of concern.

Over the years of operation, mitigation measures have substantially reduced onsite environmental contamination. DOE installed a Liquid Effluent Treatment Facility that removes pollutants (except tritium) from wastewater to below regulatory limits before discharge through a National Pollutant Discharge Elimination System (NPDES) outfall to Upper Three Runs. Direct discharge of highly tritiated disassembly basin purge water to surface streams was replaced by discharge to seepage basins, allowing substantial decay of the tritium before the water from the seepage basins outcropped to onsite streams. In addition, DOE minimized the effects of thermal discharges with the construction of a cooling lake for L-Reactor and a cooling tower intended to support K-Reactor operation.

Savannah River water quality has improved over the years and the U.S. Army Corps of Engineers has regulated the flow. Five large reservoirs upriver of SRS were constructed from the 1950s through the early 1980s. These have reduced peak flows in the Savannah River, moderated flood cycles in the Savannah River Swamp and, with the exception of a severe drought from 1985 through 1988, maintained flows sufficient for water quality and managing fish and wildlife resources downstream (DOE 1990). In 1975, the City of Augusta installed a secondary sewage treatment plant to eliminate the discharge of untreated or inadequately treated domestic and

industrial waste into the Savannah River and its tributaries. Similar treatment facilities for Aiken County began operation in 1979 (DOE 1987). Industrial dischargers to the River complied with NPDES permits issued by the U.S. Environmental Protection Agency or the State (South Carolina and Georgia), which improved water quality.

Effects of operations decreased rapidly after production ceased. For example, one indicator of potential impacts to human health is the radiation dose to the MEI. The MEI is not an actual person, but is defined as a single person receiving the highest possible offsite dose. From dose, it is possible to estimate the probability of a latent cancer fatality. The estimate of latent cancers is, at best, an order of magnitude approximation. This means that with an estimate of 10^{-5} latent cancer fatalities, the actual probability of a latent cancer fatality is between 10^{-6} and 10^{-4}. By 1997, the dose to the MEI (and the associated probability of a latent cancer fatality) had decreased to about 1/7th of its 1988 value (Arnett and Mamatey 1998a). Further detail on the MEI is discussed later in Section 5.3 (Public and Worker Health) and shown in Table 5-3.

In general, the combination of mitigation measures and post-Cold War cleanup efforts are protecting and improving the quality of the SRS environment, and further minimizing any impacts to the offsite environment. Although groundwater modeling indicates that most contaminants in the groundwater have reached their peak concentrations, several slow-moving constituents will not reach maximum groundwater concentrations for thousands of years (DOE 1987). Long-term cumulative impacts are discussed further in Section 5.6.

CEQ Cumulative Effects Guidance

A handbook prepared by CEQ (1997) guided the preparation of this chapter. In accordance with the handbook, DOE identified the resource areas in which salt processing could add to the impacts of past, present, and reasonably foreseeable actions within the project impact zones, as defined by CEQ (1997).

Spatial and Temporal Boundaries

In accordance with the CEQ guidance, DOE defined the geographic (spatial) and time (temporal) boundaries to encompass cumulative impacts on the five identified areas of concern.

For determining the human health impact from airborne emissions of radionuclides, the population within the 50-mile radius surrounding SRS was selected as the project impact zone. Although the doses are almost undetectable at the 50-mile limit, this is the standard definition of the offsite public for air emissions.

For aqueous releases, the downstream population that uses the Savannah River as its source of drinking water was selected. This population is outside the 50-mile radius used for assessing air impacts. Analyses indicate that other potential incremental impacts from salt processing, including those to air quality (with the exception of ozone), waste management, and utilities and energy diminish within or very near the Site boundaries. Ozone is not emitted directly into the air, but is formed through complex chemical reactions between emissions of volatile organic compounds and nitrogen oxides in the presence of sunlight. Both volatile organic compounds and nitrogen oxides are emitted by industrial sources. Ozone formation occurs fairly rapidly in warm climates and any ozone formation from salt processing emissions would most likely occur within the project impact zone described below. The effective project impact zone for each of these incremental impacts is identified in the discussions that follow.

Nuclear facilities in the vicinity of SRS include: Georgia Power's Plant Vogtle Electric Generating Plant across the Savannah River from SRS; Chem-Nuclear, Inc., a commercial low-level waste burial site just east of SRS; and Starmet CMI, Inc. (formerly Carolina Metals), located southeast of SRS, which processes uranium-contaminated metals. Plant Vogtle, Chem-Nuclear, and Carolina Metals are approximately 11, 8, and 15 miles, respec-

tively, from S and Z Areas. Other nuclear facilities are too far away (more than 50 miles) to contribute to any cumulative effect. Therefore, the project impact zone for cumulative impacts on air quality from radioactive emissions includes four nuclear facilities, SRS and the three smaller ones discussed above. Radiological impacts from the operation of the Vogtle Electric Generating Plant, a two-unit commercial nuclear power plant, are minimal; however, DOE has factored them into the analysis. The South Carolina Department of Health and Environmental Control *(SCDHEC) Annual Report* (SCDHEC 1995) indicates that operations of the Chem-Nuclear and Starmet CMI facilities do not noticeably impact radiation levels in air or liquid pathways in the vicinity of SRS. Therefore, they are not included in this assessment.

The counties surrounding SRS have numerous existing (e.g., Bridgestone Tire, textile mills, paper product mills, and manufacturing facilities) and planned industrial facilities with permitted air emissions and discharges to surface waters. Because of the distances between SRS and these private industrial facilities, there is little opportunity for interactions of plant emissions and no major cumulative impact on air or water quality. As indicated in results from the SRS Environmental Surveillance program report, ambient levels in air and water have remained below regulatory levels in and around the SRS region (Arnett and Mamatey 1998a).

An additional offsite facility with the potential to affect the nonradiological environment is South Carolina Electric and Gas Company's Urquhart Station. Urquhart Station is a three-unit, 250-megawatt, coal- and natural-gas-fired steam electric plant in Beech Island, South Carolina, located about 20 river miles and about 18 aerial miles north of SRS. Because of the distance between SRS and the Urquhart Station and the regional wind direction frequencies, there is little opportunity for any interaction of plant emissions, and no detectable cumulative impact on air quality. The project impact zone for nonradiological atmospheric releases is less than 18 miles.

Finally, excess utility and energy capacity is available onsite and demand is too small to affect the offsite region. Similarly, onsite waste disposal capacity can easily satisfy the small quantities generated by salt processing. Thus, the extent of the project impact zone (from utilities, energy, and waste generation) is best described as the SRS.

Temporal limits were defined by examining the period of influence from both the proposed action and other Federal and non-Federal actions that have the potential for cumulative impacts. Actions for salt processing are expected to begin in 2001. The period of interest for the cumulative impacts analysis for this EIS includes 2001 to 2023.

