APPENDIX B

ACCIDENT ANALYSIS

TABLE OF CONTENTS

List of Tables

APPENDIX B. ACCIDENT ANALYSIS

This appendix provides detailed information on potential accident scenarios associated with closure of the high-level waste (HLW) tanks at Savannah River Site (SRS). The appendix provides estimates of the quantity and composition of hazardous materials that could be released in an accident and the consequences to workers and the public, estimated in terms of dose and latent cancer fatalities for radiological releases and of concentration levels for chemical releases.

The primary sources of information for the accident analyses are a specific calculation (Yeung 1999) and the *Safety Analysis Report - Liquid Radioactive Waste Handling Facility* (WSRC 1998a).

B.1 General Accident Information

An accident, as discussed in this appendix, is an inadvertent release of radiological or chemical hazardous materials as a result of a sequence of one or more probable events. The sequence usually begins with an initiating event, such as a human error, equipment failure, or earthquake. This is followed by a succession of other events (that could be dependent or independent of the initial event) which dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

- *Internal initiators* – normally originate in and around the facility, but are always a result of facility operations. Examples include equipment or structural failures and human errors.

- *External initiators* – are independent of facility operations and normally originate from outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.

- *Natural phenomena initiators* – are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

The likelihood of an accident occurring and its consequences usually depend on the initiator and the sequence of events and their frequencies or probabilities. Accidents can be grouped into four categories–anticipated, unlikely, extremely unlikely, and beyond extremely unlikely, as described in Table B-1. The U.S. Department of Energy (DOE) based the frequencies of accidents at the liquid radioactive waste handling facility on safety analyses and historical data about event occurrences.

B.2 Accident Analysis Method

For the alternatives for HLW tank closure, Yeung (1999) identified potential accident scenarios that involved the release of both radiological and nonradiological, hazardous materials. Section B.2.1 provides information about the various alternatives for tank closure. Section B.2.2 provides details about the specific analytical methods that were used in this appendix.

The accident sequences analyzed in this environmental impact statement (EIS) would occur at frequencies generally greater than once in 1,000,000 years. However, the analyses considered accident sequences with smaller frequencies, if their impacts could provide information important to decision making.

Table B-1. Accident frequency categories.

Accident frequency category	Frequency range (occurrences per year)	Description
Anticipated	Less than once in 10 years, but greater than once in 100 years	Accidents that might occur several times during facility lifetime
Unlikely	Less than once in 100 years, but greater than once in 10,000 years	Accidents that are not likely to occur during facility lifetime; natural phenomena include Uniform Building Code-level earthquake, maximum wind gust, etc.
Extremely unlikely	Less than once in 10,000 years, but greater than once in 1,000,000 years	Accidents that probably will not occur during facility life cycle; this includes the design basis accidents
Beyond extremely unlikely	Less than once in 1,000,000 years	All other accidents

Source: DOE (1994).

B.2.1 HIGH-LEVEL WASTE TANK CLOSURE ALTERNATIVES

DOE has organized the accident data in this appendix by alternative. DOE has also organized the accident impacts in Chapter 4 by alternative to reflect potential accident occurrences for each associated alternative.

Approximately 37 million gallons of HLW are stored in underground tanks in F Area and H Area. DOE intends to remove from service all 51 HLW tanks. Because two of these tanks (Tanks 17 and 20) are already closed, this appendix addresses the potential impacts from accidents associated with the closure of the 49 remaining waste tanks.

The alternatives considered in this EIS include:

- No Action Alternative
- Stabilize Tanks Alternative:
  - Fill with Grout Option (Preferred Alternative)
  - Fill with Sand Option
  - Fill with Saltstone Option
- Clean and Remove Tanks Alternative

