Savannah River Site

Salt Processing Alternatives

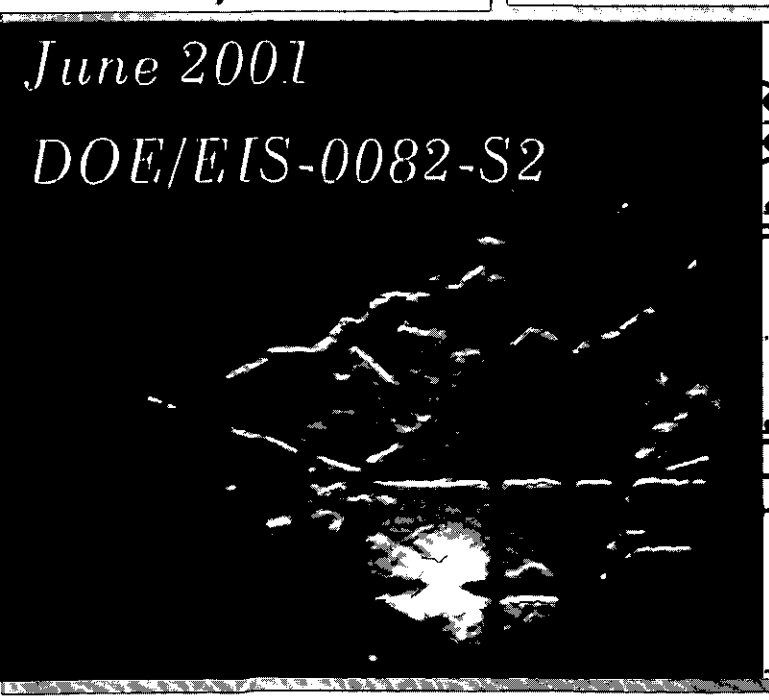
Final Supplemental Environmental Impact Statement

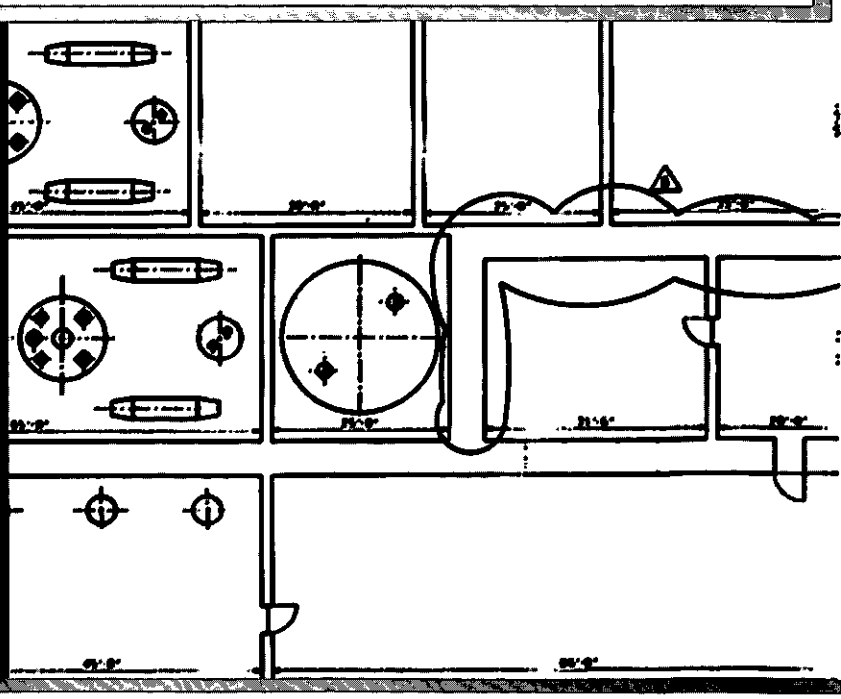
U.S. Department of Energy
Savannah River Operations Office
Aiken, South Carolina

Summary

June 2001

DOE/EIS-0082-S2





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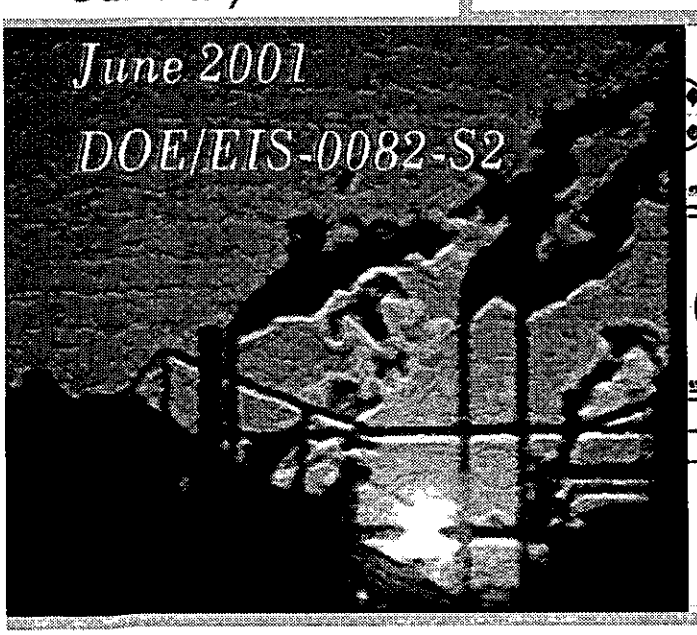

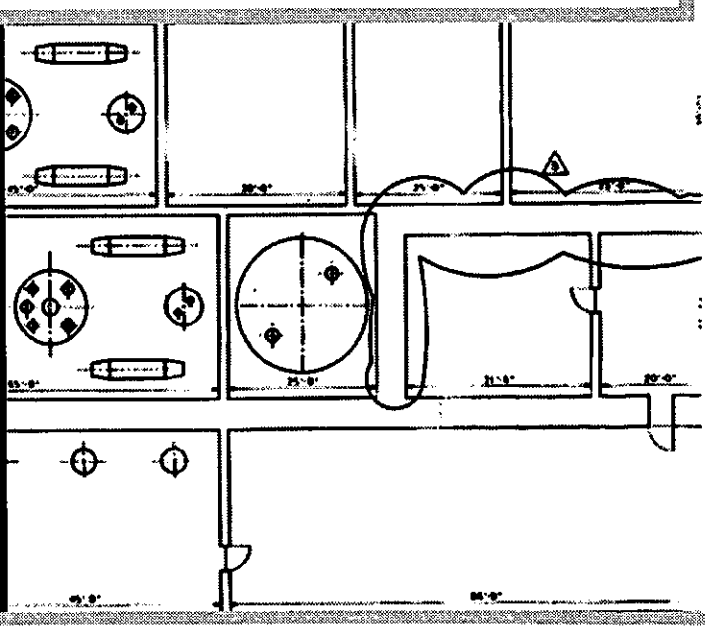

COVER SHEET

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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The SEIS will be available on the internet at: //tis.eh.doe.gov/nepa/docs/docs.htm.

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 TC facilities within S and Z Areas at SRS are identified.

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 TC 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.

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

Abbreviations and Acronyms

CST	Crystalline Silicotitanate
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HLW	high-level waste
ITP	In-Tank Precipitation
LCF	latent cancer fatality
LLW	low-level radioactive waste
MEI	maximally exposed (offsite) individual
MST	monosodium titanate
NEPA	National Environmental Policy Act
OSHA	Occupational Safety and Health Administration
OWST	organic waste storage tank
PHC	precipitate hydrolysis cell
PSD	prevention of significant deterioration
RCRA	Resource Conservation and Recovery Act
SCDHEC	South Carolina Department of Health and Environmental Control
SEIS	Supplemental Environmental Impact Statement
SRS	Savannah River Site
TPB	tetraphenylborate
VOCs	Volatile Organic Compounds
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

m	meter
m^3	cubic meter
µg	microgram
µm	micrometer
mg	milligram
mg/m^3	milligrams per cubic meter
mrem	millirem
rem	rem
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:

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

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}

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."

