Savannah River Site

Salt Processing Alternatives

Draft Supplemental

Environmental Impact Statement

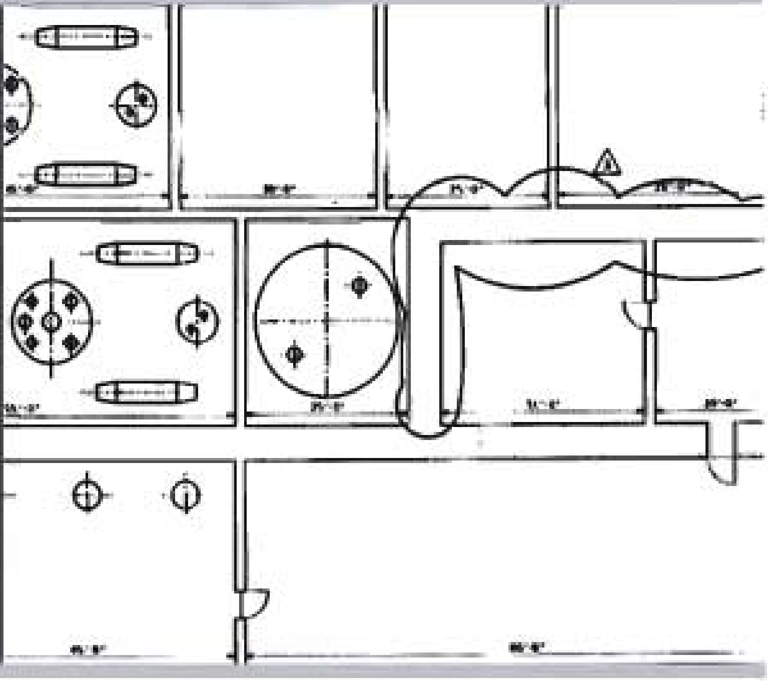
U.S. Department of Energy

Savannah River Operations Office

Aiken, South Carolina

March 2001

DOE/EIS-0082-S2D



COVER SHEET

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

TITLE: Savannah River Site Salt Processing Alternatives Draft Supplemental Environmental Impact Statement (DOE/EIS-0082-S2D)

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ABSTRACT: DOE prepared this Draft 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. DOE has not selected a Preferred Technology Alternative. Preferred sites for locating processing 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: In preparing this Draft SEIS, DOE considered comments received by letter and voice mail and comments received at two public scoping workshops held in Columbia and North Augusta, South Carolina, on March 11 and March 18, 1999, respectively.

A 45-day comment period on the Draft Salt Processing Alternatives SEIS begins with the U.S. Environmental Protection Agency's publication of a Notice of Availability in the *Federal Register*. Public meetings to discuss and receive comments on the Draft SEIS will be held on May 1, 2001, at the North Augusta Community Center in North Augusta, South Carolina, and on May 3, 2001, at the Holiday Inn Coliseum in Columbia, South Carolina. Comments may be submitted at the public meetings and by voice mail, e-mail, or regular mail to the first address above. Comments received or postmarked by the end of the comment period will be considered in the preparation of the Final SEIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

FOREWORD

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

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

The NOI requested public comments for DOE to consider in determining the scope of the SEIS and announced a public scoping period that ended on April 8, 1999. Two public scoping workshops were held during the scoping period: one on March 11, 1999, in Columbia, South Carolina, and one on March 18, 1999, in North Augusta, South Carolina. From the scoping process, DOE identified approximately 90 comments considered applicable to the Salt Processing SEIS. A Summary of the comments received during the scoping period, and how they influenced the scope of this Draft SEIS, is included in Appendix C.

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

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

- Chapter 1 describes the background and purpose and need for DOE action regarding salt processing at SRS.

- Chapter 2 describes the proposed action and the alternatives that DOE is evaluating.

- Chapter 3 describes the SRS environment as it relates to the alternatives described in Chapter 2.

- Chapter 4 assesses the potential environmental impacts of the alternatives.

- Chapter 5 discusses the cumulative impacts of salt processing in relation to other past, present, and reasonably foreseeable future activities at SRS, and in the surrounding region.

- Chapter 6 identifies irreversible and irretrievable resource commitments.

- Chapter 7 discusses applicable statutes, state and Federal regulations, and DOE Orders, and agreements.

- Appendix A describes the facilities and processes that would be used for each of the alternatives.

- Appendix B discusses the methods used for accident analysis and the results of the analysis.

- Appendix C describes the SEIS scoping process, the comments received, and how DOE has addressed those comments.

- Appendix D gives the methods and the results of long-term performance modeling that was used to evaluate the impacts of salt processing alternatives.

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CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

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

To assist the reader in understanding key terms used in this document, those terms have been **bolded** the first time they are used and are discussed in Table 1-1, Primer of Technical Terms, located at the end of this chapter.

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 uranium and

Radionuclides

Cesium (Cs)

Cesium is a silver-white, highly reactive, metallic element. Cesium-137, -135, and -134 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for cesium is Cs. Cs-137 has a half-life of 30 years, Cs-135 has a half-life of 21.3 million years, and Cs-134 has a half-life of 2 years.

Plutonium (Pu)

Plutonium is a man-made, silver-gray, metallic element in the actinide series. All isotopes of plutonium are radioactive. Plutonium is a fission fuel for reactors and atomic weapons. Plutonium-239 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for plutonium is Pu. Pu-239 has a half-life of 24,000 years.

Strontium (Sr)

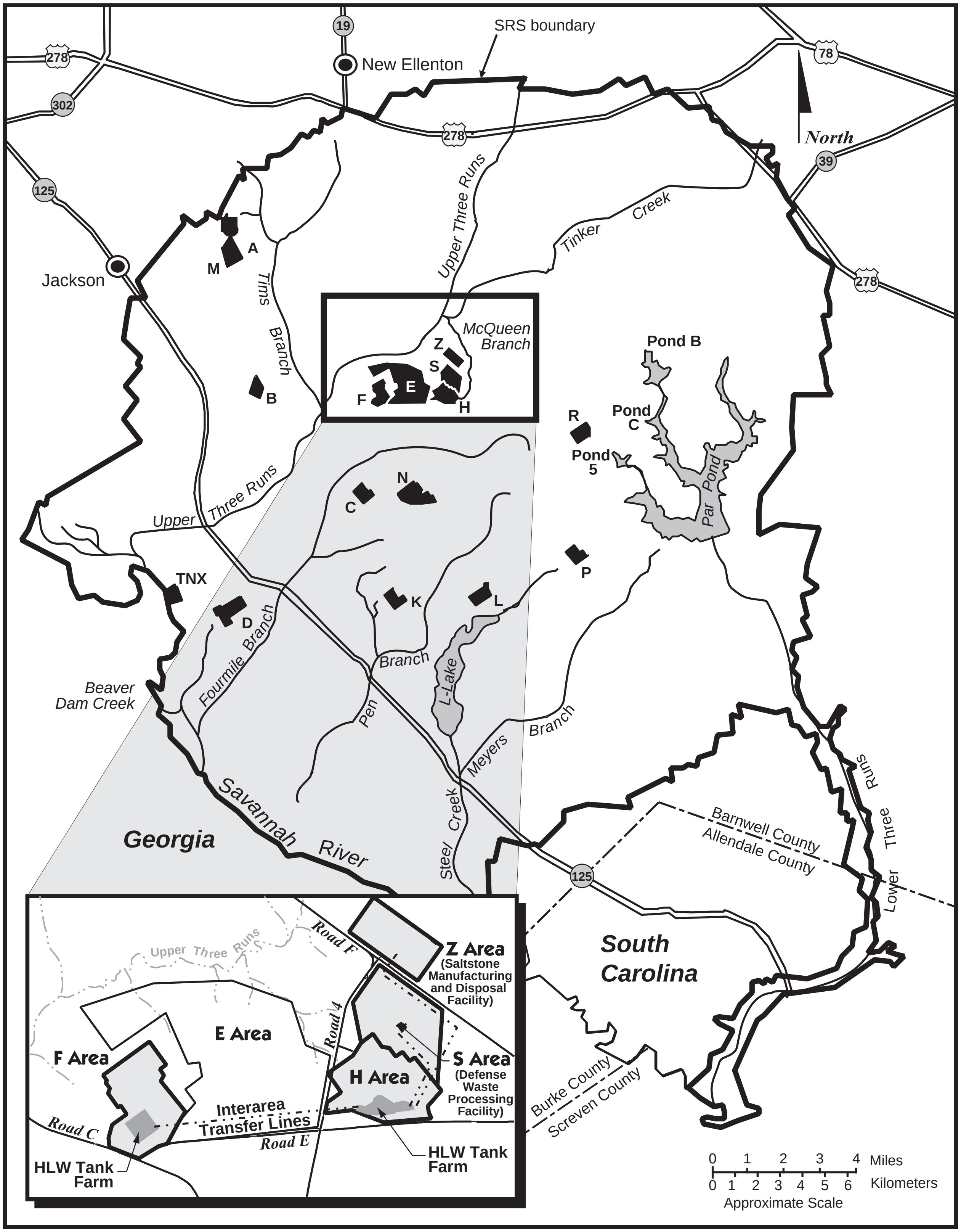
Strontium is a silver-yellow, metallic element. Strontium-90 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for strontium is Sr. Sr-90 has a half-life of 29 years.

Technetium (Tc)

Technetium is a man-made, silvery-gray, metallic element. All isotopes of technetium are radioactive. Technetium-99 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for technetium is Tc. Tc-99 has a half-life of 200,000 years.

Uranium (U)

Uranium is a silver-white, highly reactive, metallic element in the actinide series. All isotopes of uranium are radioactive. Uranium is used as a fission fuel for reactors and atomic weapons. Uranium-235 and -238 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for uranium is U. U-235 has a half-life of 700 million years and U-238 has a half-life of 4 billion years.



NW SDA EIS/Grfx/ch_1/1-1 SRS FHSZ.ai

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

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

The salt component consists of **saltcake** and **salt supernatant**. To process the salt component, solid saltcake must first be dissolved 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 salt solution would be vitrified in the DWPF, and the less radioactive constituents, still in the salt solution, would be stabilized with grout (a cement-like mixture), to create a saltstone waste form for onsite disposal as **low-level radioactive waste (LLW)**.

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

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

The reagent used to precipitate cesium in the ITP process, sodium tetraphenylborate, is subject to **catalytic** and **radiolytic decomposition**. Its decomposition inhibits its ability to bind with cesium and keep it out of 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 sodium tetraphenylborate must be limited 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 sodium 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. As a result, in March 1996, ITP operations were suspended. However, the DWPF facility continues to process and vitrify HLW sludge.

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 testing and operation of ITP not proceed further until DOE had a better understanding of how benzene was generated and released during the **precipitation** process (DNFSB 1996). In January 1998, DOE determined that ITP, as designed, could not meet production goals and safety requirements, and that it must therefore select an alternative technology for HLW salt processing.

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

The 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 below)
- 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 below).

This system is currently operating, except for the CIF and salt processing through ITP and the Late Wash Facility. ITP operations are now limited to facility surveillance and maintenance. The Late Wash Facility has been tested, using nonradioactive materials, and is in standby status.

CIF operations were suspended in October 2000. The CIF was constructed primarily to incinerate benzene generated in the ITP process and plutonium/uranium extraction (PUREX) solvent wastes from F- and H-Canyon operations. It was also scheduled to destroy some solid LLW from ongoing operations and decontamination and decommissioning (D&D) projects. As originally planned, the benzene would be used to dilute the PUREX solvent and be co-disposed during incineration. However, the benzene waste was not produced due to the suspension of ITP operations, and the D&D projects were deferred. In the absence of these wastes, DOE found that it would not be cost-effective to operate the CIF only for solid LLW and PUREX solvent. Solid LLW could be more cost-effectively managed by compaction, and operation of the CIF for disposal of the PUREX waste stream without a benzene stream for dilution would be cost-prohibitive. DOE is investigating alternatives for PUREX solvent disposal and will not operate the CIF if an effective alternative to solvent disposal by incineration can be identified. DOE expects to make a decision on CIF by April 2002.

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 (DOE 2000a), based on recommendations from the National Academy of Sciences (NAS 1999) and new research and development results. A description of DOE's salt processing program, including results of research and development, may be found on the Internet at http//www.srs.gov/general/srtech/spp/randd.htm.

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

1.2 Purpose and Need for Action

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

HLW Tank Closure Activities

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

1.3 SEIS Overview

1.3.1 SCOPE

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

In addition, the SEIS describes the potential impacts of a No Action alternative, as required by NEPA. The impacts of the No Action alternative provide a basis for comparison with the impacts of the action alternatives. The No Action alternative is defined as the continuation of actions DOE has already taken or is currently taking. As such, No Action could be defined as operation of the ITP Facility for salt processing, as projected in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility Record of Decision* (60 FR 18589 – 18594; April 12, 1995). However, because DOE has determined that the ITP process cannot simultaneously achieve both safety and production requirements, it will not be operated. A comparison of the impacts of the alternatives to the operation of the ITP Facility would not, therefore, prove meaningful. Consequently, DOE has defined No Action as a continuation of current HLW management activities, including tank space management, and vitrification of the sludge component of HLW, without operation of the ITP Facility. See Chapter 2 for a full explanation of the No Action alternative.

Decisions to be Made

Following completion of this SEIS and related technical studies, DOE will select a technology to process the salt components of the HLW stored at SRS.

DOE will complete laboratory research and development in April 2001. Following evaluation of the studies, DOE will identify a preferred alternative in the Final SEIS, planned for June 2001. No sooner than 30 days after EPA publishes a Notice of Availability of the Final SEIS, DOE will select a salt processing technology and issue a Record of Decision (ROD). DOE will construct and operate a Pilot Plant for the selected technology and then produce a final design of the facility to implement full-scale operation of the selected technology.

1.3.2 ORGANIZATION

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

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

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

1.3.3 STAKEHOLDER PARTICIPATION

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

DOE encouraged SRS stakeholders and other interested parties to submit comments and suggestions for the scope of the SEIS. DOE held scoping meetings in Columbia, South Carolina, on March 11, 1999, and in North Augusta, South Carolina, on March 18, 1999. Each meeting included a presentation on the NEPA process as it related to the proposed action, a presentation on the process used to identify reasonable alternatives for salt processing for further evaluation, public comment opportunities, and question-and-answer opportunities.

From the scoping process, DOE identified about 90 separate comments. The comments addressed six broad issues: alternatives, the ITP process, impact evaluations and analyses, criteria and regulations, schedule and process, and miscellaneous topics. A summary of the comments received during the scoping period and the way(s) in which they influenced the scope of this Draft SEIS, are included in Appendix C.

1.4 Related Information

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

1.4.1 NEPA DOCUMENTS

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

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

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

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

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

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

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

Final Environmental Impact Statement, Waste Management (DOE 1995)

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

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

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

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

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

1.4.2 OTHER RELEVANT DOCUMENTS

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

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

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

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

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

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

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

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

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

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

NAS Review Committee Interim Report (NAS 1999)

This report generally endorsed the selection of the four candidate processes considered as alternatives for salt processing, concluding that, with adequate development time and funding, each of the processes could be made to work. Major technical problems were identified for each alternative, with schedule constraints and potential regulatory restrictions noted. Recommendations included the following: (1) resolve technical questions concerning reaction kinetics of the monosodium titanate process; (2) improve understanding of the TPB decomposition process, especially catalytic reactions responsible for benzene generation; (3) evaluate Ion Exchange process cesium desorption and resin deactivation in alkaline solutions; (4) establish regulatory acceptance for the Direct Disposal in Grout alternative; (5) resume development of the Solvent Extraction process to resolve potential solvent instability, recycle, and contaminant problems.

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

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

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

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

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

Caustic
Alkaline solution containing sodium hydroxide or other light metal hydroxides. SRS HLW solutions are caustic solutions.

Caustic Side Solvent Extraction
A process for separating radioactive cesium from alkaline (caustic) HLW solutions, by transfer to an immiscible organic phase, followed by recovery into a secondary aqueous stream.

Conceptual design
The conceptual design phase includes fundamental decisions made regarding the desired chemistry or processing operations to be used, the sequencing of unit operations, the relationship of the process with other operations, and whether batch or continuous processing will be employed. Often these decisions must be made prior to the collection of any engineering data regarding actual process yields, generation of reaction by-products, or the efficacy of any needed separation steps.

Crystalline
Being, relating to, or composed of crystals.

Crystalline silicotitanate
Insoluble granular inorganic solid ($Na_4SiO_4 \bullet TiO_2$) ion exchange material developed through a cooperative research and development agreement between DOE and private industry. Provides capability for removing cesium from acid or alkaline salt solutions containing high potassium concentrations.

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

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 will typically 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.

Table 1-1. (Continued).

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

Hazardous waste
A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 40 CFR 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the U.S. Environmental Protection Agency in 40 CFR 261.31 through 40 CFR 261.33. Source, special nuclear, or by-product materials as defined by the Atomic Energy Act are not hazardous waste because they are not solid waste under RCRA.

High-level radioactive waste (HLW)
Defined by statute (the Nuclear Waste Policy Act) to mean 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 nuclides in sufficient concentrations) and other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule requires permanent isolation. The NRC has not defined "sufficient concentration" of fission products or identified "other highly radioactive material that requires permanent isolation." The NRC defines HLW to mean irradiated (spent) reactor fuel, as well as liquid waste resulting from the operation of the first cycle solvent extraction system, the concentrated wastes from subsequent extraction cycles in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted.

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 medium (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.

Low-level radioactive waste (LLW)
LLW is radioactive waste that does not meet the definition of high-level, transuranic waste, spent nuclear fuel, or by-product tailings from processing of uranium or thorium. LLW contains typically 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.

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

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

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

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

Table 1-1. (Continued).

Radiolytic decomposition	A physical process in which a compound is broken down into simpler compounds or elements from the absorption of sufficient radiation energy to break the molecular bonds.
Radionuclide/Isotope	A radionuclide is an unstable isotope that undergoes spontaneous transformation, emitting radiation. An isotope is any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number), but different numbers of neutrons, so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable, carbon-14 is radioactive).
Reagent	Substance used in a chemical reaction to detect, measure, examine, or produce other substances.
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 evaporation and concentration of the supernatant.
Salt supernatant	Highly concentrated solution of the salt component in HLW tanks.
Sorbent	A material that sorbs another substance; (i.e., that has the capacity or tendency to take up the substance by either absorption or adsorption).
Sludge	Sludge components of HLW consist of the insoluble solids that have settled at the bottom of the HLW storage tanks. Radionuclides present in the sludge include fission products and long-lived actinides.
Sodium Tetraphenylborate	Organic reagent used in tetraphenylborate precipitation process for removal of radioactive cesium from HLW salt solution. Chemical formula for sodium tetraphenylborate is $Na(C_6H_5)_4B$.
Tetraphenylborate Precipitation	Process used to separate cesium, potassium, and ammonium constituents from HLW salt solution by formation of insoluble solids. The process is projected for use in the Small Tank Precipitation salt processing alternative.
Vitrify or 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. Scientists have long considered this glassification process, called "vitrification," to be the preferred option for immobilizing high-level radioactive liquids into a more stable, manageable form until a Federal repository is ready.

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

References

DNFSB (Defense Nuclear Facilities Safety Board), 1996, Defense Nuclear Facilities Safety Board Recommendation 96-1 to the Secretary of Energy, pursuant to 42 U.S.C. § 286a(a)(5) Atomic Energy Act of 1954, as amended, John Conway, Chairman. http://www.dnfsb.gov/recommend/96-1.htm. Accessed June 1, 1999.

DOE (U.S. Department of Energy), 1982, *Final Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1987, *Final Environmental Impact Statement, Waste Management Activities for Groundwater Protection*, DOE/EIS-0120, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082S, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995, *Final Environmental Impact Statement, Waste Management*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Rev. 1, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998a, *DOE/SR Review Team Final Report on the High-Level Waste Salt Disposition Alternative*, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998b, *Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options*, DOE/EIS-0082-SA-03, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998c, *Glossary of Terms Used in DOE NEPA Documents*, Environmental, Safety and Health, Office of NEPA Policy and Assistance, Washington, D.C.

DOE (U.S. Department of Energy), 2000a, "Additional Research and Development (R&D) of Caustic Side Solvent Extraction (CSEX) Alternative." Letter from R. Schepens, DOE, to W. G. Poulson, Westinghouse Savannah River Company, February 15.

DOE (U.S. Department of Energy), 2000b, *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, Office of Environmental Management, Washington, D.C.

GAO (General Accounting Office), 1999, *Nuclear Waste–Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work*. GAO/RCED-99-69, Washington, D.C.

NAS (National Academy of Sciences), 1999, Interim Report on Technical Review of Alternatives for Processing High-Level Radioactive Waste Salt Solution at Savannah River Site. Letter from M. Levinson and G. Choppin, NAS, to E. J. Moniz, U.S. Department of Energy, October 14, 1999.

WSRC (Westinghouse Savannah River Company), 1996, *Approved Site Treatment Plan (U),* WSRC-TR-94-0608, Rev. 4, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998, *High-Level Waste Salt Disposition Systems Engineering Team Final Report*, WSRC-RP-98-00170, Rev. 0, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999a, *Savannah River Site High-Level Waste Tank Space Management Team Final Report*, WSRC-RP-99-00005, Rev. 0, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, *High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report*, WSRC-RP-99-00007, Aiken, South Carolina.

CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

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

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

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

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

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

Milestones for Salt Processing Alternatives

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

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

Source: (WSRC 2000).

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

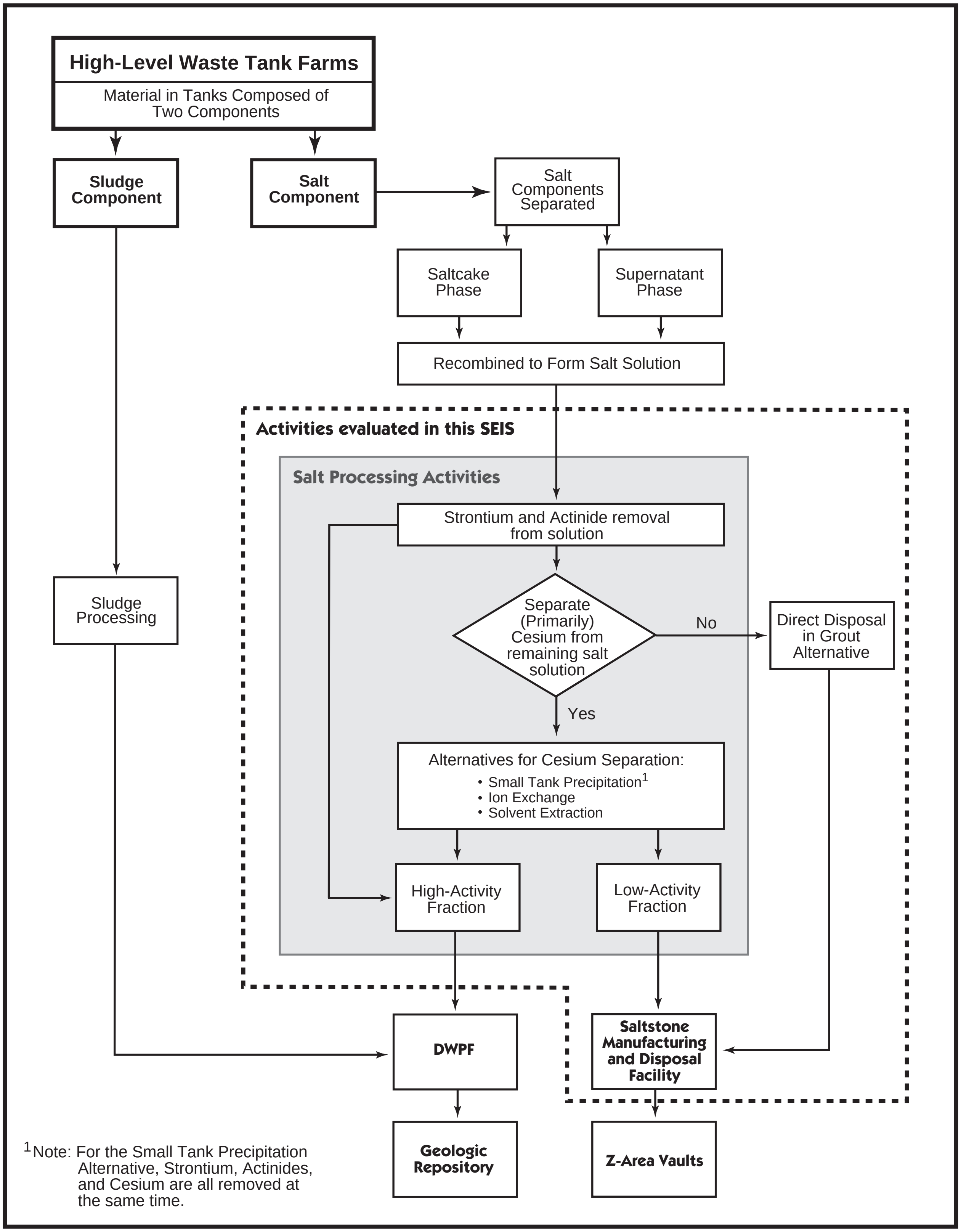

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Figure 2-1. Process Flow for High-Level Waste at the Savannah River Site.

Radionuclides

Antimony (Sb)

Antimony is a silver-white, metallic element. Antimony-125 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for antimony is Sb. Sb-125 has a half-life of 2.7 years

Carbon (C)

Carbon is a black nonmetallic element. Carbon-14 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Carbon is C. C-14 has a half-life of 5,700 years.

Cesium (Cs)

Cesium is a silver-white, highly reactive, metallic element. Cesium-137, -135, and -134 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for cesium is Cs. Cs-137 has a half-life of 30 years, Cs-135 has a half-life of 2.3 million years, and Cs-134 has a half-life of 2 years.

Iodine (I)

Iodine is a nonmetallic halogen element. Iodine-129 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Iodine is I. I-129 has a half-life of 16 million years.

Plutonium (Pu)

Plutonium is a man-made, silver-gray metallic element in the actinide series. All isotopes of plutonium are radioactive. Plutonium is a fission fuel for reactors and atomic weapons. Plutonium-239 principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for plutonium is Pu. The half-life of Pu-239 is 24,000 years.

Ruthenium (Ru)

Ruthenium is a grayish metallic element. Ruthenium-106 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Ruthenium is Ru. Ru-106 has a half-life of 372 days.

Selenium (Se)

Selenium is a lustrous gray nonmetallic element. Selenium-79 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Selenium is Se. Se-79 has a half-life of 65,000 years.

Strontium (Sr)

Strontium is a silver-yellow metallic element. Strontium-90 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for strontium is Sr. Sr-90 has a half-life of 29 years.

Technetium (Tc)

Technetium is a man-made silver-gray metallic element. All isotopes of technetium are radioactive. Technetium-99 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for technetium is Tc. Tc-99 has a half-life of 200,000 years.

Tin (Sn)

Tin is a bluish white metallic element. Tin-126 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Tin is Sn. Sn-126 has a half-life of 100,000 years.

Tritium (H-3)

Tritium is a radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons. In the HLW tanks at SRS, tritium is contained in water molecules, where it replaces one of the normal hydrogen atoms. The symbol for Tritium is H-3. Tritium has a half-life of 12.5 years.

Uranium (U)

Uranium is a silver-white, highly reactive, metallic element in the Actinide series. All isotopes of uranium are radioactive. Uranium is used as a fission fuel for reactors and atomic weapons. Uranium-235 and -238 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for uranium is U. U-235 has a half-life of 700 million years and U-238 has a half-life of 4 billion years.

2.3 No Action Alternative

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, without a process for separating the high-activity and low-activity salt fractions. DWPF would vitrify only sludge from the HLW tanks. Saltcake and salt supernatant would be stored in the HLW tanks and monitoring activities would continue. Tank space would continue to be managed to ensure 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 (WSRC 1999a) and meet tank closure commitments under the No Action alternative.

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

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

- Continue to evaporate water from liquid waste
- Use tanks for HLW storage instead of In-Tank Precipitation (ITP) processing (Tanks 49 and 50)
- Reduce the DWPF low-level liquid waste stream sent to the Tank Farms
- Implement several activities that 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) to the minimum required by the Authorization Basis determined by a safety assessment (1,300,000 gallons), as necessary.

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 immediately. The course of action that DOE would follow cannot be predicted at this time, but available options may include the following, either individually or in combination.

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

Because of the speculative nature concerning DOE's future course of action, DOE provides a mostly qualitative assessment of the No Action alternative in Chapter 4.

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

2.3.1 IDENTIFY ADDITIONAL WAYS TO OPTIMIZE TANK FARM OPERATIONS

On February 26, 1999, the HLW Salt Processing Program Manager chartered the HLW Tank

Space Management Team (SM Team). The SM Team identified approximately 300 potential ways to maximize available tank space. This detailed study by experienced engineers and scientists led to an "Intermediate List" of 24 ideas, each of which was capable of increasing available tank space by more than 900,000 gallons. These ideas were grouped into strategies, and the SM Team recommended a strategy to ensure sufficient storage capacity through 2009 (WSRC 1999a). Optimizing tank farm operations would be a reasonable first step, should the No Action alternative be implemented. Additional ideas include: bypassing the tank farms by pretreating DWPF wastewater to meet the waste acceptance criteria for the Effluent Treatment Facility or Z-Area Saltstone Manufacturing and Disposal Facility; changing the operation of DWPF to reduce the wastewater stream by reducing DWPF production; installing evaporators at the DWPF or reducing sludge washing; and using tanks outside the Tank Farms, such as in the reactor areas and offsite.

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

2.3.2 REUSE TANKS SCHEDULED TO BE CLOSED BY 2019

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

2.3.3 BUILD TANKS PERMITTED UNDER WASTEWATER TREATMENT REGULATIONS

About 340,000 of the 800,000-gallons-per-year tank space requirement is due to sludge-only processing in DWPF. DWPF wastewater could be safely stored in new tanks with designs similar to those of the older (Type I) HLW tanks. These tanks have 5-foot-high secondary annulus "pans" and active cooling, but do not have the full-height secondary containment tank design used in the newest tanks (Type III). Such tanks would not be used for storage of newly generated HLW. The net capacity of each wastewater storage tank would be about 800,000 gallons. Therefore, based on scheduled completion of sludge-only processing in 2023, it would take about six tanks to hold the DWPF wastewater. The tanks would be built in a brownfield (previously disturbed) area near existing waste transfer lines. Nearly all of the resources evaluated in Section 4.1 of this SEIS would be impacted by this option. Implementing this option also would delay the regulatory commitments for tank closure and stabilization of HLW. It would require large financial commitments to provide interim storage capacity and would increase Site restoration requirements. Further, this option would not be appropriate for more than half (460,000) of the 800,000-gallons-per-year requirement.

2.3.4 BUILD TANKS PERMITTED UNDER RCRA REGULATIONS

Resource Conservation and Recovery Act (RCRA)-permitted tanks require double liners, leachate collection systems, and other characteristics designed to ensure tank integrity. The Type III tanks in the F- and H-Area Tank Farms are RCRA-compliant. They were constructed from 1969 through 1978. They have a full-height secondary tank, active cooling systems, and are above the water table. Each of these tanks has a net usable storage capacity of about 800,000 gallons. To accommodate newly generated HLW and the waste that would be generated at DWPF, 18 new tanks would be required. They could be located in a brownfield area in or near the F- and H-Area Tank Farms (associated land use impacts are presented in Chapter 4, Section 4.1).

DOE has estimated that it would take approximately five years to design, permit, and construct the first four tanks. Thus, to avoid suspending critical operations, the effort would have to be initiated in 2005.

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

2.3.5 SUSPEND OPERATIONS AT DWPF

In the event that a salt processing technology is not available by the year 2010, DOE could suspend operations at DWPF. This would not jeopardize the environment or human health. However, if the suspension of operations at this facility is not temporary, it could result in a workforce reduction, which could have a substantial negative impact on the communities surrounding SRS. This option would also seriously delay DOE's mission of processing HLW in the DWPF to produce approximately 200 canisters of vitrified HLW per year for eventual disposal in a geologic repository. In addition, DOE would eventually have to commit a large sum of money to restart these facilities to resume operations necessary to stabilize HLW. Finally, suspending operations could result in loss of technical expertise (core competency) and, depending on the length of time the facilities are shutdown, the ability to recapture these core competencies would diminish.

2.4 Selection of Salt Processing Technologies for Evaluation as Alternatives

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

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

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

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

DOE also considered the Direct Disposal in Grout technology, based on demonstrated technology, safety, operational feasibility, and potential to reduce construction and operating costs. DOE recognized, however, that this alternative, which retained a highly radioactive constituent (cesium) in the saltstone waste form for onsite disposal, could not be implemented within regulatory constraints if other alternatives that separated the radioactive cesium for incorporation into the glass waste form proved to be technically and economically practical.

2.5 Salt Processing Facility Site Identification

WSRC prepared a site selection study to identify a suitable location at the SRS for the construction and operation of a salt processing facility in S or H Areas (WSRC 1999b). The study sought to optimize siting for engineering requirements, sensitive environmental resources, and applicable regulatory requirements. The goal of the study was to evaluate alternative siting options for site building and support facilities for either the Small Tank Precipitation technology, the Ion Exchange technology, or the Solvent Extraction technology.

Siting of the salt processing facility would be constrained by an operational requirement that it be located near the HLW processing facilities (in F, H, and S Areas, see Figure 2-2). In order to transfer the solids slurry at the proper solids concentration from the salt processing facility to the DWPF, the salt processing facility must be located within 2,000 feet of the DWPF or a low point pump pit. This constraint identified general areas suitable for construction and operation. Thirteen areas with sufficient acreage for the buildings, construction laydown, and support facilities were identified. Subsequent evaluation of these areas resulted in the identification of four candidate sites (A [subsequently excluded], B, C, and D) in S Area (Figure 2-2). A comparative analysis of the sites provided a total score, based on geological, ecological, human health, and engineering considerations. No distinct differences were identified among the four sites for geological, ecological, or human health considerations. Therefore, because Site B was superior to Sites C and D on the basis of engineering and total score, it was selected as the preferred site.

For purposes of analysis and comparison, DOE assumes in this SEIS that all facilities for the Small Tank Precipitation, the Ion Exchange, and the Solvent Extraction technologies would be located at Site B.

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

2.6 Salt Processing Alternatives

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

The alternatives, as described below and detailed in Appendix A, are based on preconceptual designs (WSRC 1998b). As conceptual designs are developed, the components of the process could be modified to optimize the efficiency, safety, environmental protection, and economics of the process. For example, DOE may need to increase the capacity of process or storage vessels to ensure continuous operation of the salt processing facility, which would receive batch input from the Tank Farms and transfer its clarified waste stream and HLW products, respectively, to batch operations in the Saltstone Manufacturing and Disposal Facility and

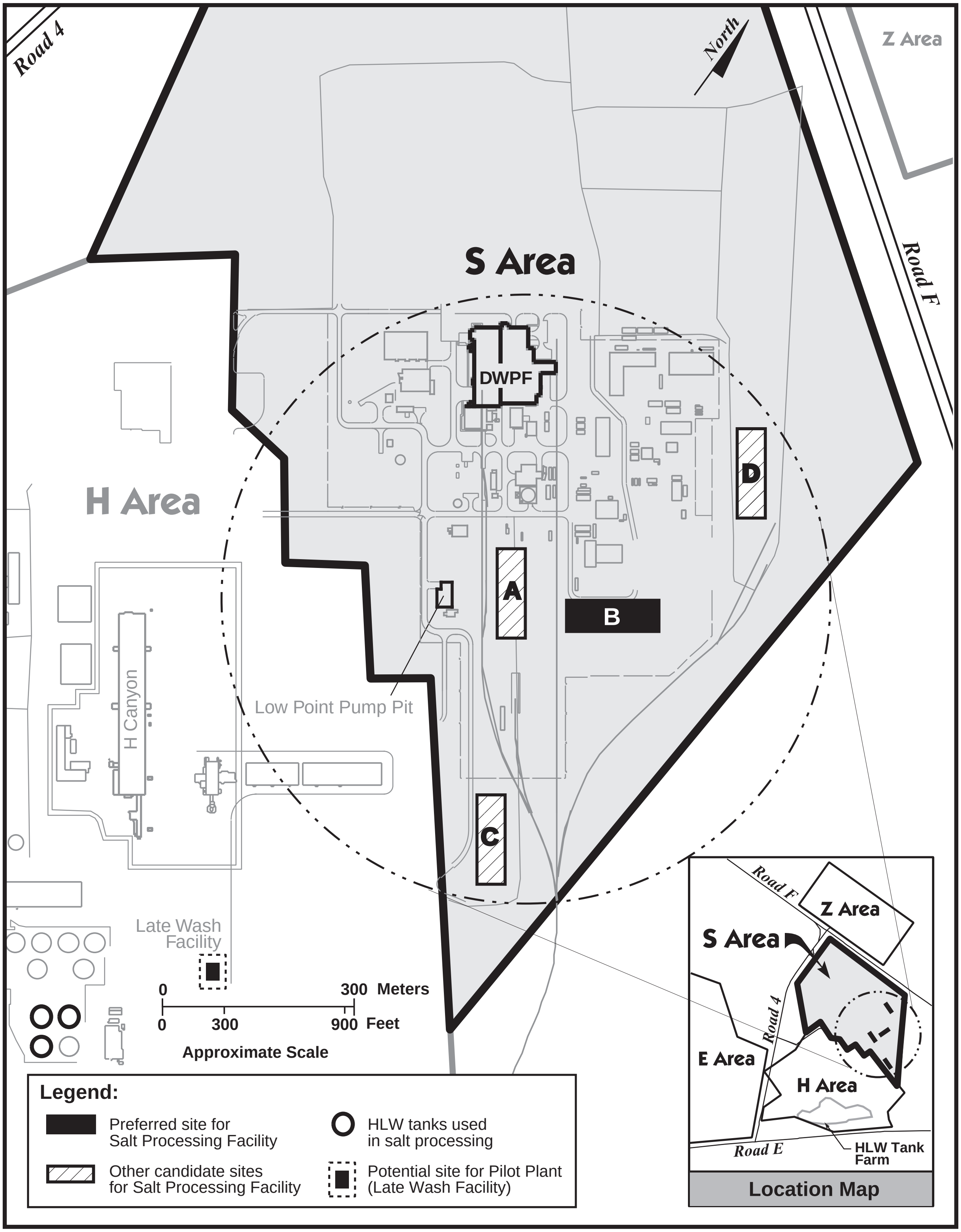

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Figure 2-2. Potential salt processing facility sites in S Area.

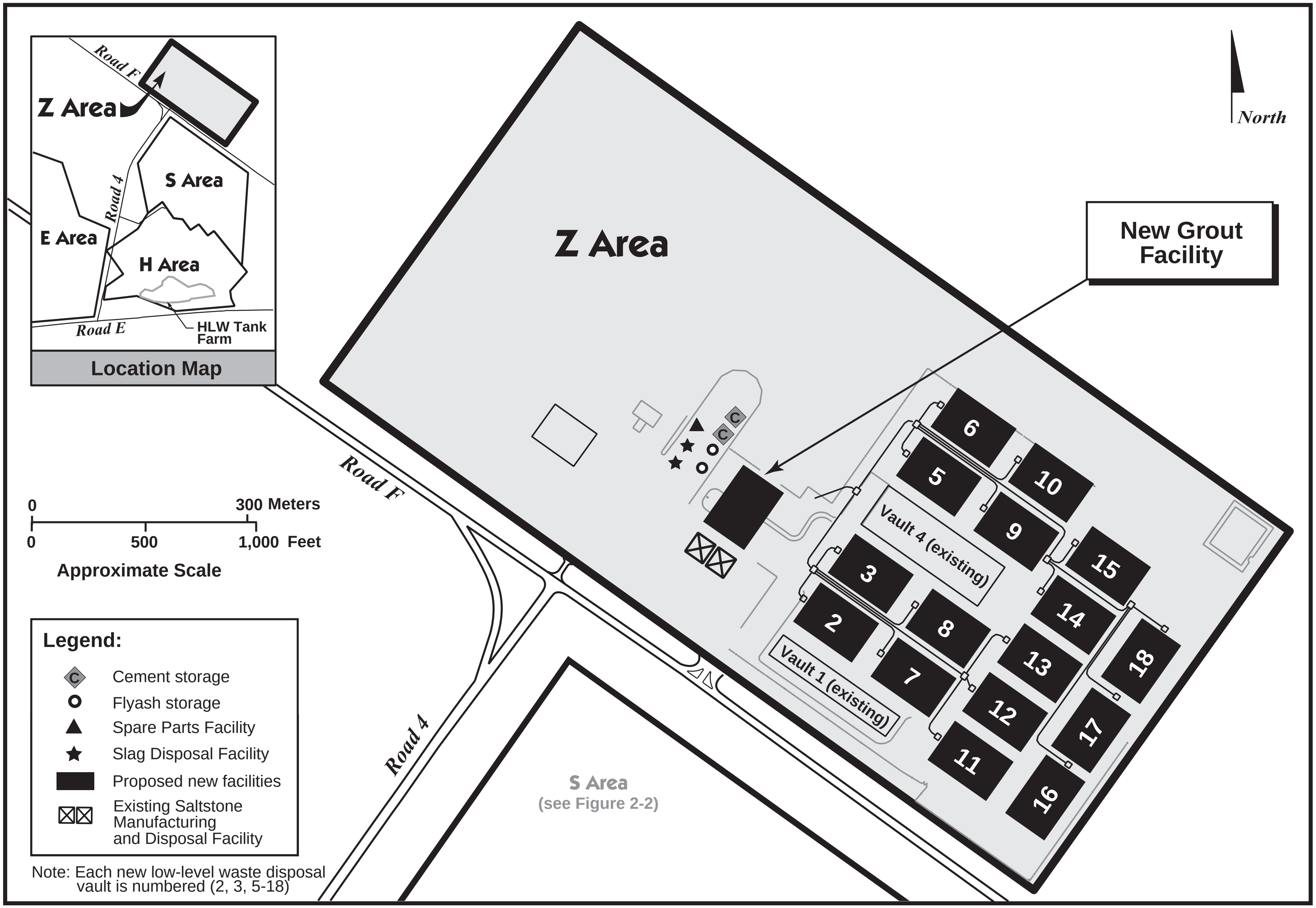

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Figure 2-3. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

DWPF. DOE will consider whether any modification that develops during conceptual or final design requires further environmental review under the National Environmental Policy Act (NEPA).

DOE, with the help of independent experts, has performed research on each of the four process alternatives to establish the technological risk(s) involved in implementing each one. The results of the research were reviewed by impartial scientists (DOE 1998). DOE has also evaluated the life-cycle cost and schedule for construction and operation for each alternative (WSRC 1998c). This Draft SEIS assesses the potential environmental impacts of each alternative, which are evaluated in Chapter 4 and compared in Section 2.9.

DOE has not yet selected a preferred alternative for processing HLW salt. This selection will be based on continuing research, evaluation, and independent review of the technology alternatives, with the preferred alternative to be identified in the final SEIS.

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

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

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

The final waste forms are similar for each alternative, except Direct Disposal in Grout, with the high-activity salt fraction extracted from the salt and incorporated into the DWPF glass waste form for eventual repository disposal, and the low-activity salt fraction immobilized as saltstone for onsite disposal. Greater detail is provided in Appendix A, Technology Descriptions.

Table 2-1. Comparison of salt processing alternatives.

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

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

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

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

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

Centrifugal contactor
A device used in Solvent Extraction salt processing alternative to separate cesium from HLW salt solution. Aqueous waste enters 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.

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

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

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

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

Nitrite
Any member of a class of compounds derived from nitrous acid. Salts of nitrous acid are ionic compounds containing the negative nitrite ion, NO_2, and a positive ion such as sodium (Na) in sodium nitrite ($NaNO_2$).

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

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

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

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

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

2.6.1 SMALL TANK PRECIPITATION

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

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

Small Tank Precipitation Features

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

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

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

2.6.2 ION EXCHANGE

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

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

The Ion Exchange process would result in the accumulation of as much as 15 million curies of radioactive cesium on the resin inventory within

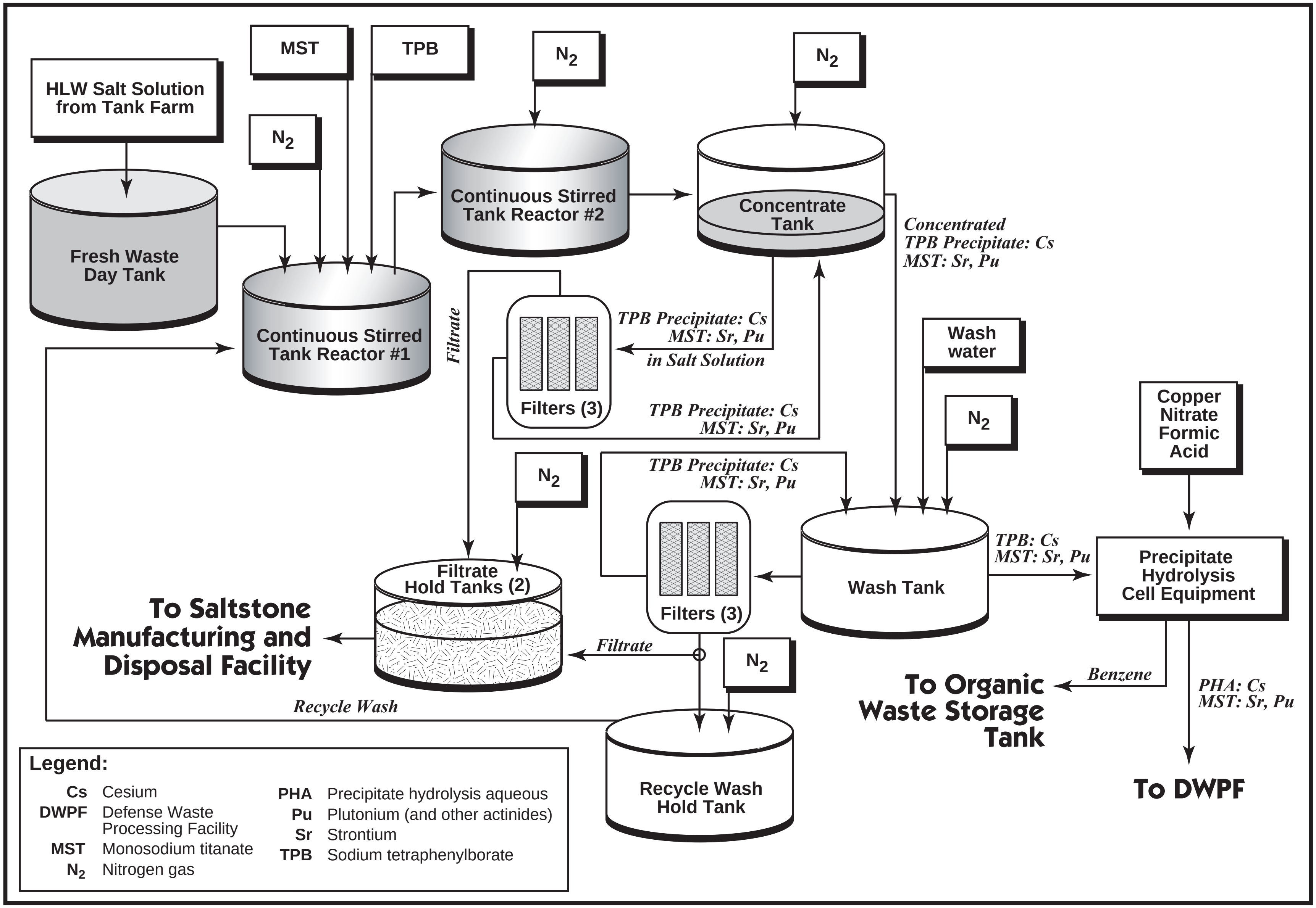

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Figure 2-4. Small Tank Precipitation process flow diagram.

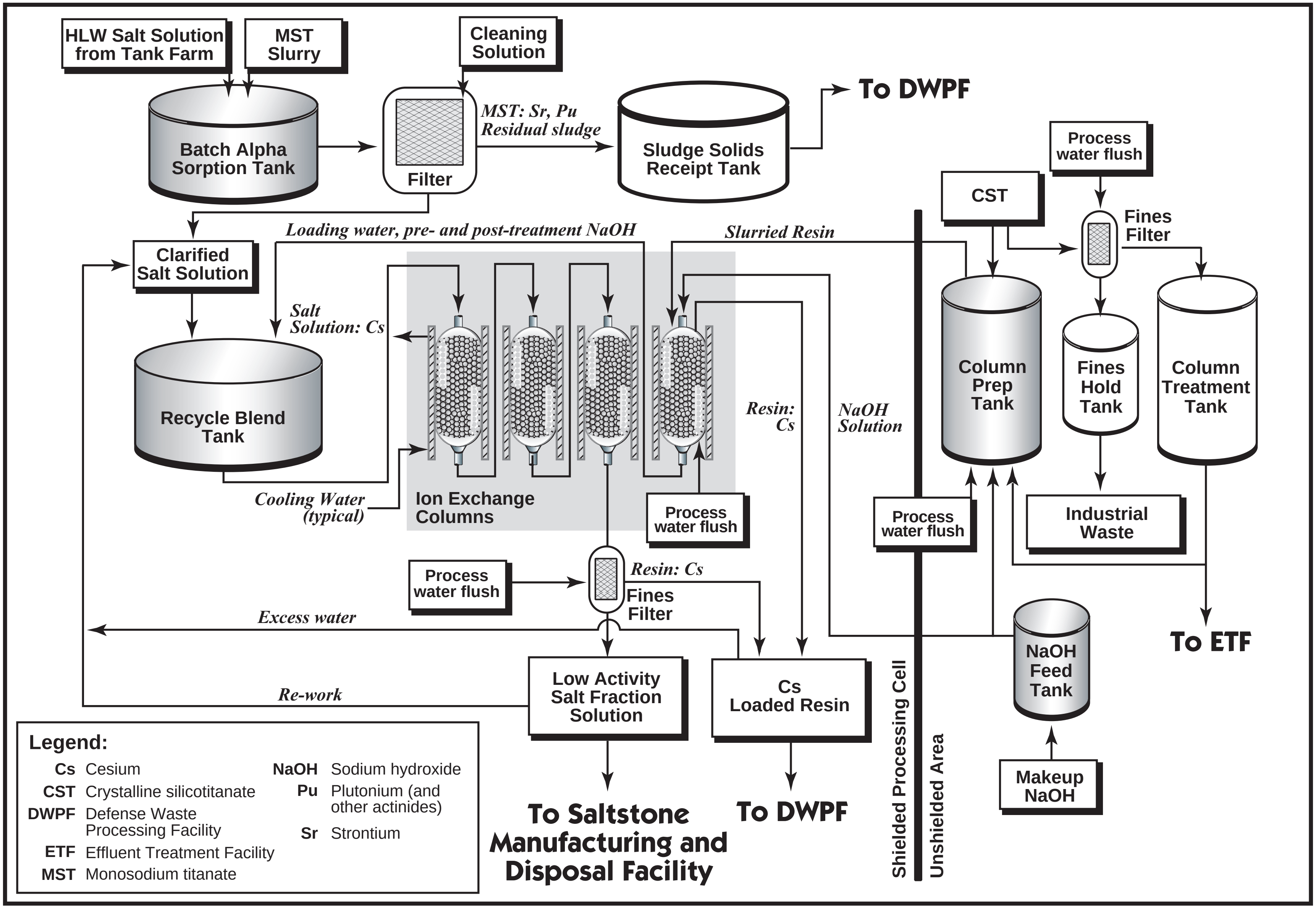

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Figure 2-5. Ion Exchange process flow diagram.

the process cell. This radioactive loading would necessitate stringent shielding requirements and operational controls because of high radioactivity, high heat generation, and the generation of hydrogen and other gases.

2.6.3 SOLVENT EXTRACTION

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

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

2.6.4 DIRECT DISPOSAL IN GROUT

Under the other three technologies considered in this SEIS, cesium would be removed from the salt solution and eventually disposed of, along with the high-activity fraction, as HLW. Under the Direct Disposal in Grout alternative, the HLW salt solution would be disposed of onsite as saltstone, without prior 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 a low-level waste. The monosodium titanate slurry would be transferred to DWPF for incorporation into HLW glass.

The clarified salt solution resulting from monosodium titanate treatment would be combined with **flyash**, **cement**, and **slag** in a grout mixer for disposal in the saltstone vaults. The resulting waste form would meet 10 CFR 61.55 Class C low-level waste limits for near-surface disposal, but would exceed Class A limits. Current regulations require SCDHEC notification if wastes in saltstone vaults exceed the Class A limits.

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

2.7 Salt Processing Facilities

2.7.1 PROCESS INPUTS AND PROCESSING REQUIREMENTS

Design of salt processing facilities depends on specifications of processing requirements, including process input and product output. Volumes of input streams and requirements for their processing to final forms are summarized in Table 2-3. The specified capacities of the process facilities would maintain an average processing of about 6 million gallons of waste salt solution per year, allowing complete processing of about 80 million gallons total (approximate volume of salt solution when the saltcake is dissolved) within about 13 years after facility startup (WSRC 1999c). It is important to finish processing the salt waste within this time so that the HLW sludge and the high-activity fraction of the HLW salt can be vitrified together in the DWPF. If salt processing is delayed beyond 2010 so that salt waste must be vitrified separately, the total number of HLW canisters would be greatly increased over that projected for concurrent sludge-salt waste vitrification. Vitrification of the combined HLW sludge and salt would produce about 5,700 glass waste canisters.

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

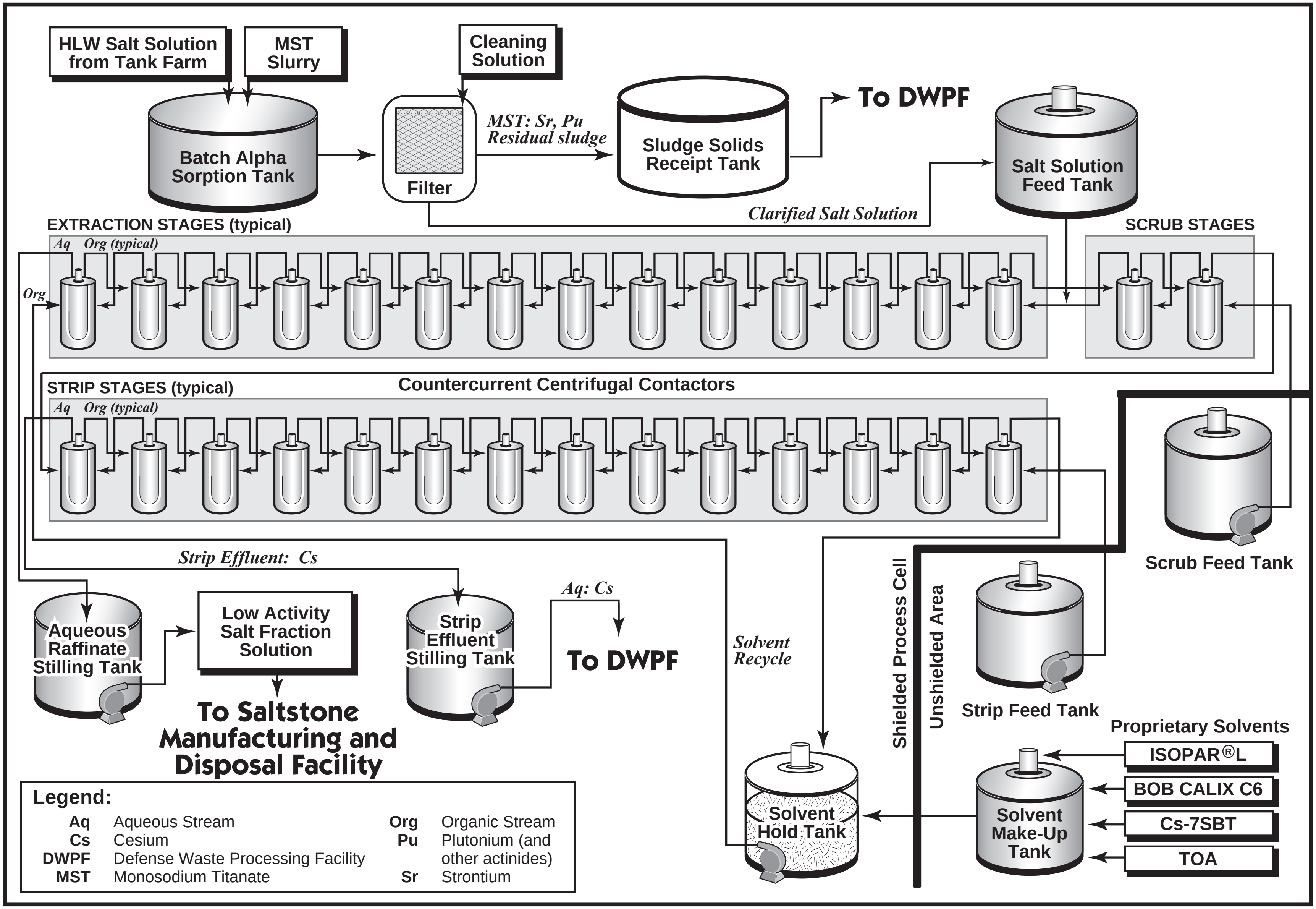

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Figure 2-6. Solvent Extraction process flow diagram.

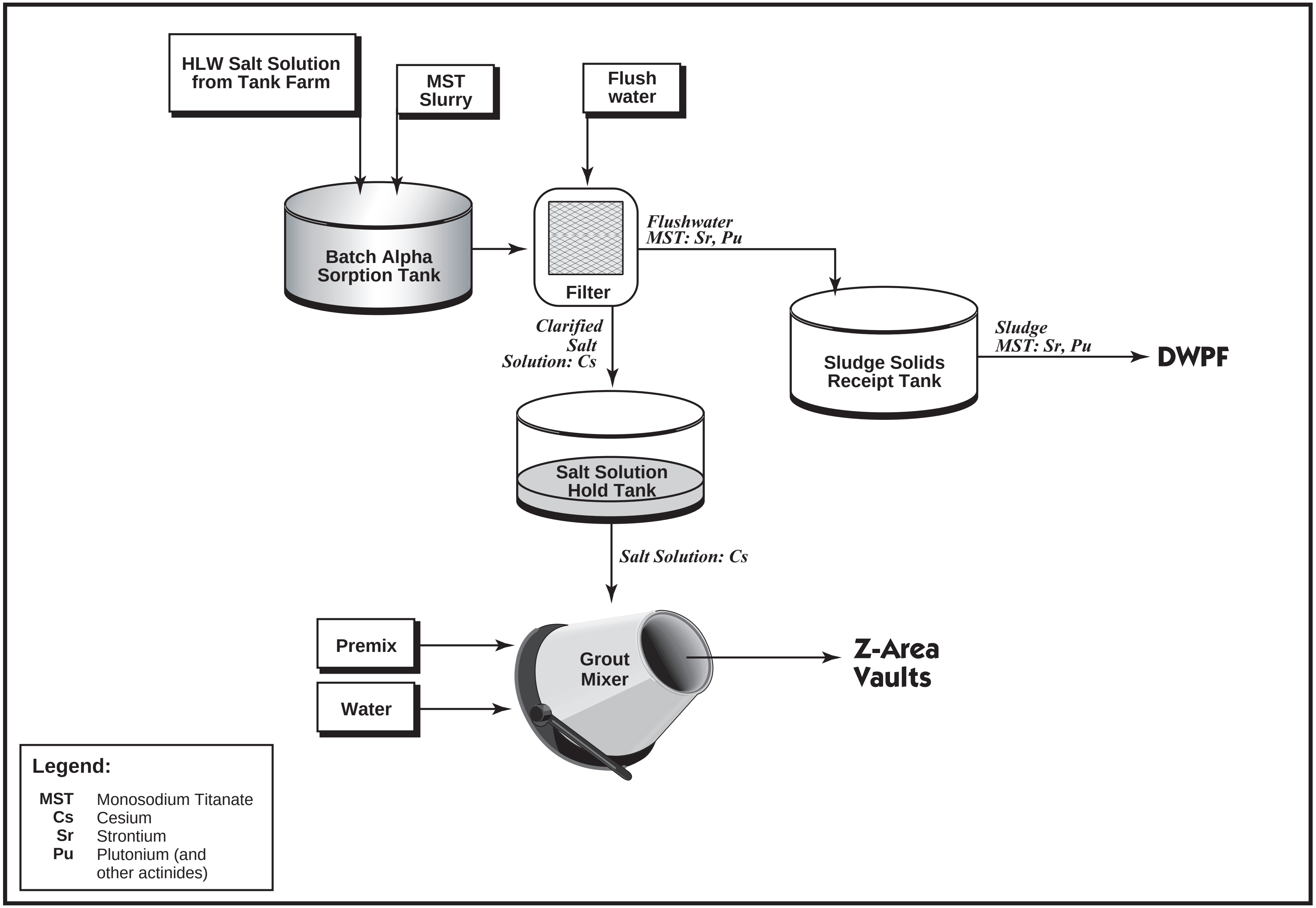

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Figure 2-7. Direct Disposal in Grout process flow diagram.

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

	Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Capacity throughput of salt solution (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[a]	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks
Number of years for construction of process facilities[b]	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[c]	13[d]	13[e]	13[f]
Planned canister production per year[g,h]	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced[g,h]	≈5,700	≈5,700	≈5,700	≈5,700
New Class A vaults[i]	16[c]	13[d]	15[j]	0[f]
New Class C vaults[i]	0[c]	0[d]	0	13[f]

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a. WSRC (1998b).
b. WSRC (1998c).
c. WSRC (1998d, 2000).
d. WSRC (1998e).
e. WSRC (1998f).
f. WSRC (1998g).
g. WSRC (2000) target case.
h. DWPF planned glass waste canister production includes both sludge and salt wastes.
i. New saltstone vaults for onsite disposal of processed salt solution.
j. This alternative would require between 14 and 15 vaults (WSRC 1998f) for purposes of impact analysis, 15 vaults were assumed.

sludge in the glass waste form. As many as 16 saltstone vaults in addition to the two existing vaults would be required for final disposal of the low-activity salt solution.

2.7.2 PRODUCT OUTPUTS

The product outputs from the process facilities, including high-radioactivity solids slurry or solution to DWPF, low-activity salt solution to grout, and saltstone generated by the salt processing alternatives are compared in Table 2-4. The Solvent Extraction facility would deliver a greater volume of product to DWPF than the other facilities because of the relatively high volume of cesium solution (strip effluent) in its product output. However, the amount of sludge processed at DWPF is the primary determinant for canister production. Therefore, the high volume of cesium solution from the Solvent Extraction facility would not affect the number of glass waste canisters produced. Differences between alternatives in salt solutions to grout and the product grout produced are not considered significant because there is a 25 percent uncertainty in the materials balance estimate.

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

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

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

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

zene. About 60,000 gallons per year (20 metric tons per year) of liquid benzene would be produced by decomposition of the tetraphenylborate salt in the precipitation hydrolysis process, to be stored for final disposition.

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

2.7.3 PROCESS FACILITIES

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

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

New shielded process buildings would be constructed, regardless of the salt processing alternative selected. The preferred site for the process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives is at Site B in S Area. The process building for the Direct Disposal in Grout alternative would be in Z Area. In each case, the process buildings would be constructed of reinforced concrete and contain shielded cells designed to handle highly radioactive materials.

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

2.7.4 SUPPORT FACILITIES

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

2.7.5 Z-AREA VAULTS

As shown in Table 2-3, as many as 16 new 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 2-2). The concrete vaults would be 300 feet long by 200 feet wide by 25 feet high. Each vault would consist of six cells, 100 feet long by 100 feet wide. Due to the heat generated during grout solidification, the cells in each vault would be filled in a rotation that would meet grout cooling requirements. All vaults would be equipped with cameras and lights to monitor filling and thermocouple assemblies to monitor heat generation during the curing process. As with the original saltstone vaults, the new vaults would be constructed at or somewhat below grade and covered over with soil after vault closure for additional shielding. Figure 2-8 illustrates how Z Area would look after vault closure.

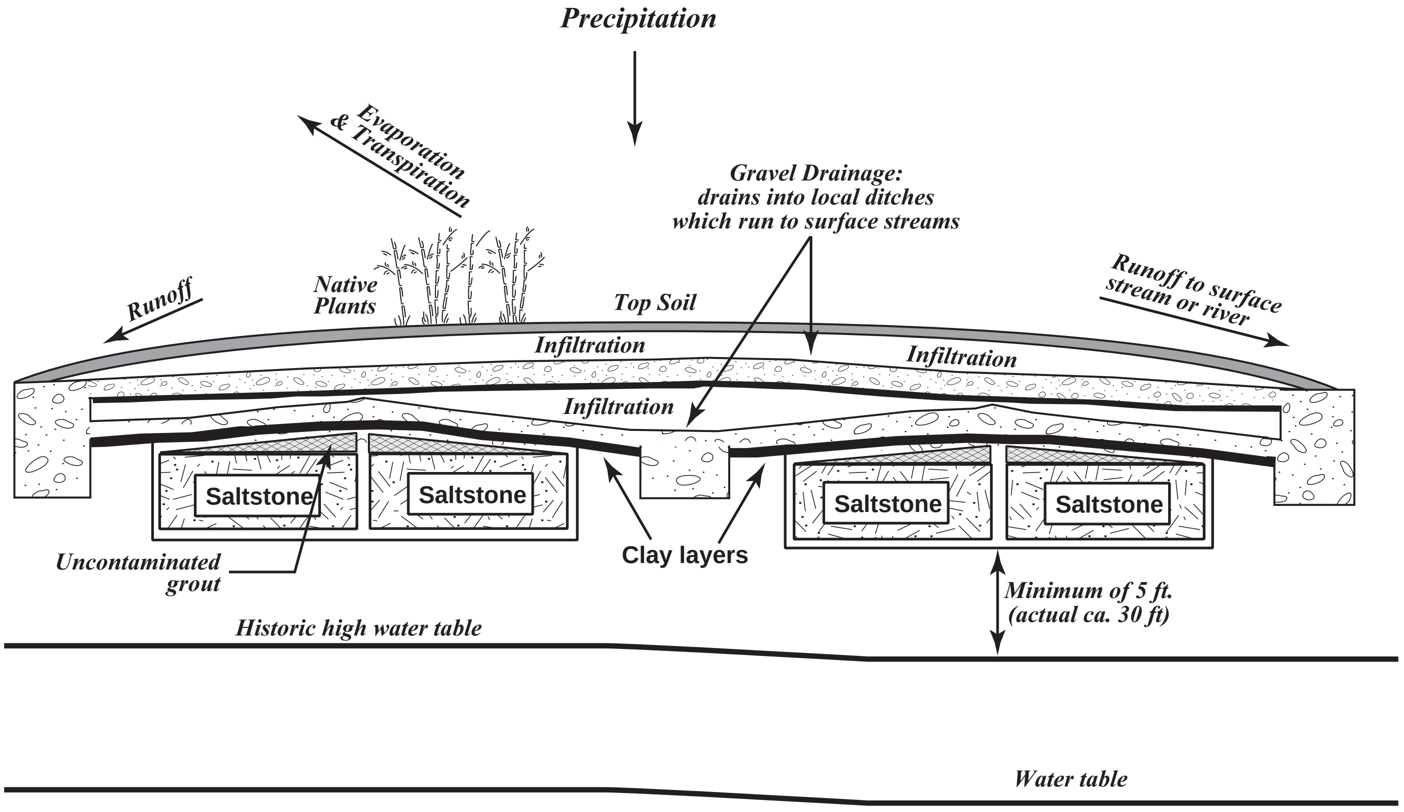
For the Direct Disposal in Grout alternative, 13 new vaults would be constructed in Z Area. Because the grout would contain large amounts of radioactive cesium, the disposal procedure for this alternative would differ from that of the other three alternatives. Each vault would have a 500-cubic-foot-per-minute ventilation system, equipped with high-efficiency particulate air filters that would operate during the cell-filling process for temperature control while the saltstone cures. Radiation monitors and dampers would be included. Because the other three alternatives would remove more radionuclides (including radioactive cesium) from the low-activity salt solution forced air ventilation would not be required under those alternatives. 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.

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

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

Source: WSRC (1998c).

a. Building specifications rounded to two significant figures.



Source: Martin Marietta, 1992.

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

2.7.6 PILOT PLANT

If DOE selects a salt processing alternative, a Pilot Plant would be designed and constructed to provide pilot-scale testing of process technology before construction and operation of the full-scale facility. The Pilot Plant would serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address key technical uncertainties will be completed in April 2001, but the uncertainties cannot be fully addressed without the performance of pilot-scale tests using actual waste from the SRS HLW system. Initial pilot-scale demonstrations would provide data required to perform preliminary and final design of the full-scale facility. Extended operation cycles, by varying operating parameters and feed blends, would provide the needed assurance and understanding of how the process works to complete full-scale design and start construction. Data on unit operations and their integration into a coordinated process would be collected, process extremes and upset conditions would be investigated, equipment operation would be evaluated, and process streams would be qualified for full-scale operations. The Pilot Plant would also provide a facility for training engineers and operators.

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

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

Detailed design and construction of the Pilot Plant would be initiated upon selection of the salt processing alternative and operation would extend through completion of final design and 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 design to facilitate remote installation and modification of the process equipment.

Services that would be provided to support operations 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 the low-level waste vaults.

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

2.7.7 FACILITY DECONTAMINATION AND DECOMMISSIONING

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

Design features that would be incorporated into the facility include the following:

- Modular confinement would be used for radioactive and hazardous materials to preclude contamination of fixed portions of the structure
- Long runs of buried piping that would carry radioactive or hazardous materials would be minimized to the extent possible, and provisions would be included in the design that would allow testing of the integrity of joints in buried pipelines
- The facility would be designed to facilitate dismantlement, removal, and packaging of contaminated equipment
- Lifting lugs would be used on equipment to facilitate remote removal from the process cell
- The piping systems that would carry hazardous products would be fully drainable.

2.8 Other Decision-Making Factors

2.8.1 NATIONAL ACADEMY OF SCIENCES REVIEW COMMITTEE FINAL REPORT

In response to a June 1999 request from the Under Secretary of Energy, the National Academy of Sciences - National Research Council provided an independent technical review of alternatives for processing the HLW salt solutions at the SRS. The review was conducted by a committee composed of expert consultants in fields of nuclear reactor and fuel cycle technology, nuclear chemistry and separations, environmental sciences, and nuclear waste disposal. The Under Secretary requested that the Council provide a preliminary report by the end of September 1999 to identify any significant issues or problems with the alternatives that could be factored into the Draft SEIS. The Council issued an interim report in October 1999. Since issuance of the Draft SEIS was delayed for over a year, the Council actually issued a final report in October 2000, prior to the issuance of this SEIS. The final Council Report (NRC 2000) endorsed in general the selection of the four candidate processes considered as alternatives for salt disposal, concluding that each of the processes was potentially appropriate and no obvious major processing options were overlooked. Recommendations for addressing the technical uncertainties associated with each of the alternative were identified, with schedule constraints and potential regulatory restrictions noted.

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

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

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

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

- *Council Conclusions:* Although deemed complex and based mainly on expert judgment employing qualitative factors, the screening procedure did result in four potentially appropriate processing alternatives.
- *DOE Actions:* Since the Council determined that the screening procedure resulted in four potentially appropriate processing alternatives, DOE took no subsequent action.

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

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

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

  Preliminary discussions with the regulators (Nuclear Regulatory Commission, SCDHEC, and EPA, Region IV) indicate general acceptance of the Direct Disposal in Grout concept, provided DOE could establish that the final waste form is not HLW. Current DOE policy includes a requirement that "key radionuclides" must be removed from HLW to the maximum extent technically and economically practical, before permitting disposal as "waste incidental to reprocessing" in a low-level waste shallow-land disposal facility. DOE considers cesium to be a "key radionuclide" in HLW. It appears that there are at least three alternatives that can technically and/or economically remove cesium from HLW. Therefore, DOE has decided not to pursue further regulator involvement in pursuit of the Direct Disposal in Grout alternative until it is determined that cesium removal by the other alternatives is not technically or economically practical.

  DOE agrees with the concept of applying an integrated systems engineering approach to salt processing. The HLW System at SRS is fully integrated and managed in consideration of the broad range of operational and regulatory constraints and requirements to achieve acceptable end states and meet the acceptance criteria for the Defense Waste Processing and Saltstone facilities. This approach is reflected in the *High-Level Waste System Plan* (WSRC 2000) and used in all HLW system planning and productions activities, including the evaluation of salt processing options. In order to conserve tank space and optimize processing for disposal in saltstone, studies have been performed to possibly take advantage of the HLW salt solution variability by tailoring waste processing. While there is variability in salt waste, a review of waste characterization data for all receipt and storage tanks indicates that saltstone grout produced from the lowest-activity tank would challenge the basis for the current saltstone operating permit. Additionally, strategies based on multiple process facilities tailored to individual tanks or groups of tanks are not considered to be viable from a cost perspective or environmentally sound when decontamination and decommissioning impacts are considered. Further evaluations of waste processing options will continue through the HLW system planning process in parallel with technology development and down-selection activities.

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

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

- *Council Conclusions:* Several recommendations are made for additional R&D to address remaining scientific and technical uncertainties for each of the four salt processing options. These recommendations generally include:
  - Resolution of technical questions concerning reaction kinetics of the monosodium titanate process for removal of strontium and actinides, as advanced for all alternatives
  - Improved understanding of the tetraphenylborate decomposition process, especially catalytic reactions responsible for benzene generation
  - Evaluation of cesium desorption and resin deactivation in alkaline solutions as encountered in the Ion Exchange process
  - Continued development of the Solvent Extraction process to resolve potential solvent instability, recycle, and contaminant problems, and to establish availability of the extraction agents in quantities required for large-scale processing
  - Establishing regulatory acceptance for the Direct Disposal (of cesium) in Grout alternative.
- *DOE Actions:* R&D activities to address each of the Council's recommendations for additional R&D work on remaining scientific and technical uncertainties were included in, and implemented in accordance with, the R&D Program Plan (TFA 2000), issued by DOE's Tanks Focus Area in May 2000. R&D activities necessary to support a technology down-selection decision are scheduled to be completed in April 2001. As discussed above, DOE will not pursue regulatory acceptance of the Direct Disposal in Grout alternative any further, unless it is determined that the cesium-removal technologies are not economically or technically practical.

2.8.2 SELF-PROTECTING HLW CANISTERS

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

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

2.8.3 COST

Based on the preconceptual designs prepared and used by the Salt Processing Systems Engineering Team, the cost through construction of the alternatives would range from $900 million to $1.2 billion (WSRC 1998a). Based on this very preliminary information, the Direct Disposal in Grout alternative is the least costly. However, as designs are refined, the cost estimates will change and estimates for each of the alternatives could be higher or lower. Because the designs are preliminary, DOE does not consider the cost estimates to be reliable enough to use as a discriminating factor. Cost estimates will, however, continue to be refined and evaluated in the ultimate selection of an alternative for implementation.

2.9 Comparison of Alternatives

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

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

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

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

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

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

2.9.1 SHORT-TERM IMPACTS

Section 4.1 presents the potential short-term impacts (those that would occur between the approximate years 2001 and 2023) for each of the action alternatives and No Action. These potential impacts are compared among the four action alternatives in Table 2-6 for normal operations. Because the specific activities that would be pursued under the No Action alternative have

Table 2-6. Summary comparison of incremental life-cycle impacts to the SRS baseline by salt processing alternative.

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

Table 2-6. (Continued).

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

Table 2-6. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Particulate matter (≤10 μm) - 24 hr. (Standard - 150)	130[d]	Minimal[b]	0.070	0.070	0.070	0.070
Carbon monoxide - 1 hr. (Standard - 40,000)	10,350[d]	Minimal[b]	15	15	15	18
Ozone - 1 hr. (Standard - 235)	216[d]	Minimal[b]	ND	ND	ND	ND
Nitrogen dioxide (NO_2) - annual (Standard -100)	26[d]	Minimal[b]	0.030	0.030	0.030	0.030
Lead - max. quarterly (Standard - 1.5)	0.03[d]	Minimal[b]	4.0×10^{-7}	4.0×10^{-7}	4.0×10^{-7}	4.0×10^{-7}
Beryllium - 24 hr. (Standard - 0.01)	0.0090[d]	Minimal[b]	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Mercury - 24 hr. (Standard - 0.25)	0.03[d]	Minimal[b]	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Benzene - 24 hr. (Standard - 150)	5[d]	Minimal[b]	4.0	0.0010	0.0010	0.0010
Biphenyl - 24 hr. (Standard - 6)	0.02[d]	Minimal[b]	0.45	None	None	None
Methanol - 24 hr. (Standard - 1,310)	0.9[d]	Minimal[b]	0.32	0.32	0.32	0.53
Annual radionuclide emissions (curies/year): (Doses are reported in Worker and Public Health Section.)	No Change[e]	Minimal[b]	5.3	18.2	25.4	9.3[f]
Worker and Public Health						
Radiological dose and health impacts to the public:						
Maximally-exposed individual (mrem/yr.)	No Change[g]	Minimal[h]	0.20	0.049	0.31	0.086
MEI project-phase latent cancer fatality	No Change[g]	Minimal[h]	1.3×10^{-6}	3.2×10^{-7}	2.0×10^{-6}	5.6×10^{-7}
Offsite population dose (person-rem/yr.)	No Change[g]	Minimal[h]	12.0	2.9	18.1	4.0
Offsite population project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	0.078	0.019	0.12	0.026

Table 2-6. (Continued).

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

Table 2-6. (Continued).

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

Table 2-6. (Continued).

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

Table 2-6. (Continued).

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

Table 2-6. (Continued).

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

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

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

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

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

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

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

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

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

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

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

k. Material shipments and associated accident and injury rates for construction transportation of up to 18 new HLW tanks would be similar to those identified under the action alternatives.

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

m. DOE could build as many as 18 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.

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

ND = Not Determined.

not been determined, only those potential activities that would be expected to have an impact on a given resource area are discussed in this section.

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

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

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

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

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

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

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

For doses to the noninvolved (onsite) worker, the involved worker, and the collective onsite population from the estimated annual radioactive emissions. The highest estimated dose would occur under the Solvent Extraction alternative, with the Small Tank Precipitation having similar results and the Ion Exchange and the Direct Disposal in Grout alternatives having lower doses. The maximum dose to the noninvolved and involved worker would be 4.8 millirem per year and 22.8 millirem per year, respectively, with radioactive cesium emissions contributing about 98 percent of the total dose. The maximum estimated dose to the onsite population would be 6.5 person-rem per year, with 94 percent of this total dose due to radioactive cesium emissions. Under the No Action alternative, air emissions from all potential scenarios would be similar to those from ongoing operations at the HLW Tank Farms.

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

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

Radiation Dose and Cancer Fatalities

Worker and public health impacts are expressed in terms of latent cancer fatalities. The primary health effect of radiation is an increased rate 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 the action would result in no additional cancer risks to the exposed population.

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

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

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

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

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

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

Under the No Action alternative, DOE could suspend operations at DWPF. If the suspension of operations at these facilities is not temporary, it would result in a sizeable workforce reduction, which would have a substantial negative impact on the communities surrounding SRS. Alternatively, DOE could construct as many as 18 new HLW tanks. Operation of new HLW tanks would require up to 65 new employees. This small increase is not expected to have a measurable effect on regional employment or population trends.

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

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

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

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

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

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

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

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

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

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

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

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

In general, accidents involving nonradiological hazardous materials would result in minimal impacts to onsite and offsite receptors. However, noninvolved workers exposed to atmospheric releases of benzene from two of the accidents evaluated under the Small Tank Precipitation alternative could experience serious or life-threatening health effects. Workers exposed to airborne benzene concentrations (950 mg/m^3) resulting from an Organic Waste Storage Tank (OWST) loss of confinement accident could develop irreversible (e.g., kidney damage) or other serious health effects that may impair their ability to take protective action (e.g., dizziness, confusion, impaired vision). Workers exposed to airborne benzene concentrations (8,840 mg/m^3) resulting from an explosion in the OWST could experience life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory arrest). Both of these accidents would occur less than once in 100,000 years and are in the extremely unlikely category.

Pilot Plant – Under the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives, DOE would design and construct a 1/100 to 1/10 scale pilot plant to demonstrate the

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

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Radioactive Materials					
Loss of Confinement	Once in 30 years				
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
LCF per year		0.0018	6.9×10^{-4}	6.8×10^{-4}	2.1×10^{-4}

Table 2-7. (Continued).

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

Table 2-7. (Continued).

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

Table 2-7. (Continued).

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

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Nonradioactive Hazardous Materials					
Accidents Involving Sodium Hydroxide Releases					
Caustic Feed Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}
Noninvolved Worker (640 m) Dose (mg/m^3)		0.18	0.18	0.18	0.18
Caustic Dilution Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		NA	NA	NA	0.0031
Noninvolved Worker (640 m) Dose (mg/m^3)		NA	NA	NA	0.93[e]
Accidents Involving Nitric Acid Releases					
Nitric Acid Feed Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		NA	NA	8.8×10^{-5}	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		NA	NA	0.026	NA
Accidents Involving Benzene Releases					
PHA Surge Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		7.4×10^{-10}	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		2.2×10^{-8}	NA	NA	NA
TPB Tank Spill	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.060	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		18.7	NA	NA	NA
Organic Evaporator Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.45	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		130	NA	NA	NA
Beyond Design Basis Earthquake	Less than once in 2,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.0026	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		0.78	NA	NA	NA
OWST Loss of Confinement	Once in 140,000				

Table 2-7. (Continued).

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

NA = not applicable.

a. Accident impacts based on bounding case.

b. Probability of latent cancer fatality (LCF) to the exposed individual.

c. An acute dose to an individual over 300 rem would likely result in death.

d. PHC = precipitate hydrolysis cell.

e. Individuals exposed to sodium hydroxide concentrations above 0.5 mg/m^3 could experience mild transient health effects (headache, nausea, rash) or perception of a clearly defined objectionable odor.

f. Individuals exposed to benzene concentrations above 480 mg/m^3 could experience or develop irreversible (kidney damage) or other serious health effects (dizziness, confusion, impaired vision).

g. Individuals exposed to benzene concentrations above 3,190 mg/m^3 could experience or develop life-threatening health effects (loss of consciousness, cardiac dysrhythmia, respiratory arrest).

salt processing technology. No Pilot Plant is needed for the Direct Disposal in Grout alternative because the technology has already been demonstrated in the existing Saltstone Manufacturing and Disposal Facility. Because the Pilot Plant would be a scaled-down version of the salt processing facility, impact would typically be no more than 10 percent of that for the full-sized facility.

2.9.2 LONG-TERM IMPACTS

Section 4.2 of the Draft SEIS discusses the long-term impacts associated with disposing of fractions of the salt solutions as a saltstone grout in Z-Area vaults. DOE estimated long-term impacts by doing a performance assessment that included fate and transport modeling to determine when certain impacts (e.g., radiation dose) could reach a maximum value. DOE used the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (Martin Marietta 1992) as the basis for analysis of the long-term water resource and human health impacts. This performance assessment was based on the original saltstone that would have resulted from the ITP process.

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

In order to estimate the impacts of no action in the long term, DOE must assume that the HLW remains in the HLW storage tanks and no action is ever taken to ensure safe management. In this scenario, the HLW tanks would eventually fail and the contents would be released to the groundwater and eventually to surface water. DOE has not attempted to model this scenario. Some indication of the potential for impacts may be gained, however, from a comparison with modeling results DOE prepared for the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000).

Under the No Action alternative in the Tank Closure Draft EIS (DOE 2000), DOE would remove most of the waste from the tanks and spray water wash the tanks, but would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves. Under the tank closure scenario, the tanks would eventually fail (after a period of perhaps several hundred years), creating physical hazards to humans and wildlife in the area and releasing the residual HLW to the groundwater at SRS. DOE estimated that residual waste in the F- and H-Area Tank Farms would contain about 200 curies of long half-life isotopes (technetium-99 and plutonium-239) and 9,900 curies of cesium-137, which has a relatively short half-life. DOE modeled the eventual release of these contaminants to the groundwater at SRS. The modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime radiation dose of 430 millirem (primarily from groundwater), and incur a risk of 2.2×10^{-4} of incurring a fatal cancer. The greatest risk occurs within about 500 years of tank abandonment, but doses for residents would be greater than 10 millirem for over 1,000 years.

In contrast, if DOE were to take no action and leave the HLW in the tanks at SRS, approximately 450,000,000 curies (160,000,000 in salt component and 290,000,000 in the sludge component, assuming that about 10 percent of the curies in the sludge component have been vitrified in DWPF) would be available for release to the groundwater. While modeling would be required to calculate exposures and health effects over time, it is clear that the impacts to human health resulting from a No Action alternative would be catastrophic.

Certain resources would not experience long-term impacts: socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, utilities and energy, and accidents. Section 4.2 analyzes long-term impacts for geologic resources, water resources (groundwater and surface water), ecological resources, land use, and public health. Table 2-8 summarizes the long-term impacts to these resources.

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

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

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

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

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

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

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

As shown in Table 2-8, the Direct Disposal in Grout alternative results in higher doses and greater health effects over the long term than the other 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.

Table 2-8. Summary comparison of long-term impacts by salt processing alternative.

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Geologic Resources				
	After saltstone degradation, soil could become contaminated.	After saltstone degradation, soil could become contaminated.	After saltstone degradation, soil could become contaminated.	After saltstone degradation, soil could become contaminated.
Surface Water				
	Contaminants in groundwater could be transported to downgradient surface waters, but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters, but concentrations would be very low.
Groundwater				
Maximum radiation dose (mrem/yr)[a] 1 meter downgradient of vaults	0.49	0.58	0.45	0.57
Maximum radiation dose (mrem/yr) 100 meters downgradient of vaults	0.042	0.044	0.038	0.048
Maximum radiation dose (mrem/yr) at seepline	0.0029	0.0028	0.0025	0.0032
Maximum nitrate concentration (mg/L)[b] 1 meter downgradient of vaults	338	395	307	394
Maximum nitrate concentration (mg/L) 100 meters downgradient of vaults	29	31	26	33
Maximum nitrate concentration at seepline (mg/L)	2.2	2.1	1.9	2.4
Ecological Resources				
	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.
Land Use				
	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.
Public Health				
Radiation dose from Agricultural Scenario (mrem/yr)	52 to 110	61 to 130	49 to 110	64 to 140
Latent Cancer Fatalities[c] from Agricultural Scenario	0.0018	0.0021 to 0.0046	0.0017 to 0.0039	0.0022 to 0.0049
Radiation dose from Residential Scenario at 100 years post-closure (mrem/yr)	0.015 to 0.11	0.017 to 0.13	0.014 to 0.1	150 to 1200

Table 2-8. (Continued).

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Latent Cancer Fatalities[c] from Residential Scenario at 100 years post-closure	5.3×10^{-7} to 3.9×10^{-6}	6.0×10^{-7} to 4.6×10^{-6}	4.9×10^{-7} to 3.5×10^{-6}	0.0053 to 0.042
Radiation dose from Residential Scenario at 1,000 years post-closure (mrem/yr)	9.2 to 69	11 to 80	8.6 to 65	11 to 85
Latent Cancer Fatalities[c] from Residential Scenario at 100 years post-closure	3.2×10^{-4} to 0.0024	3.9×10^{-4} to 0.0028	3.0×10^{-4} to 0.0023	3.9×10^{-4} to 0.0030

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a. mrem/yr = millirem per year.
b. mg/L= milligram per liter.
c. Lifetime (70 year) to an individual.

References

CEQ (Council on Environmental Quality), 1981, *Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations*, Executive Office of the President, Washington, D.C.

DOE (U.S. Department of Energy), 1996, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, July 10.

DOE (U.S. Department of Energy), 1998, *Independent Assessment of the Savannah River Site High-Level Waste Salt Disposition Alternatives Evaluation*, DOE/ID-101672, Washington, D.C.

DOE (U.S. Department of Energy), 2000, *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, Office of Environmental Management, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 1993, Federal Facility Agreement between the U.S. Environmental Protection Agency, Region IV, the U.S. Department of Energy, and the South Carolina Department of Health and Environmental Control, Docket No. 89-05-FF, August 16.

Martin Marietta (Martin Marietta Energy Systems, Inc.), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility*, WSRC-RP-92-1360, Prepared for Westinghouse Savannah River Company, Aiken, South Carolina by Martin Marietta Energy Systems, Inc.

NAS (National Academy of Sciences), 1999, Interim Report on Technical Review of Alternatives for Processing High-Level Radioactive Waste Salt Solution at Savannah River Site. Letter from M. Levinson and G. Choppin, NAS, to E. J. Moniz, U.S. Department of Energy, October 14, 1999.

NRC (National Research Council 2000), *Alternatives for High-Level Radioactive Waste Salt Processing at the Savannah River Site*. Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site, National Academy Press, Washington, D.C., October.

TFA (Tanks Focus Area), 2000, *Savannah River Site Salt Processing Project Research and Development Program Plan*, Revision 0, PNNL-13253, Richland, Washington, May 2000.

WSRC (Westinghouse Savannah River Company), 1998a, *High-Level Waste Salt Disposition Systems Engineering Team Final Report* WSRC-RP-98-00170, Rev. 0, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998b, *Bases, Assumptions, and Results of Flow Sheet Calculations for the Short List Salt Disposition Alternatives*, WSRC-RP-98-00168, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998c, *Life Cycle Cost Estimate Bases, Assumptions and Results,* Rev. 1, WSRC-RP-98-00167, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998d, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – Small Tank TPB Precipitation*, WSRC-RP-98-00126, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998e, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – CST Ion Exchange*, WSRC-RP-98-00125, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998f, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – Caustic Side Solvent Extraction*, WSRC-RP-98-00124, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998g, High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details, *Cesium Encapsulation in Grout*, WSRC-RP-98-00123, Rev. 1, Savannah River Site High-Level Waste Disposition Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998h, *Safety Analysis Report – Liquid Radioactive Waste Handling Facility*, WSRC-SA-33, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999a, *High-Level Waste Tank Space Management Team Final Report*, WSRC-RP-99-00005, Rev. 0, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, *Site Selection for the Salt Disposition Facility at the Savannah River Site*, Rev. 0, WSRC-RP-99-00513, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999c, *High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report*, WSRC-RP-99-00007, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 2000, *High-Level Waste System Plan HLW-2000-00019*, Rev. 11, Savannah River Site, Aiken, South Carolina.

CHAPTER 3. AFFECTED ENVIRONMENT

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

This chapter describes the following:

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

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

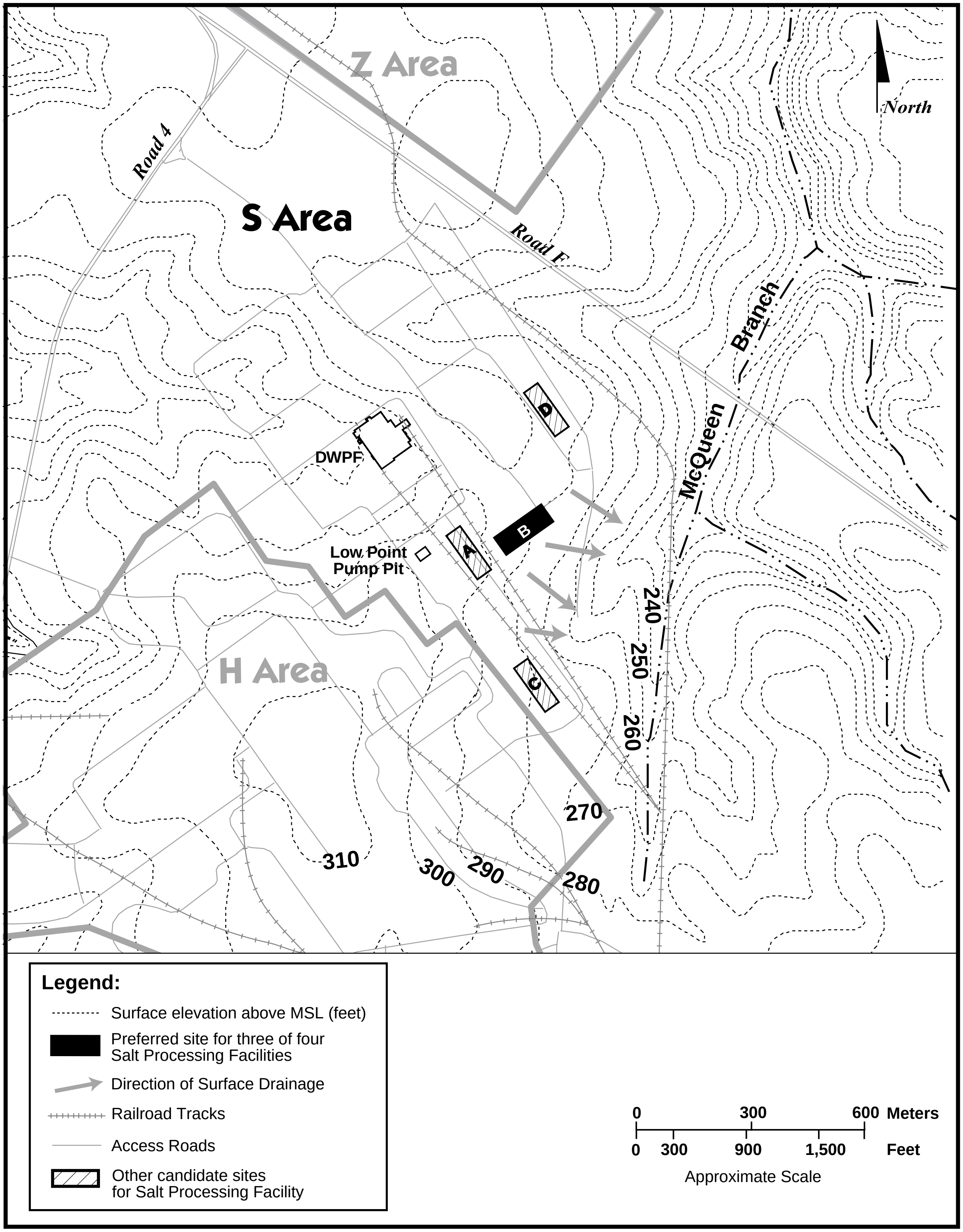
As mentioned in Chapter 2, Section 2.5, DOE proposes to locate salt processing activities in either S Area or Z Area of SRS. S Area is approximately 270 acres and Z Area is about 180 acres. Both sites are within existing heavily industrialized zones. Regardless of where salt processing activities occur,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

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

The primary site (Site B in S Area; see Figure 2-2) for a Small Tank Precipitation, Ion Exchange, or Solvent Extraction facility is approximately 25 acres. It is 950 feet east-southeast of the DWPF and approximately 650 feet east of the Low Point Pump Pit between H Area and DWPF. The site was used as a laydown area during construction of DWPF, and is situated along an eastward slope of a previously existing topographic high point. The land surface is flat, gently sloping, and covered with grass and gravel. The surface elevation is about 280 feet above mean sea level (msl) (Figure 3-1) (WSRC 1999a).

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

The remaining sections of this chapter characterize the SRS and its environs, as well as pertinent information on Site B in S Area and the Z-Area site. Chapter 4 describes potential impacts



NW SDA EIS/Grfx/ch_3/3-1 Surf Elev S.ai

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

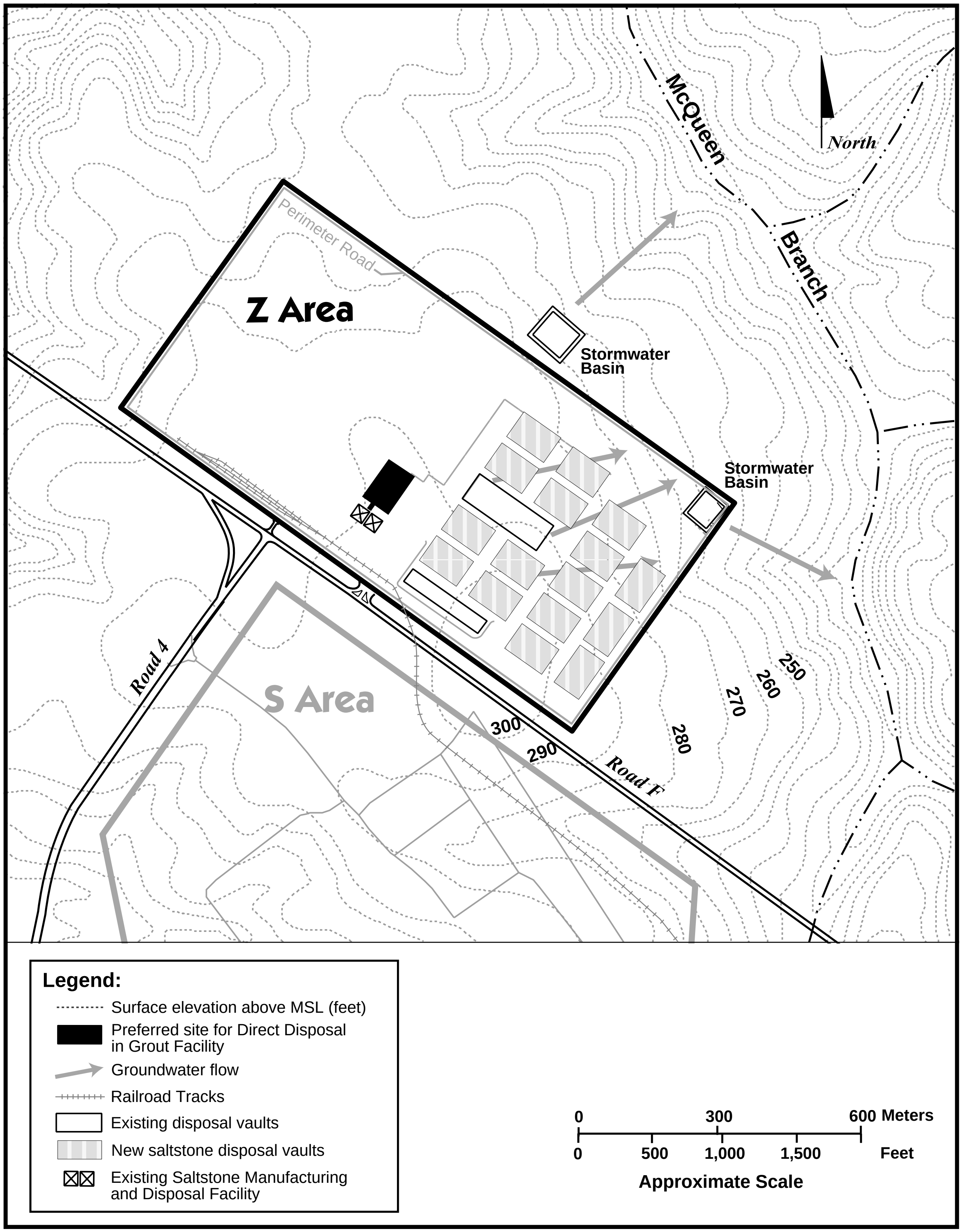


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Figure 3-2. Surface elevation and direction of surface drainage in the vicinity of Z Area.

of the No-Action alternative and the different alternatives for processing salt, including the impacts of constructing and operating processing facilities.

3.1 Geologic Setting and Seismicity

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

3.1.1 GENERAL GEOLOGY

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

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

3.1.2 SUBSURFACE FEATURES

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

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

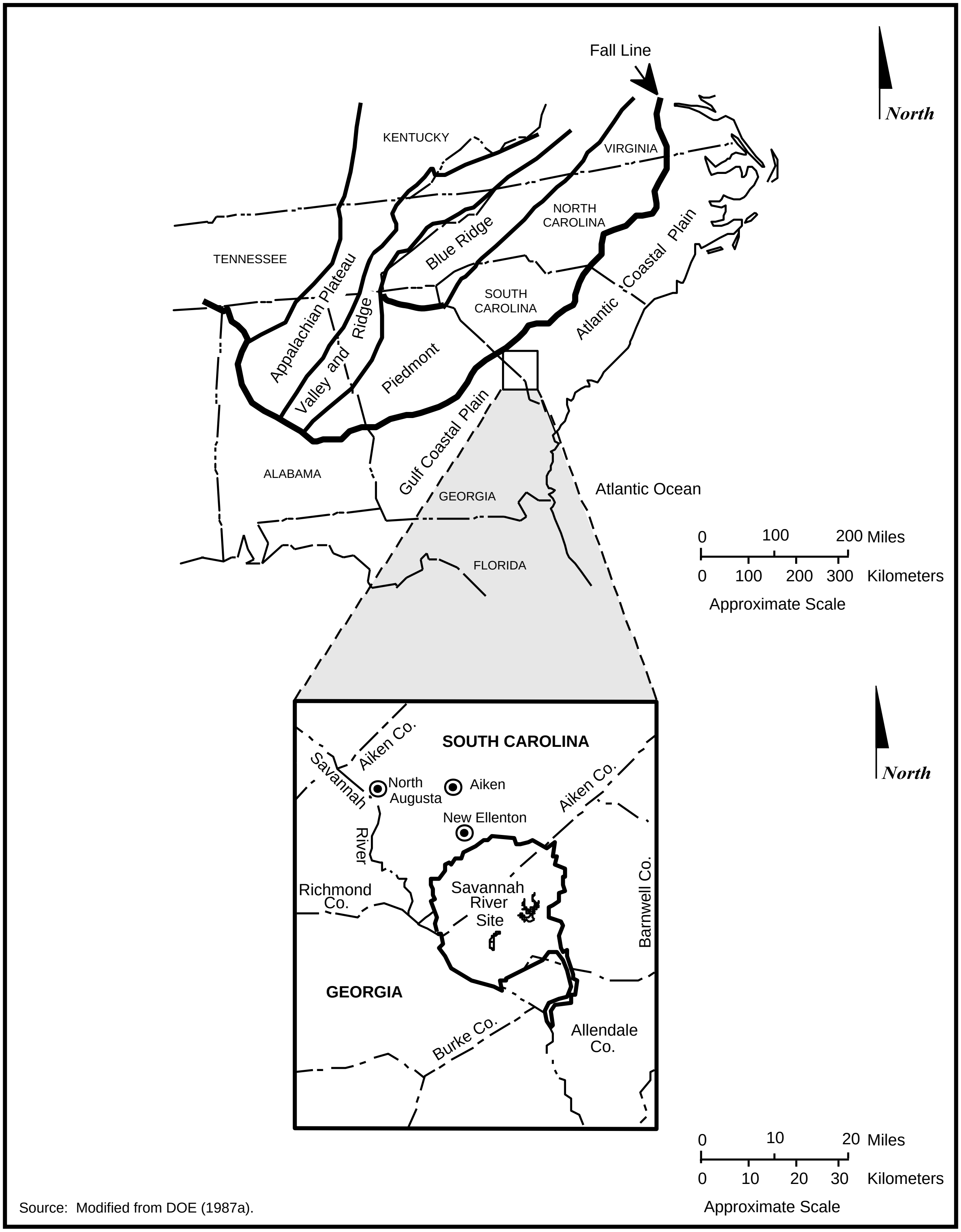
Rock strata under some areas of SRS include layers of pockets of carbonate rock that are subject to dissolution. Sites underlain by these “soft zones” are considered unsuitable for structural formations unless extensive soil stabilization is done. There are no carbonate soft zones underlying Site B (WSRC 1999a). Z Area data were not evaluated for soft zones.