Reasonably Foreseeable DOE Actions

DOE also evaluated possible impacts from its own reasonably foreseeable future actions by examining impacts to resources and the human environment identified in NEPA documents related to SRS (see Section 1.4). Impacts to the environment that are considered in this cumulative impacts section were identified in the following NEPA documents:

- *Final Environmental Impact Statement for the Interim Management of Nuclear Materials (DOE/EIS-0220)* (DOE 1995a). DOE has begun implementation of the preferred alternatives for the nuclear materials discussed in this Environmental Impact Statement (EIS). SRS baseline data in this chapter reflect projected impacts from implementation.

- *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement (DOE/EIS-0240)* (DOE 1996). This cumulative impacts analysis incorporates an alternative at SRS that would blend highly enriched uranium to 4 percent low-enriched uranium as uranyl nitrate hexahydrate, as stated in the Record of Decision (61 FR 40619; August 5, 1996).

- *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy at the Rocky Flats Environmental Technology Site (DOE/EIS-0277)* (DOE 1998). As stated in the Records of Decision (64 FR 8068; February 18, 1999, and 66 FR 4803; January 18, 2001), DOE will process certain plutonium-bearing materials currently being stored at the Rocky Flats Environmental Technology Site. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at Rocky Flats. DOE has decided to ship certain residues from the Rocky Flats Environmental Technology Site to SRS for plutonium separation and stabilization. The separated plutonium will be stored at SRS, pending disposition decisions. Environmental impacts from using F-Canyon to chemically separate the plutonium from the remaining materials at SRS are included in this section.

- *Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site (DOE/EIS-0271)* (DOE 1999a). As stated in the Record of Decision (64 FR 26369; May 14, 1999), DOE will construct and operate a Tritium Extraction Facility at SRS to provide the capability to extract tritium from commercial light-water reactor targets and targets of similar design. The purpose of the proposed action and alternatives evaluated in the EIS is to provide tritium extraction capability to support either accelerator or reactor tritium production. Environmental impacts from the maximum processing option in this EIS are included in this section.

- *Surplus Plutonium Disposition Final Environmental Impact Statement (DOE/EIS-0283)* (DOE 1999b). This EIS analyzed the activities necessary to implement DOE's disposition strategy for surplus plutonium. As announced in the Record of Decision (65 FR 1608; January 11, 2000), SRS was selected for three disposition facilities, pit (a nuclear weapon component) disassembly and conversion, plutonium conversion and immobilization, and mixed oxide fuel fabrication. The DOE decision allows the immobilization of approximately 17 metric tons of surplus plutonium and the use of up to 33 metric tons of surplus plutonium as mixed oxide fuel. Both methods in this hybrid approach ensure that surplus plutonium originally produced for nuclear weapons is never again used for nuclear weapons. Impacts from this EIS are included in this section.

- *Final Defense Waste Processing Facility Supplemental Environmental Impact Statement (DOE/EIS-0082-S)* (DOE 1994a). The selected alternative in the Record of Decision (60 FR 18589; April 12, 1995) was the completion and operation of the Defense Waste Processing Facility (DWPF) to immobilize HLW at SRS. The facility is currently processing sludge from SRS HLW tanks. However, SRS baseline data are not representative of full DWPF operational impacts, including the processing of salt solution from these tanks. Therefore, DWPF data are listed separately.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279)* (DOE 2000a). The selected alternative in the Record of Decision (65 FR 48224; August 7, 2000) is to prepare for disposal about 97 percent by volume (about 60 percent by mass) of the aluminum-based fuel considered in the EIS (48 metric tons heavy metal), using a Melt and Dilute treatment process. The remaining 3 percent by volume (about 40 percent by mass) would be managed using conventional processing in existing SRS chemical separations facilities.

  As part of the preferred alternative, DOE will develop and demonstrate the Melt and Dilute technology. Following development and demonstration of the Melt and

Dilute technology, DOE will begin detailed design, construction, testing, and startup of a new treatment and storage facility to combine the Melt and Dilute function with a new dry storage facility. The spent nuclear fuel will remain in existing wet storage until treated and then be placed in dry storage.

- *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE/EIS-0303D)* (DOE 2000b). DOE evaluated three alternatives for tank closure. All of these alternatives would start after bulk waste removal occurs. The alternatives being considered include: (1) clean tanks with water and fill with grout (preferred option), sand, or saltstone; (2) clean and remove the tanks; and (3) no action. The cumulative impact analysis includes impacts from the preferred option to clean and fill with grout.

- *Savannah River Site Waste Management Final Environmental Impact Statement (DOE/EIS-0217)* (DOE 1995b). DOE issued the SRS Waste Management EIS to provide a basis for the selection of a Site-wide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The SRS Waste Management EIS included the treatment of wastewater discharges in the Effluent Treatment Facility, F-and H-Area Tank Farm operations and waste removal, and construction and operation of a replacement HLW evaporator in the H-Area Tank Farm. In addition, it evaluated the Consolidated Incineration Facility for the treatment of mixed waste, including incineration of benzene waste from the then-planned In-Tank Precipitation (ITP) process. The first Record of Decision (60 FR 55249) on October 30, 1995, stated that DOE will configure its waste management system according to the moderate treatment alternative described in the EIS. The second Record of Decision (62 FR 27241) was published on May 9, 1997. This ROD was deferred regarding treatment of mixed waste to ensure consistency with the *Approved Site Treatment Plan* (WSRC 2000). The Waste Management EIS is relevant to the assessment of cumulative impacts because it provides the baseline forecast of waste generation from operations, environmental restoration, and decontamination and decommissioning. This forecast was updated in 1999 (Halverson 1999).

- *Final F-Canyon Plutonium Solutions Environmental Impact Statement (DOE/EIS-0219)* (DOE 1994b). As stated in the Record of Decision (60 FR 9824; February 22, 1995), DOE will process plutonium solution to a metal form using F-Canyon and FB-Line facilities at SRS. SRS baseline data include wastes and emissions from this activity.

Other materials under consideration for processing at SRS chemical separation facilities include various components currently at other DOE sites, including Oak Ridge, Rocky Flats, Los Alamos, and Hanford. These materials, which were identified during a Processing Needs Assessment, consist of various plutonium and uranium components. If DOE were to propose processing these materials in the SRS chemical separations facilities, additional NEPA reviews would need to be performed. In this chapter, estimates of the impacts of processing these materials have been included in the cumulative analysis. These estimates are qualitative, because DOE has not yet determined the impacts from processing these materials. When considering cumulative impacts, the reader should be aware of the very speculative nature of some of the estimated impacts.

In addition, the cumulative impacts analysis includes impacts from actions proposed in this SEIS. Risks to members of the public and Site workers from radiological and nonradiological releases are based on operational impacts from the salt processing alternatives described in

Chapter 4. Because these impacts vary among the alternatives, DOE has selected the alternative that produces the maximum impact for each characteristic (e.g., concentration of a specific pollutant). This ensures that the incremental impacts of the proposed action are not underestimated.

The cumulative impacts analysis also accounts for other SRS operations. Most of the SRS baseline data are based on 1997 environmental report information (Arnett and Mamatey 1998a).