SUMMARY

S.1 Introduction

Nuclear materials production operations at the Savannah River Site (SRS) (Figure S-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) some of the **HLW components**.

> To assist the reader in understanding technical terms used in this summary, those terms have been **bolded** the first time they are used and are discussed in Table S-8, Primer of Technical Terms, which is located at the end of the Summary.

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: **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 plutonium). Radionuclides found in the salt component include **isotopes** of cesium and technetium, as well as some strontium and actinides. TC

L6-10 Dewatering the salt solution by evaporation, which conserves tank space, converts the salt solution to a solid **saltcake** and a concentrated **salt supernatant**. As a first step to process the salt components, solid saltcake must be dissolved by adding water and combined with salt supernatant to form a salt solution. An important part of the DWPF system, as designed, was to then separate the highly radioactive constituents from the salt solution. The high-activity fraction removed from the 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).

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**, was to be used to remove radioactive strontium and actinides from the salt solution. An organic **reagent, sodium tetraphenylborate**, was to precipitate radioactive cesium from the salt solution. The ITP process included washing and filtration steps to separate the solid phases that contain these radioactive materials.

The reagent used to precipitate cesium in the ITP process, sodium tetraphenylborate, is subject to **catalytic** and **radiolytic decomposition**. **Decomposition** of tetraphenylborate returns the cesium to the salt solution, and results in the generation of **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 had to be controlled to minimize: (1) the amount of precipitated cesium that is returned to 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. In March 1996, ITP startup operations were suspended in order to develop a better understanding of the ITP startup process chemistry. DWPF continues to process and vitrify HLW sludge. L1-2 L6-12

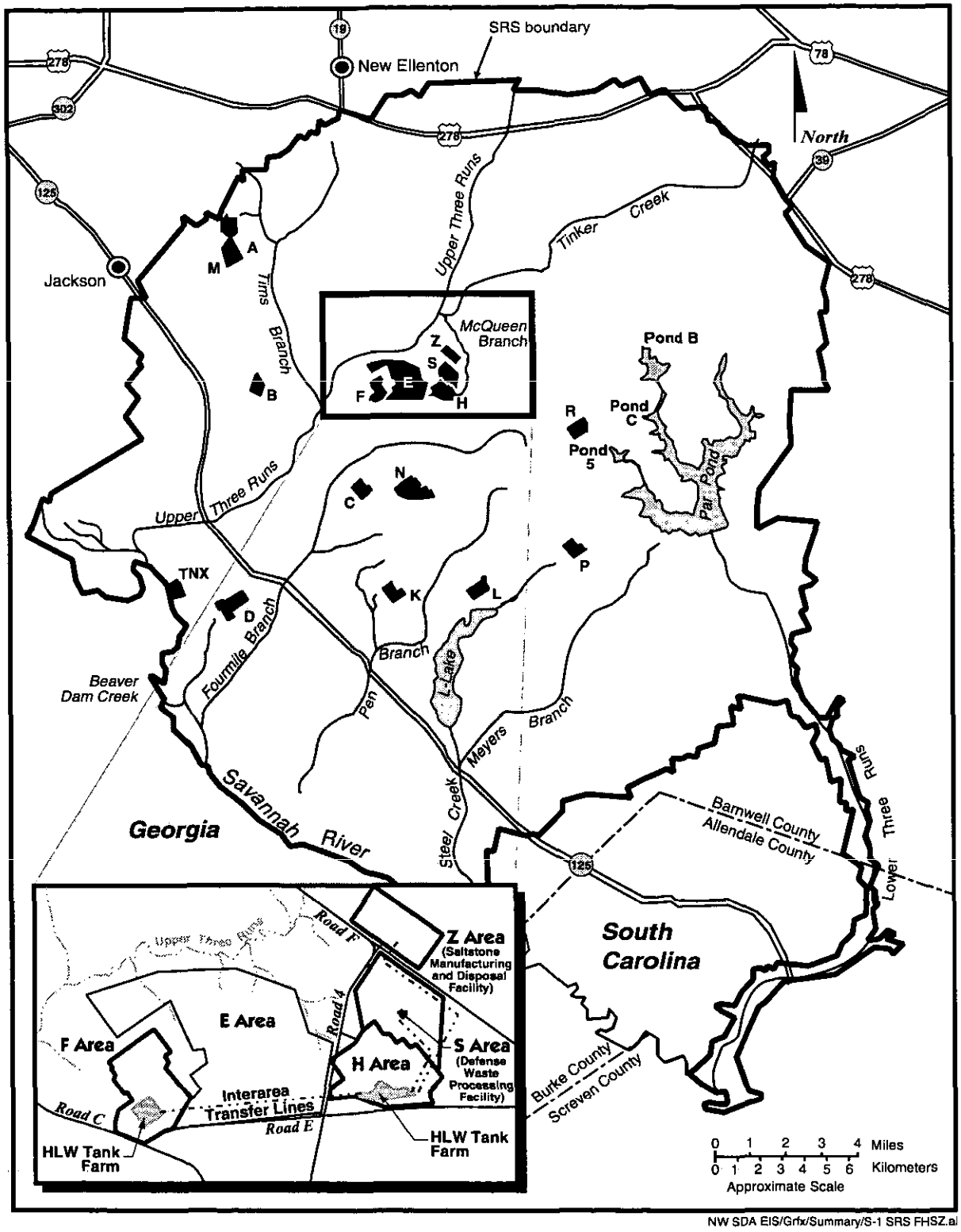


Figure S-1. Savannah River Site map with F, H, S, and Z Areas highlighted.

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-live 88 years) and Pu-239 (half-life of 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.

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. In response to the DNFSB recommendation, DOE initiated an extensive chemistry program to better understand the benzene generation and release processes. 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.

L6-12 L6-12 L6-13

DOE must develop a technology to safely process the salt component of the HLW stored at SRS. Such a technology is a crucial prerequisite for placing the salt component in a configuration acceptable for safe disposal. DOE has prepared this Supplemental Environmental Impact Statement (SEIS) to ensure that the public and DOE's decisionmakers have a thorough understanding of the potential environmental impacts of the design, construction, and operation of alternative technologies for salt processing before one technology is chosen. This Summary provides a brief description of the HLW processing technology at SRS, describes the National Environmental Policy Act (NEPA) process that DOE is using to aid in decisionmaking, summarizes the salt processing alternatives, and outlines the major conclusions about environmental impacts, areas of controversy, and issues that remain to be resolved as DOE proceeds with selection of a salt processing technology.

High-Level Waste Management System

The underground storage tanks are one of seven interconnected parts of the HLW management system at SRS, as follows:

- HLW storage and evaporation in the F- and H-Area Tank Farms
- Sludge processing in the Extended Sludge Processing Facility
- Salt processing through 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).

CIF operations were suspended in October 2000. DOE expects to make a decision on the future of CIF operations by April 2002. TC

S.2 Technology Review and Selection of Alternatives to be Evaluated

DOE evaluated the potential impacts of constructing and operating DWPF in a 1982 environmental impact statement (DOE/EIS-0082; *Final Environmental Impact Statement, Defense Waste Processing Facility*). In 1994, DOE published a SEIS to document and evaluate changes in the process proposed after the 1982 EIS was issued. The Record of Decision for the SEIS (60 FR 18589; April 12, 1995) announced that DOE would complete the construction and startup testing of DWPF and would use the ITP technology for salt processing after satisfactory completion of startup testing.

As described above, after evaluating the ITP process in one of the large underground waste tanks, DOE determined that ITP, as designed, could not meet both safety requirements and production goals. In January 1998, DOE determined that it must therefore select an alternative technology for HLW salt processing.

In response, 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. This evaluation was done and, in October 1998, WSRC presented its recommendation of alternatives to DOE. WSRC recommended four technologies for further consideration: **Small Tank Tetraphenylborate Precipitation, Crystalline Silicotitanate Ion Exchange, Caustic Side Solvent Extraction**, and **Direct Disposal** (of cesium) **in Grout**. In early 1999, following 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 at that time because it was considered technically immature. DOE restored Solvent Extraction to the list of potential alternatives in February 2000, based on recommendations from the National Academy of Sciences (NAS) and new research and development results.

