APPENDIX A

TANK FARM DESCRIPTION AND CLOSURE PROCESS

TABLE OF CONTENTS

List of Figures

APPENDIX A. TANK FARM DESCRIPTION AND CLOSURE PROCESS

A.1 Introduction

Over the last 45 years, Savannah River Site (SRS) has produced special radioactive isotopes for various national programs. These isotopes were primarily produced in the Site's nuclear reactors, which generated neutrons that bombarded specifically designed targets. The neutrons bombarding the targets result in transmutation of the target atoms to produce the desired radioisotopes. The spent nuclear fuel and the targets were reprocessed to recover unused reactor fuel and the isotopes produced in the reactors. The reprocessing activity involved dissolving the fuel and targets in large, heavily shielded chemical separations facilities in the F and H Areas, known as the F-Canyon and H-Canyon, respectively. These facilities concentrated the valuable materials that the U.S. Department of Energy (DOE) wanted to recover, but produced large quantities of high-level waste (HLW). The HLW has been stored in the tank farms in F and H Areas.

DOE has recently reviewed its HLW management practices in two recent EISs: the *DWPF Supplemental EIS* (DOE 1994) and the *SRS Waste Management EIS* (DOE 1995). This *HLW Tank Closure EIS* is focused on closure of the tank farms after the HLW has been removed. Nevertheless, a discussion on how the tank farms fit into the overall SRS HLW management program is useful to understanding the nature of the residual waste in the tanks and the tanks' current use and history. Therefore, Section A.2 provides an overview of HLW management at SRS. Section A.3 describes the tank farm equipment and operations. Section A.4 describes the activities needed to close the tank farms under the various closure alternatives.

A.2 Overview of SRS HLW Management

The main processes involved in HLW management are generation, storage, evaporation, sludge processing, salt processing, vitrification, and saltstone manufacture and disposal. Figure A-1 shows the process flows among the processes.

Although the F- and H-Canyons are the only facilities at SRS that generate HLW in the regulatory sense, other facilities produce liquid radioactive waste that has characteristics similar to those of HLW. These facilities include the Receiving Basin for Offsite Fuel, the Savannah River Technology Center, the H-Area Maintenance Facility, and the reactor areas. Selected wastes from these facilities are managed at SRS as if they were HLW and are thus sent to the tank farms for storage and ultimate processing. Also, the Defense Waste Processing Facility (DWPF), which is the final treatment for SRS HLW, recycles wastewater back to the tank farms.

The tank farms receive the HLW, immediately isolating it from the environment, SRS workers, and the public. The tank farms provide a sufficiently long period of storage to allow many of the short-lived radionuclides to decay too much lower concentrations. After pH adjustment and introduction into the tanks, the HLW is allowed to settle, separating into a sludge layer at the bottom and a salt solution layer at the top, known as supernate. SRS uses evaporators to concentrate the supernate to produce a third form of HLW in the tank farms, known as crystallized saltcake. As a result of intertank transfers, some of the tanks are now primarily salt tanks, some are primarily sludge tanks, some tanks contain a mixture of salt and sludge, and some tanks are empty.

Before 1994, the Canyons generated two waste streams that were sent to the tank farms. High-radioactivity waste, which contained most of the radionuclides, was aged in a high-radioactivity waste tank before evaporation. Low-radioactivity waste, which contained lower concentrations of radionuclides, was sent directly to an evaporator. This historical practice is shown on Figure A-1. Under current

TC

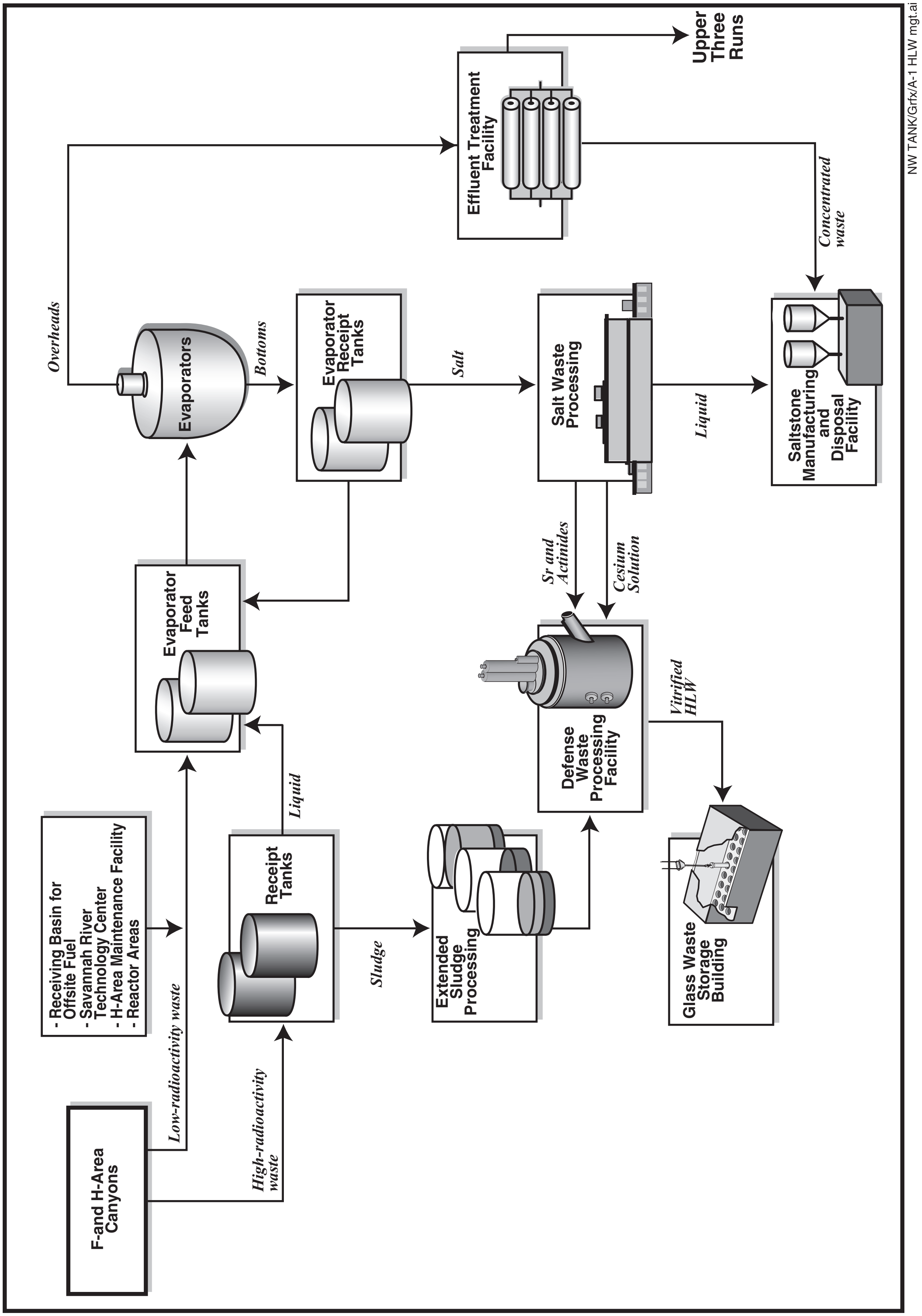


Figure A-1. Process flows for Savannah River Site high-level waste management system.

SRS operations, high-radioactivity waste is no longer generated because SRS reactors ceased operation in 1988. All incoming waste streams to the tank farms can be directed to the same receipt tanks and evaporator feed tanks.