5.1 Air Resources

Table 5-1 compares the cumulative concentrations of nonradiological air pollutant emissions from SRS to Federal and state regulatory standards. The listed values are the maximum modeled concentrations that could occur at ground level at the Site boundary. The data demonstrate that total estimated concentrations of nonradiological air pollutants from SRS would, in all cases, be below regulatory standards at the Site boundary. The highest percentages of the regulatory standards are for sulfur dioxide concentrations for the shorter time intervals (approximately 96 percent of the 3-hour averaging standard and 96 percent of the 24-hour averaging standard), for ozone (approximately 94 percent of the 1-hour averaging standard), for particulate matter less than 10 micrometers in diameter (approximately 91 percent of the 24-hour averaging standard), and total suspended particulates (approximately 90 percent of the standard). The remaining cumulative pollutant concentrations would range from 2 to 69 percent of the applicable standards.

The majority of the impact comes from estimated SRS baseline concentrations and not from salt processing and other foreseeable actions. It is unlikely that actual concentrations at any ambient monitoring stations at the SRS boundary would be as high as those listed in Table 5-1. The SRS baseline values are based on the maximum potential emissions from the 1997 air emissions inventory for all SRS sources, as well as on observed concentrations from nearby ambient air monitoring stations. The maximum cumulative concentration is an artificial calculation, which assumes that the maximum concentration from each source would occur at the same point on the SRS boundary and at the same time, without considering facility locations, operation schedules, variable wind directions, and other factors. Therefore, it is impossible to actually achieve the maximum cumulative concentration. Thus, the SRS baseline in Table 5-1 is overestimated and this affects the percent of standard values. For example, nearly all of the cumulative concentration for sulfur dioxide comes from the SRS baseline and, therefore, assuming it is 96 percent of the standard is very conservative.

DOE also evaluated the cumulative impacts of airborne radioactive releases in terms of dose to an MEI at the SRS boundary. DOE included the impacts of Plant Vogtle (NRC 1996) in this cumulative total. The radiological emissions from the operation of the Chem-Nuclear, Inc., low-level waste disposal facility and Starmet CMI, Inc., are very low (SCDHEC 1995) and are not included.

Table 5-2 lists the results of this analysis, using SRS baseline 1997 emissions (1992 for Plant Vogtle). The cumulative dose from airborne emissions to the MEI would be 4.1×10^{-4} rem (or 0.41 millirem [mrem]) per year, well below the regulatory standard of 10 mrem per year (40 CFR Part 61). Summing the doses to the MEI for the actions and baseline SRS operations listed in Table 5-2 is an extremely conservative approach because, in order to get the calculated dose from each facility, the MEI would have to occupy different physical locations at the same time, which is impossible.

Adding the population doses from current and projected activities at SRS, Plant Vogtle, and salt processing activities could yield a total annual cumulative dose of 24 person-rem from airborne sources. That total annual cumulative dose translates into 0.012 latent cancer fatality for each year of exposure for the population living within a 50-mile radius of SRS. A majority of this cumulative impact to the public is

Table 5-1. Estimated maximum nonradiological cumulative ground-level concentrations of criteria and toxic pollutants (micrograms per cubic meter) at the SRS boundary.[a]

Pollutant	Averaging time	Regulatory standard	Salt processing alternative	Other foreseeable[a]	SRS baseline[b]	Cumulative concentrations	Percent of standard
Carbon monoxide	1 hour	40,000	18.0[c]	40.7	10,354	10,413	26
	8 hours	10,000	2.3[c]	6.0	6,866	6,874	69
Nitrogen oxides	Annual	100	0.03[d]	4.7	26.2	31	31
Sulfur dioxide	3 hours	1,300	0.4[c]	9.4	1,244	1,254	96
	24 hours	365	0.05[c]	2.6	349	352	96
	Annual	80	5.0×10^{-4}[c]	0.19	33.6	34	42
Ozone	1 hr	235	2[e]	3.5	216	221	94
Lead	Max Qtr	1.5	4.0×10^{-7}[d]	5.1×10^{-6}	0.03	0.03	2
Particulate matter less than 10 microns	24 hr	150	0.07[d]	3.3	132.7	136	91
	Annual	50	1.0×10^{-3}[d]	0.17	25.3	25	51
Total suspended particulates	Annual	75	1.0×10^{-3}[d]	0.089	67.1	67	90

Sources: DOE (1994a; 1996; 1998; 1999a,b; 2000a,b).

a. All SRS sources including spent nuclear fuel management, disposition of highly enriched uranium, tritium extraction facility, management of certain plutonium and scrub alloy from the Rocky Flats site, HLW tank closure activities, plutonium disposition, and management of weapons components from the DOE complex.

b. Source: Arnett and Mamatey (1998b).

c. Based on data for the Direct Disposal in Grout alternative.

d. Estimated emissions from each of the four action alternatives are the same for this parameter.

e. Although a specific value has not been determined, ozone formation based on volatile organic compounds and nitrogen oxide emissions from the Small Tank Precipitation alternative would not be expected to exceed 2 micrograms per cubic meter.

Table 5-2. Estimated average annual cumulative radiological doses and resulting health effects to offsite population from airborne emissions.

	Offsite population			
	Maximally exposed individual		50-mile population	
Activity	Dose (rem)	Fatal cancer risk[a]	Collective dose (person-rem)	Latent cancer fatalities
SRS baseline[b]	5.0×10^{-5}	2.5×10^{-8}	2.2	1.1×10^{-3}
Salt processing[c]	3.1×10^{-4}	1.6×10^{-7}	18.1	9.1×10^{-3}
Other SRS activities[d]	5.1×10^{-5}	2.5×10^{-8}	3.4	1.7×10^{-3}
Plant Vogtle[e]	5.4×10^{-7}	2.7×10^{-10}	0.045	2.3×10^{-5}
Total	4.1×10^{-4}	2.1×10^{-7}	24	0.012

a. Probability of fatal cancer.
b. Arnett and Mamatey (1998b).
c. Based on data for the Solvent Extraction alternative.
d. Consists of dose impacts associated with reasonably foreseeable future actions such as DWPF, HLW tank closure, spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly enriched uranium, and weapons components that could be processed at SRS canyons. Sources: DOE (1994a; 1996; 1998; 1999a,b; 2000a,b).
e. NRC (1996).

directly attributable to salt processing activities from the Solvent Extraction alternative. Doses are elevated due to the larger airborne cesium-137 emissions associated with this alternative. Small Tank Precipitation, Ion Exchange, and Direct Disposal in Grout alternatives range from 16 to 66 percent of the Solvent Extraction alternative values. Doses from the No Action alternative are considerably less. For comparison, as shown in Section 3.8.1, approximately 144,000 deaths from cancer due to all causes would be likely in the same population over their lifetimes.

