CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action and Alternatives

DOE proposes to close the HLW tanks at SRS 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) (the General Closure Plan) approved by SCDHEC, which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin when bulk waste removal has been completed. Under each alternative except No Action, DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines.

DOE is evaluating three alternatives in this EIS. As described above, all of the alternatives would start after bulk waste removal occurs.

- Clean and Stabilize Tanks Alternative. DOE considers three options for tank stabilization:
  - Fill with Grout (Preferred Alternative)
  - Fill with Sand
  - Fill with Saltstone
- Clean and Remove Tanks Alternative
- No Action Alternative (evaluation required by CEQ regulations)

HLW Tank Cleaning

Tank cleaning by spray water washing involves washing each tank using hot water in rotary spray jets. The spray nozzles can remove waste near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank would be agitated with slurry pumps and pumped out of the tank. This process has been demonstrated on Tanks 16 (which has not been closed) and 17 (which has been closed). The amount of waste left after spray washing was estimated at about 3,500 gallons in Tank 16 and about 4,000 gallons in Tank 17 (du Pont 1980; WSRC 1995a). If modeling evaluations showed that performance objectives could not be met after an initial spray water washing, additional spray water washes would be used prior to employing other cleaning techniques.

After spray water washing is complete, DOE could use oxalic acid cleaning. Hot oxalic acid would be sprayed through the spray nozzles that were used for spray water washing.

Oxalic acid cleaning – In this process, after the spray washing is complete, hot oxalic acid (80°-90°C) would be sprayed through the spray nozzles that were used for water spray washing. This process has been demonstrated only on Tank 16. A number of potential cleaning agents for sludge removal were studied. Oxalic acid was chosen as the preferred cleaning agent because it dissolves sludge and is only moderately aggressive against carbon steel, the material used in the construction of the waste tanks.

Bradley and Hill (1977) describes the study that led to the selection of oxalic acid as the preferred chemical cleaning agent. The study examined cleaning agents that would not aggressively attack carbon steel and were compatible with high-level waste processes. The studies included tests with waste stimulants and also tests with actual Tank 16 sludge. The agents tested were disodium salt EDTA, glycolic acid, formic acid, sulfamic acid, citric acid, dilute sulfuric acid, alkaline permanganate, and oxalic acid. None of these agents completely dissolved the sludge, but oxalic acid was shown to dissolve about 70% of the sludge in a well-mixed sample at 25% C, which was the highest of any of the cleaning agents tested. (Concentrated mineral acids, such as nitric acid, hydrochloric acid, and concentrated sulfuric acid, will completely dissolve the sludge but also aggressively attack carbon steel.)

Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity (see Table 2-1). Use of oxalic acid in an HLW tank would require a successful demonstration that it would not create a potential for a nuclear criticality. The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited. This prohibition was established because of concern that oxalic acid could dissolve a sufficient quantity of fissile materials to create the potential for nuclear criticality.

An earlier study (Nomm 1995) had concluded that criticality in the high-level waste tanks is "beyond extremely unlikely" because neutron-absorbing substances present in the sludge would prevent criticality. However, the study assumed the waste would remain alkaline and did not address the possibility that chemicals would be used that would dissolve sludge solids. Therefore, to ensure that no criticality could occur in tank cleaning, DOE would need to prepare a formal Nuclear Criticality Safety Evaluation (i.e., a study of the potential for criticality) before deciding to use oxalic acid in cleaning a tank. If the new evaluation found that oxalic acid could be used safely, the *Liquid Radioactive Waste Facility Safety Analysis Report* would be revised and DOE could permit its use. If not, DOE would need to investigate other cleaning technologies, such as mechanical cleaning.

If oxalic acid cleaning were performed infrequently, there would be minimal impact on the downstream waste processing operations (DWPF and salt disposition). The oxalic acid used to clean a tank would be neutralized with sodium hydroxide, forming sodium oxalate. The sodium oxalate would follow the same treatment path as other salts in the tank farm inventory.

Extensive use of oxalic acid cleaning may result in conditions that, if not addressed by checks within the DWPF feed preparation process, could allow carryover of sodium oxalate to the vitrification process. The presence of oxalates in the waste feed to DWPF that would result from oxalic acid cleaning would adversely affect the quality of the HLW glass produced at DWPF. To prevent that from occurring, special batches of the salt treatment process would be scheduled in which the sodium oxalate concentrations would be controlled to not exceed their solubility limit in the low-radioactivity fraction.

DOE expects that oxalic acid cleaning would be required on tanks that contain first-cycle wastes, the most highly radioactive waste in the tanks. High-level wastes were produced as a byproduct of SRS separations processes. During processing, materials from SRS reactors passed through several cycles of solvent extraction. In these cycles, the plutonium and other products were first separated from the waste and then purified. Most of the radionuclides were removed from the processing streams during the first cycle of solvent extraction, so wastes from this cycle have most of the radionuclides. Wastes from subsequent cycles have radionuclide concentrations that are one to two orders of magnitude lower. DOE anticipates that oxalic acid would be needed to clean tanks that contain the more radioactive first cycle wastes (about three fourths of the tanks).

On the basis of performance and historical data, DOE believes that waste removal meets the Criteria 2 and 3 requirements of the evaluation process for determining that waste can be considered "waste incidental to reprocessing" (see text box). In addition, waste removal followed by spray water washing, meets the Criterion 1 requirement for removal of key radionuclides to the extent "technically and economically practical" (DOE Order 435.1). If Criteria 2 or 3 could not be met, enhanced cleaning methods such as additional water washes or oxalic acid cleaning could be employed. However, DOE considers that oxalic acid cleaning beyond the extent needed to meet performance objectives is not "technically and economically practical" within the meaning of DOE Order 435.1, for reasons discussed below.

In general, the economic costs of oxalic acid cleaning are quite high. DOE estimates that oxalic acid cleaning (including disposal costs) per tank would cost approximately $1,050,000.

Table 2-1. Tank 16 waste removal process and curies removed with each sequential step.

Sequential Waste Removal Step	Curies Removed	% of Curies Removed	Cumulative Curies Removed	Cumulative Percent Curies Removed
Bulk Waste Removal	2.74×10^{6}	97%	2.74×10^{-6}	97
Spray Water Washing	2.78×10^{4}	0.98%	2.77×10^{-6}	97.98
Oxalic Acid Wash & Rinse	5.82×10^{4}	2%	2.83×10^{-6}	99.98

DOE considers that performance of bulk waste removal and spray washing, which together result in removal of 98% to 99% of the total curies and over 99% of the volume of waste, constitutes the limit of what is economically and technically practicable for waste removal (DOE Response to U.S. Nuclear Regulatory Commission Additional Questions on SRS HLW Cover Tank Closure, April 1999). However, DOE recognizes that enhanced waste removal operations may be required for some tanks and is committed to performing the actions necessary to meet "incidental waste" determination and performance objectives. DOE further recognizes that, if it could not clean the tank components sufficiently to meet the waste incidental to reprocessing criteria, it would need to examine alternative disposition strategies. Alternatives could include disposal in place as high-level waste (which is not contemplated in DOE Order 435.1), development of new cleaning technologies, or packaging the cleaned tank pieces and storing them until DOE could ship them to a geologic repository for disposal. A geologic repository has not yet been approved and waste acceptance criteria have not yet been finalized.

Nine HLW tanks have leaked measurable amounts of waste from primary containment to secondary containment with only one leaking to the soil surrounding the tanks. For these tanks, the waste would be removed from the secondary containment using water and/or steam. Such cleaning has been attempted at SRS on only one tank (Tank 16), and the operation was only about 70 percent completed, because salts mixed with sand (from sandblasting of tank welds) made salt removal more difficult. Cleaning of the secondary containment is not a demonstrated technology and new techniques may need to be developed. The amount of waste in secondary containment is small, so the environmental risk of this waste is minimal compared to the amount of residual waste that would be contained inside the tanks after bulk waste removal and cleaning.

