CHAPTER 4. ENVIRONMENTAL IMPACTS

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

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

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

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

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

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

4.1 Short-Term Impacts

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

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

4.1.1 GEOLOGIC RESOURCES

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

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

Construction

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

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

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

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

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

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

a. As many as 18 tanks could be constructed under the No Action alternative. The footprint for each tank constructed under the No Action alternative would be about 5,000 square feet. Approximately 43,000 cubic yards of soil would be excavated for each tank built.
b. (WSRC 1998a).
c. (WSRC 1998b).

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

Operation

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

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

4.1.2 WATER RESOURCES

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

4.1.2.1 Surface Water

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

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

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

Construction

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

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

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

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

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

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

Operations

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

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

4.1.2.2 Groundwater Resources

Construction

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

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

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

a. For all scenarios under the No Action alternative, volume of wastewater generated would be similar to the wastewater generation at the existing HLW Tank Farms. Therefore, wastewater generation under No Action would be included in the SRS baseline.
b. SRS Centralized Sanitary Waste Treatment Facility capacity = 1.05 million gallons per day (Schafner 2001).
c. Adapted from WSRC (1999e). Sanitary wastewater based on estimated potable water use.
d. F/H ETF design capacity = 433,000 gallons per day (DOE 1995).
e. ETF percent utilization based on 1994 data (DOE 1995).
f. Total process wastewater (radioactive liquid waste) annually (WSRC 1999b, 2000b).

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

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

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

Operations

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

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

4.1.3 AIR RESOURCES

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

4.1.3.1 Nonradiological Emissions

Construction

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

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

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

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

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

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

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

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

Source: Hunter (2000).

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

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

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

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

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

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

Operations

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

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

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

[1] PSD limit refers to the threshold emissons rates that trigger the need for a PSD review.

Table 4-5. Estimated maximum incremental increases of air concentrations (micrograms per cubic meter) of SCDHEC-regulated nonradiological air pollutants at the SRS boundary from construction activities associated with all salt processing alternatives.

Air pollutant	Averaging time	SCDHEC standard ($\mu g/m^3$)[a]	SRS baseline concentration ($\mu g/m^3$)[b]	SRS baseline concentration (% of standard)	Maximum concen-tration ($\mu g/m^3$)[c]	SRS baseline + concentration (% of standard)
SO_2	3-hr	1,300	1,240	96	5.0	96
	24-hr	365	350	96	0.7	96
	Annual	80	34	42	0.009	42
TSP	Annual geometric mean	75	67	89	0.04	90
PM_{10}[d]	24-hr	150	130	88	2	90
	Annual	50	25	51	0.03	51
CO	1-hr	40,000	10,350	26	70	26
	8-hr	10,000	6,870	69	10	69
NO_2	Annual	100	26	26	01	26

Source: Hunter (2000).
a. SCDHEC Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards".
b. Sum of (1) an estimated maximum Site boundary concentration from modeling all SRS sources of the indicated pollutant not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations (Hunter 2000).
c. Maximum concentrations would be the same for all alternatives including construction of new tanks under No Action.
d. New standard for particulate matter may come into effect during the construction of this project.
SO_2 = sulfur dioxide, TSP = total suspended particles, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 pm, CO = carbon monoxide, NO_2 = nitrogen dioxide.

Table 4-6. Expected sources of air emissions during salt processing for the four action alternatives[a].

Alternative	Source of air emissions
All action alternatives	Minimal new emission sources (S Area)
Small Tank Precipitation, Ion Exchange, Solvent Extraction	Exhaust stack for the Process Facility (S Area) Ventilation exhaust from the Cold Chemical Feed Area (S Area) Exhaust stack for existing saltstone facility (Z Area) Exhaust from two emergency diesel generators (S Area) Exhaust from one emergency diesel generator (Z Area)
Direct Disposal in Grout	Exhaust stack for the Direct Disposal in Grout Process Facility (Z Area) Ventilation exhaust from the Cold Chemical Feed Area (Z Area) Ventilation exhaust from the Vaults (Z Area)[b] Exhaust from two emergency diesel generators (Z Area)

a. For all scenarios under the No Action alternative, the expected source of emissions would be the ventilation exhaust from each tank.
b. Vaults for the other three action alternatives would have minimal emissions because the saltstone produced by these action alternatives would have a lower activity level and the vaults would not be ventilated.

Table 4-7. Estimated nonradiological air emissions (tons per year) from routine operations for salt processing alternatives.[a]

	SRS Permit Allowance	PSD New Source Emission Limit	Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Air pollutant	(tons/yr)[b]	(tons/yr)[c]	(tons/yr)	(% of PSD limit)	(tons/yr)	% of PSD limit)	(tons/yr)	% of PSD limit)	(tons/yr)	% of PSD limit)
SO_2	3.32	40	0.33	0.81	0.33	0.81	0.33	0.81	0.30	0.75
TSP	5.51	25	0.95	3.8	0.95	3.8	0.95	3.8	0.80	3.2
PM_{10}	2.4	15	0.4	2.7	0.4	2.7	0.4	2.7	0.30	2.0
CO	86.9	100	5.4	5.4	5.4	5.4	5.4	5.4	4.9	4.9
VOCs[d]	70.23[e]	40	70	175	1.6	4.1	40	100	1.5	3.6
NO_x	232.8	40	21	53	21	53	21	53	19	48
Lead	NA[f]	0.6	4.0×10^{-4}	0.067	4.0×10^{-4}	0.067	4.0×10^{-4}	0.067	3.5×10^{-4}	0.058
Beryllium	NA[f]	4.0×10^{-4}	1.0×10^{-4}	25	1.0×10^{-4}	25	1.0×10^{-4}	25	5.0×10^{-5}	13
Mercury	0.88	0.1	0.0026	2.6	0.0026	2.6	0.0026	2.6	0.0025	2.5
Formic Acid[g]	1.6	NA[h]	1.6	-	None	-	None	-	None	-
Benzene	50.48	NA[h]	53	-	0.0085	-	0.0085	-	0.0080	-
Biphenyl[i]	NA[j]	NA[h]	1.1	-	None	-	None	-	None	-
Methanol[k]	NA[j]	NA[h]	0.42	-	0.42	-	0.42	-	0.42	-
n-Propanol[l]	NA[j]	NA[h]	0.42	-	0.42	-	0.42	-	0.42	-
Isopar®L[m]	NA[j]	NA[h]	0.0	-	0.0	-	38	-	0.0	-

Source: Hunter (2000).

a. For all scenarios under the No Action alternative, air emissions would be similar to those from the existing HLW Tank Farm operations. Therefore, No Action is represented by slight increases above the SRS baseline.
b. SCDHEC Bureau of Air Quality Control Operating Permits for HLW management facilities.
c. SCDHEC Regulation 61-62.5, Standard 7, "Prevention of Significant Deterioration".
d. VOCs are subject to a PSD limit because they are a precursor to ozone. VOCs that may be emitted as a result of the proposed action include benzene, biphenyl, methanol, n-Propanol, and Isopar®L. NO_x also contributes to ozone formation.
e. Value includes 50.48 tons per year of benzene and 19.75 tons per year of other VOCs.
f. SRS lead and beryllium emissions originate from permit-exempted units, so no allowance has been established.
g. Formic acid emissions would shift from DWPF to the Small Tank Precipitation facility, resulting in no net change in emissions.
h. No PSD limit is defined for this pollutant.
i. Also known as diphenyl.
j. This pollutant is a VOC and the SRS air permits do not have a specific permit allowance for this pollutant.
k. Also known as methyl alcohol.
l. Also known as n-Propyl alcohol; OSHA-regulated pollutant.
m. Isopar®L is a proprietary chemical; regulated as a VOC only.

NA = not applicable, SO_2 = sulfur dioxide, TSP = total suspended particulates, PM_{10} = particulate matter with an aerodynamic diameter ≤ 10 µm, CO = carbon monoxide, NO_x = oxides of nitrogen, PSD = prevention of significant deterioration, VOC = volatile organic compound.

Prevention of Significant Deterioration Review

Facilities, such as SRS, that are located in attainment areas for air quality and are classified as major facilities may trigger a PSD review under the new source review requirements of the Clean Air Act when they construct a major stationary source or make a major modification to a major source. (A major source is defined as a source with the potential to emit any air pollutant regulated under the Clean Air Act in amounts equal to or exceeding specified thresholds). The SCDHEC uses a two-step process to determine whether a new source results in a significant emissions increase of a regulated pollutant. First, the potential emissions from the new source are compared to their corresponding PSD significant emission limits. If the emission increase is by itself (without considering any contemporaneous decreases) less than the PSD limit, no further analysis is required. If, however, the emission increase is equal to or greater than the PSD limit, then all contemporaneous emissions increases and decreases must be summed and the net increase is compared to the PSD limit. A PSD permit review is required if that modification or addition to the major facility results in a net increase of any regulated pollutant over the level established in the current permit that is greater than the corresponding PSD limit.

The estimated volatile organic compounds (VOC) emissions rate of 70 tons per year for the Small Tank Precipitation alternative would exceed the threshold value established by SCDHEC for PSD permit review, whereas estimated emissions from the other alternatives are either estimated below the PSD limit or covered by existing air permit levels. Implementation of the Small Tank Precipitation alternative would result in small increases in offsite concentrations of benzene and ozone, with minimal impacts to public health. The other alternatives would have lower impacts.

VOC emissions are subject to a PSD limit because they contribute to the formation of ozone. Ozone is a photochemical oxidant and the major component of smog. Ozone is not emitted directly into the air, but is formed through complex chemical reactions between emissions of VOCs and NO_x in the presence of sunlight. Both VOCs and NO_x are emitted by industrial and transportation sources.

According to EPA AIRS databases (EPA 2001), Aiken and Barnwell Counties combined produced a total of more than 10,000 tons per year of NO_x in 1998 and anthropogenic VOC emissions were over 10,000 tons per year. According to the EPA TRENDS reports (EPA 2000), the biogenic VOC contribution for the Aiken-Barnwell region is around 9,000 tons per year. Estimated emissions from the alternative with the highest VOC emissions (i.e., Small Tank Precipitation) are 21 tons per year NO_x and 70 tons per year VOCs. Therefore, regional emissions of ozone precursors would be expected to increase by less than one percent for this alternative. From modeling results such as those presented in Carter (1994), percentage increases in ozone precursers are generally greater than the resulting changes in ozone. Therefore, ozone concentrations would be expected to increase by no more than one percent. The background level of ozone is 216 micrograms per cubic meter, and the ambient air quality standard for ozone is 235 micrograms per cubic meter. Therefore, a one percent increase in ozone, to about 218 micrograms per cubic meter, at the point of maximum impact would not exceed the ambient air quality standard.

As shown in Table 4-6, nonradionuclide emissions from routine salt processing operations would come from several sources. Using the emission rates from Table 4-7 for the listed sources, maximum concentrations of released regulated pollutants were determined using the ISC3 air dispersion model. Because the proposed sites for salt processing facilities in S and Z Areas are located in close proximity to DWPF and would be subject to the same meteorological conditions as DWPF, the stack for each process facility was assumed to be the same height as the DWPF stack (i.e., 46 meters). Emissions from the cold chemical feed area (see Section 2.7.4, Support Facilities) and from the emergency generators were assumed to occur at ground level. The process facilities and the cold chemical feed areas were assumed to emit pollutants continuously. The emergency generators were assumed to operate 250 hours per year, primarily for testing.

The ICS3 short-term modeling results provided estimated maximum concentrations at the SRS boundary, where members of the public potentially would be exposed, and at the location of a hypothetical noninvolved site worker. For the location of the noninvolved worker, the analysis used a generic location 640 meters from the release point in the direction of the greatest concentration. This location is the distance for assessing consequences from facility accidents and, for consistency, is used here for normal operations. Concentrations at the noninvolved worker location were calculated at an elevation of 1.8 meters above ground to simulate the breathing height of a typical adult.

The maximum air concentrations (micrograms per cubic meter) at the SRS boundary that would be associated with the release of regulated nonradiological pollutants are presented in Table 4-8. For the action alternatives, the incremental increase in concentrations of SO_2, TSP, PM_{10}, CO, NO_2, and lead (SCDHEC Ambient Air Quality Standards [Standard 2] regulated pollutants) would be less than 1 percent of the baseline (i.e., No Action alternative). Incremental concentration increases of air toxic pollutants (NO_2, lead, beryllium, mercury, benzene, biphenyl, methanol, and formic acid) would be small under all alternatives; for most pollutants, there would be an incremental increase of less than 1 percent of the baseline (i.e., No Action alternative). The greatest increase (7.5 percent) would occur for biphenyl under the Small Tank Precipitation alternative, but ambient concentrations would remain far below the SCDHEC Toxic Air Pollutants (Standard 8) limit. Therefore, no salt processing alternative would exceed SCDHEC standards at the SRS boundary.

The air quality impacts at the location of a hypothetical noninvolved worker in the vicinity of the processing facilities are presented in the Worker and Public Health section (Section 4.1.4.1 – Nonradiological Health Effects). For all processing alternatives, ambient concentrations of NO_2 would reach 78 percent of the Occupational Safety and Health Administration (OSHA) ceiling limit of 9 milligrams per cubic meter (mg/m^3). These NO_2 emissions would result from the periodic operation of the emergency generators. Since the estimated emissions are based on maximum potential emissions and all the emergency generators likely would not operate at the same time, the estimated emissions and resulting concentrations are conservative. All concentrations of OSHA-regulated pollutants would be below the established limits.

4.1.3.2 Radiological Emissions

Construction

No known radiological contamination exists at the proposed construction sites in S and Z Areas. DOE would use the approved siting process to ensure that any new HLW tanks constructed under the No Action alternative would be constructed in an area where no radiological contamination is known to exist. Therefore, regardless of the alternative chosen, no radiological air emissions are expected as a result of construction activities.

Operations

DOE estimated routine radionuclide air emissions for each salt alternative. Under each processing alternative, radionuclides would be emitted to the air via a stack. As discussed in Section 4.1.3.1, the stack for each process facility was assumed to be 46 meters high, the same height as the DWPF stack. For all the salt processing alternatives, the ventilation exhaust would be filtered through high-efficiency particulate air filters. The Direct Disposal in Grout alternative would have an additional emission point at each vault in operation because radioactive cesium would not be removed before grouting, requiring the vaults to have a forced air ventilation system for temperature control while the saltstone cures. Because the other three action alternatives would remove more radionuclides (including radioactive cesium) from the low-activity salt fraction, the grout would have much lower activity levels and the vaults would not need to be ventilated. Therefore, the Small Tank Precipitation, Ion Exchange, and Solvent

Table 4-8. Estimated maximum increases in air concentrations (micrograms per cubic meter) and percent of standard of SCDHEC-regulated non-radiological air pollutants at the SRS boundary from salt processing alternatives.

					Maximum concentration							
					Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Air pollutant	Averaging time	SCDHEC standard ($\mu g/m^3$)[a]	SRS baseline concentration ($\mu g/m^3$)[b]	SRS baseline concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)	Concentration ($\mu g/m^3$)	Baseline + Concentration (% of standard)
Ambient air pollutants												
SO_2	3-hr	1,300	1,240	96	0.30	96	0.30	96	0.30	96	0.40	96
	24-hr	365	350	96	0.040	96	0.040	96	0.040	96	0.050	96
	Annual	80	34	42	4.0×10^{-4}	42	4.0×10^{-4}	42	4.0×10^{-4}	42	5.0×10^{-4}	42
TSP	Annual geometric mean	75	67	89	0.0010	89	0.0010	89	0.0010	89	0.0010	89
PM_{10}[c]	24-hr	150	130	88	0.070	89	0.070	89	0.070	89	0.070	89
	Annual	50	25	51	0.0010	51	0.0010	51	0.0010	51	0.0010	51
CO	1-hr	40,000	10,350	26	15	26	15	26	15	26	18	26
	8-hr	10,000	6,870	69	1.9	69	1.9	69	1.9	69	2.3	69
Ozone[c]	1-hr	235	216	92	ND	ND	ND	ND	ND	ND	ND	ND
NO_2	Annual	100	26	26	0.030	26	0.030	26	0.030	26	0.030	26
Lead	Max. calendar quarter	1.5	0.03	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0	4.0×10^{-7}	2.0
Air toxic pollutants[e]												
Benzene	24-hr	150	5	3.1	4.0	5.7	0.0010	26	0.0010	26	0.0010	26
Mercury	24-hr	0.25	0.03	12	3.0×10^{-5}	12	3.0×10^{-5}	12	3.0×10^{-5}	12	3.0×10^{-5}	12
Biphenyl[f]	24-hr	6	0.02	0.33	0.45	7.8	None	0.33	None	0.33	None	0.33
Methanol[g]	24-hr	1,310	0.9	0.069	0.32	0.093	0.32	0.090	0.32	0.090	0.53	0.11
Beryllium	24-hr	0.01	0.0090	90	1.0×10^{-5}	90	1.0×10^{-5}	90	1.0×10^{-5}	90	1.0×10^{-5}	90
Formic Acid[h]	24-hr	225	0.15	0.067	0.01	0.067	None	0.067	None	0.067	None	0.067

Source: Hunter (2000). Concentrations are based on maximum potential emissions.

a. SCDHEC Air Pollution Regulation 61-62 5, Standard 2, "Ambient Air Quality Standards", and Standard 8, "Toxic Air Pollutants".

b. Sum of (1) estimated maximum site boundary concentration from modeling all SRS sources of the indicated pollutant not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations (Hunter 2000). For all scenarios under the No Action alternative, emissions would be similar to those from existing HLW Tank Farm operations and would be represented by slight increases over the SRS baseline.

c. New standards for this pollutant may come into effect during the lifetime of this project.

d. Source: SCDHEC (1998). Observed concentration of ozone at SCDHEC ambient monitoring station for Aiken County.

e. n-Propanol is not included on this table because it is an OSHA-regulated pollutant, not an SCDHEC-regulated pollutant.

f. Also known as diphenyl.

g. Also known as methyl alcohol.

h. Formic acid emissions would shift from DWPF to the Small Tank Precipitation Facility, resulting in no net change in emissions.