B.2.2 RADIOLOGICAL HAZARDS

The accidents identified for HLW tank closure are described in Section B.3. These descriptions include an approximation of the material at risk (MAR) that would potentially be involved in a given accident. Depending on the particular scenario, release fractions have been applied to the MAR to determine the amount of the materials that would be released to the environment. This amount is referred to as the source term. Source terms are provided in Yeung (1999) for airborne, ground surface runoff, and underground releases. The airborne releases are of short duration and could have impacts to the worker and offsite populations. The surface runoff and underground releases, however, would not have short-term impacts to any of the analyzed receptors. In the case of surface runoff, DOE would employ mitigative actions to prevent the release from reaching the Savannah River (i.e., clean-up actions, berms, dams in surface water pathways, etc.). In the unlikely event that radionuclides reached the river, DOE's mitigative actions would include notification of municipalities downstream that use the Savannah River for drinking water supplies. These mitigative actions would preclude any offsite dose from a liquid release pathway. In the case of underground releases, radiological materials released directly into the soil would take a long period of time to reach any of the human receptors evaluated in this analysis. The potential consequences of such releases are determined as part of the EIS long-term impacts.

The analysis of airborne releases used the computer code AXAIRQ to model accidental atmospheric radioactive releases from SRS that are of relatively short duration. AXAIRQ strictly follows the guidance in Regulatory Guide 1.145 (NRC 1982) on accidental releases and has been verified and validated (Simpkins 1995a and 1995b). Because all considered accidents would occur at or below ground level, the releases for AXAIRQ assumed ground-level releases with no modification for release height. In accordance with the Regulatory Guide, the code considers plume meander and fumigation under certain conditions. Information on plume rise due to buoyancy or momentum is not available. The program uses a 5-year meteorological database for SRS and determines the shortest distance to the Site boundary in each of the 16 sectors by determining the distance to one of 875 locations along the boundary. The impacts that were derived from the use of this code used the average (50 percent) meteorology. Because these accidents could occur in either F or H Area at SRS, the largest unit dose conversion factor was chosen (applicable to F or H Area), dependent on the receptor being evaluated. The code uses the shortest distance in each sector to calculate the concentration for that sector. DOE used the computer code PRIMUS, which was developed by the Oak Ridge National Laboratory, to consider decay and daughter ingrowth.

Simpkins (1997) provided unit dose conversion factors for a wide list of radionuclides for release locations in F and H Areas. These factors were applied to the airborne source terms to calculate the doses to the various receptors.

The analysis assumes that all tritium released would have the form of tritium oxide and, following International Commission on Radiological Protection methodology, the dose conversion factor for tritium has been increased by 50 percent to account for absorption through the skin. For population dose calculations, age-specific breathing rates are applied, but adult dose conversion factors are used. Radiation doses were calculated to the maximally exposed individual, to the population within 50 miles of the facility, and to a noninvolved worker assumed to be 640 meters downwind of the facility.

After DOE calculated the total radiation dose to the public, it used dose-to-risk conversion factors established by the National Council on Radiation Protection and Measurements (NCRP) to estimate the number of latent cancer fatalities (LCFs) that could result from the calculated exposure. No data indicate that small radiation doses cause cancer; however, to be conservative, the NCRP assumes that any amount of radiation has some risk of inducing cancer. DOE has adopted the NCRP factors of 0.0005 LCF for each person-rem of radiation exposure to the general public and 0.0004 LCF for each person-rem of radiation exposure to radiation workers (NCRP 1993).

B.2.3 CHEMICAL HAZARDS

For chemically toxic materials, the long-term health consequences of human exposure to hazardous materials are not as well understood as those related to radiation exposure. A determination of potential health effects from exposures to chemically hazardous materials, as compared to radiation, is more subjective. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

To determine the potential health effects to workers and the public that could result from accidents involving hazardous materials, the airborne concentrations of such materials released during an accident at varying distances from the point of release were compared to the Emergency Response Planning Guideline (ERPG) values (AIHA 1991). The American Industrial Hygiene Association established these values, which depend on the chemical substance, for the following general severity levels to ensure that the necessary emergency actions occur to minimize exposures to humans.

- ERPG-1 Values. Exposure to airborne concentrations greater than ERPG-1 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects or perception of a clearly defined objectionable odor.

- ERPG-2 Values. Exposures to airborne concentrations greater than ERPG-2 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impair a person's ability to take protective action.