In response to a June 1999 request from the Under Secretary of Energy, the National Research Council of the NAS commissioned a committee to provide an independent technical review of alternatives for processing the HLW salt solutions at the SRS. The review was conducted by a committee composed of experts in the fields of nuclear reactor and fuel cycle technology, nuclear chemistry and separations, environmental sciences, and nuclear waste disposal. The final Council Report in October, 2000 endorsed in general the selection of the four candidate processes considered as alternatives for salt disposal, concluding that each of the processes was po-

tentially appropriate and no obvious major processing options were overlooked. Recommendations for addressing the technical uncertainties associated with each of the alternatives were identified, with schedule constraints and potential regulatory restrictions noted.

In connection with the October 2000 report, DOE asked the National Research Council to provide a follow-on assessment of DOE's efforts to evaluate and select a process for separating radionuclides from soluble high-level radioactive waste at the Savannah River Site. A second NAS committee was appointed and tasked to: (1) evaluate the adequacy of the criteria DOE used to select from among the candidate processes under consideration; (2) evaluate the progress and results of the research and development work DOE undertook on the candidate processes; and (3) assess whether the technical uncertainties were sufficiently resolved to proceed with downsizing the list of candidate processes.

TC The second NAS committee issued an interim report in March 2001, which only addressed 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 of the criteria did not appear to be independent of others, and some criteria appeared unlikely to discriminate among the process alternatives.

The second NAS committee issued a final report in June 2001 (*Research and Development on a Salt Processing Alternative for High-Level Waste at the Savannah River Site*). The report concluded that "the committee believes that technical uncertainties have been resolved sufficiently to proceed with downselecting the list of candidate processes." The report noted that "Unless tests with actual waste encounter new problems, the (Caustic Side Solvent Extraction) option for cesium separation presents, at present, the fewest technical uncertainties of any of the three cesium separation alternatives." TC

S.3 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 LLW disposal at SRS.

DOE recognizes that if salt processing is delayed beyond 2010, 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.

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 construction and operation of the salt processing facility. (These costs do not include federal repository costs for transportation and disposal). L1-5 L6-16 L6-44

S.4 NEPA Process

In parallel with development of the WSRC recommendations on alternative technologies, DOE prepared a Supplement Analysis in accordance with the Department's NEPA regulations (10 CFR 1021) and made it available to the public. Based on the Supplement Analysis, DOE decided to prepare this second SEIS on DWPF and its supporting processes because necessary addi-

tional changes will significantly alter how the HLW salt is processed from that described in the original EIS and the 1994 SEIS. This second SEIS evaluates the potential environmental impacts of designing, constructing, and operating a salt processing technology to replace the ITP process. The SEIS also considers the impacts of a No Action alternative.

HLW Tank Closure

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 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*. Bulk waste must be removed from the tanks before closure can begin. Without a salt processing alternative and with continued sludge-only vitrification in DWPF, HLW storage requirements will be such that DOE may not be able to empty 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, November 2000), to evaluate the impacts of tank closure alternatives. DOE plans to issue the Tank Closure Final EIS in late 2001.

NEPA provides Federal decision-makers with a process to use when considering the potential environmental impacts of proposed actions and alternatives. This process also provides several ways the public can be informed about and influence the selection of an alternative.

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.

DOE encouraged SRS stakeholders and other interested parties to submit comments and suggestions for the scope of the SEIS. DOE held scoping meetings on the SEIS in Columbia, South Carolina, on March 11, 1999, and in North Augusta, South Carolina, on March 18, 1999. DOE received four comment letters, one comment e-mail, one recommendation from the SRS Citizens Advisory Board, and 59 oral comments at the public scoping meetings. DOE identified about 90 separate comments in these submittals and presentations. DOE considered comments received during the scoping period in preparing this SEIS. DOE's responses to the scoping comments were included in the Draft SEIS and are not repeated here. The scoping comments focused on eight areas:

- Alternative processing technologies
- Direct Disposal in Grout vault design
- Quantities of radioactive materials disposed in grout
- Description of the No-Action alternative
- HLW tank space utilization
- Research and Development activities
- Cost
- Schedule

TC

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 the Draft SEIS.

Most commenters were concerned about four major topics:

- No Action alternative
- Direct Disposal in Grout alternative
- Waste Management
- Criteria for selection of the preferred alternative

The major points made during the public comment period and DOE's responses are summarized below.

No Action Alternative

Commenters questioned the description of the No Action alternative and its impacts. They generally expressed the opinion that the long-term impacts of No Action would be more severe than DOE portrayed qualitatively in the Draft SEIS and asked that the
L3-2 No Action alternative be modified and the
L6-4 long-term impacts be analyzed quantita-
L7-3 tively. Several commenters suggested that
L8-5 DOE evaluate a scenario that assumed no
L8-6 salt processing alternative could be developed, and evaluate the impacts of leaving salt waste in HLW tanks until the eventual failure of the tanks.

Response: DOE has revised the analysis of the No Action alternative to provide a more quantitative evaluation of the impacts over the long term. DOE added text to the SEIS, and data to the appropriate tables, to compare the long-term impacts of No Action to the long-term impacts of the action alternatives. DOE evaluated the impacts of the eventual release of tank contents to the environment under a tank overflow scenario, and the consequent health impacts to a person drinking contaminated water from on-site streams and the Savannah River. DOE also addressed the radiation exposure that could result from external exposure to contaminated soil.

Direct Disposal in Grout Alternative

Several commenters questioned the implementation of the Direct Disposal in Grout alternative because, in their view, it would result in disposal of HLW at the Savannah River Site. Other commenters asked about DOE's discussions about the Direct Disposal in Grout alternative with the U.S. Environmental Protection Agency and the South Carolina Department of Health and Environmental Control.

Response: DOE describes the process for determining whether waste is waste incidental to reprocessing in Section 7.1 of the SEIS. The waste incidental to reprocessing analysis would be applied to any salt processing alternative that DOE selects for implementation. If the waste were to meet the waste-incidental-to-reprocessing criteria, it could be managed as low-level waste or as transuranic waste depending on the nature of the waste. DOE expects that the waste generated under the Direct Disposal in TC
Grout alternative would be managed as low-level waste. DOE has had preliminary discussions with the South Carolina Department of Health and Environmental Control (SCDHEC) at the staff level. SCDHEC conveyed to DOE during those discussions that, as long as DOE followed the waste incidental to reprocessing determination process, SCDHEC would find the Direct Disposal in Grout alternative to be acceptable in principle.

Waste Management

Commenters asked how wastes that would be generated by the alternatives, particularly benzene and solvents, would be managed.

Response: Waste generation that would result from implementation of each of the alternatives is described in Tables 4-18 and 4-19 of the Supplemental EIS. Currently, incineration is considered the best available treatment technology for benzene and other organic liquid wastes. DOE expects that these wastes would be disposed of by incineration. DOE has not yet determined whether the Consolidated Incineration

Facility, a portable vendor-operated facility, or a suitable offsite facility would be used for incineration of these wastes. DOE previously considered the impacts of benzene incineration in the November 1994 *Defense Waste Processing Facility Final Supplemental Environmental Impact Statement* (DOE/EIS-0082-S).

Criteria for Selection of the Preferred Alternative

Several commenters asked about the criteria DOE would use to select the preferred salt processing technology, and several commenters were especially interested in cost as a criterion.

Response: In addition to reviewing the results of research and development work on the alternative technologies, DOE evaluated each alternative against the following criteria: cost, schedule, technical maturity, technology implementability, environmental impacts, facility interfaces (with existing SRS facilities), process simplicity, process flexibility, and safety. DOE has revised the SEIS (at Section 2.8.3) to incorporate the latest approximate range of costs through construction for each of the alternatives. DOE does not consider the cost estimates available at this time to be reliable enough to be a significant discriminating factor for decision-making. TC

The NAS 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 the separation alternatives in its report to DOE, which was submitted on June 4, 2001.