5.2 Water Resources

At present, a number of SRS facilities discharge treated wastewater to Upper Three Runs and its tributaries via NPDES-permitted outfalls. These include the F/H-Area Effluent Treatment Facility and the M-Area Liquid Effluent Treatment Facility. The cumulative impact of liquid releases is measured in terms of human health effects and is presented in Section 5.3. As stated in Section 4.1.2, salt processing activities are not expected to result in any radiological or nonradiological discharges to groundwater. Discharges to surface water would be treated to remove contaminants prior to release into Upper Three Runs. Other potential sources of contaminants into Upper Three Runs during the time of salt processing activities include DWPF, the tritium extraction facility, environmental restoration, decontamination and decommissioning activities, and modifications to existing SRS facilities. Discharges associated with the tritium extraction facility activities would not add significant amounts of nonradiological contaminants to Upper Three Runs. The amount of discharge associated with environmental restoration and decontamination and decommissioning activities would vary according to the activity. All potential activities that could result in wastewater discharges would be required to comply with the NPDES permit limits that ensure protection of water quality. Studies of water quality and biota in Upper Three Runs suggest that discharges from facilities' outfalls have not degraded the stream (Halverson et al. 1997).

5.3 Public and Worker Health

Table 5-3 summarizes the cumulative radiological health effects of routine SRS operations, proposed DOE actions, and non-Federal nuclear

Table 5-3. Estimated average annual cumulative radiological doses and resulting health effects to offsite population and facility workers.

	Maximally exposed individual				Offsite population[a]				Workers	
Activity	Dose from airborne releases (rem)	Dose from liquid releases (rem)	Total dose (rem)	Probability of fatal cancer risk	Collective dose from airborne releases (person-rem)	Collective dose from liquid releases (person-rem)	Total collective dose (person-rem)	Excess latent cancer fatalities	Collective dose (person-rem)	Excess latent cancer fatalities
SRS Baseline[b]	5.0×10^{-5}	1.3×10^{-4}	1.8×10^{-4}	9.0×10^{-8}	2.2	2.4	4.6	2.3×10^{-3}	160	0.066
Salt Processing[c]	3.1×10^{-4}	(d)	3.1×10^{-4}	1.6×10^{-7}	18.1	(d)	18.1	9.1×10^{-3}	29	0.12
Other foreseeable SRS activities[e]	5.1×10^{-5}	5.7×10^{-5}	1.1×10^{-4}	5.4×10^{-8}	3.4	0.19	3.6	1.8×10^{-3}	730	0.29
Plant Vogtle[f]	5.4×10^{-7}	5.4×10^{-5}	5.5×10^{-5}	2.7×10^{-8}	0.045	2.5×10^{-3}	0.048	2.4×10^{-5}	NA	NA
Total	4.1×10^{-4}	2.4×10^{-4}	6.5×10^{-4}	3.3×10^{-7}	24	2.6	26	0.013	920	0.37

N/A = not available

a. A collective dose to the 50-mile population for atmospheric releases and to the downstream users of the Savannah River for aqueous releases.
b. Arnett and Mamatey (1998b) for 1997 data for MEI and population. Worker dose is based on 1997 data (WSRC 1998).
c. Based on data from the Solvent Extraction alternative.
d. Radioactive liquid waste would be returned to the HLW tank farms and treated in the waste evaporators. No radioactive liquids would be released to the environment. L6-62
e. Includes spent nuclear fuel, highly enriched uranium, tritium extraction facility, management of certain plutonium residues and scrub alloy concentrations, DWPF, and disposition of surplus plutonium and components from throughout the DOE complex.
f. NRC (1996).

facility operations (Plant Vogtle Electric Generating Facility). Impacts resulting from proposed DOE actions are described in the EISs listed previously in this chapter. In addition to estimated radiological doses to the hypothetical MEI, the offsite population, and involved workers, Table 5-3 also lists the potential number of latent cancer fatalities for the public and workers due to exposure to radiation. The radiation dose to the MEI from air and liquid pathways would be 6.5×10^{-4} rem (0.65 mrem) per year, which is well below the applicable DOE regulatory limits (10 mrem per year from the air pathway, 4 mrem per year from the liquid pathway, and 100 mrem per year for all pathways). The total annual population dose from current and projected activities of 26 person-rem translates into 0.013 latent cancer fatality for each year of exposure for the population living within a 50-mile radius of the SRS, or essentially no cumulative latent cancer fatalities. Most (75%) of this cumulative impact to the public is directly attributable to airborne releases from salt processing activities from the Solvent Extraction alternative (Table 5-2).

The annual radiation dose to the involved worker population in Solvent Extraction would be 920 person-rem, which could result in 0.37 latent cancer fatality. Doses to individual workers would be kept below the regulatory limit of 5,000 mrem per year (10 CFR 835). Furthermore, as low as reasonably achievable principles would be exercised to maintain individual worker doses below the SRS Administrative Control Level of 500 mrem per year. Salt processing activities would minimally increase the workers' and general public's health impacts due to radiation.

5.4 Waste Generation and Disposal Capacity

As stated in Section 4.1.11, low-level waste, hazardous/mixed waste, and sanitary/industrial waste would be generated from salt processing activities.

Table 5-4 lists cumulative volumes of high-level, low-level, transuranic, hazardous, and mixed wastes that SRS would generate. The table includes data from the SRS 30-year expected waste forecast generated by Halverson (1999), which incorporates changes in SRS activities that have occurred since the publication of the *Final SRS Waste Management Environmental Impact Statement* (DOE 1995b). The 30-year expected waste forecast is based on operations, environmental remediation, and decontamination and decommissioning waste forecasts from existing generators and the following assumptions:

- secondary waste from DWPF operations are addressed in the *Defense Waste Processing Facility EIS* (DOE 1994a); HLW volumes are based on the selected options for the *F-Canyon Plutonium Solutions EIS* (DOE 1994b) and the *Interim Management of Nuclear Materials at SRS EIS* (DOE 1995a); some investigation-derived wastes are handled as hazardous wastes per Resource Conservation and Recovery Act regulations; purge water from well samplings is handled as hazardous waste; and the continued receipt of small amounts of low-level waste from other DOE facilities and nuclear naval operations would occur.

In this forecast, the estimated quantity of radioactive/hazardous waste from operations during the next 30 years would be about 140,000 cubic meters. In addition, radioactive/hazardous waste associated with environmental restoration and decontamination and decommissioning activities would have a 30-year expected forecast of 68,000 cubic meters. Based on maximum values, waste generated from the Solvent Extraction alternative would produce 46,000 cubic meters. During this same time period, other reasonably foreseeable activities that were not included in the 30-year forecast would produce almost an additional 400,000 cubic meters. The major contributor to the other waste volumes would be weapons components from various DOE sites that could be processed in SRS canyons

Table 5-4. Estimated cumulative waste generation from SRS concurrent activities (cubic meters)[a].