2.1.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

Following bulk waste removal, DOE would remove the majority of the waste from the tanks and fill the tanks with a material to prevent future collapse and to bind up residual waste. A detailed description of this alternative can be found in Appendix A.

Tank Closure Alternatives

Implementation of each alternative would start following bulk waste removal and SCDHEC approval of a tank-specific Closure Module that is protective of human health and the environment.

- Clean with water and fill the tanks with grout (Preferred Alternative). If necessary to meet the performance objectives, oxalic acid cleaning could be used. The use of sand or saltstone as fill material would also be considered.
- Clean and remove the tanks for disposal in the SRS waste management facilities.
- No Action. Leave the tank systems in place without cleaning or stabilizing following bulk waste removal.

In the evaluation and cleaning phase, each tank system or group of tank systems, as appropriate, would be evaluated to determine the inventory of radiological and nonradiological contaminants remaining after bulk waste removal, and spray water washing. This information would be used to conduct a performance evaluation as part of the Preparation of a Closure Module. In this evaluation, DOE would consider (1) the types of contamination in the tank and the configuration of the tank system and (2) the hydrogeologic conditions at and near the tank location, such as distance from the water table and distance to nearby streams. The performance evaluation would include modeling the projected contamination pathways for selected closure methods and comparing the modeling results with the performance objectives developed in the General Closure Plan (DOE 1996). These performance objectives are described in Section 7.1.2 of this EIS. If the modeling shows that the performance objectives would be met, the Closure Module would be submitted to SCDHEC for approval.

If the modeling shows that the performance objectives would not be met, additional cleaning steps, such as additional water spray washing, oxalic acid cleaning, or other cleaning techniques, would be taken until enough residual waste had been removed that the performance objectives could be met.

Tank Stabilization

After DOE would clean a tank and demonstrate that the performance objectives could be met, SCDHEC would approve a Closure Module. The tank stabilization process would then begin. Each tank system (including the secondary containment, for those that have one) would be filled with a pumpable, self-leveling backfill material.

DOE's Preferred Alternative is to use grout, a concrete-like material, as backfill. The grout would be trucked to an area near the tank farm, batched if necessary, and pumped to the tank. The grout would be high enough in pH to be compatible with the carbon steel walls of the waste tank. Although the details of each individual closure would vary, any tank system closure under this alternative would have the following characteristics:

- The grout would be pumpable, self-leveling, designed to prevent future subsidence of the tank, and able to fill voids to the extent practical, including equipment and secondary containment.
- The grout would be poured in three distinct layers as illustrated in Figure 2.1-1. The bottom-most layer would be a specially formulated reducing grout to retard the migration of important contaminants. The middle layer would be a low-strength material designed to fill most of the volume of the tank interior. The final layer would be a high strength grout to deter inadvertent intrusion from drilling.
- The final closure configuration would meet performance objectives established by SCDHEC and EPA.

If DOE were to choose another fill material (e.g., sand, saltstone) for a tank system, all other aspects of the closure process would remain the same, as described above.

Sand is readily available and inexpensive. However, its emplacement is more difficult than the grout because it does not flow readily into voids. Any equipment or piping left on or inside the tank that might require filling to eliminate voids inside the device might not be adequately filled. Over time, the sand would tend to settle in the tank, creating additional void spaces. The dome might then become unsupported and would sag and crack. The sand would tend to isolate the contamination from the environment to some extent, limit the amount of settling of the tank top after failure, and prevent winds from spreading the contaminants. Nevertheless, water would flow readily through the sand. Sand is relatively inert and could not be formulated to retard the migration of radionuclides. Thus, the expected contamination levels in groundwater and surface streams resulting from migration of residual contaminants would be higher than the levels for the preferred option.

Saltstone could also be used as fill material. Saltstone is the low-radioactivity fraction of HLW mixed with cement, flyash, and slag to form a concrete-like mixture. Saltstone is normally disposed of as low-level waste in the SRS

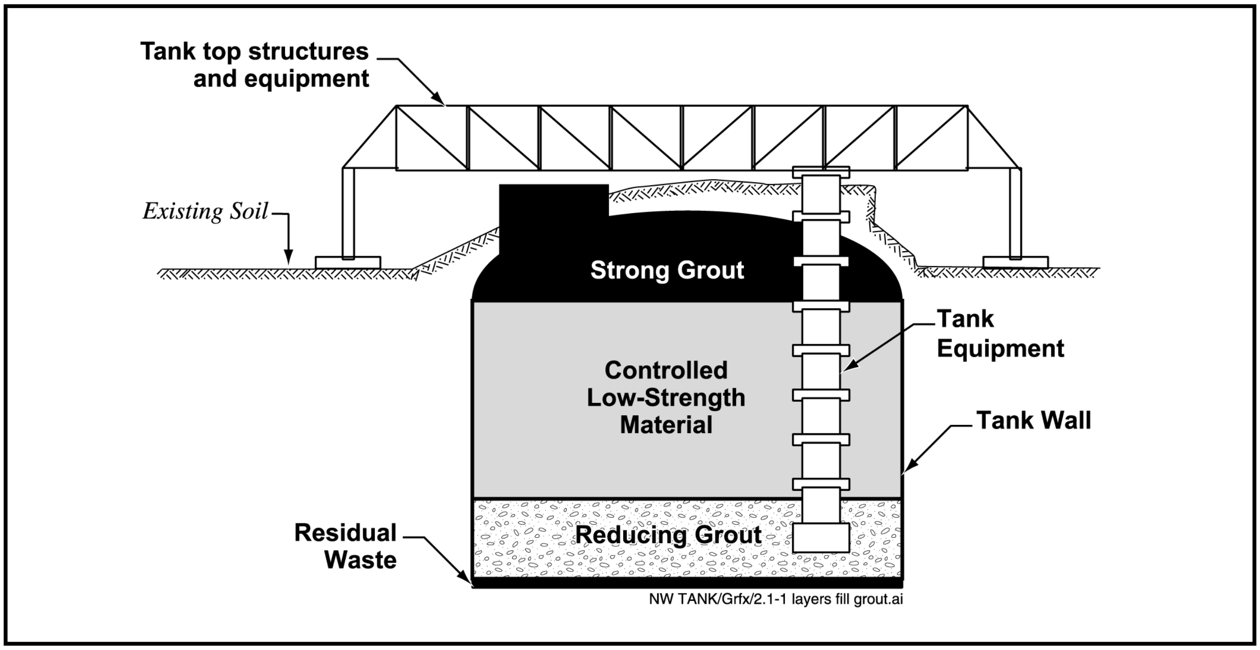

Figure 2.1-1. Typical layers of the fill with grout option.

Saltstone Disposal Facility. See Appendix A for a description of the Saltstone Manufacturing and Disposal Facility and its function within the HLW system.

This alternative would have the advantage of reducing the amount of Saltstone Disposal Facility area that would be required. Any saltstone sent to a waste tank would not require disposal space in the Saltstone Disposal Facility.

The total amount of saltstone required to stabilize the low-activity fraction of HLW would probably be greater than 160 million gallons, which is considerably in excess of the capacity of the HLW tanks. Therefore, disposal of saltstone in the Saltstone Disposal Facility would still be required. Because saltstone sets up quickly and is radioactive, it would be impractical to ship by truck or pump to the tank farms. Thus, a Saltstone Mixing Facility would need to be constructed in F-Area; another facility would be built in H-Area; and the existing Saltstone Manufacturing and Disposal Facility in Z-Area would still be operated.