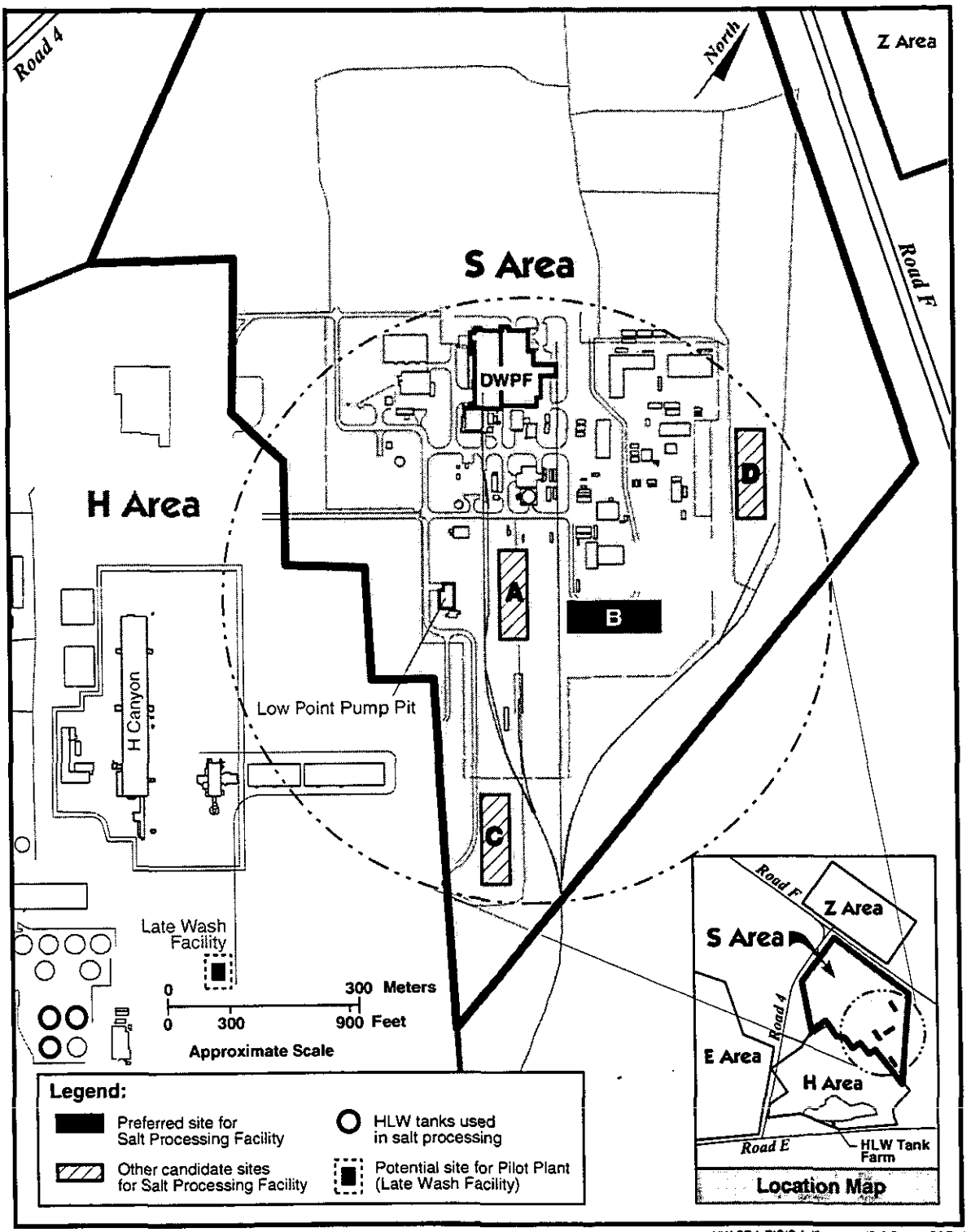
S.5 Decisions to be Made

DOE has completed laboratory research and development activities. DOE has evaluated the results of the studies and has identified the caustic side solvent extraction technology as the preferred alternative in this Final SEIS. No sooner than 30 days after EPA publishes a Notice of Availability of this Final SEIS, DOE will select a salt processing technology and issue a Record of Decision. DOE will construct and operate a Pilot Plant of the selected technology and then produce a **final design** of the facility to implement full-scale operation of the selected technology. TC

S.6 Site Selection

WSRC prepared a site selection study to identify a suitable location in S or H Areas at SRS for the construction and operation of a salt processing facility. The study sought to optimize siting for facility-specific engineering requirements, sensitive environmental resources, and applicable regulatory requirements. The goal of the study was to evaluate alternative sites for building and support facilities for 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 S-1). In order to transfer materials from the proposed salt processing facility to DWPF, the salt processing facility must be located within 2,000 feet of DWPF or of an auxiliary pumping facility. This constraint identified general areas suitable for siting the facility. Thirteen areas with sufficient acreage for the buildings, construction laydown, and support facilities were identified. Evaluations of these areas resulted in the identification of four candidate sites (A, B, C, and D) in S Area (Figure S-2). Site A was excluded because of its potential to interfere with the expansion of an existing facility and the possible partial intrusion into a known waste unit. A comparative analysis of the remaining sites provided a suitability ranking based on geologic, ecologic, human health, and engineering considerations. Overall, Site B ranked higher than Sites C or D, although no notable differences were identified between the four sites on geologic, ecologic, or human health grounds. TC



NW SDA EIS/Grfx/Summary/S-2 Potent SDF.ai

Figure S-2. Potential salt processing facility sites.

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.

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 grout production. Figure S-3 shows the location of the Direct Disposal in Grout processing facility and the saltstone disposal vaults that would be constructed and operated under any of the action alternatives.

S.7 DOE's Proposed Action and the Alternatives

DOE proposes to select a salt processing technology and to design, construct, and operate the facilities required to process HLW salt. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of LLW at SRS.

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

DOE, with the help of independent experts, has performed research on each of the three cesium-removal technology alternatives to establish the technological risk involved in implementing each alternative. Independent review teams (i.e., Independent Project Evaluation Team, the Technical Advisory Team, and the National Academy of Sciences), comprised of independent experts and subject matter experts, reviewed the results of DOE's research. The final conclusion supports the technology selection and the identification of the preferred alternative. The SEIS assesses the potential environmental impacts of each alternative, which are detailed in Chapter 4, and compared in Section 2.9. In addition to, and in consideration of this research, analysis, and independent review, DOE conducted a final management review that comparatively evaluated each of the 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, and subsequent DOE senior management validation, 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 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 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.

S.7.1 NO ACTION ALTERNATIVE

Under the No Action alternative in the near-term, DOE would continue current HLW management activities, including tank space management, 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 activi-