Waste type	Salt processing[b]	SRS operations[c]	ER/D&D activities[c]	Other waste volumes[d]	Total
HLW	45,000[f]	14,000	0	130,000	190,000
(gallons)[e]	(12,000,000)	(3,700,000)	(0)	(34,000,000)	(50,000,000)
Low-level waste	920	120,000	62,000	250,000	430,000
Hazardous/mixed waste	56	3,900	6,200	5,000	15,000
Transuranic waste	0	6,000	0	12,000	18,000
Total	46,000	140,000	68,000	400,000	653,000

a. Values are rounded to two digits. The totals may not equal the sum of the four components, due to rounding.
b. Based on maximum value (Solvent Extraction alternative).
c. Halverson (1999).
d. Includes life-cycle waste associated with reasonably foreseeable future actions such as DWPF operations, HLW tank closure, spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly enriched uranium, commercial light-water reactor waste, sodium-bonded spent nuclear fuel, and weapons components that could be processed at SRS canyons. Sources: DOE (1994a,b; 1996; 1998; 1999a,b; 2000a,b).
e. To convert from cubic meters to gallons, multiply by 264.2.
f. HLW value for salt processing is from DWPF recycle; it is not produced directly by salt processing activities.
ER/D&D = Environmental remediation/decontamination and decommissioning.

and spent nuclear fuel management activities. Therefore, the potential cumulative amount of waste generated from SRS activities during the period of interest would be 653,000 cubic meters. It is important to note that the quantities of waste generated are not equivalent to the amounts that would require disposal. For example, HLW is evaporated and concentrated to a smaller volume for final disposal.

The Three Rivers Solid Waste Authority Regional Waste Management Center at SRS accepts non-hazardous and non-radioactive solid wastes from SRS and eight surrounding South Carolina counties. This municipal solid waste landfill provides state-of-the-art Subtitle D (non-hazardous) facilities for landfilling solid wastes, while reducing the environmental consequences associated with construction and operation of multiple county-level facilities (DOE 1995c). It was designed to accommodate SRS and county solid waste disposal needs for at least 20 years, with a projected maximum operational life of 45 to 60 years (DOE 1995c). The landfill is designed to handle an average of 1,000 tons per day and a maximum of 2,000 tons per day of municipal solid wastes. The SRS and eight cooperating counties had a combined generation rate of 900 tons per day in 1995. The Three Rivers Solid Waste Authority Regional Waste Management Center opened in mid-1998.

Radioactive, hazardous, or solid wastes generated from salt processing activities and other planned SRS activities would not exceed current and projected capacities of SRS waste storage and/or management facilities.

5.5 Utilities and Energy

Table 5-5 lists the cumulative total of electricity used and water consumed by activities at SRS. The values are based on average annual consumption estimates.

Overall SRS electricity consumption would not increase greatly with the addition of salt processing activities. Electricity usage for salt processing would be less than 5 percent of the current SRS baseline level. Cumulative impacts of SRS baseline electricity consumption, coupled with salt processing and other foreseeable future usage (approximately 580,000 megawatt-hours per year), would be less than previous SRS annual consumption rates (1993 usage was over

Table 5-5. Estimated average annual cumulative utility consumption.

Activity	Electricity (megawatt-hours)	Water usage (liters)
SRS baseline	4.1×10^{5}[a]	1.7×10^{10}[b]
Salt processing	2.4×10^{4}[c]	1.2×10^{7}[d]
Other SRS foreseeable activities[e]	1.5×10^{5}	8.3×10^{8}
Total	5.8×10^{5}	1.8×10^{10}

a. Halverson (1999).
b. Arnett and Mamatey (1996).
c. Based on maximum values from the Solvent Extraction alternative.
d. Based on maximum values from the Small Tank Precipitation alternative.
e. Consists of utility consumption associated with reasonably foreseeable future actions, such as DWPF operations, HLW tank closure, spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly enriched uranium, and weapons components that could be processed at SRS canyons. Sources: DOE (1994a,b; 1996; 1998; 1999a,b; 2000a,b).

600,000 megawatt-hours per year) (DOE 1995a).

DOE has also evaluated the SRS water needs during salt processing. At present, the SRS rate of groundwater withdrawal is estimated to be a maximum of 1.7×10^{10} liters per year. The maximum estimated amount of water needed annually for salt processing and other reasonably foreseeable future actions is listed in Table 5-5. The annual cumulative level of water withdrawal of 1.8×10^{10} liters is not expected to exceed the production capacity of the aquifer of more than 3.6×10^{11} liters.

5.6 Long-Term Cumulative Impacts

Computer models predict that radiological and nonradiological contaminants leaching from the saltstone produced by any of the salt processing alternatives would always be below their respective regulatory limits in the groundwater 100 meters downgradient of the vaults and at the seeplines of McQueen Branch or Upper Three Runs.

SRS has prepared a report, referred to as the Composite Analysis (WSRC 1997), that calculated for 1,000 years into the future the potential cumulative impact to a hypothetical member of the public from releases to the environment from all sources of residual radioactive material expected to remain in the SRS General Separations Area. The General Separations Area contains all SRS waste disposal facilities, chemical separations facilities, HLW tank farms, and numerous other sources of radioactive material. The Composite Analysis considered 114 potential sources of radioactive material containing 115 radionuclides.

The Composite Analysis calculated maximum radiation doses to hypothetical members of the public at the mouth of Fourmile Branch, at the mouth of Upper Three Runs, and on the Savannah River at the Highway 301 bridge. The estimated peak all-pathway dose from all radionuclides was 14 mrem/year (mouth of Fourmile Branch), 1.8 mrem/year (mouth of Upper Three Runs), and 0.1 mrem/year (Savannah River).

The major contributors to dose were tritium, carbon-14, neptunium-237, and isotopes of uranium (WSRC 1997).

The analysis also calculated radiation doses from drinking water in Fourmile Branch and Upper Three Runs. The estimated peak drinking water doses from all radionuclides for these creeks were 23 mrem/year for Fourmile Branch and 3 mrem/year for Upper Three Runs (WSRC 1997).

As discussed in Section 4.2.2, DOE does not expect salt processing activities to add noticeable levels of radiological contaminants to the accessible environment. The dose effects of saltstone at Upper Three Runs are several orders of magnitude less than those calculated in the

Composite Analysis for the entire General Separations Area. Therefore, the peak all-pathway dose and the peak drinking water dose presented in the Composite Analysis will not be affected by salt processing activities and the conclusions of the Composite Analysis will remain the same.

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CHAPTER 6. RESOURCE COMMITMENTS

This chapter describes unavoidable adverse impacts, short-term uses of environmental resources versus long-term productivity, and irreversible and irretrievable commitments of resources associated with the construction and operation of a salt processing technology at the Savannah River Site (SRS). This chapter also includes discussions about U.S. Department of Energy Savannah River Operations Office (DOE-SR) waste minimization, pollution prevention, and energy conservation programs in relation to implementation of the proposed action.

For purposes of this Supplemental Environmental Impact Statement (SEIS), the analysis presented in this chapter has been divided between short-term and long-term impacts, where applicable. Short-term impacts cover the period from construction and implementation through completion of salt processing (from 2001 to 2023). The long-term performance evaluation for the saltstone generated by the Direct Disposal in Grout alternative involves the period of time beginning at the end of 100 years of post-closure institutional control and continuing through an extended period, during which it is assumed that residential and/or agricultural uses could occur.