ND = Not determined, SO_2 = sulfur dioxide, TSP = total suspended particulates, PM_{10} = particulate matter with an aerodynamic diameter $\leq 10\ \mu m$, CO = carbon monoxide, NO_2 = nitrogen dioxide.

Extraction alternatives would have no measurable emissions from the associated saltstone vaults. Emissions from the vaults for Direct Disposal in Grout alternative were assumed to be at ground level. The estimated total radiological air emissions for each action alternative are shown in Table 4-9 (Pike 2000). Because there are no equivalent facilities at SRS, DOE's method for estimating emission rates from the alternative salt processing facilities is conservative and ensures that total emissions are not underestimated. All action alternatives are all treated with the same conservative basis. The Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes all produce highly concentrated cesium-bearing process streams. The engineered systems designed for each facility would ensure that the cesium emissions are as low as reasonably achievable.

Air emissions under the No Action alternative would be similar to those from existing HLW Tank Farms operations for ongoing tank space management activities and all subsequent scenarios. Therefore, the No Action alternative is represented by slight increases above the baseline.

After determining routine emission rates for the action alternatives, DOE used the MAXIGASP and POPGASP computer codes to estimate radiological doses to the maximally exposed (offsite) individual (MEI), the hypothetical noninvolved worker, and the offsite population surrounding SRS. Both codes utilize the GASPAR (Eckerman et al. 1980) and XOQDOQ (Sagendorf et al. 1976, 1982) modules; GASPAR and XOQDOQ are based on U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides 1.111 and 1.109 (NRC 1977), respectively. Both GASPAR and XOQDOQ have been adapted and verified for use at SRS (Hamby 1992 and Bauer 1991, respectively). MAXIGASP and POPGASP are both Site-specific computer programs that have SRS-specific meteorological parameters (e.g., wind speeds and directions) and population distribution parameters (e.g., number of people in sectors around the Site). The 1990 census population database was used to represent the population living within a 50-mile radius of the center of SRS.

Table 4-9. Annual radionuclide emissions (curies/year) resulting from operations.[a]

	Annual emission rate			
	Small Tank Precipitation (Ci/yr)	Ion Exchange (Ci/yr)	Solvent Extraction (Ci/yr)	Direct Disposal in Grout[b] (Ci/yr)
Tritium	4.3	18	24	9.2
Strontium-90	8.3×10^{-4}	4.9×10^{-5}	0.0019	0.0036
Technetium-99	1.6×10^{-5}	1.6×10^{-6}	8.4×10^{-5}	3.4×10^{-5}
Ruthenium-106	5.2×10^{-6}	4.9×10^{-7}	2.6×10^{-5}	1.0×10^{-5}
Antimony-125	1.5×10^{-6}	1.6×10^{-7}	9.0×10^{-6}	3.5×10^{-6}
Iodine-129	1.5×10^{-8}	1.7×10^{-9}	6.9×10^{-7}	3.7×10^{-8}
Cesium-134	0.0035	0.0024	0.014	8.5×10^{-4}
Cesium-137	0.98	0.24	1.4	0.085
Total Alpha[c]	0.0010	1.5×10^{-4}	0.0060	0.011
Total	5.3	18.2	25.4	9.3

Source: Pike (2000).

a. Air emissions under the No Action alternative would be similar to those from existing HLW Tank Farm operations for continuing tank space management activities and all subsequent scenarios. Therefore, the No Action alternative is represented by slight increases over the SRS baseline. SRS baseline emissions are shown in Table 3-12.

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

c. Assumed to be plutonium-239.

Table 4-10 presents the calculated maximum radiological doses (as 50-year committed effective dose equivalents) associated with salt processing activities for all the analyzed alternatives. Based on the dispersion modeling for stack emissions from processing facilities for each alternative, the MEI (public) was identified as being located north-northeast at the SRS boundary. For ground-level releases (vault emission under the Direct Disposal in Grout alternative), the MEI would be located at the north SRS boundary (Simpkins 1999, 2000a,b). The maximum committed effective dose equivalent for the MEI would be 0.31 millirem per year for the Solvent Extraction alternative, which is higher than the other alternatives, due to higher estimated radioactive cesium emissions. Ninety percent of the dose to the MEI is associated with the radio active cesium emissions and 9.5 percent of the dose would result from the total alpha emissions. The Small Tank Precipitation alternative has a maximum committed effective dose equivalent of 0.20 millirem per year, while the Ion Exchange and Direct Disposal alternatives have a lower maximum committed effective dose equivalent for the MEI of 0.049 and 0.086, respectively. The annual MEI dose under all the alternatives would still be well below the established annual dose limit of 10 millirem for SRS atmospheric releases (40 CFR 61.92).

The maximum estimated dose to the offsite population residing within a 50-mile (80-kilometer) radius (approximately 620,000 people) would be 18.1 person-rem per year, also as a result of the Solvent Extraction alternative. As with the MEI dose, offsite concentrations of radioactive cesium would compose most (93 percent) of the total population dose. The Small Tank Precipitation alternative has an offsite population dose of 12.0 person-rem per year. The Ion Exchange and Direct Disposal in Grout alternatives have values that are similar to each other, but lower than the previous alternatives (2.9 and 4.0 person-rem per year, respectively). For all scenarios, the total offsite population dose is low.

Table 4-10. Annual doses from radiological air emissions from salt processing activities presented as 50-year committed effective dose equivalents[a].

	Maximum dose			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout[b]
Maximally exposed offsite individual dose (millirem/year)	0.20	0.049	0.31	0.086
Offsite population dose (person-rem/year)	12.0	2.9	18.1	4.0
Noninvolved worker dose (millirem/year)	3.3	0.8	4.8	1.7
Involved worker dose (millirem/year)	15.7	3.9	22.8	10.1
Onsite population dose (person-rem/year)	4.3	1.1	6.5	2.3

Source: Based on emission values listed in Table 4-7 and Simpkins (1999 and 2000a,b).
a. For all scenarios under the No Action alternative, radiological air emissions would be similar to those from existing HLW Tank Farm operations, and would be represented by slight increases above the baseline. Therefore, under the No Action alternative, doses to all receptors would be minimal.
b. Includes building stack and ground-level vault doses.

Table 4-10 also reports doses to the noninvolved (onsite) worker, the involved worker, and the collective onsite population from the estimated annual radiological emissions. For each case, the highest estimated dose would occur under the Solvent Extraction alternative, with the Small Tank Precipitation alternative having similar results and the Ion Exchange and the Direct Disposal in Grout alternatives having lower doses. The maximum dose to the noninvolved and involved worker would be 4.8 millirem per year and 22.8 millirem per year, respectively, with radioactive cesium emissions contributing about 98 percent of the total dose. The maximum estimated dose to the onsite population would be 6.5 person-rem per year, with 94 percent of this total dose due to radioactive cesium emissions. In all cases these doses are low.

For ongoing tank space management activities and all subsequent scenarios under the No Action alternative, radiological air emissions would be similar to those from existing HLW Tank Farm operations, and would be represented by slight increases above the baseline. Therefore, under the No Action alternative, doses to all receptors would be minimal.

4.1.4 WORKER AND PUBLIC HEALTH

This section discusses potential radiological and nonradiological health effects to SRS workers and the surrounding public from construction and routine operation of the salt processing alternatives; it does not include impacts of potential accidents, which are discussed in Section 4.1.13. DOE based its calculations of health effects from radiological releases to air as doses with the corresponding impacts expressed as latent cancer fatalities (LCFs) to (1) the MEI; (2) the collective population within a 50-mile (80-kilometer) radius around SRS (approximately 620,000 people); (3) the maximally exposed noninvolved worker (i.e., an SRS employee who may work in the vicinity of the salt processing facilities, but is not directly involved with the work); (4) the involved worker; (5) the onsite population of involved workers (i.e., the workers directly involved in salt processing activities); and (6) the population of SRS workers (includes both involved and noninvolved workers). All radiation doses in this SEIS are committed effective dose equivalents. This section presents total impacts for the entire length of time necessary to implement each technology. The annual impacts attributable to each phase were multiplied by the duration of that phase. The impacts from all phases were summed to calculate the total impact for the technology. This discussion characterizes health effects to populations as additional lifetime LCFs likely to occur in the general population around SRS, the population of onsite workers, and the population of workers who would be associated with implementing the alternatives. Health effects to the MEI and the noninvolved and involved worker are characterized by the additional probability of an LCF to the exposed individual.

Nonradiological health effects discussed in this section include effects from nonradiological emissions to air of toxic and criteria pollutants. In addition to radiological and nonradiological health effects, common occupational health impacts are presented in terms of estimated work-related illness and injury events associated with each of the salt processing alternatives. There are no radiological or nonradiological releases to water from any of the action alternatives.

4.1.4.1 Nonradiological Health Effects

The Occupational Health and Industrial Hygiene programs at SRS deal with all aspects of worker health and the workers' relationships with their work environment. The objective of an effective Occupational Health program is to enable employees to work safely and to recognize unsafe work practices or conditions before an accident occurs.

The objective of an Industrial Hygiene program is to evaluate toxic or hazardous chemicals in the work environment and use established procedures and routine monitoring to prevent or minimize employee exposures to these chemicals. Exposure limit values are the basis of most occupational health codes and standards and are used to regulate worker exposure to hazardous chemicals.

OSHA permissible exposure limits (PELs) (29 CFR 1910.1000) are established limits that ensure the safety of the worker population. PELs are time-weighted average concentrations that a facility cannot exceed in any 8-hour work shift of a 40-hour work week. OSHA ceiling limits are concentrations of substances that cannot be exceeded during any part of the workday. Both of these exposure limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could be exposed day after day without adverse health effects. However, because of the wide variation in individual susceptibility, a small percentage of workers could experience discomfort from some substances at concentrations at or below the permissible limits. The OSHA PEL standards for identified pollutants of concern during salt processing activities are listed in Table 3-18.

DOE evaluated the range of chemicals in facility air emissions to which the public and workers would be exposed due to salt processing activities and expects minimal health impacts from nonradiological exposures. Section 4.1.3 discusses onsite and offsite chemical concentrations from air emissions. DOE estimated noninvolved worker impacts and Site boundary concentrations to which a maximally exposed member of the public could be exposed. Site boundary concentrations were compared to the SCDHEC standards for ambient concentrations and DOE concluded that all air emission concentrations would be below the applicable standard. See Section 4.1.3 for comparison of estimated concentrations at the Site boundary with SCDHEC standards.

The noninvolved worker concentrations were compared to OSHA PELs or ceiling limits for protecting worker health, and the comparisons indicated that all criteria pollutant concentrations would be negligible compared to the OSHA standards.

Beryllium is a pollutant of concern for salt processing activities. A naturally occurring metal, beryllium is used primarily in electronic components and cellular network communication systems. It is also used in aerospace and defense applications. Most of the beryllium emissions in the United States are a result of beryllium-copper alloy production and burning of fossil fuels (e.g., coal and oil) to produce electricity. Beryllium is also a constituent of cigarette smoke (ATSDR 1988). The beryllium that would be emitted by the salt processing alternatives is primarily a constituent of the exhaust from the emergency generators (Hunter 2000), which were assumed to operate 250 hours per year for testing. Health concerns from beryllium exposure include excess lifetime cancer risk and chronic beryllium disease (CBD), which can be seriously debilitating and lead to premature death. The maximum excess lifetime cancer risks to the noninvolved worker and to the MEI from exposure to beryllium emissions were estimated to be 7.2×10^{-5} and 2.4×10^{-8}, respectively, based on the EPA's Integrated Risk Information System (IRIS) database (EPA 1998) unit risk factor for beryllium of 2.4×10^{-3} excess cancer risk per microgram per cubic meter. This excess cancer risk from beryllium emissions is the same for all given alternatives.

Exposure to respirable beryllium fumes, dusts, or powder can also cause CBD in individuals who are sensitized (allergic) to beryllium. One to six percent of workers engaged in operations producing or using beryllium and its compounds develop CBD over their lifetimes (National Jewish 2001). While some cases of CBD have been reported in individuals with no occupational exposure to beryllium, only one case has been reported since 1973. No cases of CBD have been associated with low atmospheric concentrations of beryllium, such as those observed in the vicinity of SRS (NIOSH 1986). Therefore, DOE believes that the excess CBD risk to workers and the public as a result of salt processing operations would be minimal for all salt processing alternatives.

Benzene is the pollutant of most concern for salt processing activities. The maximum excess lifetime cancer risks to the noninvolved worker and MEI from exposure to benzene emissions were estimated to be 6.6×10^{-3} and 1.7×10^{-5}, respectively, based on the EPA's IRIS database (EPA 1998) unit risk factor for benzene of 8.3×10^{-6} excess cancer risk per microgram per cubic meter. This excess cancer risk from benzene emissions is associated with the Small Tank Precipitation alternative. Because benzene emissions (primarily from the emergency generators) from the other salt processing alternatives are similar and would be much lower than the emissions from the Small Tank Precipitation alternative, they are expected to have considerably lower excess lifetime cancer risks. See Table 4-11 for additional nonradiological pollutant concentrations. Under the No Action alternative, air emissions from ongoing tank space management activities and all subsequent scenarios would be similar to air emissions from the HLW operations included in the SRS baseline. Therefore, incremental health affects would be minimal.

Engineered systems designed for the process facilities and tanks under the No Action alternative would ensure that there would be little possibility of involved workers in the proposed facilities being exposed to anything other than very small concentrations of airborne nonradiological materials that would be similar among all alternatives. Therefore, health effects from exposure to nonradiological material inside the facilities would be minimal for all alternatives.

4.1.4.2 Radiological Health Effects

Radiation can cause a variety of health effects in people. The major effect of environmental and occupational radiation exposures is a delayed cancer fatality, which is called an LCF, because the cancer can take many years to develop and cause death.

To relate a dose to its effect, DOE has adopted a dose-to-risk conversion factor of 0.0004 LCFs per person-rem for workers and 0.0005 LCFs per person-rem for the general population (NCRP 1993) to estimate the number of LCFs that could result from the calculated exposure. The factor for the general population is slightly higher because infants and children are more sensitive to radiation than the adult worker population.

Table 4-11. Estimated maximum concentration in milligrams per cubic meter (mg/m^3) of air pollutants to the noninvolved worker from facility air emissions.[a,b]

	Averaging time[c]	OSHA Standard[c]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Sulfur dioxide	8-hr TWA[d]	13	0.01	0.01	0.01	0.01
Total particulates	8-hr TWA	15	0.02	0.02	0.02	0.01
Particulates <10 microns	8-hr TWA	5	0.02	0.02	0.02	0.01
Carbon monoxide	8-hr TWA	55	0.2	0.2	0.2	0.2
Nitrogen dioxide	Ceiling[e]	9	7.0	7.0	7.0	7.0
Lead	8-hr TWA	0.5	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Beryllium	8-hr	0.002	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}
	Ceiling	0.005	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Methyl alcohol	8-hr TWA	260	0.08	0.08	0.08	0.08
n-Propyl alcohol	8-hr TWA	500	0.08	0.08	0.08	0.08
Mercury	Ceiling	0.1	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Benzene	8-hr	3.1	0.1	3.0×10^{-4}	3.0×10^{-4}	3.0×10^{-4}
	Ceiling	15.5	0.8	0.004	0.004	0.004
Formic Acid[f]	8-hr	9	2.2×10^{-4}	None	None	None

Source: Hunter (2000).
a. For a noninvolved onsite worker at a distance of 640 meters from the process building stack and a 1.8-meter breathing height.
b. Under the No Action alternative, air emissions from all scenarios would be similar to air emissions from the HLW operations included in the SRS baseline. Therefore, incremental health effects would be minimal.
c. From 29 CFR 1910.1000.
d. TWA – Time-weighted average.
e. Ceiling limits are permissible exposure limits that a facility cannot exceed at any time.
f. Formic acid emissions would be shifted from DWPF to the Small Tank Precipitation facility, resulting in no net change.

These dose-to-risk factors are consistent with the factors used by the NRC in its rulemaking *Standards for Protection Against Radiation* (10 CFR 20). The factors apply if the dose to an individual is less than 20 rem and the dose rate is less than 10 rem per hour. At doses greater than 20 rem, the factors used to relate radiation doses to LCFs are doubled. At much higher dose rates, prompt effects, rather than LCFs, would be the primary concern.

DOE expects minimal worker and public health impacts from the radiological consequences of salt processing activities under any of the technology alternatives. All alternatives are expected to result in similar radiological release levels. Public radiation doses would occur from airborne releases only (Section 4.1.3). Table 4-12 lists estimated radiation doses and corresponding incremental LCFs for the noninvolved worker (a worker not directly involved with implementing the alternative, but located 2,100 feet [640 meters] from the salt processing facility), the involved worker (a worker located 328 feet [100 meters] from the salt processing facility), the collective population of involved workers, the collective onsite (SRS) population, and the public (MEI and the collective offsite population) for each technology alternative.

As shown in Table 4-12, the highest radiological impacts to both involved and noninvolved workers and to the public would be associated with the Solvent Extraction alternative. The Small Tank Precipitation alternative would have impacts similar to Solvent Extraction, and the Ion Exchange and Direct Disposal in Grout alternatives would result in slightly lower impacts. The radiological doses from the Solvent Extraction alternative airborne emissions are higher than those for the other alternatives, and would result in an estimated additional 0.12 LCF for the general population surrounding SRS (50-mile radius) over the period of operation. Emissions from the Solvent Extraction alternative would also result in the highest impact to workers at SRS, an estimated 0.034 LCF for the collective SRS worker population (includes both involved and noninvolved workers) over the 13-year life of the project.

As expected, the collective involved worker doses and total project-phase doses shown in Table 4-12 are similar for all four action alternatives. The Solvent Extraction project-phase collective worker dose is the highest of the alternatives at 47 person-rem over the life of the project, and would result in 0.019 LCF. All doses are well within the administrative control limits for SRS workers (500 millirem per year).