SRS designed and built a facility using four H-Area Tank Farm tanks, known as the In-Tank Precipitation Facility, to process the saltcake and concentrated supernate. This salt processing facility was designed to receive redissolved saltcake and precipitate the chemical cesium that is responsible for the most prominent and penetrating radiation emitted from the waste. The cesium precipitate was designed to go DWPF for processing in the salt cell, with the aqueous cesium portion to be melted into a glass matrix and the organic portion sent to the Consolidated Incineration Facility. The remaining liquid salt solution was designed to go to the Saltstone Manufacturing and Disposal Facility for solidification and burial in underground vaults. DOE has concluded that the In-Tank Precipitation process, as currently configured, cannot achieve production goals and meet safety requirements. Therefore, in February 1999, DOE issued a Notice of Intent (64 FR 8558, February 22, 1999) to prepare a second Supplemental Environmental Impact Statement (SEIS), *High-Level Waste Salt Processing Alternatives at the Savannah River Site* (DOE/EIS-0082-S2). This SEIS analyzed the impacts of constructing and operating facilities for four alternative processing technologies. The *Final Salt Processing Alternatives SEIS* was issued in July 2001 (66 FR 37957, July 20, 2001) and the Record of Decision in October 2001 (66 FR 52752, October 17, 2001). DOE selected the Caustic Side Solvent Extraction Alternative for separation of radioactive cesium from SRS salt wastes.

The sludge in the tanks, which contains approximately 54 percent of the HLW radioactivity, is treated in a process known as Extended Sludge Processing. Extended Sludge Processing uses existing tanks in the H-Area Tank Farm. The process removes aluminum hydroxide and soluble salts from the sludge before transferring the sludge to the DWPF for vitrification. Aluminum affects the hardness of the glass and the overall volume of glass waste. The soluble salts interfere with the desired chemical composition of the glass. The wastewaters from Extended Sludge Processing and the DWPF are recycled back to the tank farm.

The DWPF receives washed sludge and salt precipitate, mixes it with appropriate additives, and melts it into a glass form in a process known as vitrification. The glass is poured into stainless steel canisters and stored in the Glass Waste Storage Building, a facility containing an underground vault for canister storage. Because the In-Tank Precipitation Facility has been inoperable, the DWPF has been vitrifying only sludge waste. The DWPF will continue sludge-only processing until the feed is available from the salt processing facility. In order to minimize the number of HLW canisters that are produced, SRS planning documents (WSRC 1998a) call for maintaining the sludge and salt precipitate feeds to the DWPF in an acceptable balance to avoid having any precipitate left over when all of the sludge inventory has been vitrified. The ultimate disposition of the HLW glass canisters is a geologic repository. The proposed construction, operation and monitoring, and closure of a geologic repository at the Yucca Mountain site in Nevada is the subject of a separate EIS. As part of that process, DOE issued a Draft EIS for a geologic repository at Yucca Mountain, Nevada, in August 1999 (64 Federal Register [FR] 156), and a Supplement to the Draft EIS in May 2001 (66 FR 22540). The Final EIS was approved and DOE announced the electronic and reading room availability in February 2002 (67 FR 9048). The President has recommended to the Congress that the Yucca Mountain Site is suitable as a geologic repository. If the Yucca Mountain site is licensed by the Nuclear Regulatory Commission (NRC) for development as a geologic repository, current schedules indicate that the repository could begin receiving waste as early as 2010.

The Saltstone Manufacturing and Disposal Facility receives the low-activity salt solution. The salt solution is mixed with cement, slag, and flyash to form a grout having chemical and physical properties designed to retard the leaching of contaminants over time. The grout is poured into disposal vaults and hardens into what is known as saltstone.

This is the Final Disposition of the Salt Solution. The Saltstone Manufacturing and Disposal Facility has received salt solution from the In-Tank Precipitation Process demonstration operations and concentrated wastes from the F/H-Area Effluent Treatment Facility and has been producing saltstone from these waste feeds. The Effluent Treatment Facility receives evaporator overheads from the Separations Areas and tank farms evaporators and treats the water for discharge to Upper Three Runs.

A.3 Description of the Tank Farms

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks, evaporator systems, transfer pipelines, diversion boxes, and pump pits. Figure A-2 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site that contains 29 active waste tanks, evaporator systems (including the new Replacement High-level Waste Evaporator), the Extended Sludge Processing Facility, transfer pipelines, diversion boxes, and pump pits. Figure A-3 shows the general layout of the H-Area Tank Farm.

A.3.1 TANKS

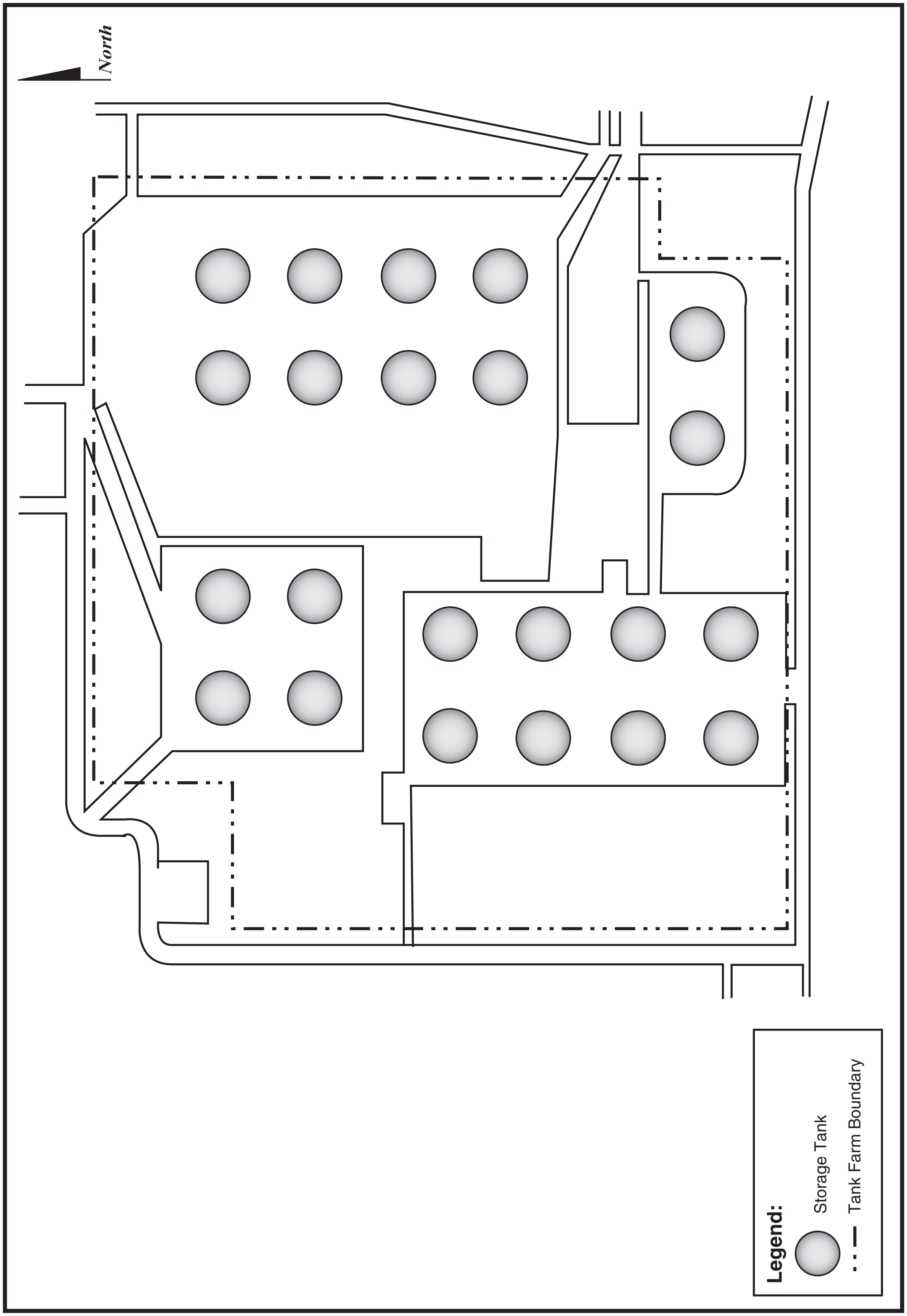
The F- and H-Area tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. Two designs (Types I and II) have secondary annulus "pans" and active cooling (Figure A-4).