3.1.3 SEISMICITY

Two major earthquakes have occurred within 186 miles of SRS.

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

- As summarized by Geomatrix (1991), the Union County, South Carolina, earthquake of 1913 had an estimated magnitude of 4.5



Source: Modified from DOE (1987a).

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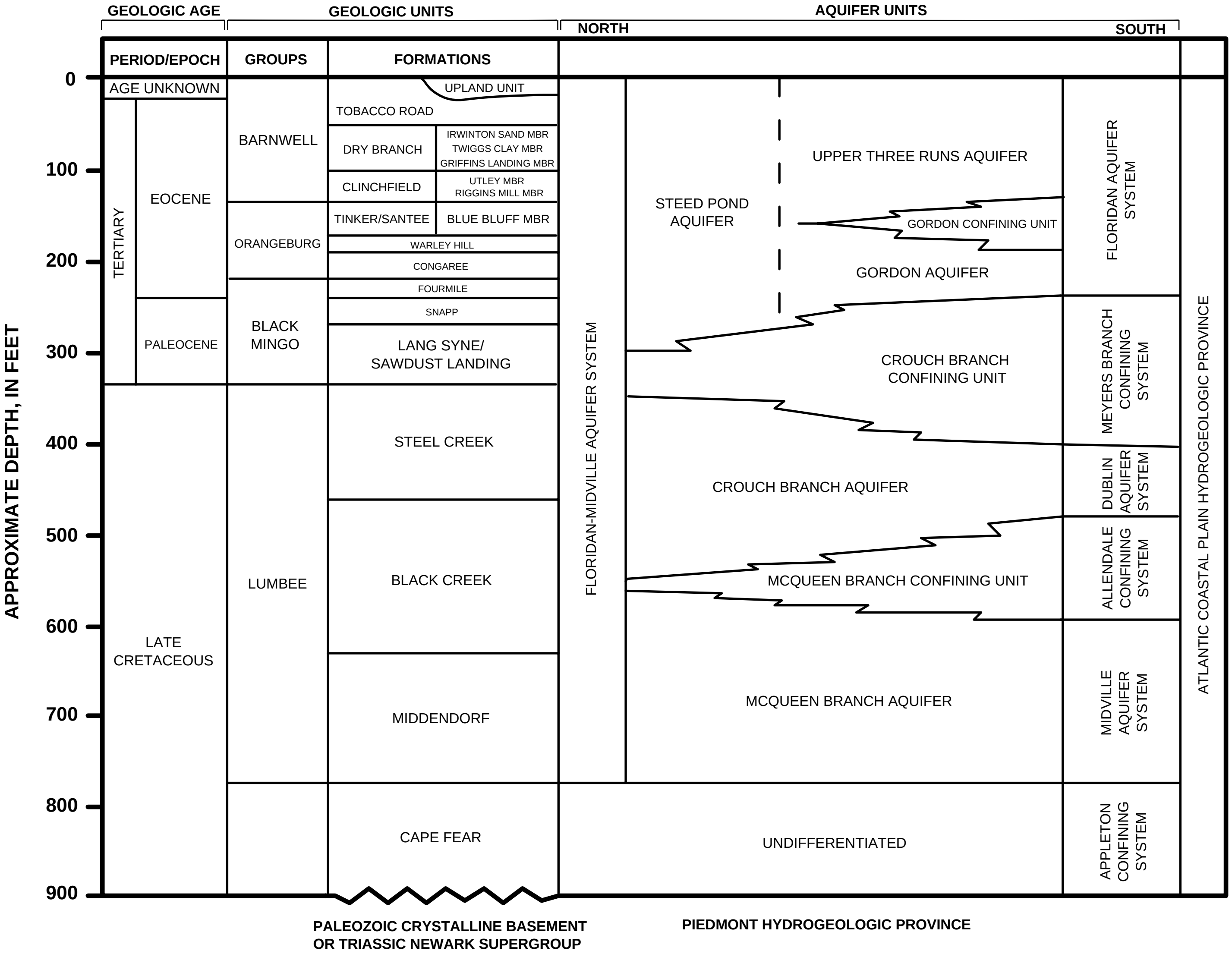
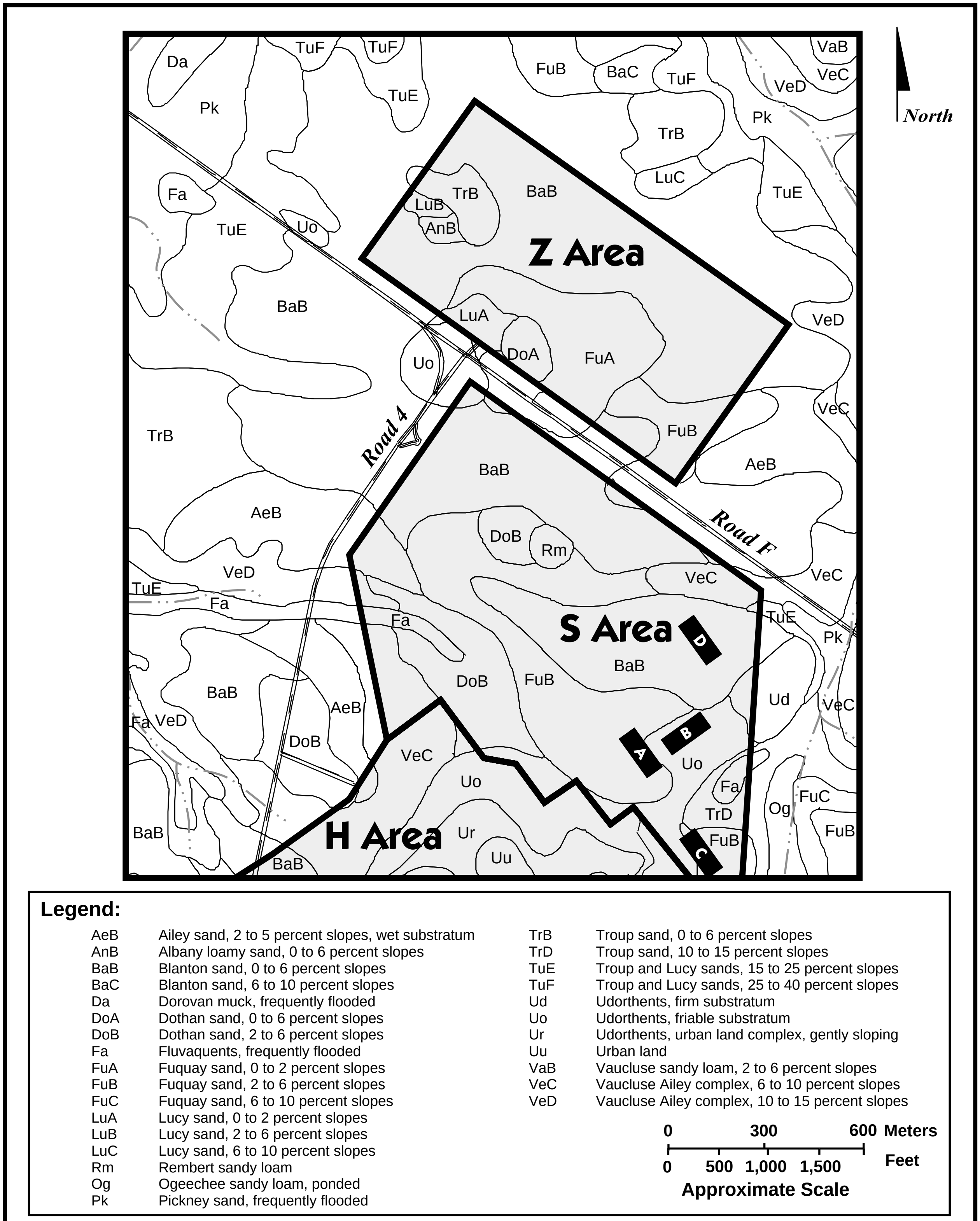
Figure 3-3. Generalized location of Savannah River Site and its relationship to physiographic provinces of southeastern United States.



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

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

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



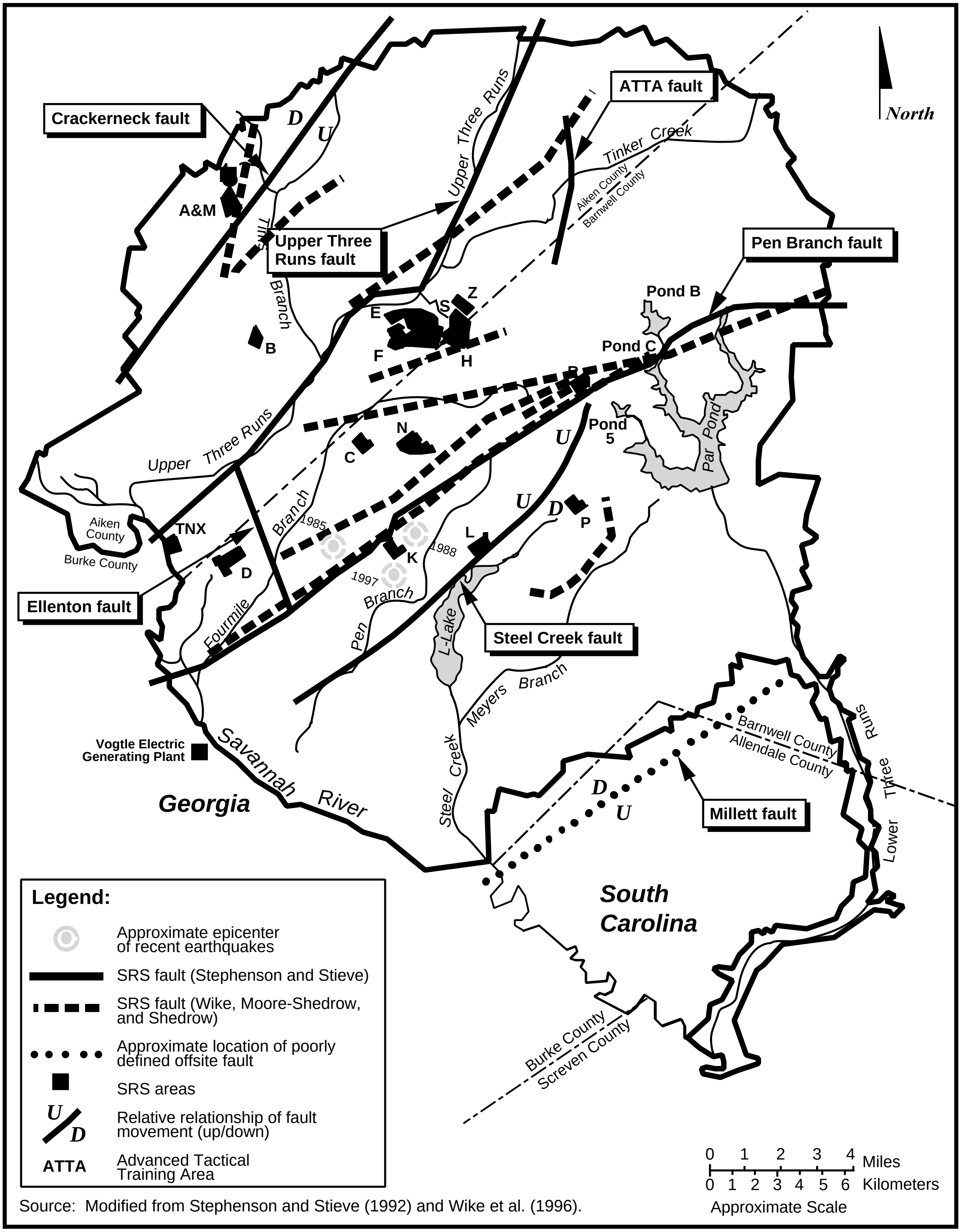
Legend:

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

Source: Modified from USDA (1990).

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

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



Source: Modified from Stephenson and Stieve (1992) and Wike et al. (1996).

NW SDA EIS/Grfx/ch_3/F3-6 Fault lines.ai

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

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

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

- On May 17, 1997, with a Richter magnitude of 2.3 and a focal depth of 3.38 miles; its epicenter was southeast of K Area
- On August 5, 1988, with a Richter magnitude of 2.0 and a focal depth of 1.6 miles; its epicenter was northeast of K Area
- On June 8, 1985, with a Richter magnitude of 2.6 and a focal depth of 3.7 miles; its epicenter was south of C Area and west of K Area.

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

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

3.2 Water Resources

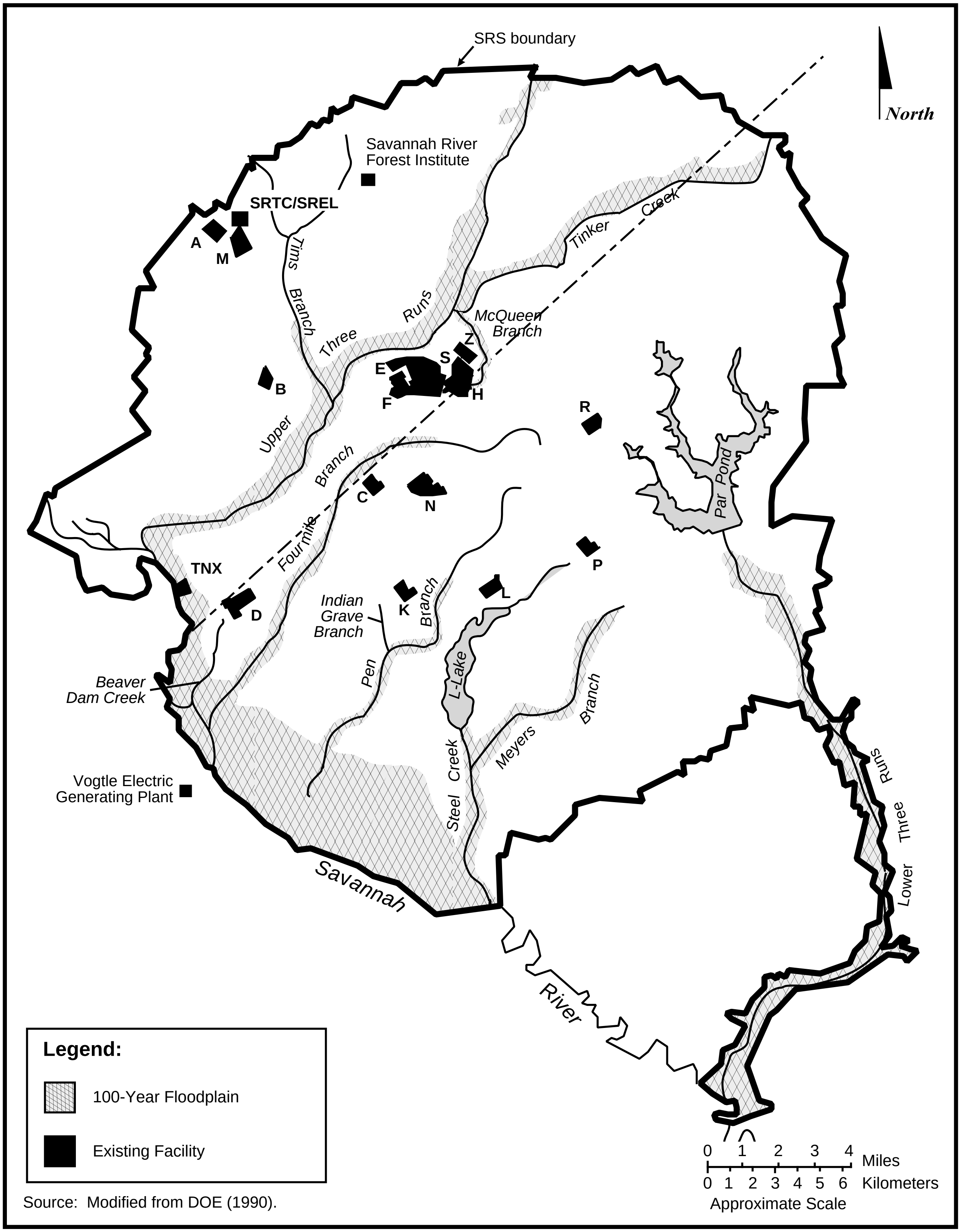
This section describes surface and subsurface water in the area potentially affected by the proposed action. Surface water and groundwater are characterized in terms of flow and quality (physical properties and concentrations of chemicals and contaminants).

3.2.1 SURFACE WATER

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

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

The SRS streams that could be affected by the alternatives are blackwater streams, which means that the water has a dark coloration due to the dissolution of natural organic matter from soils and decaying vegetation. Three SRS streams potentially could be affected by construction and operation of salt processing facilities in S Area or Z Area: McQueen Branch, Upper Three Runs, and Fourmile Branch (Figure 3-7). Of the three, only Fourmile Branch ever received the high flows and elevated temperatures associated with thermal discharges from nuclear reactors. McQueen Branch, which lies east of the proposed facilities, receives surface runoff from both proposed sites (Figures 3-1 and 3-2) and potentially could be affected by land-disturbing construction activities. Process wastewater from salt processing operations would be treated in the Effluent Treatment Facility (ETF) and discharged to Upper Three Runs via National Pollutant Discharge Elimination System (NPDES) outfall H-16. Sanitary wastewater from salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES outfall G-10 (WSRC 1999b).



Source: Modified from DOE (1990).

NW SDA EIS/Grfx/F3-7100 yr flood.ai

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

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

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

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

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

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

In 1997, major releases of radionuclides from the SRS to surface waters amounted to 8,950 curies of tritium, 0.262 curie of strontium-89 and -90, and 0.177 curie of cesium-137 (Arnett and Mamatey 1998b). Table 3-2 lists radioactive liquid releases by source for 1997; Table 3-3 lists radioactive liquid releases by outfall or facility and compares annual average radionuclide concentrations to DOE concentration guides. Figure 3-8 shows outfall and facility locations for radioactive surveillance. The resulting dose to a downriver consumer of river water from radionuclides released from the Site was less than 2 percent of the U.S. Environmental Protection Agency (EPA) and DOE standards for public water supplies (40 CFR Part 141 and DOE Order 5400.5, respectively) and less than 0.1 percent of the DOE dose standard from all pathways (DOE 1990; Arnett and Mamatey 1998b). Table 3-4 lists potential contributors of contamination to Upper Three Runs and Fourmile Branch.

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

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

Source: Arnett and Mamatey (1998a).

a. Parameters DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.

b. Water Quality Criteria for aquatic life unless otherwise indicated.

c. Concentration exceeded WQC; however, these criteria are for comparison only. WQCs are not legally enforceable.

d. ND = Not detected.

e. NA = Not applicable.

f. MCL = Maximum Contaminant Level; State Primary Drinking Water Regulations.

g. DCG = DOE Derived Concentration Guides for Water (DOE Order 5400.5). DCG values are based on committed effective dose of 100 millirem per year; however, because drinking water MCL is based on 4 millirem per year, value listed is 4 percent of DCG.

h. Shall not be increased more than 2.8°C (5°F) above natural temperature conditions or exceed a maximum of 32.2°C (90°F) as a result of the discharge of heated liquids, unless appropriate temperature criterion mixing zone has been established.

i. Secondary MCL; State Drinking Water Regulations.

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

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

Notes: Blank spaces indicate no quantifiable activity.

Source: Arnett and Mamatey (1998a).

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

b. Includes separations, waste management, and tritium facilities.

c. Includes unidentified beta.

d. Includes unidentified alpha.

TNX = a technology development facility adjacent to the Savannah River.

SRTC = Savannah River Technology Center.

3.2.2 GROUNDWATER RESOURCES

3.2.2.1 Groundwater Features

In the SRS region, the subsurface contains two hydrogeologic provinces. The uppermost, consisting of a wedge of unconsolidated Coastal Plain sediments of Late Cretaceous and Tertiary age, is the Atlantic Coastal Plain hydrogeologic province. Beneath the sediments of the Atlantic Coastal Plain hydrogeologic province are rocks of the Piedmont hydrogeologic province. These rocks consist of Paleozoic igneous and metamorphic basement rocks and Upper Triassic Age lithified mudstone, sandstone, and conglomerates of the Upper Triassic Dunbarton basin. Sediments of the Atlantic Coastal Plain hydrogeologic province are divided into three aquifer systems: the Floridan Aquifer System, the Dublin Aquifer System, and the Midville Aquifer System as shown in Figure 3-4 (Aadland, Gellici, and Thayer 1995). The Meyers Branch Confining System and/or the Allendale Confining System, as shown in Figure 3-4, separate the aquifer systems.

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

Groundwater flow in the shallow (Floridan) aquifer system is generally horizontal, but does have a vertical component. In divide areas between surface-water drainages, the vertical component of the hydraulic gradient typically is

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

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

Table 3-3. (Continued).

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

Notes: MDL denotes "minimum detectable level."

Source: Arnett and Mamatey (1998a).

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

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

downward. In the lower reaches of streams, groundwater again moves generally in a horizontal direction, but may have an upward vertical component.

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

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

Based on data in the SRS groundwater geochemical database, no groundwater plumes are

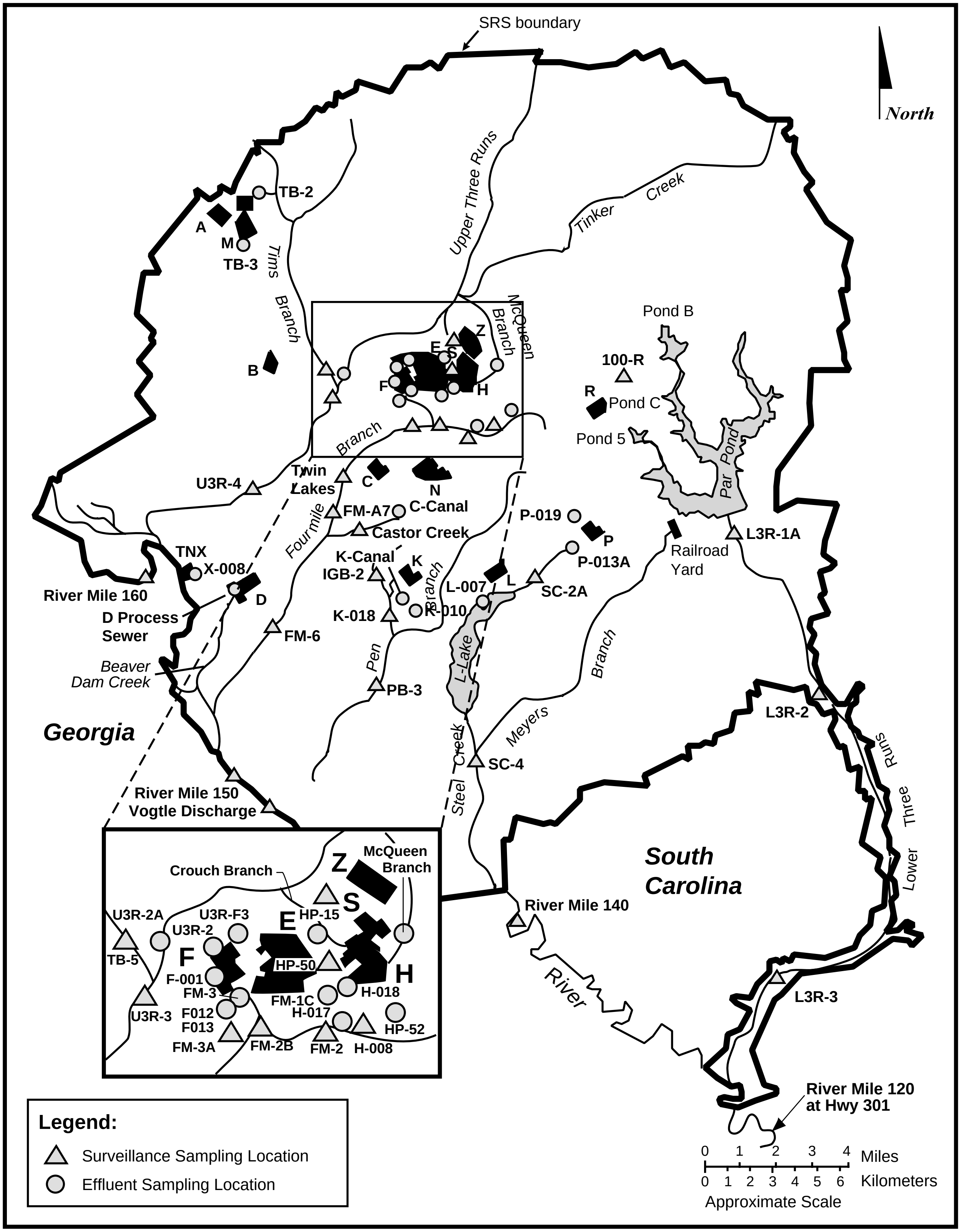


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Figure 3-8. Radiological surface water sampling locations.

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

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

Source: WSRC (1996)

a. Units located in more than one watershed.

mapped as emanating from S- or Z-Area sources. However, a preliminary review of groundwater monitoring data for S Area indicates tritium contamination in one monitoring well. The contamination is likely from the tritium facility in H Area. This well is located just south of Site B. No tritium contamination was noted in groundwater monitoring data for Z Area. Within the immediate vicinity of Site B in S Area, depth to the water table averages approximately 45 feet below grade. Groundwater flow in the area is to the northeast to McQueen Branch (Figure 3-9). At the Z-Area site, average depth to the water table ranges from 70 to 60 feet. Groundwater flow below the subject site is to the northeast toward McQueen Branch (Figure 3-10).

3.2.2.2 Groundwater Use

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

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

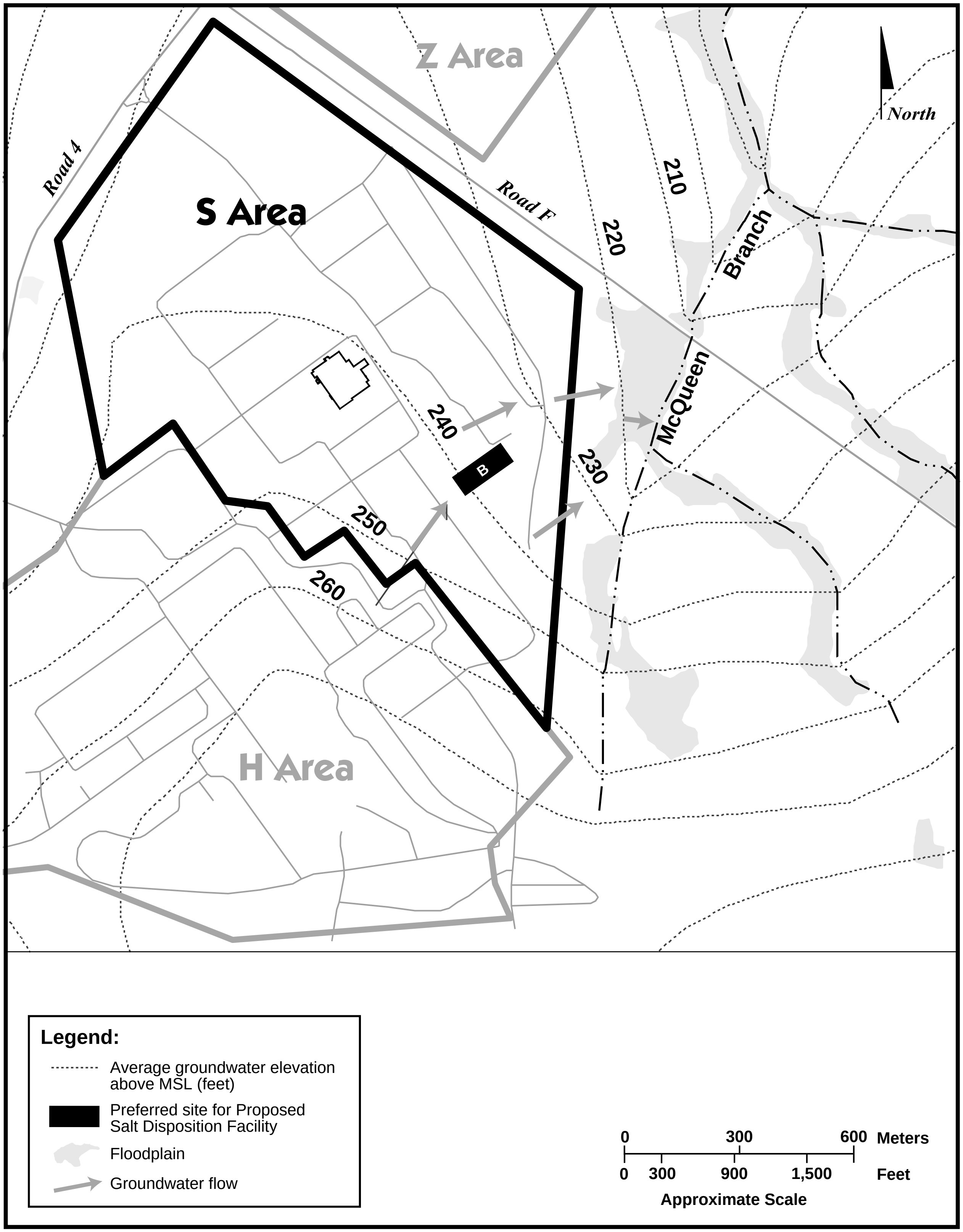

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Figure 3-9. Average groundwater elevation and direction of flow in the vicinity of S Area.

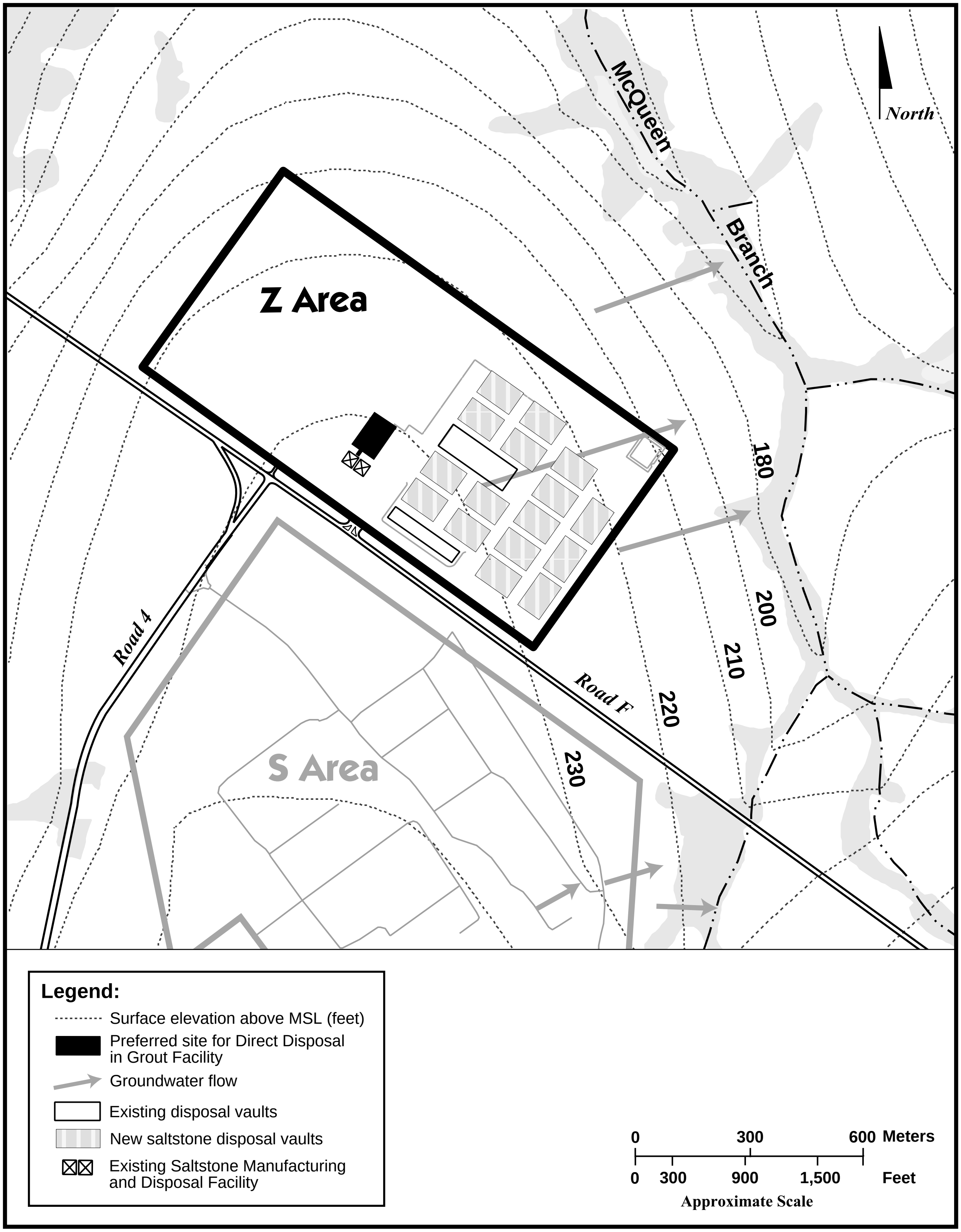

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Figure 3-10. Average groundwater elevation and direction of groundwater flow in vicinity of Z Area.

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

3.2.2.3 Hydrogeology

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

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

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

3.2.2.4 Groundwater Quality

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

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

3.3 Air Resources

3.3.1 METEOROLOGY

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

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

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

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

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

Analyte	Concentration	Regulatory limit
Aluminum[a]	13,000 µg/L[b]	50 µg/L[c]
Bis (2-ethylhexyl) phthalate	142 µg/L	6 µg/L[d]
Dichloromethane	8.45 µg/L	5 µg/L[d]
Gross alpha	9.74×10^{-8} µCi/mL[b]	1.5×10^{-8} µCi/mL[d]
Iodine-129	1.09×10^{-7} µCi/mL	1.0×10^{-9} µCi/mL[e]
Iron[a]	17,100 µg/L	300 µg/L[c]
Lead[a]	417 µg/L	50 µg/L[f]
Manganese[a]	1,650 µg/L	50 µg/L[c]
Mercury[a]	18.5 µg/L	2.0 µg/L[d]
Nickel-63	4.79×10^{-7} µCi/mL	5.0×10^{-8} µCi/mL[e]
Nitrate-nitrite as nitrogen	52,800 µg/L	10,000 µg/L[d]
Nonvolatile beta	3.37×10^{-6} µCi/mL	5.0×10^{-8} µCi/mL[e]
Phosphate	2.28 µg/L	1.7 µg/L[g]
Radium-226	6.52×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[e, h]
Radium-228	6.98×10^{-8} µCi/mL	5.0×10^{-9} µCi/mL[e,h]
Radium, total alpha emitting	6.70×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[e]
Ruthenium-106	3.81×10^{-8} µCi/mL	3.0×10^{-8} µCi/mL[e]
Strontium-89,90	1.01×10^{-8} µCi/mL	8.0×10^{-9} µCi/mL[d]
Strontium-90	1.24×10^{-6} µCi/mL	8.0×10^{-9} µCi/mL[d]
Thallium[a]	1,060 µg/L	2 µg/L[d]
Trichloroethylene	14.7 µg/L	5 µg/L[d]
Tetrachloroethylene	12.6 µg/L	5 µg/L[d]
Tritium	1.02×10^{-2} µCi/mL	2.0×10^{-5} µCi/mL[d]
Uranium-233,234	4.28×10^{-8} µCi/mL	1.38×10^{-8} µCi/mL[i]
Uranium-238	4.20×10^{-8} µCi/mL	1.46×10^{-8} µCi/mL[i]
Vanadium[a]	139 µg/L	133 µg/L[h]

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a. Total recoverable.

b. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.

c. EPA National Secondary Drinking Water Standards (WSRC 1997a; 1998a,b,c).

d. EPA Final Primary Drinking Water Standards (WSRC 1997a; 1998a,b,c).

e. EPA Interim Final Primary Drinking Water Standard (WSRC 1997a; 1998a,b,c).

f. SCDHEC Final Primary Drinking Water Standards (WSRC 1997a; 1998a,b,c).

g. Drinking Water Standards do not apply. Criterion 10 × a recently published 90th percentile detection limit was used (WSRC 1997a; 1998a,b,c).

h. Radium-226, 228 combined proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.

i. EPA Proposed Primary Drinking Water Standard (WSRC 1997a; 1998a,b,c).

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

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

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

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

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

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

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

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

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

3.3.1.1 Local Climatology

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

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

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

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

3.3.1.2 Severe Weather

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

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

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

3.3.2 AIR QUALITY

3.3.2.1 Nonradiological Air Quality

The SRS is located in the Augusta-Aiken Interstate Air Quality Control Region (AQCR). All areas within this region are classified as achieving attainment with the National Ambient Air Quality Standards (NAAQS). Ambient air is defined as that portion of the atmosphere, external to buildings, to which the general public has access. The NAAQS define ambient concentration criteria or limits for sulfur dioxide (SO_2), particulate matter equal to or less than 10 micrometers in aerodynamic diameter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb). These pollutants are generally referred to as "criteria pollutants". The nearest area not in attainment with the NAAQS is Atlanta, Georgia, which is approximately 150 miles west of SRS.

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

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

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

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

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

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

3.3.2.2 Radiological Air Quality

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

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

Atmospheric emissions of radionuclides from DOE facilities are limited under the EPA regulation "National Emission Standards for Hazardous Air Pollutants (NESHAP)," 40 CFR Part 61, Subpart H. The EPA annual effective dose equivalent limit of 10 millirem (mrem) per year to members of the public for the atmospheric pathway is also incorporated in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." To demonstrate compliance with the NESHAP regulations, DOE annually calculates maximally exposed offsite individual (MEI) and collective doses and a percentage of dose contribution from each radionuclide, using the CAP88 computer code. The dose to the MEI from 1997 SRS emissions was estimated at 0.05 mrem which is 0.5 percent of the 10 mrem-per-year EPA standard. The CAP88 collective dose was estimated at 5.5 person-rem. Tritium oxide accounts for 94 percent of both the MEI and the population dose (Arnett and Mamatey 1998b). The contributions to dose from other radionuclides can be found in *SRS Environmental Data for 1997* (Arnett and Mamatey 1998a). Table 3-13 lists average and maximum atmospheric concentrations of radioactivity at the SRS boundary and at background monitoring locations (100-mile radius) during

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

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

Source: SCDHEC (1998).

a. Second highest maximum concentration observed.

b. Arithmetic mean of observed concentrations.

c. Columbia, Richland County, South Carolina (nearest monitoring station to SRS).

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

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

Source: Mamatey (1999). Includes actual emissions from all SRS sources (permitted and unpermitted).

a. Includes an additional pollutant, PM-10, regulated under SCDHEC, Standard 2. Note: gaseous fluoride is also regulated under Standard 2, but is not expected to be emitted as a result of salt processing activities.

b. VOCs are not criteria pollutants, but they are reported here because they are precursors to ozone, which is regulated.

c. Pollutants listed include only air toxics of interest to salt processing activities. A complete list of air toxic emissions from SRS can be found in Mamatey (1999).

VOCs = volatile organic compounds

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

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

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a. Source: SCDHEC Standard 2, "Ambient Air Quality Standards," and Standard 8, "Toxic Air Pollutants" (SCDHEC 1976).

b. Source: Hunter (2000). Concentration is the sum of modeled air concentrations using the permitted maximum potential emissions from the 1998 air emissions inventory for all SRS sources not exempted by Clean Air Act Title V requirements and observed concentrations from nearby ambient air monitoring stations.

c. Based partly on dispersion modeling of emissions for all oxides of sulfur (SO_x).

d. New NAAQS for particulate matter ≤2.5 microns (24-hour limit of 65 μg/m^3 and an annual average limit of 15 μg/m^3) will become enforceable during the life of this project.

e. Based partly on dispersion modeling of emissions for all oxides of nitrogen (NO_x).

f. New NAAQS for ozone (8 hours limit of 0.08 parts per million) will become enforceable during the life of this project.

1997. SRS-specific computer dispersion models, such as MAXIGASP and POPGASP, were used to calculate radiological doses to members of the public from the 1997 releases, based on the amounts released and the estimated concentration in the environment. Whereas the CAP88 code assumes that all releases occur from one point (for SRS, at the center of the site), MAXIGASP models multiple release locations, which is more representative of actual conditions.

3.4 Ecological Resources

3.4.1 NATURAL COMMUNITIES OF THE SAVANNAH RIVER SITE

The SRS comprises a variety of diverse habitat types that support terrestrial, aquatic, and semi-aquatic wildlife species. These habitat types include upland pine forests, mixed hardwood forests, bottomland hardwood forests, swamp forests, and Carolina bays. Since the early

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

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

Table 3-12. (Continued).

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

Table 3-12. (Continued).

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

Source: Arnett and Mamatey (1998a).

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

b. Includes F- and H-Area releases.

c. SRTC = Savannah River Technology Center.

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

e. Includes unidentified beta emissions.

f. Includes unidentified alpha emissions.

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

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

Source: Arnett and Mamatey (1998a).

a. The average value is the average value of the arithmetic means reported for the Site perimeter sampling locations.

b. Below background levels.

c. The maximum value is the highest value of the maximums reported for the Site perimeter sampling locations.

1950s, the site has changed from 60 percent forest and 40 percent agriculture to 90 percent forest, with the remainder in aquatic habitats and developed (facility) areas (Halverson et al. 1997). The wildlife correspondingly shifted from forest-farm edge species to a predominance of forest-dwelling species. The SRS now supports 44 species of amphibians, 59 species of reptiles, 255 species of birds, and 54 species of mammals (Halverson et al. 1997). Comprehensive descriptions of the SRS's ecological resources and wildlife can be found in documents such as *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a).

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

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

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

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

S and Z Areas

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

The site for the Direct Disposal in Grout facilities occupies the eastern half of Z Area, a 180-acre area dedicated in the mid-1980s for the Saltstone Manufacturing and Disposal and support facilities (see Figure 2-2). The western part of Z Area encompasses approximately 70 acres of planted pines. This community is dominated by 35-foot and taller slash pine, with a dense mid-story hardwood component. Dominant tree and shrub species in the mid-story and understory include southern red oak (*Quercus rubra*), water oak (*Q. nigra*), willow oak (*Q. phellos)*, hickory *(Carya* spp.*)*, sassafras (*Sassafras albidum*), cherry (*Prunus* spp.), wild plum (*Prunus* spp.), and smooth sumac (*Rhus glabra*) (WSRC 1999a). The developed portion of Z Area consists of the Saltstone Manufacturing and Disposal Facility, vaults, and parking areas. The eastern portion of Z Area consists of old fields and early successional wooded habitats (herbaceous vegetation, small slash pine, and small hardwoods). A few scattered mature southern red oaks are also present (WSRC 1999a). Wildlife of SRS old fields and open woodlands includes upland game birds (e.g., bobwhite quail, Eastern wild turkey), songbirds (e.g., Eastern meadowlark, field sparrow, song sparrow), small mammals (e.g., cotton mouse, cotton rat, and Eastern cottontail), reptiles (e.g., fence lizard, pine snake, scarlet snake, black racer), and amphibians (e.g., southern toad, eastern narrow-mouthed toad) (Sprunt and Chamberlain 1970; Cothran et al. 1991; Gibbons and Semlitsch 1991; Halverson et al. 1997). The terrestrial habitat adjacent to Z Area consists primarily of pine plantations that grade into a riparian hardwood community along the McQueen Branch stream corridor.

There are no jurisdictional wetlands (wetlands protected by law) within or immediately adjacent to either of the proposed salt processing sites. However, there are jurisdictional wetlands along McQueen Branch in the general vicinity of Z Area. There are no threatened or endangered species or critical habitats on the sites proposed for development (WSRC 1999a).

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

Aquatic Communities Downstream of S and Z Areas

Upper Three Runs

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

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

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

Fourmile Branch

Until C Reactor was shut down in 1985, the distribution and abundance of aquatic biota in Fourmile Branch were strongly influenced by reactor operations (high water temperatures and flows downstream of the reactor discharge). Following the shutdown of C Reactor, macroinvertebrate communities began to recover and, in some reaches of the stream, began to resemble those in nonthermal and unimpacted streams of the SRS (Halverson et al. 1997). Surveys of macroinvertebrates in more recent years showed that some reaches of Fourmile Branch had healthy macroinvertebrate communities (high measures of taxa richness), while others had depauperate macroinvertebrate communities (low measures of diversity or communities dominated by pollution-tolerant forms). Differences appeared to be related to variations in dissolved oxygen levels in different portions of the stream. In general, macroinvertebrate communities of Fourmile Branch show more diversity (taxa richness) in downstream reaches than upstream reaches (Halverson et al. 1997). Recent fish sampling (Specht and Paller 1998) indicates that fish diversity is greater at downstream locations than at upstream locations. This is probably related to factors other than NPDES discharges (Specht and Paller 1998).

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

Savannah River

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

ment for the Shutdown of the River Water System at the Savannah River Site (DOE 1997a), and the EIS for *Accelerator Production of Tritium at the Savannah River Site* (DOE 1999a).

3.5 Land Use

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

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

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

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

3.6 Socioeconomics and Environmental Justice

3.6.1 SOCIOECONOMICS

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

Population

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

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

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

Employment

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

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

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

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

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

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

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

3.6.2 ENVIRONMENTAL JUSTICE

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

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

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

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

3.7 Cultural Resources

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

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

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

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

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

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

3.8 Public and Worker Health

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

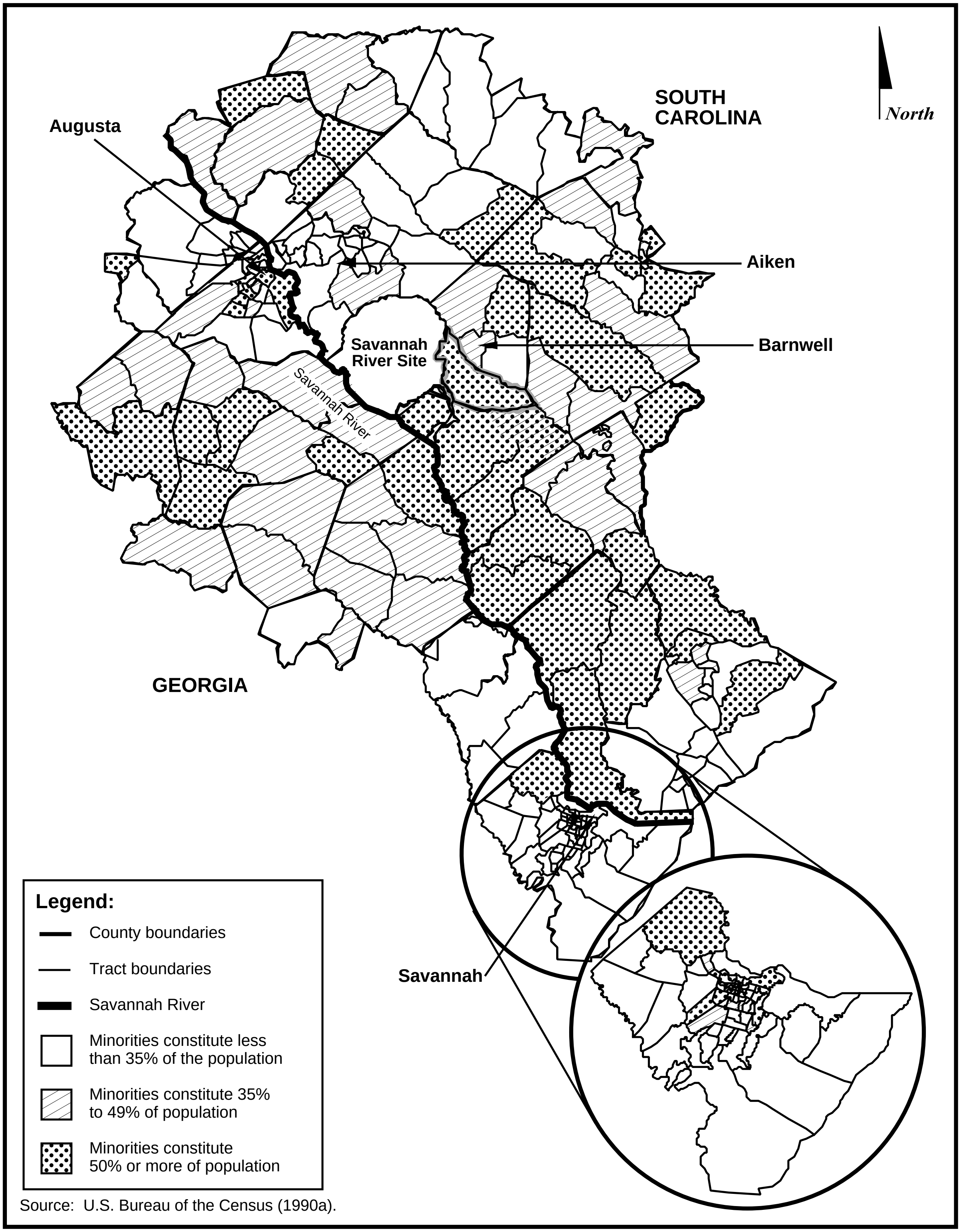
3.8.1 PUBLIC RADIOLOGICAL HEALTH

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

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

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

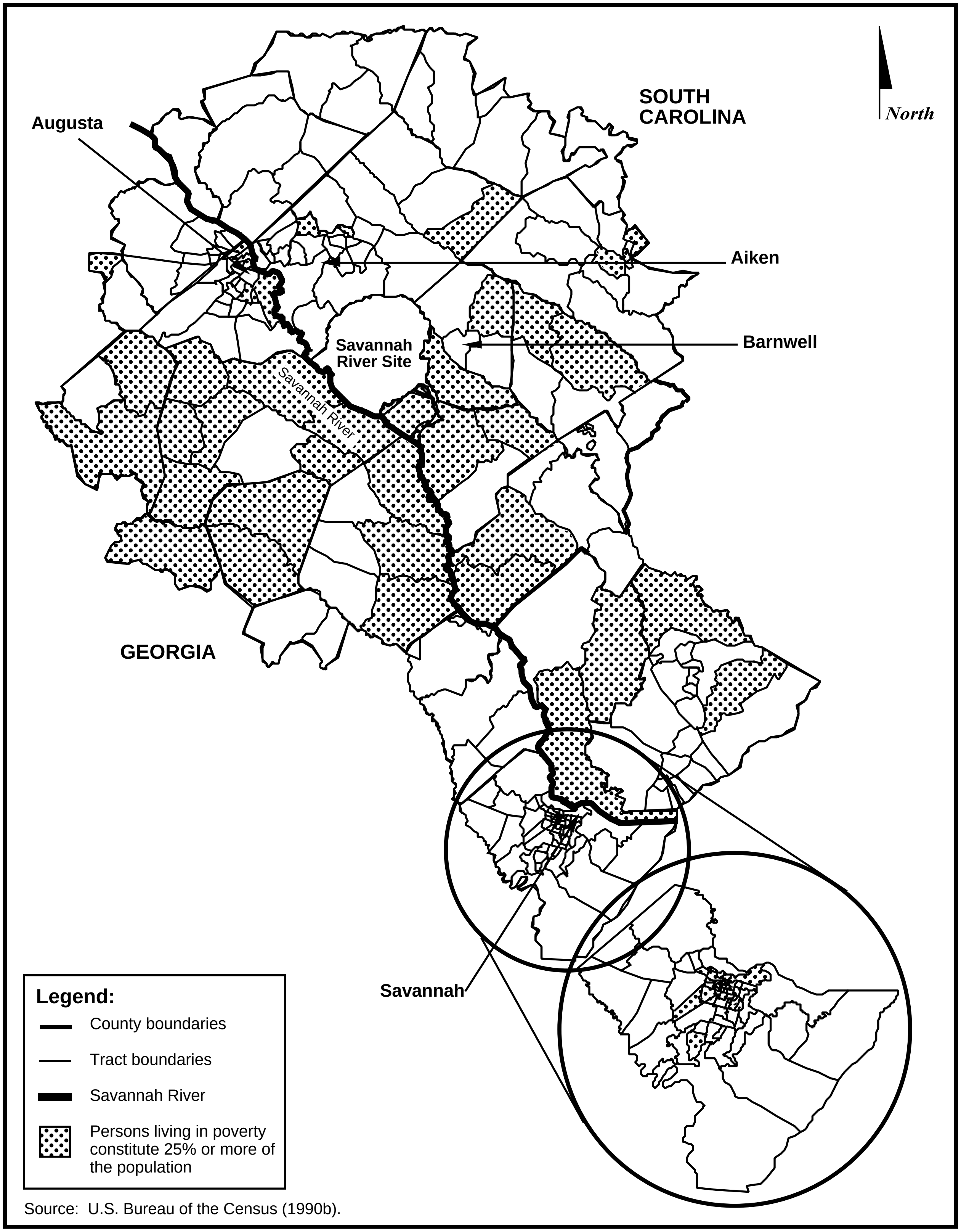
Other nuclear facilities within 50 miles of SRS include a low-level waste disposal site operated by Chem-Nuclear Systems, Inc., near the eastern Site boundary and approximately 11 miles from S Area and Georgia Power Company's Vogtle Electric Generating Plant, directly across the Savannah River from SRS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



Source: U.S. Bureau of the Census (1990a).

NW SDA EIS/Grfx/ch_3/3-11 Dist min pop.ai

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



Source: U.S. Bureau of the Census (1990b).

NW SDA EIS/Grfx/ch_3/F3-12 Low income.ai

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

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

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

---

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

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

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

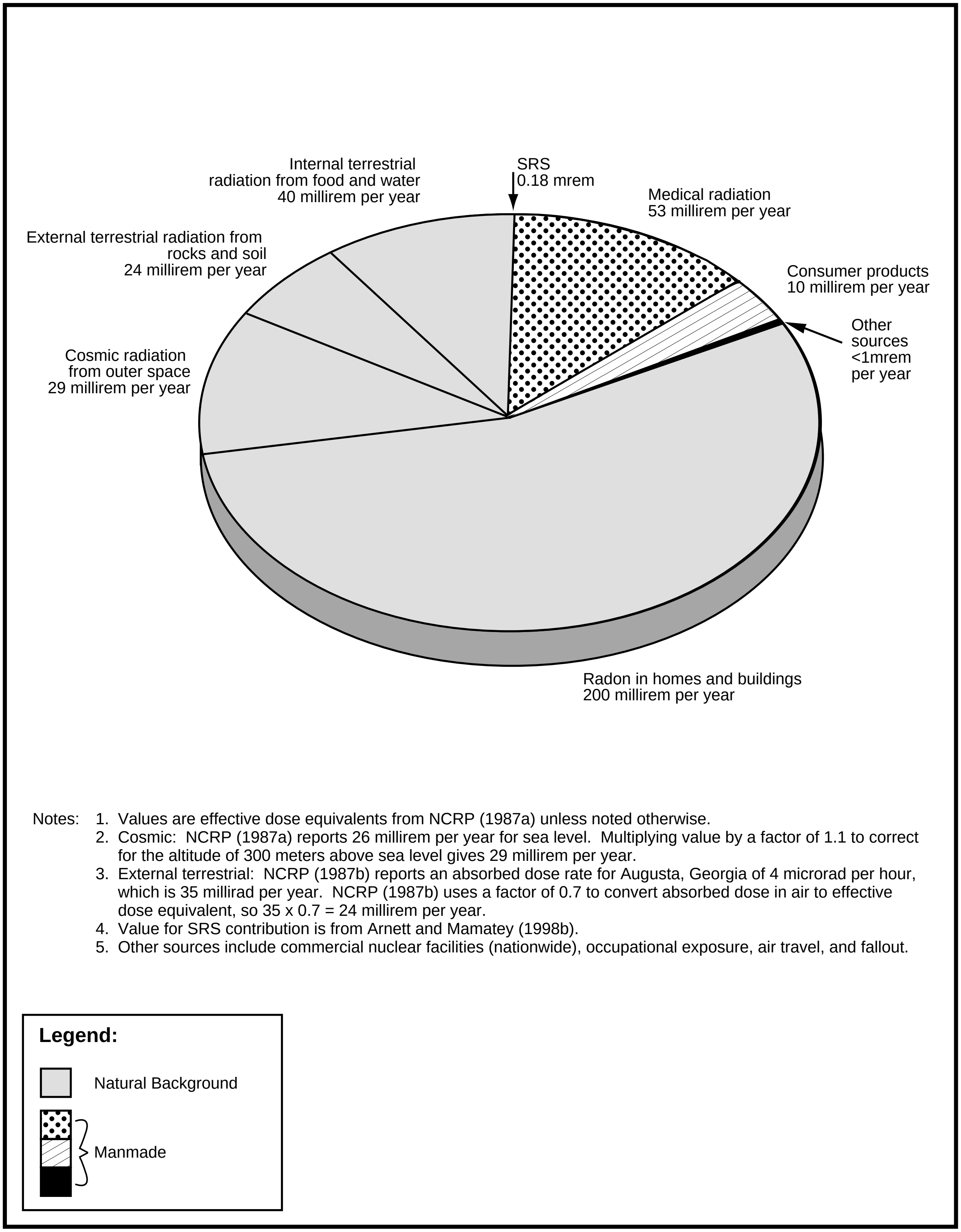
The estimated maximum dose from water pathways to downstream consumers of Savannah River water – 0.07 mrem – occurred to users of the Port Wentworth and the Beaufort-Jasper public water supplies (Arnett and Mamatey 1998b).

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

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

3.8.2 PUBLIC NONRADIOLOGICAL HEALTH

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



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

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

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

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

3.8.3 WORKER RADIOLOGICAL HEALTH

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

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

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

3.8.4 WORKER NONRADIOLOGICAL HEALTH

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

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

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

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

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

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

Sources: duPont (1989), Petty (1993), WSRC (1991, 1992, 1993, 1994, 1995b, 1996, 1997b, 1998d, 1999c).

a. The average dose includes only workers who received a measurable dose during the year.

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

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

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

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

3.9 Waste and Hazardous Materials Management

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

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

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

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a. Source: DOE (2000b). Data includes direct-hire and subcontract construction hours worked for the years 1995 through 1999.

b. Source: Bureau of Labor Statistics (2000). Industry average for the years 1995 through 1998. No data available for 1999.

c. 200,000 hours is the standard base for incidence rates, and represents the equivalent of 100 employees working 40 hours per week for 50 weeks.

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

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

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a. Source: DOE (2000b). Data includes direct-hire and subcontract operations hours worked for the years 1995 through 1999.

b. Source: Bureau of Labor Statistics (2000). Industry average for the years 1995 through 1998. No data available for 1999.

c. 200,000 hours is the standard base for incidence rates, and represents the equivalent of 100 employees working 40 hours per week for 50 weeks.

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

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

3.9.1 LOW-LEVEL RADIOACTIVE WASTE

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

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

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

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

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

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

3.9.2 MIXED LOW-LEVEL WASTE

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

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

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

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

3.9.3 HIGH-LEVEL WASTE

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

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

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

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

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

a. Sanitary waste is not stored at SRS; therefore, it is not addressed in this table.

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

c. As of April 1998, there were approximately 660,000 gallons of space available in each of the HLW Tank Farms.

d. Twenty-four of these tanks do not meet secondary containment requirements and have been scheduled for closure.

e. Usable storage capacity of 2,159 canisters due to floor plug problems.

f. Transuranic waste storage capacities depend on the packaging of the waste and the configuration of packages on the pads.

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

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

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

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

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

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

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

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

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

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

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

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

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

d. SRS is scheduled for WIPP certification audit in fall 2000 and SRS waste is scheduled to be shipped to WIPP in early 2001.

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

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

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

3.9.4 SANITARY WASTE

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

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

3.9.5 HAZARDOUS WASTE

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

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

3.9.6 TRANSURANIC AND ALPHA WASTE

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

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

3.9.7 HAZARDOUS CHEMICALS

The *Savannah River Site Tier II Emergency and Hazardous Chemical Inventory Report* for 1998 (WSRC 1999g) lists more than 79 hazardous chemicals that were present at SRS at some time during the year in amounts that exceeded the minimum reporting thresholds (generally 10,000 pounds for hazardous chemicals and 500 pounds for extremely hazardous substances). Four of the 79 hazardous chemicals are considered extremely hazardous substances under the Emergency Planning and Community Right-to-Know Act of 1986. The actual number and quantity of hazardous chemicals present on and at individual facilities changes daily as a function of use and demand.

3.10 Energy and Utilities

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

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

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

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

References

Aadland, R. K., J. A. Gellici, and P. A. Thayer, 1995, *Hydrogeologic Framework of West-Central South Carolina*, Report 5, State of South Carolina Department of Natural Resources – Water Resources Division, Columbia, South Carolina.

Aiken Standard, 1993, "Early Sunday Quake Jolts Aiken County," Volume 26, No. 221, Aiken, South Carolina, August 9.

Arnett, M. W. and A. R. Mamatey, 1998a, *Savannah River Site Environmental Data for 1997*, WSRC-TR-97-00324, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W. and A. R. Mamatey, 1998b, *Savannah River Site Environmental Report for 1997*, WSRC-TR-97-00322, Westinghouse Savannah River Company, Aiken, South Carolina.

Bennett, D. H. and R. W. McFarlane, 1983, *The Fishes of the Savannah River Plant: National Environmental Research Park*, SRO-NERP-12, Savannah River Ecology Laboratory, Aiken, South Carolina.

Britton, J. C. and S. L. H. Fuller, 1979, *The Freshwater Bivalve Mollusca of the Savannah River Plant*, SRO-NERP-3, Savannah River Ecology Laboratory, Aiken, South Carolina.

Bureau of Labor Statistics, 2000, Number of nonfatal occupational injuries and illnesses by industry and selected case types, 1990-2000, U.S. Department of Labor, Washington, D.C. Available at http://146.142.4.24/cgi-bin/dsrv. Accessed September 26, 2000.

CDC (Centers for Disease Control and Prevention), 1999, *National Vital Statistics Report*, Volume 47, Number 19, Deaths: Final Data for 1997, U.S. Department of Health and Human Services, Washington, D.C., June 30.

Cothran, E. G., M. H. Smith, J. O. Wolff, and J. B. Gentry, 1991, *Mammals of the Savannah River Site*, SRO-NERP-21, Savannah River Ecology Laboratory, Aiken, South Carolina, June.

DOE (U.S. Department of Energy), 1982, *Defense Waste Processing Facility Environmental Impact Statement*, DOE/EIS-0082, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1987, *Final Environmental Impact Statement, Alternative Cooling Water Systems*, DOE/EIS-0121, Savannah River Field Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1990, *Final Environmental Impact Statement for the Continued Operations of K-, L-, and P-Reactors, Savannah River Site, Aiken, South Carolina*, DOE/EIS-0147, Savannah River Field Office, Aiken, South Carolina, December.

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility*, DOE/EIS-0082-S, Savannah River Operations Office, Aiken, South Carolina, November.

DOE (U.S. Department of Energy), 1995a, *Final Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement*, DOE/EIS-0203, Idaho Operations Office, Idaho Falls, Idaho.

DOE (U.S. Department of Energy), 1995b, *Savannah River Site Waste Management Final Environmental Impact Statement*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995c, *Final Environmental Impact Statement for the Interim Management of Nuclear Materials*, DOE/EIS-0220, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997a, *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site*, DOE/EIS-0268, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997b, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997c, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS-0026-S-2, Carlsbad Area Office, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1998a, *Spent Nuclear Fuel Management Environmental Impact Statement*, DOE/EIS-0279D, Savannah River Operations Office, Aiken, South Carolina, December.

DOE (U.S. Department of Energy), 1998b, *Savannah River Site Future Use Plan*, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998c, *Workforce Restructuring [Online],* http://www.srs.gov/general/aboutsrs/pub_rel/factsheets/workforce.html.

DOE (U.S. Department of Energy), 1999a*, Environmental Impact Statement, Accelerator Production of Tritium at the Savannah River Site*, DOE/EIS-0270, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999b, *Radioactive Waste Management Manual*, DOE M 435.1-1, Office of Environmental Management, Washington, D.C., July 9. http://www.explorer.doc.gov:1176/htmls/directives.html.

DOE (U.S. Department of Energy), 2000a, *High-Level Waste Tank Closure Draft Environmental Impact Statement,* DOE/EIS-0303D, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 2000b, Savannah River Operations Injury an Illness Experience – By Organization for 1995 through 1999. Available at http://tis.eh.doe.gov/cairs/cairs/fieldof/to994/i855y.html. Accessed September 26, 2000.

duPont, (E. I. du Pont de Nemours and Company, Inc.), 1987, *Comprehensive Cooling Water Study Final Report,* Volumes I - VIII, DP-1739, Savannah River Laboratory, Aiken, South Carolina.

duPont (E. I. du Pont de Nemours and Company, Inc.), 1989, *Radiation Exposure Report, Annual Report for 1988*, DPSPU-89-11-1, Savannah River Plant, Aiken, South Carolina.

EPA (U.S. Environmental Protection Agency), 1999, *June 28, 1999 EPA Summary of the Court's Decision*, http://ttnwww.rtpnc.epa.gov/naaqsfin/, July 19.

Geomatrix, 1991, *Ground Motion Following Selection of SRS Design Basis Earthquake and Associated Deterministic Approach,* Geomatrix Consultants, March.

Gibbons, J. W. and R. D. Semlitsch, 1991, *Guide to the Reptiles and Amphibians of the Savannah River Site*, University of Georgia Press, Athens, Georgia.

Halverson, N. 1999, interoffice memorandum to C. B. Shedrow, "Revised Cumulative Impacts Data," SRT-EST-99-0328, Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, August 17.

Halverson, N. V., L. D. Wike, K. K. Patterson, J. A. Bowers, A. L. Bryan, K. F. Chen, C. L. Cummins, B. R. del Carmen, K. L. Dixon, D. L. Dunn, G. P. Friday, J. E. Irwin, R. K. Kolka, H. E. Mackey, Jr., J. J. Mayer, E. A. Nelson, M. H. Paller, V. A. Rogers, W. L. Specht, H. M. Westbury, and E. W. Wilde, 1997, *SRS Ecology Environmental Information Document*, WSRC-TR-97-0223, Westinghouse Savannah River Company, Aiken, South Carolina.

HNUS (Halliburton NUS Corporation), 1997, *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site*, Aiken, South Carolina.

Hunter, C. H., 2000, "Nonradiological Air Quality Modeling for the High-Level Waste Salt Disposition Environmental Impact Statement," WSRC-TR-99-00403, Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, July 27.

Lee, R. C., M. E. Maryak, and M. D. McHood, 1997, SRS Seismic Response Analysis and Design Basis Guidelines, WSRC-TR-97-0085, Rev. 0, Savannah River Company, Aiken, South Carolina.

Mamatey, A. R., Westinghouse Savannah River Company, 1999, electronic message to L. Wike, Westinghouse Savannah River Company, "Nonrad Air Emissions Data," Aiken, South Carolina, July 6.

Mayer, J. J. and L. D. Wike, 1997, *SRS Urban Wildlife Environmental Information Document*, WSRC-TR-97-0093, Westinghouse Savannah River Company, Aiken, South Carolina.

NCRP (National Council on Radiation Protection and Measurements), 1987, *Ionizing Radiation Exposure of the Population of the United States*, Report No. 93, Washington, D.C.

NCRP (National Council on Radiation Protection and Measurements), 1993*, Limitation of Exposure to Ionizing Radiation*, Report 116, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1996*, Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites in 1992*, NUREG/CR-2850, Vol. 14, Washington, D.C.

Petty, K. R., 1993, "Health Protection Department 1992 Annual Report," interoffice memorandum to Distribution, Westinghouse Savannah River Company, WSRC-ESH-HPD-9200-035, Aiken, South Carolina.

SCDHEC (South Carolina Department of Health and Environmental Control), 1976, *Air Pollution Control Regulations and Standards*, South Carolina Code of Laws, Regulations 61-62, Columbia, South Carolina.

SCDHEC (South Carolina Department of Health and Environmental Control), 1998, *South Carolina Air Quality Annual Report*, Vol. XVIII 1997, Bureau of Air Quality, Columbia, South Carolina.

SCDHEC (South Carolina Department of Health and Environmental Control), 1995, *South Carolina Nuclear Facility Monitoring – Annual Report 1995*, Columbia, South Carolina.

Shedrow, C. B. and L. D. Wike, 1999, *Chapter Three Data Response, Affected Environment Salt Disposition Alternatives at the Savannah River Site, Supplemental Environmental Impact Statement,* WSRC-TR-99-00221, Rev. 0, Westinghouse Savannah River Company, Aiken, South Carolina, June.

Specht, W. L., and M. H. Paller, 1998, *In-Stream Biological Assessment of NPDES Point Source Discharges at the Savannah River Site*, 1997-1998, WSRC-TR-98-00321, Westinghouse Savannah River Company, Aiken, South Carolina.

Sprunt, A. and E. B. Chamberlain, 1970, *South Carolina Bird Life*, University of South Carolina Press, Columbia, South Carolina.

SRFS (Savannah River Forest Station), 1994, *Savannah River Site Proposed, Threatened, Endangered, and Sensitive Plants and Animals*, U.S. Department of Agriculture Forest Service, Aiken, South Carolina, August.

SRFS (Savannah River Forest Station), 1996, *Savannah River Site Threatened, Endangered, and Sensitive Flora and Fauna*, map, compiled by SRFS-GIS, New Ellenton, South Carolina, July.

Stephenson, D. E. and A. L. Stieve, 1992, *Structured Model of the Basement in the Central Savannah River Area, South Carolina and Georgia*, WSRC-TR-92-120, Westinghouse Savannah River Company, Aiken, South Carolina.

U.S. Bureau of the Census, 1999, *County Population Estimates for July 1, 1982* [online], http://www.census.gov/population/estimates/county, release date March 12.

USDA (U.S. Department of Agriculture), 1990, *Soil Survey of Savannah River Plant Area, Parts of Aiken, Barnwell, and Allendale Counties, South Carolina*, Soil Conservation Service, June.

Weber et al. 1998, *Tornado, Maximum Wind Gust, and Extreme Rainfall Event Recurrence Frequencies at the Savannah River Site*, WSRC-TR-98-00329, Westinghouse Savannah River Company, Aiken, South Carolina.

Wells, D., 1997, personal communication with G. Gunter (Tetra-Tech NUS), Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, February 6.

Wike, L. D., D. B. Moore-Shedrow, and C. B. Shedrow, 1996, *Site Selection for the Accelerator for Production of Tritium at the Savannah River Site*, WSRC-TR-96-0279, Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, October 9.

WSRC (Westinghouse Savannah River Company), 1991, *Radiation Protection and Industrial Hygiene Annual Report*, 1989, ESH-QIS-910027, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1992, 1990 *Health Protection Annual Report*, ESH-HPD-920072, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1993, *Radiological Control Procedure Manual*, 5Q, Chapter 1, Part 1, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1994, *Savannah River Site Radiological Performance*, Fourth Quarter 1993, ESH-PAS-94-0018, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1995a, *Environmental Protection Department's Well Inventory*, ESH-EMS-950419, Aiken, South Carolina, October.

WSRC (Westinghouse Savannah River Company), 1995b, *Savannah River Site Radiological Performance*, Fourth Quarter 1994, ESH-RCD-95-0016, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1996, *Savannah River Site Radiological Performance*, Fourth Quarter 1995, ESH-RCO-96-0002, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1997a, *The Savannah River Site's Groundwater Monitoring Program*, Fourth Quarter 1997, ESH-EMS-970491, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1997b, *WSRC Radiological Performance*, Fourth Quarter 1996, WSRC-SHP-970012, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998a, *The Savannah River Site's Groundwater Monitoring Program*, First Quarter 1998, ESH-EMS-980568, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998b, *The Savannah River Site's Groundwater Monitoring Program*, Second Quarter 1998, ESH-EMS-980569, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998c, *The Savannah River Site's Groundwater Monitoring Program*, Third Quarter 1998, ESH-EMS-980570, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998d, *WSRC Radiological Performance*, Fourth Quarter CY97, ESH-SHP-980007, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999a, *Site Selection for the Salt Disposition Facility at the Savannah River Site*, Rev. 0, WSRC-RP-99-00513, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, *South Carolina Department of Health and Environmental Control Water Use Report - January through December, 1998*, January 22.

WSRC (Westinghouse Savannah River Company), 1999c, *WSRC Radiological Performance Indicators (U)*, Fourth Quarter CY98, ESH-HPT-99-0017, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999d, *Savannah River Site Approved Site Treatment Plan, 1998 Annual Update*, WSRC-TR-94-0608, Revision 6, Savannah River Operations Office, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999e *Savannah River Site News Release: New SRS Evaporator Set to Begin Radioactive Operations*, http://:rmsrv02.srs.gov/general/aboutsrs/pub_rel/releases/evaporator.html, accessed July 10, 2000.

WSRC (Westinghouse Savannah River Company), 1999f, *Waste Isolation Pilot Plant Progress Report April 1999*, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999g, *Savannah River Site Tier II Emergency and Hazardous Chemical Inventory Report*, Aiken, South Carolina, March.

WSRC (Westinghouse Savannah River Company), 2000, *Savannah River Site High Level Waste System Plan*, Revision 11, HLW-2000-00019, High Level Waste Division, Aiken, South Carolina, April.

CHAPTER 4. ENVIRONMENTAL IMPACTS

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

- No Action
- Small Tank Precipitation
- Ion Exchange
- Solvent Extraction
- Direct Disposal in Grout

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

Section 4.1 describes the short-term impacts associated with construction and operation of each alternative, including No Action. For purposes of the analyses in this Supplemental Environmental Impact Statement (SEIS), the short-term impacts span from the year 2001 until completion of salt processing operations (approximately 2023). As indicated in Chapter 2, the time of completion varies slightly with the selected technology. Section 4.2 describes for each action alternative the long-term impacts of the radioactive and non-radioactive constituents solidified in saltstone and disposed of in the saltstone disposal vaults. Long-term assessment involves a performance evaluation beginning with a 100-year period of institutional control and continuing through an extended period, during which it is assumed that residential and/or agricultural uses could occur.

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

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

4.1 Short-Term Impacts

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

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

4.1.1 GEOLOGIC RESOURCES

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

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

Construction

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

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

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

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

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

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

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

b. (WSRC 1998a).

c. (WSRC 1998b).

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

Operation

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

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

4.1.2 WATER RESOURCES

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

4.1.2.1 Surface Water

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

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

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

Construction

As discussed in Section 4.1.1 for the action alternatives, up to 23 acres of land would be cleared and 23,000 to 82,000 cubic yards of soil would be excavated for construction of the salt processing facility. A slight increase in suspended solids and particulates in stormwater runoff could occur as soils are disturbed during the four-year period when process and support facilities are being built, but would be expected only during periods of unusually high rainfall. Soil excavated for building foundations would be used as backfill or trucked to suitable disposal sites on SRS, greatly reducing the likelihood that loose or stockpiled soil would be transported to streams along with stormwater. In accordance with best management practices, DOE would stabilize exposed soils by seeding with grasses or legumes (e.g., clovers) in a water medium that includes mulch and fertilizer. Hydroseeding is often used at SRS to stabilize disturbed areas and control erosion.

As discussed in Section 4.1.1, DOE could build as many as 18 new HLW storage tanks under the No Action alternative; DOE would use approved siting procedures to ensure that any new tanks would be built in previously disturbed industrial areas with a water table well below ground surface. Each new tank would require excavation of approximately 43,000 cubic yards of soil. Excavated soil would be used as backfill or trucked to suitable disposal sites on SRS. Best management practices would be used to stabilize soils and prevent runoff, reducing the likelihood that loose or stockpiled soil would be transported to streams along with stormwater.

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

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

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

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

Operations

Sanitary wastewater from salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES Outfall G-10. Process wastewater from salt processing facilities would be treated at the F/H Effluent Treatment Facility (ETF) and discharged to Upper Three Runs via NPDES Outfall H-16. As can be seen in Table 4-2, the volume of sanitary and process wastewater generated by each of the action alternatives is similar and low. The Solvent Extraction alternative would generate the highest volume of both wastewater streams, but would only constitute 2.2 percent of the SRS sanitary wastewater treatment capacity and 0.57 percent of the ETF capacity. In both instances, current treatment capacity would be more than adequate to handle the additional demand from salt processing facilities. Current NPDES discharge limitations would remain in effect, meaning that no degradation of water quality in Fourmile Branch, Upper Three Runs, or the Savannah River would be expected.

Under the No Action alternative, sanitary and process wastewater generation rates would continue at current levels.

4.1.2.2 Groundwater Resources

Construction

Elements of the processing facility would be constructed below grade. The depth below grade for the Small Tank Precipitation and Ion Exchange process buildings would be about 45 feet, while the process building for Solvent

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

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

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a. For all scenarios under the No Action alternative, volume of wastewater generated would be similar to the wastewater generation at the existing HLW Tank Farms. Therefore, wastewater generation under No Action would be included in the SRS baseline.

b. SRS Centralized Sanitary Waste Treatment Facility capacity = 1.05 million gallons per day (Schafner 2001).

c. Adapted from WSRC (1999e). Sanitary wastewater based on estimated potable water use.

d. F/H ETF design capacity = 433,000 gallons per day (DOE 1995).

e. ETF percent utilization based on 1994 data (DOE 1995).

f. Total process wastewater (radioactive liquid waste) annually (WSRC 1999b, 2000b).

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

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

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

Operations

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

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

4.1.3 AIR RESOURCES

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

4.1.3.1 Nonradiological Emissions

Construction

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

During construction, the excavation and transfer of soils and the disturbance of surface dust by heavy equipment all result in particulate matter emissions. These emissions of particulate matter caused by wind or man's activities, or both, are known as fugitive dust. In accordance with good dust control practices required by South Carolina regulations, measures would be implemented to control fugitive particulate matter. Best management practices would be used during land clearing, road grading, and construction to minimize airborne dust. Dust control measures could include seeding, wind speed reduction (e.g., wind barriers), wet or chemical suppression, or early paving. The U.S. Environmental Protection Agency's (EPA's) Fugitive Dust Model (FDM) (EPA 1990) computer program was used to model all fugitive emissions from construction activities.

Heavy-duty construction equipment (i.e., trucks, bulldozers, and other diesel-powered support equipment) would be used for excavation and grading, hauling soil and debris for disposal, and other routine construction activities. Exhaust emissions from these diesel engines would result in releases of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM_{10}), carbon monoxide (CO), and total suspended particulate (TSP) matter. A detailed listing of the construction equipment that would be used is documented in WSRC (1999b).

Facility construction (including new tanks under the No Action alternative) would necessitate a concrete batch plant at the building site. Particulate matter, consisting primarily of cement

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

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

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

Air pollutant	Vehicle exhaust (tons per year)	Fugitive Dust (tons per year)[a]	Concrete Batch Plant (tons per year)
SO_2	13	–	–
TSP	16	100	14
PM_{10}	NA[b]	25	NA
CO	60	–	–
NO_2	150	–	–

Source: Hunter (2000).

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

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

SO_2 = sulfur dioxide, TSP = total suspended particles, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 micrometers, CO = carbon monoxide, NO_2 = nitrogen dioxide.

dust, would be the only regulated pollutant emitted in the concrete mixing process. Emissions would occur at the point of transfer of cement to the silo. However, DOE would use filter bags, which have control efficiencies as high as 99 percent, or a similar technology to remove particulate emissions. Particulate emission limits for the operation of a concrete batch plant would be established in a construction permit granted by SCDHEC. Any fugitive dust emissions from sand and aggregate piles around the batch plant would be controlled by water suppression, chemical dust suppressants, or other approved methods. Using the emission rates from construction vehicles and the concrete batch plant (Table 4-4), maximum concentrations of regulated pollutants were determined, using Release 3 of the Industrial Source Complex – Short Term (ISC3) air dispersion model (EPA 1995).

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

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

Operations

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

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

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

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

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

Air pollutant	Averaging time	SCDHEC standard (μg/m^3)[a]	SRS baseline concentration (μg/m^3)[b]	SRS baseline concentration (% of standard)	Maximum concen-tration (μg/m^3)[c]	SRS baseline + concentration (% of standard)
SO$_2$	3-hr	1,300	1,240	96	5.0	96
	24-hr	365	350	96	0.7	96
	Annual	80	34	42	0.009	42
TSP	Annual geometric mean	75	67	89	0.04	90
PM$_{10}$[d]	24-hr	150	130	88	2	90
	Annual	50	25	51	0.03	51
CO	1-hr	40,000	10,350	26	70	26
	8-hr	10,000	6,870	69	10	69
NO$_2$	Annual	100	26	26	01	26

Source: Hunter (2000).

a. SCDHEC Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards".

b. Sum of (1) an estimated maximum Site boundary concentration from modeling all SRS sources of the indicated pollutant not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations (Hunter 2000).

c. Maximum concentrations would be the same for all alternatives including construction of new tanks under No Action.

d. New standard for particulate matter may come into effect during the construction of this project.

SO$_2$ = sulfur dioxide, TSP = total suspended particles, PM$_{10}$ = particulate matter with an aerodynamic diameter ≤ 10 pm, CO = carbon monoxide, NO$_2$ = nitrogen dioxide.

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

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

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a. For all scenarios under the No Action alternative, the expected source of emissions would be the ventilation exhaust from each tank.

b. Vaults for the other three action alternatives would have minimal emissions because the saltstone produced by these action alternatives would have a lower activity level and the vaults would not be ventilated.

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

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

Source: Hunter (2000).

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

b. SCDHEC Bureau of Air Quality Control Operating Permits for HLW management facilities.

c. SCDHEC Regulation 61-62.5, Standard 7, "Prevention of Significant Deterioration".

d. VOCs are subject to a PSD limit because they are a precursor to ozone. VOCs that may be emitted as a result of the proposed action include benzene, biphenyl, methanol, n-Propanol, and Isopar®L. NO_x also contributes to ozone formation.

e. Value includes 50.48 tons per year of benzene and 19.75 tons per year of other VOCs.

f. SRS lead and beryllium emissions originate from permit-exempted units, so no allowance has been established.

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

h. No PSD limit is defined for this pollutant.

i. Also known as diphenyl.

j. This pollutant is a VOC and the SRS air permits do not have a specific permit allowance for this pollutant.

k. Also known as methyl alcohol.

l. Also known as n-Propyl alcohol; OSHA-regulated pollutant.

m. Isopar®L is a proprietary chemical; regulated as a VOC only.

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

Prevention of Significant Deterioration Review

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

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

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

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

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

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

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

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

4.1.3.2 Radiological Emissions

Construction

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

Operations

DOE estimated routine radionuclide air emissions for each salt alternative. Under each processing alternative, radionuclides would be emitted to the air via a stack. As discussed in Section 4.1.3.1, the stack for each process facility was assumed to be 46 meters high, the same height as the DWPF stack. For all the salt processing alternatives, the ventilation exhaust would be filtered through high-efficiency particulate air filters. The Direct Disposal in Grout alternative would have an additional emission point at each vault in operation because radioactive cesium would not be removed before grouting, requiring the vaults to have a forced air ventilation system for temperature control while the saltstone cures. Because the other three action alternatives would remove more radionuclides (including radioactive cesium) from the low-activity salt fraction, the grout would have much lower activity levels and the vaults would not need to be ventilated. Therefore, the Small Tank Precipitation, Ion Exchange, and Solvent

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

					Maximum concentration							
					Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Air pollutant	Averaging time	SCDHEC standard (µg/m³)[a]	SRS baseline concentration (µg/m³)[b]	SRS baseline concentration (% of standard)	Concentration (µg/m³)	Baseline + Concentration (% of standard)	Concentration (µg/m³)	Baseline + Concentration (% of standard)	Concentration (µg/m³)	Baseline + Concentration (% of standard)	Concentration (µg/m³)	Baseline + Concentration (% of standard)
Ambient air pollutants												
SO_2	3-hr	1,300	1,240	96	0.30	96	0.30	96	0.30	96	0.40	96
	24-hr	365	350	96	0.040	96	0.040	96	0.040	96	0.050	96
	Annual	80	34	42	4.0×10^{-4}	42	4.0×10^{-4}	42	4.0×10^{-4}	42	5.0×10^{-4}	42
TSP	Annual geometric mean	75	67	89	0.0010	89	0.0010	89	0.0010	89	0.0010	89
PM_{10}[c]	24-hr	150	130	88	0.070	89	0.070	89	0.070	89	0.070	89
	Annual	50	25	51	0.0010	51	0.0010	51	0.0010	51	0.0010	51
CO	1-hr	40,000	10,350	26	15	26	15	26	15	26	18	26
	8-hr	10,000	6,870	69	1.9	69	1.9	69	1.9	69	2.3	69
Ozone[c]	1-hr	235	216	92	ND	ND	ND	ND	ND	ND	ND	ND
NO_2	Annual	100	26	26	0.030	26	0.030	26	0.030	26	0.030	26
Lead	Max. calendar quarter	1.5	0.03	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0
Air toxic pollutants[e]												
Benzene	24-hr	150	5	3.1	4.0	5.7	0.0010	26	0.0010	26	0.0010	26
Mercury	24-hr	0.25	0.03	12	3.0×10^{-5}	12	3.0×10^{-5}	12	3.0×10^{-5}	12	3.0×10^{-5}	12
Biphenyl[f]	24-hr	6	0.02	0.33	0.45	7.8	None	0.33	None	0.33	None	0.33
Methanol[g]	24-hr	1,310	0.9	0.069	0.32	0.093	0.32	0.090	0.32	0.090	0.53	0.11
Beryllium	24-hr	0.01	0.0090	90	1.0×10^{-5}	90	1.0×10^{-5}	90	1.0×10^{-5}	90	1.0×10^{-5}	90
Formic Acid[h]	24-hr	225	0.15	0.067	0.01	0.067	None	0.067	None	0.067	None	0.067

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

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

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

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

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

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

f. Also known as diphenyl.

g. Also known as methyl alcohol.

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

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

Extraction alternatives would have no measurable emissions from the associated saltstone vaults. Emissions from the vaults for Direct Disposal in Grout alternative were assumed to be at ground level. The estimated total radiological air emissions for each action alternative are shown in Table 4-9 (Pike 2000). Because there are no equivalent facilities at SRS, DOE's method for estimating emission rates from the alternative salt processing facilities is conservative and ensures that total emissions are not underestimated. All action alternatives are all treated with the same conservative basis. The Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes all produce highly concentrated cesium-bearing process streams. The engineered systems designed for each facility would ensure that the cesium emissions are as low as reasonably achievable.

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

After determining routine emission rates for the action alternatives, DOE used the MAXIGASP and POPGASP computer codes to estimate radiological doses to the maximally exposed (offsite) individual (MEI), the hypothetical noninvolved worker, and the offsite population surrounding SRS. Both codes utilize the GASPAR (Eckerman et al. 1980) and XOQDOQ (Sagendorf et al. 1976, 1982) modules; GASPAR and XOQDOQ are based on U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides 1.111 and 1.109 (NRC 1977), respectively. Both GASPAR and XOQDOQ have been adapted and verified for use at SRS (Hamby 1992 and Bauer 1991, respectively). MAXIGASP and POPGASP are both Site-specific computer programs that have SRS-specific meteorological parameters (e.g., wind speeds and directions) and population distribution parameters (e.g., number of people in sectors around the Site). The 1990 census population database was used to represent the population living within a 50-mile radius of the center of SRS.

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

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

Source: Pike (2000).

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

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

c. Assumed to be plutonium-239.

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

The maximum estimated dose to the offsite population residing within a 50-mile (80-kilometer) radius (approximately 620,000 people) would be 18.1 person-rem per year, also as a result of the Solvent Extraction alternative. As with the MEI dose, offsite concentrations of radioactive cesium would compose most (93 percent) of the total population dose. The Small Tank Precipitation alternative has an offsite population dose of 12.0 person-rem per year. The Ion Exchange and Direct Disposal in Grout alternatives have values that are similar to each other, but lower than the previous alternatives (2.9 and 4.0 person-rem per year, respectively). For all scenarios, the total offsite population dose is low.

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

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

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

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

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

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

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

4.1.4 WORKER AND PUBLIC HEALTH

This section discusses potential radiological and nonradiological health effects to SRS workers and the surrounding public from construction and routine operation of the salt processing alternatives; it does not include impacts of potential accidents, which are discussed in Section 4.1.13. DOE based its calculations of health effects from radiological releases to air as doses with the corresponding impacts expressed as latent cancer fatalities (LCFs) to (1) the MEI; (2) the collective population within a 50-mile (80-kilometer) radius around SRS (approximately 620,000 people); (3) the maximally exposed noninvolved worker (i.e., an SRS employee who may work in the vicinity of the salt processing facilities, but is not directly involved with the work); (4) the involved worker; (5) the onsite population of involved workers (i.e., the workers directly involved in salt processing activities); and (6) the population of SRS workers (includes both involved and noninvolved workers). All radiation doses in this SEIS are committed effective dose equivalents. This section presents total impacts for the entire length of time necessary to implement each technology. The annual impacts attributable to each phase were multiplied by the duration of that phase. The impacts from all phases were summed to calculate the total impact for the technology. This discussion characterizes health effects to populations as additional lifetime LCFs likely to occur in the general population around SRS, the population of onsite workers, and the population of workers who would be associated with implementing the alternatives. Health effects to the MEI and the noninvolved and involved worker are characterized by the additional probability of an LCF to the exposed individual.

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

4.1.4.1 Nonradiological Health Effects

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

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

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

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

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

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

Exposure to respirable beryllium fumes, dusts, or powder can also cause CBD in individuals who are sensitized (allergic) to beryllium. One to six percent of workers engaged in operations producing or using beryllium and its compounds develop CBD over their lifetimes (National Jewish 2001). While some cases of CBD have been reported in individuals with no occupational exposure to beryllium, only one case has been reported since 1973. No cases of CBD have been associated with low atmospheric concentrations of beryllium, such as those observed in the vicinity of SRS (NIOSH 1986). Therefore, DOE believes that the excess CBD risk to workers and the public as a result of salt processing operations would be minimal for all salt processing alternatives.

Benzene is the pollutant of most concern for salt processing activities. The maximum excess lifetime cancer risks to the noninvolved worker and MEI from exposure to benzene emissions were estimated to be 6.6×10^{-3} and 1.7×10^{-5}, respectively, based on the EPA's IRIS database (EPA 1998) unit risk factor for benzene of 8.3×10^{-6} excess cancer risk per microgram per cubic meter. This excess cancer risk from benzene emissions is associated with the Small Tank Precipitation alternative. Because benzene emissions (primarily from the emergency generators) from the other salt processing alternatives are similar and would be much lower than the emissions from the Small Tank Precipitation alternative, they are expected to have considerably lower excess lifetime cancer risks. See Table 4-11 for additional nonradiological pollutant concentrations. Under the No Action alternative, air emissions from ongoing tank space management activities and all subsequent scenarios would be similar to air emissions from the HLW operations included in the SRS baseline. Therefore, incremental health affects would be minimal.

Engineered systems designed for the process facilities and tanks under the No Action alternative would ensure that there would be little possibility of involved workers in the proposed facilities being exposed to anything other than very small concentrations of airborne nonradiological materials that would be similar among all alternatives. Therefore, health effects from exposure to nonradiological material inside the facilities would be minimal for all alternatives.

4.1.4.2 Radiological Health Effects

Radiation can cause a variety of health effects in people. The major effect of environmental and occupational radiation exposures is a delayed cancer fatality, which is called an LCF, because the cancer can take many years to develop and cause death.

To relate a dose to its effect, DOE has adopted a dose-to-risk conversion factor of 0.0004 LCFs per person-rem for workers and 0.0005 LCFs per person-rem for the general population (NCRP 1993) to estimate the number of LCFs that could result from the calculated exposure. The factor for the general population is slightly higher because infants and children are more sensitive to radiation than the adult worker population.

Table 4-11. Estimated maximum concentration in milligrams per cubic meter (mg/m^3) of air pollutants to the noninvolved worker from facility air emissions.[a,b]

	Averaging time[c]	OSHA Standard[c]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Sulfur dioxide	8-hr TWA[d]	13	0.01	0.01	0.01	0.01
Total particulates	8-hr TWA	15	0.02	0.02	0.02	0.01
Particulates <10 microns	8-hr TWA	5	0.02	0.02	0.02	0.01
Carbon monoxide	8-hr TWA	55	0.2	0.2	0.2	0.2
Nitrogen dioxide	Ceiling[e]	9	7.0	7.0	7.0	7.0
Lead	8-hr TWA	0.5	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Beryllium	8-hr	0.002	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}
	Ceiling	0.005	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Methyl alcohol	8-hr TWA	260	0.08	0.08	0.08	0.08
n-Propyl alcohol	8-hr TWA	500	0.08	0.08	0.08	0.08
Mercury	Ceiling	0.1	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Benzene	8-hr	3.1	0.1	3.0×10^{-4}	3.0×10^{-4}	3.0×10^{-4}
	Ceiling	15.5	0.8	0.004	0.004	0.004
Formic Acid[f]	8-hr	9	2.2×10^{-4}	None	None	None

Source: Hunter (2000).

a. For a noninvolved onsite worker at a distance of 640 meters from the process building stack and a 1.8-meter breathing height.

b. Under the No Action alternative, air emissions from all scenarios would be similar to air emissions from the HLW operations included in the SRS baseline. Therefore, incremental health effects would be minimal.

c. From 29 CFR 1910.1000.

d. TWA – Time-weighted average.

e. Ceiling limits are permissible exposure limits that a facility cannot exceed at any time.

f. Formic acid emissions would be shifted from DWPF to the Small Tank Precipitation facility, resulting in no net change.

These dose-to-risk factors are consistent with the factors used by the NRC in its rulemaking *Standards for Protection Against Radiation* (10 CFR 20). The factors apply if the dose to an individual is less than 20 rem and the dose rate is less than 10 rem per hour. At doses greater than 20 rem, the factors used to relate radiation doses to LCFs are doubled. At much higher dose rates, prompt effects, rather than LCFs, would be the primary concern.

DOE expects minimal worker and public health impacts from the radiological consequences of salt processing activities under any of the technology alternatives. All alternatives are expected to result in similar radiological release levels. Public radiation doses would occur from airborne releases only (Section 4.1.3). Table 4-12 lists estimated radiation doses and corresponding incremental LCFs for the noninvolved worker (a worker not directly involved with implementing the alternative, but located 2,100 feet [640 meters] from the salt processing facility), the involved worker (a worker located 328 feet [100 meters] from the salt processing facility), the collective population of involved workers, the collective onsite (SRS) population, and the public (MEI and the collective offsite population) for each technology alternative.

As shown in Table 4-12, the highest radiological impacts to both involved and noninvolved workers and to the public would be associated with the Solvent Extraction alternative. The Small Tank Precipitation alternative would have impacts similar to Solvent Extraction, and the Ion Exchange and Direct Disposal in Grout alternatives would result in slightly lower impacts. The radiological doses from the Solvent Extraction alternative airborne emissions are higher than those for the other alternatives, and would result in an estimated additional 0.12 LCF for the general population surrounding SRS (50-mile radius) over the period of operation. Emissions from the Solvent Extraction alternative would also result in the highest impact to workers at SRS, an estimated 0.034 LCF for the collective SRS worker population (includes both involved and noninvolved workers) over the 13-year life of the project.

As expected, the collective involved worker doses and total project-phase doses shown in Table 4-12 are similar for all four action alternatives. The Solvent Extraction project-phase collective worker dose is the highest of the alternatives at 47 person-rem over the life of the project, and would result in 0.019 LCF. All doses are well within the administrative control limits for SRS workers (500 millirem per year).

The estimated number of LCFs in the public (Table 4-12) due to airborne emissions from each action alternative can be compared to the projected number of fatal cancers (approximately 140,000) in the public around the SRS from all causes (as discussed in Section 3.8.1). Similarly, the estimated number of fatal cancers in the involved worker population can be compared to the percent of the general population that succumbs from cancer regardless of cause (approximately 23.3 percent; see Section 3.8.1). In all cases, the incremental impacts from the alternatives would be minimal.

4.1.4.3 Occupational Health and Safety

The established method of determining a company or facility's safety record is by using its historic number of total recordable cases (TRCs) and lost workday cases (LWCs). Table 4-13 provides estimates of the number of TRCs and LWCs that would occur during a year and during the facility life cycle for the estimated number of involved workers for each alternative. The projected injury rates are based on historic SRS injury rates over a four-year period (1995 through 1999) multiplied by the employment levels and years for each alternative and the appropriate TRC and LWC rates.

The TRC rate includes work-related deaths, illnesses, or injuries that resulted in loss of consciousness, restriction from work or motion, transfer to another job, or required medical treatment beyond first aid. The LWC rate represents the number of workdays, beyond the day of injury or onset of illness, the employee was away from work or limited to restricted work activity because of an occupational injury or illness.

Table 4-12. Estimated public and occupational radiological doses and health impacts from atmospheric emissions during operations.[a,b,c]

Receptor[d,e]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout[f]
MEI dose (millirem/year)	0.20	0.049	0.31	0.086
Probability of an LCF from MEI dose[g]	1.3×10^{-6}	3.2×10^{-7}	2.0×10^{-6}	5.6×10^{-7}
Dose to population within 50 miles of SRS (person-rem/year)	12.0	2.9	18.1	4.0
Estimated number of project-phase LCFs in the population within 50 miles of SRS[g]	0.078	0.019	0.12	0.026
Noninvolved worker dose (millirem/year)	3.3	0.8	4.8	1.7
Probability of an LCF from noninvolved worker dose[g]	1.7×10^{-5}	4.2×10^{-6}	2.5×10^{-5}	8.6×10^{-6}
Annual number of radiological workers[h]	140	100	160	110
Involved worker dose (millirem/year)	16	3.9	23	10
Probability of an LCF from involved worker dose[g]	8.2×10^{-5}	2.0×10^{-5}	1.2×10^{-4}	5.3×10^{-5}
Annual dose to the population of involved workers (person-rem per year)	2.2	0.39	3.6	1.1
Project-phase dose to involved workers (person-rem)	29	5.0	47	14
Estimated number of project-phase LCFs to involved workers[g]	0.012	0.0020	0.019	0.0056
Annual dose to the population of SRS workers (person rem/year)	4.3	1.1	6.5	2.3
Estimated number of project-phase LCFs in the worker population at SRS[g]	0.022	0.0055	0.034	0.012

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a. Source term is based on data from Pike (2000).
b. Doses represent increment above baseline values from existing SRS activities.
c. Under the No Action alternative, air emissions from all scenarios would be similar to emissions from the HLW operations included in the SRS baseline. Therefore, incremental health effects would be minimal.
d. The MEI is 11,800 meters from the facility stack(s). The noninvolved worker is located 640 meters from the facility stack(s). The involved worker is located 100 meters from the facility stack(s).
e. Doses presented here are based on emissions from a 46-meter stack elevation.
f. Includes dose from operations and vaults.
g. LCFs are calculated for the project duration only. (When facility operations cease, residual contaminant levels would be negligible.) Each of the four action alternatives would operate for 13 years.
h. Assumes 75 percent of operations staff are radiological workers (WSRC 1999c).

The results in Table 4-13 indicate that each action alternative has similar TRCs and LWCs, but the Solvent Extraction alternative would have the highest TRCs and LWCs. The higher number of injuries for this alternative is due to the larger number of workers needed to operate the facility. The number of TRCs and LWCs would remain at current levels during continuation of tank space management activities under the No Actin alternative. Up to 65 new workers would be employed for operation of any new tanks built under No Action. This small increase in employment levels would result in 11 TRCs and 5 LWCs over the 13-year operations phase of the new tanks.

Tables 3-19 and 3-20 demonstrate that the SRS health and safety program has resulted in lower incidences of injury and illness than those in the general industry and manufacturing workforces.

Table 4-13. Estimated total recordable cases and lost workdays annually and for the life cycle of each alternative.[a]

Incident rate	No Action[b]	Small Tank Precipitation[c]	Ion Exchange[c]	Solvent Extraction[c]	Direct Disposal in Grout[c]
Total recordable cases (annual)	0.8	2.2	1.7	2.7	1.8
Total lost workday cases (annual)	0.35	1.0	0.72	1.2	0.77
Total recordable cases (facility life cycle)	11	32	24	39	25
Total lost workday cases (facility life cycle)	5	14	10	17	11

Source: WSRC (1998b, 1999d), DOE (2000b).

a. Based on working 8 hours per day, 250 days per year.

b. Based on 65 new workers for a period of 13 years to operate any new tanks built under the No Action alternative.

c. Facility life cycle includes 1.3 years for startup and 13 years of full operations.

These lower injury and illness rates for a proposed workforce ranged between 135 and 220 workers annually and for a period of 14.3 years are represented in Table 4-13. Considering the improvements the SRS safety program has made and continues to make in lowering the TRC and LWC rates, the numbers presented in Table 4-13 are conservative and future safety rates are expected to be much lower than the rates currently presented.

4.1.5 ENVIRONMENTAL JUSTICE

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs each Federal agency to “make…achieving environmental justice part of its mission” and to identify and address “…disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.” The Presidential Memorandum that accompanied Executive Order 12898 emphasized the importance of using existing laws, including the National Environmental Policy Act (NEPA), to identify and address environmental justice concerns, “including human health, economic, and social effects, of Federal actions.”

The Council on Environmental Quality (CEQ), which oversees the Federal government’s compliance with Executive Order 12898 and NEPA, subsequently developed guidelines to assist Federal agencies in incorporating the goals of Executive Order 12898 in the NEPA process. This guidance, published in 1997, was intended to “…assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed.”