Filling the tank with saltstone, which is contaminated with radionuclides would considerably complicate the project and increase worker radiation exposure, which would increase risk to workers and add to the cost of closure. In addition, the saltstone would contain large quantities of nitrate that would not be present in the tank residual. Because nitrates are very mobile in the environment, these large quantities of nitrate would adversely impact the groundwater near the tank farms in the long term.

One of the alternatives being evaluated in the Supplemental EIS for high-level waste salt disposition would not involve the manufacture of saltstone (64 FR 8558; February 22, 1999). If this alternative (known as the Direct Disposal in Grout Alternative) is selected, the option of using saltstone as a HLW tank stabilization material would no longer be applicable. The Direct Disposal in Grout Alternative involves the manufacture of a grout with substantially greater radioactive content than saltstone, which would be unsuitable for use as HLW tank stabilization material.

For any of the above options, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over these tanks that could facilitate the degradation of the tank structure.

2.1.2 CLEAN AND REMOVE TANKS ALTERNATIVE

The Clean and Remove Tanks alternative would include cleaning the tanks, cutting them up in situ, removing them from the ground, and transporting tank components for disposal in an engineered disposal facility at another location on the SRS. This alternative has not been demonstrated on HLW tanks.

For the Clean and Remove Tanks Alternative, DOE would have to perform enhanced cleaning beyond that contemplated for the other action alternatives, until tanks were clean enough to be safely removed and could meet waste acceptance criteria at SRS Low-Level Waste Disposal Facilities. Worker exposure would have to be As Low As Reasonably Achievable to ensure protection of the individuals required to perform the tank removal operations. This might require the use of cleaning technologies such as oxalic acid cleaning, mechanical cleaning, and additional steps as yet undefined on most of the tanks.

Following bulk waste removal and cleaning, the steel components of the tank would be cut up, removed, placed in radioactive waste transport containers (approximately 3,900 SRS low-level waste disposal boxes per tank), and transported to SRS radioactive waste disposal facilities for disposal (assuming these components are considered waste incidental to reprocessing). During tank removal activities, the top of the tank would have HEPA-filtered enclosures or airlocks. The tank would remain under negative pressure during cutting operations, and the exhaust would be filtered through HEPA filtration. This alternative would require the construction of approximately 16 new low-activity waste vaults at SRS for disposal of the low-level waste disposal boxes containing the tank components from all 49 tanks. This number of new low-activity waste vaults is within the range DOE previously analyzed in the *Savannah River Site Waste Management Final Environment Impact Statement* (DOE 1995). That EIS analyzed a range of waste treatment alternatives that resulted in the construction of up to 31 new low-activity waste vaults. The long-term impacts presented in that EIS for the low-activity waste vaults are approximately one-one thousandth of the long-term tank closure impacts presented in Section 4.2 of this EIS and are incorporated into this EIS by reference. 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.

With removal of all the tanks, backfilling of the excavations left after the removal would be required. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

2.1.3 NO ACTION

For HLW tanks, the No Action Alternative would involve leaving in place the tank systems after bulk waste removal from each tank has taken place and the storage space is no longer needed. Even after bulk waste removal, each tank would contain residual waste and in those tanks that reside in the water table, ballast water, which is required to prevent the tank from "floating" out of the ground. Tanks would not be backfilled.

After some period of time, the reinforcing bar in the roof of the tank would rust and the roof of the tank would fail, causing the structural integrity of the tank to degrade. Similarly, the floor and walls of the tank would degrade over time. Rainwater would readily pour into the exposed tank, flushing contaminants from the residual waste in the tank and eventually carrying these contaminants into the groundwater. Contamination of the groundwater would happen much more quickly than it would if the tank were backfilled and residual wastes were bound with the fill material.

No Action would be the least costly of the alternatives (less than $100,000 per tank), require the fewest worker hours and exposure to radiation (about two person-rem), and would require fewer workers per tank system than the Clean and Stabilize Tanks Alternative. There would be ongoing maintenance and no interruption of operations in the tank farm.

Future inhabitants of the area would be exposed to the contamination in a tank, and injuries or fatalities could occur if an intruder ventured into the area of the tank and the roof were to collapse due to structural failure. Also, movement of the contaminants into the groundwater would be more rapid compared to the other alternatives, and expected contamination levels in groundwater and surface streams would be higher than for the Clean and Stabilize Tanks Alternative because there would be no material to retard movement of the radionuclides. This alternative would be the least protective of human health and safety and of the environment.

2.1.4 ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

2.1.4.1 Management of Tank Residuals as High-Level Waste

The alternative of managing the tank residuals as HLW is not preferred, in light of the requirements embodied in the State-approved General Closure Plan for a regulatory approach based on the designation of the residuals as waste incidental to reprocessing.

The waste incidental to reprocessing designation does not create a new radioactive waste type. The terms "incidental waste" or "waste incidental to reprocessing" refer to a process for identifying waste streams that might otherwise be considered HLW due to their origin, but are actually low-level or transuranic waste, if the waste incidental to reprocessing requirements contained in DOE Manual 435.1-1 are met. The goal of the waste incidental to reprocessing determination process is to safely manage a limited number of reprocessing waste streams that do not warrant geologic repository disposal because of their low threat to human health or the environment. Although the technical alternatives of managing tank residuals under the General Closure Plan would likely be the same as those that would apply to managing residuals as HLW, the application of regulatory requirements would be different.

As described in the General Closure Plan, DOE will meet the waste incidental to reprocessing requirements of DOE Manual 435.1-1, which entail a step for removing key radionuclides to the extent that is technically and economically practical, a step for incorporating the residues into a solid form, and a process for demonstrating that appropriate disposal performance objectives are met. The technical alternatives evaluated in the EIS represent a range of tank cleaning and stabilization techniques. The radionuclides in residual waste would be the same whether the material is HLW, low-level waste, or transuranic waste; however, the regulatory regime would be different.

DOE must demonstrate its ability to meet certain performance objectives before SCDHEC will approve a Closure Module. Appendix C of the General Closure Plan describes the process DOE used to determine the performance objectives (dose limits and concentrations established to be protective of human health) incorporated in the General Closure Plan. As described in Chapter 7 of this EIS, DOE will establish performance standards for the closure of each HLW tank. In the General Closure Plan, DOE considered dose limits and concentrations found in current (40 CFR 191, 10 CFR 60) and proposed (40 CFR 197, 10 CFR 63) HLW management requirements in defining the performance standards. DOE considered the HLW management dose limits and concentrations as performance indicators of the ability to protect human health and the environment, even though the residual would not be considered HLW. That evaluation (described in Appendix C of the General Closure Plan) identified numerical performance standards (concentrations or dose limits for specific radiological or chemical constituents released to the environment) based on the requirements and guidance. Those numerical standards apply to all exposure pathways and to specific media (air, groundwater, and surface water), at different points of compliance, and over various periods during and after closure.

If DOE determines through the waste incidental to reprocessing process that the tank residues cannot be managed as LLW, as expected, or alternatives as TRU waste, the residues would be managed as HLW. The technical alternatives for managing the residues as HLW, however, would be the same as those for managing the residues under the LLW requirements. Thus, DOE expects that the potential environmental impacts that could result from managing the residues under the LLW requirements would be representative of the impacts if the HLW standards were applicable. For these reasons, this EIS does not present the management of tank residues as HLW as a separate alternative.

2.1.4.2 Other Alternatives Considered, but not Analyzed

DOE considered the alternative of delaying closure of additional tanks, pending the results of research. For the period of delay, the impacts of this approach would be the same as the No Action Alternative. DOE continues to conduct research and development efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of delaying closure.

DOE considered an alternative that would represent grouting of certain tanks and removal of others. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet performance requirements for a given tank, the decisionmakers may elect to remove a tank if it is not possible to meet the performance requirements by using another method. This EIS captures the environmental and health and safety impacts of both options.