The 12 Type I tanks (Tanks 1 through 12) were built in 1952 and 1953; seven of these (Tanks 1, 5, 6, and 9 through 12) have known leak sites in which waste leaked from the primary containment to the secondary containment. The leaked waste is kept dry by air circulation and, based upon groundwater monitoring results, there is no evidence that the waste has leaked from the secondary containment. The level of waste in these tanks has been lowered to below these leak sites. In 1961, the fill line to Tank 8 leaked approximately 1,500 gallons to the soil and potentially to the groundwater. The tank tops are below grade and the bottoms of Tanks 1 through 8 are situated above the seasonal high water table. The bottoms of Tanks 9 through 12 are in the water table.

The four Type II tanks (Tanks 13 through 16) were built in 1956. All four have known leak sites, in which waste leaked from primary to secondary containment. In 1983, about 100 gallons of waste spilled onto the surface of Tank 13 through a cracked flush water line attached to an evaporator feed pump. No spilled waste reached the subsurface. The spill was cleaned up and the contaminated material returned to the waste tank or disposed (Boore et al., 1986). The contamination remaining is negligible and would affect neither tank closure nor future cleanup of the tank farm areas. In Tank 16, in 1962 the waste overflowed the annulus pan (secondary containment) and a few tens of gallons of waste migrated into the surrounding soil, presumably through a construction joint in the concrete encasement. Waste removal from the Tank 16 primary vessel was completed in 1980. DOE removed some waste from the annulus at that time, but some dry waste still remains in the annulus. These tanks are above the seasonal high water table.

The eight Type IV tanks (Tanks 17 through 24) were built between 1958 and 1962. These tanks have a single steel wall and do not have active cooling (Figure A-4). Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank walls. Small amounts of groundwater have leaked into these tanks (WSRC 2000); there is no evidence that waste ever leaked out. The level of the waste in Tank 19, which is the next tank scheduled to be closed, is below these cracks. Tanks 17 through 20 are slightly above the water table. Tanks 21 through 24 are above the groundwater table; however, they are in a perched water table caused by the original basemat under the tank area. Tanks 17 and 20 have already been closed in a manner described in DOE's Preferred Alternative.

TC



NW TANK/Grfx/A-2 F_Tank.ai

Figure A-2. General layout of F-Area Tank Farm.

TC

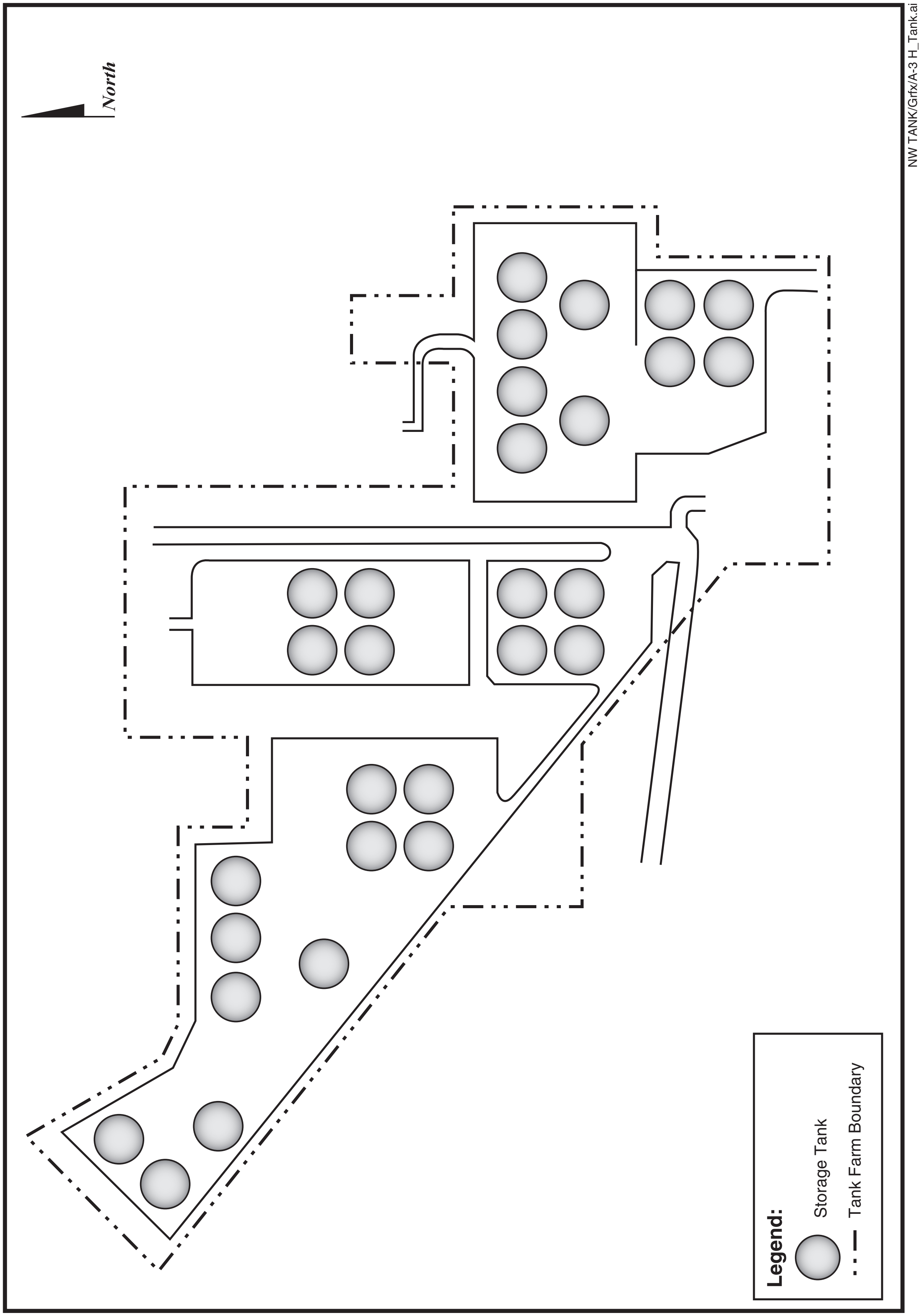


Figure A-3. General layout of H-Area Tank Farm.