The estimated number of LCFs in the public (Table 4-12) due to airborne emissions from each action alternative can be compared to the projected number of fatal cancers (approximately 140,000) in the public around the SRS from all causes (as discussed in Section 3.8.1). Similarly, the estimated number of fatal cancers in the involved worker population can be compared to the percent of the general population that succumbs from cancer regardless of cause (approximately 23.3 percent; see Section 3.8.1). In all cases, the incremental impacts from the alternatives would be minimal.

4.1.4.3 Occupational Health and Safety

The established method of determining a company or facility's safety record is by using its historic number of total recordable cases (TRCs) and lost workday cases (LWCs). Table 4-13 provides estimates of the number of TRCs and LWCs that would occur during a year and during the facility life cycle for the estimated number of involved workers for each alternative. The projected injury rates are based on historic SRS injury rates over a four-year period (1995 through 1999) multiplied by the employment levels and years for each alternative and the appropriate TRC and LWC rates.

The TRC rate includes work-related deaths, illnesses, or injuries that resulted in loss of consciousness, restriction from work or motion, transfer to another job, or required medical treatment beyond first aid. The LWC rate represents the number of workdays, beyond the day of injury or onset of illness, the employee was away from work or limited to restricted work activity because of an occupational injury or illness.

Table 4-12. Estimated public and occupational radiological doses and health impacts from atmospheric emissions during operations.[a,b,c]

Receptor[d,e]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout[f]
MEI dose (millirem/year)	0.20	0.049	0.31	0.086
Probability of an LCF from MEI dose[g]	1.3×10^{-6}	3.2×10^{-7}	2.0×10^{-6}	5.6×10^{-7}
Dose to population within 50 miles of SRS (person-rem/year)	12.0	2.9	18.1	4.0
Estimated number of project-phase LCFs in the population within 50 miles of SRS[g]	0.078	0.019	0.12	0.026
Noninvolved worker dose (millirem/year)	3.3	0.8	4.8	1.7
Probability of an LCF from noninvolved worker dose[g]	1.7×10^{-5}	4.2×10^{-6}	2.5×10^{-5}	8.6×10^{-6}
Annual number of radiological workers[h]	140	100	160	110
Involved worker dose (millirem/year)	16	3.9	23	10
Probability of an LCF from involved worker dose[g]	8.2×10^{-5}	2.0×10^{-5}	1.2×10^{-4}	5.3×10^{-5}
Annual dose to the population of involved workers (person-rem per year)	2.2	0.39	3.6	1.1
Project-phase dose to involved workers (person-rem)	29	5.0	47	14
Estimated number of project-phase LCFs to involved workers[g]	0.012	0.0020	0.019	0.0056
Annual dose to the population of SRS workers (person rem/year)	4.3	1.1	6.5	2.3
Estimated number of project-phase LCFs in the worker population at SRS[g]	0.022	0.0055	0.034	0.012

a. Source term is based on data from Pike (2000).
b. Doses represent increment above baseline values from existing SRS activities.
c. Under the No Action alternative, air emissions from all scenarios would be similar to emissions from the HLW operations included in the SRS baseline. Therefore, incremental health effects would be minimal.
d. The MEI is 11,800 meters from the facility stack(s). The noninvolved worker is located 640 meters from the facility stack(s). The involved worker is located 100 meters from the facility stack(s).
e. Doses presented here are based on emissions from a 46-meter stack elevation.
f. Includes dose from operations and vaults.
g. LCFs are calculated for the project duration only. (When facility operations cease, residual contaminant levels would be negligible.) Each of the four action alternatives would operate for 13 years.
h. Assumes 75 percent of operations staff are radiological workers (WSRC 1999c).

The results in Table 4-13 indicate that each action alternative has similar TRCs and LWCs, but the Solvent Extraction alternative would have the highest TRCs and LWCs. The higher number of injuries for this alternative is due to the larger number of workers needed to operate the facility. The number of TRCs and LWCs would remain at current levels during continuation of tank space management activities under the No Actin alternative. Up to 65 new workers would be employed for operation of any new tanks built under No Action. This small increase in employment levels would result in 11 TRCs and 5 LWCs over the 13-year operations phase of the new tanks.

Tables 3-19 and 3-20 demonstrate that the SRS health and safety program has resulted in lower incidences of injury and illness than those in the general industry and manufacturing workforces.

Table 4-13. Estimated total recordable cases and lost workdays annually and for the life cycle of each alternative.[a]

Incident rate	No Action[b]	Small Tank Precipitation[c]	Ion Exchange[c]	Solvent Extraction[c]	Direct Disposal in Grout[c]
Total recordable cases (annual)	0.8	2.2	1.7	2.7	1.8
Total lost workday cases (annual)	0.35	1.0	0.72	1.2	0.77
Total recordable cases (facility life cycle)	11	32	24	39	25
Total lost workday cases (facility life cycle)	5	14	10	17	11

Source: WSRC (1998b, 1999d), DOE (2000b).
a. Based on working 8 hours per day, 250 days per year.
b. Based on 65 new workers for a period of 13 years to operate any new tanks built under the No Action alternative.
c. Facility life cycle includes 1.3 years for startup and 13 years of full operations.

These lower injury and illness rates for a proposed workforce ranged between 135 and 220 workers annually and for a period of 14.3 years are represented in Table 4-13. Considering the improvements the SRS safety program has made and continues to make in lowering the TRC and LWC rates, the numbers presented in Table 4-13 are conservative and future safety rates are expected to be much lower than the rates currently presented.

4.1.5 ENVIRONMENTAL JUSTICE

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs each Federal agency to "make…achieving environmental justice part of its mission" and to identify and address "…disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations." The Presidential Memorandum that accompanied Executive Order 12898 emphasized the importance of using existing laws, including the National Environmental Policy Act (NEPA), to identify and address environmental justice concerns, "including human health, economic, and social effects, of Federal actions."

The Council on Environmental Quality (CEQ), which oversees the Federal government's compliance with Executive Order 12898 and NEPA, subsequently developed guidelines to assist Federal agencies in incorporating the goals of Executive Order 12898 in the NEPA process. This guidance, published in 1997, was intended to "…assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed."

As part of this process, DOE identified (in Section 3.6.2) minority and low-income populations within a 50-mile radius of the SRS (plus areas downstream of the Site that withdraw drinking water from the Savannah River), which was defined as the region of influence for the environmental justice analysis. The following section discusses whether implementing the alternatives described in Chapter 2 would result in disproportionately high and adverse impacts to minority or low-income populations.

DOE referred to the Draft Guidance on Environmental Justice and NEPA (DOE 2000c) in preparing this section.

4.1.5.1 <u>Background</u>

The CEQ issued guidance on assessing potential environmental justice impacts. No standard formula has been issued on how environmental justice issues should be identified or addressed.

However, the following six principles provide general guidance (CEQ 1997):

- The composition of the area should be considered to determine whether minority populations, low-income populations, or Indian tribes are present in the area affected by the proposed action and, if so, whether there may be disproportionately high and adverse human health or environmental effects on those populations.
- Relevant public health data and industry data concerning the potential for multiple or cumulative exposures to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards should be considered.
- The interrelated cultural, social, occupational, historical, and economic factors that may amplify the natural and physical environmental effects of the proposed action should be recognized.
- Effective public participation strategies should be developed.
- Meaningful community representation in the process should be ensured.
- Tribal representation in the process should be sought in a manner that is consistent with the government-to-government relationship between the United States and tribal governments.

Environmental justice guidance developed by CEQ defines "minority" as individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic (CEQ 1997). The Council identifies these groups as minority populations when either (1) the minority population of the affected area exceeds 50 percent or (2) the minority population percentage in the affected area is meaningfully greater than the minority population percentage in the general population or appropriate unit of geographical analysis.

Low-income populations are identified using statistical poverty thresholds from the Bureau of Census Current Population Reports, Series P-60 on Income and Poverty. In identifying low-income populations, a community may be considered either as a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effects.

Environmental justice impacts can result if the proposed activities cause disproportionately high and adverse human health or environmental effects to minority or low-income populations. DOE assesses three factors to the extent practicable to identify disproportionately high and adverse human health effects:

- Whether the health effects are significant (as used by NEPA) or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death.
- Whether the risk or rate of exposure by a minority or low-income population to an environmental hazard is significant (within the meaning of NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group.
- Whether health effects occur in a minority or low-income population affected by cumulative or multiple adverse exposures from environmental hazards.

4.1.5.2 Methodology

First, DOE assessed the impacts of the proposed action and alternatives to the general population which, near the SRS, includes minority and low-income populations. No special considerations, such as unique exposure pathways or cultural practices, contribute to any discernible disproportionate impacts. The only identified cultural practice (or unusual pathway) potentially associated with minority and low-income populations is use of the Savannah River for subsistence fishing. For the Final *Accelerator Production of Tritium for the Savannah River Site Environmental Impact Statement* (EIS) (issued in 1999), DOE reviewed the limited body of literature available on subsistence activities in the region.

DOE concluded that, because the identified minority or low-income communities are widely distributed, and the potential impact to the general population is not discernible, there would be no potential for disproportionate impacts among minority or low-income populations. Second, having concluded that the potential offsite consequences to the general public of the proposed action and the alternatives would be small, DOE concluded that there would be no disproportionately high and adverse impacts to minority or low-income populations.

These conclusions are based on the comparison of salt processing actions to past actions for which environmental justice issues were evaluated in detail. In 1995, DOE conducted an analysis of economic and racial characteristics of the population potentially affected by SRS operations within a 50-mile radius of the Site (DOE 1995). In addition, DOE examined the population downstream of the Site that withdraws drinking water from the Savannah River. The economic and racial characterization was based on 1990 census tract data from the U.S. Census Bureau. More recent census tract data are not available. The nearest minority and low-income populations to SRS are south of Augusta, Georgia, northwest of the Site.

This environmental justice analysis was based on the assessment of potential impacts associated with the various HLW salt processing alternatives to determine if there would be high and adverse human health or environmental impacts. In this assessment, DOE reviewed potential impacts arising under the major disciplines and resource areas, including: socioeconomics; cultural, air, water, and ecological resources; and public and worker health over the short term (approximately the years 2001 to 2023) and long term (approximately 10,000 years after saltstone was placed in vaults). Regarding health effects, both normal facility operations and postulated accident conditions were analyzed, with accident scenarios evaluated in terms of risk to workers and the public.

Although no high and adverse impacts were predicted for the activities analyzed in this SEIS, DOE nevertheless considered whether there were any means for minority or low-income populations to experience disproportionately high and adverse impacts. The basis for making this determination would be a comparison of areas predicted to experience human health or environmental impacts with areas in the region of influence known to contain high percentages of minority or low-income populations.

The environmental justice analysis for the HLW salt processing alternatives was assessed for a 50-mile area surrounding SRS (plus downstream areas), as discussed in Section 3.6.2.

Short-Term Impacts

For environmental justice concerns to be initiated, high and adverse human health or environmental impacts must disproportionately affect minority or low-income populations.

None of the proposed alternatives would produce appreciable short-term impacts to surface water (see Section 4.1.2.1) or groundwater (see Section 4.1.2.2). With the exception of VOCs, emissions of nonradiological and radiological air pollutants from HLW salt processing activities would be below regulatory limits (see Section 4.1.3) and would result in minimal impacts to workers and the public (see Section 4.1.4.2). The estimated radiological doses and health impacts to the noninvolved worker and the public are small (highest dose is 4.8 millirem per year to the noninvolved worker, under the Solvent Extraction alternative).

Because all salt processing activities would take place in an area that has been dedicated to industrial use for more than 40 years, no short-term impacts to ecological resources (see Section 4.1.6), existing land uses (see Section 4.1.7), or cultural resources (see Section 4.1.9) are expected.

Relatively small numbers of workers would be required to carry out salt processing activities, regardless of the alternative selected (see Section 4.1.8); as a result, none of the alternatives would affect socioeconomic trends (i.e., unemployment, wages, housing) in the region of influence.

As noted in Section 4.2, no long-term environmental justice impacts are anticipated.

Because short-term impacts would not substantially affect the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the alternatives.

Subsistence Consumption of Fish, Wildlife, and Game

Section 4-4 of Executive Order 12898 directs Federal agencies "whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence and that Federal governments communicate to the public the risks of these consumption patterns." There is no evidence to suggest that minority or low-income populations in the SRS region of influence are dependent on subsistence fishing, hunting, or gathering. DOE nevertheless considered whether there were any means for minority or low-income populations to be disproportionately affected by examining levels for contaminants in vegetables, fruit, livestock, and game animals collected from the SRS or adjacent lands. In addition, DOE assessed concentrations of contaminants in fish collected from SRS waterbodies and from the Savannah River up- and downstream of the Site.

Based on recent monitoring results, concentrations of radiological and nonradiological contaminants in vegetables, fruit, livestock, game animals, and fish from the SRS and surrounding areas are generally low, in virtually all instances below applicable DOE standards (Arnett and Mamatey 1998a,b). Consequently, no disproportionately high and adverse human health impacts would be expected in minority or low-income populations in the region that rely on subsistence consumption of fish, wildlife, or native plants.

It should be noted that mercury, which is present in relatively high concentrations in fish collected from SRS and the middle reaches of the Savannah River, could pose a potential threat to individuals and populations that rely on subsistence fishing. This mercury in fish has been attributed to upstream (non-DOE) industrial sources and natural sources (DOE 1997a). The salt processing alternatives under consideration would not affect mercury concentrations in SRS waterbodies or the Savannah River.

4.1.6 ECOLOGICAL RESOURCES

Construction

Depending on the salt processing alternative selected by DOE, construction of several new facilities would be required in either S or Z Area. Process buildings for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives would be built in S Area, while the process building for the Direct Disposal in Grout alternative would be built in Z Area. Regardless of the salt processing alternative (thus, process facility configuration) chosen, support facilities, including a service building, office building, and an electrical substation would be constructed in close proximity to the main process building (see Chapter 2 and Appendix A for details). New salt disposal vaults would be built in Z Area under all of the salt processing action alternatives.

As shown in Table 4-1, construction of process facilities for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives would require the excavation of approximately 77,000, 78,000, 82,000 and 23,000 cubic yards of soil, respectively. The total land area that would be cleared in S area (see Figure 3-1) for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative is 23 acres or 0.12 percent of SRS land dedicated to industrial use. Approximately 15 acres or 0.078 percent of SRS land dedicated to industrial use would be cleared for the Direct Disposal in Grout facility in Z Area (see Figure 3-2). Land in Z Area would also be required for construction of new saltstone vaults. All land-disturbing activity would be within the fenced boundaries of S and Z Areas, areas currently devoted to industrial use (waste management facilities).

As noted in Section 3.4.1, the preferred site (Site B) for salt processing facilities in S Area is approximately one-quarter mile south of DWPF (an active industrial facility) and, as a result, is within an area with relatively high levels of noise and activity. Because the Saltstone Manufacturing and Disposal Facility has not operated since 1998, the preferred site in Z Area has lower levels than S Area of noise and activity, limited for the most part to security patrols and an occasional tour.

There is the potential to disturb wildlife in both S and Z Areas and in adjacent woodlands during the construction phase of the project (approximately four years for site preparation and facility construction). Construction would involve the movement of workers and construction equipment and would be associated with relatively loud noises from earth-moving equipment (including backhoes, bulldozers, and graders), portable generators, and air compressors. Although noise levels in construction areas could be as high as 110 decibels (dBA), these high local noise levels would not extend far beyond the boundaries of the proposed project sites.

Table 4-14 shows the attenuation of construction noise over relatively short distances. At 400 feet from the construction sites, construction noises would range from approximately 55 to 85 dBA. Golden et al. (1980) suggest that noise levels higher than 80 to 85 dBA are sufficient to startle or frighten birds and small mammals. Thus, there would be little potential for disturbing birds and small mammals outside a 400-foot radius of the construction sites.

Although noise levels would be relatively low outside the immediate construction areas, the combination of construction noise and human activity probably would displace small numbers of animals (e.g., songbirds and small mammals) that forage, feed, nest, rest, or den in the woodlands to the east of S Area and to the south and

Table 4-14. Peak and attenuated noise (in dBA) levels expected from operation of construction equipment.

Source	Noise level (peak)	Distance from source			
		50 feet	100 feet	200 feet	400 feet
Heavy trucks	95	84-89	78-83	72-77	66-71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
Pile driver	105	95	89	83	77
Fork lift	100	95	89	83	77

Source: Golden et al. (1980).

east of Z Area. It should be noted that an access road and a railroad spur (Z Line) separate Site B in S Area from woodlands to the east (see Figure 3-1), reducing the value of Site B and adjacent woodlands as wildlife habitat. The proposed site in Z Area (see Figure 3-2) is farther removed from roads and the railroad spur (and heavy industrial facilities in H and S Areas) and is presumed to have marginally higher value as wildlife habitat. Construction-related disturbances in both areas are likely to create impacts to wildlife that would be small, intermittent, and localized. Some animals could be driven from the area permanently, while others could become accustomed to the increased noise and activity and return to the area. Species likely to be affected (e.g., gray squirrel, opossum, white-tailed deer) are common to ubiquitous on SRS.

Under the No Action alternative, DOE would use approved siting procedures to ensure that any new tanks would be built in a previously disturbed industrial area. Studies and continued monitoring would also be performed to determine the presence of any threatened or endangered species and ensure that critical habitats would not be affected.

Operations

Operation of salt processing facilities would be less disruptive to wildlife than construction activities, but would entail movement of workers and equipment and noise from public address systems (e.g., testing of radiation and fire alarms), air compressors, pumps, and HVAC-related equipment. These activities would be similar under all alternatives, including No Action. With the possible exception of the public address systems, noise levels generated by these kinds of sources are not expected to disturb wildlife outside of facility boundaries.

As noted in Section 3.4, no threatened or endangered species or critical habitats occur in or near S or Z Areas, which are industrial sites surrounded by roads, parking lots, construction shops, and construction lay-down areas that are continually exposed to high levels of human disturbance. Proposed salt processing activities (and Tank Farm operations under No Action) would not disturb any threatened or endangered species, would not degrade any critical or sensitive habitat, and would not affect any wetlands. DOE would continue to monitor the areas around S and Z Areas for the presence of threatened or endangered species. If a listed species were found, DOE would determine if salt processing activities would affect that species. If DOE were to determine that adverse impacts could occur, DOE would initiate consultation with the U.S. Fish and Wildlife Service, as required by Section 7 of the Endangered Species Act.