2.2 Other Cleaning Technologies

The approved General Closure Plan contemplates cleaning the tanks with hot water streams, as described in the Clean and Stabilize Tanks Alternative. Several cleaning technologies have been investigated but are not considered reasonable alternatives to hot water cleaning at this time. However, DOE continues to research cleaning methods and should a particular method prove practical and be required to meet the performance criteria for a specific tank, its use would be proposed in the Closure Module for that tank. DOE would conduct the appropriate NEPA review for any proposal to use such new technology.

Mechanical and chemical cleaning using advanced techniques has not been demonstrated in actual HLW tanks. A number of techniques have been studied involving such technologies as robotic arms, wet-dry vacuum cleaners, and remote cutters. However, none of these techniques have been demonstrated for this application. For example, no robotic arms have been demonstrated that could navigate through the cooling coils that are found in most SRS waste tanks. These techniques could be applied for specific tank closures based on the waste characteristics (e.g., presence of zeolite or insoluble materials) and other circumstances (e.g., cooling coils or other obstructions) for specific SRS tank closures.

There are more aggressive cleaning agents than oxalic acid (e.g., nitric acid). However, in addition to the same safety questions involving the use of oxalic acid (see Section 2.2.1), these cleaning agents have an unacceptable environmental risk because they attack the carbon steel wall of the waste tank, causing deterioration of the metal, and reducing the intact containment life of the tank. This would result in much more rapid release of contaminants to the environment.

2.3 Considerations in the Decision Process

This environmental impact statement evaluates the environmental impacts of several alternatives for closure of the high-level waste tanks at the Savannah River Site. The closure process would take place over a period of up to 30 years. The selection of a tank closure alternative following completion of this EIS would guide the selection and implementation of a closure method for each high-level waste tank at the SRS. Within the framework of the selected alternative, and the environmental impacts of closure described in the EIS, DOE will select and implement a closure method for each tank.

The tank closure program will operate under a number of laws, regulations and regulatory agreements, described in Chapter 7 of this EIS. In addition to the General Closure Plan, a document prepared by DOE based on responsibilities under the Atomic Energy Act and other laws and regulations, the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. The Closure Module incorporates a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving the Closure Module, DOE will select a closure method that is consistent with the closure alternative selected following completion of this EIS. The selected closure method will result in a closure that has impacts on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. If DOE elects to use such a technology, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank using the new technology.

During scoping for this EIS, a commentor suggested that DOE should consider the alternative of delaying closure of additional tanks pending the results of research. For the period of delay, the impacts of this approach would be the same as the No-Action Alternative. DOE continues to conduct research and development (R&D) efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of the alternative suggested by the commentor.

A comment was made that tank removal and grouting should be combined as an alternative. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet the performance requirements for a given tank, the decisionmaker may elect to remove a tank if it is not possible to meet the performance requirements by another method. This EIS captures the environmental and health and safety impacts of both options. Additional discussion on these and other comments made during scoping is included in Appendix D.

As stewards of the Nation's financial resources, DOE decision-makers must also consider cost of the alternatives. DOE has prepared rough order-of-magnitude estimates of cost for each of the alternatives (DOE 1997). These costs, which are presented on a per tank basis, are as follows:

No Action Alternative – <$100,000

Clean and Stabilize Tanks Alternative

- Clean and Fill with Grout Option - $3.8-4.6 million
- Clean and Fill with Sand Option - $3.8 million
- Clean and Fill with Saltstone Option - $6.3 million
- Clean and Remove Tanks Alternative - >$100 million

2.4 Comparison of Environmental Impacts Among Alternatives

Closure of the HLW tanks would affect the environment, and human health and safety, during the period of time when work is being done to close the tanks and after the tanks have been closed. For purposes of analysis in this EIS, DOE has defined the period of short-term impacts to be from the year 2000 through about 2030, when all of the existing HLW tanks are proposed to be closed. Long-term impacts would be those resulting from the eventual release of residual waste contaminants from the stabilized tanks to the environment. In this EIS, DOE has estimated these impacts over a period of 10,000 years.

Chapter 4 presents estimates of the potential short-term and long-term environmental impacts associated with each tank closure alternative, as well as the No Action Alternative. Section 2.4.1 summarizes the short-term impacts and accident scenarios, while Section 2.4.2 summarizes the long-term impacts.

2.4.1 SHORT-TERM IMPACTS

Section 4.1 presents the potential short-term impacts (approximately the years 2000 to 2030) for each of the alternatives. These potential impacts are summarized in Table 2-2 and discussed in more detail in the sections that follow.

Geologic and water resources – Each of the tank stabilization options under the Clean and Stabilize Tanks Alternative would require an estimated 170,000 cubic meters of soil for backfill. The Clean and Remove Tank Alternative would require more, approximately 356,000 cubic meters. Short-term impacts to surface water and groundwater are expected to be negligible for any of the alternatives.

Nonradiological air quality – Tank closure activities would result in the release of regulated nonradiological pollutants to the surrounding air. The primary source of air pollutants for the Clean and Fill with Grout Option would be a portable concrete batch plant and three diesel generators. For the Clean and Fill with Sand Option, pollutants would be emitted from operation of a portable sand feed plant and three diesel generators. The Clean and Fill with Saltstone Option would require saltstone batching facilities in F- and H- Areas. Regulated nonradiological air pollutants released as a result of activities associated with the No Action Alternative and Clean and Remove Tanks Alternative would consist largely of emissions from vehicular traffic. All alternatives except the No Action Alternative include the cleaning of interior tank walls with oxalic acid. The acid would be transferred to the HLW tanks through a sealed pipeline. No releases are expected during this procedure. The cleaning process would consist of spraying hot (80-90°C) acid using remotely operated water sprayers.

The tanks would be ventilated with 300-400 cfm of air which would pass thorough a HEPA filter; acid releases from the ventilated air are expected to be minimal. Under all alternatives, the expected emission rate for each source would be less than the Prevention of Significant Deterioration Standards.

The maximum air concentrations at the SRS boundary associated with the release of regulated pollutants would be highest for the Clean and Fill with Saltstone Option. However, ambient concentrations for all the pollutants and alternatives would be less then 1 percent of the regulatory limits. The concentrations at the location of the hypothetical noninvolved worker would be highest for the Clean and Fill with Saltstone Option. All concentrations, however, would be below the Occupational Safety and Health Administration (OSHA) limits; all concentrations with the exception of nitrogen oxide (as NO_x) would be less than 1 percent of the regulatory limit. Nitrogen dioxide (NO_x) could reach 8 percent of the regulatory limit for the Clean and Fill with Grout and Clean and Fill with Sand Options, while NO_x levels under the Clean and Fill with Saltstone Option could reach about 16 percent of the OSHA limit. These emissions would be attributable to the diesel generators.

Radiological air quality – Radiation dose to the maximally-exposed offsite individual from air emissions during tank closure would be essentially the same for all alternatives and options, 2.5×10^{-5} to 2.6×10^{-5} millirem per year. Estimated dose to the offsite population would also be similar for all alternatives and options, from 1.4×10^{-3} to 1.5×10^{-3} person-rem per year.

Ecological resources – Construction-related disturbance under the Clean and Stabilize Tanks Alternative and Clean and Remove Tank Alternative 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.

Table 2-2. Summary comparison of short-term impacts by tank closure alternative.

