10 SAVANNAH RIVER SITE: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 4 AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 4 (in a new trench disposal facility) and Alternative 5 (in a new vault disposal facility) at SRS. Alternative 3 (disposal in a new borehole disposal facility) is not evaluated for SRS primarily because of the shallow depth to groundwater conditions prevalent there. Alternative 3 is described in Section 5.6.1. Environmental consequences that are common to all the sites for which Alternatives 4 and 5 are evaluated (including SRS) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to SRS are discussed in Chapter 13 of this EIS.

10.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference location at SRS. The GTCC reference location is situated on an upland ridge within the Tinker Creek drainage, about 3.2 km (2 mi) to the northeast of the Z-Area in the north-central portion of SRS (see Figure 10.1-1). The reference location shown was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a GTCC LLRW and GTCC-like waste disposal facility at SRS.

10.1.1 Climate, Air Quality, and Noise

10.1.1.1 Climate

South Carolina is located between the southern slopes of the Appalachian Mountains and the Atlantic Ocean. It has a long coastline along which the warm Gulf Stream current flows. During the summer, weather in South Carolina is dominated by a maritime tropical air mass known as the Bermuda high. Passing over the Gulf Stream, it brings warm and moist air inland from the ocean (SCSCO 2007). As the air comes inland, it rises and forms localized thunderstorms, resulting in maximum precipitation. The mountains to the north and west tend to block or delay many cold air masses approaching from those directions, thus making the winters somewhat milder. The area around SRS has a temperate climate, characterized by long, humid summers and short, mild winters (DCS 2002).

The annual average wind speed is 2.5 m/s (5.7 mph) at Bush Field, which is located in Augusta, Georgia, about 31 km (19 mi) west-northwest of the GTCC reference location (NCDC 2008a). Wind speed is higher in winter and spring, with the highest speed being 2.9 m/s (6.5 mph) in spring, and it is lower in summer and autumn, with the lowest speed being 2.2 m/s

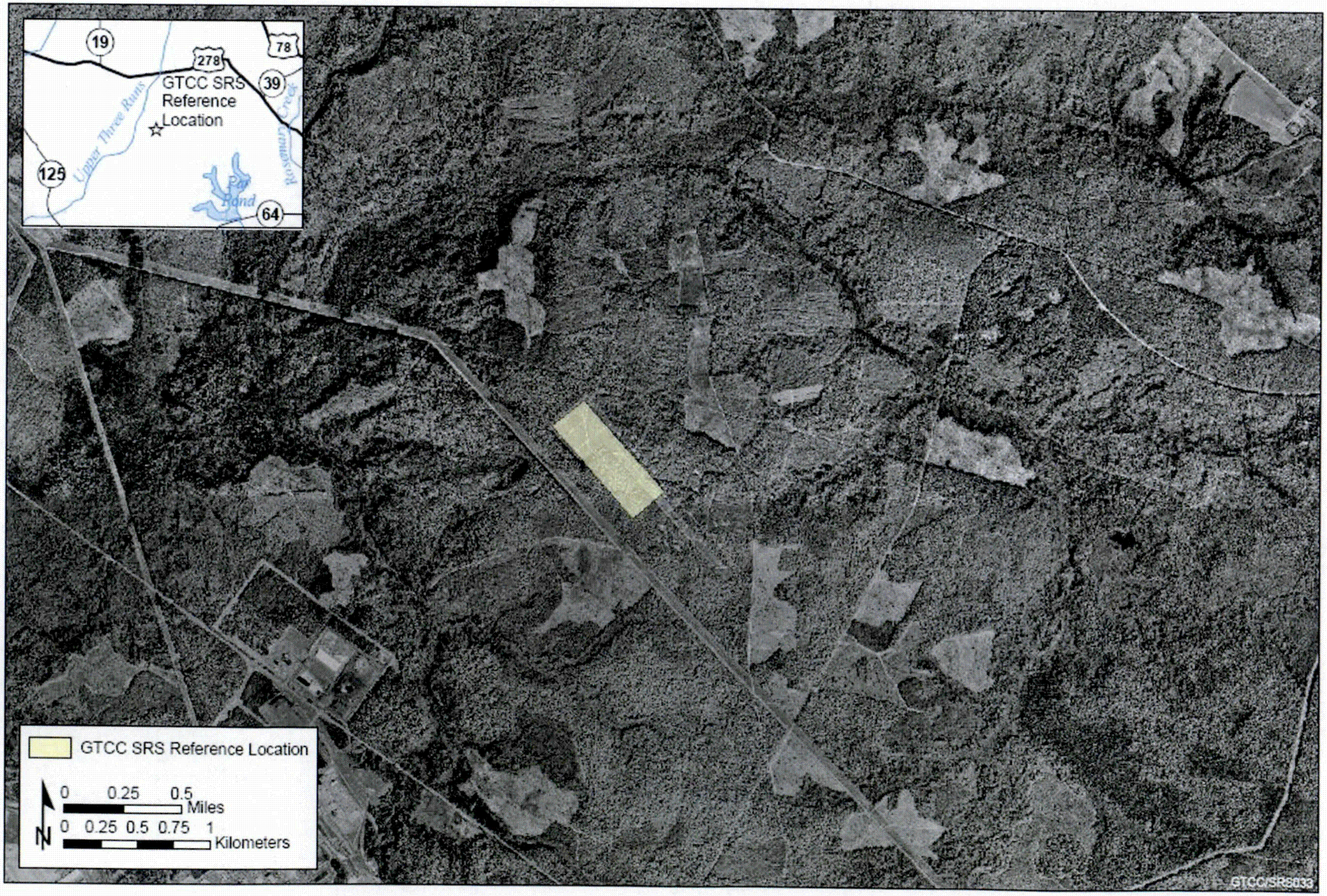

FIGURE 10.1-1 GTCC Reference Location at SRS

(5.0 mph) in autumn. Overall, the prevailing wind direction is from the west, albeit it is not prominent. Monthly prevailing wind directions vary, being mostly from west-northwest in November through March, from south to southeast in April through August, and from north-northeast in September and October.

A wind rose at the 61-m (200-ft) meteorological tower in the H-Area at SRS for the 5-year period of 1992 through 1996 is presented in Figure 10.1.1-1. There is no prominent wind direction at SRS; about 30% of the time, the wind blows from the northeast quadrant, and about 40% of the time, it blows from southwest quadrant. The annual average wind speed is about 3.9 m/s (8.8 mph), and the wind speed is relatively uniform with the wind direction. The wind patterns are different at Bush Field and at the on-site H-Area meteorological tower; the pattern at Bush Field is representative of the surface wind, which is considerably affected by surface

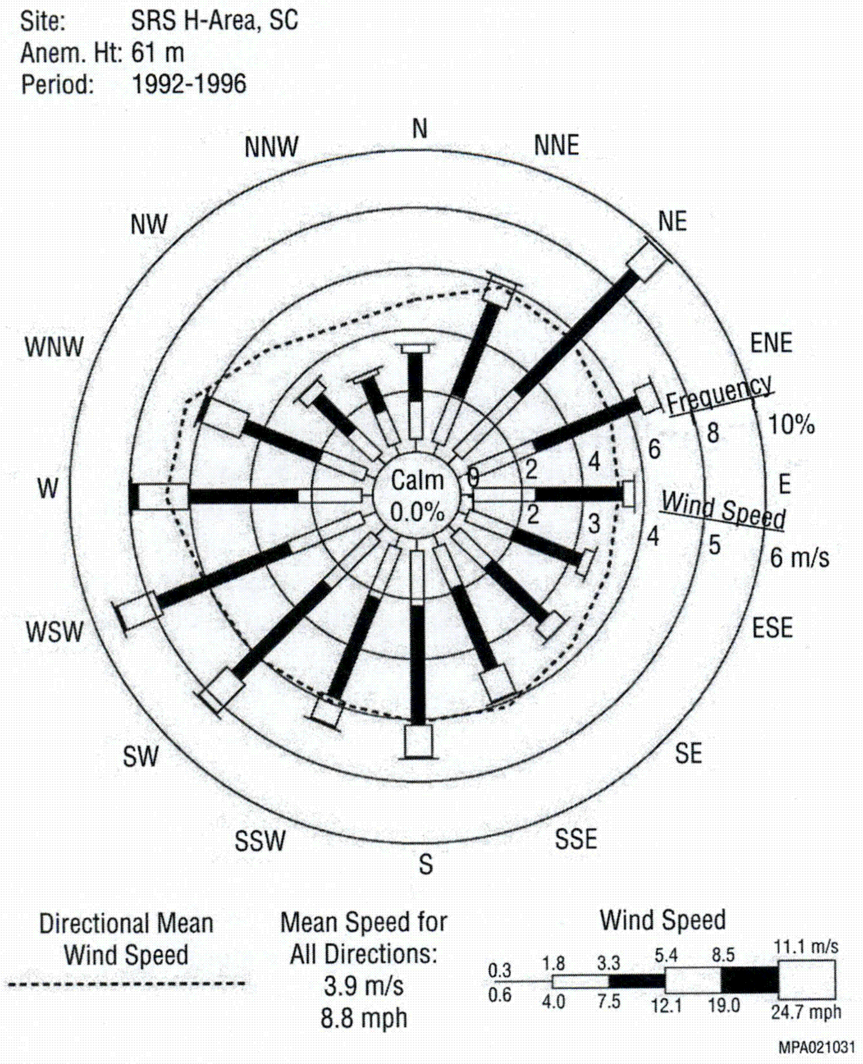

FIGURE 10.1.1-1 Wind Rose at the 61-m (200-ft) Level for the SRS H-Area Meteorological Tower, South Carolina, 1992–1996 (Source: Arnett and Mamatey 2000)

friction, and the pattern at the tower is representative of general upper wind. On-site wind patterns reflect the presence and orientation of the Appalachian Mountains somewhat, and they generally run in a general northeast-southwest direction.

For the last 30-year period, the annual average temperature at Bush Field has been 17.3°C (63.2°F) (NCDC 2008a). January is the coldest month, averaging 7.1°C (44.8°F), and July is the warmest month, averaging 27.1°C (80.8°F). During the last 57 years, the highest temperature was 42.2°C (108°F), and the lowest was −18.3°C (−1°F). The number of days with a maximum temperature higher than or equal to 32.2°C (90°F) is about 75, while days with a minimum temperature lower than or equal to 0°C (32°F) number about 52.

Generally, precipitation is ample in all parts of the state. Annual precipitation at Bush Field averages about 113.2 cm (44.58 in.) (NCDC 2008a). Precipitation is light in autumn, increases in winter and spring, and peaks in summer. Measurable precipitation of 0.025 cm (0.01 in.) or more occurs on an average of 109 days per year. Measurable snow is a rarity, and, if it occurs, remains on the ground for only a short time. Light snow typically occurs from December through February, and the annual average snowfall in the area is about 3.6 cm (1.4 in.).

Severe weather occurs in South Carolina occasionally in the form of violent thunderstorms and tornadoes (Ruffner 1985). Thunderstorms are common in the summer months, but the really violent ones generally accompany the squall lines and active cold fronts of spring. Strong thunderstorms usually bring high winds, hail, and considerable lightning, and they sometimes spawn a tornado.

Tornadoes are rare in the area surrounding SRS, and they are less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 878 tornadoes were reported in South Carolina, with an average of 15.1 tornadoes per year (NCDC 2008b). For the same period, a total of 93 tornadoes, at an average of 1.6 tornadoes per year, were reported in the SRS area; 57 occurred in the three counties encompassing SRS, and 36 occurred in the neighboring counties in Georgia (Burke, Richmond, and Screven). However, most tornadoes occurring in those counties were relatively weak (i.e., 91 tornadoes were less than or equal to F2 on the Fujita tornado scale, and two were F3). Nine tornadoes caused damage on SRS, one of which had estimated wind speeds as high as 67 m/s (150 mph). None caused damage to buildings on SRS (DCS 2002).

Tropical storms or hurricanes affect South Carolina about once every other year. Most do little damage and affect only the outer coastal plains, decreasing rapidly in intensity as they move inland. Those that do move far inland can cause considerable flooding (Ruffner 1985). Between 1851 and 2007, 28 major storms (4 hurricanes and 24 tropical storms) passed within 80 km (50 mi) of the GTCC reference location (NOAA 2008). Most hurricanes had been downgraded to tropical storms or tropical depressions before reaching SRS, which is located approximately 160 km (100 mi) inland. The only hurricane-force winds measured at SRS were associated with Hurricane Gracie on September 29, 1959, when wind speeds of 34 m/s (75 mph) were measured at the F-Area (DCS 2002).

10.1.1.2 Existing Air Emissions

The CAA of 1970 and CAAA of 1990 provide the basis for protecting and maintaining ambient air quality. The EPA delegated implementation and enforcement authority for the CAA to the State of South Carolina. The air pollution control rules developed and administered by the South Carolina Department of Health and Environmental Control (SCDHEC) are designed to ensure compliance with the CAA. The SCDHEC Air Permit Program is the primary driver by which emission sources are reported to and regulated by the State. Operating permits are legally enforceable documents that permitting authorities issue to air pollution sources after the source has begun to operate. In particular, a Title V permit is required for large stationary sources, such as power plants or major industrial facilities.

The SRS currently has two Title V (or Part 70 Air Quality Permit) operating permits: one including all SRS emission sources, and one for the 484-D Powerhouse (WSRC 2007a).[1]

The primary emission sources of criteria air pollutants and/or air toxics are the coal-fired powerhouse boiler in the D-Area, No. 2 oil-fired package steam generating boilers (those in the K-Area and portable units), fuel-oil-fired water heaters, and the biomass-fired and fuel-oil-fired boilers in the A-Area (WSRC 2007a). Other emissions include those from diesel-fired equipment (including portable air compressors, generators, and emergency cooling water pumps), several soil vapor extraction units, two air strippers, coal piles and coal processing facilities, vehicle traffic, controlled burning of forestry areas, and temporary emissions from construction-related activities.

Annual emissions from major facility sources and total point and area sources of criteria pollutants and VOCs in year 2002 in Aiken, Allendale, and Barnwell Counties, South Carolina, which encompass SRS, are presented in Table 10.1.1-1 (EPA 2008a). Data for 2002 are the most recent emission inventory data available on the EPA website. Area sources consist of nonpoint and mobile sources. Annual emissions are much higher in Aiken County than in Allendale and Barnwell Counties for both source categories and pollutant types because it has many industrial facilities and Interstate 20 (I-20). Point sources account for most of the SO_2 emissions, and point and area sources are equally attributable to NO_x emissions. Area sources are major contributors to CO, VOC, PM_{10}, and $PM_{2.5}$. Emissions of criteria pollutants except CO and of VOCs from two South Carolina Electric and Gas (SCE&G) coal-fired power stations in Urquhart and in the SRS D-Area in Aiken County were predominant for point source emissions in three counties.

Annual emissions of criteria pollutants and VOCs for the period 2003–2005 were estimated by SRS and are presented in Table 10.1.1-2 (WSRC 2007a). Recently, emissions of several pollutants, notably SO_2 and NO_x, increased significantly. During the 2006 annual air compliance inspection, all SRS permitted sources were found to be in compliance with their respective permit conditions and limits, and all required reports were determined to have been submitted to SCDHEC within specified time limits.

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[1] On February 1, 2006, Westinghouse Savannah River Company (WSRC) assumed operational responsibility from South Carolina Electric and Gas (SCE&G), which had operated the facility for DOE under a separate contract since 1995.

TABLE 10.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Counties Encompassing SRS[a]

	Emission Rates (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Aiken County						
SCE&G Urquhart Power Station[b]	*13,724*	*4,374*	*123*	*15.1*	*858*	*668*
	67.85%[c]	*28.68%*	*0.21%*	*0.14%*	*8.76%*	*23.13%*
	66.30%	*25.23%*	*0.17%*	*0.10%*	*6.27%*	*16.87%*
SCE&G SRS Area-D Powerhouse[d]	*3,830*	*2,479*	*40.5*	*3.3*	*429*	*315*
	18.93%	*16.26%*	*0.07%*	*0.03%*	*4.38%*	*10.91%*
	18.50%	*14.30%*	*0.05%*	*0.02%*	*3.14%*	*7.95%*
Westinghouse: Savannah River Site	*272*	*325*	*117*	*10.6*	*25.0*	*18.7*
	1.34%	*2.13%*	*0.20%*	*0.10%*	*0.26%*	*0.65%*
	1.31%	*1.87%*	*0.16%*	*0.07%*	*0.18%*	*0.47%*
Point sources	18,634	8,569	775	1,055	1,724	1,291
Area sources	1,595	6,681	57,779	9,934	8,067	1,597
Total	20,229	15,250	58,555	10,989	9,791	2,888
Allendale County						
Point sources	47.6	25.1	14.2	112	25.8	13.4
Area sources	113	807	8,143	1,896	1,917	651
Total	161	832	8,157	2,008	1,943	664
Barnwell County						
Point sources	68.2	73.2	19.5	217	16.1	14.5
Area sources	242	1,181	7,427	1,881	1,928	393
Total	310	1,254	7,447	2,098	1,944	408
Three-county total	20,700	17,336	74,159	15,095	13,678	3,960

[a] Emission data for selected major facilities and for total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield totals.

[c] The top and bottom rows with % signs show emissions as percentages of Aiken County total emissions and three-county total emissions, respectively.

[d] On February 1, 2006, WSRC assumed operational responsibility from SCE&G, which had operated the facility for DOE under a separate contract since 1995.

Source: EPA (2009)

TABLE 10.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds Estimated by SRS for the Period 2003–2005[a]

	Emission Rate (tons/yr)								
Year	SO_2	NO_x	CO	O_3 (VOCs)	PM_{10}	$PM_{2.5}$	Lead	Total PM	Gaseous Fluorides (as HF)
2003	536	266	2,290	93.3	118	NC[b]	0.558	302	0.114
2004	2,150	4,240	982	544	189	NC	0.158	489	0.139
2005	6,970	7,180	1,030	548	571	477	0.174	928	0.143

[a] CO = carbon monoxide, HF = hydrogen fluoride, NO_x = nitrogen oxides, O_3 = ozone, PM = particulate matter, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] NC = not calculated.

Source: WSRC (2007a)

10.1.1.3 Air Quality

The South Carolina SAAQS for six criteria pollutants — SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead — are almost the same as the NAAQS (EPA 2008a; Flynn 2007), as shown in Table 10.1.1-3. In addition, the State has adopted standards for gaseous fluorides (expressed as HF) and has still retained the annual standard for total suspended particulates (TSP), which used to be one of criteria pollutants but was replaced by PM_{10} in 1987 (SCDHEC 2004).

The GTCC reference location (which is within SRS, mostly in Aiken and Barnwell Counties and with a much smaller section in Allendale County) is situated in the Augusta (Georgia)-Aiken (South Carolina) Interstate Air Quality Control Region (AQCR). Currently, the entire AQCR is designated as being in attainment for all criteria pollutants (40 CFR 81.311 and 81.341).

Under existing regulations, SRS is not subject to on-site monitoring requirements for ambient air quality; however, the site is required to demonstrate compliance with various air quality standards (WSRC 2007a). To accomplish this compliance, air dispersion modeling was conducted during 2006 for new emission sources or modified sources as part of the sources' construction permitting process. The modeling analysis indicated that SRS air emission sources were in compliance with all applicable regulations.

The highest concentration levels of criteria pollutants (such as SO_2, NO_2, CO, TSP, PM_{10}, and lead) around SRS are less than or equal to 49% of their respective standards in Table 10.1.1-3 (EPA 2009; SCDHEC 2008), except for O_3, which exceeded the applicable standard, and $PM_{2.5}$, which was 97% of the applicable standard. Both pollutants are primarily of regional concern. Monitoring data in Jackson, Aiken County, showed that concentration levels for O_3 and $PM_{2.5}$ vary from year to year. It is hard to determine any trend for $PM_{2.5}$

TABLE 10.1.1-3 National Ambient Air Quality Standards (NAAQS) or South Carolina State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at SRS, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.50 ppm	0.019 ppm (3.8)	Barnwell Co. (2004)
	24-hour	0.14 ppm	0.007 ppm (5.0)	Barnwell Co. (2003)
	Annual	0.03 ppm	0.002 ppm (6.7)	Barnwell Co. (2007)
NO_2	1-hour	0.100 ppm	–	–
	Annual	0.053 ppm	0.004 ppm (7.5)	Jackson, Aiken Co. (2007)
CO	1-hour	35 ppm	3.0 ppm (8.6)	Columbia, Richland Co. (2004)
	8-hour	9 ppm	2.3 ppm (26)	Columbia, Richland Co. (2004)
O_3	1-hour	0.12 ppm[f]	0.101 ppm (84)	Jackson, Aiken Co. (2007)
	8-hour	0.075 ppm	0.082 ppm (109)	Jackson, Aiken Co. (2007)
TSP	Annual geometric mean	75 $\mu g/m^3$	35.9 (49)	Cayce, Lexington Co. (2003)
PM_{10}	24-hour	150 $\mu g/m^3$	56 $\mu g/m^3$ (37)	Barnwell Co. (2006)
	Annual	50 $\mu g/m^3$	–	–
$PM_{2.5}$	24-hour	35 $\mu g/m^3$	34 $\mu g/m^3$ (97)	Jackson, Aiken Co. (2004)
	Annual	15.0 $\mu g/m^3$	14.5 $\mu g/m^3$ (97)	Jackson, Aiken Co. (2006)
Lead[g]	Calendar quarter	1.5 $\mu g/m^3$	0.00 $\mu g/m^3$ (0.0)	Aiken Co. (2003)
	Rolling 3 month	0.15 $\mu g/m^3$	–	–
Gaseous fluorides (as HF)	12 hours	3.7 $\mu g/m^3$ [h]	–	–
	24 hours	2.9 $\mu g/m^3$ [h]	–	–
	1 week	1.6 $\mu g/m^3$ [h]	–	–
	1 month	0.8 $\mu g/m^3$ [h]	–	–

[a] CO = carbon monoxide, HF = hydrogen fluoride, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, TSP = total suspended particulates.

[b] The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

[c] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; 2nd-highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, 1-hour O_3, and 24-hour PM_{10}; 4th-highest for 8-hour O_3; 98th percentile for 24-hour $PM_{2.5}$; arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$; geometric mean for annual TSP.

[d] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

Footnotes continue on next page.

TABLE 10.1.1-3 (Cont.)

e A dash indicates that no measurement is available.

f On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment EAC areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

g Used old standard because no data in the new standard format are available.

h Arithmetic average.

Sources: 40 CFR 52.21; EPA (2008a, 2009); Flynn (2007); SCDHEC (2004, 2008)

concentrations because data were limited (for 2004–2006 only), but there was a general downward trend in O_3 concentrations during the period 1997–2006 (SCDHEC 2008). Measured concentration levels for TSP in the neighboring county of SRS were consistently less than 50% of the SAAQS, and no recent measurement data were available for hydrogen fluoride.

SRS and its vicinity are classified as PSD Class II areas. No Class I areas are located within 100 km (62 mi) of the GTCC reference location. The nearest Class I area is the Cape Romain National Wildlife Refuge, about 190 km (120 mi) east of the GTCC reference location; it is the only Class I area in South Carolina (40 CFR 81.426). The facilities at SRS have not been required to obtain a PSD permit (DCS 2002).

10.1.1.4 Existing Noise Environment

Aiken County has quantitative noise-limit ordinances by frequency band, as shown in Table 10.1.1-4, although the States of South Carolina and Georgia do not.

Similar to those at any other industrial site, major noise sources in active areas at SRS include industrial facilities and equipment (e.g., cooling systems, transformers, engines, vents, paging systems), construction and materials-handling equipment, and vehicles. Noise impacts on the general public arise primarily from transportation of people and materials to and from the site by vehicles, helicopters, and trains (DCS 2002).

SRS is located in a rural setting, and no residences and sensitive receptors (e.g., schools, hospitals) are located in the immediate vicinity of the GTCC reference location. Most SRS activities are far enough from the site boundaries and any neighboring communities, and trees and other vegetation in-between tend to attenuate sound considerably, so the associated noise levels at the boundary are not measurable or are barely distinguishable from background levels. A noise survey was conducted in the SRS area in 1989 and 1990 (NUS Corporation 1990). Seven off-site locations were selected along major routes used by SRS employees entering and leaving the site. Summer L_{dn} levels ranged from 62 to 72 dBA; winter L_{dn} levels ranged from

TABLE 10.1.1-4 Maximum Allowable Noise Levels in Aiken County, South Carolina

	Maximum Allowable Sound Pressure Levels at Property Boundary (dB)	
Frequency Band (Hz)	Residential	Nonresidential
0–75	72	79
75–150	67	74
150–300	59	66
300–600	52	59
600–1,200	46	53
1,200–2,400	40	47
2,400–4,800	34	41
4,800–10,000	32	39

Source: County of Aiken (2008)

51 to 70 dBA. Measured L_{dn} levels at three on-site locations were in a range of 54–62 dBA in summer and 37–59 dBA in winter. These levels for a typical rural environment primarily result from the traffic and/or bird and insect noise. For the general area surrounding SRS, the countywide L_{dn} levels based on population density are estimated to be 36, 38, and 43 dBA for Allendale, Barnwell, and Aiken Counties, respectively, typical of rural areas (Miller 2002; Eldred 1982).

10.1.2 Geology and Soils

10.1.2.1 Geology

10.1.2.1.1 Physiography. SRS is located on the Aiken Plateau of the Upper Atlantic Coastal Plain physiographic province, about 40 km (25 mi) southeast of the fall line, an erosional scarp that separates the crystalline rocks of the Piedmont province to the west from the sedimentary rocks of the Atlantic Coastal Plain (Figure 10.1.2-1). The Coastal Plain is underlain by a wedge of seaward-dipping unconsolidated and poorly consolidated sediments deposited during a series of sea transgressions and regressions and reflecting a variety of depositional environments, including fluvial, deltaic, and shallow marine. The sediments increase in thickness from zero at the fall line to more than 1,219 m (4,000 ft) near the South Carolina coast. At SRS, Coastal Plain sediments range in thickness from about 183 to 366 m (600 to 1,200 ft) (Hunt 1973; Aadland et al. 1995; Denham 1995; Fallaw and Price 1992).

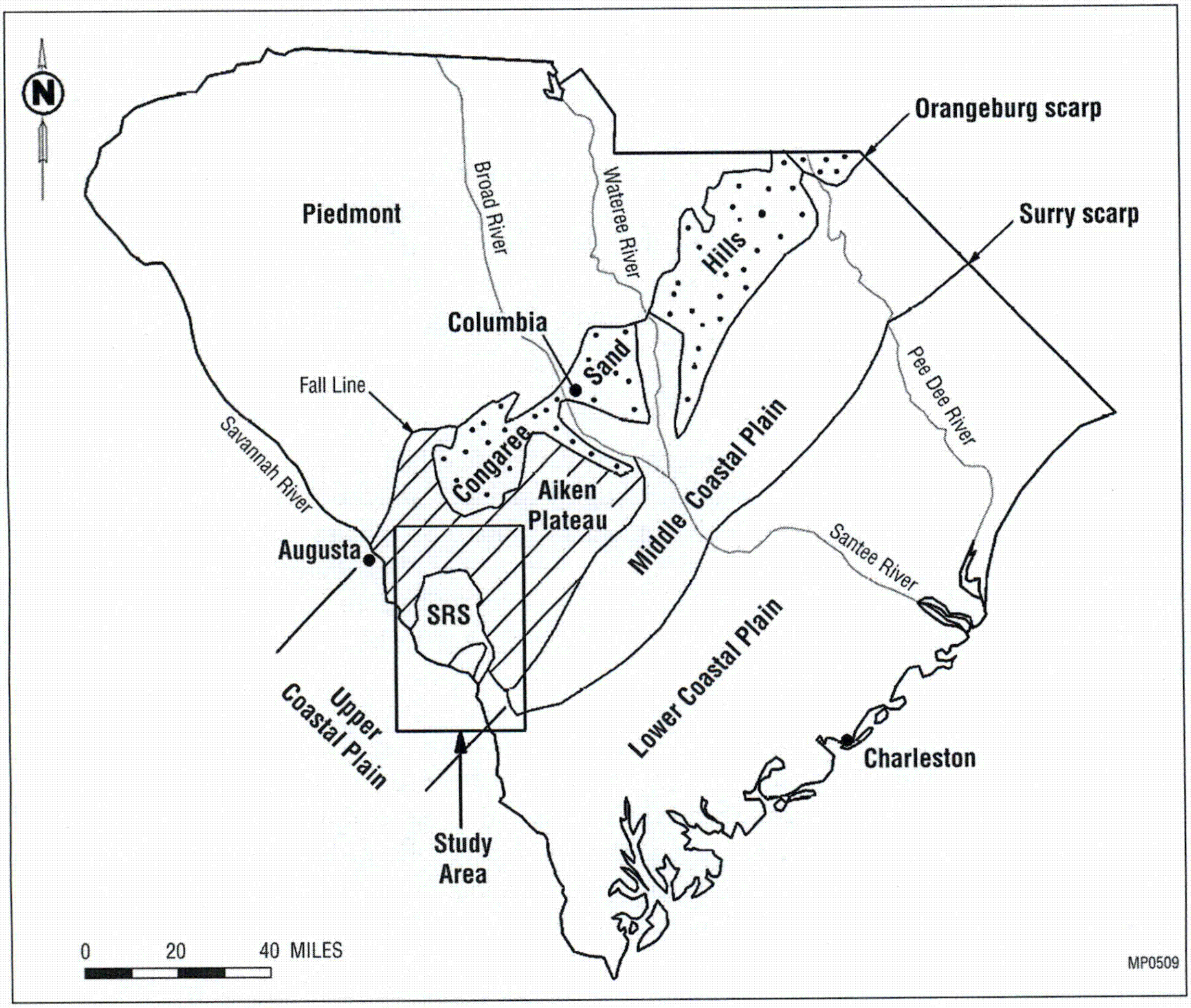


FIGURE 10.1.2-1 Location of SRS on the Atlantic Coastal Plain near the Fall Line (Source: Wyatt et al. 2000)

The Aiken Plateau is bounded by the Savannah and Congaree Rivers. It is highly dissected and characterized by broad interfluvial areas with narrow, steep-sided valleys. Regional dip is to the southeast; the plateau slopes from an elevation of approximately 200 m (650 ft) above MSL at the fall line to an elevation of about (250 ft MSL) on its southeast edge. It is typically well drained, although poorly drained sinks and depressions occur in topographically high areas (above 75 m MSL [250 ft MSL]). Because SRS is situated near the Piedmont province, its relief is greater than near-coastal areas, with on-site elevations ranging from 128 m MSL (420 ft MSL) near the Aiken Gate House on Road 2 to about 24.4 m MSL (80 ft MSL) where Steel Creek enters the Savannah River (Aadland et al. 1995; Denham 1995; Rogers 1990).

The Congaree Sand Hills region of the Coastal Plain province stretches across the base of the Piedmont province at the fall line, just to the north and northeast of the Aiken Plateau (Figure 10.1.2-1). The hills are composed of sandy soils and are typically gently sloping with

rounded summits. The sand hills are remnants of ancient coastal dunes deposited during an episode of sea regression (Aadland et al. 1995).

10.1.2.1.2 Topography. The GTCC reference location is situated on a broad upland area typical of the Aiken Plateau. The elevation is fairly flat, ranging from about 90 to 100 m (300 to 330 ft) MSL, with an average slope of less than 4%. The upland area extends to the south but drops off steeply to the north, east, and west. Slopes range from 10% to 40% along the narrow valleys between the upland area and the floodplains along nearby Mill Creek, McQueen Branch, Tinker Creek, and Upper Three Runs.