TC

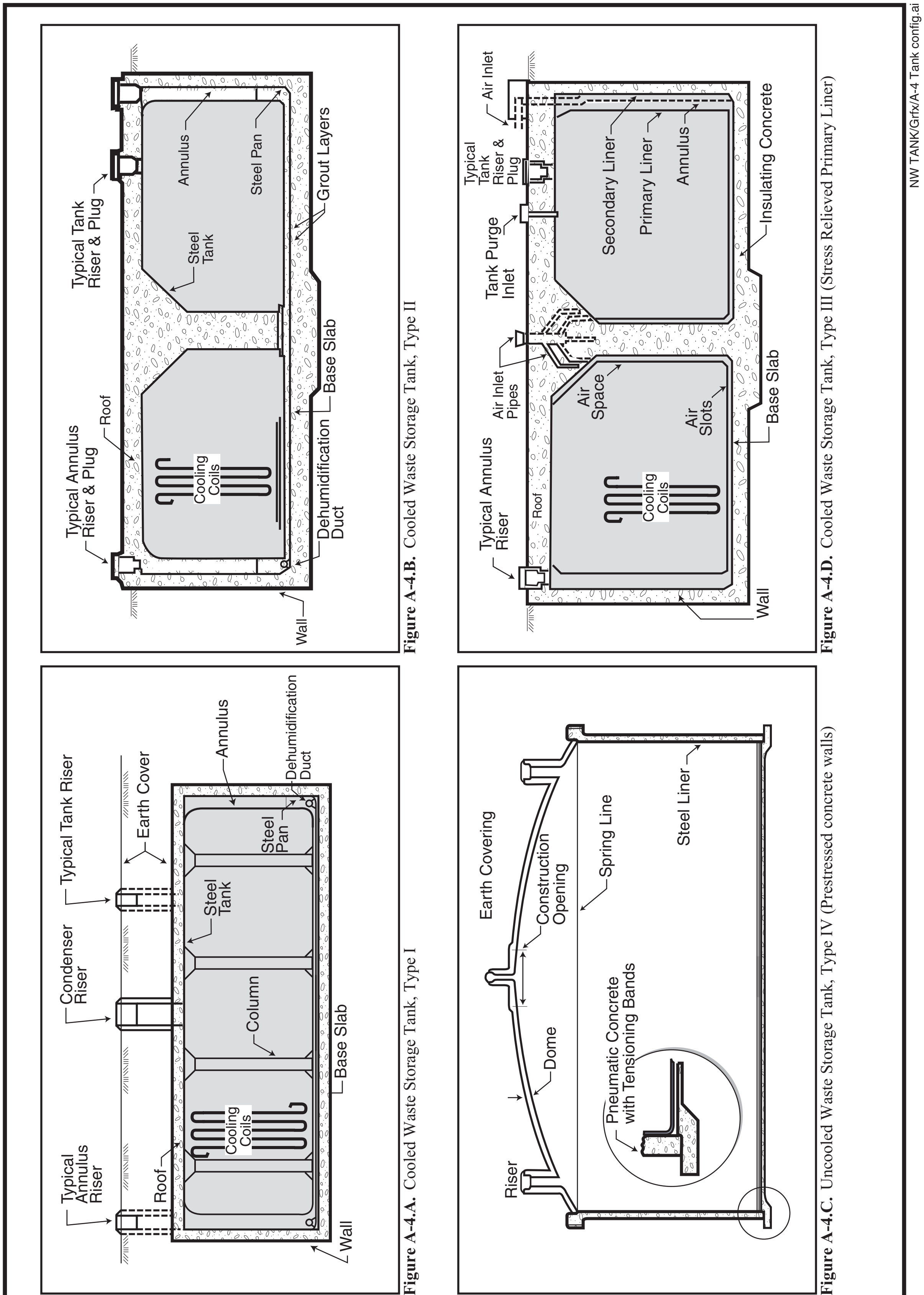


Figure A-4.A. Cooled Waste Storage Tank, Type I

Figure A-4.B. Cooled Waste Storage Tank, Type II

Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls)

Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner)

Figure A-4. Tank configurations.

The newest design (Type III) has a full-height secondary tank and active cooling (Figure A-4). All of the Type III tanks (25 through 51) are above the water table. These tanks were placed in service between 1969 and 1986 and none of them has known leak sites. In 1989, a Tank 37 transfer line leaked about 500 pounds of concentrated waste to the environment.

By 2022, DOE is required to remove from service and close all the remaining tank systems that have experienced leaks or do not have full-height secondary containment (WSRC 1998a). The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for the tanks. Areas of contamination in the tank farms have been identified, based on groundwater monitoring past incident reports and contamination surveys. The areas of significant contamination have been identified in the SRS Federal Facility Agreement and have been designated as Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (RCRA/CERCLA) units or Site Evaluation Units. Controls are in place to ensure that any activities performed around these areas are conducted in a manner protective of human health and the environment, and in a way that minimizes the impact on future investigation, removal, and remedial action (WSRC 1996).

A total of 17 RCRA/CERCLA units or Site Evaluation Units have been identified in the tank farms. In 14 of the 17 areas, contamination is the result of past spills on the surface, and the contamination is on or near the surface (EPA 1993). The amount of contamination in these 14 sites appears to be small and will probably not add significantly to the dose reported in this EIS for tank closure, for the following reasons:

1. The sizes of these spills are small, compared to the residual tank contents.

2. The contamination is outside the tanks and would thus transport through the soil and groundwater much more rapidly than those contaminants bound inside the tanks. This would cause their impacts to be noncoincident in time with those from tank closure.

3. Contamination outside the tanks would be addressed in the CERCLA closure of the tank farm areas. Tank closure and CERCLA closure are being coordinated so that cumulative impacts are within limits established with SRS regulators through the risk-based closure process. Therefore, if any spill appears to produce a large contribution, it would be remediated until it produces a small contribution.

In 2 of the 17 areas, the contamination came from pipelines located below grade that leaked directly into the ground. The first area was a leak from the secondary containment of a pipeline near Tank 8, which happened in 1961. The leak resulted from an inadvertent overfill of Tank 8. The volume leaked to the soil was estimated to be 1,500 gallons (Odum 1976). The second area was a leak from a Concentrate Transfer System near the Tank 37 line, which was discovered in 1989 (the actual date of the leak is not known). The volume of this leak was estimated to be a few gallons (d'Entremont 1989).

The last area, the Tank 16 RCRA/CERCLA unit, is the only instance at SRS where waste is known to have leaked to the soil from a HLW tank. In September 1960, leaks from the Tank 16 primary tank caused the level in the annulus pan (the tank secondary containment) to exceed the top of the pan. The waste was still contained in the concrete encasement that surrounds the tank, but surveys indicated that some waste leaked into the soil, presumably through a construction joint on the side of the encasement that is located near the top of the annulus pan. Based on soil borings around the tank, it is estimated that some tens of gallons of waste leaked into the soil (Poe 1974). Assuming that the waste did leak from the construction joint, the leaked waste is in the vicinity of the seasonal water table and is at times below the water table.

Because all tanks at SRS have leak detection, it is unlikely that any large leaks have occurred that have not been detected. In eight tanks other than Tank 16, observable amounts of waste have leaked from primary containment into secondary containment. These tanks are managed to ensure that the leaked waste remains dry and L-7-66 immobile. The waste in the annuli of these L-7-67 tanks has been observed carefully over a period of years and minimal movement of the waste has been observed. Other than Tank 16, there is no evidence that waste has leaked from a tank into the soil.

A.3.2 EVAPORATOR SYSTEMS

The tank farms had five evaporators that L-7-25 concentrated waste following receipt from the L-7-68 Canyons. At present, three evaporators are operational, one in F-Area Tank Farm and two in H-Area Tank Farm. Each operational evaporator is made of stainless steel with a hastelloy tube bundle, and operates at near-atmospheric pressure under alkaline conditions. Because of the radioactivity emitted from the waste, the evaporator systems are either shielded (i.e., lead, steel, or concrete vaults) or placed underground. The process equipment is designed to be remotely operated and maintained.

Waste supernate is transferred from the evaporator feed tanks and heated to the aqueous boiling point in the evaporator vessel. The evaporated liquids (overheads) are condensed and, if required, processed through an ion-exchange column for cesium removal. The overheads are transferred to the F/H Effluent Treatment Facility for final treatment before being discharged to Upper Three Runs. The overheads can be recycled back to a waste tank, if evaporator process upsets occur. Supernate can be reduced to about 25 percent of its original volume by successive evaporations of liquid L-7-71 supernate. This concentrated waste crystallizes into a solid saltcake, which reduces its mobility.

A.3.3 TRANSFER SYSTEM

A network of transfer lines is used to transfer wastes between the waste tanks, process units, and various SRS areas (i.e., F Area, H Area, S Area, and Z Area). These transfer lines have diversion boxes that contain removable pipe segments (called jumpers) to complete the desired transfer route. Jumpers of various sizes and shapes can be fabricated and installed to enable the transfer route to be changed. The use of diversion boxes and jumpers allows flexibility in the movement of wastes. The diversion boxes are usually underground, constructed of reinforced concrete, and either sealed with waterproofing compounds or lined with stainless steel.

Pump pits are intermediate pump stations in the F- and H-Area Tank Farm transfer systems. These pits contain pump tanks and hydraulic pumps or jet pumps. Many pump pits are associated with diversion boxes. The pits are constructed of reinforced concrete and have a stainless-steel liner.