As part of this process, DOE identified (in Section 3.6.2) minority and low-income populations within a 50-mile radius of the SRS (plus areas downstream of the Site that withdraw drinking water from the Savannah River), which was defined as the region of influence for the environmental justice analysis. The following section discusses whether implementing the alternatives described in Chapter 2 would result in disproportionately high and adverse impacts to minority or low-income populations.

DOE referred to the Draft Guidance on Environmental Justice and NEPA (DOE 2000c) in preparing this section.

4.1.5.1 <u>Background</u>

The CEQ issued guidance on assessing potential environmental justice impacts. No standard formula has been issued on how environmental justice issues should be identified or addressed.

However, the following six principles provide general guidance (CEQ 1997):

- The composition of the area should be considered to determine whether minority populations, low-income populations, or Indian tribes are present in the area affected by the proposed action and, if so, whether there may be disproportionately high and adverse human health or environmental effects on those populations.

- Relevant public health data and industry data concerning the potential for multiple or cumulative exposures to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards should be considered.

- The interrelated cultural, social, occupational, historical, and economic factors that may amplify the natural and physical environmental effects of the proposed action should be recognized.

- Effective public participation strategies should be developed.

- Meaningful community representation in the process should be ensured.

- Tribal representation in the process should be sought in a manner that is consistent with the government-to-government relationship between the United States and tribal governments.

Environmental justice guidance developed by CEQ defines “minority” as individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic (CEQ 1997). The Council identifies these groups as minority populations when either (1) the minority population of the affected area exceeds 50 percent or (2) the minority population percentage in the affected area is meaningfully greater than the minority population percentage in the general population or appropriate unit of geographical analysis.

Low-income populations are identified using statistical poverty thresholds from the Bureau of Census Current Population Reports, Series P-60 on Income and Poverty. In identifying low-income populations, a community may be considered either as a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effects.

Environmental justice impacts can result if the proposed activities cause disproportionately high and adverse human health or environmental effects to minority or low-income populations. DOE assesses three factors to the extent practicable to identify disproportionately high and adverse human health effects:

- Whether the health effects are significant (as used by NEPA) or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death.

- Whether the risk or rate of exposure by a minority or low-income population to an environmental hazard is significant (within the meaning of NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group.

- Whether health effects occur in a minority or low-income population affected by cumulative or multiple adverse exposures from environmental hazards.

4.1.5.2 Methodology

First, DOE assessed the impacts of the proposed action and alternatives to the general population which, near the SRS, includes minority and low-income populations. No special considerations, such as unique exposure pathways or cultural practices, contribute to any discernible disproportionate impacts. The only identified cultural practice (or unusual pathway) potentially associated with minority and low-income populations is use of the Savannah River for subsistence fishing. For the Final *Accelerator Production of Tritium for the Savannah River Site Environmental Impact Statement* (EIS) (issued in 1999), DOE reviewed the limited body of literature available on subsistence activities in the region.

DOE concluded that, because the identified minority or low-income communities are widely distributed, and the potential impact to the general population is not discernible, there would be no potential for disproportionate impacts among minority or low-income populations. Second, having concluded that the potential offsite consequences to the general public of the proposed action and the alternatives would be small, DOE concluded that there would be no disproportionately high and adverse impacts to minority or low-income populations.

These conclusions are based on the comparison of salt processing actions to past actions for which environmental justice issues were evaluated in detail. In 1995, DOE conducted an analysis of economic and racial characteristics of the population potentially affected by SRS operations within a 50-mile radius of the Site (DOE 1995). In addition, DOE examined the population downstream of the Site that withdraws drinking water from the Savannah River. The economic and racial characterization was based on 1990 census tract data from the U.S. Census Bureau. More recent census tract data are not available. The nearest minority and low-income populations to SRS are south of Augusta, Georgia, northwest of the Site.

This environmental justice analysis was based on the assessment of potential impacts associated with the various HLW salt processing alternatives to determine if there would be high and adverse human health or environmental impacts. In this assessment, DOE reviewed potential impacts arising under the major disciplines and resource areas, including: socioeconomics; cultural, air, water, and ecological resources; and public and worker health over the short term (approximately the years 2001 to 2023) and long term (approximately 10,000 years after saltstone was placed in vaults). Regarding health effects, both normal facility operations and postulated accident conditions were analyzed, with accident scenarios evaluated in terms of risk to workers and the public.

Although no high and adverse impacts were predicted for the activities analyzed in this SEIS, DOE nevertheless considered whether there were any means for minority or low-income populations to experience disproportionately high and adverse impacts. The basis for making this determination would be a comparison of areas predicted to experience human health or environmental impacts with areas in the region of influence known to contain high percentages of minority or low-income populations.

The environmental justice analysis for the HLW salt processing alternatives was assessed for a 50-mile area surrounding SRS (plus downstream areas), as discussed in Section 3.6.2.

Short-Term Impacts

For environmental justice concerns to be initiated, high and adverse human health or environmental impacts must disproportionately affect minority or low-income populations.

None of the proposed alternatives would produce appreciable short-term impacts to surface water (see Section 4.1.2.1) or groundwater (see Section 4.1.2.2). With the exception of VOCs, emissions of nonradiological and radiological air pollutants from HLW salt processing activities would be below regulatory limits (see Section 4.1.3) and would result in minimal impacts to workers and the public (see Section 4.1.4.2). The estimated radiological doses and health impacts to the noninvolved worker and the public are small (highest dose is 4.8 millirem per year to the noninvolved worker, under the Solvent Extraction alternative).

Because all salt processing activities would take place in an area that has been dedicated to industrial use for more than 40 years, no short-term impacts to ecological resources (see Section 4.1.6), existing land uses (see Section 4.1.7), or cultural resources (see Section 4.1.9) are expected.

Relatively small numbers of workers would be required to carry out salt processing activities, regardless of the alternative selected (see Section 4.1.8); as a result, none of the alternatives would affect socioeconomic trends (i.e., unemployment, wages, housing) in the region of influence.

As noted in Section 4.2, no long-term environmental justice impacts are anticipated.

Because short-term impacts would not substantially affect the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the alternatives.

Subsistence Consumption of Fish, Wildlife, and Game

Section 4-4 of Executive Order 12898 directs Federal agencies "whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence and that Federal governments communicate to the public the risks of these consumption patterns." There is no evidence to suggest that minority or low-income populations in the SRS region of influence are dependent on subsistence fishing, hunting, or gathering. DOE nevertheless considered whether there were any means for minority or low-income populations to be disproportionately affected by examining levels for contaminants in vegetables, fruit, livestock, and game animals collected from the SRS or adjacent lands. In addition, DOE assessed concentrations of contaminants in fish collected from SRS waterbodies and from the Savannah River up- and downstream of the Site.

Based on recent monitoring results, concentrations of radiological and nonradiological contaminants in vegetables, fruit, livestock, game animals, and fish from the SRS and surrounding areas are generally low, in virtually all instances below applicable DOE standards (Arnett and Mamatey 1998a,b). Consequently, no disproportionately high and adverse human health impacts would be expected in minority or low-income populations in the region that rely on subsistence consumption of fish, wildlife, or native plants.

It should be noted that mercury, which is present in relatively high concentrations in fish collected from SRS and the middle reaches of the Savannah River, could pose a potential threat to individuals and populations that rely on subsistence fishing. This mercury in fish has been attributed to upstream (non-DOE) industrial sources and natural sources (DOE 1997a). The salt processing alternatives under consideration would not affect mercury concentrations in SRS waterbodies or the Savannah River.

4.1.6 ECOLOGICAL RESOURCES

Construction

Depending on the salt processing alternative selected by DOE, construction of several new facilities would be required in either S or Z Area. Process buildings for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives would be built in S Area, while the process building for the Direct Disposal in Grout alternative would be built in Z Area. Regardless of the salt processing alternative (thus, process facility configuration) chosen, support facilities, including a service building, office building, and an electrical substation would be constructed in close proximity to the main process building (see Chapter 2 and Appendix A for details). New salt disposal vaults would be built in Z Area under all of the salt processing action alternatives.

As shown in Table 4-1, construction of process facilities for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives would require the excavation of approximately 77,000, 78,000, 82,000 and 23,000 cubic yards of soil, respectively. The total land area that would be cleared in S area (see Figure 3-1) for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative is 23 acres or 0.12 percent of SRS land dedicated to industrial use. Approximately 15 acres or 0.078 percent of SRS land dedicated to industrial use would be cleared for the Direct Disposal in Grout facility in Z Area (see Figure 3-2). Land in Z Area would also be required for construction of new saltstone vaults. All land-disturbing activity would be within the fenced boundaries of S and Z Areas, areas currently devoted to industrial use (waste management facilities).

As noted in Section 3.4.1, the preferred site (Site B) for salt processing facilities in S Area is approximately one-quarter mile south of DWPF (an active industrial facility) and, as a result, is within an area with relatively high levels of noise and activity. Because the Saltstone Manufacturing and Disposal Facility has not operated since 1998, the preferred site in Z Area has lower levels than S Area of noise and activity, limited for the most part to security patrols and an occasional tour.

There is the potential to disturb wildlife in both S and Z Areas and in adjacent woodlands during the construction phase of the project (approximately four years for site preparation and facility construction). Construction would involve the movement of workers and construction equipment and would be associated with relatively loud noises from earth-moving equipment (including backhoes, bulldozers, and graders), portable generators, and air compressors. Although noise levels in construction areas could be as high as 110 decibels (dBA), these high local noise levels would not extend far beyond the boundaries of the proposed project sites.

Table 4-14 shows the attenuation of construction noise over relatively short distances. At 400 feet from the construction sites, construction noises would range from approximately 55 to 85 dBA. Golden et al. (1980) suggest that noise levels higher than 80 to 85 dBA are sufficient to startle or frighten birds and small mammals. Thus, there would be little potential for disturbing birds and small mammals outside a 400-foot radius of the construction sites.

Although noise levels would be relatively low outside the immediate construction areas, the combination of construction noise and human activity probably would displace small numbers of animals (e.g., songbirds and small mammals) that forage, feed, nest, rest, or den in the woodlands to the east of S Area and to the south and

Table 4-14. Peak and attenuated noise (in dBA) levels expected from operation of construction equipment.

Source	Noise level (peak)	Distance from source			
		50 feet	100 feet	200 feet	400 feet
Heavy trucks	95	84-89	78-83	72-77	66-71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
Pile driver	105	95	89	83	77
Fork lift	100	95	89	83	77

Source: Golden et al. (1980).

east of Z Area. It should be noted that an access road and a railroad spur (Z Line) separate Site B in S Area from woodlands to the east (see Figure 3-1), reducing the value of Site B and adjacent woodlands as wildlife habitat. The proposed site in Z Area (see Figure 3-2) is farther removed from roads and the railroad spur (and heavy industrial facilities in H and S Areas) and is presumed to have marginally higher value as wildlife habitat. Construction-related disturbances in both areas are likely to create impacts to wildlife that would be small, intermittent, and localized. Some animals could be driven from the area permanently, while others could become accustomed to the increased noise and activity and return to the area. Species likely to be affected (e.g., gray squirrel, opossum, white-tailed deer) are common to ubiquitous on SRS.

Under the No Action alternative, DOE would use approved siting procedures to ensure that any new tanks would be built in a previously disturbed industrial area. Studies and continued monitoring would also be performed to determine the presence of any threatened or endangered species and ensure that critical habitats would not be affected.

Operations

Operation of salt processing facilities would be less disruptive to wildlife than construction activities, but would entail movement of workers and equipment and noise from public address systems (e.g., testing of radiation and fire alarms), air compressors, pumps, and HVAC-related equipment. These activities would be similar under all alternatives, including No Action. With the possible exception of the public address systems, noise levels generated by these kinds of sources are not expected to disturb wildlife outside of facility boundaries.

As noted in Section 3.4, no threatened or endangered species or critical habitats occur in or near S or Z Areas, which are industrial sites surrounded by roads, parking lots, construction shops, and construction lay-down areas that are continually exposed to high levels of human disturbance. Proposed salt processing activities (and Tank Farm operations under No Action) would not disturb any threatened or endangered species, would not degrade any critical or sensitive habitat, and would not affect any wetlands. DOE would continue to monitor the areas around S and Z Areas for the presence of threatened or endangered species. If a listed species were found, DOE would determine if salt processing activities would affect that species. If DOE were to determine that adverse impacts could occur, DOE would initiate consultation with the U.S. Fish and Wildlife Service, as required by Section 7 of the Endangered Species Act.

4.1.7 LAND USE

The *Savannah River Site Future Use Plan* (DOE 1998) provides an Integral Site Model that lays out intended future land use policies. DOE determined that this model most realistically accommodates development during the next 50 years. The model divides the SRS into three zones: industrial, industrial support, and restricted public use. The future use plan does not contemplate DOE relinquishing ownership of or institutional control over any portion of the SRS. The industrial zone surrounds facilities that: process or store radioactive liquid or solid waste, fissionable materials, or tritium; conduct separations operations; or conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations. The new salt processing facility would be constructed in areas (S or Z) designated as industrial. As shown in Table 4-1, approximately 23 acres (0.12 percent of SRS land dedicated to industrial use) would be cleared and graded for salt processing facilities at the selected site in S Area (see Figure 3-1), should the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative be selected. Approximately 15 acres (0.078 percent of SRS land dedicated to industrial use) would be cleared and graded for salt processing facilities in Z Area (see Figure 3-2), should the Direct Disposal in Grout alternative be selected. All land-disturbing activity would be within the fenced boundaries of S and Z Areas, areas currently devoted to industrial use (waste management facilities).

DOE would use the approved siting process to ensure that any new tanks under the No Action alternative would be constructed in a previously disturbed industrial area with a deep groundwater table. Due to the speculative nature of the No Action alternative, DOE has not determined how much land would be cleared for construction of any new HLW storage tanks. However, DOE assumes the area would be similar to that required under the action alternatives. Construction and operation of the proposed salt processing facility, including ongoing tank space management activities and building new tanks under the No Action alternative, would be consistent with the current SRS land use plans (DOE 1998).

4.1.8 SOCIOECONOMICS

Socioeconomic impact assessments are performed to determine the effects changes in local economic variables (e.g., number of jobs in a particular industry, wage rates, or increases in capital investment) may have on other economic measures (total regional employment, population, and total personal income).

New economic information was not developed for this SEIS. However, in 1999, DOE issued its *Accelerator Production of Tritium for the Savannah River Site Final Environmental Impact Statement* (DOE 1999). This EIS proposed a large accelerator for the SRS, and a full array of socioeconomic impact assessments was performed for the EIS. Based on these assessments, DOE concluded that the potential impacts attributed to construction and operation of the accelerator were relatively small in comparison with historical economic trends in the region and were not expected to stress existing regional infrastructures or result in an economic "boom."

Construction

During the construction phase of this project, based on preliminary design information, each salt processing alternative would employ approximately 500 construction workers annually, or about 50 percent fewer than the accelerator in its peak year of construction. Additionally, the estimated construction phase for the salt processing alternatives would be about 4 years, rather than 11 years for the accelerator, so potential construction impacts would be shorter in duration than those for the accelerator would have been.

Table 4-15 presents the estimated employment levels for each salt processing action alternative. The construction workforce is assumed to be constant over the life of the construction phase. The construction phase, expected to last approximately 4 years for each action alternative, would require less than 3.6 percent of the existing SRS workforce.

Under the No Action alternative, up to 500 construction workers may be employed to construct new HLW tanks. Tank construction would be expected to last 4 or more years (DOE 1980).

Operations

The Small Tank Precipitation alternative would require approximately 180 operations employees. The Ion Exchange alternative would require approximately 135 operations employees.

Table 4-15. Estimated salt processing employment by alternative.

Project phase	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction	500[a]	500	500	500	500
Operations	65[b]	180	135	220	145

Source: (WSRC 1998a, 2000a)

a. Up to 500 construction workers could be employed if new HLW tanks were built under the No Action alternative.

b. Up to 65 operations workers could be employed if new HLW tanks were built under the No Action alternative. However, a workforce reduction could occur if operations at the DWPF were suspended under No Action.

The Solvent Extraction alternative would require approximately 220 operations employees, and the Direct Disposal in Grout alternative would require approximately 145 operations employees, (WSRC 1998a, 2000a). During the operations phase, the Solvent Extraction alternative would require the most workers, but would still require less than 1.5 percent of the existing SRS workforce.

DOE believes staffing requirements for construction and operations of any salt processing action alternative could be filled with existing SRS employees. Given the size of the local economy, any supplemental workforce requirements could be met without measurable impacts or the influx of large workforces. Therefore, DOE does not expect any salt processing action alternative to have measurable socioeconomic impacts.

Under the No Action alternative, DOE would continue tank space management activities for a period of approximately 10 years and employment would remain at the current level. Subsequent activities under No Action could impact employment levels. DOE could suspend operations at DWPF. Suspension of operations at these facilities could result in a workforce reduction, which would have a negative impact on the communities surrounding SRS. Alternatively, up to 65 new employees would be needed for the operation of any new HLW tanks constructed under No Action (DOE 1980).

4.1.9 CULTURAL RESOURCES

Depending on the salt processing alternative selected by DOE, construction of new facilities would be required in either S (Site B) or Z Area. Process buildings for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives would be built in S Area, while the process building for the Direct Disposal in Grout alternative would be built in Z Area. Regardless of the salt processing alternative (thus, facility configuration) chosen, support facilities including a service building, office building, and an electrical substation would also be constructed in close proximity to the main process building (see Chapter 2 and Appendix A for details). New salt disposal vaults would be built in Z Area under any of the salt processing alternatives.

Because no important archaeological resources were discovered during the S Area surveys conducted in support of the *Final Environmental Impact Statement Defense Waste Processing Facility Savannah River Plant* (DOE 1982), DOE believes additional construction within this area would not adversely impact cultural resources. Most of Z Area also has been surveyed in the past, and no important cultural resources were discovered (DOE 1994). Both areas have been disturbed repeatedly by construction activity over the last 15 to 20 years, and the likelihood of undiscovered cultural or historic resources is small.

DOE would use the approved siting process to ensure that any new tanks for the No Action alternative would be constructed in a previously disturbed industrial area. DOE would ensure that any tank construction would not impact cultural or historic resources.

If any archaeological or cultural resources were discovered in the course of developing the previously described facilities in S and Z Areas or new tanks for the No Action alternative, DOE would contact the Savannah River Archaeological Research Program and the State Historic Preservation Officer in compliance with Section 106 of the National Historic Preservation Act for guidance on mitigating potential impacts to these resources.

4.1.10 TRAFFIC AND TRANSPORTATION

SRS is served by more than 199 miles of primary roads and more than 995 miles of unpaved secondary roads. The primary highways used by SRS commuters are State Routes 19, 64, and 125; 40, 10, and 50 percent of the workers, respectively, use these routes. Traffic congestion can occur during peak periods onsite on SRS Road 1-A, State Routes 19 and 125, and U.S. Route 278 at SRS access points. Vehicles associated with this project would use these same routes and access points. None of the routes would require additional traffic controls or highway modifications, as explained below.

Construction

As shown in Table 4-16, concrete premix would be required during construction of the facilities under all action alternatives. Assuming that these materials are supplied by vendor facilities in Jackson and New Ellenton (for a round-trip distance of 18 miles), implementation of the alternatives would result in 55,000 to 61,000 freight miles traveled. Using Federal Highway Administration roadway composite statistics for South Carolina for the 1994 to 1996 period of record (Saricks and Tompkins 1999), these shipments would result in a maximum occurrence of 0.05 accidents, no fatalities, and 0.03 injuries as a result of material transport activities during construction. These projections are similar for all action alternatives. Therefore, it is highly unlikely that material transport activities during construction would lead to any accidents, fatalities, or injuries, regardless of the alternative selected.

As shown in Table 4-17, approximately 500 workers would travel to the Site 5 days a week (250 round trips per year for each worker) for 45 to 50 months during the construction phase of the project. Assuming no ride sharing and a round-trip commute distance of 50 miles, up to 26 million commuter miles would be traveled during the construction phase. Using 1998 national transportation statistics (BTS 1998), as many as 98 vehicle accidents could occur with this mileage, resulting in a maximum of 0.4 fatalities and 43 injuries. These projections are similar for all action alternatives.

Building new HLW tanks under the No Action alternative would require a similar number of material shipments as that required for construction of the action alternatives. DOE anticipates that the construction workforce under the No Action alternative would also be similar to the number of workers employed for construction of the action alternatives.

Operations

As shown in Table 4-16, saltstone premix and process reagents would be required during operation of the facilities under all action alternatives. Assuming that these materials are supplied by vendor facilities in Jackson and New Ellenton (for a round-trip distance of 18 miles), implementation of the alternatives would result in 340,000 to 470,000 miles traveled. Using Federal Highway Administration roadway composite statistics for South Carolina for the 1994 to 1996 period of record (Saricks and Tompkins 1999), these shipments would result in a maximum occurrence of 0.4 accidents, 0.02 fatalities, and 0.3 injuries as a result of material transport activities during construction. These projections are similar for all action alternatives. Therefore, it is very unlikely that material transport activities during construction would lead to any accidents, fatalities, or injuries, regardless of the alternative selected.

As shown in Table 4-17, between approximately 135 and 220 workers, depending on the alternative selected, would travel to the Site 5 days a week (250 round trips per year for each worker) for the 14.3-year startup and operation phase of the project. Assuming no ride sharing and a round-trip commute distance of 50 miles, up to 39 million commuter miles would be traveled during the operations phase. Using 1998 national transportation statistics (BTS 1998), as many as 148 vehicle accidents could occur with this mileage, resulting in a maximum of 0.6 fatalities and 65 injuries. The projections are similar for all action alternatives.

For the No Action alternative, up to 65 new employees would be needed for the 13-year operation phase (2010-2023) for any tanks constructed (DOE 1980). Therefore, approximately 39 vehicle accidents could occur under the No Action alternative, resulting in a maximum occurrence of 0.2 fatalities and 17 injuries.

The surrounding area already has a certain volume of truck and car traffic associated with SRS logging, agriculture, and industrial activity. The

Table 4-16. Material (totals for the construction and operation phases) transportation impacts associated with the salt processing alternatives.

Material use/worker travel impact categories	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction				
Structural concrete premix shipments[a,b]	3,000	3,000	3,000	3,400
Total round-trip shipment (distance miles)	55,000	55,000	55,000	61,000
Number of Accidents	0.04	0.04	0.04	0.05
Fatalities	0	0	0	0
Injuries	0.03	0.03	0.03	0.03
Operations[c]				
Saltstone premix	25,500	21,100	23,800	19,000
Sodium hydroxide	6	56	416	4
Oxalic acid	1	1	1	1
Tetraphenylborate	710	NA	NA	NA
Monosodium titanate	1	1	1	1
Crystalline Silicotitanate	NA	11	NA	NA
90% Formic acid[b]	66	NA	NA	NA
15% Cupric nitrate[b]	45	NA	NA	NA
Nitric Acid	NA	NA	9	NA
Isopar®L	NA	NA	40	NA
Trioctylamine	NA	NA	1	NA
Calixarene	NA	NA	1	NA
Cs-7SBT	NA	NA	1	NA
Total number of shipments	26,000	21,000	24,000	19,000
Total round-trip shipment distance (miles)	470,000	380,000	440,000	340,000
Number of Accidents	0.4	0.3	0.3	0.3
Fatalities	0.02	0.02	0.02	0.01
Injuries	0.3	0.2	0.2	0.2

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a. Data for structural concrete use adapted from Attachments 9.2, 9.3, 9.4, and 9.5 of the life cycle cost estimate report (WSRC 1998a) using an assumed blended concrete premix density of 3,934 lb/yd^3 and a truck load capacity of 50,000 pounds.

b. Concrete requirements for construction of any new tanks under the No Action alternative would be similar to those required for the action alternatives.

c. For operations under the No Action alternative, material shipments would remain at current levels.

d. Corresponding decrease at DWPF.

NA = not applicable. The chemical would not be used in that particular alternative.

Table 4-17. Worker transportation impacts associated with the salt processing alternatives.

Worker travel impact categories	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction worker travel					
Number of workers	500[a]	500	500	500	500
Total number of Site trips	500,000[a]	500,000	520,000	500,000	480,000
Total round-trip distance (million miles)	25[a]	25	26	25	24
Number of Accidents	95[a]	95	98	95	91
Fatalities	0.4[a]	0.4	0.4	0.4	0.4
Injuries	42[a]	42	43	42	40
Operations worker travel					
Number of workers	65[b]	180	135	220	145
Total number of Site trips	210,000[b]	640,000	480,000	780,000	510,000
Total round-trip distance (million miles)	11[b]	32	24	39	26
Number of Accidents	39[b]	122	91	148	97
Fatalities	0.2[b]	0.5	0.4	0.6	0.4
Injuries	17[b]	53	40	65	42

a. Based on 500 construction workers over a 4-year construction period. The construction period could be longer, depending on the number of tanks built.
b. Up to 65 workers would be required for operation of any new tanks built under No Action.

amount of traffic associated with any of the alternatives (including No Action) is not expected to substantially increase traffic volume.

4.1.11 WASTE GENERATION

4.1.11.1 Wastes From Salt Processing

Each of the action alternatives would produce a low-activity salt waste stream that would be grouted for disposal in vaults in Z Area. The characteristics and volumes of grout produced from the low-activity salt solutions would vary among the alternatives. In addition, the high-activity materials separated from the salt solution would be transferred to DWPF for processing to borosilicate glass. Details of the wastes from salt processing under each of the action alternatives are discussed below.

Under the Small Tank Precipitation alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. New cement silos would be built to accommodate saltstone production. Sixteen new vaults would be needed to accommodate the expected grout volume (188 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55 (see Appendix A for Class A limits). Approximately 2.9 million gallons of slurry, containing monosodium titanate (MST) solids and precipitate hydrolysis aqueous (PHA) product, would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository. Processing the precipitate in the Small Tank Precipitation Facility would create a benzene waste stream that is unique to this salt processing alternative. The management of this benzene waste is described in Section 4.1.11.2.

Under the Ion Exchange alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. No modifications to the existing grouting process would be required. Thirteen new vaults would be needed to accommodate the expected grout volume (156 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55. Approximately 2 million gallons of slurry containing MST solids and 600,000 gallons of cesium-loaded crystalline silicotitanate (CST) resin would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository.

Under the Solvent Extraction alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. No modifications to the existing grouting process would be required. Fifteen new vaults would be needed to accommodate the expected grout volume (175 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55. Approximately 2 million gallons of slurry containing MST solids and 6.8 million gallons of cesium-loaded strip solution would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository. The Solvent Extraction process would also generate a liquid organic solvent. Management of this solvent waste is described in Section 4.1.11.2.

Under the Direct Disposal in Grout alternative, radioactive cesium would not be separated from salt solutions. Because of the shielding requirements for handling the cesium-containing salt solution, this material could not be processed in the existing Z Area Saltstone Manufacturing and Disposal Facility. After treatment with MST and filtration to remove strontium, uranium, plutonium, and entrained sludge, the clarified salt solution would be transferred to a new grouting facility located in Z Area. Thirteen new vaults would be needed to accommodate the expected grout disposal volume (141 million gallons). Because of its cesium content, the grout would be equivalent to Class C LLW, as defined in 10 CFR 61.55 (see Appendix A for Class C limits). Approximately 2 million gallons of slurry containing MST solids would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository.

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, without a process for separating the high-activity and low-activity salt fractions. DWPF would vitrify only sludge from the HLW tanks. HLW salt would be stored in existing tanks and monitoring activities would continue. Current tank space management projections indicate that, after 2010, additional tank space would be needed to support continued operations (WSRC 1999d). The course of action that DOE would follow cannot be predicted at this time but, regardless of which option DOE would pursue, waste generation rates under No Action would not be expected to increase from current levels.

4.1.11.2 Secondary Waste

This section presents the secondary waste generation estimates for each salt processing alternative that DOE considers in this SEIS. Unlike wastes from salt processing that are the direct result of processing the salt solutions, secondary wastes are those wastes generated as a result of construction, operation, and maintenance of the salt processing facilities under the action alternatives. Impacts are assessed in terms of the amount of secondary waste projected for each of the alternatives, relative to the quantity of waste that would otherwise be managed at SRS during the period of analysis. Table 4-18 provides estimates of the maximum annual waste generation. Table 4-19 provides the total waste volumes that would be generated over the life cycle of each of the salt processing alternatives.

Table 4-18. Maximum annual waste generation for the salt processing action alternatives[a].

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	300,000	250,000	900,000	150,000
Nonradioactive liquid waste (gallons)	Negligible[b]	34,000[b,c]	Negligible[b]	Negligible[b]
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
LLW (m^3)	71	71	71	71
Hazardous waste (m^3)	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1
Mixed LLW (m^3)	1	1	1	1
Mixed low-level liquid waste (gallons)	60,000	None	1,000	None
Industrial waste (metric tons)	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20
Sanitary waste (metric tons)	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41

Source: WSRC (1999b, 2000b).

a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.

b. Assumes continuous operation.

c. CST resin pretreatment generates a spent 1 M NaOH solution and CST fines slurry.

d. Assumes a 1.3-year duration for startup activities under each action alternative.

Table 4-19. Total estimated waste generation for the salt processing action alternatives[a].

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	3.9×10^6	3.3×10^6	1.2×10^7	2.0×10^6
Nonradioactive liquid waste (gallons)	negligible	4.9×10^5	negligible	negligible
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
LLW (m^3)	920	920	920	920
Hazardous waste (m^3)	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13
Mixed LLW (m^3)	13	13	13	13
Mixed low-level liquid waste (gallons)	780,000	None	13,000	None
Industrial waste (metric tons)	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260
Sanitary waste (metric tons)	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530

a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.

b. Assumes a 1.3-year duration for startup activities and 13 years of operation for each of the action alternatives.

Waste generation under the No Action alternative would be similar to waste generation rates at the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline. Baseline forecasts are provided in Table 5-4.

Liquid Waste

The radioactive wastewater that would be generated as a result of salt processing activities is produced during the DWPF vitrification process. The incremental increase in DWPF radioactive liquid waste would be associated with processing the high-activity waste (e.g., MST slurry, PHA product, loaded CST resin, cesium strip solution) from the various salt processing action alternatives, and would vary from about 150,000 gallons per year for the Direct Disposal in Grout alternative to 900,000 gallons per year for the Solvent Extraction alternative. The Small Tank Precipitation and the Ion Exchange alternatives would generate 300,000 and 250,000 gallons per year, respectively. The DWPF radioactive wastewater would be returned to the Tank Farm to be processed in the waste evaporators. Evaporator overheads would be treated in the ETF and discharged to Upper Three Runs via NPDES outfall H-16. DOE currently is examining options to ensure sufficient capacity in the Tank Farms to accommodate the DWPF radioactive liquid waste stream and other projected influents to the SRS HLW management system (WSRC 1999d).

Transuranic waste

DOE would not expect to generate transuranic wastes as a result of the proposed salt processing activities.

LLW

Under each of the action alternatives, DOE would expect to generate approximately 71 cubic meters per year of LLW. The projected volume represents about 0.5 percent of the forecasted SRS LLW generation through 2029 (Halverson 1999). Compactible LLW would be segregated from non-compactible LLW and processed in a volume reduction facility before disposal. Currently all LLW is disposed of onsite, but DOE is investigating the possibility of sending some LLW offsite for commercial treatment and disposal (DOE 2000d).

Hazardous waste

Under each of the action alternatives, DOE would expect to generate approximately 23 cubic meters per year of hazardous waste as a result of startup activities. This waste would consist of nonradioactive chemicals used to test the new facilities prior to actual waste processing. An additional 1 cubic meter per year of hazardous waste is expected during operations. The projected volume represents about 0.7 percent of the forecasted SRS hazardous waste generation through 2029 (Halverson 1999). This waste would be shipped offsite to commercial facilities for treatment and disposal (DOE 2000d).

Mixed LLW

Under each of the action alternatives, DOE would expect to generate small amounts (about 1 cubic meter per year) of mixed waste. These projected volumes represent about 0.4 percent of the forecasted SRS mixed LLW generation through 2029 (Halverson 1999). This waste would be treated onsite or at other DOE sites. Disposal would be at offsite facilities (DOE 2000d).

Under the Small Tank Precipitation alternative, additional mixed LLW would be produced as a result of processing the precipitate. In a section of the Small Tank Precipitation facility, the precipitate slurry would undergo acid hydrolysis to separate it into a low-radioactivity organic portion (benzene) and a high-radioactivity aqueous portion. The organic portion would then be separated from the aqueous portion, washed to reduce the level of cesium, and transferred to the Organic Waste Storage Tank in S Area, which has a storage capacity of 150,000 gallons. A maximum of 60,000 gallons per year of benzene waste could be produced. DOE is investigating treatment and disposal options for this waste stream.

Under the Solvent Extraction alternative, additional mixed LLW would be produced as a result of solvent replacement. The total solvent inventory for the process, consisting primarily of the diluent Isopar®L, is a projected 1,000 gallons. Using the conservative assumption that the solvent inventory is replaced once per year, a total of 13,000 gallons of organic solvent could be accumulated over the 13-year operating life. DOE is investigating treatment and disposal options for this waste stream.

Industrial waste

Under each of the action alternatives, DOE would expect to generate approximately 30 metric tons per year of industrial (nonhazardous, nonradioactive) waste as a result of startup activities and an additional 20 metric tons per year during operations. The projected volume represents less than 1 percent of the forecasted SRS industrial waste generation through 2029 (Halverson 1999). This waste would be recovered for recycling or disposed of onsite at the Three Rivers Landfill (DOE 2000d).

Sanitary waste

Sanitary wastewater from the salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES outfall G-10. These discharges would be expected to comply with current NPDES permit limitations.

Under each of the action alternatives, DOE would expect to generate approximately 62 metric tons per year of solid sanitary wastes as a result of startup activities and an additional 41 metric tons per year during operations. The projected volume represents about 5 percent of the forecasted SRS sanitary waste generation through 2029 (Halverson 1999). This waste would be disposed of onsite at the Three Rivers landfill (DOE 2000d).

4.1.12 UTILITIES AND ENERGY

This section discusses potential utility and energy impacts from construction and operation under each of the salt processing alternatives. The scope of the analysis includes electric power, fuel (diesel and gasoline) consumption, process water consumption, and steam use. DOE used applicable past SRS operations or engineering to estimate the energy and utility requirements of the alternatives. Estimates of water use include: process additions, cooling, and flushing; product washes; and grout production. Steam is used primarily to operate the ventilation systems and to heat waste solutions during processing. Fuel consumption is based on use of diesel-powered equipment during construction activities and diesel emergency power generators. The analysis compared the use of electricity, water, and steam to the available capacities discussed in Section 3.10.

DOE would obtain utilities and energy from existing sources and suppliers. Water would come from existing site wells; and electricity and fuel would come from existing on- and offsite suppliers. Steam would be produced onsite.

Table 4-20 lists electric energy, fuel, steam, and water use during the construction and operation phases of each action alternative. Overall, DOE does not expect substantial increases in water use or energy consumption with implementation of any of the alternatives, including No Action.

4.1.12.1 Water Use

During the approximately 4-year construction phase, the estimated demand for water would range from 33 to 37 million gallons, depending on the processing alternative selected. On a daily average basis, the highest use would represent about 2.3 percent of water used in H-, S-, and Z-Area facilities in 1998 (SCDHEC 1999a) and 0.2 percent of the lowest estimated production capacity of the aquifer (16 million gallons per day) (WSRC 1998b).

Under the No Action alternative, construction of any new tanks would require approximately 660,000 gallons of water per tank (DOE 1980), which is less than 0.1 percent of the aquifer production capacity.

Table 4-20. Estimated project total energy and utilities use for the salt processing alternatives.

Phase[a]	SRS Baseline[b]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Potable water use (million gallons)					
Construction	NA	19	20	19	18
Operation	NA	99	95	120	75
Project subtotal use	NA	118	115	139	93
Process water use (million gallons)					
Construction	NA	16	17	16	15
Operation	23,000[c]	301	271	225	181
Project subtotal use	NA	317	288	241	196
Project total water use (million gallons)	NA	435	403	380	289
Peak electrical power demand (megawatts)					
Construction	NA	1.66	1.66	1.66	1.66
Operation	130[c]	24	24	32	18
Electricity use (gigawatt-hours)					
Construction	NA	76	79	76	73
Operation	410[c]	243	286	315	172
Project total use	NA	319	365	391	245
Steam use (million pounds)					
Construction	NA	0	0	0	0
Operation	NA	2,548	2,300	1,915	1,536
Project total use	NA	2,548	2,300	1,915	1,536
Fuel use (million gallons)					
Construction	NA	8.4	9	8.4	8
Operation	8.75[d]	0.3	0.3	0.3	0.2
Project total use	NA	8.7	9.3	8.7	8.2

Adapted from WSRC (1999e).

a. From Table 2-1, the construction and operation duration of each alternative are as follows: Small Tank Precipitation – 48 months and 13 years; Ion Exchange – 50 months and 13 years; Solvent Extraction – 48 months and 13 years; and Direct Disposal in Grout – 46 months and 13 years. The total project duration includes a startup duration of 1.3 years for each alternative (WSRC 1999f).

b. Construction of any new tanks would require approximately 660,000 gallons of water and 45,000 gallons of fuel per tank. Utility and energy use under the No Action alternative would be similar to use at the existing HLW Tank Farms, and is included in the baseline.

c. Halverson (1999).

d. DOE (1995).

NA = Not Available.

During the 13-year operational phase, total water use for the action alternatives would be similar and would vary between 256 and 400 million gallons, depending on the processing alternative selected. On a daily average use basis, the highest use would be about 22.6 percent of the volume used in H-, S-, and Z-Area facilities during 1998 (SCDHEC 1999a), and 1.5 percent of the lowest estimated production capacity of the aquifer (WSRC 1998b).

Water use for the entire duration of the project would be similar for all action alternatives and would be between 289 and 435 million gallons, for the Direct Disposal in Grout and Small Tank Precipitation alternatives, respectively.

For the No Action alternative, water use during operation under any scenario would be slightly higher than the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline.

4.1.12.2 Electricity Use

During construction, the estimated peak electrical power demand would be 1.7 megawatts for each alternative, with use varying between about 73 and 79 gigawatt-hours, depending on the processing alternative selected. The peak power demand would be a small fraction of the H-Area power distribution network's capacity (64 megawatts) (WSRC 1996). Power for S and Z Areas would be supplied through the H-Area network.

Electric power demand during construction of any tanks under the No Action alternative would be similar to that of the action alternatives.

During operations, the peak electric power demand would be very similar for each action alternative and would vary between 18 and 32 megawatts, depending on the processing alternative selected. In combination with the 22-megawatt demand for power from H-Area facilities, a total demand of 54 megawatts is possible, which represents 84 percent of the H-Area power distribution network's capacity (WSRC 1996). The highest peak power demands and electricity use would occur under the Solvent Extraction alternative. Electricity use during operations would be similar for each action alternative and would vary between 172 and 315 gigawatt-hours, depending on the alternative selected.

Electricity use for the entire duration of the project would be between 245 and 391 gigawatt-hours, for the Direct Disposal in Grout and Solvent Extraction alternatives, respectively.

For the No Action alternative, electric power demand during operation of any scenario would be slightly higher than the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline.

4.1.12.3 Steam Use

No steam would be used during the construction phase for any of the alternatives, including No Action. The main uses for steam during the operation phase would be operation of building ventilation systems and waste solution heating. Operation of the ventilation systems would account for most of the steam used. Total steam use during the operations phase would be similar under each alternative and would range from 1.5 to 2.5 billion pounds for the Direct Disposal in Grout and Small Tank Precipitation alternatives, respectively. On a daily average use basis, the highest use would be about 18.3 percent of the steam used in H-, S-, and Z-Area facilities, and 1.5 percent of the steam production capacity for H-, S-, and Z-Area facilities (WSRC 1996).

Steam use under the No Action alternative would be slightly higher than current use rates at the existing HLW Tank Farms. Therefore, the No Action alternative would constitute a slight increase over the baseline.

4.1.12.4 Fuel Use

Diesel and gasoline fuels would be used during the construction and operation phases of the project, primarily for the operation of mobile heavy equipment and stationary support equipment. Fuel consumption would be similar under all the action alternatives. The highest consumption of liquid fuels, about 9 million gallons, would be during the construction phase of the Ion Exchange alternative (2.1 million gallons per year). Liquid fuel use during the operations phase of any alternative is low, at less than 300,000 gallons total. As a comparison, operations at SRS used approximately 8.75 million gallons of liquid fuels in 1994 (DOE 1995).

Under the No Action alternative, a total of approximately 45,000 gallons of diesel fuel and gasoline would be required per tank during construction (DOE 1980). Liquid fuel use during the operation phase would be similar to the existing Tank Farm and is included in the baseline.

4.1.13 ACCIDENT ANALYSIS

This section summarizes risks to the public and workers from potential accidents associated with the various salt processing action alternatives at SRS.

Detailed descriptions of each accident, including the scenario description, probability of occurring, radiological source terms, nonradiological hazardous chemical release rates, and consequences are provided in Appendix B.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

- *Internal initiators* normally originate in and around the facility, but are always a result of facility operations. Examples include equipment or structural failures and human errors.

- *External initiators* are independent of facility operations and normally originate outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.

- *Natural phenomena initiators* are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

Because current operations are the basis from which each of the proposed alternatives begins, the hazards associated with each of the action alternatives are in addition to those of current operations. However, after the period of operation, the hazards associated with salt processing are eliminated and those associated with the storage of salt solutions would be substantially reduced. Because the No Action alternative includes primarily current operations that have been evaluated under the NEPA process and in approved safety analysis reports, accidents associated with current tank space management operations are not evaluated here. Failure of a Salt Solution Hold Tank is addressed in the High-level Waste Tank Closure Draft EIS (DOE 2000e). The radiological and nonradiological hazards associated with the four action alternatives were evaluated in this section and Appendix B.

Nonradiological

The long-term health consequences of human exposure to nonradiological hazardous materials are not as well understood as those related to radiation exposure. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

Table 4-21 summarizes the impacts of accidents involving the release of nonradiological hazardous materials to the MEI and noninvolved workers. In general, impacts to these receptors resulting from accidents involving nonradiological hazardous materials are minimal. However, noninvolved workers exposed to atmospheric releases of benzene from two of the accidents evaluated under the Small Tank Precipitation alternative could develop serious or life-threatening health effects. Workers exposed to airborne benzene concentrations (950 mg/m^3) resulting from an Organic Waste Storage Tank (OWST) loss of confinement accident could experience serious health effects that may impair their ability to take protective action (e.g., dizziness, confusion, impaired vision). Workers exposed to airborne benzene concentrations (8,840 mg/m^3) resulting from an explosion in the OWST, could experience life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory failure). Both of these accidents would occur less than once in 100,000 years and are in the extremely unlikely category.

Radiological

Tables 4-22 through 4-25 summarize for each salt processing alternative the estimated impacts to onsite workers and the public from potential accidents involving the release of radiological materials. These tables list potential accident consequences for all receptors as LCFs per accident and LCFs per year. The LCF per accident values are an estimate of the consequences without accounting for the probability of the accident occurring. The LCF per year values do take the accident's probability into consideration and provide a common basis for comparison of accident consequences.

DOE estimated impacts to five receptors: (1) the MEI at the SRS boundary; (2) the offsite population in an area within 50 miles (80 kilometers); (3) an involved worker 328 feet (100 meters) from the accident; (4) a noninvolved worker 2,100 feet (640 meters) from the accident location, as discussed in DOE (1994); and (5) the onsite population (includes both involved and noninvolved workers).

For all of the accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. In some cases, the impacts to the involved worker would be greater than to the noninvolved worker. DOE estimated the increased probability of an LCF to an involved and a noninvolved worker from radiation exposure during each of the accident scenarios.

However, prediction of latent potential health effects becomes increasingly difficult to quantify with any certainty as the distance between the accident location and the receptor decreases, because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The involved worker may be acutely injured or killed by physical effects of the accident itself. DOE identified potential accidents in Cappucci et al. (1999) and estimated impacts using the AXAIRQ computer model (Simpkins 1995a,b), as discussed in Appendix B.

4.1.14 PILOT PLANT

As discussed in Section 2.7.6, a Pilot Plant would be designed and constructed to demonstrate the overall process objectives of the selected salt processing alternative. Details of the proposed demonstration objectives are provided in Appendix A. Detailed design and construction of the Pilot Plant would be initiated upon selection of the salt processing alternative and operation would extend through completion of final design and potentially through startup of the full-scale facility. This section discusses potential impacts from construction and operation of the Pilot Plant for each salt processing action alternative.

For the purposes of this SEIS, DOE assumes that the Pilot Plant components would be sized to operate on a scale of approximately 1/100 to 1/10 that of the full-size facility, and would utilize a modular design to facilitate remote installation and modification of the process equipment. A Pilot Plant for the Direct Disposal

Table 4-21. Estimated consequences of accidents involving nonradioactive hazardous materials.

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Sodium Hydroxide Releases				
Caustic Feed Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}
Noninvolved Worker (640 m) Dose (mg/m^3)	0.18	0.18	0.18	0.18
Caustic Dilution Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	NA	NA	NA	0.0031
Noninvolved Worker (640 m) Dose (mg/m^3)	NA	NA	NA	0.93[a]
Accidents Involving Nitric Acid Releases				
Nitric Acid Feed Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	NA	NA	8.8×10^{-5}	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	NA	NA	0.026	NA
Accidents Involving Benzene Releases				
PHA Surge Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	7.4×10^{-10}	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	2.2×10^{-8}	NA	NA	NA
TPB Tank Spill – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	0.060	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	18.7	NA	NA	NA
Organic Evaporator Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	0.45	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	130	NA	NA	NA
Beyond Design Basis Earthquake – Frequency: Less than once in 2,000 years				
MEI Dose (mg/m^3)	0.0026	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	0.78	NA	NA	NA
OWST Loss of Confinement – Frequency: Once in 140,000 years				
MEI Dose (mg/m^3)	3.2	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	950[b]	NA	NA	NA
Loss of Cooling – Frequency: Once in 170,000 years				
MEI Dose (mg/m^3)	0.0015	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	0.44	NA	NA	NA
Benzene Explosion in the OWST – Frequency: Once in 770,000 years				
MEI Dose (mg/m^3)	30	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	8,840[c]	NA	NA	NA

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a. Individuals exposed to sodium hydroxide concentrations above 0.5 mg/m^3 could experience mild transient health effects (e.g., rash, headache, nausea) or perception of a clearly defined objectionable odor.

b. Individuals exposed to benzene concentrations above 480 mg/m^3 could experience or develop irreversible or other serious health effects (e.g., dizziness, confusion, impaired vision).

c. Individuals exposed to benzene concentrations above 3,190 mg/m^3 could experience or develop life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory failure).

NA = Not Applicable, MEI - maximally exposed (offsite) individual, PHA = precipitate hydrolysis aqueous, OWST = Organic Waste Storage Tank, TPB = tetraphenylborate.

Table 4-22. Estimated accident consequences for the Small Tank Precipitation process.

	Loss of Confinement - PHA surge tank[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell-PHA Surge tank[a]	Benzene explosion	Helicopter Impact - PHA Surge Tank[a]	Aircraft Impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 99,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI dose (rem)	0.0016	0.31	0.014	0.70	3.3	5.4
MEI LCF per accident[c]	8.2×10^{-7}	1.5×10^{-4}	7.2×10^{-6}	3.5×10^{-4}	0.0016	0.0027
MEI LCF per year[c]	2.8×10^{-8}	7.6×10^{-8}	7.2×10^{-10}	3.5×10^{-9}	7.9×10^{-10}	1.0×10^{-9}
Offsite population dose (person-rem)	88	16,000	780	38,000	170,000	280,000
Offsite population LCF per accident	0.044	8.0	0.39	19	87	140
Offsite population LCF per year	0.0015	0.0040	3.9×10^{-5}	1.9×10^{-4}	4.2×10^{-5}	5.3×10^{-5}
Noninvolved worker Dose (rem)	0.024	9.6	0.21	10	100	170
Noninvolved worker LCF per accident[c]	9.5×10^{-6}	0.0038	8.5×10^{-5}	0.0041	0.041	0.067
Noninvolved worker LCF per year[c]	3.2×10^{-7}	1.9×10^{-6}	8.5×10^{-9}	4.1×10^{-8}	2.0×10^{-8}	2.5×10^{-8}
Involved worker dose (rem)	3.2×10^{-6}	310[d]	2.8×10^{-5}	0.0014	3,300[d]	5,400[d]
Involved worker LCF per accident[c]	1.3×10^{-9}	0.12	1.1×10^{-8}	5.5×10^{-7}	1.3	2.1
Involved worker LCF per year[c]	4.3×10^{-11}	6.1×10^{-5}	1.1×10^{-12}	5.6×10^{-12}	6.3×10^{-7}	8.0×10^{-7}
Onsite population dose (person-rem)	39	9,000	340	17,000	97,000	160,000
Onsite population LCF per accident	0.016	3.6	0.14	6.7	39	63
Onsite population LCF per year	5.3×10^{-4}	0.0018	1.4×10^{-5}	6.8×10^{-5}	1.9×10^{-5}	2.3×10^{-5}

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a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.

PHA = precipitate hydrolysis aqueous; PHC = precipitate hydrolysis cell; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-23. Estimated accident consequences for the Ion Exchange process.

	Loss of Confinement - Alpha Filter Cell[a]	Beyond Design-Basis Earthquake[b]	Loss of Cooling-Loaded Resin Hold Tank[a]	Fire in a Process Cell - Alpha Filter Cell[a]	Helicopter Impact - Alpha Filter Cell[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 5,300 years	Once in 10,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	8.3×10^{-4}	0.12	9.4×10^{-7}	0.0094	1.7	2.0
MEI LCF per accident[c]	4.2×10^{-7}	5.9×10^{-5}	4.7×10^{-10}	4.7×10^{-6}	8.5×10^{-4}	0.0010
MEI LCF per year[c]	1.4×10^{-8}	2.9×10^{-8}	8.9×10^{-14}	4.7×10^{-10}	4.1×10^{-10}	3.7×10^{-10}
Offsite population Dose (person-rem)	45	6,200	0.052	500	89,000	110,000
Offsite population LCF per accident	0.022	3.1	2.6×10^{-5}	0.25	45	53
Offsite population LCF per year	7.6×10^{-4}	0.0016	5.0×10^{-9}	2.5×10^{-5}	2.1×10^{-5}	2.0×10^{-5}
Noninvolved Worker Dose (rem)	0.012	3.7	1.4×10^{-5}	0.14	53	63
Noninvolved Worker LCF per accident[c]	4.9×10^{-6}	0.0015	5.7×10^{-9}	5.5×10^{-5}	0.021	0.025
Noninvolved Worker LCF per year[c]	1.6×10^{-7}	7.4×10^{-7}	1.1×10^{-12}	5.5×10^{-9}	1.0×10^{-8}	9.4×10^{-9}
Involved Worker Dose (rem)	6.4×10^{-8}	120	8.8×10^{-8}	9.1×10^{-7}	1,700[d]	2,000[d]
Involved Worker LCF per accident[c]	2.6×10^{-11}	0.047	3.5×10^{-11}	3.6×10^{-10}	0.68	0.81
Involved Worker LCF per year[c]	8.7×10^{-13}	2.4×10^{-5}	6.7×10^{-15}	3.6×10^{-14}	3.2×10^{-7}	3.0×10^{-7}
Onsite population Dose (person-rem)	20	3,500	0.023	220	50,000	59,000
Onsite population LCF per accident	0.0080	1.4	9.0×10^{-6}	0.089	20	24
Onsite population LCF per year	2.7×10^{-4}	6.9×10^{-4}	1.7×10^{-9}	8.9×10^{-6}	9.5×10^{-6}	8.8×10^{-6}

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a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-24. Estimated accident consequences for the Solvent Extraction process.

	Loss of Confinement - SSRT[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell - Alpha Filter Cell[a]	Hydrogen Explosion-Extraction Cell[a]	Helicopter Impact - Alpha Filter Cell[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 1,300,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	8.3×10^{-4}	0.12	0.0094	0.0029	1.7	2.0
MEI LCF per accident[c]	4.2×10^{-7}	5.8×10^{-5}	4.7×10^{-6}	1.4×10^{-6}	8.5×10^{-4}	0.0010
MEI LCF per year[c]	1.4×10^{-8}	2.9×10^{-8}	4.7×10^{-10}	1.1×10^{-12}	4.1×10^{-10}	3.8×10^{-10}
Offsite population Dose (person-rem)	45	6,100	500	160	89,000	110,000
Offsite population LCF per accident	0.022	3.0	0.25	0.081	45	54
Offsite population LCF per year	7.6×10^{-4}	0.0015	2.5×10^{-5}	6.1×10^{-8}	2.1×10^{-5}	2.0×10^{-5}
Noninvolved Worker Dose (rem)	0.012	3.6	0.14	0.044	53	64
Noninvolved Worker LCF per accident[c]	4.9×10^{-6}	0.0015	5.5×10^{-5}	1.8×10^{-5}	0.021	0.026
Noninvolved Worker LCF per year[c]	1.6×10^{-7}	7.3×10^{-7}	5.5×10^{-9}	1.3×10^{-11}	1.0×10^{-8}	9.5×10^{-9}
Involved Worker Dose (rem)	6.4×10^{-8}	120	7.2×10^{-7}	2.7×10^{-4}	1,700[d]	2,000[d]
Involved Worker LCF per accident[c]	2.6×10^{-11}	0.046	2.9×10^{-10}	1.1×10^{-7}	0.68	0.81
Involved Worker LCF per year[c]	8.7×10^{-13}	2.3×10^{-5}	2.9×10^{-14}	8.1×10^{-14}	3.3×10^{-7}	3.0×10^{-7}
Onsite population Dose (person-rem)	20	3,400	220	70	50,000	60,000
Onsite population LCF per accident	0.0080	1.4	0.089	0.028	20	24
Onsite population LCF per year	2.7×10^{-4}	6.8×10^{-4}	8.9×10^{-6}	2.1×10^{-8}	9.6×10^{-6}	8.9×10^{-6}

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a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
SSRT = sludge solids receipt tank; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-25. Estimated accident consequences for the Direct Disposal in Grout process.

	Loss of Confinement - SSRT[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell - SSRT[a]	Helicopter Impact - SSRT[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	2.4×10^{-4}	0.042	0.0027	0.53	0.74
MEI LCF per accident[c]	1.2×10^{-7}	2.1×10^{-5}	1.4×10^{-6}	2.7×10^{-4}	3.7×10^{-4}
MEI LCF per year[c]	4.1×10^{-9}	1.0×10^{-8}	1.4×10^{-10}	1.3×10^{-10}	1.4×10^{-10}
Offsite population Dose (person-rem)	14	2,300	160	29,000	40,000
Offsite population LCF per accident	0.0072	1.1	0.081	14	19
Offsite population LCF per year	2.4×10^{-4}	5.7×10^{-4}	8.1×10^{-6}	6.9×10^{-6}	7.4×10^{-6}
Noninvolved Worker Dose (rem)	0.0036	1.3	0.041	17	23
Noninvolved Worker LCF per accident[c]	1.5×10^{-6}	5.3×10^{-4}	1.6×10^{-5}	0.0067	0.0093
Noninvolved Worker LCF per year[c]	4.9×10^{-8}	2.6×10^{-7}	1.6×10^{-9}	3.2×10^{-9}	3.4×10^{-9}
Involved Worker Dose (rem)	7.3×10^{-8}	42	8.2×10^{-7}	53	740[d]
Involved Worker LCF per accident[c]	2.9×10^{-11}	0.017	3.3×10^{-10}	0.21	0.30
Involved Worker LCF per year[c]	9.8×10^{-13}	8.4×10^{-6}	3.3×10^{-14}	1.0×10^{-7}	1.1×10^{-7}
Onsite population Dose (person-rem)	42	1,000	48	13,000	18,000
Onsite population LCF per accident	0.0017	0.41	0.19	5.3	7.3
Onsite population LCF per year	5.7×10^{-5}	2.1×10^{-4}	1.9×10^{-6}	2.5×10^{-6}	2.7×10^{-6}

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a. Tank/cell listed is bounding case (e.g., results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
SSRT = sludge solids receipt tank; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

in Grout alternative is not planned because this technology is better developed than the other action alternatives, and has been demonstrated at full scale in the Saltstone Manufacturing and Disposal Facility. Therefore, this SEIS does not include a demonstration of the Direct Disposal in Grout alternative.

DOE intends to only construct and operate a Pilot Plant for the selected alternative. Knowledge gained from the demonstration could lead to a decision to demonstrate more than one salt processing alternative technology. In the event that DOE decides to demonstrate more than one technology, the Pilot Plant units would be developed and operated in series. Therefore, impacts associated with more than one Pilot Plant would not occur at the same time, but would extend over a longer period.

The Pilot Plant would be designed to demonstrate the processing of real radioactive wastes. Principal process operations would be conducted inside shielded cells.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the existing Late Wash Facility in H Area (see Figure 2-3), which was designed and built to handle radiological operations and is located near S Area and DWPF, or in another area similar to the location of the full-scale facility.

Services to support operations would be provided, including utilities, process chemicals, ventilation systems, and habitability services. An appropriate chemical storage area would be developed, with isolation of acids, caustics, oxidizing and reducing agents, and other incompatible reactants. Ventilation systems would be operated such that airflow is from regions of low contamination to areas of higher contamination.

The generation and dispersion of radioactive and hazardous materials would be minimized. Process waste would be managed at appropriate site locations, such as DWPF, Saltstone Manufacturing and Disposal Facility, HLW Tank Farms and the LLW vaults.

All Pilot Plants are at the pre-conceptional stage, therefore, the analysis in this section is qualitative.

4.1.14.1 Geologic Resources

The Pilot Plant would be constructed in an existing facility in a previously disturbed area. Therefore, no additional impact to geologic resources would occur.

4.1.14.2 Water Resources

The Pilot Plant would be constructed in an existing facility. No additional land would be disturbed therefore the water table would not be disturbed and no increase in suspended solids in stormwater runoff would be expected. Therefore, no impact to surface water or groundwater resources would occur during construction.

The Pilot Plant would generate less than 10 percent of the sanitary and process wastewater of the full size salt processing facility on an annual basis. DOE concluded in Section 4.1.2 that regardless of the alternative selected, impacts to surface water as a result of salt processing facility activities would be minimal and there would be no impact to groundwater quality. The quantity of sanitary and process wastewater generated by the Pilot Plant would be much smaller than the amount generated by the salt processing facility, therefore surface water impacts from operation of the Pilot Plant would be minimal and there would be no impact to groundwater quality.

4.1.14.3 Air Resources

The Pilot Plant would use skid-mounted equipment and be constructed in an existing facility. No land would be disturbed during construction, therefore the use of heavy-duty construction equipment (i.e., trucks, bulldozers, and other diesel-powered support equipment) would be minimized. Therefore, impacts to air quality during construction would be minimal.

As shown in Table 4-7, with the exception of VOCs, the nonradiological air emissions from the full-scale salt processing facility for each alternative are similar and would be well below the SCDHEC PSD limit. The estimated VOC emissions for the full-scale Ion Exchange facility would not be greater than 5 percent of the PSD limit of 40 tons per year. The estimated VOC emissions for the full-scale Small Tank Precipitation facility would be 70 tons per year, while the emissions from the full-scale Solvent Extraction facility would be 40 tons per year. VOC emissions from both full-scale facilities would exceed the PSD limit of 40 tons per year. Because air emissions from the Pilot Plant would not be greater than 10 percent of the emissions from the full-size facility, all nonradiological emissions from the Pilot Plant would be much lower than their corresponding PSD limits.

Similarly, incremental increases in air concentrations at the SRS boundary would also be much lower than those projected for the full-scale facility.

As shown in Table 4-8, all radiological air emissions from the full-scale facility for each alternative would be similar and low. Because air emissions from the Pilot Plant would not be greater than 10 percent of the emissions from the full-size facility, incremental impacts of radiological emissions from the Pilot Plant would be minimal.

4.1.14.4 Worker and Public Health

In Section 4.1.4 DOE concluded the overall occupational and health impacts (radiological, nonradiological, and occupational safety) would be minimal for the full-scale Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout facilities. Doses to the noninvolved worker would be well below Federal limits and SRS administrative guides and would not result in adverse impacts. Exposures to the MEI would result in an annual dose that is below the Federal exposure limits. The Pilot Plant would not be greater than 1/10 the size of the preferred salt processing alternative and would be operated in a manner that minimizes the generation and dispersion of radioactive and hazardous materials. Therefore, the overall occupational and health impacts (radiological, nonradiological, and occupational safety) would be similar and minimal.

4.1.14.5 Environmental Justice

In Section 4.1.5, DOE concluded that the potential offsite consequences to the general public of the proposed action and the alternatives would be small, and there would be no disproportionately high and adverse impacts to minority or low-income populations. The Pilot Plant would not be greater than 1/10 the size of the preferred salt processing alternative and would be operated in a manner that minimizes the generation and dispersion of radioactive and hazardous materials. Therefore, by similarity, the Pilot Plant would have no disproportionately high and adverse impacts to minority or low-income populations.

4.1.14.6 Ecological Resources

The Pilot Plant would be constructed in an existing facility located in a heavily industrialized area that has marginal value as wildlife habitat. Construction would involve the movement of workers and construction equipment, but no earth-moving equipment would be anticipated, so noise levels would be somewhat lower than the levels that would be experienced during construction of the full-scale facility. Construction-related disturbances are likely to create impacts to wildlife that would be small, intermittent, and localized.

Operation of the Pilot Plant would entail movement of workers and equipment and noise from public address systems (e.g., testing of radiation and fire alarms), air compressors, pumps, and HVAC-related equipment. With the possible exception of the public address systems, noise levels generated by these kinds of sources are not expected to disturb wildlife outside of facility boundaries.

4.1.14.7 Land Use

The Pilot Plant would be constructed in an existing facility located in an area designated for industrial use. Therefore, no change in land use patterns would occur.

4.1.14.8 Socioeconomics

The Pilot Plant would be constructed in an existing facility. During construction of the Pilot Plant, the number of workers would be restricted by space constraints inside the proposed facility. In addition, the Pilot Plant would have a modular design that maximizes the use of skid-mounted equipment, which would facilitate remote installation and further limit the number of workers required for construction. Therefore, the number of workers involved in the construction of the Pilot Plant would be much lower than the number of workers required for construction of the salt processing facility.

The Small Tank Precipitation process facility would require approximately 180 operations employees. The Ion Exchange process facility would require approximately 135 operations employees. The Solvent Extraction process facility would require approximately 220 operations employees, (WSRC 1998a, 2000a). These same employees would be trained in and would operate the Pilot Plant.

4.1.14.9 Cultural Resources

The Pilot Plant would be constructed in an existing facility and would, therefore, not disturb any cultural or historic resources. Therefore, no impact to cultural resources would occur.

4.1.14.10 Traffic and Transportation

In Section 4.1.10, DOE estimated that material shipments required for implementation of the alternatives would result in 403,000 to 529,000 miles traveled over the 13 year life of the facility and no accidents involving injuries or fatalities would be expected during those material shipments. The Pilot Plant would operate potentially for a period of approximately 5.5 years and the number of material shipments would be substantially lower, so no accidents involving injuries or fatalities would be expected during material shipments to the Pilot Plant.

During the life of the Pilot Plant, workers would make between 184,250 and 292,000 Site trips. Under the Small Tank Precipitation Pilot Plant, workers would make approximately 240,000 Site trips; 45 accidents, 20 injuries and no fatalities would be expected. Under the Ion Exchange Pilot Plant, workers would make approximately 184,250 Site trips; 35 accidents, 15 injuries and no fatalities would be expected. Under the Solvent Extraction Pilot Plant, workers would make approximately 292,000 Site trips; 55 accidents, 24 injuries and no fatalities would be expected.

4.1.14.11 Waste Generation

The Pilot Plant would generate no greater than 10 percent of the waste of the full-size salt processing facility on an annual basis. Waste generation under the Solvent Extraction Pilot Plant would be slightly higher than the other Pilot Plant units, due to the inclusion of a 1/5-scale centrifugal contactor.

As with the full-scale salt processing facility, the Pilot Plant would generate minimal quantities of low-level, transuranic, hazardous, industrial, and sanitary waste under all scenarios. All operations would generate a small amount of radioactive liquid waste, but the quantity generated by the Solvent Extraction Pilot Plant would be somewhat higher than that generated by the other three Pilot Plants. The Ion Exchange Pilot Plant would generate a small amount of nonradioactive liquid waste, while the Pilot Plants for the other two action alternatives would generate minute quantities of nonradioactive liquid waste. All Pilot Plant operations would generate a small amount of mixed LLW, but the quantity generated by the Solvent Extraction Pilot Plant would be higher than that generated by the Small Tank Precipitation and Ion Exchange Pilot Plants. Because it produces a comparatively large amount of benzene, the Small Tank Precipitation Pilot Plant would generate considerably more mixed low-level liquid waste than the other two Pilot Plants.

4.1.14.12 Utilities and Energy

Utility and energy use during construction of the Pilot Plant would be minimal. No steam would be used, and the use of skid-mounted equipment and the fact that the Pilot Plant would be constructed in an existing facility would limit water, electricity, and fuel requirements.

Utility and energy use during operation of the Pilot Plant would not be greater than 10 percent of the amount used in the full-size salt processing facility on an annual basis. Utility and energy demand for the Solvent Extraction Pilot Plant would be slightly higher than the other Pilot Plants due to the inclusion of a 1/5-scale centrifugal contactor. The impact to SRS utility and energy supplies would be minimal during operation of the Pilot Plant.

4.2 Long-Term Impacts

This section presents estimates of long-term impacts of the four salt processing action alternatives. For all the action alternatives, the major source of long-term impacts would be the saltstone that would result from each of the four alternatives. As discussed in Chapter 2, the saltstone vaults would be located in Z Area, regardless of the selected alternative. Therefore, this SEIS analyzes impacts only from the placement of saltstone in Z Area. Short-term impacts of manufacturing the saltstone are included in Section 4.1.

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

In order to estimate the impacts of no action in the long term, DOE must assume that the HLW remains in the HLW storage tanks and no action is ever taken to ensure safe management. In this scenario, following loss of institutional control after 100 years, the HLW tanks would eventually fail and the contents would be released to groundwater and eventually, to surface water. DOE has not attempted to model this scenario because of the numerous uncertainties involved. Some indication of the potential for impacts may be gained, however, from a comparison with modeling results DOE prepared for the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000e), as described in the following paragraph.

Under the No Action alternative in the Tank Closure Draft EIS (DOE 2000e), DOE would remove most of the waste from the tanks and spray water wash the tanks, but would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves. Under the tank closure scenario, the tanks would eventually fail (after a period of perhaps several hundred years), creating physical hazards to humans and wildlife in the area and releasing the residual HLW to the groundwater at SRS. DOE estimated that residual waste in the F- and H-Area Tank Farms would contain about 200 curies of long half-life isotopes, technetium-99 and plutonium-239, and 9,900 curies of cesium-137, which has a relatively short half-life of 30 years. DOE modeled the eventual release of these contaminants to the groundwater at SRS. The modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime radiation dose of 430 millirem (primarily from groundwater), and incur an incremental risk of 2.2×10^{-4} of a fatal cancer. The greatest risk would occur within about 500 years of tank abandonment, but doses for residents would be greater than 10 millirem for over 1,000 years.

In contrast, if DOE were to take no action and leave the HLW in the tanks at SRS, approximately 450,000,000 curies (160,000,000 in salt component, and 290,000,000 in the sludge component, assuming that about 10 percent of the curies in the sludge component have been vitrified in DWPF) would be available for release to the groundwater. While modeling would be required to calculate exposures and health effects over time, it is clear that the impacts to human health resulting from a No Action alternative would be catastrophic.

Salt processing would have no long-term impact on the following areas: air, socioeconomics, worker health, environmental justice, cultural resources, traffic and transportation, waste generation, utilities and energy, and accidents. Therefore, Section 4.2 does not analyze or discuss long-term impacts to these resources. The following disciplines are analyzed: geologic resources, water resources, ecological resources, land use, and public health.

4.2.1 GEOLOGIC RESOURCES

The Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives include disposal of radioactive waste in vaults in Z Area. Failure of the vaults at some time in the future would have the potential to contaminate the surrounding soils. If the integrity of a vault were breached, infiltration of water could result in contaminants leaching to groundwater. The water-borne contaminants would contaminate nearby soils, but would not alter their physical structure. No detrimental effect on surface soils, topography, or on the structural or load-bearing properties of geologic deposits would occur because of release of contaminants from the vaults.

4.2.2 WATER RESOURCES

4.2.2.1 Surface Water

Surface water impacts would only occur by discharge of contaminated groundwater. Because the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives would result in radioactive waste being disposed in the Z-Area vaults, the potential exists for long-term impacts to groundwater (see Section 4.2.2.2). Contaminants in groundwater could then be transported through the Upper Three Runs Aquifer and the underlying Gordon Aquifer to the seeplines along McQueen Branch and Upper Three Runs, respectively (see Section 4.2.2.2 for a more detailed discussion). The factors that govern the movement of contaminants through groundwater (i.e., the hydraulic conductivity, hydraulic gradient, effective porosity, and dispersion of aquifers in the area) and the processes resulting in attenuation of radiological and nonradiological contaminants (i.e., radioactive decay, ion exchange in the soil, and adsorption to soil particles) would be expected to reduce or mitigate impacts to surface water resources.

As described in Appendix D, DOE used an analysis based on the PORFLOW-3D computer code to model the fate and transport of contaminants in groundwater and subsequent flux (i.e., groundwater discharge at the seepline) to surface waters. The groundwater discharge at the seepline would naturally mix with the stream flow. Assuming that the upstream concentration of all contaminants in surface water is zero, and that no storm runoff is present, the resulting concentration of contaminants in surface water would be the result of the seepline groundwater mixing with uncontaminated surface water. The resulting concentrations in surface water would thus always be less than the groundwater seepline concentrations, due to dilution. The average flows in McQueen Branch and Upper Three Runs at the point of mixing with the groundwater discharge along the seeplines would be on the order of 2 to 3 cubic feet per second and 135 to 150 cubic feet per second, respectively (Parizek and Root 1986).

EPA periodically publishes water quality criteria as concentrations of substances that are known to affect "diversity, productivity, and stability" of aquatic communities including "plankton, fish, shellfish, and wildlife" (EPA 1986, 1999). These recommended criteria provide guidance for state regulatory agencies developing location-specific water quality standards to protect aquatic life (SCDHEC 1999b). Such standards are used in a number of environmental protection programs, including setting discharge limits in NPDES permits. Water quality criteria and standards are generally not legally enforceable; however, NPDES discharge limits based on these criteria and standards are legally binding and are enforced by SCDHEC.

The fate and transport modeling indicates that movement of radiological contaminants from failed vaults to nearby surface waters via groundwater discharge would be minimal. Based on the previous radiological performance assessment (RPA) contaminant screening (WSRC 1992), the radiological contaminants of concern would be carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135. Table 4-26 shows maximum radiation doses from all contaminants to humans and corre-

Table 4-26. Maximum dose and health effects from concentrations of radionuclides in groundwater 1 meter and 100 meters downgradient of Z Area vaults and at the seepline.

	Maximum dose							
	Upper Three Runs Aquifer				Gordon Aquifer			
Exposure point	Small Tank Precipitation	Ion Exchange	Solvent Exchange	Direct Disposal in Grout	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
1 meters downgradient								
Total dose	0.080	0.095	0.074	0.096	0.49	0.58	0.45	0.57
Lifetime LCF[a]	2.8×10^{-6}	3.3×10^{-6}	2.6×10^{-6}	3.4×10^{-6}	1.7×10^{-8}	2.0×10^{-5}	1.6×10^{-5}	2.0×10^{-5}
100 meters downgradient								
Total dose (millirem/year)	0.0068	0.0073	0.0062	0.0079	0.042	0.044	0.038	0.048
Lifetime LCF[a]	2.4×10^{-7}	2.6×10^{-7}	2.2×10^{-7}	2.8×10^{-7}	1.5×10^{-6}	1.5×10^{-6}	1.3×10^{-6}	1.7×10^{-6}
Seepline								
McQueen Branch								
Maximum dose (millirem/year)	0.0019	0.0020	0.0017	0.0022	NA	NA	NA	NA
Lifetime LCF[a]	6.7×10^{-8}	7.0×10^{-8}	6.0×10^{-8}	7.7×10^{-8}	NA	NA	NA	NA
Upper Three Runs								
Maximum dose (millirem/year)	NA	NA	NA	NA	0.0029	0.0028	0.0025	0.0032
Lifetime LCF[a]	NA	NA	NA	NA	1.0×10^{-7}	6.3×10^{-8}	8.8×10^{-8}	1.1×10^{-7}
Regulatory limit (millirem /year)	4	4	4	4	4	4	4	4

a. Increased probability of an LCF to the exposed individual over a 70-year period.
b. The discharge point for the Upper Three Runs aquifer is the McQueen Branch seepline, and the discharge point for the Gordon aquifer is the Upper Three Runs seepline.
c. Maximum impacts would not occur at the same time due to the different radionuclide transport times to the potential exposure locations.
LCF = latent cancer fatality.

sponding impacts expressed as LCFs from groundwater at the seeplines of McQueen Branch and Upper Three Runs before dilution with surface water. Doses would be low under each action alternative and would be below the drinking water standard of 4 millirem per year (40 CFR 141.16) in all cases. As discussed above, the in-stream concentrations resulting from the mixing of groundwater discharge at the seepline with the upstream flow would result in lower downstream concentrations than shown in Table 4-26. These data represent that point in time.

The 4-millirem-per-year standard applies only to beta-emitting radionuclides but, because the total dose would be less than 4 millirem per year, the standard would be met.

The results of the fate and transport modeling of nonradiological contaminant migration from failed vaults to nearby surface water via groundwater discharge are presented in Table 4-27. Based on the previous RPA contaminant screening (WSRC 1992), the only nonradiological contaminant of concern would be nitrate. The recent modeling results indicate that

Table 4-27. Maximum nonradiological contaminant concentrations (mg/L) in groundwater 1 meter and 100 meters downgradient and at the seepline.

	Maximum concentration							
	Upper Three Runs Aquifer[a]				Gordon Aquifer[b]			
Exposure point/ contaminant	Small Tank Precipitation	Ion Exchange	Solvent Exchange	Direct Disposal in Grout	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
1 meter downgradient								
Nitrate (mg/L)	56	66	51	66	338	395	307	394
100 meters downgradient								
Nitrate (mg/L)	4.8	5.1	4.4	5.6	29	31	26	33
Seepline								
Nitrate (mg/L)	1.4	1.5	1.3	1.6	2.2	2.1	1.9	2.4
EPA MCL (mg/L)	44	44	44	44	44	44	44	44

a. Surfaces at McQueen Branch seepline.
b. Surfaces at Upper Three Runs seepline.
c. Nitrate as total nitrogen.
MCL = maximum contaminant level.

there would be little difference between the alternatives and that none of the four action alternatives would result in an exceedance of the drinking water criteria for nitrate in the groundwater discharge at the seeplines of McQueen Branch or Upper Three Runs. Concentrations of nitrate at the seeplines would be small (less than 3 milligrams per liter [mg/L]) in all cases. Taking into account the dilution effect of the groundwater discharge mixing with the in-stream flow (assumed to be contaminant-free), the predicted concentrations of nonradiological contaminants would be even lower than those in Table 4-27. Therefore, no health impacts are anticipated from nitrates discharged to surface waters.

4.2.2.2 Groundwater

Each of the action alternatives proposed in Chapter 2 includes actions that could result in potential long-term impacts to groundwater beneath the Z-Area vaults. Because groundwater is in a state of constant flux, impacts that occur directly below the vaults could propagate to areas hydraulically downgradient of Z Area.

The primary action that would result in long-term impacts to groundwater is failure of the vaults and the generation of contaminated leachate that would enter the vadose zone soils. The contamination has the potential to contaminate groundwater at some point in the future, due to leaching and water-borne transport of contaminants. As described in detail in Appendix D, shallow groundwater beneath the vaults flows toward McQueen Branch, but also includes a vertical flow component toward deeper aquifers. In the analyzed alternatives, the mobile contaminants that leached from the vault would gradually migrate downward through unsaturated soil to the hydrogeologic units comprising the shallow aquifers underlying the vaults. As described in Section 4.1.2.1, because the vaults will be constructed above the typical elevation of the water table, contaminants released from the vaults would be released into the vadose zone and not directly into the shallow groundwater.

The shallowest hydrogeologic unit affected would be the upper zone of the Upper Three Runs Aquifer, formally known as the Water Table Aquifer (Aadland, Gellici, and Thayer 1995). Hydrogeologic studies and modeling (Flach and Harris 1996) conducted for the area of SRS where S and Z Areas are located, suggest however that flow in the upper zone of the Upper

Three Runs Aquifer that originates in the proposed vault disposal area does not outcrop to McQueen Branch. Rather, water in the upper zone would migrate downward into the lower zone of the Upper Three Runs Aquifer (formally known as the Barnwell-McBean Aquifer). Some contaminants would be transported subsequently to the northeast by groundwater flow through the lower zone of the Upper Three Runs Aquifer and discharge at the seepline along McQueen Branch.

The previous modeling results for the General Separations Area (the location of S and Z Areas) (Flach and Harris 1996), also suggested that a portion of the contaminant mass released to the Upper Three Runs Aquifer would migrate downward and then laterally through the Gordon Aquifer to a point of discharge at the seepline along Upper Three Runs. The groundwater flow direction in the Gordon Aquifer is toward the north-northwest.

Summary of Predicted Concentrations

The results of the groundwater fate and transport modeling for radiological and nonradiological contaminants entering the Upper Three Runs and Gordon Aquifers are presented in Tables 4-26 and 4-27. The modeling calculated impacts to each aquifer layer. The results are presented for each alternative for groundwater wells 1 meter and 100 meters downgradient of the vaults and for the seeplines. The specific concentrations for each radiological and nonradiological contaminant for each aquifer layer and each exposure point are presented in Appendix D.

For radiological contaminants, the doses in millirem per year from all radionuclides are considered additive for any given aquifer layer at any exposure point. The concentrations in groundwater from the various aquifers are, however, not additive. The maximum radiation dose (millirem per year), regardless of the aquifer layer is therefore presented in the tables for each exposure point. These data represent the increment in time when the sum of all beta-gamma emitters would be greatest, but not necessarily when all radionuclides are at their maximum concentrations. This method of data presentation shows the overall maximum dose or concentration that could occur at each exposure point. Based on the previous RPA contaminant screening (WSRC 1992), the radiological contaminants of concern in groundwater would be carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135.

Based on the previous RPA contaminant screening (WSRC 1992), the only non-radiological contaminant of concern would be nitrate; therefore, only nitrate was modeled. The maximum concentration of nitrate, regardless of time, was determined for each aquifer layer and for each exposure point.

Comparison of Alternatives

The groundwater radiological concentrations (Table 4-26) consistently show that the greatest long-term impacts for beta-gamma emitters at the 100-meter well would occur under the Direct Disposal in Grout or the Ion Exchange alternative, although the differences among alternatives are small. The results also indicate that none of the alternatives would result in an exceedance of the regulatory limit for dose to humans in drinking water (i.e., 4 millirem per year), either at the wells or at the seeplines (i.e., groundwater discharge points).

The nonradiological results presented in Table 4-27 identify a consistent trend for nitrate at all points of exposure; the highest concentration occurs under the Ion Exchange and Direct Disposal in Grout alternatives, but there are only small differences among alternatives. The data show that nitrate would exceed the maximum contaminant level (MCL) for drinking water 1 meter downgradient of the facility for all alternatives, but would not exceed the 100 meters downgradient of the vaults for any alternatives. The MCL would not be exceeded at the seepline for either aquifer layer.

4.2.3 ECOLOGICAL RESOURCES

This section presents an evaluation of the potential long-term impacts of salt processing alternatives to ecological receptors. DOE assessed the potential risks to ecological receptors at the seeplines of McQueen Branch (a tributary of Upper Three Runs near Z Area) and Upper Three Runs.

Groundwater-to-surface water discharge of contaminants was the only long-term migration pathway evaluated because the disposal vaults will be several meters underground, precluding overland runoff of contaminants and associated terrestrial risks. The vaults would have concrete roofs and be capped with clay and gravel. This would provide an impervious layer for deep plant roots. As a result, only risks to aquatic or semi-aquatic biota were considered possible. The habitat in the vicinity of the seeplines is bottomland (riparian) hardwood forest along the channels of McQueen Branch and Upper Three Runs. Upslope of the floodplain, the forest is a mixture of pine and hardwood.

The Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives were assessed for their potential long-term ecological impacts. Modeling of groundwater-to-surface water migration of contaminants from the disposal vaults indicated that nitrate was the only nonradiological chemical that would reach McQueen Branch and Upper Three Runs, and that carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135 were the radionuclides that would reach the two streams. The model generated concentrations of these contaminants in the groundwater at the seeplines.

4.2.3.1 Radiological Contaminants

The Oak Ridge National Laboratory (ORNL) has developed screening guidelines for the protection of aquatic organisms from radiological chemicals in surface water (Bechtel Jacobs Company 1998). These guidelines were developed by back-calculating the DOE Order 5400.5 dose rate limit for aquatic biota of 1.0 rad per day (rad/d) to obtain corresponding concentrations of radionuclides in surface water. These guidelines can then be compared to ambient concentrations to assess potential risks to aquatic biota. The guidelines are in picocuries per liter (pCi/L) and were developed separately for small fish and large fish. All guidelines include exposures from parent isotopes and all short-lived daughter products. They also include exposures from all major alpha, beta, and gamma emissions for each isotope. It should be noted that ORNL developed its guidelines for radionuclides of concern at the Oak Ridge Reservation. No similar values have been calculated for SRS. However, the ORNL values were derived using generic data and are based on types of fish that could occur on SRS. The groundwater chemical data for this SEIS were modeled for thousands of years after disposal and, therefore, the isotopes that comprise the data are not generally in agreement with ORNL's (i.e., in this analysis, credit was taken for radioactive decay). Only a guideline for technetium-99 was available.

The predicted radiological concentrations in groundwater at the McQueen Branch and Upper Three Runs seeplines are presented in Table 4-28 for each of the four action alternatives. The concentrations of technetium-99 were orders of magnitude lower than the ORNL guideline. Again, no ORNL guidelines were available for the other elements (their particular isotopes). However, a surrogate value for radioactive cesium of 6.19×10^3 pCi/L can be used to assess risks from the elements other than technetium-99. This value generates an acceptable dose of 1 rad/day. Radioactive cesium has a higher energy emitted per decade than other elements in the seepwater. Because the surrogate guideline concentration is orders of magnitude higher than all those of the detected radionuclides in the seepwater, it can be inferred that the risks from those elements would be much lower. Because the maximum radiological concentrations predicted for McQueen Branch and Upper Three Runs are all far below this surrogate guideline, it can be concluded that potential risks to aquatic biota in McQueen Branch and Upper Three Runs from radionuclides in seepwater would be very low.

4.2.3.2 Nonradiological Contaminants

Nitrate is considered to be essentially non-toxic to fish and wildlife, and is important as a plant nutrient in aquatic systems (Wetzel 1983).

Table 4-28. Maximum concentrations of radiological contaminants in seepline groundwater compared to ORNL screening guidelines (pCi/L).

		Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Contaminant	ORNL guideline Small/Large Fish[a]	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)
Carbon-14	NA[b]	1.9×10^{-6}	2.0×10^{-6}	2.1×10^{-6}	1.9×10^{-6}	1.8×10^{-6}	1.7×10^{-6}	2.2×10^{-6}	2.1×10^{-6}
Selenium-79	NA[b]	0.16	0.23	0.17	0.23	0.15	0.20	0.19	0.25
Technetium-99	1.94×10^{-6}/ 1.94×10^{-6}	0.42	0.66	0.44	0.64	0.38	0.58	0.48	0.72
Tin-126	NA[b]	5.7×10^{-5}	3.9×10^{-5}	6.1×10^{-5}	3.9×10^{-5}	5.2×10^{-4}	3.5×10^{-5}	6.6×10^{-5}	4.3×10^{-5}
Iodine-129	NA[b]	0.0028	0.0045	0.0029	0.0044	0.0025	0.0039	0.0032	0.0049
Cesium-135	7,720/6,190	9.8×10^{-7}	1.5×10^{-6}	1.0×10^{-6}	1.5×10^{-6}	8.9×10^{-7}	1.3×10^{-6}	0.012	0.017

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a. The value presented for cesium-135 is a surrogate value for cesium-137 (radioactive cesium). Cesium-137 has a higher decay energy than cesium-135. Therefore, this is a conservative estimate of the guideline for cesium-135.

b. Specific guidelines for these radionuclides are not available. However, because cesium accumulates in biological tissues and because cesium-137 has a higher decay energy than any of the other radionuclides listed, guidelines for these radionuclides are unlikely to be smaller than the guideline for cesium-137.

Nitrates are generally considered to be a potential human health hazard at high concentrations in drinking water because they are reduced to nitrites in the digestive system (EPA 1986). Nitrites are capable of oxidizing hemoglobin to produce methemoglobin, which is incapable of transporting oxygen (EPA 1986). However, in well-oxygenated aquatic systems, nitrite is typically oxidized to nitrate.

The relatively low ecotoxicity from nitrates is reflected in the lack of surface water screening levels and criteria. EPA (1986) points out that concentrations of nitrate or nitrite with toxic effects on fish could "rarely occur in nature" and, therefore, "restrictive criteria are not recommended". No Federal ambient water quality criteria based on protection of aquatic organisms are available for nitrates (or nitrites) (EPA 1999). Nevertheless, some guidelines for nitrate/nitrite toxicity are available. EPA (1986) concludes that (1) concentrations of nitrate at or below 90 mg/L will have no adverse effects on warmwater fishes, (2) nitrite at or below 5 mg/L would be protective of most warmwater fishes, and (3) nitrite at or below 0.06 mg/L should be protective of salmonid fishes (no salmonid fishes are present on SRS). The Canadian Council of Ministers of the Environment (CCME) presents a surface water guideline protective of aquatic organisms of 0.06 mg/L (Environment Canada 1998). In the past, DOE has used an MCL of 10 mg/L as a surrogate protective concentration for semi-aquatic wildlife, such as mink (DOE 1997b).

Generally speaking, the only effects of elevated nitrate concentrations in streams and reservoirs are the fertilization of algae and macrophytes and the hastening of eutrophication. This occurs mainly when significantly increased nitrate inputs and inputs of other nutrients, mainly phosphorous, continue over a long period of time (Wetzel 1983). The concentrations of nitrate in groundwater at the McQueen Branch and Upper Three Runs seeplines are presented in Table 4-29 for each of the four action alternatives. On the whole, the predicted concentrations in seepwater for all four action alternatives exceeded the EPA nitrite guideline for protection of coldwater fishes and the CCME nitrite guideline for protection of aquatic biota. The concentrations were comparable to the EPA nitrite guideline for protection of warmwater fishes and were an order of magnitude or more lower than the EPA nitrate no-adverse-effects guideline for warmwater fishes. They also were less than the human health nitrate MCL. It should be noted that guidelines for coldwater fishes are conservative because they are usually based on toxicity data for salmonids, which are generally more sensitive to contaminants than warmwater fishes (Mayer and Ellersieck 1986).

If the ratio of nitrates to nitrites introduced from the alternatives was lower, or the introduced nitrate was transformed to nitrite in appreciable quantities, substantive risks could potentially be present. However, EPA (1986) states that, in oxygenated natural water systems, nitrite is rapidly oxidized to nitrate. Upper Three Runs tends to be well oxygenated (Halverson et al. 1997).

More importantly, the assessment of risk to ecological receptors was performed on groundwater at the seepline and, hence, did not account for dilution by stream volumes. After dilution, the concentration of nitrate (and nitrite) would likely be much lower, probably by orders of magnitude.

Toxicity data for semi-aquatic receptors (e.g., mink) are scarce for nitrate, reflecting its relatively low ecotoxicity. Only one study of the effects of nitrate on mammals that applied to ecological risk considerations could be located. The study involved the effects of potassium nitrate on guinea pigs, using oral ingestion of water as the exposure medium (ORNL 1996). No adverse effects were observed at a dose of 507 milligrams per kilogram (mg/kg) of body weight per day (mg/kg/day). A reduction in the number of live births was observed at 1,130 mg/kg/day. ORNL (1996) extrapolated toxicity and dose concentration data from this study to determine potentially toxic concentrations in various media to wildlife species. Based on the ORNL study, nitrate concentrations of at least 6,341 and 4,932 mg/L in surface water would be necessary to produce toxic effects for the short-tailed shrew and mink, respectively. The con-

Table 4-29. Maximum concentrations of nitrate in seepline groundwater compared to ecotoxicity guidelines (mg/L).

	Alternative (mg/L)				Ecotoxicity guideline (mg/L)				
Aquifer	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	No-adverse-effects on warmwater fishes (nitrate as nitrogen)[a]	Protection of warmwater fishes (nitrite as nitrogen)[a]	Protection of cold-water fishes (nitrite as nitrogen)[a]	CCME guideline for protection of aquatic biota (nitrite as nitrogen)[b]	MCL (nitrate as nitrogen)[c]
McQueen Branch (Upper Three Runs Aquifer)	1.4	1.5	1.3	1.6	90	5	0.06	0.06	10
Upper Three Runs (Gordon Aquifer)	2.2	2.1	1.9	2.4	90	5	0.06	0.06	10

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a. EPA (1986).

b. Environment Canada (1998).

c. Maximum Contaminant Level (MCL) for drinking water (EPA 1999).

centrations are several orders of magnitude higher than the maximum modeled concentrations presented in Table 4-29. EPA (1986) does not indicate that nitrate bioaccumulates and, therefore, concentrations in the prey or forage of semi-aquatic wildlife would likely be low.

For these reasons, the potential risks to aquatic and semi-aquatic biota in McQueen Branch and Upper Three Runs from nitrate would be low for all alternatives.

4.2.4 LAND USE

Long-term impacts from saltstone disposal vaults would not affect proposed SRS future land use. However, the presence of 13 to 16 low-level radioactive vaults in Z Area (see Table 4-1) would limit any other use for as long as the vaults remained, a period of time modeled to 10,000 years in this analysis.

4.2.5 PUBLIC HEALTH

This section presents the potential impacts on human health from contaminants in the saltstone at some point after the period of institutional control of Z Area. To determine the long-term impacts, DOE evaluated data for Z Area, including the following:

- Expected source inventory that would be present in the saltstone
- Existing technical information on geological and hydrogeological parameters in the vicinity of Z Area
- Arrangement of the saltstone vaults within the stratigraphy
- Actions to be completed under each of the alternatives.

In its evaluation, DOE reviewed the methodology and conclusions contained in the *Radiological Performance Assessment for the Z-Area Saltstone Facility* (WSRC 1992) to determine what changes in the RPA analysis, if any, would result from implementing any of the salt processing alternatives. (The RPA was done for saltstone that would have resulted from the In-Tank Precipitation process.) Based on its review, DOE believes the exposure pathway methodology in the RPA is technically valid. DOE has modified certain input parameters to represent the alternatives. Therefore, DOE believes this modeling is valid for evaluating long term impacts. See Appendix D for additional details.

The RPA considers multiple routes of exposure for humans in the future. Z Area is zoned as an industrial area, and DOE does not expect that any public access to Z Area would be allowed. However, for purposes of analysis, DOE assumed that people would have access to the land beginning 100 years after the last vault was closed. The RPA considered multiple routes of exposure for humans following a 100-year period of institutional control and determined that two scenarios would have the greatest potential for exposing a hypothetical individual to saltstone contaminants:

- An agricultural scenario, in which the individual unknowingly farms and constructs a home on the soil above the saltstone vaults. In this scenario, the individual is assumed to derive half of his vegetable consumption from a garden planted in contaminated soil located over the vaults. The time spent gardening is assumed to be short compared to the amount of time spent indoors or farming. Only potential impacts from external radiation, inhalation, incidental soil ingestion, and vegetable ingestion are calculated for indoor residence and outdoor gardening activities. Since the farming activities would occur over a widespread area that would include uncontaminated and undisturbed soil not subject to irrigation with contaminated water, the meat and milk pathways would not contribute significantly to the individual's dose. Because of DOE's expectation that the saltstone would remain relatively intact for an extended period of time, DOE does not believe this scenario could be reasonable until approximately 10,000 years post-closure because, at least until that time, the individual could identify that he was digging through a cementitious material. However, for conservatism, DOE has calculated the impacts of the agricultural scenario at 1,000 years post-closure. This scenario includes the 1,000-year residential scenario described below.

- A residential scenario, in which the individual constructs and lives in a permanent residence on the vaults. This scenario analyzes two options: construction at 100 years and at 1,000 years. Under the first option, a sufficient layer of soil would cover the still-intact vaults so that the individual would not know that the residence was constructed on the vaults. Under the second option, the saltstone is assumed to have been exposed and weathered sufficiently so that a person could build a home directly on a degraded vault without being aware of the saltstone.

4.2.5.1 Radiological Contaminants

In addition to these scenarios and options, the RPA also determined the impacts from consuming water from a well drilled 100 meters from the saltstone vaults after the period of institutional control. The original analysis considered the two uppermost aquifers underneath the saltstone facility and determined the concentrations downgradient of the vaults.

Using this information from the RPA, DOE calculated new results for the groundwater concentrations and the exposure scenarios. First, DOE used the engineering data developed during the alternative development process to determine how the saltstone composition would differ for the alternatives analyzed in this SEIS, as compared to the composition of the saltstone analyzed in the original RPA. Second, DOE determined how the new saltstone compositions (including concentrations of contaminants) affected the results in the original RPA and used that information as the basis to determine results for the analyzed alternatives in this SEIS. For those issues that the RPA did not address (such as direct disposal of cesium in grout), DOE performed the necessary original calculations to account for the newer information. A detailed discussion of DOE's methodology is contained in Appendix D.

Table 4-30 shows the calculated groundwater concentrations and radiation doses from the exposure scenarios. DOE compared groundwater results to the regulatory limits for drinking water specified in 40 CFR 141. The applicable drinking water standards for radionuclides are 4 millirem per year for beta/gamma-emitting radionuclides and 15 pCi/L for alpha-emitting radionuclides. The RPA analyses indicated that alpha-emitting radionuclides would not be transported from the saltstone vaults except in minute quantities, and DOE therefore excluded them from the impacts analysis. For nonradiological constituents (primarily nitrate), DOE compared the water concentrations directly to the concentrations listed as MCLs in 40 CFR 141.

The differences in calculated concentrations and doses among the alternatives are primarily a function of the differences in composition of the saltstones. The Small Tank Precipitation alternative would produce a saltstone very similar to that analyzed in the RPA, and the results for this alternative (in Table 4-30) are therefore consistent with the results in the RPA. The Ion Exchange alternative would result in a salt solution with slightly higher contaminant concentrations, resulting in higher contaminant concentrations in saltstone and associated greater impacts. Similarly, the Solvent Extraction salt solution has slightly lower concentrations.

The Direct Disposal in Grout alternative would result in a salt solution with slightly higher concentrations for most constituents than the other alternatives, but with essentially all of the cesium. Radioactive cesium has a relatively short half-life (approximately 30 years), so the radioactive cesium concentration at the end of 100 years would be decreased by a factor of about 10, with subsequent decreases as time elapses. Therefore, for most of the scenarios in Table 4-30, the impacts of Direct Disposal in Grout are comparable to those of the other alternatives. However, for the residential scenario that assumes construction at 100 years directly on top of the saltstone facility, radioactive cesium would still be present in quantities sufficient to produce a dose noticeably higher than the other

Table 4-30. Summary comparison of long-term human exposure scenarios and health effects.

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Nitrate concentration at 100-meter well (mg/L)[a]	29	31	26	33
Radiation dose (millirem per year) from 100-meter well	0.042	0.044	0.038	0.048
LCF from 100-meter well[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)	52-110	61-130	49-110	64-140
LCF from Agricultural Scenario	1.8×10^{-3} to 3.9×10^{-3}	2.1×10^{-3} to 4.6×10^{-3}	1.7×10^{-3} to 3.9×10^{-3}	2.2×10^{-3} to 4.9×10^{-3}
Radiation dose from Residential Scenario at 100 years post-closure (millirem per year)	0.015-0.11	0.017-0.13	0.014-0.1	150-1,200
LCF from Residential Scenario at 100 years post-closure	5.3×10^{-7} to 3.9×10^{-6}	6.0×10^{-7} to 4.6×10^{-6}	4.9×10^{-7} to 3.5×10^{-6}	5.3×10^{-3} to 4.2×10^{-2}
Radiation dose from Residential Scenario at 1,000 years post-closure (millirem per year)	9.2-69	11-80	8.6-65	11-85
LCF from Residential Scenario at 1,000 years post-closure	3.2×10^{-4} to 2.4×10^{-3}	3.9×10^{-4} to 2.8×10^{-3}	3.0×10^{-4} to 2.3×10^{-3}	3.9×10^{-4} to 3.0×10^{-3}

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a. Nitrate MCL is 10 mg/L (EPA 1999).
b. Health effects are expressed as lifetime (70-year) LCFs to an individual.

alternatives. Because the second residential scenario assumes construction at 1,000 years, the radioactive cesium would have undergone approximately 30 half-lives, resulting in a greatly decreased dose contribution from that radionuclide (however, the longer-lived cesium-135 isotope would still be present).

The maximum doses from the drinking water, agricultural, and 100-year residential scenarios are not expected to occur concurrently, although the agricultural scenario values in the table include the 1,000-year residential scenario contribution, as discussed above. Therefore, it is not appropriate to add the doses from these scenarios.

As shown in Table 4-30, the 1,000-year residential scenario doses for all four action alternatives are similar and would be below the 100-millirem-per-year public dose limit. They range from as low as approximately 10 millirem per year to as high as 85 millirem per year. Doses for the agricultural scenario are similar, but could exceed the 100-millirem-per-year public dose limit. Doses for the agricultural scenario would range from 49 to 140 millirem per year. For the 100-year residential scenario, the dose would be highest for the Direct Disposal in Grout alternative (150 to 1,200 millirem per year) and would exceed the 100-millirem-per-year public dose limit. The 100-year residential scenario doses for the other three action alternatives would be much smaller and would not exceed 0.13 millirem per year.

As discussed in Section 4.1.4.1, DOE adopted a dose-to-risk conversion factor of 0.0005 LCFs per person-rem to estimate the probability of an individual developing a fatal cancer from the calculated radiation exposure. Because estimation of future populations is very speculative, DOE based the analysis of each scenario on an individual with a 70-year life span. As shown in Table 4-30, the probability of an LCF resulting from the long-term exposure scenarios is low. Therefore, DOE expects no adverse health impacts due to these radiation exposures.

References

Aadland, R. K., J. A. Gellici, and P. A. Thayer, 1995, *Hydrogeologic Framework of West-Central South Carolina,* Report 5, State of South Carolina Department of Natural Resources – Water Resources Division, Columbia, South Carolina.

Arnette, M. W. and A. R. Mamatey, 1998a, *Savannah River Site Environmental Data for 1997,* WSRC-TR-97-00324, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnette, M. W. and A. R. Mamatey, 1998b, *Savannah River Site Environmental Data for 1997,* WSRC-TR-97-00322, Westinghouse Savannah River Company, Aiken, South Carolina.

ATSDR (Agency for Toxic Substances and Disease Registry), 1988, Public Health Statement - Beryllium, Division of Toxicology, Atlanta, Georgia. Available at http://www.atsdr.cdc.gov/ToxProfiles/PHS/Beryllium.1988.html.

Bauer, L. R., 1991, *Modeling Chronic Atmospheric Releases at the SRS: Evaluation and Verification of XOQDOQ,* WSRC-RP-91-0320, Savannah River Laboratory, Aiken, South Carolina.

Bechtel Jacobs Company, 1998, Radiological Benchmarks for Screening Contaminants of Potential Concern for Effects on Aquatic Biota at Oak Ridge National Laboratory, Oak Ridge, Tennessee, BJC-OR-80, Oak Ridge, Tennessee.

BTS (Bureau of Transportation Statistics), 1998, *The National Transportation Statistics for 1998* (NTS), Table 3-20, U.S. Department of Transportation, Washington, D.C. Available at http://www.bts.gov/btsprod1nts/chp3v.html. Accessed June 16, 2000.

Cappucci, A. J., S. A. Bates, and D. E. Welliver, 1999, *Determination of Accident Sequence, Frequency, and Source Term Selections for the Salt Disposition Supplemental Environmental Impact Statement (U),* S-CLC-G-00187, Revision A, Westinghouse Safety Management Solutions, Aiken, South Carolina.

Carter, W. P. L., 1994, Development of Ozone Reactivity Scales for Volatile Organic Compounds, Journal of the Air and Waste Management Association, Vol. 44, pp. 881-899, January 20. Available at ftp://ftp.cert.ucr.edu/pub/carter/pubs/reactpap.pdf. Accessed February 26, 2001.

CEQ (Council on Environmental Quality), 1997, *Environmental Justice Guidance under the National Environmental Policy Act,* Executive Office of the President, Washington, D.C., March.

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement (Supplement to ERDA-1537, September 1977) Waste Management Operational Double-Shell Tanks for Defense High-Level Radioactive Waste Storage*, DOE/EIS-0062, Savannah River Plant, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1982, *Final Environmental Impact Statement Defense Waste Processing Facility Savannah River Plant, Aiken, South Carolina,* DOE/EIS-0082, U.S. Department of Energy, Office of Defense Waste and Byproducts Management, Washington, D.C.

DOE (U.S. Department of Energy), 1993, *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements.*

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility at the Savannah River Site,* DOE/EIS-0082-S, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995, *Final Environmental Impact Statement for the Interim Management of Nuclear Materials,* DOE/EIS-0220, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997a, *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site*, DOE/EIS-0268, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997b, *Industrial Wastewater Closure Module for the High-Level Waste Tank 17 System,* Construction Permit Number 17,424-lW, Rev. 2, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998, *Savannah River Site Future Use Plan,* Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999, *Accelerator Production of Tritium for the Savannah River Site Final Environmental Impact Statement,* DOE/EIS-0270, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 2000a, *Guidance on Clean Air Act General Conformity Requirements and the National Environmental Policy Act Process,* Office of Environment, Washington, D.C.

DOE (U.S. Department of Energy), 2000b, Savannah River Operations Injury and Illness Experience by Organization for 1995-1999. Available at http://tis.eh.doe.gov/cairs/cairs/field_of/fo994/i858yr.html. Assessed September 28, 2000.