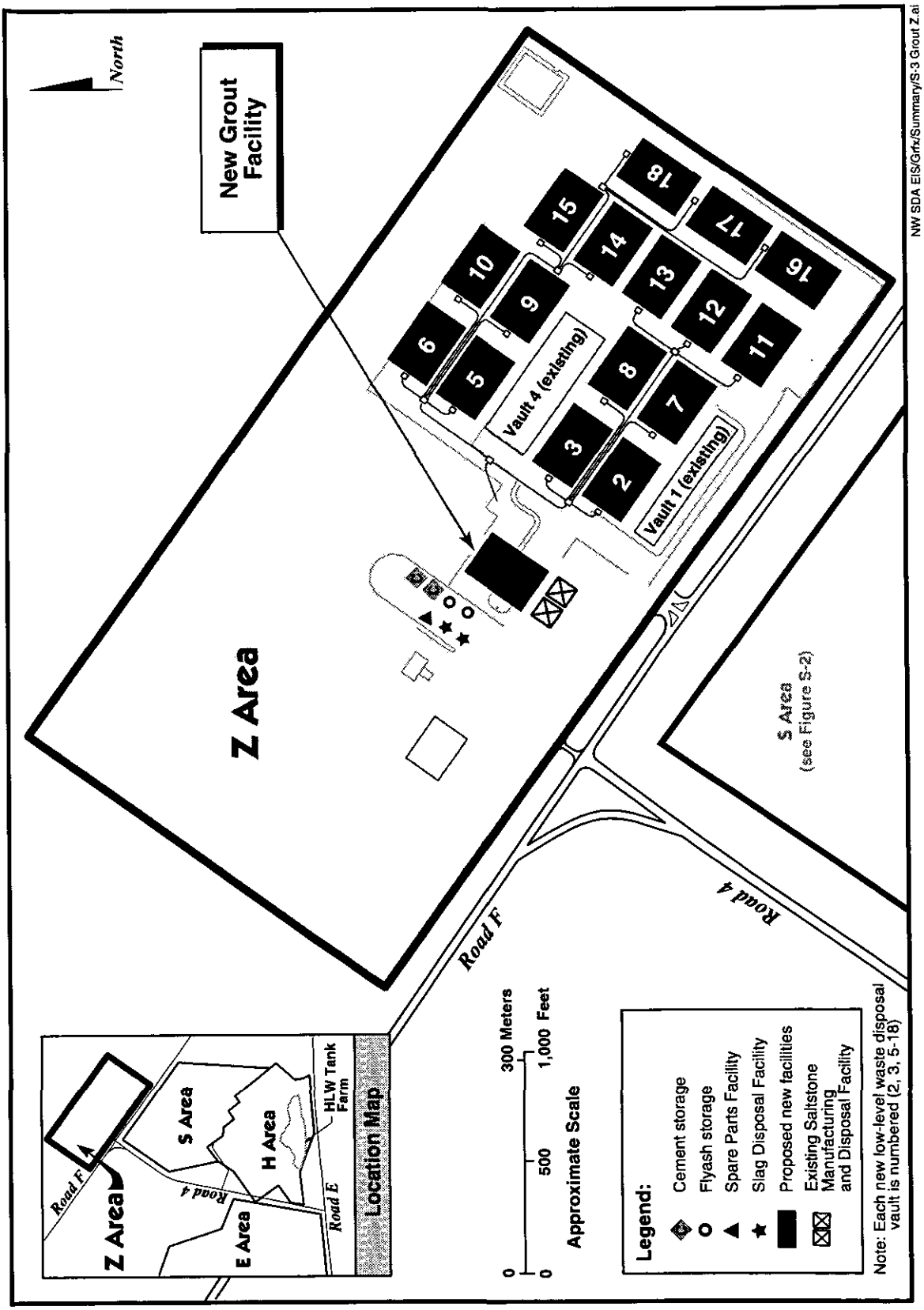


Figure S-3. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

ties would continue. Tank space would continue to be managed to ensure adequate 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 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:

- Continue to evaporate water from liquid waste
- 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 safety (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.

S.7.2 SALT PROCESSING ALTERNATIVES

Common features of all processes include initial separation of low-concentration soluble radioactive strontium and actinides (including plutonium) by **sorption** (Table S-1) onto granular solid monosodium titanate (MST), followed by filtration. The essential difference among the alternatives is the technology for removal of the relatively high concentrations of radioactive cesium, except for the Direct Disposal in Grout alternative, in which cesium would not be removed. The final waste forms are similar for each of the other action alternatives with the high-activity salt fraction extracted from the salt and incorporated into the vitrified waste form for eventual repository disposal, and the low-activity salt fraction immobilized as salt stone for onsite disposal.

In the Direct Disposal in Grout alternative, although the high activity salt solution would also be vitrified for eventual repository disposal, the cesium would remain in the fraction immobilized as saltstone for onsite disposal. A diagram and an overview comparing the process phases for the salt processing alternatives are presented in Figure S-4 and Table S-1, respectively. Greater detail is provided in Appendix A, Technology Descriptions. TC

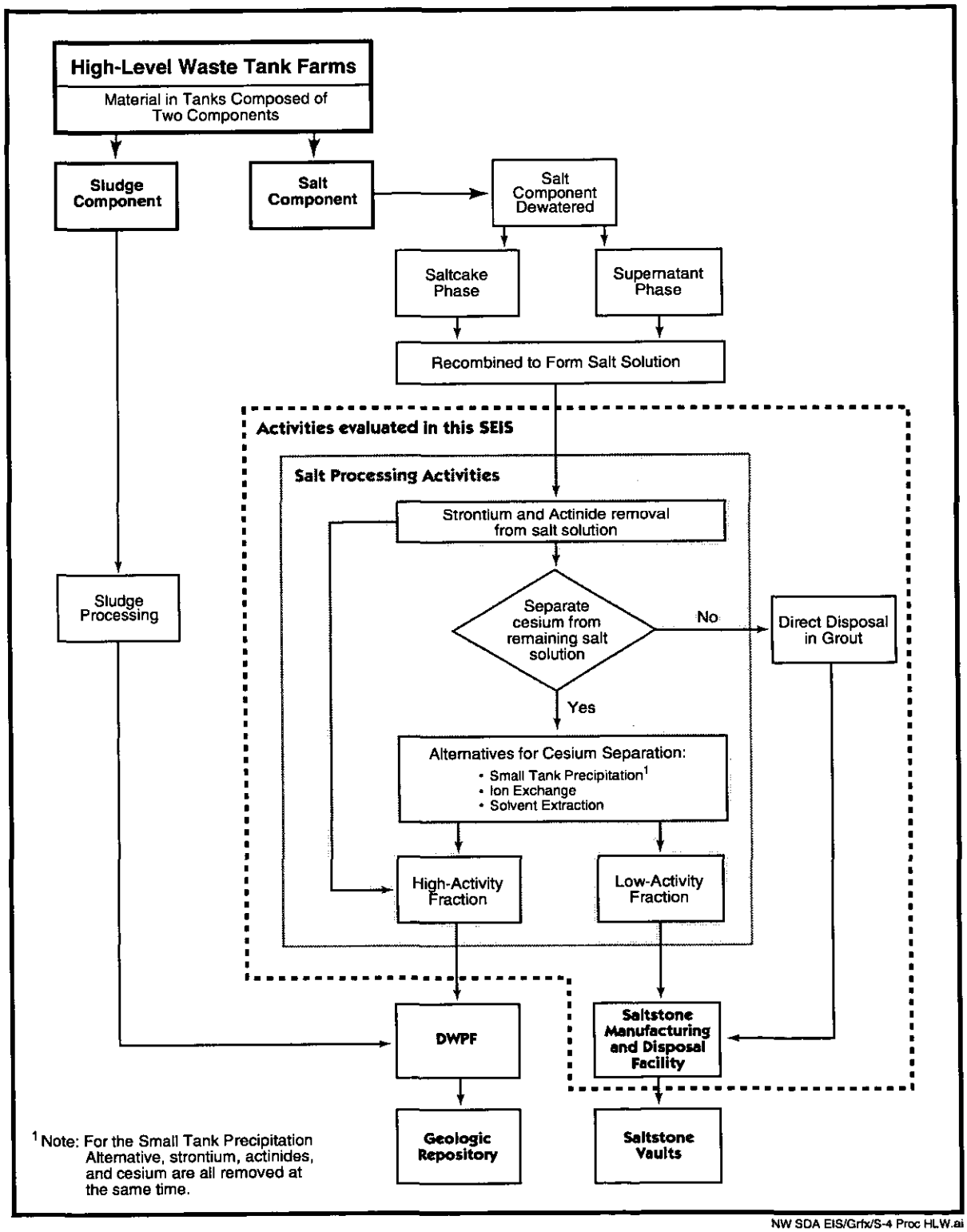


Figure S-4. Process Flow for High-Level Waste at the Savannah River Site.

Table S-1. Comparison of salt processing alternatives.