4.1.7 LAND USE

The *Savannah River Site Future Use Plan* (DOE 1998) provides an Integral Site Model that lays out intended future land use policies. DOE determined that this model most realistically accommodates development during the next 50 years. The model divides the SRS into three zones: industrial, industrial support, and restricted public use. The future use plan does not contemplate DOE relinquishing ownership of or institutional control over any portion of the SRS. The industrial zone surrounds facilities that: process or store radioactive liquid or solid waste, fissionable materials, or tritium; conduct separations operations; or conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations. The new salt processing facility would be constructed in areas (S or Z) designated as industrial. As shown in Table 4-1, approximately 23 acres (0.12 percent of SRS land dedicated to industrial use) would be cleared and graded for salt processing facilities at the selected site in S Area (see Figure 3-1), should the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternative be selected. Approximately 15 acres (0.078 percent of SRS land dedicated to industrial use) would be cleared and graded for salt processing facilities in Z Area (see Figure 3-2), should the Direct Disposal in Grout alternative be selected. All land-disturbing activity would be within the fenced boundaries of S and Z Areas, areas currently devoted to industrial use (waste management facilities).

DOE would use the approved siting process to ensure that any new tanks under the No Action alternative would be constructed in a previously disturbed industrial area with a deep groundwater table. Due to the speculative nature of the No Action alternative, DOE has not determined how much land would be cleared for construction of any new HLW storage tanks. However, DOE assumes the area would be similar to that required under the action alternatives. Construction and operation of the proposed salt processing facility, including ongoing tank space management activities and building new tanks under the No Action alternative, would be consistent with the current SRS land use plans (DOE 1998).

4.1.8 SOCIOECONOMICS

Socioeconomic impact assessments are performed to determine the effects changes in local economic variables (e.g., number of jobs in a particular industry, wage rates, or increases in capital investment) may have on other economic measures (total regional employment, population, and total personal income).

New economic information was not developed for this SEIS. However, in 1999, DOE issued its *Accelerator Production of Tritium for the Savannah River Site Final Environmental Impact Statement* (DOE 1999). This EIS proposed a large accelerator for the SRS, and a full array of socioeconomic impact assessments was performed for the EIS. Based on these assessments, DOE concluded that the potential impacts attributed to construction and operation of the accelerator were relatively small in comparison with historical economic trends in the region and were not expected to stress existing regional infrastructures or result in an economic "boom."

<u>Construction</u>

During the construction phase of this project, based on preliminary design information, each salt processing alternative would employ approximately 500 construction workers annually, or about 50 percent fewer than the accelerator in its peak year of construction. Additionally, the estimated construction phase for the salt processing alternatives would be about 4 years, rather than 11 years for the accelerator, so potential construction impacts would be shorter in duration than those for the accelerator would have been.

Table 4-15 presents the estimated employment levels for each salt processing action alternative. The construction workforce is assumed to be constant over the life of the construction phase. The construction phase, expected to last approximately 4 years for each action alternative, would require less than 3.6 percent of the existing SRS workforce.

Under the No Action alternative, up to 500 construction workers may be employed to construct new HLW tanks. Tank construction would be expected to last 4 or more years (DOE 1980).

<u>Operations</u>

The Small Tank Precipitation alternative would require approximately 180 operations employees. The Ion Exchange alternative would require approximately 135 operations employees.

Table 4-15. Estimated salt processing employment by alternative.

Project phase	No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction	500[a]	500	500	500	500
Operations	65[b]	180	135	220	145

Source: (WSRC 1998a, 2000a)

a. Up to 500 construction workers could be employed if new HLW tanks were built under the No Action alternative.

b. Up to 65 operations workers could be employed if new HLW tanks were built under the No Action alternative. However, a workforce reduction could occur if operations at the DWPF were suspended under No Action.

The Solvent Extraction alternative would require approximately 220 operations employees, and the Direct Disposal in Grout alternative would require approximately 145 operations employees, (WSRC 1998a, 2000a). During the operations phase, the Solvent Extraction alternative would require the most workers, but would still require less than 1.5 percent of the existing SRS workforce.

DOE believes staffing requirements for construction and operations of any salt processing action alternative could be filled with existing SRS employees. Given the size of the local economy, any supplemental workforce requirements could be met without measurable impacts or the influx of large workforces. Therefore, DOE does not expect any salt processing action alternative to have measurable socioeconomic impacts.

Under the No Action alternative, DOE would continue tank space management activities for a period of approximately 10 years and employment would remain at the current level. Subsequent activities under No Action could impact employment levels. DOE could suspend operations at DWPF. Suspension of operations at these facilities could result in a workforce reduction, which would have a negative impact on the communities surrounding SRS. Alternatively, up to 65 new employees would be needed for the operation of any new HLW tanks constructed under No Action (DOE 1980).

4.1.9 CULTURAL RESOURCES

Depending on the salt processing alternative selected by DOE, construction of new facilities would be required in either S (Site B) or Z Area. Process buildings for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction alternatives would be built in S Area, while the process building for the Direct Disposal in Grout alternative would be built in Z Area. Regardless of the salt processing alternative (thus, facility configuration) chosen, support facilities including a service building, office building, and an electrical substation would also be constructed in close proximity to the main process building (see Chapter 2 and Appendix A for details). New salt disposal vaults would be built in Z Area under any of the salt processing alternatives.

Because no important archaeological resources were discovered during the S Area surveys conducted in support of the *Final Environmental Impact Statement Defense Waste Processing Facility Savannah River Plant* (DOE 1982), DOE believes additional construction within this area would not adversely impact cultural resources. Most of Z Area also has been surveyed in the past, and no important cultural resources were discovered (DOE 1994). Both areas have been disturbed repeatedly by construction activity over the last 15 to 20 years, and the likelihood of undiscovered cultural or historic resources is small.

DOE would use the approved siting process to ensure that any new tanks for the No Action alternative would be constructed in a previously disturbed industrial area. DOE would ensure that any tank construction would not impact cultural or historic resources.

If any archaeological or cultural resources were discovered in the course of developing the previously described facilities in S and Z Areas or new tanks for the No Action alternative, DOE would contact the Savannah River Archaeological Research Program and the State Historic Preservation Officer in compliance with Section 106 of the National Historic Preservation Act for guidance on mitigating potential impacts to these resources.

4.1.10 TRAFFIC AND TRANSPORTATION

SRS is served by more than 199 miles of primary roads and more than 995 miles of unpaved secondary roads. The primary highways used by SRS commuters are State Routes 19, 64, and 125; 40, 10, and 50 percent of the workers, respectively, use these routes. Traffic congestion can occur during peak periods onsite on SRS Road 1-A, State Routes 19 and 125, and U.S. Route 278 at SRS access points. Vehicles associated with this project would use these same routes and access points. None of the routes would require additional traffic controls or highway modifications, as explained below.

Construction

As shown in Table 4-16, concrete premix would be required during construction of the facilities under all action alternatives. Assuming that these materials are supplied by vendor facilities in Jackson and New Ellenton (for a round-trip distance of 18 miles), implementation of the alternatives would result in 55,000 to 61,000 freight miles traveled. Using Federal Highway Administration roadway composite statistics for South Carolina for the 1994 to 1996 period of record (Saricks and Tompkins 1999), these shipments would result in a maximum occurrence of 0.05 accidents, no fatalities, and 0.03 injuries as a result of material transport activities during construction. These projections are similar for all action alternatives. Therefore, it is highly unlikely that material transport activities during construction would lead to any accidents, fatalities, or injuries, regardless of the alternative selected.

As shown in Table 4-17, approximately 500 workers would travel to the Site 5 days a week (250 round trips per year for each worker) for 45 to 50 months during the construction phase of the project. Assuming no ride sharing and a round-trip commute distance of 50 miles, up to 26 million commuter miles would be traveled during the construction phase. Using 1998 national transportation statistics (BTS 1998), as many as 98 vehicle accidents could occur with this mileage, resulting in a maximum of 0.4 fatalities and 43 injuries. These projections are similar for all action alternatives.

Building new HLW tanks under the No Action alternative would require a similar number of material shipments as that required for construction of the action alternatives. DOE anticipates that the construction workforce under the No Action alternative would also be similar to the number of workers employed for construction of the action alternatives.

Operations

As shown in Table 4-16, saltstone premix and process reagents would be required during operation of the facilities under all action alternatives. Assuming that these materials are supplied by vendor facilities in Jackson and New Ellenton (for a round-trip distance of 18 miles), implementation of the alternatives would result in 340,000 to 470,000 miles traveled. Using Federal Highway Administration roadway composite statistics for South Carolina for the 1994 to 1996 period of record (Saricks and Tompkins 1999), these shipments would result in a maximum occurrence of 0.4 accidents, 0.02 fatalities, and 0.3 injuries as a result of material transport activities during construction. These projections are similar for all action alternatives. Therefore, it is very unlikely that material transport activities during construction would lead to any accidents, fatalities, or injuries, regardless of the alternative selected.

As shown in Table 4-17, between approximately 135 and 220 workers, depending on the alternative selected, would travel to the Site 5 days a week (250 round trips per year for each worker) for the 14.3-year startup and operation phase of the project. Assuming no ride sharing and a round-trip commute distance of 50 miles, up to 39 million commuter miles would be traveled during the operations phase. Using 1998 national transportation statistics (BTS 1998), as many as 148 vehicle accidents could occur with this mileage, resulting in a maximum of 0.6 fatalities and 65 injuries. The projections are similar for all action alternatives.

For the No Action alternative, up to 65 new employees would be needed for the 13-year operation phase (2010-2023) for any tanks constructed (DOE 1980). Therefore, approximately 39 vehicle accidents could occur under the No Action alternative, resulting in a maximum occurrence of 0.2 fatalities and 17 injuries.

The surrounding area already has a certain volume of truck and car traffic associated with SRS logging, agriculture, and industrial activity. The

Table 4-16. Material (totals for the construction and operation phases) transportation impacts associated with the salt processing alternatives.

Material use/worker travel impact categories		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction					
Structural concrete premix shipments[a,b]		3,000	3,000	3,000	3,400
Total round-trip shipment (distance miles)		55,000	55,000	55,000	61,000
Number of	Accidents	0.04	0.04	0.04	0.05
	Fatalities	0	0	0	0
	Injuries	0.03	0.03	0.03	0.03
Operations[c]					
Saltstone premix		25,500	21,100	23,800	19,000
Sodium hydroxide		6	56	416	4
Oxalic acid		1	1	1	1
Tetraphenylborate		710	NA	NA	NA
Monosodium titanate		1	1	1	1
Crystalline Silicotitanate		NA	11	NA	NA
90% Formic acid[b]		66	NA	NA	NA
15% Cupric nitrate[b]		45	NA	NA	NA
Nitric Acid		NA	NA	9	NA
Isopar®L		NA	NA	40	NA
Trioctylamine		NA	NA	1	NA
Calixarene		NA	NA	1	NA
Cs-7SBT		NA	NA	1	NA
Total number of shipments		26,000	21,000	24,000	19,000
Total round-trip shipment distance (miles)		470,000	380,000	440,000	340,000
Number of	Accidents	0.4	0.3	0.3	0.3
	Fatalities	0.02	0.02	0.02	0.01
	Injuries	0.3	0.2	0.2	0.2

a. Data for structural concrete use adapted from Attachments 9.2, 9.3, 9.4, and 9.5 of the life cycle cost estimate report (WSRC 1998a) using an assumed blended concrete premix density of 3,934 lb/yd^3 and a truck load capacity of 50,000 pounds.
b. Concrete requirements for construction of any new tanks under the No Action alternative would be similar to those required for the action alternatives.
c. For operations under the No Action alternative, material shipments would remain at current levels.
d. Corresponding decrease at DWPF.
NA = not applicable. The chemical would not be used in that particular alternative.

Table 4-17. Worker transportation impacts associated with the salt processing alternatives.

Worker travel impact categories		No Action	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Construction worker travel						
Number of workers		500[a]	500	500	500	500
Total number of Site trips		500,000[a]	500,000	520,000	500,000	480,000
Total round-trip distance (million miles)		25[a]	25	26	25	24
Number of	Accidents	95[a]	95	98	95	91
	Fatalities	0.4[a]	0.4	0.4	0.4	0.4
	Injuries	42[a]	42	43	42	40
Operations worker travel						
Number of workers		65[b]	180	135	220	145
Total number of Site trips		210,000[b]	640,000	480,000	780,000	510,000
Total round-trip distance (million miles)		11[b]	32	24	39	26
Number of	Accidents	39[b]	122	91	148	97
	Fatalities	0.2[b]	0.5	0.4	0.6	0.4
	Injuries	17[b]	53	40	65	42

a. Based on 500 construction workers over a 4-year construction period. The construction period could be longer, depending on the number of tanks built.
b. Up to 65 workers would be required for operation of any new tanks built under No Action.

amount of traffic associated with any of the alternatives (including No Action) is not expected to substantially increase traffic volume.

4.1.11 WASTE GENERATION

4.1.11.1 Wastes From Salt Processing

Each of the action alternatives would produce a low-activity salt waste stream that would be grouted for disposal in vaults in Z Area. The characteristics and volumes of grout produced from the low-activity salt solutions would vary among the alternatives. In addition, the high-activity materials separated from the salt solution would be transferred to DWPF for processing to borosilicate glass. Details of the wastes from salt processing under each of the action alternatives are discussed below.

Under the Small Tank Precipitation alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. New cement silos would be built to accommodate saltstone production. Sixteen new vaults would be needed to accommodate the expected grout volume (188 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55 (see Appendix A for Class A limits). Approximately 2.9 million gallons of slurry, containing monosodium titanate (MST) solids and precipitate hydrolysis aqueous (PHA) product, would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository. Processing the precipitate in the Small Tank Precipitation Facility would create a benzene waste stream that is unique to this salt processing alternative. The management of this benzene waste is described in Section 4.1.11.2.

Under the Ion Exchange alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. No modifications to the existing grouting process would be required. Thirteen new vaults would be needed to accommodate the expected grout volume (156 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55. Approximately 2 million gallons of slurry containing MST solids and 600,000 gallons of cesium-loaded crystalline silicotitanate (CST) resin would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository.

Under the Solvent Extraction alternative, the low-activity salt solution would be transferred to the existing Saltstone Manufacturing and Disposal Facility in Z Area for disposal as grout. No modifications to the existing grouting process would be required. Fifteen new vaults would be needed to accommodate the expected grout volume (175 million gallons). The grout would be equivalent to Class A LLW, as defined in 10 CFR 61.55. Approximately 2 million gallons of slurry containing MST solids and 6.8 million gallons of cesium-loaded strip solution would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository. The Solvent Extraction process would also generate a liquid organic solvent. Management of this solvent waste is described in Section 4.1.11.2.

Under the Direct Disposal in Grout alternative, radioactive cesium would not be separated from salt solutions. Because of the shielding requirements for handling the cesium-containing salt solution, this material could not be processed in the existing Z Area Saltstone Manufacturing and Disposal Facility. After treatment with MST and filtration to remove strontium, uranium, plutonium, and entrained sludge, the clarified salt solution would be transferred to a new grouting facility located in Z Area. Thirteen new vaults would be needed to accommodate the expected grout disposal volume (141 million gallons). Because of its cesium content, the grout would be equivalent to Class C LLW, as defined in 10 CFR 61.55 (see Appendix A for Class C limits). Approximately 2 million gallons of slurry containing MST solids would be transferred to DWPF. Treatment of this material by adding it to the HLW sludge to be vitrified in DWPF would produce HLW canisters that would be included in the total of approximately 5,700 HLW canisters destined for a geologic repository.

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, without a process for separating the high-activity and low-activity salt fractions. DWPF would vitrify only sludge from the HLW tanks. HLW salt would be stored in existing tanks and monitoring activities would continue. Current tank space management projections indicate that, after 2010, additional tank space would be needed to support continued operations (WSRC 1999d). The course of action that DOE would follow cannot be predicted at this time but, regardless of which option DOE would pursue, waste generation rates under No Action would not be expected to increase from current levels.

4.1.11.2 Secondary Waste

This section presents the secondary waste generation estimates for each salt processing alternative that DOE considers in this SEIS. Unlike wastes from salt processing that are the direct result of processing the salt solutions, secondary wastes are those wastes generated as a result of construction, operation, and maintenance of the salt processing facilities under the action alternatives. Impacts are assessed in terms of the amount of secondary waste projected for each of the alternatives, relative to the quantity of waste that would otherwise be managed at SRS during the period of analysis. Table 4-18 provides estimates of the maximum annual waste generation. Table 4-19 provides the total waste volumes that would be generated over the life cycle of each of the salt processing alternatives.

Table 4-18. Maximum annual waste generation for the salt processing action alternatives[a].

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	300,000	250,000	900,000	150,000
Nonradioactive liquid waste (gallons)	Negligible[b]	34,000[b,c]	Negligible[b]	Negligible[b]
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
LLW (m^3)	71	71	71	71
Hazardous waste (m^3)	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1	Startup – 23[d] Operations – 1
Mixed LLW (m^3)	1	1	1	1
Mixed low-level liquid waste (gallons)	60,000	None	1,000	None
Industrial waste (metric tons)	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20	Startup – 30[d] Operations – 20
Sanitary waste (metric tons)	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41	Startup – 62[d] Operations – 41

Source: WSRC (1999b, 2000b).
a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.
b. Assumes continuous operation.
c. CST resin pretreatment generates a spent 1 M NaOH solution and CST fines slurry.
d. Assumes a 1.3-year duration for startup activities under each action alternative.

Table 4-19. Total estimated waste generation for the salt processing action alternatives[a].