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Geologic Resources **Soil backfill (m^3)**	None	170,000	170,000	170,000	356,000
Water Resources Surface Water	None	None	None	None	None
Groundwater		<0.6% of F-Area well production required	<0.6% of F-Area well production required	<0.6% of F-Area well production required	<0.6% of F-Area well production required
Air Resources					
Nonradiological air emissions (tons/yr.):					
Sulfur dioxide (as SO_x)	None	2.2	2.2	3.3	None
Total suspended particulates	None	(a)	(a)	3.0	None
Particulate matter	None	4.5	3.1	1.7	None
Carbon monoxide	None	5.6	5.6	8.0	None
Volatile organic compounds	None	2.3	2.3	3.3	None
Nitrogen dioxide (as NO_x)	None	33	33	38	None
Lead	None	9.0×10^{-4}	9.0×10^{-4}	1.5×10^{-3}	None
Beryllium	None	1.7×10^{-4}	1.7×10^{-4}	2.8×10^{-4}	None
Mercury	None	2.2×10^{-4}	2.2×10^{-4}	4.3×10^{-4}	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations-$\mu g/m^3$):[b]					
Sulfur dioxide (as SO_x) – 3 hr.	None	0.2	0.0	0.6	None
Total suspended particulates – annual	None	(a)	(a)	0.005	None
Particulate matter – 24 hr.	None	0.08	0.06	0.06	None
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Nitrogen dioxide (as NO_x) - annual	None	0.03	0.03	0.07	None
Lead – max. quarterly	None	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-6}	None
Beryllium – 24 hr.	None	3.2×10^{-6}	3.2×10^{-6}	1.1×10^{-5}	None

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Mercury – 24 hr.	None	4.0×10^{-6}	4.0×10^{-6}	1.6×10^{-5}	None
Benzene	None	3.8×10^{-4}	3.8×10^{-4}	2.0×10^{-2}	None
Annual radionuclide emissions (curies/year):					
F-Area	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}
H-Area	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Saltstone mixing facility	Not used	Not used	Not used	0.46	Not used
Annual dose from radiological air emissions:					
Noninvolved worker dose (mrem/yr.)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
Maximally Exposed Offsite Individual dose (mrem/yr.)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Offsite population dose (person-rem)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
Ecological Resources	No change	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
Land Use	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns
Socioeconomics (employment – full time equivalents)					
Annual employment	40	85	85	131	284
Life of project employment	980	2,078	2,078	3,210	6,963
Cultural Resources	None	None	None	None	None

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Worker and Public Health					
Radiological dose and health impacts to the public and non-involved workers:					
Maximally-exposed offsite individual (mrem/yr.)	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
Maximally exposed offsite individual estimated latent cancer fatality risk	6.1×10^{-10}	6.1×10^{-10}	6.1×10^{-10}	6.4×10^{-10}	6.1×10^{-10}
Noninvolved worker estimated latent cancer fatality risk	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}
Estimated increase in number of latent cancer fatalities in population within 50 miles of SRS	3.4×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	3.7×10^{-5}	3.4×10^{-5}
Radiological dose and health impacts to involved workers:					
Closure collective dose (total person-rem)	29.4[c]	1,600	1,600	1,800	12,000
Closure latent cancer fatalities	0.012	0.65	0.65	0.72	4.9
Nonradiological air pollutants at noninvolved worker location (max conc.):					
Sulfur dioxide (as SO_x) – 8 hr.	None	5.0×10^{-3}	5.0×10^{-3}	0.02	None
Total suspended particulates – 8 hr.	None	ND	ND	0.01	None
Particulate matter – 8 hr.	None	9.0×10^{-3}	6.0×10^{-3}	8.0×10^{-3}	None
Carbon monoxide – 8 hr.	None	0.01	0.01	0.04	None
Oxides of nitrogen (as NO_x) - ceiling	None	0.70	0.70	1.40	None
Lead – 8 hr.	None	2.1×10^{-6}	2.1×10^{-6}	6.5×10^{-6}	None

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Beryllium – 8 hr.	None	4.1×10^{-7}	4.1×10^{-7}	1.3×10^{-6}	None
Mercury - ceiling	None	4.2×10^{-6}	4.2×10^{-6}	1.4×10^{-5}	None
Benzene – 8 hr.	None	4.8×10^{-5}	4.8×10^{-5}	1.0×10^{-3}	None
Occupational Health and Safety:					
Recordable injuries-closure	110[d]	120	120	190	400
Lost workday cases-closure	60[d]	62	62	96	210
Environmental Justice	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations
Transportation (offsite round-trip truckloads)	0	654	653	19	5
Waste Generation					
Maximum annual waste generation:					
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Transuranic waste (m^3)	0	0	0	0	0
Low-level waste (m^3)	0	60	60	60	900
Hazardous waste (m^3)	0	2	2	2	2
Mixed low-level waste (m^3)	0	12	12	12	20
Industrial waste (m^3)	0	20	20	20	20
Sanitary waste (m^3)	0	0	0	0	0

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Total estimated waste generation					
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Transuranic waste (m^3)	0	0	0	0	0
Low-level waste (m^3)	0	1,284	1,284	1,284	19,260
Hazardous waste (m^3)	0	42.8	42.8	42.8	42.8
Mixed low-level waste (m^3)	0	257	257	257	428
Industrial waste (m^3)	0	428	428	428	428
Sanitary waste (m^3)	0	0	0	0	0
Utility and Energy Usage:					
Water (total gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Electricity	NA	NA	NA	NA	NA
Steam (total pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (total gallons)	NA	214,000	214,000	214,000	428,000
Utility cost (total)	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

a. No data on TSP emissions for these sources is readily available and therefore is not reflected in the analysis.
b. No exceedences of air quality standards are expected.
c. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.
d. For the No Action Alternative, recordable injuries and lost work day cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.

NA = Not applicable; ND = Below detection limit.

Land use – From a land use perspective, the F- and H- Area Tank Farms are zoned Heavy Industrial and are within existing heavily industrialized areas. SRS land use patterns are not expected to change over the short term due to closure activities.

Socioeconomics – An annual average of 284 workers would be required for tank closure activities under the Clean and Remove Tanks Alternative. Fewer workers (85 to 131) would be required by the three tank stabilization options under the Clean and Stabilize Tanks Alternative. None of the alternatives or options is expected to measurably affect regional employment or population trends.

Cultural resources – There would be no impacts on cultural resources under any of the alternatives. The Tank Farms lie in a previously-disturbed, highly-industrialized area of the SRS.

Worker and public health impacts – All alternatives are expected to result in similar airborne radiological release levels. Public radiation doses and potential adverse health effects could occur from airborne releases only. Latent cancer fatality risk to the maximally-exposed offsite individual from air emissions during tank closure would be highest (6.4×10^{-10}) under the Clean and Fill with Saltstone Option due to the operation of the saltstone batch plant. Latent cancer fatality risk to the maximally-exposed offsite individual from other alternatives and options would be slightly lower, 6.1×10^{-10}. Estimated latent cancer fatalities to the offsite population of 620,000 people would also be highest under the Clean and Fill with Saltstone Option (3.7×10^{-5}), with other alternatives and options expected to result in a nominally-lower number of latent cancer fatalities of 3.4×10^{-5}.

Collective involved worker dose for closure of all 49 tanks would be highest under the Clean and Remove Tanks Alternative (12,000 person-rem), with the three stabilization options under the Clean and Stabilize Tanks Alternative ranging from 1,600 (Clean and Fill with Grout and Clean and Fill with Sand options) to 1,800 person-rem (Clean and Fill with Saltstone Option). Increased latent cancer fatalities attributable to these collective doses would be 4.9 (Clean and Remove Tanks Alternative), 0.72 (Clean and Fill with Saltstone Option), and 0.65 (Clean and Fill with Grout and Clean and Fill with Sand Options), respectively. The higher dose associated with the Clean and Remove Tanks Alternative relates to larger numbers of personnel required to implement the alternative.

> The primary health effect of radiation is the incidence of cancer. Radiation impacts on workers and public health are expressed in terms of latent cancer fatalities. A radiation dose to a population is estimated to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The EPA 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 very likely result in no additional cancer in the exposed population.