6.1 Unavoidable Adverse Impacts

6.1.1 OPERATING-LIFE IMPACTS

Implementing any of the alternatives (including No Action) considered in this SEIS for replacement of the ITP process for management of the high-level waste (HLW) salt solutions would result in unavoidable adverse impacts to the human environment. Implementation of the Small Tank Precipitation alternative, the Ion Exchange alternative, or the Solvent Extraction alternative, in association with the continued operation of the existing saltstone manufacturing and disposal facility in Z Area, would result in minimal short-term adverse impacts. These impacts would be primarily to geologic and water resources, air quality, waste generation, worker and public health, traffic and transportation, and utility and energy consumption, as presented in Chapter 4. Likewise, the construction and operation of a Direct Disposal in Grout facility in Z Area would result in minimal adverse impacts to the same resources during the operating-life of the facility as discussed in Chapter 4.

All construction activities for any of the alternatives would occur in previously disturbed areas. S Area encompasses 270 total acres, and the implementation of Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative within S Area would require approximately 23 of these acres. Z Area encompasses 180 total acres, and the implementation of the Direct Disposal in Grout alternative within Z Area would require approximately 15 acres. In addition, construction of any alternative in either S or Z Area would require the temporary use of approximately 20 acres to accommodate construction materials, equipment, and a concrete batch plant. Once construction was completed, these areas would be revegetated and available for other uses.

Because the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative would be constructed in S Area partly below grade (to a maximum depth of 45 feet), extensive soil excavations (77,000 to 82,000 cubic meters) could result in potential adverse impacts to geologic, groundwater, and surface water resources. The base of the facility might be in the water table aquifer, potentially requiring dewatering during construction. Construction of the Direct Disposal in Grout alternative in Z Area would result in the removal of approximately 23,000 cubic yards of soil. The aquifer is at a depth of 60 feet or more below Z Area and would therefore not require dewatering. Final grading would be required for all alternatives, to prevent surface water runoff from collecting in surface depres-

sions and impacting facility operations or vaults. As part of the required sediment and erosion control plan, storm water management and sediment control measures would be required to mitigate runoff and any potential discharges of silts, solids, and other contaminants to surface water streams. Best management practices, such as the development of retention basins, would be utilized. Any storm water collected in the retention basins would be diverted to current drainage control systems and discharged to McQueen Branch. In addition, use of best management practices would mitigate any short-term adverse impacts to geologic resources.

Implementation of the No Action alternative options identified in Chapter 2 could result in adverse impacts to the geologic and water resources. This is especially true if the option of constructing new wastewater treatment tanks is implemented. Each new tank would require the excavation of approximately 43,000 cubic meters of soil, of which approximately 28,000 cubic meters would be used for backfill. Implementation of this option could potentially result in adverse impacts to the geologic and water resources. However, DOE would mitigate these adverse impacts by utilizing best management practices to stabilize the soil and control erosion. Additional adverse impacts could result from construction of additional new tanks.

Air resources could be adversely impacted by any of the alternatives. These impacts would occur both during the construction (4 years) and during operation of the facilities (13 years). Adverse impacts during construction would be associated with heavy equipment (primarily diesel-powered) emissions and the dust created by their operation. In addition, the operation of a temporary concrete batch plant would produce adverse air quality impacts. Potential adverse impacts from fugitive dust would be mitigated by implementing best management practices. In addition, particulate emission limits for the operation of the concrete batch plant would be established in a construction permit from South Carolina Department of Health and Environmental Control (SCDHEC). Based on a review of expected sources of emissions and emission rates, the emissions would increase background levels by 1 to 2 percent. Therefore, these increases and any impacts associated with construction would be considered negligible and, in addition, would cease once construction was completed.

During operation of the facilities, regulated air pollutants would be released and could have adverse impacts to the surrounding environment. A review of the expected emissions, compared to the regulatory limits, indicated that all emission rates (with the exception of volatile organic compounds [VOCs]) would be below SCDHEC, Clean Air Act, or Occupational Safety and Health Administration (OSHA) limits and should not have any adverse impacts.

The estimated VOC emissions rate for the Small Tank Precipitation alternative would exceed the threshold value established by SCDHEC for additional permit review, whereas estimated emissions from the other alternatives are either covered by existing air permit levels or below the threshold value. Implementation of the Small Tank Precipitation alternative would result in small increases in offsite concentrations of benzene and ozone, with minimal impacts to public health. The other alternatives would have lower impacts.

Implementation of any of the alternatives would result in the generation of wastes as an unavoidable result of normal operations. Each of the alternatives, excluding the No Action alternative, would produce a salt waste stream as a primary waste that would be grouted for disposal in vaults in Z Area. A total of 13 to 16 vaults would be needed, depending on the alternative selected. Any of the alternatives would also produce a high-level radioactive waste stream that would be vitrified in the Defense Waste Processing Facility (DWPF).

The types of secondary waste generated include low-level, hazardous, mixed, industrial, and sanitary. Table 6-1 lists the total estimated waste generation by each action alternative. Although DOE has implemented a number of pollution prevention measures (see Section 6.4), generation of wastes would be unavoidable. DOE would comply with all regulatory requirements related to the proper disposal of these wastes.

During operation of any of the proposed alternatives, a minimal amount of radioactive material and activation products would be released to the environment and could result in unavoidable adverse impacts. As presented in Section 4.2.4.2, the highest radiation dose received by a noninvolved worker would be 4.8 millirem per year, well below the SRS administrative limit of 500 millirem/per year for the maximum individual exposure goal. The greatest collective dose to the surrounding population would be 18.1 person-rem/per year, resulting in an estimated 0.12 latent cancer fatality to the public within 50 miles of SRS. Doses would vary among the alternatives; the Solvent Extraction alternative would produce the highest dose.

SRS workers routinely handle hazardous and toxic chemicals; exposure to these materials would be unavoidable. In order to reduce impacts, occupational health codes and standards would be used to regulate worker exposure to these materials. Analysis has shown that chemical pollutant emissions to offsite areas would be minimal and below the applicable standards, and would not pose a danger to the public. See Section 4.2.4.2 for more details.

Construction and operation of any of the alternatives would result in injuries to workers and lost workdays, which are unavoidable adverse impacts. As discussed in Section 4.2.4.3, 1.7 to 2.7 recordable cases (which include death, illness, or injury) could occur annually, resulting in 0.72 to 1.2 lost workdays each year. The incidences of injury and illness reported for SRS are lower than those that occur in the general industry and manufacturing workforces. DOE continues to work to reduce these levels and SRS has shown continuous improvement over the years; therefore, the numbers presented in this SEIS are considered conservatively high.

Table 6-1. Total estimated waste generation for the salt processing action alternatives.[a]

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	3.9×10^6	3.3×10^6	1.2×10^7	2.0×10^6
Nonradioactive liquid waste (gallons)	negligible	4.9×10^5	negligible	negligible
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
Low-level waste (m^3)	920	920	920	920
Hazardous waste (m^3)	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13
Mixed low-level waste (m^3)	13	13	13	13
Mixed low-level liquid waste (gallons)	780,000	None	13,000	None
Industrial waste (metric tons)	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260
Sanitary waste (metric tons)	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530

a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.
b. Assumes a 1.3-year duration for startup activities and 13 years of operation for each of the action alternatives.