DOE (U.S. Department of Energy), 2000c, *Draft Guidance on Incorporating Environmental Justice Considerations into the Department of Energy's National Environmental Policy Act Process,* Office of NEPA Policy and Assistance, Washington, D.C.

DOE (U.S. Department of Energy), 2000d, Discussion Draft, Savannah River Site Long-Range Comprehensive Plan, Savannah River Operations Office, Aiken, South Carolina. Available at http://www.srs.gov/general/srinfo/compplan.pdf. Accessed March 9, 2001.

DOE (U.S. Department of Energy), 2000e, *High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, Savannah River Operations Office, Aiken, South Carolina.

Eckerman, K. F., F. J. Congel, A. K. Roecklein, and W. J. Pasciak, 1980, *Users Guide to GASPAR Code,* NUREG-0597, U.S. Nuclear Regulatory Commission, Washington, D.C.

Environment Canada, 1998, *Summary of Canadian Water Quality Guidelines for the Protection of Aquatic Life*. Interim draft guidelines transmitted on April 20, 1998 to G. P. Friday from Robert Kent, Head Water Quality Guidelines and Assessments Section, Guidelines and Standards Division.

EPA (U.S. Environmental Protection Agency), 1986, *Quality Criteria for Water,* EPA 440/5-86-001, Office of Water, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 1990, *Fugitive Dust Model (FDM).*

EPA (U.S. Environmental Protection Agency), 1995*, EPA's Industrial Source Complex – Short-Term Air Dispersion Model,* EPA-454/B-95-003a, September.

EPA (U.S. Environmental Protection Agency), 1998, Integrated Risk Information System (IRIS) Database. Available at http://www.epa.gov/ngispgm3/iris/index.html. Accessed March 7, 2001.

EPA (U.S. Environmental Protection Agency), 1999, *National Recommended Water Quality Criteria — Correction,* EPA 822-Z99-001, Office of Water, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 2000, National Air Pollutant Emission Trends: 1900-1998, EPA 454/R-00-002, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. Available at www.epa.gov/ttn/chief/trends/trends98/trends98.pdf. Accessed February 26, 2001

EPA (U.S. Environmental Protection Agency), 2001, Aerometric Information Retrieval System (AIRS) Database. Available at http://www.epa.gov/airsdata. Accessed February 26, 2001.

Flach, G. P., and M. K. Harris, 1996, *Integrated Hydrogeological Model of the General Separations Area (U), Volume 2: Groundwater Flow Model (U),* WSRC-TR-96-0399, Westinghouse Savannah River Company, Aiken, South Carolina.

Golden, J., R. R. Ouellette, S. Saari, P. N. Cheremisinoff, 1980, *Environmental Impact Data Book,* Ann Arbor Science Publishers, Ann Arbor, Michigan.

Halverson, N. V., L. D. Wike, K. K. Patterson, J. A. Bowers, A. L. Bryan, K. F. Chen, C. L. Cummins, B. R. del Carmen, K. L. Dixon, D. L. Dunn, G. P. Friday, J. E. Irwin, R. K. Kolka, H. E. Westbury, and E. W. Wilde, 1997, *SRS Ecology Environmental Information Document,* WSRC-TR-97-0223, Westinghouse Savannah River Company, Aiken, South Carolina.

Halverson, N. V., 1999, Interoffice memorandum to C. B. Shedrow, *Revised Cumulative Impacts Data,* SRT-EST-99-0328, Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, August 17.

Hamby, D. M., 1992, *Verification of GASPAR Dose Assessment Module Used in MAXIGASP and POPGASP,* WSRC-RP-92-418, Savannah River Laboratory, Aiken, South Carolina.

Hunter, C. H., 2000, *Non-Radiological Air Quality Modeling for the High-Level Waste Salt Disposition Environmental Impact Statement,* WSRC-TR-99-00403, Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, July 27.

Mayer, F. L. and M. R. Ellersieck, 1986, *Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals,* United States Fish and Wildlife Service, Resource Publication 160, Washington, D.C.

National Jewish (National Jewish Medical and Research Center), 2001, Facts about Beryllium Disease. Available at http://www.nationaljewish.org/medfacts/beryllium_medfact.html. Accessed February 13, 2001.

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitations of Exposure to Ionizing Radiation,* Report Number 116, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1977, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 20, Appendix I,* Revision 1, Washington, D.C.

NIOSH (National Institute for Occupational Safety and Health), 1986, Occupational Respiratory Diseases, Publication Number 86-102, U.S. Department of Health and Human Services, Washington D.C. Available at http://www.cdc.gov/niosh/86-102.html. Accessed March 7, 2001.

ORNL (Oak Ridge National Laboratory), 1996, *Toxicological Benchmarks for Wildlife: 1996 Revision,* ES/ER/TM-86/R3, Health Sciences Research Division, Oak Ridge, Tennessee.

Parizek, R. R. and R. W. Root, 1986, *Development of a Ground Water Velocity Model for the Radioactive Waste Management Facility,* Savannah River Plant, South Carolina, Final Report.

Pike, J. A., 2000, *Preliminary Source Term and Emissions Data for Salt Processing Environmental Impact Statement,* HLW-SDT-0161, Rev. 5, Westinghouse Savannah River Company, Aiken, South Carolina.

Sagendorf, J. F., J. T. Croll, and W. F. Sandusky, 1976, *XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations,* NUREG/CR2919, U.S. Nuclear Regulatory Commission, Washington, D.C.

Sagendorf, J. F., J. T. Croll, and W. F. Sandusky, 1982, *XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations. Final Report,* NUREG/CR-2919, U.S. Nuclear Regulatory Commission, Washington, D.C.

Saricks, C. L. and M. M. Tompkins, 1999, *State-Level Accident Rates of Surface Freight Transportation: A Re-examination,* ANL/ESD/TM-150*,* The Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, Argonne, Illinois.

SCDHEC (South Carolina Department of Health and Environmental Control), 1996, “General Permit for Land Disturbing/Construction Activities SRS/Aiken County,” Letter to Westinghouse Savannah River Company, December 11.

SCDHEC (South Carolina Department of Health and Environmental Control), 1999a, *Water Use Report—Savannah River Site 1998* (compilation of quarterly water use reports), Permit and Data Administration Section, Columbia, South Carolina.

SCDHEC (South Carolina Department of Health and Environmental Control), 1999b, Water Classifications and Standards (R.61-68) and Classified Waters (R.61-69), Bureau of Water, Columbia, South Carolina.

Schafner, J. R., 2001, Interoffice Memorandum to J. Zimmerly, Tetra Tech NUS, Wastewater Treatment Capacities and Utilization, Westinghouse Savannah River Company, Aiken, South Carolina, February 20.

Simpkins, A. A., 1995a, *Verification of AXAIRQ,* WSRC-RP-95-708, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1995b, *AXAIRQ User's Manual,* WSRC-RP-95-709, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1999, *Salt Disposition Facility EIS Routine Releases Environmental Dosimetry Calculations,* SRT-EST-99-310, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina, July 21.

Simpkins, A. A., 2000a, *Salt Disposition Facility EIS Routine Release Worker Environmental Dosimetry Calculations,* SRT-EST-2000-236, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina

Simpkins, A. A., 2000b, *Salt Disposition Facility EIS Routine Release Worker Environmental Dosimetry Calculations,* SRT-EST-2000-240, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Wetzel, R. G., 1983, *Limnology,* McGraw-Hill Books, Philadelphia, Pennsylvania.

WSRC (Westinghouse Savannah River Company), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (WSRC-RP-92-1360), Prepared for Westinghouse Savannah River Company, Aiken, South Carolina, by Martin Marietta Energy Systems, Inc.

WSRC (Westinghouse Savannah River Company), 1993, *Storm Water Pollution Prevention Plan (U),* WSRC-IM-93-28, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1996, *Site Infrastructure,* Site Utilities Department, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998a, "Life Cycle Cost Estimate Report," WSRC-98-0167, Rev. 1, October 21.

WSRC (Westinghouse Savannah River Company) 1998b, *High-Level Waste Salt Disposition Engineering Team Final Report (U),* WSRC-RP-98-00170, Rev. 0, Aiken, South Carolina, October 29.

WSRC (Westinghouse Savannah River Company), 1999a, *SRTC Non-Rad Air Emissions Data Needs for Construction Activities (DOE/EIS-0082-S2),* HLW-SDT-99-0151, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, *Response to Data Call for Salt Disposition Alternatives at the Savannah River Site, DOE/EIS-0082-S2,* HLW-SDT-99-0181, Aiken, South Carolina, June 24.

WSRC (Westinghouse Savannah River Company), 1999c, *Radiological Performance Indicators, 4th Quarter CY 1998,* ESH-HPT-99-0017, Aiken, South Carolina, January.

WSRC (Westinghouse Savannah River Company), 1999d, *High-Level Waste Tank Space Management Team Final Report,* WSRC-RP-99-00005, Rev. 0, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999e, *SEIS DOE/EIS-0082-S2,* "Response to Supplemental Data Needs (U)", Interoffice memorandum from J. Sessions to C. B. Shedrow, August 18.

WSRC (Westinghouse Savannah River Company), 1999f, *Answer to phone questions, email J. Sessions to B. Bradford,* August 23.

WSRC (Westinghouse Savannah River Company), 2000a, *Data Response: Supplemental Environmental Impact Statement for High-Level Waste Salt Disposition,* ESH-EAP-2000-0011, Aiken, South Carolina, June 12.

WSRC (Westinghouse Savannah River Company), 2000b, WSRC *Response to TtNUS Supplemental Data Call,* HLW-SDT-2000-00263, Revision 0, Aiken, South Carolina, July 17.

CHAPTER 5. CUMULATIVE IMPACTS

The Council on Environmental Quality (CEQ) regulations that implement the procedural provisions of the National Environmental Policy Act (NEPA) define cumulative impacts as impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.7).

Based on an examination of the environmental impacts resulting from salt processing, coupled with those from U.S. Department of Energy (DOE) and other agency actions and some private actions, it was determined that cumulative impacts for the following areas need to be presented: (1) air resources; (2) water resources; (3) public and worker health; (4) waste generation; and (5) utilities and energy consumption. Discussion of cumulative impacts for the following subject areas is omitted because impacts to these topics from the proposed salt processing alternatives would be so small that their potential contribution to cumulative impacts would be minimal: geologic resources, ecological resources, aesthetic and scenic resources, cultural resources, traffic, and socioeconomics.

The baseline represents current conditions at Savannah River Site (SRS), as detailed in Chapter 3. In this chapter, DOE considers the baseline to represent the No Action alternative because the No Action alternative would continue current high-level waste (HLW) management activities through 2010. Any incremental impacts under the No Action alternative would occur after that. DOE provides a mostly qualitative assessment of the No Action alternative in Chapter 4.

Impacts that vary among the salt processing alternatives

The cumulative impacts analysis presented in this section is based on the actions associated with the SRS salt processing alternative with the greatest impact for each resource, other onsite activities, reasonably foreseeable future actions, and offsite activities with a potential for related environmental impacts. In certain cases, the magnitude of an impact to a particular resource varies among the salt processing alternatives. To be conservative, DOE based this analysis of cumulative impacts on the alternative with the highest impact for a particular resource category, but not on the same alternative for all resource areas (see data tables in this chapter).

As an overview, the resource categories that varied among the alternatives and the salt processing alternatives with the highest and lowest impacts are presented below:

Carbon monoxide and sulfur dioxide ground-level concentrations

- Highest – Direct Disposal in Grout
- Lowest – Small Tank Precipitation, Ion Exchange, and Solvent Extraction would be equal and have 83 percent of the Direct Disposal in Grout concentration for carbon monoxide, 75 percent of the highest 3-hour and annual sulfur dioxide concentrations, and 80 percent of the highest concentration for 24-hour sulfur dioxide.
- Conclusion – The addition to baseline concentrations is very small (less than 0.5 percent) for all action alternatives.

Ozone ground-level concentrations

- Highest – Small Tank Precipitation would not be expected to contribute more than 1 percent of observed background levels.
- Lowest – Concentration under Direct Disposal in Grout would be substantially lower than that for Small Tank Precipitation.
- Conclusion – The effect of any salt processing alternative is minimal on ozone concentration.

Project phase radiological dose and health effects

- Highest – Solvent Extraction would result in essentially no latent cancer fatalities from exposure during the 13 years of operation ($1.6x10^{-7}$) for the maximally exposed offsite individual (MEI), and 0.009 and 0.12, respectively, for the offsite population and involved worker populations.

- Lowest – Ion Exchange would have 16 percent of Solvent Extraction's offsite population health impacts and 11 percent of the Solvent Extraction impacts to involved workers.

- Conclusion – Health effects from the salt processing alternatives are well below levels of concern.

Liquid High-Level Waste generation

- Highest – Solvent Extraction would be a major contributor (24 percent) to cumulative HLW generation.

- Lowest – Direct Disposal in Grout would contribute 16 percent of the Solvent Extraction contribution.

- Conclusion – If an HLW salt processing alternative is implemented, current and future liquid HLW generation would be managed effectively and safely.

Electric energy consumption

- Highest – Solvent Extraction would consume a minor portion (4 percent) of the cumulative energy consumption at SRS.

- Lowest – Direct Disposal in Grout would use 55 percent of the Solvent Extraction energy consumption rate.

- Conclusion – Existing electrical capacity is adequate to supply these very small increases in electrical energy consumption.

Water usage

- Highest – Small Tank Precipitation would consume a minute fraction of the production capacity of the aquifer.

- Lowest – Direct Disposal in Grout would use 67 percent of Small Tank Precipitation water requirements.

- Conclusion – The increment of water usage from salt processing is very small and would not be noticeable.

DOE has examined impacts of the construction and operation of SRS over its 50-year history. It has analyzed trends in the environmental characteristics of the Site and nearby resources to establish a baseline for measurement of the incremental impact of salt processing activities.

SRS History

In 1950, the U.S. Government selected a large rural area in southwestern South Carolina for construction and operation of facilities required to produce nuclear fuels (primarily defense-grade plutonium and tritium) for the Nation's defense. Then called the Savannah River Plant, the facility had full production capability, including fuel and target fabrication, irradiation of the fuel in five production reactors, product recovery in two chemical separations plants, and waste management facilities, including the HLW Tank Farms (DOE 1980). In 1988, DOE placed the active SRS reactors in standby, and the end of the Cold War in the early 1990s prompted their permanent shutdown.

Construction impacts included land clearing, excavation, air emissions from construction vehicles, relocation of about 6,000 persons, and the formation of mobile home communities to house workers and families during construction. Peak construction employment totaled 38,500 in 1952 (DOE 1980).

Early impacts to surrounding communities stabilized quickly. The largest community on the Site, Ellenton, was relocated immediately north of the Site boundary and was renamed New Ellenton.

The SRS has had a beneficial effect on employment in the region. The operations workforce has varied from 7,500 (DOE 1980) to almost 26,000 (Halliburton NUS 1992), and presently numbers approximately 14,000 (DOE 2000a).

Currently, the SRS is approximately 90 percent natural areas, with 10 percent devoted to industrial facilities and infrastructure. The Savannah River Site Natural Resource Management and Research Institute (SRI), formerly the Savannah River Forest Station, manages natural resources at SRS. The SRI supports forest research projects, erosion control projects, and native plants and animals (through maintenance and improvements to their habitats). SRI sells timber, manages control-burns, plants seedlings, and maintains secondary roads and exterior boundaries (Arnett and Mamatey 1998a).

Normal SRS operations produced nonradioactive and radioactive emissions of pollutants to the surrounding air and discharges of pollutants to onsite streams. Impacts of these releases to the environment were minimal. In addition, large withdrawals of cooling water from the Savannah River caused minimal entrainment and impingement of aquatic biota from the river and severe thermal impacts to onsite streams, due to the discharge of high volumes of heated cooling water. The discharges stripped the vegetation along stream channels and adjacent banks and destroyed cypress-tupelo forests in the Savannah River Swamp. In 1991, DOE committed to reforest the Pen Branch delta in the Savannah River Swamp, using appropriate wetland species, and to manage it until successful reforestation had been achieved (56 FR 5584-5587; February 11, 1991). Groundwater contamination occurred in areas of hazardous, radioactive, and mixed waste sites and seepage basins.

Because of the large buffer area between the center of operations and the Site boundary, offsite effects were minimal. Thermal effects from surface water discharges did not extend beyond the Site boundary. Groundwater contamination plumes did not move offsite, and onsite surface water contamination had minimal effects offsite because SRS streams discharge to the Savannah River and the large volume of river water, compared to the small volumes of onsite creek water, reduced the concentrations of pollutants to well below concentrations of concern.

Over the years of operation, mitigation measures have substantially reduced onsite environmental contamination. DOE installed a Liquid Effluent Treatment Facility that removes pollutants (except tritium) from wastewater to below regulatory limits before discharge through a National Pollutant Discharge Elimination System (NPDES) outfall to Upper Three Runs. Direct discharge of highly tritiated disassembly basin purge water to surface streams was replaced by discharge to seepage basins, allowing substantial decay of the tritium before the water from the seepage basins outcropped to onsite streams. In addition, DOE minimized the effects of thermal discharges with the construction of a cooling lake for L-Reactor and a cooling tower intended to support K-Reactor operation.

Savannah River water quality has improved over the years and the U.S. Army Corps of Engineers has regulated the flow. Five large reservoirs upriver of SRS were constructed from the 1950s through the early 1980s. These have reduced peak flows in the Savannah River, moderated flood cycles in the Savannah River Swamp and, with the exception of a severe drought from 1985 through 1988, maintained flows sufficient for water quality and managing fish and wildlife resources downstream (DOE 1990). In 1975, the City of Augusta installed a secondary sewage treatment plant to eliminate the discharge of untreated or inadequately treated domestic and industrial waste into the Savannah River and its tributaries. Similar treatment facilities for Aiken County began operation in 1979 (DOE 1987). Industrial dischargers to the River complied with NPDES permits issued by the U.S. Environmental Protection Agency or the State (South Carolina and Georgia), which improved water quality.

Effects of operations decreased rapidly after production ceased. For example, one indicator of potential impacts to human health is the radiation dose to the MEI. The MEI is not an actual person, but is defined as a single person receiving the highest possible offsite dose. From dose, it is possible to estimate the probability of a latent cancer fatality. The estimate of latent cancers is, at best, an order of magnitude approximation. This means that with an estimate of 10^{-5} latent cancer fatalities, the actual probability of a latent cancer fatality is between 10^{-6} and 10^{-4}. By 1997, the dose to the MEI (and the associated probability of a latent cancer fatality) had decreased to about 1/7th of its 1988 value (Arnett and Mamatey 1998a). Further detail on the MEI is discussed later in Section 5.3 (Public and Worker Health) and shown in Table 5-3.

In general, the combination of mitigation measures and post-Cold War cleanup efforts are protecting and improving the quality of the SRS environment, and further minimizing any impacts to the offsite environment. Although groundwater modeling indicates that most contaminants in the groundwater have reached their peak concentrations, several slow-moving constituents will not reach maximum groundwater concentrations for thousands of years (DOE 1987). Long-term cumulative impacts are discussed further in Section 5.6.

CEQ Cumulative Effects Guidance

A handbook prepared by CEQ (1997) guided the preparation of this chapter. In accordance with the handbook, DOE identified the resource areas in which salt processing could add to the impacts of past, present, and reasonably foreseeable actions within the project impact zones, as defined by CEQ (1997).

Spatial and Temporal Boundaries

In accordance with the CEQ guidance, DOE defined the geographic (spatial) and time (temporal) boundaries to encompass cumulative impacts on the five identified areas of concern.

For determining the human health impact from airborne emissions of radionuclides, the population within the 50-mile radius surrounding SRS was selected as the project impact zone. Although the doses are almost undetectable at the 50-mile limit, this is the standard definition of the offsite public for air emissions.

For aqueous releases, the downstream population that uses the Savannah River as its source of drinking water was selected. This population is outside the 50-mile radius used for assessing air impacts. Analyses indicate that other potential incremental impacts from salt processing, including those to air quality (with the exception of ozone), waste management, and utilities and energy diminish within or very near the Site boundaries. Ozone is not emitted directly into the air, but is formed through complex chemical reactions between emissions of volatile organic compounds and nitrogen oxides in the presence of sunlight. Both volatile organic compounds and nitrogen oxides are emitted by industrial sources. Ozone formation occurs fairly rapidly in warm climates and any ozone formation from salt processing emissions would most likely occur within the project impact zone described below. The effective project impact zone for each of these incremental impacts is identified in the discussions that follow.

Nuclear facilities in the vicinity of SRS include: Georgia Power's Plant Vogtle Electric Generating Plant across the Savannah River from SRS; Chem-Nuclear, Inc., a commercial low-level waste burial site just east of SRS; and Starmet CMI, Inc. (formerly Carolina Metals), located southeast of SRS, which processes uranium-contaminated metals. Plant Vogtle, Chem-Nuclear, and Carolina Metals are approximately 11, 8, and 15 miles, respectively, from S and Z Areas. Other nuclear facilities are too far away (more than 50 miles) to contribute to any cumulative effect. Therefore, the project impact zone for cumulative impacts on air quality from radioactive emissions includes four nuclear facilities, SRS and the three smaller ones discussed above. Radiological impacts from the operation of the Vogtle Electric Generating Plant, a two-unit commercial nuclear power plant, are minimal; however, DOE has factored them into the analysis. The South Carolina Department of Health and Environmental Control (*SCDHEC) Annual Report* (SCDHEC 1995) indicates that operations of the Chem-Nuclear and Starmet CMI facilities do not noticeably impact radiation levels in air or liquid pathways in the vicinity of SRS. Therefore, they are not included in this assessment.

The counties surrounding SRS have numerous existing (e.g., Bridgestone Tire, textile mills, paper product mills, and manufacturing facilities) and planned industrial facilities with permitted air emissions and discharges to surface waters. Because of the distances between SRS and these private industrial facilities, there is little opportunity for interactions of plant emissions and no major cumulative impact on air or water quality. As indicated in results from the SRS Environmental Surveillance program report, ambient levels in air and water have remained below regulatory levels in and around the SRS region (Arnett and Mamatey 1998a).

An additional offsite facility with the potential to affect the nonradiological environment is South Carolina Electric and Gas Company's Urquhart Station. Urquhart Station is a three-unit, 250-megawatt, coal- and natural-gas-fired steam electric plant in Beech Island, South Carolina, located about 20 river miles and about 18 aerial miles north of SRS. Because of the distance between SRS and the Urquhart Station and the regional wind direction frequencies, there is little opportunity for any interaction of plant emissions, and no detectable cumulative impact on air quality. The project impact zone for nonradiological atmospheric releases is less than 18 miles.

Finally, excess utility and energy capacity is available onsite and demand is too small to affect the offsite region. Similarly, onsite waste disposal capacity can easily satisfy the small quantities generated by salt processing. Thus, the extent of the project impact zone (from utilities, energy, and waste generation) is best described as the SRS.

Reasonably Foreseeable DOE Actions

Temporal limits were defined by examining the period of influence from both the proposed action and other Federal and non-Federal actions that have the potential for cumulative impacts. Actions for salt processing are expected to begin in 2001. The period of interest for the cumulative impacts analysis for this EIS includes 2001 to 2023.

DOE also evaluated possible impacts from its own reasonably foreseeable future actions by examining impacts to resources and the human environment identified in NEPA documents related to SRS (see Section 1.4). Impacts to the environment that are considered in this cumulative impacts section were identified in the following NEPA documents:

- *Final Environmental Impact Statement for the Interim Management of Nuclear Materials (DOE/EIS-0220)* (DOE 1995a). DOE has begun implementation of the preferred alternatives for the nuclear materials discussed in this Environmental Impact Statement (EIS). SRS baseline data in this chapter reflect projected impacts from implementation.

- *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement (DOE/EIS-0240)* (DOE 1996). This cumulative impacts analysis incorporates an alternative at SRS that would blend highly enriched uranium to 4 percent low-enriched uranium as uranyl nitrate hexahydrate, as stated in the Record of Decision (61 FR 40619; August 5, 1996).

- *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy at the Rocky Flats Environmental Technology Site (DOE/EIS-0277)* (DOE 1998). As stated in the Records of Decision (64 FR 8068; February 18, 1999, and 66 FR 4803; January 18, 2001), DOE will process certain plutonium-bearing materials currently being stored at the Rocky Flats Environmental Technology Site. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at Rocky Flats. DOE has decided to ship certain residues from the Rocky Flats Environmental Technology Site to SRS for plutonium separation and stabilization. The separated plutonium will be stored at SRS, pending disposition decisions. Environmental impacts from using F-Canyon to chemically separate the plutonium from the remaining materials at SRS are included in this section.

- *Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site (DOE/EIS-0271)* (DOE 1999a). As stated in the Record of Decision (64 FR 26369; May 14, 1999), DOE will construct and operate a Tritium Extraction Facility at SRS to provide the capability to extract tritium from commercial light-water reactor targets and targets of similar design. The purpose of the proposed action and alternatives evaluated in the EIS is to provide tritium extraction capability to support either accelerator or reactor tritium production. Environmental impacts from the maximum processing option in this EIS are included in this section.

- *Surplus Plutonium Disposition Final Environmental Impact Statement (DOE/EIS-0283)* (DOE 1999b). This EIS analyzed the activities necessary to implement DOE's disposition strategy for surplus plutonium. As announced in the Record of Decision (65 FR 1608; January 11, 2000), SRS was selected for three disposition facilities, pit (a nuclear weapon component) disassembly and conversion, plutonium conversion and immobilization, and mixed oxide fuel fabrication. The DOE decision allows the immobilization of approximately 17 metric tons of surplus plutonium and the use of up to 33 metric tons of surplus plutonium as mixed oxide fuel. Both methods in this hybrid approach ensure that surplus plutonium originally produced for nuclear weapons is never again used for nuclear weapons. Impacts from this EIS are included in this section.

- *Final Defense Waste Processing Facility Supplemental Environmental Impact Statement (DOE/EIS-0082-S)* (DOE 1994a). The selected alternative in the Record of Decision (60 FR 18589; April 12, 1995) was the completion and operation of the Defense Waste Processing Facility (DWPF) to immobilize HLW at SRS. The facility is currently processing sludge from SRS HLW tanks. However, SRS baseline data are not representative of full DWPF operational impacts, including the processing of salt solution from these tanks. Therefore, DWPF data are listed separately.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279)* (DOE 2000a). The selected alternative in the Record of Decision (65 FR 48224; August 7, 2000) is to prepare for disposal about 97 percent by volume (about 60 percent by mass) of the aluminum-based fuel considered in the EIS (48 metric tons heavy metal), using a Melt and Dilute treatment process. The remaining 3 percent by volume (about 40 percent by mass) would be managed using conventional processing in existing SRS chemical separations facilities.

  As part of the preferred alternative, DOE will develop and demonstrate the Melt and Dilute technology. Following development and demonstration of the Melt and Dilute technology, DOE will begin detailed design, construction, testing, and startup of a new treatment and storage facility to combine the Melt and Dilute function with a new dry storage facility. The spent nuclear fuel will remain in existing wet storage until treated and then be placed in dry storage.

- *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE/EIS-0303D)* (DOE 2000b). DOE evaluated three alternatives for tank closure. All of these alternatives would start after bulk waste removal occurs. The alternatives being considered include: (1) clean tanks with water and fill with grout (preferred option), sand, or saltstone; (2) clean and remove the tanks; and (3) no action. The cumulative impact analysis includes impacts from the preferred option to clean and fill with grout.

- *Savannah River Site Waste Management Final Environmental Impact Statement (DOE/EIS-0217)* (DOE 1995b). DOE issued the SRS Waste Management EIS to provide a basis for the selection of a Site-wide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The SRS Waste Management EIS included the treatment of wastewater discharges in the Effluent Treatment Facility, F-and H-Area Tank Farm operations and waste removal, and construction and operation of a replacement HLW evaporator in the H-Area Tank Farm. In addition, it evaluated the Consolidated Incineration Facility for the treatment of mixed waste, including incineration of benzene waste from the then-planned In-Tank Precipitation (ITP) process. The first Record of Decision (60 FR 55249) on October 30, 1995, stated that DOE will configure its waste management system according to the moderate treatment alternative described in the EIS. The second Record of Decision (62 FR 27241) was published on May 9, 1997. This ROD was deferred regarding treatment of mixed waste to ensure consistency with the *Approved Site Treatment Plan* (WSRC 2000). The Waste Management EIS is relevant to the assessment of cumulative impacts because it provides the baseline forecast of waste generation from operations, environmental restoration, and decontamination and decommissioning. This forecast was updated in 1999 (Halverson 1999).

- *Final F-Canyon Plutonium Solutions Environmental Impact Statement (DOE/EIS-0219)* (DOE 1994b). As stated in the Record of Decision (60 FR 9824; February 22, 1995), DOE will process plutonium solution to a metal form using F-Canyon and FB-Line facilities at SRS. SRS baseline data include wastes and emissions from this activity.

Other materials under consideration for processing at SRS chemical separation facilities include various components currently at other DOE sites, including Oak Ridge, Rocky Flats, Los Alamos, and Hanford. These materials, which were identified during a Processing Needs Assessment, consist of various plutonium and uranium components. If DOE were to propose processing these materials in the SRS chemical separations facilities, additional NEPA reviews would need to be performed. In this chapter, estimates of the impacts of processing these materials have been included in the cumulative analysis. These estimates are qualitative, because DOE has not yet determined the impacts from processing these materials. When considering cumulative impacts, the reader should be aware of the very speculative nature of some of the estimated impacts.

In addition, the cumulative impacts analysis includes impacts from actions proposed in this SEIS. Risks to members of the public and Site workers from radiological and nonradiological releases are based on operational impacts from the salt processing alternatives described in Chapter 4. Because these impacts vary among the alternatives, DOE has selected the alternative that produces the maximum impact for each characteristic (e.g., concentration of a specific pollutant). This ensures that the incremental impacts of the proposed action are not underestimated.

The cumulative impacts analysis also accounts for other SRS operations. Most of the SRS baseline data are based on 1997 environmental report information (Arnett and Mamatey 1998a).

5.1 Air Resources

Table 5-1 compares the cumulative concentrations of nonradiological air pollutant emissions from SRS to Federal and state regulatory standards. The listed values are the maximum modeled concentrations that could occur at ground level at the Site boundary. The data demonstrate that total estimated concentrations of nonradiological air pollutants from SRS would, in all

Table 5-1. Estimated maximum nonradiological cumulative ground-level concentrations of criteria and toxic pollutants (micrograms per cubic meter) at the SRS boundary.[a]

Pollutant	Averaging time	Regulatory standard	Salt processing alternative	Other foreseeable[a]	SRS baseline[b]	Cumulative concentrations	Percent of standard
Carbon monoxide	1 hour	40,000	18.0[c]	40.7	10,354	10,413	26
	8 hours	10,000	2.3[c]	6.0	6,866	6,874	69
Nitrogen oxides	Annual	100	0.03[d]	4.7	26.2	31	31
Sulfur dioxide	3 hours	1,300	0.4[c]	9.4	1,244	1,254	96
	24 hours	365	0.05[c]	2.6	349	352	96
	Annual	80	5.0×10^{-4}[c]	0.19	33.6	34	42
Ozone	1 hr	235	2[e]	3.5	216	221	94
Lead	Max Qtr	1.5	4.0×10^{-7}[d]	5.1×10^{-6}	0.03	0.03	2
Particulate matter less than 10 microns	24 hr	150	0.07[d]	3.3	132.7	136	91
	Annual	50	1.0×10^{-3}[d]	0.17	25.3	25	51
Total suspended particulates	Annual	75	1.0×10^{-3}[d]	0.089	67.1	67	90

Sources: DOE (1994a; 1996; 1998; 1999a,b; 2000a,b).

a. All SRS sources including spent nuclear fuel management, disposition of highly enriched uranium, tritium extraction facility, management of certain plutonium and scrub alloy from the Rocky Flats site, HLW tank closure activities, plutonium disposition, and management of weapons components from the DOE complex.

b. Source: Arnett and Mamatey (1998b).

c. Based on data for the Direct Disposal in Grout alternative.

d. Estimated emissions from each of the four action alternatives are the same for this parameter.

e. Although a specific value has not been determined, ozone formation based on volatile organic compounds and nitrogen oxide emissions from the Small Tank Precipitation alternative would not be expected to exceed 2 micrograms per cubic meter.

cases, be below regulatory standards at the Site boundary. The highest percentages of the regulatory standards are for sulfur dioxide concentrations for the shorter time intervals (approximately 96 percent of the 3-hour averaging standard and 96 percent of the 24-hour averaging standard), for ozone (approximately 94 percent of the 1-hour averaging standard), for particulate matter less than 10 micrometers in diameter (approximately 91 percent of the 24-hour averaging standard), and total suspended particulates (approximately 90 percent of the standard). The remaining cumulative pollutant concentrations would range from 2 to 69 percent of the applicable standards.

The majority of the impact comes from estimated SRS baseline concentrations and not from salt processing and other foreseeable actions. It is unlikely that actual concentrations at any ambient monitoring stations at the SRS boundary would be as high as those listed in Table 5-1. The SRS baseline values are based on the maximum potential emissions from the 1997 air emissions inventory for all SRS sources, as well as on observed concentrations from nearby ambient air monitoring stations. The maximum cumulative concentration is an artificial calculation, which assumes that the maximum concentration from each source would occur at the same point on the SRS boundary and at the same time, without considering facility locations, operation schedules, variable wind directions, and other factors. Therefore, it is impossible to actually achieve the maximum cumulative concentration. Thus, the SRS baseline in Table 5-1 is overestimated and this affects the percent of standard values. For example, nearly all of the cumulative concentration for sulfur dioxide comes from the SRS baseline and, therefore, assuming it is 96 percent of the standard is very conservative.

DOE also evaluated the cumulative impacts of airborne radioactive releases in terms of dose to an MEI at the SRS boundary. DOE included the impacts of Plant Vogtle (NRC 1996) in this cumulative total. The radiological emissions from the operation of the Chem-Nuclear, Inc., low-level waste disposal facility and Starmet CMI, Inc., are very low (SCDHEC 1995) and are not included.

Table 5-2 lists the results of this analysis, using SRS baseline 1997 emissions (1992 for Plant Vogtle). The cumulative dose from airborne emissions to the MEI would be 4.1×10^{-4} rem (or 0.41 millirem [mrem]) per year, well below the regulatory standard of 10 mrem per year (40 CFR Part 61). Summing the doses to the MEI for the actions and baseline SRS operations listed in Table 5-2 is an extremely conservative approach because, in order to get the calculated dose from each facility, the MEI would have to occupy different physical locations at the same time, which is impossible.

Adding the population doses from current and projected activities at SRS, Plant Vogtle, and salt processing activities could yield a total annual cumulative dose of 24 person-rem from airborne sources. That total annual cumulative dose translates into 0.012 latent cancer fatality for each year of exposure for the population living within a 50-mile radius of SRS. A majority of this cumulative impact to the public is directly attributable to salt processing activities from the Solvent Extraction alternative. Doses are elevated due to the larger airborne cesium-137 emissions associated with this alternative. Small Tank Precipitation, Ion Exchange, and Direct Disposal in Grout alternatives range from 16 to 66 percent of the Solvent Extraction alternative values. Doses from the No Action alternative are considerably less. For comparison, as shown in Section 3.8.1, approximately 144,000 deaths from cancer due to all causes would be likely in the same population over their lifetimes.

5.2 Water Resources

At present, a number of SRS facilities discharge treated wastewater to Upper Three Runs and its tributaries via NPDES-permitted outfalls. These include the F/H-Area Effluent Treatment Facility and the M-Area Liquid Effluent Treatment Facility. The cumulative impact of liquid releases is measured in terms of human health effects and is presented in Section 5.3. As stated

Table 5-2. Estimated average annual cumulative radiological doses and resulting health effects to offsite population from airborne emissions.

	Offsite population			
	Maximally exposed individual		50-mile population	
Activity	Dose (rem)	Fatal cancer risk[a]	Collective dose (person-rem)	Latent cancer fatalities
SRS baseline[b]	5.0×10^{-5}	2.5×10^{-8}	2.2	1.1×10^{-3}
Salt processing[c]	3.1×10^{-4}	1.6×10^{-7}	18.1	9.1×10^{-3}
Other SRS activities[d]	5.1×10^{-5}	2.5×10^{-8}	3.4	1.7×10^{-3}
Plant Vogtle[e]	5.4×10^{-7}	2.7×10^{-10}	0.045	2.3×10^{-5}
Total	4.1×10^{-4}	2.1×10^{-7}	24	0.012

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a. Probability of fatal cancer.
b. Arnett and Mamatey (1998b).
c. Based on data for the Solvent Extraction alternative.
d. Consists of dose impacts associated with reasonably foreseeable future actions such as DWPF, HLW tank closure, spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly enriched uranium, and weapons components that could be processed at SRS canyons. Sources: DOE (1994a; 1996; 1998; 1999a,b; 2000a,b).
e. NRC (1996).

in Section 4.1.2, salt processing activities are not expected to result in any radiological or nonradiological discharges to groundwater.

Discharges to surface water would be treated to remove contaminants prior to release into Upper Three Runs. Other potential sources of contaminants into Upper Three Runs during the time of salt processing activities include DWPF, the tritium extraction facility, environmental restoration, decontamination and decommissioning activities, and modifications to existing SRS facilities. Discharges associated with the tritium extraction facility activities would not add significant amounts of nonradiological contaminants to Upper Three Runs. The amount of discharge associated with environmental restoration and decontamination and decommissioning activities would vary according to the activity. All potential activities that could result in wastewater discharges would be required to comply with the NPDES permit limits that ensure protection of water quality. Studies of water quality and biota in Upper Three Runs suggest that discharges from facilities' outfalls have not degraded the stream (Halverson et al. 1997).

5.3 Public and Worker Health

Table 5-3 summarizes the cumulative radiological health effects of routine SRS operations, proposed DOE actions, and non-Federal nuclear facility operations (Plant Vogtle Electric Generating Facility). Impacts resulting from proposed DOE actions are described in the EISs listed previously in this chapter. In addition to estimated radiological doses to the hypothetical MEI, the offsite population, and involved workers, Table 5-3 also lists the potential number of latent cancer fatalities for the public and workers due to exposure to radiation. The radiation dose to the MEI from air and liquid pathways would be 6.5×10^{-4} rem (0.65 mrem) per year, which is well below the applicable DOE regulatory limits (10 mrem per year from the air pathway, 4 mrem per year from the liquid pathway, and 100 mrem per year for all pathways). The total annual population dose from current and projected activities of 26 person-rem translates into 0.013 latent cancer fatality for each year of exposure for the population living within a 50-mile radius of the SRS, or essentially no cumulative latent cancer fatalities. Most (75%) of this cumulative

Table 5-3. Estimated average annual cumulative radiological doses and resulting health effects to offsite population and facility workers.

	Maximally exposed individual				Offsite population[a]				Workers	
Activity	Dose from airborne releases (rem)	Dose from liquid releases (rem)	Total dose (rem)	Probability of fatal cancer risk	Collective dose from airborne releases (person-rem)	Collective dose from liquid releases (person-rem)	Total collective dose (person-rem)	Excess latent cancer fatalities	Collective dose (person-rem)	Excess latent cancer fatalities
SRS Baseline[b]	5.0×10^{-5}	1.3×10^{-4}	1.8×10^{-4}	9.0×10^{-8}	2.2	2.4	4.6	2.3×10^{-3}	160	0.066
Salt Processing[c]	3.1×10^{-4}	(d)	3.1×10^{-4}	1.6×10^{-7}	18.1	(d)	18.1	9.1×10^{-3}	29	0.12
Other foreseeable SRS activities[e]	5.1×10^{-5}	5.7×10^{-5}	1.1×10^{-4}	5.4×10^{-8}	3.4	0.19	3.6	1.8×10^{-3}	730	0.29
Plant Vogtle[f]	5.4×10^{-7}	5.4×10^{-5}	5.5×10^{-5}	2.7×10^{-8}	0.045	2.5×10^{-3}	0.048	2.4×10^{-5}	NA	NA
Total	4.1×10^{-4}	2.4×10^{-4}	6.5×10^{-4}	3.3×10^{-7}	24	2.6	26	0.013	920	0.37

N/A = not available

a. A collective dose to the 50-mile population for atmospheric releases and to the downstream users of the Savannah River for aqueous releases.

b. Arnett and Mamatey (1998b) for 1997 data for MEI and population. Worker dose is based on 1997 data (WSRC 1998).

c. Based on data from the Solvent Extraction alternative.

d. Less than minimum reportable levels.

e. Includes spent nuclear fuel, highly enriched uranium, tritium extraction facility, management of certain plutonium residues and scrub alloy concentrations, DWPF, and disposition of surplus plutonium and components from throughout the DOE complex.

f. NRC (1996).

impact to the public is directly attributable to airborne releases from salt processing activities from the Solvent Extraction alternative (Table 5-2).

The annual radiation dose to the involved worker population in Solvent Extraction would be 920 person-rem, which could result in 0.37 latent cancer fatality. Doses to individual workers would be kept below the regulatory limit of 5,000 mrem per year (10 CFR 835). Furthermore, as low as reasonably achievable principles would be exercised to maintain individual worker doses below the SRS Administrative Control Level of 500 mrem per year. Salt processing activities would minimally increase the workers' and general public's health impacts due to radiation.

5.4 Waste Generation and Disposal Capacity

As stated in Section 4.1.11, low-level waste, hazardous/mixed waste, and sanitary/industrial waste would be generated from salt processing activities.

Table 5-4 lists cumulative volumes of high-level, low-level, transuranic, hazardous, and mixed wastes that SRS would generate. The table includes data from the SRS 30-year expected waste forecast generated by Halverson (1999), which incorporates changes in SRS activities that have occurred since the publication of the *Final SRS Waste Management Environmental Impact Statement* (DOE 1995b). The 30-year expected waste forecast is based on operations, environmental remediation, and decontamination and decommissioning waste forecasts from existing generators and the following assumptions:

- secondary waste from DWPF operations are addressed in the *Defense Waste Processing Facility EIS* (DOE 1994a); HLW volumes are based on the selected options for the *F-Canyon Plutonium Solutions EIS* (DOE 1994b) and the *Interim Management of Nuclear Materials at SRS EIS* (DOE 1995a); some investigation-derived wastes are handled as hazardous wastes per Resource Conservation and Recovery Act regulations; purge water from well samplings is handled as hazardous waste; and the continued receipt of small amounts of low-level waste from other DOE facilities and nuclear naval operations would occur.

In this forecast, the estimated quantity of radioactive/hazardous waste from operations during the next 30 years would be about 140,000 cubic meters. In addition, radioactive/hazardous waste associated with environmental restoration and decontamination and decommissioning activities would have a 30-year expected forecast of 68,000 cubic meters. Based on maximum values, waste generated from the Solvent Extraction alternative would produce 46,000 cubic meters. During this same time period, other reasonably foreseeable activities that were not included in the 30-year forecast would produce almost an additional 400,000 cubic meters. The major contributor to the other waste volumes would be weapons components from various DOE sites that could be processed in SRS canyons and spent nuclear fuel management activities. Therefore, the potential cumulative amount of waste generated from SRS activities during the period of interest would be 653,000 cubic meters. It is important to note that the quantities of waste generated are not equivalent to the amounts that would require disposal. For example, HLW is evaporated and concentrated to a smaller volume for final disposal.

The Three Rivers Solid Waste Authority Regional Waste Management Center at SRS accepts non-hazardous and non-radioactive solid wastes from SRS and eight surrounding South Carolina counties. This municipal solid waste landfill provides state-of-the-art Subtitle D (non-hazardous) facilities for landfilling solid wastes, while reducing the environmental consequences associated with construction and operation of multiple county-level facilities (DOE 1995c). It was designed to accommodate SRS and county solid waste disposal needs for at least 20 years, with a projected maximum operational life of 45 to 60 years (DOE 1995c). The landfill is

Table 5-4. Estimated cumulative waste generation from SRS concurrent activities (cubic meters)[a].

Waste type	Salt processing[b]	SRS operations[c]	ER/D&D activities[c]	Other waste volumes[d]	Total
HLW	45,000[f]	14,000	0	130,000	190,000
(gallons)[e]	(12,000,000)	(3,700,000)	(0)	(34,000,000)	(50,000,000)
Low-level waste	920	120,000	62,000	250,000	430,000
Hazardous/mixed waste	56	3,900	6,200	5,000	15,000
Transuranic waste	0	6,000	0	12,000	18,000
Total	46,000	140,000	68,000	400,000	653,000

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a. Values are rounded to two digits. The totals may not equal the sum of the four components, due to rounding.
b. Based on maximum value (Solvent Extraction alternative).
c. Halverson (1999).
d. Includes life-cycle waste associated with reasonably foreseeable future actions such as DWPF operations, HLW tank closure, spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly enriched uranium, commercial light-water reactor waste, sodium-bonded spent nuclear fuel, and weapons components that could be processed at SRS canyons. Sources: DOE (1994a,b; 1996; 1998; 1999a,b; 2000a,b).
e. To convert from cubic meters to gallons, multiply by 264.2.
f. HLW value for salt processing is from DWPF recycle; it is not produced directly by salt processing activities.
ER/D&D = Environmental remediation/decontamination and decommissioning.

designed to handle an average of 1,000 tons per day and a maximum of 2,000 tons per day of municipal solid wastes. The SRS and eight cooperating counties had a combined generation rate of 900 tons per day in 1995. The Three Rivers Solid Waste Authority Regional Waste Management Center opened in mid-1998.

Radioactive, hazardous, or solid wastes generated from salt processing activities and other planned SRS activities would not exceed current and projected capacities of SRS waste storage and/or management facilities.

5.5 Utilities and Energy

Table 5-5 lists the cumulative total of electricity used and water consumed by activities at SRS. The values are based on average annual consumption estimates.

Overall SRS electricity consumption would not increase greatly with the addition of salt processing activities. Electricity usage for salt processing would be less than 5 percent of the current SRS baseline level. Cumulative impacts of SRS baseline electricity consumption, coupled with salt processing and other foreseeable future usage (approximately 580,000 megawatt-hours per year), would be less than previous SRS annual consumption rates (1993 usage was over 600,000 megawatt-hours per year) (DOE 1995a).

DOE has also evaluated the SRS water needs during salt processing. At present, the SRS rate of groundwater withdrawal is estimated to be a maximum of 1.7×10^{10} liters per year. The maximum estimated amount of water needed annually for salt processing and other reasonably foreseeable future actions is listed in Table 5-5. The annual cumulative level of water withdrawal of 1.8×10^{10} liters is not expected to exceed the production capacity of the aquifer of more than 3.6×10^{11} liters.

5.6 Long-Term Cumulative Impacts

Computer models predict that radiological and nonradiological contaminants leaching from the saltstone produced by any of the salt processing alternatives would always be below their respective regulatory limits in the groundwater 100 meters downgradient of the vaults and at the seeplines of McQueen Branch or Upper Three Runs.

Table 5-5. Estimated average annual cumulative utility consumption.

Activity	Electricity (megawatt-hours)	Water usage (liters)
SRS baseline	4.1×10^{5}[a]	1.7×10^{10}[b]
Salt processing	2.4×10^{4}[c]	1.2×10^{7}[d]
Other SRS foreseeable activities[e]	1.5×10^{5}	8.3×10^{8}
Total	5.8×10^{5}	1.8×10^{10}

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a. Halverson (1999).
b. Arnett and Mamatey (1996).
c. Based on maximum values from the Solvent Extraction alternative.
d. Based on maximum values from the Small Tank Precipitation alternative.
e. Consists of utility consumption associated with reasonably foreseeable future actions, such as DWPF operations, HLW tank closure, spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly enriched uranium, and weapons components that could be processed at SRS canyons. Sources: DOE (1994a,b; 1996; 1998; 1999a,b; 2000a,b).

SRS has prepared a report, referred to as the Composite Analysis (WSRC 1997), that calculated for 1,000 years into the future the potential cumulative impact to a hypothetical member of the public from releases to the environment from all sources of residual radioactive material expected to remain in the SRS General Separations Area. The General Separations Area contains all SRS waste disposal facilities, chemical separations facilities, HLW tank farms, and numerous other sources of radioactive material. The Composite Analysis considered 114 potential sources of radioactive material containing 115 radionuclides.

The Composite Analysis calculated maximum radiation doses to hypothetical members of the public at the mouth of Fourmile Branch, at the mouth of Upper Three Runs, and on the Savannah River at the Highway 301 bridge. The estimated peak all-pathway dose from all radionuclides was 14 mrem/year (mouth of Fourmile Branch), 1.8 mrem/year (mouth of Upper Three Runs), and 0.1 mrem/year (Savannah River).

The major contributors to dose were tritium, carbon-14, neptunium-237, and isotopes of uranium (WSRC 1997).

The analysis also calculated radiation doses from drinking water in Fourmile Branch and Upper Three Runs. The estimated peak drinking water doses from all radionuclides for these creeks were 23 mrem/year for Fourmile Branch and 3 mrem/year for Upper Three Runs (WSRC 1997).

As discussed in Section 4.2.2, DOE does not expect salt processing activities to add noticeable levels of radiological contaminants to the accessible environment. The dose effects of saltstone at Upper Three Runs are several orders of magnitude less than those calculated in the Composite Analysis for the entire General Separations Area. Therefore, the peak all-pathway dose and the peak drinking water dose presented in the Composite Analysis will not be affected by salt processing activities and the conclusions of the Composite Analysis will remain the same.

References

Arnett, M. W., and A. R. Mamatey, 1996, *Savannah River Site Environmental Report for 1995*, WSRC-TR-96-0075, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1998a, *Savannah River Site Environmental Report for 1997*, WSRC-TR-97-00322, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1998b, *Savannah River Site Environmental Data for 1997*, WSRC-TR-97-00324, Westinghouse Savannah River Company, Aiken, South Carolina.

CEQ (Council on Environmental Quality), 1997, *Considering Cumulative Effects Under the National Environmental Policy Act*, Executive Office of the President, Washington, D.C.

DOE (U.S. Department of Energy), 1980, *The Savannah River Plant*, DOE/SR-0002, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1987, *Environmental Impact Statement, Waste Management Activities for Groundwater Protection, Savannah River Plant, Aiken, South Carolina*, DOE/EIS-0120, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1990, *Final Environmental Impact Statement for the Continued Operations of K-, L-, and P- Reactors, Savannah River Site, Aiken, South Carolina*, DOE/EIS-0147, Savannah River Field Office, Aiken, South Carolina, December.

DOE (U.S. Department of Energy), 1994a, *Final Defense Waste Processing Facility Supplemental Environmental Impact Statement*, DOE/EIS 0082-S, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1994b, *Final F-Canyon Plutonium Solutions Environmental Impact Statement,* DOE/EIS 0219, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995a, *Final Environmental Impact Statement for the Interim Management of Nuclear Materials*, DOE/EIS-0220, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995b, *Savannah River Site Waste Management Final Environmental Impact Statement*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995c, *Environmental Assessment for the Construction and Operation of the Three Rivers Solid Waste Authority Regional Waste Management Center at the Savannah River Site*, DOE/EA-1079, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement*, DOE/EIS-0240, Office of Fissile Materials Disposition, Washington, D.C.

DOE (U.S. Department of Energy), 1998, *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy at the Rocky Flats Environmental Technology Site,* DOE/EIS-0277F, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999a, *Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site*, DOE/EIS-0271, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999b, *Surplus Plutonium Disposition Final Environmental Impact Statement*, DOE/EIS-0283, Office of Fissile Materials Disposition, Washington, D.C.

DOE (U.S. Department of Energy), 2000a, *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement*, DOE/EIS-0279, Savannah River Operations Office, Aiken, South Carolina, March.

DOE (U.S. Department of Energy), 2000b, *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement,* DOE/EIS-0303D, Savannah River Operations Office, Aiken, South Carolina.

Halliburton NUS Environmental Corporation, 1992, *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site*, Aiken, South Carolina.

Halverson, N. V., L. D. Wike, K. K. Patterson, J. A. Bowers, A. L. Bryan, K. F. Chen, C. L. Cummins, B. R. del Carmen, K. L. Dixon, D. L. Dunn, G. P. Friday, J. E. Irwin, R. K. Kolka, H. E. Mackey, Jr., J. J. Mayer, E. A. Nelson, M. H. Paller, V. A. Rogers, W. L. Specht, H. M. Westbury, and E. W. Wilde, 1997, *SRS Ecology Environmental Information Document*, WSRC-TR-97-0223, Westinghouse Savannah River Company, Aiken, South Carolina.

Halverson, N. V., 1999, "Revised Cumulative Impacts Data," SRT-EST-99-0328, Rev. 1, Interoffice Memorandum to C. B. Shedrow, Westinghouse Savannah River Company, August 17, Aiken, South Carolina.

NRC (U.S. Nuclear Regulatory Commission), 1996, *Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites in 1992*, NUREG/CR 2850, Vol. 14, Washington, D.C.

SCDHEC (South Carolina Department of Health and Environmental Control), 1995, *South Carolina Nuclear Facility Monitoring - Annual Report 1995*, Columbia, South Carolina.

WSRC (Westinghouse Savannah River Company), 1997, *Composite Analysis - E-Area Vaults and Saltstone Disposal Facilities*, WSRC-RP-97-311, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998, *Savannah River Site Radiological Performance, 4th Quarter 1997,* ESH-SHP-98-0007, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 2000, Savannah River Site Approved Site Treatment Plan, 2000 Annual Update, WSRC-TR-94-0608, Revision 8, Aiken, South Carolina.

CHAPTER 6. RESOURCE COMMITMENTS

This chapter describes unavoidable adverse impacts, short-term uses of environmental resources versus long-term productivity, and irreversible and irretrievable commitments of resources associated with the construction and operation of a salt processing technology at the Savannah River Site (SRS). This chapter also includes discussions about U.S. Department of Energy Savannah River Operations Office (DOE-SR) waste minimization, pollution prevention, and energy conservation programs in relation to implementation of the proposed action.

For purposes of this Supplemental Environmental Impact Statement (SEIS), the analysis presented in this chapter has been divided between short-term and long-term impacts, where applicable. Short-term impacts cover the period from construction and implementation through completion of salt processing (from 2001 to 2023). The long-term performance evaluation for the saltstone generated by the Direct Disposal in Grout alternative involves the period of time beginning at the end of 100 years of post-closure institutional control and continuing through an extended period, during which it is assumed that residential and/or agricultural uses could occur.

6.1 Unavoidable Adverse Impacts

6.1.1 OPERATING-LIFE IMPACTS

Implementing any of the alternatives (including No Action) considered in this SEIS for replacement of the ITP process for management of the high-level waste (HLW) salt solutions would result in unavoidable adverse impacts to the human environment. Implementation of the Small Tank Precipitation alternative, the Ion Exchange alternative, or the Solvent Extraction alternative, in association with the continued operation of the existing saltstone manufacturing and disposal facility in Z Area, would result in minimal short-term adverse impacts. These impacts would be primarily to geologic and water resources, air quality, waste generation, worker and public health, traffic and transportation, and utility and energy consumption, as presented in Chapter 4. Likewise, the construction and operation of a Direct Disposal in Grout facility in Z Area would result in minimal adverse impacts to the same resources during the operating-life of the facility as discussed in Chapter 4.

All construction activities for any of the alternatives would occur in previously disturbed areas. S Area encompasses 270 total acres, and the implementation of Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative within S Area would require approximately 23 of these acres. Z Area encompasses 180 total acres, and the implementation of the Direct Disposal in Grout alternative within Z Area would require approximately 15 acres. In addition, construction of any alternative in either S or Z Area would require the temporary use of approximately 20 acres to accommodate construction materials, equipment, and a concrete batch plant. Once construction was completed, these areas would be revegetated and available for other uses.

Because the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative would be constructed in S Area partly below grade (to a maximum depth of 45 feet), extensive soil excavations (77,000 to 82,000 cubic meters) could result in potential adverse impacts to geologic, groundwater, and surface water resources. The base of the facility might be in the water table aquifer, potentially requiring dewatering during construction. Construction of the Direct Disposal in Grout alternative in Z Area would result in the removal of approximately 23,000 cubic yards of soil. The aquifer is at a depth of 60 feet or more below Z Area and would therefore not require dewatering. Final grading would be required for all alternatives, to prevent surface water runoff from collecting in surface depressions and impacting facility operations or vaults. As part of the required sediment and erosion control plan, storm water management and sediment control measures would be required to mitigate runoff and any potential discharges of silts, solids, and other contaminants to surface water streams. Best management practices, such as the development of retention basins, would be utilized. Any storm water collected in the retention basins would be diverted to current drainage control systems and discharged to McQueen Branch. In addition, use of best management practices would mitigate any short-term adverse impacts to geologic resources.

Implementation of the No Action alternative options identified in Chapter 2 could result in adverse impacts to the geologic and water resources. This is especially true if the option of constructing new wastewater treatment tanks is implemented. Each new tank would require the excavation of approximately 43,000 cubic meters of soil, of which approximately 28,000 cubic meters would be used for backfill. Implementation of this option could potentially result in adverse impacts to the geologic and water resources. However, DOE would mitigate these adverse impacts by utilizing best management practices to stabilize the soil and control erosion. Additional adverse impacts could result from construction of additional new tanks.

Air resources could be adversely impacted by any of the alternatives. These impacts would occur both during the construction (4 years) and during operation of the facilities (13 years). Adverse impacts during construction would be associated with heavy equipment (primarily diesel-powered) emissions and the dust created by their operation. In addition, the operation of a temporary concrete batch plant would produce adverse air quality impacts. Potential adverse impacts from fugitive dust would be mitigated by implementing best management practices. In addition, particulate emission limits for the operation of the concrete batch plant would be established in a construction permit from South Carolina Department of Health and Environmental Control (SCDHEC). Based on a review of expected sources of emissions and emission rates, the emissions would increase background levels by 1 to 2 percent. Therefore, these increases and any impacts associated with construction would be considered negligible and, in addition, would cease once construction was completed.

During operation of the facilities, regulated air pollutants would be released and could have adverse impacts to the surrounding environment. A review of the expected emissions, compared to the regulatory limits, indicated that all emission rates (with the exception of volatile organic compounds [VOCs]) would be below SCDHEC, Clean Air Act, or Occupational Safety and Health Administration (OSHA) limits and should not have any adverse impacts.

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

Implementation of any of the alternatives would result in the generation of wastes as an unavoidable result of normal operations. Each of the alternatives, excluding the No Action alternative, would produce a salt waste stream as a primary waste that would be grouted for disposal in vaults in Z Area. A total of 13 to 16 vaults would be needed, depending on the alternative selected. Any of the alternatives would also produce a high-level radioactive waste stream that would be vitrified in the Defense Waste Processing Facility (DWPF).

The types of secondary waste generated include low-level, hazardous, mixed, industrial, and sanitary. Table 6-1 lists the total estimated waste generation by each action alternative. Although DOE has implemented a number of pollution prevention measures (see Section 6.4), generation of wastes would be unavoidable.

Table 6-1. Total estimated waste generation for the salt processing action alternatives.[a]

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	3.9×10^6	3.3×10^6	1.2×10^7	2.0×10^6
Nonradioactive liquid waste (gallons)	negligible	4.9×10^5	negligible	negligible
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
Low-level waste (m^3)	920	920	920	920
Hazardous waste (m^3)	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13
Mixed low-level waste (m^3)	13	13	13	13
Mixed low-level liquid waste (gallons)	780,000	None	13,000	None
Industrial waste (metric tons)	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260
Sanitary waste (metric tons)	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530

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a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.
b. Assumes a 1.3-year duration for startup activities and 13 years of operation for each of the action alternatives.

DOE would comply with all regulatory requirements related to the proper disposal of these wastes.

During operation of any of the proposed alternatives, a minimal amount of radioactive material and activation products would be released to the environment and could result in unavoidable adverse impacts. As presented in Section 4.2.4.2, the highest radiation dose received by a noninvolved worker would be 4.8 millirem per year, well below the SRS administrative limit of 500 millirem/per year for the maximum individual exposure goal. The greatest collective dose to the surrounding population would be 18.1 person-rem/per year, resulting in an estimated 0.12 latent cancer fatality to the public within 50 miles of SRS. Doses would vary among the alternatives; the Solvent Extraction alternative would produce the highest dose.

SRS workers routinely handle hazardous and toxic chemicals; exposure to these materials would be unavoidable. In order to reduce impacts, occupational health codes and standards would be used to regulate worker exposure to these materials. Analysis has shown that chemical pollutant emissions to offsite areas would be minimal and below the applicable standards, and would not pose a danger to the public. See Section 4.2.4.2 for more details.

Construction and operation of any of the alternatives would result in injuries to workers and lost workdays, which are unavoidable adverse impacts. As discussed in Section 4.2.4.3, 1.7 to 2.7 recordable cases (which include death, illness, or injury) could occur annually, resulting in 0.72 to 1.2 lost workdays each year. The incidences of injury and illness reported for SRS are lower than those that occur in the general industry and manufacturing workforces. DOE continues to work to reduce these levels and SRS has shown continuous improvement over the years; therefore, the numbers presented in this SEIS are considered conservatively high.

Implementation of any of the alternatives would require transportation of many different materials, and such transport could have unavoidable adverse consequences. Transporting materials along public highways could impose unavoidable adverse effects on the environment through vehicle emissions, spills, and accidents resulting in injuries or fatalities. As presented in Table 4-17, a total of just over 19,000 shipments (340,000 miles) to almost 26,400 shipments (470,000 miles) would be made during construction and operation, depending on the alternative selected. Using Federal Highway Administration statistics for South Carolina, these shipments and the associated miles driven would result in less than one accident, no fatalities, and less than 0.3 injuries. However, during construction, workers would commute approximately 26 million miles (see Table 4-18). U.S. Department of Transportation statistics predict that 98 accidents would occur, resulting in 0.4 fatalities and 43 injuries.

Adverse impacts to the ecological resources would be minimal and of short duration. Most activities would occur within previously disturbed areas. Although noise levels would be relatively low outside the immediate areas of construction, the combination of construction noise and human activity probably would displace small numbers of animals within a 400-foot radius of the construction site. No threatened or endangered species or critical habitats occur in or near S or Z Areas. In addition, no construction or operational activities would affect any wetlands in S or Z Areas. DOE has committed to monitoring the areas for threatened and endangered species and would initiate consultation with the U.S. Fish and Wildlife Service if DOE determined that the potential for adverse impact to the species or its habitat existed.

6.1.2 LONG-TERM IMPACTS

Long-term impacts are those that would continue or commence after the completion of all salt processing (i.e., 2023). DOE believes that the major source of these long-term impacts would be from the saltstone that would result from each of the four action alternatives and tanks filled with salt under No Action. The saltstone vaults would be located in Z Area, regardless of the alternative selected.

For National Environmental Policy Act (NEPA) analysis of long-term impacts, DOE assumed that institutional control would be maintained for 100 years post-closure, during which time the land encompassing the saltstone vaults would be managed to prevent erosion or other conditions that would lead to early degradation of the vaults. DOE also assumed that the public would not have access to Z Area during this time to set up residence.

As discussed in Chapter 2, the No Action alternative does not provide for permanent salt processing. DOE believes that, although the No-Action alternative could be selected, it would not be implemented indefinitely. DOE would have to manage the salt portion of the HLW. However, if one of the action alternatives were not implemented, it is speculative at this time to determine how the salt wastes would be managed. DOE assumes a 100-year period of institutional control of the salt-filled tanks, then tank failure, for which a qualitative analysis was performed.

Unavoidable adverse long-term impacts to geologic resources would be minimal, based on a performance evaluation that included fate and transport modeling. Results indicate no detrimental effect on surface soils or topography, or to the structural or load-bearing properties of the geologic deposits.

Construction and operation of grout disposal facilities for any of the four action alternatives in Z Area would result in unavoidable adverse impacts to future land use of the area. The 15 acres that would be committed to the vaults and grout production facility would not be available for other productive uses.

Unavoidable long-term adverse impacts to groundwater resources could result from any of the alternatives. The fate and transport modeling results indicate that movement of radiological contaminants from failed vaults to nearby surface waters via groundwater discharge would be minimal and below regulatory standards for drinking water (4 millirem per year). Therefore, there would be no unavoidable adverse impacts to groundwater resources. However, long-term impacts to groundwater could occur as the saltstone ages.

Based on modeling results, the long-term movement of nonradiological residual contaminants (primarily nitrate) from the Z-Area vaults to nearby streams would be extremely small and, in all cases, would be below applicable standards. However, modeling results indicate that there would be little difference in impacts among the alternatives. None of the four action alternatives would result in an exceedance of the drinking water criteria for nitrate (i.e., 44 milligrams per liter). There would be no exceedances or any other constituent in groundwater discharge at the seeplines of McQueen Branch or Upper Three Runs. Therefore, there would be no unavoidable adverse impacts to surface water resources.

As a result of radioactive material being released many years after vault closure and the long half-lives of some of the radionuclides, there could be unavoidable adverse impacts to human receptors. Therefore, DOE described and modeled several future-use scenarios to determine the potential impacts to humans (see Section 4.2.5). Results indicate that doses for all scenarios, except the 100-year residential scenario for Direct Disposal in Grout, would be below or very near the 100-millirem-per-year dose limit. The 1,000-year residential scenario doses for all four action alternatives are similar and would be below the 100-millirem-per-year public dose limit. They range from as low as approximately 10 millirem per year to as high as 85 millirem per year. Doses for the agricultural scenario are similar, but could exceed the 100-millirem-per-year public dose limit. Doses for the agricultural scenario would range from 49 to 140 millirem per year. For the 100-year residential scenario, the dose would be highest for the Direct Disposal in Grout alternative (150 to 1,200 millirem per year) and would exceed the 100-millirem-per-year public dose limit. The 100-year residential scenario doses for the other three action alternatives would be much smaller and would not exceed 0.13 millirem per year.

6.2 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Under any of the alternatives, the proposed locations for any new facilities would be within previously disturbed and developed industrial landscapes. The existing infrastructure (e.g., roads, utilities.) within S and Z Areas would be sufficient to support the proposed facilities.

After the end of the operational life of the facilities associated with salt processing, DOE could decontaminate and decommission the facilities in accordance with applicable regulatory requirements and restore the areas to brownfield sites that would be available for other industrial use. Appropriate NEPA review would be conducted prior to the initiation of any decontamination and decommissioning activities. In all likelihood, none of the sites would be restored to a natural habitat (DOE 1998).

The project-related uses of environmental resources for the implementation of any of the proposed alternatives are characterized in the following paragraphs.

- Groundwater from Site wells would be used during both construction and operations, regardless of the alternative selected. Water would be used for process additions, cooling and flushing, product washes, and grout production. During construction, water consumption would represent just over 2 percent of water used in H-, S-, and Z-Area facilities in 1998 and 0.2 percent of the lowest estimated production capacity of the aquifer (see Section 4.2.12.1). Groundwater use during operations would represent about 23 percent of the water used in H-, S-, and Z-Area facilities in 1998 and 1.5 percent of the lowest estimated production capacity of the aquifer (see Section 4.2.12.1). After use and treatment in the F- and H-Area Effluent Treatment Facility, this water would be released through permitted discharges into surface water streams. Therefore, the withdrawal, use, and treatment of groundwater would not affect the long-term productivity of this resource.

- Air emissions associated with any of the alternatives would add small amounts of radiological and nonradiological constituents to the air of the region. These emissions would be well below air quality or radiation exposure standards, and below applicable SRS permit limits. All concentrations would be below OSHA limits and all concentrations, with the exception of nitrogen dioxide (which could reach 78 percent of the limit), would be less than 5 percent of their respective regulatory limits. Nitrogen dioxide emissions would result from operation of diesel generators during construction and operations. Therefore, there would be no significant effects to the long-term quality of air resources.

- Radiological and nonradiological constituents could contaminate the groundwater below and adjacent to the Z-Area disposal vaults in the distant future. Some contaminants from the vaults could be transported by groundwater to the seepline of nearby streams. Beta-gamma dose, alpha concentrations, and nonradiological constituent concentrations would all be below the regulatory limit at the seepline of McQueen Branch or Upper Three Runs. Therefore, any radiological or nonradiological releases from the disposal vaults should have no impact on the long-term productivity of the ecosystems in the receiving streams.

- The management and disposal of wastes (low-level, hazardous, mixed, industrial, and sanitary) over the project's life would require energy and space at SRS treatment, storage, and disposal facilities (e.g., Z-Area Vaults, E-Area Vaults, or Three Rivers Sanitary Landfill). The land to meet these solid waste needs would require a long-term commitment of terrestrial resources. DOE established a future use policy for the SRS for the next 50 years in the 1998 *Savannah River Site Future Use Plan* (DOE 1998). This report sets forth guidance that established appropriate land uses for SRS areas and established policies to prevent nonconforming land uses.

6.3 Irreversible and Irretrievable Resource Commitments

Resources that would be irreversibly and irretrievably committed during the construction and operation of any salt processing alternative include those that cannot be recovered or recycled and those that are consumed or reduced to unrecoverable forms. The commitment of capital, energy, labor, and material during this time would generally be irreversible.

A maximum of 180 acres would be set aside for the vaults under any action alternative, and from 15 acres (Direct Disposal in Grout alternative) to 23 acres (all other action alternatives) would be utilized for salt processing facilities. Each tank would have a footprint of approximately 5,000 square feet. The total land required for any new tanks built under the No Action alternative has not been determined, however, impacts to all of this land could be irreversible and irretrievable once it is committed to the selected alternative and would thus be unavailable for other productive uses. However, (as stated in Section 6.2) at the end of the operational life of the facilities, DOE could decontaminate and decommission the facilities in accordance with applicable regulatory requirements. Implementation of decontamination and decommissioning would require significant commitment of resources and the impacts of implementation would undergo appropriate NEPA review. Regardless, the land committed to vaults under the action alternatives and tanks under No Action would not be retrievable.

Energy expended would be in the form of fuel for equipment and vehicles, electricity and steam for facility operations, and labor. Construction would generate nonrecyclable materials, such as sanitary solid waste and construction debris. Implementation of any of the alternatives would generate nonrecyclable radiological and nonradiological waste streams. However, certain materials (e.g., steel, copper, stainless steel) used during construction and operation of any proposed facility could be recycled when the facility has been decontaminated and decommissioned. Some construction materials would not be salvageable, due to radioactive contamination.

The implementation of the any of the salt processing alternatives considered in this SEIS, including the No Action alternative, would require water, electricity, diesel fuel, and other energy and materials. Table 6-2 lists estimated total amounts of energy, utilities, and materials required for the construction and operation of each alternative.

Water would be obtained from onsite groundwater wells. Steam would be obtained from the D-Area Power Plant. Electricity, diesel fuel, concrete pre-mix, steel, saltstone pre-mix, sodium hydroxide, oxalic acid, tetraphenylborate (TPB), monosodium titanate (MST), crystalline silicotitanate (CST) resins, and other chemicals would be purchased from commercial vendors. The amounts required would not have an appreciable impact on available supplies or the ability to supply other industries.

6.4 Waste Minimization, Pollution Prevention, and Energy Conservation

6.4.1 WASTE MINIMIZATION AND POLLUTION PREVENTION

DOE-SR has developed and implemented an aggressive waste minimization and pollution prevention program that promotes source reduction and recycling practices that reduce the use of hazardous materials, energy, water, and other resources, while protecting resources through conservation or more efficient use. This Pollution Prevention Program also reduces the costs of the management of pollutants. As a result of this program, DOE has reduced the volumes of wastes discharged into the environment or sent to landfills and has saved money by recycling or selling usable materials.

Pollutant reduction is first accomplished by eliminating or minimizing the generation of pollutants at the source. All materials used at SRS are recycled or reused, when practical. The remaining wastes are managed to comply with Federal and state environmental regulations to reduce volume, toxicity, and/or mobility before storage or disposal.

DOE-SR, in conjunction with the Site's management and operations contractor, Westinghouse Savannah River Company and its partners, establishes SRS's pollution prevention goals and program objectives through a Solid Waste Management Council. A Pollution Prevention Group provides overall program leadership, coordination, and guidance in the development and implementation of pollution prevention systems. A Waste Minimization Subcommittee, comprised of representatives from across the Site, assists with development and implementation of waste minimization strategies and dissemination of information.

The Pollution Prevention Program is made up of the following seven elements:

1. Solid Waste Minimization
2. Toxic Chemicals Reduction
3. Energy Conservation
4. Environmental Emissions Reduction
5. Recycle and Reuse
6. Affirmative Procurement
7. Remediation

1. Solid Waste Minimization: Between 1991 and 1999, waste generators achieved approximately an 80 percent volume reduction (760,000

Table 6-2. Estimated project total energy, utilities, and material use for the salt processing alternatives.

Phase[a]	SRS Baseline[b]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Peak electrical power demand (megawatts)					
Construction	NA	1.66	1.66	1.66	1.66
Operation	130[c]	24	24	32	18
Electricity use (gigawatt-hours)					
Construction	NA	76	79	76	73
Operation	410[c]	243	286	315	172
Project total use	NA	319	365	391	245
Fuel use (million gallons)					
Construction	NA	8.4	9	8.4	8
Operation	8.75[d]	0.3	0.3	0.3	0.2
Project total use	NA	8.7	9.3	8.7	8.2
Steam use (million pounds)					
Construction	NA	0	0	0	0
Operation	NA	2,548	2,300	1,915	1,536
Project total use	NA	2,548	2,300	1,915	1,536
Potable water use (million gallons)					
Construction	NA	19	20	19	18
Operation	NA	99	95	120	75
Project subtotal use	NA	118	115	139	93
Process water use (million gallons)					
Construction	NA	16	17	16	15
Operation	23,000[c]	301	271	225	181
Project subtotal use	NA	317	288	241	196
Project total water use (million gallons)		435	403	380	289
Material use					
Concrete pre-mix (cubic yards)[e]	NA	30,029	38,481	38,522	42,756
Saltstone pre-mix (pounds)	None	1.277 billion	1.057 billion	1.192 billion	950 million
Sodium hydroxide (pounds)	None	253,000	2,800,000	20,800,000	202,000
Oxalic Acid (pounds)	None	27,200	27,200	27,200	27,200
Sodium TPB (gallons)	None	2.84 million	None	None	None
MST (pounds)	None	47,000	47,000	47,000	47,000
CST Resin (pounds)	None	None	538,000	None	None
Stainless steel for canisters (pounds)	6,600,000	6,555,000	6,555,000	6,555,000	6,555,000

Adapted from WSRC (1999a).

a. The construction and operation durations for each alternative are as follows: Small Tank Precipitation – 45 months and 15 years; Ion Exchange – 50 months and 13 years; and Direct Disposal in Grout – 46 months and 13 years (adapted from Attachments 14.5, 14.3, and 14.4 of WSRC (1998a). The total project duration includes a startup time of 1.3 years for each alternative (WSRC 1999b).

b. Under the No Action alternative, utility and energy use would be included in the current site baseline.

c. Halverson (1999)

d. DOE (1995)

e. Adapted from WSRC 1998b.

NA = Not Available.

cubic feet per year) of solid, hazardous, and radioactive waste. The Pollution Prevention Program has implemented over 508 pollution prevention projects since 1995 (beginning of formal pollution prevention tracking), eliminating over 490,000 cubic feet of radioactive and hazardous waste, and saving approximately $130 million in costs for waste disposal. This reduction was primarily due to improved waste generator work practices including: improved employee awareness, substitution of reusable for consumable goods in radiological areas, enhanced work planning, non-hazardous solvent substitution, recovery of radiological areas, and use of new pollution prevention technologies.

2. Toxic Chemicals Reduction: SRS has met the Executive Order 12856 goal to reduce chemical releases by 50 percent by 1999. Reportable toxic chemical releases have been reduced by approximately 2 million pounds since 1987, when the SRS filed its first Toxic Chemical Release Inventory Report to the U.S. Environmental Protection Agency (EPA). The Site's Chemical Commodity Management Center will continue to strive to reduce chemical releases by substituting less hazardous chemicals and integrating chemical use, excess, and procurement activities.

3. Energy Conservation: SRS has adapted a plan to enhance energy efficiency and conservation in all buildings by establishing an Energy Management Council and implementing a new Energy Services Company contract. SRS's Energy Management Program has achieved the conservation goals mandated by Executive Order 12902, *Energy Efficiency and Water Conservation at Federal Facilities*.

4. Environmental Emissions Reduction: The SRS Air and Water Programs ensure that all emissions to the environment meet regulatory requirements. Strategies are continually identified to meet compliance and environmental As Low As Reasonably Achievable (ALARA) guidelines.

5. Recycle and Reuse: SRS has an ongoing comprehensive recycling program. Since 1994, SRS has recycled more than 17,000 tons of materials through its Salvage Operations and Office Recycle Programs. Examples of materials recycled and their amounts from 1994 to 1999 include:

• Scrap metal	10,762 tons
• Office paper and cardboard	5,332 tons
• Scrap aluminum	287 tons
• Aluminum cans	99 tons
• Lead-acid batteries	210 tons
• Laser printer toner cartridges	55,809 each

6. Affirmative Procurement: This program promotes the purchase and use of products made from recovered and recycled materials. SRS met the DOE Secretarial goal to procure 100 percent of RCRA-specified products, when it was technically and economically feasible, in both 1998 and 1999. SRS has purchased more than $6.6 million worth of products containing recovered or recycled materials.

7. Remediation: A large part of the Site's current mission is remediation of legacy waste sites. The Pollution Prevention Program identifies techniques to reduce the environmental impacts of existing waste at these sites and the means to minimize the generation of new waste during Site closure and corrective action activities. SRS strives to reduce cleanup and stabilization waste by 10 percent per year.

The Site has an approved Pollution Prevention in Design Procedure that provides the process, responsibilities, and requirements for inclusion of pollution prevention into the design phase of new facilities or modification to existing facilities. Pollution prevention in design is applied using a value-added, quality-driven, graded approach to project management. When properly applied, the expense of implementing pollution prevention changes during design is offset by the resulting cost savings over the life of the facility. Pollution prevention design activities are generally implemented at the Preliminary Design phase and not during the Preconceptual

Design. The alternatives under consideration in this SEIS are at the Preconceptual Design phase. However, a number of early planning efforts have identified specific activities that could be implemented. Examples include the following:

- Benzene abatement: It is anticipated that some type of benzene abatement would be added to the Small Tank Precipitation alternative.
- Recycled solvent: The solvent used in the Solvent Extraction alternative has been identified for recycling.
- Process design: Changes would be implemented to eliminate the potential for spills.
- Recycling of construction material: Stainless steel, paint, and other construction material would be recycled, if possible.

As the design moves from Preconceptual into the Conceptual Design, Preliminary Design, and finally the Detailed Design phase, considerable effort would be expended to identify opportunities for pollution prevention. A series of worksheets would be developed when the design reaches the Conceptual phase. Anticipated waste streams would be identified, quantified (including costs), and prioritized within a set of established criteria. These worksheets would be generated for all activities during construction, operations, and closure of the facility. Finally, the construction contractor would be selected, based in part on prior pollution prevention practices.

6.4.2 ENERGY CONSERVATION

SRS has an active energy conservation and management program. As stated in Section 6.4.1, SRS has adopted a plan to enhance energy efficiency and conservation in all buildings by establishing an Energy Management Council and implementing a new Energy Services Company contract.

Since the mid-1990s, more than 50 onsite administrative buildings have undergone energy efficiency upgrades. Representative actions include the installation of energy-efficient light fixtures, the use of occupancy sensors in rooms, the use of diode light sticks in exit signs, and the installation of insulating blankets around hot water heaters.

As stated in Section 6.4.1, pollution prevention and energy conservation measures are not specifically identified until DOE reaches the Conceptual Design phase of the project. Currently, SRS is in the Preconceptual Design phase. Regardless of the alternative selected, the incorporation of these types of energy-efficient technologies into facility Conceptual Design, along with the implementation of process efficiencies and waste minimization concepts, will facilitate energy conservation at SRS.

References

DOE (U.S. Department of Energy), 1995, *Environmental Impact Statement for the Interim Management of Nuclear Materials*, DOE/EIS-0220, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998, *Savannah River Site Future Use Plan*, Savannah River Operations Office, Aiken, South Carolina, March.

Halverson, N. V., 1999, Interoffice memorandum to C. B. Shedrow, *Revised Cumulative Impacts Data*, SRT-EST-99-0328, Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, August 17.

WSRC (Westinghouse Savannah River Company), 1998a, *High-Level Waste Salt Disposition Engineering Team Final Report (U)*, WSRC-RP-98-00170, Rev. 0, October 28, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998b, *Life Cycle Cost Estimate Bases, Assumptions, and Results,* Rev. 1, WSRC-RP-98-00167, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999a, *Response to Data Call for Salt Disposition Alternatives at the Savannah River Site, DOE/EIS-0082-S2,* HLW-SDT-99-0181, Rev. 0, June 24, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, "Answer to phone questions," email from J. Sessions, Westinghouse Savannah River Company, to B. Bradford, Tetra Tech NUS, August 23.

CHAPTER 7. APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

This chapter identifies and summarizes the major laws, regulations, Executive Orders, and U.S. Department of Energy (DOE) Orders that could apply to the Savannah River Site (SRS) salt processing alternatives. Permits or licenses could be required under some of these laws and regulations. DOE would determine the specific requirements for permits or licenses, which would depend on the alternative chosen, after consultation with the appropriate regulating agencies.

Section 7.1 describes the process that DOE will follow to determine if the low-activity salt solution produced under the salt processing alternatives can be considered waste incidental to reprocessing. Section 7.2 discusses the major Federal and State of South Carolina statutes and regulations that impose environmental protection requirements on DOE and that require DOE to obtain a permit, or permits, prior to implementing a given salt processing alternative. Each of the applicable authorities establishes how potential releases of pollutants and radioactive materials are to be controlled or monitored and include requirements for the issuance of permits for new operations or new emission sources. In addition to environmental permit requirements, the authorities may require consultations with various regulators to determine if an action requires the implementation of protective or mitigative measures. Section 7.2 also discusses the environmental permitting process and lists the environmental permits and consultations (Table 7-1) applicable to the salt processing alternatives.

Sections 7.3 and 7.4 address the major Federal regulations and Executive Orders that address issues such as emergency planning, worker safety, and protection of public health and the environment. The Executive Orders clarify issues of national policy and set guidelines under which Federal agencies must act.

DOE implements its responsibilities for protection of public health, safety, and the environment through a series of Departmental Orders (see Section 7.5) that typically are mandatory for operating contractors of DOE-owned facilities.

7.1 Waste Incidental to Reprocessing Determination

DOE Manual 435.1-1 establishes a process for making waste incidental to reprocessing determinations. This process evaluates candidate waste streams to determine if they can be managed as low-level waste (LLW) or transuranic waste (DOE Manual 435.1-1; DOE 1999). Because salt solutions at SRS originated from waste generated by reprocessing of spent nuclear fuel, they meet the source-based definition of high-level waste (HLW). However, under all alternatives in this Supplemental Environmental Impact Statement (SEIS), the low-activity fraction of the salt solution could be appropriately managed as LLW as long as the waste satisfies the waste incidental to reprocessing criteria in DOE Manual 435.1-1.

DOE Manual 435.1-1 describes two processes, a "citation" process and an "evaluation" process, for waste-incidental-to-reprocessing determinations (DOE 1999). The criteria used in the "evaluation" process are based on the treatment of the waste and the characteristics of the disposal form. Wastes can be managed as LLW if they meet the following criteria or other appropriate criteria approved by DOE.

"1. Have been processed or will be processed to remove key radionuclides to the maximum extent that is technically and economically practical." DOE Guidance 435.1-1 (DOE 1999) explains that key radionuclides are generally understood to be those radionuclides that are concentration limits in 10 CFR 61.55 (i.e., the long-lived radionuclides carbon-14, nickel-59, niobium-94, technetium-99, iodine-129, plutonium-241, and curium-242; alpha-emitting transuranic nuclides with half-lives greater than 5 years;

Table 7-1. Environmental permits and consultations required by law.

Activity/Topic	Law	Requirements	Agency
Site Preparation	Federal Clean Water Act (Section 404)	Stormwater Pollution Prevention Plan for Industrial Activity	SCDHEC[a]
Industrial Waste Disposal	S.C. Pollution Control Act	Permit for Industrial Waste Disposal	SCDHEC
Wastewater Discharges	Federal Clean Water Act S.C. Pollution Control Act	Stormwater Pollution Prevention/Erosion Control Plan for construction activity	SCDHEC
		NPDES Permit(s) for Process Wastewater Discharges	SCDHEC
		Industrial Wastewater Treatment Systems Construction and Operation Permits (if applicable)	SCDHEC
		Sanitary Wastewater Pumping Station Tie-in Construction Permit; Permit to Operate	SCDHEC
Air	Clean Air Act – NESHAP[b]	Rad Emissions - Approval to construct new emission source (if needed)	EPA[c]
		Air Construction and Operation permits - as required (e.g., fire water pumps, diesel generators)	SCDHEC
		General source – stacks, vents, concrete batch plant	SCDHEC
		Air Permit - Prevention of Significant Deterioration (PSD)	SCDHEC
Domestic Water	Safe Drinking Water Act	Construction and operation permits for line to domestic water system	SCDHEC

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a. South Carolina Department of Health and Environmental Control
b. National Emission Standards for Hazardous Air Pollutants
c. U.S. Environmental Protection Agency
d. U.S. Fish and Wildlife Service
e. National Marine Fisheries Service

and the short-lived radionuclides tritium, cobalt-60, nickel-63, strontium-90, and cesium-137), and any other radionuclides that are important to satisfying the performance objectives of 10 CFR 61, Subpart C (e.g., selenium-79, tin-126, neptunium-237); and

"2. Will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR 61, Subpart C, "Performance Objectives;" and"

"3. Are to be managed, pursuant to DOE's authority under the Atomic Energy Act, as amended, and in accordance with the provisions of Chapter IV of DOE Manual 435.1-1, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55, "Waste Classification", or will meet alternative requirements for waste classification and characteristics, as DOE may authorize."

DOE is conducting a research and development program, and is continuing design efforts, to determine the technical and economic feasibility of the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives. Through an evaluation of potential salt processing alternatives, DOE identified potential technologies that would remove key radionuclides. Variations of three of the salt processing technologies being considered (Small Tank Precipitation, Ion Exchange, and Solvent Extraction) have been evaluated previously against the incidental waste criteria. The low-activity salt solution fraction that would be produced using ion exchange has previously been characterized as incidental waste (i.e., non-HLW) (52 FR 5993, February 27, 1987). The low-activity salt solution produced using the small tank precipitation or solvent extraction process is expected to meet the same key radionuclide removal requirements, as previously analyzed, and the other evaluation determination process.

Implementation of the Direct Disposal in Grout alternative would result in the removal of the key radionuclides, as suggested in DOE Guidance 435.1-1, except for cesium-137. However, this short-lived radionuclide can be effectively isolated by the combination of a stabilized waste form and engineered barriers for the period (about 400 years) needed for it to decay so that it no longer poses a significant hazard. The long-term performance evaluation (Section 4.2) indicates that the low-activity salt solution produced under the Direct Disposal in Grout alternative meets performance objectives comparable to those in 10 CFR 61, as required to meet the waste incidental to reprocessing criteria in DOE Manual 435.1-1. DOE is currently conducting studies to investigate the technical and economic practicality of these alternatives. Cesium removal from SRS salt solutions at a pilot or production scale, using the Small Tank Precipitation, Ion Exchange, or Solvent Extraction processes, has not been demonstrated. Cesium removal by the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives ultimately could prove to not be technically and economically practical. In such a case, the criterion requiring key radionuclide removal would be considered met because the key radionuclides, other than cesium, would have been removed to the extent technically and economically practical and the waste could be properly managed as LLW, in accordance with the waste incidental to reprocessing requirements of DOE Manual 435.1-1.

Per DOE Manual 435.1-1, the DOE Field Element Manager is responsible for ensuring that waste incidental to reprocessing determinations are made consistent with either the citation or the evaluation process. A determination made using the evaluation process will include consultation and coordination with the DOE Office of Environmental Management. The U.S. Nuclear Regulatory Commission (NRC) has participated in regulatory reviews using these evaluation criteria in the past and has expertise that is expected to complement DOE's internal review. Hence, consultation with NRC staff regarding the requirements for the evaluation process is strongly encouraged by DOE (Guidance 435.1-1). DOE plans to consult with NRC regarding an incidental waste determination for the low-activity salt solution. To facilitate the consultations, DOE will provide documentation that the low-activity salt solution satisfies criteria for management as LLW under the waste incidental to reprocessing evaluation process.

7.2 Statutes and Regulations Requiring Permits or Consultations

Environmental regulations require that the owner or operator of a facility obtain permits for the construction and operation of new (water and air) emissions sources and for new domestic drinking water systems. To obtain these permits, the facility operator must apply to the appropriate government agency for a discharge permit for discharges of wastewater to the waters of the state and submit construction plans and specifications for the new emission sources, including new air sources. The environmental permits contain specific conditions with which the permittee must comply during construction and operation of a new emission source, describe pollution abatement and prevention methods to be utilized for reduction of pollutants, and contain emissions limits for pollutants that will be emitted from the facility. Section 7.2.1 discusses the environmental statutes and regulations under which DOE will be required to obtain permits, and Table 7-1 lists the applicable permits.

7.2.1 ENVIRONMENTAL PROTECTION PERMITS

Clean Air Act, as amended, (42 USC 7401 et seq.), and implementing regulations (40 CFR Parts 50-99); South Carolina Pollution Control Act (Section 48-1-30 et seq., SCDHEC Regulation 61-62)

The Clean Air Act, as amended, is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population [42 USC 7401(b)(1)]." Section 118 of the Clean Air Act, as amended, requires each Federal agency, such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, to comply with "all Federal, State, interstate, and local requirements" with regard to the control and abatement of air pollution.

The Act requires the U.S. Environmental Protection Agency (EPA) to define National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC 7409). The Act also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC 7411) and requires specific emission increases to be evaluated so as to prevent a significant deterioration in air quality (42 USC 7470). Hazardous air pollutants, including radionuclides, are regulated separately (42 USC 7412). Air emissions are regulated by EPA in 40 CFR Parts 50 through 99. In particular, radionuclide emissions, other than radon from DOE facilities, are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP) program (see 40 CFR Part 61, Subpart H).

The EPA has overall authority for the Clean Air Act; however, it delegates primary authority to states that have established air pollution control programs approved by EPA. In South Carolina, EPA has retained authority over radionuclide emissions (40 CFR Part 61) and has delegated to the South Carolina Department of Health and Environmental Control (SCDHEC) the responsibility for the rest of the regulated pollutants under the authority of the South Carolina Pollution Control Act (48-1-10 et seq.) and SCDHEC Air Pollution Control Regulations 61-62.

Construction and operation permits or exemptions will be required for new nonradiological air emission sources (e.g., diesel generators, concrete batch plants) constructed and operated as part of SRS salt processing. The permits will contain operating conditions and effluent limitations for pollutants emitted from the facilities (Table 7-1).

DOE would determine if a NESHAP permit will be required for radiological emissions from any facilities (stacks, process vents, etc.) used in SRS salt processing. As described in 40 CFR Part 61.96, if the effective dose equivalent caused by all emissions from facility operations is projected to be less than 1 percent of the 10 millirem per year NESHAP standard, an application for approval to construct under 40 CFR Part 61.07 is not required to be filed. 40 CFR Part 61.96 also allows DOE to use, with prior EPA approval, methods other than EPA standard methods for estimating the source term for use in calculating the projected dose. If DOE's calculations indicate that the emissions from salt processing will exceed 0.1 millirem per year, DOE will, prior to the start of construction, complete an application for approval to construct under 40 CFR 61.07.

Federal Clean Water Act, as amended (33 USC 1251 et seq.); SC Pollution Control Act (SC Code Section 48-1-10 et seq., 1976) (SCDHEC Regulation 61-9.122 et. seq.)

The Clean Water Act (CWA), 33 U.S.C. §§ 1251 et. seq., which originated in 1972 as amendments to the Federal Water Pollution Control Act, establishes the basic structure for regulating discharges of pollutants to waters of the United States. Enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," the CWA gave EPA the authority to set effluent standards on an industry basis and continued existing requirements to set water quality standards for all contaminants in surface waters (33 U.S.C. § 1251). The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters of the United States unless a permit is obtained under the Act's National Pollutant Discharge Elimination System (the NPDES permit system). The NPDES system lies at the core of the administration and enforcement of the CWA. The United States government is subject to the terms and prohibitions of the CWA in essentially the same manner as any other person (33 U.S.C. § 1323).

The CWA provides for the delegation by EPA to state governments of many permitting, administrative, and enforcement aspects of the law. In states with the authority to implement CWA programs, EPA still retains oversight responsibilities. EPA has delegated to South Carolina responsibility for administering the NPDES program.

EPA has delegated primary enforcement authority for the CWA and the NPDES Permitting Program to SCDHEC for waters in South Carolina. In 1996, SCDHEC, under the authority of the Pollution Control Act (48-1-10 et seq.) and Regulation 61-9.122, issued NPDES Permit SC0000175, which addresses wastewater discharges to SRS streams, and NPDES permit SCG250162, which addresses general utility water discharges. The permit contains effluent limitations for physical parameters, such as flow and temperature, and for chemical pollutants with which DOE must comply. DOE will apply for a discharge permit for salt processing facility operations, if the process alternative chosen results in discharges to waters of the State (Table 7-1).

Under Section 402(p) of the CWA, EPA established regulations (40 CFR Part 122.26) for issuing permits for storm water discharges associated with industrial activity. Accordingly, SCDHEC has issued a General Permit for Storm Water Discharges Associated with Industrial Activities (Permit No. SCR000000), authorizing DOE to make stormwater discharges to the waters of the State of South Carolina in accordance with effluent limitations, monitoring requirements, and conditions as set forth in the permit. This permit requires preparation and submittal of a Pollution Prevention Plan for all new and existing point-source discharges associated with industrial activity. Accordingly, DOE-Savannah River Operations Office (SR) has developed a Storm Water Pollution Prevention Plan for storm water discharges at SRS. The SRS Storm Water Pollution Prevention Plan would need to be revised to include pollution prevention measures to be implemented for salt processing operations (Table 7-1), if industrial activities are exposed to storm water. SCDHEC has issued a General Permit for storm water discharges from construction activities that are "Associated with Industrial Activity" (Permit No. SCR100000). An approved plan would be needed that includes erosion control and pollution prevention measures to be implemented for construction activities.

Section 404 of the CWA requires that a permit be issued for discharge of dredge or fill material into the waters of the United States. The authority to implement these requirements has been given to the U.S. Army Corps of Engineers. Section 401 of the CWA requires certification that discharges from construction or operation of facilities, including discharges of dredge and fill material into navigable waters, will comply with applicable water standards. This certification, which is granted by SCDHEC, is a prerequisite for the permit under Section 404. DOE does not believe that such a permit will be required for salt processing.

Section 303(d)(1)(C) of the CWA and the EPA implementing regulation (40 CFR 130.7(c)(1) require the identification of total maximum daily loads (TMDLs) for waters identified in Section 303(d)(1)(A) of the CWA. On December 8, 2000, EPA published a proposed TMDL for mercury in the Middle and Lower Savannah River Watershed (EPA 2000). The proposed TMDL affects the portion of the Savannah River within the State of Georgia. It does not specify wasteload allocations for South Carolina NPDES-permitted facilities or other pollution sources discharging to portions of the Savannah River Watershed within the State of South Carolina. However, the TMDL does provide a target concentration of mercury to be achieved at the mid-point of the Savannah River, which is the boundary between Georgia and South Carolina. The majority (99 percent) of the mercury loading in the Savannah River Watershed results from air deposition sources. EPA expects that the reductions in mercury deposition needed to reduce levels of mercury in the Savannah River to the TMDL can be achieved by 2010 through full implementation of the current Clean Air Act Maximum Achievable Control Technology requirements (EPA 2000). The proposed TMDL is not expected to affect implementation of the salt processing alternatives because mercury emissions from the proposed facilities would not be limited by these requirements.

Federal Safe Drinking Water Act, as amended [42 USC 300 (F) et seq., implementing regulations 40 CFR Parts 100-149]; South Carolina Safe Drinking Water Act (Title 44-55-10 et seq.), State Primary Drinking Water Regulations, (SCDHEC R.61-58)

The primary objective of the Safe Drinking Water Act (42 USC 300), as amended, is to protect the quality of the public water supplies. Safe Drinking Water Act requirements have been promulgated by EPA in 40 CFR Parts 100 through 149. The implementing regulations, administered by EPA unless delegated to the states, establish standards applicable to public water systems. They promulgate maximum contaminant levels (MCLs) (including those for radionuclides) in public water systems, which are defined as water systems that serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Construction and operation permits would be required for any major new components associated with SRS salt processing activities (Table 7-1). Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

As a regulatory practice and policy, the Safe Drinking Water Act MCLs also are used as groundwater protection standards. For example, the regulations specify that the average annual concentration of manmade radionuclides in drinking water shall not produce a dose equivalent to the total body or an internal organ dose greater than 4 millirem (mrem) per year beta-gamma activity. This radionuclide MCL is a primary performance objective for the disposal of the grouted low-activity salt solution produced under the salt processing alternatives.

On December 7, 2000, EPA published revisions to the MCLs for certain radionuclides (65 FR 76708). The new rule includes requirements for uranium, which was not previously regulated, and revisions to monitoring requirements. EPA decided to retain the current standards for combined radium-226 and -228 and gross alpha particle radioactivity. EPA also retained the current MCL for beta particle and photon radioactivity, pending further review. The new standard for uranium will be considered with the other MCLs for radionuclides in assessing impacts to groundwater from the salt processing alternatives.

EPA has delegated primary enforcement authority to SCDHEC for public water systems in South Carolina. Under the authority of the South Carolina Safe Drinking Water Act (44-55-10 *et seq.*), SCDHEC has established a drinking water regulatory program (R.61-58). SCDHEC has also established groundwater and surface water classifications and standards under R. 61-68. Along with the Federal MCLs (40 CFR 141), these South Carolina water quality standards are the groundwater and surface water performance standards applicable to disposal of the grouted low-activity salt solution.

Resource Conservation and Recovery Act, as amended (Solid Waste Disposal Act) (42 USC 6901 et seq.); South Carolina Hazardous Waste Management Act, Section 44-56-30, South Carolina Hazardous Waste Management Regulations (R.61-79.124 et seq.)

The treatment, storage, or disposal of hazardous and nonhazardous waste is regulated under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments of 1984. Pursuant to Section 3006 of the Act, any state that seeks to administer and enforce a hazardous waste program pursuant to RCRA may apply for EPA authorization of its program. The EPA regulations implementing RCRA (40 CFR Parts 260 through 280) define hazardous wastes and specify their transportation, handling, treatment, storage, and disposal requirements. EPA has delegated primary enforcement authority to SCDHEC, which has established hazardous waste management requirements under SC Regulation R.61-79.

The regulations imposed on a generator or a treatment, storage, or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, or disposed. The method of treatment, storage, or disposal also affects the extent and complexity of the requirements.

Under Section 3004(u) of RCRA, DOE is required to assess releases from solid waste management units and implement corrective action plans where necessary. The RCRA corrective action requirements for SRS are set forth in the Federal Facility Agreement (FFA) (Section 7.3.2).

The HLW managed in the F- and H-Area Tank Farms is considered mixed waste because it exhibits characteristics of RCRA hazardous waste (i.e., corrosivity and toxicity for certain metals) and contains source, special nuclear, or byproduct material regulated under the Atomic Energy Act. Waste removed from the tank systems will be managed in accordance with applicable RCRA requirements (i.e., treated to meet the land disposal restrictions standards prior to disposal). DOE would demonstrate that any saltstone produced by grouting the low-activity salt solution would meet applicable RCRA standards. The SRS HLW processing facilities (e.g., Tank Farms, Effluent Treatment Facility, Defense Waste Processing Facility) are exempt from the design and operating standards and permitting requirements for hazardous waste management units because they are wastewater treatment units regulated under the CWA [40 CFR 260.10, 264.1(g)(6) and 270.1(c)(2)(v)]. DOE expects that the new processing facilities for the salt processing alternatives also would be permitted as wastewater treatment units under the CWA.

The Z-Area Saltstone Disposal Facility is permitted as an industrial waste disposal facility (SCDHEC 1986). The current permit application is based on the saltstone composition that was expected to result from the In-Tank Precipitation (ITP) process. The permit application would need to be modified to reflect any differences in the composition of the saltstone resulting from any new salt processing technology. One salt processing alternative, Direct Disposal in Grout, would produce a more radioactive saltstone than the others because cesium would not be removed from the salt solution. That saltstone would be equivalent to Class C (versus Class A for the other salt processing alternatives) LLW as defined by NRC regulations (see 10 CFR 61.55). The current vault design would meet NRC regulations for Class C disposal, although the current permit restricts the average curie content of the saltstone to be within Class A limits. NRC regulations require that Class C waste be structurally stable and provided with protection against inadvertent intrusion for 500 years. The depth of burial and structural stability of the saltstone monoliths would provide the requisite protection against inadvertent intrusion. Modifications to the current vaults would be required under certain salt processing alternatives (e.g., Direct Disposal in Grout).

The Federal Facility Compliance Act (42 USC 6921 et seq.)

The Federal Facility Compliance Act, enacted on October 6, 1992, amended RCRA. The Act waived sovereign immunity for fines and penalties for RCRA violations at Federal facilities. DOE's immunity continues for fines and penalties resulting from land-disposal-restriction storage-prohibition violations for mixed waste, if DOE prepares plans for developing the required treatment capacity for mixed waste stored or generated at each facility and meets other applicable RCRA requirements. Each plan must be approved by the host state or EPA, after consultation with other affected states, and a consent order must be issued by the regulator requiring compliance with the plan. On September 20, 1995, SCDHEC approved the Site Treatment Plan for SRS. SCDHEC issued a consent order, signed by DOE, requiring compliance with the plan on September 29, 1995. DOE provides SCDHEC with annual updates to the information in the SRS Site Treatment Plan. DOE would be required to notify SCDHEC of any new mixed waste streams generated as a result of salt processing activities.

7.2.2 PROTECTION OF BIOLOGICAL, HISTORIC, AND ARCHAEOLOGICAL RESOURCES

The following statutes pertain to protection of endangered or threatened animal and plants, and of historic and cultural resources.