Occupational Health and Safety – Recordable injuries and lost workday cases would be the lowest for the No Action Alternative and highest for the Clean and Remove Tanks Alternative. Of the three options under the Clean and Stabilize Tanks Alternative, the Fill with Saltstone option would have about 50% more recordable injuries and lost workday cases than the Fill with Grout and Fill with Sand options.

Environmental Justice – Because short-term impacts from tank closure 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 tank closure alternatives.

Transportation – Offsite transportation of material by truck to clean and fill tanks would require from zero round-trips per tank for the No Action Alternative to 654 round trips per tank for the Clean and Fill with Grout Option. The amount of increased traffic expected under the proposed action and alternatives would be minimal. There would be no transportation of material under the No Action Alternative.

Waste generation – Tank cleaning activities under the Clean and Remove Tank Alternative would generate as much as 1.2 million gallons of radioactive liquid waste annually, while tank cleaning activities under the Clean and Stabilize Tanks Alternative (regardless of tank stabilization option) would generate as much as 600,000 gallons annually. This radioactive liquid waste would be managed as HLW. Small amounts of mixed low-level waste, hazardous waste, and industrial waste would be produced under both the Preferred Alternative and Clean and Remove Tanks Alternative. The amount of low-level radioactive waste generated by the Clean and Remove Tanks Alternative would be much higher than that generated by any of the other alternatives. No radioactive or hazardous wastes would be generated under the No Action Alternative.

Utilities and energy consumption – None of the alternatives would require electricity usage beyond that associated with current tank farm operations. Electrical power for field activities would be supplied by portable diesel generators. The Clean and Remove Tanks Alternative would require twice the fossil fuel use of the three options under the Clean and Stabilize Tanks Alternative. Total utility costs under the Clean and Remove Tanks Alternative would be approximately three times the costs of the options under the Clean and Stabilize Tanks Alternative. The increased costs are primarily associated with fossil fuel consumption and steam generation. Water consumption is not a substantial contributor to overall utility costs. The highest water usage would be expected for the Clean and Fill with Grout Option. The Clean and Remove Tanks Alternative would require the next highest water usage. The water required to clean tanks, mix tank fill material, or to be used as tank ballast would require less than 0.6 percent (or 0.006) of the annual production from F-Area wells.

Accidents – DOE evaluated the impacts of potential accidents related to each of the alternatives (Table 2-3). For the tank stabilization options, DOE considered transfers during cleaning, a design basis seismic event during cleaning, and failures of the salt solution hold tank. For the Clean and Remove Tanks Alternative, DOE considered transfer errors during cleaning and a seismic event.

For each accident, the impacts were evaluated as radiation dose and latent cancer fatalities (or increased risk of a latent cancer fatality) to the noninvolved workers, to the offsite maximally-exposed individual, and to the offsite population. For the Clean and Stabilize Tanks Alternative and the Clean and Remove Tank Alternative option, a design basis earthquake would result in the highest potential dose and the highest potential increase in latent cancer fatalities or increased risk of latent cancer for each of the receptor groups. The Clean and Fill with Saltstone Option was reviewed to identify potential accidents resulting from producing saltstone and using it to fill tanks. The highest consequence accident identified for saltstone production and use was the failure of the Salt Solution Hold Tank. This accident would result in lower dose and cancer impacts than the bounding accidents for other phases of the alternative.

2.4.2 LONG-TERM IMPACTS

Section 4.2 presents a discussion of impacts associated with residual radioactive and nonradioactive material remaining in the closed HLW tanks. DOE estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a long time span (10,000 years) to determine when certain measures of impacts (e.g., radiation dose) reach their peak value.

There is always uncertainty associated with the results of analyses, especially if the analyses attempt to predict impacts over a long period of

Table 2-3. Estimated accident consequences by alternative.

Alternative	Accident frequency	Consequences					
		Noninvolved worker (rem)	Latent cancer fatalities	Maximally exposed offsite individual (rem)	Latent cancer fatalities	Offsite population (person-rem)	Latent cancer fatalities
Clean and Stabilize Tanks Alternative							
Transfer errors during cleaning	0.1% per year (once in 1,000 years)	7.3	2.9×10^{-3}	0.12	4.8×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	0.0019% per year (once in 53,000 years)	15	6.0×10^{-3}	0.24	9.6×10^{-5}	11,000	5.5
Failure of Salt Solution Hold Tank (Saltstone option only)	0.005% per year (once in 20,000 years)	0.02	8.0×10^{-6}	4.2×10^{-4}	1.7×10^{-7}	17	8.4×10^{-3}
Clean and Remove Tank Alternative							
Transfer errors during cleaning	0.1% per year (once in 1,000 years)	7.3	2.9×10^{-3}	0.12	4.8×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	0.0019% per year (once in 53,000 years)	15	6.0×10^{-3}	0.24	9.6×10^{-5}	11,000	5.5

time. The uncertainty could be the result of assumptions used, the complexity and variability of the process being analyzed, the use of incomplete information, or the unavailability of information. The uncertainties involved in estimating impacts over the 10,000 year period analyzed in this EIS are described in Section 4.2 and in Appendix C.

Because long-term impacts to certain resources were not anticipated, detailed analyses of impacts to these resources were not conducted. These included air resources, socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, utilities and energy, and accidents. Therefore Section 4.2 (as summarized in Table 2-4) focuses on the following discipline areas: geologic resources, water resources, ecological resources, land use, and public health. Tables 2-5 through 2-7 present the long-term transport of nonradiological constituents in groundwater.

Geologic resources – Filling the closed-in-place tanks with ballast water (No Action), grout, sand, or saltstone (the three tank stabilization options under the Clean and Stabilize Tanks Alternative) could increase the infiltration of rainwater at some point in the future, allowing more percolation of water into the underlying geologic deposits. No detrimental effect on surface soils, topography, or to the structural or load-bearing properties of the geologic deposits would occur from these actions. With tank failure, the underlying soil could become contaminated for either the No Action Alternative or any of the options under the Clean and Stabilize Tanks Alternative. No long-term impacts to geologic resources are anticipated from the Clean and Remove Tanks Alternative.

Water resources/surface water – Based on modeling results, any of the three tank stabilization options under the Clean and Stabilize Tanks Alternative would be effective in limiting the long-term movement of residual contaminants in closed tanks to nearby streams via groundwater. Concentrations of non-radiological contaminants moving to Upper Three Runs via the Upper Three Runs seepline would be minuscule, in most cases several times below applicable standards. Concentrations of non-radiological contaminants reaching Upper Three Runs and Fourmile Branch would be low under the No Action Alternative as well, but somewhat higher than those expected under the Clean and Stabilize Tanks Alternative. In all instances, predicted long-term concentrations of nonradiological contaminants would be well below applicable water quality standards.

The fate and transport modeling indicates that movement of residual radiological contaminants from closed HLW tanks to nearby surface waters via groundwater would also be limited by the three stabilization options under the Clean and Stabilize Tanks Alternative. Based on the modeling results, all three stabilization options under the Clean and Stabilize Tanks Alternative would be more effective than the No Action Alternative. The Clean and Fill with Grout Option would be the most effective of the three tank stabilization options as far as minimizing long-term movement of residual radiological contaminants.

Water resources/groundwater – The highest concentrations of radionuclides in groundwater would occur under the No Action Alternative. For this alternative, the EPA primary drinking water maximum contaminant level of 4.0 millirem per year for beta-gamma emitting radionuclides would be exceeded at all points of exposure since essentially all of the drinking water dose is due to beta-gamma emitting radionuclides. The Clean and Fill with Grout Option shows the lowest groundwater concentrations of radionuclides at all exposure points. Only this option and the Clean and Fill with Sand Option would meet the maximum contaminant level at the seepline. The beta-gamma maximum contaminant level would be substantially exceeded at the 1-meter and 100-meter wells under all alternatives.