Implementation of any of the alternatives would require transportation of many different materials, and such transport could have unavoidable adverse consequences. Transporting materials along public highways could impose unavoidable adverse effects on the environment through vehicle emissions, spills, and accidents resulting in injuries or fatalities. As presented in Table 4-17, a total of just over 19,000 shipments (340,000 miles) to almost 26,400 shipments (470,000 miles) would be made during construction and operation, depending on the alternative selected. Using Federal Highway Administration statistics for South Carolina, these shipments and the associated miles driven would result in less than one accident, no fatalities, and less than 0.3 injuries. However, during construction, workers would commute approximately 26 million miles (see Table 4-18). U.S. Department of Transportation statistics predict that 98 accidents would occur, resulting in 0.4 fatalities and 43 injuries.

Adverse impacts to the ecological resources would be minimal and of short duration. Most activities would occur within previously disturbed areas. Although noise levels would be relatively low outside the immediate areas of construction, the combination of construction noise and human activity probably would displace small numbers of animals within a 400-foot radius of the construction site. No threatened or endangered species or critical habitats occur in or near S or Z Areas. In addition, no construction or operational activities would affect any wetlands in S or Z Areas. DOE has committed to monitoring the areas for threatened and endangered species and would initiate consultation with the U.S. Fish and Wildlife Service if DOE determined that the potential for adverse impact to the species or its habitat existed.

6.1.2 LONG-TERM IMPACTS

Long-term impacts are those that would continue or commence after the completion of all salt processing (i.e., 2023). DOE believes that the major source of these long-term impacts would be from the saltstone that would result from each of the four action alternatives and from tanks filled with salt under No Action. The saltstone vaults would be located in Z Area, regardless of the action alternative selected.

For National Environmental Policy Act (NEPA) analysis of long-term impacts, DOE assumed that institutional control would be maintained for 100 years post-closure, during which time the land encompassing the saltstone vaults would be managed to prevent erosion or other conditions that would lead to early degradation of the vaults. DOE also assumed that the public would not have access to Z Area during this time to set up residence.

For the No Action alternative DOE assumes a 100-year period of institutional control of the salt-filled tanks, after which the tank tops fail, allowing precipitation to fill the tanks and eventually salt solution would overflow and run off to onsite streams. L6-60

Unavoidable adverse long-term impacts to geologic resources would be minimal, based on a performance evaluation that included fate and transport modeling. Results indicate no detrimental effect on topography or to the structural or load-bearing properties of the geologic deposits. Because of the contamination under the No Action alternative, future land use at SRS under this scenario would not support human or ecological habitats. L6-60

Construction and operation of grout disposal facilities for any of the four action alternatives in Z Area would result in unavoidable adverse impacts to future land use of the area. The 15 acres that would be committed to the vaults and grout production facility would not be available for other productive uses.

Unavoidable long-term adverse impacts to groundwater resources could result from any of the alternatives. The fate and transport modeling results indicate that, under the action alternatives, movement of radiological contaminants

from failed vaults to nearby surface waters via groundwater discharge would be minimal and below regulatory standards for drinking water (4 millirem per year). Therefore, there would be no unavoidable adverse impacts to groundwater resources. However, long-term impacts to groundwater could occur as the saltstone ages.

Based on modeling results, the long-term movement of nonradiological residual contaminants (primarily nitrate) from the Z-Area vaults to nearby streams would be extremely small and, in all cases, would be below applicable standards. However, modeling results indicate that there would be little difference in impacts among the alternatives. None of the four action alternatives would result in an exceedance of the drinking water criteria for nitrate (i.e., 44 milligrams per liter). There would be no exceedances or any other constituent in groundwater discharge at the seeplines of McQueen Branch or Upper Three Runs. Therefore, there would be no unavoidable adverse impacts to surface water resources.

As a result of radioactive material being released many years after vault closure and the long half-lives of some of the radionuclides, there could be unavoidable adverse impacts to human receptors. Therefore, DOE described and modeled several future-use scenarios to determine the potential impacts to humans (see Section 4.2.5). Results indicate that doses for all scenarios, except the 100-year residential scenario for Direct Disposal in Grout, would be below or very near the 100-millirem-per-year dose limit. The 1,000-year residential scenario doses for all four action alternatives are similar and would be below the 100-millirem-per-year public dose limit. They range from as low as approximately 10 millirem per year to as high as 85 millirem per year. Doses for the agricultural scenario are similar, but could exceed the 100-millirem-per-year public dose limit. Doses for the agricultural scenario would range from 49 to 140 millirem per year. For the 100-year residential scenario, the dose would be highest for the Direct Disposal in Grout alternative (150 to 1,200 millirem per year) and would exceed the 100-millirem-per-year public dose limit. The 100-year residential scenario doses for the other three action alternatives would be much smaller and would not exceed 0.13 millirem per year.

6.2 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Under any of the alternatives, the proposed locations for any new facilities would be within previously disturbed and developed industrial landscapes. The existing infrastructure (e.g., roads, utilities.) within S and Z Areas would be sufficient to support the proposed facilities.

After the end of the operational life of the facilities associated with salt processing, DOE could decontaminate and decommission the facilities in accordance with applicable regulatory requirements and restore the areas to brownfield sites that would be available for other industrial use. Appropriate NEPA review would be conducted prior to the initiation of any decontamination and decommissioning activities. In all likelihood, none of the sites would be restored to a natural habitat (DOE 1998).

The project-related uses of environmental resources for the implementation of any of the proposed alternatives are characterized in the following paragraphs.

- Groundwater from Site wells would be used during both construction and operations, regardless of the alternative selected. Water would be used for process additions, cooling and flushing, product washes, and grout production. During construction, water consumption would represent just over 2 percent of water used in H-, S-, and Z-Area facilities in 1998 and 0.2 percent of the lowest estimated production capacity of

the aquifer (see Section 4.2.12.1). Groundwater use during operations would represent about 23 percent of the water used in H-, S-, and Z-Area facilities in 1998 and 1.5 percent of the lowest estimated production capacity of the aquifer (see Section 4.2.12.1). After use and treatment in the F- and H-Area Effluent Treatment Facility, this water would be released through permitted discharges into surface water streams. Therefore, the withdrawal, use, and treatment of groundwater would not affect the long-term productivity of this resource.

- Air emissions associated with any of the alternatives would add small amounts of radiological and nonradiological constituents to the air of the region. These emissions would be well below air quality or radiation exposure standards, and below applicable SRS permit limits. All concentrations would be below OSHA limits and all concentrations, with the exception of nitrogen dioxide (which could reach 78 percent of the limit), would be less than 5 percent of their respective regulatory limits. Nitrogen dioxide emissions would result from operation of diesel generators during construction and operations. Therefore, there would be no significant effects to the long-term quality of air resources.