10.1.2.1.3 Site Geology and Stratigraphy. Coastal Plain sediments at SRS consist of sand, silt, clay, limestone, and conglomerate ranging in age from Late Cretaceous to Holocene. These sediments are underlain by Paleozoic metamorphic rocks (gneiss and schist, with lesser amounts of quartzite) that have been intruded by somewhat younger Paleozoic granitic plutons. In the southeastern portion of SRS, coastal plain sediments have a thickness of up to 366 m (1,200 ft) and rest unconformably on (Mesozoic Triassic) age rocks in the Dunbarton basin (Fallaw and Price 1995; Prowell 1996).

The GTCC reference location is about 32 km (2 mi) to the east-northeast of the Z-Area, in the north-central portion of SRS. It is situated on an upland ridge overlooking Tinker Creek to the north, on unconsolidated Tertiary sediments (Tobacco Road sand; Figure 10.1.2-2). Tertiary deposits make up a majority of surface exposures and most of the shallow subsurface rocks at SRS. These deposits represent marine (deltaic) and marginal marine (fluvial) depositional environments typical of the Coastal Plain province (Prowell 1996).

The following summary of stratigraphy at the SRS is based on the work of Fallaw et al. (1992), Fallaw and Price (1995), Prowell (1996), and Wyatt et al. (2000). Figure 10.1.2-2 shows the geology of the area surrounding the GTCC reference location. Figure 10.1.2-3 presents a stratigraphic column for the SRS and vicinity.

Paleozoic and Triassic Basement Rock. Igneous and metamorphic rocks of the Piedmont and Blue Ridge provinces are the source of sediments in the Coastal Plain. Rocks similar to those exposed in the Piedmont province underlie the Coastal Plain sediments at the SRS. These include metamorphic rocks (slate, phyllite, schist, gneiss), volcanic and metavolcanic rocks, and intrusive rocks (granite) of Paleozoic age that formed during several orogenic episodes in the Appalachians.

The southeastern portion of SRS is underlain by rocks of the Triassic Newark Supergroup in Dunbarton Basin. The Dunbarton Basin is a Triassic-Jurassic rift basin filled with lithified terrigenous and lacustrine sediments (predominantly fanglomerate, sandstone, siltstone, and mudstone), with minor amounts of mafic volcanic and intrusive rock.

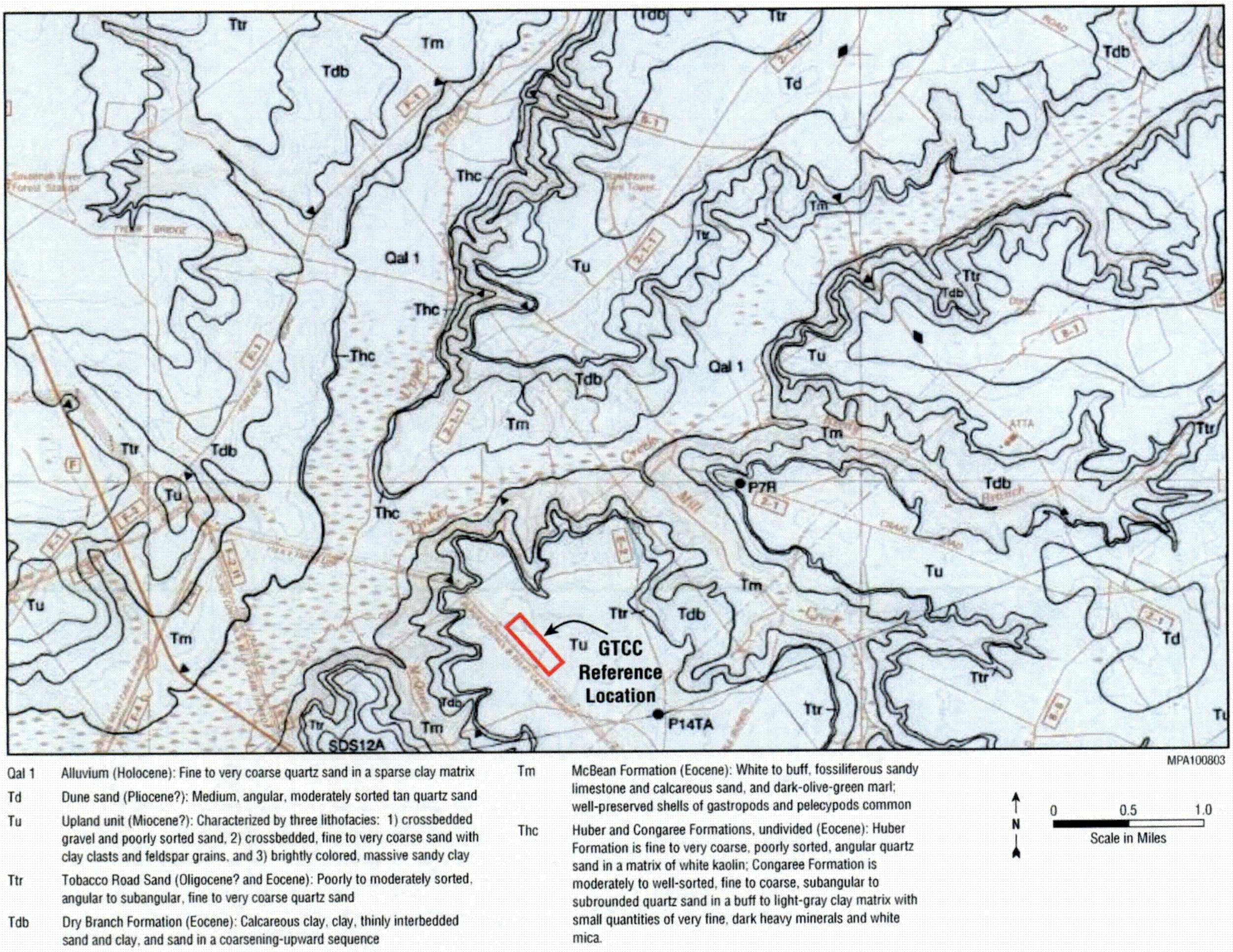


FIGURE 10.1.2-2 Geologic Map of the GTCC Reference Location at SRS (Source: Adapted from Prowell 1996)

The surface of the Paleozoic rocks and Triassic sediments was leveled by erosion over time, forming the basement rock over which Coastal Plain sediments were deposited. The surface of the basement rock dips about 9.5 m/km (50 ft/mi) to the southeast at SRS.

Upper Cretaceous Sediments. Upper Cretaceous sediments overlie Paleozoic basement rock or lower Mesozoic (Triassic) rocks throughout SRS. The Upper Cretaceous section is divided into four units (from older to younger): Cape Fear Formation, Middendorf Formation, Black Creek Group, and Steel Creek Formation. Its thickness at SRS ranges from 120 m (400 ft) at the site's northwestern boundary to 240 m (800 ft) at the southeastern boundary. The sediments are typical of braided stream deposits, consisting predominantly of poorly consolidated, clay-rich, fine- to medium-grained micaceous sand, sandy clay, and gravels, suggesting a high relief in the Appalachians during this time.

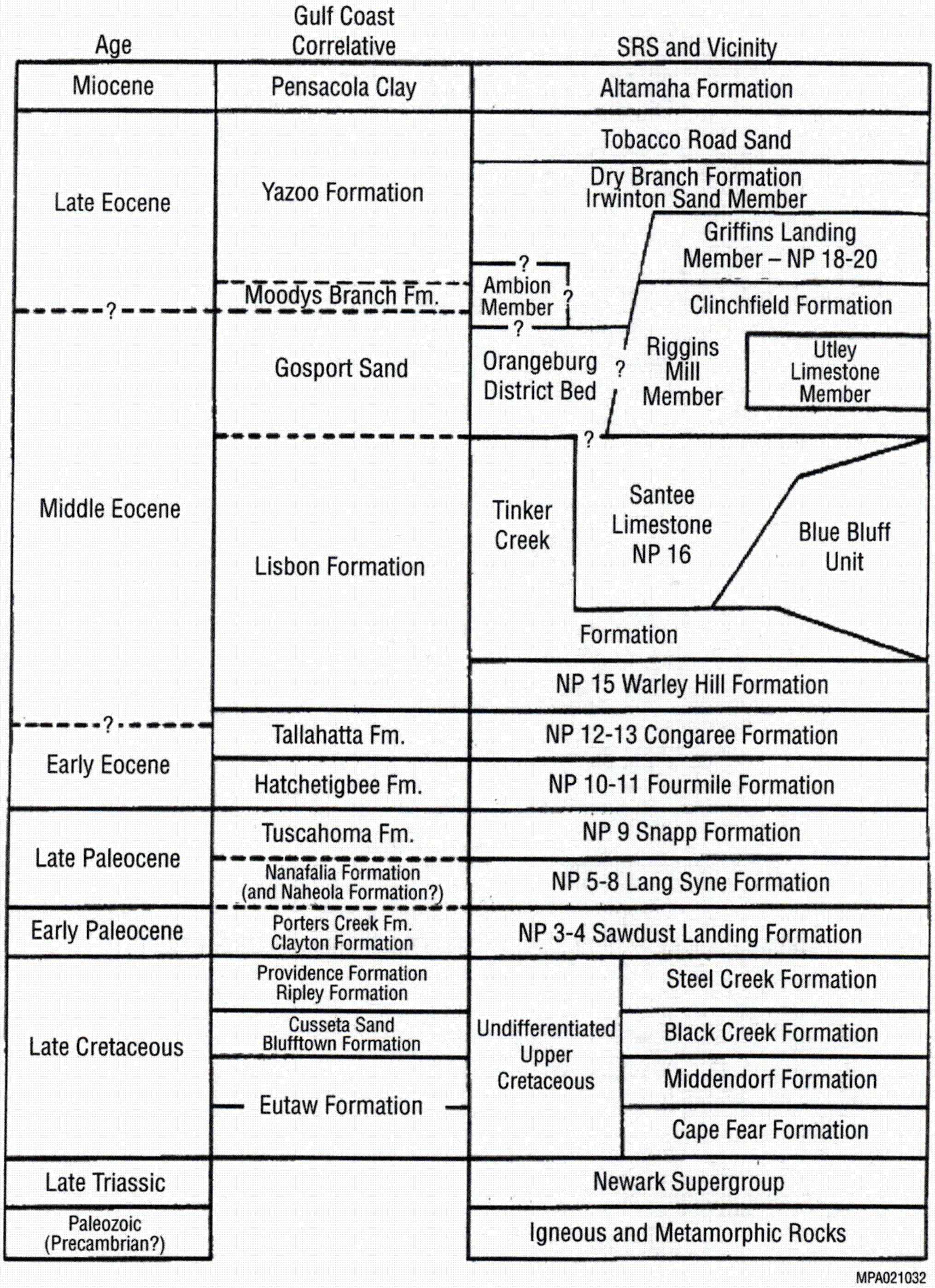


FIGURE 10.1.2-3 Stratigraphic Column for SRS and Vicinity (Source: Adapted from Fallaw and Price 1995)

Tertiary (Paleocene, Eocene and Miocene) Sediments. Tertiary sediments range in age from Early (Lower) Paleocene to Miocene. These sediments consist predominantly of light-colored, kaolinitic, coarse-grained, cross-bedded quartz sands, micaceous sands, and kaolin, and they were deposited in fluvial to marine shelf environments.

Quaternary Deposits. SRS lies within the interfluvial area between the Savannah and Salkehatchie Rivers; its drainage systems consist entirely of streams that are tributaries of the Savannah River. Fluvial terraces are preserved above the modern floodplain along the river and some of its major tributaries. These features, along with colluvial and alluvial deposits, make up the Quaternary section at SRS.

10.1.2.1.4 Seismicity. Earthquakes have been recorded in both the Piedmont and Coastal Plain provinces of South Carolina. Most of the seismicity in the Piedmont province has been associated with reservoirs in northwestern and central South Carolina. The largest earthquake in the Piedmont occurred in Union County in 1913 (with a modified Mercalli intensity of VI to VIII and an estimated body wave magnitude of 4.5), about 150 km (93 mi) north of SRS (Stephenson 1992; DOE 2002).

Seismicity in the Coastal Plain occurs in three distinct zones: Middleton Place-Summerville seismic zone (MPSSZ), about 20 km (12 mi) northwest of Charleston; Bowman seismic zone, about 60 km (37 mi) northwest of the MPSSZ; and Adams Run seismic zone, about 30 km (19 mi) southwest of the MPSSZ. Earthquakes also occur in spatially isolated areas of the Coastal Plain. The largest earthquake in the southeastern United States occurred in the South Carolina Coastal Plain in 1886 (with a measured body wave magnitude of 6.7); its epicenter was about 20 to 30 km (12 to 19 mi) northwest of Charleston in the MPSSZ. The Charleston area is considered the most seismically active region in the Coastal Plain province, and it is the most significant source of seismicity affecting SRS (Stephenson 1992).

Figure 10.1.2-4 shows the major fault lines (and relative movement along them) at SRS, based on the work of Stephenson and Stieve (1992) and Wike et al. (1996). The lines shown are projections to the ground surface; the actual faults do not reach the ground surface (most are several hundred feet bgs). The Upper Three Runs fault (a Paleozoic fault located in the crystalline rock below the Coastal Plain sediments) crosses SRS about 1.6 km (1 mi) to the north and west of E-Area.

None of the fault systems at SRS is considered "capable" (as defined in 10 CFR Part 100) because there has been no movement along these faults that can be traced to the ground surface in the past 35,000 years (DOE 2002).

The locations of earthquakes at SRS are also shown on Figure 10.1.2-4. They include the most recent earthquake, which occurred on October 8, 2001, near Upper Three Runs Creek, about 2.5 km (1.6 mi) north of the GTCC reference site. It had a body wave magnitude of 2.6 and a focal depth of about 3.9 km (2.4 mi). Three earthquakes with magnitudes ranging from 2.0 to 2.6 occurred before this 2001 event and after the SRS seismic recording network was

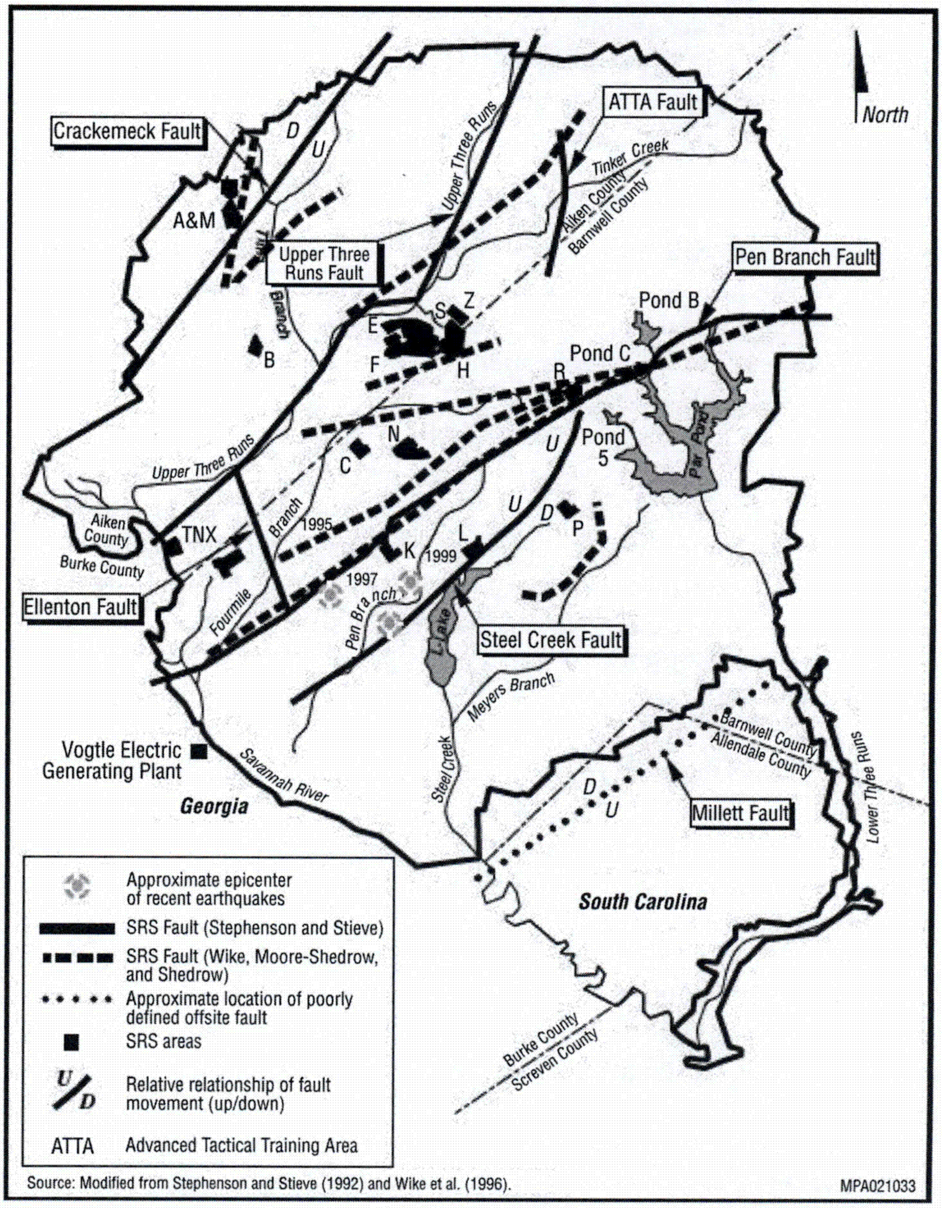


FIGURE 10.1.2-4 Seismic Fault Lines and Locations of On-Site Earthquakes at SRS (Source: Adapted from DOE 2002)

installed in 1976; all were clustered near the south-central region of SRS (Stevenson and Talwani 2004; DOE 2002). Also, a 3.2-magnitude earthquake occurred on August 8, 1993, near Aiken, South Carolina, about 19 km (12 mi) to the north of the SRS north boundary. It was felt most strongly in Couchton, South Carolina (Stevenson and Talwani 2004).

Probabilistic seismic hazard assessments conducted since the late 1960s have determined the seismic design basis for SRS reactors to be 0.20g peak horizontal ground acceleration. These assessments have estimated the annual probability of exceeding the design basis to be within a range of 0.002 to 0.00005 (once every 500 to 20,000 years) (Stephenson 1992).

10.1.2.1.5 Volcanic Activity. There are no active volcanoes in the vicinity of SRS.

10.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors at the GTCC reference location have been reported that would affect the engineering aspects of slope stability, as long as the facility is built at some distance from the edge of the upland ridge to the north, east, and west. The upland area itself is fairly flat, with a slope of generally less than 4%.

The Santee Formation (Figure 10.1.2-3) comprises a soil zone of marine origin occurring at depths of 30 to 70 m (100 to 250 ft) across SRS. This zone has locally high concentrations of calcium carbonate and is characterized by a stronger matrix of material through which weak zones, referred to as "soft zones," are interspersed. Soft zones occur in the saturated zone and are generally stable under static conditions (showing minimal carbonate dissolution). However, load increases that could result from a seismic event could lead to subsidence, especially in areas where the soft zone is thick and laterally extensive. It is not known whether soft zones exist below the GTCC reference site (Aadland et al. 1999; WSRC 2000).

Liquefaction of saturated sediments is a potential hazard during or immediately after large earthquakes. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake, peak ground velocity, liquefaction susceptibility of soils, and depth to groundwater. Previous studies at other SRS sites (e.g., F-Area) found the liquefaction susceptibility of soils to be low because of their low clay content and liquid limit and because earthquakes at SRS historically do not have the shear wave velocities required to subject soils to liquefaction (WSRC 2000). Lewis et al. (2004) also report that the liquefaction potential for soils at SRS is very low; soil strength is attributed to factors such as aging and over-consolidation.

10.1.2.2 Soils

The undisturbed soils within the study area are predominantly sands, and they overlie a substratum of loamy sand or sandy clay loam. These soils tend to be low in organic content and water storage capacity. Upland soils (Ailey and Lakeland sands) are gently sloping (0 to 6%) and well to excessively drained. These soils have a permeability that ranges from low to high and a low erosion hazard rating. Soils on the southeastern banks of Upper Three Runs Creek and Tinker Creek (Troup and Lucy sands) occur on steep slopes (15 to 25%) and are well drained. These soils are moderately permeable and have a moderate erosion hazard rating (Rogers 1990).

10.1.2.3 Mineral and Energy Resources

There are no reported mineral or energy resources being developed within the boundaries of SRS. Economic mineral resources in South Carolina include gold, copper, lead, zinc, silver, titanium, rare earths, zirconium, tin, refractory minerals, lithium, mica, and feldspar minerals. Industrial resources include clay, limestone, sand, gravel, crushed rock, building stone, slate, and aggregate.

10.1.3 Water Resources

10.1.3.1 Surface Water

10.1.3.1.1 Rivers and Streams. The major surface water systems and their 100-year floodplains at the 800-km^2 (310-mi^2) SRS are shown in Figure 10.1.3-1. SRS streams and the Savannah River are classified as "freshwater," which is defined as surface water that is suitable (1) for primary and secondary contact recreation, (2) as a source of drinking water after conventional treatment, (3) for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora, and (4) for industrial and agricultural uses. None of these water features are classified as Wild and Scenic.

The largest river in the area is Savannah River, which forms the southwestern border of SRS for about 32 km (20 mi). It is formed by the confluence of the Tugaloo and Seneca Rivers in northeast Georgia. The Savannah River watershed drains about 27,388 km^2 (10,547 mi^2) and encompasses western South Carolina, eastern Georgia, and a small portion of southwestern North Carolina. It forms the boundary between Georgia and South Carolina. At SRS, flow within the Savannah River averages about 283 cms (10,000 cfs) (DOE 2002; Wike et al. 2006).

Five upstream reservoirs — Jocassee, Keowee, Hartwell, Richard B. Russell, and Strom Thurmond/Clarks Hill — moderate the effects of droughts and low flows on downstream water quality and accompanying impacts on aquatic and wildlife resources that depend on the river (DOE 1997, 2002; Wike et al. 2006).

Upstream of SRS, the Savannah River supplies domestic and industrial water for Augusta, Georgia, and for North Augusta, South Carolina. The river also receives sewage treatment plant effluents from Augusta, Georgia; North Augusta, Aiken, and Horse Creek Valley, South Carolina; and from a variety of SRS operations through permitted stream discharges. About 209 river km (130 river mi) downstream, the river supplies domestic and industrial water for the Port Wentworth (Savannah, Georgia) water treatment plant at River Mile 29 and for Beaufort and Jasper Counties in South Carolina at River Mile 39.2. Georgia Power's Vogtle Electric Generating Plant withdraws an average of 1.3 cms (46 cfs) for cooling and returns an average of 0.35 cms (12 cfs). Also, SCE&G's Urquhart Steam Generating Station at Beech Island, South Carolina, withdraws approximately 7.4 cms (261 cfs) of once-through cooling water (DOE 1997, 2002).

There are five SRS tributaries that discharge directly into the Savannah River: Upper Three Runs Creek, Beaver Dam Creek, Fourmile Branch, Steel Creek, and Lower Three Runs (Figure 10.1.3-1). A sixth tributary, Pen Branch, discharges to the Savannah River floodplain swamp. All these streams flow to the south/southwest, descending 15.2 to 61 m (50 to 200 ft) before discharging into the river. These streams have historically received effluent from SRS operating areas; they are not commercial sources of water.

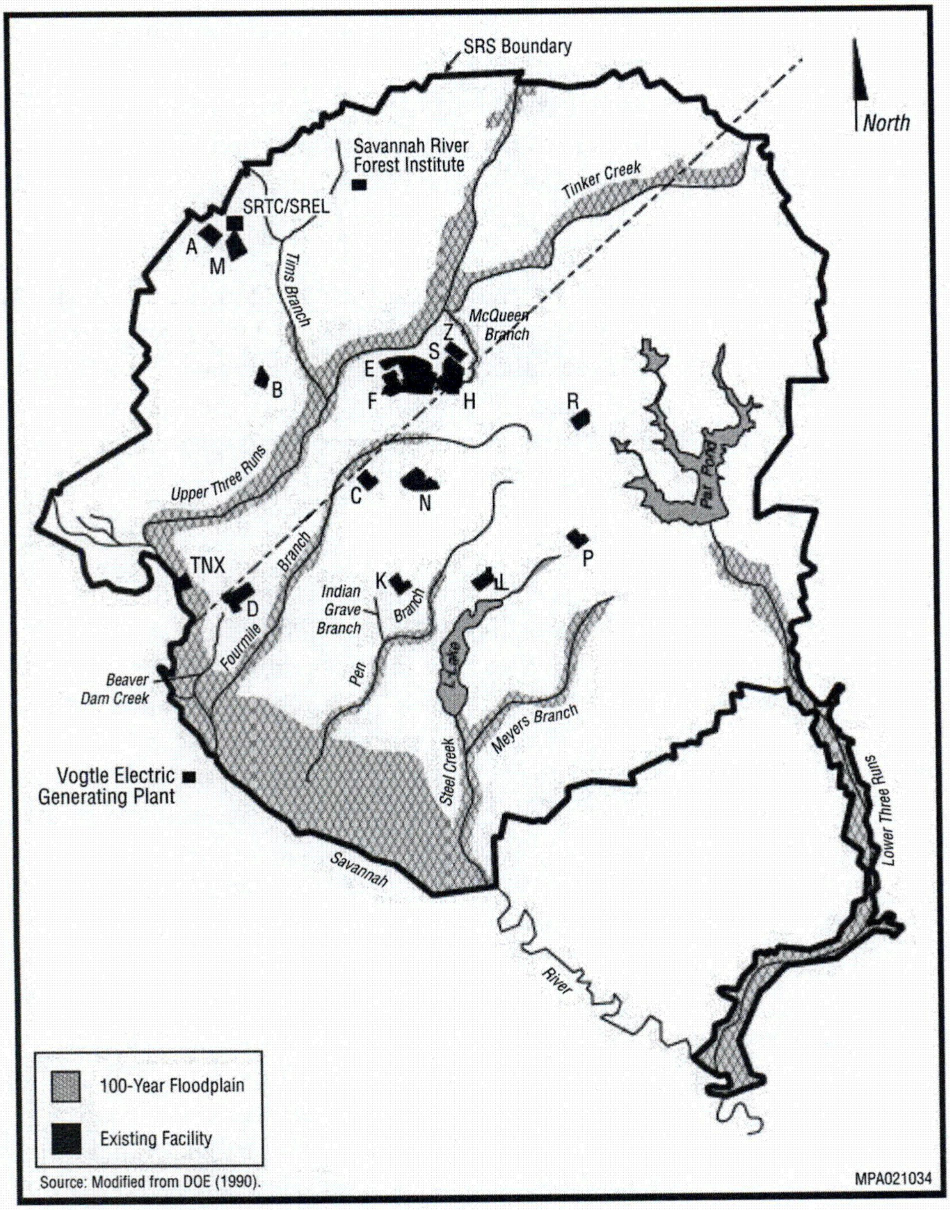


FIGURE 10.1.3-1 Major Surface Water Stream Systems and the 100-Year Floodplain at SRS (Source: DOE 2002)

E-Area is situated between F-Area and H-Area on a divide that separates the drainage into the Upper Three Runs Creek to the north (with its tributaries Tinker Creek, McQueen Branch, Crouch Branch, and Tims Branch) and Fourmile Branch to the south. The upper aquifer zone of the Upper Three Runs Aquifer crops out and seeps along both the Upper Three Runs and Fourmile Branch (DOE 2002; Wike et al. 2006). The GTCC reference location at SRS is situated a short distance northeast of Z-Area, which is located about 5 km (3 mi) northeast of E-Area.

Z-Area is located just west of McQueen Branch, near the confluence of McQueen Branch and Upper Three Runs Creek. McQueen Branch is joined by the Tinker Branch on SRS. Tinker Branch then joins Upper Three Runs Creek about 50 km (31 mi) downstream of the McQueen/Tinker Creek confluence. McQueen Branch is typical of the streams in the area; it has a small gradient, a predominantly sandy substrate, little gravel, and no cobble or bedrock (Sheldon and Meffe 1994).

10.1.3.1.2 Upper Three Runs Creek. Upper Three Runs Creek, the longest of the SRS streams, is a large, blackwater stream just north of the General Separations Area (GSA). The GSA is a 40-km^2 (15-mi^2) region in central SRS that includes the E-, F-, H-, S-, and Z-Areas (Figure 10.1.3-1). A blackwater stream has a dark color attributable to tannins released from the decomposition of leaves and acids released from heavily organic soils (North Augusta 2004). The creek is about 40-km (25-mi) long, with its lower 28 km (17 mi) being within the boundaries of SRS. It drains an area of about 545 km^2 (209 mi^2) and flows to the southwest, discharging directly into the Savannah River. Its two significant tributaries are Tinker Creek, the largest, and Tims Branch. Upper Three Runs Creek receives more water from underground sources than do other SRS streams, and it is the only stream with headwaters that arise off-site (near Aiken, South Carolina) (DOE 2002; Wike et al. 2006).

The creek receives various NPDES-permitted effluents (either directly or through its tributaries), including cooling water, blowdown, stormwater, lab drains, air stripper discharge, steam condensate, M-Area wastes, process water, neutralization wastewater, and F/H-Area Effluent Treatment Project (ETP) wastewater. It is the only major tributary that has not received thermal discharges. The F/H-Area ETP discharges to the creek just downstream of the Road C bridge (DOE 2002; Wike et al. 2006; Mast and Turk 1999).

Stream flow was monitored between 1974 and 2002 at three locations on Upper Three Runs Creek, including two on-site locations (Road A [Station 02197315] and Road C [Station 02197310]). Annual discharge at the stations at Road C between 1975 and 2002 (based on a water year, which lasts from October of one year through September of the next year) averaged 5.78 cms (204.2 cfs), with a range of 3.45 cms (121.8 cfs) in 2002 to 8.34 cms (294.5 cfs) in 1995. At Road A station, it averaged 6.63 cms (234.3 cfs), with a range of 3.68 cms (130.0 cfs) in 2002 to 8.21 cms (289.8 cfs) in 1991 (USGS 2007). Neither station is currently monitored; no data after September 2002 are available (Wike et al. 2006).

10.1.3.1.3 Fourmile Branch. Fourmile Branch is a blackwater stream that originates to the south of the GSA. It is about 24-km (15-mi) long. The stream drains an area of about 57 km^2 (22 mi^2) and flows to the southwest, discharging through a main delta channel into the Savannah River. A small portion of its discharge flows west and enters Beaver Dam Creek. When the Savannah River floods, water from Fourmile Branch flows south along the northern boundary of a floodplain swamp and joins Pen Branch and Steel Creek (DOE 2002; Wike et al. 2006).

Fourmile Branch receives various NPDES-permitted effluents from the F-, H-, and C-Areas and Central Shops. Discharges from the C Reactor ceased after it shut down in 1985. (Prior to that, thermal discharges of reactor cooling water were discharged to Castor Creek, a tributary to Fourmile Branch.) Effluent discharges from the Central Sanitary Wastewater Treatment Facility (CSWTF) began in 1995.