Endangered Species Act, as amended (16 USC 1531 et seq.)

The Endangered Species Act provides a program for the conservation of threatened or endangered species and the ecosystems on which those species rely. All Federal agencies must assess whether the potential impacts of a proposed action could adversely affect threatened or endangered species or their habitat. If so, the agency must consult with the U.S. Fish and Wildlife Service (part of the U.S. Department of the Interior) and the National Marine Fisheries Service (part of the U.S. Department of Commerce), as required under Section 7 of the Act. The outcome of this consultation may be a biological opinion by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service that states whether the proposed action would jeopardize the continued existence of the species under consideration. If there is a non-jeopardy opinion, but the possibility exists that some individual members of a species might be killed incidentally as a result of the proposed action, the Services can determine that such losses are not prohibited, as long as mitigation measures outlined by the Services are followed. Regulations implementing the Endangered Species Act are codified at 50 CFR Part 15 and 402.

The proposed facilities for the salt processing alternatives are located within fenced, disturbed industrial areas. Proposed salt processing activities would not disturb any threatened or endangered species, would not degrade any critical or sensitive habitat, and would not affect any jurisdictional wetland. Therefore, DOE concludes that no consultation with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service concerning the alternatives considered in this SEIS is required.

Migratory Bird Treaty Act, as amended (16 USC 703 et seq.)

The Migratory Bird Treaty Act, as amended, is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the harvesting of migratory birds by specifying things such as the mode of harvesting, hunting seasons, and bag limits. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill...any migratory bird." Executive Order 13186 (66 FR 3853; 1/17/01) requires that environmental analyses of Federal actions required by the National Environmental Policy Act (NEPA) or other established environmental review processes evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern. If impacts to migratory birds were expected, DOE would be required to consult with the U.S. Fish and Wildlife Service and to evaluate ways to avoid or minimize these effects in accordance with the U.S. Fish and Wildlife Service Mitigation Policy (46 FR 7644). The proposed facilities for the salt processing alternatives are within fenced industrial areas without habitat suitable for migratory birds. Therefore, DOE concludes that no consultation with the U.S. Fish and Wildlife Service concerning the alternatives considered in this SEIS is required.

Bald and Golden Eagle Protection Act, as amended (16 USC 668-668d)

The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald and golden eagles, their nests, or their eggs anywhere in the United States (Sections 668, 668c). A permit must be obtained from the U.S. Department of the Interior to relocate a nest that interferes with resource development or recovery operations. The proposed facilities for the salt processing alternatives are within fenced industrial areas without habitat suitable for nesting eagles.

National Historic Preservation Act, as amended (16 USC 470 et seq.)

The National Historic Preservation Act, as amended, provides that sites with significant national historic value be placed on the *National Register of Historic Places*. No permits or certifications are required under the Act. However, if a particular Federal activity could impact an historic property resource, consultation with the Advisory Council on Historic Preservation will usually generate a Memorandum of Agreement, including stipulations that must be followed to minimize adverse impacts. Coordination with the South Carolina State Historic Preservation Officer ensures the proper identification of potentially significant sites and the implementation of appropriate mitigative actions. The proposed facilities for the salt processing alternatives would be within previously disturbed industrial sites. Therefore, DOE does not expect this Act to apply.

Archaeological Resource Protection Act, as amended (16 USC 470 et seq.)

This Act requires a permit for any excavation or removal of archaeological resources from public or Native American lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed are to remain the property of the United States. Consent must be obtained from the Indian Tribe owning lands on which a resource is located before a permit is issued, and the permit must contain terms or conditions requested by the Tribe. The proposed facilities for salt processing alternatives would be within previously disturbed industrial sites. Therefore, DOE does not expect this Act to apply.

Native American Grave Protection and Repatriation Act of 1990 (25 USC 3001)

This law directs the Secretary of the Interior to assume responsibility for repatriation of Federal archaeological collections and collections held by museums receiving Federal funding that are culturally affiliated with Native American Tribes. Major actions to be taken under this law include: (1) establishing a review committee with monitoring and policy-making responsibilities, (2) developing regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims, (3) overseeing museum programs designed to meet the inventory requirements and deadlines of this law, and (4) developing procedures to handle unexpected discoveries of graves or grave goods during activities on Federal or tribal lands. The proposed facilities for salt processing alternatives would be within previously disturbed industrial sites. Therefore, DOE does not expect this Act to apply.

American Indian Religious Freedom Act of 1978 (42 USC l996)

This Act reaffirms Native American religious freedom under the First Amendment and sets U.S. policy to protect and preserve the inherent and constitutional right of Native Americans to believe, express, and exercise their traditional religions. The Act requires that Federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religion. The proposed facilities for salt processing alternatives would be within previously disturbed industrial sites. Therefore, DOE does not expect this Act to apply.

In conjunction with 1991 studies related to the New Production Reactor, DOE solicited the concerns of Native Americans about religious rights in the Central Savannah River Valley. During this study, three Native American groups – the Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy – expressed general concerns about SRS and the Central Savannah River Area, but did not identify specific sites as possessing religious significance. The Yuchi Tribal Organization and the National Council of Muskogee Creek are interested in plant species traditionally used in tribal ceremonies, such as redroot, button snakeroot, and American ginseng (DOE 1991). Redroot and button snakeroot are known to occur on the SRS (Batson, Angerman, and Jones 1985). The proposed facilities for salt processing alternatives would be within previously disturbed industrial sites. Therefore, DOE does not expect this Act to apply.

7.3 Statutes, Regulations, and Guidelines Related to Emergency Planning, Worker Safety, and Protection of Public Health and the Environment

7.3.1 ENVIRONMENTAL PROTECTION

National Environmental Policy Act of 1969, as amended (42 USC 4321 et seq.)

The NEPA establishes a national policy promoting awareness of the environmental consequences of human activity on human health and the environment, and consideration of environmental impacts during the planning and decision-making stages of a project. This Act requires Federal agencies to prepare a detailed statement on the environmental effects of proposed major Federal actions that may significantly affect the quality of the human environment.

This SEIS has been prepared in compliance with NEPA requirements and policies and in accordance with Council on Environmental Quality (40 CFR Parts 1500 through 1508) and DOE (10 CFR Part 1021) regulations for implementing the procedural provisions of NEPA.

Pollution Prevention Act of 1990 (42 USC 13101 et seq.)

The Pollution Prevention Act of 1990 established a national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal. Disposal or releases to the environment should occur only as a last resort. In response, DOE has committed to participate in the Superfund

Amendments and Reauthorization Act Section 313, EPA 33/50 Pollution Prevention Program. The goal for facilities already involved in Section 313 compliance is to achieve by 1997 a 33-percent reduction in the release of 17 priority chemicals from a 1993 baseline. On August 3, 1993, President Clinton issued Executive Order 12856, expanding the 33/50 program such that DOE must reduce its total releases of all toxic chemicals by 50 percent by December 31, 1999. In addition, DOE is requiring each of its sites to establish site-specific goals to reduce the generation of all waste types.

Comprehensive Guideline for Procurement of Products Containing Recovered Materials (40 CFR Part 247)

This guideline is issued under the authority of Section 6002 of RCRA and Executive Order 12783, which set forth requirements for Federal agencies to procure products containing recovered materials for use in their operations, using guidelines established by the EPA. The purpose of these regulations is to promote recycling by using government purchasing to expand markets for recovered materials. RCRA Section 6002 requires that any purchasing agency, when using appropriated funds to procure an item, shall purchase it with the highest percentage of recovered materials practicable. The procurement of materials to be used in the SRS salt processing activities will be conducted in accordance with these regulations.

Toxic Substances Control Act, as amended (USC 2601 et seq.) (40 CFR Part 700 et seq.)

The Toxic Substances Control Act regulates the manufacture, use, treatment, storage, and disposal of certain toxic substances not regulated by RCRA or other statutes, particularly polychlorinated biphenyls (40 CFR Part 761), chlorofluorocarbons (40 CFR Part 762), and asbestos (40 CFR Part 763). DOE does not expect to use these materials under any of the salt processing alternatives.

7.3.2 EMERGENCY PLANNING AND RESPONSE

This section discusses the regulations that address protection of public health and worker safety and require the establishment of emergency plans and coordination with local and Federal agencies related to facility operations. DOE Orders generally set forth the programs and procedures required to implement the requirements of these regulations. See Section 7.5.

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.)

The Atomic Energy Act of 1954, as amended, authorizes DOE to establish standards to protect health and minimize dangers to life or property with respect to activities under its jurisdiction [42 USC 2201(b)]. Through a series of Orders, DOE has established an extensive system of standards and requirements to promote the safe operation of its facilities.

Section 202(4) of the Energy Reorganization Act of 1974 (42 USC §5842(4)), which amended the Atomic Energy Act, gives the NRC licensing authority over DOE facilities authorized for long-term storage of HLW generated by DOE. DOE (Sullivan 1998) determined that NRC's licensing authority is limited to DOE facilities that are (1) authorized by Congress for the express purpose of long-term storage of HLW, and (2) developed and constructed after the passage of the Energy Reorganization Act. None of the facilities associated with the salt processing alternatives meet both criteria. Although DOE has responsibility for such determinations, the Savannah River Operations Office plans to consult with NRC on the incidental waste determination for the low-activity salt solution as described in Section 7.1.

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.); Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release (10 CFR Part 30.72 Schedule C)

The list of quantities in Schedule C of 10 CFR 30.72 is the basis for both the public and private sector to determine if the radiological materials they deal with must have an emergency response plan for unscheduled releases. It establishes threshold criteria documents for DOE Emergency Preparedness Hazard Assessments required by DOE Order 151.1, "Comprehensive Emergency Management System". An emergency response plan addressing salt processing facility operations would be prepared in accordance with this regulation.

The Disaster Relief and Emergency Assistance Amendments of 1988 (42 USC 5121 et seq.), Emergency Management and Assistance (44 CFR Part 351)

These regulations generally include the policies, procedures, and responsibilities of the Federal Emergency Management Agency, NRC, and DOE (44 CFR 351.24) for implementing a Federal Emergency Preparedness Program to include radiological planning and preparedness. An emergency response plan, including radiological planning and preparedness for salt processing facility operations, would need to be prepared and implemented, in accordance with this regulation.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC 11001 et seq.) (also known as "SARA Title III")

The Emergency Planning and Community Right-to-Know Act of 1986 (also known as "SARA Title III") requires emergency planning and notice to communities and government agencies of the presence and release of specific chemicals. EPA implements this Act under regulations found at 40 CFR Parts 355, 370, and 372. Under Subtitle A of this Act, Federal facilities provide various information (such as inventories of specific chemicals used or stored and releases that occur from these facilities) to the State Emergency Response Commission and the Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. DOE's implementation of the provisions of this Act began voluntarily in 1987, and inventory and annual emissions reporting began in 1988. In addition, DOE requires compliance with SARA Title III as a matter of Departmental policy. DOE submits hazardous chemical inventory reports for SRS to SCDHEC. The chemical inventory could change, depending on the salt processing alternative DOE implements; however, subsequent reports would reflect any change to the inventory.

Transportation of Hazardous Materials (49 USC 5101 et seq.); Hazardous Materials Tables & Communications, Emergency Response Information Requirements (49 CFR Part 172)

The regulatory requirements for marking, labeling, placarding, and documenting hazardous materials shipments are defined in 40 CFR Part 172. This regulation also specifies the requirements for providing hazardous material information and training. Materials shipped to the salt processing facilities would comply with these regulations.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (42 USC 9601 et seq.); National Oil and Hazardous Substance Contingency Plan (40 CFR Part 300 et seq.)

More popularly known as CERCLA or "Superfund," the Act and implementing regulations provide the authority for Federal and state governments to respond directly to hazardous substances incidents. The regulations require reporting of spills, including radioactive materials, to the National Response Center. DOE Orders generally set forth the programs for development of internal procedures for implementing the regulations. DOE would be required to comply with these regulations in the event of spills of hazardous substances at the salt processing facilities.

DOE, SCDHEC, and EPA have signed an FFA to coordinate cleanup at SRS, as required by Section 120 of CERCLA. Section IX of the Agreement sets forth requirements for the SRS HLW tank systems. Design and operating standards for the tank systems are found in Appendix B of the Agreement. DOE has submitted a waste removal plan and schedule for the tank systems that do not meet applicable secondary containment standards. The approved FFA waste removal schedule appears in Appendix E of the *Savannah River Site High Level Waste System Plan* (WSRC 2000). DOE must provide an annual report on the status of the HLW tank systems being removed from service. After waste removal is completed, the tank systems are available for closure in accordance with general closure strategy for the F- and H-Area waste tank systems (DOE 1996). Implementation of salt processing is essential to meeting DOE's obligations under the FFA. Under the No Action alternative, DOE would continue to store the salt solutions. If salt processing is not operational by 2010, DOE would consider other options, as described in Section 2.3.

Occupational Safety and Health Act of 1970, as amended (29 USC 651 et seq.); Occupational Safety and Health Administration Emergency Response, Hazardous Waste Operations and Worker Right to Know (29 CFR Part 1910 et seq.)

The Occupational Safety and Health Act (29 USC 651) establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration (OSHA), a U.S. Department of Labor agency. While OSHA and EPA both have a mandate to reduce exposures to toxic substances, OSHA's jurisdiction is limited to safety and health conditions that exist in the workplace environment. In general, under the Act, it is the duty of each employer to furnish all employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. The OSHA regulations (29 CFR) establish specific standards with which employers must comply to achieve a safe and healthful working environment. This regulation sets down the OSHA requirements for employee safety in a variety of working environments. It addresses employee emergency and fire prevention plans (Section 1910.38), hazardous waste operations and emergency response (Section 1910.120), and hazard communication (Section 1910.1200) that enable employees to be aware of the dangers they face from hazardous materials at their workplaces. DOE places emphasis on compliance with these regulations at its facilities and prescribes, through DOE Orders, OSHA standards that contractors shall meet, as applicable to their work at government-owned, contractor-operated facilities. DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths required by OSHA regulations.

Noise Control Act of 1972, as amended (42 USC 4901 et seq.)

Section 4 of the Noise Control Act of 1972, as amended, directs all Federal agencies to carry out "to the fullest extent within their authority" programs within their jurisdictions in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare.

7.4 Executive Orders

The following executive orders would apply to the SRS salt processing activities. DOE Orders generally set forth the programs and procedures required to implement the requirements of the Orders.

Executive Order 11514 (Protection and Enhancement of Environmental Quality)

Executive Order 11514 requires Federal agencies to monitor and control their activities continually to protect and enhance the quality of the environment to develop procedures to ensure the fullest practicable provision of timely public information and understanding of Federal plans and programs with environmental impacts, and to obtain the views of interested parties.

Executive Order 11988 (Floodplain Management)

Executive Order 11988 requires Federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain, and that floodplain impacts be avoided to the extent practicable.

Executive Order 11990 (Protection of Wetlands)

Executive Order 11990 requires government agencies to avoid any short- and long-term adverse impacts on wetlands, wherever there is a practicable alternative.

Executive Order 12856 (Right-to-Know Laws and Pollution Prevention Requirements)

Executive Order 12856 requires all Federal agencies to reduce the toxic chemicals entering any waste stream. This order also requires Federal agencies to report toxic chemicals entering waste streams; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative pollution prevention technologies.

Executive Order 12898 (Environmental Justice)

Executive Order 12898 directs Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

Executive Order 12902 (Energy Efficiency and Water Conservation at Federal Facilities)

Executive Order 12902 requires Federal agencies to develop and implement programs for conservation of energy and water resources.

7.5 DOE Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its facilities are the promulgation of regulations and the issuance of DOE Orders. Table 7-2 lists the major DOE Orders applicable to the salt processing alternatives.

The DOE regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For purposes of this SEIS, relevant regulations include 10 CFR Part 820, *Procedural Rules for DOE Nuclear Facilities*; 10 CFR Part 830, *Nuclear Safety Management, Contractor and Subcontractor Activities*; 10 CFR Part 835*, Occupational Radiation Protection*; 10 CFR Part 1021*, Compliance with NEPA*; and 10 CFR Part 1022*, Compliance with Floodplains/Wetlands Environmental Review Requirements*. DOE has enacted occupational radiation protection standards to protect DOE and its contractor employees. These standards are set forth in 10 CFR Part 835*, Occupational Radiation Protection*; the rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities, including those conducted by DOE contractors. The activity may be, but is not limited to, design, construction, or operation of DOE facilities.

Table 7-2. DOE Orders and Standards relevant to the salt processing alternatives.

151.1A	Comprehensive Emergency Management System
225.1A	Accident Investigation
231.1	Environment, Safety and Health Reporting
232.1A	Occurrence Reporting and Processing of Operations Information
252.1	Technical Standards Program
420.1	Facility Safety
425.1B	Startup and Restart of Nuclear Facilities
430.1A	Life Cycle Asset Management
435.1	Radioactive Waste Management
440.1A	Worker Protection Management for DOE Federal and Contractor Employees
451.1B	National Environmental Policy Act Compliance Program
460.1A	Packaging and Transportation Safety
460.2	Departmental Materials Transportation and Packaging Management
470.1	Safeguards and Security Program
471.1A	Identification and Protection of Unclassified Controlled Nuclear Information
471.2A	Information Security Program
472.1B	Personnel Security Activities
474.1A	Control and Accountability of Nuclear Materials
1270.2B	Safeguards Agreement with the International Atomic Energy Agency
3790.1B	Federal Employee Occupational Safety and Health Program
4330.4B	Maintenance Management Program
4700.1	Project Management System
5400.1	General Environmental Protection Program
5400.5	Radiation Protection of the Public and the Environment
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities
5480.21	Unreviewed Safety Questions
5480.22	Technical Safety Requirements
5480.23	Nuclear Safety Analysis Reports
5632.1C	Protection and Control of Safeguards and Security Interests
5660.1B	Management of Nuclear Materials
6430.1A	General Design Criteria
1020-94	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities
1021-93	Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components
1024-92	Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites for Department of Energy Facilities
1027-92	Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23 Nuclear Safety Analysis Reports
3009-94	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports
3011-94	Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans

References

Batson, W. T., J. S. Angerman, and J. T. Jones, 1985, *Flora of the Savannah River Plant: An Inventory of the Vascular Plants on the Savannah River Plant, South Carolina*, Savannah River Plant National Environmental Research Park Program, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1991, *American Indian Religious Freedom Act Compliance at the Savannah River Site*, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Industrial Wastewater Closure Plan for the F- and H-Area High-Level Waste Tank Systems, Savannah River Site, Construction Permit Numbers 14,338, 14,520, 17,424-IW,* Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999, *Radioactive Waste Management*, DOE Order 435.1 and Manual 435.1-1, Office of Environmental Management, Washington DC, [Order and Manual are available at http://www.explorer.doe.gov:1776/htmls/directives.html], July 9.

EPA (U.S. Environmental Protection Agency), 2000, *Proposed Total Maximum Daily Load for Total Mercury in the Middle/Lower Savannah River, Georgia*, Region 4, Atlanta, Georgia, [available online at http://www.epa.gov/region4/water/tmdl/georgia/savannah/savhgtmdl.pdf], December 8.

SCDHEC (South Carolina Department of Health and Environmental Control), 1986, *Industrial Waste Permit IWP-217, Z-Area Saltstone Disposal Facility, Savannah River Plant, Aiken County*, Columbia, South Carolina, October 31. (This permit is reviewed and renewed every 3 years.)

Sullivan, M. A., 1998, U.S. Department of Energy, General Counsel, letter to J. T. Greeves, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, "Natural Resources Defense Council Petition to Exercise Licensing Authority over Savannah River Site High-Level Waste Tanks," September 30.

WSRC (Westinghouse Savannah River Company), 2000, *Savannah River Site High-Level Waste System Plan, HLW-2000-0019*, Revision 11, Aiken, South Carolina, April.

APPENDIX A

TECHNOLOGY DESCRIPTIONS

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APPENDIX A. TECHNOLOGY DESCRIPTIONS

A.1 Introduction

The Savannah River Site (SRS) currently stores 34 million gallons of aqueous high-level waste (HLW) in F- and H-Area Tank Farms (Figures A-1 and A-2; see also text box on this page). This waste comprises approximately 2.8 million gallons of insoluble sludge, 15.2 million gallons of solid saltcake, and 16 million gallons of supernatant salt, all contained in 49 large underground steel tanks. The U.S. Department of Energy (DOE) is committed to removing this waste material from the HLW tanks and processing it for final disposal to resolve critical safety and regulatory issues.

DOE has developed processes and facilities to convert the aqueous wastes into environmentally safe forms for long-term storage and final disposal (DOE 1994, 1995). Sludge components of the wastes, which contain most of the radioactive strontium and alpha-emitting actinides (such as plutonium and uranium), are washed and treated with sodium hydroxide to reduce the aluminum content, then mixed with glass frit for melting into a glass waste form in the Defense Waste Processing Facility (DWPF). Soluble salt components of the wastes were to be treated in a large waste tank, using a precipitation-sorption process denoted In-Tank Precipitation (ITP), to remove radioactive cesium (principally cesium-137) and other radionuclides for vitrification, along with sludge, in DWPF. The cesium would have been precipitated as an insoluble tetraphenylborate solid, and residual strontium and actinides (such as plutonium and uranium) would have been sorbed to a particulate solid, monosodium titanate, then both would be filtered from the solution for transfer to the DWPF. The low activity salt solution would then have been fixed in a concrete-like material (saltstone) for onsite disposal in engineered vaults. SRS would provide interim storage of the waste glass in stainless steel canisters until such time as they could be shipped to a monitored geologic repository for final disposal.

The sludge processing operations were successfully implemented and immobilization of these wastes in glass at DWPF is in progress. During startup of the ITP process, however, it was observed that decomposition of the tetraphenylborate produced benzene in amounts higher than predicted. A comprehensive review of the process concluded that the tetraphenylborate decomposition and benzene release associated with ITP operation could exceed the design capability of the existing facilities, preventing simultaneously meeting safety and production requirements in a cost-effective manner (see text box page A-4).

Evaluation of alternative technologies resulted in the identification of four candidates to replace the ITP process (WSRC 1998a):

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

Waste Tank Concerns and Commitments

Two of the original 51 HLW storage tanks (numbers 17 and 20) at SRS had waste removed and have been closed. Of the remaining 49 tanks, 9 (numbers 1, 9, 10, 11, 12, 13, 14, 15, and 16) have leaked observable quantities of liquid waste from primary to secondary containment and one tank (number 16) leaked a few tens of gallons of waste to the environment (WSRC 1998b). One other tank (number 19) has cracks in the tank wall above the level of the waste, although no waste has been observed to leak through these cracks. Tanks 1 through 24 do not meet U.S. Environmental Protection Agency (EPA) secondary containment and leak detection standards for storage of hazardous waste, effective January 12, 1987 (40 CFR 264). Removal of wastes and closure of these tanks by 2022 is required by the Federal Facility Agreement (FFA) for SRS entered into by the DOE, EPA, and the South Carolina Department of Health and Environmental Control (SCDHEC) (EPA 1993). All HLW at SRS is land-disposal-restricted waste, prohibited from long-term storage, and must be removed from the HLW tanks by the year 2028 as a result of FFA (WSRC 2000a).

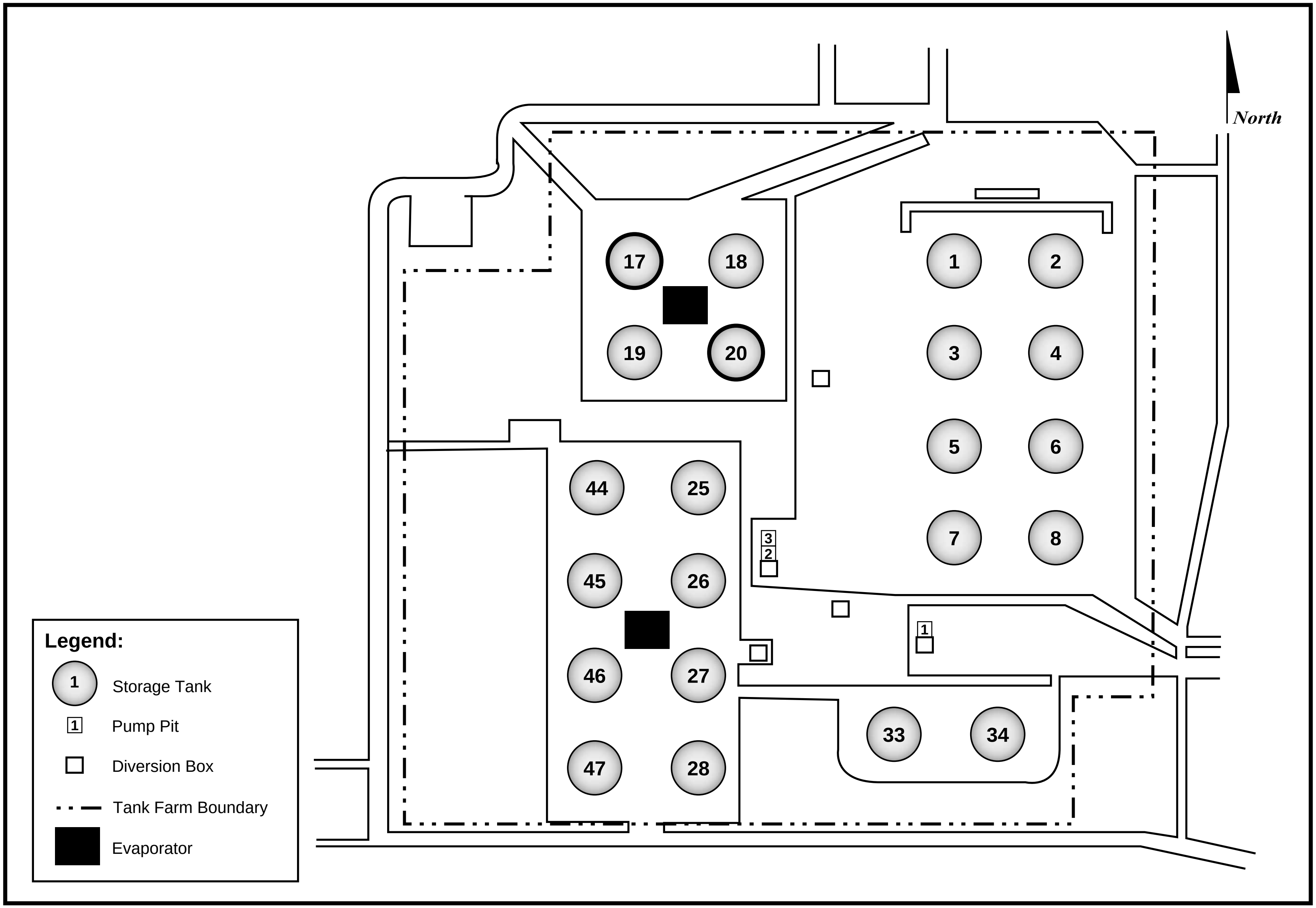

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Figure A-1. General layout of F-Area Tank Farm (Tanks 17 and 20 are closed).

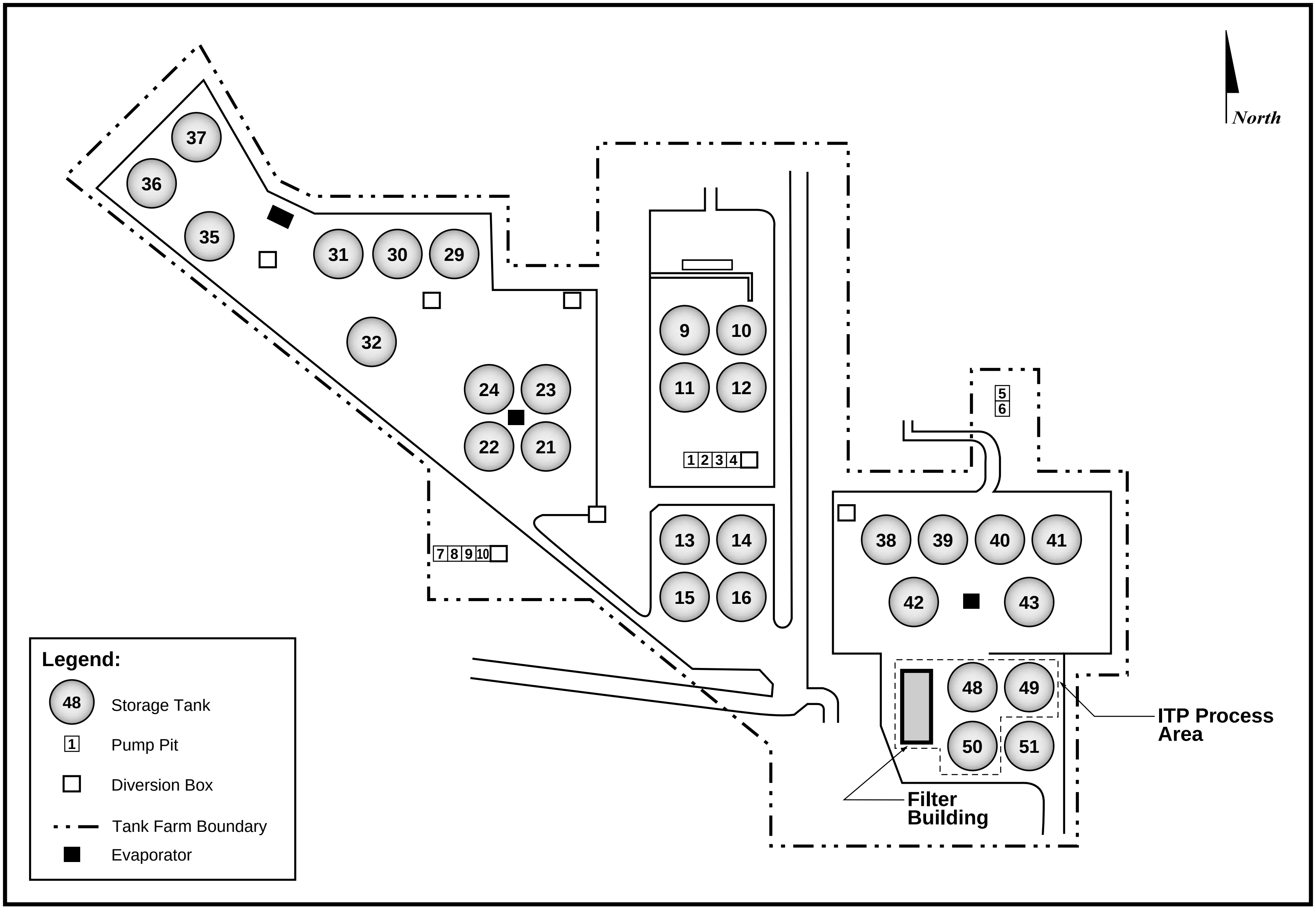

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Figure A-2. General layout of H-Area Tank Farm.

The environmental impacts of constructing and operating facilities for these alternative technologies are being identified and evaluated in this *Salt Disposition Alternatives Supplemental Environmental Impact Statement* (SEIS) (DOE 1998a, 1999).

Need for ITP Replacement

Benzene generated during the ITP process results from the decomposition of tetraphenylborate (TPB), which is used to separate soluble radioactive cesium from the HLW salt solution. The cesium is precipitated as an insoluble solid that can be filtered from the waste solution. Under certain conditions the tetraphenylborate is subject to a radiolytic and catalytic decomposition that forms benzene and allows the separated cesium to return to the salt solution. Benzene is a toxic, flammable, and potentially explosive organic substance that must be safely controlled. The redissolution of cesium as a result of tetraphenylborate decomposition must be curtailed to achieve the required decontamination of the salt solution.

Tetraphenylborate decomposition is catalyzed by certain metals in the radioactive waste, notably the fission product palladium. The extent and rate of tetraphenylborate decomposition is affected by the chemical form of the catalyst, and increases with time of exposure to and temperature of the catalyst. Controlled release of benzene from the salt solution, as required to mitigate potential benzene hazards, is promoted by agitation or stirring. Flammability is controlled by maintaining a nitrogen gas cover that excludes oxygen above concentrations that could cause benzene combustion.

The ITP facilities were unsuitable to control tetraphenylborate decomposition and benzene generation because:

- Large volumes and long cycle times allowed excessive tetraphenylborate decomposition before the precipitate could be separated by filtration from the salt solution.
- Adequate temperature control was not possible in the large tank.
- Agitation by slurry pumps produced insufficient mixing.
- Purge of the nitrogen gas cover was inadequate because the large tank was not adaptable to positive pressure or secondary confinement.

These limitations were assessed against requirements for safely processing the large inventory of HLW salt within the time projected for completion of sludge processing in the DWPF. Based on this assessment, DOE concluded that the ITP process could not simultaneously achieve safety and production requirements for the high-level radioactive waste system.

A.2 Current HLW System Configuration

The SRS HLW system was developed to receive and store radioactive wastes in a safe and environmentally sound manner and to convert these wastes into forms suitable for final disposal (DOE 1994). A schematic of the process is shown in Figure A-3 (WSRC 1998b). As planned, sludge components and the highly radioactive soluble constituents recovered from the salt components of the wastes would be immobilized in DWPF as borosilicate glass contained in stainless steel canisters for disposal in a monitored geologic repository. Low activity salt solutions would be immobilized in cementitious form (saltstone) for disposal in onsite vaults. Secondary products from these operations, including mercury derived from sludge processing and benzene released during salt processing operations, would be recovered for appropriate disposition (recycling or destruction). Miscellaneous radioactive and hazardous process wastes would be incorporated into the SRS waste management system for disposal.

A.3 Processes and Facilities

A.3.1 HLW STORAGE AND EVAPORATION

HLW from SRS chemical processing operations is received in the F- and H-Area Tank Farms as an aqueous slurry of insoluble sludge and soluble salts in alkaline solution. The tank farms concentrate (by evaporation of excess water) and store these wastes, pending further processing in other facilities. The sludge component of the alkaline wastes settles to the bottom of the storage tank, and the salt solution is decanted and concentrated by evaporation, leaving a solid saltcake and a concentrated supernatant. Evaporation reduces the volume and mobility of the wastes, enhancing long-term storage. The water driven off by evaporation is processed through the Effluent Treatment Facility (ETF) to decontaminate it before release to an onsite stream. No water is released from ETF to a stream unless it meets all regulatory criteria.

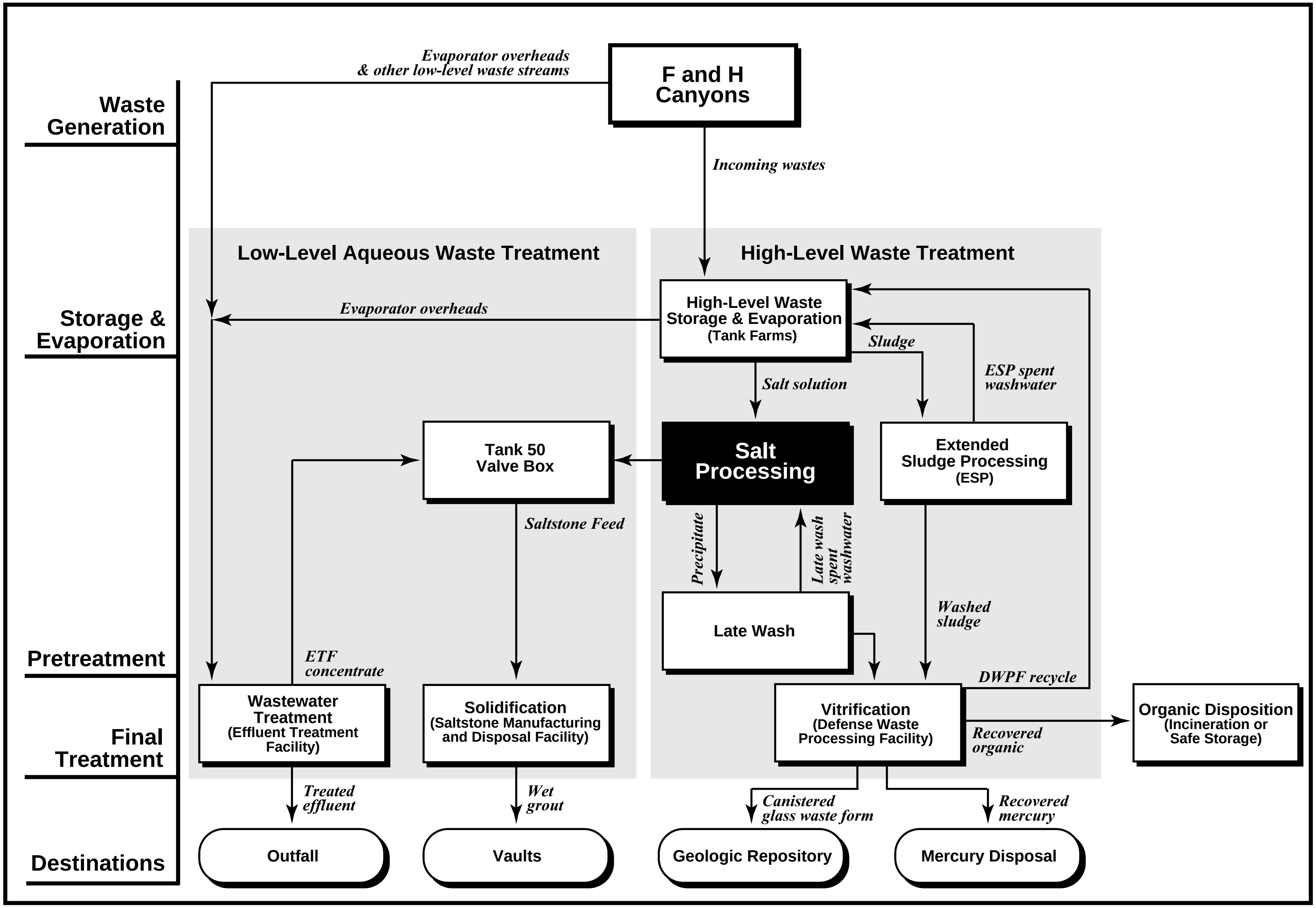

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Figure A-3. SRS high-level waste system configuration.

A.3.2 EXTENDED SLUDGE WASHING

The insoluble sludges accumulated in the tanks are hydraulically slurried and transferred to tank farm facilities for washing with inhibited water to remove soluble salts entrained in the sludge. (Inhibited water contains low concentrations of sodium nitrite and sodium hydroxide to inhibit corrosion of the steel waste tanks.) To reduce the quantity of glass waste formed, sludge with high levels of aluminum is treated with caustic (3 to 5 molar sodium hydroxide) to convert aluminum hydroxide to soluble sodium aluminate, which is washed from the sludge along with other soluble salts. The wash solutions are concentrated by evaporation and returned to the waste tanks as salt waste components. The washed sludge is transferred to DWPF for conversion to the borosilicate glass waste form.

A.3.3 SALT PROCESSING

In the salt processing operations, as originally projected, saltcake in the waste tanks would be redissolved and combined with concentrated supernatant, and the resulting salt solution transferred hydraulically to the ITP facilities. ITP was to be conducted in a large waste tank; tetraphenylborate would be added to the salt solution to coprecipitate radioactive cesium (along with essentially nonradioactive potassium) as an insoluble solid, and a slurry of the particulate solid monosodium titanate would be added to react with residual strontium and actinides by a sorption process. The resulting precipitate solids would be concentrated in the tank and separated by cross-flow filtration before being transferred to DWPF for melting into a glass waste form, along with sludge components of the waste. (Cross-flow filtration is a process in which the solid slurry is passed through porous membrane tubes under pressure to force the salt solution into a surrounding vessel and concentrate the solids in the slurry.) The low activity salt solution recovered by filtration would be immobilized in onsite vaults as saltstone.

A.3.4 DWPF GLASS PROCESSING

If the ITP process were operational, sludge and salt precipitate solids would be transferred as aqueous slurries to DWPF for conversion in a glass melter to the glass waste form. Currently, only sludge is being vitrified at DWPF.

In DWPF, the sludge slurry would be acidified and treated chemically to extract mercury before the sludge was sent to the glass melter. The recovered mercury would be stored for future disposal. The precipitate slurry would be treated in DWPF, using a hydrolysis process to decompose the tetraphenylborate solids. The hydrolysis reaction would produce an aqueous solution of inorganic salts including the radioactive cesium, several organic products (principally benzene), boric acid, and residual titanate solids. The benzene would be distilled from the mixture, washed, and collected for incineration. To avoid potential explosion hazards from benzene, the tetraphenylborate precipitate would be processed in a carbon dioxide atmosphere. The aqueous residues of the precipitate hydrolysis process would be mixed with sludge and glass frit as feed for the DWPF melter. Molten glass would be poured into stainless steel canisters about 2 feet in diameter by 10 feet long, suitable for interim onsite storage and permanent disposal in a monitored geologic repository.

Storage of Recycle DWPF Wastes

DWPF operations produce large volumes of recycle wastes, mostly water, returned to the HLW storage tanks. Without a salt processing technology in place, the DWPF sludge-only operation will increase the volume of waste that must be stored in the HLW tanks. Management of existing tank space and equipment would allow DOE to continue sludge-only vitrification in DWPF until about 2010, the projected time for startup of salt processing plant operations (text box page 2-2).

Tank space management would include some or all of the following activities intended to reduce storage requirements in the HLW tanks (WSRC 1999a):

- Continue to evaporate liquid waste
- Use Tank 49 for HLW storage instead of ITP processing

- Return Tank 50 to HLW service
- Implement several activities that gain small incremental volumes
- Near the end of the period, reduce the available emergency space in the tank farm to the minimum required by the Authorization Basis, as necessary.

A.3.5 SALTSTONE PROCESSING

The low activity salt solution from the ITP process would be mixed with a blend of cement, flyash, and slag in the Saltstone Manufacturing and Disposal Facility to produce a grout suitable for disposal in onsite vaults. The grout would be poured into the vaults to solidify into large saltstone monoliths.

As originally designed, the saltstone vaults are near-surface concrete containment structures that serve as forms for the cast saltstone and provide a diffusion barrier to the environment (Wilhite 1986; Wilhite et al. 1989). The vaults, 300 feet in length, 200 feet wide, and about 25 feet high, with 1.5-foot-thick sidewalls, a 2.5-foot base and a 2.0-foot cover, are sized to contain approximately 1.4 million cubic feet (40,000 m^3) of saltstone within six subdivided cells of the vault. During decommissioning, clay caps would be placed over the vaults, with drainage systems installed between the caps to reduce the volume of rainwater infiltrating the disposal site.

The grout composition and the vault design were specified to minimize the release rate of waste components into the surrounding environment (Langton 1988; Wilhite 1986). Performance criteria imposed on the saltstone vaults required that groundwater quality at the disposal site meet drinking water standards. Performance modeling, validated by field tests, demonstrated the capability of the saltstone vaults to meet these standards (Martin Marietta 1992).

A.4 Salt Processing Alternatives

Facility capabilities have been demonstrated and all waste processing operations for the SRS HLW management system are currently operational, with the exception of ITP processing and related late wash of the precipitate. In December 1995, DOE determined that the ITP process was generating benzene at higher rates than expected and operational testing was suspended in March 1996. Benzene is a flammable product of the decomposition of tetraphenylborate added to precipitate cesium from the salt solution. The excess benzene resulted from the decomposition of tetraphenylborate in the processing tank, allowing redissolution of the precipitate before it could be separated by filtration. In concurrence with a Defense Nuclear Facility Safety Board recommendation, chemical studies were initiated that would better explain the underlying mechanisms for benzene generation and release during the tetraphenylborate precipitation process. These studies demonstrated that the process to remove cesium from the salt solution, as then configured, could not simultaneously achieve production goals and meet safety requirements for processing the salt wastes.

In early 1998, the ITP project was suspended and DOE directed Westinghouse Savannah River Company (WSRC) to initiate a program for evaluation of alternative salt processing technologies. A High-Level Waste Salt Processing Systems Engineering Team (SET) was chartered to identify technologies to replace the ITP process, evaluate the technologies, and recommend a selected technology or technologies to convert the HLW salt solution (supernatant plus dissolved saltcake) to waste forms that could meet regulatory requirements. The SET was composed of WSRC employees with technical support from universities, several national laboratories, independent consultants, and the DOE complex.

A.4.1 SCREENING

The SET employed a phased approach, as summarized in Figure A-4. In Phase I, approximately 140 possible technology options were identified to replace ITP, and meet safety and production requirements. Each option was evaluated against a set of screening criteria that established minimum requirements. This initial

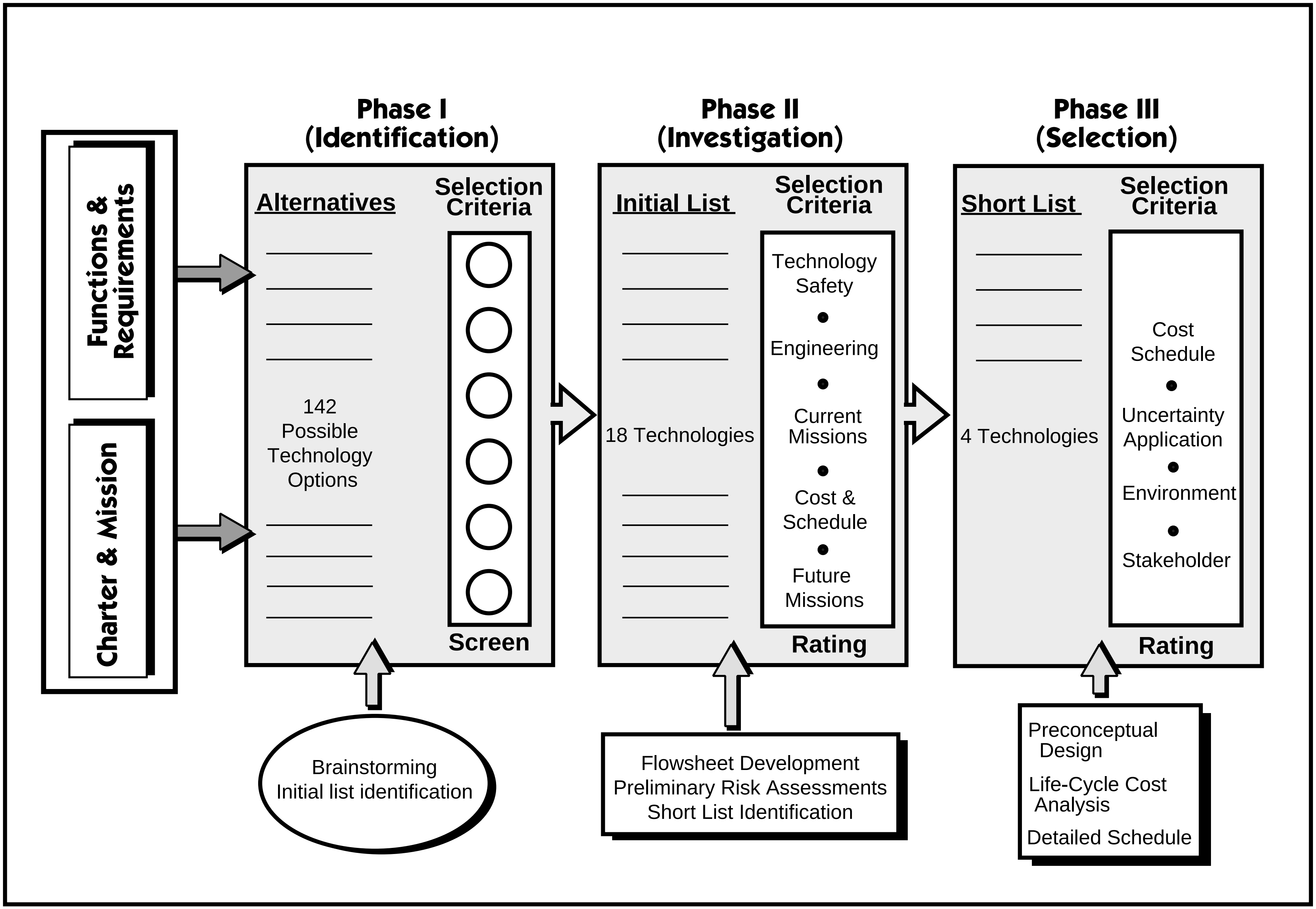

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Figure A-4. Current phased approach to screening and selecting salt processing technologies.

The initial screening of approximately 140 salt processing technologies options identified 18 for further evaluation. The 18 technologies, grouped by general category (WSRC 1998c), were:

Crystallization
- Fractional Crystallization – DWPF Vitrification

Electrochemical Separation
- Electrochemical Separation and Destruction – DWPF Vitrification

Ion Exchange
- Elutable Ion Exchange – DWPF Vitrification
- Acid Side Ion Exchange – DWPF Vitrification
- Crystalline Silicotitanate Ion Exchange – DWPF Vitrification
- Crystalline Silicotitanate Ion Exchange – New Facility Vitrification
- Crystalline Silicotitanate Ion Exchange – Ceramic Waste Form
- Zeolite Ion Exchange – DWPF Vitrification

Precipitation
- Potassium Removal followed by Tetraphenylborate Precipitation – DWPF Vitrification
- Reduced Temperature ITP – DWPF Vitrification
- Catalyst Removal ITP – DWPF Vitrification
- ITP with Enhanced Safety Features – DWPF Vitrification
- Small Tank Tetraphenylborate Precipitation – DWPF Vitrification

Solvent Extraction
- Caustic Side Solvent Extraction – DWPF Vitrification
- Acid Side Solvent Extraction – DWPF Vitrification

Vitrification
- Direct Vitrification
- Supernatant Separation – DWPF Vitrification
- Direct Disposal of Cesium in Grout – DWPF Vitrification

screening reduced the original 140 options to 18 technologies that were selected for further evaluation.

During Phase II of the technology selection process, the SET performed a preliminary technical and programmatic risk assessment for each of the 18 technologies to establish a short list for in-depth analysis. As part of the Phase II analysis, the SET evaluated preliminary material balances, cycle times, and impacts to the HLW system for each of the 18 technologies. A technical document (WSRC 1998d) provides supporting data and the results of this assessment, which narrowed the list of 18 technologies to four:

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

Phase III of the process evaluated the final four technologies in still greater detail, including life-cycle cost estimates and schedule assessments. Some of the uncertainties and assumptions in the Phase II efforts were resolved in Phase III by additional research, literature review, calculations, and experiments. The facility components of the technologies, such as tanks and transport systems, were described in greater detail. Equipment sizing was refined and used to develop pre-conceptual facility layouts and process flow configurations. The layouts were used to develop project schedules and life-cycle cost estimates. This analysis is documented (WSRC 1998e) and forms the basis for the environmental impact analysis presented in this SEIS.

A.4.2 RECOMMENDATION AND REVIEW

On October 29, 1998, following review by the WSRC Review Panel Team, WSRC recommended to DOE the Small Tank Precipitation process as the most reasonable replacement salt processing technology and the Ion Exchange process as a backup technology (WSRC 1998e).

A DOE Savannah River (SR) Review Team evaluated the WSRC recommendation and concluded that the remaining technical uncertainties for each of the alternatives were too significant to justify selection of a preferred technology (DOE 1998b). The DOE-SR Review Team recommended that additional research and development be conducted to address the key technical uncertainties associated with the two technologies, so that one could be identified as most reasonable. The Review Team agreed with WSRC that one of the four technologies considered in Phase III, Solvent Extraction, should be eliminated from further consideration because of its insufficient technical maturity. The DOE Review Team concluded that the Direct Disposal in Grout alternative should not be eliminated, based on its potential to reduce construction and operating costs and the high confidence in its technology, safety, and feasibility for implementation.

A DOE-Headquarters Independent Review Team concluded that both the Small Tank Precipitation and the Ion Exchange alternatives were technically feasible. This team agreed with the SET that Direct Disposal in Grout should be eliminated from further consideration, because of regulatory issues that had the potential to substantially increase the time required to implement the technology (DOE 1998c), therefore further investigations regarding implementing this alternative will not occur as long as a cesium-separation technology can be proved technically and economically practical.

In January 1999, DOE directed WSRC to conduct additional research and development in the Small Tank Precipitation and Ion Exchange alternatives, while the Department pursued resolution of issues pertaining to Direct Disposal in Grout. These additional studies concluded with WSRC maintaining its recommendation to pursue design and construction for the Small Tank Precipitation process. WSRC further noted that, with additional development to reduce technical and engineering risk factors, the Ion Exchange process could also prove suitable for SRS, as well as a DOE complex-wide application for salt processing.

During this period, the technology for the Solvent Extraction process advanced independent of the SRS alternative evaluations. This information, coupled with recommendations from the National Research Council of the National Academy of Sciences and improved understanding of tank farm water management issues, led the Department to reconsider the potential to mature and implement this alternative in time to support HLW salt processing needs.

In February 2000, DOE requested WSRC to initiate further development of the Solvent Extraction alternative, aimed at the timely resolution of previously identified problems (DOE 2000). Consequently, the Solvent Extraction technology is included as a reasonable alternative in the SEIS.

A.4.3 PROCESS DESCRIPTIONS

A.4.3.1 Small Tank Tetraphenylborate Precipitation

In the Small Tank Precipitation technology (WSRC 1998c,e,f), the soluble salt components of the wastes would be processed using precipitation-sorption procedures analogous to the ITP process to separate cesium and other soluble radionuclides from the waste solutions. The process would be conducted as a continuous operation in stirred small tanks (15,000 gallons) with the solution agitated constantly to avoid excessive decomposition of tetraphenylborate and accompanying generation of benzene before separation. In the Small Tank Precipitation technology, tetraphenylborate solution would be added to precipitate cesium and potassium, and a slurry of monosodium titanate would be added to sorb residual strontium and actinides from the salt solution. The resulting solids, along with residual sludge, would be concentrated by filtration and washed to remove soluble salts, then treated chemically to convert the precipitate to a non-flammable form for transfer to DWPF. Catalytic decomposition of the precipitate, with removal of the benzene formed, would generate a product stream containing cesium in aqueous solution and strontium and actinides sorbed onto monosodium titanate for vitrification. The low activity salt solution recovered by filtration would be transferred to the Saltstone Manufacturing and Disposal Facility for processing. The wash water would be recycled into the incoming soluble salt solution.

Small Tank Precipitation would be performed in a new facility to be constructed at Site B in S Area. Process flows for the Small Tank Precipitation alternative are shown in Figure A-5. Salt solution would be collected in an H-Area tank and pumped to the Small Tank Precipitation facility. A section of new interarea transfer line would be required to connect the new facility to the existing transfer line. The precipitation process would be conducted in two Continuous Stirred Tank Reactors. Salt solution mixed with tetraphenylborate, monosodium titanate, process water, and recycled wash water in the first tank reactor would flow to the second tank reactor, providing reaction conditions needed to maximize decontamination factors for the precipitation and sorption processes.

The precipitate slurry, containing about one weight percent tetraphenylborate and monosodium titanate solids, would be transferred continuously from the second tank reactor to a Concentrate Tank, where it would be concentrated to about 10 weight percent solids by cross-flow filtration. The resulting filtrate would be pumped to a Filtrate Hold Tank for later transfer to the Saltstone Manufacturing and Disposal Facility for immobilization in the saltstone vaults.

The precipitate slurry accumulated in the Concentrate Tank would be transferred to the Wash Tank for washing in a batch process to remove soluble sodium salts. Spent wash water would be separated from the precipitate by cross-flow filtration. The washed precipitate would be treated in the Precipitate Hydrolysis Cell (PHC) of the facility to eliminate benzene and generate an aqueous product stream termed Precipitate Hydrolysis Aqueous (PHA).

The PHC incorporates process operations formerly assigned to the Salt Processing Cell of DWPF (see text box below). Process flows for the PHC are shown in Figure A-6. In the PHC,

Transfer of DWPF Salt Processing Cell Operations to Small Tank Precipitation Facility

The design basis for the Small Tank Precipitation facility was modified to include the precipitate decomposition operations previously programmed for the DWPF. These operations, to be conducted in a PHC, had been tested during DWPF nonradioactive process runs, but were not employed during radioactive (sludge only) processing because of the unavailability of ITP feed. Major justifications for transferring the PHC operations to the Small Tank Processing facility are as follows:

- Safety – Lessons learned in DWPF design would provide PHC equipment with increased safety and control margins. As redesigned, the equipment would operate under slight positive pressure and low purge rates of inert cover gas.
- Capacity – Increased throughputs of PHC equipment would provide Small Tank Precipitation processing capacity needed to match required HLW salt removal schedules, with a substantial reduction in life-cycle processing time and significant cost savings.
- Flexibility – The vacated cell in the DWPF would become available for other potentially needed operations, including evaporation of DWPF recycle waste streams to conserve Tank Farm space pending startup of salt processing operations.
- Organic Disposition – Precipitate Hydrolysis Cell operations in the Small Tank Precipitation facility would confine generation and disposal of flammable organic byproducts to the process facility. This would avoid buildups of high-boiling organics in DWPF process and ventilation systems, and transfer in DWPF recycle streams to the Tank Farm. Lag storage and transfer to DWPF would be provided for the non-flammable aqueous product of the PHC operations, rather than the flammable tetraphenylborate precipitate product.

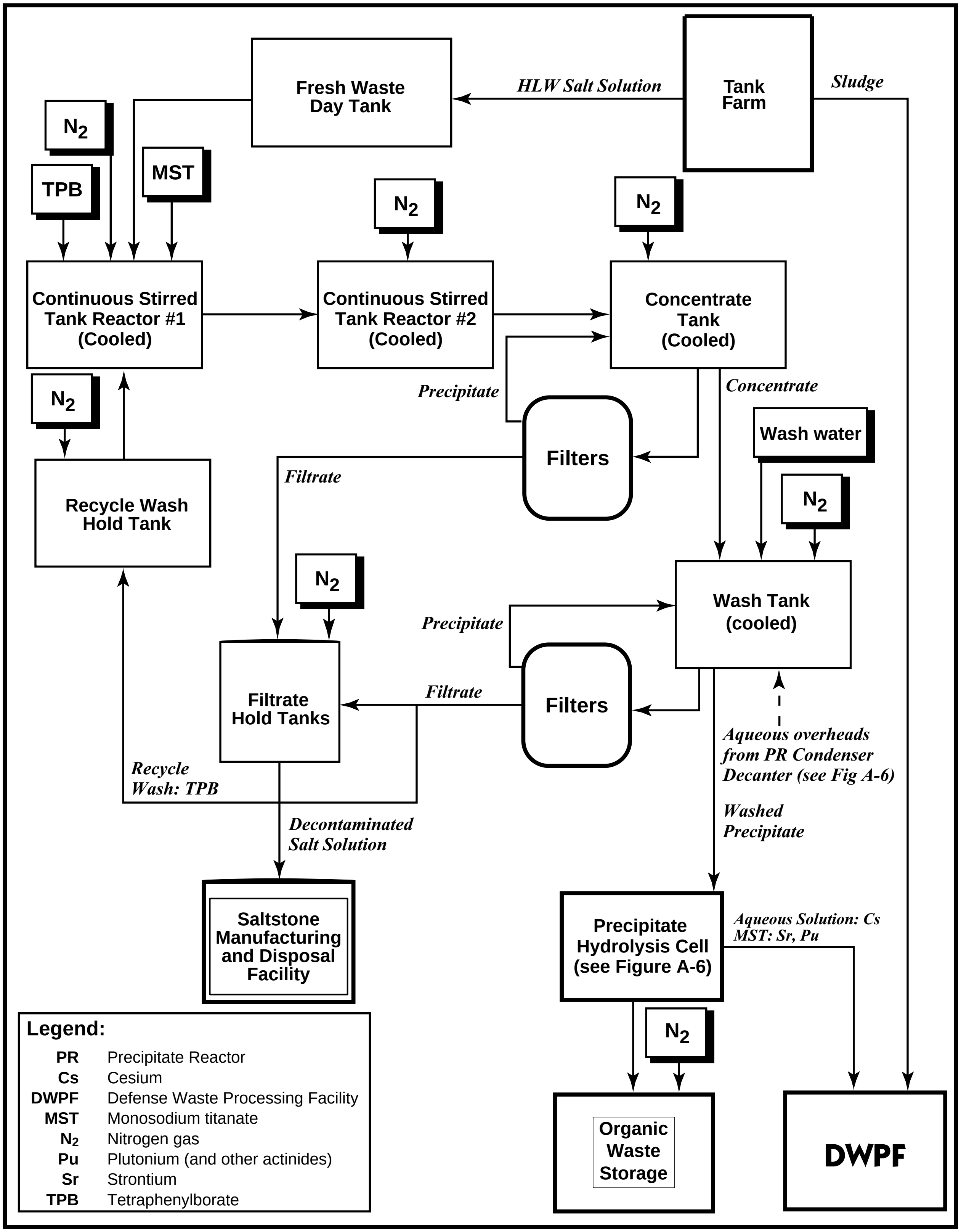

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Figure A-5. Small Tank Precipitation process flow diagram.

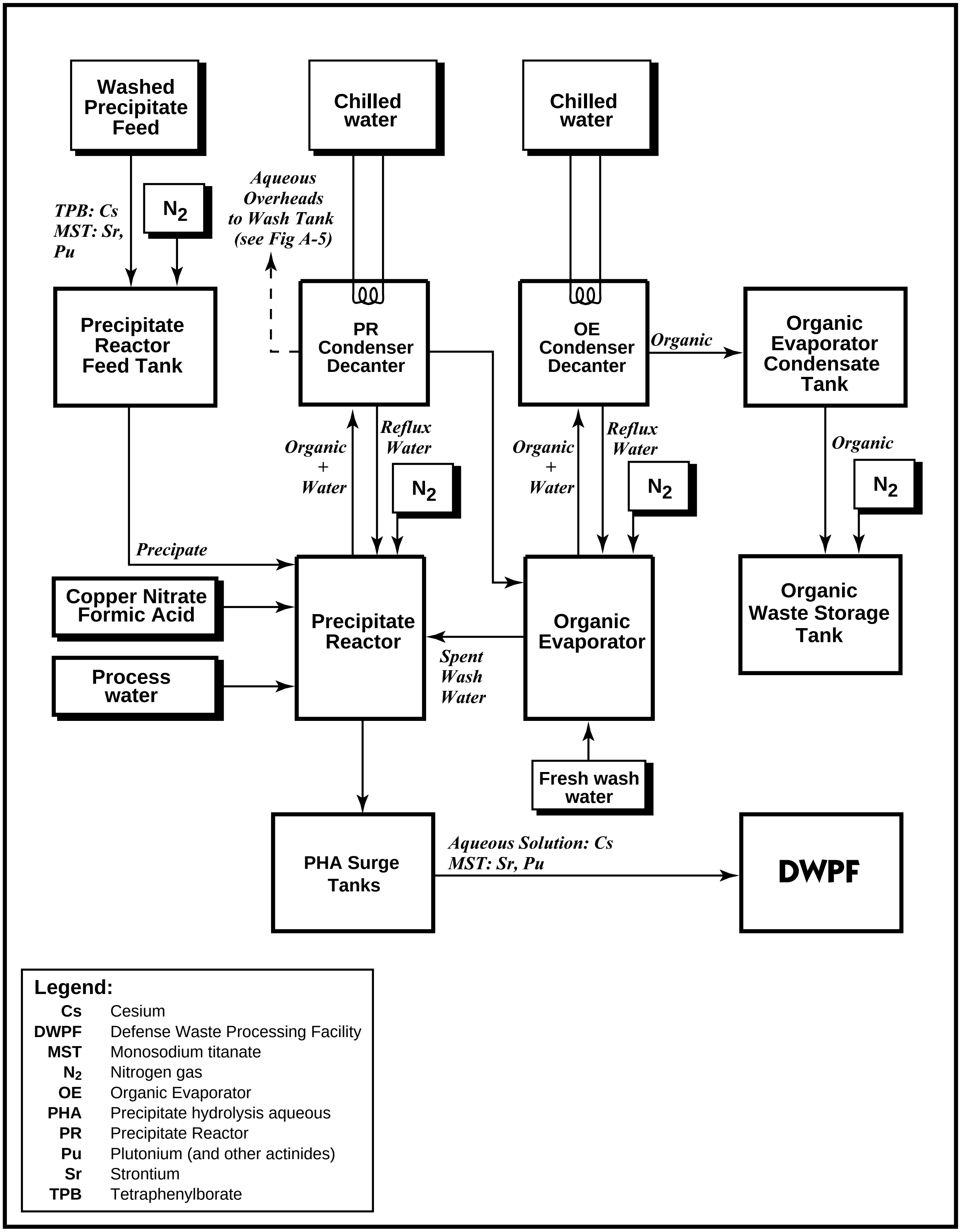

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Figure A-6. Precipitate Hydrolysis Cell flow diagram for Small Tank Precipitation process.

the washed precipitate would be combined with a copper nitrate-formic acid solution in the Precipitate Reactor to catalytically decompose the tetraphenylborate precipitate. The Precipitate Reactor would be heated to boiling and the benzene would be removed as it is formed. The benzene and water vaporized during boiling would be condensed in the Precipitate Reactor Condenser, with aqueous and organic condensates separated by decantation for return to the Precipitate Evaporator and Organic Evaporator, respectively. After a period of reflux boiling, the PHA product would be concentrated by distillation, with the aqueous overheads transferred to the Precipitate Wash Tank.

A second evaporation would be conducted in the PHC to ensure that the separated organic was sufficiently decontaminated for transfer outside the containment area. Wash water would be added to the Organic Evaporator and the boiling, evaporation, and decantation cycle would be repeated, with the twice-distilled benzene collected in the Organic Evaporator Condensate Tank for transfer to the Organic Waste Storage Tank.

The tetraphenylborate employed in the Small Tank Precipitation process could undergo radiolytic and, under certain conditions, catalytic degradation, producing benzene before the decomposition reactions prescribed in the PHC. The Small Tank Precipitation process would require controlled benzene removal in all steps. Benzene production in the precipitation and washing operations would be limited by the continuous processing of relatively small waste volumes, by a short processing time, and by chilling the process vessels. Accumulation of benzene would be avoided by continuous agitation to prevent retention in the process mixtures and a flowing nitrogen gas blanket to sweep benzene vapors from the system. Benzene formation during precipitate decomposition in the PHC would be controlled by process constraints, with all process vessels purged with nitrogen to maintain oxygen concentrations below combustion limits.

A.4.3.2 Crystalline Silicotitanate Ion Exchange

The Ion Exchange Process (WSRC 1998e,g,h) would employ a crystalline silicotitanate particulate solid (resin) to remove the cesium from the salt solution. In the ion exchange reaction, the radioactive cesium displaces nonradioactive constituents (sodium) of the resin. As in the Small Tank Precipitation process, residual strontium and actinides in the salt solution would be sorbed onto monosodium titanate and, in conjunction with residual sludge, filtered from the salt solution prior to the crystalline silicotitanate ion exchange treatment. The cesium-loaded crystalline silicotitanate resin and the monosodium titanate solids would be transferred to DWPF as slurries to be combined with sludge for incorporation into the glass waste form. Low activity salt solution would be immobilized as saltstone in onsite vaults at the Saltstone Manufacturing and Disposal Facility.

The Ion Exchange process would be performed in a new facility built at Site B in S Area. Process operations are illustrated in the flow diagram in Figure A-7. Salt solution would be pumped from an H-Area tank to the Ion Exchange facility. A new feed line between the existing inter-area transfer line and the Ion Exchange facility would be required for this transfer. In initial feed clarification operations in the batch Alpha Sorption Tank, the salt solution would be mixed with monosodium titanate to sorb soluble strontium and actinides and then filtered by cross-flow filtration to remove monosodium titanate solids and residual sludge. These clarification operations would be necessary to prevent plugging of the ion exchange columns during subsequent processing of the salt solution. The product slurry, washed and concentrated to about 5 weight percent solids, would be pumped through new and existing transfer lines to DWPF as feed for the vitrification process.

After filtration, the clarified salt solution would be transferred to the Recycle Blend Tank in the Ion Exchange facility for dilution with process

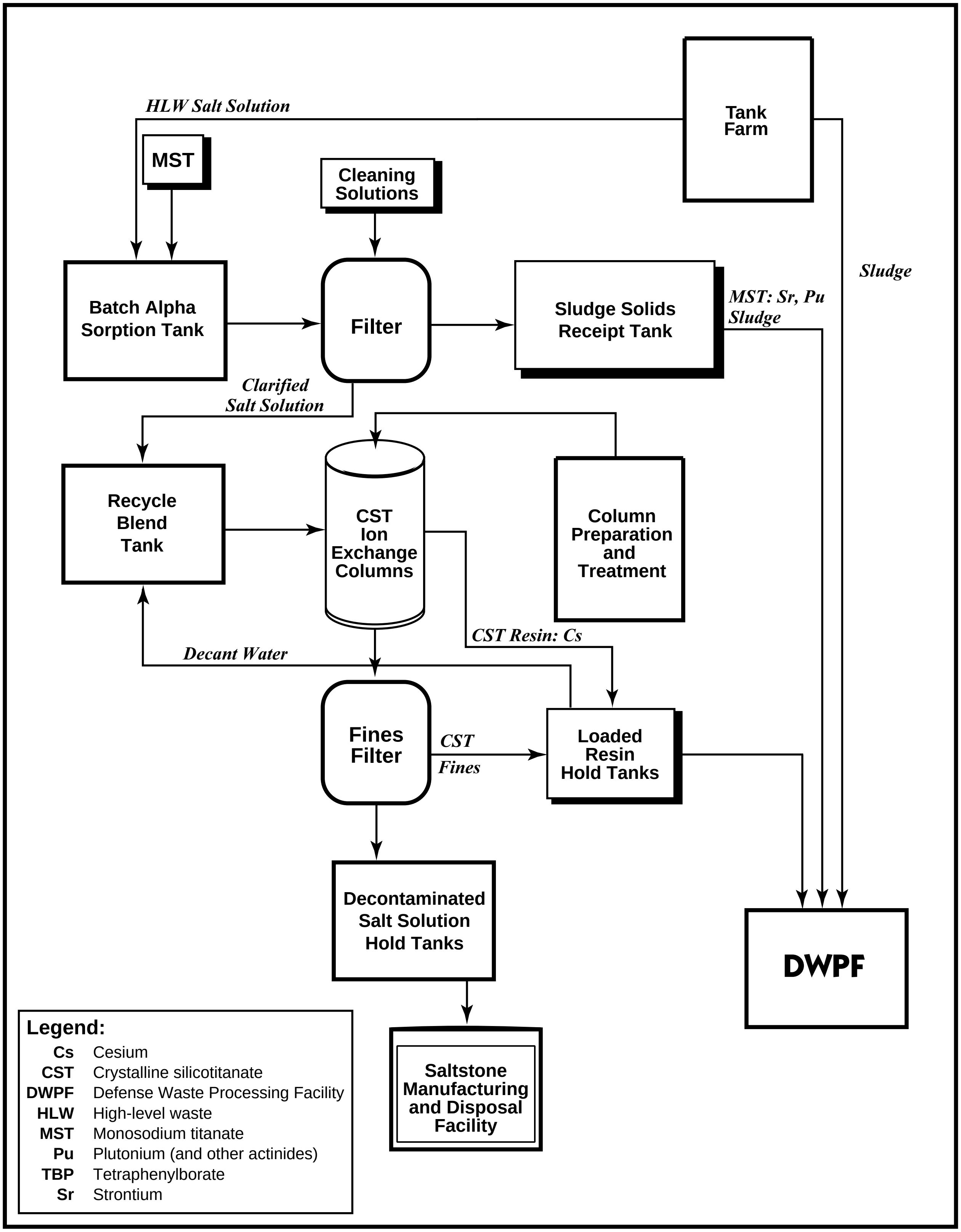

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Figure A-7. Ion Exchange process flow diagram.

water, and pumped through a series of four ion exchange columns to remove radioactive cesium. Cesium transfer from the salt solution would take place in the first three columns, with the fourth column in reserve for use when the first column in the series reached saturation (> 90 percent maximum capacity) and was taken out of service. Saturated resin in the column would be flushed with water and pumped as slurry to DWPF. The first ion exchange column would then be replenished with fresh resin and held in reserve (as the fourth column) while cesium ion exchange took place in what had been the second, third, and fourth columns. The cycle would continue with the lead column reaching saturation and the reserve column becoming the last in the series of three operating columns. Low activity salt solution recovered as effluent from the third column would be filtered to prevent any cesium-loaded fine particles from recontaminating the salt solution. The low activity salt solution would be sampled in a Product Holdup Tank prior to transfer to the Decontaminated Salt Solution Hold Tanks, to ensure that requirements for disposal as saltstone were met. The low activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal in onsite vaults. All process wastewater would be recycled and reused.

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

A.4.3.3 Caustic Side Solvent Extraction

In the Solvent Extraction process (WSRC 1999b,c), radioactive cesium would be separated from the caustic HLW salt solution by extracting it from the aqueous phase into an insoluble organic phase, thereby generating a low activity salt solution for immobilization in saltstone. The separated cesium, recovered from the organic phase by back extraction (stripping) into an acidic aqueous solution, would be transferred to DWPF for incorporation, along with HLW sludge, into the glass waste form. Processing of the HLW salt solution by monosodium titanate to remove soluble strontium and actinides, followed by filtration of monosodium titanate solids and residual sludge, before the solvent extraction process would be necessary to meet saltstone acceptance limits and avoid interference of residual solids in the solvent extraction process.

The organic phase into which the cesium would be extracted is a kerosene-like solvent (diluent) containing an organic extractant (termed BoB-CalixC6) and a diluent modifier (typically Cs-7SBT). The extractant is highly specific for cesium, permitting separation from sodium by a factor of 10^4 (10,000) and from potassium by a factor of 10^2 (100). The diluent modifier increases the cesium extraction capability by increasing extractant solubility in the diluent. The subsequent stripping of separated cesium back into an aqueous solution is promoted by addition of a suppressor constituent, typically trioctylamine (TOA), to the organic phase. The TOA also mitigates the deleterious effects of impurities in the aqueous solution. Chemical structures and concentrations of the additions to the diluent organic phase are specified in the text box on page A-18.

The Solvent Extraction process would be performed in a new facility at Site B in S Area. Process operations are represented by the flow diagram in Figure A-8. In operations similar to that for the Ion Exchange process, initial clarification of the salt solution in the Batch Alpha Sorption Tank would remove strontium and actinides by sorption onto monosodium titanate, followed by filtration of the monosodium titanate solids and any residual sludge, for transfer to DWPF. The separation of radioactive cesium from the salt solution by solvent extraction would take place in a multi-stage countercurrent extraction facility. The facility consists typically of an assembly of centrifugal two-phase contactors for extraction of cesium into the organic phase, scrub contactors for removing non-cesium salt constituents from the organic phase, and strip contactors for back extraction of the cesium into an acidic aqueous stream. The design and operation of the centrifugal contactors is shown in the text box on page A-19.

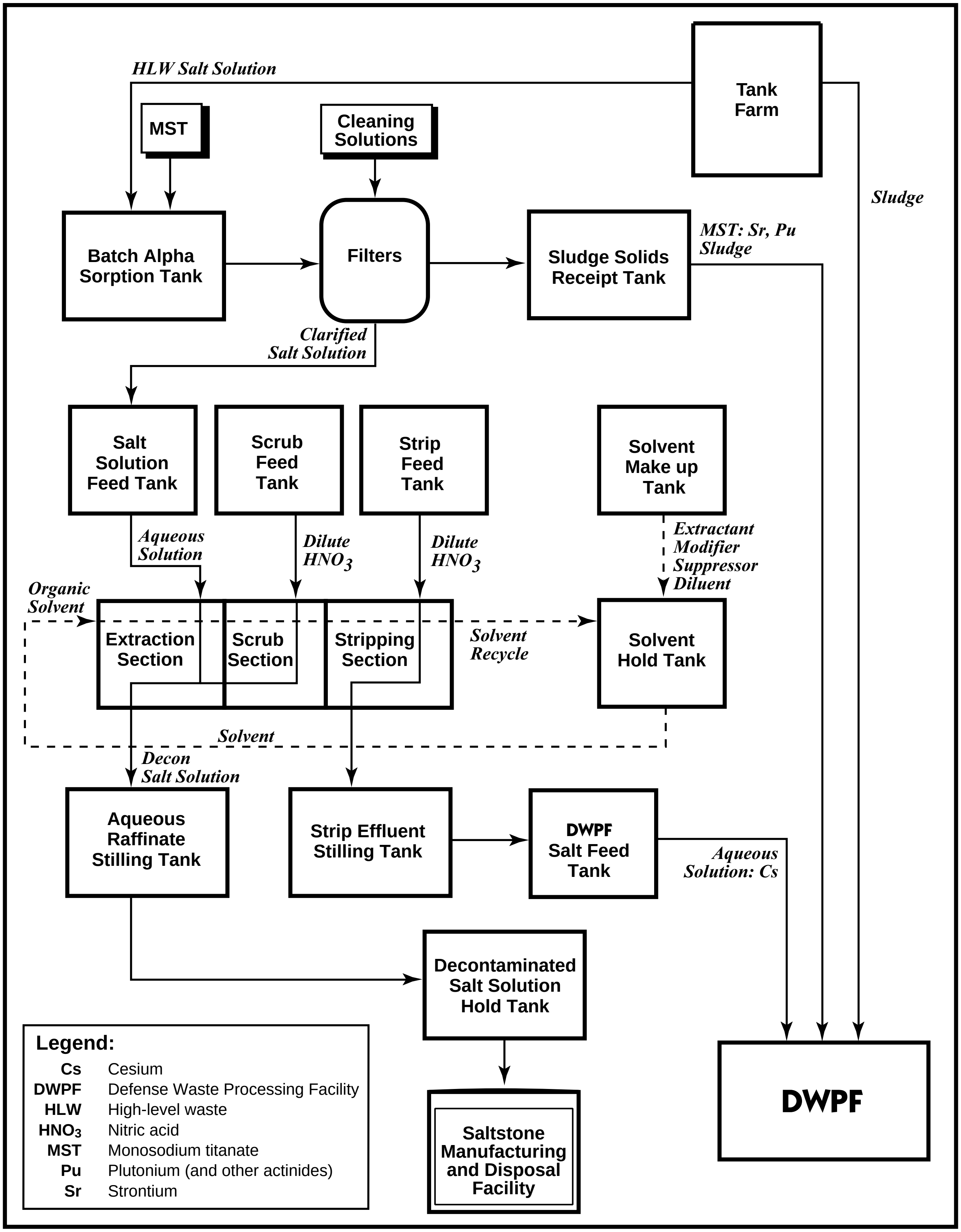

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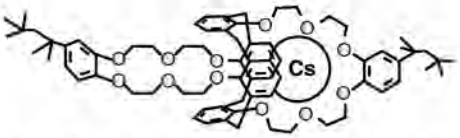
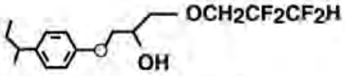
Figure A-8. Solvent Extraction process flow diagram.

Components of Organic Phase used in Solvent Extraction Process

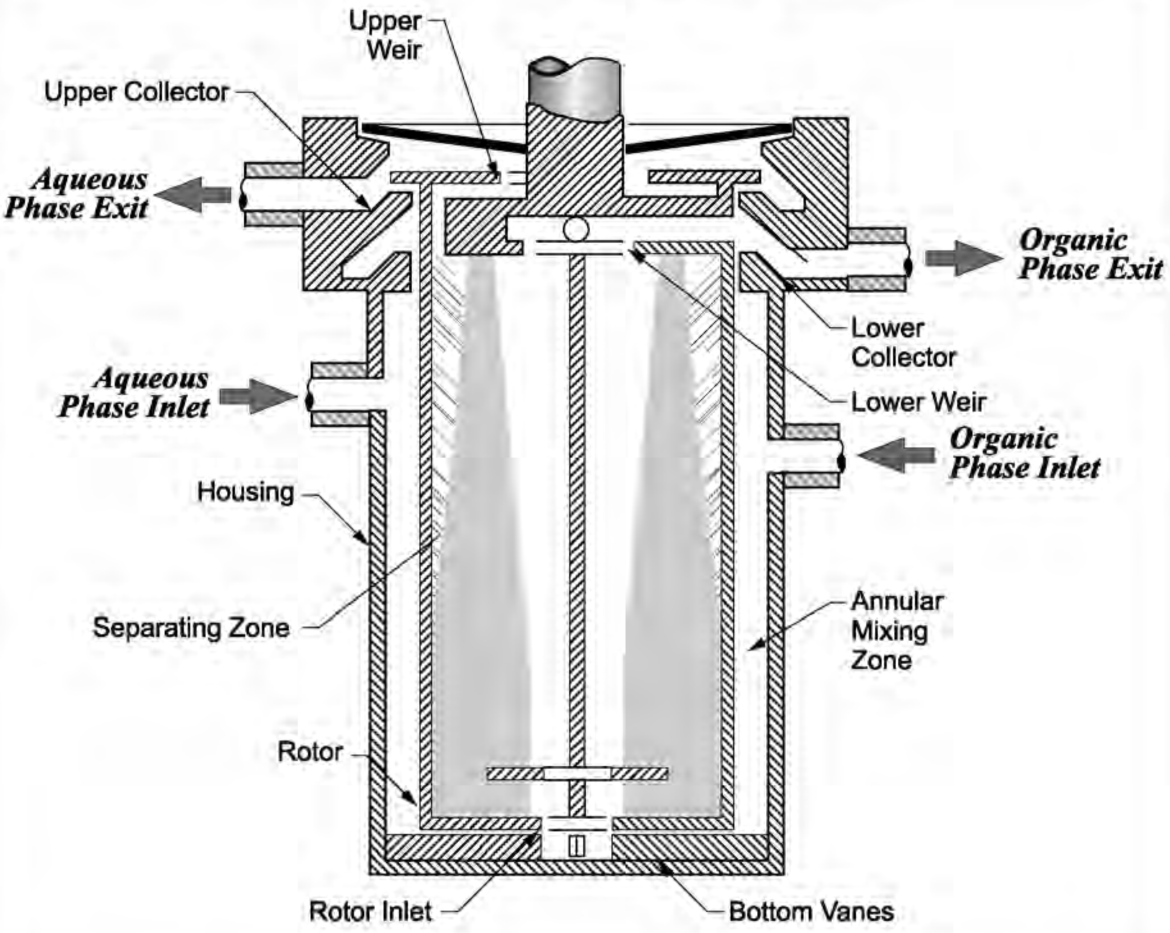
Chemical Type	Concentration in Solvent	Function
Diluent Blend of alkane hydrocarbons "Isopar ® L"	Principal component	Organic phase solvent
Cesium Extractant (with complexed Cs)  Cs Calix[4]arene-bis(*tert*-octylbenzo-crown-6) "BoBCalixC6"	0.01 M	Highly specific Cs extraction into organic phase from caustic aqueous solution
Diluent Modifier  $OCH_2CF_2CF_2H$ OH Aromatic fluoroalcohol "Cs-7SBT"	0.5 M	Increases extractant strength for Cs, prevents precipitation and third phase formation
Suppressor $N(C_8H_{17})_3$ Trioctylamine "TOA"	0.001 M	Promotes back extraction of Cs from organic to aqueous phase during stripping operation

NW SDA EIS/Grfx/App A/Comp organic.ai

The cesium-containing caustic salt solution injected into the contactor assembly at the head end of the extraction section (between extraction and scrub sections) would be progressively depleted of cesium as the aqueous phase moves through the extraction contactors, and would emerge at the back end of the extraction section as a salt solution with very low cesium content. The organic phase (solvent), injected at the back end of the extraction section for countercurrent movement through the contactors, would be progressively concentrated with cesium, scrubbed to remove other salt constituents, then stripped of cesium by contact with a dilute acid aqueous stream. The strip effluent would emerge from the back end of the stripping section as a high-cesium-containing aqueous solution. The organic solvent recovered from the stripping operation would be washed with dilute acid and caustic to remove degradation products, and recycled through the extraction process, with losses made up by replacement. Occasional purging of degraded solvent during washing would generate a low-volume organic waste stream that would be stored for appropriate disposal.

Following solvent extraction separations, both decontaminated salt (raffinate) and concentrated cesium solutions (strip effluent) would be processed through stilling tanks, to float and decant entrained organic (mostly diluent) before transferring the solutions to final disposition. The decontaminated raffinate solution would be

Centrifugal Contactor Design and Operation



The separation of radioactive cesium from a high-level waste salt solution by solvent extraction utilizes countercurrent centrifugal contactors to provide high surface area interaction between the organic solvent and aqueous solution. These contactors consist of a rapidly rotating inner chamber (rotor) contained within a stationary housing, allowing mixing of organic and aqueous phases as an emulsion in the outer chamber, followed by centrifugal separation of the lesser density organic phase from the greater density aqueous phase in the rotor. The organic and aqueous phases are injected into the housing for transport through an annular mixing zone to an inlet at the bottom of the rotor. Centrifugal separation of the two phases occurs in the rotor as the emulsion flows upward, collected at the top as aqueous phase from the outer circumference and as organic phase from the center of the rotor. For extraction cycles, the cesium is transferred from the caustic aqueous phase to the organic phase and for stripping cycles it is transferred from the organic phase to an acidic aqueous phase during contactor operation.

NW SDA EIS/Grfx/App A/Centrifugal.ai

consigned to a hold tank for processing to saltstone and the strip effluent solution, assuming no concentration by evaporation, would be transferred to a hold tank for vitrification in DWPF. The wash solutions from the organic solvent cleanup would be processed to saltstone.

A.4.3.4 Direct Disposal in Grout

In the Direct Disposal (of cesium) in Grout alternative (WSRC 1998e), the HLW salt solution would be immobilized in saltstone vaults without separation of the radioactive cesium. The saltstone produced would meet acceptance criteria for near-surface disposal of low-level radioactive Class C waste (as defined in 10 CFR 61.55), but would exceed limits for Class A wastes. Treatment of the salt solution to remove strontium and actinides, as well as residual sludge, would still be required to meet restrictions on alpha-emitting radionuclides and HLW constituents in the saltstone.

If saltstone waste containing radioactive cesium was disposed in Z-Area vaults, revision of the existing SCDHEC permit for saltstone disposal would be required. The current SCDHEC permit restricts saltstone vault disposal to wastes containing radioactive constituents within Class A limits, although wastes with higher radionuclide content would be allowed if shown to not produce unacceptable radiation exposure to the public, onsite workers, and inadvertent intruders. A performance assessment to demonstrate acceptability of the high-radioactivity cesium grout in the vaults would be required for the Direct Disposal in Grout alternative.

For the Direct Disposal in Grout alternative, a new facility would be constructed in Z Area, using grout production equipment modified to provide radiation shielding and enable remote operation and maintenance, because of the anticipated radioactive cesium concentrations. Direct Disposal in Grout process operations are illustrated in the flow diagram in Figure A-9. The salt solution would be collected in an H-Area tank and pumped to the Direct Disposal in Grout facility through a new Low Point Drain Tank (LPDT) facility, using the existing inter-area line. The new LPDT would be required to provide adequate shielding for the higher radioactivity in the waste stream than is present in the current feed.

In the new Direct Disposal in Grout facility, salt solution would be fed into a large Batch Alpha Sorption Tank for treatment with monosodium titanate to remove soluble radioactive contaminants other than cesium (strontium and actinides). The monosodium titanate and entrained sludge solids would be separated from the salt solution by cross-flow filtration and washed. The washed solids, collected as slurry in the Sludge Solids Receipt Tank, would be pumped through new and existing transfer lines to the DWPF melter for conversion into the glass waste form. This would be the only Direct Disposal in Grout waste stream incorporated into the DWPF waste glass production operation.

The clarified salt solution resulting from monosodium titanate treatment in the Direct Disposal in Grout facility would be transferred to a Salt Solution Hold Tank to be processed to saltstone.

During saltstone processing, the filtered salt solution would be pumped to a mixer and combined with flyash, cement, and slag to form a batch of grout for disposal in the saltstone vaults. The grout mixture would be pumped to a Grout Hold Tank serving as the feed tank for the Grout Feed Pumps transferring the grout to the saltstone vaults. Thirteen additional vaults would be constructed in Z Area to accommodate Direct Disposal in Grout processing. After each batch of grout was processed and transferred to a vault, the grout transfer lines, Grout Hold Tank, and Grout Feed Pumps would be flushed to remove any residual material for recycle through the process. Direct Disposal in Grout would generate no secondary waste streams.

Chemical composition of the saltstone from the Direct Disposal in Grout process is compared with that from Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes in Table A-1. Expected concentrations of major radionuclides in the saltstone are shown in Table A-2. The values are from an earlier characterization of saltstone, produced during ITP processing of HLW salt solutions (Martin

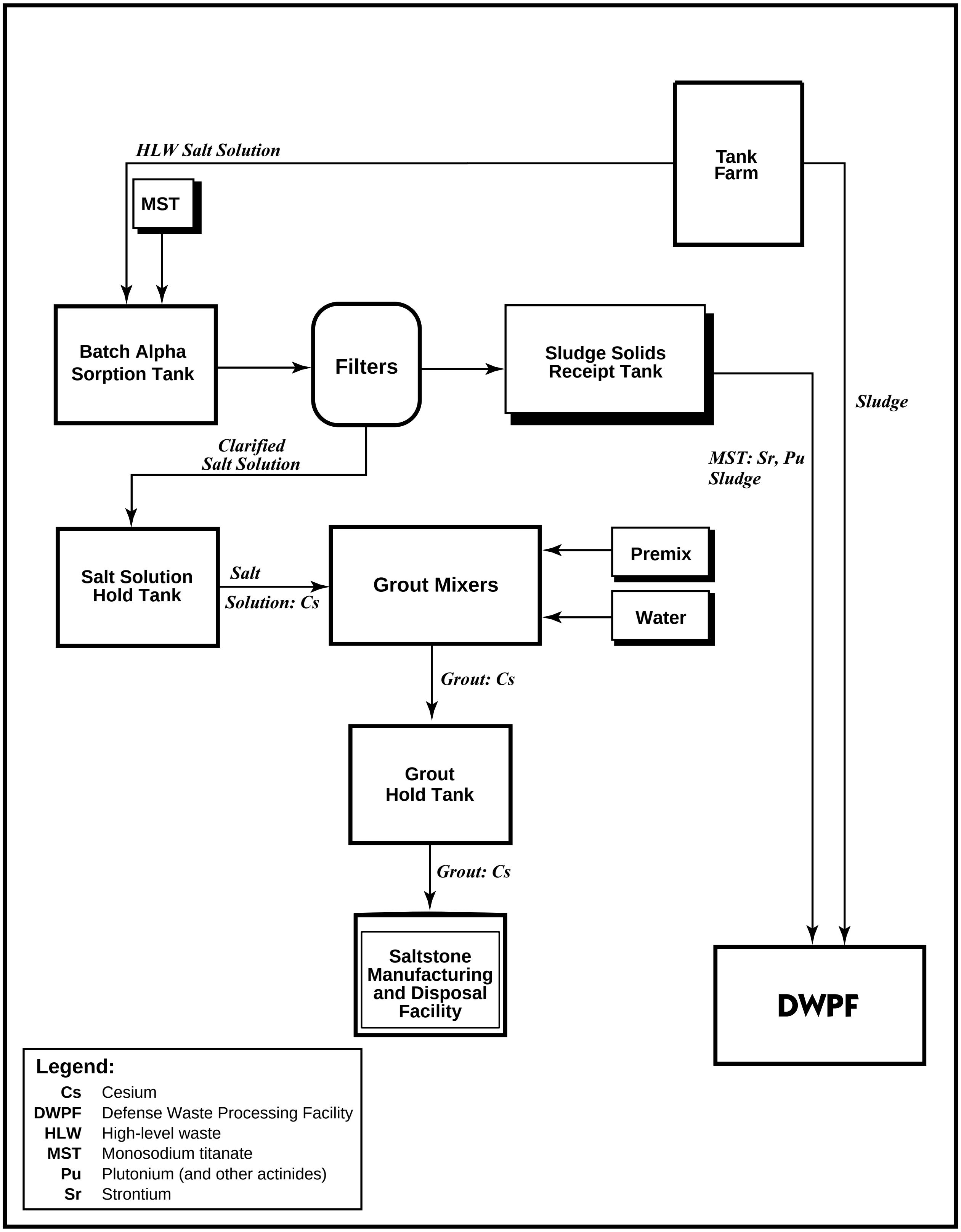


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Figure A-9. Direct Disposal in Grout process flow diagram.

Table A-1. Chemical composition of saltstone for salt processing alternatives.

	Composition, weight percent [a]			
Component	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
H_2O	33.70	32.88	34.03	32.57
$NaNO_3$	6.60	7.60	6.20	8.00
NaOH	1.90	2.20	1.80	2.40
$NaNO_2$	1.60	1.90	1.50	2.00
$NaAl(OH)_4$	1.20	1.40	0.94	1.40
$NaCO_3$	0.65	0.75	0.61	0.79
Na_2SO_4	0.65	0.75	0.61	0.79
$Na_2C_2O_4$	0.07	0.08	0.07	0.09
NaCl	0.05	0.05	0.05	0.06
Na_3PO_4	0.05	0.05	0.05	0.06
Na_2SiO_3	0.03	0.03	0.03	0.03
NH_4NO_3	0.03	0.04	0.03	0.04
$NaB(C_6H_5)_4$	0.03	-	-	-
Na_2CrO_4	0.02	0.02	0.02	0.02
NaF	0.02	0.03	0.02	0.03
$CaSO_4$	0.02	0.02	0.02	0.02
NaHgO (OH)	(b)	(b)	(b)	(b)
KNO_3	(b)	(b)	(b)	(b)
Salt Solution Total	46.61	47.80	45.98	48.30
Dry Blend[c]	53.39	52.20	54.02	51.70
Total	100	100	100	100

---

a. The values presented are taken from a previous characterization of saltstone produced during ITP processing of HLW Salt Solution (Martin Marietta 1992), adjusted for dilution in the new salt processing alternatives using sodium concentrations of 4.58 molar for Small Tank Precipitation, 5.31 molar for Ion Exchange, 4.30 molar for Solvent Extraction, and 5.63 molar for Direct Disposal in Grout processing, compared to 4.58 molar for ITP processing.
b. Expected present; concentration less than 0.01 weight percent.
c. Dry Blend is cement, flyash, and slag.

Marietta 1992) and adjusted for dilution by the new salt processing alternatives, based on the sodium concentrations of the saltstone feed streams.

A.4.3.5 Process Inputs and Product Streams

A general objective of the salt processing operations is the disposition of about 80 million gallons of HLW salt solution. The capacity throughputs of the process facilities are specified to maintain a long-term average drawdown of salt solution by about 6 million gallons per year, allowing completion of processing of reconstituted salt solution within about 13 years after facility startup. Processing within this time period is necessary to integrate the high-radioactivity salt waste components into the DWPF vitrification operations for processing with radioactive sludge components of the waste. (See key milestones textbox in Chapter 2).

Process throughput streams for the salt processing alternatives are compared in Table A-3.

The capacity throughputs are somewhat higher than the required long-term average throughputs for Small Tank Precipitation, Ion Exchange, and Solvent Extraction facilities to allow for DWPF outages during melter changeout. The Direct Disposal in Grout facility, not closely coupled to DWPF operation, can operate at capacity throughput equal to the required long-term average throughput (6 million gallons per year).

Table A-2. Radionuclide content of saltstone for salt processing alternatives.

	Concentration (nCi/g)			
Radionuclide	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Technetium-99	33	38	31	40
Ruthenium-106+d[a]	17	20	16	21
Cesium-137+d[a]	10	12	9	254,000[b]
Tritium	10	12	9	12
Antimony-125	3.3	3.8	3.1	4.0
Promethium-147	2.0	2.3	1.9	2.4
Samarium-151	1.0	1.2	0.95	1.2
Strontium-90+d[a]	0.35	0.40	0.33	0.42
Europium-154	0.33	0.38	0.31	0.40
Selenium-79	0.16	0.19	0.15	0.20
Europium-155	0.16	0.19	0.15	0.20
Cobalt-60	0.11	0.12	0.10	0.13
Tellurium-125m	0.10	0.12	0.09	0.12
Tin-126+d[a]	0.07	0.08	0.07	0.08
Cesium-134	0.03	0.04	0.03	440
Tin-121m	0.01	0.02	0.01	0.02
Iodine-129	0.01	0.01	0.01	0.01
Nickel-63	0.01	0.01	0.01	0.01
Antimony-126	0.01	0.01	0.01	0.01
Carbon-14	0.003	0.004	0.003	0.004
Cesium-135	0.00002	0.00002	0.00003	0.26
Other beta gamma	3.3	3.8	3.1	4.0
Plutonium-238	0.03	0.03	0.03	0.03
Plutonium-241	0.02	0.02	0.02	0.02
Americium-241	0.07	0.08	0.07	0.08

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nCi/g = nanocuries per gram.

[a] +d = with daughter product.

[b] Cesium-137+d content of the saltstone for Direct Disposal in Grout alternative corresponds to 225 Ci/m^3 of cesium-137 (WSRC 1998b,i).

Table A-3. Salt solution processed.

Alternative	Capacity throughput (million gallons per year)	Long-term average throughput (million gallons per year)	Throughput limitation
Small Tank Precipitation	6.9	6.0	Salt removal rate from waste tanks
Ion Exchange	6.9	6.0	Salt removal rate from waste tanks
Solvent Extraction	6.9	6.0	Salt removal rate from waste tanks
Direct Disposal in Grout	6.0	6.0	Salt removal rate from waste tanks

Source: WSRC (1998d).

The product outputs of the process facilities, including high-radioactivity solids slurry or solution to DWPF, processed salt solution to grout, and saltstone generated by the salt processing alternatives, are compared in Table A-4. The Solvent Extraction process would deliver a greater volume of product to DWPF than the other alternative processes because of the high volume of cesium solution (strip effluent) in the product output of that process. Salt solutions to grout and saltstone produced would be about the same for each alternative, with the ratio of saltstone volume produced to salt solution volume uniform at about 1.8.

In addition to the principal product outputs specified in Table A-4, the Small Tank Precipitation process would generate by-product benzene. About 60,000 gallons (20 metric tons) of liquid benzene would be produced annually by decomposition of the tetraphenylborate salt in the process facilities.

In the Small Tank Precipitation process, gaseous benzene would also be generated in the process facilities, to be dispersed into the atmosphere. Issues associated with gaseous benzene generation have resulted in a number of design features that would reduce or mitigate this problem. Controlled benzene removal, because of flammability concerns, would be accomplished by operating the process vessels with a nitrogen atmosphere. The tank vent systems would be equipped with both primary and backup nitrogen purge systems (WSRC 1998c). The Ion Exchange, Solvent Extraction, and Direct Disposal in Grout processes do not have the same benzene concerns. Rather, the issue for these alternatives is radiolytic decomposition of water into hydrogen and oxygen. Air sweeps of tanks are generally considered sufficient to eliminate the danger of explosions (WSRC 1998g). However, since the consequences of an explosion are unacceptable, due to the high radioactive loading

Table A-4. Product outputs.

	Annual			Life cycle		
Alternative	Solids slurry (and solution) to DWPF (gallons per year)	Salt solution to Grout (million gallons per year)	Grout produced (million gallons per year)	Solids slurry (and solution) to DWPF (million gallons)	Salt solution to Grout (million gallons)	Grout produced (million gallons)
Small Tank Precipitation (13 years)[a]	223,000	8.0	14.5	2.9	104	188
Ion Exchange (13 years)[b]	200,000	6.6	12.0	2.6[f]	86	156
Solvent Extraction (13 years)[c]	677,000[e]	7.5	13.5	8.8[e]	97	175
Direct Disposal in Grout (13 years)[d]	154,000	5.9	10.8	2.0	77	141

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a. WSRC (1998j; 2000b).
b. WSRC (1998k).
c. WSRC (1998l; 2000b).
d. WSRC (1998i).
e. Includes 154,000 gal/yr solids slurry and 523,000 gal/yr solution (strip effluent without evaporation) (WSRC 1998e).
f. Includes 2 million gallons monosodium titanate slurry and 600,000 gallons Crystalline Silicotitanate slurry (WSRC 1998e,k).

Note: Material balance estimates are ± 25 percent.

Comparison of Significant Radionuclide Concentrations in Saltstone from Direct Disposal in Grout Process with Limits for Low-Level Waste Disposal Categories (10 CFR 61.55)

Radionuclide	Concentration in Saltstone (Ci/m^3)	Concentration Limit (Ci/m^3)		
		Class A	Class B	Class C
Long-Lived Activities				
Technetium-99	0.07	0.6	0.6	6.0
Iodine-129	0.00002	0.002	-	0.02
Total alpha	0.0002	0.03	0.03	0.3
Short-Lived Activities				
Tritium	0.02	80	(a)	(a)
Strontium-90	0.0004	0.04	150	7,000
Cesium-137	225	1	44	4,600

a. No limit.
Ci/m^3 = curies per cubic meter.

within the process tanks, the design for Ion Exchange, Solvent Extraction, and Direct Disposal in Grout facilities would include both primary and backup purge systems, comparable to those used in the Small Tank Precipitation facility.

The Solvent Extraction process would also generate a liquid organic waste requiring final disposition (WSRC 2000c). The total solvent inventory for the process, consisting primarily of the diluent Isopar®L, is projected to be 1,000 gallons. This inventory is conservatively assumed to be replaced once per year. For an operational time of 13 years, the accumulated total volume of solvent requiring disposition would be 13,000 gallons. Onsite or offsite disposal of this solvent is projected.

A.5 Process Facilities

A.5.1 PROCESS BUILDINGS

New shielded process buildings (WSRC 1998e,m) would be constructed for each salt processing alternative. The process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives would be at Site B in S Area and for the Direct Disposal in Grout alternative, they would be in Z Area.

In each case, the process buildings would be constructed of reinforced concrete and include the shielding required for handling highly radioactive materials. The facilities would be sized to contain large feed, storage, and product hold tanks to ensure an average processing rate of 25,000 gallons per day of salt solution. The size of the tanks would also serve to decouple or buffer the continuous flows of the Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes from the batch flows of the tank farms, and ensure the capability to process the expected average 6 million gallons-per-year of salt solution.

The building specifications would be similar for each of the four salt processing alternatives. Preliminary design dimensions are provided in Table A-5. The buildings would range from 64 to 71 feet above ground level, with crane maintenance bays up to 106 feet high. They would extend down to as much as 45 feet below ground level, allowing shielded, remotely operated, chemical processing cells to be located partially below grade. Site requirements for each alternative process facility are presented in Table A-6.