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Radioactive liquid waste (gallons)	3.9×10^6	3.3×10^6	1.2×10^7	2.0×10^6
Nonradioactive liquid waste (gallons)	negligible	4.9×10^5	negligible	negligible
Transuranic waste (m^3)	negligible	negligible	negligible	negligible
LLW (m^3)	920	920	920	920
Hazardous waste (m^3)	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13	Startup – 30[b] Operations – 13
Mixed LLW (m^3)	13	13	13	13
Mixed low-level liquid waste (gallons)	780,000	None	13,000	None
Industrial waste (metric tons)	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260	Startup – 39 Operations – 260
Sanitary waste (metric tons)	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530	Startup – 81 Operations – 530

a. Under the No Action alternative, waste generation rates would be similar to those at the existing HLW Tank Farms. Therefore, waste generation rates would not be expected to increase from current levels.
b. Assumes a 1.3-year duration for startup activities and 13 years of operation for each of the action alternatives.

Waste generation under the No Action alternative would be similar to waste generation rates at the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline. Baseline forecasts are provided in Table 5-4.

Liquid Waste

The radioactive wastewater that would be generated as a result of salt processing activities is produced during the DWPF vitrification process. The incremental increase in DWPF radioactive liquid waste would be associated with processing the high-activity waste (e.g., MST slurry, PHA product, loaded CST resin, cesium strip solution) from the various salt processing action alternatives, and would vary from about 150,000 gallons per year for the Direct Disposal in Grout alternative to 900,000 gallons per year for the Solvent Extraction alternative. The Small Tank Precipitation and the Ion Exchange alternatives would generate 300,000 and 250,000 gallons per year, respectively. The DWPF radioactive wastewater would be returned to the Tank Farm to be processed in the waste evaporators. Evaporator overheads would be treated in the ETF and discharged to Upper Three Runs via NPDES outfall H-16. DOE currently is examining options to ensure sufficient capacity in the Tank Farms to accommodate the DWPF radioactive liquid waste stream and other projected influents to the SRS HLW management system (WSRC 1999d).

Transuranic waste

DOE would not expect to generate transuranic wastes as a result of the proposed salt processing activities.

LLW

Under each of the action alternatives, DOE would expect to generate approximately 71 cubic meters per year of LLW. The projected volume represents about 0.5 percent of the forecasted SRS LLW generation through 2029 (Halverson 1999). Compactible LLW would be segregated from non-compactible LLW and processed in a volume reduction facility before disposal. Currently all LLW is disposed of onsite, but DOE is investigating the possibility of sending some LLW offsite for commercial treatment and disposal (DOE 2000d).

Hazardous waste

Under each of the action alternatives, DOE would expect to generate approximately 23 cubic meters per year of hazardous waste as a result of startup activities. This waste would consist of nonradioactive chemicals used to test the new facilities prior to actual waste processing. An additional 1 cubic meter per year of hazardous waste is expected during operations. The projected volume represents about 0.7 percent of the forecasted SRS hazardous waste generation through 2029 (Halverson 1999). This waste would be shipped offsite to commercial facilities for treatment and disposal (DOE 2000d).

Mixed LLW

Under each of the action alternatives, DOE would expect to generate small amounts (about 1 cubic meter per year) of mixed waste. These projected volumes represent about 0.4 percent of the forecasted SRS mixed LLW generation through 2029 (Halverson 1999). This waste would be treated onsite or at other DOE sites. Disposal would be at offsite facilities (DOE 2000d).

Under the Small Tank Precipitation alternative, additional mixed LLW would be produced as a result of processing the precipitate. In a section of the Small Tank Precipitation facility, the precipitate slurry would undergo acid hydrolysis to separate it into a low-radioactivity organic portion (benzene) and a high-radioactivity aqueous portion. The organic portion would then be separated from the aqueous portion, washed to reduce the level of cesium, and transferred to the Organic Waste Storage Tank in S Area, which has a storage capacity of 150,000 gallons. A maximum of 60,000 gallons per year of benzene waste could be produced. DOE is investigating treatment and disposal options for this waste stream.

Under the Solvent Extraction alternative, additional mixed LLW would be produced as a result of solvent replacement. The total solvent inventory for the process, consisting primarily of the diluent Isopar®L, is a projected 1,000 gallons. Using the conservative assumption that the solvent inventory is replaced once per year, a total of 13,000 gallons of organic solvent could be accumulated over the 13-year operating life. DOE is investigating treatment and disposal options for this waste stream.

Industrial waste

Under each of the action alternatives, DOE would expect to generate approximately 30 metric tons per year of industrial (nonhazardous, nonradioactive) waste as a result of startup activities and an additional 20 metric tons per year during operations. The projected volume represents less than 1 percent of the forecasted SRS industrial waste generation through 2029 (Halverson 1999). This waste would be recovered for recycling or disposed of onsite at the Three Rivers Landfill (DOE 2000d).

Sanitary waste

Sanitary wastewater from the salt processing facilities would be treated in the Centralized Sanitary Wastewater Treatment Facility and discharged to Fourmile Branch via NPDES outfall G-10. These discharges would be expected to comply with current NPDES permit limitations.

Under each of the action alternatives, DOE would expect to generate approximately 62 metric tons per year of solid sanitary wastes as a result of startup activities and an additional 41 metric tons per year during operations. The projected volume represents about 5 percent of the forecasted SRS sanitary waste generation through 2029 (Halverson 1999). This waste would be disposed of onsite at the Three Rivers landfill (DOE 2000d).

4.1.12 UTILITIES AND ENERGY

This section discusses potential utility and energy impacts from construction and operation under each of the salt processing alternatives. The scope of the analysis includes electric power, fuel (diesel and gasoline) consumption, process water consumption, and steam use. DOE used applicable past SRS operations or engineering to estimate the energy and utility requirements of the alternatives. Estimates of water use include: process additions, cooling, and flushing; product washes; and grout production. Steam is used primarily to operate the ventilation systems and to heat waste solutions during processing. Fuel consumption is based on use of diesel-powered equipment during construction activities and diesel emergency power generators. The analysis compared the use of electricity, water, and steam to the available capacities discussed in Section 3.10.

DOE would obtain utilities and energy from existing sources and suppliers. Water would come from existing site wells; and electricity and fuel would come from existing on- and offsite suppliers. Steam would be produced onsite.

Table 4-20 lists electric energy, fuel, steam, and water use during the construction and operation phases of each action alternative. Overall, DOE does not expect substantial increases in water use or energy consumption with implementation of any of the alternatives, including No Action.

4.1.12.1 Water Use

During the approximately 4-year construction phase, the estimated demand for water would range from 33 to 37 million gallons, depending on the processing alternative selected. On a daily average basis, the highest use would represent about 2.3 percent of water used in H-, S-, and Z-Area facilities in 1998 (SCDHEC 1999a) and 0.2 percent of the lowest estimated production capacity of the aquifer (16 million gallons per day) (WSRC 1998b).

Under the No Action alternative, construction of any new tanks would require approximately 660,000 gallons of water per tank (DOE 1980), which is less than 0.1 percent of the aquifer production capacity.

Table 4-20. Estimated project total energy and utilities use for the salt processing alternatives.

Phase[a]	SRS Baseline[b]	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Potable water use (million gallons)					
Construction	NA	19	20	19	18
Operation	NA	99	95	120	75
Project subtotal use	NA	118	115	139	93
Process water use (million gallons)					
Construction	NA	16	17	16	15
Operation	23,000[c]	301	271	225	181
Project subtotal use	NA	317	288	241	196
Project total water use (million gallons)	NA	435	403	380	289
Peak electrical power demand (megawatts)					
Construction	NA	1.66	1.66	1.66	1.66
Operation	130[c]	24	24	32	18
Electricity use (gigawatt-hours)					
Construction	NA	76	79	76	73
Operation	410[c]	243	286	315	172
Project total use	NA	319	365	391	245
Steam use (million pounds)					
Construction	NA	0	0	0	0
Operation	NA	2,548	2,300	1,915	1,536
Project total use	NA	2,548	2,300	1,915	1,536
Fuel use (million gallons)					
Construction	NA	8.4	9	8.4	8
Operation	8.75[d]	0.3	0.3	0.3	0.2
Project total use	NA	8.7	9.3	8.7	8.2

Adapted from WSRC (1999e).

a. From Table 2-1, the construction and operation duration of each alternative are as follows: Small Tank Precipitation – 48 months and 13 years; Ion Exchange – 50 months and 13 years; Solvent Extraction – 48 months and 13 years; and Direct Disposal in Grout – 46 months and 13 years. The total project duration includes a startup duration of 1.3 years for each alternative (WSRC 1999f).

b. Construction of any new tanks would require approximately 660,000 gallons of water and 45,000 gallons of fuel per tank. Utility and energy use under the No Action alternative would be similar to use at the existing HLW Tank Farms, and is included in the baseline.

c. Halverson (1999).

d. DOE (1995).

NA = Not Available.

During the 13-year operational phase, total water use for the action alternatives would be similar and would vary between 256 and 400 million gallons, depending on the processing alternative selected. On a daily average use basis, the highest use would be about 22.6 percent of the volume used in H-, S-, and Z-Area facilities during 1998 (SCDHEC 1999a), and 1.5 percent of the lowest estimated production capacity of the aquifer (WSRC 1998b).

Water use for the entire duration of the project would be similar for all action alternatives and would be between 289 and 435 million gallons, for the Direct Disposal in Grout and Small Tank Precipitation alternatives, respectively.

For the No Action alternative, water use during operation under any scenario would be slightly higher than the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline.

4.1.12.2 Electricity Use

During construction, the estimated peak electrical power demand would be 1.7 megawatts for each alternative, with use varying between about 73 and 79 gigawatt-hours, depending on the processing alternative selected. The peak power demand would be a small fraction of the H-Area power distribution network's capacity (64 megawatts) (WSRC 1996). Power for S and Z Areas would be supplied through the H-Area network.

Electric power demand during construction of any tanks under the No Action alternative would be similar to that of the action alternatives.

During operations, the peak electric power demand would be very similar for each action alternative and would vary between 18 and 32 megawatts, depending on the processing alternative selected. In combination with the 22-megawatt demand for power from H-Area facilities, a total demand of 54 megawatts is possible, which represents 84 percent of the H-Area power distribution network's capacity (WSRC 1996). The highest peak power demands and electricity use would occur under the Solvent Extraction alternative. Electricity use during operations would be similar for each action alternative and would vary between 172 and 315 gigawatt-hours, depending on the alternative selected.

Electricity use for the entire duration of the project would be between 245 and 391 gigawatt-hours, for the Direct Disposal in Grout and Solvent Extraction alternatives, respectively.

For the No Action alternative, electric power demand during operation of any scenario would be slightly higher than the existing HLW Tank Farms and would therefore constitute a slight increase over the baseline.

4.1.12.3 Steam Use

No steam would be used during the construction phase for any of the alternatives, including No Action. The main uses for steam during the operation phase would be operation of building ventilation systems and waste solution heating. Operation of the ventilation systems would account for most of the steam used. Total steam use during the operations phase would be similar under each alternative and would range from 1.5 to 2.5 billion pounds for the Direct Disposal in Grout and Small Tank Precipitation alternatives, respectively. On a daily average use basis, the highest use would be about 18.3 percent of the steam used in H-, S-, and Z-Area facilities, and 1.5 percent of the steam production capacity for H-, S-, and Z-Area facilities (WSRC 1996).

Steam use under the No Action alternative would be slightly higher than current use rates at the existing HLW Tank Farms. Therefore, the No Action alternative would constitute a slight increase over the baseline.

4.1.12.4 Fuel Use

Diesel and gasoline fuels would be used during the construction and operation phases of the project, primarily for the operation of mobile heavy equipment and stationary support equipment. Fuel consumption would be similar under all the action alternatives. The highest consumption of liquid fuels, about 9 million gallons, would be during the construction phase of the Ion Exchange alternative (2.1 million gallons per year). Liquid fuel use during the operations phase of any alternative is low, at less than 300,000 gallons total. As a comparison, operations at SRS used approximately 8.75 million gallons of liquid fuels in 1994 (DOE 1995).

Under the No Action alternative, a total of approximately 45,000 gallons of diesel fuel and gasoline would be required per tank during construction (DOE 1980). Liquid fuel use during the operation phase would be similar to the existing Tank Farm and is included in the baseline.

4.1.13 ACCIDENT ANALYSIS

This section summarizes risks to the public and workers from potential accidents associated with the various salt processing action alternatives at SRS.

Detailed descriptions of each accident, including the scenario description, probability of occurring, radiological source terms, nonradiological hazardous chemical release rates, and consequences are provided in Appendix B.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released. Initiating events fall into three categories:

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

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

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

Because current operations are the basis from which each of the proposed alternatives begins, the hazards associated with each of the action alternatives are in addition to those of current operations. However, after the period of operation, the hazards associated with salt processing are eliminated and those associated with the storage of salt solutions would be substantially reduced. Because the No Action alternative includes primarily current operations that have been evaluated under the NEPA process and in approved safety analysis reports, accidents associated with current tank space management operations are not evaluated here. Failure of a Salt Solution Hold Tank is addressed in the High-level Waste Tank Closure Draft EIS (DOE 2000e). The radiological and nonradiological hazards associated with the four action alternatives were evaluated in this section and Appendix B.

<u>**Nonradiological**</u>

The long-term health consequences of human exposure to nonradiological hazardous materials are not as well understood as those related to radiation exposure. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

Table 4-21 summarizes the impacts of accidents involving the release of nonradiological hazardous materials to the MEI and noninvolved workers. In general, impacts to these receptors resulting from accidents involving nonradiological hazardous materials are minimal. However, noninvolved workers exposed to atmospheric releases of benzene from two of the accidents evaluated under the Small Tank Precipitation alternative could develop serious or life-threatening health effects. Workers exposed to airborne benzene concentrations (950 mg/m^3) resulting from an Organic Waste Storage Tank (OWST) loss of confinement accident could experience serious health effects that may impair their ability to take protective action (e.g., dizziness, confusion, impaired vision). Workers exposed to airborne benzene concentrations (8,840 mg/m^3) resulting from an explosion in the OWST, could experience life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory failure). Both of these accidents would occur less than once in 100,000 years and are in the extremely unlikely category.

Radiological

Tables 4-22 through 4-25 summarize for each salt processing alternative the estimated impacts to onsite workers and the public from potential accidents involving the release of radiological materials. These tables list potential accident consequences for all receptors as LCFs per accident and LCFs per year. The LCF per accident values are an estimate of the consequences without accounting for the probability of the accident occurring. The LCF per year values do take the accident's probability into consideration and provide a common basis for comparison of accident consequences.

DOE estimated impacts to five receptors: (1) the MEI at the SRS boundary; (2) the offsite population in an area within 50 miles (80 kilometers); (3) an involved worker 328 feet (100 meters) from the accident; (4) a noninvolved worker 2,100 feet (640 meters) from the accident location, as discussed in DOE (1994); and (5) the onsite population (includes both involved and noninvolved workers).

For all of the accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. In some cases, the impacts to the involved worker would be greater than to the noninvolved worker. DOE estimated the increased probability of an LCF to an involved and a noninvolved worker from radiation exposure during each of the accident scenarios.

However, prediction of latent potential health effects becomes increasingly difficult to quantify with any certainty as the distance between the accident location and the receptor decreases, because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The involved worker may be acutely injured or killed by physical effects of the accident itself. DOE identified potential accidents in Cappucci et al. (1999) and estimated impacts using the AXAIRQ computer model (Simpkins 1995a,b), as discussed in Appendix B.

4.1.14 PILOT PLANT

As discussed in Section 2.7.6, a Pilot Plant would be designed and constructed to demonstrate the overall process objectives of the selected salt processing alternative. Details of the proposed demonstration objectives are provided in Appendix A. Detailed design and construction of the Pilot Plant would be initiated upon selection of the salt processing alternative and operation would extend through completion of final design and potentially through startup of the full-scale facility. This section discusses potential impacts from construction and operation of the Pilot Plant for each salt processing action alternative.

For the purposes of this SEIS, DOE assumes that the Pilot Plant components would be sized to operate on a scale of approximately 1/100 to 1/10 that of the full-size facility, and would utilize a modular design to facilitate remote installation and modification of the process equipment. A Pilot Plant for the Direct Disposal

Table 4-21. Estimated consequences of accidents involving nonradioactive hazardous materials.

	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Sodium Hydroxide Releases				
Caustic Feed Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}	5.9×10^{-4}
Noninvolved Worker (640 m) Dose (mg/m^3)	0.18	0.18	0.18	0.18
Caustic Dilution Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	NA	NA	NA	0.0031
Noninvolved Worker (640 m) Dose (mg/m^3)	NA	NA	NA	0.93[a]
Accidents Involving Nitric Acid Releases				
Nitric Acid Feed Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	NA	NA	8.8×10^{-5}	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	NA	NA	0.026	NA
Accidents Involving Benzene Releases				
PHA Surge Tank Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	7.4×10^{-10}	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	2.2×10^{-8}	NA	NA	NA
TPB Tank Spill – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	0.060	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	18.7	NA	NA	NA
Organic Evaporator Loss of Confinement – Frequency: Once in 30 years				
MEI Dose (mg/m^3)	0.45	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	130	NA	NA	NA
Beyond Design Basis Earthquake – Frequency: Less than once in 2,000 years				
MEI Dose (mg/m^3)	0.0026	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	0.78	NA	NA	NA
OWST Loss of Confinement – Frequency: Once in 140,000 years				
MEI Dose (mg/m^3)	3.2	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	950[b]	NA	NA	NA
Loss of Cooling – Frequency: Once in 170,000 years				
MEI Dose (mg/m^3)	0.0015	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	0.44	NA	NA	NA
Benzene Explosion in the OWST – Frequency: Once in 770,000 years				
MEI Dose (mg/m^3)	30	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)	8,840[c]	NA	NA	NA

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

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

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

NA = Not Applicable, MEI - maximally exposed (offsite) individual, PHA = precipitate hydrolysis aqueous, OWST = Organic Waste Storage Tank, TPB = tetraphenylborate.

Table 4-22. Estimated accident consequences for the Small Tank Precipitation process.