Stream flow was monitored between 1974 and 2002 at two locations on Fourmile Branch (Site No. 7 [Station 02197342], just upstream of Castor Creek, and Road A-12.2 [Station 02197344]). Annual discharge at Site No. 7 between 1975 and 2002 (based on a water year) averaged 0.47 cms (16.5 cfs), with a range of 0.19 cms (6.78 cfs) in 2002 to 0.93 cms (32.7 cfs) in 1991. Annual discharge at Road A-12.2 between 1986 (when C Reactor discharges were discontinued) and 2002 (based on a water year) averaged 0.90 cms (31.9 cfs), with a range of 0.30 cms (10.6 cfs) in 2002 to 1.79 cms (63.1 cfs) in 1991 (USGS 2007). Neither station is currently monitored; no data after September 2002 are available (Wike et al. 2006).

Both Fourmile Branch and Upper Three Runs Creek at SRS are prone to flooding. Upstream reservoirs, additional tributaries, and crossing conduits complicate floodplain analyses. However, a 100-year floodplain has been produced for the site (Figure 10.1.3-1). Flood potential is greatest along the southwestern boundary of the site along the Savannah River. The potential for flooding in the E-Area and nearby Z-Area is small; any flooding would occur on the north side of Upper Three Runs Creek and along McQueen Branch.

10.1.3.1.4 Reservoirs. There are two reservoirs at SRS: L Lake and Par Pond (Figure 10.1.3-1). Both ponds are located south of the GSA. L Lake is in the south-central portion of the site. It was formed in 1985 by damming the headwaters of Steel Creek about 7.2 km (4.5 mi) above its mouth. Its average width is about 0.64 km (0.40 mi), reaching a maximum of about 1.3 km (0.8 mi). At its normal pool elevation of 58 m (190 ft) MSL, the dam impounds about 31 million m^3 (1,100 million ft^3) of water. L Lake gains water via groundwater flow at its upstream end and loses water to the groundwater system along its downstream shorelines (Wike et al. 2006).

Par Pond is a 1,012-ha (2,500-ac) reactor-cooling reservoir created in 1958 by constructing an earthen dam, Cold Dam, across Lower Three Runs Creek (Wike et al. 2006). It was constructed to augment the cooling system for the P and R Reactors. Par Pond's capacity is 85,900 ac-ft (3,742 million ft^3); normal storage is 54,400 ac-ft (2,370 million ft^3). Maximum discharge from Cold Dam is 66 cms (2,340 cfs) (Find Lakes 2008). The pond runs along the course of Poplar Branch, Joyce Branch, and the upper reach of the Lower Three Runs drainage

system. The reservoir surface elevation fluctuates between 61.0 and 59.4 m (200 and 195 ft) MSL.

10.1.3.1.5 Other Surface Water. Other surface waters at SRS include the Savannah River swamp, wetlands, and Carolina Bays. The SRS Savannah River swamp borders 16 km (10 mi) of SRS and has an average width of about 2.2 km (1.4 mi). About 3,800 ha (9,400 ac) of the Savannah River swamp lie within SRS between Upper Three Runs Creek and Steel Creek. A levee and embankment run along the east side of the Savannah River. Breaches in the levee allow water from Beaver Dam Creek, Fourmile Branch, and Steel Creek to flow to the river. The combined discharges of Steel Creek and Pen Branch enter the river near the southeast edge of the swamp. During periods of high water, river water overflows the levee and floods the swamp. The river begins to overflow into the swamp when river elevations reach between 27 and 28 m (89 and 92 ft) above MSL or at flows of about 433 cms (15,300 cfs). During flooding, the water from SRS streams flows through the swamp parallel to the river and enters the river downstream of Steel Creek (Wike et al. 2006). There are no wetlands in the vicinity of Z-Area.

10.1.3.1.6 Surface Water Quality. Contamination in the Upper Three Runs Creek and Fourmile Branch watersheds is related to operational areas F and H and has been listed in the *Federal Facility Agreement for the Savannah River Site* (WSRC 1993). Table 10.1.3-1 summarizes the water quality of Upper Three Runs Creek and Fourmile Branch for 1998.

Tritium, the predominant radionuclide detected above background levels in SRS streams, was observed at all stream locations in 2006 except the Upper Three Runs Creek control point and Site X-008 near T-Area. In 2006, tritium concentrations generally declined in all site streams, except in Steel Creek, where they remained stable. In 2006, tritium concentrations in Upper Three Runs Creek and Fourmile Branch were 189 and 650 pCi/L, respectively. Tritium measured in the Savannah River below SRS in 2006 was 3,830 pCi/L. No detectable concentrations of Co-60 were observed in any of the five major SRS streams. The maximum concentration of Cs-137 in Fourmile Branch was 34.9 pCi/L; for Upper Three Runs Creek, the maximum Cs-137 concentration was 5.0 pCi/L. Maximum gross beta measurements taken in 2006 at Upper Three Runs Creek and Fourmile Branch were 2.84 and 35.1 pCi/L, respectively. Gross alpha values, at the same time, were 1.59 and 14.0 pCi/L, respectively (WSRC 2007a).

Cs-137 and Co-60 were the only man-made gamma-emitting radionuclides observed in river and stream sediments. The highest Cs-137 concentration in streams, 497 pCi/g, was detected in sediment from R Canal; the lowest levels were below detection at several locations. The highest level found on the river, 0.486 pCi/g, was measured at River Mile 129. Co-60 was detected in stream sediment at a concentration of 0.441 pCi/g at the R Canal location — the only location where Co-60 was detected. Sr-89 and Sr-90 were above the minimum detectable concentrations in sediment at six stream locations. The maximum detected value was 0.37 pCi/g at the Fourmile Branch at the Road A-7 location. Pu-238 was detected in sediment during 2006 at all stream locations and at four river locations. The results ranged from a maximum of 0.139 pCi/g at FM-A7 to below detection at several locations. Pu-239 was detected in sediment

TABLE 10.1.3-1 Water Quality Data for Upper Three Runs Creek and Fourmile Branch in 1998

Parameter[a]	Unit of Measure	Fourmile Branch (FM-6) Average	Upper Three Runs (U3R-4) Average	Water Quality Criterion,[b] MCL,[c] or DCG[d]
Aluminum	mg/L	0.285[e]	0.294[e]	0.087
Cadmium	mg/L	NR[f]	NR	0.00066
Calcium	mg/L	NR	NR	NA[g]
Ce-137	pCi/L	4.74	0.67	120[d]
Chromium	mg/L	ND[h]	ND	0.011
Copper	mg/L	0.006	ND	0.0065
Dissolved oxygen	mg/L	8.31	6.3	≥5
Iron	mg/L	0.717	0.547	1
Lead	mg/L	0.18	0.011	0.0013
Magnesium	mg/L	NR	NR	0.3
Manganese	mg/L	0.045	0.026	1
Mercury	mg/L	0.0002	ND	0.000012
Nickel	mg/L	ND	ND	0.088
Nitrate (as nitrogen)	mg/L	1.29	0.26	10[c1]
pH	pH	6.4	5.8	6–8.5
Pu-238	pCi/L	0.003	ND	1.6[d]
Pu-239	pCi/L	0.001	0.005	1.2[d]
Sr-89 and Sr-90	pCi/L	6.79	0.04	8[c2]
Suspended solids	mg/L	3.9	5.9	NA
Temperature[i]	°C	20.2	18.8	32.2
Tritium	pCi/L	1.9×10^5	4.2×10^3	20,000[c2]
U-234	pCi/L	0.69	0.093	20[d]
U-235	pCi/L	0.053	0.046	24[d]
U-238	pCi/L	0.84	0.11	24[d]
Zinc	mg/L	0.019	0.02	0.059

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

b Water quality criterion is "aquatic, chronic toxicity" unless otherwise indicated.

c MCL = maximum contaminant level: State Primary Drinking Water Regulations.
c1 = Chapter 61-58.5 (b)(2)h of Arnett and Mamatey (1999); c2 = Chapter 61-58.5(h)(2)b of Arnett and Mamatey (1999).

d DCG = DOE derived concentration guides for water (DOE Order 5400.5). DCG values are based on a committed effective dose of 100 mrem per year; however, because the drinking water MCL is based on 4 mrem per year, the value listed is 4% of DCG.

e Concentration exceeded water quality criterion; however, these criteria are for comparison only. Water quality criteria are not legally enforceable.

f NR = not reported.

g NA = not applicable.

h ND = not detected.

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

Sources: Arnett and Mamatey (1999); DOE (2002)

at most stream locations and four river locations. The maximum value was 0.182 pCi/g, also found at FM-A7. U-234, U-235, and U-238 were detected at most locations (WSRC 2007a).

At every site, most nonradiological water quality parameters and metals were detected in at least one sample. Only three samples had detectable pesticides/herbicides in 2006. These results continue to indicate that SRS discharges are not significantly affecting the water quality of the on-site streams or the river. The maximum mercury concentration for Fourmile Branch in 2006 was 0.022 µg/L; the maximum aluminum concentration was 0.023 mg/L. No detectable pesticides or herbicides were found. In 2006, maximum concentrations of mercury and aluminum in Tims Branch (a tributary of Upper Three Runs Creek) were 0.02 µg/L and 0.5 mg/L, respectively. As was the case for Fourmile Branch, no detectable pesticides or herbicides were found (WSRC 2007a).

In 2006, as in the previous five years, no pesticides or herbicides were found to be above the quantitation limits in sediment samples from SRS surface waters. Results from metal analyses for 2006 also were comparable to those of the previous five years (WSRC 2007a).

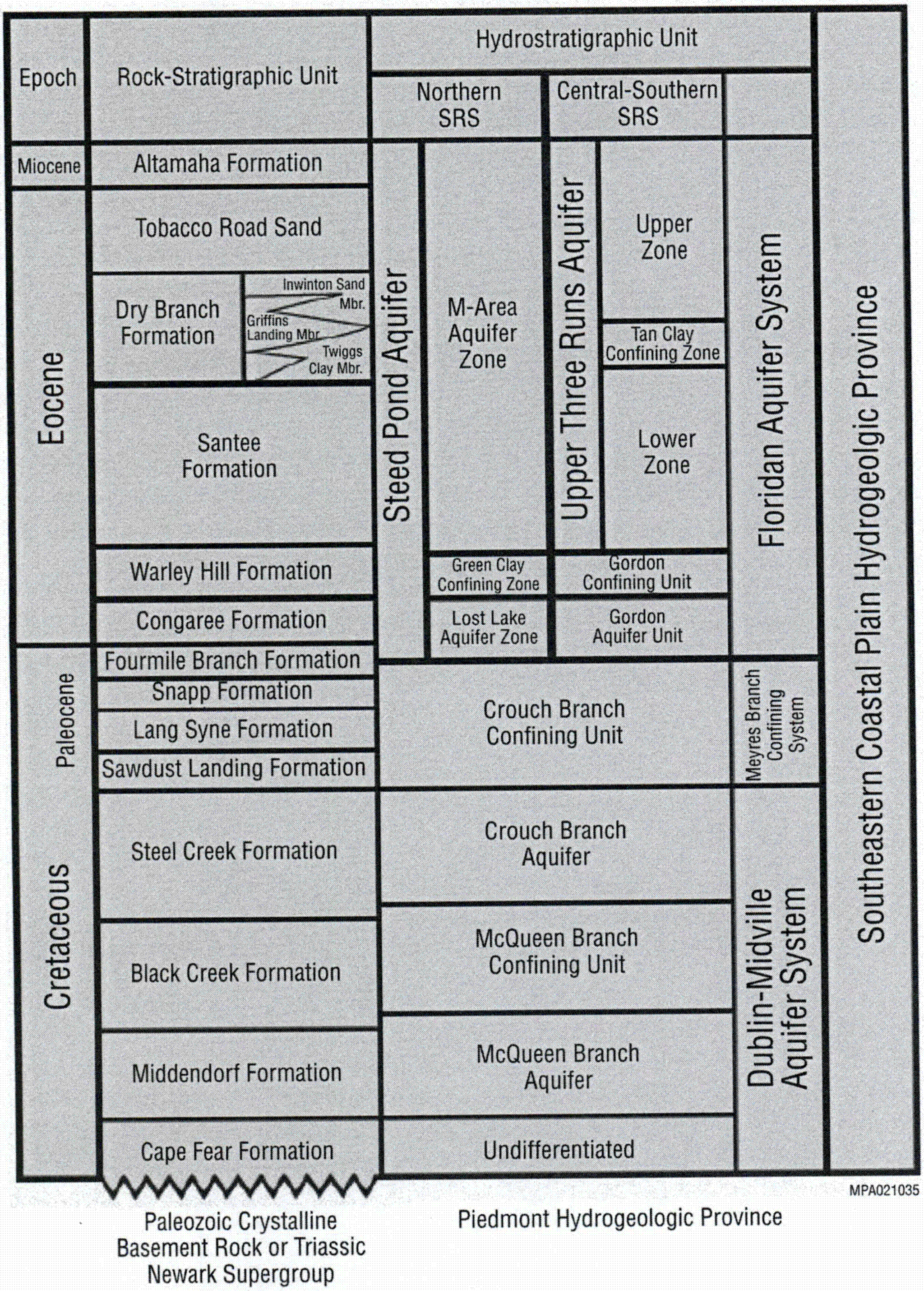
10.1.3.2 Groundwater

10.1.3.2.1 Unsaturated Zone. Groundwater at SRS occurs in both unsaturated (vadose) and saturated (phreatic) zones. In topographically high areas, the thickness of the unsaturated zone can reach 30 m (100 ft); in regions adjacent to streams, the thickness of the unsaturated zone can be small and varies from zero to tens of feet.

10.1.3.2.2 Aquifer Units. The sand and clay sediments of the Atlantic Coastal Plain are the principal source of groundwater for SRS. These sediments are collectively referred to as the Southeastern Coastal Plain hydrogeologic province. Beneath the GSA, there are two major aquifer systems — the overlying Floridan Aquifer System and the underlying Dublin-Midville Aquifer System — separated by the Meyers Branch Confining System. Figure 10.1.3-2 shows the hydrostratigraphic units within these systems at SRS and their relationship to the lithologic units described in Section 10.1.2.1, based on the nomenclature established by Aadland et al. (1995).

The following unit descriptions are taken from Aadland et al. (1995), Denham (1995), Harris et al. (1998), Flach and Harris (1999), Wyatt et al. (2000), and WSRC (2007a) and include information specific to two reference wells, P-27 and P-28, located near the GTCC reference location.

Floridan Aquifer System. The Floridan Aquifer System consists of a thick sequence of Paleocene to Miocene sands with minor amounts of gravel, clay, and limestone deposited in a marine environment. The aquifer system is divided into the overlying Upper Three Runs Aquifer and the underlying Gordon Aquifer, separated by the Gordon Confining Unit.



Source: Modified from Aadland et al. (1995) and Fallaw and Price (1995).

FIGURE 10.1.3-2 Hydrogeologic Units at SRS (Source: WSRC 2007a)

Upper Three Runs Aquifer Unit. The Upper Three Runs Aquifer Unit occurs between the water table and the Gordon Confining Unit (Figure 10.1.3-2). It includes all the strata above the Warley Hill Formation and the Blue Bluff Member of the Santee Limestone. The aquifer is defined by the hydrogeologic properties of the sediments penetrated in Reference Well P-27. In this well, the aquifer is about 40.2-m (132-ft) thick and consists mainly of quartz sand and clayey sand of the Tinker/Santee Formation; sand with interbedded tan to gray clay of the Dry Branch Formation; and sand, pebbly sand, and minor clay beds of the Tobacco Road Formation. Calcareous sand, clay, and limestone occur throughout the GSA.

The hydraulic head distribution within the Upper Three Runs Aquifer is controlled by the location and depth of incisement of streams that dissect the area. The incisement of streams divides the interstream areas of the water table aquifer into "groundwater islands" that behave independently, with their own unique recharge and discharge areas. Head distribution tends to follow the topography; higher heads occur in the interstream areas and decline in the direction of the bounding streams. Groundwater divides are present near the center of the interstream areas (Figure 10.1.3-3). Water table elevations range from 76 m (250 ft) MSL to the northwest of E-Area (Figure 10.1.3-4) and to about 30 m (100 ft) MSL near the Savannah River.

The porosity and permeability of the Upper Three Runs Aquifer are variable across SRS and are reduced by the presence of interstitial silt and clay and poorly sorted sediments.

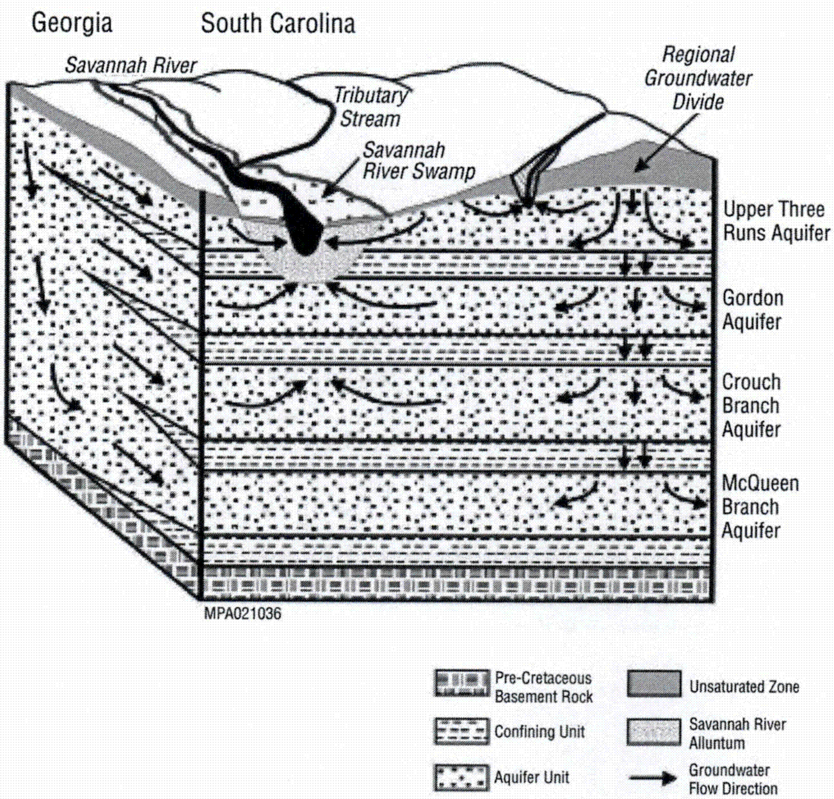


FIGURE 10.1.3-3 Groundwater Flow System at SRS (Source: WSRC 2007a)

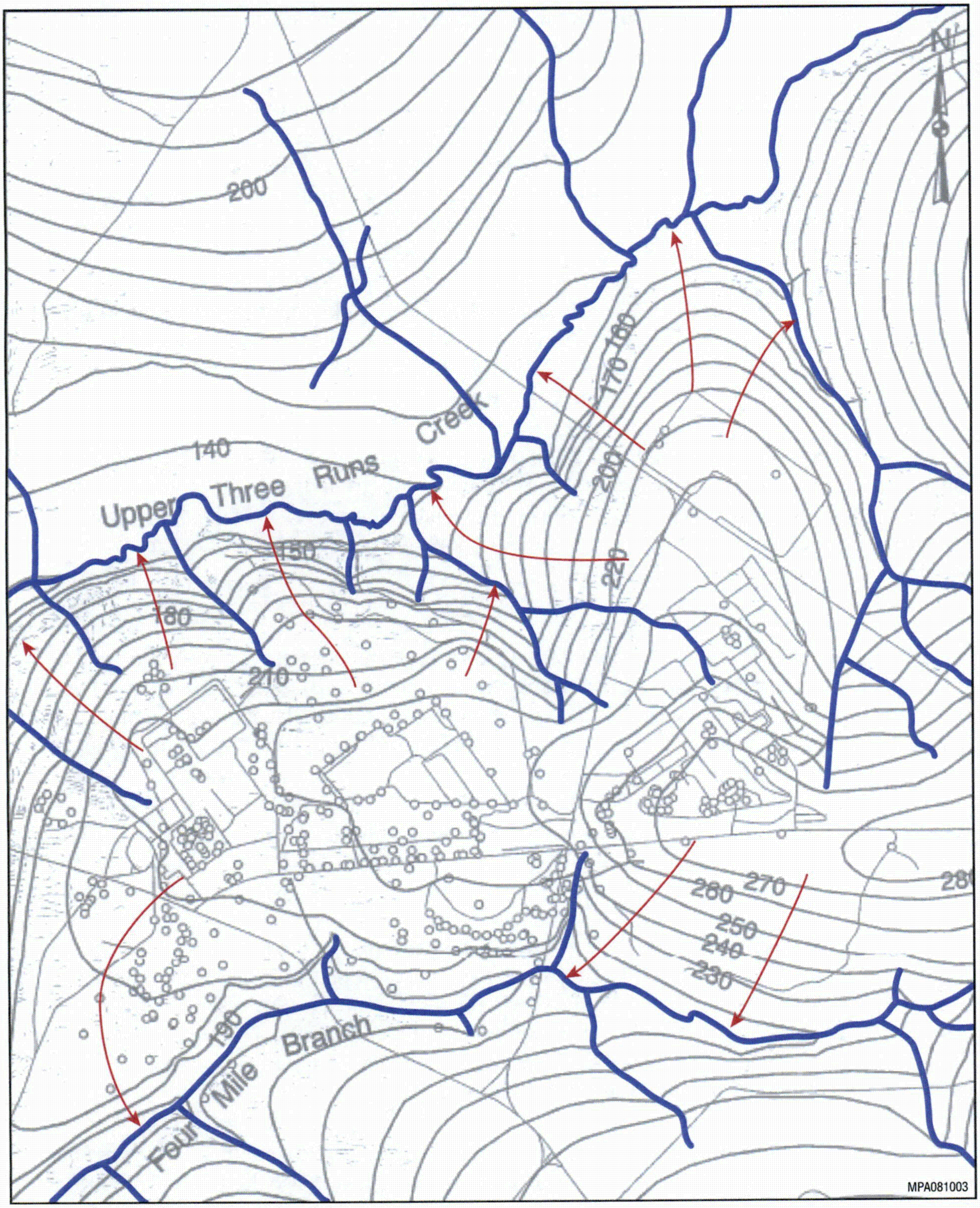


FIGURE 10.1.3-4 Water Table Elevation in the Vicinity of the General Separations Area at SRS (Source: modified from Hiergesell 1998)

High-permeability zones occur beneath the GSA and may locally increase the movement of groundwater.

The aquifer is divided into two aquifer zones — an upper aquifer zone and a lower aquifer zone — separated by the tan clay confining zone. The upper aquifer zone consists of sand and clayey sand with minor intercalated clay layers. The lower aquifer zone is predominantly fine-grained, well-sorted sand and clayey sand. The tan clay confining zone, which has an average thickness of about 3.4 m [11 ft] beneath the GSA, is leaky across most of the site and absent in places.

In the vicinity of the GTCC reference location, the thickness of the Upper and Lower Three Runs Aquifer is approximately 28 m (92 ft). This value represents the mean of the range of site-specific data (15.5 to 40.2 m [51 to 132 ft]), including thicknesses from the upper and lower aquifer zones and the tan clay confining zone (Cook et al. 2004).

Recharge of the water table in the upper aquifer zone occurs by infiltration from the land surface. The upper aquifer zone has a downward potential; groundwater leaking across the tan clay recharges the lower aquifer zone. Most of the water then moves laterally toward the bounding streams; the remainder flows vertically downward across the Gordon Confining Unit into the Gordon Aquifer.

Gordon Confining Unit. The Gordon Confining Unit consists of clayey sand and clay of the Warley Hill Formation and clayey, micritic limestone of the Blue Bluff Member of the Santee Limestone. The clay is stiff to hard and commonly fissile. Glauconite is a common constituent and imparts a distinctive greenish cast to the sediment; hence, the informal name of "green clay" was given to this unit (Hiergesell et al. 2000). Thicknesses measured by Aadland et al. (1995) in GSA Wells P-27 and P-28 were 2.1 m (7 ft) and 5.5 m (18 ft), respectively. Wyatt et al. (2000) notes that the confining unit thickens (up to 25 m [85 ft]) to the southeast.

Gordon Aquifer. The Gordon Aquifer is the basal unit of the Floridan Aquifer System. It consists of all the saturated strata that occur between the Gordon Confining Unit and the Crouch Branch Confining Unit. The strata are the sandy parts of the Snapp Formation and the overlying Fourmile and Congaree Formations. Thin clay layers and stringers occur in places but are discontinuous across SRS. Thicknesses measured by Aadland et al. (1995) in GSA Wells P-27 and P-28 were 24 m (77 ft) and 23 m (75 ft), respectively.

Recharge occurs via precipitation in outcrop areas and by leakage from overlying and underlying aquifers (upward potential occurs along streams that incise the Upper Three Runs Aquifer). Discharge areas are the swamps and marshes along Upper Three Runs Creek and the Savannah River. The aquifer is under confined to semiconfined conditions.

Meyers Branch Confining System. The Meyers Branch Confining System corresponds to clay and interbedded sand of the uppermost Steel Creek Formation and clay and laminated shale of the Sawdust Landing, Lang Syne, and Snapp Formations. The clay in these formations tends to be thick and relatively continuous. The Crouch Branch Confining Unit is the sole unit making up the Meyers Branch Confining System. It ranges in thickness from about 17 to 56 m (57 to 184 ft) and dips about 3.0 m/km (16 ft/mi) to the southeast. The unit has an upper and lower confining zone composed of clay and sandy clay beds, separated by a middle sand zone of clayey sand and sand.

Groundwater in the confining system has an upward potential mainly because of the deep incisement by the Savannah River and Upper Three Runs Creek into the overlying Gordon Aquifer (Figure 10.1.3-3).

Dublin-Midville Aquifer System. The Dublin-Midville Aquifer System includes all the Cretaceous sediments from the Middendorf Formation up to the sand beds in the lower part of the Steel Creek Formation. The aquifer system ranges in thickness from about 76 to 168 m (250 to 550 ft) and dips about 3.8 m/km (20 ft/mi) to the southeast. At GSA Well P-27, the aquifer system is about 154 m (505 ft) thick.

The Dublin-Midville Aquifer System is divided into the overlying Crouch Branch Aquifer and the underlying McQueen Branch Aquifer. These aquifers are separated by the McQueen Branch Confining Unit. The Crouch Branch Aquifer ranges in thickness from 30 to 107 m (100 to 350 ft) and thins significantly to the east. Sediments are mainly sand, muddy sand, and gravelly sand with thin, discontinuous layers of sandy clay and sandy mud. High-permeability zones occur near the Pen Branch Fault (Gellici et al. 1994).

The McQueen Branch Confining Unit consists of interbedded, silty, sandy clay, and sand beds of the middle portion of the Black Creek Formation. At GSA Well P-27, the confining unit is 17-m (55-ft) thick and occurs between elevations of −100 to −117 m (−329 to −384 ft) MSL. Clay makes up about 82% of the total thickness of the unit.

The McQueen Branch Aquifer Unit underlies the confining unit. At GSA Well P-27, the aquifer system is about 62-m (203-ft) thick and occurs between elevations of −117 to −180 m (−384 to −587 ft) MSL. It dips 4.7 m/km (25 ft/mi) to the southeast. Sand makes up about 90% of the total thickness of this unit.

10.1.3.2.2 Groundwater Flow. Upon entering the saturated zone at the water table, water moves predominantly in a horizontal direction toward local discharge zones along the headwaters and midsections of streams, while some of the water moves into the deeper aquifers. The water lost to successively deeper aquifers also migrates laterally within those units toward the more distant regional discharge zones. These are typically located along the major streams and rivers in the area, such as the Savannah River discharge zones. Groundwater flow within these units is extremely slow when compared with surface water flow. Groundwater velocities of

aquitards and aquifers are also different; they range from several inches to several feet per year in aquitards and from tens to hundreds of feet per year in aquifers (WSRC 2007a).

By using a simplified model for a number of pumping scenarios on SRS (i.e., advection only), Cherry (2006) demonstrated that transriver contaminant transport from recharge areas in the central SRS (D- and K-Areas) to receptors in Georgia could occur within 80 to 1,100 years. The shortest time of travel was for particles moving vertically from the base of the Upper Three Runs Aquifer and then laterally through the Gordon Aquifer beneath the Savannah River to discharge points in Georgia. The transit times do not include the time required for groundwater to migrate vertically downward across the uppermost aquifer and do not include other processes, such as the radioactive decay of tritium. Actual travel times could be up to several decades longer than what is reported. SRS continues to maintain and sample Georgia monitoring wells annually. In 2006, none of the tritium results exceeded 1,000 pCi/L; EPA's MCL for tritium is 20,000 pCi/L (WSRC 2007a).

Measured hydraulic head distributions in the upper aquifer (water table) zone of the Upper Three Runs Aquifer and the deeper Gordon Aquifer are shown in Figures 10.1.3-5 and 10.1.3-6, respectively; they are based on the work of Flach and Harris (1999).