Adjacent operating areas above grade would extend around the perimeter of the processing cells and contain chemical feed pumps and tanks, radioactive and non-radioactive laboratories for sample testing, electrical and mechanical

Table A-5. Building specifications for each action alternative.

	Process Alternative[a]			
	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	4,500,000	3,600,000	3,900,000	1,200,000
Processing cell floor area, ft.^{2}	16,000	12,000	13,000	11,000
Processing cell volume, ft.^{3}	640,000	550,000	600,000	570,000

Source: WSRC (1998i).

a. Building specifications rounded to two significant figures.

Table A-6. Site requirements for the process building and required support facilities.

Small Tank Precipitation, Ion Exchange, and Solvent Extraction Alternatives	Direct Disposal in Grout Alternative
Clear 23 acres in S Area	Clear 15 acres in Z Area
Construct 5,000 linear feet of access roads	Same
Construct 1,000 linear feet of site roads	Same
Construct a paved parking area for 200 cars (40,000 square feet)	Same
Construct a storm sewer system	Same
Construct site security fence with two vehicle gates	Same
Construct a security fence around the substation	Same
Construct 2,500 feet of sewer line to tie into the existing sewer system	Same
Construct 3,000 feet of water line to tie into the existing potable water system	Construct 2,000 feet of water line
Construct 7,500 feet of power line	Construct 700 feet of power line
Construct a 13.8-kV to 480-V switchyard	Same
Install yard piping for water and sewer distribution systems	Same
Install electrical ductbank distribution system	Same
Install security lighting	Same

Source: WSRC (1998m).

equipment areas, and a truck unloading area. Shielded maintenance areas would be provided for remote equipment laydown, equipment decontamination, and crane maintenance. Figure A-10 presents the floor plan for the Small Tank Precipitation facility, and Figure A-11 presents the elevation for the facility. Figures A-12 and A-13 present the corresponding plans for the Ion Exchange facility, Figures A-14 and A-15 for the Solvent Extraction facility, and Figures A-16 and A-17 for the Direct Disposal in Grout facility.

The process cells would contain equipment required for the respective process alternatives. These include precipitate and sorption reactor tanks; chemical storage, feed, and product hold tanks with associated transfer and sample pumps; pass-through filter assemblages; and grout mixers and transfer equipment. In the case of the Ion Exchange alternative, the ion exchange columns for cesium removal would also be housed in the process cells. In the case of the Solvent Extraction alternative, the centrifugal contactors would be housed in the process cells.

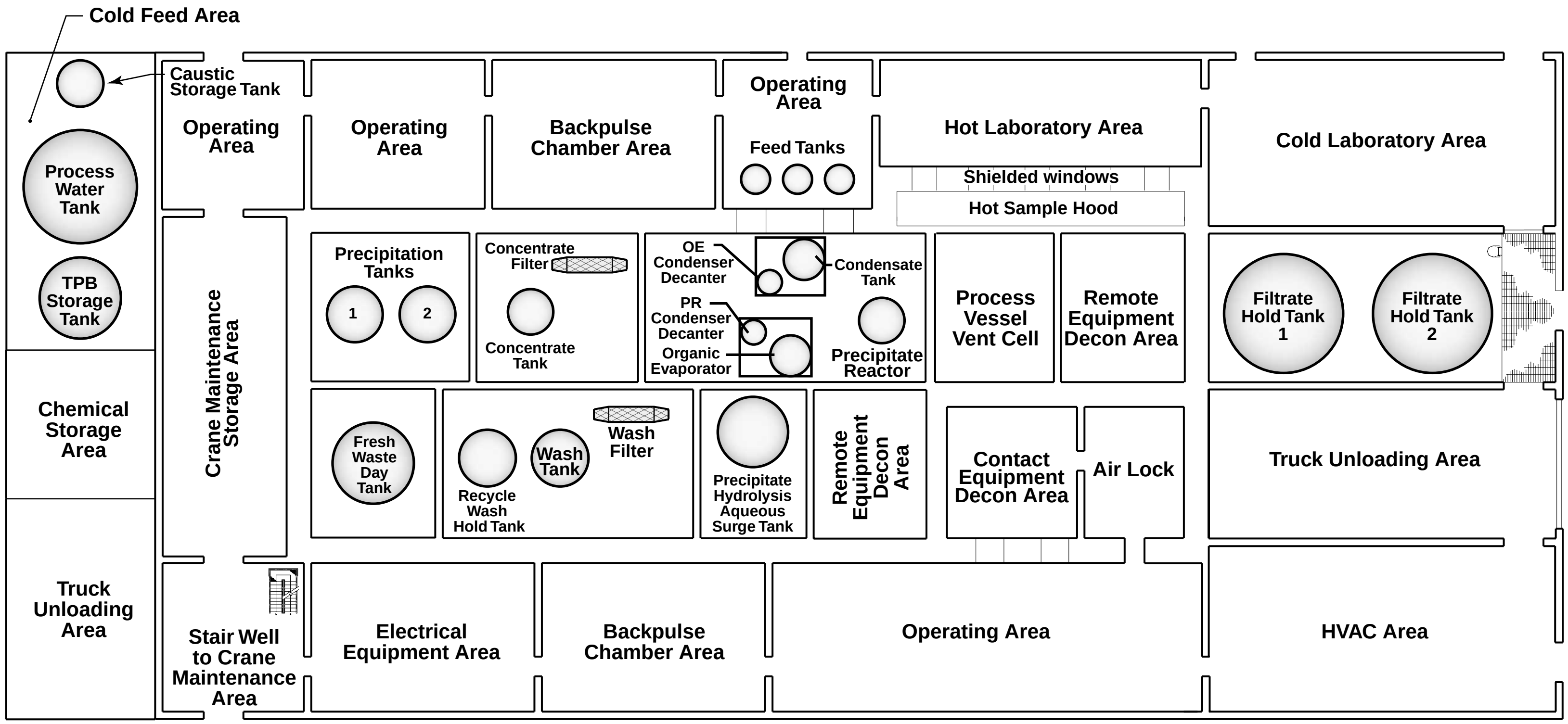
Sumps with leak detection and collection capability would be provided in the cells. The cells would be protected by concrete cell covers and accessible by a remotely-operated crane. The building configurations would allow crane or manipulator access to all shielded process, maintenance, and sampling areas. The cell components would be designed for remote maintenance, replacement, and later decommissioning.

Safety features for each salt processing alternative incorporated into facility design would include:

- Systems to detect leaks in processing piping and vessels
- Structurally strengthened process buildings and process cells to protect process vessels and equipment in case of seismic or other natural phenomena hazard events
- Process vessel vent or purge systems
- Systems to cover process vessels with inert gases, to prevent catastrophic fires
- Leak detection systems and engineered safety features, designed to automatically stop the process before material is released to the environment, if a leak is detected
- Primary confinement of process piping and vessels that could withstand natural phenomena hazard events
- Secondary confinement systems, including ventilation systems, designed to prevent or mitigate unscheduled events and to continue operating, even in the event of a loss of power
- Seismically-qualified equipment, including vessels and piping
- Remote operations
- Adequate shielding
- Temperature monitoring systems to alert operators to any loss of cooling for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction processes
- Radiation and airborne contamination monitors.

A.5.2 TANK REQUIREMENTS

The types and sizes of process and storage tanks and vessels needed for facility operations would depend on the salt processing alternative utilized. Summary listings of the tanks required for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout processes are given in Tables A-7, A-8, A-9, and A-10, respectively (WSRC 2000d). The characteristics of these tanks form the basis for development of accident scenarios and consequences projected in Appendix B.



Small Tank Precipitation Facility Floor Plan

Legend:

HVAC	Heating, ventilation, air conditioning
PR	Precipitate Reactor
OE	Organic Evaporator

Note: Only process areas are shown.

Source: Modified from WSRC (1998g).

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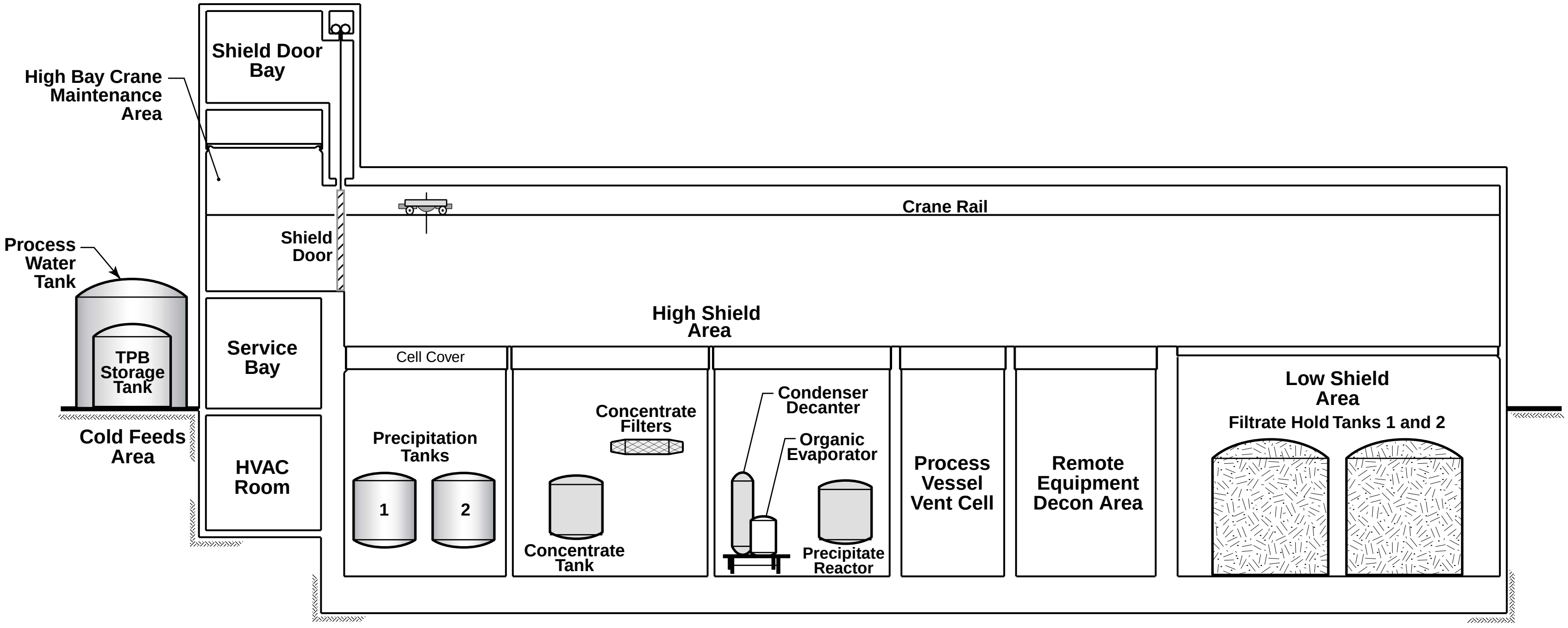
Figure A-10. Floor plan for Small Tank Precipitation facility.



Small Tank Precipitation Facility Elevation

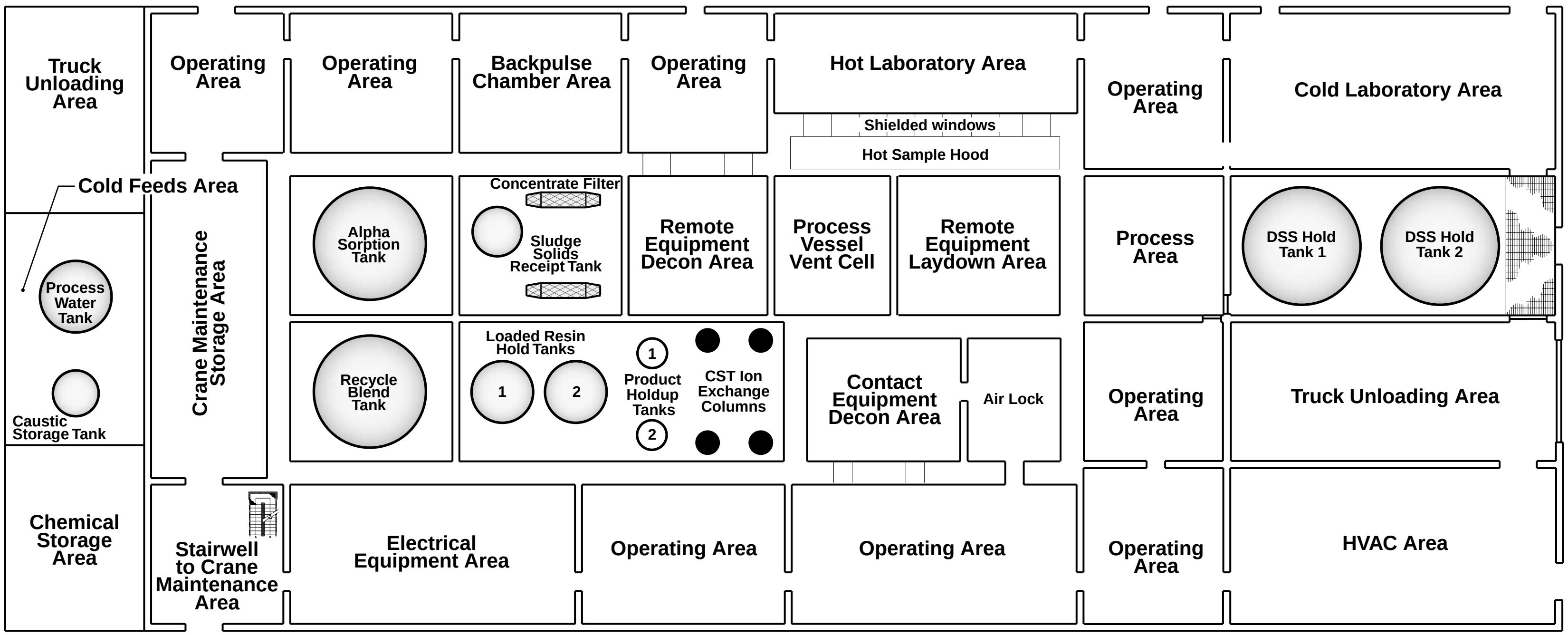
HVAC	Heating, ventilation, air conditioning
TPB	Tetraphenylborate

Note: Only process areas are shown.

Source: Modified from WSRC (1998g).

NW SDA EIS/Grfx/App_A/A_11 Elev Sm T.ai

Figure A-11. Elevation Plan for Small Tank Precipitation facility.



Ion Exchange Facility Floor Plan

Legend:

CST	Crystalline silicotitanate
DSS	Decontaminated salt solution
HVAC	Heating, ventilation, air conditioning

Note: Only process areas are shown.
Source: Modified from WSRC (1998g).

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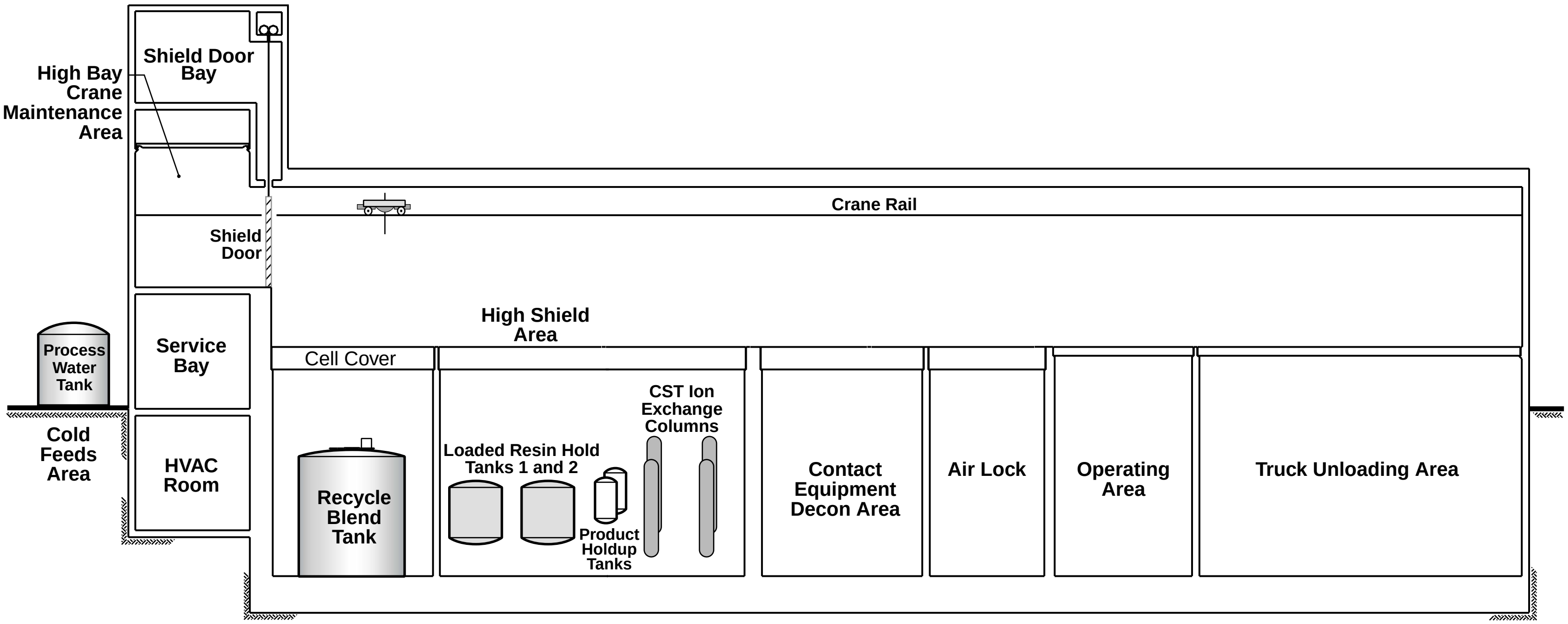
Figure A-12. Floor plan for Ion Exchange facility.



Ion Exchange Facility Elevation

Legend:

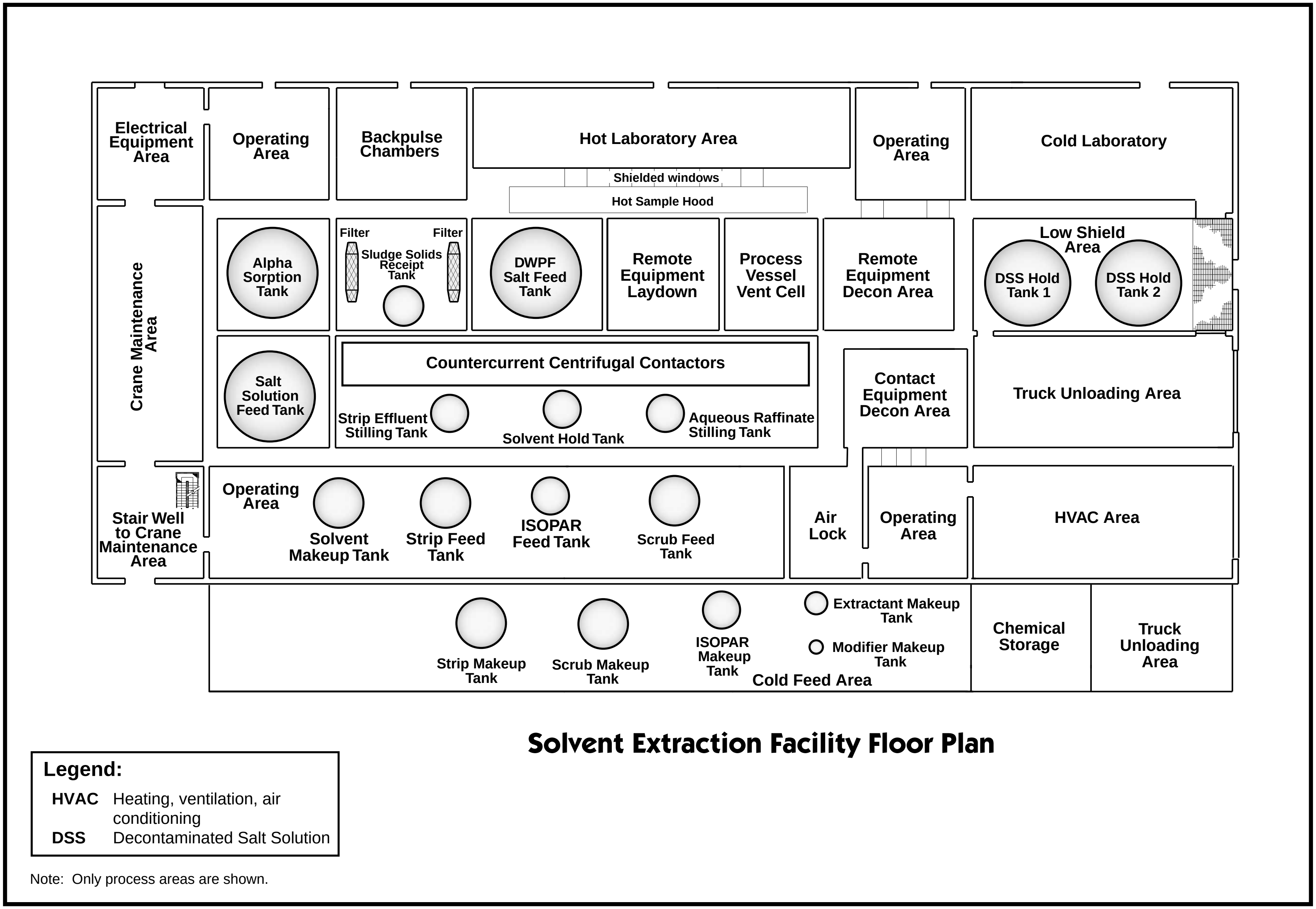
CST	Crystalline silicotitanate
DSS	Decontaminated salt solution
HVAC	Heating, ventilation, air conditioning

Note: Only process areas are shown.

Source: Modified from WSRC (1998g).

NW SDA EIS/Grfx/App_A/A-13 Elev CST Ion.ai

Figure A-13. Elevation plan for Ion Exchange facility.



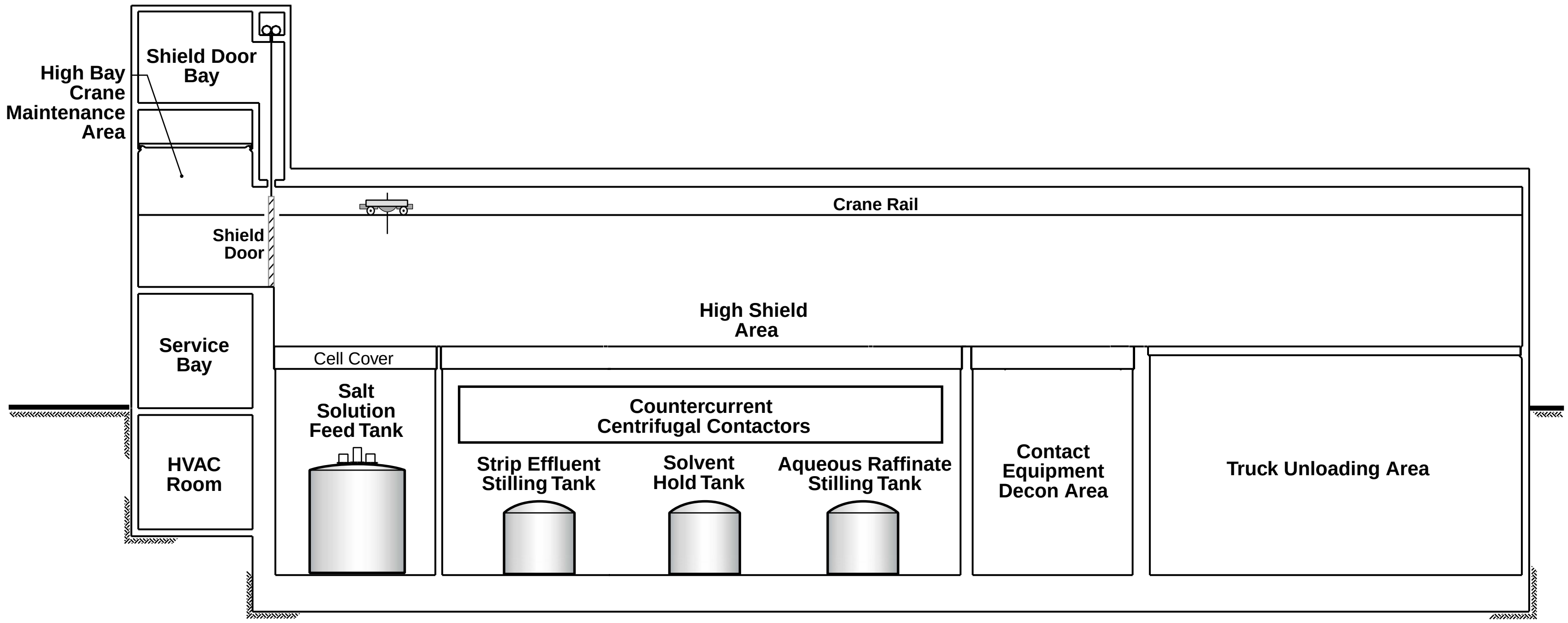
Legend:

HVAC	Heating, ventilation, air conditioning
DSS	Decontaminated Salt Solution

Note: Only process areas are shown.

NW SDA EIS/Grfx_NW_SDAEIS/App_A/A-14 Fl Plan CS.ai

Figure A-14. Floor plan for Solvent Extraction facility.



Solvent Extraction Facility Elevation

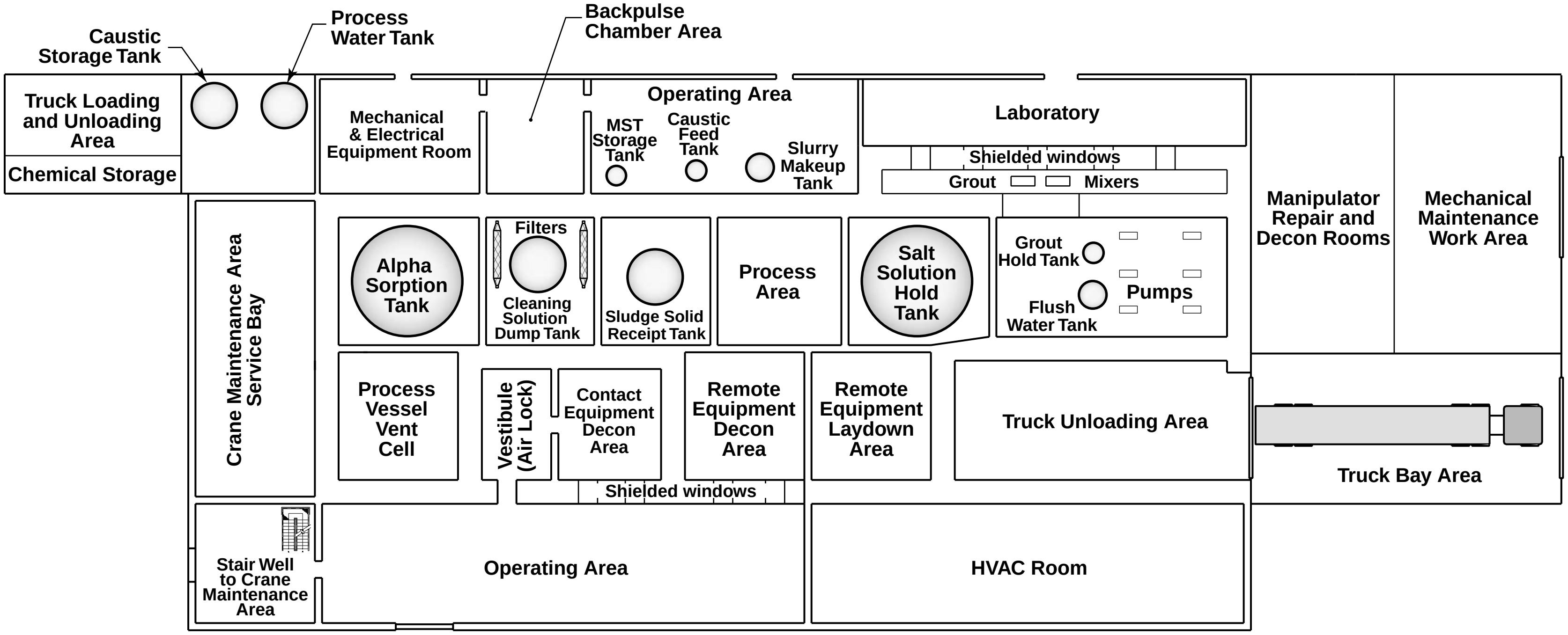
Legend:

HVAC Heating, ventilation, air conditioning

Note: Only process areas are shown.

NW SDA EIS/Grfx/App_A/A-15 Elev plan CS.ai

Figure A-15. Elevation plan for Solvent Extraction facility.



Direct Disposal in Grout Facility Floor Plan

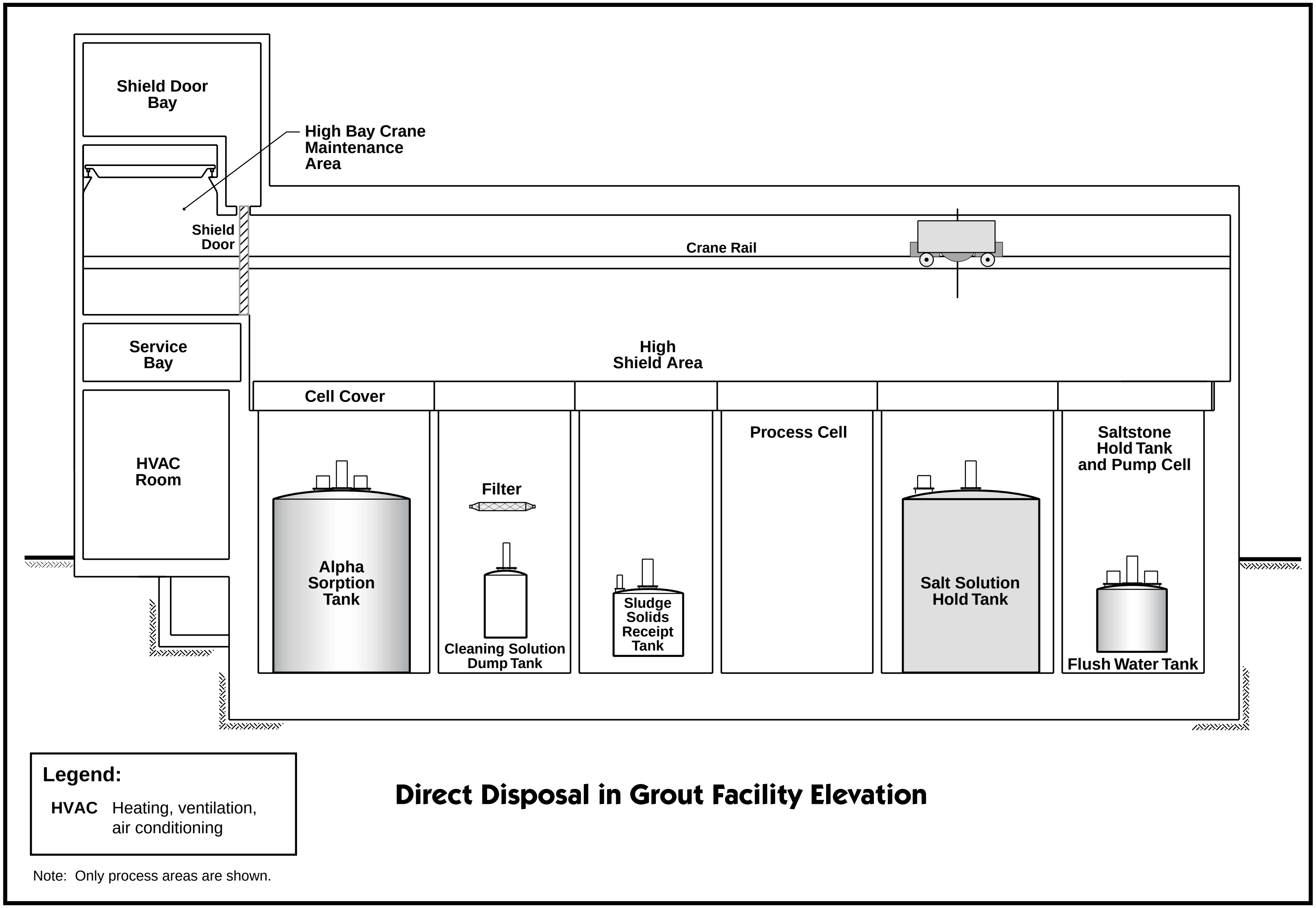
Legend:

HVAC	Heating, ventilation, air conditioning
MST	Monosodium titanate

Note: Only process areas are shown.

NW SDA EIS/Grfx/App_A/A-16 Fl Dir Disp.ai

Figure A-16. Floor plan for Direct Disposal in Grout facility.



Direct Disposal in Grout Facility Elevation

Legend:

HVAC	Heating, ventilation, air conditioning

Note: Only process areas are shown.

NW SDA EIS/Grfx/App_A/A-17 Dir Disp elev.ai

Figure A-17. Elevation plan for Direct Disposal in Grout facility.

Table A-7. Tanks for Small Tank Precipitation Process.

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation flow per tank (cfm)
MST Storage Tank	400	1	No	MST	Natural
Process Water Tank	80,000	1	No	Well water	Natural
NaTPB Storage Tank	20,000	1	No	NaTPB solution	100
Copper Nitrate Feed Tank	500	1	No	15 wt% Copper Nitrate	Natural
Formic Acid Feed Tank	500	1	No	90 wt% Formic Acid	Natural
Fresh Waste Day Tank	25,000	1	Yes	Feed	100
Precipitation Tank	15,000	2	Yes	Feed/PPT	10
Concentrate Tank	10,000	1	Yes	PPT	10
Filtrate Hold Tanks	100,000	2	Yes	DSS	10
Wash Tank	10,000	1	Yes	PPT	10
Recycle Wash Hold Tank	10,000	1	Yes	Feed/DSS[a]	10
Precipitate Reactor Feed Tank	10,000	1	Yes	PPT	10
Precipitate Reactor	10,000	1	Yes	PPT/PHA	10
Precipitate Reactor Condenser	610	1	Yes	PHA	(b)
Precipitate Reactor Decanter	610	1	Yes	PHA	(b)
Precipitate Reactor Overheads Tank	7,500	1	Yes	Dilute PHA[c]	10
Precipitate Hydrolysis Aqueous Surge Tank	40,000	1	Yes	PHA	10
Organic Evaporator	1,750	1	Yes	Benzene[d]	10
Organic Evaporator Condenser	610	1	Yes	Benzene[d]	(b)
Organic Evaporator Decanter	610	1	Yes	Benzene[d]	(b)
Organic Evaporator Condensate Tank	1,000	1	Yes	Benzene[d]	(b)
Salt Cell Vent Condenser	310	1	Yes	Benzene[d]	(b)
Organic Waste Storage Tank	40,000	1	Yes	Benzene[d]	10
Cleaning Solution Dump Tanks	1,000	2	Yes	0.01 × PPT[e]	10

DSS = Decontaminated Salt Solution, cfm = cubic feet per minute, PPT = Precipitate slurry, PHA = Precipitate Hydrolysis Aqueous, NaTPB = sodium tetraphenylborate.

a. Recycled wash water will hold a diluted DSS but with higher cesium concentration. This stream is conservatively chosen to be feed for radionuclide emissions and DSS for chemical emissions.

b. Condensers and decanters do not have independent ventilation. The vapor stream that enters each of these devices includes the nitrogen purge of each of the originating vessels.

c. The final processing step in the precipitate reactor concentrates PHA by evaporation. This is the only time the precipitate reactor overheads tank receives any waste. The condensed overheads consists of water and entrained PHA. The amount of entrainment is assumed the same as any other boiling interface, $DF=4.4 \times 10^6$.

d. Benzene includes minor quantities of other, heavier organic compounds including biphenyl. The radionuclide concentration in the solution is less than dilute PHA and make an insignificant contribution to radionuclide emissions.

e. Cleaning solution is used to clean the cross flow filters and may be contaminated with some dilute mixture of PPT slurry. This stream is conservatively chosen to be 0.01 times the concentrations for PPT slurry.

Table A-8. Tanks for Ion Exchange Process.

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation Flow per tank (cfm)
Process Water Tank	20,000	1	No	Well Water	Natural
MST Storage Tank	400	1	No	MST	Natural
Caustic Feed Tank	5,000	1	No	1 M NaOH	100
Resin Make-up Tank/Column Preparation Tank	2,000/ 3,000	1	No	CST	100
Oxalic Acid Feed Tank	200	1	No	2% $H_2C_2O_4$	100
Caustic Feed Tank	500	1	No	1 M NaOH	100
Loaded Resin Hold Tank	15,000	2	Yes	CST	100
Ba-137 Decay Tanks/Product Holdup Tank	2,000/ 5,000	2	Yes	DSS	100
DSS Hold Tanks	100,000	2	Yes	DSS	100
Resin Hold Tank	10,000	1	Yes	CST Slurry	Existing tank in DWPF[a]
Alpha Sorption Tank	100,000	1	Yes	Feed	100
Recycle Blend Tank	100,000	1	Yes	CSS	100
Sludge Solids Receipt Tank	10,000	1	Yes	Feed/MST Slurry	100
Cleaning Solution Dump Tank	1,000	1	Yes	0.01 × MST Slurry[b]	100
Wash Water Hold Tank	25,000	1	Yes	0.25 × CSS[c]	100
CST Ion Exchange Column	3,000 3,000	2 2	Yes Yes	CST Slurry, DSS[d]	10 10

CSS = Clarified Salt Solution: DSS = Decontaminated Salt Solution; MST = Monosodium Titanate: CST = Crystalline Silicotitanate ion exchange resin, cfm = cubic feet per minute.

a. This change at DWPF is not expected to impact DWPF stack emissions.

b. Cleaning solution is used to clean the cross flow filters may be contaminated with some dilute mixture of MST slurry. This stream is conservatively chosen to be 0.01 time the concentrations for MST slurry.

c. The wash water hold tank will hold wash water from the sludge solids receipt tank. The solution washed from the sludge is CSS, which is diluted by the washed water. The dilution is conservatively chosen to be 0.25.

d. Two columns are assumed loaded at any one time and the other two are assumed to contain only DSS-resin slurry.

A.5.3 TRANSFER FACILITIES

New transfer facilities would be required to direct the flow of process streams among the various facilities employed in the salt processing alternatives. These include feed lines to the facilities, transfer lines between facilities, and several valve boxes, diversion boxes, and pump pits directing the stream flows (WSRC 1998m, 2000c). Details of the processing-related transport facilities are described in Table A-11. The integration of these new facilities into existing facilities is illustrated in Figures A-18 through A-21 (WSRC 1998e; 2000c).

A.5.4 SUPPORT FACILITIES

Each alternative would require other support facilities including service, office, and substation buildings. The service building would be a single-story, 21,000-23,700-square-foot steel-framed structure with concrete or brick siding. This building would contain electrical and mechanical maintenance shops, control rooms for the process and for the remote crane, a health physics office, conference room, and offices for operations personnel. The structure would also house two 500-kilowatt (kW) diesel generators and associated equipment (WSRC 1998m). The

Table A-9. Tanks for Solvent Extraction Process.

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation flow per tank (cfm)
Process Water Tank	20,000	1	No	Well water	Natural
MST Storage Tank	400	1	No	MST	Natural
Caustic Feed Tank	5,000	1	No	1 M NaOH	10
Oxalic Acid Feed Tank	200	1	No	2% $H_2C_2O_4$	10
Caustic Feed Tank	500	1	No	1 M NaOH	10
Caustic Dilution Feed Tank	15,000	1	No	2.0 M caustic	10
Caustic Storage Tank	5,000	1	No	50% caustic	10
Filter Cleaning Caustic Tank	500	1	No	1 M NaOH	10
Caustic Makeup Tank	1,000	1	No	0.5 M NaOH	10
Solvent Wash Solution Makeup Tank	1,000	1	No	0.5 M NaOH	10
Nitrate Acid Feed Tank	1,000	1	No	50% HNO_3	10
Nitrate Acid Charge Tank	1	1	No	50% HNO_3	Natural
Strip Feed Tank	4,000	1	No	0.005 M HNO_3	
Chem Additive Tank	100	1	No	Process water	10
Isopar Makeup Tank	2,000	1	No	Isopar®L	10
Isopar Hold Tank	5,000	1	No	Isopar®L	10
Isopar Feed Tank	500	1	No	Isopar®L	10
Modifier Makeup Tank	500	1	No	1.0 M Cs7SBT in Isopar®L	10
Extractant Makeup Tank	50	1	No	0.2 M BobCalix in Isopar®L	10
Trioctylamine Tank	5	1	No	Trioctylamine	10
Solvent Makeup Tank	1,000	1	No	0.01 BobCalix, 0.5 M Cs7SBT, and 0.001 M TOA in Isopar®L	10
Alpha Sorption Tank	125,000	1	Yes	Feed	100
Salt Solution Feed Tank	125,000	1	Yes	Clarified salt solution	100
Strip Stages (15)	114	1	Yes	Organic phase	None
Strip Effluent Stilling Tank	500	1	Yes	Strip solution	100
Strip Make-up Tank	25,000	1	Yes	Strip solution	100
Strip Organic Removal Stages (2)	15	1	Yes	Strip solution	100
Wash Water Hold Tank	25,000	1	Yes	~2M Na salt solution, 1/4 dilution of CSS	100
Ba-137 Decay Tanks	2,500	2	Yes	DSS	100
Caustic Solvent Wash Tank	1,000	1	Yes	DSS	100
Solvent Hold Tank	1,000	1	Yes	Organic phase	100
Solvent Wash Tank	1,000	1	Yes	Organic phase	100

Table A-9. (Continued).

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation flow per tank (cfm)
Kerosene Still	1,000	1	Yes	Organic phase	None
Kerosene Condensate Tank	1,000	1	Yes	Organic phase	None
Re-alkaline Stages (2)	15	1	Yes	Organic phase	None
Solvent Acid Wash Stages (2)	15	1	Yes	Organic phase	None
Scrub Stages (2)	15	1	Yes	Organic phase	None
Raffinate Organic Removal Stages (2)	15	1	Yes	DSS	None
Extraction Stages (15)	114	1	Yes	Clarified salt solution	None
DWPF Salt Feed Tank	100,000	1	Yes	Strip solution	100
Aqueous Raffinate Stilling Tank	500	1	Yes	DSS	100
DSS Hold Tanks	100,000	2	Yes	DSS	100
Sludge Solids Receipt Tank	10,000	1	Yes	Feed/MST slurry	100
Cleaning Solution Dump Tank	1,000	1	Yes	0.01 × MST slurry[a]	100

CSS = Clarified Salt Solution; DSS = Decontaminated Salt Solution; MST = Monosodium Titanate.

a. Cleaning solution is used to clean the cross flow filters and may be contaminated with some dilute mixture of MST slurry. This stream is conservatively chosen to be 0.01 times the concentrations for MST slurry.

Table A-10. Tanks for Direct Disposal in Grout Process.

Tank	Tank Size (gallons)	Number of Tanks	Radioactive	Stream Characteristics	Ventilation Flow (cfm)
MST Storage Tank (non-rad)	400	1	No	MST	natural
Process Water Tank (non-rad)	5,000	1	No	Well Water	natural
Oxalic Acid Feed Tank (non-rad)	200	1	No	2% $H_2C_2O_4$	natural
Caustic Feed Tank (non-rad)	500	1	No	1M NaOH	100
Caustic Storage Tank (non-rad)	500	1	No	50% NaOH	natural
Alpha Sorption Tank	100,000	1	Yes	Feed	100
Sludge Solids Receipt Tank	10,000	1	Yes	MST Slurry	100
Cleaning Solution Dump Tank	1,000	1	Yes	(a)	100
Salt Solution Hold Tank	100,000	1	Yes	CSS	100
Flush Water Receipt Tank	10,000	1	Yes	CSS[b]	100
Saltstone Hold Tank	500	1	Yes	CSS with gout	100

CSS = Clarified Salt Solution; MST = Monosodium Titanate; cfm = cubic feet per minute.

a. Cleaning solution used to clear cross flow filters may be contaminated with MST slurry. Stream chosen to be 0.01 times concentration for MST slurry.

b. Flush water receipt tank holds water used to flush process lines at the mixer and saltstone hold tank, thus, will contain a diluted form of CSS. This stream is conservatively chosen to be 0.01 times the concentrations for CSS.

Table A-11. New transfer facilities.

Facility	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
	Processing facility at Site B[a]	Processing facility at Site B[a]	Processing facility at Site B[a]	Processing facility in Z Area[a]
Interarea feed line from H-Area Tank Farm to new processing facility	Extension of interarea feed line from the H-Area Tank Farm to the processing facility, consisting of a 150-foot-long double-walled pipe[b], installed 6 feet underground	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	A feed line from the interarea feed line to the processing facility, consisting of a double-walled pipe[b], approximately 500 feet long, installed 6 feet underground
Saltstone feed line	A pipe line from the processing facility to the feed line from H-Area Tank Farm to Saltstone Manufacturing and Disposal Facility, connecting at a valve box. Line is a double-walled pipe[b], approximately 150 feet long, installed 6 feet underground	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	NA
Vault feed line	A feed line from the Saltstone Manufacturing and Disposal Facility to the vaults consisting of a galvanized carbon steel pipe, 300 feet long, laid in a concrete trench 5 feet deep, 3 feet wide, with 1.5-foot-thick sides and top	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	A feed line identical in specifications to the Small Tank Tetraphenylborate Precipitation vault feed line that would run from the new grout processing facility to the saltstone vaults
ETF Bottoms Holding Tank	A 50,000-gallon ETF Bottoms Holding Tank constructed between ETF and the Saltstone Manufacturing and Disposal Facility	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	A 50,000-gallon Bottoms Holding Tank constructed between ETF and the H-Area Tank Farm
Precipitate Hydrolysis Aqueous transfer line	A pipe line from the processing facility to the existing Low Point Pump Pit, connecting with existing feed line to DWPF. Line is a double-walled pipe 2,300 feet long, buried 6 feet below grade	NA	NA	NA

Table A-11. (Continued).

Facility	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
Valve box	A valve box constructed between the processing facility and the Saltstone Manufacturing and Disposal Facility, providing tie-in for feed lines from processing facility and ETF	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	NA
Feed line from ETF to valve box	A feed line from the ETF Bottoms Holding Tank to the new valve box, consisting of a double-walled pipe[b], approximately 1 mile long, installed 6 feet underground	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	NA
Low Point Pump Pit	NA	A new Low Point Pump Pit to transfer resin between the processing facility and DWPF	A new Low Point Pump Pit between the processing facility and DWPF to transfer monosodium titanate/sludge slurry	NA
Resin transfer line	NA	A feed line from the processing facility through the new Low Point Pump Pit to the DWPF, consisting of a double-walled pipe[b], 2,300 feet long, installed 6 feet underground	NA	NA
Monosodium Titanate/Sludge Slurry transfer line	NA	A pipe line from the processing facility to the existing Low Point Pump Pit, connecting with existing feed line to DWPF. Line is a double-walled pipe 2,300 feet long, buried 6 feet below grade	A pipeline from the processing facility through the new Low Point Pump Pit to the DWPF Line is a double-walled pipe, 2,300 feet long, buried 6 feet below grade	NA

Table A-11. (Continued).

Facility	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
Monosodium Titanate/Sludge Receipt Tank in DWPF	NA	A 15,000-gallon tank installed in the DWPF	Same as Crystalline Silicotitanate Ion Exchange	Same as Crystalline Silicotitanate Ion Exchange
Resin Hold tank in DWPF	NA	A 10,000-gallon tank installed in the DWPF	NA	NA
Cesium Strip Effluent transfer line	NA	NA	A pipe line from the processing facility to the existing Low Point Pump Pit connecting with the existing feed line to the DWPF	NA
Cesium Strip Effluent Hold Tank in DWPF	NA	NA	A 10,000-gallon tank installed in the DWPF	NA
Low Point Drain Tank facility	NA	NA	NA	A Low Point Drain Tank Facility to serve transfer lines between the H-Area Tank Farm and the processing facility and between the processing facility and DWPF. It would be used to transfer salt solution to the grout facility and monosodium titanate/sludge slurry to DWPF
Monosodium Titanate/Slurry feed line to DWPF	NA	NA	NA	A feed line from the processing facility through the Low Point Drain Tank Facility to DWPF, consisting of a doubled-walled pipe 1 mile long, installed 6 feet underground

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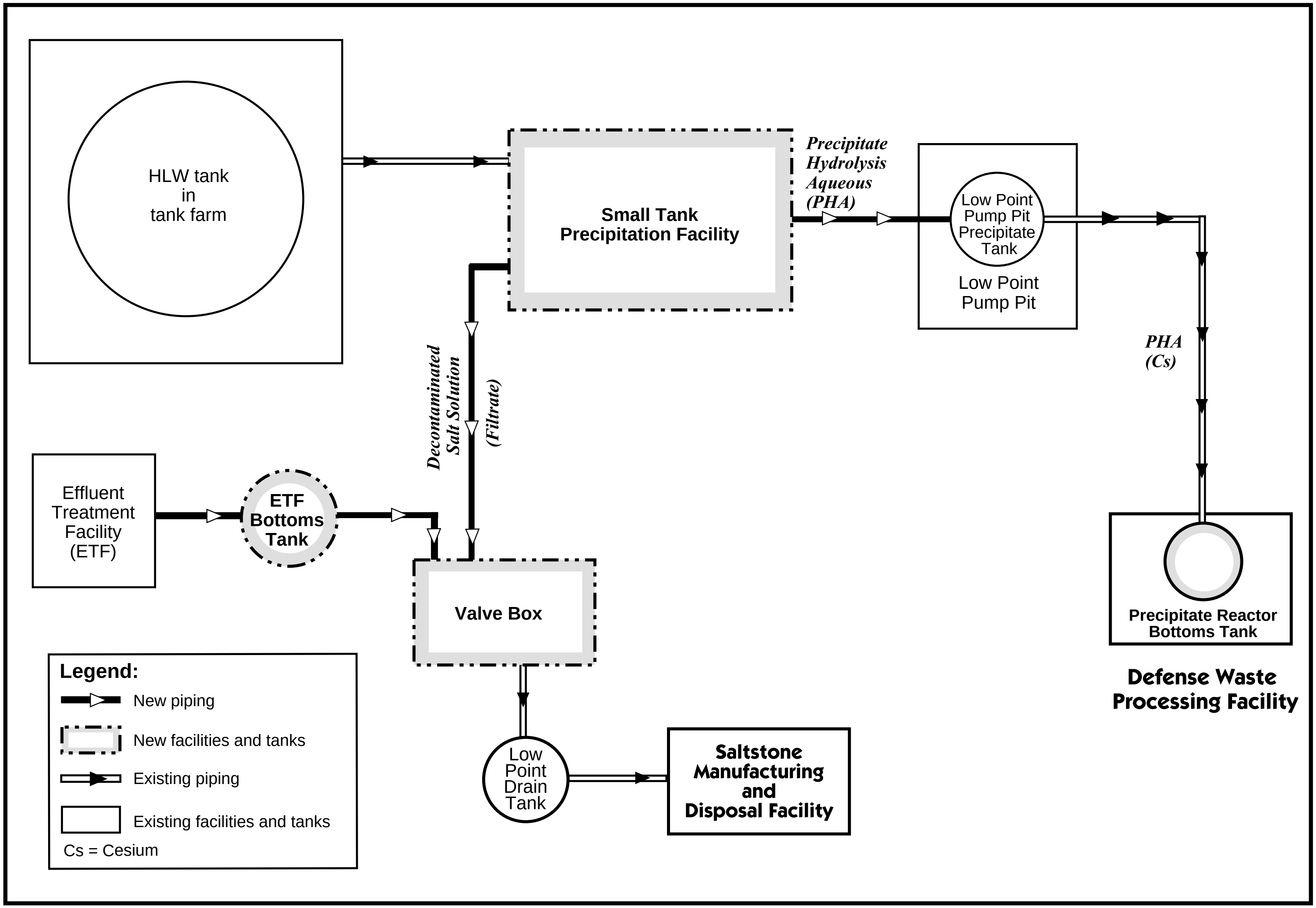
a. See text for description of the proposed facilities.

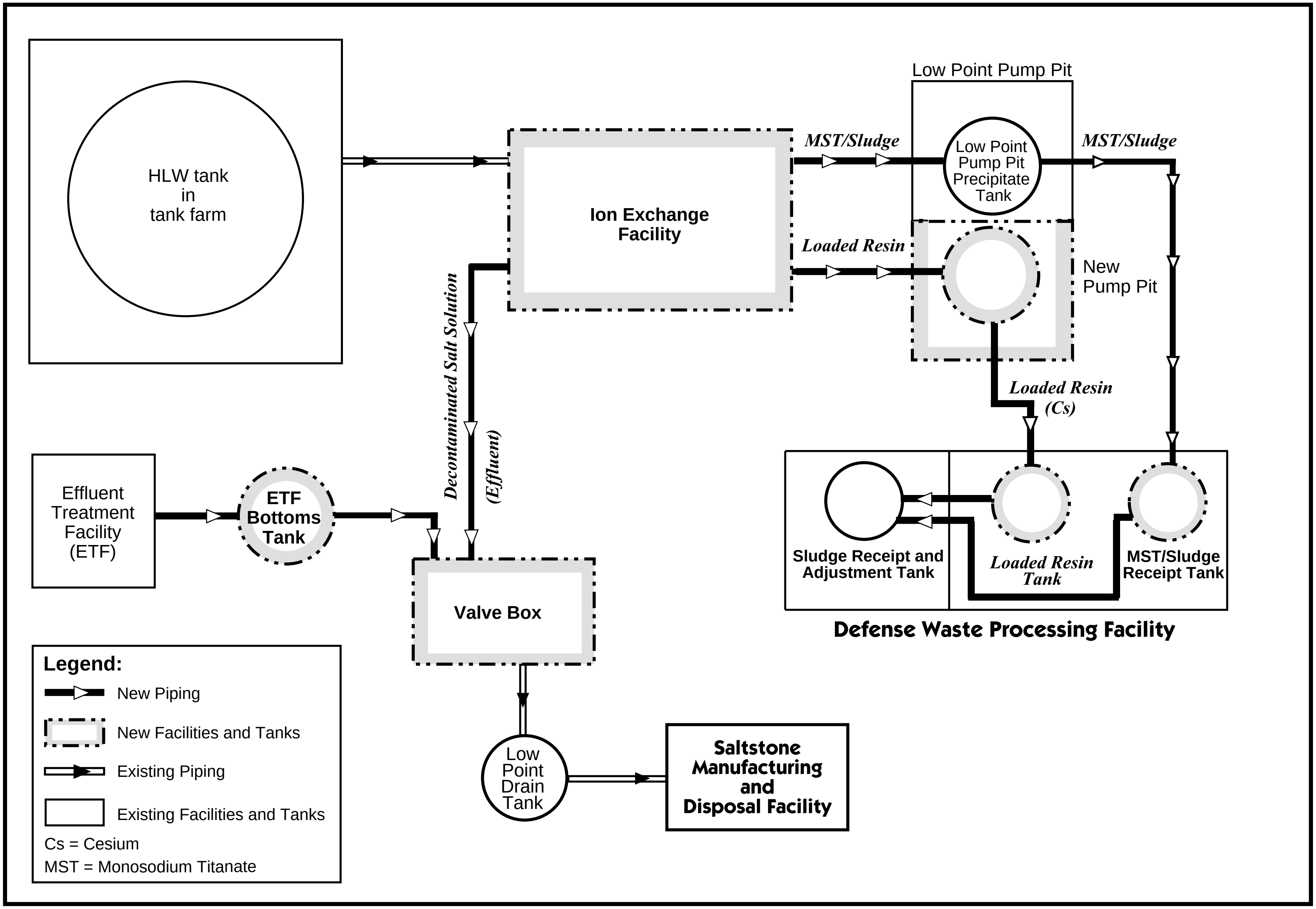
b. All double-walled transfer lines, comprised of 3-in.-diameter, schedule 40 (or 80), Type 304L stainless steel inner pipe and 6-in.-diameter, schedule 40, carbon steel outer pipe.

NA = not applicable.



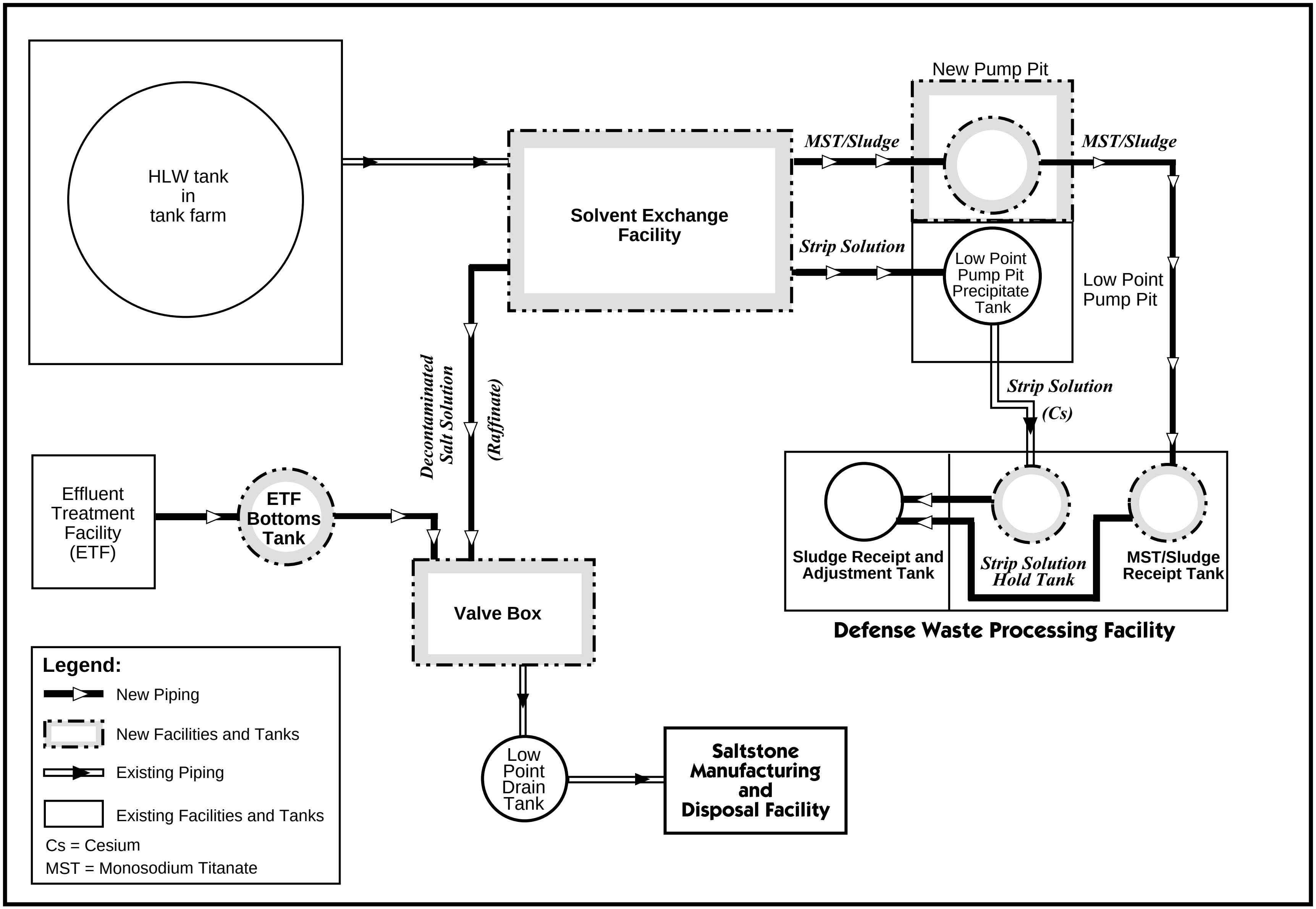
NW SDA EIS/Grfx/App A/A-18 Trans Sm Tank.ai

Figure A-18. Transfer facilities for Small Tank Precipitation alternative.



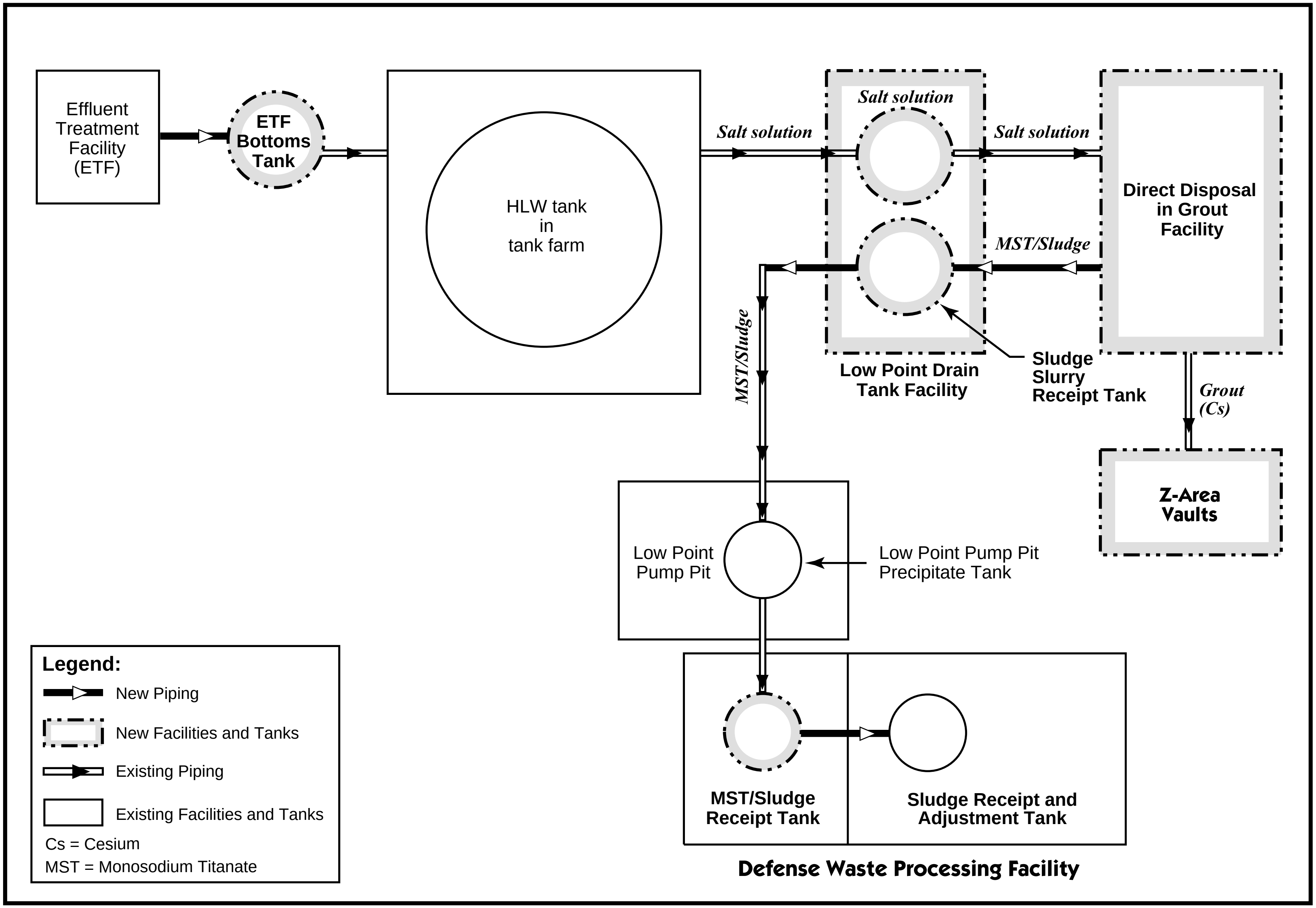
NW SDA EIS/Grfx/App A/A-19 Trans CST.ai

Figure A-19. Transfer facilities for Ion Exchange alternative.



NW SDA EIS/Grfx/App A/A-20 Trans CST Solv.ai

Figure A-20. Transfer facilities for Solvent Extraction alternative.



NW SDA EIS/Grfx/App A/A-21 Trans Dir Disp.ai

Figure A-21. Transfer facilities for Direct Disposal in Grout alternative.

office building would typically be a 22,500-square-foot single-story structure capable of providing personnel emergency shelter protection. It would house offices, a conference area, cafeteria, and restroom facilities for support personnel (e.g., engineering support, facility management, and clerical staff). The support facilities for each technology would include a process simulator building.

An electrical substation building, encompassing 600 square feet, would be needed for each alternative. A chemical storage area would be located on a concrete slab adjacent to the process building and add approximately 30 feet to the length of the process building. The area would be protected from the elements and contain storage tanks for chemicals used in the process. Dikes would be located around the tanks to contain any potential spills and to prevent inadvertent mixing of chemicals.

A.5.5 SALTSTONE VAULTS

As many as 16 saltstone disposal vaults beyond the currently existing two vaults would be constructed in Z Area to support the salt disposal alternatives (Figure A-22). Nominal dimensions of the additional 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, to contain about 6,600 cubic meters of saltstone grout per cell. Interior and exterior walls would be 18 inches thick and the base slab would be 30 inches thick. The roof slab would be 24 inches thick. The interior floor and walls for each cell would be painted with epoxy to inhibit infiltration of moisture during grout curing. Any voids left in the grout in a cell would be filled with nonradioactive grout prior to final vault closure to help ensure structural integrity. All vaults would be equipped with cameras and lights to monitor filling, and thermocouple assemblies to monitor heat generation during the curing process. As with the existing saltstone vaults, the additional vaults would be considered near-surface containment structures and covered with soil after vault closure for additional shielding.

The six-cell configuration of the additional vaults would facilitate a pouring rotation that would meet grout-cooling requirements. A 500-cubic-foot-per-minute ventilation system would be equipped with a pre-filter, high-efficiency particulate air (HEPA) filter and fan, and connected ductwork to control contamination during vault filling operations. Radiation monitors and dampers would be included (WSRC 1998m).

A.5.6 PILOT PLANT

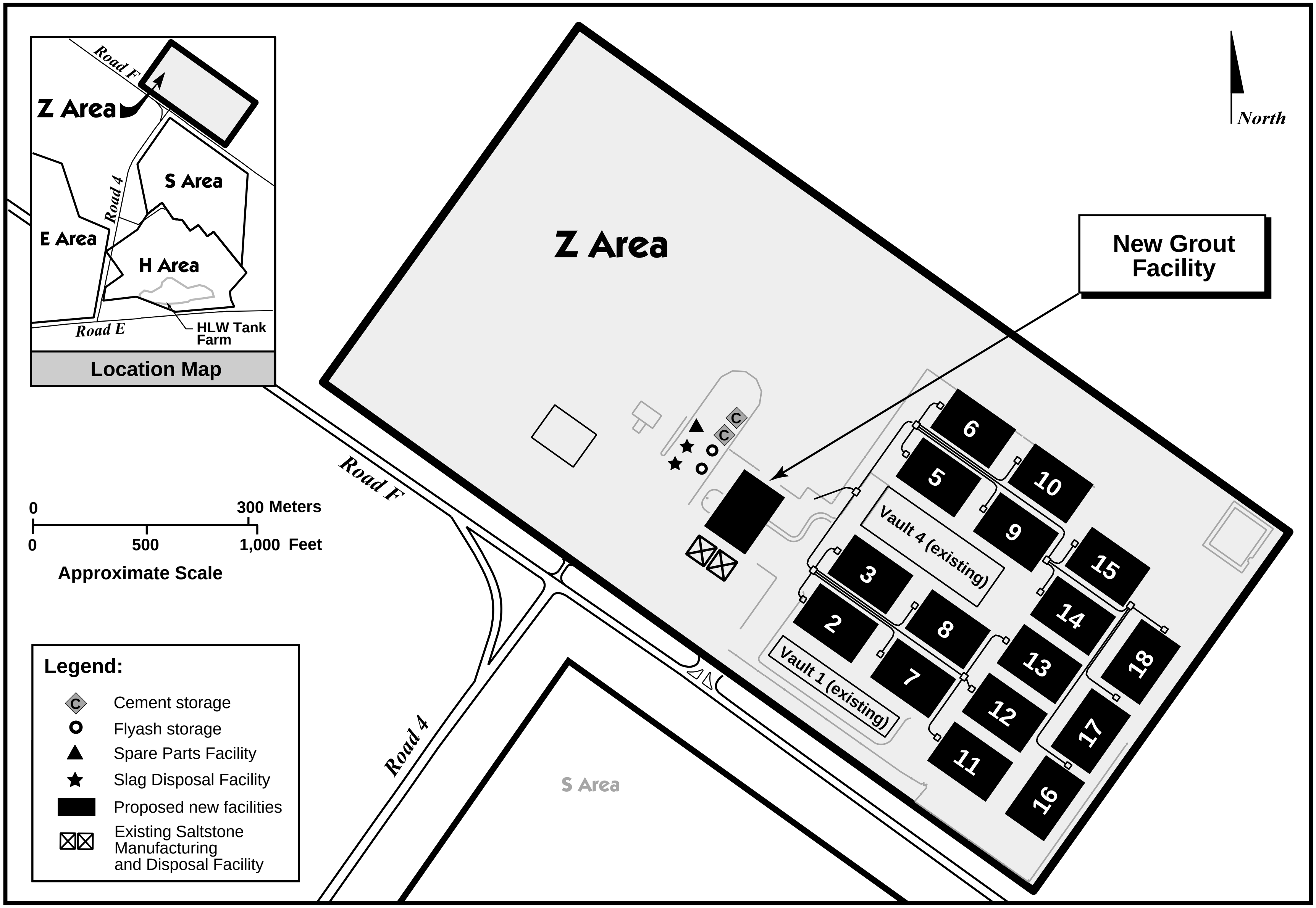
To achieve pilot scale testing of the selected salt processing process before operation of the full-scale facility, a pilot plant would be needed, as defined in Chapter 2 (Section 2.7.5). The pilot plant would provide scaled process data, utilizing equipment ranging from 1/100 to 1/10 the size of the full-scale facility (WSRC 2000e). Process streams would consist of real radioactive waste from various HLW tanks to demonstrate required decontamination factors (DF), as follows:

Cs-137	DF 40,000
Sr-90	DF 100 or greater
Pu-238	DF 10 or greater

The capability for appropriate waste disposal would be required in the pilot plant.

Installation of pilot plant process equipment in the existing Late Wash Facility provided for ITP is projected. The Late Wash Facility has three highly shielded cells designed to contain up to 5,000 gallons of concentrated precipitate slurry, into which salt processing equipment mounted in frames could be installed. If additional shielded space was required, the filter cell previously provided to support ITP operations would be considered.

Test runs designed to demonstrate the process flowsheet for the selected salt processing alternative would be conducted in the pilot plant. Functional process flows would parallel those for the full-scale facility. Major equipment would be tested to confirm vessel sizing and de-



NW SDA EIS/Grfx/App_A/A-22 Loc Z Area.ai

Figure A-22. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

sign constraints, and process parameters would be evaluated to ensure satisfactory resolution of problems encountered during process development.

Process demonstrations would be designed to meet the following objectives:

Small Tank Precipitation – Validity design parameters, as determined by kinetics of cesium precipitation by tetraphenylborate, and strontium and actinide sorption on monosodium titanate; feed stream mixing rates; and excess tetraphenylborate recovery. Resolve processing uncertainties related to the activation of tetraphenylborate decomposition catalysts at operating temperatures, and foam formation.

Major equipment would include:

Process Feed Tank
Precipitation Tanks (Continuous Stirred Tank Reactors 1 and 2)
Concentrate Tanks
Concentrate Filter and Cleaning System
Filtrate Hold Tank
Wash Tank
Wash Filter and Cleaning System
Precipitate Surge Tank
Recycle Wash Hold Tank
Cold Feeds and Facilities
Laboratory Facilities

Ion Exchange – Resolve key issues, including the kinetics of strontium and actinide sorption onto monosodium titanate; filtration of monosodium titanate solids; the kinetics of cesium removal on crystalline silicotitanate as function of temperature and waste composition; and design parameters for the ion-exchange columns. Resolve processing uncertainties relating to hydrogen generation in the ion-exchange columns at high cesium loadings; desorption of cesium from the crystalline silicotitanate ion exchange resin; resin stability; and extraneous solids formation.

Major equipment would include:

Alpha Sorption Tank
Alpha/Sludge Filter and Cleaning System
Sludge Solids Receipt Tank
Recycle Blend Tank
Crystalline Silicotitanate Columns in series (1 ft diam × 16 ft length)
Loaded Resin Hold Tank
Decontaminated Salt Solution Hold Tank
Cold Feeds and Facilities
Laboratory Facilities

Solvent Extraction – Demonstrate or confirm the kinetics of strontium and actinide sorption onto monosodium titanate with removal by filtration; cesium separation and concentration in centrifugal contactor operation with minimal long-term chemical and radiolytic degradation of solvent; solvent cleanup and recycle capabilities, including self purification by back extraction to aqueous phase; and final separation of organics from aqueous raffinate and strip effluent product streams.

Major equipment would include:

Alpha Sorption Tank
Alpha/Sludge Filter and Cleaning System
Sludge Solids Receipt Tank
Salt Solution Feed Tank
Solvent Extraction Contactors in Series
Solvent Hold Tank and Cleaning System
Raffinate Stilling Tank
Strip Effluent Stilling Tank
Decontaminated Salt Solution Hold Tank

Direct Disposal in Grout – A requirement for the demonstration of the Direct Disposal in Grout alternative has not been confirmed. Because this technology is better developed than the other alternatives and has been thoroughly demonstrated by the existing Saltstone Manufacturing and Disposal Facility, it is not anticipated that any further demonstration of this technology will be necessary.

A.5.7 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 its ultimate decontamination and decommissioning or reuse. Areas of the facility that might become contaminated with radioactive or other hazardous materials under normal or off-normal 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 any of the facilities are described below.

- 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 to allow the inspection of the integrity of joints in buried pipelines. The facility would be designed to facilitate dismantlement, removal, and packaging of contaminated equipment.
- Modular shielding would be used in interior areas to permit modification to larger shielded areas for future use.
- Lifting lugs would be used on equipment to facilitate remote removal from the contaminated process cells.
- The piping systems that would carry hazardous products would be fully drainable.

References

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082-S, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995, *Final Environmental Impact Statement Savannah River Site Waste Management*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998a, *Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options at the Savannah River Site*, DOE/EIS-0082-SA-03, Savannah River Operations Office, Aiken, South Carolina, November.

DOE (U.S. Department of Energy), 1998b, *Review Team Final Report on the High-Level Waste Salt Disposition Alternatives Evaluation*, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998c, *Independent Assessment of Savannah River Site High-Level Waste Salt Disposition Alternatives Evaluation*, DOE-ID-101672, Washington, D.C.

DOE (U.S. Department of Energy), 1999, *Notice of Intent to Prepare a Supplemental Environmental Impact Statement for Alternatives to the In-Tank Precipitation Process at the Savannah River Site, Aiken, South Carolina*, Federal Register 64 (34): 8558-8560, February 22.

DOE (U.S. Department of Energy), 2000, "Additional Research and Development (R&D) of Caustic Side Solvent Extraction (CSEX) Alternative." Letter to W. G. Poulson, Westinghouse Savannah River Company, February 15.

EPA (U.S. Environmental Protection Agency), 1993, Federal Facility Agreement between the U.S. Environmental Protection Agency, Region IV, the U.S. Department of Energy, and the South Carolina Department of Health and Environmental Control, Docket No. 89-05-FF, August 16.

Langton, C. A., 1988, "Slag-Based Saltstone Formations," *Ninth Annual DOE Low-Level Waste Management Forum,* CONF-87059-Session I, U.S. Department of Energy, Denver, Colorado.

Martin Marietta (Martin Marietta Energy Systems, Inc.), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility*, WSRC-RP-92-1360, prepared for Westinghouse Savannah River Company, Aiken, South Carolina, by Martin Marietta Energy Systems, Inc.

Wilhite, E. L, 1986, "Waste Salt Disposal at the Savannah River Plant," *SPECTRUM '86 – Waste Management, Decontamination, and Decommissioning*, American Nuclear Society.

Wilhite, E. L., C. A. Langton, H. F. Sturm, R. L. Hooker, and E. S. Occhipinti, 1989, "Saltstone Processing Startup at the Savannah River Plant," *SPECTRUM '88 Nuclear and Hazardous Waste Management International Topical Meeting*, American Nuclear Society, Pasco, Washington.

WSRC (Westinghouse Savannah River Company), 1998a, *High-Level Waste Salt Disposition Systems Engineering Team Final Report* (U) WSRC-RP-98-00170, Rev. 0, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998b, *High-Level Waste Salt Disposition Interface Requirements*, WSRC-RP-98-00164, Rev. 0, Savannah River Site, Aiken, South Carolina, June 25.

WSRC (Westinghouse Savannah River Company), 1998c, *Preconceptual Design Package for the Small Tank TPB Precipitation Facility* (U), G-CDP-H-00003, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998d*, WSRC Review Panel Report on the Selection of High-Level Waste Salt Disposition Alternatives*, Savannah River Site, Aiken, South Carolina, November.

WSRC (Westinghouse Savannah River Company), 1998e, *Bases, Assumptions, and Results of Flowsheet Calculations for the Short List Salt Disposition Alternatives*, WSRC-RP-98-00168, Rev. 1, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998f, *Facility Design Description-Chapter One for High Level Waste Management Division – Small Tank TPB Precipitation Facility*, G-FDD-H-00014, Rev. B, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998g, *Preconceptual Design Package for the CST Non-Elutable Ion Exchange Facility* (U), G-CDP-H-0004, Savannah River Site, Aiken, South Carolina, October 29.

WSRC (Westinghouse Savannah River Company), 1998h, *Facility Design Description for High-Level Waste Management Division CST Non-Elutable Ion Exchange Facility*, G-FDD-H-00013, Rev. A, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998i, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – Cesium Encapsulation in Grout*, WSRC-RP-98-00123, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998j, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – Small Tank TPB Precipitation*, WSRC-RP-98-00126, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998k, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – CST Ion Exchange*, WSRC-RP-98-00125, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998l, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details - Caustic Side Solvent Extraction*, WSRC-RP-98-001234, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998m, *Life Cycle Cost Estimate Bases, Assumptions, and Results, Rev. 1*, WSRC-RP-98-00167, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999a, *Savannah River Site High-Level Waste Tank Space Management Team Final Report*, WSRC-RP-99-0005, Rev. 0, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999b, *High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report (U)*, WSRC-RP-99-00007, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999c, A Robust Alkaline Side CSEX Solvent High-Level Waste - P. V. Bonnesen, L. H. Delmau, B. A. Mayer (Oak Ridge National Laboratory), and R. A. Leonard (Argonne National Laboratory). Draft Manuscript HLW-SDT-99-0283, September 13-14, 1999.

WSRC (Westinghouse Savannah River Company), 2000a, *High-Level Waste System Plan, Revision 11 (U)*, HLW-2000-00019, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 2000b, *WSRC Response to Needed Information for Inclusion of Caustic Side Solvent Extraction and Small Tank TPB Precipitation with Saltcell in Salt Disposition Alternatives SEIS*. HLW-SDT-2000-00136, Rev. 0, June 6, 2000.

WSRC (Westinghouse Savannah River Company), 2000c, *WSRC Response to TtNUS Supplemental Data Call*, HLW-SDT-2000-00263, Rev. 0, July 17, 2000.

WSRC (Westinghouse Savannah River Company), 2000d, *Preliminary Source Term and Emissions Data for Salt Processing Environmental Impact Statement*, HLW-SDT-99-0161, Rev. 5, August 22, 2000.

WSRC (Westinghouse Savannah River Company), 2000e, *Technical Demonstration Unit*, HLW-SDT-2000-00169, May 16, 2000; *Position Paper on Salt Disposition Pilot Facilities Approach*, HLW-SDT-99-0225, Rev. 0, July 22, 1999.

APPENDIX B

ACCIDENT ANALYSIS

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APPENDIX B. ACCIDENT ANALYSIS

This Appendix provides detailed information on potential accident scenarios associated with various alternatives for salt processing at the Department of Energy's (DOE) Savannah River Site (SRS). The Appendix provides estimates of the quantity and composition of hazardous materials that could be released in an accident, as well as the consequences to workers and the public. Estimates are given in terms of dose and latent cancer fatalities for radiological releases and of concentration levels for chemical releases.

The primary source of information for the accident analyses is an engineering calculation prepared specifically to document the accident sequences, frequencies, and source terms for the various alternatives. Unless specifically noted, all references in this Appendix are to Cappucci et al. (2000).

B.1 General Accident Information

An accident, as discussed in this Appendix, is an inadvertent release of radiological or chemical hazardous materials as a result of a sequence of one or more probable events. The sequence usually begins with an initiating event, such as a human error, equipment failure, or earthquake, followed by a succession of other events (which could be either dependent on or independent of the initial event), that dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

- *Internal initiators* – normally originate in and around the facility, but are always a result of facility operations. Examples include equipment or structural failures and human errors.

- *External initiators* – independent of facility operations and normally originate outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include helicopter, aircraft, or vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.

- *Natural phenomena initiators* – natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

The likelihood of an accident occurring and its consequences usually depend on the initiator, the sequence of events, and their frequencies or probabilities. Accidents can be grouped into four categories—anticipated, unlikely, extremely unlikely, and beyond extremely unlikely, as listed in Table B-1. DOE based the frequencies of accidents on safety analyses and historical data about event occurrences.

B.2 Accident Analysis Methods

For the salt processing alternatives, potential accident scenarios that could involve release of both radiological and nonradiological hazardous materials were identified. Section B.2.1 provides information about the various alternatives. Sections B.2.2 and B.2.3 provide details about the specific analysis methods used in this Appendix.

The accident sequences analyzed in this SEIS would occur at frequencies generally greater than once in 1,000,000 years. However, the analysis considered accident sequences with smaller frequencies, if their impacts could provide information important to decision making.

Table B-1. Accident frequency categories.

Accident frequency category	Frequency range	Description
Anticipated	Less than once in 10 years but greater than once in 100 years	Accidents that might occur several times during a facility lifetime
Unlikely	Less than once in 100 years but greater than once in 10,000 years	Accidents that are not likely to occur during a facility lifetime; natural phenomena include Uniform Building Code-level earthquake, maximum wind gust, etc.
Extremely unlikely	Less than once in 10,000 years but greater than once in 1,000,000 years	Accidents that probably will not occur during a facility life cycle; this includes the design-basis accidents.
Beyond extremely unlikely	Less than once in 1,000,000 years	All other accidents.

Source: DOE (1994a).

The methods of accident analysis are consistent with the guidance provided by DOE's Office of National Environmental Policy Act (NEPA) Policy and Assistance in *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993). In addition to the specific guidance on accident analyses, DOE has applied the recommendation to base analysis on realistic, rather than overly conservative, exposure conditions. DOE has also applied the recommendation to use a *sliding scale* approach, which means to provide a level of detail in the analysis of specific issues and their impacts in proportion to their significance.

Recently the Office of NEPA Policy and Assistance issued draft guidance entitled *Analyzing Accidents Under NEPA* (DOE 2000a). It clarifies and supplements the information in the 1993 guidance. DOE has used the guidance's clarifications on the use of the sliding-scale approach, range of accident scenarios, avoidance of compounding conservatisms, frequency, and risk. However, this Appendix does not include the suggestion in the guidance to present direct and indirect effects of post-accident activities. Such analysis would require the development of methodology to measure these impacts in a consistent basis, followed by the integration of this methodology into the specific salt processing accidents analyzed in this Appendix. In light of these circumstances and judicious application of the sliding-scale approach, DOE Savannah River Office (SR) considers the evaluation of post-accident cleanup impacts to be both inefficient and minor in comparison to the customary evaluation of human health impacts of potential accidents.

B.2.1 SALT PROCESSING ALTERNATIVES

The accident data in this Appendix are organized by alternative. The accident impacts in Chapter 4 are also organized by alternative to reflect potential accident occurrences for the associated alternative.

DOE proposes to select a technology and design, construct, and operate the required facilities to replace the In-Tank Precipitation (ITP) process to separate the highly radioactive components of high-level waste (HLW) salt solutions from the low-activity components of the salt solution. The new process would be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of low-level waste at the SRS. The alternatives being considered in this SEIS are:

- No Action
- Small Tank Tetraphenylborate Precipitation
- Crystalline Silicotitanate Ion Exchange
- Caustic Side Solvent Extraction
- Direct Disposal in Grout

Each alternative is discussed in detail in Chapter 2 and Appendix A; however, a brief description of each alternative is included here.

No Action Alternative

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, without a process to separate the high-activity and low-activity salt fractions. The Defense Waste Processing Facility (DWPF) would vitrify only sludge from the HLW tanks. Saltcake and supernatant would remain in the HLW tanks, and monitoring activities would continue. Current tank space management projections indicate that, after 2010, additional tank space would be needed to support continued operations and meet tank closure commitments under the No Action alternative.

As soon as DOE determined 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.

Because the No Action alternative is the basis from which each of the proposed alternatives progresses, the hazards associated with each action alternative are supplemental to those of the No Action alternative. However, through the processing of salt solution, hazards associated with continued storage would decrease over time. Therefore, since the No Action alternative includes only current tank space management operations, which have been evaluated under the NEPA process and in approved safety analysis reports and the activities DOE would pursue during the post tank space management phase have not been determined, this Appendix does not analyze accidents associated with No Action failure of a salt solution hold tank is analyzed in the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000b). The radiological and nonradiological hazards associated with the four action alternatives are evaluated in this Appendix.

Small Tank Precipitation

DOE would construct a new shielded facility to house process equipment to implement this alternative. The Small Tank Precipitation alternative would use the same chemical process as the ITP process to remove high-activity radionuclides from the salt solution. However, radioactive HLW would be processed through the facility in a manner that would control the high benzene generation rates that led DOE to develop an alternative salt processing technology.

Soluble radioactive metal ions (cesium, strontium, uranium, and plutonium) in the salt solution and concentrated supernatant would be precipitated with tetraphenylborate (TPB) or sorbed on monosodium titanate (MST) to form insoluble solids. The resulting solids would be concentrated by filtration and the product slurry treated to yield a non-flammable stream for transfer to DWPF for vitrification. The decontaminated salt solution, containing primarily sodium hydroxide, nitrate, and nitrite would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout.

Ion Exchange

DOE would construct a new shielded facility to house chemical processing equipment (tanks, pumps, filter systems, ion exchange columns) to implement this alternative. The Ion Exchange process would use crystalline silicotitanate (CST) resin in ion exchange columns to remove cesium from the salt solution. Strontium, plutonium, and uranium would first be removed by adsorption on MST, and the resulting solids would then be transferred to DWPF for vitrification. The cesium-loaded resin would also 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.

Solvent Extraction

DOE would construct a new shielded facility to house chemical processing equipment (tanks, pumps, filter systems, contactors). The Solvent Extraction process would employ a highly specific organic extractant in a diluent solvent to remove cesium from the caustic salt solution, using centrifugal contactors to provide high surface area interactions between the organic solvent and aqueous solution. The separated cesium would be extracted into an acidic aqueous stream to be transferred as an all-liquid phase to DWPF for vitrification. Prior treatment with MST would remove strontium, uranium, and plutonium from the salt solution for transfer to DWPF. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout.

Direct Disposal in Grout

DOE would construct a new shielded facility to immobilize the HLW salt solution in grout, without separation of radioactive cesium. Prior treatment with MST would remove strontium, uranium, and plutonium from the salt solution for transfer to DWPF. The cesium-containing solution would be mixed with cement, flyash, and slag for disposal as grout in shielded saltstone vaults in Z Area.

The saltstone waste form generated in this alternative would be required to meet U.S. Nuclear Regulatory Commission (NRC) Class C low-level waste disposal requirements for near surface disposal.

B.2.2 RADIOLOGICAL HAZARDS

The accidents identified for the salt processing alternatives are described in Section B.3. These descriptions include an approximation of the material at risk (MAR) that would potentially be involved in a given type of accident. Depending on the particular scenario, release fractions have been applied to the MAR to determine the amount of material that could be released to the environment via the air. This amount is referred to as the source term. Source terms are provided as curies of fission products and transuranics. The fission product source term is significantly dominated by radioactive cesium, while plutonium-239 has one of the highest dose factors of the common alpha-emitters found in SRS radiological effluents. Therefore, the analysis used radioactive cesium to represent the fission product source term and plutonium-239 to represent the transuranic source term.

The source terms were calculated by spreadsheet using Microsoft Excel. The Source Term and the Resuspension Source Term were determined using the following formulas.

Source Term: $ST = MAR \times DR \times ARF \times RF \times LPF$, where:

DR = Damage Ratio: fraction of MAR actually impacted by the accident

ARF = Airborne Release Fraction: the coefficient used to estimate the amount of radioactive material suspended in air as an aerosol and thus available for airborne transport due to physical stress from a given accident

LPF = Leak Path Factor: fraction of radionuclides or chemicals in the air transported through some confinement or filtration mechanism.

Resuspension Source Term: $ST_r = MAR \times ARR \times RF$, where:

MAR = Material at Risk: amount of radioactive materials or chemicals available to be acted upon by an event

ARR = Airborne Release Rate: the coefficient used to estimate the amount of material that can be suspended in air and made available for airborne transport under a specific set of induced physical stresses as a function of time.

RF = Respirable Fraction: fraction of airborne radionuclides or chemicals as particles that can be transported through the air and inhaled into the respiratory system

The analysis of airborne releases used the computer code AXAIRQ, which models accidental atmospheric radioactive releases from SRS that are of relatively short duration. AXAIRQ determines the concentration of radiological releases to the atmosphere in every direction around the release location. The code considers the height of the release and wind speed and direction changes in the calculation. AXAIRQ strictly follows the guidance in Regulatory Guide 1.145 (NRC 1982) on accidental releases, and has been verified and validated (Simpkins 1995a and 1995b). Because all considered accidents would occur at either ground level or from a 46-meter stack, the releases for both heights were evaluated using AXAIRQ. In accordance with the regulatory guide, the code considers plume meander and fumigation under certain conditions. Plume rise due to buoyancy or momentum is not available. The program uses a 5-year meteorological database for the SRS, and determines the shortest distance to the Site boundary in each of the 16 compass direction sectors by determining the distance to one of 875 locations along the boundary. The impacts derived from this code used the average, or 50 percent meteorology. The code uses the shortest distance in each sector to calculate the concentration for that sector.

DOE used the computer code PRIMUS, which was developed by the Oak Ridge National Laboratory, to consider decay and daughter ingrowth. PRIMUS determines radionculide ingrowth matrices from user specified sources. Ingrowth must be considered for radionculides that are generated from the decay of more than one isotopic chain and their own decay.

Simpkins (1999) provided unit dose conversion factors for the applicable radionuclides for release locations in S and Z Areas. These factors were applied to the airborne source terms from the previously described excel spreadsheet to calculate the doses to various receptors.

For population dose calculations, age-specific breathing rates were applied, but adult dose conversion factors were used. Radiation doses were calculated to the maximally exposed offsite individual (MEI), to the population within 50 miles of the facility, to a noninvolved worker assumed to be 2,100 feet (640 meters) downwind of the facility, to an involved worker assumed to be 328 feet (100 meters) downwind of the facility, and to the onsite population. All doses are committed effective dose equivalents.

After DOE calculated the total radiation dose to the public, it used dose-to-risk conversion factors established by the National Council on Radiation Protection and Measurements (NCRP) to estimate the number of latent cancer fatalities (LCFs) that could result from the calculated exposure. There is inconclusive data that small radiation doses cause cancer; however, to be conservative the NCRP assumes that any amount of radiation has some risk of inducing cancer. DOE has adopted the NCRP factors of 0.0005 LCF for each person-rem of radiation exposure to the general public and 0.0004 LCF for each person-rem of radiation exposure to radiation workers for doses less than 20 rem. For larger doses, when the rate of exposure would be greater than 10 rads per hour, the increased likelihood of LCF is doubled, assuming the body's diminished capability to repair radiation damage (NCRP 1993).

B.2.3 CHEMICAL HAZARDS

For chemically toxic materials, the long-term health consequences of human exposure to hazardous materials are not as well understood as those related to radiation exposure. A determination of potential health effects from exposures to chemically hazardous materials, compared to radiation, is more subjective. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

To determine potential health effects to workers and the public that could result from accidents involving hazardous materials, the airborne concentrations of such materials released during an accident at varying distances from the point of release were compared to the Emergency Response Planning Guideline (ERPG) values (AIHA 1991). The American Industrial Hygiene Association established these values, which depend on the chemical substance, for the following general severity levels to ensure that necessary emergency actions occur to minimize exposures to humans.

- ERPG-1 Values – Exposure to airborne concentrations greater than ERPG-1 values for a period greater than one hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects (i.e., rash, nausea, headache) or the perception of a clearly defined objectionable odor.

- ERPG-2 Values – Exposure to airborne concentrations greater than ERPG-2 values for a period greater than one hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects (i.e., organ damage, seizures, pneumonitis) or symptoms that could impair a person's ability to take protective action (i.e., dizziness, confusion, impaired vision).

- ERPG-3 Values – Exposure to airborne concentrations greater than ERPG-3 values for a period greater than one hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects (i.e., loss of consciousness, cardiac arrest, respiratory arrest).

B.3 Postulated Accident Scenarios Involving Radioactive Materials

These sections describe the potential accident scenarios associated with each alternative that could involve the release of radioactive materials. The impacts of these scenarios are described in Section B.4.

Several of the accidents identified for a particular alternative are also common to other alternatives. However, they will be discussed individually for each alternative.

B.3.1 SMALL TANK PRECIPITATION

The accidents identified for the Small Tank TPB Precipitation process that result in the release of radiological materials to the environment include:

- Loss of confinement in a process cell
- Beyond design-basis earthquake
- Fire in a process cell
- Benzene explosion in the Precipitate Hydrolysis Cell (PHC)
- Helicopter or aircraft crash
- Benzene explosion in Precipitate Hydrolysis Aqueous (PHA) Surge Tank

B.3.1.1 Loss of Confinement in a Process Cell

Scenario: Mechanical failure or an external event, such as a dropped cell cover or crane mishap, could cause a failure of the primary confinement for a tank or its associated piping. A failure of primary confinement would release material into the process cell. For this event, the entire tank contents at maximum capacity would be released through the rupture. It was assumed that the release would not be cleaned up for 168 hours (7 days).

The tanks of concern would be the Precipitate Reactor and the PHA Surge Tank. A failure of the Precipitate Reactor or associated piping would release material to the PHC, while a failure of the PHA Surge Tank or associated piping would release material to the PHA Surge Tank process cell. Flammable benzene vapors and hydrogen generated by leaking slurry from the PHA Surge Tank could cause an explosion, if they were allowed to reach flammable concentrations in the presence of an ignition source. A benzene explosion following a PHA Surge Tank loss of confinement event is in the beyond-extremely-unlikely category and is bounded by the benzene explosion in the PHA Surge Tank event discussed in Section B.3.1.6. The precipitate slurry would also be somewhat flammable and, if allowed to reach a combustible state, a large enough ignition source could cause a precipitate fire in the process cell. For this scenario, however, it is assumed that no explosion or fire occurs.

A leak detection system would mitigate the consequences of releases from process tanks and associated piping. This system would be designed to detect the leak and terminate the process, thus minimizing the amount of material that would leak from the system. A shielded secondary confinement system would protect onsite workers from radiological consequences of the leaks.

Probability: The initiating event for the loss of primary confinement of a process tank could be mechanical failure or an external event. External events could cause leaks from tanks or piping. Impacts during cell cover and crane movement are assumed to cause spills from a rupture in the tank or associated piping. It was assumed that there would be 50 feet of piping associated with each tank. The annual frequency of a loss of primary confinement for a process tank was calculated to be 3.4×10^{-2}. Therefore, a loss of confinement accident would be expected once in 30 years.

Source Term: A dropped cell cover or crane mishap was assumed to damage the affected tank significantly enough to release the entire contents of the tank to the cell. Good engineering practices would be used during design of the process facility to ensure that high-efficiency particulate air (HEPA) filters would be located in a remote part of the facility away from process cells (e.g., event location). DOE would perform regular in-place testing to ensure that installed HEPA filters would have a particle removal efficiency of greater than 99.9 percent. Therefore, the HEPA filters and ventilation system were assumed to be operating due to the physical distance between the filter location and event location, reducing the amount of radioactivity released from the process cell within 99 percent efficiency. The radiological source terms associated with this accident are provided in Table B-2. In addition, a loss of primary confinement for the PHA Surge Tank would release benzene in an uncontrolled manner to the process cell ventilation system. The source terms associated with nonradiological chemical releases are addressed in Section B.5. All releases were postulated to occur from the 46-meter stack.

Table B-2. Source terms for loss of confinement in a process cell of the Small Tank Precipitation facility.

	Source term (Ci)	
	Fission products	Transuranics
Precipitate Reactor	1.1	3.1×10^{-3}
PHA Surge Tank	4.2	0.012

B.3.1.2 Beyond Design-Basis Earthquake

Scenario: The structures for the Small Tank Precipitation process would be designed to withstand Performance Category-3 (PC-3) earthquakes, straight winds, and tornadoes. The PC-3 earthquake is considered to be the bounding Natural Phenomena Hazards (NPH) event. The process vessels, piping, and structures that house the hardware would be designed to withstand such an earthquake. For the beyond design-basis event, an earthquake slightly stronger than the design-basis earthquake is postulated to occur. This earthquake would cause the primary and secondary confinement to fail, releasing the entire facility inventory into the building. The ventilation system and HEPA filters are also postulated to collapse, resulting in some airborne releases of both transuranic and fission product inventories.

Probability: The structure, primary confinement, and secondary confinement were conservatively assumed to fail due to an earthquake only slightly stronger than the design-basis earthquake of 0.16 g. The annual probability of exceeding a 0.16 g earthquake is 5.0×10^{-4}. Therefore, structural failure of the facility would be expected to occur less than once in 2,000 years.

Source Term: A release of the full inventory from the facility was postulated from collapse of the structure and of the primary and secondary confinement. The airborne source term associated with this accident would consist of 700 curies (Ci) of fission products and 2.0 Ci of transuranics. The release was postulated as a ground-level release.

B.3.1.3 Fire in a Process Cell

Scenario: A fire in any of the process cells could release radiological materials contained in the process vessels. The process would not introduce any combustible materials into the process cells; however, equipment or material that might be left behind during maintenance activities could lead to the initiation of this event. Good engineering practices would be used during design of the processing facility to ensure that HEPA filters would be located in a remote part of the facility away from process cells (e.g., event location). DOE would perform regular in-place testing to ensure that installed HEPA filters would have a particle removal efficiency of greater than 99.9 percent. The fire was assumed to challenge the ventilation system and process equipment; however, the HEPA filters would be expected to maintain their function due to the physical distance between the filter location and event location and would minimize releases to the environment within 99 percent efficiency. The entire cell inventory was assumed to be at risk. A leak was expected to occur from the fire.

In this scenario, the benzene releases are negligible compared to releases from fires/explosions elsewhere (i.e. Precipitate Hydrolysis Cell) due to the small amount of benzene in the PHA Surge Tank.

Probability: A fire in a process cell was assumed to be limited by the combustible control program, the fire barriers, and the fire department. The annual probability of a fire occurring in a process cell was calculated to be 1.0×10^{-4}. Therefore, a fire in a process cell would be expected to occur once in 10,000 years.

Source Term: The fire was assumed to damage the process vessel enough to cause a leak. The damage was assumed to be equivalent to a 0.5-inch-diameter opening. The leak was assumed to be stopped within 24 hours, allowing the fire department to put out the fire, a response plan to be developed, and implementation of the response plan to control the consequences of the leak. The worst-case scenario would be a fire in the process cell containing the PHA Surge Tank, because this cell has the greatest amount of material. The airborne source term associated with this accident would consist of 37 Ci of fission products and 0.11 Ci of transuranics. Any release was postulated to occur from the 46-meter stack.

B.3.1.4 Benzene Explosion in the PHC

Scenario: Benzene could be introduced into the cell if one of the benzene-containing vessels or piping within the cell developed a leak. An ignition source could then cause a deflagration in the PHC, over-pressurizing the cell and dislodging the cell covers. The cell covers could then fall back into the PHC, striking the Organic Evaporator, Organic Evaporator Condensate Tank, Organic Evaporator Condenser, Organic Evaporator Decanter, and Salt Cell Vent Condenser and spilling liquid benzene onto the cell floor. Benzene vapors evolving from this spilled inventory could lead to a second PHC deflagration, damaging and releasing the contents of the Precipitate Reactor. This accident assumes that the remaining liquid benzene on the PHC floor would ignite and burn.

The PHC design would incorporate a ventilation system to maintain airflow through the cell and minimize the possibility that benzene could leak into the cell and reach explosive concentrations.

Probability: A benzene explosion in the PHC that damages the cell would have the potential to damage and release the contents of multiple tanks that contain benzene and the Precipitate Reactor. For an explosion to occur, a large explosive benzene vapor cloud must form in the PHC and an ignition source must be present. For an explosive benzene cloud to form, the ventilation system was assumed to fail, eliminating airflow to the PHC, and forcing benzene from the PHC vessels. The annual probability that an explosion would occur in the PHC with damage to the cell was calculated to be 1.01×10^{-5}. Therefore, a benzene explosion would be expected to occur once in 99,000 years.

Source Term: An explosion in the PHC that would damage the cell was assumed to spill the entire contents of multiple tanks that contain benzene, as well as the Precipitate Reactor, which contains radiological material, into the cell. An ensuing fire would consume the benzene, so the accident would only involve radiological releases. HEPA filters are assumed to be damaged, failing to mitigate the release. The airborne source term associated with this accident would consist of 1,800 Ci of fission products and 5.3 Ci of transuranics. The release was postulated to occur from the 46-meter stack.

B.3.1.5 Helicopter or Aircraft Crash

Scenario: External events that could impact the facility include helicopter, aircraft, or vehicle impacts and external fire. According to Cappucci (2000), an unmitigated aircraft impact has the potential to release the entire facility inventory. A vehicle impact would be postulated to only release the contents of the vessel impacted and is therefore no different than the loss of confinement events addressed earlier. The building structure would be a PC-3 structure. Therefore, the building would mitigate the consequences from the postulated vehicle crash by protecting the inventory in primary and secondary confinement within the structure. Additionally, segmentation of the process cells would further mitigate the consequences of this external event. However, the PC-3 structure was assumed to experience local structural failure (collapse) from a helicopter crash and full structural failure (collapse) from an aircraft crash. The helicopter crash was assumed to release the inventory in one cell and the aircraft crash was assumed to release the entire building inventory. Both structural failures were assumed to be coincident with fires from ignition of the helicopter or aircraft fuel. The fires would compound the radiological release inventories.