- ERPG-3 Values. Exposure to airborne concentrations greater than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

Not all hazardous materials have ERPG values. For chemicals that do not have ERPG values, a comparison was made to the most restrictive available exposure limits established by other guidelines to control worker accidental exposures to hazardous materials. In this document, the ERPG-2 equivalent that is used is the PEL-TWA (Permissible Exposure Limit – Time Weighted Average) from 29 Code of Federal Regulations (CFR) Part 1910.1000, Subpart Z.

B.3 Postulated Accident Scenarios Involving Radioactive Materials

These sections describe the potential accident scenarios associated with each alternative that could involve the release of radioactive materials. The impacts of these scenarios are shown in Section B.4.

B.3.1 STABILIZE TANKS ALTERNATIVE

The Stabilize Tanks Alternative, including all of its stabilization options, could require cleaning the inside of the tank. This cleaning could involve a two-step process. Initially, after bulk waste removal, the waste tank interiors would be water-washed, using rotary spray jets put down into the tank interior through the tank risers. Water for these jets would be supplied from a skid-mounted tank and pump system. Following water washing, additional cleaning may be required, using a hot oxalic acid solution through the same spray jets.

Six potential accident scenarios associated with the cleaning process that required evaluation were identified in Yeung (1999). These included:

- Deflagration
- Transfer errors
- Vehicle impacts
- Chemical (oxalic acid) spill
- Seismic event
- Tornado

Criticality was not addressed as a potential accident scenario in Yeung (1999) because DOE considers inadvertent criticality to be beyond extremely unlikely in the HLW tanks (Nomm 1995). The criticality safety of the waste sludge was based on the neutron-absorbing characteristics of the iron and manganese contained in the sludge. However, the review assumed that the waste would remain alkaline and did not address the possibility that chemicals wold be used that would dissolve sludge solids. Therefore, the *Safety Analysis Report - Liquid Radioactive Waste Handling Facility* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited.

A formal Nuclear Criticality Safety Evaluation (Unreviewed Safety Question Evaluation and subsequent Safety Analysis Report revision) must be completed before oxalic acid could be introduced into the tank farms. Oxalic acid can dissolve uranium, plutonium, and the two neutron poisons that are credited for preventing a criticality - iron and manganese. The Nuclear Criticality Safety Evaluation would address the relative rates at which each of these species dissolves and would examine potential scenarios that could cause fissile material to concentrate.

TC The tanks would be back-filled with a pumpable material (grout, sand, or saltstone). Yeung (1999) indicated that the scenarios identified above for the cleaning operations bound all postulated accidents during back-filling the EC waste tanks with either grout or sand. Because saltstone is a radioactive material, any TC uncontrolled release of radioactive materials associated with the Fill with Saltstone Option must be evaluated. WSRC (1992a) evaluated a failure of the Salt Solution Hold Tank. Yeung (1999) identified no accident scenarios for the post-closure period for this alternative.

B.3.1.1 Deflagration

Scenario: One postulated accident during cleaning of the waste tanks would be a release of radiological materials due to an explosion inside of the waste tank. The explosion could possibly consist of a deflagration or detonation. The transition from deflagration to detonation would occur only if the deflagration flame front accelerates to sonic speeds. In order for the deflagration to occur, flammable chemicals must be introduced into the waste tanks as a result of human error, and ignition sources must be present (Yeung 1999).

Probability: The determination of the probability of this event was based on the availability of flammable chemicals, the EC potential that they would be introduced into the waste tanks, and the fact that an ignition source is present. There are no flammable chemicals required for the cleaning process. For a deflagration to occur, multiple operator errors and violation of multiple administrative controls would be required. From Benhardt et al. (1994), the combined probability of violation of an administrative control bringing in the flammable chemical and chemical addition into the tank would be 1.5×10^{-6} per year. Considering that, in addition to the above, a significant amount of EC flammable material would be required to be introduced into a tank (e.g., 440 kilograms of benzene), by engineering judgment, the additional probability of this event was EC estimated to be 1×10^{-2} per year (Yeung 1999). Therefore, the probability of a deflagration during the cleaning process was estimated to be 1.5×10^{-8} per year. Because the tanks are EC relatively free of internal structures, the transition from deflagration to detonation occurs less than one time in a hundred for a near stoichiometric mixture. Therefore, the frequency of a detonation event was estimated to be 1×10^{-10} per year (Yeung 1999).