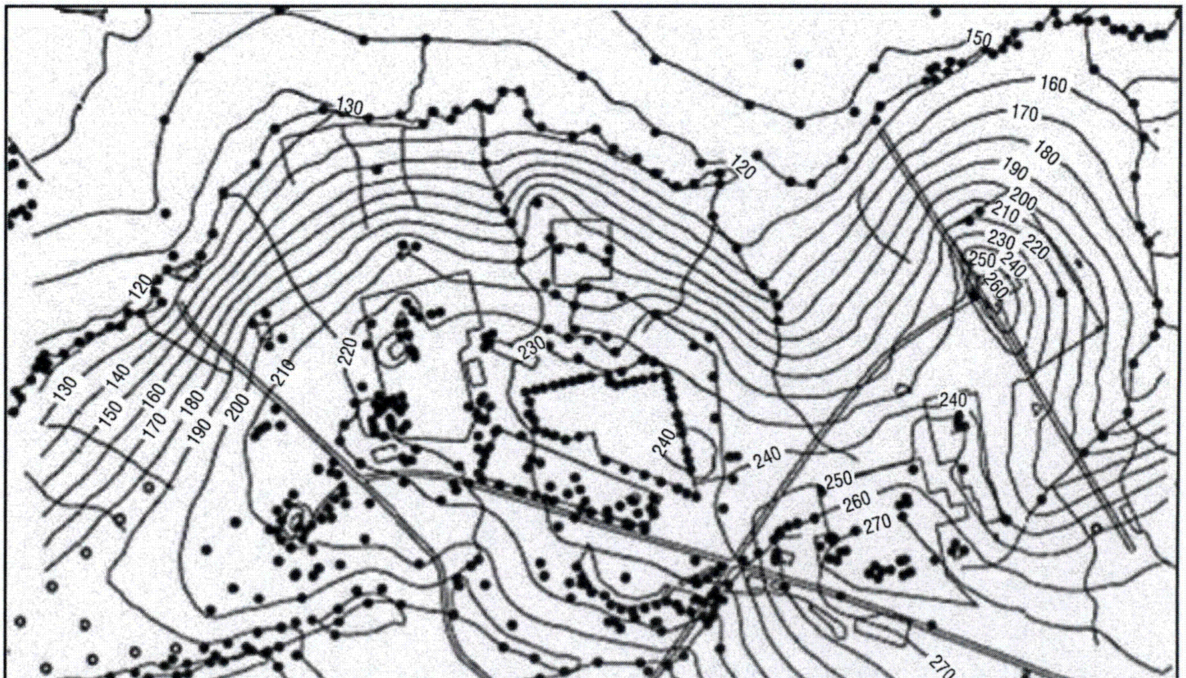


FIGURE 10.1.3-5 Measured Hydraulic Head (in feet) in the Upper Aquifer Zone of the Three Runs Aquifer (Source: Flach and Harris 1999)

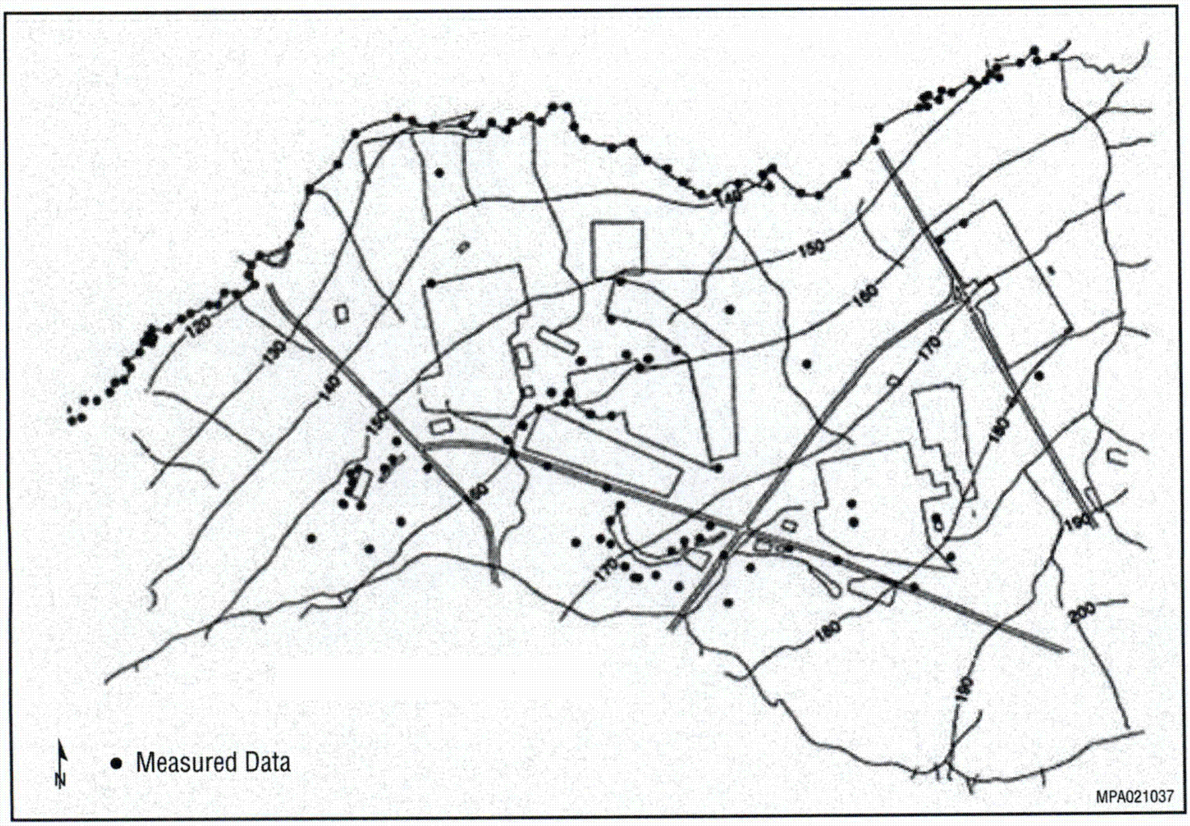


FIGURE 10.1.3-6 Measured Hydraulic Head (in feet) in the Gordon Aquifer (Source: Flach and Harris 1999)

Natural recharge for the water table aquifers (i.e., the Upper Three Runs Creek Aquifer and Gordon Aquifer) is primarily the result of infiltration of local rainfall at the land surface. Recharge areas for the deeper aquifers are updip of SRS, near the fall line, although some recharge areas are located at the northernmost edge of the site. Natural recharge over the GSA travels as deep as the Gordon Aquifer before discharging to Upper Three Runs Creek, Fourmile Branch, McQueen Branch, or a tributary of these. Artificial recharge occurs as a result of infiltration within man-made basins and ponds (as shown in Figure 10.1.3-7) and the various process, domestic, storm, and wastewater systems.

10.1.3.2.3 Groundwater Quality. The water in Coastal Plain sediments is generally of good quality and suitable for municipal and industrial use with only minimum treatment needed. The water is generally soft, slightly acidic (pH of 4.9 to 7.7), and low in dissolved and suspended solids. High dissolved iron concentrations occur in some aquifers. Groundwater is the only source of domestic water at SRS, and, where necessary, it is treated to raise the pH and remove the iron (WSRC 2007a).

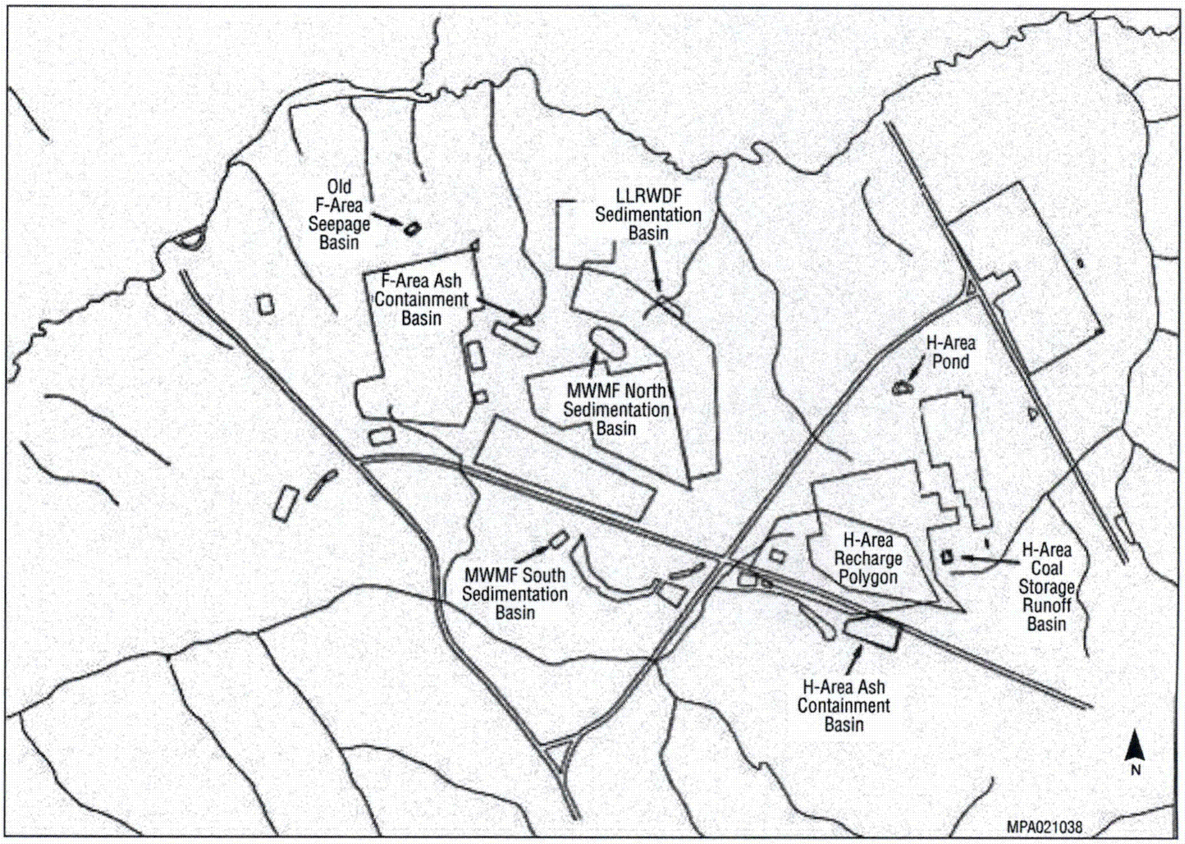


FIGURE 10.1.3-7 Sources of Artificial Groundwater Recharge within the General Separations Area (Source: Flach and Harris 1999)

Industrial solvents, metals, tritium, and other constituents used or generated at SRS have contaminated the shallow aquifers beneath 5% to 10% of SRS. Groundwater contamination has not been detected outside SRS boundaries. In the general separations and waste management areas (E-, F-, H-, S-, and Z-Areas), located in the center of the site, groundwater is contaminated with VOCs (mainly TCE and PCE), radionuclides, metals, and other constituents. These areas encompass many smaller and, in some cases, overlapping groundwater plumes. The shallow groundwater in the southern portion of the E-, F-, and H-Areas discharges to Four Mile Creek and its tributaries; in the northern portion of these areas, the shallow groundwater discharges to Upper Three Runs Creek and its tributaries. The S- and Z-Areas are located on the groundwater divide between Upper Three Runs Creek and its tributaries to the west (ATSDR 2007). Groundwater flow below the Z-Area is to the northeast toward McQueen Branch (DOE 2002). Table 10.1.3-2 lists maximum groundwater concentration exceedances for the Z-Area prior to 2002.

TABLE 10.1.3-2 Summary of Groundwater Exceedances for Z-Area Prior to 2002

Analyte	Concentration (μCi/mL)	Regulatory Limit (μCi/mL)
Gross alpha	9.77×10^{-8}	1.5×10^{-8}
Nonvolatile beta	5.26×10^{-8}	5.0×10^{-8}
Ra-226	7.78×10^{-9}	5.0×10^{-9}
Ra-228	8.09×10^{-9}	5.0×10^{-9}
Radium, total alpha emitting	5.55×10^{-8}	5.0×10^{-9}
Ruthenium-106	3.08×10^{-8}	3.0×10^{-8}

Source: DOE (2002)

10.1.3.3 Water Use

SRS is the largest self-supplied industrial consumer of groundwater in South Carolina; it used about 14.8 million L/d (3.9 million gal/d) in 2006. Drinking and process water are supplied by a network of approximately 40 wells across the site; 8 of these wells are dedicated to the domestic water system (there are treatment facilities at A-, D-, and K-Areas). The wells range in capacity from 760 to 5,700 L/min (200 to 1,500 gpm). Most groundwater production is from the deep Crouch Branch and McQueen Aquifers, with a few lower-capacity wells pumping from the shallower Gordon Aquifer and the lower zone of the Upper Three Runs Aquifer. Every major operating area at SRS has groundwater-producing wells. The amount of water pumped at SRS has decreased significantly since 1986, when the pump rate was as high as 41 million L/d (11 million gal/d), owing to the consolidation of the domestic water system completed in 1997 (DOE 2002; WSRC 2007a).

Regional domestic water supplies are primarily drawn from the shallow aquifers, including the Gordon Aquifer and the Upper Three Runs Aquifer. The municipal and industrial water supplies in Aiken County come from the deeper Crouch Branch and McQueen Aquifers. In Barnwell and Allendale Counties, municipal water supplies are drawn from the Gordon Aquifer and overlying units that thicken to the southeast. In 2005, Aiken County ranked as the 16th largest public water suppliers in South Carolina, with an average pump rate of 33.3 million L/d (8.8 million gal/d) and a per capita use of about 890 L/d (235 gal/d) (DOE 2002; Newcome 2005).

10.1.4 Human Health

Potential radiation exposures to the off-site general public residing in the vicinity of SRS would be a relatively small fraction of the dose limit of 100 mrem/yr set by DOE to protect the public from the operations of its facilities (DOE Order 458.1). The dose to the highest-exposed individual is estimated to be less than 0.4 mrem/yr. This dose is composed of the dose from

airborne releases of radionuclides (0.044 mrem/yr) (SRNS 2015) and 0.12 mrem contributed by exposures associated with waterborne releases of radionuclides. For the waterborne component, the maximum dose from ingestion of contaminated water is estimated to be 0.011 mrem; the maximum dose from ingestion of fish is 0.03 mrem; and the maximum dose from ingestion of vegetables, meat, and milk contaminated through irrigation is 0.074 mrem (SRNS 2015).

There are other unlikely situations under which the radiation dose incurred by the off-site general public could be higher. For example, an individual could hunt in the Savannah River Swamp on the privately owned Creek Plantation (which contains the highest concentrations of radioactive contamination in soil). If this individual hunted for 120 hours per year at that location, he or she could incur a radiation dose of 2.9 mrem/yr from direct radiation, soil ingestion, and inhalation of resuspended dust particles. If the hunter consumed a deer or hog harvested at that location, which is assumed to be sufficient to meet all of an individual's requirements for meat for a year, the hunter might incur another dose of 3.2 mrem/yr (SRNS 2015). This estimate was obtained by using the average measured Cs-137 concentration in the flesh of all deer and hogs harvested in 2014. Table 10.1.4-1 provides the radiation doses estimated for the different exposure scenarios; the footnotes provide more detailed explanations regarding the methods used to develop these dose estimates.

According to the 2014 worker radiation exposure data published in DOE (2015), a total of 1,584 workers received measurable doses. A collective total dose of 92.8 person-rem was recorded, resulting in an average individual dose of 58 mrem/yr. This collective total dose is based on 0.164 person-rem from internal exposure and 92.636 person-rem from external exposure. Among the workers who registered measurable doses, most received external radiation; only 8 workers had measurable internal doses. The collective internal dose was 0.164 person-rem; if distributed evenly among the 8 workers, the average individual dose was 0.02 mrem/yr (DOE 2015, Exhibit B-4). No radiation worker received a dose greater than the DOE administrative control level of 2 rem/yr in 2014. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

10.1.5 Ecology

A Natural Resources Management Plan (USFS 2005) was prepared for SRS. It covers all natural resource operations, including management, education, and research programs. For natural resource management purposes, SRS is divided into six management areas (USFS 2005). The GTCC LLRW and GTCC-like waste disposal facility would be located within the 15,558-ha (38,444-ac) Industrial Core Management Area. The primary objective in this area is to support facilities and site missions, with other important objectives being promoting conservation and restoration, providing research and educational opportunities, and generating the sale of forest products (USFS 2005). Natural resource management programs conducted within SRS include (1) habitat, population, invasive species, threatened species, and endangered species management; (2) forest products harvesting and silviculture management; (3) secondary roads, boundary, and trails management; (4) watershed management; (5) fire management; (6) DOE

1 **TABLE 10.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at SRS**

Receptor	Radiation Source	Exposure Pathway	Annual Dose to Individual (mrem/yr)	Annual Dose to Population (person-rem/yr)
On-site workers	Radioactive materials handled in operations	Inhalation and ingestion	0.02[a]	0.164[a]
	Radioactive materials handled in operations	Direct radiation	58[b]	92.636[b]
General public	Airborne release	Submersion; inhalation; ingestion of plant foods (contaminated through deposition), meat, and milk; direct radiation from deposition	0.044[c]	1.7[d]
	Surface water contamination	Ingestion of water	0.011[e]	
		Ingestion of fish	0.028[f]	
		Ingestion of leafy and nonleafy vegetables, meat, and milk (resulting from irrigation)	0.074[g]	
	Swamp soil	External radiation, soil ingestion, and dust inhalation (from hunting activities)	2.9[h]	
	Wildlife animals	Ingestion of deer/hog	3.2[i]	
Worker/public	Natural background radiation and man-made sources		620[j]	484,260[k]

[a] In 2014, among the workers monitored for internal exposure, 8 had measurable doses. A collective dose of 0.164 person-rem was recorded (DOE 2015).

[b] In 2014, 1,584 workers received measurable doses. The total collective dose for these workers was 92.8 person-rem (DOE 2015). After subtracting the collective dose of internal exposure from the total collective dose and distributing the remaining dose evenly among the workers, an average individual external dose of 58 mrem/yr was obtained.

[c] Radiation dose was calculated with MAXDOSE-SR, a computer code developed to demonstrate compliance with DOE environmental orders at SRS. Monitored airborne releases and estimated airborne releases of diffuse and fugitive materials were added, and the sums were used with meteorological data in the calculation (SRNS 2015).

[d] The collective dose was estimated with POPDOSE-SR by using the population data within 80 km (50 mi) around the SRS. The population size is about 781,060 (SRNS 2015). Like MAXDOSE-SR, POPDOSE-SR was developed to demonstrate compliance with DOE environmental orders at SRS.

Footnotes continue on next page.

TABLE 10.1.4-1 (Cont.)

e The dose corresponds to drinking water supplied by the public water treatment plant (BJSWA Chelsea, BJSWA Purrysburg, and Savannah I&D) (SRNS 2015). The potential dose was calculated by using the measured tritium concentration in surface water and calculated concentrations of other radionuclides on the basis of monitored liquid effluent discharge rates along with data on the river flow rate.

f The dose corresponds to eating 24 kg (53 lb) of bass caught exclusively from the mouth of Steel Creek (SRNS 2015). The potential dose resulted mainly from Cs-137, of which the concentration in the flesh of fish caught from the creek was measured and used in the dose calculation.

g The dose was calculated by assuming that contaminated Savannah River water was used for irrigation. A land area of 400 ha (1,000 ac) was assumed to be devoted to each of the major food types: vegetation, milk, and meat (SRNS 2015).

h The dose corresponded to hunting for 120 hours in Savannah River Swamp soil on the privately owned Creek Plantation that had the highest soil contamination measured in 2007 (SRNS 2015). The radiation dose was calculated by using the RESRAD computer code (Yu et al. 2000). The potential dose corresponding to fishing activities would be less; a dose of 0.28 mrem/yr was calculated, assuming an exposure duration of 250 hours per year on the South Carolina bank of the Savannah River near the mouth of Steel Creek (SRNS 2015).

i The dose was calculated on the basis of the average concentration of Cs-137 measured in all deer (1.29 pCi/g) or hogs (1.29 pCi/g) harvested from SRS during 2014. The deer or hogs were assumed to constitute the entire meat diet of the hunter (SRNS 2015).

j Average dose to a member of the U.S. population as estimated in Report No. 160 of the National Council on Radiation Protection and Measurements (NCRP 2009).

k Collective dose to the population of 781,058 within 80 km (50 mi) of the SRS from natural background radiation and man-made sources.

research set-aside areas; and (7) research (USFS 2005). In 1972, SRS was designated as the first NERP. Significant components of the NERP include the 30 DOE research set-aside areas that total 5,568 ha (14,005 ac). These areas are representative habitats that DOE has preserved for ecological research. They are protected from public intrusion and most site-related activities (DOE 2002).

SRS is in the transition area between the northern oak-hickory-pine forest and the southern mixed forest. It therefore contains species common to both forest types. About 90% of SRS contains upland pine, hardwood, and mixed (pines and hardwoods) forests and bottomland hardwood forests. The loblolly-longleaf-slash pine (*Pinus taeda, P. palustris, P. elliottii*) community covers about 65% of the site (DOE 1997). More than 1,300 plant species have been reported from SRS (Wike et al. 2006).

The GTCC reference location would be situated in an area dominated by stands of loblolly and slash pine. Understory species in the pine stands include black cherry (*Prunus serotina*), oaks (*Quercus* spp.), and persimmon (*Diospyros virginiana*). The site area also has small pockets of upland hardwood stands of white oak (*Quercus alba*), southern red oak (*Quercus falcata*), and hickory (*Carya* spp.). Ground cover at the site includes Japanese honeysuckle (*Lonicera japonica*), greenbrier (*Smilax* spp.), muscadine grape (*Vitis rotundifolia*), spotted wintergreen (*Chimaphila maculata*), and various grasses, legumes, and composites (DOE 1997).

More than 19,830 ha (49,000 ac) of wetlands occur on SRS (DOE 1997). They are widely distributed throughout the site, making up more than 20% of the site. Wetlands present include bottomland hardwood forests, cypress-tupelo swamp forests, floodplains, creeks, impoundments, and more than 300 Carolina bays (naturally occurring pond formations that cover about 445 ha [1,100 ac] of SRS) and wetland depressions. The Savannah River Swamp is a major wetland area that borders the Savannah River and covers about 3,800 ha (9,400 ac) of SRS (DOE 1997). No wetlands occur within the GTCC reference location.

Wildlife species that occur at SRS include 55 species of mammals, 255 species of birds, and 104 species of reptiles and amphibians (Wike et al. 2006). More than 150 species have been documented as using developed areas on SRS, with most species using landscaped areas away from buildings or other structures (Mayer and Wike 1997). White-tailed deer, feral hog, and American beaver populations are controlled through selective harvests, including public hunts for deer and boars. Concern has been expressed that the nine-banded armadillos may disturb and possibly breach waste unit closure caps, which could result in increased rainwater infiltration (Wike et al. 2006).

Bird species likely to occur within the pine-dominated forests of the GTCC reference location include Carolina wren (*Thryothorus ludovicianus*), wood thrush (*Hylocichla mustelina*), northern mockingbird (*Mimus polyglottos*), eastern towhee (*Pipilo erythrophthalmus*), pine warbler (*Dendroica pinus*), prairie warbler (*D. discolor*), red-eyed vireo (*Vireo olivaceus*), red-bellied woodpecker (*Melanerpes carolinus*), yellow-shafted flicker (*Colaptes auratus auratus*), sharp-shinned hawk (*Accipiter striatus*), eastern screech owl (*Megascops asio*), northern bobwhite (*Colinus virginianus*), and wild turkey (*Meleagris gallopavo*) (DOE 1997).

The Savannah River is the major aquatic habitat in the SRS vicinity. SRS also contains more than 50 man-made ponds, including two large water bodies: the 1,012-ha (2,500-ac) Par Pond and the 405-ha (1,000-ac) L Lake. These water bodies were created by damming Lower Three Runs Creek and Steel Creek, respectively. More than 80 species of fish have been identified on SRS, including commercial and recreational species (NRC 2005). The designated area for the GTCC reference location is within Upper Three Runs Creek watershed. Tinker, Mill, and McQueen Creeks are the bodies of water that are closest to the site (Figure 10.1.3-1). Minnow and sunfish species dominate the fish population in Upper Three Runs, while shiners, madtoms, and darters occur within the tributary streams (DOE 1997).

The federally and state-listed species identified from Aiken County are listed in Table 10.1.5-1. No designated critical habitat for any federally threatened or endangered species occurs within the area designated for the GTCC reference location (DOE 1997). The Eastern indigo snake (*Drymarchon couperi*, federally threatened), while not known to occur in Aiken County (SCDNR 2009), may be present in the county. Major natural resource management actions on SRS are aimed at habitat management for the red-cockaded woodpecker (*Picoides borealis*).

10.1.6 Socioeconomics

Socioeconomic data for SRS describes an ROI surrounding the site composed of four counties: Columbia County and Richmond County in Georgia and Aiken County and Barnwell County in South Carolina. More than 80% of SRS workers reside in these counties (NRC 2005).

10.1.6.1 Employment

In 2011, total employment in the ROI stood at 214,636 (U.S. Department of Labor 2012). Employment grew at an annual average rate of 0.4% between 2002 and 2011. The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing more than 70% of all employment (see Table 10.1.6-1). The manufacturing sector is also a significant employer in the ROI, with 12% of total ROI employment. Employment at SRS was 13,616 in 2000 (NRC 2005).

10.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 10.1.6-2). Over the period 2002–2011, the average rate in Barnwell County was 11.7%, with lower rates in Richmond County (7.4%), Aiken County (6.6%), and Columbia County (4.9%). The average rate in the ROI over this period was 6.7%, higher than the average rate for Georgia (6.5%) and lower than the average rate for South Carolina (7.8%). Unemployment rates for 2010 were similar to those for 2011; in Barnwell County, the unemployment rate fell from 17.6% to 15.6%, while in Richmond County, the rate declined from 10.8% to 10.6%. The average rate for the ROI fell from 9.4% to 9.2%; the rate for Georgia fell from 10.2% to 9.8%; and for South Carolina, that rate fell from 11.2% to 10.3%.

TABLE 10.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species in Aiken County, South Carolina

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Harperella (*Ptilimnium nodosum*)	E/-
Relict trillium (*Trillium reliquum*)	E/-
Smooth coneflower (*Echinacea laevigata*)	E/-
Fishes	
Shortnose sturgeon (*Acipenser brevirostrum*)	E/SE
Amphibians	
Gopher frog (*Rana capito*)	-/SE
Reptiles	
Eastern indigo snake (*Drymarchon couperi*)	T/-
Gopher tortoise (*Gopherus polyphemus*)	-/SE
Spotted turtle (*Clemmys guttata*)	-/ST
Birds	
Bald eagle (*Haliaeetus leucocephalus*)	-/SE
Red-cockaded woodpecker (*Picoides borealis*)	E/SE
Mammals	
Rafinesque's big-eared bat (*Plecotus rafinesquii*)	-/SE

[a] E (endangered): A species in danger of extinction throughout all or a significant portion of its range.

SE (state endangered): An animal species or subspecies whose prospects of survival or recruitment in South Carolina are in jeopardy.

ST (state threatened): An animal species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its South Carolina range.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

-: Not listed.

Source: SCDNR (2006)

10.1.6.3 Personal Income

Personal income in the ROI stood at almost $17 billion in 2009, growing at an annual average rate of growth of 1.4% over the period 2000–2009 (Table 10.1.6-3). ROI personal income per capita also rose, from $32,686 in 2000 to $34,364 in 2009. Per-capita incomes were higher in Columbia County ($41,943 in 2009) than elsewhere in the ROI.

TABLE 10.1.6-1 SRS: County and ROI Employment by Industry in 2009

	Georgia		South Carolina			
Sector	Columbia County	Richmond County	Aiken County	Barnwell County	ROI Total	% of ROI Total
Agriculture[a]	266	105	779	337	1,487	0.9
Mining	10	104	78	0	192	0.1
Construction	2,580	3,318	7,500	109	13,507	8.3
Manufacturing	3,184	7,712	6,964	1,616	19,476	11.9
Transportation and public utilities	335	2,253	3,871	112	6,571	4.0
Trade	6,986	12,610	7,806	913	28,315	17.3
Finance, insurance, and real estate	1,141	3,476	1,747	202	6,566	4.0
Services	12,472	52,296	20,813	1,848	87,429	53.5
Other	10	10	10	10	40	0.0
Total	26,951	81,899	49,445	5,027	163,322	

[a] USDA (2008).

Source: U.S. Bureau of the Census (2012a)

TABLE 10.1.6-2 SRS: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Columbia County, Georgia	4.9	7.0	7.1
Richmond County, Georgia	7.4	10.8	10.6
Aiken County, South Carolina	6.6	8.8	8.8
Barnwell County, South Carolina	11.7	17.6	15.6
ROI	6.7	9.4	9.2
Georgia	6.5	10.2	9.8
South Carolina	7.8	11.2	10.3

Source: U.S. Department of Labor (2012)

10.1.6.4 Population

The population of the ROI was 507,322 in 2010 (U.S. Bureau of the Census 2012b) and was expected to reach 519,503 by 2012 (Table 10.1.6-4). In 2010, 200,549 people were living in Richmond County (40% of the ROI total), and 160,099 people (32% of the total) resided in Aiken County. Over the period 2000–2010, the population in the ROI rate as a whole grew slightly, with an average growth rate of 1.1% and a higher-than-average growth rate in Columbia County (3.3%). The population in Georgia as a whole grew at a rate of 1.7% over the same period; in South Carolina, the population grew at a rate of 1.4%.

TABLE 10.1.6-3 SRS: County, ROI, and State Personal Income in Selected Years

Income	2000	2009	Average Annual Growth Rate (%), 2000–2009
Columbia County			
Total personal income (2011 $ in billions)	3.6	4.7	3.2
Personal income per capita (2011 $)	40,103	41,943	0.5
Richmond County			
Total personal income (2011 $ in billions)	5.9	6.0	0.2
Personal income per capita (2011 $)	29,292	29,907	0.2
Aiken County			
Total personal income (2011 $ in billions)	4.8	5.6	1.8
Personal income per capita (2011 $)	33,460	35,813	0.8
Barnwell County			
Total personal income (2011 $ in billions)	0.7	0.6	–1.5
Personal income per capita (2011 $)	28,667	25,904	–1.1
ROI total			
Total personal income (2011 $ in billions)	14.9	16.9	1.4
Personal income per capita (2011 $)	32,686	34,364	0.6
Georgia			
Total personal income (2011 $ in billions)	306.7	351.7	1.5
Personal income per capita (2011 $)	37,468	35,784	–0.5
South Carolina			
Total personal income (2011 $ in billions)	131.3	155.5	1.8
Personal income per capita (2011 $)	32,856	34,081	0.4

Source: DOC (2012)

10.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 1.5% over the period 2000–2010 (Table 10.1.6-5), with the total number of housing units being 217,690 in 2010. A total of 29,879 new units were added to the existing housing stock in the ROI between 2000 and 2010. There were 19,180 vacant housing units in the ROI in 2010, of which 7,515 were rental units that could be available to construction workers at the proposed facility.

TABLE 10.1.6-4 SRS: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 2000–2010	2012[a]
Georgia					
Columbia County	66,031	89,288	124,053	3.3	132,486
Richmond County	189,719	199,775	200,549	0.0	200,704
South Carolina					
Aiken County	120,940	142,552	160,099	1.1	163,860
Barnwell County	20,293	23,478	22,621	–0.4	22,453
ROI total	396,983	455,093	507,322	1.1	519,503
Georgia	6,478,216	8,186,453	9,687,653	1.7	10,019,433
South Carolina	3,486,703	4,012,012	4,625,364	1.4	4,758,857

[a] Argonne National Laboratory projections.

Sources: U.S. Bureau of the Census (2012b)

10.1.6.6 Fiscal Conditions

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures could come primarily from state and local sales tax revenues associated with employee spending during construction and operations and be used to support additional local community services currently provided by each jurisdiction. Table 10.1.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

10.1.6.7 Public Services

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could require increases in employment in order to provide public safety, fire protection, community, and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands could also be placed on local physician services. Table 10.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 10.1.6-8 provides data on teachers and level of service, and Table 10.1.6-9 covers physicians.

TABLE 10.1.6-5 SRS: County and ROI Housing Characteristics in Selected Years

Type of Housing	2000	2010
Columbia County		
Owner occupied	25,557	35,475
Rental	5,563	9,423
Vacant units	2,201	3,728
Total units	33,321	48,626
Richmond County		
Owner occupied	42,840	41,682
Rental	31,080	35,242
Vacant units	8,392	9,407
Total units	82,312	86,331
Aiken County		
Owner occupied	42,036	46,956
Rental	13,551	17,297
Vacant units	6,400	7,996
Total units	61,987	72,249
Barnwell County		
Owner occupied	6,810	6,280
Rental	2,211	2,657
Vacant units	1,170	1,547
Total units	10,191	10,484
ROI total		
Owner occupied	117,243	130,393
Rental	52,405	64,619
Vacant units	18,163	22,678
Total units	187,811	217,690

Source: U.S. Bureau of the Census (2012b)

TABLE 10.1.6-6 SRS: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Local Government	School District
Georgia		
Columbia County	52.7	102.8
Richmond County	122.0	190.4
South Carolina		
Aiken County	88.5	120.1
Barnwell County	20.9	23.9
ROI total	284.1	437.2
Georgia	42,324	13,945
South Carolina	17,299	6,003

[a] Argonne National Laboratory projections.

10.1.7 Environmental Justice

Figures 10.1.7-1 and 10.1.7-2 and Table 10.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around SRS from Census Bureau data for the year 2010 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in Georgia, 48.1% of the population is classified as minority, while 17.2% is classified as low income. However, the number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Georgia portion of the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Georgia portion of the 50-mi (80-km) area around the reference location as a whole.

Within the 50-mi (80-km) radius in South Carolina, 40.2% of the population is classified as minority, while 18.2% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority

TABLE 10.1.6-7 SRS: County, ROI, and State Public Service Employment in 2009

	Columbia County		Richmond County		Aiken County	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	217	1.9	645	3.2	128	1.8
Fire protection[b]	87	0.8	366	1.8	150	1.0

	Barnwell County		ROI		Georgia[c]	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	25	1.1	1,015	2.1	19,170	2.0
Fire protection	0	0.0	603	1.2	10,411	1.1

	South Carolina[c]	
Service	No.	Level of Service[a]
Police protection	8,799	2.0
Fire protection	4,680	1.1

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

[c] 2006 data.