Probability: The most likely causes of releases from the Small Tank Precipitation facility from external events would be impacts from helicopter or aircraft crashes. The frequency of a helicopter crash onto the Small Tank Precipitation facility was calculated to be 4.8×10^{-7} per year, while the frequency of an aircraft impact was calculated to be 3.7×10^{-7} per year. Therefore, a helicopter crash would be expected once in 2,100,000 years and an aircraft impact would be expected once in 2,700,000 years.

Source Term: The Small Tank Precipitation facility would be a PC-3 structure with primary and secondary confinement. The building structure would be expected to withstand vehicle crashes. Benzene and radiological releases would be expected to occur from helicopter or aircraft crashes. However, benzene would be consumed by the ensuing fire, so airborne releases would only include radiological material. HEPA filters are assumed to be damaged, failing to mitigate the release. The airborne source terms calculated for the various accident scenarios are shown in Table B-3. These releases were postulated as ground-level releases.

Table B-3. Source terms for helicopter or aircraft crashes into the Small Tank Precipitation facility.

	Source term (Ci)	
	Fission Products	Transuranics
Helicopter Crash[a]		
Fresh Waste Day Tank Cell	160	0.32
Precipitation Tank Cell	190	0.38
Concentrate Tank Cell	760	2.2
Filtrate Hold Tank Cell	8.8	0.025
Wash Tank Cell	940	2.2
PHA Surge Tank	7,400	22
PHC	2,800	8.3
Aircraft Crash	12,000	35

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a. Cappucci 2000.

B.3.1.6 Benzene Explosion in PHA Surge Tank

Scenario: Degradation of TPB produces benzene that would be released to the vapor space of the PHA Surge Tank. Hydrogen and oxygen are produced from the radiolysis (decomposition) of water, forming a flammable mixture. Because the consequences of such an event are unsatisfactory, the PHA Surge Tank would be equipped with a safety-class nitrogen inerting system. In this scenario, both the primary and backup nitrogen systems are assumed to fail and the failure to go undetected. An ignition source could then cause an explosion (detonation or deflagration) in the vapor space and a subsequent fire. (In a deflagration, the shock wave travels at less than the speed of sound; in a detonation, the shock wave travels faster than the speed of sound.) The tanks and piping would maintain their integrity during a deflagration, but not during a detonation; therefore, the event was conservatively assumed to be a detonation. It was also conservatively assumed that the detonation in the process tanks or piping would release the entire tank contents. The HEPA filters and ventilation were assumed to be damaged and bypassed, failing to mitigate the release. An explosion in the PHA Surge Tank, because of the amount of material at risk, would bound explosions in all other process tanks.

Probability: A benzene explosion in the PHA Surge Tank has the potential to damage the tank and release the entire tank contents. For an explosion to occur, an ignition source and an explosive gas mixture in the tank vapor space must be present. Failure of a safety-class system further increases the probability of occurrence. The annual probability that an explosion would occur in the PHA Surge Tank was calculated to be 1.84×10^{-8}. Therefore, an explosion in the PHA Surge Tank would be expected to occur once in 54,000,000 years and is not a credible event. Since the likelihood of this event is below the credibility threshold of once in 10,000,000 years, it is not evaluated further in this Appendix.

B.3.2 ION EXCHANGE

The accidents identified for the Ion Exchange process that would result in the release of radiological materials to the environment include:

- Loss of confinement in a process cell
- Beyond design-basis earthquake
- Loss of cooling to the Loaded Resin Hold Tanks (LRHTs)
- Fire in a process cell
- Helicopter or aircraft crash
- Hydrogen explosion in a process cell

B.3.2.1 Loss of Confinement in a Process Cell

Scenario: The tanks of concern are the Alpha Sorption Tank (AST), the LRHTs, and tanks in the Alpha Filter Cell (Washwater Hold Tank, Sludge Solids Receipt Tank, and Cleaning Solution Dump Tank [CSDT]). Because the material inventory in the CSDT would be small compared to the other vessels in the alpha filter cell, a release from the CSDT would be bounded by releases from the other tanks in the cell. See Section B.3.1.1 for a description of the scenario.

Probability: See Section B.3.1.1 for a discussion of the probability of the event occurring.

Source Term: A dropped cell cover or crane mishap was assumed to damage the affected tank significantly enough to release the entire contents of the tank to the cell. Good engineering practices would be used during design of the process facility to ensure that HEPA filters would be located in a remote part of the facility away from process cells (e.g., event location). DOE would perform regular in-place testing to ensure that installed HEPA filters would have a particle removal efficiency of greater than 99.9 percent. The HEPA filters and ventilation system were assumed to be operating due to the physical distance between the filter location and event location, reducing the amount of radioactivity released from the process cell within 99 percent efficiency. The airborne source terms associated with this accident are shown in Table B-4. The release was postulated to occur from the 46-meter stack.

Table B-4. Source terms for loss of confinement in a process cell of the Ion Exchange facility.

	Source term (Ci)	
	Fission products	Transuranics
AST	0.37	7.2×10^{-4}
Washwater Hold Tank	0.023	4.5×10^{-7}
Sludge Solids Receipt Tank	0.041	0.0064
LRHT	2.3	1.1×10^{-6}

B.3.2.2 Beyond Design-Basis Earthquake

Scenario: The structures for the Ion Exchange process would be designed to withstand PC-3 earthquakes, straight winds, and tornadoes. See Section B.3.1.2 for a description of the scenario.

Probability: See Section B.3.1.2 for a discussion of the probability of the event occurring.

Source Term: A release of the full inventory from the facility was postulated from collapse of the structure and of the primary and secondary confinement. HEPA filters are assumed to be damaged, failing to mitigate the release. The airborne source term associated with this accident would consist of 1,100 Ci of fission products and 0.72 Ci of transuranics. The release was postulated as a ground-level release.

B.3.2.3 Loss of Cooling to the LRHTs

Scenario: A loss of cooling water to the LRHTs would allow the decay heat of the fission products to raise the temperature of the liquid phase in the involved tanks enough to boil. It was assumed that the liquid would boil for eight hours. Vapors from the boiling liquid would be vented and filtered through HEPA filters operating with an efficiency of 99 percent. It was assumed that the cooling water coils would be designed so that leakage of radionuclides into the cooling water system would not be credible, thereby eliminating direct releases to the aquatic environment.

Probability: The equipment in this scenario was assumed to be similar to vessels in DWPF. Therefore, frequencies and probabilities for DWPF were used as a basis for evaluation. The initiating events that could lead to loss of cooling would be power failure, human error, or equipment failure. In order for a loss of cooling event to result in damage to the vessel, the loss of cooling was coupled with the failure of pressure and temperature indicators. The frequency was estimated to be 1.9×10^{-4} per year. Therefore, a loss of cooling water to the LRHTs would be expected once in 5,300 years.

Source Term: The source term for this scenario was based on the assumption that 65 gallons of the LRHT inventory and 100 gallons of the first CST column (liquid) inventory would be involved. This assumption was based on an estimation of the liquid mass evaporated by the decay heat of the fission products in eight hours. The airborne source terms associated with this accident are shown in Table B-5. The releases were postulated to occur from the 46-meter stack.

Table B-5. Source terms for loss of cooling event in Ion Exchange facility.

	Source term (Ci)	
	Fission products	Transuranics
LRHTs	0.11	5.3×10^{-8}
CST Column	0.0041	8.1×10^{-8}

B.3.2.4 Fire in a Process Cell

Scenario: See Section B.3.1.3 for a description of the scenario.

Probability: See Section B.3.1.3 for a discussion of probability.

Source Term: The fire was assumed to damage the process vessel sufficiently to cause a leak. The damage was assumed to be equivalent to a 0.5-inch-diameter opening. The leak was assumed to be stopped within 24 hours, allowing for the fire department to put out the fire, a response plan to be developed, and implementation of the response plan to control the leak. The process cells that would bound this accident for Ion Exchange would be the AST Cell, the Alpha Filter Cell, and the CST Columns Cell. The airborne source terms associated with a fire in each of these process cells are provided in Table B-6. Any release was postulated to occur from the 46-meter stack.

Table B-6. Source terms for process cell fires in the Ion Exchange facility.

	Source term (Ci)	
	Fission products	Transuranics
AST Cell	1.6	0.0031
Alpha Filter Cell	0.72	0.072
CST Columns Cell	55	3.6×10^{-5}

B.3.2.5 Helicopter or Aircraft Crash

Scenario: See Section B.3.1.5 for a description of the scenario.

Probability: The most likely causes of releases from the Ion Exchange Facility from external events would be impacts from helicopter or aircraft crashes. See Section B.3.1.5 for a discussion of the probability of either event occurring.

Source Term: The Ion Exchange facility would be a PC-3 structure with primary and secondary confinement. The building structure would be expected to withstand vehicle crashes. Releases would be expected to occur from helicopter or aircraft crashes. HEPA filters are assumed to be damaged, failing to mitigate the release. The source terms calculated for the various accident scenarios are shown in Table B-7. These releases were postulated as ground-level releases.

Table B-7. Source terms for helicopter or aircraft crashes into the Ion Exchange facility.

	Source Term (Ci)	
	Fission Products	Transuranics
Helicopter Crash[a]		
AST Cell	5,700	11
Alpha Filter Cell	980	99
CST Columns Cell	75,000	0.050
Aircraft Crash	87,000	110

a. Cappucci 2000.

B.3.2.6 Hydrogen Explosion in a Process Cell

Scenario: The decomposition of water as a result of radiolysis leads to the production of hydrogen and oxygen. These flammable gases could accumulate in the vapor space of process vessels and, if left unchecked, could eventually reach the lower flammability limit (LFL) required for an explosion. Failure of the purge system to remove flammable gases, coupled with the presence of an ignition source, could initiate a hydrogen explosion (deflagration or detonation). The tanks of concern include the AST, the tanks in the Alpha Filter Cell (Sludge Solids Receipt Tank, Washwater Hold Tank, and CSDT), and the tanks in the CST columns cell (LRHTs, the CST Columns, and the Product Holdup Tank). The tanks and piping would maintain their integrity during a deflagration, but not during a detonation; therefore, the event was conservatively assumed to be a detonation. An explosion in a process cell was conservatively assumed to release the contents of all vessels within that cell. Significant damage to the HEPA filters and ventilation system was assumed, allowing for an unmitigated radioactive release from the process cell.

Probability: The process equipment was assumed to be similar to process equipment in DWPF. Therefore, frequencies and probabilities for DWPF were used as a basis for this evaluation. The initiating events for a hydrogen explosion in the tank would be the presence of an ignition source and the presence of the explosive gas mixture. The presence of the explosive gas mixture would be due to the loss of purge to the tank that goes undetected and uncorrected. The annual probability that a hydrogen explosion would occur was calculated to be 4.7×10^{-8}. Therefore, a hydrogen explosion in a process cell would be expected to occur once in 21,000,000 years and is not a credible event. Since the likelihood of this event is below the credibility threshold of once in 10,000,000 years, it is not evaluated further in this Appendix.

B.3.3 SOLVENT EXTRACTION

The accidents identified for the Solvent Extraction alternative that would result in the release of radiological materials to the environment include:

- Loss of confinement in a process cell
- Beyond design-basis earthquake
- Fire in a process cell
- Hydrogen explosion in the Extraction Cell
- Helicopter or aircraft crash
- Hydrogen explosion in a process cell

B.3.3.1 Loss of Confinement in a Process Cell

Scenario: Mechanical failure or an external event, such as a dropped cell cover or crane mishap, could cause a loss of the primary confinement for a tank or its associated piping. A loss of primary confinement would release material into the process cell. The tanks of concern are the AST, the tanks in the Alpha Filter Cell (Washwater Hold Tank, Sludge Solids Receipt Tank, CSDT), the Salt Solution Feed Tank, tanks in the Extraction Cell, and the DWPF Salt Feed Tank. Because the material inventory in the CSDT would be small compared to the other vessels in the Alpha Filter Cell, a release from the CSDT would be bounded by releases from the other tanks in the cell. The Strip Effluent Stilling Tank was assumed to contain the bounding inventory in the Extraction Cell. For this event, the entire contents of the bounding tank at maximum capacity would be released through a leak from the tank or associated piping. It was assumed that the release would not be cleaned up for 168 hours (7 days).

A leak detection system would mitigate the consequences of releases from process tanks and associated piping. This system would be designed to detect the leak and terminate the process, thus minimizing the amount of material that would leak from the system. A shielded secondary confinement system would protect onsite workers from radiological consequences of the leaks.

Probability: The initiating event for the loss of primary confinement of a process tank could be mechanical failure or an external event. External events could cause leaks from tanks or from piping. Impacts during cell cover and crane movement are assumed to cause spills from a rupture in the tank or associated piping. It was assumed there would be 50 feet of piping associated with each tank. The annual frequency of a loss of primary confinement for a process tank was calculated to be 3.4×10^{-2}. Therefore, a loss of confinement accident would be expected once in 30 years.

Source Term: A dropped cell cover or crane mishap was assumed to damage the affected tank significantly enough to release the entire contents of the tank to the cell. Good engineering practices would be used during design of the process facility to ensure that HEPA filters would be located in a remote part of the facility away from process cells (e.g., event location). DOE would perform regular in-place testing to ensure that installed HEPA filters would have a particle removal efficiency of greater than 99.9 percent. The HEPA filters and ventilation system were assumed to be operating due to the physical distance between the filter location and the event location, reducing the amount of radioactivity released from the process cell within 99 percent efficiency. The airborne source terms associated with this accident are shown in Table B-8. The release was postulated to occur from the 46-meter stack.

B.3.3.2 Beyond Design-Basis Earthquake

Scenario: The structures for the Solvent Extraction process would be designed to withstand PC-3 earthquakes, straight winds, and tornadoes. See Section B.3.1.2 for a description of the scenario.

Probability: See Section B.3.1.2 for a discussion of the probability of the event occurring.

Table B-8. Source terms for loss of confinement in a process cell of the Solvent Extraction facility.

	Source term (Ci)	
	Fission products	Transuranics
AST	0.46	9.1×10^{-4}
Washwater Hold Tank	0.023	4.5×10^{-7}
Sludge Solids Receipt Tank	0.041	0.0064
Salt Solution Feed Tank	0.46	9.0×10^{-6}
Extraction Cell	0.024	1.8×10^{-9}
DWPF Salt Feed Tank	4.8	3.6×10^{-7}

Source Term: A release of the full inventory from the facility was postulated from collapse of the structure and of the primary and secondary confinement. The airborne source term associated with this accident would consist of 580 Ci of fission products and 0.74 Ci of transuranics.

The release was postulated as a ground-level release.

B.3.3.3 Fire in a Process Cell

Scenario: See Section B.3.1.3 for a description of the scenario.

Probability: See Section B.3.1.3 for a discussion of the probability.

Source Term: The fire was assumed to damage the process vessel sufficiently to cause a leak. The damage was assumed to be equivalent to a 0.5-inch-diameter opening. The leak was assumed to be stopped within 24 hours, allowing the fire department to put out the fire, a response plan to be developed, and implementation of the response plan to control the leak. The process cells that would bound this accident for the Solvent Extraction process would be the AST Cell, the Alpha Filter Cell, the Extraction Cell, the DWPF Salt Feed Tank Cell, the Salt Solution Feed Tank Cell, and the Decontaminated Salt Solution (DSS) Hold Tank Cell. The airborne source terms associated with a process cell fire in any of these cells are provided in Table B-9. The releases were postulated to occur from the 46-meter stack.

Table B-9. Source terms for process cell fires in the Solvent Extraction facility.

	Source term (Ci)	
	Fission products	Transuranics
AST Cell	1.6	0.0031
Alpha Filter Cell	0.46	0.072
Extraction Cell	0.27	2.0×10^{-8}
DWPF Salt Feed Tank Cell	21	1.6×10^{-6}
Salt Solution Feed Tank Cell	1.6	3.1×10^{-5}
DSS Hold Tank Cell	0.011	3.1×10^{-5}

B.3.3.4 Hydrogen Explosion in the Extraction Cell

Scenario: The decomposition of water as a result of radiolysis leads to the production of hydrogen and oxygen. These flammable gases could accumulate in the vapor space of process vessels and, if left unchecked, could eventually reach the LFL required for an explosion. Failure of the purge system and the presence of an ignition source could initiate a hydrogen explosion (deflagration or detonation). The vessels of concern would include the Stripping Effluent Stilling Tank, the Aqueous Raffinate Stilling Tank, and six centrifugal contactors. The vessels were assumed to contain a deflagration, but not a detonation. In a deflagration, the process HEPA filters were assumed to be severely damaged, causing a release from the stack. A detonation would be expected to damage the vessel of concern and release its entire inventory. A hydrogen detonation of any of the vessels would be expected to impact other vessels, due to their co-location in the process cell. To prevent this event, a tank purge or inerting system was assumed to be present. The secondary confinement was assumed to mitigate this event.

Probability: A hydrogen explosion in the process vessels would have the potential to damage the vessels and release all the contents. For this explosion to occur, ignition sources and an explosive gas mixture would have to be present.

For explosive gases to be present, the nitrogen purge system was assumed to fail and the failure to be undetected. The detonation in this cell was assumed to release the inventories of all 16 vessels containing radionuclides within that process cell. This would result in an overall hydrogen detonation frequency of 7.6×10^{-7} per year. Therefore, a hydrogen explosion in the Extraction Cell would be expected once in 1,300,000 years.

Source Term: The hydrogen explosion was assumed to release the entire contents of the Stripping Effluent Stilling Tank, the Aqueous Raffinate Stilling Tank, and six centrifugal contactors within the cell. The HEPA filters and the ventilation system were assumed to be damaged and bypassed, failing to mitigate the release from the process cell. The airborne source term associated with this accident would consist of 357 Ci of fission products and 0.00057 Ci of transuranics. The releases were postulated to occur from the 46-meter stack.

B.3.3.5 Helicopter or Aircraft Crash

Scenario: See Section B.3.1.5 for a discussion of the scenario.

Probability: The most likely causes of releases from the Solvent Extraction facility from external events would be impacts from helicopter or aircraft crashes. See Section B.3.1.5 for a discussion of the probability of such events occurring.

Source Term: The Solvent Extraction facility would be a PC-3 structure with primary and secondary confinement. The building structure would be expected to withstand vehicle crashes. Releases would be expected to occur from helicopter or aircraft crashes. HEPA filters are assumed to be damaged, failing to mitigate the release. The source terms calculated for the various accident scenarios are shown in Table B-10. These releases were postulated as ground-level releases.

Table B-10. Source Terms for Helicopter or Aircraft Crashes into the Solvent Extraction facility.

	Source term (Ci)	
	Fission products	Transuranics
Helicopter Crash[a]		
AST Cell	810	1.6
Alpha Filter Cell	110	28
Extraction Cell	62	0.00088
Salt Solution Feed Tank Cell	810	0.016
DSS Hold Tank Cell	4.4	0.013
DWPF Salt Feed Tank Cell	8,350	0.00063
Aircraft Crash	10,000	13

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a. Cappucci 2000.

B.3.3.6 Hydrogen Explosion in a Process Cell

Scenario: The tanks of concern include the AST, the tanks in the Alpha Filter Cell (Sludge Solids Receipt Tank, Washwater Hold Tank, and CSDT), the Salt Solution Feed Tank, and the DWPF Salt Feed Tank. See Section B.3.2.6 for a description of the scenario.

Probability: See Section B.3.2.6 for a discussion of the probability.

B.3.4 DIRECT DISPOSAL IN GROUT

The accidents identified for the Direct Disposal in Grout alternative which could result in the release of radiological materials to the environment include:

- Loss of confinement in a process cell
- Beyond design-basis earthquake
- Fire in a process cell
- Helicopter or aircraft crash
- Hydrogen explosion in a process cell

B.3.4.1 Loss of Confinement in a Process Cell

Scenario: Mechanical failure or an external event, such as a dropped cell cover or crane mishap, could cause a loss of primary confinement for a tank or its associated piping. A loss of primary confinement would release material into the process cell. The tanks of concern are the AST, the Sludge Solids Receipt Tank, the CSDT, the Salt Solution Hold Tank, and the Saltstone Hold Tank. For this event, the entire tank contents at maximum capacity would be released through a leak from the tank or associated piping. It was assumed that the release would not be cleaned up for 168 hours (7 days).

With the exception of the Saltstone Hold Tank, a leak detection system would mitigate the consequences of releases from process tanks and associated piping. This system would be designed to detect the leak and terminate the process, thus minimizing the amount of material that would leak from the system. Because of the viscous nature of the saltstone grout mixture, a leak detection system might not detect a leak from the Saltstone Hold Tank or piping. However, radiation monitors would be available to detect leakage. The monitors were assumed to be properly positioned and calibrated to ensure detection of a grout mixture leak. A shielded secondary confinement system would protect onsite workers from radiological consequences of leaks from tanks and associated piping. No credit was taken for the leak detection system in the analysis of this event.

Probability: See Section B.3.1.1 for a discussion of the probability of the event occurring.

Source Term: A dropped cell cover or crane mishap was assumed to damage the affected tank significantly enough to release entire inventory to the cell. Good engineering practices would be used during design of the process facility to ensure that HEPA filters would be located in a remote part of the facility away from process cells (e.g., event location). DOE would perform regular in-place testing to ensure that installed HEPA filters would have a particle removal efficiency of greater than 99.9 percent. The HEPA filters and ventilation system were assumed to be operating due to the physical distance between the filter location and event location, reducing the amount released from the process cell within 99 percent efficiency. The airborne source terms associated with this accident are shown in Table B-11. The release was postulated to occur from the 46-meter stack.

Table B-11. Source terms for loss of confinement in a process cell of the Direct Disposal in Grout facility.

	Source term (Ci)	
	Fission products	Transuranics
AST	0.37	7.2×10^{-4}
Sludge Solids Receipt Tank	0.038	0.0020
CSDT	3.8×10^{-5}	2.0×10^{-6}
Salt Solution Hold Tank	0.37	7.2
Saltstone Hold Tank	0.0018	3.6×10^{-8}

B.3.4.2 Beyond Design-Basis Earthquake

Scenario: The structures for the Direct Disposal in Grout process would be designed to withstand PC-3 earthquakes, straight winds, and tornadoes. See Section B.3.1.2 for a description of the scenario.

Probability: See Section B.3.1.2 for a discussion of the probability of the event occurring.

Source Term: A release of the full inventory from the facility was postulated from collapse of the structure and of the primary and secondary confinement. The airborne source term associated with this accident would consist of 77 Ci of fission products and 0.28 Ci of transuranics. The release was postulated as a ground-level release.

B.3.4.3 Fire in a Process Cell

Scenario: See Section B.3.1.3 for a description of the scenario.

Probability: See Section B.3.1.3 for a discussion of the probability of the event occurring.

Source Term: The fire was assumed to damage the process vessel sufficiently to cause a leak. The damage was assumed to be equivalent to a 0.5-inch-diameter opening. The leak was assumed to be stopped within 24 hours, allowing the fire department to put out the fire, a response plan to be developed, and implementation of the response plan to control the leak. The process cells that would bound this accident for the Direct Disposal in Grout process would be the AST Cell, the Sludge Solids Receipt Tank Cell, and the Salt Solution Hold Tank Cell. Good engineering practices would be used during design of the process facility to ensure that HEPA filters would be located in a remote part of the facility away from process cells (e.g., event location). DOE would perform regular in-place testing to ensure that installed HEPA filters would have a particle removal efficiency of greater than 99.9 percent. HEPA filters would be expected to maintain their function due to the physical distance between the filter location the event location, and would minimize releases to the environment 99 percent efficiency. The airborne source terms associated with a process cell fire in any of these cells are provided in Table B-12. The releases were postulated to occur from the 46-meter stack.

Table B-12. Source terms for process cell fires in the Direct Disposal in Grout facility.

	Source term (Ci)	
	Fission products	Transuranics
AST Cell	1.5	0.0029
Sludge Solids Receipt Tank Cell	0.43	0.023
Salt Solution Hold Tank Cell	1.5	2.9×10^{-5}
Saltstone Hold Tank Cell	0.021	4.0×10^{-7}

B.3.4.4 Helicopter or Aircraft Crash

Scenario: See Section B.3.1.5 for a description of the scenario.

Probability: The most likely causes of releases from the Direct Disposal in Grout facility from external events would be impacts from helicopter or aircraft crashes. See Section B.3.1.5 for a discussion of the probability of the event occurring.

Source Term: The Direct Disposal in Grout facility would be a PC-3 structure with primary and secondary confinement. The building structure would be expected to withstand vehicle crashes. Releases would be expected to occur from helicopter or aircraft crashes. HEPA filters are assumed to be damaged, failing to mitigate the release. The source terms calculated for the various accident scenarios are shown in Table B-13. These releases were postulated as ground-level releases.

Table B-13. Source Terms for helicopter or aircraft crashes into the Direct Disposal in Grout facility.

	Source Term (Ci)	
	Fission Products	Transuranics
Helicopter Crash[a]		
AST Cell	5,700	11
Sludge Solids Receipt Tank Cell	590	31
CSDT Cell	0.067	0.0036
Salt Solution Hold Tank Cell	5,700	0.11
Saltstone Hold Tank Cell	3.9	7.6×10^{-5}
Aircraft Crash	1,400	4.8

a. Cappucci 2000.

B.3.4.5 Hydrogen Explosion in a Process Cell

Scenario: The tanks of concern include the AST, the Sludge Solids Receipt Tank, the CSDT, the Salt Solution Hold Tank, and the Saltstone Hold Tank. See Section B.3.2.6 for a description of the scenario.

Probability: See Section B.3.2.6 for a discussion of the probability of the event occurring.

B.4 Accident Impacts Involving Radioactive Materials

This section presents the potential impacts, including LCFs, expected from offsite impacts associated with accident scenarios involving the release of radioactive materials identified in Section B.3.

B.4.1 SMALL TANK PRECIPITATION

Table B-14 provides the radiological impacts to onsite and offsite receptors from the accidents described in Section B.3.1. The accidents are ordered by decreasing frequency.

B.4.2 ION EXCHANGE

Table B-15 provides radiological impacts to onsite and offsite receptors from the accidents described in Section B.3.2. The accidents are ordered by decreasing frequency.

B.4.3 SOLVENT EXTRACTION

Table B-16 provides radiological impacts to onsite and offsite receptors from the accidents described in Section B.3.3. The accidents are ordered by decreasing frequency.

B.4.4 DIRECT DISPOSAL IN GROUT

Table B-17 provides radiological impacts to onsite and offsite receptors from the accidents described in Section B.3.4. The accidents are ordered by decreasing frequency.

B.5 Postulated Accidents Involving Nonradioactive Hazardous Materials

This section summarizes the potential accident scenarios involving nonradioactive hazardous chemicals for the various processes.

B.5.1 SMALL TANK PRECIPITATION

The accidents identified for the Small Tank Precipitation process that result in the release of non-radioactive hazardous materials to the environment include:

- Caustic Tank loss of confinement
- TPB Storage Tank spill
- Organic Evaporator loss of confinement
- PHA Surge Tank loss of confinement
- Beyond design-basis earthquake
- Organic Waste Storage Tank (OWST) loss of confinement
- Loss of cooling
- Benzene explosion in the OWST

B.5.1.1 <u>Caustic Tank Loss of Confinement</u>

Scenario: The Small Tank Precipitation facility would have 5,000 gallons of 50-percent sodium hydroxide in the Caustic Storage Tank and 500 gallons in the Caustic Feed Tank (CFT). The limiting event considered was the spill of the entire inventory of the 5,000-gallon Caustic Storage Tank.

Probability: A leak or rupture of the tank would have the potential to release the tank contents. Spilling of the tank contents could occur from a leak or rupture of the tank or piping. The overall frequency of a spill from a leak or rupture was estimated to be 3.4×10^{-2} per year, or once in 30 years.

Source Term: The source term was estimated by assuming the sodium hydroxide tank would be full and the entire inventory would be released to a diked area outside the facility. The release rate of 1,030 milligrams per second was assumed be at ground level.

B.5.1.2 <u>TPB Storage Tank Spill</u>

Scenario: TPB contains a small amount of benzene (up to 650 parts per million). The TPB Storage Tank would be a 20,000-gallon tank located in the Cold Feeds Area, outside the process areas. A spill from the TPB Storage Tank was assumed to occur, which would cause a benzene release. Some typical causes of acci-

Table B-14. Accident impacts for the Small Tank Precipitation process.

Accident	Annual frequency (frequency category)	Maximally exposed individual (rem)[a]	Maximally exposed individual LCF	Offsite population (person-rem)[a]	Offsite population LCF	Noninvolved worker (rem)[a]	Noninvolved worker LCF	Involved worker (rem)[a]	Involved worker LCF	Onsite population (person-rem)[a]	Onsite population LCF
Loss of confinement	3.4×10^{-2} (Anticipated)										
PHA Surge Tank		0.0016	8.2×10^{-7}	88	0.044	0.024	9.5×10^{-6}	3.2×10^{-6}	1.3×10^{-9}	39	0.016
Precipitate Reactor		4.1×10^{-4}	2.0×10^{-7}	22	0.011	0.0060	2.4×10^{-6}	8.0×10^{-7}	3.2×10^{-10}	9.7	0.0039
Beyond design-basis earthquake	$<5.0\times10^{-4}$ (Unlikely)	0.31	1.5×10^{-4}	16,000	8.0	9.6	0.0038	310	0.12	9,000	3.6
Fire in a process cell	1.0×10^{-4} (Unlikely)	0.014	7.2×10^{-6}	780	0.39	0.21	8.5×10^{-5}	2.8×10^{-5}	1.1×10^{-8}	340	0.14
Benzene explosion in the PHC	1.0×10^{-5} (Extremely Unlikely)	0.70	3.5×10^{-4}	38,000	19	10	0.0041	0.0014	5.5×10^{-7}	17,000	6.7
Helicopter Crash	4.8×10^{-7} (Beyond Extremely Unlikely)										
Fresh Waste Day Tank Cell		0.049	2.5×10^{-5}	2,600	1.3	1.5	6.2×10^{-4}	49	0.020	1,400	0.58
Precipitation Tank Cell		0.059	2.9×10^{-5}	3,100	1.6	1.8	7.4×10^{-4}	59	0.024	1,700	0.69
Concentrate Tank Cell		0.34	1.7×10^{-4}	18,000	9.0	11	0.0043	340	0.14	10,000	4.0
Filtrate Hold Tank Cell		0.0039	1.9×10^{-6}	200	0.10	0.12	4.9×10^{-5}	3.9	0.0016	110	0.046
Wash Tank Cell		0.34	1.7×10^{-4}	18,000	9.1	11	0.0043	350	0.14	10,000	4.0
PHA Surge Tank Cell		3.3	0.0016	170,000	87	100	0.041	3,300	1.3	97,000	39
PHC		1.3	6.3×10^{-4}	67,000	33	40	0.016	1,300	0.51	37,000	15
Aircraft Crash	3.7×10^{-7} (Beyond Extremely Unlikely)	5.4	0.0027	280,000	140	170	0.067	5,400	2.1	160,000	63

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a. Refer to the Glossary for the definition of rem and person-rem.

LCF = latent cancer fatality.

PHA = Precipitate Hydrolysis Aqueous.

PHC = Precipitate Hydrolysis Cell.

Table B-15. Accident impacts for the Ion Exchange process.

Accident	Annual frequency (frequency category)	Maximally exposed individual (rem)[a]	Maximally exposed individual LCF	Offsite population (person-rem)[a]	Offsite population LCF	Noninvolved worker (rem)[a]	Noninvolved worker LCF	Involved worker (rem)[a]	Involved worker LCF	Onsite population (person-rem)[a]	Onsite population LCF
Loss of confinement	3.4×10^{-2} (Anticipated)										
AST		9.7×10^{-5}	4.9×10^{-8}	5.2	0.0026	0.0014	5.7×10^{-7}	2.8×10^{-7}	1.1×10^{-10}	2.3	9.3×10^{-4}
Sludge Solids Receipt Tank		8.3×10^{-4}	4.2×10^{-7}	45	0.022	0.012	4.9×10^{-6}	6.4×10^{-8}	2.6×10^{-11}	20	0.0080
Washwater Hold Tank		2.4×10^{-7}	1.2×10^{-10}	0.0013	6.6×10^{-6}	3.6×10^{-6}	1.4×10^{-9}	1.7×10^{-8}	6.9×10^{-12}	0.0057	2.3×10^{-6}
LRHT		1.8×10^{-5}	9.2×10^{-9}	1.0	5.1×10^{-4}	2.8×10^{-4}	1.1×10^{-7}	1.7×10^{-6}	7.0×10^{-10}	0.44	1.8×10^{-4}
Beyond design-basis earthquake	$<5.0\times10^{-4}$ (Unlikely)	0.12	5.9×10^{-5}	6,200	3.1	3.7	0.0015	120	0.047	3,500	1.4
Loss of cooling to the LRHTs[b]	1.9×10^{-4} (Unlikely)	9.4×10^{-7}	4.7×10^{-10}	0.052	2.6×10^{-5}	1.4×10^{-5}	5.7×10^{-9}	8.8×10^{-8}	3.5×10^{-11}	0.023	9.0×10^{-6}
Fire in a process cell	1.0×10^{-4} (Unlikely)										
AST cell		4.2×10^{-4}	2.1×10^{-7}	23	0.011	0.0062	2.5×10^{-6}	1.2×10^{-6}	4.8×10^{-10}	10	0.0040
Alpha Filter Cell		0.0094	4.7×10^{-6}	500	0.25	0.14	5.5×10^{-5}	9.1×10^{-7}	3.6×10^{-10}	220	0.089
CST Process Cell		4.4×10^{-4}	2.2×10^{-7}	25	0.012	0.0067	2.7×10^{-6}	4.1×10^{-5}	1.7×10^{-8}	11	0.0043
Helicopter Crash	4.8×10^{-7} (Beyond extremely unlikely)										
AST		0.20	9.8×10^{-5}	10,000	5.2	6.2	0.0025	200	0.079	5,800	2.3
Alpha Filter Cell		1.7	8.5×10^{-4}	89,000	45	53	0.021	1,700	0.68	50,000	20
CST Columns Cell		0.11	5.5×10^{-5}	5,800	2.9	3.5	0.0014	110	0.045	3,300	1.3
Aircraft Crash	3.7×10^{-7} (Beyond extremely unlikely)	2.0	0.0010	110,000	53	63	0.025	2,000	0.81	59,000	24

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[a] Refer to the Glossary for the definition of rem and person-rem.

[b] Combined source terms from the LRHTs and the CST Column were used to determine impacts from the loss of cooling event.

LCF = latent cancer fatality; LRHT = Loaded Resin Hold Tank; AST = Alpha Sorption Tank.

Table B-16. Accident impacts for the Solvent Extraction process.

Accident	Annual frequency (frequency category)	Maximally exposed individual (rem)[a]	Maximally exposed individual LCF	Offsite population (person-rem)[a]	Offsite population LCF	Noninvolved worker (rem)[a]	Noninvolved worker LCF	Involved worker (rem)[a]	Involved worker LCF	Onsite population (person-rem)[a]	Onsite population LCF
Loss of confinement	3.4×10^{-2} (Anticipated)										
AST		1.2×10^{-4}	6.1×10^{-8}	6.5	0.0033	0.0018	7.1×10^{-7}	3.5×10^{-7}	1.4×10^{-10}	2.9	0.0012
Wash Water Hold Tank		2.4×10^{-7}	1.2×10^{-10}	0.013	6.6×10^{-6}	3.6×10^{-6}	1.4×10^{-9}	1.7×10^{-8}	6.9×10^{-12}	0.0057	2.3×10^{-6}
Sludge Solids Receipt Tank		8.3×10^{-4}	4.2×10^{-7}	45	0.22	0.012	4.9×10^{-6}	6.4×10^{-8}	2.6×10^{-11}	20	0.0080
Salt Solution Feed Tank		4.8×10^{-6}	2.4×10^{-9}	0.26	1.3×10^{-4}	7.2×10^{-5}	2.9×10^{-8}	3.4×10^{-7}	1.4×10^{-10}	0.11	4.6×10^{-5}
Extraction Cell		1.9×10^{-7}	9.4×10^{-11}	0.010	5.2×10^{-6}	2.9×10^{-6}	1.1×10^{-9}	1.8×10^{-8}	7.1×10^{-12}	0.0045	1.8×10^{-6}
DWPF Salt Feed Tank		3.8×10^{-5}	1.9×10^{-8}	2.1	0.0010	5.7×10^{-4}	2.3×10^{-7}	3.6×10^{-6}	1.4×10^{-9}	0.91	3.6×10^{-4}
Beyond design-basis earthquake	$<5.0\times10^{-4}$ (Unlikely)	0.12	5.8×10^{-5}	6,100	3.0	3.6	0.0015	120	0.046	3,400	1.4
Fire in a process cell	1.0×10^{-4} (Unlikely)										
AST Cell		4.2×10^{-4}	2.1×10^{-7}	23	0.011	0.0062	2.5×10^{-6}	1.2×10^{-6}	4.8×10^{-10}	10	0.0040
Alpha Filter Cell		0.0094	4.7×10^{-6}	500	0.25	0.14	5.5×10^{-5}	7.2×10^{-7}	2.9×10^{-10}	220	0.089
Extraction Cell		2.1×10^{-6}	1.1×10^{-9}	0.012	5.9×10^{-5}	3.2×10^{-5}	1.3×10^{-8}	2.0×10^{-7}	8.0×10^{-11}	0.051	2.0×10^{-5}
Salt Solution Feed Tank Cell		1.7×10^{-5}	8.3×10^{-9}	0.92	4.6×10^{-4}	2.5×10^{-4}	1.0×10^{-7}	1.2×10^{-6}	4.8×10^{-10}	0.40	1.6×10^{-4}
DSS Hold Tank Cell		4.2×10^{-6}	2.1×10^{-9}	0.22	1.1×10^{-4}	6.1×10^{-5}	2.4×10^{-8}	8.3×10^{-9}	3.3×10^{-12}	0.099	4.0×10^{-5}
DWPF Salt Feed Tank Cell		1.6×10^{-4}	8.1×10^{-8}	9.1	0.0045	0.0025	9.9×10^{-7}	1.5×10^{-5}	6.2×10^{-9}	3.9	0.0016
Hydrogen Explosion in the Extraction Cell	7.6×10^{-7} (Beyond extremely unlikely)	0.0029	1.4×10^{-6}	160	0.081	0.044	1.8×10^{-5}	2.7×10^{-4}	1.1×10^{-7}	70	0.028
Helicopter Crash	4.8×10^{-7} (Beyond extremely unlikely)										
AST Cell		0.25	1.2×10^{-4}	13,000	6.5	7.7	0.0031	250	0.099	7,200	2.9
Alpha Filter Cell		1.7	8.5×10^{-4}	89,000	45	53	0.021	1,700	0.68	50,000	20
Extraction Cell		7.2×10^{-4}	3.6×10^{-7}	38	0.019	0.023	9.1×10^{-6}	0.74	2.9×10^{-4}	21	0.0085
Salt Solution Feed Tank Cell		0.0099	5.0×10^{-6}	530	0.26	0.32	1.3×10^{-4}	10	0.0041	290	0.12
DSS Hold Tank Cell		0.0019	9.7×10^{-7}	100	0.051	0.061	2.4×10^{-5}	1.9	7.8×10^{-4}	57	0.023
DWPF Salt Feed Tank Cell		0.079	3.9×10^{-5}	4,200	2.1	2.5	0.0010	81	0.032	2,300	0.94
Aircraft Crash	3.7×10^{-7} (Beyond extremely unlikely)	2.0	0.0010	110,000	54	64	0.026	2,000	0.81	60,000	24

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a. Refer to the Glossary for the definition of rem and person-rem.

LCF = latent cancer fatality, AST = Alpha Sorption Tank, DSS = Decontaminated salt solution.

Table B-17. Accident impacts for the Direct Disposal in Grout process.

Accident	Annual frequency (frequency category)	Maximally exposed individual (rem)[a]	Maximally exposed individual LCF	Offsite population (person-rem)[a]	Offsite population LCF	Involved worker (rem)[a]	Involved worker LCF	Noninvolved worker (rem)[a]	Noninvolved worker LCF	Onsite population (person-rem)[a]	Onsite population LCF
Loss of confinement	3.4×10^{-2} (Anticipated)										
AST		9.0×10^{-5}	4.5×10^{-8}	5.3	0.0027	0.0013	5.4×10^{-7}	6.6×10^{-7}	2.6×10^{-10}	1.6	6.3×10^{-4}
Sludge Solids Receipt Tank		2.4×10^{-4}	1.2×10^{-7}	14	0.0072	0.0036	1.5×10^{-6}	7.3×10^{-8}	2.9×10^{-11}	4.2	0.0017
CSDT		2.4×10^{-7}	1.2×10^{-10}	0.014	7.2×10^{-6}	3.6×10^{-6}	1.5×10^{-9}	7.3×10^{-11}	2.9×10^{-14}	0.0042	1.7×10^{-6}
Salt Solution Hold Tank		3.7×10^{-6}	1.9×10^{-9}	0.22	1.1×10^{-4}	5.3×10^{-5}	2.1×10^{-8}	6.6×10^{-7}	2.6×10^{-10}	0.063	2.5×10^{-5}
Saltstone Hold Tank		1.9×10^{-8}	9.3×10^{-12}	0.0011	5.4×10^{-7}	2.7×10^{-7}	1.1×10^{-10}	3.3×10^{-9}	1.3×10^{-12}	3.1×10^{-4}	1.3×10^{-7}
Beyond design-basis earthquake	$<5.0\times10^{-4}$ (Unlikely)	0.042	2.1×10^{-5}	2300	1.1	1.3	5.3×10^{-4}	42	0.017	1000	0.41
Fire in a process cell	1.0×10^{-4} (Unlikely)										
AST Cell		3.6×10^{-4}	1.8×10^{-7}	21	0.011	0.0054	2.2×10^{-6}	2.7×10^{-6}	1.1×10^{-9}	6.3	0.0025
Sludge Solids Receipt Tank Cell		0.0027	1.4×10^{-6}	160	0.081	0.041	1.6×10^{-5}	8.2×10^{-7}	3.3×10^{-10}	48	0.019
Salt Solution Hold Tank Cell		1.5×10^{-5}	7.5×10^{-9}	0.87	4.4×10^{-4}	2.2×10^{-4}	8.6×10^{-8}	2.7×10^{-6}	1.1×10^{-9}	0.25	1.0×10^{-4}
Saltstone Hold Tank Cell		2.1×10^{-7}	1.0×10^{-10}	0.012	6.1×10^{-6}	3.0×10^{-6}	1.2×10^{-9}	3.7×10^{-8}	1.5×10^{-11}	0.0035	1.4×10^{-6}
Helicopter Crash	4.8×10^{-7} (Beyond extremely unlikely)										
AST Cell		0.20	9.8×10^{-5}	11,000	5.3	6.2	0.0025	200	0.079	4800	1.9
Sludge Solids Receipt Tank Cell		0.53	2.7×10^{-4}	29,000	14	17	0.0067	530	0.21	13,000	5.3
CSDT Cell		0.0081	4.0×10^{-6}	430	0.22	0.25	1.0×10^{-4}	8.2	0.0033	200	0.078
Salt Solution Hold Tank Cell		4.8×10^{-5}	2.4×10^{-8}	2.6	0.0013	0.0015	6.1×10^{-7}	0.049	2.0×10^{-5}	1.2	4.7×10^{-4}
Saltstone Hold Tank Cell		5.3×10^{-4}	2.7×10^{-7}	29	0.014	0.017	6.7×10^{-6}	0.53	2.1×10^{-4}	13	0.0053
Aircraft Crash	3.7×10^{-7} (Beyond extremely unlikely)	0.74	3.7×10^{-4}	40000	20	23	0.0093	740	0.30	18,000	7.3

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a. Refer to the Glossary for the definition of rem and person-rem.

LCF = latent cancer fatality.
AST = Alpha Sorption Tank.
CSDT = Cleaning Solution Dump Tank.

dental spills of chemicals would be overflows, transfer errors, and leaks. The most likely initiator would be a valve or flange leak.

There would be a sump and a dike around the TPB Storage Tank large enough to contain the entire contents of the tank, to prevent it from reaching the environment or process areas in case of a leak.

Probability: The frequency of a spill from the TPB Storage Tank was estimated to be 3.4×10^{-2} per year, or once in 30 years.

Source Term: The following assumptions were made in calculating the benzene source term resulting from a spill from the TPB Storage Tank:

- The concentration of benzene in TPB would be 650 parts per million.
- The spill would result in all of the TPB (20,000 gallons) being released to the Cold Feeds Area dike. At 650 parts per million, the total amount of benzene spilled would be 112 pounds (51.0 kilograms).

The benzene release rate from the spill was calculated to be 110,000 milligrams per second. Release of benzene would occur for 7.5 minutes. The release was assumed to occur at ground level.

B.5.1.3 Organic Evaporator Loss of Confinement

Scenario: A failure of the Organic Evaporator or its associated piping would cause a release of benzene into the PHC. For this event, the entire contents of the evaporator were assumed to be released. A number of initiating events could cause a loss of primary confinement of the evaporator (i.e., leaks, ruptures, crane or cell cover impacts).

Probability: The initiating event frequency is similar to all other loss of confinement events evaluated in this Appendix with a frequency of 3.4×10^{-2} per year, or once in 30 years.

Source Term: The hazardous material source term calculated for this event was a release of 7.8×10^{5} milligrams per second of benzene.

B.5.1.4 PHA Surge Tank Loss of Confinement

Scenario: A failure of the PHA Surge Tank or its associated piping would cause a release of benzene into the PHA Surge Tank process cell. For this event, the entire contents of the tank were assumed to be released. A number of initiating events could cause a loss of primary confinement of the evaporator (i.e., leaks, ruptures, crane or cell cover impacts).

Probability: The initiating event frequency is similar to all other loss of confinement events evaluated in this Appendix with a frequency of 3.4×10^{-2} per year, or once in 30 years.

Source Term: The hazardous material source term calculated for this event was a release of 0.0013 milligrams per second of benzene.

B.5.1.5 Beyond Design-Basis Earthquake

Scenario: The structures for the Small Tank Precipitation process would be designed to withstand PC-3 earthquakes, straight winds, and tornadoes. The PC-3 earthquake is considered to be the bounding NPH event. The process vessels, piping, and structures that house the hardware would be designed to withstand such an earthquake. For the beyond design-basis event, an earthquake slightly stronger than the design-basis earthquake is postulated to occur. This earthquake would cause the primary and secondary confinement to fail, releasing the entire facility inventory into the building. The ventilation system and HEPA filters are also postulated to collapse, resulting in some airborne releases of benzene.

Probability: The initiating event frequency is similar to all beyond design basis earthquake events evaluated in this Appendix with a frequency of 5.0×10^{-4} per year, or once in 2,000 years.

Source Term: The hazardous material source term calculated for this event was a release of 4,600 milligrams per second of benzene.

B.5.1.6 OWST Loss of Confinement

Scenario: The OWST would be a 40,000-gallon tank located outside the process areas. Leak detection would be provided within the secondary tank to alert operators to leakage from the primary tank. The secondary tank would contain any leakage from the primary tank; however, failure of the secondary tank would allow benzene to be released to the ground outside the tank. This scenario would be considered incredible; however, a more likely release scenario would be the failure of the 2-inch process line during benzene transfers from the PHC to the OWST.

Probability: The frequency of concurrent failures of the primary and secondary tanks was calculated to be 7.4×10^{-8}. Failure of the 2-inch process line, however, was deemed to be credible. Assuming that 700 feet of piping would be associated with the tank, and that the transfer operation would be performed 100 hours per year, the frequency of a large spill from the transfer line was calculated to be 7.0×10^{-6} per year, or once in 140,000 years.

Source Term: A rupture of the transfer line from the PHC to the OWST was assumed to release benzene during the transfer operation. The source term calculated for this release of benzene was 5.6×10^{6} milligrams per second.

B.5.1.7 Loss of Cooling

A loss of cooling to the Precipitation, Concentrate, or Wash Tanks would increase the temperature of the liquid phase of the contents of each tank. Benzene generation and releases, due to the radiolytic and catalytic decomposition of TPB, would accelerate. The enhanced benzene evolution would result in a higher benzene concentration in the effluent gas released from these tanks. The effects of a loss of cooling on the Recycle Wash Hold or Filtrate Hold Tanks would be minimal, due to the lack of solids in the liquid phase.

Even with a loss of cooling, the nitrogen flow through the tanks would still maintain the tanks in an inerted condition and would prevent explosions and fires from occurring in the tanks.

The low decay heat rate (approximately 0.005 watts per curie) of the tank contents would mitigate the effects of a loss-of-cooling event. A significant period of time would be required to sufficiently raise the temperature of the tanks to increase benzene generation rates, which would allow operating personnel time to minimize the effects of the accident. In addition, the height of the process stack through which benzene would be released is designed to prevent high concentrations of benzene from reaching onsite workers.

Probability: The frequency of a failure of the cooling water system that would last long enough for process vessels to overheat, resulting in increased benzene emissions, is 6.0×10^{-6} per year, or once in 170,000 years.

Source Term: The following assumptions were made when calculating the benzene source term resulting from a loss of cooling:

- The Small Tank Precipitation facility building stack was assumed to be 46 meters above grade.
- Average exit velocity from the stack would be 10 to 40 meters per second.
- Effluent temperature would be the temperature of the material in the process tanks (45°C).
- The benzene generation per hour would be 50 milligrams per liter of material in the tank.
- Tanks would be at maximum capacity (Precipitation Tanks #1 and #2 – 15,000 gallons each; Concentrate Tank – 10,000 gallons; Wash Tank – 10,000 gallons).

The resulting benzene source term was calculated as 2,600 milligrams per second.

B.5.1.8 Benzene Explosion in OWST

Scenario: Benzene and other organic compounds would normally be present in the OWST. The primary tank would be equipped with a floating roof to restrict organic waste evaporation and to reduce benzene emissions. The primary stainless steel tank would be within a secondary carbon steel tank. To prevent the vapor space from becoming flammable, the OWST would be pressurized with a safety-class nitrogen inerting system. However, the vapor space could become explosive if positive pressure was lost and air leaked into the vessel. With the presence of an ignition source, a deflagration could occur in the tank vapor space and cause the vessel to fail, spilling the liquid benzene inventory into the secondary tank. For this scenario, the secondary tank was also assumed to leak from the force of the explosion.

The OWST would be equipped with a nitrogen purge system and a seismically qualified liquid nitrogen vessel and vaporizer.

Probability: A benzene explosion in the OWST would have the potential to damage and release the entire inventory of benzene. The frequency that an explosion in the tank would occur was calculated to be 1.3×10^{-6} per year, or once in 770,000 years.

Source Term: An explosion of the OWST was assumed to release the entire contents of the primary tank into the secondary tank. The secondary tank was assumed to leak from the force of the primary tank explosion, releasing the entire contents outside the tank. The hazardous material source term was calculated to be 5.2×10^{7} milligrams per second of benzene. The release was assumed to occur at ground level.

B.5.2 ION EXCHANGE AND DIRECT DISPOSAL IN GROUT

One bounding chemical accident was evaluated, a CFT loss of confinement that would be common to both the Ion Exchange and the Direct Disposal in Grout processes.

Scenario: The Ion Exchange facility would have 5,000 gallons of 50-percent sodium hydroxide in the CFT and the Direct Disposal in Grout facility would have 500 gallons of the 50-percent sodium hydroxide solution. Therefore, the limiting event was assumed to be a spill of the entire inventory of the sodium hydroxide tank (5,000 gallons).

Probability: A leak or rupture of the CFT could release the tank contents. The overall frequency of a spill from a leak or rupture was estimated to be 3.4×10^{-2} per year, or once in 30 years.

Source Term: The source term was estimated by conservatively assuming the sodium hydroxide tank would be full and the entire inventory would be released into a diked area outside the building. The release rate of sodium hydroxide was estimated to be 1,030 milligrams per second.

B.5.3 SOLVENT EXTRACTION

The accidents identified for the Solvent Extraction process that result in the release of nonradioactive hazardous materials to the environment include:

- Caustic Tank release
- Caustic Dilution Feed Tank release
- Nitric Acid Feed Tank loss of confinement

B.5.3.1 Caustic Storage Tank Release

Scenario: The Solvent Extraction facility would have sodium hydroxide in the CFT, Filter Cleaning Caustic Tank, Caustic Dilution Feed Tank, Caustic Storage Tank, Caustic Make-up Tank, and Solvent Wash Solution Make-up Tank. The limiting event considered was the spill of the entire inventory of the 5,000-gallon, 50-percent sodium hydroxide Caustic Storage Tank.

Probability: See Section B.5.2 for a discussion of the probability of the event occurring.

Source Term: See Section B.5.2 for a discussion of the source term.

B.5.3.2 Caustic Dilution Feed Tank Loss of Confinement

Scenario: The Solvent Extraction facility would have 15,000 gallons of 2-molar sodium hydroxide in the Caustic Dilution Feed Tank, which would be located in the operating area corridor. For conservatism, the postulated event was assumed to be a spill of the entire inventory, which would be contained in a diked area.

Probability: A leak or rupture of the tank would have the potential for releasing the tank contents. Spilling of the tank contents could occur because of a leak from the tank or piping, or rupture of the tank or piping. The overall frequency of a spill from a leak or rupture was estimated to be 3.4×10^{-2} per year, or once in 30 years.

Source Term: The release of the sodium hydroxide was assumed to be at ground level. The release rate was calculated to be 5,500 milligrams per second.

B.5.3.3 Nitric Acid Feed Tank Loss of Confinement

Scenario: The Solvent Extraction facility would have 1,000 gallons of 50-percent nitric acid in the Nitric Acid Feed Tank located in the Cold Feeds Area outside the main building. For conservatism, the postulated event was assumed to be a spill of the entire inventory, which would be contained in a diked area.

Probability: A leak or rupture of the tank would have the potential for releasing the tank contents. Spilling of the tank contents could occur because of a leak from the tank or piping, or rupture of the tank or piping. The overall frequency of a spill from a leak or rupture was estimated to be 3.4×10^{-2} per year, or once in 30 years.

Source Term: The release of the nitric acid was assumed to be at ground level. The release rate was calculated to be 160 milligrams per second.

B.6 Accident Impacts Involving Nonradioactive Hazardous Materials

As Section B.4 provided for the radiological consequences of identified accidents, this Section provides the potential impacts associated with the release of nonradioactive hazardous materials from the various accident scenarios.

B.6.1 SMALL TANK PRECIPITATION

The accidents described in Section B.5.1 would release hazardous chemicals (sodium hydroxide and benzene). Table B-18 provides atmospheric dispersion factors for two individual receptors: the noninvolved worker and the MEI (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-18.

The ERPG-1 value (described in Section B.2.3) is 0.5 milligrams per cubic meter (mg/m^3) for sodium hydroxide and 160 mg/m^3 for benzene; therefore, no significant impacts would occur to offsite receptors due to a loss-of-cooling accident or spills from the CFT, the TPB tank, or the Organic Evaporator. By definition, individuals exposed to airborne concentrations below EPRG-1 threshold concentrations would not experience even mild transient adverse health effects or the perception of a clearly defined objectionable odor.

Three of the accidents were shown to exceed the ERPG-2 value of 480 mg/m^3 for benzene concentrations to nonninvolved workers. Airborne concentrations from two of these accidents, an explosion in the PHC and OWST loss of confinement, would be below the ERPG-3 value of 3,190 mg/m^3. By definition, individuals exposed to airborne concentrations above the ERPG-2 threshold could experience or develop irreversible or other serious health effects or symptoms that may impair their ability to take protective action. Airborne concentrations from

Table B-18. Chemical release concentrations from Small Tank Precipitation process.

Scenario	Frequency (frequency category)	Evaporation release rate (mg/s)	Atmospheric dispersion factor (sec/m^3)		Resultant concentration (mg/m^3)[a,b,c,d]		Total atmospheric release (mg)
			Noninvolved worker	MEI	Noninvolved worker	MEI	
Sodium hydroxide							
CFT Loss of Confinement	3.4×10^{-2} (Anticipated)	1,030	1.7×10^{-4}	5.7×10^{-7}	0.18	5.9×10^{-4}	770
Benzene							
TPB tank spill	3.4×10^{-2} (Anticipated)	110,000	1.7×10^{-4}	5.7×10^{-7}	18.7	0.06	5.1×10^{7}
Organic Evaporator Loss of Confinement	3.4×10^{-2} (Anticipated)	780,000	1.7×10^{-4}	5.7×10^{-7}	130	0.45	5.7×10^{9}
PHA Surge Tank Loss of Confinement	3.4×10^{-2} (Anticipated)	0.0013	1.7×10^{-4}	5.7×10^{-7}	2.2×10^{-8}	7.41×10^{-10}	800
Beyond Design-Basis Earthquake	5.0×10^{-4} (Unlikely)	4,600	1.7×10^{-4}	5.7×10^{-7}	0.78	0.0026	1.4×10^{7}
OWST Loss of Confinement	7.0×10^{-6} (Extremely unlikely)	5,600,000	1.7×10^{-4}	5.7×10^{-7}	950	3.2	3.3×10^{9}
Loss of cooling accident	6.0×10^{-6} (Extremely unlikely)	2,600	1.7×10^{-4}	5.7×10^{-7}	0.44	0.0015	7.6×10^{7}
OWST explosion	1.3×10^{-6} (Extremely unlikely)	52,000,000	1.7×10^{-4}	5.7×10^{-7}	8,840	30	9.3×10^{9}

Source: WSMS 2000.

a. ERPG-1 value (sodium hydroxide) = 0.5 mg/m^3.

b. ERPG-1 value (benzene) = 160 mg/m^3.

c. ERPG-2 value (benzene) = 480 mg/m^3.

d. ERPG-3 value (benzene) = 3190 mg/m^3.

mg/s = milligrams per second.
sec/m^3 = seconds per cubic meter.
mg/m^3 = milligrams per cubic meter.
CFT = Caustic Feed Tank, PHA = Precipitate Hydrolysis Aqueous, OWST = Organic Waste Storage Tank.

the third accident, an explosion in the OWST, would exceed the ERPG-3 value. By definition, individuals exposed to airborne concentrations above the ERPG-3 threshold could experience or develop life-threatening health effects. All three of these accidents are in the extremely unlikely category.

B.6.2 ION EXCHANGE AND DIRECT DISPOSAL IN GROUT

The CFT accident described in Section B.5.2 would release sodium hydroxide at a release rate of 1,030 milligrams per second. Table B-19 provides atmospheric dispersion factors for two individual receptors, the noninvolved worker and the MEI (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-19.

The ERPG-1 value described in Section B.2.3 is 0.5 mg/m^3 for sodium hydroxide; therefore, no significant impacts would occur to onsite or offsite receptors from this accident. Refer to the discussions in Section B.6.1 on the effects of concentrations below EPRG-1 thresholds.

B.6.3 SOLVENT EXTRACTION

The accidents described in Section B.5.3 would release hazardous chemicals (sodium hydroxide and nitric acid). Table B-20 provides atmospheric dispersion factors for two individual receptors, the noninvolved worker and the MEI (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-20.

The ERPG-1 value (described in Section B.2.3) is 0.5 mg/m^3 for sodium hydroxide and 2.6 mg/m^3 for nitric acid; therefore, no significant impacts would occur to offsite receptors from these accidents. By definition, individuals exposed to airborne concentrations below EPRG-1 threshold concentrations would not experience even mild transient adverse health effects or the perception of a clearly defined objectionable odor. The Caustic Dilution Feed Tank accident would result in concentrations of sodium hydroxide to the noninvolved worker slightly higher than the ERPG-1 values. By definition, individuals exposed to airborne concentrations above the ERPG-1 threshold may experience mild transient health effects.

B.7 Environmental Justice

In the event of an accidental release of radioactive or hazardous chemical substances, the dispersion of such substances would depend on meteorological conditions, such as wind direction, at the time. Given the variability of meteorological conditions and the low probability and risk of accidents, an accident would be unlikely to occur that would result in disproportionately high or adverse human health and environmental impacts to minorities or low-income populations.

Table B-19. Sodium hydroxide release concentrations from Ion Exchange and Direct Disposal in Grout processes.

		Evaporation	Atmospheric dispersion factor (sec/m^3)		Resultant concentration (mg/m^3)[a]		Total
Scenario	(frequency category	release rate (mg/s)	Noninvolved worker	MEI	Noninvolved worker	MEI	atmospheric release (mg)
CFT Loss of Confinement	3.4×10^{-2} (Anticipated)	1,030	1.7×10^{-4}	5.7×10^{-7}	0.18	5.9×10^{-4}	770

Source: WSMS 2000.

a. ERPG-1 value = 0.5 mg/m^3.

mg/s = milligrams per second.
sec/m^3 = seconds per cubic meter.
mg/m^3 = milligrams per cubic meter.

Table B-20. Chemical release concentrations from Solvent Extraction process.

	Frequency	Evaporation	Atmospheric dispersion factor (sec/m^3)		Resultant concentration (mg/m^3)^{a,b,c}		Total
Scenario	(frequency category)	release rate (mg/s)	Noninvolved worker	MEI	Noninvolved worker	MEI	atmospheric release (mg)
Sodium hydroxide							
CFT Loss of Confinement	3.4×10^{-2} (Anticipated)	1,030	1.7×10^{-4}	5.7×10^{-7}	0.18	5.9×10^{-4}	770
Caustic Dilution Feed Tank Loss of Confinement	3.4×10^{-2} (Anticipated)	5,470	1.7×10^{-4}	5.7×10^{-7}	0.93	0.0031	5.5×10^{3}
Nitric acid							
Nitric Acid Feed Tank Loss of Confinement	3.4×10^{-2} (Anticipated)	155	1.7×10^{-4}	5.7×10^{-7}	0.026	8.8×10^{-5}	95

Source: WSMS 2000.

a. ERPG-1 value (sodium hydroxide) = 0.5 mg/m^3.

b. ERPG-2 value (sodium hydroxide) = 5.0 mg/m^3.

c. ERPG-1 value (nitric acid) = 2.6 mg/m^3.

mg/s = milligrams per second.
sec/m^3 = seconds per cubic meter.
mg/m^3 = milligrams per cubic meter.

References

AIHA (American Industrial Hygiene Association), 1991, *Emergency Response Planning Guideline*, Emergency Response Planning Guidelines Committee, Akron, Ohio.

Cappucci, A. J., Jr., M. L. Baker, D. E. Welliver, 2000, Determination of Accident Sequence, Frequency, and Source Term Selection for the Salt Disposition Supplemental Environmental Impact Statement (U), S-CLC-G-00187, Rev. 2, Westinghouse Safety Management Solutions, Aiken, South Carolina.

Cappucci, A. J., Jr., 2000, (Westinghouse Safety Management Solutions) electronic message to B. Bradford (Tetra Tech NUS), "Corrected Table," Aiken, South Carolina, September 19.

DOE (U.S. Department of Energy), 1993*, Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, Office of Environment, Safety, and Health (EH-25)*, Washington, D.C.

DOE (U.S. Department of Energy), 1994a, *Preparation Guide for U.S. DOE Non-reactor Nuclear Facility Safety Analysis Reports*, Standard DOE-STD-3009-94, Washington, D.C.

DOE (U.S. Department of Energy), 2000a, *Analyzing Accidents under NEPA*, – Draft –, Office of NEPA Policy and Assistance, Washington, D.C., April 21.

DOE (U.S. Department of Energy), 2000b, *High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS0303D, Savannah River Operations Office, Aiken, South Carolina.

Hope, E. P., 1999, *Parametric Dispersion Calculations for H-Area Releases*, S-CLC-H-00693, Rev. 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitation of Exposure to Ionizing Radiation*, Report No. 116, Bethesda, Maryland.

NRC (U.S. Nuclear Regulatory Commission), 1982, *Regulatory Guide 1.145: Atmospheric Dispersion Models for Potential Accidental Consequence Assessments at Nuclear Power Plants*, Rev. 1, Washington, D.C.

Simpkins, A. A., 1995a, *Verification of AXAIRQ*, WSRC-RP-95-708, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1995b, *AXAIRQ User Manual*, WSRC-RP-95-709, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1999, memorandum to C. B. Shedrow, "Salt Disposition Facility EIS Accidental Release Environmental Dosimetry Calculations," SRT-EST-99-316, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, July 22.

WSMS (Westinghouse Safety Management Solutions), 2000, "ERPGs and TEELs for Chemicals of Concern: Rev. 16," WSMS-SAE-00-0001, Aiken, South Carolina, January 3.

APPENDIX C

PUBLIC SCOPING SUMMARY

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APPENDIX C. PUBLIC SCOPING SUMMARY

Appendix C describes the process followed by the U.S. Department of Energy (DOE) to define the scope of the *Salt Processing Alternatives Supplemental Environmental Impact Statement* (SEIS). It also describes the issues raised during the scoping process, the comments received from the stakeholders of the Savannah River Site (SRS) on the planned SEIS, and the DOE responses to these comments.

C.1 Scoping Process

On February 22, 1999, DOE announced its intent to prepare an SEIS to assess the environmental impacts of constructing and operating a facility to process the salt component of the high-level waste (HLW) stored at SRS (64 FR 8558). The Notice of Intent began a scoping period that extended until April 12, 1999, and announced that DOE would hold scoping meetings in Columbia and North Augusta, South Carolina, during the scoping period. The scoping meetings were subsequently announced in local newspapers.

DOE encouraged SRS stakeholders and other interested parties to submit comments for consideration in the preparation of the SEIS. DOE established several methods for such submittals:

- By letter to the Savannah River Operations Office
- By voice mail using a toll-free telephone number
- By facsimile transmission (fax) using a toll-free telephone number
- By electronic mail (e-mail) to an address at the Savannah River Site
- Orally or in writing at public scoping meetings.

DOE held scoping meetings on the planned SEIS in Columbia, South Carolina, on March 11, 1999, and in North Augusta, South Carolina, on March 18, 1999. Each meeting consisted of an afternoon and an evening session. Each session included an introduction to the National Environmental Policy Act (NEPA) process in relation to the process for selecting a technology for salt processing. Each session also included opportunities to ask questions of DOE officials and to offer comments on the scope of the SEIS for the record. Transcripts of the question and answer and comment portions of the meetings are available for inspection at the DOE Public Reading Room, Gregg-Graniteville Library, University of South Carolina at Aiken, University Parkway, Aiken, South Carolina.

C.2 Summary of Scoping Comments and Issues

During the scoping period, DOE received the following:

- Four comment letters
- One comment e-mail
- One recommendation from the SRS Citizens Advisory Board
- Thirty-two verbal comments from eight individuals at the Columbia scoping meetings
- Twenty-seven verbal comments from nine individuals at the North Augusta scoping meetings.

In these submittals and presentations, DOE identified 93 separate comments. The Department reviewed and categorized these comments into six categories:

- Alternatives
- ITP process
- Impact Evaluation and Analysis
- Criteria and Regulations

- Schedule and Process
- Miscellaneous Topics.

The following paragraphs discuss the comments and provide DOE's responses to them.

The letters are numbered L1 through L4. The SRS Citizens Advisory Board recommendation is numbered R1, and individual comments within the letters are numbered consecutively. The transcript from the North Augusta public meeting is designated TNA and the transcript from the Columbia public meeting is designated TC, with comments numbered consecutively.

Comments About the Alternatives: Twenty-five comments addressed various aspects of the alternatives. Comments included the following:

Comments About the Small Tank Precipitation Alternative:

- The SEIS should describe why the Small Tank Precipitation alternative could be successful, when the ITP process was not. The chemistry of the two processes is the same. Why even consider it? (L1-1, TC-22, TC-23, TNA-14, TNA-16)

DOE Response: The SEIS describes the Small Tank Precipitation alternative and the differences between it and the ITP process. The process is being considered because it shows promise as a viable process. With process controls, the problems evident in the ITP process may be overcome. Research and development efforts are underway to address the known problems with the ITP process.

- For the Small Tank Precipitation alternative, how would benzene generation be controlled and how would the benzene that is generated be managed? (TC-1, TC-29, TC-30, TC-31)

DOE Response: The small tank concept involves two tanks in series, in order to give adequate residence time for the reaction to take place, while at the same time allowing the product to be filtered and sent to the Defense Waste Processing Facility (DWPF) on a schedule to minimize the time that the precipitate sits in the tanks and undergoes chemical decomposition, which produces benzene. Appendix A provides more detail about the process. The tanks can be designed to reduce flammability by using an inert gas atmosphere and continuous cooling. In addition, product would be filtered and sent to DWPF following a residence time that allows the reactions to take place, but does not allow for a great deal of decomposition. Benzene releases will be controlled and would comply with emissions limits.

- Is the salt loading of the glass in the Small Tank Precipitation alternative actually higher than in the ITP case? (TNA-12)

DOE Response: Yes. Because the chemical process would be slightly different, the glass would contain more salt waste. The glass would have to meet certain standards to ensure that waste acceptance criteria for a geologic repository would be met.

Comments About the Ion Exchange Alternative:

- The Ion Exchange alternative should be divided into elutable and non-elutable ion exchange alternatives. For the Ion Exchange alternative, would the salt go through the column as opposed to adding the resin to a tank? How many changes of the resins would be required in a year, and are the spent resins considered HLW (L1-2, TC-20, TC-21, TNA-11, TNA-20)

DOE Response: Elutable ion exchange is not considered a reasonable alternative. This process was evaluated, but eliminated because it did not appear superior to the non-elutable ion exchange process. The process for selecting salt processing technologies for further design and research and development is described in Chapter 2 and Appendix A of the SEIS.

The Ion Exchange alternative being considered would involve passing the salt solution through ion exchange columns. The resin beds have an expected life of about 90 days. The spent resin would be HLW and would be sent to DWPF for vitrification.

Comments About the Direct Disposal in Grout Alternative:

- The Direct Disposal in Grout alternative should discuss storage vault design and performance and include any changes or upgrades to the existing vault system to safely dispose of the high-cesium grout. The integrity of the room system should be determined. (L1-3, TNA-10, TNA-21)

DOE Response: The description of the Direct Disposal in Grout alternative in Chapter 2 and Appendix A includes a discussion of the vault requirements and design. If the Direct Disposal in Grout alternative is chosen as the salt processing technology, DOE would prepare a Radiological Performance Assessment to describe in detail the expected performance of the vault design and grout mixture over time. This SEIS makes certain assumptions about vault performance, which DOE believes to be reasonable, in order to predict the environmental impacts of this alternative on the basis of currently available information.

- The SRS Citizens Advisory Board is concerned about consideration of the Direct Disposal in Grout alternative and will not favor it unless it is fully justified. They will not accept it as the preferred alternative if the sole reason given is that funds are not available for the other choices. To be acceptable to the Citizens Advisory Board, the preferred alternative must be justified for reasons of technical feasibility, worker safety, and public health and environmental protection. (R-1)

DOE Response: Information on the issues cited by the commentor is included in the SEIS for each alternative. Preliminary cost estimates have been prepared and are included in Section 2.8.3 of the SEIS. Cost does not provide any differentiation between alternatives. Initial estimates of cost are from $900 million to $1.2 billion, such that costs of all the alternatives are in the same range.

- Are the curie measurements total curies, per cubic meter, or something else? (TNA-1)

DOE Response: Measurements of curies are given as total curies disposed of in saltstone for each alternative.

Comments About the No Action Alternative:

- DOE should pursue one of the three technical alternatives rather than No Action. Tank waste is thought to represent the greatest hazard to the offsite environment and public safety and it must be dealt with sooner or later. (TNA-3)

DOE Response: DOE proposes to pursue one of the processing technologies rather than take no action. However, No Action is analyzed under NEPA to provide a basis for comparison of the action alternatives.

- The No Action alternative is inadequately described (in DOE's Notice of Intent). Also, the No Action alternative for this SEIS is different from the No Action alternative for the HLW Tank Closure EIS. (L1-4, L1-10, L1-13, TNA-22, TNA-27)

DOE Response: DOE has revised the No Action alternative from that presented in the Notice of Intent (64 FR 8558) to provide a more complete description and to ensure a consistent approach between the two HLW NEPA reviews. Under the No Action alternative, 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 activities would continue.

- Why would you revisit the No Action alternative (from the 1994 DWPF SEIS) because of this proposed change in a part of the system addressed in the 1994 DWPF SEIS? (TNA-5)

DOE Response: DOE has changed the No Action alternative for this SEIS from that presented in the Notice of Intent (64 FR 8558). The No Action alternative for the 1994 DWPF SEIS was to not operate the DWPF or related facilities, including the ITP process. DOE decided to operate DWPF, however, in the April 12, 1995, Record of Decision (60 FR 18589-18594) for the Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility. The No Action alternative for this SEIS has therefore been defined as continuing the status quo, which includes operating the DWPF.

- For purposes of analysis, how far into the future do you assess the No Action alternative? (TNA-2)

DOE Response: DOE recognizes that the No Action alternative, continuing the status quo (including tank space management), cannot go on indefinitely in the absence of an operational salt processing alternative. Using evaporators and other existing equipment, DOE believes that tank space could be adequate and that tank closure commitments could be met until about 2010. After that, new tanks would be needed to continue the No Action alternative. Thus, the period through 2023 is used for analysis of the near term impacts of the No Action alternative.

<u>**Comments About All of the Alternatives**</u>:

- Compare the total curie content and concentrations for all known radioactive low-level burial grounds country-wide with the curie content in the saltstone for all three alternatives (i.e., 26,000 curies in saltstone for the Small Tank Precipitation and Ion Exchange alternatives and 120,000,000 curies for the Direct Disposal alternative). (R-4)

DOE Response: To date, DOE has disposed of about 9,710,000 curies in the SRS Old Radioactive Waste Burial Ground, the Mixed Waste Management Facility, and the Low-Level Radioactive Waste Disposal Facility, and expects to dispose of an additional 5,480,000 curies over the next 20 years from projects other than those analyzed in this SEIS. The ChemNuclear facility at Barnwell, South Carolina, disposes of about 225,000 curies per year, or about 7 million curies since the facility opened in 1974. Information on other facilities is not readily available. DOE estimates that the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives would result in less than 20,000 curies disposed of in saltstone over the life of the project. If the Direct Disposal in Grout alternative were selected, about 120,000,000 curies of cesium would be disposed of onsite in saltstone.

- Each of the alternatives should be evaluated in the same depth. Do not make judgments on some that delete the necessary analysis. (L1-5, TNA-23)

DOE Response: DOE has evaluated each alternative at a similar level of detail, consistent with the available information.

- There should be a long-term risk analysis for each of the alternatives. The analyses should consider loss of institutional control and facility degradation leading to the release of waste contents. Differences in leach resistance of the material to be left at SRS should be included. The materials that would be left at SRS under each alternative should be defined. (L1-6, TNA-24, R-3)

DOE Response: Analyses of the long-term impacts of the alternatives are included in the draft SEIS. For disposal facilities (i.e., the saltstone vaults) a detailed Radiological Performance Assessment is required by DOE Order 435.1 and would be prepared following the selection of an alternative for implementation. Because DOE has no plans for relinquishing institutional control of the SRS or the area immediately surrounding the saltstone vaults, institutional control is considered to apply for each alternative, in accordance with DOE Order 435.1 and DOE Manual 435.1-1. However, for purposes of this NEPA review loss of institutional control was analyzed for all alternatives. A description of the materials and fission products that would be converted to saltstone is provided for each alternative.

- Does the EIS scope include a transfer facility or a transfer mechanism? Does the scope include decontamination and decommissioning of the existing Saltstone Manufacturing and Disposal Facility?

DOE Response: Material transfer mechanisms are evaluated as part of each alternative considered in this SEIS. Because portions of the existing Saltstone Manufacturing and Disposal Facility would be utilized for each of the alternatives, decontamination and decommissioning of the existing facility is not considered in this SEIS.

- The salt fraction is technically a solid, but what is it actually like? (TC-7)

DOE Response: The salt fraction is best described as a slurry.

Comments Concerning the ITP Process: Twelve comments questioned the ITP process.

- In the ITP process, how was benzene generated, why was it not anticipated, and weren't there reports from the Institute for Energy and Environmental Research that indicated the process would not work? (TC-3, TC-4, TC-5, TC-11, TC-12, TC-24, TC-25, TC-26, TC-27, TC-28)

DOE Response: Benzene was generated as a result of the radiolytic and catalytic breakdown of tetraphenylborate (TPB), a chemical used to precipitate cesium from the salt solution. Some benzene generation, from sodium tetraphenylborate radiolytic decomposition and also from its catalytic reaction with copper, was anticipated. HLW was tested to determine its composition and identify elements that might interfere with the reaction. Copper was identified as present in the waste stream and was known to be a catalyst. However, research after the 1996 suspension of ITP operations demonstrated that palladium and potentially other elements present in the HLW tanks, and compounds resulting from TPB decomposition, also contribute to benzene generation.

Several parties raised concerns in the 1980s and early 1990s about the ITP process. DOE's research at that time had indicated the potential problems could be overcome and the process could be successful.

- Was an effort made to look into Hanford HLW management approaches and technologies and potentially avoid the ITP problems? (TC-13, TC-14)

DOE Response: HLW treatment at DOE's Hanford site is not as far along as it is at SRS. Hanford currently has no process available for HLW treatment or stabilization. In addition, HLW at Hanford differs from HLW at SRS. Hanford used several chemical separation technologies, while SRS used only two (one in F Canyon and one in H Canyon). Consequently there is considerably more chemical variability in the Hanford HLW than the SRS HLW. Also, in general, SRS process knowledge and characterization of HLW sent to the HLW tanks is better than that available at Hanford. There was no Hanford experience or technology research from which SRS could learn when the DWPF process, including ITP, was being developed.

- Is the ITP to be used (in the SEIS) strictly as a comparison with the proposed technologies? (TC-2)

DOE Response: DOE has decided to define the No Action alternative as a continuation of the status quo, which does not include operation of ITP. DOE does not consider operation of ITP to be a reasonable alternative.

- Several individuals and groups concluded in the past that the sodium TPB process could fail because of high rates of benzene generation. Alternatives, including alkaline solvent extraction, should be given careful consideration. The commentor would be pleased to assist in the evaluation of alternatives. (L2-1, L2-2, L2-3)

DOE Response: The Small Tank Precipitation alternative involves the use of the same chemistry as the ITP process. However, as described in the SEIS, the continuously stirred tank reactors are expected to allow greater control over the waste residence time and therefore limit the generation of benzene. DOE reviewed a large number of potential salt processing alternatives, including alkaline solvent extraction. After very careful review, DOE has decided to pursue the four alternatives described in this SEIS, including an alkaline solvent extraction process termed Caustic Side Solvent Extraction. DOE has a number of independent reviewers providing oversight of the technology selection process, and providing technical support to technology research and development efforts.

Comments Related to Impact Evaluation and Analysis: Several comments concerned the evaluation and analysis of potential environmental impacts of the alternatives.

- What is the primary concern for long-term impacts on groundwater? Is it nitrate or technetium? (L1-8)

DOE Response: Because it is an extremely long-lived radionuclide, technetium is expected to outcrop at the point of compliance for the Z-Area saltstone vaults, and it dominates the radiological source term in groundwater over the long term (10,000 years). Nitrate is an important nonradiological contaminant in the short term. Modeling of nitrate behavior in the long term shows that its projected concentrations at points of discharge would not be high enough to cause health concerns.

- The major difference with the Direct Disposal in Grout alternative is that SRS would not remove the cesium from the salt solution that would be disposed of in the Z-Area saltstone vaults. What impact does this have? (L1-9)

DOE Response: If the Direct Disposal in Grout alternative is selected, approximately 120,000,000 curies of cesium-137 would be disposed of in a grout mixture in the Z-Area saltstone vaults. The potential impacts are described in Chapter 4 of the SEIS.

- The planned institutional control should be discussed for each alternative. What will the staff do during this institutional control? How will the life-cycle costs be affected? (L1-11)

DOE Response: DOE has no plans to release any part of the SRS from institutional control. Current and reasonably foreseeable missions extend well beyond 50 years from the present. In accordance with DOE Order 435.1, DOE may establish an appropriate buffer zone based on current plans for institutional control. Permit requirements would require monitoring at 100 meters from the vaults for releases from the Z-Area saltstone vaults. SRS employees would perform maintenance, monitoring, and security functions during the period of institutional control.

- Since implementation time for each of these alternatives will be different and canyon operations will continue generating new waste, the SEIS should discuss waste tank utilization. The risk difference of waste tank leakage must be evaluated. For example, if some alternatives require use of only Type III waste tanks, they would have a different risk than an alternative that would require use of older Type I tanks. The commentor hopes there is no planned use of single-shell tanks. (L1-12)

DOE Response: Waste tank utilization and tank space management are discussed in Chapter 2 and Appendix A of the SEIS. DOE will manage tank space in accordance with the High-Level Waste System Plan. DOE is committed, through the Federal Facility Agreement, to remove waste from tanks on an agreed-upon schedule. DOE intends to manage the selection, construction, and operation of a replacement salt processing facility and current facilities, such that these commitments can be met.

- Are there comprehensive studies planned to both identify (by chromatographic and spectroscopic techniques), and characterize (using cyclic voltammetry or other electrochemical techniques), metal ions that may play significant roles in the catalytic decomposition of sodium TPB? (L4-1)

- Has the formation of a polymeric film or compound been noted in the tanks, and, if so, are studies planned to characterize the polymer and identify the source? (L4-2, L4-3)

- Will studies be performed to determine if catalytic decomposition effects of metal, metal-complex, or surfaces can be removed? Are there plans to characterize the chemical and potential catalytic properties under the Small Tank Precipitation option? (L4-4, L4-5)

- Are there tests planned to characterize resins in regard to performance, fouling, decomposition, and safety hazards using actual HLW prior to approval for use at production levels? (L4-6)

DOE Response: DOE is conducting an extensive program of research and development on each of the salt processing alternatives. Work is being done at the Savannah River Technology Center and at Oak Ridge, Sandia, Pacific Northwest, and Argonne National Laboratories. Because the decomposition of sodium TPB catalyzed by copper and palladium (and possibly other elements and compounds) caused the high rates of benzene generation in the ITP process, extensive studies of potential catalysts and methods to reduce or eliminate their impacts on the reaction are part of the research and development effort. Similarly, characterization of resin performance in a highly radioactive environment is the focus of studies on the Ion Exchange alternative.

- Are the results of the technology studies intended to coincide with the development of the SEIS? When the SEIS is published in draft, will the trade studies or the research and development studies also be made available for public review? Is there any way that the resolution of the technical issues will be communicated to the public as they begin to review the draft SEIS? (TC-8, TC-18, TNA-8)

DOE Response: Technology research and development studies are being carried out in parallel with the development of the SEIS. The results of the studies are being made available for public review. Research and development reports and test results are available now on the SRS web site at www.srs.gov/general/srtech/spp/randd.htm, and can be reviewed in conjunction with this Draft SEIS.

- Will cost be included in the scope of the SEIS to differentiate between alternatives? Will cost studies for the alternatives be prepared? Is there any feel yet on an order of magnitude basis for the comparative costs? Are they all about the same? How much money is needed to go through the analytical portion and the research and development to select the right alternative? And how much do you have? (TC-17, TC-32)

DOE Response: Preliminary cost estimates have been prepared and are included in Section 2.8.3 of the SEIS. Cost does not provide any differentiation between alternatives in regard to environmental impacts. Initial estimates of cost are from $900 million to $1.2 billion, such that costs of all the alternatives are in the same range. DOE funded about $17 million for the research and development effort in Fiscal Year 2000 and about $29 million in Fiscal Year 2001 to ensure that the alternative ultimately selected will achieve the salt processing and safety goals.

- Would it be correct to say that the cesium grout is probably the quickest and the cheapest alternative to implement? Is that why it is attractive? Money spent on this would take away from something else. (TNA-7)

DOE Response: The greatest attraction of the Direct Disposal in Grout alternative is that it has no technical uncertainty. Estimated costs of implementation of the alternatives are similar, given the preliminary state of the designs.

- Do you believe there are any showstoppers in those five technical issues that you talked about? (TNA-9)

DOE Response: DOE decided to carry out additional research and development to ensure that any alternative selected could in fact be implemented. Certain elements of the technologies have not been demonstrated, like the continuous processing of the Small Tank Precipitation alternative. DOE has found no fatal flaws in any of the four alternatives.

- If the SEIS is approved a year from now, when would your process be operating? (TNA-19)

DOE Response: DOE intends to have the selected salt processing alternative operating in about Fiscal Year 2010, assuming a two-year startup period.

- There should be an evaluation of the impacts of different time periods for the four alternatives and the impacts they will have on waste tank operations and the availability of tank space. (TNA-26)

DOE Response: Waste tank utilization is discussed in Chapter 2 and Appendix A. DOE is committed, through the Federal Facility Agreement, to remove waste from tanks on an agreed-upon schedule. DOE intends to manage the selection, construction, and operation of a replacement salt processing facility, such that these commitments can be met.

Comments About Schedule and Process:

- What is the schedule for completion of the studies and the facility? (TC-16)

DOE Response: Planned startup of the new salt processing facility is about 2010. DOE expects to complete research and development and identify a preferred technology by June 2001. Results of research and development studies will be an important factor in the technology selection. Decision by Summer 2001 is critical to selecting a design contractor, initiating pilot-scale studies of the selected technology, and ultimately, bringing a salt processing alternative on line in time to meet SRS commitments for HLW vitrification and HLW tank closure.

Comments About Criteria and Regulations:

- What is the status of discussions on the Direct Disposal in Grout alternative with the regulators, and what kind of reaction have you gotten? What are the responsibilities of the U.S. Nuclear Regulatory Commission (NRC) versus the U.S. Environmental Protection Agency (EPA) or the South Carolina Department of Health and Environmental Control (SCDHEC)? (TNA-6)

DOE Response: DOE has discussed the Direct Disposal in Grout alternative with SCDHEC and EPA, in the context of the permitted saltstone disposal facility. The NRC is not involved in permitting the saltstone disposal facility. 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.

Comments About Miscellaneous Topics:

- ARCTECH wishes to submit information about our *HUMASORB-CS*^{TM} absorbant technology for the In-Tank Precipitation process. ARCTECH is demonstrating application of the product under the Federal Energy Technology Industry Programs supported by DOE. ARCTECH believes the product can provide a safe and cost-effective solution for separation of the high-activity waste fraction. We request that DOE consider this for further evaluation and design of an applicability approach. (L3-1, L3-2, L3-3, L3-4)

DOE Response: The *HUMASORB-CS*^{TM} product is utilized in an organic resin form that must be disposed of once the material is loaded with contaminants. The disposal process recommended by ARCTECH is incineration of the combustible organic resin for volume reduction and ash disposal. This resin-processing method does not meet final waste form requirements and would potentially require major modifications to the vitrification process. Specifically, the limits on the amount of carbon-based material that could be fed to the DWPF melter would be exceeded. The melter cannot function as an incinerator and could be damaged if used in that capacity.

- Consider the life-cycle costs for all options, including institutional care for all four options. (R-2)

DOE Response: Because facility construction and operation costs are still very preliminary, reliable life cycle cost data will not be available when the technology selection is made.

- Evaluate the impact of the Direct Disposal in Grout alternative on the proliferation resistance of the HLW canisters. Proliferation resistance to terrorists who might be tempted to recover the plutonium from the vitrified canisters to build nuclear weapons depends upon the high radiation fields from the presence of cesium-137 in the HLW. Removing the cesium-137 from the vitrification process and disposing of it in grout in the ground at SRS means that the radioactive cesium will not be available to enhance the proliferation resistance of the plutonium in canisters of vitrified HLW. (R-5)

DOE Response: The National Academy of Sciences (1994) has suggested two "complementary" standards to maintain proliferation resistance during weapon and plutonium dismantlement, storage, and disposition. The *stored weapon standard* would mean the "high standards of security and accounting applied to storage of intact nuclear weapons should be maintained for these materials throughout these processes." The *spent fuel standard* would mean that the plutonium is "roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel." The NRC and the International Atomic Energy Agency consider materials emitting more than 100 rad per hour at 1 meter (the radiation part of the spent fuel standard) to be sufficiently self-protecting to require a lower level of safeguarding. DWPF canisters without cesium-137, such as the "sludge only" canisters being produced now, emit about 1 to 2 rads per hour at 1 meter, well above the yearly administrative limit of 0.5 rad for SRS workers, but well below the self-protecting standard. Canisters with cesium could emit hundreds of rad per hour. Canisters produced using the Direct Disposal in Grout alternative would not meet the self-protecting requirement without the addition of another radiation source. Therefore, the Direct Disposal in Grout alternative, as currently designed, does not support plans to meet the spent fuel standard for plutonium immobilized in HLW canisters.

- Is the Salt Processing Engineering Team Final Report a publicly available document? (TC-10)

DOE Response: Yes. This report has been made available in the DOE reading room cited in this SEIS.

- Before DWPF, were there problems with precipitated material that was difficult to get out of the tanks? (TC-15)

DOE Response: DOE has recognized for a long time that sludges in the HLW tanks might be difficult to remove. However, the technology exists to overcome this problem and has been demonstrated in the waste removal and closure of Tanks 17 and 20. This issue is discussed in detail in the Draft *HLW Tank Closure EIS* (DOE 2000).

- How much are Citizens Advisory Board advice or suggestions taken into account? (TC-18, TNA-15)

DOE Response: Recommendations from the SRS Citizens Advisory Board are always taken very seriously and considered very carefully. An SRS Citizens Advisory Board focus group reviewed the technology selection process that led to the four alternatives currently being considered, and the SRS Citizens Advisory Board has provided recommendations on the scope of this SEIS.

• What do you plan to do with the large tanks that have already been treated with TPB? (TNA-17)	**DOE Response:** Two tanks were used for processing activities using TPB. DOE intends to return Tank 49 to service. DOE is reviewing options and has not decided what to do with Tank 48.

References

DOE (U.S. Department of Energy), 2000. *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, Office of Environmental Management, Washington, D.C.

NAS (National Academy of Sciences), 1994. *Management and Disposition of Excess Weapons Plutonium*, National Academy Press.

APPENDIX D

LONG-TERM PERFORMANCE EVALUATION

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APPENDIX D. LONG-TERM PERFORMANCE EVALUTAION

This Appendix describes the methodology used by the U.S. Department of Energy (DOE) in determining long-term impacts that could occur from implementation of the action alternatives described in Chapter 2 of this Supplemental Environmental Impact Statement (SEIS).

In order to estimate the impacts of no action in the long term, DOE must assume that the HLW remains in the HLW storage tanks and no action is ever taken to ensure safe management. In this worst-case scenario, the HLW tanks would eventually fail and the contents would be released to the groundwater and eventually, to surface water. DOE has not attempted to model this scenario. Some indication of the potential for impacts may be gained, however, from a comparison with modeling results DOE prepared for the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000).

Under the No Action alternative in the Tank Closure Draft EIS (DOE 2000), DOE would remove most of the waste from the tanks and spray water wash the tanks, but would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves. Under the tank closure scenario, the tanks would eventually fail (after a period of perhaps several hundred years), creating physical hazards to humans and wildlife in the area and releasing the residual HLW to the groundwater at SRS. DOE estimated that residual waste in the F- and H-Area Tank Farms would contain about 200 curies of long half-life isotopes, technetium-99 and plutonium-239, and 9,900 curies of cesium-137, which has a relatively short half-life. DOE modeled the eventual release of these contaminants to the groundwater at SRS. The modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime radiation dose of 430 millirem (primarily from groundwater), and incur a risk of 2.2×10^{-4} of incurring a fatal cancer. The greatest risk occurs within about 500 years of tank abandonment, but doses for residents would be greater than 10 millirem for over 1,000 years.

In contrast, if DOE were to take no action and leave the HLW in the tanks at SRS, approximately 450,000,000 curies (160,000,000 in salt component, and 290,000,000 in the sludge component, assuming that about 10 percent of the curies in the sludge component have been vitrified in DWPF) would be available for release to the groundwater. While modeling would be required to calculate exposures and health effects over time, it is clear that the impacts to human health resulting from a No Action alternative would be catastrophic.

The discussion in this Appendix is centered around the action alternatives. The long-term analysis covers that period of time following 100 years of institutional control as specified in DOE Order 435.1 for determining impacts of low-level waste disposal facilities. DOE expects the primary source of long-term impacts to be saltstone disposal in Z Area. In accordance with the requirements of DOE Order 5480.2A, the *Radiological Performance Assessment for the Z-Area Saltstone Facility* (WSRC 1992), referred to as the RPA, was prepared based on the expected chemical composition of the salt solution that would be transferred from the In-Tank Precipitation (ITP) Facility and the Effluent Treatment Facility. As part of this SEIS process, DOE reviewed the RPA to determine how its conclusions could change if the chemical composition of the salt solution changed as a result of the alternatives analyzed in this SEIS, and how information from the RPA could be used to estimate impacts of the alternative salt solutions.

Although new groundwater models for the Savannah River Site (SRS) are currently under development, DOE believes that the methodology used in the RPA provides a reasonable basis for estimating impacts in this SEIS. Therefore, DOE has chosen to use the general methodology of the RPA to the maximum extent practical, making changes only for those parameters that are unique to the proposed new processes and those that were not analyzed in the RPA, such as differing concentrations of salt in the feed solution among alternatives.

D.1 Description of RPA Approach

This section provides a brief overview of the general methodology used to determine impacts in the RPA. The reader is referred to the RPA (WSRC 1992) for additional details.

As stated, the RPA based its analysis on the source term in the salt solution that was expected to be transferred to the Saltstone Manufacturing and Disposal Facility from the ITP and the Effluent Treatment Facilities, with the bulk of the material coming from ITP.

Because the high-level waste (HLW) tanks contain a myriad of fission products, activation products, actinides, and chemicals, the RPA performed a sensitivity analysis to identify those contaminants that would be most likely to present long-term impacts. This was based on a variety of factors, such as the quantity of the material projected to be present in the saltstone, the half-lives of the radiological constituents, and the ability of the saltstone to chemically bind the contaminants to minimize leaching.

The RPA also considered the pathways by which individuals could be exposed in the future to determine which pathways warranted detailed analysis. Based on early estimates, the primary pathways to which a person could be exposed were the following:

- A drinking water scenario where the individual consumes water from a well drilled into the aquifer that contains contaminants from the saltstone. This scenario is not assumed to be possible until at least 100 years post-closure.
- An agricultural scenario, in which an individual unknowingly farms on the soil above the saltstone vaults and constructs a home on the vaults. In this scenario, the individual is assumed to derive half of his vegetable consumption from a garden planted in contaminated soil located over the vaults. The time spent gardening is assumed to be short (100 hr/yr), compared to the amount of time spent indoors (4000 hr/yr) or farming. Doses from external radiation, inhalation, incidental soil ingestion, and vegetable ingestion are calculated only for indoor residence and outdoor gardening activities. Since the farming activities are assumed to occur over a widespread area that would include uncontaminated and undisturbed soil not subject to irrigation with contaminated water, the meat and milk pathways would not contribute significantly to the individual's dose. DOE expects that the saltstone would remain relatively intact for an extended period of time; therefore, DOE does not believe this scenario would be reasonable until approximately 10,000 years post-closure because, at least until that time, an individual could identify that he was digging into a cementitious material. However, for conservatism, DOE calculated the impacts of the agricultural scenario at 1,000 years post-closure.
- A residential scenario, in which an individual constructs and lives in a permanent residence on the vaults. This scenario has two options: construction at 100 years post-closure and construction at 1,000 years post-closure (evaluated as part of the agricultural scenario). Under the first option, a sufficient layer of soil would be present over the still-intact vaults so that the resident would be unaware that the residence was constructed on the vaults. Under the second option, the saltstone is assumed to have weathered sufficiently so that the resident could construct a residence without being aware of the presence of the saltstone.

The RPA assumed that institutional control would be maintained for 100 years after closure, during which time the land encompassing the saltstone vaults would be managed to prevent erosion or other conditions that would lead to early degradation of the vaults. The public is also assumed to have no access to Z Area during this time.

The analysis of groundwater impacts is based on PORFLOW-3D, a 3-dimensional finite difference model of flow and transport for both the near field and the far field. The near-field analysis considers flow and transport from the ground surface, through the saltstone, vault, and unsaturated zone, to the water table. The far-field analysis considers flow and transport through the water table and underlying aquifers. The ultimate results of the modeling effort are the maximum concentrations of the contaminants of interest at a point 100 meters downgradient from the downgradient edge of the disposal facility. It is at this "compliance" point that the groundwater quality is compared to water quality standards.

The analysis of doses from other pathways in the agricultural and residential scenarios begins with the calculated concentrations in the saltstone and surrounding soil, to which the appropriate pathway transfer coefficients and dose conversion factors are applied.

The RPA examined the potential impacts of saltstone disposal for the cases in which the saltstone remained intact and in which the saltstone failed structurally. For groundwater modeling, the greater impacts presented in the RPA are associated with failed saltstone. Therefore, this SEIS presents the results associated with failed saltstone.

D.2 Modifications to the RPA Approach for the SEIS Analysis

Because of the extensive nature of the RPA, DOE chose to rely on many of the technical bases presented in it. However, DOE did modify the calculations in the RPA to account for the following:

- the differences in salt solution concentrations for the Ion Exchange alternative, the Solvent Exchange alternative, and the Direct Disposal in Grout alternative from those for the ITP case (equivalent to the Small Tank Precipitation alternative)

- the difference in number and design of vaults for the current suite of alternatives, compared to the vaults analyzed in the RPA

- the need to calculate groundwater concentrations 1 meter downgradient from the downgradient edge of the disposal facility to be consistent with the SRS Tank Closure EIS. Because Z Area is a low-level waste disposal facility, it is exempt from the Resource Conservation and Recovery Act (RCRA) regulations pertinent to the high-level waste tanks that require an assessment of impacts 1 meter downgradient. The analysis is included to better compare the impacts of the two actions.

- the need to calculate groundwater concentration at the seeplines of nearby streams to determine impacts on ecological resources

- the difference in measured properties of the current formulation of saltstone, compared to those analyzed previously in the RPA.

The saltstone concentrations for analysis in this SEIS were based on the concentrations in the original RPA, adjusted to account for the increase in sodium molarity as projected in the engineering flow sheets (WSRC 1998) for the alternatives. Increased sodium molarity is indicative of increased overall concentrations; the alternatives with higher sodium molarities were assumed to also have higher overall concentrations of other constituents in proportion to the increase in sodium molarity. The concentration of cesium isotopes for the Direct Disposal in Grout alternative was calculated, based on the estimated cesium-137 inventory in the HLW tanks and the volume of saltstone produced. The concentrations of other cesium isotopes were calculated, based on isotopic ratios derived from the RPA. For this SEIS, the source information from Tables A-1 and A-2 in Appendix A was used.

The methodology used in the RPA for the agricultural and residential scenarios was unchanged and is not repeated in this Appendix. Most of the other changes to calculations in the RPA pertained to groundwater modeling, as discussed in the following section.

D.3 Groundwater Modeling Modifications

The present analysis is based on the results of the detailed peer-reviewed model in the RPA. The results presented there are used here, for conditions at which the RPA calculations and the SEIS are equivalent. For non-equivalent conditions, the RPA results are scaled by use of an analytical model which includes all of the important transport mechanisms. Modifications to the previous study were included to account for changes in the release rate to the water table (Table D-1). These changes would occur because of changes in radionuclide content of the saltstone among the alternatives, because of modifications to saltstone transport parameters established in Langton 1999, and because of a change in the total number of vault cells from the earlier study. Extensions to the previous modeling study were also included to allow for calculation of concentrations at locations other than the compliance point. Specifically, concentrations were calculated for a well 1-meter downgradient of Z Area and for the seeplines of the water table (to McQueen Branch) and Gordon (to Upper Three Runs) aquifers. The seepline aquifer discharge points were taken to be 450 and 1,500 meters, respectively, from the downgradient edge of the facility.

The extension of the previous modeling study was based on the assumption that an analytical model of aquifer transport, which includes the important mechanisms included in the original study, would simulate the relative downgradient concentrations in the aquifer. The model chosen (Pigford et al. 1980) considers three-dimensional dispersion, advection, adsorption, and decay from a continuous release. Continuous release is necessary because of the long-term releases from the facility. This model includes daughter ingrowth and independent transport (i.e., with the daughter's transport parameters), although the contaminants of concern for the present study are not daughter products. The model, as originally presented, calculates concentration as a function of release rate, aquifer velocity, dispersivity (in three dimensions), decay rate, adsorption coefficient, and time. The concentrations are given in terms of distance (longitudinal, lateral, and vertical to aquifer flow) from a point source release. Because of the size of the facility (on the order of a few hundred meters on a side), relative to the downgradient distances of interest (i.e., 1 and 100 meters), it was necessary to modify the point source solution to account for an area source. The point source solution of the original source was generalized to a horizontal area source solution (consistent with the saltstone footprint) by integrating the point source solution over the facility area and dividing by this area. If the area source solution described above is denoted $C_a(x,y,z,t)$ and the solution of the previous detailed model is $C_{rpa}(100,0,0,t_{max})$ (i.e., the maximum concentration at the compliance point), then the concentration as presented here is estimated as:

$$Cs = \frac{C_{rpa}\,(100,0,0,t_{max}) \times C_a\,(x,y,z,t)}{C_a\,(100,0,0,t_{max})}$$

where C = concentration, x = distance along aquifer flow path, y = distance horizontally transverse to aquifer flow, z = vertical distance (all directions measured from the projection of the middle of the downgradient edge of the facility on the water table), and t = time from initial release to water table.

For the conditions analyzed in the RPA ($x = 100m$, $y = z = 0$, $t = t_{max}$), $Cs = C_{rpa}$), comparing Table D-2 with the results of the RPA illustrates some of the changes from the RPA analysis to this SEIS. The Small Tank Precipitation alternative is most similar to the process analyzed in the RPA; the Direct Disposal in Grout alternative is the least similar. Therefore, the Small Tank Precipitation alternative results would be expected to be most similar to the RPA results, based on the number of vault cells (see Table D-1); with fewer vault cells, the other cesium removal alternatives should result in smaller concentrations at 100 meters. This is the case (Table D-2). Using this reasoning, the Direct Disposal in Grout alternative would also be expected to result in smaller concentrations than

Table D-1. Modifications to the RPA's parameters for this SEIS.