Because the likelihood of these events is well EC below 1×10^{-7}, they are considered beyond extremely unlikely and are not evaluated further in this EIS.

B.3.1.2 Transfer Errors

Scenario: The *Safety Analysis Report - Liquid Radioactive Waste Handling Facility* (WSRC EC 1998a) reports that all transfer error events in the Liquid Radioactive Waste Handling Facility can be bounded by a waste tank overflow event, which would result in an aboveground spill of 15,600 gallons of waste (520 [gpm] for 30 minutes). A postulated accident during water spray washing of the waste tanks would be a release of diluted waste, due to continuous maximum flow through a transfer line direct to the environment for 30 minutes without operator intervention. WSRC (1998a) assumed that the spill would occur aboveground and result in seepage into the ground and evaporation into the air. This scenario would bound all leak/spill events, including loss of containment. L-7-83

Probability: It is considered unlikely that aboveground equipment failures leading to leakage or catastrophic release of the tank contents would go undetected (WSRC 1998a). Therefore, failures of aboveground equipment and the failure of the operators to detect and stop the leaks were considered in Yeung (1999). It was estimated that equipment failures and operator errors to detect and stop the leaks leading to the release of the bounding source terms described below could occur with a frequency of 1×10^{-3} per year (Yeung 1999). This frequency is in the unlikely range.

Source Term: After bulk waste removal and before spray washing, there would be approximately 9,000 gallons of HLW in the form of sludge or sludge slurry left in each tank. Based on the bounding sludge dose potential as given in the *Safety Analysis Report* (WSRC 1998a), it was assumed that the sludge slurry before spray washing would be characterized by the activities of 81,000 curies (Ci) of plutonium-238 (Pu-238) and 2,180,000 Ci of strontium-90 (Sr-90). The volume of the water used for spray cleaning was assumed to be 140,000 gallons (WSRC 1998b). This would result in a total waste volume of 149,000 gallons, with nuclide concentrations in the diluted waste solution estimated at 0.54 Ci/gallons and 14.63 Ci/gallons for Pu-238 and Sr-90, respectively. The instantaneous airborne release for a spill of 15,600 gallons was estimated to be 0.34 Ci of Pu-238 and 9.1 Ci of Sr-90 (Yeung 1999). An additional entrainment source term of 0.34 Ci of Pu-238 and 9.1 Ci of Sr-90 was estimated, assuming no mitigative actions were taken within a 10-hour period following the event.

B.3.1.3 <u>Vehicle Impact</u>

Scenario: Another postulated accident during cleaning of the waste tanks would be a release of diluted waste, due to failure of the aboveground pumping equipment and piping resulting from a construction vehicle impact. It was assumed that the equipment used to pump out the wastewater slurry from the tanks would be damaged to the point where pumping continued, releasing the slurry onto the ground.

Probability: The frequency of a vehicle crash occurring over all the Liquid Radioactive Waste Handling Facilities is bounded between 7.4×10^{-4} and 4.7×10^{-3} events per year (WSRC 1998a). The *Safety Analysis Report* (WSRC 1998a) conservatively assumes that 0.1 percent of the accidents occurring at the H Area and F Area Tank Farms impact aboveground equipment, resulting in an overall frequency of 2.7×10^{-6} per year. The possibility that a fire could occur following a crash was also evaluated. Assuming that 97.7 percent of all truck accidents are minor (WSRC 1992b), and that fires resulting from minor accidents have an extremely low probability, the overall frequency of a fire resulting from a vehicle crash is estimated to be 6.2×10^{-8} per year. Therefore, vehicle impacts involving a coincident fire were considered to be beyond extremely unlikely.

Source Term: The MAR for this scenario was assumed to be the same as that in Section 3.1.2. Because the source term for this scenario is the same as estimated for the transfer errors and the expected frequency is smaller, the risk associated with this scenario would be bounded by the transfer errors accident. No further evaluation of vehicle impacts is required in this appendix. EC EC

B.3.1.4 <u>Chemical (Oxalic Acid) Spill</u>

This accident would involve the release of nonradiological hazardous materials, which is addressed in Section B.5.