The results for alpha-emitting radionuclides also show that the highest concentrations would occur for the No Action Alternative. For this alternative, the maximum contaminant level of 15 picocuries per liter would be exceeded at the 1-meter and 100-meter wells for both tank farms

Table 2-4. Summary comparison of long-term impacts by tank closure alternative.[a]

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option
Geologic Resources	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated
Surface Water	Limited movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters
Nonradiological constituents in Upper Three Runs at point of compliance (mg/L)				
Aluminum	(b)	(b)	(b)	(b)
Chromium IV	(b)	(b)	(b)	(b)
Copper	(b)	(b)	(b)	(b)
Iron	3.7×10^{-5}	(b)	(b)	(b)
Lead	(b)	(b)	(b)	(b)
Mercury	(b)	(b)	(b)	(b)
Nickel	(b)	(b)	(b)	(b)
Silver	1.2×10^{-6}	(b)	(b)	(b)
Nonradiological constituents in Fourmile Branch at point of compliance (mg/L)				
Aluminum	(b)	(b)	(b)	(b)
Chromium IV	(b)	(b)	(b)	(b)
Copper	(b)	(b)	(b)	(b)
Iron	4.9×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Lead	(b)	(b)	(b)	(b)
Mercury	(b)	(b)	(b)	(b)
Nickel	(b)	(b)	(b)	(b)
Silver	1.1×10^{-4}	8.8×10^{-5}	6.5×10^{-6}	8.8×10^{-6}

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option
Maximum dose from beta-gamma emitting radionuclides in surface water (millirem/year)				
Upper Three Runs	0.45	(b)	4.3×10^{-3}	9.6×10^{-3}
Fourmile Branch	2.3	9.8×10^{-3}	0.019	0.130
Groundwater				
Groundwater concentrations from contaminant transport – F-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline, Fourmile Branch (1,800 meters downgradient)	430	1.9	3.5	25
Alpha concentration (pCi/L)				
1-meter well	1,700	13	13	13
100-meter well	530	4.8	4.7	4.8
Seepline, Fourmile Branch (1,800 meters downgradient)	9.2	0.04	0.039	0.04
Groundwater concentrations from contaminant transport – H-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1×10^{5}
100-meter well	9.0×10^{4}	300	920	870
Seepline (1,200 meters downgradient)				
North of Groundwater Divide	2,500	2.5	25	46
South of Groundwater Divide	200	0.95	1.4	16
Alpha concentration (pCi/L)				
1-meter well	13,000	24	290	24

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option
100-meter well	3,800	7.0	38	7.0
Seepline, North of Groundwater Divide	34	0.15	0.33	0.15
Seepline, South of Groundwater Divide	4.9	0.02	0.19	0.02
Ecological Resources				
Maximum hazard indices for aquatic environments	2.0	1.42	0.18	0.16
Maximum hazard quotients for terrestrial environments				
Aluminum	(c)	(c)	(c)	(c)
Barium	(c)	(c)	(c)	(c)
Chromium	0.04	0.02	(c)	(c)
Copper	(c)	(c)	(c)	(c)
Fluoride	0.19	0.08	0.01	0.01
Lead	(c)	(c)	(c)	(c)
Manganese	(c)	(c)	(c)	(c)
Mercury	(c)	(c)	(c)	(c)
Nickel	(c)	(c)	(c)	(c)
Silver	1.55	0.81	0.09	0.13
Uranium	(c)	(c)	(c)	(c)
Zinc	(c)	(c)	(c)	(c)
Maximum absorbed dose to aquatic and terrestrial organisms (in millirad per year):				
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Land Use	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS
Public Health				
Radiological contaminant transport from F-Tank Farm:				
Adult resident latent cancer fatality risk	2.2×10^{-4}	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}
Child resident latent cancer fatality risk	2.0×10^{-4}	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}
Seepline worker latent cancer fatality risk	2.2×10^{-7}	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}
Intruder latent cancer fatality risk	1.1×10^{-7}	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}
Adult resident maximum lifetime dose (millirem)[f]	430	1.9	3.6	26
Child resident maximum lifetime dose (millirem)[f]	400	1.7	3.3	24
Seepline worker maximum lifetime dose (millirem)[f]	0.54	0.002	0.004	0.03
Intruder maximum lifetime dose (millirem)[f]	0.27	0.001	0.002	0.02
1-meter well drinking water dose (millirem per year)	3.6×10^{5}	130	420	790
1-meter well alpha concentration (picocuries per liter)	1,700	13	13	13
100-meter well drinking water dose (mrem/yr)	1.4×10^{4}	51	190	510
100-meter well alpha concentration (picocuries per liter)	530	4.8	4.7	4.8
Seepline drinking water dose (millirem per year)	430	1.9	3.5	25
Seepline alpha concentration (picocuries per liter)	9.2	0.04	0.039	0.04
Radiological contaminant transport from H-Tank Farm:				
Adult resident latent cancer fatality risk	8.5×10^{-5}	2.0×10^{-6}	5.5×10^{-7}	6.5×10^{-6}
Child resident latent cancer fatality risk	7.5×10^{-5}	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}
Seepline worker latent cancer fatality risk	8.4×10^{-8}	(e)	4.0×10^{-10}	6.8×10^{-9}
Intruder latent cancer fatality risk	4.4×10^{-8}	(e)	(e)	3.2×10^{-9}

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Adult resident maximum lifetime dose (millirem)[f]	170	4	1.1	13
Child resident maximum lifetime dose (millirem)[f]	150	0.65	1.1	1.3
Seepline worker maximum lifetime dose (millirem)[f]	0.21	(d)	0.001	0.017
Intruder maximum lifetime dose (millirem)[f]	0.11	(d)	(d)	0.008
1-meter well drinking water dose (millirem per year)	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1.0×10^{5}
1-meter well alpha concentration (picocuries per liter)	13,000	24	290	24
100-meter well drinking water dose (millirem per year)	9.0×10^{4}	300	920	870
100-meter well alpha concentration (picocuries per liter)	3,800	7.0	38	7.0
Seepline drinking water dose (millirem per year)	2.5×10^{3}	2.5	25	46
Seepline alpha concentration (picocuries per liter)	34	0.15	0.33	0.15

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities; impacts of this facility are evaluated in the SRS Waste Management EIS (DOE/EIS-0217).

b. Radiation dose less than 1.0×10^{-6} or non-radiological concentration less than 1.0×10^{-6} mg/L.

c. Hazard quotient is less than ~ 1×10^{-2}.

d. The radiation dose for this alternative is less than 1×10^{-3} millirem.

e. The risk for this alternative is less than 4.0×10^{-10}.

f. Calculated based on an assumed 70-year lifetime.

Table 2-5. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, 1-meter well.[a]

	Maximum concentration (percent of MCL)				
1-Meter well	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	18.5	320	6,500	150
Barnwell McBean	0.0	47.5	380	0.0	270
Congaree	0.0	6.8	0.0	0.0	62
Grout Fill Option					
Water Table	0.0	0.3	21	70	2.3
Barnwell McBean	0.0	5	23	0.0	21
Congaree	0.0	0.1	0.0	0.0	0.5
Saltstone Fill Option					
Water Table	0.0	0.3	21	70	240,000
Barnwell McBean	0.0	5	23	0.0	440,000
Congaree	0.0	0.1	0.0	0.0	160,000
Sand Fill Option					
Water Table	0.0	1.6	8.5	37	6.7
Barnwell McBean	0.0	5.3	19	0.0	22
Congaree	0.0	0.1	0.0	0.0	0.7

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

Table 2-6. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, 100-meter well.[a]