Parameter	Previous study (RPA)	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Number of cells	174	109	90	101	82
Waste solution sodium molarity	4.6	4.6	5.3	4.3	5.6
Nitrate diffusivity through saltstone, (square centimeters per second)	5.07×10^{-9}	6.00×10^{-8}	6.00×10^{-8}	6.00×10^{-8}	6.00×10^{-8}
Cesium adsorption coefficient in saltstone (milliliters per gram)	2	200	200	200	200

the Small Tank Precipitation alternative because it has fewer vault cells. However, in this case, a reduction in the number of vault cells is offset by an increase in solution sodium molarity of Direct Disposal in Grout saltstone (Table D-2). Both alternatives result in slightly lower concentrations than that of the RPA analysis. Note that the RPA did not analyze the concentration of Cs-135; it is a relatively important contributor only to the Direct Disposal in Grout alternative.

The number of saltstone vaults is presented in Chapter 2 and Appendix A of this document. The effect of reducing the number of saltstone vaults on the modeling is to decrease the surface area through which precipitation will infiltrate and leach the constituents; the previous study's release rates were therefore multiplied by the ratio of facility surface areas. The saltstone concentration increases with increasing sodium molarity; the previous study's release rates were multiplied by the ratio of molarities. The exception to the latter was for the cesium isotopes in the Direct Disposal in Grout alternative, as described in Chapter 2 and Appendix A of this SEIS.

A recent laboratory study (Langton 1999) indicates that the diffusivity of nitrate through saltstone is greater than that assumed in the previous RPA. This has the potential to increase the nitrate release rate from the saltstone after failure. The RPA showed that the nitrate release has two components: an advective "fracture" release (decreasing over time) from the cracks formed in the grout; and a later "intact" diffusive release from the internal pores of the grout to the fracture planes. Changes in the "intact" diffusive release have been shown to be proportional to the square root of the ratio of diffusivities (Wallace 1986). The time-dependent nitrate release rate indicated in the previous RPA was re-examined in light of the revision in diffusivity indicated in Table D-1. It was found that the initial "fracture" release was larger than the sum of the later "fracture" releases plus the "intact" release. The initial "fracture" release rate, which is independent of diffusivity, was conservatively assumed for this analysis.

The Langton study also indicated an increase in cesium adsorption coefficient in saltstone from that used in the RPA. This increase in saltstone constituent adsorption coefficient results in an approximately linear decrease in cesium concentration in pore water and, therefore, an approximately linear decrease in the cesium release rate.

The values from the Langton study are expected to better represent the conditions for salt processing than the values chosen for the RPA. The former were laboratory measurements of adsorption between the constituents studies (nitrate and cesium) and the saltstone formulae that would be used for this project; the latter were conservatively low choices from a range of literature values describing adsorption of the constituents with concrete not specific to salt processing. Use of the cesium adsorption coefficient suggested by the Langton study, in place of the

Table D-2. Maximum Groundwater concentrations at 1 meter downgradient, 100 meters downgradient, and at the seepline.[a]

		Carbon-14 (picocuries per liter)[b]	Selenium-79 (picocuries per liter)[b]	Technetium-99 (picocuries per liter)[b]	Tin-126 (picocuries per liter)[b]	Iodine-129 (picocuries per liter)[b]	Cesium-135 (picocuries per liter)[b]	Nitrate (milligrams per liter)[c]
1-meter concentrations								
Upper Three Runs Aquifer	Small Tank Precipitation	1.0×10^{-4}	7.0	17	0.0039	0.11	4.0×10^{-5}	56
	Ion Exchange	1.1×10^{-4}	8.2	20	0.0047	0.13	4.5×10^{-5}	66
	Solvent Extraction	9.4×10^{-5}	6.4	15	0.0036	0.10	3.7×10^{-5}	51
	Direct Disposal in Grout	1.2×10^{-4}	8.2	20	0.0046	0.13	0.50	66
Gordon Aquifer	Small Tank Precipitation	6.7×10^{-4}	42	104	0.024	0.68	2.5×10^{-4}	338
	Ion Exchange	6.7×10^{-4}	49	121	0.029	0.82	2.7×10^{-4}	395
	Solvent Extraction	5.6×10^{-4}	38	94	0.022	0.63	2.3×10^{-4}	307
	Direct Disposal in Grout	7.2×10^{-4}	49	120	0.029	0.81	3.1	394
100-meter concentrations								
Upper Three Runs Aquifer	Small Tank Precipitation	8.2×10^{-6}	0.59	1.4	3.0×10^{-4}	0.0096	3.5×10^{-6}	4.8
	Ion Exchange	8.9×10^{-6}	0.63	1.5	3.2×10^{-4}	0.01	3.7×10^{-6}	5.1
	Solvent Extraction	7.5×10^{-6}	0.54	1.3	2.7×10^{-4}	0.0088	3.2×10^{-6}	4.4
	Direct Disposal in Grout	9.6×10^{-6}	0.68	1.7	3.5×10^{-4}	0.011	4.2×10^{-2}	5.6
Gordon Aquifer	Small Tank Precipitation	5.0×10^{-5}	3.5	8.8	0.0019	0.059	2.2×10^{-5}	29
	Ion Exchange	5.3×10^{-5}	3.8	9.4	0.002	0.063	2.3×10^{-5}	31
	Solvent Extraction	4.5×10^{-5}	3.2	8.0	0.0017	0.054	2.0×10^{-5}	26
	Direct Disposal in Grout	5.8×10^{-5}	4.1	10	0.0022	0.069	0.26	33
	RPA[c]	6.0×10^{-6}	4.4	11	0.0022	0.075	Not calculated	36
Seepline concentrations								
McQueen Branch	Small Tank Precipitation	1.9×10^{-6}	0.16	0.42	5.7×10^{-5}	0.0028	9.8×10^{-7}	1.4
	Ion Exchange	2.1×10^{-6}	0.17	0.44	6.1×10^{-5}	0.0029	1.0×10^{-6}	1.5
	Solvent Extraction	1.8×10^{-6}	0.15	0.38	5.2×10^{-5}	0.0029	8.9×10^{-7}	1.3
	Direct Disposal in Grout	2.2×10^{-6}	0.19	0.48	6.6×10^{-5}	0.0032	0.012	1.6
Upper Three Runs	Small Tank Precipitation	2.0×10^{-6}	0.23	0.66	3.9×10^{-5}	0.0045	1.5×10^{-6}	2.2
	Ion Exchange	1.9×10^{-6}	0.23	0.64	3.9×10^{-5}	0.0044	1.5×10^{-6}	2.1
	Solvent Extraction	1.7×10^{-6}	0.20	0.58	3.5×10^{-5}	0.0039	1.3×10^{-6}	1.9
	Direct Disposal in Grout	2.1×10^{-6}	0.25	0.72	4.3×10^{-5}	0.0049	0.017	2.4

Source: WSRC (1992) Table 4.1-6.

a. The concentrations reported are the maximum for each nuclide and alternative that would occur in the 1,000-year period of analysis. The maximum occurrences are not simultaneous; they would occur at different times during the 1,000-year time period.

b. Concentrations of radiological constituents are presented in units of picocuries per liter.

c. Concentrations of nonradiological constituents are presented in units of milligrams per liter.

literature value used in the RPA, will significantly decrease the predicted cesium transport.

All other parameters used in the previous study were used in the present study. Because the previous study only considered a single point (compliance point), a single value of dispersivity for each direction was used. The values used at that location (3 meters for longitudinal, 0.3 meters for transverse) were generalized to other distances by assuming that the ratio of distance to dispersivity is constant. The vertical dispersivity was taken as 2.5×10^{-3} times the longitudinal dispersivity (Buck et al. 1995).

D.4 Results

Table D-2 presents the maximum groundwater concentrations calculated by using the methodology described above. For comparison purposes, the results from the RPA are presented at the 100m compliance point. Table D-3 presents the radiological doses resulting from concentrations of radiological constituents in the groundwater. The source information in these tables was used for the SEIS.

Table D-4 presents the calculated doses for the agricultural and residential scenarios. For all the scenarios, most of the dose is due to external exposure. A range of external radiation exposures was calculated, based on the same assumptions regarding post-closure conditioning in the vaults used in the RPA. These assumptions included the application of two mutually exclusive approaches for deriving dose correction factors. One approach considered a finite size of the excavation, which would not uncover the area of an entire vault and would result in a four-fold reduction in external dose relative to the dose from a fully uncovered vault. The other approach assumed that a minimum soil thickness of 30 cm (12 inches) would be required to sustain plant growth, and would therefore provide some additional shielding. The application of either of these factors to the maximum unshielded dose results in a range of doses differing by a factor of approximately seven, with the first approach resulting in the higher dose. The differences in the ranges of external doses among alternatives are due to the different concentrations of radionuclides. For the 100-year residential exposure scenario, the external dose is due primarily to cesium-137; for all other alternatives and scenarios, the external dose is due primarily to tin-126 and its decay products.

D.5 Discussion of Uncertainty

In this SEIS, DOE has made assumptions regarding the numerical parameters that affect the calculated impacts. Some uncertainty is associated with the values of these parameters, due to unavailable data and current knowledge concerning closure processes and long-term behaviors of materials. The principal parameters that affect modeling results are the following:

- **Saltstone characteristics:** The volume of saltstone and constituent chemical and radionuclide concentrations determine the concentrations of release constituents at any given location. As discussed earlier, the concentrations of the saltstone constituents inventory are based primarily on data previously presented in the RPA and updated with information from more recent engineering flow sheets.

- **Hydraulic conductivity:** The rate of water movement through material is ultimately affected by the hydraulic conductivity of the geologic strata underneath the source. Generally, the grout or concrete basemat is the limiting layer with regard to water infiltration. Over time, cracks developing in the saltstone increase the hydraulic conductivity dramatically, making more water available to carry contaminants to the aquifer. This increase results in greater doses/concentrations, due to the increased transport of the contaminants.

- **Distribution coefficient:** The distribution coefficient (K_d) affects the rate at which contaminants move through the geologic strata. Large K_d values provide holdup time for short-lived radionuclides.

Table D-3. Radiological doses due to consumption of groundwater 1 meter downgradient, 100 meters downgradient, and at the seepline.

Downgradient		Total (millirem per year)	Carbon-14 (millirem per year)	Selenium-79 (millirem per year)	Technetium-99 (millirem per year)	Tin-126 (millirem per year)	Iodine-129 (millirem per year)	Cesium-135 (millirem per year)
1-meter doses								
Upper Three Runs Aquifer	Small Tank Precipitation	0.080	1.5×10^{-7}	4.3×10^{-2}	1.6×10^{-2}	5.0×10^{-5}	2.2×10^{-2}	2.1×10^{-7}
	Ion Exchange	0.095	1.7×10^{-7}	5.0×10^{-2}	1.9×10^{-2}	6.1×10^{-5}	2.6×10^{-2}	2.3×10^{-7}
	Solvent Extraction	0.074	1.4×10^{-7}	3.9×10^{-2}	1.5×10^{-2}	4.7×10^{-5}	2.0×10^{-2}	1.9×10^{-7}
	Direct Disposal in Grout	0.096	1.8×10^{-7}	5.0×10^{-2}	1.9×10^{-2}	6.0×10^{-5}	2.6×10^{-2}	2.6×10^{-3}
Gordon Aquifer	Small Tank Precipitation	0.49	9.1×10^{-7}	2.6×10^{-1}	9.8×10^{-2}	3.1×10^{-4}	1.4×10^{-1}	1.3×10^{-6}
	Ion Exchange	0.58	1.0×10^{-6}	3.0×10^{-1}	1.2×10^{-1}	3.8×10^{-4}	1.6×10^{-1}	1.4×10^{-6}
	Solvent Extraction	0.45	8.4×10^{-7}	2.3×10^{-1}	8.9×10^{-2}	2.9×10^{-4}	1.3×10^{-1}	1.2×10^{-6}
	Direct Disposal in Grout	0.57	1.1×10^{-6}	3.0×10^{-1}	1.1×10^{-1}	3.8×10^{-4}	1.6×10^{-1}	1.6×10^{-2}
100-meter doses								
Upper Three Runs Aquifer	Small Tank Precipitation	6.8×10^{-3}	1.2×10^{-8}	3.6×10^{-3}	1.4×10^{-3}	3.8×10^{-6}	1.9×10^{-3}	1.8×10^{-8}
	Ion Exchange	7.3×10^{-3}	1.3×10^{-8}	3.8×10^{-3}	1.5×10^{-3}	4.2×10^{-6}	2.1×10^{-3}	2.0×10^{-8}
	Solvent Extraction	6.2×10^{-3}	1.1×10^{-8}	3.3×10^{-3}	1.2×10^{-3}	3.5×10^{-6}	1.8×10^{-3}	1.7×10^{-8}
	Direct Disposal in Grout	7.9×10^{-3}	1.4×10^{-8}	4.2×10^{-3}	1.6×10^{-3}	4.5×10^{-6}	2.2×10^{-3}	2.2×10^{-4}
Gordon Aquifer	Small Tank Precipitation	4.2×10^{-2}	7.4×10^{-8}	2.2×10^{-2}	8.4×10^{-3}	2.5×10^{-5}	1.2×10^{-2}	1.1×10^{-7}
	Ion Exchange	4.4×10^{-2}	8.0×10^{-9}	2.3×10^{-2}	8.9×10^{-3}	2.7×10^{-5}	1.3×10^{-2}	1.2×10^{-7}
	Solvent Extraction	3.8×10^{-2}	6.8×10^{-8}	2.0×10^{-2}	7.6×10^{-3}	2.2×10^{-5}	1.1×10^{-2}	1.1×10^{-7}
	Direct Disposal in Grout	4.8×10^{-2}	8.7×10^{-8}	2.5×10^{-2}	9.7×10^{-3}	2.9×10^{-5}	1.4×10^{-2}	1.3×10^{-3}
Seepline doses								
McQueen Branch	Small Tank Precipitation	1.9×10^{-3}	2.9×10^{-9}	1.0×10^{-3}	4.0×10^{-4}	7.4×10^{-7}	5.6×10^{-4}	5.1×10^{-9}
	Ion Exchange	2.0×10^{-3}	3.1×10^{-9}	1.0×10^{-3}	4.2×10^{-4}	7.9×10^{-7}	5.9×10^{-4}	5.4×10^{-9}
	Solvent Extraction	1.7×10^{-3}	2.7×10^{-9}	9.0×10^{-4}	3.6×10^{-4}	6.7×10^{-7}	5.0×10^{-4}	4.8×10^{-9}
	Direct Disposal in Grout	2.2×10^{-3}	3.4×10^{-9}	1.1×10^{-3}	4.5×10^{-4}	8.5×10^{-7}	6.4×10^{-4}	6.0×10^{-5}
Upper Three Runs	Small Tank Precipitation	2.9×10^{-3}	2.9×10^{-9}	1.4×10^{-3}	6.3×10^{-4}	5.1×10^{-7}	8.9×10^{-4}	7.8×10^{-9}
	Ion Exchange	1.8×10^{-3}	2.9×10^{-9}	1.4×10^{-3}	6.1×10^{-4}	5.0×10^{-7}	8.7×10^{-4}	7.7×10^{-9}
	Solvent Extraction	2.5×10^{-3}	2.6×10^{-9}	1.2×10^{-3}	5.5×10^{-4}	4.5×10^{-7}	7.8×10^{-4}	7.3×10^{-9}
	Direct Disposal in Grout	3.2×10^{-3}	3.2×10^{-9}	1.5×10^{-3}	6.8×10^{-4}	5.6×10^{-7}	9.7×10^{-4}	8.5×10^{-5}

Table D-4. Radiological doses from the agricultural and residential scenarios.

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Agricultural scenario at 1,000 years post-closure[a]				
Inhalation while outdoors (millirem per year)	0.010	0.012	0.0096	0.013
Ingestion of vegetables (millirem per year)	42	49	39	52
Incidental ingestion of soil (millirem per year)	0.7	0.81	0.66	0.88
Inhalation while indoors (millirem per year)	0.26	0.3	0.24	0.32
External radiation while outdoors[b] (millirem per year)	0.045-0.33	0.052-0.39	0.042-0.31	0.055-0.41
External radiation while indoors[b] (millirem per year)	9.2-69	11-80	8.6-65	11-85
Total (millirem per year)	52-110	61-130	49-110	64-140
Residential scenario at 100 years post-closure[b] (millirem per year)	0.015-0.11	0.017-0.13	0.014-0.10	150-1200
Residential scenario at 1,000 years post-closure[a,b] (millirem per year)	9.2-69	11-80	8.6-65	11-85

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a. Residential scenario at 1,000 years post-closure is also included in the agricultural scenario.

b. The range of values for external radiation is due to different assumptions regarding size of the source and the amount of shielding provided by topsoil.

- **Vadose zone thickness:** The thickness of the geologic strata between the contaminated region and the aquifer does not necessarily reduce the concentration as much as it slows movement of contaminants toward the aquifer. For shorter-lived radionuclides, extra time provided by thicker strata decreases the activity of the contaminants reaching the aquifer.

- **Distance downgradient to receptor location:** The distance to a given receptor location affects (a) the time at which contaminants will arrive at the receptor location, and (b) the extent of dispersion that occurs. For greater distances, longer travel times will occur, resulting in lower activity values for short-lived radioactive constituents and greater dispersion for all constituents.

DOE recognizes that, over the period of analysis in this SEIS, there is also uncertainty in the structural behaviors of materials and the geologic and hydrogeologic setting of the SRS. DOE realizes that overly conservative assumptions can be used to bound the estimates of impacts; however, this approach could result in masking differences of impacts among alternatives. Therefore, DOE has used assumptions in its modeling analysis that are reasonable, based on current knowledge, to develop meaningful comparisons among alternatives considered.

References

Buck, J. W., G. Whelan, J. G. Droppo, Jr., D. L. Strenge, K. J. Castleton, J. P. McDonald, C. Sato, and G. P. Striele, 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance*, PNL-10395/UC-630, Pacific Northwest Laboratory, Richland, Washington.

Langton, C. A., 1999, *Direct Grout Stabilization of High Cesium Salt Waste: Cesium Leaching Studies,* WSRC-TR-99-00227, Rev. 0, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Pigford, T. H., P. L. Chambré, M. Albert, M. Foglia, M. Harada, F. Iwamoto, T. Kanki, D. Lenng, S. Masnada, S. Muraoka, and D. Ting, 1980, *Migration of Radionuclides through Sorbing Media Analytical Solutions – II*, LBL-11616, Lawrence Berkeley Laboratory Earth Sciences Division, Berkeley, California.

Wallace, R. M., 1986, "Simple Model of Nitrate Release from a Saltstone Vault Containing Concrete Barriers," DPST-86-487, memorandum to E. L. Wilhite, Savannah River Laboratory, Aiken, South Carolina, June 6.

WSRC (Westinghouse Savannah River Company), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (WSRC-RP-92-1360), Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998, *Bases, Assumptions, and Results of the Flowsheet Calculations for the Short List Salt Disposition Alternatives*, WSRC-RP-98-00168, Rev. 1, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 2000, *Savannah River Site High Level Waste System Plan*, Revision 11, HLW-2000-00019, High Level Waste Division, Aiken, South Carolina, April.

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NEPA DISCLOSURE STATEMENT
FOR
PREPARATION OF THE SAVANNAH RIVER SITE HIGH LEVEL WASTE SALT PROCESSING ALTERNATIVES SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

CEQ Regulations at 40 CFR 1506.5c, which have been adopted by the U. S. Department of Energy (DOE) (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure statement specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at Question 17(a) and (b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)." See 46 FR 18026-18031.

In accordance with these requirements, I hereby certify (or as a representative of my organization, I hereby certify) that, to the best of my knowledge and belief, no facts exist relevant to any past, present or currently planned interests or activities (financial, contractual, organizational or otherwise) which relate to the proposed work and bear on whether I have (or the organization has) a possible conflict of interest with respect to (1) being able to render impartial, technically sound, and objective assistance or advise, or (2) being given an unfair or competitive advantage.

Certified by:

Daniel M. Evans
Signature

Daniel M. Evans
Name (Printed)

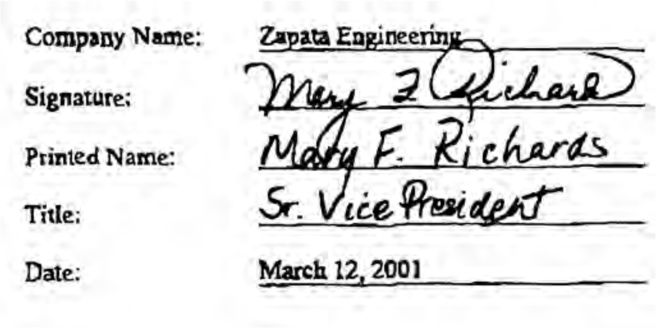
General Manager
Title

Tetra Tech NUS, Inc.
Company

March 26, 1999
Date

ORGANIZATIONAL CONFLICT OF INTEREST DISCLOSURE STATEMENT FOR PREPARATION OF THE SAVANNAH RIVER SITE HIGH LEVEL WASTE SALT PROCESSING ALTERNATIVES SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

No actual or potential conflict of interest or unfair competitive advantage exists with respect to other advisory and assistance services being provided by Zapata Engineering relative to the Salt Disposition Alternatives Supplemental Environmental Impact Project under Subcontract No. GCRB-99-77613-034 between Tetra Tech NUS, Inc. and Zapata Engineering.



Company Name: Zapata Engineering
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Printed Name: Mary F. Richards
Title: Sr. Vice President
Date: March 12, 2001

ORGANIZATIONAL CONFLICT OF INTEREST DISCLOSURE STATEMENT FOR PREPARATION OF THE SAVANNAH RIVER SITE HIGH LEVEL WASTE SALT PROCESSING ALTERNATIVES SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

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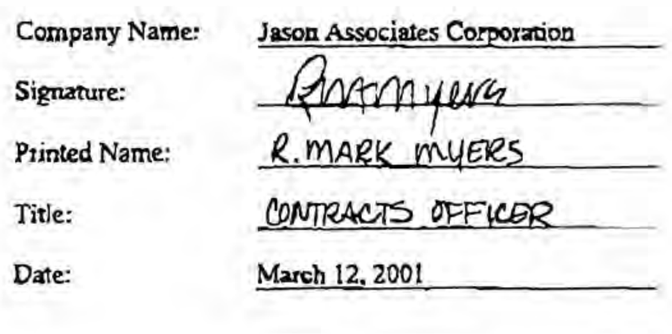

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Date:	March 12, 2001

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The Honorable Ernest F. Hollings
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GLOSSARY

Terms in this glossary are defined in accord with customary usage, as presented in the Glossary of Terms used in DOE NEPA Documents, followed as needed by specific usage in the context of this SEIS.

accident

An unplanned sequence of events that results in undesirable consequences.

acid solution

A liquid in which an acid compound is mixed with water. As used in this SEIS, it is an aqueous solution containing a low concentration of nitric acid, used to remove or recover salt constituents from organic phase in the solvent extraction process.

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.

adsorption

The adhesion of a substance to the surface of a solid or solid particle.

alternative

A major choice or strategy to address the SEIS "Purpose and Need" statement, as opposed to the engineering options available to achieve the goal of an alternative.

antimony

Metallic element belonging to the nitrogen family (Group Va of the periodic table). The symbol for antimony is Sb; Sb-125 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

applicable or relevant and appropriate requirements (ARARs)

Requirements, including cleanup standards, standards of control, and other substantive environmental protection requirements and criteria for hazardous substances, as specified under Federal and state law and regulations, that must be met when complying with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

aqueous phase

Water-based solution of soluble chemical species, generally inorganic salts.

aquifer

A body of rock or sediment that is capable of transmitting groundwater and yielding usable quantities of water to wells or springs.

as low as reasonably achievable (ALARA)

A process by which a graded approach is applied to maintaining dose levels to workers and the public, and releases of radioactive materials to the environment at a rate that is as far below applicable limits as is reasonably achievable.

atomic number

The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

average throughput

Volume of salt solution processed per year as restricted by limitations external to a given facility.

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.

backfill

Material, such as soil or sand, used in refilling an excavation.

background radiation

Radiation from cosmic sources, naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

batch process

Process with operations performed on fixed volumes of material requiring specific time period(s) for completion.

benzene

Toxic, flammable organic liquid containing six carbon and six hydrogen atoms (C_6H_6); major decomposition product of tetraphenylborate.

beyond design basis accident (BDBA)

An accident with an annual frequency of occurrence between 1 in 1,000,000 and 1 in 10,000,000 (1.0×10^{-6} and 1.0×10^{-7}).

biodiversity

Pertains to the variety of life (e.g., plants, animals, and other organisms) that inhabits a particular area or region.

biphenyl

Organic solid consisting of two phenyl groups ($C_{12}H_{10}$); minor decomposition product of tetraphenylborate.

blackwater stream

Water in coastal plains, creeks, swamps, and/or rivers that has been imparted a dark or black coloration due to dissolution of naturally occurring organic matter from soils and decaying vegetation.

borosilicate

A form of glass containing silica sand, boric oxide, and soda ash.

borosilicate glass

Refractory glass waste form with high capacity for immobilization of HLW components; representative composition 10 weight percent B_2O_3, 45 weight percent SiO_2, 10 weight percent Na_2O, 35 weight percent waste oxides.

borrow material

Material, such as soil or sand, that is removed from one location and used as fill material in another location.

bounding accident

A hypothetical accident, the calculated consequences of which equal or exceed the consequences of all other potential accidents for a particular activity or facility.

cancer

The name given to a group of diseases characterized by uncontrolled cellular growth.

canister

A container (generally stainless steel) into which immobilized radioactive waste is placed and sealed.

capable fault

In part, a capable fault is one that may have had movement at or near the ground surface at least once within the past 35,000 years, or has had recurring movement within the past 500,000 years. Further definition can be found in 10 CFR 100, Appendix A.

capacity throughput

Maximum volume of salt solution that a facility is designed to process per year.

carbon

Nonmetallic chemical element in Group IVa of the periodic table. The symbol for carbon is C; C-14 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

carcinogen

A radionuclide or nonradiological chemical that has been proven or is suspected to be either a promoter or initiator of cancer in humans or animals.

catalyst

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

catalytic decomposition

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

caustic solution

Alkaline solution containing sodium hydroxide or other light metal hydroxides. SRS HLW solutions are caustic solutions. As used in this SEIS, an aqueous solution containing 3-5 molar concentrations of sodium hydroxide used to convert insoluble aluminum hydroxide in HLW sludge to soluble aluminate form.

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 contractor and is mixed with an organic solvent, which extracts the cesium. The two liquids are then separated by centrifugal force in a rapidly rotating inner chamber of the device.

cesium

Chemical element of Group Ia of the periodic table, the alkali metal group, of which sodium and potassium are also members. The symbol for cesium is Cs; Cs-137, Cs-135, and Cs-134 are the principal radioactive isotopes of this element present in the HLW tanks at SRS.

characterization

The determination of waste composition and properties (by review of process knowledge, nondestructive examination or assay, or sampling and analysis), generally done for the purpose of determining appropriate storage, treatment, handling, transport, and disposal requirements.

chronic exposure

A continuous or intermittent exposure of an organism to a stressor (e.g., a toxic substance or ionizing radiation) over an extended period of time or significant fraction (often 10 percent or more) of the life span of the organism. Generally, chronic exposure is considered to produce only effects that can be observed some time following initial exposure. These may include impaired reproduction or growth, genetic effects, and other effects such as cancer, precancerous lesions, benign tumors, cataracts, skin changes, and congenital defects.

clarification

As used in this SEIS, a process in which small residual volumes of insoluble solids (sludge) are removed from soluble salt solution.

Class A, B, & C low-level waste limits

Waste classification system in 10 CFR 61.55 that prescribes requirements for disposal of low-level radioactive wastes in accordance with the concentrations of radioactive constituents in the wastes.

Code of Federal Regulations (CFR)

A document containing the regulations of Federal executive departments and agencies.

collective effective dose equivalent

The sum of the individual effective dose equivalents received in a given period of time by a specified population from exposure to a specified source of radiation. The units for this are person-rem or person-sievert.

committed dose equivalent

The committed dose in a particular organ or tissue accumulated in a specified period (e.g., 50 years) after intake of a radionuclide.

committed effective dose equivalent

The dose value obtained by (1) multiplying the committed dose equivalents for the organs or tissues that are irradiated and the weighting factors applicable to those organs or tissues, and (2) summing all the resulting products. Committed effective dose equivalent is expressed in units of rem.

conceptual design

The conceptual design phase includes the fundamental decisions that are made regarding the desired chemistry or processing operations to be used, the sequencing of unit operations, the relationship of the process with other operations, and whether batch or continuous processing will be employed. Often, these decisions must be made preliminary to the collection of any engineering data regarding actual process yields, generation of reaction by-products, or the efficacy of any needed separation steps. The conceptual design phase is also used to determine the economic feasibility of a process.

condensate

Liquid that results from condensing a gas by cooling below its saturation temperature.

condenser-decanter

As used in this SEIS, a process vessel used to separate benzene distilled from a mixture produced by decomposition of tetraphenylborate precipitate. Benzene and water vapors are cooled to immiscible liquids in the condenser and separated by withdrawal of lighter benzene from the top of the decanter.

confining (unit)

A rock layer (or stratum) having very low hydraulic conductivity (or permeability) that restricts the movement of groundwater either into or out of adjacent aquifers.

contaminant

Any gaseous, chemical, or organic material that contaminates (pollutes) air, soil, or water. This term also refers to any hazardous substance that does not occur naturally or that occurs at levels greater than those naturally occurring in the surrounding environment (background).

contamination

As used in this SEIS, the deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

continuous process

As used in this SEIS, process conducted in a flowing system to promote mixing, rapid reaction, and separation of radioactive constituents within limited times needed to minimize competitive side reactions (decomposition).

countercurrent extraction

A liquid-liquid extraction process in which the organic and the aqueous process streams in contact flow in opposite directions, progressively concentrating the extracted constituent in one phase while depleting the constituent in the other phase.

crane maintenance area

Shielded space in a process facility that is provided for inspection and repair of overhead crane mechanisms.

criticality

The condition in which a system (including materials such as plutonium) is capable of sustaining a nuclear chain reaction.

crossflow filtration

As used in this SEIS, a process for concentrating precipitate slurry by passing it through a porous metal pipe under pressure to force solution into surrounding pipe.

crystalline

Being, relating to, or composed of crystals.

crystalline silicotitanate

Insoluble granular inorganic solid ($Na_4SiO_4 \bullet TiO_2$) ion exchange material. As used in this SEIS, a specially developed material to provide capability for removal of cesium from acid or alkaline solutions containing high sodium and potassium concentrations.

curie (Ci)

The basic unit used to describe the intensity of radioactivity in a sample of material. A curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second. A unit of radioactivity equal to 37 billion disintegrations per second (i.e., 37 billion becquerels); also a quantity of any radionuclide or mixture of radionuclides having 1 curie of radioactivity.

decommissioning

The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

decomposition

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

decontamination

The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination on or in facilities, soil, or equipment. Decontamination processes include washing, chemical action, mechanical cleaning, or other techniques.

decontamination factor

Ratio of initial specific radioactivity to final specific radioactivity resulting from a separations process.

dedicated area

Space in a facility set aside and equipped for a specific function, such as tool and equipment decontamination.

Defense Waste Processing Facility (DWPF) melter

Large ceramic vessel used to incorporate HLW components into molten glass; internally (Joule) heated by electric current flow within the glass melt.

design basis accident (DBA)

An accident postulated for the purpose of establishing functional and performance requirements for safety structures, systems, and components.

design-basis earthquake

The maximum-intensity earthquake that might occur along the fault nearest to a structure. Structures are built to withstand a design-basis earthquake.

diluent

A substance used to dilute. As used in this SEIS, the principal component of organic phase employed to separate constituents from aqueous phase in a solvent extraction process.

diversion boxes

Specialized containment spaces using removable pipe segments (jumpers) to direct the transfer of process streams; usually underground, constructed of reinforced concrete, and sealed with waterproofing compounds or lined with stainless steel.

DOE Orders

Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

dosage

The concentration-time profile for exposure to toxicological hazards.

dose (or radiation dose)

A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

dose equivalent

A measure of radiological dose that correlates with biological effect on a common scale for all types of ionizing radiation. Defined as a quantity equal to the absorbed dose in tissue multiplied by a quality factor (the biological effectiveness of a given type of radiation) and all other necessary modifying factors at the location of interest. The unit of dose equivalent is the rem.

drinking water standards

Prescribed limits on chemical, biological, and radionuclide concentrations in groundwater sources of drinking water, expressed as maximum contaminant levels (MCLs).

effective dose equivalent (EDE)

The dose value obtained by multiplying the dose equivalents received by specified tissues or organs by the appropriate weighting factors applicable to the tissues or organs irradiated, and then summing all of the resulting products. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rem.

effluent

A waste stream flowing into the atmosphere, surface water, groundwater, or soil. Most frequently, the term applies to wastes discharged to surface waters.

effluent monitoring

Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

elevation

Vertical cross-section of a facility, showing height requirements for operating areas and process facilities.

elutable ion exchange

Process in which a chemical species is separated from solution by replacement of a constituent of a solid (resin), then removed from the resin by replacement (elution) with another chemical species in solution.

endemic

Native to a particular area or region.

environmental restoration

Cleanup and restoration of sites and decontamination and decommissioning of facilities contaminated with radioactive and/or hazardous substances during past production, accidental releases, or disposal activities.

environmental restoration program

A DOE subprogram concerned with all aspects of assessment and cleanup of both contaminated facilities in use and of sites that are no longer a part of active operations. Remedial actions, most often concerned with contaminated soil and groundwater, and decontamination and decommissioning are responsibilities of this program.

evaporator

A facility that mechanically reduces the water contents in tank waste to concentrate the waste and reduce storage space needs.

exposure pathways

The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a release site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium, such as air or water, is also included.

external accident (or initiator)

An accident that is initiated by manmade energy sources not associated with operation of a given facility. Examples include airplane crashes, induced fires, transportation accidents adjacent to a facility, and so forth.

extractant

As used in this SEIS, a component of the solvent used in the solvent extraction process to facilitate the removal of radioactive cesium from HLW salt solution.

facility flowrate

Volume of salt solution processed per unit time under normal operating conditions, as required to meet design performance objectives.

final design

In the final design phase, the emphasis shifts 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 (P&ID) will typically 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

A nuclear transformation that is typically characterized by the splitting of a heavy nucleus into at least two other nuclei, the emission of one or more neutrons, and the release of a relatively large amount of energy. Fission of heavy nuclei can occur spontaneously or be induced by neutron bombardment.

fission products

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

floodplain

The level area adjoining a river or stream that is sometimes covered by flood water.

flyash

Fine particulate material 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. As used in this SEIS, an ingredient in saltstone to limit water infiltration by decreasing porosity.

frames

Structural components holding assemblies of centrifugal contactors for installation into a remotely operated shielded process cell.

fresh resin

Condition of an ion exchange solid (resin) before loading with chemical species to be separated from solution.

geologic repository

A deep (on the order of 600 meters [1,928 feet] or more) underground mined array of tunnels used for permanent disposal of radioactive waste.

groundwater

Water occurring beneath the earth's surface in the interstices between soil grains, in fractures, and in porous formations.

grout

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

grout curing

Process for bringing freshly placed grout to required strength and quality by maintaining humidity and temperature at specified levels for a given period of time.

habitat

The sum of environmental conditions in a specific place occupied by animals, plants, and other organisms.

half-life

The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

hazard index

The sum of several hazard quotients for multiple chemicals and/or multiple exposure pathways. A hazard index of greater than 1.0 is indicative of potential adverse health effects. Health effects could be minor temporary effects or fatal, depending on the chemical and amount of exposure.

hazard quotient

The ratio of an exposure level to a substance to a toxicity reference value selected for risk assessment purposes.

hazardous chemical

A term defined under the Occupational Safety and Health Act and the Emergency Planning and Community Right-to-Know Act as any chemical that is a physical hazard or a health hazard.

hazardous material

A substance or material, including a hazardous substance, which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous substance

Any substance that, when released to the environment in an uncontrolled or unpermitted fashion, becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

hazardous waste

A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 40 CFR 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the Environmental Protection Agency in 40 CFR 261.31 through 40 CFR 261.33. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

heavy metals

Metallic elements with high atomic weights (for example, mercury, chromium, cadmium, arsenic, and lead) that can damage living things at low concentrations and tend to accumulate in the food chain.

HEPA filter (High Efficiency Particulate Air filter)

Gas filter with fibrous medium that produces a particle removal efficiency greater than 99.97 percent.

high-level waste or high-level radioactive waste (HLW)

Defined by statute (the Nuclear Waste Policy Act) 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 nuclides in sufficient concentrations; and other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule requires permanent isolation. The NRC has not defined "sufficient concentrations" of fission products or identified "other highly radioactive material that requires permanent isolation." The NRC defines HLW to mean irradiated (spent) reactor fuel, as well as liquid waste resulting from the operation of the first cycle solvent extraction system, the concentrated wastes from subsequent extraction cycles in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted. In this SEIS, "high-level waste" is stored in the F- and H-Area Tank Farms.

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.

hydrology

The study of water, including groundwater, surface water, and rainfall.

hydrolysis	Decomposition of chemical substance by water. As used in this SEIS, the process by which tetraphenylborate precipitate is catalytically decomposed to benzene and a soluble salt solution of waste constituents that is fed to the DWPF melter.
immobilization	A process (e.g., grouting or vitrification) used to stabilize waste. Stabilizing the waste inhibits the release of waste to the environment.
in situ	A Latin term meaning “in place”.
inadvertent intrusion	The inadvertent disturbance of a disposal facility or its immediate environment by a potential future occupant that could result in loss of containment of the waste or exposure of personnel. Inadvertent intrusion is a significant consideration that shall be included either in the design requirements or waste acceptance criteria of a waste disposal facility.
incineration	Controlled burning of solid or liquid wastes to oxidize the combustible constituents and, especially for liquid wastes, to vaporize water so as to reduce waste volume; in this SEIS, the process used to destroy benzene generated from decomposition of tetraphenylborate precipitate in DWPF.
inhibited water	Water to which sodium hydroxide has been added to inhibit corrosion.
institutional control	The control of waste disposal sites or other contaminated sites by human institutions in order to prevent or limit exposures to hazardous materials. Institutional control may be accomplished by (1) active control measures, such as employing security guards and maintaining security fences to restrict site access, and (2) passive control measures, such as using physical markers, deed restrictions, government regulations, and public records and archives to preserve knowledge of the site and prevent inappropriate uses.
In-Tank Precipitation (ITP)	Previously selected process for separation of radioactive cesium and other radioactive constituents from HLW salt solutions by tetraphenylborate precipitation and associated sorption processes, to be replaced by another salt processing alternative that avoids excessive benzene generation.
internal accidents	Accidents that are initiated by man-made energy sources associated with the operation of a given facility. Examples include process explosions, fires, spills, and criticalities.
involved workers	Workers who would be involved in a proposed action (as opposed to workers who would be on the site of a proposed action, but not involved in the action).

iodine

Chemical element of Group VIIa of the periodic table, the halogen group, of which chlorine is a member. The symbol for iodine is I; I-129 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

ion exchange, ion exchange medium (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

One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon; the numbers denote the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often have different physical properties (for example, carbon-12 and -13 are stable, while carbon-14 is radioactive).

jumpers

As used in this SEIS, removable pipe segments used to direct the flow of process streams in transfer operations.

Late Wash Facility

Assemblage of currently inoperative tanks originally intended for washing soluble corrosion inhibitors from tetraphenylborate precipitate stream from ITP to DWPF. Proposed location of Pilot Plant for selected salt processing alternative.

latent cancer fatality

Death from cancer resulting from, and occurring some time after, exposure to ionizing radiation or other carcinogens.

layout plan

Floor plan of facility showing operating areas and typical process equipment.

lifting lug

Projection on a metal part that serves as handle, support, or fitting connection for attachment of a lifting device.

low-level mixed waste (LLMW)

Waste that contains both hazardous waste under RCRA and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954 (42 USC 2011, et seq.).

low-level waste (LLW)

Radioactive waste that contains typically small amounts of radioactivity and is not classified as, HLW transuranic waste, spent nuclear fuel or by-product tailings from processing uranium or thorium ore.

low point drain tank

Intermediate transfer facility for delivery of high-activity salt solution from a tank farm to the Grout Facility in the Direct Disposal in Grout alternative, and transfer of washed MST and sludge solids from the Grout Facility to DWPF.

macroinvertebrate

Small animal, such as a larval aquatic insect, that is visible to the naked eye and has no vertebral column.

manipulator

Mechanical device for handling operations inside a radiation-shielded area, controlled manually by hand operations outside the shielded area.

maximally exposed individual (MEI)

A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure).

millirad

One thousandth of a rad (see rad).

millirem

One thousandth of a rem (see rem).

mixed waste

Waste that contains both hazardous material wastes under RCRA and radioactive source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

modifier

Component of organic phase added to solvent to enhance separation of a specified constituent in the solvent extraction process.

modular confinement

Containment system consisting of movable, replaceable structural units.

modular shielding

Shielding components assembled from movable, replaceable units.

modular structure

Building constructed of pre-assembled or pre-sized units of a standard design.

module

Self-contained unit that serves as a building block for a structure.

monosodium titanate (MST)

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

nanocurie

One billionth of a curie (see curie).

natural grade

Elevation of a finished surface for an engineering project; ground level.

natural phenomena accidents

Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, and so forth.

nitrate

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

nitrite

Any member of a class of compounds derived from nitrous acid. Salts of nitrous acid are ionic compounds containing the negative nitrite ion, NO_2, and a positive ion such as sodium (Na) in sodium nitrite ($NaNO_2$).

nonelutable ion exchange

Process in which a chemical species is separated from solution by replacement of a constituent of a solid (resin), but is not removed (eluted) from the solid before final disposition.

noninvolved workers

Workers in a fixed population outside the day-to-day process safety management controls of a given facility area. In practice, this fixed population is normally the workers at an independent facility area located a specific distance (often 100 meters) from the reference facility area.

nuclear criticality

A self-sustaining nuclear chain reaction.

nuclide

A general term referring to any one of all known isotopes, both stable (279) and unstable (about 5,000), of the chemical elements.

offsite

Away from the SRS site.

offsite population

For facility accident analyses, the collective sum of individuals located within a 50-mile (80-kilometer) radius of a facility and within the path of the plume with the wind blowing in the most populous direction.

onsite

On the SRS property.

Organic Evaporator

As used in this SEIS, a process vessel provided to decontaminate benzene recovered from the decomposition of tetraphenylborate precipitate. Benzene is washed with water and separated by distillation.

oxalic acid

A water-soluble organic acid, $H_2C_2O_4$, being considered as a cleaning agent to use in spray washing of tanks, because it dissolves sludge and is only moderately aggressive against carbon steel, the material used in construction of the waste tanks.

particulate

Pertains to minute, separate particles. An example of dry particulate is dust.

performance modeling

A systematic mathematical analysis to estimate potential human exposures to hazardous and radioactive substances. It may include specification of potential releases, exposure pathways, effects of facility degradation, transport in the environment, uptake by the affected recipient, and comparison of estimated exposures to regulatory limits or other established performance.

performance objectives

Parameters within which a facility must perform to be considered acceptable.

permanent disposal

For HLW, the term means emplacement in a repository for HLW, spent nuclear fuel, or other highly radioactive material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste.

permeability

The degree of ease with which water can pass through rock or soil.

person-rem

A unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in a specified population or group.

pH

A measure of the relative acidity or alkalinity of a solution. A neutral solution has a pH of 7, acids have a pH of less than 7, and bases have a pH of greater than 7.

picocurie

One trillionth of a curie (see curie).

plutonium

Chemical element of the actinide series in Group IIIb of the periodic table. All isotopes of plutonium are radioactive. The symbol for plutonium is Pu.

population

For risk assessment purposes, population consists of the total potential members of the public or workforce who could be exposed to a possible radiation or chemical dose from an exposure to radionuclides or carcinogenic chemicals.

population dose

The overall dose to population, consisting of the sum of the doses received by individuals in the population.

Precipitate Hydrolysis

As used in this SEIS, a chemical process in which tetraphenylborate precipitate is catalytically decomposed to benzene and a soluble salt solution of waste constituents to be fed to the DWPF water.

Precipitate Hydrolysis Aqueous

As used in this SEIS, the soluble salt solution generated by the precipitate hydrolysis process to be fed to the DWPF melter.

Precipitate Hydrolysis Cell

As used in this SEIS, a shielded enclosure in the Small Tank Precipitation facility that is equipped for tetraphenylborate precipitate decomposition operations.

Precipitate Reactor

As used in this SEIS, a process vessel provided for decomposition of tetraphenylborate precipitate by the precipitate hydrolysis process to eliminate benzene.

precipitate washing

Process in which precipitate solids are washed to remove water-soluble salts and excess sodium tetraphenylborate.

precipitation (chemical)

The formation of an insoluble solid by chemical or physical reaction of constituent in solution.

preconceptual design

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

pump pits

As used in this SEIS, intermediate stations in the waste transfer system equipped with tanks and pumps to maintain the flow of process streams, constructed of reinforced concrete with stainless steel liners for containment of radioactive solutions.

purge system

A method for replacing atmosphere in a containment vessel by an inert gas to prevent the formation of a flammable or explosive mixture.

rad

The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

radiation (ionizing radiation)

Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as it is used here, does not include nonionizing radiation such as radio- or microwaves or visible, infrared, or ultraviolet light.

radiation worker

A worker who is occupationally exposed to ionizing radiation and receives specialized training and radiation monitoring devices to work in such circumstances.

radioactive

Describing a property of some elements having isotopes that spontaneously transform into one or more different nuclides, giving off energy in the process.

radioactive waste

Waste that is managed for its radioactive content.

radioactivity

The property of unstable nuclei in certain atoms of spontaneously emitting ionizing radiation in the form of subatomic particles or electromagnetic energy during nuclear transformations.. The unit of radioactivity is the curie (or becquerel).

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.

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.

raffinate

Decontaminated salt solution produced by removal of radionuclides from HLW solution, using the solvent extraction process.

reagent

A substance used in a chemical reaction to detect, measure, examine, or produce other substances.

Record of Decision (ROD)

A concise public document that records a Federal agency's decision(s) concerning a proposed action.

reconstituted salt solution

Waste salt solution obtained by dissolving saltcake in water and combining with supernatant salt solution in HLW tanks.

reducing grout

A grout formulated to behave as a chemical reducing agent. A chemical reducing agent is a substance that reduces other substances (i.e., decreases their positive charge or valence) by supplying electrons. The purpose of a reducing grout is to provide long-term chemical durability against leaching of the residual waste by water. Reducing grout could be composed primarily of cement, blast furnace slag, masonry sand, and silica fume.

reinforced concrete

Concrete containing steel bars to increase structural integrity.

rem

A unit of radiation dose that reflects the ability of different types of radiation to damage human tissues and the susceptibility of different tissues to the damage. Rems are a measure of effective dose equivalent. The dose equivalent in rems equals the absorbed dose in rads multiplied by factors that express the biological effectiveness of the radiation producing it.

remote equipment laydown area

Shielded space provided in processing facility for temporary placement and storage of equipment used in facility operation.

risk

Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

ruthenium

Chemical element, one of the platinum metals of Group VIII of the periodic table. The symbol for ruthenium is Ru; Ru-106 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

Safety Analysis Report (SAR)

A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarizes the hazards associated with the operation of a particular facility and defines minimum safety requirements.

salt

As used in this SEIS, salt is the soluble component of the radioactive wastes in the HLW tanks. The salt component consists of saltcake and salt supernate containing principally sodium nitrate with radionuclides mainly isotopes of cesium and technetium.

saltcake

Solid crystalline phase of salt component in HLW tanks remaining after the dewatering of salt solution by evaporation.

salt supernatant

Concentrated solution of salt components in HLW tanks after dewatering of primary salt solution by evaporation.

saltstone

Cementitious solid waste form employing blend of cement, flyash, and slag to immobilize low-radioactivity salt solutions for onsite disposal.

saltstone vaults

Near-surface concrete containment structures that are used for disposal of low-level radioactive waste in the form of saltstone. The vaults serve as forms for poured saltstone.

saturated resin

Condition of an ion exchange solid (resin) used to separate a chemical species from solution when no additional quantity of the chemical species can be loaded onto the solid.

scrub

Process stage in a solvent extraction procedure for removing secondary salt constituents from organic phase before recovery of principal constituent.

secondary containment system

Supplementary means for containment of gases or liquids that leak or escape from primary waste process or storage vessels.

seepline

An area where subsurface water or groundwater emerges from the earth and slowly flows over land.

segregation

The process of separating (or keeping separate) individual waste types and/or forms in order to facilitate their cost-effective treatment, storage, and disposal.

seismicity

The phenomena of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

selenium

Chemical element in the oxygen family (Group VIa) of the periodic table, closely allied in chemical and physical properties with the elements sulfur and tellurium. The symbol for selenium is Se; Se-79 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

slag

The vitreous material left as a residue by the smelting of metallic ore. As used in this SEIS, a component of saltstone added to reduce release of certain waste constituents (technetium, chromium).

sludge

Component of HLW consisting of the insoluble solids that have settled at the bottom of the HLW storage tanks. Radionculides present in the sludge include fission products and long-lived actinides.

sodium

Chemical element of Group Ia of the periodic table, the alkali metal group. The symbol for sodium is Na. Sodium salts are a major constituent of the salt component in the HLW tanks.

sodium tetraphenylborate

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

solids slurry washing

As used in this SEIS, dilution of salt solution in contact with solids, followed by filtration to reduce concentration of soluble salts in slurried solids.

solvent

Substance (usually liquid) capable of dissolving one or more other substances.

solvent extraction

Process for separation of a constituent from an aqueous solution by transfer to an immiscible organic phase. As used in this SEIS, employed to separate radioactive cesium from HLW salt solution.

sorbent

A material that sorbs another substance; i.e. that has the capacity or tendency to assimilate the substance by either absorption or adsorption.

sorption

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

source material

(a) Uranium, thorium, or any other material that is determined by the U.S. Nuclear Regulatory Commission pursuant to the provisions of the Atomic Energy Act of 1954, Section 61, to be source material; or (b) ores containing one or more of the foregoing materials, in such concentration as the U.S. Nuclear Regulatory Commission may by regulation determine from time-to-time [Atomic Energy Act 11(z)]. Source material is exempt from regulation under the RCRA.

source term
: The amount of a specific pollutant (e.g., chemical, radionuclide) emitted or discharged to a particular environmental medium (e.g., air, water) from a source or group of sources. It is usually expressed as a rate (e.g., amount per unit time).

spent nuclear fuel
: Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.

stabilization
: Treatment of waste to protect the environment from contamination. This includes rendering a waste immobile or safe for handling and disposal.

stilling tanks
: Process vessels for holdup of decontaminated salt raffinate and concentrated strip effluent from solvent extraction operations to allow floating and removal of entrained organic phase.

strip effluent
: As used in this SEIS, the aqueous cesium solution resulting from the back extraction of cesium from the organic phase in the Solvent Extraction salt processing alternative.

stripping
: Process operation for recovery of constituents extracted into the organic phase in the solvent extraction operation by contacting the organic phase with a dilute acid stream.

strontium
: Chemical element of Group IIa of the periodic table, the alkaline-earth metal group, of which calcium is a member. The symbol for strontium is Sr; Sr-90 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

subsurface
: The area below the land surface (including the vadose zone and aquifers).

supernatant salt solution
: Saturated solution of salt wastes remaining in waste tanks after dewatering of salt wastes by evaporation.

suppressor
: Component of organic phase added to diluent to promote recovery of constituent extracted into organic phase in solvent extraction operations.

tank farm
: An installation of multiple adjacent tanks, usually interconnected, for storage of liquid radioactive waste.

technetium
: Chemical element, a metal of Group VIIb of the periodic table. All isotopes of technetium are radioactive. The symbol for technetium is Tc; Tc-99 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

tetraphenylborate

Chemical consisting of four phenyl groups attached to boron atom $(C_6H_5)_4B$. Sodium tetraphenylborate used to separate radioactive cesium from HLW salt solution by precipitation, forming insoluble cesium tetraphenylborate.

Tetraphenylborate Precipitation

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

tin

Chemical element belonging to the carbon family, Group IVa of the periodic table. The symbol for tin is Sn; Sn-126 is the principal radioactive isotope of this element present in the HLW tanks at SRS.

total effective dose equivalent

The sum of the external dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transuranic waste

Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) HLW; (b) waste that the U.S. Department of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

treatment

Any activity that alters the chemical or physical nature of a hazardous waste to reduce its toxicity, volume, or mobility or to render it amenable for transport, storage, or disposal.

tritium

A radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons. The symbol for tritium is H-3. In the HLW tanks at SRS, tritium is usually bound in water molecules, where it replaces one of the ordinary hydrogen atoms.

uranium

Chemical element of the actinide series in Group IIIb of the periodic table. All isotopes of uranium are radioactive. The symbol for uranium is U.

vadose zone

The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

valve box

Transfer system component regulating the flow of process streams in a piping system by manual or remote valve adjustment.

vitrification

As used in this SEIS, a method of immobilizing waste (e.g., radioactive, hazardous, and mixed), by melting glass frit and waste into a solid waste form suitable for long-term storage and disposal.

volatile organic compounds (VOCs)

Compounds that readily evaporate and vaporize at normal temperatures and pressures.

waste minimization

An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, or recycling.

waste stream

A waste or group of wastes with similar physical form, radiological properties, U. S. Environmental Protection Agency waste codes, or associated land disposal restriction treatment standards. May result from one or more processes or operations.

wetlands

Areas that are inundated or saturated by surface water or groundwater and that typically support vegetation adapted for life in saturated soils. Wetlands generally include swamps, marshes, bogs, and similar areas.

wind rose

A circular diagram showing, for a specific location, the percentage of the time the wind is from each compass direction. A wind rose for use in assessing consequences of airborne releases also shows the frequency of different wind speeds for each compass direction.

Savannah River Site

Salt Processing Alternatives

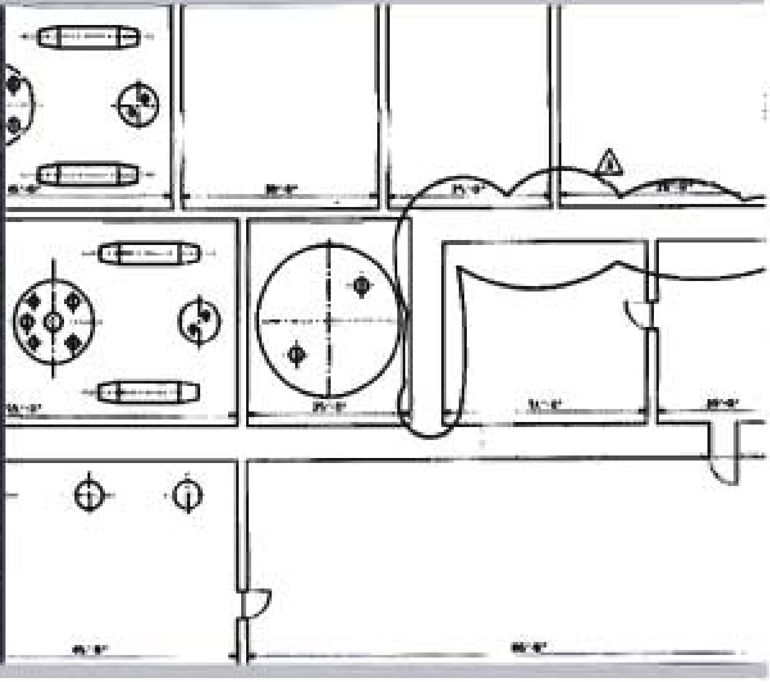
Draft Supplemental Environmental Impact Statement

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

Summary

March 2001

DOE/EIS-0082-S2D



COVER SHEET

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

TITLE: Savannah River Site Salt Processing Alternatives Draft Supplemental Environmental Impact Statement (DOE/EIS-0082-S2D)

CONTACT: For additional information on this supplemental environmental impact statement (SEIS), write or call:

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

ABSTRACT: DOE prepared this Draft 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. DOE has not selected a Preferred Technology Alternative. Preferred sites for locating processing 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: In preparing this Draft SEIS, DOE considered comments received by letter and voice mail and comments received at two public scoping workshops held in Columbia and North Augusta, South Carolina, on March 11 and March 18, 1999, respectively.

A 45-day comment period on the Draft Salt Processing Alternatives SEIS begins with the U.S. Environmental Protection Agency's publication of a Notice of Availability in the *Federal Register*. Public meetings to discuss and receive comments on the Draft SEIS will be held on May 1, 2001, at the North Augusta Community Center in North Augusta, South Carolina, and on May 3, 2001, at the Holiday Inn Coliseum in Columbia, South Carolina. Comments may be submitted at the public meetings and by voice mail, e-mail, or regular mail to the first address above. Comments received or postmarked by the end of the comment period will be considered in the preparation of the Final SEIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

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

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
FFA	Federal Facility Agreement
FR	Federal Register
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
ITP	In-Tank Precipitation
LCF	latent cancer fatality
MEI	maximally exposed (offsite) individual
MST	monosodium titanate
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
OWST	organic waste storage tank
PHA	precipitate hydrolysis aqueous
PSD	prevention of significant deterioration
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
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}

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 key terms used in this document, 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 uranium and plutonium). Radionuclides found in the salt component include **isotopes** of cesium and technetium, as well as some strontium and actinides.

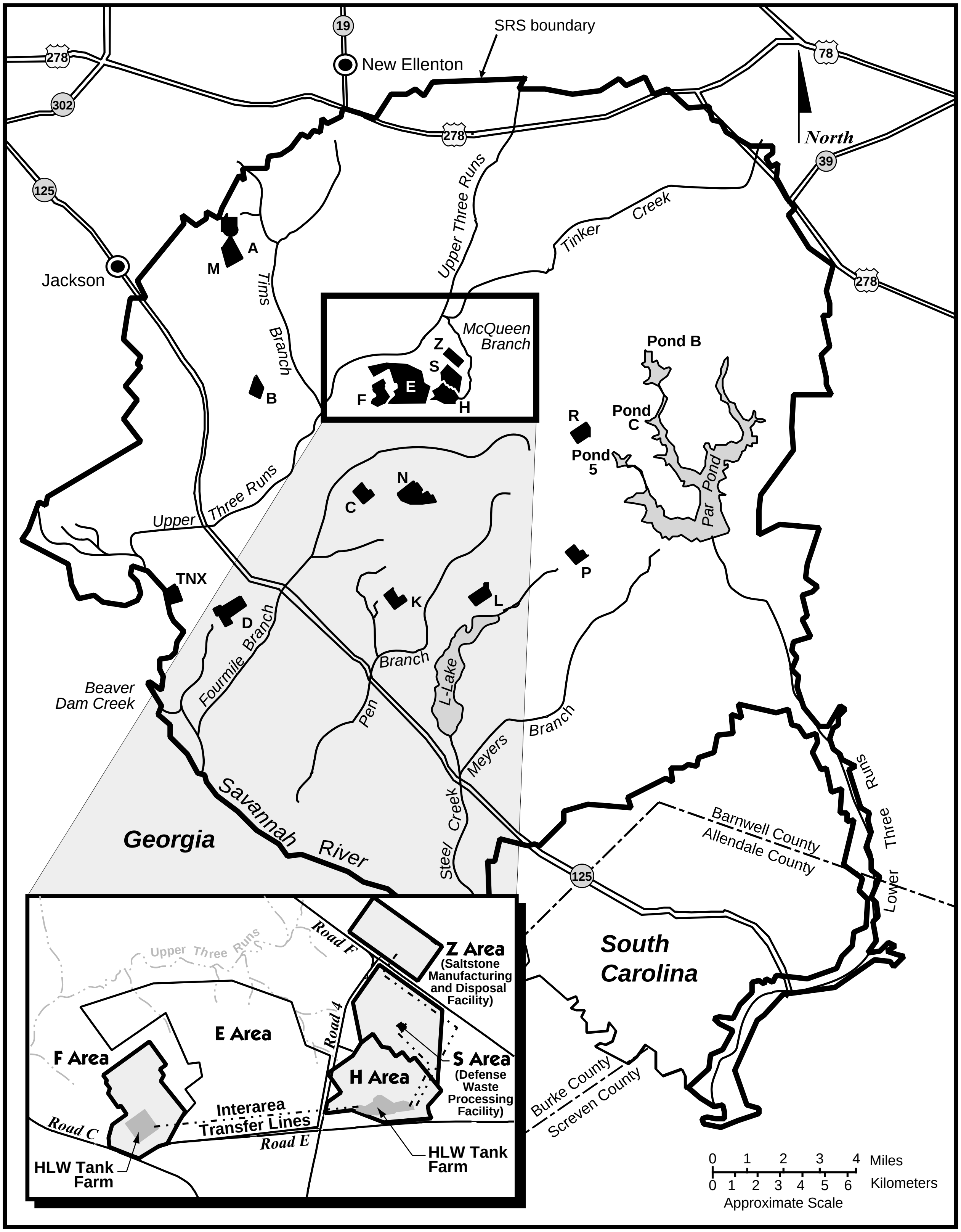
The salt component consists of **saltcake** and **salt supernatant**. To process the salt component, solid saltcake must first be dissolved and combined with salt supernatant to form a salt solution. An important part of the DWPF system, as designed, was to then separate the highly radioactive constituents 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 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 actinides and radioactive strontium from the salt solution. An organic **reagent**, **sodium tetraphenylborate**, was to precipitate radioactive cesium from the salt solution. The ITP process also included washing and filtration steps to separate the solid phases holding these radioactive materials.

The reagent used to precipitate cesium in the ITP process, sodium tetraphenylborate, is subject to **catalytic** and **radiolytic decomposition**. Its decomposition inhibits its ability to bind with cesium and keep it out of 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 sodium tetraphenylborate must be limited 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 sodium 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. As a result, in March 1996, ITP operations were suspended. However, the DWPF facility continues to process and vitrify HLW sludge.

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



NW SDA EIS/Grfx/Summary/S-1 SRS FHSZ.ai

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

Radionuclides

Antimony (Sb)

Antimony is a silver-white, metallic element. Antimony-125 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for antimony is Sb. Sb-125 has a half-life of 2.7 years.

Carbon (C)

Carbon is a black, nonmetallic element. Carbon-14 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Carbon is C. C-14 has a half-life of 5,700 years.

Cesium (Cs)

Cesium is a silver-white, highly reactive, metallic element. Cesium-137, -135, and -134 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for cesium is Cs. Cs-137 has a half-life of 30 years, Cs-135 has a half-life of 2.3 million years, and Cs-134 has a half-life of 2 years.

Iodine (I)

Iodine is a nonmetallic, halogen element. Iodine-129 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Iodine is I. I-129 has a half-life of 16 million years.

Plutonium (Pu)

Plutonium is a man-made, silver-gray, metallic element in the actinide series. All isotopes of plutonium are radioactive. Plutonium is a fission fuel for reactors and atomic weapons. Plutonium-239 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for plutonium is Pu. The half-life of Pu-239 is 24,000 years.

Ruthenium (Ru)

Ruthenium is a grayish, metallic element. Ruthenium-106 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Ruthenium is Ru. Ru-106 has a half-life of 372 days.

Selenium (Se)

Selenium is a lustrous gray, nonmetallic element. Selenium-79 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Selenium is Se. Se-79 has a half-life of 65,000 years.

Strontium (Sr)

Strontium is a silver-yellow, metallic element. Strontium-90 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for strontium is Sr. Sr-90 has a half-life of 29 years.

Technetium (Tc)

Technetium is a man-made, silver-gray, metallic element. All isotopes of technetium are radioactive. Technetium-99 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for technetium is Tc. Tc-99 has a half-life of 200,000 years.

Tin (Sn)

Tin is a bluish-white, metallic element. Tin-126 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Tin is Sn. Sn-126 has a half-life of 100,000 years.

Tritium (H-3)

Tritium is a radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons. In the HLW tanks at SRS, tritium is usually bound in water molecules, where it replaces one of the normal hydrogen atoms. The symbol for Tritium is H-3. Tritium has a half-life of 12.5 years.

Uranium (U)

Uranium is a silver-white, highly reactive, metallic element in the actinide series. All isotopes of uranium are radioactive. Uranium is used as a fission fuel for reactors and atomic weapons. Uranium-235 and -238 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for uranium is U. U-235 has a half-life of 700 million years and U-238 has a half-life of 4 billion years.

public health and safety, recommended that testing and operation of ITP not proceed further until DOE had a better understanding of how benzene was generated and released during the **precipitation** process. In January 1998, DOE determined that ITP, as designed, could not meet production goals and safety requirements.

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 SRS HLW 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 decision-making, summarizes the salt processing alternatives, and outlines the major conclusions, 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 below)
- 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 below).

This system is currently operating, except for salt processing through ITP, CIF, and the Late Wash Facility. ITP operations are now limited to facility surveillance and maintenance. The Late Wash Facility has been tested, using nonradioactive materials, and is in standby status.

CIF operations were suspended in October 2000. The CIF was constructed primarily to incinerate benzene generated in the ITP process and solvent wastes from F- and H-Canyon operations. If an effective alternative to solvent disposal by incineration can be identified, DOE will no longer operate CIF.

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 (EIS). In 1994, DOE published an SEIS to evaluate changes in the process proposed after the 1982 EIS was issued. The Record of Decision (60 FR 18589; April 12, 1995) announced that DOE would complete the construction and startup testing of DWPF and would use the ITP technology for salt processing after satisfactory completion of startup testing.

After evaluating the ITP process in the large waste tank, DOE determined that ITP, as designed, could not meet both safety requirements and production goals. In 1998, DOE determined that it must therefore select an alternative technology for HLW salt processing.

In early 1998, 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 and new research and development results.

In response to a June 1999 request from the Under Secretary of Energy, the National Academy of Sciences - National Research Council provided an independent technical review of alternatives for processing the HLW salt solutions at the SRS. The review was conducted by a committee composed of expert consultants in the fields of nuclear reactor and fuel cycle technology, nuclear chemistry and separations, environmental sciences, and nuclear waste disposal. The final Council Report endorsed in general the selection of the four candidate processes considered as alternatives for salt disposal, concluding that each of the processes was potentially appropriate and no obvious major processing options were overlooked. Recommendations for addressing the technical uncertainties associated with each of the alternative were identified, with schedule constraints and potential regulatory restrictions noted.

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 disposal as LLW at SRS.

If salt processing is delayed beyond 2010, DOE recognizes that the salt waste must be vitrified separately from the sludge component of the HLW, and the total number of HLW canisters would be greatly increased over that projected for concurrent sludge and salt waste vitrification.

HLW Tank Closure

DOE, 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 the 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, to evaluate the impacts of the tank closure program.

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 additional 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.

NEPA provides Federal decisionmakers 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. Each meeting included a presentation on the NEPA process as it related to the proposed action, a presentation on the process used to identify reasonable alternatives for salt processing for further evaluation, public comment opportunities, and question-and-answer opportunities. DOE considered comments received during the scoping period in preparing this Draft SEIS. The comments, along with DOE's responses, are given in Appendix C of this SEIS and briefly summarized here.

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.

Several comments related to the alternative salt processing technologies. Commentors questioned how the Small Tank Precipitation alternative could be successful when the ITP, which used the same chemical process, was not. Commentors were specifically concerned about how generation of benzene from this process could be controlled. DOE believes the Small Tank Precipitation alternative may be a viable process, because differences in design between the Small Tank Precipitation process and the ITP process are intended to control benzene generation.

Commentors questioned the vault design for the Direct Disposal in Grout alternative, and asked that it be justified on technical and health and safety grounds. DOE has described the vault design and the potential impacts on human health and safety in the Draft SEIS, and has compared the Direct Disposal in Grout alternative to the other technologies in this regard.

Commentors stated that DOE should pursue one of the technologies rather than take no action, and questioned the description of the No Action alternative. DOE proposes to pursue one of the processing technologies rather than take no action. However, No Action is analyzed under NEPA to provide a basis for comparison of the action alternatives. DOE has revised the No Action alternative to represent a continuation of DOE's ongoing tank management activities as long as tank space is available. Under No Action, DOE estimates that additional tank space would be required around 2010, and assumes for purposes of analysis that DOE would build new tanks. For analysis of long-term impacts, DOE assumes loss of institutional control 100 years after the short-term action period ends (2023).

Because the Direct Disposal in Grout alternative would result in millions of curies of cesium being disposed of at SRS, commentors were interested in the quantities of radioactive materials disposed of in other locations, and wanted to be sure that DOE evaluated the long-term impacts of disposal. DOE has disposed of almost 10 million curies at SRS, and about 7 million curies of LLW have been disposed of at nearby Barnwell, South Carolina. In the SEIS, DOE evaluates the long-term impacts of disposal of about 120 million curies in saltstone vaults, which would be the result of the Direct Disposal in Grout alternative.

Commentors had questions about waste tank utilization, particularly about reuse of old tanks if a salt processing technology were not available. DOE discusses waste tank utilization in Chapter 2 and Appendix A of the SEIS. DOE intends to manage the selection, construction, and operation of a salt processing facility and current facilities such that tank waste removal and tank closure commitments can be met.

Commentors had several specific questions about the technology research and development activities that DOE is conducting, and how these activities were coordinated with the SEIS. The SEIS describes the technology research. The Final SEIS will be available to the public and the decisionmakers before DOE selects a technology for salt processing. In addition, the results of several studies are available now for public review on the SRS web site at www.srs.gov/general/srtech/spp/randd.htm.

Commentors asked if cost would be included in the SEIS to differentiate between alternatives. Commentors also asked if cost was the sole attraction of the Direct Disposal in Grout alternative. The preliminary cost estimates that are available do not provide any differentiation between alternatives and, at this preliminary stage, are all in the same range. The greatest attraction of the Direct Disposal in Grout alternative is not cost, but the fact that there is no technical uncertainty involved in its implementation.

Commentors asked about the schedule for salt processing technology selection and implementation. DOE expects to complete preliminary research and development and identify a preferred technology by June 2001. DOE will identify the preferred technology in the Final SEIS and announce its decision in a Record of Decision no sooner than 30 days after EPA publishes a Notice of Availability of the Final SEIS. Selection by the Summer of 2001 is critical to selecting a design contractor, initiating Pilot Plant studies of the selected technology and, ultimately, bringing a salt processing alternative on line in time to meet SRS commitments for HLW vitrification and HLW tank closure. Startup of the salt processing facility is planned for about 2010.

S.5 Decisions to be Made

Following completion of this SEIS and related technical studies, DOE will select a technology to process the salt components of the HLW stored at SRS.

DOE will complete laboratory research and development in April 2001. Following evaluation of the studies, DOE will identify a preferred alternative in the Final SEIS, planned for June 2001. No sooner than 30 days after EPA publishes a Notice of Availability of the 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.

S.6 Site Selection

WSRC prepared a site selection study to identify a suitable location at the SRS for the construction and operation of a salt processing facility in S or H Areas. 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 the DWPF, the salt processing facility must be located within 2,000 feet of the DWPF or a low point pump pit. This constraint identified general areas suitable for construction and operation. Thirteen areas with sufficient acreage for the buildings, construction laydown, and support facilities were identified. Subsequent evaluation of these areas resulted in the identification of four candidate sites (A [subsequently excluded], B, C, and D) in S Area (Figure S-2). A comparative analysis of the sites provided a suitability ranking based on geological, ecological, human health, and engineering considerations. Overall, Site B ranked higher than Sites C or D, although no distinct differences were identified between the four sites for geological, ecological, or human health considerations.

Because there were no distinct differences and Site B is representative of all sites, DOE assumes for purposes of analysis and comparison,

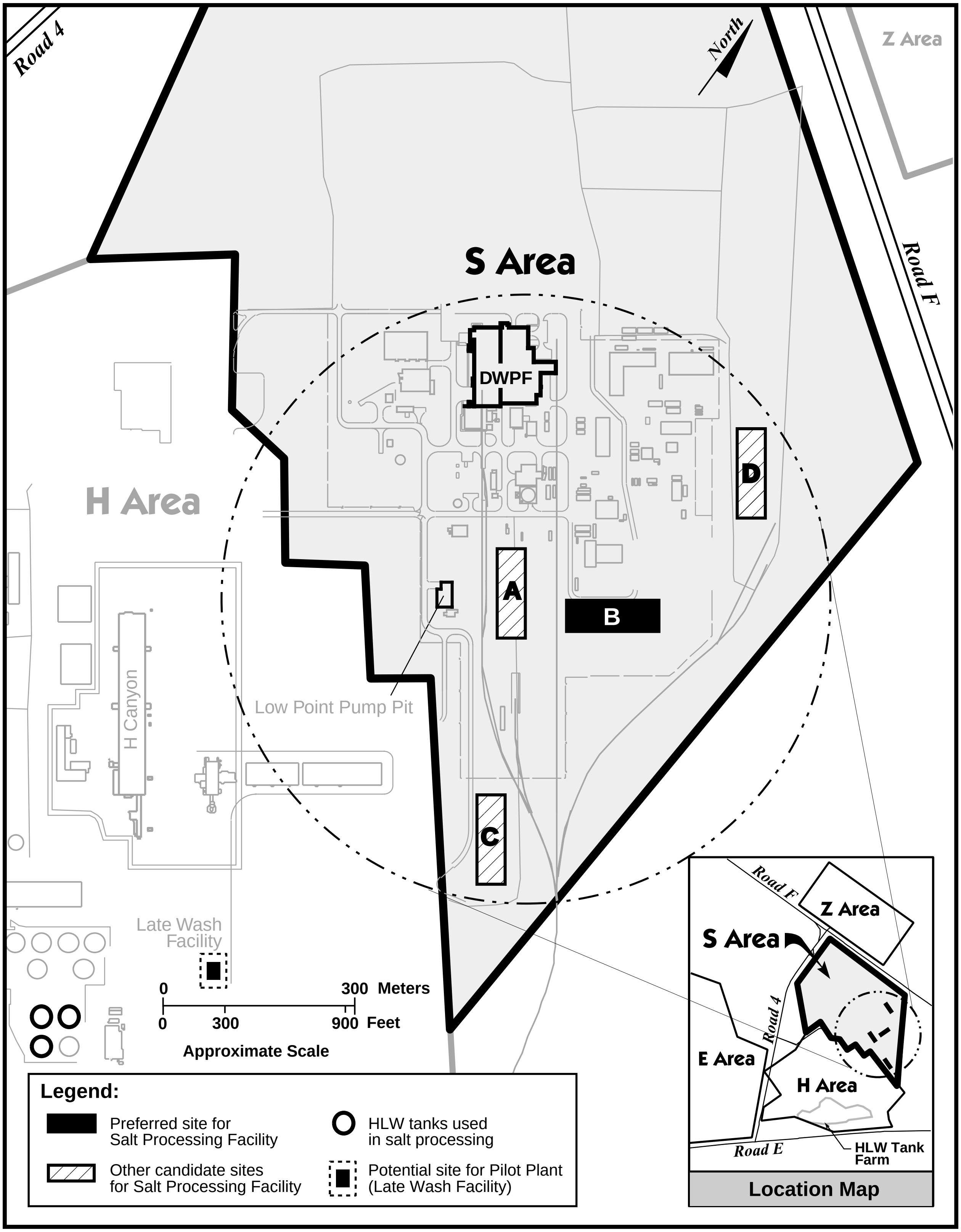


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Figure S-2. Potential salt processing facility sites.

DOE assumes in this SEIS that all facilities for the Small Tank Precipitation, the Ion Exchange, or the Solvent Extraction technologies would be located at Site B.

The Direct Disposal in Grout technology was not considered in the siting study because the grout manufacturing facility would need to be located in Z Area, near the saltstone vaults and existing infrastructure that could support the grout production. Figure S-3 shows the preferred 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 Draft 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 four process alternatives to establish the technological risk(s) involved in implementing each one. Independent scientists reviewed the results of the research. This Draft SEIS assesses the potential environmental impacts of each alternative.

DOE has not yet selected a preferred alternative for processing HLW salt. The identification of a preferred alternative will be based on research, evaluation, and independent review of the technology alternatives to be completed in April 2001, with the preferred alternative to be identified in the Final SEIS.

No Action Alternative

Under the No Action alternative, 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 activities 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
- Use tanks for HLW storage instead of In-Tank Precipitation (ITP) processing (Tanks 49 and 50)
- Reduce the DWPF low-level liquid waste stream sent to the Tank Farms
- Implement several activities that gain small incremental storage volumes (e.g., optimize washwater use at Extended Sludge Processing)

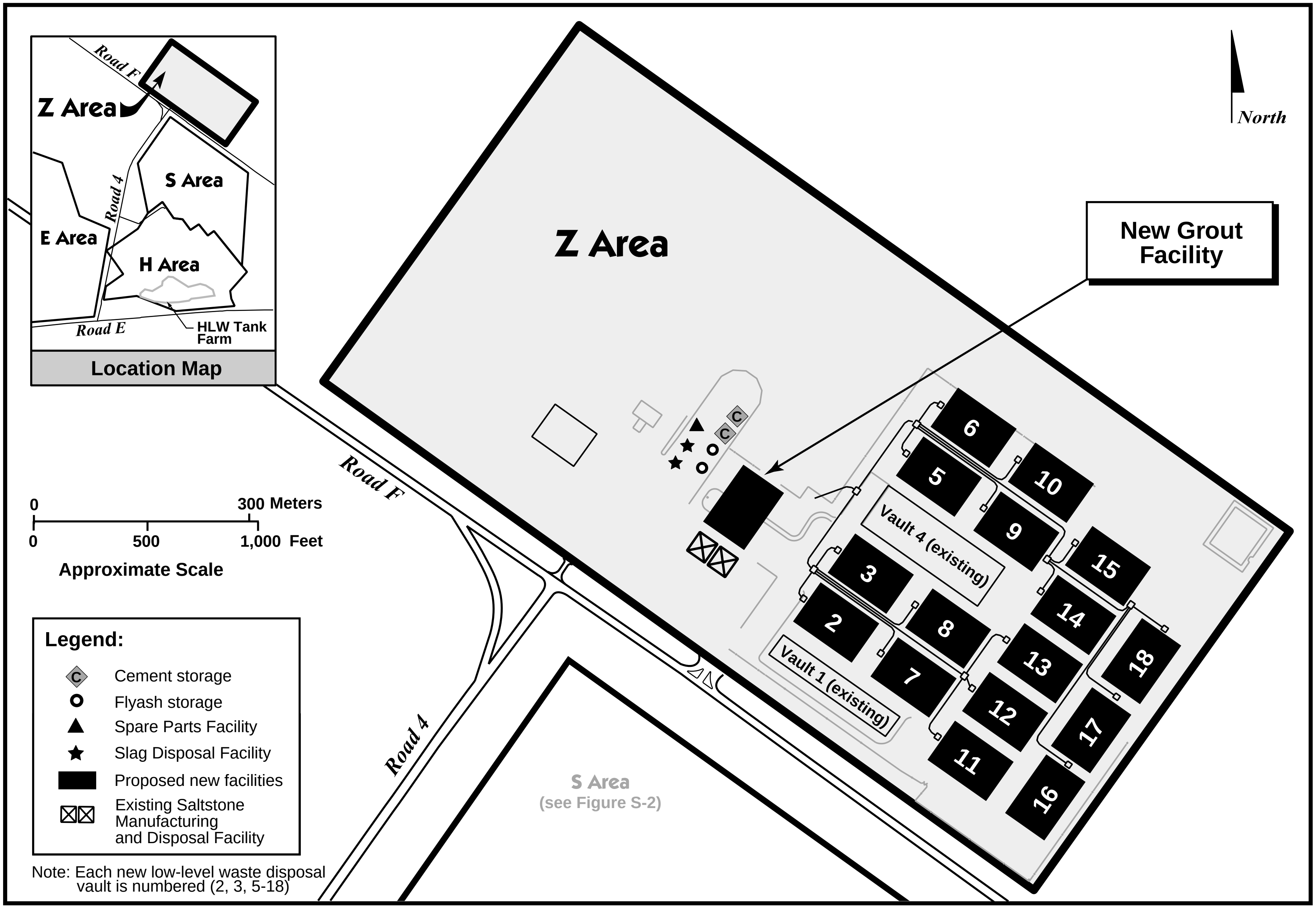

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Figure S-3. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

- As 2010 approaches, reduce the available emergency space in the Tank Farms (presently 2,600,000 gallons) to the minimum required by the Authorization Basis determined by a safety assessment (1,300,000 gallons), as necessary.

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 immediately. The course of action that DOE would follow cannot be predicted at this time, but available options may include the following, either individually or in combination.

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.

Because of the speculative nature concerning DOE's future course of action, DOE provides a mostly qualitative assessment of the No Action alternative in Chapter 4.

Salt Processing Alternatives

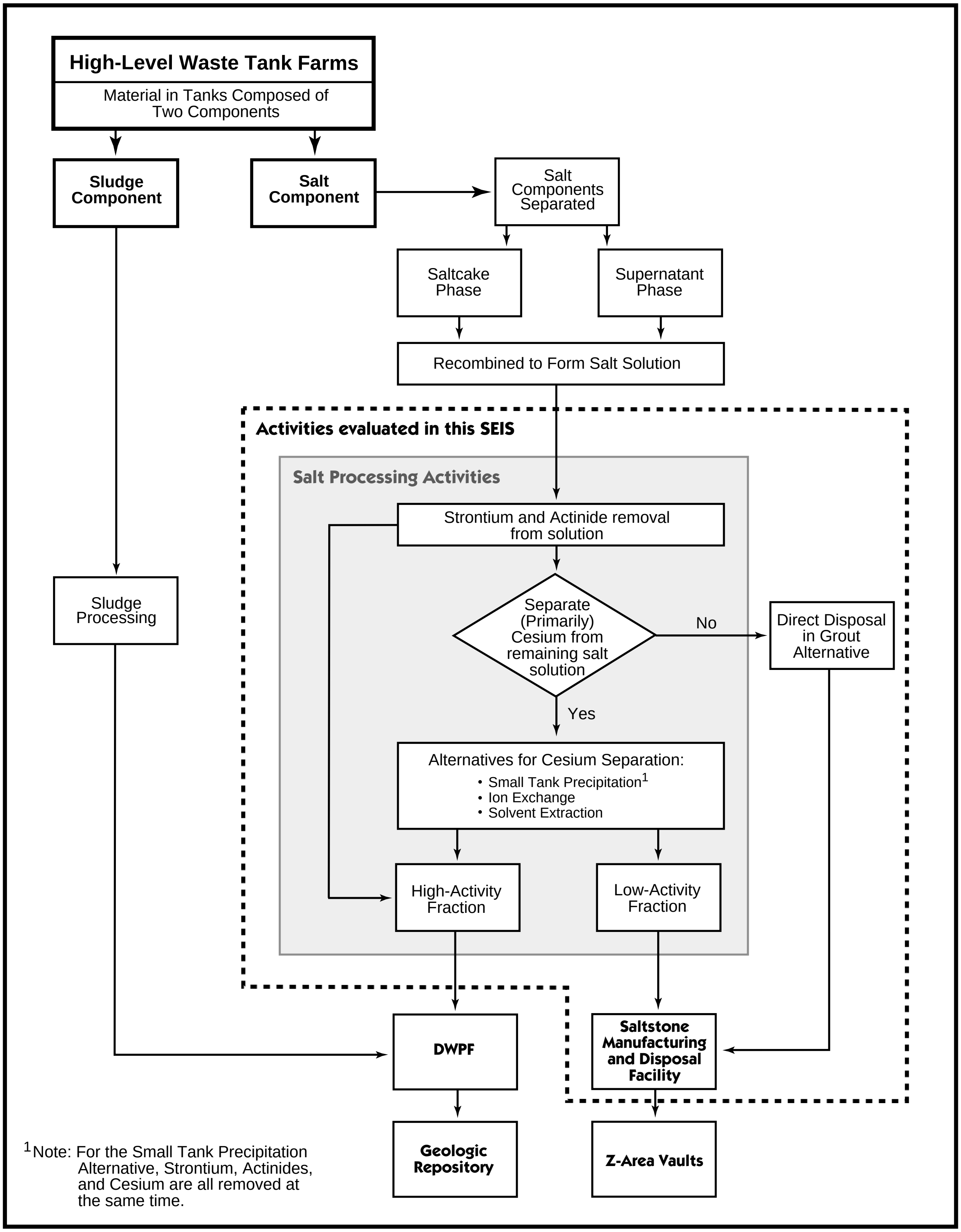
Common features of all processes include initial separation of low-concentration soluble radioactive strontium and actinides (including plutonium) by **sorption** (Table S-1) on granular solid monosodium titanate (MST), followed by filtration. Essential differences in the alternatives are the technologies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

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

Table S-1. Comparison of salt processing alternatives.

	Process phases			
			Final waste form	
Salt processing alternatives	Strontium and actinide (Pu) removal from salt solution	Cesium removal from salt solution	DWPF glass	Saltstone
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-bearing salt solution

MST = Monosodium Titanate, CST = Crystalline Silicotitanate, TPB = Tetraphenylborate.



[1] Note: For the Small Tank Precipitation Alternative, Strontium, Actinides, and Cesium are all removed at the same time.

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

Waste Management). The waste incidental to reprocessing determination process is described in detail in Chapter 7.

S.7.1 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 by a precipitation hydrolysis process to decompose the tetraphenylborate precipitate and remove the benzene formed. The solids slurry containing the separated radioactive constituents is called **Precipitate Hydrolysis Aqueous** (PHA). This slurry would be transferred to DWPF for vitrification. The low-activity salt fraction 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

S.7.2 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.

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.7.3 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 (strip effluent) for vitrification in DWPF. Prior treatment of the HLW salt solution, using monosodium titanate to separate soluble strontium and actinides and filtration to remove those solids and residual sludge, would be required to meet salt solution decontamination requirements and avoid interference in the solvent extraction process. The monosodium titanate solids would be transferred to DWPF for vitrification along with the strip effluent solution. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

S.7.4 DIRECT DISPOSAL IN GROUT

Under the other three technologies considered in this SEIS, cesium would be removed from the salt solution and eventually disposed of, 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 prior 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.

The clarified salt solution resulting from monosodium titanate treatment would be combined with flyash, cement, and slag in a grout mixer for disposal in the saltstone vaults. The resulting waste form would meet 10 CFR 61.55 Class C LLW limits for near-surface disposal, but would exceed Class A limits. Current regulations require SCDHEC notification if wastes in saltstone vaults exceed the Class A limits.

S.7.5 PROCESS INPUTS AND PROCESSING REQUIREMENTS

Design of salt processing facilities depends on specifications of processing requirements, including product input and 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. This processing rate would allow complete processing of about 80 million gallons total (approximate volume of salt solution when the saltcake is dissolved) within about 13 years after facility startup. It is important to finish processing the salt waste within this time so that the HLW sludge and the high-activity fraction of the HLW salt can be vitrified together in the DWPF. If salt processing is delayed so that salt waste must be vitrified separately, the total number of HLW canisters would be greatly increased over that projected for concurrent sludge-salt waste vitrification. Vitrification of the combined HLW sludge and salt would produce about 5,700 glass waste canisters.

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.7.6 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 facility would deliver a greater volume of product to DWPF than the other facilities because of the relatively high volume of cesium solution (strip effluent) in its product output. However, the amount of sludge processed at DWPF is the primary determinant for canister production. Therefore, the high volume of cesium solution from the solvent extraction facility would not affect the number of canisters produced. Salt solutions to grout and the product grout produced would be about the same for each alternative.

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

	Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Capacity throughput of salt solution (million gallons per year)	6.9	6.9	6.9	6.0
Long-term average throughput of salt solution (million gallons per year)	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[a]	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced[a]	≈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[b]	0	0	0	13

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a. DWPF planned glass waste canister production includes both sludge and salt wastes.
b. Additional saltstone vaults for onsite disposal of processed salt solution.
c. This alternative would require between 14 and 15 vaults; for purposes of impact analysis, 15 vaults were assumed.

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

	Alternative			
Product Output	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

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a. Includes 0.154 million gallons/yr solids slurry and 0.523 million gallons/yr strip effluent 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.

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 (20 metric tons per year) of liquid benzene would be produced by decomposition of the tetraphenylborate salt in the precipitation hydrolysis process, to be stored for final disposition.

The Solvent Extraction process would generate a liquid organic solvent also requiring final processing. The total 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 processing would be 13,000 gallons.

S.7.7 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 contain 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 buffer the continuous salt processes 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. In each case, the process buildings would be constructed of reinforced concrete and contain shielded cells designed to handle highly radioactive materials.

The building specifications would be similar for each of the four salt processing alternatives, albeit somewhat less for Direct Disposal in Grout. Preliminary design dimensions are provided in Table S-4.

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

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a. Building specifications rounded to two significant figures.

The floor plans and elevations for the salt processing facilities are shown in Chapter 2 of the Draft SEIS, 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.7.8 Z-AREA VAULTS

As many as 16 new 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. As with the original Z-Area vaults, the new vaults would be constructed at or somewhat below grade and covered over 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 new 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 during the cell-filling process for temperature control while the saltstone cures. Radiation monitors and dampers would be included. Because the other three alternatives would remove more radionuclides (including radioactive cesium) from the low-activity salt solution, forced air ventilation would not be required under those alternatives. 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.

S.7.9 FACILITY DECONTAMINATION AND DECOMMISSIONING

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

Design features that would be incorporated into the facility include the following:

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

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

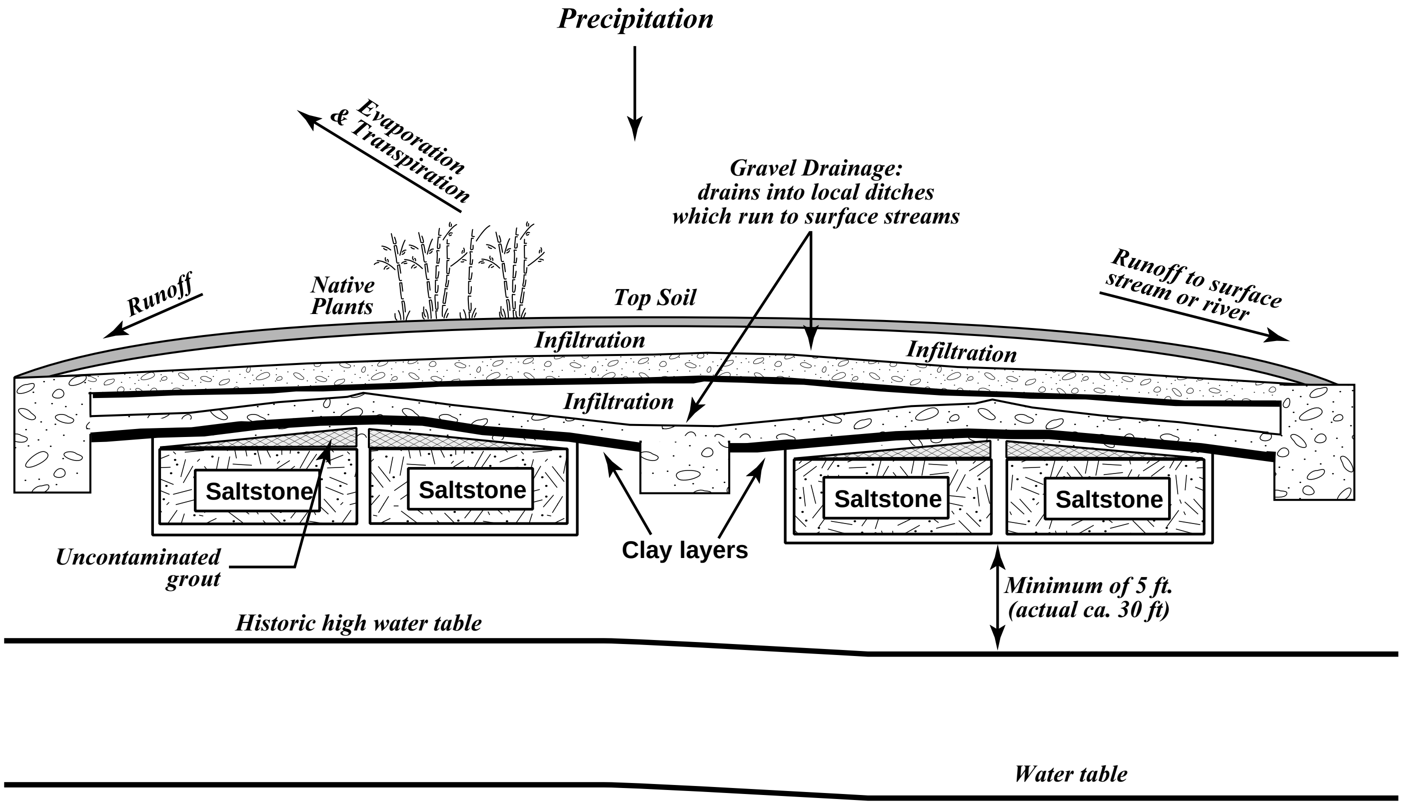
- The facility would be designed to facilitate dismantlement, removal, and packaging of contaminated equipment

- Lifting lugs would be used on equipment to facilitate remote removal from the process cell

- The piping systems that would carry hazardous products would be fully drainable.

S.8 Pilot Plant

If 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. The



Source: Martin Marietta, 1992.

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

Pilot Plant would serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address the remaining key technical uncertainties will be completed in April 2001, but the uncertainties cannot be fully addressed without the performance of pilot-scale tests using actual waste from the SRS HLW system. The Pilot Plant components would be sized to operate on a scale ranging from 1/100 to 1/10 of a full-sized facility.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the Late Wash Facility in H Area (see Figure S-1), near DWPF in S Area, or in another area similar to the location of the 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 design to facilitate remote installation and modification of the process equipment. Services that would be provided to support operations 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 Draft SEIS, DOE has defined the facility life cycle to be from the year 2001 through about 2023, when salt processing would be complete. This is the period used to estimate short-term impacts. For the No Action alternative, short-term impacts are considered for the two periods, Continuing Tank Space Management (until 2010) and Post Tank Space Management. DOE expects the long-term impacts to be those that could result 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 Draft 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 decisionmaker(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 Draft SEIS. These impacts would occur between the approximate years 2001 and 2023 for each of the action alternatives. Notable differences between the alternatives are shown in Table S-6. The analysis of impacts summarized here shows that, in general, the differences in impacts 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
- Environmental Justice
- 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 Draft 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 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 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; 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.

Table S-5. Summary comparison of short-term impacts.

	No Action[a]					
Parameter	Continue Tank Space Management	Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
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}	2.0×10^{-6}	5.6×10^{-7}
Offsite population dose (person-rem/yr.)	No Change[g]	Minimal[h]	12.0	2.9	18.1	4.0
Offsite population project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	0.078	0.019	0.12	0.026

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 Scenarios				
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}	2.5×10^{-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]	1.7×10^{-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}
Benzene - ceiling (OSHA Standard - 15.5 m^3)	No Change[g]	Minimal[h]	0.8	0.004	0.004	0.004

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 Scenarios				
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

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 Scenarios				
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

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a. Under the No Action alternative DOE would continue tank space management activities until approximately 2010, when the existing HLW tanks would reach capacity. Because the course of action that DOE would pursue after the initial period of tank space management has not been determined. For each resource evaluated, only those post tank 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 TPB 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 TPB 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 18 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.

ND = Not Determined.

Radiation Dose and Cancer Fatalities

Worker and public health impacts are expressed in terms of latent cancer fatalities. The primary health effect of radiation is an increased rate 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 the action would result in no additional cancer risks to the exposed population.

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.

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 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.

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
LCF per year		0.0018	6.9×10^{-4}	6.8×10^{-4}	2.1×10^{-4}

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				
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
LCF per year		6.8×10^{-5}	NA	NA	NA

Table S-6. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
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.

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 Draft SEIS discusses fractions of 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 based on the original saltstone that would have resulted from the ITP process.

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

In order to estimate the impacts of no action in the long term, DOE must assume that the HLW remains in the HLW storage tanks and no action is ever taken to ensure safe management. In this scenario, following loss of institutional control after 100 years, the HLW tanks would eventually fail and the contents would be released to the groundwater and eventually to surface water. DOE has not attempted to model this scenario because of the numerous uncertainties involved. Some indication of the potential for impacts may be gained, however, from a comparison with modeling results DOE prepared for the *High-Level Waste Tank Closure Draft Environmental Impact Statement* as described in the following paragraph.

Under the No Action alternative in the Tank Closure Draft EIS, DOE would remove most of the waste from the tanks and spray water wash the tanks, but would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves. Under this scenario, the tanks would eventually fail (after a period of perhaps several hundred years), creating physical hazards to humans and wildlife in the area and releasing the residual HLW to the groundwater at SRS. DOE estimated that residual waste in the F- and H-Area Tank Farms would contain about 200 curies of long half-life isotopes, technetium-99 and plutonium-239, and 9,900 curies of cesium-137, which has a relatively short half-life of 30 years. DOE modeled the eventual release of these contaminants to the groundwater at SRS. The modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime radiation dose of 430 millirem (primarily from groundwater), and incur an incremental risk of 2.2×10^{-4} of a fatal cancer. The greatest risk would occur within about 500 years of tank abandonment, but doses for residents would be greater than 100 millirem for over 1,000 years.

In contrast, if DOE were to take no action and leave the HLW in the tanks at SRS, approximately 450,000,000 curies (160,000,000 in salt component, and 290,000,000 in the sludge component assuming that about 10 percent of the curies in the sludge component have been vitrified in DWPF) would be available for release to the groundwater. While modeling would be required to calculate exposures and health effects over time, it is clear that the impacts to human health resulting from a No Action alternative would be catastrophic.

Certain resources would not experience long-term impacts: socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, utilities and energy, and accidents. Similarly, all impacts in areas other than public health are very similar between alternatives over the long term.

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 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 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.

Table S-7. Summary comparison of long-term impacts by salt processing alternative.

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Public Health				
Radiation dose from Agricultural Scenario (mrem/yr)	52-110	61-130	49-110	64-140
Latent Cancer Fatalities[a] from Agricultural Scenario	1.8×10^{-3} to 3.9×10^{-3}	2.1×10^{-3} to 4.6×10^{-3}	1.7×10^{-3} to 3.9×10^{-3}	2.2×10^{-3} to 4.9×10^{-3}
Radiation dose from Residential Scenario at 100 years post-closure (mrem/yr)	0.015-0.11	0.017-0.13	0.014-0.1	150-1200
Latent Cancer Fatalities[a] from Residential Scenario at 100 years post-closure	5.3×10^{-7} to 3.9×10^{-6}	6.0×10^{-7} to 4.6×10^{-6}	4.9×10^{-7} to 3.5×10^{-6}	5.3×10^{-3} to 4.2×10^{-2}
Radiation dose from Residential Scenario at 1,000 years post closure (mrem/yr)	9.2-69	11-80	8.6-65	11-85
Latent Cancer Fatalities[a] from Residential Scenario at 100 years post-closure	3.2×10^{-4} to 2.4×10^{-3}	3.9×10^{-4} to 2.8×10^{-3}	3.0×10^{-4} to 2.3×10^{-3}	3.9×10^{-4} to 3.0×10^{-3}

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a. Lifetime (70 year) to an individual.

Table S-8. Primer of Technical Terms (other scientific terms are defined in the glossary).[a]

Actinide

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

Benzene

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

Catalyst

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

Catalytic decomposition

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

Caustic

A substance capable of burning, corroding, dissolving, or eating away by chemical action.

Caustic Side Solvent Extraction

A process for separating radioactive cesium from alkaline (caustic) HLW solutions, by transfer to an immiscible organic phase, followed by recovery into a secondary aqueous stream.

Conceptual design

The conceptual design phase includes the fundamental decisions that are made regarding the desired chemistry or processing operations to be used, the sequencing of unit operations, the relationship of the process with other operations, and whether batch or continuous processing will be employed. Often, these decisions must be made preliminary to the collection of any engineering data regarding actual process yields, generation of reaction by-products, or the efficacy of any needed separation steps.

Crystalline

Being, relating to, or composed of crystal or crystals.

Crystalline silicotitanate

Insoluble granular inorganic solid ($Na_4SiO_4 \bullet TiO_2$) 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-potassium cancer concentrations.

Decomposition

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

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 will typically 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.

Table S-8. (Continued).

Hazardous waste
A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 40 CFR 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the U.S. Environmental Protection Agency (EPA) in 40 CFR 261.31 through 40 CFR 261.33. Source, special nuclear, or by-product materials as defined by the Atomic Energy Act are not hazardous waste because they are not solid waste under RCRA.

High-level radioactive waste (HLW)
Defined by statute (the Nuclear Waste Policy Act) 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 nuclides in sufficient concentrations; and other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule to require permanent isolation. The NRC has not defined “sufficient concentration” of fission products or identified “other highly radioactive material that requires permanent isolation.” The NRC defines HLW to mean irradiated (spent) reactor fuel, as well as liquid waste resulting from the operation of the first cycle solvent extraction system, the concentrated wastes from subsequent extraction cycles in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted.

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 medium (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.

Low-level radioactive waste (LLW)
LLW is radioactive waste that does not meet the definition of high-level, transuranic waste, spent nuclear fuel, or by-product tailings from processing of uranium or thorium. LLW contains typically 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.

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

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.

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

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.

Table S-8. (Continued).

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.

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 evaporation and concentration of the supernatant.

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

Sludge
Sludge components of HLW consist of the insoluble solids that have settled at the bottom of the HLW storage tanks. Radionuclides present in the sludge include fission products and long-lived actinides.

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 method for separating mixtures by exploiting differences in the solubilities of the components. For example, a coffee machine extracts the soluble components of ground coffee with water, and leaves the insoluble components behind. The sample is shaken or mixed with solvent (or with two immiscible solvents) to effect the separation. The “like dissolves like” is a useful guide for selecting solvents to use in the extraction. Nonpolar substances are usually successfully extracted into nonpolar solvents like hexane or methylene chloride. Polar and ionic substances are often extracted with water.

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

Tetraphenylborate Precipitation
Process used to separate cesium, potassium, and ammonium 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 or 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. Scientists have long considered this glassification process, called "vitrification," as the preferred option for immobilizing high-level radioactive liquids into a more stable, manageable form until a Federal repository is ready.

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a. See also *Glossary of Terms used in DOE NEPA Documents*.