Sources: U.S. Bureau of the Census (2008a,b, 2012b,c); FBI (2012); Fire Departments Network (2012)

individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the South Carolina portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the South Carolina portion of the 50-mi area (80-km) area around the reference location as a whole.

10.1.8 Land Use

SRS occupies about 80,130 ha (198,000 ac) within a generally rural area. Existing land use at SRS can be characterized under three main categories: (1) 73% is undeveloped/forest, (2) 22% is wetlands/water, and (3) 5% is developed (NRC 2005). The developed areas of the site contain production and support facilities, infrastructure, R&D, and waste management facilities to meet SRS's mission of serving the nation through safe, secure, cost-effective management of the U.S. nuclear stockpile, nuclear materials, and the environment. The remainder of SRS is

TABLE 10.1.6-8 SRS: County, ROI, and State Education Employment in 2011

Location	No. of Teachers	Level of Service[a]
Georgia		
Columbia County	1,470	15.9
Richmond County	2,240	14.5
South Carolina		
Aiken County	1,471	16.7
Barnwell County	276	15.7
ROI total	5,458	15.5
Georgia	115,918	14.4
South Carolina	46,980	15.4

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

TABLE 10.1.6-9 SRS: County, ROI, and State Medical Employment in 2010

Location	No. of Physicians	Level of Service[a]
Georgia		
Columbia County	803	6.5
Richmond County	1,315	6.6
South Carolina		
Aiken County	252	1.6
Barnwell County	14	0.6
ROI total	2,384	4.7
Georgia[b]	19,143	2.0
South Carolina[b]	9,100	2.1

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

primarily forest and wetlands (DOE 2002; USFS 2005). Most of the forested areas are pine forests managed by the USFS through an interagency agreement with DOE. In 1972, the entire site was designated as a NERP. A little more than 5,666 ha (14,000 ac) within 30 set-aside areas have been established on SRS to be used exclusively for nondestructive environmental research coordinated by the University of Georgia's Savannah River Ecology Laboratory (Davis and Janecek 1997). None of the set-aside areas are located near the GTCC reference location. Public use of the site is limited primarily to controlled hunts and science literacy programs (DOE 2002). Fishing also is allowed within the Crackerneck Wildlife Management Area.

The *Savannah River Future Use Plan* (DOE 1998, as cited in DOE 2002) states as policy that (1) SRS boundaries will remain unchanged and the land shall remain under ownership of the federal government, consistent with the site's designation as a NERP; (2) residential use of all SRS land is prohibited; and (3) the integral site model that incorporates three planning zones (industrial, industrial support, and restricted public uses) will be utilized. The land between Upper Three Runs Creek and Fourmile Branch (which includes the designated area for the GTCC reference location) is considered to be within the industrial land use category (DOE 2002).

For natural resources management purposes, SRS has been divided into six management areas on the basis of existing biological and physical conditions, operations capability, and suitability for mission objectives. These areas are the (1) 15,558-ha (38,444-ac) Industrial Core Management Area, (2) 35,289-ha (87,200-ac) Red-Cockaded Woodpecker Management Area, (3) 19,061-ha (47,100-ac) Supplemental Red-Cockaded Woodpecker Management Area,

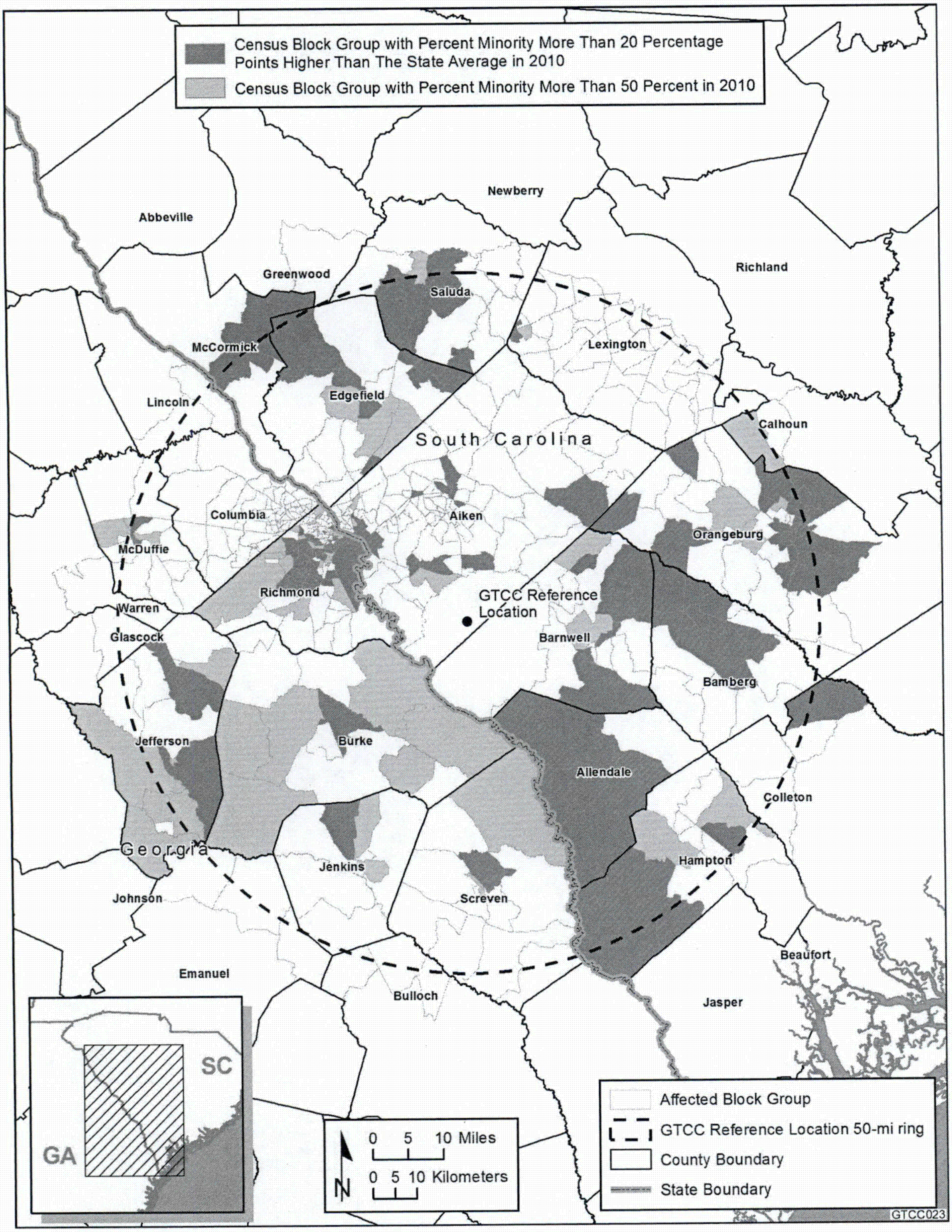


FIGURE 10.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at SRS (Source: U.S. Bureau of the Census 2012b)

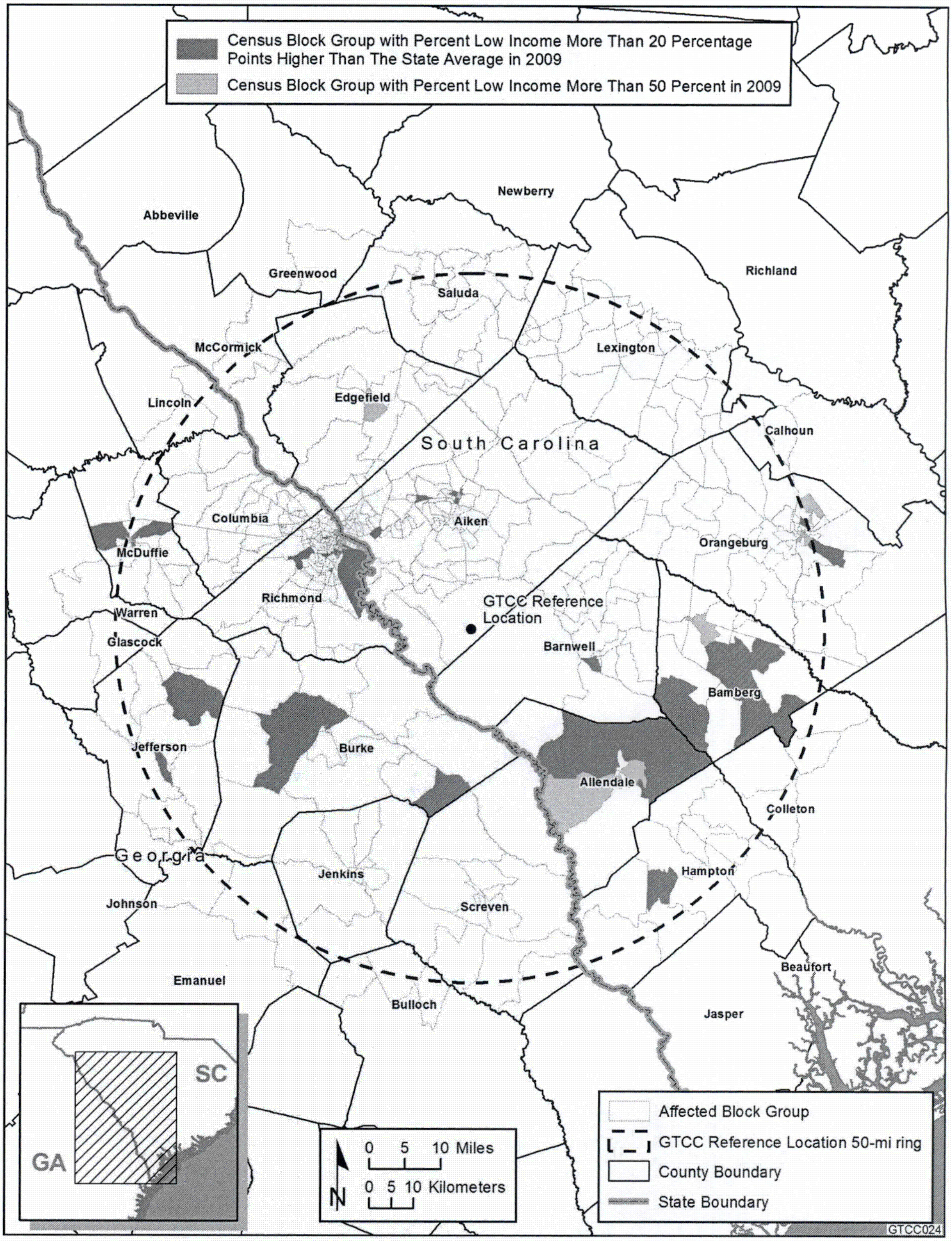


FIGURE 10.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at SRS (Source: U.S. Bureau of the Census 2012b)

TABLE 10.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of SRS

Population	Georgia Block Groups	South Carolina Block Groups
Total population	418,463	441,450
White, Non-Hispanic	217,376	263,936
Hispanic or Latino	16,705	19,810
Non-Hispanic or Latino minorities	184,382	157,704
One race	176,406	151,947
Black or African American	165,786	146,919
American Indian or Alaskan Native	1,116	1,609
Asian	8,323	2,891
Native Hawaiian or other Pacific Islander	593	131
Some other race	588	397
Two or more races	7,976	5,757
Total minority	201,087	177,514
Percent minority	48.1%	40.2%
Low-income	25,541	28,689
Percent low-income	17.2%	18.2%
State percent minority	44.1%	35.9%
State percent low-income	16.5%	17.1%

Source: U.S. Bureau of the Census (2012b)

(4) 4,532-ha (11,200-ac) Crackerneck Wildlife Management Area and Ecological Reserve, (5) 4,047-ha (10,000-ac) Savannah River Swamp Management Area, and (6) 1,781-ha (4,400-ac) Lower Three Runs Corridor Management Area (USFS 2005). The GTCC reference location is located within the Supplemental Red-Cockaded Woodpecker Management Area. The goal of protecting the red-cockaded woodpecker has a strong influence on natural resource decisions in this management area. Natural resource management in this area is designed to promote conservation and restoration, provide research and educational opportunities, and generate revenue from the sale of forest products (USFS 2005).

Forest and agricultural lands are the predominant lands bordering the SRS site (NRC 2005). Various industrial, manufacturing, medical, and farming operations occur near SRS (DOE 2005).

10.1.9 Transportation

Vehicular access to SRS is provided by South Carolina SRs 19, 64, and 125 and by US 278. SR 19 runs north from the site through New Ellenton toward Aiken, approximately 16 km (10 mi) from the northern border of SRS. SR 64 runs in an easterly direction from the site toward Barnwell. SR 125 runs through the site in a southeasterly direction between North Augusta and Allendale, passing through Beech Island and Jackson. US 278 also runs through the

site between North Augusta and Barnwell in a southeasterly direction. SR 781 connects US 278 with Williston to the northeast of the site. Annual traffic counts for local roads are provided in Table 10.1.9-1.

On-site, SRS has approximately 210 km (130 mi) of primary roads and 1,800 km (1,100 mi) of secondary roads to handle the site's transportation needs (DOE 2005). About 20,000 vehicle trips per day (employees driving to and from work as well as driving between site areas) occur on-site to support shipments of materials and obtain access to test wells, utility lines, research sites, and natural resource management activities (DOE 2005).

The railroad infrastructure at SRS consists of 53 km (33 mi) of track for deliveries of foreign fuel shipments, movement of material and equipment on-site, and deliveries of materials for construction projects (DOE 2005). Rail service to SRS is provided by CSX Transportation.

10.1.10 Cultural Resources

Research on the archaeological resources at SRS has been ongoing since 1973. The Savannah River Archaeological Research Program of the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, has been the primary group involved in the research. The Archaeological Research Program has been involved in identifying cultural resources at the site and developing management documents for maintaining them there. In 1999, the DOE Savannah River Operations Office, South Carolina SHPO, and ACHP developed a Programmatic Agreement to define how the site will consider the resources under its jurisdiction.

Cultural resources at SRS include archaeological sites, historic structures, and traditional cultural properties. Two main prehistoric periods have been defined for the region in which SRS is located. Each of these periods is divided into subsets of early, middle, and late. The older period is the Archaic, which spans the period between 8000 and 1000 B.C. The subsets of the Archaic are Early (8000 to 6000 B.C.), Middle (6000 to 3000 B.C.), and Late (3000 to 1000 B.C.). In general, the Archaic period is characterized by variable weather patterns, which, in turn, greatly affected the density and distribution of people across the continent. The next major period is the Woodland period (1000 B.C to A.D. 1100). The Woodland period is defined by major changes in subsistence strategies, such as the introduction of agriculture and the bow and arrow for more efficient hunting. During the Woodland period, populations continued to grow, and the first large-scale permanent settlements are found. It was during the Woodland Period that pottery was first widely produced. A final prehistoric period noted in the SRS region is the Mississippian period, which extends from A.D. 1100 to 1450.

European settlement of the area began during the colonial period between 1730 and 1780 and was focused along major waterways, such as the Savannah River and its tributaries. During the 1700s and early 1800s, this pattern of concentration of settlements along rivers persisted. Early farms used the richer soils along the rivers and focused on subsistence farming, with only surpluses being sold. During the 19th century, the situation began to change, with more cash crops, such as cotton, being grown. A relatively small amount of slave labor was employed.

TABLE 10.1.9-1 Traffic Counts in the Vicinity of SRS

Location		Average Daily Traffic Volume
US 278	West of SR 302	4,400
	Between SR 125 and SR 302	7,100
	North of the city of Barnwell	6,800
	Between SR 300 and US 301	3,900
SR 3	Near US 278	1,350
	Between SR 125 and US 301	900
SR 19	In the vicinity of US 78	7,200
	North of New Ellenton at Medwell Hill Rd.	13,200
SR 125	In Aiken County near Barnwell County line	3,200
	South of site boundary	2,100
	West of SR 3	1,650
SR 302	SR 125 to US 278	1,150
	North of US 278	5,400
	SR 118 to SR 19	22,400

Source: SCDOT (2007)

Settlement patterns did not begin changing until after the Civil War. The introduction of the railroads, which relieved the dependence on rivers for transportation, was a major factor in the land use changes (Cabak et al. 1996). After the Civil War, the tenant farming and share cropper systems began to take hold in the region. The Depression of the 1930s caused many people to leave the region for urban centers. After World War II, the increased mechanization of farming also resulted in people leaving the region as larger land holdings became common.

The Savannah River Project was established in 1950 by the AEC. The plant was operated by E.I. duPont de Nemours and Company, Inc., to produce basic materials for use in the manufacture of nuclear weapons. The plant site was constructed between 1951 and 1956. The site consisted of five nuclear reactors, two large chemical separation plants, a tritium processing facility, a heavy-water extraction plant, a uranium fuel processing facility, a fuel and target fabrication facility, and a waste management facility. The contract to operate and manage the operations switched to the Westinghouse Savannah River Company in 1989. The name of the facility changed from the Savannah River Project to Savannah River Site in 1989 as well.

There are more than 850 archaeological sites known on the SRS property (NRC 2005). Of these 850 sites, 67 have been determined potentially eligible for listing on the *National Register*. Prehistoric sites at SRS include village sites, base camps, limited activity sites, quarries, and workshops. Historic sites at SRS include farmsteads, tenant dwellings, mills, plantations, slave quarters, rice farm dikes, dams, cattle pens, ferry locations, churches, schools, towns, cemeteries, commercial buildings, and roads. Roughly 400 historic sites have been documented at SRS. No architectural surveys have been conducted at SRS. Numerous specialized facilities at SRS have the potential to be considered eligible for the NRHP.

A predictive model for the presence of cultural resources was developed during the 1970s for SRS. The model identifies three zones of archaeological sensitivity. Zone 1 has the highest potential for having numerous large archaeological sites. Zone 2 has moderate potential, and Zone 3 has the lowest potential (DOE 1997). The GTCC reference location is in Zone 3.

Traditional cultural properties are locations that are important to a group for maintaining its cultural identity. While these resources are most often related to Native Americans, they can be associated with other groups as well. The Apalachee, Cherokee, Chicksaw, Creek, Shawnee, Westo, and Yuchi all have traditional ties to the SRS property. The Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy have expressed interest in the SRS property with regard to it containing traditional religious locations. The Yuchi Tribal Organization and the National Council of Muskogee Creek expressed concern about plants that they use in traditional ceremonies that can be found on SRS land.

10.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 4 and 5 are discussed in Section 5.3.11.

10.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The potential impacts from the construction, operations, and post-closure of the trench (Alternative 4) and vault (Alternative 5) disposal methods are presented in this section for the resource areas evaluated. The affected environment for each resource area is described in Section 10.1. The GTCC reference location for SRS is shown in Figure 10.1-1.

10.2.1 Climate and Air Quality

This section discusses potential climate and air quality impacts from the construction and operations of each of the two disposal methods (trench and vault) at SRS. Noise impacts are presented in Section 5.3.1.

10.2.1.1 Construction

During the construction period, emissions of criteria pollutants (SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions. Accordingly, only the potential impacts of fugitive PM_{10} and $PM_{2.5}$ emissions from construction activities on ambient air quality are discussed.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities were estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. The estimates are provided in Table 10.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix C. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for all three counties encompassing SRS (Aiken, Allendale, and Barnwell Counties). Peak-year emissions for all criteria pollutants and VOCs would be higher for the vault method, which would consume more materials and resources for vault construction and disturb more areas than would the trench method. In terms of absolute value and contribution to the emissions total, the peak-year emissions of NO_x for the vault method would be the highest, about 0.18% of the three-county emissions total, while it is estimated that other criteria pollutants and VOCs would be less than 0.03% of the three-county emissions total.

The highest background concentration levels for $PM_{2.5}$ in the area approached the standards (around 97%) (see Table 10.1.1-3). Construction activities would occur at least 14 km (9 mi) from the site boundary and thus would not be likely to result in exceedances of the standards. However, construction activities would still be conducted in a manner that would minimize potential impacts of construction-related emissions on ambient air quality. Also, construction permits typically require fugitive dust control by means of established standard dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

Although O_3 levels in the area exceeded the standard (about 109%) (see Table 10.1.1-3), the three counties encompassing SRS are currently in attainment for O_3 (40 CFR 81.341). O_3 precursor emissions from the proposed GTCC LLRW and GTCC-like waste disposal facility for both methods would be relatively small (less than 0.18% and 0.02% of the three-county total NO_x and VOC emissions, respectively), and they would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased from approximately 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase, and most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of its sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site would be significant with respect to global warming. As shown in Table 10.2.1-1, the highest peak-year amount of CO_2 emissions

TABLE 10.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Trench and Vault Disposal Facilities at SRS

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)			
		Trench (%)[b]		Vault (%)[b]	
SO_2	20,700	0.90	(<0.01)	3.2	(0.02)
NO_x	17,336	8.1	(0.05)	31	(0.18)
CO	74,159	3.3	(<0.01)	11	(0.01)
VOCs	15,095	0.90	(0.01)	3.6	(0.02)
PM_{10}[c]	13,678	5.0	(0.04)	8.6	(0.06)
$PM_{2.5}$[c]	3,960	1.5	(0.04)	3.6	(0.09)
CO_2		670		2,300	
County[d]	4.25×10^6		(0.02)		(0.05)
South Carolina[e]	9.62×10^7		(0.0007)		(0.002)
U.S.[e]	6.54×10^9		(0.00001)		(0.00004)
World[e]	3.10×10^{10}		(0.000002)		(0.000007)

a Total emissions in 2002 for all three counties encompassing SRS (Aiken, Allendale, and Barnwell Counties). See Table 10.1.1-1 for criteria pollutants and VOCs.

b Numbers in parentheses are percent of total emissions.

c Estimates for GTCC construction include diesel particulate emissions.

d Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

e Annual CO_2 emissions in South Carolina, the United States, and worldwide in 2005.

Source: EIA (2008); EPA (2008b, 2009)

from construction would be less than 0.05%, 0.002% and 0.00004%, respectively, of 2005 county, state, and U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Emissions from construction would be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would extend over more years; thus, emissions in nonpeak years would be lower than peak-year emissions in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at SRS because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.341).

10.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 10.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix C. As shown in the table, annual emissions from operations are estimated to be higher than those from construction under the trench method; estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. Except for PM_{10} emissions, the emission estimates for the vault method are about the same for the construction and operations phases. Compared with annual emissions for counties encompassing SRS, annual NO_X emissions for both the trench and vault methods are about 0.15% of the total emissions, while emissions of other criteria pollutants and VOCs are about 0.02% of the total.

Concentration levels from operational activities, except O_3 and $PM_{2.5}$ concentrations, are expected to remain well below the standards. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. As discussed in the construction section, established fugitive dust control measures (primarily the watering of unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_X and VOCs would be comparable to those resulting from construction activities (about 0.16% and 0.02% of the three-county emission totals, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest emissions of CO_2 among the disposal methods would be comparable to the highest construction-related emissions; thus, their potential impacts on climate change would also be negligible.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

10.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the GTCC LLRW and GTCC-like waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered for both the trench and vault disposal methods and the vertical displacement of geologic materials for the trench disposal method (the borehole disposal method is not evaluated for SRS). The increased potential for soil erosion would be an indirect impact from land disturbance at the construction site. Indirect impacts

TABLE 10.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Trench and Vault Disposal Facilities at SRS

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr) Trench (%)[b]		Vault (%)[b]	
SO_2	20,700	3.3	(0.02)	3.3	(0.02)
NO_x	17,336	27	(0.16)	27	(0.16)
CO	74,159	15	(0.02)	15	(0.02)
VOCs	15,095	3.1	(0.02)	3.1	(0.02)
PM_{10}[c]	13,678	2.5	(0.02)	2.5	(0.02)
$PM_{2.5}$[c]	3,960	2.2	(0.06)	2.2	(0.06)
CO_2		3,200		3,300	
County[d]	4.25×10^6		(0.08)		(0.08)
South Carolina[e]	9.62×10^7		(0.003)		(0.003)
U.S.[e]	6.54×10^9		(0.00005)		(0.00005)
World[e]	3.10×10^{10}		(0.00001)		(0.00001)

a Total emissions in 2002 for all three counties encompassing SRS (Aiken, Allendale, and Barnwell Counties). See Table 10.1.1-1 for criteria pollutants and VOCs.

b Numbers in parentheses are percent of total emissions.

c Estimates for GTCC operations include diesel particulate emissions.

d Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

e Annual CO_2 emissions in South Carolina, the United States, and worldwide in 2005.

Source: EIA (2008); EPA (2008b, 2009)

would also result from the consumption of geologic materials (e.g., aggregate) for facility and other associated infrastructure construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

10.2.2.1 Construction

Impacts from disturbing the land surface area would be a function of the disposal method (trench or vault) implemented at the site, but the impacts from the two methods would be comparable. Geologic and soil material requirements are listed in Table 5.3.2-1. The vault facility would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, neither of the

disposal methods is expected to result in adverse impacts on geologic and soil resources at SRS, since these resources are in abundant supply in South Carolina.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. Mitigation measures would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic hazards. SRS is in a seismically active region, and small-magnitude earthquakes occur regularly. There is no volcanic risk for SRS. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

10.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operations phase as waste was delivered to the site for disposal over time. Mitigation measures would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials are expected to be low, since mineral and energy development does not occur within the boundary of SRS.

10.2.3 Water Resources

Direct and indirect impacts on water resources could result from water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) on water resources from construction and operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides from the waste inventory into groundwater could occur, depending on the post-closure performance of the trench and vault disposal facilities discussed in Section 10.2.4.2.

10.2.3.1 Construction

Of the two land disposal methods considered for SRS, construction of a vault facility would have the higher water requirement (Table 5.3.3-1). Water demands for construction at SRS would be met by using groundwater from on-site wells. (Wells at the SRS currently draw from the deep Crouch Branch and McQueen Aquifers, with a few lower-capacity wells pumping from the shallower Gordon Aquifer and the lower zone of the Upper Three Runs Aquifer.) No surface water would be used at the site during construction. As a result, no direct impacts on

surface water resources are expected. The potential for indirect surface water impacts on the Savannah River and its tributaries related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. The GTCC reference location is not within the 100-year floodplain of Fourmile Branch or Upper Three Run Creek.

Currently, SRS uses about 5.3 billion L (1.4 billion gal) of groundwater per year. Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at SRS by a maximum of about 0.06% (vault method) over the 20-year period that construction would occur. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at SRS. As a result, impacts due to groundwater withdrawals are expected to be negligible.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and then by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap in the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 25 ha [60 ac], depending on the disposal method) is small relative to the SRS land area.

Disposal of waste (including sanitary waste) generated during construction of the trench or vault disposal facility would have a negligible impact on the quality of water resources at SRS (see Sections 5.3.11 and 10.2.11). The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

10.2.3.2 Operations

The two land disposal methods considered for SRS would have the same water requirement (Table 5.3.3-1). Water demands for operations at SRS would be met by using groundwater from on-site wells. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at SRS by a maximum of about 0.1% (trench or vault method). Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at SRS. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of waste (including sanitary waste) generated during operations of the trench or vault disposal facility would have a negligible impact on the quality of water resources at SRS (see Sections 5.3.11 and 10.2.11). The potential for indirect impacts on surface water or groundwater related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

10.2.4 Human Health

Potential impacts on members of the general public and on involved workers from the construction and operations of the waste disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal methods, and these impacts are described in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the SRS GTCC reference location, since these impacts would be site dependent.

10.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a GTCC LLRW and GTCC-like waste disposal facility located at SRS are provided in Table 10.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that includes operational events and natural causes is analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, they represent maximum impacts expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but this assessment conservatively addresses what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose accounts for approximately 20% of the collective population dose shown in Table 10.2.4-1. External exposure is negligible in all cases. All exposures are dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 45 person-rem, would be from a hypothetical release from a SWB caused by a fire in the WHB (Accident 9). This dose is not expected to lead to any additional LCFs in the population. This dose would be released to the 263,000 people living to the west-northwest of the facility, resulting in an average dose of less than 0.0002 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

TABLE 10.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at SRS[a]

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.001	<0.00001	0.0001	<0.00001
2	Single SWB drops, lid failure in Waste Handing Building	0.002	<0.00001	0.0002	<0.00001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.002	<0.00001	0.0002	<0.00001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.003	<0.00001	0.0003	<0.00001
5	Single drum drops, lid failure outside	1	0.0006	0.095	0.00006
6	Single SWB drops, lid failure outside	2.2	0.001	0.22	0.0001
7	Three drums drop, puncture, lid failure outside	1.8	0.001	0.17	0.0001
8	Two SWB drops, puncture, lid failure outside	3.1	0.002	0.3	0.0002
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	45	0.03	4.3	0.003
10	Single RH waste canister breach	<0.001	<0.00001	<0.00001	<0.00001
11	Earthquake, affects 18 pallets, each with 4 CH drums	29	0.02	2.7	0.002
12	Tornado, missile hits one SWB, contents released	8.9	0.005	0.86	0.0005

a CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

b The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

c LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 10.2.4-1, the highest estimated dose to an individual, 4.3 rem, would result from Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the north of the accident location. As discussed above, the estimated dose of 4.3 rem would be accumulated over a 50-year period after intake and would not result in any symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual is approximately 0.3% on the basis of a total dose of 4.3 rem.

10.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site public after the closure of either the trench or vault disposal facility would be small. RESRAD-OFFSITE calculation results indicate that the potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposure would be caused mainly by inhalation of radon gas and its short-lived progeny.

At SRS, the climate is generally humid, with an average annual precipitation rate of about 1.2 m/yr (3.9 ft/yr). The natural water infiltration rate to deeper soils is estimated to be about 0.38 m/yr (1.2 ft/yr), which is much larger than the natural infiltration rate estimated for other sites considered in this EIS. As a result, more radionuclides would be carried to the groundwater table in a shorter period of time. It is estimated that within 10,000 years, the peak annual radiation dose associated with the use of contaminated groundwater from disposal of the entire GTCC LLRW and GTCC-like waste inventory at SRS by a hypothetical resident farmer living 100 m (330 ft) from the disposal facility would be 1,300 mrem/yr for the vault method and 1,700 mrem/yr for the trench method (see Table 10.2.4-2).

The peak annual doses are calculated to occur quite quickly for SRS because the water infiltration rate is so high there. The maximum annual dose would occur about 54 years (for the vault method) and 29 years (for the trench method) after failure of the engineered cover and barriers. These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The exposure pathways related to the use of contaminated groundwater considered in this analysis include the ingestion of contaminated groundwater, soil, plants, meat, and milk; external radiation; and the inhalation of radon gas and its short-lived progeny.

The peak annual doses and LCF risks given in Tables 10.2.4-2 and 10.2.4-3 to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) are those associated with the disposal of the entire GTCC LLRW and GTCC-like waste inventory by using the vault and trench disposal methods. In these tables, the annual doses and LCF risks contributed by each waste type

TABLE 10.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at SRS[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Vault disposal									1,300[b]
Group 1 stored	2.0	-	0.0	1.3	0.21	0.0	15	1,000	
Group 1 projected	30	0.0	-	0.039	0.53	0.0	4.2	3.6	
Group 2 projected	14	0.0	6.5	230	-	-	8.3	18	
Trench disposal									1,700[b]
Group 1 stored	2.2	-	0.0	1.0	0.24	0.0	31	1,100	
Group 1 projected	33	0.0	-	0.031	0.60	0.0	8.7	2.9	
Group 2 projected	16	0.0	13	460	-	-	17	31	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 1,300 mrem/yr for vaults and 1,700 mrem/yr for trenches were calculated to be about 54 years and 29 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. The primary contributors to the dose are GTCC LLRW Other Waste - RH and GTCC-like Other Waste - RH. The primary radionuclides causing this dose would be C-14, Tc-99, I-129, and Np-237.