	Loss of Confinement - PHA surge tank[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell-PHA Surge tank[a]	Benzene explosion	Helicopter Impact - PHA Surge Tank[a]	Aircraft Impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 99,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI dose (rem)	0.0016	0.31	0.014	0.70	3.3	5.4
MEI LCF per accident[c]	8.2×10^{-7}	1.5×10^{-4}	7.2×10^{-6}	3.5×10^{-4}	0.0016	0.0027
MEI LCF per year[c]	2.8×10^{-8}	7.6×10^{-8}	7.2×10^{-10}	3.5×10^{-9}	7.9×10^{-10}	1.0×10^{-9}
Offsite population dose (person-rem)	88	16,000	780	38,000	170,000	280,000
Offsite population LCF per accident	0.044	8.0	0.39	19	87	140
Offsite population LCF per year	0.0015	0.0040	3.9×10^{-5}	1.9×10^{-4}	4.2×10^{-5}	5.3×10^{-5}
Noninvolved worker Dose (rem)	0.024	9.6	0.21	10	100	170
Noninvolved worker LCF per accident[c]	9.5×10^{-6}	0.0038	8.5×10^{-5}	0.0041	0.041	0.067
Noninvolved worker LCF per year[c]	3.2×10^{-7}	1.9×10^{-6}	8.5×10^{-9}	4.1×10^{-8}	2.0×10^{-8}	2.5×10^{-8}
Involved worker dose (rem)	3.2×10^{-6}	310[d]	2.8×10^{-5}	0.0014	3,300[d]	5,400[d]
Involved worker LCF per accident[c]	1.3×10^{-9}	0.12	1.1×10^{-8}	5.5×10^{-7}	1.3	2.1
Involved worker LCF per year[c]	4.3×10^{-11}	6.1×10^{-5}	1.1×10^{-12}	5.6×10^{-12}	6.3×10^{-7}	8.0×10^{-7}
Onsite population dose (person-rem)	39	9,000	340	17,000	97,000	160,000
Onsite population LCF per accident	0.016	3.6	0.14	6.7	39	63
Onsite population LCF per year	5.3×10^{-4}	0.0018	1.4×10^{-5}	6.8×10^{-5}	1.9×10^{-5}	2.3×10^{-5}

a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
PHA = precipitate hydrolysis aqueous; PHC = precipitate hydrolysis cell; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-23. Estimated accident consequences for the Ion Exchange process.

	Loss of Confinement - Alpha Filter Cell[a]	Beyond Design-Basis Earthquake[b]	Loss of Cooling-Loaded Resin Hold Tank[a]	Fire in a Process Cell - Alpha Filter Cell[a]	Helicopter Impact - Alpha Filter Cell[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 5,300 years	Once in 10,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	8.3×10^{-4}	0.12	9.4×10^{-7}	0.0094	1.7	2.0
MEI LCF per accident[c]	4.2×10^{-7}	5.9×10^{-5}	4.7×10^{-10}	4.7×10^{-6}	8.5×10^{-4}	0.0010
MEI LCF per year[c]	1.4×10^{-8}	2.9×10^{-8}	8.9×10^{-14}	4.7×10^{-10}	4.1×10^{-10}	3.7×10^{-10}
Offsite population Dose (person-rem)	45	6,200	0.052	500	89,000	110,000
Offsite population LCF per accident	0.022	3.1	2.6×10^{-5}	0.25	45	53
Offsite population LCF per year	7.6×10^{-4}	0.0016	5.0×10^{-9}	2.5×10^{-5}	2.1×10^{-5}	2.0×10^{-5}
Noninvolved Worker Dose (rem)	0.012	3.7	1.4×10^{-5}	0.14	53	63
Noninvolved Worker LCF per accident[c]	4.9×10^{-6}	0.0015	5.7×10^{-9}	5.5×10^{-5}	0.021	0.025
Noninvolved Worker LCF per year[c]	1.6×10^{-7}	7.4×10^{-7}	1.1×10^{-12}	5.5×10^{-9}	1.0×10^{-8}	9.4×10^{-9}
Involved Worker Dose (rem)	6.4×10^{-8}	120	8.8×10^{-8}	9.1×10^{-7}	1,700[d]	2,000[d]
Involved Worker LCF per accident[c]	2.6×10^{-11}	0.047	3.5×10^{-11}	3.6×10^{-10}	0.68	0.81
Involved Worker LCF per year[c]	8.7×10^{-13}	2.4×10^{-5}	6.7×10^{-15}	3.6×10^{-14}	3.2×10^{-7}	3.0×10^{-7}
Onsite population Dose (person-rem)	20	3,500	0.023	220	50,000	59,000
Onsite population LCF per accident	0.0080	1.4	9.0×10^{-6}	0.089	20	24
Onsite population LCF per year	2.7×10^{-4}	6.9×10^{-4}	1.7×10^{-9}	8.9×10^{-6}	9.5×10^{-6}	8.8×10^{-6}

a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-24. Estimated accident consequences for the Solvent Extraction process.

	Loss of Confinement - SSRT[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell - Alpha Filter Cell[a]	Hydrogen Explosion-Extraction Cell[a]	Helicopter Impact - Alpha Filter Cell[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 1,300,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	8.3×10^{-4}	0.12	0.0094	0.0029	1.7	2.0
MEI LCF per accident[c]	4.2×10^{-7}	5.8×10^{-5}	4.7×10^{-6}	1.4×10^{-6}	8.5×10^{-4}	0.0010
MEI LCF per year[c]	1.4×10^{-8}	2.9×10^{-8}	4.7×10^{-10}	1.1×10^{-12}	4.1×10^{-10}	3.8×10^{-10}
Offsite population Dose (person-rem)	45	6,100	500	160	89,000	110,000
Offsite population LCF per accident	0.022	3.0	0.25	0.081	45	54
Offsite population LCF per year	7.6×10^{-4}	0.0015	2.5×10^{-5}	6.1×10^{-8}	2.1×10^{-5}	2.0×10^{-5}
Noninvolved Worker Dose (rem)	0.012	3.6	0.14	0.044	53	64
Noninvolved Worker LCF per accident[c]	4.9×10^{-6}	0.0015	5.5×10^{-5}	1.8×10^{-5}	0.021	0.026
Noninvolved Worker LCF per year[c]	1.6×10^{-7}	7.3×10^{-7}	5.5×10^{-9}	1.3×10^{-11}	1.0×10^{-8}	9.5×10^{-9}
Involved Worker Dose (rem)	6.4×10^{-8}	120	7.2×10^{-7}	2.7×10^{-4}	1,700[d]	2,000[d]
Involved Worker LCF per accident[c]	2.6×10^{-11}	0.046	2.9×10^{-10}	1.1×10^{-7}	0.68	0.81
Involved Worker LCF per year[c]	8.7×10^{-13}	2.3×10^{-5}	2.9×10^{-14}	8.1×10^{-14}	3.3×10^{-7}	3.0×10^{-7}
Onsite population Dose (person-rem)	20	3,400	220	70	50,000	60,000
Onsite population LCF per accident	0.0080	1.4	0.089	0.028	20	24
Onsite population LCF per year	2.7×10^{-4}	6.8×10^{-4}	8.9×10^{-6}	2.1×10^{-8}	9.6×10^{-6}	8.9×10^{-6}

a. Tank/cell listed is bounding case (e.g., it results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
SSRT = sludge solids receipt tank; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

Table 4-25. Estimated accident consequences for the Direct Disposal in Grout process.

	Loss of Confinement - SSRT[a]	Beyond Design-Basis Earthquake[b]	Fire in a Process Cell - SSRT[a]	Helicopter Impact - SSRT[a]	Aircraft impact[b]
Frequency	Once in 30 years	Less than once in 2,000 years	Once in 10,000 years	Once in 2,100,000 years	Once in 2,700,000 years
MEI Dose (rem)	2.4×10^{-4}	0.042	0.0027	0.53	0.74
MEI LCF per accident[c]	1.2×10^{-7}	2.1×10^{-5}	1.4×10^{-6}	2.7×10^{-4}	3.7×10^{-4}
MEI LCF per year[c]	4.1×10^{-9}	1.0×10^{-8}	1.4×10^{-10}	1.3×10^{-10}	1.4×10^{-10}
Offsite population Dose (person-rem)	14	2,300	160	29,000	40,000
Offsite population LCF per accident	0.0072	1.1	0.081	14	19
Offsite population LCF per year	2.4×10^{-4}	5.7×10^{-4}	8.1×10^{-6}	6.9×10^{-6}	7.4×10^{-6}
Noninvolved Worker Dose (rem)	0.0036	1.3	0.041	17	23
Noninvolved Worker LCF per accident[c]	1.5×10^{-6}	5.3×10^{-4}	1.6×10^{-5}	0.0067	0.0093
Noninvolved Worker LCF per year[c]	4.9×10^{-8}	2.6×10^{-7}	1.6×10^{-9}	3.2×10^{-9}	3.4×10^{-9}
Involved Worker Dose (rem)	7.3×10^{-8}	42	8.2×10^{-7}	53	740[d]
Involved Worker LCF per accident[c]	2.9×10^{-11}	0.017	3.3×10^{-10}	0.21	0.30
Involved Worker LCF per year[c]	9.8×10^{-13}	8.4×10^{-6}	3.3×10^{-14}	1.0×10^{-7}	1.1×10^{-7}
Onsite population Dose (person-rem)	42	1,000	48	13,000	18,000
Onsite population LCF per accident	0.0017	0.41	0.19	5.3	7.3
Onsite population LCF per year	5.7×10^{-5}	2.1×10^{-4}	1.9×10^{-6}	2.5×10^{-6}	2.7×10^{-6}

a. Tank/cell listed is bounding case (e.g., results in the greatest impacts to offsite receptors and noninvolved workers).
b. Accident involves the entire facility.
c. Increased probability of an LCF to the exposed individual.
d. An acute dose to an individual over 300 rem would likely result in death.
SSRT = sludge solids receipt tank; MEI = maximally exposed offsite individual; LCF = latent cancer fatality.

in Grout alternative is not planned because this technology is better developed than the other action alternatives, and has been demonstrated at full scale in the Saltstone Manufacturing and Disposal Facility. Therefore, this SEIS does not include a demonstration of the Direct Disposal in Grout alternative.

DOE intends to only construct and operate a Pilot Plant for the selected alternative. Knowledge gained from the demonstration could lead to a decision to demonstrate more than one salt processing alternative technology. In the event that DOE decides to demonstrate more than one technology, the Pilot Plant units would be developed and operated in series. Therefore, impacts associated with more than one Pilot Plant would not occur at the same time, but would extend over a longer period.

The Pilot Plant would be designed to demonstrate the processing of real radioactive wastes. Principal process operations would be conducted inside shielded cells.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the existing Late Wash Facility in H Area (see Figure 2-3), which was designed and built to handle radiological operations and is located near S Area and DWPF, or in another area similar to the location of the full-scale facility.

Services to support operations would be provided, including utilities, process chemicals, ventilation systems, and habitability services. An appropriate chemical storage area would be developed, with isolation of acids, caustics, oxidizing and reducing agents, and other incompatible reactants. Ventilation systems would be operated such that airflow is from regions of low contamination to areas of higher contamination.

The generation and dispersion of radioactive and hazardous materials would be minimized. Process waste would be managed at appropriate site locations, such as DWPF, Saltstone Manufacturing and Disposal Facility, HLW Tank Farms and the LLW vaults.

All Pilot Plants are at the pre-conceptional stage, therefore, the analysis in this section is qualitative.

4.1.14.1 Geologic Resources

The Pilot Plant would be constructed in an existing facility in a previously disturbed area. Therefore, no additional impact to geologic resources would occur.

4.1.14.2 Water Resources

The Pilot Plant would be constructed in an existing facility. No additional land would be disturbed therefore the water table would not be disturbed and no increase in suspended solids in stormwater runoff would be expected. Therefore, no impact to surface water or groundwater resources would occur during construction.

The Pilot Plant would generate less than 10 percent of the sanitary and process wastewater of the full size salt processing facility on an annual basis. DOE concluded in Section 4.1.2 that regardless of the alternative selected, impacts to surface water as a result of salt processing facility activities would be minimal and there would be no impact to groundwater quality. The quantity of sanitary and process wastewater generated by the Pilot Plant would be much smaller than the amount generated by the salt processing facility, therefore surface water impacts from operation of the Pilot Plant would be minimal and there would be no impact to groundwater quality.

4.1.14.3 Air Resources

The Pilot Plant would use skid-mounted equipment and be constructed in an existing facility. No land would be disturbed during construction, therefore the use of heavy-duty construction equipment (i.e., trucks, bulldozers, and other diesel-powered support equipment) would be minimized. Therefore, impacts to air quality during construction would be minimal.

As shown in Table 4-7, with the exception of VOCs, the nonradiological air emissions from the full-scale salt processing facility for each alternative are similar and would be well below the SCDHEC PSD limit. The estimated VOC emissions for the full-scale Ion Exchange facility would not be greater than 5 percent of the PSD limit of 40 tons per year. The estimated VOC emissions for the full-scale Small Tank Precipitation facility would be 70 tons per year, while the emissions from the full-scale Solvent Extraction facility would be 40 tons per year. VOC emissions from both full-scale facilities would exceed the PSD limit of 40 tons per year. Because air emissions from the Pilot Plant would not be greater than 10 percent of the emissions from the full-size facility, all nonradiological emissions from the Pilot Plant would be much lower than their corresponding PSD limits.

Similarly, incremental increases in air concentrations at the SRS boundary would also be much lower than those projected for the full-scale facility.

As shown in Table 4-8, all radiological air emissions from the full-scale facility for each alternative would be similar and low. Because air emissions from the Pilot Plant would not be greater than 10 percent of the emissions from the full-size facility, incremental impacts of radiological emissions from the Pilot Plant would be minimal.

4.1.14.4 Worker and Public Health

In Section 4.1.4 DOE concluded the overall occupational and health impacts (radiological, nonradiological, and occupational safety) would be minimal for the full-scale Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout facilities. Doses to the noninvolved worker would be well below Federal limits and SRS administrative guides and would not result in adverse impacts. Exposures to the MEI would result in an annual dose that is below the Federal exposure limits. The Pilot Plant would not be greater than 1/10 the size of the preferred salt processing alternative and would be operated in a manner that minimizes the generation and dispersion of radioactive and hazardous materials. Therefore, the overall occupational and health impacts (radiological, nonradiological, and occupational safety) would be similar and minimal.

4.1.14.5 Environmental Justice

In Section 4.1.5, DOE concluded that the potential offsite consequences to the general public of the proposed action and the alternatives would be small, and there would be no disproportionately high and adverse impacts to minority or low-income populations. The Pilot Plant would not be greater than 1/10 the size of the preferred salt processing alternative and would be operated in a manner that minimizes the generation and dispersion of radioactive and hazardous materials. Therefore, by similarity, the Pilot Plant would have no disproportionately high and adverse impacts to minority or low-income populations.

4.1.14.6 Ecological Resources

The Pilot Plant would be constructed in an existing facility located in a heavily industrialized area that has marginal value as wildlife habitat. Construction would involve the movement of workers and construction equipment, but no earth-moving equipment would be anticipated, so noise levels would be somewhat lower than the levels that would be experienced during construction of the full-scale facility. Construction-related disturbances are likely to create impacts to wildlife that would be small, intermittent, and localized.

Operation of the Pilot Plant would entail movement of workers and equipment and noise from public address systems (e.g., testing of radiation and fire alarms), air compressors, pumps, and HVAC-related equipment. With the possible exception of the public address systems, noise levels generated by these kinds of sources are not expected to disturb wildlife outside of facility boundaries.

4.1.14.7 Land Use

The Pilot Plant would be constructed in an existing facility located in an area designated for industrial use. Therefore, no change in land use patterns would occur.

4.1.14.8 Socioeconomics

The Pilot Plant would be constructed in an existing facility. During construction of the Pilot Plant, the number of workers would be restricted by space constraints inside the proposed facility. In addition, the Pilot Plant would have a modular design that maximizes the use of skid-mounted equipment, which would facilitate remote installation and further limit the number of workers required for construction. Therefore, the number of workers involved in the construction of the Pilot Plant would be much lower than the number of workers required for construction of the salt processing facility.

The Small Tank Precipitation process facility would require approximately 180 operations employees. The Ion Exchange process facility would require approximately 135 operations employees. The Solvent Extraction process facility would require approximately 220 operations employees, (WSRC 1998a, 2000a). These same employees would be trained in and would operate the Pilot Plant.

4.1.14.9 Cultural Resources

The Pilot Plant would be constructed in an existing facility and would, therefore, not disturb any cultural or historic resources. Therefore, no impact to cultural resources would occur.

4.1.14.10 Traffic and Transportation

In Section 4.1.10, DOE estimated that material shipments required for implementation of the alternatives would result in 403,000 to 529,000 miles traveled over the 13 year life of the facility and no accidents involving injuries or fatalities would be expected during those material shipments. The Pilot Plant would operate potentially for a period of approximately 5.5 years and the number of material shipments would be substantially lower, so no accidents involving injuries or fatalities would be expected during material shipments to the Pilot Plant.

During the life of the Pilot Plant, workers would make between 184,250 and 292,000 Site trips. Under the Small Tank Precipitation Pilot Plant, workers would make approximately 240,000 Site trips; 45 accidents, 20 injuries and no fatalities would be expected. Under the Ion Exchange Pilot Plant, workers would make approximately 184,250 Site trips; 35 accidents, 15 injuries and no fatalities would be expected. Under the Solvent Extraction Pilot Plant, workers would make approximately 292,000 Site trips; 55 accidents, 24 injuries and no fatalities would be expected.

4.1.14.11 Waste Generation

The Pilot Plant would generate no greater than 10 percent of the waste of the full-size salt processing facility on an annual basis. Waste generation under the Solvent Extraction Pilot Plant would be slightly higher than the other Pilot Plant units, due to the inclusion of a 1/5-scale centrifugal contactor.