B.3.1.5 <u>Seismic Event</u>

Scenario: Yeung (1999) postulated that a design basis earthquake could occur during cleaning of the waste tanks, resulting in a release of liquid radiological materials. Only one tank in each tank farm would undergo closure at any one time. It was therefore assumed that the earthquake would occur immediately following water spray washing, which had been performed on two tanks simultaneously (one in each tank farm). The seismic event was assumed to fail the same transfer piping and equipment as was mentioned in the previous scenarios.

Probability: The design basis earthquake has an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the cleaning of two tanks would take approximately 14 days, a release of the bounding source term would occur at an annual probability of 1.9×10^{-5}. This accident would be categorized as extremely unlikely.

Source Term: The aboveground MAR was assumed to be same as in Section 3.1.2, except that the source term would be doubled because two tanks would be involved. Yeung (1999) provided the source term as an instantaneous airborne release of 0.68 Ci of Pu-238 and 18 Ci of Sr-90. If mitigation measures were not taken, entrainment would result in an additional airborne release of 0.68 Ci of Pu-238 and 18 Ci of Sr-90 over a 10-hour period.

B.3.1.6 Tornado

The design basis tornado was postulated to occur during water spray washing of the waste tanks. From WSRC (1998a), it was assumed that administrative controls stipulate the cessation of EC waste transfer operations at the first instance of a tornado/high wind warning.

All waste tanks are underground and are EC protected by concrete roofs. With all transfer operations stopped, there would be no MAR aboveground. Some aboveground components of the transfer system may fail, but their contributions to the release of radiological materials were considered insignificant (Yeung 1999). As a result, this scenario would be bounded by several other scenarios and is not EC evaluated further.

B.3.1.7 Failure of Salt Solution Hold Tank

Scenario: This scenario assumes that a Saltstone Mixing Facility would be built in F Area and H Area, similar to that currently operating in Z Area. This accident would involve a worst-case release of the salt solution contained in a Salt Solution Hold Tank, prior to mixing with cement, flyash, and slag to form the saltstone. The Salt Solution Hold Tank was assumed to contain 45,000 gallons of salt solution. The entire volume was assumed to be EC released and allowed to evaporate over a 2-hour period (WSRC 1992a). No credit was taken for operator intervention, absorption into the ground, or containment of the spill in the diked area of the tank. In reality, this would significantly reduce the airborne release. It would take an extremely high-energy event to vaporize such a large quantity in such a short period of time (WSRC 1992a). Failure of the Salt Solution Hold Tank was assumed to occur during the design basis earthquake.

Probability: The design basis earthquake has an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the Salt Solution Hold Tank has a 10 percent chance of failing during the earthquake, a release of the bounding source term was estimated to occur at an annual probability of 5×10^{-5}. This scenario would be extremely unlikely.

Source Term: The 45,000 gallons of salt solution (1.2 kilograms per liter) in the Salt Solution Hold Tank was assumed to contain the radionuclides in Table B-2 (WSRC 1992a). Table B-2 also contains the assumed release fractions resulting in the final estimated source terms (unmitigated) (WSRC 1992a). This accident would also involve the release of nonradiological hazardous materials. The evaluation of these releases is addressed in Section B.5.

B.3.2 CLEAN AND REMOVE TANKS ALTERNATIVE

Following bulk waste removal, water spray washing, and additional cleaning (including the EC use of oxalic acid), additional cleaning steps (yet to be defined) would be performed until the tanks are clean enough to remove. The additional cleaning steps would increase worker radiation exposure and contamination. They would also increase the potential for industrial safety accidents. Following cleaning, the tank components would be sectioned, removed, placed in burial boxes for disposal, and transported to onsite waste disposal facilities.

The scenarios in Section B.3.1 were assumed to bound any postulated tank accident scenarios associated with this alternative.