Salt processing alternatives	Process stages: Strontium and actinide (Pu) removal from salt solution	Process stages: Cesium removal from salt solution	Final waste form: DWPF glass (HLW)	Final waste form: 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

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

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 LLW under the waste incidental to reprocessing criteria in DOE Manual 435.1-1 (which provides procedures for implementing DOE Order 435.1, Radioactive Waste Management). The waste incidental to reprocessing determination process is described in detail in Chapter 7.

S.7.2.1 Small Tank Precipitation

The Small Tank Precipitation alternative would use the same chemical reaction as ITP (i.e., **tetraphenylborate precipitation**) to remove the radioactive cesium from the HLW salt solution. However, 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.

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 to decompose the tetraphenylborate precipitate and remove the benzene formed. The solids slurry containing the separated radioactive constituents would be transferred to DWPF for vitrification. The low-activity salt fraction would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults. L6-21 L6-21

S.7.2.2 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 pass 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 those 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.

Benzene Control for Small Tank Precipitation

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

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.

S.7.2.3 Solvent Extraction

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 for vitrification in DWPF. Before separating cesium from the salt solution, monosodium titanate would separate soluble strontium and actinides followed by filtration to remove those solids and residual sludge. This pretreatment 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 concentrated cesium solution. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

S.7.2.4 Direct Disposal in Grout

The first three technologies considered in this SEIS remove cesium from the salt solution for eventual disposal, along with the high-activity fraction, as HLW. Under the Direct Disposal in Grout alternative, the HLW salt solution would be disposed onsite as saltstone without separation of radioactive cesium. Prior to solidifying the salt solution as grout, monosodium titanate would be used to remove the strontium and actinides to meet saltstone waste acceptance criteria as LLW. The monosodium titanate slurry would be transferred to DWPF for incorporation into HLW glass.

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 saltstone 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 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 TC

TC form under the Direct Disposal in Grout alternative.

S.7.3 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 S-2. The specified capacities of the process facilities would maintain an average processing of about 6 million gallons of waste salt solution per year at 75 percent attainment. This processing rate would allow complete processing of about 80 million gallons of salt solution total (approximate volume after the saltcake is dissolved) within about 13 years after facility startup. The throughput of all action alternatives is limited to 6 million gallons per year due to physical constraints on removing waste from the waste tanks. It is important to process the salt waste concurrent with processing the HLW sludge so that the high-activity fraction of the HLW salt can be vitrified with the sludge fraction in DWPF. If salt processing is delayed 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 salt-only canisters would add about 150 glass waste canisters per year. About 1,100 sludge-only canisters had been produced through May 2001. Vitrification of the combined HLW sludge and salt would produce about 5,700 glass waste canisters.

L6-23 TC TC

Table S-2. 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]	6.9	6.9	6.9	6.0
Long-term average throughput of salt solution (million gallons per year)[a]	6.0	6.0	6.0	6.0
Throughput limitation	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	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	13	13	13
Planned canister production per year[b]	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced[b]	≈5,700	≈5,700	≈5,700	≈5,700
Additional vaults for Class A waste	16	13	15[c]	0
Additional vaults for Class C waste[d]	0	0	0	13

L6-23 L6-23

a. The required processing rate for the salt processing facilities exceed the long-term average 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. L6-23
b. DWPF planned glass waste canister production includes both sludge and salt wastes.
c. This alternative would require between 14 and 15 vaults; for purposes of impact analysis, 15 vaults were assumed.
d. Additional saltstone vaults for onsite disposal of processed salt solution.

Differences in the total number of combined sludge and salt waste canisters produced following 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.

S.7.4 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 S-3.

The Solvent Extraction technology would produce a greater volume of product sent to DWPF than the other technologies because of the relatively high volume of concentrated cesium solution it produces. However, vitrification of sludge at DWPF produces most of the glass volume. Therefore, the relatively high volume of cesium solution from the solvent extraction facility would not affect the number of canisters produced. Salt solutions sent to the saltstone facility and the grout produced would be about the same for each alternative.

In addition to the principal product outputs specified in Table S-3, the Small Tank Precipitation process would generate by-product 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 precipitation hydrolysis process, and stored for final disposition. This waste would be treated in an incineration facility either on or offsite and disposed in a permitted disposal facility. TC TC L1-11

The Solvent Extraction process would require an organic solvent also requiring final processing. The solvent inventory for the process is projected to be 1,000 gallons. DOE conservatively assumes that this inventory would be replaced once per year. For a facility operation time of 13 years, the accumulated total volume of solvent requiring storage for disposal would be 13,000 gallons. This waste would be treated in an incineration facility either on or offsite and disposed in a permitted facility. TC L1-11

Table S-3. Product outputs for the salt processing alternatives. TC L1-11

Product Output	Alternative: Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Solids Slurry (and solution) to DWPF				
Annual (million gallons)	0.22	0.20	0.68[a]	0.15
Life cycle (million gallons)	2.9	2.6[b]	8.8[a]	2.0
Salt solution to grout				
Annual (million gallons)	8	6.6	7.5	5.9
Life cycle (million gallons)	104	86	97	77
Grout produced				
Annual (million gallons)	15	12	14	11
Life cycle (million gallons)	190	160	180	140

a. Includes 0.154 million gallons/yr solids slurry and 0.523 million gallons/yr concentrated cesium solution, assuming no evaporation; analogous life cycle outputs shown.
b. Includes 2 million gallons monosodium titanate slurry and 0.6 million gallons crystalline silicotitanate slurry.
Note: Material balance estimates are ± 25 percent.

S.7.5 PROCESS FACILITIES

DOE would construct a new shielded facility to house chemical processing equipment (tanks, pumps, filter systems) to implement any alternative. The facility would be sized to accommodate large feed storage and product hold tanks to ensure an average daily processing rate of 25,000 gallons of salt solution. The process facilities are more fully described in Chapter 2 and Appendix A. The large tanks would also enable continuous operation 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 disposal 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 monosodium titanate treatment to remove strontium and actinides from the salt solution and to provide enhanced shielding and remote handling for grout operation. 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, albeit somewhat smaller for Direct Disposal in Grout. Preliminary design dimensions are provided in Table S-4.

The floor plans and elevations for the salt processing facilities are presented in Chapter 2 and Appendix A provides more detail. Each alternative would also require support facilities, including a service and office building and an electrical substation. Support facilities are described in detail in Appendix A.