A.3.4 SALT PROCESSING

DOE has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8558, February 22, 1999). TC

Therefore, in February 1999, DOE issued a Notice of Intent (64 FR 8558, February 22, 1999) to prepare a second SEIS*, High-Level Waste Salt Processing Alternatives at the Savannah River Site* (DOE/EIS-0082-S2). This SEIS analyzed the impacts of constructing and operating facilities for four alternative processing technologies. The *Final Salt Processing Alternatives SEIS* was issued in July 2001 (66 FR 37957, July 20, 2001) and the Record of Decision in October 2001 (66 FR 52752, October 17, 2001). DOE selected the EC Caustic Side Solvent Extraction Alternative for separation of radioactive cesium from SRS salt wastes.

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

A.3.5 SLUDGE WASHING SYSTEM

The waste streams generated by the F- and H-Area Canyons form insoluble and highly radioactive metal hydroxides (manganese, iron, and aluminum) that settle to the bottom of the waste tanks to form a sludge layer. In addition to the fresh waste aging, the accumulated sludge is aged to allow radioactive decay. The aged sludge is transferred to the sludge processing tanks for washing and, if necessary, aluminum dissolution with a sodium hydroxide solution. The sludge processing takes place in two Type III tanks in H Area. The washed sludge slurry is transferred to the DWPF for vitrification into a solid glass matrix that is easier to handle and much more suitable for disposal.

A.4 Tank Farm Closure Activities

A.4.1 WASTE REMOVAL

In the Federal Facility Agreement between DOE, the U.S. Environmental Protection Agency (EPA), and the State of South Carolina, DOE committed to removing wastes from older tanks that do not meet secondary containment requirements (Types I, II, and IV). DOE has reviewed bulk waste removal from the HLW tanks in the *Waste Management Operations, Savannah River Plant EIS* and the *Long-term Management for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS* (ERDA 1537). In addition, the *SRS Waste Management EIS* (DOE/EIS-0023) discusses HLW management activities as part of the No Action Alternative (continuing the present course of action), and the *Defense Waste Processing Facility Savannah River Plant EIS* (DOE/EIS-0082) and the *Final Supplemental Environmental Impact Statement Defense Waste Processing Facility* (DOE/EIS-0082S) discuss management of HLW after it is removed from the tanks. As described in this EIS, however, tank closure activities would comply with the proposed plan and schedule provided under the Agreement. Also, even under the No Action Alternative, DOE would continue to remove waste from the tanks as their missions cease. All tanks would be empty by 2028.

The schedule for removing waste from the tanks is closely linked to salt and sludge processing capacity and the DWPF schedule. The priorities for determining the sequence of waste removal from the tanks are as follows:

1. Maintain emergency tank space in accordance with safety analyses
2. Control tank chemistry, including radionuclides and fissile material inventory
3. Enable continued operation of the evaporators
4. Ensure blending of processed waste to meet salt processing, sludge processing, defense waste processing, and saltstone feed criteria
5. Remove waste from tanks with leakage history
6. Remove waste from tanks that do not meet the Federal Facility Agreement requirements
7. Provide continuous radioactive waste feed to the DWPF

8. Maintain an acceptable precipitate balance with the salt processing facility

9. Support the startup and continued operation of the Replacement High-Level Waste Evaporator

10. Remove waste from the remaining tanks.

The general technique for waste removal is hydraulic slurrying. First, slurry pump support structures are installed above the tank top, along with electrical service and motor controls. Then, slurry pumps are installed in the risers of the tank, usually three for salt removal and four for sludge removal. For the salt tanks, the pump discharges are positioned just above the level of the saltcake. Water is added to the tanks and the pumps turned on to agitate and dissolve a layer of salt. When the water becomes saturated with salt, the solution is pumped out. For sludge tanks, the pumps are placed into the top layer of sludge. As with salt removal, water is added and the pumps turned on to agitate the sludge. When the sludge is well mixed, the slurry is pumped out. For both salt and sludge, the pumps are then lowered to continue the process. Pumps may be lowered one or more times before a salt or sludge transfer is made. DOE is also exploring other methods for more efficient waste removal.

A.4.2 DETERMINATION AND USE OF PERFORMANCE OBJECTIVES

DOE has identified pertinent substantive requirements with which it will comply and guidance it will consider (Chapter 7) to ensure that closure of the tank systems will be protective of human health and the environment. DOE will use these requirements and guidance to develop an overall closure performance objective that provide a basis for comparison of different closure configurations. The performance objective applies to the completed closure of all 51 tank systems; however, DOE must close the tanks one at a time over a period of decades. (DOE anticipated that the need for HLW tanks will cease some time before 2030. The tanks would be closed as their individual missions end.) Therefore, the Department evaluates the impacts of each tank closure in the context of the entire tank farm. This methodology ensures that, as tanks are closed, the total closure impacts do not exceed the overall performance objective.

TC
TC
TC

To further ensure that closure of the tank system will be protective of human health and the environment, DOE also evaluates contamination from non-tank-farm-related sources. Studies of groundwater transport (DOE 1996) in the General Separations Area indicate that contaminant plumes from F and H Area tanks would not intersect. Therefore, DOE has established independent Groundwater Transport Segments for the two tank farms that represent the contaminant plumes from the tank farms. DOE requires that contributions from all contaminant sources within a Groundwater Transport Segment, both tank-farm-related and non-tank-farm-related, be considered in comparing modeled impacts to the performance objectives. EC

A.4.3 TANK CLEANING

If needed, DOE's first method for tank cleaning is spray water washing. In this process, heated water would be sprayed throughout a tank, using spray jets installed in the tank risers. After spraying, the contents of the tank would be agitated with slurry pumps and pumped to another HLW tank still in service.

EC
EC
EC

After the spray washing, remotely operated video cameras are used to survey the interior of the tank to identify areas needing further cleaning. Based on experience with two tanks that have been spray-washed, DOE has learned that some sludge tends to remain on the bottom of the tank and that the sludge tends to be distributed around the edge of the tank bottom after the single water wash performed as the last phase of waste removal.

To determine the characteristics of the residual material that would remain in the closed HLW tanks, DOE obtained and analyzed sludge samples from waste tanks containing each of the major waste streams that have gone to the tank farms. These samples were washed in the

L-1-5

laboratory, approximating what might remain after waste removal, and the concentrations of various components in the washed sludge were measured. DOE used the results of these samples in developing the process knowledge L-1-5 database that was used for the modeling described in Appendix C. Samples of the actual residuals that would remain in each tank after waste removal would be collected and analyzed after the completion of waste removal in that tank.

Eleven HLW tanks at SRS have shown evidence of cracks in the primary tank shell. In two of the tanks, the cracks are above the current liquid level and there is no evidence that waste escaped primary containment. In the remaining nine tanks, leaked salt has been observed on the exterior of the primary tank shell. The cracks in these tanks are hairline cracks and the annuli in these tanks are ventilated to dry the waste. The waste seeped through the cracks slowly and dried in the annulus. This waste appears as dried salt deposits on the side of the primary tank and sometimes on the floor of the secondary tank (WSRC 2000). DOE has developed methods to clean the annulus, using recirculating water jets installed through annulus risers. The water is heated and circulated through the annulus into the primary tank.

In five of the tanks (Tanks 1, 11, 12, 13, and 15), photographic inspections indicate that the amount of leaked waste is small. The waste is limited to salt deposits on the walls of the tank or perhaps covering part of the floor of the annulus. The leaked waste is virtually all salt because sludge is relatively immobile and will not migrate significantly through hairline cracks. The small amount of salt in these annuli should be relatively easy to remove with water.

In the remaining four tanks (Tanks 9, 10, 14, and 16), enough waste has leaked to completely cover the floor of the annulus. The annuli of EC these four tanks will be the most difficult of all the tanks to clean. Because of the large amount of waste that leaked in these four tanks, some waste may have leaked underneath the primary tanks. Also, waste has entered the ventilation ducts in the annuli. Special waste removal techniques will need to be developed for these tanks to ensure that water penetrates to the locations of the waste.