B.3.2.1 Flooding

Scenario: Yeung (1999) postulated that abandoning the waste tanks in place following waste removal would lead to long-term tank degradation, failure of the tank roofs, and EC exposure of the radiological materials to potential flooding and release to the environment. DOE has assumed that institutional control would be maintained for a period of at least 100 years. Beyond EC institutional control, it has been assumed that the waste tanks would retain their basic structural

Table B-2. Radiological source term for failure of Salt Solution Hold Tank.

Radionuclide	Activity (curies)[a]	Assumed release fraction	Total airborne activity released (curies)[a]
H-3	380	1.0	380
Co-60	15	1.0×10^{-4}	0.0015
Sr-89	13	1.0×10^{-4}	0.0013
Sr-90	13	1.0×10^{-4}	0.0013
Tc-99	210	1.0×10^{-2}	2.1
Ru-106	130	1.0×10^{-2}	1.3
Sb-125	31	1.0×10^{-2}	0.31
I-129	4.2	3.0×10^{-1}	1.3
Cs-137	21	1.0×10^{-2}	0.21
Ba-137m	21	1.0×10^{-2}	0.21
Eu-154	3.4	1.0×10^{-4}	0.00034
Total alpha	11	1.0×10^{-4}	0.0011
Other beta-gamma	840	1.0×10^{-4}	0.084
Total	1680		383

Source: WSRC (1992a)
a. Values rounded to 2 significant figures.

integrity for another 100 years without catastrophic failure. Therefore, this EIS considers any impacts associated with failure of these waste tanks after a period of 200 years to be long-term impacts and they are not addressed further in this appendix.

B.3.3 NO ACTION ALTERNATIVE

For the No Action Alternative, no action would be taken to remove waste from the tanks beyond that which is included in bulk waste removal. Flooding was the only scenario identified in Yeung (1999), applicable to this alternative, which would result in an airborne release of radiological materials.

B.4 Accident Impacts Involving Radioactive Materials

This section presents the potential impacts associated with the accident scenarios involving the release of radioactive materials identified in Section B.3. Table B-3 provides the accident impacts for each of the scenarios from airborne releases. It also provides the resultant LCFs expected from the offsite impacts.

B.5 Postulated Accidents Involving Nonradioactive Hazardous Materials

This section summarizes the potential accident scenarios involving hazardous chemicals for the various alternatives. Two accidents involving hazardous material releases were identified in Yeung (1999).

B.5.1 OXALIC ACID SPILL

Scenario: A postulated accident during cleaning of the waste tanks would be a worst-case spill of 10,000 gallons of 4 percent (concentration) oxalic acid from any cause (vehicle crash, earthquake, or tornado). It was assumed that oxalic acid used for cleaning would be stored in an aboveground 10,000-gallon stainless steel portable tank. The oxalic acid was assumed to be heated to a temperature of 80°C. This scenario would bound all accidents involving a chemical release of oxalic acid.

Table B-3. Radiological impacts from airborne releases.

Accident	Total curies released	Accident frequency	Non-involved worker (rem)	Maximally exposed individual (rem)	Offsite population (person-rem)	Latent cancer fatalities
Transfer errors	19	Once in 1,000 years	7.3	0.12	5,500	2.8
Seismic (DBE)	38	Once in 53,000 years	14.6	0.24	11,000	5.5
Salt Solution Hold Tank failure	380	Once in 20,000 years	0.015	0.00042	16.7	0.0084

Probability: The annual probability of exceedance for the design basis earthquake is 5.0×10^{-4} (WSRC 1998c). Assuming that the oxalic acid tank would be used for 30 days of the year, the overall frequency was calculated to be 4.1×10^{-5} per year. For the design basis tornado, the annual probability of exceedance is 2×10^{-5} (WSRC 1998c). Combined with the 30-day time at risk, probability resulted in an overall annual probability of 1.6×10^{-6}. If the tank were moved into a shelter or protected by administrative controls (e.g., erect missile barrier and/or tie down the tank), the annual probability for this event could be reduced to 8×10^{-8} (Yeung 1999). If a vehicle crash is considered, the frequency of a vehicle crash occurring over all the Liquid Radioactive Waste Handling Facilities is bounded between 7.4×10^{-4} and 4.7×10^{-3} events per year (WSRC 1998a). Conservatively assuming that 0.1 percent of the accidents occurring at the F- and H-Area Tank Farms (WSRC 1998a) impact the oxalic acid tank resulted in an overall frequency of 2.7×10^{-6} per year. Considering these three different initiating events, the most credible scenario would be a design basis earthquake with an annual probability of 4.1×10^{-5}. This scenario would be extremely unlikely.