TABLE 10.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at SRS[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Vault disposal									8E-04[b]
Group 1 stored	1E-06	-	0E+00	8E-07	1E-07	0E+00	9E-06	6E-04	
Group 1 projected	2E-05	0E+00	-	2E-08	3E-07	0E+00	3E-06	2E-06	
Group 2 projected	9E-06	0E+00	4E-06	1E-04	-	-	5E-06	1E-05	
Trench disposal									1E-03[b]
Group 1 stored	1E-06	-	0E+00	6E-07	1E-07	0E+00	2E-05	7E-04	
Group 1 projected	2E-05	0E+00	-	2E-08	4E-07	0E+00	5E-06	2E-06	
Group 2 projected	9E-06	0E+00	8E-06	3E-04	-	-	1E-05	2E-05	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 8E-04 for vaults and 1E-03 for trenches were calculated to be about 54 years and 29 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of peak LCF risks. The primary contributors to the LCF risk are GTCC LLRW Other Waste - RH and GTCC-like Other Waste - RH. The primary radionuclides causing this risk would be C-14, Tc-99, I-129, and Np-237.

(i.e., dose and risk for each waste type at the time or year when the peak dose or risk for the entire inventory is observed) to the peak dose and risk are also tabulated. The doses and LCF risks presented for the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own. Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 10.2.4-2 (although for some cases, these sums might be close to those presented in the site-specific chapters).

The radiation doses are largely associated with the GTCC-like Other Waste - RH; GTCC LLRW Other Waste - RH contributes about one-fourth of the peak annual dose. Activated metals also contribute a measurable amount to the peak dose and LCF risk for each disposal method.

It is calculated that within 100 years after a breach of the engineered barriers (including cover), C-14, Tc-99, I-129, and Np-237 would reach the groundwater table and a well installed by the hypothetical resident farmer. These radionuclides are highly soluble in water, a characteristic that could lead to potentially significant groundwater concentrations and subsequently high doses and LCF risks to this hypothetical receptor. Additional radionuclides that would contribute to the groundwater dose within 10,000 years include Ni-59, Ni-63, Ra-226, Am-241, and Th-230. Of these five radionuclides, it is calculated that Ni-59, Ni-63, and Ra-226 would reach the groundwater table and a well located 100 m (330 ft) downgradient of the disposal facility, while the radiation doses attributable to Am-241 and Th-230 would largely be those associated with the decay products of these two radionuclides (Np-237 and Ra-226).

Figure 10.2.4-1 is a temporal plot of the doses associated with the use of contaminated groundwater for the vault and trench disposal methods for a period extending to 10,000 years, and Figure 10.2.4-2 shows these results to 100,000 years. Note that the time scale in Figure 10.2.4-1 is logarithmic, while the time scale in Figure 10.2.4-2 is linear. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 10,000 years.

As shown in Figure 10.2.4-2, a number of additional actinides (mainly isotopes of uranium, plutonium, and thorium) would contribute to the groundwater dose thousands of years after closure and last over a very long duration. The peak annual doses from these radionuclides would occur about 30,000 years following closure of the trench disposal facility and about 40,000 years following closure of the vault facility. These maximum doses are lower than those that are predicted to occur within the first 10,000 years by the RESRAD-OFFSITE computer code.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower these estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

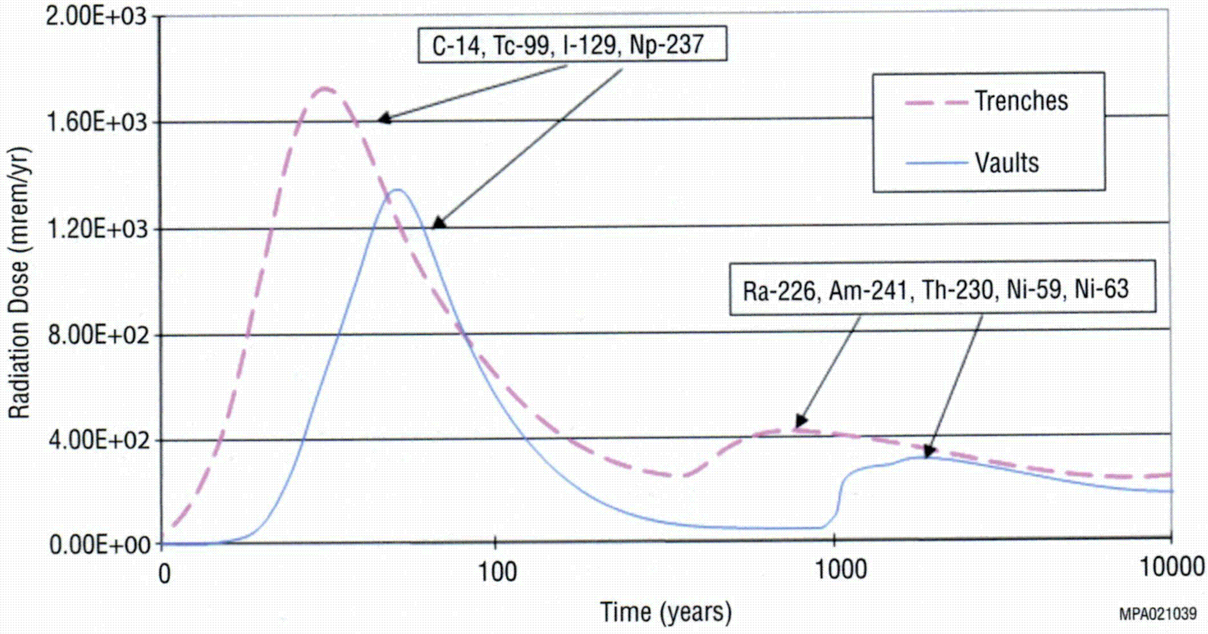


FIGURE 10.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Trench and Vault Disposal Methods at SRS

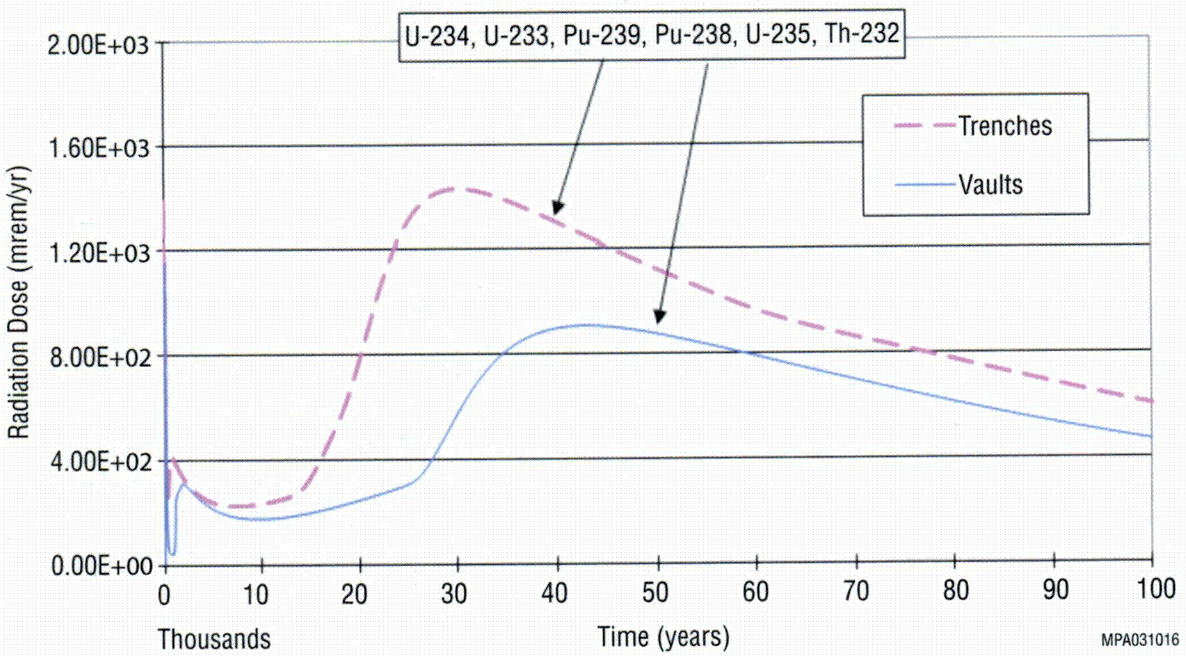


FIGURE 10.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Trench and Vault Disposal Methods at SRS

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because it is expected that the engineered systems (including the disposal facility cover) would last longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken in this analysis for the effectiveness of this stabilizing agent after 500 years. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, the doses would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure good cover is placed over the closed disposal units. Also, the doses would be lower if it was assumed that the grout would last for a longer time. Because of the long-lived nature of the radionuclides associated with some of the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce any releases to very low levels, thereby minimizing potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

10.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction, operations, and post-closure maintenance of the GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts of the facility on the ecological resources at SRS.

Initial loss of mostly upland pine and some hardwood forest habitats, followed by eventual establishment of low-growth vegetation on the disposal site, are not expected to create a long-term reduction in the regional ecological diversity. After closure of the GTCC LLRW and GTCC-like waste disposal facility, the cover would be planted with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds" (EPA 1995).

Clearing of forest habitat for the GTCC LLRW and GTCC-like waste disposal facility could result in a localized loss of wildlife species that occupy forest habitats. White-tailed deer could also lose a source of mast and potential cover against weather extremes. Species that might occur at the GTCC LLRW and GTCC-like waste disposal facility once vegetation became established include species that are currently found on urban areas near SRS. However, fencing (during the institutional control/monitored post-closure period) of the disposal site would lessen the potential for mid- to large-size mammals to enter the area. Some wildlife species might frequent the area between the forest and GTCC reference location (field/forest-edge habitat) (Peterson et al. 2005). Species more dependent on forested habitat or more sensitive to disturbance (e.g., wood warblers and vireos) would probably be permanently displaced from the GTCC reference location (DOE 1997).

Wildlife-vehicle collisions stemming from increased traffic associated with construction and operations of the GTCC LLRW and GTCC-like waste disposal facility would result in mortality of some wildlife species. Population-level impacts are not expected from these losses since these species are common throughout SRS (DOE 1997).

Because no aquatic or wetland habitats occur within the immediate vicinity of the GTCC reference location, direct impacts on aquatic and wetland biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soil. The GTCC LLRW and GTCC-like waste disposal facility retention pond is not expected to become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would amphibian, reptile, and mammal species that might enter the site.

Several of the federally and state-listed or special-status species listed in Table 10.1.5-1 could occur at the GTCC reference location. However, the area of forested habitat that would be disturbed by construction would be small relative to the overall area of such habitat on SRS. Also, mitigation measures would minimize the potential for adverse impacts on these species. Therefore, construction of the GTCC disposal facility would have a small to negligible impact on the populations of special-status species at SRS.

The GTCC reference location does not contain red-cockaded woodpecker nesting or foraging areas that are utilized by the birds; however, it does contain unoccupied habitat approaching suitable age that could be utilized by the species (DOE 1997). Forest removal during construction of the facility would eliminate only about 0.1% of the Supplemental Red-

Cockaded Woodpecker Management Area at SRS. This small reduction is not expected to have an effect on the population of the red-cockaded woodpecker at SRS (USFS 2005).

No other threatened or endangered species occur on the GTCC reference location. The site could establish a vegetative cover that could provide habitat suitable for the smooth coneflower (*Echinacea laevigata*) (i.e., abundant sunlight with little competition in the herbaceous layer). Habitats at SRS that provide suitable habitat for that species include open woods, cedar barrens, roadsides, clearcuts, and transmission line ROWs (DOE 1997). DOE would continue to review the site during construction and operations to ensure that no adverse impacts on listed species were occurring.

Among the goals of the waste management mission at DOE sites is to maintain disposal facilities in a manner that protects the environment and complies with regulations (DOE 2002). Therefore, impacts associated with the GTCC LLRW and GTCC-like waste disposal facility that could affect ecological resources would be minimized and mitigated.

10.2.6 Socioeconomics

10.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at SRS would be relatively small for both the trench and vault disposal methods. Construction activities would create direct employment of 62 people (trench method) to 145 people (vault method) in the peak construction year and an additional 64 indirect jobs (trench method) to 168 indirect jobs (vault method) in the ROI (Table 10.2.6-1). Construction activities would constitute less than 1% of the total ROI employment in the peak year. A GTCC LLRW and GTCC-like waste disposal facility would produce between $4.8 million in income (trench method) and $12.7 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 27 people (trench) and 64 people (vault method) would in-migrate to the ROI (Table 10.2.6-1), as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require less than 1% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

10.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be relatively small for both the trench and vault disposal methods.

TABLE 10.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for SRS[a]

Impact Category	Trench Construction	Trench Operations	Vault Construction	Vault Operations
Employment (number of jobs)				
Direct	62	48	145	51
Indirect	64	43	168	45
Total	126	91	313	96
Income ($ in millions)				
Direct	2.3	3.2	6.2	3.4
Indirect	2.5	1.6	6.5	1.6
Total	4.8	4.8	12.7	5.0
Population (number of new residents)	27	2	64	2
Housing (number of units required)	14	1	32	1
Public finances (% impact on expenditures)				
Cities and counties[b]	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1
Public service employment (number of new employees)				
Local government employees[d]	0	0	1	0
Teachers	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Moderate	Small

a Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

b Includes impacts that would occur in the cities of Aiken, Jackson, New Ellenton, North Augusta, Wagener, Barnwell, Blackville, Williston, Grovetown, Harlem, Augusta, Blyth, and Hephzibah; in Aiken and Barnwell Counties in South Carolina; and in Colombia and Richmond Counties in Georgia.

c Includes impacts that would occur in Aiken County, Barnwell Additional Voluntary Contribution, Barnwell #19, Barnwell #29, Barnwell #45, Columbia, and Richmond County School Districts.

d Includes police officers, paid firefighters, and general government employees.

Operational activities would create about 48 direct jobs (trench method) to 51 direct jobs (vault method) annually and an additional 43 indirect jobs (trench method) to 45 indirect jobs (vault method) in the ROI (Table 10.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $4.8 and $5.0 million in income annually during operations.

Two people would move to the area at the beginning of operations (Table 10.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small impact on levels of service in the local transportation network surrounding the site.

10.2.7 Environmental Justice

10.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the trench and vault methods. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from the construction of each facility on the minority and low-income populations would not be significant.

10.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during disposal operations and no adverse health impacts on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts from routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption, or well water use) to determine any additional potential health and environmental impacts.

10.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.03 LCF for the population groups residing to the west-northwest of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the west-northwest of the site because of the prevailing wind condition in this case. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

10.2.8 Land Use

Section 5.3.8 presents an overview of the potential impacts on land use that could result from the GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts from the GTCC LLRW and GTCC-like waste disposal facility on land use at SRS.

The GTCC reference location is situated in an area designated as a forest timber unit (DOE 1997). The site would be redesignated to accommodate the GTCC LLRW and GTCC-like waste disposal facility and be considered a developed site. Marketable timber on the site would be removed and sold. As mentioned in Section 10.2.5, forest removal during construction of the facility would eliminate about 0.1% of the Supplemental Red-Cockaded Woodpecker Management Area at SRS. Land use on areas surrounding SRS would not be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize the integrity of the facility, create a security risk, or create a worker or public safety risk.

10.2.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all waste at SRS was evaluated. As discussed in Section 5.3.9, transportation of all cargo is considered for both truck and rail modes of transport as separate options for the purposes of this EIS. Transportation impacts are expected to be the same for disposal in trenches or vaults because the same type of transportation packaging would be used regardless of the disposal method.

As discussed in Appendix C, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 10.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 10.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of a radioactive or hazardous chemical material (Section 10.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to SRS are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double the rates for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents depend on the amount of radioactive material in a shipment and the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

10.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 10.2.9-1 and 10.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments resulting in about 18 million km (11 million mi) of travel would cause no LCFs in the truck crew members

TABLE 10.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at SRS[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	39,000	0.41	0.023	0.067	0.072	0.16	0.00022	0.0002	<0.0001	0.0011
Past PWRs	143	331,000	3.4	0.18	0.56	0.61	1.3	0.0015	0.002	0.0008	0.0082
Operating BWRs	569	778,000	8.1	0.44	1.3	1.4	3.2	0.0035	0.005	0.002	0.023
Operating PWRs	1,720	2,500,000	26	1.3	4.2	4.6	10	0.01	0.02	0.006	0.069
Sealed sources - CH	209	283,000	0.12	0.063	0.19	0.2	0.45	0.039	<0.0001	0.0003	0.0078
Cesium irradiators - CH	240	325,000	0.14	0.073	0.21	0.23	0.52	0.0044	<0.0001	0.0003	0.0089
Other Waste - CH	5	11,200	0.0047	0.0018	0.0068	0.008	0.017	<0.0001	<0.0001	<0.0001	0.00027
Other Waste - RH	54	39,700	0.41	0.026	0.065	0.073	0.16	<0.0001	0.0002	<0.0001	0.0016
GTCC-like waste											
Activated metals - RH	38	107,000	1.1	0.039	0.17	0.2	0.4	<0.0001	0.0007	0.0002	0.003
Sealed sources - CH	1	1,350	0.00057	0.0003	0.00089	0.00097	0.0022	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	110,000	0.046	0.022	0.068	0.079	0.17	0.001	<0.0001	0.0001	0.0036
Other Waste - RH	1,160	1,570,000	16	0.84	2.5	2.9	6.3	0.0019	0.01	0.004	0.053

TABLE 10.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	293,000	3	0.15	0.48	0.54	1.2	0.0012	0.002	0.0007	0.0075
New PWRs	833	1,160,000	12	0.54	1.9	2.1	4.5	0.0043	0.007	0.003	0.032
Additional commercial waste	1,990	2,940,000	31	1.6	4.7	5.4	12	<0.0001	0.02	0.007	0.1
Other Waste - CH	139	205,000	0.086	0.043	0.13	0.15	0.32	0.0026	<0.0001	0.0002	0.0071
Other Waste - RH	3,790	5,170,000	53	2.8	8.3	9.5	21	0.00056	0.03	0.01	0.18
GTCC-like waste											
Other Waste - CH	44	44,800	0.019	0.01	0.029	0.032	0.072	0.00035	<0.0001	<0.0001	0.0015
Other Waste - RH	1,400	1,920,000	20	1	3.1	3.5	7.7	0.0016	0.01	0.005	0.066
Total Groups 1 and 2	12,600	17,800,000	170	9.2	28	32	69	0.072	0.1	0.04	0.57

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 10.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at SRS[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	16,600	0.14	0.07	0.0037	0.069	0.14	0.00054	<0.0001	<0.0001	0.0019
Past PWRs	37	92,700	0.79	0.38	0.021	0.38	0.78	0.0025	0.0005	0.0005	0.0074
Operating BWRs	154	234,000	2.4	1	0.05	1.2	2.3	0.0039	0.001	0.001	0.018
Operating PWRs	460	734,000	7.4	3	0.15	3.6	6.7	0.01	0.004	0.004	0.054
Sealed sources - CH	105	187,000	0.53	0.29	0.012	0.34	0.64	0.0021	0.0003	0.0004	0.0087
Cesium irradiators - CH	120	214,000	0.6	0.33	0.014	0.39	0.73	0.00024	0.0004	0.0004	0.01
Other Waste - CH	3	7,800	0.019	0.013	0.00058	0.013	0.026	<0.0001	<0.0001	<0.0001	0.00051
Other Waste - RH	27	29,000	0.35	0.11	0.0037	0.17	0.29	<0.0001	0.0002	0.0002	0.0032
GTCC-like waste											
Activated metals - RH	11	33,000	0.27	0.09	0.0046	0.12	0.21	<0.0001	0.0002	0.0001	0.003
Sealed sources - CH	1	1,780	0.005	0.0027	0.00011	0.0033	0.0061	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	65,500	0.18	0.11	0.0051	0.12	0.24	<0.0001	0.0001	0.0001	0.0046
Other Waste - RH	579	936,000	9.3	3.8	0.17	4.2	8.2	0.00019	0.006	0.005	0.066

TABLE 10.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	86,000	0.86	0.35	0.015	0.4	0.77	0.00059	0.0005	0.0005	0.006
New PWRs	227	341,000	3.5	1.2	0.056	1.7	3	0.0029	0.002	0.002	0.021
Additional commercial waste	498	883,000	8.5	3.7	0.17	3.8	7.7	<0.0001	0.005	0.005	0.067
Other Waste - CH	70	124,000	0.35	0.22	0.01	0.23	0.46	0.00029	0.0002	0.0003	0.0094
Other Waste - RH	1,900	3,160,000	31	13	0.57	14	28	<0.0001	0.02	0.02	0.25
GTCC-like waste											
Other Waste - CH	22	26,300	0.088	0.05	0.0022	0.058	0.11	<0.0001	<0.0001	<0.0001	0.0018
Other Waste - RH	702	1,150,000	11	4.8	0.22	5.1	10	0.00017	0.007	0.006	0.085
Total Groups 1 and 2	5,010	8,320,000	78	33	1.5	36	70	0.024	0.05	0.04	0.62

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

or members of the public. One fatality directly related to accidents is expected. No LCFs are estimated for the rail option, with approximately 5,010 railcar shipments resulting in about 8 million km (5 million mi) of travel. However, one fatality from accidents could occur.

10.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors included transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and/or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the SRS entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

10.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the most severe category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

10.2.10 Cultural Resources

The GTCC reference location at SRS is situated northeast of Zone Z along the Aiken and Barnwell County line. The location is in Archaeological Zone 3, which means it has a low potential for containing cultural resources. The project area was partially examined for the presence of archaeological material in 1986, and no materials were found at that time (Brooks et al. 1986). The remaining portion was examined in 1996 by the Savannah River Archaeological Research Program. The survey identified seven archaeological sites: one prehistoric lithic scatter and six late 19th and early 20th century homesteads. It is not known if any of these sites have been evaluated for listing on the NRHP. The seven archaeological sites found in the project area would require evaluation for listing on the NRHP. If any archaeological site was found to be eligible for listing and could not be avoided, then appropriate mitigation would be developed. Mitigation would be determined through consultation with the South Carolina SHPO and the appropriate Native American tribes. Before projects could begin, Native

American tribes would need to be contacted to determine if they had any concerns about the location chosen for the project. Native Americans have indicated that resources of concern to them are present on SRS.

The land disposal methods evaluated (trench and vault) have the potential to affect cultural resources as a result of the ground clearing needed for construction. Potential impacts from the trench method would be less than those from the vault method. The vault method also requires large amounts of soil to cover the waste. The location for soil extraction has not been chosen. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Depending on the location chosen for excavating the soil for the cover, the impacts could be greater from this component of the project than from construction of the disposal facility. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all project locations.

Minimal impacts are expected from operational and post-closure activities because no new ground-disturbing activities are anticipated; most impacts would occur during construction. If any of the eligible archaeological sites were avoided during construction, they would require consideration during any operational or post-closure activities. In the event that any post-construction activities would affect an eligible archaeological site, mitigation for the impacts would be developed in consultation with the SHPO and the appropriate Native American tribes. Tribal consultation might be necessary, depending on the status of resources of concern to the tribe near the project area.

10.2.11 Waste Management

The construction of either of the land disposal facilities (trench or vault) would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is likely that no impacts on waste management programs at SRS would result from the waste that might be generated from the construction and operation of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at SRS for the waste types generated.

10.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 and 4 are summarized by resource area as follows:

Air quality. The potential impacts from construction and operations at SRS on ambient air quality would be negligible. Under the trench method, peak-year emissions of all criteria pollutants, VOCs, and CO_2 would be lowest during construction but highest during operations. The highest emissions associated with the trench and vault methods would be about 0.18% of the

three-county emissions total for NO_X. O_3 levels in the three counties encompassing SRS are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small — less than 0.18% and 0.03% of NO_X and VOC emissions, respectively, and much lower than those for the regional air shed. CO_2 emissions during construction and operations would be negligible. All construction and operational activities would occur at least 14 km (9 mi) from the site boundary and would not contribute much to concentrations at the boundary or the nearest residence.

Noise. The highest composite noise during construction would be about 91 dBA at 15 m (50 ft) from the source. Noise levels at 610 m (2,000 ft) from the source would be below the EPA guidelines. This distance is well within the SRS boundary, and there are no residences within this distance. Noise generated during operations would be less than noise during construction.

Geology. No adverse impacts from the extraction and use of geologic and soil resources are expected, nor are any significant changes in surface topography or natural drainages expected. The potential for erosion would be reduced by best management practices.

Water resources. Construction of a vault facility would have a higher water requirement than the trench option. Water demands for construction at SRS would be met by using groundwater from on-site wells. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at SRS by a maximum of about 0.06% (vault method), and operations would increase it by a maximum of about 0.1% (trench or vault method). Since these increases would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. Water demands during the decommissioning phase at SRS would be smaller than those during construction, and there would be no water demands during the post-closure period. Groundwater could become contaminated with some radionuclides during the post-closure period; indirect impacts on surface water could occur as a result of aquifer discharges to springs and rivers.

Human health. The impacts on workers from operations would be mainly those from the radiation doses associated with handling the wastes. It is estimated that the annual radiation dose would be 4.6 person-rem/yr for the trench method and 5.2 person-rem/yr for the vault method. Neither of these doses is expected to result in any LCFs (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (2 rem/yr) for site operations. It is expected that the maximum dose to any individual workers over the entire project would not exceed a few rem.

The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling accidents. It is estimated that the annual number of lost workdays due to injuries and illnesses would be 2 for both the trench and vault methods, and no fatalities would result from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the

radioactive nature of the wastes but would simply be those expected to occur in any construction project of this size.

It is not expected that the general public would receive any measurable doses during waste disposal operations, given the solid nature of the wastes and the distance of waste handling activities from potential affected individuals. The highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire affecting an SWB) is estimated to be 4.3 rem and to not result in any LCFs. The total dose to the affected population from such an event is estimated to be 45 person-rem. The peak annual dose to a hypothetical nearby receptor (resident farmer) who resides 100 m (330 ft) from the edge of the disposal site in the first 10,000 years after closure of the disposal facility is estimated to be 1,700 mrem/yr under the trench method and 1,300 mrem/yr under the vault method. These doses would be mainly from GTCC LLRW Other Waste - RH and GTCC-like Other Waste - RH and would occur about 29 years (for the trench method) and 54 years (for the vault method) following failure of the engineered cover and barriers.

Ecological resources. The initial loss of upland pine and some hardwood forest habitats, followed by eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. Wildlife-vehicle collisions stemming from increased traffic associated with the facility would contribute to losses; however, population-level impacts are not expected. After closure, the cover would become vegetated with annual and perennial grasses and forbs. Clearing of forest habitat for construction of the GTCC LLRW and GTCC-like waste disposal facility could result in localized loss of wildlife species. White-tailed deer could also lose a source of mast and potential cover against weather extremes. Fences (during the institutional control/monitored post-closure period) at the site would lessen the potential for mid-sized to large mammals to enter the site. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and length of retention, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, and mammals) could become established. Several state-listed and special-status species occur within the project area. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall area of such habitat at SRS. Forest removal during construction would eliminate about 0.1% of the Supplemental Red-Cockaded Woodpecker Management Area; population-level impacts are not expected.

Socioeconomics. Impacts would be small. Construction would create direct employment for 145 people (vault method) in the peak construction year and 168 indirect jobs (vault method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce up to $12.7 million in income (vault method) in the peak construction year. Up to 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating up to 51 direct jobs (vault method) and up to 45 indirect jobs (vault method) in the ROI annually. The disposal facility would produce up to $5 million in income annually during operations.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. The GTCC reference location would be in an area designated as a forest timber unit. This area could be reclassified to accommodate the GTCC LLRW and GTCC-like waste disposal facility and be considered a developed site. Marketable timber on the site would have to be removed and could be sold.

Transportation. Shipment of all waste to SRS by truck would result in approximately 12,600 shipments involving a total distance of 18 million km (11 million mi). To ship all waste by rail would require 5,010 railcar shipments involving 8 million km (5 million mi) of travel. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from accidents could occur.

Cultural resources. There are seven archaeological sites within the GTCC reference location area at SRS; these sites would require evaluation for listing on the NRHP. Mitigation for eligible sites would be determined through consultation with the South Carolina SHPO and appropriate tribes. Of the two disposal methods considered, the trench method has the least potential to affect cultural resources (especially during the construction phase) because it has the smallest land requirement. Impacts at the source location for soil to cover a vault facility would also be considered.

Waste management. The waste that could be generated from the construction and operations of the land disposal methods is not expected to affect current waste management programs at SRS.

10.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at SRS, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 10.1).

10.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable actions at SRS are summarized in the following sections. These actions were identified primarily from a review of the EIS on the construction and operation of the proposed Mixed Oxide (MOX) Fuel Fabrication Facility at SRS (NRC 2005). The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at SRS.

10.4.1.1 Mixed Oxide Fuel Fabrication Facility

In 1999, DOE signed a contract with a consortium (now called Shaw AREVA MOX Services, LLC) to design, build, and operate a MOX Fuel Fabrication Facility in the F-Area at the center of SRS. The facility is a major component of a U.S. program to dispose of surplus weapons-usable plutonium. The 55,742-m^2 (600,000-ft^2) facility consists of two major sections. The first is a five-level section where weapons-usable material will be cleaned and purified via aqueous polishing; the second section is where fabrication will take place. Current material needs for the facility's construction include 129,974 m^3 (170,000 yd^3) of concrete, 31,751 metric tons or t (35,000 tons) of reinforcing steel, 914,400 linear m (3 million linear ft) of power and control cable, and 128 km (80 mi) of piping. Once operational, the facility will be capable of converting 3.5 t (3.9 tons) of weapons-grade plutonium into MOX fuel assemblies each year (NNSA 2008).

The NRC is responsible for licensing the facility. On March 30, 2005, it issued a construction authorization (NRC 2008). As of 2008, the $4.8 billion facility employed more than 1,000 workers, and it will employ at least 1,000 workers for the next two decades. Construction is expected to last into 2016 (Blanchard 2008).

10.4.1.2 Spent Nuclear Fuel Management

SRS, as an important component of the U.S. nonproliferation program, provides for the safe receipt and interim storage of irradiated SNF assemblies from domestic and foreign test and research reactors. The first off-site fuel was received and stored in February 1997. Since then, fuel has been stored in wet storage facilities. Disassembly basins are located in all five of SRS's reactor areas. Currently, only L-Basin still contains and receives fuel material. Thousands more assemblies are expected to be received and stored in L-Basin in the coming decade. The SNF stored and received at L-Basin may be transferred to H-Canyon for disposition off-site or to the INL Site for storage pending disposition (SRS 2007; DOE 2008).

10.4.1.3 Highly Enriched Uranium

In 1996, DOE published a ROD (61 FR 40619, August 1996) to blend HEU at SRS to 4% low-enriched uranium (LEU). Processing the uranium from weapons-usable HEU to LEU makes the material less attractive and supports U.S. nuclear nonproliferation goals. In its HEU

blend-down program, SRS blended down approximately 16.7 t (18.4 tons) of HEU into 260.5 t (287.2 tons) of LEU through the site's H-canyon chemical separation facility. This material was provided to the Tennessee Valley Authority (TVA) via an Interagency Agreement with DOE. The TVA processed the material into reactor fuel for use in two commercial reactors at the Browns Ferry Nuclear Plant, which produces commercial electrical power in Athens, Alabama. DOE and TVA intend to extend the Interagency Agreement and continue downblending weapons-usable uranium to a non-proliferable form for use in power reactors (DOE 1996, 2002; Savannah River Operations Office 2006).