	Maximum concentration (percent of MCL)				
100-Meter well	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	8.3	74	265	69
Barnwell McBean	0.0	12.5	81	0.0	58
Congaree	0.0	1.2	0.0	0.0	11
Grout Fill Option					
Water Table	0.0	0.1	2.7	1.5	0.7
Barnwell McBean	0.0	1.1	4.4	0.0	4.7
Congaree	0.0	0.0	0.0	0.0	0.1
Saltstone Fill Option					
Water Table	0.0	0.1	2.7	1.5	68,000
Barnwell McBean	0.0	1.1	4.4	0.0	180,000
Congaree	0.0	0.0	0.0	0.0	21,000
Sand Fill Option					
Water Table	0.0	0.3	1.5	2.7	1.3
Barnwell McBean	0.0	1.2	3.7	0.0	4.9
Congaree	0.0	0.0	0.0	0.0	0.1

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

Table 2-7. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, seepline.[a]

	Maximum concentration (percent of MCL)				
Fourmile Branch seepline	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	0.4	1.0	0.0	3.4
Barnwell McBean	0.0	0.5	0.8	0.0	2.4
Congaree	0.0	0.0	0.0	0.0	0.1
Grout Fill Option					
Water Table	0.0	0.0	0.0	0.0	0.0
Barnwell McBean	0.0	0.0	0.0	0.0	0.1
Congaree	0.0	0.0	0.0	0.0	0.0
Saltstone Fill Option					
Water Table	0.0	0.0	0.0	0.0	3,000
Barnwell McBean	0.0	0.0	0.0	0.0	3,300
Congaree	0.0	0.0	0.0	0.0	300
Sand Fill Option					
Water Table	0.0	0.0	0.0	0.0	0.1
Barnwell McBean	0.0	0.0	0.0	0.0	0.2
Congaree	0.0	0.0	0.0	0.0	0.0

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

and the seepline north of the groundwater divide for H-Tank Farm. The Grout, Sand, and Saltstone Options show similar concentrations at most locations. For these three options, the maximum contaminant level for alpha-emitting radionuclides would be exceeded only in H-Area at the 1-meter well (all three options) and at the 100-meter well (Sand Option).

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tank systems themselves would be removed and transported to SRS radioactive waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217). The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are about one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health.

For nonradiological constituents, the EPA primary drinking water maximum contaminant levels would be exceeded only for the No Action Alternative and Clean and Fill with Saltstone Option. The impacts would be greatest in terms of the variety of contaminants that exceed the maximum contaminant level for the No Action Alternative, but exceedances of the maximum contaminant levels only occur primarily at the 1-meter well, with mercury exceeding the MCL also at the 100-meter well. Impacts from the Clean and Fill with Saltstone Option would occur at all exposure points, including the seepline; however, nitrate is the only contaminant that would exceed its maximum contaminant level. The maximum contaminant levels would not be exceeded for any contaminant in any aquifer layer, at any point of exposure, for either the Grout or the Sand Options.

Ecological resources – Risks to aquatic organisms in Fourmile Branch and Upper Three Runs for non-radiological contaminants would be negligible under the Clean and Fill with Sand and Clean and Fill with Saltstone Options. For the Clean and Fill with Grout Option and the No Action Alternative, there would be relatively low risk to aquatic organisms.

Risks to terrestrial organisms such as the shrew and mink (and other small mammalian carnivores with limited home range sites) from non-radiological contaminants would be negligible for all options under the Clean and Stabilize Tanks Alternative. For the No Action Alternative, there would be generally low risk to terrestrial organisms.

All calculated radiological doses to terrestrial and aquatic animal organisms were well below the limit of 365,000 millirad per year (1.0 rad per day) established in DOE Order 5400.5, including the No Action Alternative.

Land use – Long-term land use impacts at the tank farm areas are not expected because of DOE's established land use policy for the SRS. In the *Savannah River Site Future Use Plan*, DOE established a future use policy for the SRS. Several key elements of that policy would maintain the lands that are now part of the tank farm areas for heavy industrial use and exclude use from non-conforming land uses. Most notable are:

- Protection and safety of SRS workers and the public shall be a priority.

- The integrity of site security shall be maintained.

- A "restricted use" program shall be developed and followed for special areas (e.g., CERCLA and RCRA regulated units).

- SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government.

- Residential uses of all SRS land shall be prohibited in any area of the site.

As mentioned above, the tank farm areas will remain in an industrialized zone. In principle, industrial zones are ones in which the facilities pose either a potentially significant nuclear or non-nuclear hazard to employees or the general public. In the case of the Industrial-Heavy Nuclear zone, facilities included (1) produce, process, store and/or dispose of radioactive liquid or solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations.

Public health – DOE evaluated the impacts over a 10,000-year period. Structural collapse of the tanks would pose a safety hazard under the No Action Alternative, creating unstable ground conditions and forming holes into which workers or other site users could fall. Neither the Clean and Stabilize Tanks Alternative nor the Clean and Remove Tanks Alternative would have this safety hazard, although there could be some moderate ground instability with the Clean and Fill with Sand Option. Airborne releases from the tanks are considered to be possible only under the No Action Alternative, and their likelihood is considered to be minimal for that alternative because the presence of moisture and the considerable depth of the tanks below grade would tend to discourage resuspension of tank contents. Therefore, the principal source of potential impacts to public health is leaching and groundwater transport of contaminants. DOE calculated risks to public health based on postulated release and transport scenarios.

The maximum calculated dose to the adult resident for either tank farm, as presented in Table 2-3, would be 430 mrem for a 70-year lifetime for the No Action Alternative. This dose is less than the 100 mrem per year public dose limit and represents only a marginal increase in the annual average exposure of individuals in the United States of approximately 360 mrem due to natural and manmade sources of radiation exposure. Based on this low dose, DOE would not expect any health effects if an individual were to receive this hypothetical dose.

At the one-meter well, the highest calculated peak drinking water dose under the No Action Alternative is 9,300,000 millirem per year (9,300 rem per year), which would lead to acute radiation health effects, including death. Peak doses at this well for the Clean and Stabilize Tanks Alternative are calculated to be in the range of 100,000 to 130,000 millirem per year (100 to 130 rem per year), which substantially exceeds all criteria for acceptable exposure, could result in acute health effects, and would give a significantly increased probability of a latent cancer fatality. Peak doses calculated at the 100-meter well range from 300 millirem (0.3 rem per year) per year for the Clean and Fill with Grout Option to 90,000 millirem per year (90 rem per year) for the No Action Alternative. Individuals exposed to 300 millirem per year would experience a lifetime increased risk of latent cancer fatality of less that 0.02 percent per year of exposure. The estimated doses at the 1- and 100-meter wells are extremely conservative (high) estimates because the analysis treated all of the tanks in a given group as being at the same physical location. Realistic doses at these close-in locations would be substantially smaller.

DOE considered the potential exposures to people who live in a home built over the tanks at some time in the future when they are unaware that the residence was built over closed waste tanks. DOE previously modeled this type of exposure for the saltstone disposal vaults in the Z Area. That analysis found that external radiation exposure was the only potentially significant pathway of potential radiological exposure other than groundwater use (WSRC 1992). For the Clean and Fill with Grout and Clean and Fill with Sand Options of the Clean and Stabilize Tanks Alternative, external radiation doses to onsite residents would be negligible because the thick layers of nonradioactive material between the waste (near the bottom of the tanks) and the ground surface would shield residents from any direct radiation emanating from the waste. External radiation exposures could occur under the Clean and Fill with Saltstone Option which would place radioactive saltstone near the ground surface. If it is conservatively assumed that all of the backfill soil is eroded or excavated away and there is no other cap over the saltstone, so that a home is built directly on the saltstone, analysis presented in WSRC (1992) indicates that 1000 years after tank closure a resident would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. Backfill soils or caps would eliminate or substantially reduce the potential external exposure. For example, with a 30-inch-thick intact concrete cap, the dose would be reduced to 0.1 mrem/year. For the No Action Alternative external exposures to onsite residents would be expected to be unacceptably high due to the potential for contact with the residual waste.

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