Source Term: The chemical release MAR would consist of 10,000 gallons of 4 percent oxalic acid. The oxalic acid source term was conservatively estimated to be an airborne release of 150 grams of 100-percent oxalic acid at a release rate of 168 milligrams per second (Yeung 1999).

B.5.2 FAILURE OF SALT SOLUTION HOLD TANK

Scenario: As described in Section B.3.1.7, this scenario would involve the failure of the Salt Solution Hold Tank, which would be used in one of the options in the Stabilize Tanks Alternative during preparation of the saltstone that would be used to backfill the empty tanks. The Salt Solution Hold Tank would contain both radiological and hazardous materials. The radiological impacts are discussed in Section B.4.

Probability: The initiating event that was assumed to cause the Salt Solution Hold Tank failure was a design basis earthquake with an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the Salt Solution Hold Tank has a 10-percent chance of failing during the earthquake, a release of the bounding source term was estimated to occur at an annual probability of 5×10^{-5}. This scenario would be extremely unlikely.

Source term: The source term for hazardous materials released from the failed Salt Solution Hold Tank is given in Table B-4. It was obtained from the *Safety Analysis Report for the Saltstone Facility* (WSRC 1992a).

Table B-4. Chemical source term for failure of Salt Solution Hold Tank.

Chemical	Total inventory in Salt Solution Hold Tank (kg)	Assumed release fraction	Evaporation release rate (milligrams per second)
Arsenic	170	1.0×10^{-4}	2.4
Barium	170	1.0×10^{-4}	2.4
Cadmium	51	1.0×10^{-4}	0.71
Chromium	340	1.0×10^{-4}	4.7
Lead	170	1.0×10^{-4}	2.4
Mercury	85	1.0×10^{-4}	1.2
Selenium	60	1.0×10^{-4}	0.83
Silver	170	1.0×10^{-4}	2.4
Benzene	0.52	1.0	73
Phenol	170	1.0×10^{-2}	240

Source: Yeung (1999).

B.6 Accident Impacts Involving Nonradioactive Hazardous Materials

As Section B.4 provided for the radiological consequences of identified accidents; this section provides the potential impacts associated with the release of nonradioactive hazardous materials from the two accident scenarios.

B.6.1 OXALIC ACID SPILL

The oxalic acid spill, described in Section B.5.1, would result in the release of 150 grams of oxalic acid at a release rate of 168 milligrams per second. Table B-5 provides atmospheric dispersion factors for the two individual receptors, the uninvolved worker and the maximally exposed offsite individual (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-5.

EC Because the Permissible Exposure Limit – Time Weighted Average (PEL-TWA), which equates to the ERPG-2 value described in Section B.2.3, is 1.0 milligrams per cubic meter for oxalic acid, there would be no significant impacts to the onsite or offsite receptors from this accident.

B.6.2 FAILURE OF SALT SOLUTION HOLD TANK

The failure of the Salt Solution Hold Tank, described in Section B.5.2, would result in the release of the hazardous chemical inventory provided in Table B-4. Table B-6 provides atmospheric dispersion factors for the two individual receptors, the non-involved worker and the maximally exposed offsite individual (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-6.

Because the most restrictive exposure limits for EC
these hazardous materials is 0.5 milligrams per cubic meter, there would be no significant impacts to the onsite or offsite receptors from this accident.

EC

B.7 Environmental Justice

In the event of an accidental release of radioactive or hazardous chemical substances, the dispersion of such substances would depend on meteorology conditions (such as wind direction) at the time. Given the variability of meteorology conditions, the low probability of accidents, the location of minority and low-income communities in relation to SRS, and the

Table B-5. Chemical concentrations to various receptors for oxalic acid spill accident.