10.4.1.4 Tritium Extraction Facility

The SRS's Tritium Extraction Facility (TEF) became fully operational in 2007. The facility, located in H-Area, extracts tritium from target-bearing rods irradiated in commercial light water reactors. Its purpose is to ensure a sustainable supply of tritium for the U.S. nuclear weapons stockpile (WSRC 2008).

The TEF consists of three major structures: the Remote Handling Building (RHB), Tritium Processing Building (TPB), and Tritium Support Building (TSB). The RHB is approximately 18-m (60-ft) high, 26-m (86-ft) wide, and 66-m (215-ft) long. It has a truck receiving area, cask decontamination area, tritium-producing burnable absorber rods, waste preparation area, furnaces, hot maintenance area, and glove boxes for extraction pumps and tanks. It also has an overhead crane and RH equipment. The TBP provides preliminary purification of the extracted gases. It is a single-story facility, approximately 38-m (125-ft) wide by 47-m (155-ft) long, and is built above ground. The TPB houses the main control room, crane control room, and miscellaneous rooms for gas analysis and radiation control activities. The TSB houses management and support staff; it also has change rooms, maintenance support areas, and a loading dock (WSRC 2008).

The facility was staffed by about 600 workers during construction and has an operations staff of about 100 permanent employees. Shipments of the irradiated rods are received at TEF. In addition, the NNSA is evaluating the optimum mode of operations for the TEF; it will be based on the most efficient use of SRS resources and the changing demands for new tritium to support the nuclear weapons stockpile (WSRC 2008).

10.4.1.5 Salt Waste Processing Facilities

Salt waste processing facilities at SRS use two removal processes: the actinide removal process (ARP) and the modular caustic side solvent extraction unit (MCU). Removing the salt waste, which fills approximately 90% of the tank space in the SRS tank farms, is a major step toward closing SRS's 47 high-level radioactive waste tanks that currently contain about 136 million L (36 million gal) of waste. ARP and MCU together make up the interim salt disposal processing system, which separates the high-activity fraction from the low-activity fraction from SRS's waste storage tanks to be safely dispositioned. The low-activity fraction is stabilized with cement in the Saltstone Production Facility and disposed of in on-site vaults.

The high-activity fraction is vitrified in the Defense Waste Processing Facility (DWPF; see Section 10.4.1.7). SRS first received radioactive salt waste solution for processing at the ARP and MCU facilities in April 2008, and it completed a successful test run as the facilities were brought on line in a deliberate, sequenced process to ensure safe operations. In combination with the Saltstone Production Facility and Saltstone Disposal Facility, this approach treats, decontaminates, and disposes of radioactive salt waste removed from SRS storage tanks (SRS 2008). The Salt Waste Processing Facility is currently being constructed at SRS to replace the interim treatment described above. The Salt Waste Processing Facility can treat a higher volume of waste with greater decontamination than can the interim process.

10.4.1.6 Tank Closure

DOE has considered alternatives for closing the 49 high-level radioactive waste tanks and associated equipment at SRS, such as evaporator systems, transfer pipelines, diversion boxes, and pump pits. DOE needs to close these tanks to reduce human health and safety risks at and near the waste tanks and to reduce the eventual introduction of contaminants into the environment. DOE has selected the preferred alternative identified in its waste tank closure EIS (DOE 2002), "Stabilize Tanks — Fill with Grout," to help develop and implement the process for closing the tanks and associated equipment at SRS. Following bulk waste removal (as described in Section 11.4.12.5 of DOE 2002), DOE cleans the tanks to meet the performance objectives contained in the general closure plan and the tank-specific closure module and then fills the tanks with grout (DOE 2002; WSRC 2007b).

10.4.1.7 Defense Waste Processing Facility

The DWPF converts the high-activity fraction of liquid waste from the storage tanks into a solid glass form suitable for long-term storage and disposal. It is the largest such plant in the world. The glassification process, called vitrification, immobilizes radioactivity in glass, thereby reducing the risks associated with the continued storage of liquid nuclear wastes at SRS, and it prepares the waste for ultimate disposal in a federal repository. About 136 million L (37 million gal) of liquid nuclear wastes (in sludge and salt forms) are now stored in 47 underground waste tanks at SRS; the majority of the high-activity portion of this waste will be vitrified at the DWPF (WSRC 2007c).

The DWPF vitrifies sludge from waste by mixing a sandlike borosilicate glass, called frit, with the waste and then heating it in a ceramic melter. The molten glass-waste mixture is poured into stainless-steel canisters to cool and harden. Each canister is 3-m (10-ft) tall and 0.6 m (2 ft) in diameter; a filled canister weighs about 2.3 t (5,000 lb). Canisters are welded shut and then sent to storage buildings at SRS, where they are lowered into an underground, reinforced, concrete vault. SRS has the capacity to safely store about 4,400 canisters, a number that represents about 16 to 20 years of canisters at current production rates (although more storage buildings could be built if necessary) (WSRC 2007c).

Construction of the DWPF began in late 1983, and operations began in March 1996. The DWPF is projected to produce more than 5,000 canisters by the year 2019 (WSRC 2007c).

10.4.2 Cumulative Impacts from the GTCC Proposed Action at SRS

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The summary of environmental impacts in Section 10.3 indicates that the potential impacts from the GTCC EIS proposed action (construction and operations of either a trench or vault disposal facility) would be small for all the resource areas evaluated. On the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 10.4.1) reported in NUREG 1767 (NRC 2005), the additional potential impacts from a GTCC proposed action would not result in the exceedance of any of the thresholds discussed in that report. For example, the annual levels of the criteria pollutants related to air quality reported in NUREG 1767 ranged from 32% (NO_2) to 52% (PM_{10}) of the SAAQS standards. It is estimated that the GTCC proposed action would result in no more than 0.16% of the total emissions in the surrounding counties. The highest NO_2 level reported for the surrounding counties of 0.004 ppm is 7.5% of the 0.053-ppm SAAQS standard, and the county level at 56 $\mu g/m^3$ is 37% of the 150-$\mu g/m^3$ PM_{10} SAAQS standard.

A potential long-term impact from a GTCC action would be the groundwater radionuclide concentrations that could result if the integrity of the facility did not remain intact in the distant future. The human health evaluation for the post-closure phase of the proposed action indicates that as much as 1,700 mrem/yr could be incurred by the hypothetical resident farmer assumed to be 100 m (330 ft) from the edge of the disposal facility in about 29 years (trench method) to 54 years (vault method) after failure of the cover and engineered barrier, which is assumed to begin 500 years after the closure of the disposal facility. The estimates are primarily attributable to the GTCC-like RH waste (primary radionuclide contributors include C-14, Tc-99, I-129, and Np-237). The analysis took credit for engineered barriers incorporated to prolong the protectiveness of the facility. The sensitivity analysis that was performed for this EIS indicates that the doses could be reduced more if the receptor was assumed to be farther away from the facility. An annual review of the performance assessment and composite analysis for the E-Area low-level waste facility indicated that the calculated maximum dose to a hypothetical future member of the public would be about 14 mrem/yr (Millings 2009; Swingle 2008). Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new trench or vault disposal facility at SRS would provide more detailed analyses of site-specific issues, including cumulative impacts.

10.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR SRS

A review of existing settlement agreements and consent orders for SRS did not identify any that would contain requirements that would be affected by Alternatives 4 and 5 for this EIS.

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11 WASTE ISOLATION PILOT PLANT VICINITY: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at the WIPP Vicinity reference locations. Alternatives 3 to 5 are described in Section 5.1. Environmental consequences common to the sites for which Alternatives 3 to 5 are evaluated (including the WIPP Vicinity locations) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to the WIPP Vicinity locations are discussed in Chapter 13 of this EIS.

11.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference locations at the WIPP Vicinity. One reference location is in Section 27 (inside the WIPP Land Withdrawal Boundary [WIPP LWB]), and the other is in Section 35 (on a parcel of land managed by the BLM just outside the WIPP LWB) (see Figure 11.1-1). Both the reference locations are located within T22S, R31E. These reference locations were selected primarily for evaluation purposes for this EIS. The actual location or locations would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at the WIPP Vicinity.

11.1.1 Climate, Air Quality, and Noise

Climate, air quality, and noise conditions at the WIPP Vicinity reference locations (within Sections 27 and 35) are similar to the conditions at the WIPP site described in Section 4.2.1 because of their proximity to each other, so the descriptions are not repeated here.

11.1.2 Geology and Soils

The WIPP Vicinity reference locations occupy two 2.6-km^2 (1-mi^2) or 260-ha (640-ac) parcels: Section 27, which is inside the WIPP LWB, and Section 35, which is outside and immediately adjacent to the southeast corner of the WIPP repository site. Given the close proximity of the WIPP Vicinity reference locations to the WIPP repository site, their regional geologic setting and stratigraphy at the reference locations can be inferred from the extensive data on the WIPP site that are summarized in Section 4.2.2. The text that follows summarizes the site stratigraphy on the basis of the work discussed in Powers (2009), with an emphasis on near-surface formations (above the Rustler Formation) in the vicinity of Sections 27 and 35.

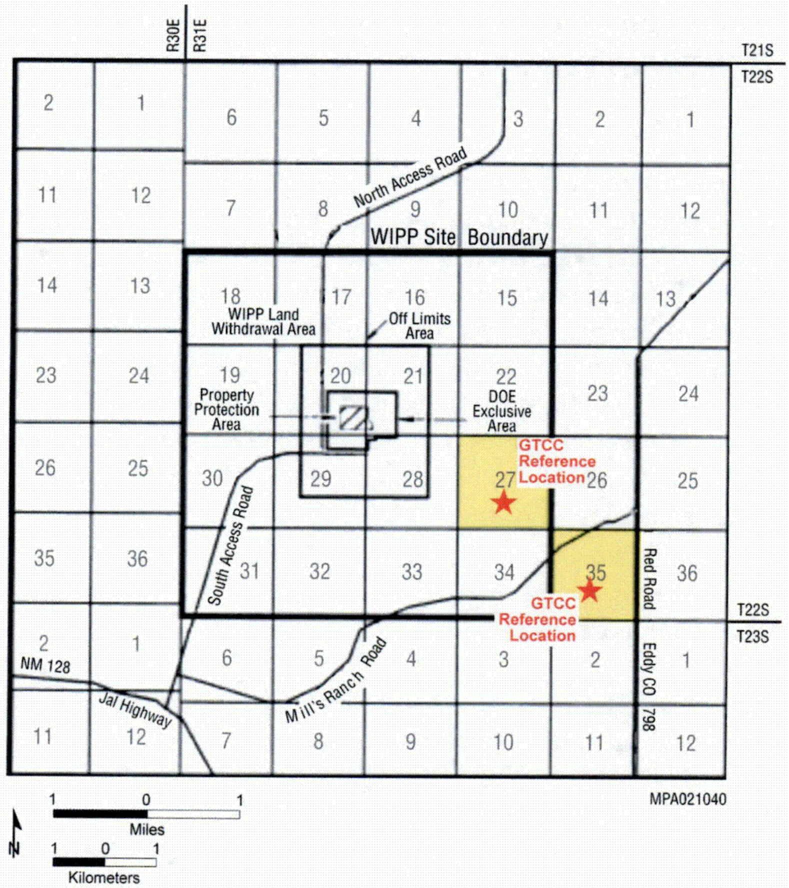

FIGURE 11.1-1 WIPP Vicinity GTCC Reference Locations

The topography across the WIPP Vicinity reference locations exhibits some broad valley forms, possibly indicating areas of concentrated surface runoff and integrated drainages during prolonged rainfall events. Sand dunes are present, but likely thinner and more uniform than local dune fields. Calcrete[1] exposures appear as heavily vegetated semicircular features on aerial photos of Section 35. These are thought to represent intradune areas that focus water drainage and enhance vegetation growth, causing degradation of the underlying calcrete and creating slight topographic depressions. These surface features, however, have no relationship to dissolution or subsidence of deeper evaporite units.

The WIPP Vicinity reference locations are situated on Quaternary age alluvium, playa lake deposits, and semi-stabilized and active dune sands. These deposits compose the majority of surface exposures and most of the shallow subsurface sediments in the WIPP Vicinity region. Just below these deposits is a fairly continuous mantle of caliche (called the Mescalero). The Mescalero caliche is a well-lithified alluvial deposit of chalky, finely crystalline limestone that is fairly continuous across the WIPP site and can be up to 1.8-m (6-ft) thick. It thickens and is more indurated to the east of the site near Sections 27 and 35. There is a caliche borrow pit

[1] Calcrete is a conglomerate of surficial gravel and sand that is cemented by carbonate material.

near the southeast corner of Section 35; deposits in the pit indicate the Mescalero is thick and indurated enough to be quarried. Overlying the Mescalero is the Berino soil, a thick, reddish, semiconsolidated sand containing little carbonate, ranging in thickness from centimeters (inches) to 0.3 to 0.6 m (1 to 2 ft).

The top of the Dewey Lake Formation is at least 15-m (50-ft) deep across both Sections 27 and 35, with depths of more than 30 m (100 ft) expected in Section 27. The overlying Santa Rosa Formation likely occurs within 11 m (35 ft) of the ground surface across both sections, with shallower depths (less than 3 m [10 ft]) expected along the eastern portion of Section 27 and possibly all of Section 35. The Gatuña Formation thins to the east and may be absent along much of the eastern portion of both sections.

No natural factors within the WIPP Vicinity reference locations that would affect the engineering aspects of slope stability or subsidence have been reported. The presence of the Mescalero caliche is generally considered to be an indicator of surface stability (DOE 1997).

Liquefaction of saturated sediments is a potential hazard during or immediately following large earthquakes. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake, peak ground velocity, susceptibility of soils to liquefaction, and depth to groundwater. No surface displacement or faulting younger than early Permian has been reported at WIPP, indicating that tectonic movement since then, if any, has not been noteworthy. No mapped Quaternary (last 1.9 million years) or Holocene (last 10,000 years) faults exist closer to the site than the western escarpment of the Guadalupe Mountains, about 100 km (60 mi) to the west-southwest (DOE 1997). The strongest earthquake on record within 290 km (180 mi) of the site was the Valentine, Texas, earthquake of August 16, 1931 (DOE 1997), with an estimated Richter magnitude of 6.4. From 1974 to 2006, recorded earthquakes within a 300-km (184-mi) radius of WIPP ranged from magnitude 2.3 to 5.7 (USGS 2010).

11.1.3 Water Resources

Given the close proximity of the WIPP Vicinity reference locations to the WIPP repository site, the hydrological conditions at the reference locations can be inferred from the extensive amount of information available on the WIPP site, which is summarized in Section 4.2.3. The discussions that are most relevant to the WIPP Vicinity reference locations are those on surface water (Section 4.2.3.1) and those on the aquifer units above the Salado Formation (Section 4.2.3.2.1).

11.1.4 Human Health

The two WIPP Vicinity GTCC reference locations are Section 27 (within the WIPP LWB) and Section 35 (adjacent to the WIPP LWB). The following discussion is based on operations at WIPP and assumed to be applicable to both reference locations.

Radiation exposures of the off-site general public could occur as a result of three pathways: (1) air transport, (2) water ingestion, and (3) ingestion of game animals. Of these three pathways, only the air pathway is considered to be credible. Elevated concentrations of radionuclides have not been detected in groundwater or game animals in the site vicinity. In 2014, the whole body dose to the highest-exposed individual from airborne releases was estimated to be 5.86×10^{-3} mrem/yr (DOE 2015). This individual was assumed to reside 7.5 km (4.6 mi) west–northwest of the site. A hypothetical individual residing at the site fence line in the northwest sector was estimated to receive a whole body dose of 2.38×10^{-1} mrem/yr. These values are well below the dose limit of 100 mrem/yr from all exposure pathways set by DOE to protect the general public from the operation of its facilities.

In 2010, the collective dose to the population living within 80 km (50 mi) of WIPP was calculated to be 7.99×10^{-3} person-rem/yr (DOE 2015). If this dose was distributed uniformly to all individuals living within 80 km (50 mi) of the site – a total of 92,599 people (DOE 2015) – the average dose to each person would be about 8.63×10^{-5} mrem/yr. This is an extremely small fraction of the average dose of 620 mrem/yr to members of the general public from exposure to natural background and man-made sources of radiation (NCRP 2009).

11.1.5 Ecology

The description of ecological resources at the WIPP Vicinity reference locations is similar to the description of these resources at the WIPP site, which is provided in Section 4.2.5.

11.1.6 Socioeconomics

Socioeconomic data for the WIPP Vicinity cover the ROI surrounding the reference locations, which is composed of two counties in New Mexico: Eddy County and Lea County. The majority of workers associated with the waste disposal facility at either of the WIPP Vicinity reference locations would reside in these counties (DOE 1997). The socioeconomic data are the same as the data presented in Section 4.2.6 for the WIPP repository.

11.1.7 Environmental Justice

Because of the proximity of the WIPP Vicinity reference locations to the WIPP repository, the effects on environmental justice are the same as those presented for the WIPP repository site under Alternative 2. Figures 4.2.7-1 and 4.2.7-2 and Table 4.2.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer from Census Bureau data for the year 2010 (U.S. Bureau of the Census 2012) and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals who identify themselves as Hispanic or Latino are included in the table

as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identify themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in New Mexico, 53.0% of the population is classified as minority, while 15.5% is classified as low income. Although the number of minority individuals does not exceed the state average by 20 percentage points or more, the number of minority individuals exceeds 50% of the total population in the area; that is, there is a minority population in the New Mexico portion of the 50-mi (80-km) area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the New Mexico portion of the 50-mi (80-km) area around the reference location as a whole.

Within the 50-mi (80-km) radius in Texas, 45.3% of the population is classified as minority, while 15.4% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Texas portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Texas portion of the 50-mi area (80-km) area around the reference location as a whole.

11.1.8 Land Use

The primary land use within the WIPP Vicinity reference location Section 35 is for oil and gas production. The land use description for the WIPP site contains further information applicable to land use within the WIPP site area (including for Section 27) (see Section 4.2.8). Figures 11.1.8-1 and 11.1.8-2 show potash leases in the vicinity of WIPP and the WIPP Vicinity reference locations, and a map of oil wells within 1.6 km (1 mi) of the WIPP LWB, respectively. There are no potash leases on Sections 27 and 35. There is an oil well on Section 35.

11.1.9 Transportation

Highway access to the WIPP region is by US 285 (north-south) or US 62/180 (northeast-southwest). Both highways pass through Carlsbad, New Mexico. Situated 40 km (25 mi) east of Carlsbad, WIPP can be reached from US 62/180 to the north and from New Mexico SR 128 to the south. The North Access Road from US 62/180 is about 21 km (13 mi) in length and is restricted to official WIPP business or to DOE and BLM personnel, permittees, licensees, or lessees (DOE 2002a). The South Access Road is Eddy County Road 802 originating at SR 128. General public access on Eddy County Road 802 can be restricted at the Off-Limits Area boundary if it is determined that there would be a significant safety risk to WIPP personnel

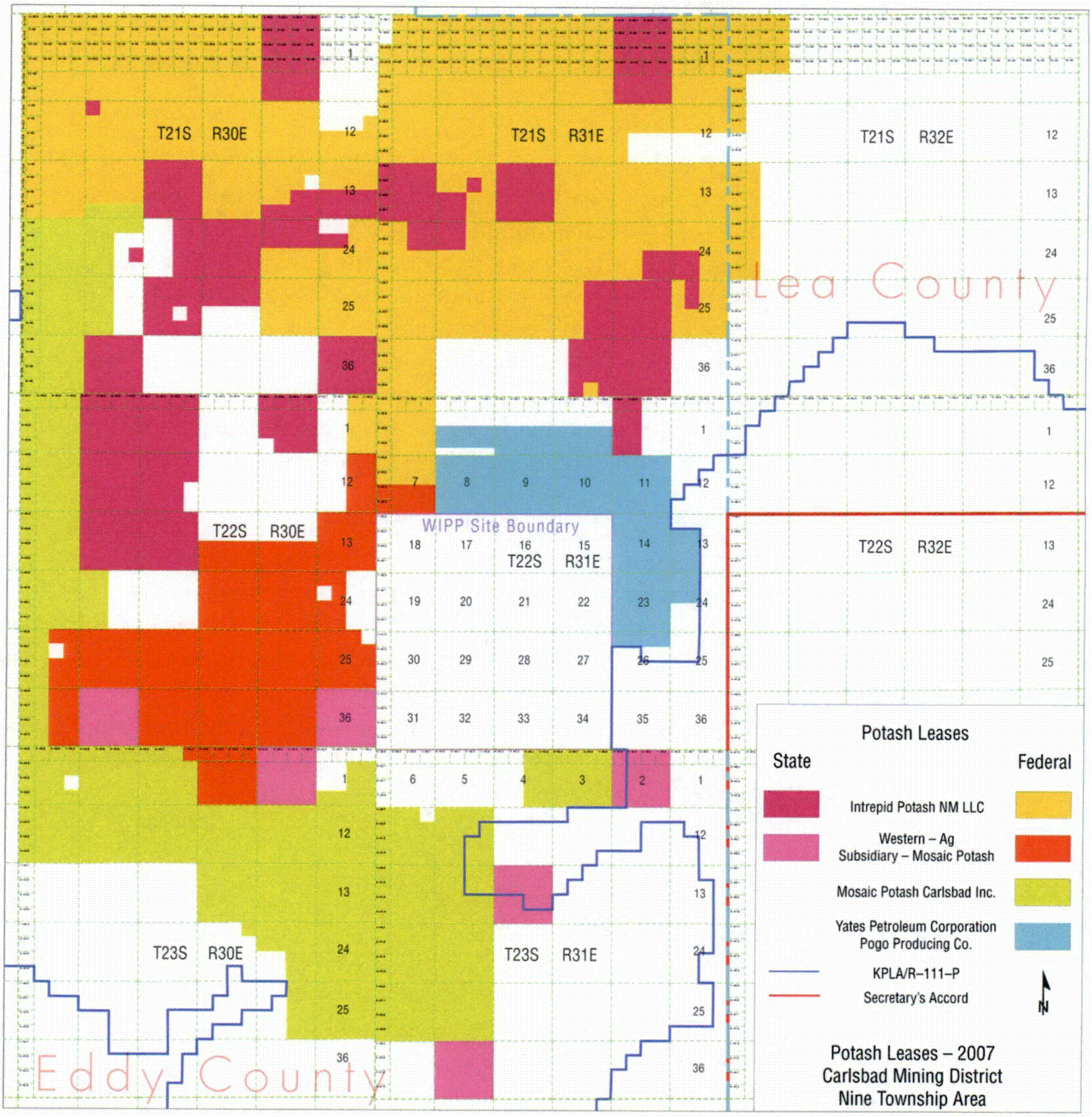

FIGURE 11.1.8-1 Potash Leases in the Vicinity of WIPP (as of 2007)

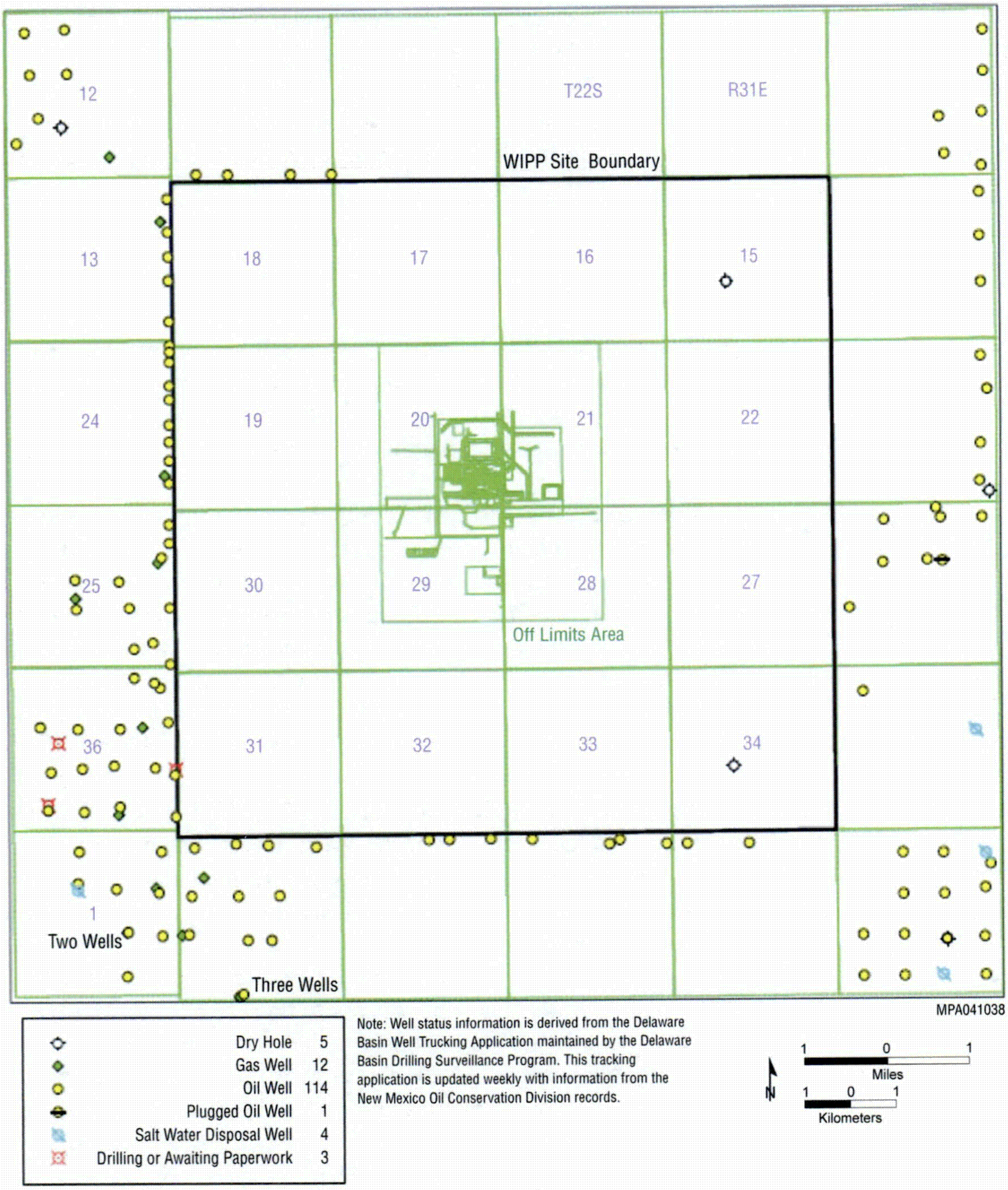

FIGURE 11.1.8-2 Map of Oil Wells within 1.6 km (1 mi) of WIPP Land Withdrawal Boundary

(DOE 2002a). Average daily traffic on the access roads is estimated to be 800 vehicles on the North Access Road and 400 vehicles on the South Access Road (NMED 2007).

Rail access to the WIPP Vicinity locations is provided by a rail line that connects with a spur of the BNSF Railroad near Mosaic Potash's Nash Draw Mine, 10 km (6 mi) southwest of the site (DOE 2002a).

11.1.10 Cultural Resources

Roughly 1,370 ha (3,380 ac) of the 4,140 ha (10,240 ac) managed by WIPP have been surveyed for cultural resources. The surveys identified approximately 60 archaeological sites and 90 isolated finds (DOE 2006). The largest survey was done in 1987 by Mariah and Associates. The 1987 survey examined portions of 45 sections surrounding the WIPP facility (DOE 2002a).

People have been living in the desert southwest for more than 10,000 years. Prehistoric people tended to live nomadic lifestyles, collecting resources from different areas at different times of the year (DOE 2002a). Most prehistoric archaeological sites in the WIPP area represent short-term use. In the mid 1500s, the Jumano and Apachean people used the area. They collected goods seasonally and traded with nearby Puebloan people. The Spanish were the first Europeans to cross what would become southeastern New Mexico. In historic times, the region was only lightly populated because of a lack of resources. Some ranching took place on the WIPP property during the 1940s and 1950s. Evidence of these activities is still visible in some locations.

The WIPP Vicinity reference location in Section 27 is in the WIPP LWB, and Section 35 is located on BLM-managed land just to the southeast of the WIPP LWB. The majority of Section 27 (T22S, R31E) and the majority of Section 35 (T22S, R31E) have not been examined for the presence of cultural resources. However, some cultural resource surveys were undertaken, and archaeological sites were found in both sections. In Section 27, a cultural resource survey was done for a proposed haul road. The survey identified Site 32632. The site consists of a surface artifact scatter of prehistoric materials. The site appears to represent a short-term occupation site that was revisited several times. On the basis of the potsherds found at the site, the resource dates to the Jornada Mogollon period (A.D. 900 to 1450) (Hunt 1994). Site 32632 was recommended as being potentially eligible for listing on the NRHP. Site 32632 is the only cultural resource currently known to be within Section 27.

Section 35 was surveyed on several occasions in anticipation of development. Currently there are seven known cultural resources located in Section 35. Of the seven resources, only one, 54373, is currently recommended as being potentially eligible for listing on the NRHP. Another site, 83670, has been very heavily impacted by past activities and no longer requires consideration.

A review of cultural resource information for the region revealed that the Maroon Cliffs Archaeological District is located northeast of WIPP. It is the closest archaeological district to the reference locations. The 4,770-ha (11,780-ac) district contains evidence of habitation ranging from the Archaic period (5000 B.C.) to the Jornada Mogollon (A.D. 900 to 1450) (BLM 1988).

Pit houses have been reported among the archaeological sites documented at this location. The district includes a wide variety of topographic features. The district is located roughly 11 km (7 mi) northwest of the project area.

11.1.11 Waste Management

Currently no waste management activities are being conducted at the WIPP Vicinity reference location in Section 35. It is expected that at the WIPP Vicinity reference location in Section 27, the waste management activities for the WIPP repository could accommodate the waste types generated by the land disposal methods (Alternatives 3 to 5), as discussed in Section 5.3.11.

11.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The potential impacts from the construction, operations, and post-closure of the land disposal methods (borehole, trench, and vault) are presented in this section for the resource areas evaluated. The discussion of the affected environment for the WIPP Vicinity locations is presented in Section 11.1 (and Section 4.2 for some resource areas, as indicated). The WIPP Vicinity locations are shown in Figure 11.1-1. The following sections address the potential environmental and human health consequences for each resource area discussed in Section 11.1.

11.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts that could result from construction, operations, decommissioning, and post-closure of each of the three land disposal alternatives (borehole, trench, and vault) at either of the WIPP Vicinity locations. Noise impacts are presented in Section 5.3.1.