In three of the four tanks (Tanks 9, 10, and 14), the waste in the annulus is primarily salt, so it should be relatively easy to remove once it is dissolved. The difficulty is primarily getting the water to where it is needed and then removing the salt solution. Since the problem is limited to a few tanks, plans are to develop these techniques when needed. The techniques may differ between tanks (for example, a different annulus cleaning technique would be needed if waste has seeped underneath the primary tank).

Tank 16 is the most badly cracked tank and represents a special case for annulus cleaning. In this tank, a number of welds were sandblasted to understand the stress corrosion cracking phenomena. The sand fell on top of the salt and then mixed with the salt during a waste removal effort in 1978 that removed about 70 percent of the salt. Recent samples have shown that the sand and compounds that formed when the sand mixed with the salt make it more difficult to dissolve the waste in this annulus. Chemical cleaning (such as oxalic acid) may be needed to dissolve the waste in the Tank 16 annulus. Because this will be a one-time operation, plans EC are to develop the cleaning techniques when needed.

It is possible that some tanks may prove to be more difficult to clean than others. To meet performance criteria for tank closure, DOE may need to perform more rigorous cleaning than spray water washing. The method DOE expects to use is oxalic acid cleaning. In this process, hot oxalic acid is sprayed through the nozzles that were used for spray washing. Oxalic acid was selected above other cleaning agents for the following reasons (Bradley and Hill 1977):

- Oxalic acid dissolves portions of the sludge and causes the particles to break down, allowing removal of sludge deposits that are difficult to mobilize using spray washing alone.

- Oxalic acid is only moderately aggressive against carbon steel. Corrosion rates are on the order of 0.001 inch per week. This rate is acceptable for a short-term process such as cleaning. More aggressive agents such as nitric acid would be more effective in tank cleaning, but they could potentially cause release of contaminants to the environment in a mobile form.

- Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is much more effective than spray water washing for removal of radioactivity. However, at the present time, potential safety considerations restrict the use of oxalic acid in the HLW tanks. The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998b) specifically states that oxalic acid cleaning of any waste tank is prohibited. A Nuclear Criticality Safety Evaluation would be necessary to address oxalic acid use, because oxalic acid would reduce the pH of the cleaning solution to the point where a quantity of fissile materials greater than currently anticipated would go into solution. This could create the potential for a nuclear criticality. In addition, an Unreviewed Safety Question evaluation and subsequent SAR revision would be necessary.

Between 1978 to 1980, Tank 16 was the subject of a rigorous waste removal, water washing, and oxalic acid cleaning demonstration. More than 99.9 percent of the original volume of sludge was removed during cleaning (approximately 10 kilograms of solid material was left). Based upon sample results, approximately 830 curies of strontium-90 (the predominant radionuclide) remained. The demonstration determined the increased effectiveness of oxalic acid cleaning. However, the process generates large quantities of sodium oxalate that must be disposed in the Saltstone Manufacturing and Disposal Facility. After oxalic acid cleaning is complete, the tank would be spray washed with inhibited water to neutralize the remaining acid.

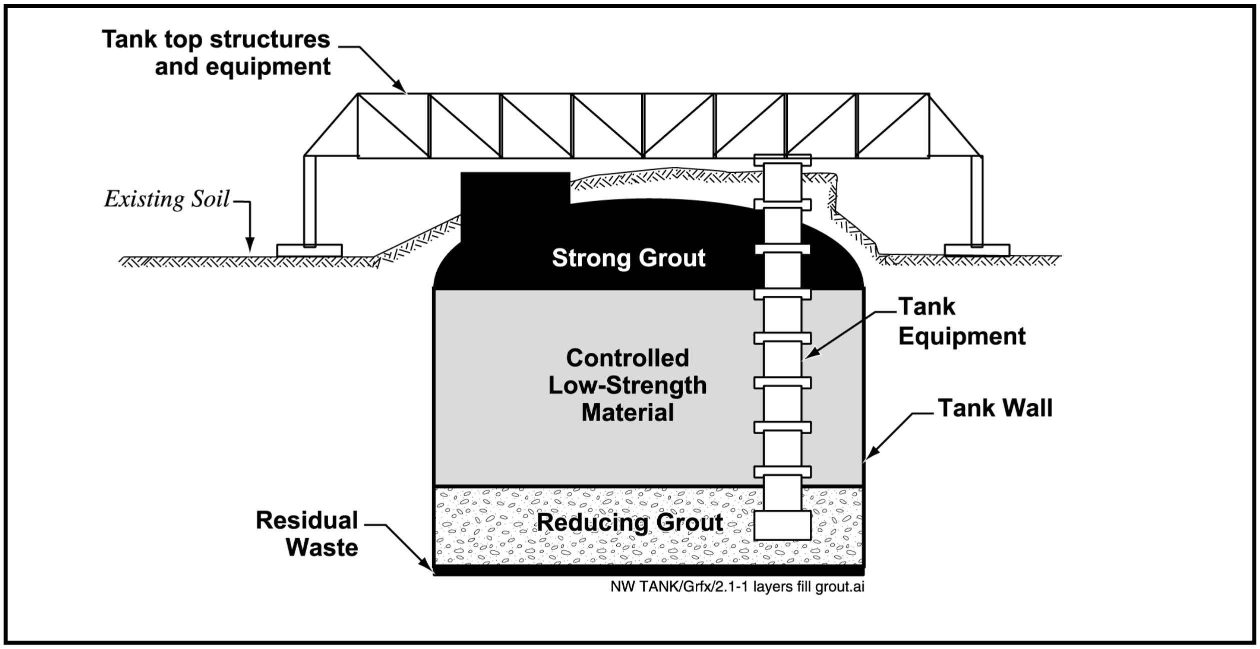
A.4.4 STABILIZATION

DOE has identified three options for tank stabilization under the Stabilize Tanks Alternative described in Chapter 2: grout fill, sand fill, and saltstone fill. In addition, another alternative would not stabilize the tank, but would remove the interior liner (which has been in contact with the HLW) from the concrete vault for disposal in some other location. The sections below describe the activities associated with the action alternatives.

<u>Grout Fill</u>

Each tank and its associated piping and ancillary equipment would be filled with a pumpable, self-leveling grout (a concrete-like material). The material would have a high pH to be compatible with the carbon steel of the tank. The fill material would also be formulated with chemical properties that would retard the movement of radionuclides and chemical constituents from the closed tank. A combination of different types of grout would be used. They would be mixed at a nearby batch plant constructed for the purpose and pumped to the tank. Figure A-5 shows how the sandwich layers of grout would be poured. DOE could also use an all-in-one grout, if it provided the same performance and protection. The potential combination of layers of grout is as follows:

- Reducing grout is a pumpable, self-leveling backfill material (similar in composition to that used at the SRS Saltstone Manufacturing and Disposal Facility), composed primarily of cement, flyash, and blast furnace slag. The chemical properties of the liquid that leaches through this backfill material will reduce the mobility of selected radionuclides and chemical constituents. The formulation of the backfill material for each waste tank will be adjusted, based on specific circumstances for each tank. The material is pumped into the waste tank through an available opening (e.g., tank riser). Observations of Tank 20



EC **Figure A-5.** Typical layers of the Fill with Grout Option.

during pouring of the reducing grout indicate that the grout lifts some of the sludge on the bottom of the tank and carries it like a wave until it eventually envelops the sludge in the grout. Nevertheless, DOE's use of the reducing grout is not dependent on fully enveloping the sludge, but upon the grout's ability to chemically alter any water leaching through the grout to the sludge.

EC

- Controlled Low-Strength Material (CLSM) is a self-leveling concrete composed of sand and cement formers. Similar to reducing grout, it is pumped into the tank. The compressive strength of the material is controlled by the amount of cement in the mixture. The advantages of using CLSM rather than ordinary concrete or grout for most of the fill are:

  – The compressive strength of the material can be controlled so it will provide adequate strength for the overlying strata and yet could potentially be excavated with conventional excavation equipment. Although excavation of the tank is not anticipated, filling the tank with low-strength material would enhance the opportunity for future removal of tank contaminants or perhaps the tank itself, if future generations were to decide that excavation is desirable.