Chemical	Evaporation release rate (milligrams per second)	Atmospheric dispersion factor (seconds per cubic meter)		Resultant concentration (micrograms per cubic meter)	
		Noninvolved worker	Maximally exposed individual	Noninvolved Worker	Maximally exposed individual
4-percent oxalic acid	168	1.7×10^{-4}	5.7×10^{-7}	0.03	0.0001

Table B-6. Chemical concentrations to various receptors for failure of the Salt Solution Hold Tank.

Chemical	Evaporation release rate (milligrams per second)	Atmospheric dispersion factor (seconds per cubic meter)		Resultant concentration (milligrams per cubic meter)	
		Noninvolved worker	Maximally exposed individual	Noninvolved Worker	Maximally exposed individual
Arsenic	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Barium	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Cadmium	0.71	1.7×10^{-4}	5.7×10^{-7}	0.0001	4.0×10^{-7}
Chromium	4.7	1.7×10^{-4}	5.7×10^{-7}	0.0022	2.7×10^{-6}
Lead	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Mercury	1.2	1.7×10^{-4}	5.7×10^{-7}	0.0002	6.7×10^{-7}
Selenium	0.83	1.7×10^{-4}	5.7×10^{-7}	0.0001	4.7×10^{-7}
Silver	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Benzene	73	1.7×10^{-4}	5.7×10^{-7}	0.012	4.2×10^{-5}
Phenol	240	1.7×10^{-4}	5.7×10^{-7}	0.040	1.4×10^{-4}

small magnitude of estimated offsite impacts, disproportionately high or adverse human health and environmental impacts to minorities or low-income populations are not expected to be very likely. EC

References

AIHA (American Industrial Hygiene Association), 1991, *Emergency Response Planning Guidelines*, Emergency Response Planning Guidelines Committee, Akron, Ohio.

Benhardt, H. C., et al., 1994, *Savannah River Site Human Error Database Development for Non-reactor Nuclear Facilities*, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1994, *Preparation Guide for U.S. DOE Non-reactor Nuclear Facility Safety Analysis Reports*, Standard DOE-STD-3009-94, Washington, D.C. (Available at http://tis.eh.doe.gov/techstds/standard/std3009/std300994CN.pdf).

Hope, E. P., 1999, *Parametric Dispersion Calculations for H-Area Releases*, S-CLC-H-00693, Revision 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitation of Exposure to Ionizing Radiation*, Report No. 116, Bethesda, Maryland.

Nomm, E., 1995, Frequency of Criticality in High Level Waste Facilities (U), S-CLC-H-00380, Revision 0, Westinghouse Savannah River Company, Aiken, South Carolina.

NRC (U.S. Nuclear Regulatory Commission), 1982, *Regulatory Guide 1.145: Atmospheric Dispersion Models for Potential Accidental Consequence Assessments at Nuclear Power Plants*, Revision 1, Washington, D.C.

Simpkins, A. A., 1995a, *Verification of AXAIRQ*, WSRC-RP-95-708, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1995b, *Verification of AXAIRQ*, WSRC-RP-95-709, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1997, memorandum to C. B. Shedrow, "Spent Nuclear Fuel EIS Accidental Release Environmental Dosimetry Calculations," SRT-EST-97-196, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, March 13.

WSRC (Westinghouse Savannah River Company), 1992a, *Safety Analysis Report – Z-Area, Chapter 9, Analysis of Operations,* WSRC-SA-3, DOE Review Draft, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1992b, *Evaluation of Accident Risks in the Transportation of Hazardous Materials by Truck and Rail at the Savannah River Site*, Savannah River Site, Aiken, South Carolina.

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

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

WSRC (Westinghouse Savannah River Company), 1998c, *Structural Design Criteria*, Savannah River Site Engineering Standard 01060, Savannah River Site Engineering Standards Manual, WSRC-TM-95-1, Revision 3, Savannah River Site, Aiken, South Carolina.

Yeung, M. R., 1999, *Determination of Accident Sequence, Frequency, and Source Term Selection for the Waste Tank Closure Environmental Impact Statement*, S-CLC-G-00181, Revision 0, Westinghouse Safety Management Solutions, Aiken, South Carolina.