- Radiological and nonradiological constituents could contaminate the groundwater below and adjacent to the Z-Area disposal vaults in the distant future. Some contaminants from the vaults could be transported by groundwater to the seepline of nearby streams. Beta-gamma dose, alpha concentrations, and nonradiological constituent concentrations would all be below the regulatory limit at the seepline of McQueen Branch or Upper Three Runs. Therefore, any radiological or nonradiological releases from the disposal vaults should have no impact on the long-term productivity of the ecosystems in the receiving streams.

- The management and disposal of wastes (low-level, hazardous, mixed, industrial, and sanitary) over the project's life would require energy and space at SRS treatment, storage, and disposal facilities (e.g., Z-Area Vaults, E-Area Vaults, or Three Rivers Sanitary Landfill). The land to meet these solid waste needs would require a long-term commitment of terrestrial resources. DOE established a future use policy for the SRS for the next 50 years in the 1998 *Savannah River Site Future Use Plan* (DOE 1998). This report sets forth guidance that established appropriate land uses for SRS areas and established policies to prevent nonconforming land uses.

6.3 Irreversible and Irretrievable Resource Commitments

Resources that would be irreversibly and irretrievably committed during the construction and operation of any salt processing alternative include those that cannot be recovered or recycled and those that are consumed or reduced to unrecoverable forms. The commitment of capital, energy, labor, and material during this time would generally be irreversible.

A maximum of 180 acres would be set aside for the vaults under any action alternative, and from 15 acres (Direct Disposal in Grout alternative) to 23 acres (all other action alternatives) would be utilized for salt processing facilities. Each tank would have a footprint of approximately 5,000 square feet. The total land required for any new tanks built under the No Action alternative has not been determined, however, impacts to all of this land could be irreversible and irretrievable once it is committed to the selected alternative and would thus be unavailable for other productive uses. However, (as stated in Section 6.2) at the end of the operational life of the facilities, DOE could decontaminate and

decommission the facilities in accordance with applicable regulatory requirements. Implementation of decontamination and decommissioning would require significant commitment of resources and the impacts of implementation would undergo appropriate NEPA review. Regardless, the land committed to vaults under the action alternatives and tanks under No Action would not be retrievable.

Energy expended would be in the form of fuel for equipment and vehicles, electricity and steam for facility operations, and labor. Construction would generate nonrecyclable materials, such as sanitary solid waste and construction debris. Implementation of any of the alternatives would generate nonrecyclable *radiological and nonradiological* waste streams. However, certain materials (e.g., steel, copper, stainless steel) used during construction and operation of any proposed facility could be recycled when the facility has been decontaminated and decommissioned. Some construction materials would not be salvageable, due to radioactive contamination.

The implementation of the any of the salt processing alternatives considered in this SEIS, including the No Action alternative, would require water, electricity, diesel fuel, and other energy and materials. Table 6-2 lists estimated total amounts of energy, utilities, and materials required for the construction and operation of each alternative.

Water would be obtained from onsite groundwater wells. Steam would be obtained from the D-Area Power Plant. Electricity, diesel fuel, concrete pre-mix, steel, saltstone pre-mix, sodium hydroxide, oxalic acid, tetraphenylborate (TPB), monosodium titanate (MST), crystalline silicotitanate (CST) resins, and other chemicals would be purchased from commercial vendors. The amounts required would not have an appreciable impact on available supplies or the ability to supply other industries.

6.4 Waste Minimization, Pollution Prevention, and Energy Conservation

6.4.1 WASTE MINIMIZATION AND POLLUTION PREVENTION

DOE-SR has developed and implemented an aggressive waste minimization and pollution prevention program that promotes source reduction and recycling practices that reduce the use of hazardous materials, energy, water, and other resources, while protecting resources through conservation or more efficient use. This Pollution Prevention Program also reduces the costs of the management of pollutants. As a result of this program, DOE has reduced the volumes of wastes discharged into the environment or sent to landfills and has saved money by recycling or selling usable materials.

Pollutant reduction is first accomplished by eliminating or minimizing the generation of pollutants at the source. All materials used at SRS are recycled or reused, when practical. The remaining wastes are managed to comply with Federal and state environmental regulations to reduce volume, toxicity, and/or mobility before storage or disposal.

DOE-SR, in conjunction with the Site's management and operations contractor, Westinghouse Savannah River Company and its partners, establishes SRS's pollution prevention goals and program objectives through a Solid Waste Management Council. A Pollution Prevention Group provides overall program leadership, coordination, and guidance in the development and implementation of pollution prevention systems. A Waste Minimization Subcommittee, comprised of representatives from across the Site, assists with development and implementation of waste minimization strategies and dissemination of information.

The Pollution Prevention Program is made up of the following seven elements:

Table 6-2. Estimated project total energy, utilities, and material use for the salt processing alternatives.

Phase[a]	SRS Baseline[b]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Peak electrical power demand (megawatts)					
Construction	NA	1.66	1.66	1.66	1.66
Operation	130[c]	24	24	32	18
Electricity use (gigawatt-hours)					
Construction	NA	76	79	76	73
Operation	410[c]	243	286	315	172
Project total use	NA	319	365	391	245
Fuel use (million gallons)					
Construction	NA	8.4	9	8.4	8
Operation	8.75[d]	0.3	0.3	0.3	0.2
Project total use	NA	8.7	9.3	8.7	8.2
Steam use (million pounds)					
Construction	NA	0	0	0	0
Operation	NA	2,548	2,300	1,915	1,536
Project total use	NA	2,548	2,300	1,915	1,536
Potable water use (million gallons)					
Construction	NA	19	20	19	18
Operation	NA	99	95	120	75
Project subtotal use	NA	118	115	139	93
Process water use (million gallons)					
Construction	NA	16	17	16	15
Operation	23,000[c]	301	271	225	181
Project subtotal use	NA	317	288	241	196
Project total water use (million gallons)		435	403	380	289
Material use					
Concrete pre-mix (cubic yards)[e]	NA	30,029	38,481	38,522	42,756
Saltstone pre-mix (pounds)	None	1.277 billion	1.057 billion	1.192 billion	950 million
Sodium hydroxide (pounds)	None	253,000	2,800,000	20,800,000	202,000
Oxalic Acid (pounds)	None	27,200	27,200	27,200	27,200
Sodium TPB (gallons)	None	2.84 million	None	None	None
MST (pounds)	None	47,000	47,000	47,000	47,000
CST Resin (pounds)	None	None	538,000	None	None
Stainless steel for canisters (pounds)	6,600,000	6,555,000	6,555,000	6,555,000	6,555,000

Adapted from WSRC (1999).

a. The construction and operation durations for each alternative are as follows: Small Tank Precipitation – 45 months and 15 years; Ion Exchange – 50 months and 13 years; and Direct Disposal in Grout – 46 months and 13 years (adapted from Attachments 14.5, 14.3, and 14.4 of WSRC (1998a). The total project duration includes a startup time of 1.3 years for each alternative (Sessions 1999).

b. Under the No Action alternative, utility and energy use would be included in the current site baseline.

c. Halverson (1999)

d. DOE (1995)

e. Adapted from WSRC 1998b.

NA = Not Available.