  EC

  – CLSM has a low heat of hydration, which allows large or continuous pours. The heat of hydration in ordinary grout limits the rate at which the material can be placed because the high temperatures generated by thick pours prevent proper curing of the grout. Thus, large pours of grout are usually made in layers, allowing the grout from each layer to cool before the next layer is poured.

  – CLSM is relatively inexpensive.

  – CLSM is widely used at SRS, so there is considerable experience with its formulation and placement and in controlling the composition to provide the required properties.

- Strong grout is a runny grout with compressive strengths in the normal concrete range. This formulation is advantageous near the top of the tank because:

- The runny consistency of the grout is advantageous for filling voids near the top of the tank created around risers and tank equipment. The grout would be injected in such a manner to ensure that voids were filled to the extent practicable. This may involve several injection points, each with a vent.

- A relatively strong grout will discourage an intruder from accidentally accessing the waste, if institutional control of the area is discontinued.

Other potential combinations of multiple or single grout layers may be used.

The specific actions needed before and during closure include tank isolation, tank modifications to facilitate introduction of grout, production and installation of grout, and riser cleanup. These activities are described below in more detail.

Mechanical and electrical services would be isolated from the tank such that future use is prohibited. Tank isolation is an activity that must be performed regardless of the closure option. Accessible piping and conduits would be removed and pulled back from each riser so that a physical break is made from the tank. Any transfer lines would be cut and capped.

DOE would leave the tank structures intact. No support steel would be removed unless it is necessary to be removed to disconnect services from the tank risers. Equipment already installed in the tank and equipment directly used in tank closure operations (such as temporary submersible pumps, cables, temporary transfer hoses, backfill transfer pipes or tremmies, and sample pump) would be entombed in the backfill material as part of the closure process. Items removed in preparation for closure under this module (such as slurry pump motors, instrument racks, piping, and insulation) may be decontaminated to such levels that they may be sent to the Solid Waste Management Facilities as scrap. Otherwise, they would be appropriately characterized and shipped as low-level waste.

The tank risers would be modified to permit backfill material to be placed into the tank. Provisions would be made to provide a delivery point into the tank, to manage air displacement, to address bleed water build-up, and to handle any tank top overflow.

Risers would be prepared to allow addition of the backfill material. Equipment located at the riser would be disconnected. A backfill transfer line would be inserted through an access port to allow introduction of the backfill into the tank. Tank venting would be predominantly through the existing permanently installed ventilation system until the backfill material nears the top of the tank. However, a newly constructed vent device, equipped with a breather high-efficiency particulate filter, would be supplied for the final filling operation.

During the filling process, excess water (bleed water) is expected to float to the top of the grout and CLSM. The amount of bleed water would be minimized during the actual closure operation by limiting the amount of water in the grout and CLSM and by specifying the fill material cure times. It is expected that any bleed water produced would be re-absorbed back into the fill material. The amount of re-absorption would be dictated by the cure times. Any bleed water not absorbed would be removed from the tank and (1) returned to the tank farm systems by siphoning it off and transferring it through a temporary aboveground transfer line to another waste tank or (2) processed at the Effluent Treatment Facility. The possible overflow of bleed water and grout from around the riser joints would be controlled by constructing forms around the risers and sealing those forms for watertightness as part of pre-closure preparation for riser grouting operations. Each riser would be prepared for local filling and venting to ensure that the top void spaces are filled.

EC

Portable concrete batch plants would supply the grout and CLSM backfill needed to fill the tanks. The plants may require a South Carolina Department of Health and Environmental Control (SCDHEC) Bureau of Air Quality permit to operate. All process water would be recycled.

EC

Backfill material produced at the plants would be introduced into the risers of the tanks through piping from the plants located just outside the tank farm fences.

The actual backfill material installation would be governed by SRS procedures in accordance with Design Engineering requirements, as outlined in the construction and subcontractor work packages. The filling progress would be monitored by an in-tank video camera. The backfill material level would be measured, using visual indications. During riser closure operations, containment provisions would be made to restrict or contain grout overflows. Tank components such as the transfer pump, slurry pumps, wiring, cables, steel tapes, hoses, and sample collection apparatus would be encapsulated during tank grouting operations.

The risers and void spaces in the installed equipment remaining in the tank would be filled with highly flowable reducing grout material to ensure that all voids are filled to the fullest extent possible. The tank fill and riser backfilling operations would be performed in such a way as to eliminate rainwater intrusion into the tank. Upon completion of the tank closure, the riser tops would be left in a clean and orderly condition. Risers would be encapsulated in concrete, using forms constructed of rolled steel plates or removable wooden forms previously installed around each riser. The riser encapsulation would be completed at the end of the tank dome fill operation.

Piping and conduit at each riser that is not removed would be entombed in the riser filling operations. Each riser and the lead lining would be encased in concrete, and decontamination of the remaining riser formwork structures and adjacent areas will be performed, if necessary. The tank appurtenances, such as the riser inspection port plugs, riser plug caps, and the transfer valve box covers, which would have been removed to ensure complete backfilling of the tank, would be entombed at the same time that the associated risers are filled and backfilled.

<u>Sand Fill</u>

This option is similar to the Fill with Grout Option, except that sand would be used instead of grout. There would be no layers for intruder protection or chemical conditioning of leaching water. The sand would be carried by truck to an area near each tank farm and conveyed to the tank.

Sand is readily available and is inexpensive. However, its emplacement is more difficult than grout as it does not flow readily into voids. Over time, sand would settle in the tank, creating additional void spaces. The tank top would then become unsupported and would sag and crack, although there would not be the catastrophic collapse that would be anticipated in the No Action case. Also, the sand would tend to protect the contamination to some extent and prevent winds from spreading the contaminants. However, sand is highly porous and rainwater infiltrates rapidly and does not run off. Also, sand is relatively inert and could not be formulated to retard the migration of radionuclides and chemical constituents. Thus, the expected contamination levels in groundwater would be higher than for the Fill with Grout Option.

A variation of this alternative could involve filling the tanks with contaminated soils excavated during the remediation of SRS waste sites. Placement of soils in the tanks would present similar disadvantages to those described above for sand fill. In addition, handling contaminated soils would complicate the project, resulting in increased costs. Soils could not be readily formulated to retard the migration of radionuclides and chemical constituents; the additional contamination associated with the soil fill would have to be factored into the performance evaluation for the closure configuration. Because of these disadvantages, the use of contaminated soils as a fill material is not evaluated further in this EIS.

<u>Saltstone Fill</u>

This option is the same as the Fill with Grout Option, except that saltstone would replace the reducing grout and the CLSM. Saltstone is a low-radioactivity fraction that meets the waste Incidental to Reprocessing requirements and is mixed with cement, flyash, and slag to form a concrete-like mixture. This option has the advantage of reducing the amount of disposal space needed at the Saltstone Manufacturing and Disposal Facility; however, it has several disadvantages:

TC

- Because of the fast saltstone set-up times, two new saltstone mixing facilities (one in F Area and one in H Area) would be required.
- The amount of saltstone to be made is projected to be greater than 160 million gallons. This volume is considerably greater than the capacity of the HLW tanks. Therefore, the existing Saltstone Manufacturing and Disposal Facility in Z Area would still need to be operated.
- Filling the tank with a grout mixture that is contaminated would considerably complicate the project and increase worker radiation exposure, further adding to expense and risk.
- Saltstone grout cannot be poured as fast as CLSM because of its relatively high heat of hydration. Saltstone grout would have to be poured in discrete pours, allowing sufficient time between pours for the grout to cool.

Clean and Remove Tanks

EC

This alternative involves cleaning of the tanks beyond that described in Section A.4.3. Such cleaning could include mechanical cleaning or other steps not yet defined. The steel components (including any piping and ancillary equipment) would be sectioned, removed, placed in burial boxes for disposal, and transported to SRS low-level waste disposal facilities.