As with the full-scale salt processing facility, the Pilot Plant would generate minimal quantities of low-level, transuranic, hazardous, industrial, and sanitary waste under all scenarios. All operations would generate a small amount of radioactive liquid waste, but the quantity generated by the Solvent Extraction Pilot Plant would be somewhat higher than that generated by the other three Pilot Plants. The Ion Exchange Pilot Plant would generate a small amount of nonradioactive liquid waste, while the Pilot Plants for the other two action alternatives would generate minute quantities of nonradioactive liquid waste. All Pilot Plant operations would generate a small amount of mixed LLW, but the quantity generated by the Solvent Extraction Pilot Plant would be higher than that generated by the Small Tank Precipitation and Ion Exchange Pilot Plants. Because it produces a comparatively large amount of benzene, the Small Tank Precipitation Pilot Plant would generate considerably more mixed low-level liquid waste than the other two Pilot Plants.

4.1.14.12 Utilities and Energy

Utility and energy use during construction of the Pilot Plant would be minimal. No steam would be used, and the use of skid-mounted equipment and the fact that the Pilot Plant would be constructed in an existing facility would limit water, electricity, and fuel requirements.

Utility and energy use during operation of the Pilot Plant would not be greater than 10 percent of the amount used in the full-size salt processing facility on an annual basis. Utility and energy demand for the Solvent Extraction Pilot Plant would be slightly higher than the other Pilot Plants due to the inclusion of a 1/5-scale centrifugal contactor. The impact to SRS utility and energy supplies would be minimal during operation of the Pilot Plant.

4.2 Long-Term Impacts

This section presents estimates of long-term impacts of the four salt processing action alternatives. For all the action alternatives, the major source of long-term impacts would be the saltstone that would result from each of the four alternatives. As discussed in Chapter 2, the saltstone vaults would be located in Z Area, regardless of the selected alternative. Therefore, this SEIS analyzes impacts only from the placement of saltstone in Z Area. Short-term impacts of manufacturing the saltstone are included in Section 4.1.

For NEPA analysis of long-term impacts, DOE assumed that institutional control would be maintained for 100 years post-closure, during which the land encompassing the saltstone vaults would be managed to prevent erosion or other conditions that would lead to early degradation of the vaults. DOE also assumed that the public would not have access to Z Area during this time to set up residence. DOE estimated long-term impacts by doing a performance evaluation that included fate and transport modeling to determine when certain impacts (e.g., radiation dose) could peak. DOE used the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* (WSRC 1992) as the basis for the water resources and human health analyses. This performance assessment was done for the original saltstone that would have resulted from the In-Tank Precipitation process. For this SEIS, DOE modified the source terms for each of the action alternatives. See Appendix D for details of the analysis.

In order to estimate the impacts of no action in the long term, DOE must assume that the HLW remains in the HLW storage tanks and no action is ever taken to ensure safe management. In this scenario, following loss of institutional control after 100 years, the HLW tanks would eventually fail and the contents would be released to groundwater and eventually, to surface water. DOE has not attempted to model this scenario because of the numerous uncertainties involved. Some indication of the potential for impacts may be gained, however, from a comparison with modeling results DOE prepared for the *High-Level Waste Tank Closure Draft Environmental Impact Statement* (DOE 2000e), as described in the following paragraph.

Under the No Action alternative in the Tank Closure Draft EIS (DOE 2000e), DOE would remove most of the waste from the tanks and spray water wash the tanks, but would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves. Under the tank closure scenario, the tanks would eventually fail (after a period of perhaps several hundred years), creating physical hazards to humans and wildlife in the area and releasing the residual HLW to the groundwater at SRS. DOE estimated that residual waste in the F- and H-Area Tank Farms would contain about 200 curies of long half-life isotopes, technetium-99 and plutonium-239, and 9,900 curies of cesium-137, which has a relatively short half-life of 30 years. DOE modeled the eventual release of these contaminants to the groundwater at SRS. The modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime radiation dose of 430 millirem (primarily from groundwater), and incur an incremental risk of 2.2×10^{-4} of a fatal cancer. The greatest risk would occur within about 500 years of tank abandonment, but doses for residents would be greater than 10 millirem for over 1,000 years.

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

Salt processing would have no long-term impact on the following areas: air, socioeconomics, worker health, environmental justice, cultural resources, traffic and transportation, waste generation, utilities and energy, and accidents. Therefore, Section 4.2 does not analyze or discuss long-term impacts to these resources. The following disciplines are analyzed: geologic resources, water resources, ecological resources, land use, and public health.

4.2.1 GEOLOGIC RESOURCES

The Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives include disposal of radioactive waste in vaults in Z Area. Failure of the vaults at some time in the future would have the potential to contaminate the surrounding soils. If the integrity of a vault were breached, infiltration of water could result in contaminants leaching to groundwater. The water-borne contaminants would contaminate nearby soils, but would not alter their physical structure. No detrimental effect on surface soils, topography, or on the structural or load-bearing properties of geologic deposits would occur because of release of contaminants from the vaults.

4.2.2 WATER RESOURCES

4.2.2.1 Surface Water

Surface water impacts would only occur by discharge of contaminated groundwater. Because the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives would result in radioactive waste being disposed in the Z-Area vaults, the potential exists for long-term impacts to groundwater (see Section 4.2.2.2). Contaminants in groundwater could then be transported through the Upper Three Runs Aquifer and the underlying Gordon Aquifer to the seeplines along McQueen Branch and Upper Three Runs, respectively (see Section 4.2.2.2 for a more detailed discussion). The factors that govern the movement of contaminants through groundwater (i.e., the hydraulic conductivity, hydraulic gradient, effective porosity, and dispersion of aquifers in the area) and the processes resulting in attenuation of radiological and nonradiological contaminants (i.e., radioactive decay, ion exchange in the soil, and adsorption to soil particles) would be expected to reduce or mitigate impacts to surface water resources.

As described in Appendix D, DOE used an analysis based on the PORFLOW-3D computer code to model the fate and transport of contaminants in groundwater and subsequent flux (i.e., groundwater discharge at the seepline) to surface waters. The groundwater discharge at the seepline would naturally mix with the stream flow. Assuming that the upstream concentration of all contaminants in surface water is zero, and that no storm runoff is present, the resulting concentration of contaminants in surface water would be the result of the seepline groundwater mixing with uncontaminated surface water. The resulting concentrations in surface water would thus always be less than the groundwater seepline concentrations, due to dilution. The average flows in McQueen Branch and Upper Three Runs at the point of mixing with the groundwater discharge along the seeplines would be on the order of 2 to 3 cubic feet per second and 135 to 150 cubic feet per second, respectively (Parizek and Root 1986).

EPA periodically publishes water quality criteria as concentrations of substances that are known to affect “diversity, productivity, and stability” of aquatic communities including “plankton, fish, shellfish, and wildlife” (EPA 1986, 1999). These recommended criteria provide guidance for state regulatory agencies developing location-specific water quality standards to protect aquatic life (SCDHEC 1999b). Such standards are used in a number of environmental protection programs, including setting discharge limits in NPDES permits. Water quality criteria and standards are generally not legally enforceable; however, NPDES discharge limits based on these criteria and standards are legally binding and are enforced by SCDHEC.

The fate and transport modeling indicates that movement of radiological contaminants from failed vaults to nearby surface waters via groundwater discharge would be minimal. Based on the previous radiological performance assessment (RPA) contaminant screening (WSRC 1992), the radiological contaminants of concern would be carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135. Table 4-26 shows maximum radiation doses from all contaminants to humans and corre-

Table 4-26. Maximum dose and health effects from concentrations of radionuclides in groundwater 1 meter and 100 meters downgradient of Z Area vaults and at the seepline.

	Maximum dose							
	Upper Three Runs Aquifer				Gordon Aquifer			
Exposure point	Small Tank Precipitation	Ion Ex-change	Solvent Ex-change	Direct Disposal in Grout	Small Tank Precipitation	Ion Ex-change	Solvent Extraction	Direct Disposal in Grout
1 meters downgradient								
Total dose	0.080	0.095	0.074	0.096	0.49	0.58	0.45	0.57
Lifetime LCF[a]	2.8×10^{-6}	3.3×10^{-6}	2.6×10^{-6}	3.4×10^{-6}	1.7×10^{-8}	2.0×10^{-5}	1.6×10^{-5}	2.0×10^{-5}
100 meters downgradient								
Total dose (millirem/year)	0.0068	0.0073	0.0062	0.0079	0.042	0.044	0.038	0.048
Lifetime LCF[a]	2.4×10^{-7}	2.6×10^{-7}	2.2×10^{-7}	2.8×10^{-7}	1.5×10^{-6}	1.5×10^{-6}	1.3×10^{-6}	1.7×10^{-6}
Seepline								
McQueen Branch								
Maximum dose (millirem/year)	0.0019	0.0020	0.0017	0.0022	NA	NA	NA	NA
Lifetime LCF[a]	6.7×10^{-8}	7.0×10^{-8}	6.0×10^{-8}	7.7×10^{-8}	NA	NA	NA	NA
Upper Three Runs								
Maximum dose (millirem/year)	NA	NA	NA	NA	0.0029	0.0028	0.0025	0.0032
Lifetime LCF[a]	NA	NA	NA	NA	1.0×10^{-7}	6.3×10^{-8}	8.8×10^{-8}	1.1×10^{-7}
Regulatory limit (millirem /year)	4	4	4	4	4	4	4	4

a. Increased probability of an LCF to the exposed individual over a 70-year period.
b. The discharge point for the Upper Three Runs aquifer is the McQueen Branch seepline, and the discharge point for the Gordon aquifer is the Upper Three Runs seepline.
c. Maximum impacts would not occur at the same time due to the different radionuclide transport times to the potential exposure locations.
LCF = latent cancer fatality.

sponding impacts expressed as LCFs from groundwater at the seeplines of McQueen Branch and Upper Three Runs before dilution with surface water. Doses would be low under each action alternative and would be below the drinking water standard of 4 millirem per year (40 CFR 141.16) in all cases. As discussed above, the in-stream concentrations resulting from the mixing of groundwater discharge at the seepline with the upstream flow would result in lower downstream concentrations than shown in Table 4-26. These data represent that point in time.

The 4-millirem-per-year standard applies only to beta-emitting radionuclides but, because the total dose would be less than 4 millirem per year, the standard would be met.

The results of the fate and transport modeling of nonradiological contaminant migration from failed vaults to nearby surface water via groundwater discharge are presented in Table 4-27. Based on the previous RPA contaminant screening (WSRC 1992), the only nonradiological contaminant of concern would be nitrate. The recent modeling results indicate that

Table 4-27. Maximum nonradiological contaminant concentrations (mg/L) in groundwater 1 meter and 100 meters downgradient and at the seepline.

	Maximum concentration							
	Upper Three Runs Aquifer[a]				Gordon Aquifer[b]			
Exposure point/ contaminant	Small Tank Precipita-tion	Ion Ex-change	Solvent Exchange	Direct Disposal in Grout	Small Tank Precipita-tion	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
1 meter downgradient								
Nitrate (mg/L)	56	66	51	66	338	395	307	394
100 meters downgradient								
Nitrate (mg/L)	4.8	5.1	4.4	5.6	29	31	26	33
Seepline								
Nitrate (mg/L)	1.4	1.5	1.3	1.6	2.2	2.1	1.9	2.4
EPA MCL (mg/L)	44	44	44	44	44	44	44	44

a. Surfaces at McQueen Branch seepline.
b. Surfaces at Upper Three Runs seepline.
c. Nitrate as total nitrogen.
MCL = maximum contaminant level.

there would be little difference between the alternatives and that none of the four action alternatives would result in an exceedance of the drinking water criteria for nitrate in the groundwater discharge at the seeplines of McQueen Branch or Upper Three Runs. Concentrations of nitrate at the seeplines would be small (less than 3 milligrams per liter [mg/L]) in all cases. Taking into account the dilution effect of the groundwater discharge mixing with the instream flow (assumed to be contaminant-free), the predicted concentrations of nonradiological contaminants would be even lower than those in Table 4-27. Therefore, no health impacts are anticipated from nitrates discharged to surface waters.

4.2.2.2 Groundwater

Each of the action alternatives proposed in Chapter 2 includes actions that could result in potential long-term impacts to groundwater beneath the Z-Area vaults. Because groundwater is in a state of constant flux, impacts that occur directly below the vaults could propagate to areas hydraulically downgradient of Z Area.

The primary action that would result in long-term impacts to groundwater is failure of the vaults and the generation of contaminated leachate that would enter the vadose zone soils. The contamination has the potential to contaminate groundwater at some point in the future, due to leaching and water-borne transport of contaminants. As described in detail in Appendix D, shallow groundwater beneath the vaults flows toward McQueen Branch, but also includes a vertical flow component toward deeper aquifers. In the analyzed alternatives, the mobile contaminants that leached from the vault would gradually migrate downward through unsaturated soil to the hydrogeologic units comprising the shallow aquifers underlying the vaults. As described in Section 4.1.2.1, because the vaults will be constructed above the typical elevation of the water table, contaminants released from the vaults would be released into the vadose zone and not directly into the shallow groundwater.

The shallowest hydrogeologic unit affected would be the upper zone of the Upper Three Runs Aquifer, formally known as the Water Table Aquifer (Aadland, Gellici, and Thayer 1995). Hydrogeologic studies and modeling (Flach and Harris 1996) conducted for the area of SRS where S and Z Areas are located, suggest however that flow in the upper zone of the Upper

Three Runs Aquifer that originates in the proposed vault disposal area does not outcrop to McQueen Branch. Rather, water in the upper zone would migrate downward into the lower zone of the Upper Three Runs Aquifer (formally known as the Barnwell-McBean Aquifer). Some contaminants would be transported subsequently to the northeast by groundwater flow through the lower zone of the Upper Three Runs Aquifer and discharge at the seepline along McQueen Branch.

The previous modeling results for the General Separations Area (the location of S and Z Areas) (Flach and Harris 1996), also suggested that a portion of the contaminant mass released to the Upper Three Runs Aquifer would migrate downward and then laterally through the Gordon Aquifer to a point of discharge at the seepline along Upper Three Runs. The groundwater flow direction in the Gordon Aquifer is toward the north-northwest.

Summary of Predicted Concentrations

The results of the groundwater fate and transport modeling for radiological and nonradiological contaminants entering the Upper Three Runs and Gordon Aquifers are presented in Tables 4-26 and 4-27. The modeling calculated impacts to each aquifer layer. The results are presented for each alternative for groundwater wells 1 meter and 100 meters downgradient of the vaults and for the seeplines. The specific concentrations for each radiological and nonradiological contaminant for each aquifer layer and each exposure point are presented in Appendix D.

For radiological contaminants, the doses in millirem per year from all radionuclides are considered additive for any given aquifer layer at any exposure point. The concentrations in groundwater from the various aquifers are, however, not additive. The maximum radiation dose (millirem per year), regardless of the aquifer layer is therefore presented in the tables for each exposure point. These data represent the increment in time when the sum of all beta-gamma emitters would be greatest, but not necessarily when all radionuclides are at their maximum concentrations. This method of data presentation shows the overall maximum dose or concentration that could occur at each exposure point. Based on the previous RPA contaminant screening (WSRC 1992), the radiological contaminants of concern in groundwater would be carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135.

Based on the previous RPA contaminant screening (WSRC 1992), the only nonradiological contaminant of concern would be nitrate; therefore, only nitrate was modeled. The maximum concentration of nitrate, regardless of time, was determined for each aquifer layer and for each exposure point.

Comparison of Alternatives

The groundwater radiological concentrations (Table 4-26) consistently show that the greatest long-term impacts for beta-gamma emitters at the 100-meter well would occur under the Direct Disposal in Grout or the Ion Exchange alternative, although the differences among alternatives are small. The results also indicate that none of the alternatives would result in an exceedance of the regulatory limit for dose to humans in drinking water (i.e., 4 millirem per year), either at the wells or at the seeplines (i.e., groundwater discharge points).

The nonradiological results presented in Table 4-27 identify a consistent trend for nitrate at all points of exposure; the highest concentration occurs under the Ion Exchange and Direct Disposal in Grout alternatives, but there are only small differences among alternatives. The data show that nitrate would exceed the maximum contaminant level (MCL) for drinking water 1 meter downgradient of the facility for all alternatives, but would not exceed the 100 meters downgradient of the vaults for any alternatives. The MCL would not be exceeded at the seepline for either aquifer layer.

4.2.3 ECOLOGICAL RESOURCES

This section presents an evaluation of the potential long-term impacts of salt processing alternatives to ecological receptors. DOE assessed the potential risks to ecological receptors at the seeplines of McQueen Branch (a tributary of Upper Three Runs near Z Area) and Upper Three Runs.

Groundwater-to-surface water discharge of contaminants was the only long-term migration pathway evaluated because the disposal vaults will be several meters underground, precluding overland runoff of contaminants and associated terrestrial risks. The vaults would have concrete roofs and be capped with clay and gravel. This would provide an impervious layer for deep plant roots. As a result, only risks to aquatic or semi-aquatic biota were considered possible. The habitat in the vicinity of the seeplines is bottomland (riparian) hardwood forest along the channels of McQueen Branch and Upper Three Runs. Upslope of the floodplain, the forest is a mixture of pine and hardwood.

The Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout alternatives were assessed for their potential long-term ecological impacts. Modeling of groundwater-to-surface water migration of contaminants from the disposal vaults indicated that nitrate was the only nonradiological chemical that would reach McQueen Branch and Upper Three Runs, and that carbon-14, selenium-79, technetium-99, tin-126, iodine-129, and cesium-135 were the radionuclides that would reach the two streams. The model generated concentrations of these contaminants in the groundwater at the seeplines.