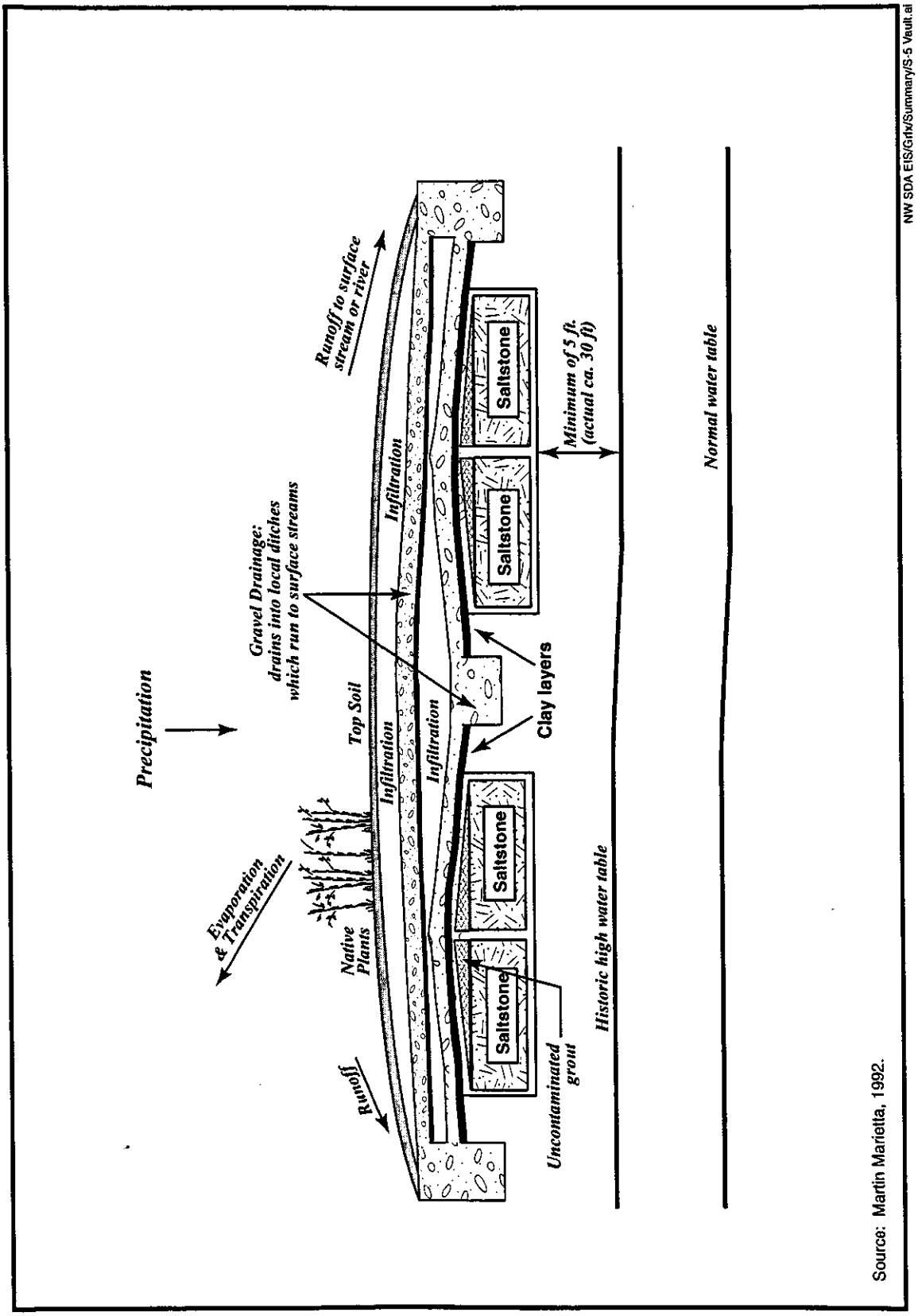
S.7.6 SALTSTONE VAULTS TC

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 alternatives (Figure S-4). 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, under each alternative 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 Z-Area vaults, the additional vaults would be constructed at or somewhat below grade and covered with soil after vault closure for additional shielding. Figure S-5 illustrates how Z Area would look after vault closure.

For the Direct Disposal in Grout alternative, 13 additional vaults would be constructed in Z Area. Because the grout would contain 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.

S.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 decommis-



Source: Martin Marietta, 1992.

Figure S-5. Cross-section diagram of vault closure concept.

Table S-4. 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

a. Building specifications rounded to two significant figures.

sioning 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.

S.8 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 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. 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 serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address the 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. The Pilot Plant components would be sized to operate on a scale from 1/100 to 1/10 of a full-sized facility. M4-3 M4-10 M4-11 TC

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 S-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 preferred salt processing alternative and operation would extend through completion of final design and potentially through 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 unit 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. 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 LLW vaults. Limited radioactive material inventories and appropriate operating parameters would ensure that the overall environmental impacts would be substantially less than those of the full-scale facility.

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

S.9 Comparison of Environmental Impacts Among Alternatives

Design, construction, and operation of a salt processing facility would affect the environment and human health and safety during the time of facility construction and operation, as well as after operations ceased. For purposes of analysis in this SEIS, DOE has defined the facility life cycle to be from the year 2001 through about 2023, when salt processing would be complete. This period is used to estimate short-term impacts. For the No Action alternative, short-term impacts are considered for two time periods: Continuing Tank Space Management (until 2010) and Post Tank Space Management. DOE expects the long-term impacts to be those that could result after 2023 from the eventual release of residual waste from the Z-Area vaults (or from tanks containing salt solution under the No Action alternative) to the environment. In this SEIS, DOE has used modeling to predict these long-term impacts.

This section compares the impacts of the No Action alternative and the four action alternatives: Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout. The action alternatives would involve very similar construction and operations activities that enable a sharply-focused comparison of impacts to each environmental resource. The purpose of this section is to present impacts of the alternatives in comparative form to provide the decision-maker(s) and the public a clear basis for choosing among the alternatives.

In general, the impacts of construction and operation of the action alternatives may be described as similar and not significant. Where differences appear, many are due to the presence of benzene in the Small Tank Precipitation alternative. In the long term, the environmental concern would be contamination of groundwater

from the saltstone vaults under the action alternatives. The presence of 120 million curies in the vaults from the Direct Disposal in Grout alternative would be evident in the long-term impacts, but the impacts of all the alternatives may still be described as small.

S.9.1 SHORT-TERM IMPACTS

DOE has evaluated the short-term impacts of the alternatives in Section 4.1 of the SEIS. These impacts would occur between approximately the years 2001 and 2023 for each of the action alternatives. Notable differences between the alternatives are shown in Table S-5. The analysis of impacts summarized here shows that, in general, the differences between the alternatives is attributable to the presence of benzene in the Small Tank Precipitation alternative and its absence from the other alternatives. There are some processes that are unique to a particular alternative. These are shown in Table S-5 to point out the differences, but the impacts are small.

There are no notable differences between alternatives and the impacts are small, in the following areas:

- Geologic resources
- Water resources
- Occupational Health and Safety
- Ecological Resources
- Land Use
- Cultural resources
- Transportation

These resources areas are not discussed further here, but a complete assessment may be found in Section 4.1 of the SEIS.

Nonradiological air quality – For any of the four action alternatives, the increases in pollutant concentrations resulting from construction activities would be small, would not exceed regulatory limits, and are not expected to result in any adverse health effects.

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 below the threshold values.

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. None of these emissions are expected to result in adverse health effects (i.e., latent cancer fatalities [LCF]; see text box).

Radiological doses to the noninvolved onsite worker, the involved worker, and the collective onsite population from life-cycle operation of any of the alternatives are not expected to result in adverse health effects.

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 for the Ion Exchange alternative to 220 for the Solvent Extraction alternative. None of the action alternatives is expected to have a measurable effect on regional employment or population trends.

Table S-5. Summary comparison of short-term impacts. (Values in bold indicate alternative with greatest impact on 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				
Air Resources						
Nonradiological air emissions (tons/yr.):						
Volatile organic compounds (PSD Standard - 40)	No Change	Minimal[b]	**70**	1.6	40	1.5
Nitrogen dioxide (PSD Standard - 40)	No Change	Minimal[b]	21	21	21	19
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
Isopar®L (PSD Standard - NA)	None	None	None	None	**38**	None
Air pollutants at the SRS boundary (maximum concentrations-$\mu g/m^3$):						
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
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						
Radiological dose and health impacts to the public:						
Maximally-exposed individual (MEI) (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}	$\mathbf{2.0\times10^{-6}}$	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 S-5. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management				
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
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}	$\mathbf{2.5\times10^{-5}}$	8.6×10^{-6}
Worker and Public Health - Nonradiological						
Nonradiological health impacts to the public:						
Maximally exposed offsite individual						
Latent cancer fatality from benzene	No Change[g]	Minimal[h]	$\mathbf{1.7\times10^{-5}}$	(i)	(i)	(i)
Nonradiological health impacts to noninvolved workers:						
Latent cancer fatality from benzene	No Change[g]	Minimal[h]	**0.0066**	(i)	(i)	(i)
OSHA-regulated nonradiological air pollutants at noninvolved worker location (max conc. in mg/m^3)						
Oxides of nitrogen (as NO_x) - ceiling (OSHA Standard - 9)	No Change[g]	Minimal[h]	7.0	7.0	7.0	7.0
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}

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Table S-5. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management				
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
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
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
Mixed low-level liquid waste (gallons)	No Change	No Change	**60,000**	None	1,000	None
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
Utilities (total life cycle)						
Water (million gallons)			**435**	403	380	289
Construction	None	(k)	35	37	35	33
Operations	No Change	No Change	400	366	345	256
Electricity (gigawatt-hours)			319	365	**391**	245
Construction	None	(k)	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	(k)	0	0	0	0
Operations	No Change	No Change	2,548	2,300	1,915	1,536

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Table S-5. (Continued).