For tank removal operations, DOE would enclose the tops of the tanks with structures designed to contain airborne contamination. These structures would be fitted with air locks and operate at negative pressure during cutting operations. Air discharges from the tanks and enclosures would be filtered with high-efficiency particulate air filters. DOE would backfill the void created by tank removal with a soil type similar to soils currently surrounding the tank.

The advantages of this option are:

- This alternative has the advantage of allowing disposal of the contaminated tank system in a waste management facility that is already approved for receiving low-level waste.
- This option exposes the surrounding soils such that they could be exhumed. This is the only option that has the potential to leave the waste tank area as an unrestricted area for future uses.

The disadvantages include:

- High radiation exposure to workers during the removal process
- Extremely high cost to remove the tank
- Considerable impact on other SRS operations
- Extremely high cost to dispose of the tank components elsewhere. Also, disposal of the tank could create another zone of restricted use (i.e., the restricted use zone is merely shifted, rather than being eliminated).

A.4.5 ENVIRONMENTAL RESTORATION PROGRAM ACTIVITIES

After a tank is closed, the SRS Environmental Restoration Program will conduct field investigations and remedial actions. The Environmental Restoration Program is concerned with all aspects of assessment and cleanup of both contaminated facilities in use and sites that are no longer a part of active operations. Remedial actions, most often concerned with contaminated soil and EC groundwater, are responsibilities of this program. The investigations will take place after nearby tanks in an operational grouping are closed (to avoid interference with the other operational tanks) and conditions are determined to be safe for Environmental Restoration intrusive sampling. Once an operational grouping is closed, the HLW operations organization and the Environmental Restoration organization will establish a Co-Occupancy Plan to ensure safe and efficient soils assessment and remediation. The HLW organization will be responsible for operational control and the Environmental Restoration organization will be responsible for Environmental Restoration activities. The primary purpose of the Co-Occupancy Plan is to provide the two organizations with a formal process to plan, control, and coordinate the Environmental Restoration activities in the tank farm areas where the existing HLW management and operational procedures can be continuously utilized.

The *High-Level Waste Tank Closure Program Plan* (DOE 1996) provides general information on post-closure activities and tank-specific closure modules will also address post-closure activities. However, the investigation, determination of remediation requirements, and implementation of potential remedial actions related to soil and groundwater contamination at the tank farms will be conducted in accordance with RCRA/CERCLA requirements pursuant to the Federal Facility Agreement. The Environmental Restoration organization would have the responsibility for these activities. Plans for such postclosure measures as monitoring, inspections, and corrective action plans would also be governed by the Federal Facility Agreement and would be premature to state at this time because conditions that would exist at the restored area are not known. For example, the area may be capped or an *in situ* groundwater treatment system may be installed.

Figure A-6 presents an example of the closure configuration for a group of tanks. (EC) The necessity for a low-permeability cap, such as a clay cap, over a tank group to reduce rainwater infiltration would be established in accordance (EC) with the Environmental Restoration Program described in the Federal Facility Agreement (EPA 1993). Figure A-6 shows a conceptual cap (EC) design. The cap construction would ensure that rain falling on the area drains away from the closed tank(s) and surrounding soil. A soil cover could be placed over the cap and seeded to prevent erosion.

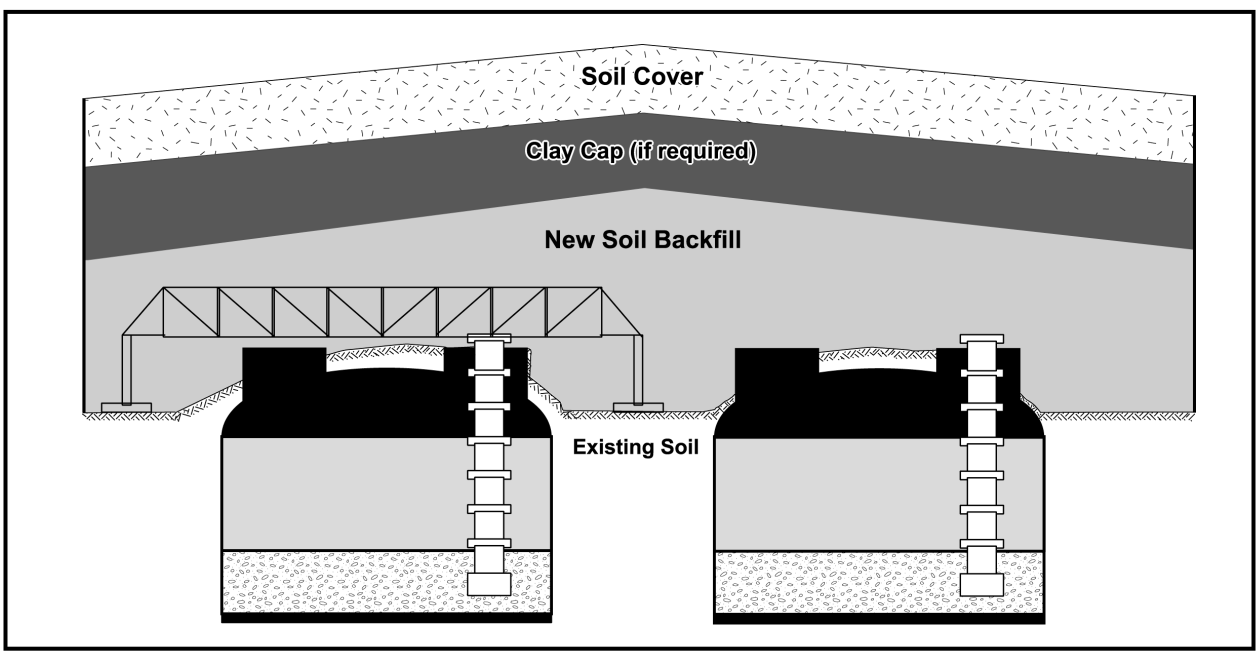


Figure A-6. Area closure example.

References

Boore, W. B., et al., 1986, *Radioactive Waste Spill and Cleanup on Storage Tank at the Savannah River Plant*, DP-1722, March.

Bradley, R. F. and A. J. Hill, 1997, *Chemical Dissolving of Sludge from a High-Level Waste Tank at the Savannah River Site*, DP-1471, November.

d'Entremont, P. D., 1989, *Written Report on Contingency Plan Activation*, WSRC-RP-89-259, Westinghouse Savannah River Company, Aiken, South Carolina. L-7-64

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

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

DOE (U.S. Department of Energy), 1996, *High-Level Waste Tank Closure Program Plan*, Revision 0, Savannah River Operations Office, Aiken, South Carolina, December 16.

TC

EPA (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. (Available at http://www.srs.gov/general/srenviro/erd/ffa/ffaa.pdf).

Odum, J. V., 1976, *Soil Contamination Adjacent to Waste Tank 8*, DPSPU 76-11-4, E.I. du Pont de Nemours and Company, Inc., Aiken, South Carolina, November.

Poe, W. L, 1974, *Leakage from Waste Tank 16: Amount, Fate and Impact*, DP-1358, Aiken, South Carolina. L-7-65 L-7-57

WSRC (Westinghouse Savannah River Company), 1996, *SRS Plan for Performing Maintenance in Federal Facility Agreement Areas (Operations and Maintenance Plan)* WSRC-RP-96-45, Westinghouse Savannah River Company, Aiken, South Carolina, December 15. TC

WSRC (Westinghouse Savannah River Company), 1998a, *High-Level Waste System Plan*, Revision 9, HLW-OVP-98-0037, High-Level Waste Management Division, Aiken, South Carolina, April. (Available at https://www.osti.gov/servlets/purl/301986-t5EGMP/webviewable/301986.pdf).

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

EC

WSRC (Westinghouse Savannah River Company), 2000, *Annual Radioactive Waste Tank Inspection Program – 1999*, WSRC-TR-2000-00067, Westinghouse Savannah River Company, Aiken, South Carolina, May.