4.2.3.1 Radiological Contaminants

The Oak Ridge National Laboratory (ORNL) has developed screening guidelines for the protection of aquatic organisms from radiological chemicals in surface water (Bechtel Jacobs Company 1998). These guidelines were developed by back-calculating the DOE Order 5400.5 dose rate limit for aquatic biota of 1.0 rad per day (rad/d) to obtain corresponding concentrations of radionuclides in surface water. These guidelines can then be compared to ambient concentrations to assess potential risks to aquatic biota. The guidelines are in picocuries per liter (pCi/L) and were developed separately for small fish and large fish. All guidelines include exposures from parent isotopes and all short-lived daughter products. They also include exposures from all major alpha, beta, and gamma emissions for each isotope. It should be noted that ORNL developed its guidelines for radionuclides of concern at the Oak Ridge Reservation. No similar values have been calculated for SRS. However, the ORNL values were derived using generic data and are based on types of fish that could occur on SRS. The groundwater chemical data for this SEIS were modeled for thousands of years after disposal and, therefore, the isotopes that comprise the data are not generally in agreement with ORNL's (i.e., in this analysis, credit was taken for radioactive decay). Only a guideline for technetium-99 was available.

The predicted radiological concentrations in groundwater at the McQueen Branch and Upper Three Runs seeplines are presented in Table 4-28 for each of the four action alternatives. The concentrations of technetium-99 were orders of magnitude lower than the ORNL guideline. Again, no ORNL guidelines were available for the other elements (their particular isotopes). However, a surrogate value for radioactive cesium of 6.19×10^3 pCi/L can be used to assess risks from the elements other than technetium-99. This value generates an acceptable dose of 1 rad/day. Radioactive cesium has a higher energy emitted per decade than other elements in the seepwater. Because the surrogate guideline concentration is orders of magnitude higher than all those of the detected radionuclides in the seepwater, it can be inferred that the risks from those elements would be much lower. Because the maximum radiological concentrations predicted for McQueen Branch and Upper Three Runs are all far below this surrogate guideline, it can be concluded that potential risks to aquatic biota in McQueen Branch and Upper Three Runs from radionuclides in seepwater would be very low.

4.2.3.2 Nonradiological Contaminants

Nitrate is considered to be essentially non-toxic to fish and wildlife, and is important as a plant nutrient in aquatic systems (Wetzel 1983).

Table 4-28. Maximum concentrations of radiological contaminants in seepline groundwater compared to ORNL screening guidelines (pCi/L).

		Small Tank Precipitation		Ion Exchange		Solvent Extraction		Direct Disposal in Grout	
Contaminant	ORNL guide-line Small/Large Fish[a]	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aquifer)	McQueen Branch (Upper Three Runs Aquifer)	Upper Three Runs (Gordon Aqui-fer)
Carbon-14	NA[b]	1.9×10^{-6}	2.0×10^{-6}	2.1×10^{-6}	1.9×10^{-6}	1.8×10^{-6}	1.7×10^{-6}	2.2×10^{-6}	2.1×10^{-6}
Selenium-79	NA[b]	0.16	0.23	0.17	0.23	0.15	0.20	0.19	0.25
Technetium-99	1.94×10^{-6}/ 1.94×10^{-6}	0.42	0.66	0.44	0.64	0.38	0.58	0.48	0.72
Tin-126	NA[b]	5.7×10^{-5}	3.9×10^{-5}	6.1×10^{-5}	3.9×10^{-5}	5.2×10^{-4}	3.5×10^{-5}	6.6×10^{-5}	4.3×10^{-5}
Iodine-129	NA[b]	0.0028	0.0045	0.0029	0.0044	0.0025	0.0039	0.0032	0.0049
Cesium-135	7,720/6,190	9.8×10^{-7}	1.5×10^{-6}	1.0×10^{-6}	1.5×10^{-6}	8.9×10^{-7}	1.3×10^{-6}	0.012	0.017

a. The value presented for cesium-135 is a surrogate value for cesium-137 (radioactive cesium). Cesium-137 has a higher decay energy than cesium-135. Therefore, this is a conservative estimate of the guideline for cesium-135.

b. Specific guidelines for these radionuclides are not available. However, because cesium accumulates in biological tissues and because cesium-137 has a higher decay energy than any of the other radionuclides listed, guidelines for these radionuclides are unlikely to be smaller than the guideline for cesium-137.

Nitrates are generally considered to be a potential human health hazard at high concentrations in drinking water because they are reduced to nitrites in the digestive system (EPA 1986). Nitrites are capable of oxidizing hemoglobin to produce methemoglobin, which is incapable of transporting oxygen (EPA 1986). However, in well-oxygenated aquatic systems, nitrite is typically oxidized to nitrate.

The relatively low ecotoxicity from nitrates is reflected in the lack of surface water screening levels and criteria. EPA (1986) points out that concentrations of nitrate or nitrite with toxic effects on fish could "rarely occur in nature" and, therefore, "restrictive criteria are not recommended". No Federal ambient water quality criteria based on protection of aquatic organisms are available for nitrates (or nitrites) (EPA 1999). Nevertheless, some guidelines for nitrate/nitrite toxicity are available. EPA (1986) concludes that (1) concentrations of nitrate at or below 90 mg/L will have no adverse effects on warmwater fishes, (2) nitrite at or below 5 mg/L would be protective of most warmwater fishes, and (3) nitrite at or below 0.06 mg/L should be protective of salmonid fishes (no salmonid fishes are present on SRS). The Canadian Council of Ministers of the Environment (CCME) presents a surface water guideline protective of aquatic organisms of 0.06 mg/L (Environment Canada 1998). In the past, DOE has used an MCL of 10 mg/L as a surrogate protective concentration for semi-aquatic wildlife, such as mink (DOE 1997b).

Generally speaking, the only effects of elevated nitrate concentrations in streams and reservoirs are the fertilization of algae and macrophytes and the hastening of eutrophication. This occurs mainly when significantly increased nitrate inputs and inputs of other nutrients, mainly phosphorous, continue over a long period of time (Wetzel 1983). The concentrations of nitrate in groundwater at the McQueen Branch and Upper Three Runs seeplines are presented in Table 4-29 for each of the four action alternatives. On the whole, the predicted concentrations in seepwater for all four action alternatives exceeded the EPA nitrite guideline for protection of coldwater fishes and the CCME nitrite guideline for protection of aquatic biota. The concentrations were comparable to the EPA nitrite guideline for protection of warmwater fishes and were an order of magnitude or more lower than the EPA nitrate no-adverse-effects guideline for warmwater fishes. They also were less than the human health nitrate MCL. It should be noted that guidelines for coldwater fishes are conservative because they are usually based on toxicity data for salmonids, which are generally more sensitive to contaminants than warmwater fishes (Mayer and Ellersieck 1986).

If the ratio of nitrates to nitrites introduced from the alternatives was lower, or the introduced nitrate was transformed to nitrite in appreciable quantities, substantive risks could potentially be present. However, EPA (1986) states that, in oxygenated natural water systems, nitrite is rapidly oxidized to nitrate. Upper Three Runs tends to be well oxygenated (Halverson et al. 1997).

More importantly, the assessment of risk to ecological receptors was performed on groundwater at the seepline and, hence, did not account for dilution by stream volumes. After dilution, the concentration of nitrate (and nitrite) would likely be much lower, probably by orders of magnitude.

Toxicity data for semi-aquatic receptors (e.g., mink) are scarce for nitrate, reflecting its relatively low ecotoxicity. Only one study of the effects of nitrate on mammals that applied to ecological risk considerations could be located. The study involved the effects of potassium nitrate on guinea pigs, using oral ingestion of water as the exposure medium (ORNL 1996). No adverse effects were observed at a dose of 507 milligrams per kilogram (mg/kg) of body weight per day (mg/kg/day). A reduction in the number of live births was observed at 1,130 mg/kg/day. ORNL (1996) extrapolated toxicity and dose concentration data from this study to determine potentially toxic concentrations in various media to wildlife species. Based on the ORNL study, nitrate concentrations of at least 6,341 and 4,932 mg/L in surface water would be necessary to produce toxic effects for the short-tailed shrew and mink, respectively. The con-

Table 4-29. Maximum concentrations of nitrate in seepline groundwater compared to ecotoxicity guidelines (mg/L).

	Alternative (mg/L)				Ecotoxicity guideline (mg/L)				
Aquifer	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout	No-adverse-effects on warmwater fishes (nitrate as nitrogen)[a]	Protection of warmwater fishes (nitrite as nitrogen)[a]	Protection of cold-water fishes (nitrite as nitrogen)[a]	CCME guideline for protection of aquatic biota (nitrite as nitrogen)[b]	MCL (nitrate as nitrogen)[c]
McQueen Branch (Upper Three Runs Aquifer)	1.4	1.5	1.3	1.6	90	5	0.06	0.06	10
Upper Three Runs (Gordon Aquifer)	2.2	2.1	1.9	2.4	90	5	0.06	0.06	10

a. EPA (1986).
b. Environment Canada (1998).
c. Maximum Contaminant Level (MCL) for drinking water (EPA 1999).

centrations are several orders of magnitude higher than the maximum modeled concentrations presented in Table 4-29. EPA (1986) does not indicate that nitrate bioaccumulates and, therefore, concentrations in the prey or forage of semi-aquatic wildlife would likely be low.

For these reasons, the potential risks to aquatic and semi-aquatic biota in McQueen Branch and Upper Three Runs from nitrate would be low for all alternatives.

4.2.4 LAND USE

Long-term impacts from saltstone disposal vaults would not affect proposed SRS future land use. However, the presence of 13 to 16 low-level radioactive vaults in Z Area (see Table 4-1) would limit any other use for as long as the vaults remained, a period of time modeled to 10,000 years in this analysis.

4.2.5 PUBLIC HEALTH

This section presents the potential impacts on human health from contaminants in the saltstone at some point after the period of institutional control of Z Area. To determine the long-term impacts, DOE evaluated data for Z Area, including the following:

- Expected source inventory that would be present in the saltstone
- Existing technical information on geological and hydrogeological parameters in the vicinity of Z Area
- Arrangement of the saltstone vaults within the stratigraphy
- Actions to be completed under each of the alternatives.

In its evaluation, DOE reviewed the methodology and conclusions contained in the *Radiological Performance Assessment for the Z-Area Saltstone Facility* (WSRC 1992) to determine what changes in the RPA analysis, if any, would result from implementing any of the salt processing alternatives. (The RPA was done for saltstone that would have resulted from the In-Tank Precipitation process.) Based on its review, DOE believes the exposure pathway methodology in the RPA is technically valid. DOE has modified certain input parameters to represent the alternatives. Therefore, DOE believes this modeling is valid for evaluating long term impacts. See Appendix D for additional details.

The RPA considers multiple routes of exposure for humans in the future. Z Area is zoned as an industrial area, and DOE does not expect that any public access to Z Area would be allowed. However, for purposes of analysis, DOE assumed that people would have access to the land beginning 100 years after the last vault was closed. The RPA considered multiple routes of exposure for humans following a 100-year period of institutional control and determined that two scenarios would have the greatest potential for exposing a hypothetical individual to saltstone contaminants:

- An agricultural scenario, in which the individual unknowingly farms and constructs a home on the soil above the saltstone vaults. In this scenario, the individual is assumed to derive half of his vegetable consumption from a garden planted in contaminated soil located over the vaults. The time spent gardening is assumed to be short compared to the amount of time spent indoors or farming. Only potential impacts from external radiation, inhalation, incidental soil ingestion, and vegetable ingestion are calculated for indoor residence and outdoor gardening activities. Since the farming activities would occur over a widespread area that would include uncontaminated and undisturbed soil not subject to irrigation with contaminated water, the meat and milk pathways would not contribute significantly to the individual's dose. Because of DOE's expectation that the saltstone would remain relatively intact for an extended period of time, DOE does not believe this scenario could be reasonable until approximately 10,000 years post-closure because, at least until that time, the individual could identify that he was digging through a cementitious material. However, for conservatism, DOE has calculated the impacts of the agricultural scenario at 1,000 years post-closure. This scenario includes the 1,000-year residential scenario described below.

- A residential scenario, in which the individual constructs and lives in a permanent residence on the vaults. This scenario analyzes two options: construction at 100 years and at 1,000 years. Under the first option, a sufficient layer of soil would cover the still-intact vaults so that the individual would not know that the residence was constructed on the vaults. Under the second option, the saltstone is assumed to have been exposed and weathered sufficiently so that a person could build a home directly on a degraded vault without being aware of the saltstone.

4.2.5.1 Radiological Contaminants

In addition to these scenarios and options, the RPA also determined the impacts from consuming water from a well drilled 100 meters from the saltstone vaults after the period of institutional control. The original analysis considered the two uppermost aquifers underneath the saltstone facility and determined the concentrations downgradient of the vaults.

Using this information from the RPA, DOE calculated new results for the groundwater concentrations and the exposure scenarios. First, DOE used the engineering data developed during the alternative development process to determine how the saltstone composition would differ for the alternatives analyzed in this SEIS, as compared to the composition of the saltstone analyzed in the original RPA. Second, DOE determined how the new saltstone compositions (including concentrations of contaminants) affected the results in the original RPA and used that information as the basis to determine results for the analyzed alternatives in this SEIS. For those issues that the RPA did not address (such as direct disposal of cesium in grout), DOE performed the necessary original calculations to account for the newer information. A detailed discussion of DOE's methodology is contained in Appendix D.

Table 4-30 shows the calculated groundwater concentrations and radiation doses from the exposure scenarios. DOE compared groundwater results to the regulatory limits for drinking water specified in 40 CFR 141. The applicable drinking water standards for radionuclides are 4 millirem per year for beta/gamma-emitting radionuclides and 15 pCi/L for alpha-emitting radionuclides. The RPA analyses indicated that alpha-emitting radionuclides would not be transported from the saltstone vaults except in minute quantities, and DOE therefore excluded them from the impacts analysis. For nonradiological constituents (primarily nitrate), DOE compared the water concentrations directly to the concentrations listed as MCLs in 40 CFR 141.

The differences in calculated concentrations and doses among the alternatives are primarily a function of the differences in composition of the saltstones. The Small Tank Precipitation alternative would produce a saltstone very similar to that analyzed in the RPA, and the results for this alternative (in Table 4-30) are therefore consistent with the results in the RPA. The Ion Exchange alternative would result in a salt solution with slightly higher contaminant concentrations, resulting in higher contaminant concentrations in saltstone and associated greater impacts. Similarly, the Solvent Extraction salt solution has slightly lower concentrations.

The Direct Disposal in Grout alternative would result in a salt solution with slightly higher concentrations for most constituents than the other alternatives, but with essentially all of the cesium. Radioactive cesium has a relatively short half-life (approximately 30 years), so the radioactive cesium concentration at the end of 100 years would be decreased by a factor of about 10, with subsequent decreases as time elapses. Therefore, for most of the scenarios in Table 4-30, the impacts of Direct Disposal in Grout are comparable to those of the other alternatives. However, for the residential scenario that assumes construction at 100 years directly on top of the saltstone facility, radioactive cesium would still be present in quantities sufficient to produce a dose noticeably higher than the other

Table 4-30. Summary comparison of long-term human exposure scenarios and health effects.

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Nitrate concentration at 100-meter well (mg/L)[a]	29	31	26	33
Radiation dose (millirem per year) from 100-meter well	0.042	0.044	0.038	0.048
LCF from 100-meter well[b]	1.5×10^{-6}	1.5×10^{-6}	1.3×10^{-6}	1.7×10^{-6}
Radiation dose from Agricultural Scenario (millirem per year)	52-110	61-130	49-110	64-140
LCF from Agricultural Scenario	1.8×10^{-3} to 3.9×10^{-3}	2.1×10^{-3} to 4.6×10^{-3}	1.7×10^{-3} to 3.9×10^{-3}	2.2×10^{-3} to 4.9×10^{-3}
Radiation dose from Residential Scenario at 100 years post-closure (millirem per year)	0.015-0.11	0.017-0.13	0.014-0.1	150-1,200
LCF from Residential Scenario at 100 years post-closure	5.3×10^{-7} to 3.9×10^{-6}	6.0×10^{-7} to 4.6×10^{-6}	4.9×10^{-7} to 3.5×10^{-6}	5.3×10^{-3} to 4.2×10^{-2}
Radiation dose from Residential Scenario at 1,000 years post-closure (millirem per year)	9.2-69	11-80	8.6-65	11-85
LCF from Residential Scenario at 1,000 years post-closure	3.2×10^{-4} to 2.4×10^{-3}	3.9×10^{-4} to 2.8×10^{-3}	3.0×10^{-4} to 2.3×10^{-3}	3.9×10^{-4} to 3.0×10^{-3}

a. Nitrate MCL is 10 mg/L (EPA 1999).
b. Health effects are expressed as lifetime (70-year) LCFs to an individual.

alternatives. Because the second residential scenario assumes construction at 1,000 years, the radioactive cesium would have undergone approximately 30 half-lives, resulting in a greatly decreased dose contribution from that radionuclide (however, the longer-lived cesium-135 isotope would still be present).

The maximum doses from the drinking water, agricultural, and 100-year residential scenarios are not expected to occur concurrently, although the agricultural scenario values in the table include the 1,000-year residential scenario contribution, as discussed above. Therefore, it is not appropriate to add the doses from these scenarios.

As shown in Table 4-30, the 1,000-year residential scenario doses for all four action alternatives are similar and would be below the 100-millirem-per-year public dose limit. They range from as low as approximately 10 millirem per year to as high as 85 millirem per year. Doses for the agricultural scenario are similar, but could exceed the 100-millirem-per-year public dose limit. Doses for the agricultural scenario would range from 49 to 140 millirem per year. For the 100-year residential scenario, the dose would be highest for the Direct Disposal in Grout alternative (150 to 1,200 millirem per year) and would exceed the 100-millirem-per-year public dose limit. The 100-year residential scenario doses for the other three action alternatives would be much smaller and would not exceed 0.13 millirem per year.

As discussed in Section 4.1.4.1, DOE adopted a dose-to-risk conversion factor of 0.0005 LCFs per person-rem to estimate the probability of an individual developing a fatal cancer from the calculated radiation exposure. Because estimation of future populations is very speculative, DOE based the analysis of each scenario on an individual with a 70-year life span. As shown in Table 4-30, the probability of an LCF resulting from the long-term exposure scenarios is low. Therefore, DOE expects no adverse health impacts due to these radiation exposures.

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