Parameter	No Action[a] Continue Tank Space Management	No Action[a] Post Tank Space Management	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Fuel (million gallons)			8.7	**9.3**	8.7	8.2
Construction	None	(k)	8.4	9	8.4	8
Operations	No Change	No Change	0.3	0.3	0.3	0.2

a. Under the No Action alternative DOE would continue tank space management activities until approximately 2010, when the existing HLW tanks would reach capacity. 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 space 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 and F and H Canyons, which, if prolonged, could result in a sizeable workforce reduction.
k. 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.

PSD = Prevention of significant deterioration; OSHA = Occupational Safety and Health Administration.

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Radiation Dose and Cancer Fatalities

TC Worker and public health impacts are expressed in terms of latent cancer fatalities. The primary adverse 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.

Waste generation – Salt processing activities under the action alternatives would generate 150,000 (Direct Disposal in Grout) to 900,000 (Solvent Extraction) 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. The solvent extraction alternative would thus have the greatest requirement for evaporator operation and tank space.

Utilities and energy consumption – In general, the Direct Disposal in Grout alternative would consume the least water, electricity, and steam compared to the other alternatives, which would consume a similar amount of these utilities.

Accidents – DOE evaluated the impacts of potential accidents related to each of the action alternatives (Table S-6). For each action alternative, the accidents considered were: loss of confinement; earthquakes; loss of cooling; external events, such as aircraft and helicopter crashes; and explosions from benzene and radiation-generated hydrogen. In general, accident consequences would be highest for the Small Tank Precipitation alternative and lowest for the Direct Disposal in Grout alternative.

Because the No Action alternative in the short-term includes primarily current operations that have been evaluated in approved safety analysis reports, only the radiological and nonradiological hazards associated with accidents under the four action alternatives were evaluated. L6-29

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

Pilot Plant – Under the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives, DOE would design and construct a 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, impacts would typically be no more than 10 percent of the full-sized facility.

Table S-6. 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				
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				
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

Table S-6. (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				
LCF per year		0.0018	6.9×10^{-4}	6.8×10^{-4}	2.1×10^{-4}
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
Benzene Explosion in PHC[d]	Once in 99,000 years				
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

Table S-6. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
LCF per year		6.8×10^{-5}	NA	NA	NA
Hydrogen Explosion in Extraction Cell	Once in 1,300,000 years				
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
Accidents Involving Nonradioactive Hazardous Materials					
Accidents Involving Sodium Hydroxide Releases					
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					
Organic Evaporator Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.45	NA	NA	NA

Table S-6. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Noninvolved Worker (640 m) Dose (mg/m^3)		130	NA	NA	NA
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
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

NA = not applicable; LCF = latent cancer fatality; OWST = Organic Waste Storage Tank.

a. Accident impacts based on bounding case.
b. Probability of latent cancer fatality (LCF) to the exposed individual.
c. An acute dose of over 300 rem to an individual 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, such as loss of consciousness, cardiac disrhythmia, respiratory arrest.

S.9.2 LONG-TERM IMPACTS

Section 4.2 of the SEIS discusses the long-term impacts associated with disposing 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* as the basis for analysis of the long-term water resource and human health impacts. This performance assessment was done for the original saltstone that would have resulted from the ITP process. For this SEIS, DOE modified the source terms for each of the action alternatives. TC

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 Draft SEIS are described in Appendix D.

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 L3-2 L6-4 L7-3 L8-5 L8-7

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

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.

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. 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. L6-5

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.

L6-5

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).

The impacts to air, geologic resources, groundwater and surface water, ecological resources, and land use from any of the action alternatives would be very small and would not differ among alternatives. The No Action alternative would adversely affect surface water, ecological resources, and land uses. The impacts to public health are discussed in the following paragraphs.

TC

Public health – 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 action 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. 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 S-7, the Direct Disposal in Grout alternative results in higher doses and greater health effects over the long term than the other action alternatives. However, in all cases 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.

Table S-7. Summary comparison of long-term impacts by salt processing alternative. Bold indicates the alternative with the greatest impact for a particular parameter.

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}	$\mathbf{4.9\times10^{-3}}$	L6-32
Radiation dose from Residential Scenario at 100 years post-closure (millirem per year)	**2,320,000**[d]	0.11	0.13	0.1	1,200[e]	L7-1
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}	$\mathbf{4.2\times10^{-2}}$	
Radiation dose from Residential Scenario at 1,000 years post-closure (millirem per year)[g]	NA	69	80	65	**85**	
LCF from Residential Scenario at 1,000 years post-closure	NA	2.4×10^{-3}	2.8×10^{-3}	2.3×10^{-3}	$\mathbf{3.0\times10^{-3}}$	L6-33

a. Nitrate MCL is 10 mg/L.
b. Based on consumption of contaminated surface water at Fourmile Branch.
c. Health effects are expressed as lifetime (70-year) individual probability of a latent cancer fatality.
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 alternatives and scenarios, the external dose is primarily due to the isotopes with long half-lives. L4-10
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 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.

LCF = latent cancer fatality.
NA = not applicable.

Table S-8. Primer of technical terms (other scientific terms are defined in the glossary).

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.

Back extraction
Transfer of extracted constituent in organic phase to secondary aqueous phase in solvent extraction process. As used in this SEIS, this process serves to recover separated radioactive cesium for delivery to DWPF.

Benzene
Benzene, the simplest aromatic hydrocarbon compound has the chemical formula 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 Tetraphenylborate salt processing alternative.

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 or 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.

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. As used in this SEIS, an ingredient of saltstone.

Centrifugal contactor
A device used in the Solvent Extraction salt processing alternative to separate cesium from HLW salt solution. Aqueous waste enters the 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. The cesium is recovered by back extraction from the organic solvent into a secondary aqueous phase in another centrifigual contactor.

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 removal of cesium from acid or alkaline salt solution containing high sodium or potassium concentrations. **Crystalline** refers to being, relating to, or composed of crystal or 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.

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

Table S-8. (Continued).

Direct Disposal in Grout
L6-15 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.

Extractant
A component of the solvent used in the solvent extraction process to facilitate the removal of radioactive cesium from HLW salt solution.

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 the fission fragments' radioactive decay.

Flyash
Fine particulate matter 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. It is an ingredient in saltstone to limit water infiltration by decreasing porosity.

Grout
A fluid mixture of cement, flyash, slag, and salt solution that hardens into solid form (saltstone).

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.

Table S-8. (Continued).

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 personal exposure. The SRS generates LLW in both solid and liquid forms.

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

Precipitation (chemical)
Conversion of a dissolved substance into insoluble form by chemical or physical means.

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
A 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 by evaporation of the supernatant.

Saltstone
Cementitious solid waste form that uses a blend of cement, flyash, and slag to immobilize low radioactivity salt solution for onsite disposal.

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

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

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.

Table S-8. (Continued).

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
L6-15 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.

Sodium tetraphenylborate
An organic reagent used to remove cesium, potassium, and ammonium ions from a salt solution by precipitation of an insoluble solid. The chemical formula for sodium tetraphenylborate is $Na(C_6H_5)_4B$. This reagent was used in the ITP process to separate radioactive cesium from HLW salt solution, forming insoluble cesium tetraphenylborate. It would be used for the same purpose in the Small Tank Precipitation salt processing alternative.

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
Solvent extraction is a process to separate a constituent of an aqueous solution by transferring it to an immiscible organic phase. It is used to separate radioactive cesium from HLW salt solution.

Sorbent/Sorption
A material that sorbs another substance; (i.e., that has the capacity or tendency to take it up by either absorption or adsorption). **Sorption** is the assimilation of one substance by a material in a different phase.

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 Tetraphenylborate Precipitation salt processing alternative.

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, the preferred option for immobilizing high-level radioactive liquids into a stable, manageable form for disposal in a geologic repository.