11.2.1.1 Construction

During the construction period, emissions of criteria pollutants (such as SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities were estimated for the peak year, when site preparation and construction of support facilities and some disposal cells would take place. The estimates are provided in Table 11.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is presented in Appendix D. As shown in the table, it is estimated that total peak-year emission rates would be rather small when compared with the Eddy County emissions total. Peak-year

TABLE 11.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at the WIPP Vicinity

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench		Borehole		Vault	
SO_2	7,783	0.90	(0.01)[b]	3.0	(0.04)	3.2	(0.04)
NO_x	8,437	8.1	(0.10)	26	(0.31)	31	(0.37)
CO	25,725	3.3	(0.01)	11	(0.04)	11	(0.04)
VOCs	8,222	0.90	(0.01)	2.7	(0.03)	3.6	(0.04)
PM_{10}[c]	27,327	5.0	(0.02)	13	(0.05)	8.6	(0.03)
$PM_{2.5}$[c]	4,744	1.5	(0.03)	4.1	(0.09)	3.6	(0.08)
CO_2		670		2,200		2,300	
County[d]	1.85×10^6		(0.04)		(0.12)		(0.12)
New Mexico[e]	6.50×10^7		(0.001)		(0.003)		(0.004)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
Worldwide[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for Eddy County, in which WIPP is located. See Table 4.2.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008, 2009)

emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for the vault method, the construction of which would consume more materials and resources than would construction of the other two methods. The borehole method would disturb more area, so its fugitive dust emissions are estimated to be the highest. Peak-year emissions of all pollutants would be the lowest for the trench method, which would disturb the smallest area among the disposal methods. In terms of contribution to the emissions total, the peak-year emissions of NO_x under the vault method would be the highest, about 0.37% of the total county emissions, while emissions of other criteria pollutants and VOCs would be 0.08% or less of the county emissions total.

Background concentration levels for PM_{10} and $PM_{2.5}$ at the WIPP Vicinity reference locations are well below the standards (less than 59% of SAAQS); estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions (Table 4.2.1-2). Construction at the WIPP Vicinity locations could occur within a few tens of meters of the boundary of both sections. Under unfavorable dispersion conditions, high concentrations of PM_{10} or $PM_{2.5}$ are expected and could exceed the standards at the location boundaries, although such exceedances would be rare. Construction

activities would not contribute much to concentrations at the expected nearest residence. These activities would be conducted to minimize the potential impacts of related emissions on ambient air quality. In so doing, where appropriate, fugitive dust would be controlled by established, standard dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles, as stipulated in the construction permits.

Although O_3 levels in Carlsbad, about 42 km (26 mi) west of the WIPP site area, have exceeded the standard (see Table 4.2.1-2), Eddy County, including the WIPP Vicinity GTCC reference locations, is currently in attainment for O_3 (40 CFR 81.332). The WIPP Vicinity GTCC reference locations are located far from any major cities, and O_3 precursor emissions from a disposal facility under all three methods would be relatively small, 0.37% or less and 0.04% or less of the county total NO_x and VOC emissions, respectively. The O_3 precursor emissions would be much lower than those from the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased, going from approximately 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase. Most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of its sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 11.2.1-1, the highest peak-year amount of CO_2 emissions from construction would be under 0.12%, 0.004%, and 0.00004% of 2005 county, state, and U.S. CO_2 emissions, respectively. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Potential impacts on climate change from construction emissions would be small.

An initial construction period of 3.4 years is assumed (see Appendix D). Because the disposal units would be constructed as the waste became available for disposal, the construction phase would be extended over more years. Emissions would thus be lower in nonpeak years than in the peak year, as presented in Table 11.2.1-1. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the WIPP Vicinity locations because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

11.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimates of annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 11.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, annual operational emissions are estimated to be lower than those from construction under the borehole method. Annual emissions from operations are about the same for the trench and vault methods but higher than those for the borehole method. Compared with annual emissions for Eddy County, annual emissions of NO_x for the trench and vault methods would be the highest, about 0.32% of the county total, while emissions of other criteria pollutants and VOCs would be about 0.06% or less.

TABLE 11.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at the WIPP Vicinity

		Operation Emissions (tons/yr)					
Pollutant	Total Emissions (tons/yr)[a]	Trench		Borehole		Vault	
SO_2	7,783	3.3	(0.04)[b]	1.2	(0.02)	3.3	(0.04)
NO_x	8,437	27	(0.32)	10	(0.12)	27	(0.32)
CO	25,725	15	(0.06)	6.7	(0.03)	15	(0.06)
VOCs	8,222	3.1	(0.04)	1.2	(0.01)	3.1	(0.04)
PM_{10}[c]	27,327	2.5	(0.01)	0.91	(0.003)	2.5	(0.01)
$PM_{2.5}$[c]	4,744	2.2	(0.05)	0.81	(0.02)	2.2	(0.05)
CO_2		3,200		1,700		3,300	
County[d]	1.85×10^6		(0.17)		(0.09)		(0.18)
New Mexico[e]	6.50×10^7		(0.005)		(0.003)		(0.005)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
Worldwide[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for Eddy County, in which WIPP is located. See Table 4.2.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008, 2009)

Except for O_3 and particulates, concentration levels from operational activities are expected to remain well below the standards. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. However, although lower than their impacts during construction, fugitive dust emissions during operations (emplacement of waste) could exceed the standards under unfavorable meteorological conditions. Established fugitive dust control measures (primarily watering unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs during operations would be comparable to those during construction (about 0.32% and 0.04% of the county total, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest emissions of CO_2 among the three disposal methods would be comparable to the highest construction-related emissions, and thus their potential impacts on climate change would also be negligible. PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

11.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure. Land disturbance would include the surface area covered for each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) for facility and new road construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

11.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at the site (Table 5.1-1). Of the three disposal facility layouts, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth 40 m (130 ft), with boreholes completed in unconsolidated sand, silt, clay, caliche, and evaporites.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal facilities, the vault facility would require the most material since it would involve the installation of cover systems that use soil material. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources in the WIPP Vicinity reference locations, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced by the low precipitation rates in the WIPP Vicinity. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. The WIPP Vicinity is in a seismically active region, and small-magnitude earthquakes (usually less than 3 on the Richter scale) occur frequently. Larger-magnitude earthquakes are probable at the site. New facilities in the WIPP Vicinity would be sited and designed with safeguards to avoid or minimize the risks associated with seismic hazards. The annual probability of a volcanic event is considered to be very low, since the nearest volcanic field is in northwestern New Mexico, and the volcanoes within this field are dormant. The potential for liquefaction and subsidence are also considered to be low, given the deep water table and low precipitation rates in the area.

11.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase, because waste would be delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced by the low precipitation rates at the WIPP Vicinity reference locations. Mitigation measures would also be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials are expected to be low, since only the area within the facility itself would be unavailable for mining or drilling. The WIPP Vicinity reference locations are currently closed to commercial mineral development; however, oil and gas production is currently taking place in Section 35, and potash mining does occur at other sections (especially to the north and southwest). Waste disposal activities in Section 35 would not have adverse impacts on the extraction of economic minerals in the surrounding region.

11.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the impacts from water use (in terms of change in annual water use) on water resources that would occur during construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides from the waste inventory into groundwater could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 11.2.4.2.

11.2.3.1 Construction

Of the three types of land waste disposal facilities considered for the WIPP Vicinity reference locations, a vault facility would require the greatest amount of water during construction (Table 5.3.3-1). Water demands for construction at the WIPP Vicinity reference locations would be met by using groundwater piped in from off-site wells within the city of Carlsbad's water supply system. There are no surface water bodies at the site, and no surface water would be used during construction. As a result, no direct or indirect impacts on surface water resources are expected. The WIPP Vicinity reference locations are not located within 100-year or 500-year floodplains.

Currently, no water is used at the WIPP Vicinity reference locations. The Carlsbad Double Eagle South Well Field supplies water to the WIPP repository site to the south; its annual water production is about 1.4 million L (360 million gal). Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the pumpage for the Double Eagle water system by a maximum of about 0.24% (vault method) (Table 5.3.3-2). Because increased withdrawals of groundwater would be relatively small, they would be easily accommodated by the Double Eagle water system. The 61-cm (24-in.) pipeline that carries water from this water system to the WIPP repository site has the capacity to transport the increased volume of water effectively. The increase in the water volume needed would be relatively small, and impacts on the water table elevation and any change in the direction of groundwater flow would be negligible.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at the WIPP Vicinity locations. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

11.2.3.2 Operations

Of the three land waste disposal facilities considered for the WIPP Vicinity reference locations, the trench and vault facilities would require the most water during operations (Table 5.3.3-1). Water demands for operations at the WIPP Vicinity reference locations would be met by using groundwater from the Carlsbad water supply system. There are no surface water bodies at the site, and no surface water would be used during operations. As a result, no direct or indirect impacts on surface water resources are expected. The GTCC WIPP Vicinity reference locations are not located within 100-year or 500-year floodplains.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the overall demand on the Double Eagle water system by about 0.39% (Table 5.3.3-3). Because withdrawals of groundwater would be relatively small, they would be easily accommodated by the Double Eagle water system. The increased water demand would slightly lower the existing water table below the well fields. However, because the volume increase

would be relatively small, impacts on the water table elevation and any change in the direction of groundwater flow would be negligible.

Disposal of waste (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at the WIPP Vicinity reference locations. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

11.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations associated with the land disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal methods. These impacts are discussed in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the long-term post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the WIPP Vicinity reference locations, since these impacts would be site dependent but are expected to be the same for both sections (27 and 35).

11.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a land GTCC LLRW and GTCC-like waste disposal facility located at a WIPP Vicinity reference location are provided in Table 11.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, the impacts represent the maximum expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely happen if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (see Accidents 1–9, 11, and 12 on Table 11.2.4-1), the ingestion dose accounted for about 20% of the collective population dose shown in Table 11.2.4-1. External exposure was found to be negligible in all cases. All exposures were dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 7.0 person-rem, would be from a hypothetical release from an SWB caused by a fire in the WHB (Accident 9). The WHB discussed in Chapter 11 is hypothetical and does not refer to the WHB that currently exists at the

nearby WIPP geologic repository facility. Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 28,800 people living west of the facility, resulting in an average dose of about 0.0002 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 11.2.4-1, the highest estimated dose to an individual, 7.5 rem, would be for Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose would be to a hypothetical individual located 100 m (330 ft) north-northeast or east-southeast of the accident location. As discussed above, the estimated dose of 7.5 rem would be accumulated over a 50-year period after intake; it is not expected that it would result in symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be about 0.5% on the basis of a total dose of 7.5 rem.

11.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site public after the closure of a waste disposal facility would be small. RESRAD-OFFSITE calculation results indicate that there would be no measurable exposure from this pathway from a borehole facility. Small radiation exposures are estimated to occur from use of the trench and vault disposal methods. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone of the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault disposal facility.

On the basis of the RESRAD-OFFSITE calculation results, within 10,000 years, no radiation exposure would be incurred by a hypothetical resident farmer living 100 m (330 ft) from the disposal facility as a result of using groundwater. Potential exposure could occur after 10,000 years and would be caused mainly by I-129 and Tc-99 that reached the groundwater table. Transport times needed by other radionuclides to reach the groundwater table would be longer than 100,000 years as a result of their greater retardation in the soil.

TABLE 11.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at the WIPP Vicinity Reference Locations[a]

		Off-Site Public		Individual[b]	
Accident No.	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.00015	<0.0001	0.00017	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.00035	<0.0001	0.00038	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.00027	<0.0001	0.0003	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.00049	<0.0001	0.00053	<0.0001
5	Single drum drops, lid failure outside	0.15	<0.0001	0.17	<0.0001
6	Single SWB drops, lid failure outside	0.35	0.0002	0.38	0.0002
7	Three drums drop, puncture, lid failure outside	0.27	0.0002	0.3	0.0002
8	Two SWBs drop, puncture, lid failure outside	0.49	0.0003	0.53	0.0003
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	7	0.004	7.5	0.005
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	4.3	0.003	4.8	0.003
12	Tornado, missile hits one SWB, contents released	1.4	0.0008	1.5	0.0009

a CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box. The WHB discussed in this chapter is hypothetical and does not refer to the Waste Handling Building or WHB that currently exists at the nearby WIPP geologic repository facility.

b The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker.

c LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). LCF values are rounded to one significant figure.

Figure 11.2.4-1 shows the temporal plot of the radiation doses associated with the use of contaminated groundwater for a time frame extended to 100,000 years under the three land disposal methods. The late occurrence of radiation exposure associated with the use of contaminated groundwater is attributed to a small natural water infiltration rate (0.2 cm/yr or 0.08 in./yr) and a deep groundwater table of about 150 m (500 ft). The peak annual doses are calculated to be 84 mrem/yr for use of boreholes, 99 mrem/yr for use of trenches, and 110 mrem/yr for use of the vault disposal method. These peak annual doses are estimated to occur in about 11,000 years, 14,000 years, and 15,000 years for the borehole, trench, and vault methods, respectively. Most of this dose would be from Tc-99 and associated with the GTCC LLRW activated metal waste and GTCC-like Other Waste - RH. There is a high degree of uncertainty associated with results like these, which are for such a long time of analysis.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower these estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed

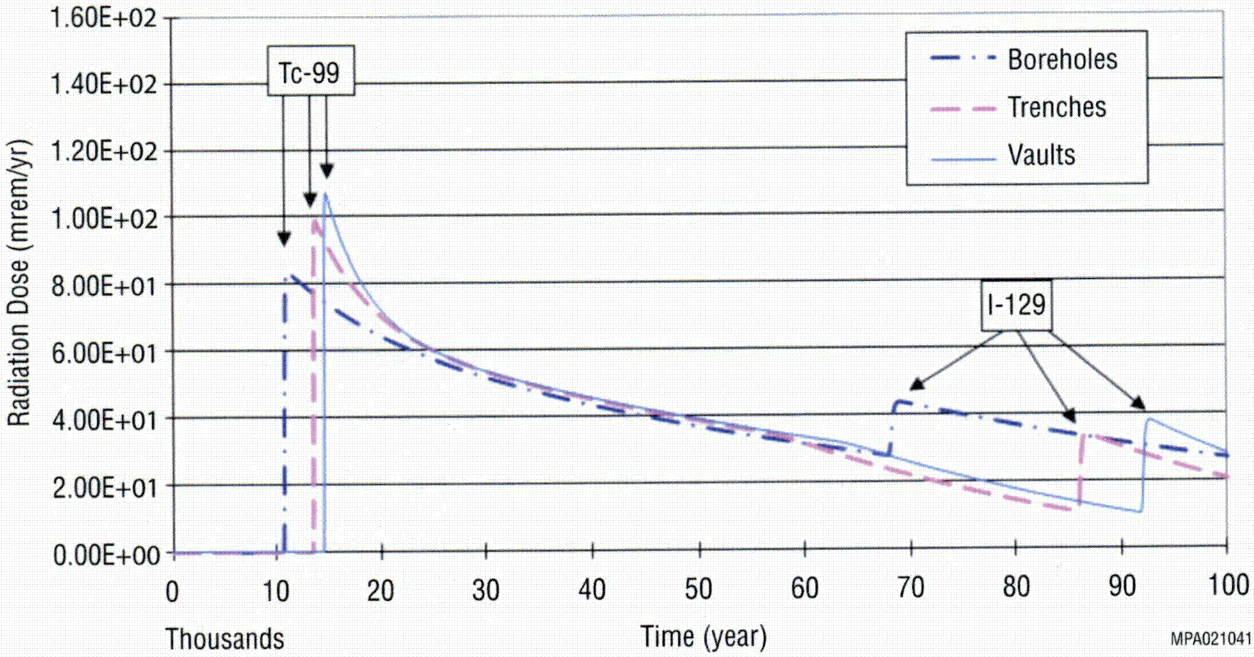

FIGURE 11.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at the WIPP Vicinity

that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is assumed to be conservative because it is expected that the engineered systems (including the disposal facility cover) would last longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This scenario is assumed to be conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce any releases to very low levels, thereby minimizing potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

11.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources from the construction, operations, and post-closure maintenance of the GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts of the GTCC LLRW and GTCC-like waste disposal facility on the ecological resources at the WIPP Vicinity reference locations at Sections 27 and 35.

It is not expected that the initial loss of shrub-dominated sand dune habitat, followed by the eventual establishment of low-growth vegetation on the disposal site, would create a long-term reduction in the local or regional ecological diversity. After closure of the GTCC LLRW and GTCC-like waste disposal site, the cover would be planted with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds" (EPA 1995). Priority would be given to native plant species that are conducive to soil stabilization and to wildlife needs. A revegetation program would also be recommended in order to minimize the potential for nonnative species to become established at the site.

Since wetlands do not occur within the area of the WIPP Vicinity reference locations, direct impacts on wetlands from construction, operations, and post-closure of the GTCC LLRW and GTCC-like waste disposal facility would not occur. However, wetland plants could potentially develop along the borders of the GTCC LLRW and GTCC-like waste disposal facility retention pond, and depending on the slope of the pond margins and the amount and length of time that the pond would retain water, the shoreline areas of the pond might function in a manner similar to that of a natural emergent wetland.

DOE's objectives for managing wildlife habitat within the WIPP land withdrawal area include the protection and maintenance of (1) crucial habitats for big game, upland game birds, and raptors; (2) crucial habitats for nongame species of special interest and concern to state or federal agencies; and (3) habitats for federally or state-listed species identified as inhabiting the land within the WIPP LWB (DOE 2002a). DOE's objectives for managing wildlife habitat at the WIPP Vicinity reference locations would be similar.

Because no aquatic habitats occur within the immediate area of the WIPP Vicinity reference locations, impacts on aquatic biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. The GTCC LLRW and GTCC-like waste disposal facility stormwater retention pond is not expected to become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained in the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal species that might enter the site.

None of the endangered, threatened, and other special-status species listed in Table 4.2.5-1 have been observed in the WIPP Vicinity (DOE 1997). However, favorable habitat for the lesser prairie-chicken (*Tympanuchus pallidicinctus*), a federal candidate species, does occur within the WIPP Vicinity reference locations, although Section 35 appears to provide a less favorable habitat than do the sections north of it (BLM 2008). One measure for minimizing potential impacts on wildlife is the establishment of periods during which off-site field activities may not be performed during the species' breeding season. Also, special seed mixes for replanting disturbed areas identified by BLM are used where possible to preserve lesser prairie-chicken habitat (BLM 2008). Similar measures would be enacted for the GTCC LLRW and GTCC-like waste disposal facility. Because only a small proportion of the sand dune habitat within the area would be affected by the GTCC LLRW and GTCC-like waste disposal facility, it is not expected that there would be a population-level impact on the lesser prairie-chicken.

Among the goals of the waste management mission at DOE sites is to maintain disposal facilities in a manner that protects the environment and complies with regulations (DOE 2002b). Therefore, potential impacts on ecological resources from the GTCC LLRW and GTCC-like waste disposal facility would be minimized and mitigated.

11.2.6 Socioeconomics

11.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) to 145 people (vault method) in the peak construction year and an additional 58 indirect jobs (trench method) to 152 indirect jobs (vault method) in the ROI (Table 11.2.6-1). Construction activities would constitute less than 1% of the total ROI employment in the peak year. A GTCC LLRW and GTCC-like waste disposal facility would produce between $4.4 million in income (trench method) and $11.7 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 41 people (borehole method) and 127 people (vault method) would in-migrate to the ROI (Table 11.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require up to 2% of vacant housing in the peak year. No significant impact on public finances would occur as a result of in-migration; up to four local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

11.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Operational activities would create about 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 32 indirect jobs (borehole method) to 38 indirect jobs (vault method) in the ROI (Table 11.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $3.8 million in income (borehole method) and $4.8 million in income (vault method) annually during operations.

Three to four people would move to the area at the beginning of operations (Table 11.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would need to be hired in order to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have only a small impact on levels of service in the local transportation network surrounding the site.

TABLE 11.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for the WIPP Vicinity[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operations	Construction	Operations	Construction	Operations
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	58	37	78	32	152	38
Total	120	85	125	70	297	89
Income ($ in millions)						
Direct	2.2	3.2	1.9	2.6	6.0	3.4
Indirect	2.2	1.3	3.3	1.2	5.7	1.4
Total	4.4	4.5	5.2	3.8	11.7	4.8
Population (number of new residents)	55	4	41	3	127	4
Housing (number of units required)	27	2	21	2	63	2
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	1	0	1	0	2	0
Teachers	1	0	1	0	2	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operation.

[b] Includes impacts that would occur in the cities of Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum and in Eddy and Lea Counties.

[c] Includes impacts that would occur in the Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum school districts.

[d] Includes police officers, paid firefighters, and general government employees.

11.2.7 Environmental Justice

11.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of a trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Since the health impacts from each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from construction of each facility on the minority and low-income population would not be significant.

11.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during operations, nor would there be any adverse health effects on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that here would be no disproportionately high and adverse impacts on minority or low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential adverse health and environmental impacts.

11.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.004 LCF for the population groups residing to the west of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the west of the site because of the prevailing wind condition in this case. Airborne

releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

11.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from the GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts from the GTCC LLRW and GTCC-like waste disposal facility on land use at the WIPP Vicinity reference locations.

Use of the WIPP Vicinity reference location Section 27 would have to be considered against requirements described in the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201). Use of the WIPP Vicinity reference location Section 35 for disposal of GTCC LLRW and GTCC-like waste would alter the current land use of up to 44 ha (110 ac) from multiple use to use by a waste disposal facility. DOE would consider existing lease holders in determining implementability at Section 35. A loss of about 0.2% of a 22,493-ha (55,581-ac) grazing allotment would also occur.

As was the case for the WIPP repository, the land (in Section 35) would be permanently withdrawn from all forms of entry, appropriation, and disposal under the public land laws and reserved for uses associated with the purposes of the GTCC LLRW and GTCC-like waste disposal facility. DOE would prepare a land management plan, as appropriate, and provide opportunities for the public and for federal, state, and local agencies to participate in the land use planning. Land use on areas surrounding the WIPP Vicinity locations is not expected to be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize the integrity of the facility, create a security risk, or create a worker or public safety risk.

11.2.9 Transportation

The transportation impacts of all GTCC LLRW and GTCC-like waste for disposal at the WIPP Vicinity reference locations was evaluated. As discussed in Section 5.2.9, transportation of all cargo is considered for both truck and rail modes of transport as separate options for the purposes of this EIS. Transportation impacts are expected to be the same for the borehole, trench, and vault methods because the same type of transportation packaging would be used regardless of the disposal method. In addition, it is expected that impacts for both Sections 27 and 35 would be the same because the transportation routes would be similar.

As discussed in Appendix C, Section C.9, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 11.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 11.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 11.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to the WIPP Vicinity locations are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double the rates for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents depend on the amount of radioactive material in a shipment and the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

11.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are only calculated for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 11.2.9-1 and 11.2.9-2, respectively. For the truck option, it is estimated that approximately 12,600 shipments involving about 36 million km (23 million mi) of travel would cause no LCFs to truck crew members or members of the general public. One fatality related to accidents is expected. No LCFs are estimated for the rail option, involving approximately 5,010 railcar shipments and about 14 million km (9 million mi) of travel. However, one fatality from accidents could occur.

TABLE 11.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at the WIPP Vicinity Reference Locations[a]

			Cargo-Related[b] Radiological Impacts									Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	63,300	0.66	0.027	0.1	0.12	0.24	0.00022	0.0004	0.0001	0.0015
Past PWRs	143	407,000	4.2	0.16	0.64	0.75	1.5	0.0012	0.003	0.0009	0.0091
Operating BWRs	569	1,550,000	16	0.57	2.4	2.8	5.8	0.0039	0.01	0.003	0.035
Operating PWRs	1,720	4,170,000	43	1.5	6.4	7.7	16	0.011	0.03	0.009	0.095
Sealed sources - CH	209	360,000	0.15	0.031	0.2	0.26	0.49	0.017	<0.0001	0.0003	0.0091
Cesium irradiators - CH	240	413,000	0.17	0.036	0.23	0.3	0.56	0.0028	0.0001	0.0003	0.01
Other Waste - CH	5	603	0.00025	<0.0001	0.00032	0.00043	0.00077	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	54	150,000	1.5	0.062	0.23	0.28	0.57	<0.0001	0.0009	0.0003	0.0034
GTCC-like waste											
Activated metals - RH	38	85,800	0.89	0.021	0.12	0.16	0.3	<0.0001	0.0005	0.0002	0.0035
Sealed sources - CH	1	1,720	0.00072	0.00015	0.00096	0.0012	0.0023	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	211,000	0.088	0.029	0.12	0.15	0.3	0.00097	<0.0001	0.0002	0.0044
Other Waste - RH	1,160	3,370,000	35	1.2	5.1	6.2	12	0.0022	0.02	0.007	0.07

TABLE 11.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	348,000	3.6	0.099	0.51	0.64	1.3	0.00077	0.002	0.0008	0.0083
New PWRs	833	1,940,000	20	0.7	3	3.6	7.2	0.0049	0.01	0.004	0.044
Additional commercial waste	1,990	6,200,000	64	2.2	9.4	11	23	<0.0001	0.04	0.01	0.13
Other Waste - CH	139	433,000	0.18	0.06	0.26	0.31	0.63	0.003	0.0001	0.0004	0.009
Other Waste - RH	3,790	11,500,000	120	4.2	17	21	43	0.0008	0.07	0.03	0.24
GTCC-like waste											
Other Waste - CH	44	117,000	0.049	0.016	0.069	0.084	0.17	0.0004	<0.0001	0.0001	0.0025
Other Waste - RH	1,400	4,210,000	43	1.5	6.4	7.7	16	0.0022	0.03	0.009	0.088
Total Groups 1 and 2	12,600	35,600,000	350	12	52	64	130	0.051	0.2	0.08	0.76

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 11.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at the WIPP Vicinity Reference Locations[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	21,300	0.17	0.056	0.0033	0.077	0.14	0.00035	0.0001	<0.0001	0.0017
Past PWRs	37	103,000	0.86	0.27	0.016	0.39	0.67	0.0014	0.0005	0.0004	0.006
Operating BWRs	154	422,000	3.5	1.1	0.062	1.7	2.8	0.0025	0.002	0.002	0.018
Operating PWRs	460	1,200,000	10	3.4	0.18	4.8	8.4	0.0081	0.006	0.005	0.055
Sealed sources - CH	105	190,000	0.53	0.16	0.0085	0.38	0.56	0.00095	0.0003	0.0003	0.0062
Cesium irradiators - CH	120	217,000	0.61	0.19	0.0097	0.44	0.64	0.00013	0.0004	0.0004	0.0071
Other Waste - CH	3	2,740	0.011	0.0025	0.00017	0.0083	0.011	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	27	85,600	0.68	0.27	0.012	0.33	0.61	<0.0001	0.0004	0.0004	0.0025
GTCC-like waste											
Activated metals - RH	11	23,400	0.21	0.051	0.0028	0.1	0.16	<0.0001	0.0001	<0.0001	0.0024
Sealed sources - CH	1	1,810	0.0051	0.0016	<0.0001	0.0037	0.0053	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	99,700	0.24	0.11	0.0066	0.18	0.29	0.00011	0.0001	0.0002	0.0036
Other Waste - RH	579	1,670,000	14	4.5	0.25	6.7	11	0.00024	0.008	0.007	0.061

TABLE 11.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	113,000	1	0.32	0.017	0.5	0.84	0.00058	0.0006	0.0005	0.0052
New PWRs	227	569,000	4.9	1.7	0.08	2.3	4.1	0.0033	0.003	0.002	0.026
Additional commercial waste	498	1,450,000	12	3.8	0.23	6	10	<0.0001	0.007	0.006	0.054
Other Waste - CH	70	203,000	0.49	0.23	0.014	0.36	0.6	0.00035	0.0003	0.0004	0.0076
Other Waste - RH	1,900	5,550,000	45	15	0.85	23	38	<0.0001	0.03	0.02	0.2
GTCC-like waste											
Other Waste - CH	22	64,300	0.15	0.078	0.0039	0.11	0.19	<0.0001	<0.0001	0.0001	0.0023
Other Waste - RH	702	2,040,000	17	5.4	0.31	8.3	14	0.00022	0.01	0.008	0.076
Total Groups 1 and 2	5,010	14,000,000	110	36	2.1	55	94	0.018	0.07	0.06	0.53

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

11.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the entrance to the WIPP Vicinity locations and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

11.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus is not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

11.2.10 Cultural Resources

Eight cultural resources have been identified in Section 27 (T22S, R31E) and Section 35 (T22S, R31E); one is in Section 27, and seven are in Section 35. Neither section has been fully examined for the presence of cultural resources. Most of the cultural resources being discovered appear to be the remains of camps that show the evidence of food preparation.

If this location was chosen for development, the NHPA Section 106 process for considering the impact of the project on significant cultural resources would be followed. The Section 106 process requires the facility location and any ancillary locations that would be affected by the project to be investigated for the presence of cultural resources prior to disturbance. If the project occurred near one of the known resources, additional research would be needed to determine if the resource was eligible for listing on the NRHP. If it was, all impacts on the resource would need to be mitigated. Avoidance is always the preferred mitigation measure.

The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is almost twice the amount needed to construct the vault or the trench method. The majority of the impacts

on cultural resources are expected to occur during the construction phase. On the basis of previous research in the region, it is expected that some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the project area. One prehistoric site is known within the project area, and it has yet to be evaluated for listing on the NRHP. If additional archaeological sites were identified, they would require evaluation for listing on the NRHP.

Unlike the other two methods being considered, the vault method requires large amounts of soil to cover the waste. Impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operations of the vault method could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, additional land would be disturbed to obtain the soil for the cover. Most impacts on significant cultural resources could be mitigated through data recovery, but avoidance is the preferred mitigation. The appropriate mitigation would be determined through consultation with the New Mexico SHPO and the appropriate Native American tribes. These tribes would be consulted to ensure that no traditional cultural properties that could be disturbed were located in the project area.

It is expected that activities associated with construction, operations, and post-closure would have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operations and post-closure activities.

11.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These wastes could be sent off-site for disposal; therefore, no impacts from the waste generated from the construction and operations of the land disposal methods are expected. Section 5.3.11 summarizes the management and handling procedures that could be followed for the waste that might be generated by the land disposal facilities at the WIPP Vicinity.

11.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from Alternatives 3, 4, and 5 discussed in Section 11.2 are summarized by resource area as follows:

Air quality. Total peak-year emission rates are estimated to be rather small when compared with the Eddy County total emissions. Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) would be small. Construction at the WIPP Vicinity GTCC reference

locations could occur within less than 100 m (330 ft) of the site boundary. Under unfavorable dispersion conditions, high concentrations of PM_{10} or $PM_{2.5}$ could occur and exceed the standards at the site boundary, although such exceedances would be rare. Compared with annual emissions for Eddy County, annual emissions of NO_x for the vault method during construction would be the highest, about 0.37% of the county total, while emissions of other criteria pollutants and VOCs would be about 0.06% or less. Except for O_3 and particulates, concentration levels from operational activities are expected to remain well below the standards. During operations, fugitive dust emissions could exceed the standards under unfavorable meteorological conditions.

Noise. The highest composite noise level during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA as L_{dn} for residential zones. There would be no residences within this distance. Noise generated during operations would be less than noise during construction. No impacts from ground-borne vibration are anticipated because the generating equipment would not be high-vibration equipment and because there are no residences or vibration-sensitive buildings nearby.

Geology. During the construction phase, the borehole facility footprint would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth, 40 m (130 ft), with boreholes being completed in unconsolidated sand, silt, clay, caliche, and evaporites. No adverse impacts from extraction or use of geologic and soil resources are expected. No significant changes in surface topography or natural drainages would occur. The potential for erosion would be reduced because of the low precipitation rates at the WIPP Vicinity and further reduced by best management practices.

Water resources. Construction of a vault facility and operations of a vault or trench facility would have the highest water requirement. Water demands for construction at the WIPP Vicinity reference locations would be met by using groundwater from the Carlsbad Double Eagle water system. There are no surface water bodies at the site, and no surface water would be used during construction; therefore, no direct or indirect impacts on surface water are expected. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the pumpage for the Double Eagle water system by a maximum of about 0.24% and 0.39%, respectively. This volume increase would be relatively small, and impacts would be negligible. It is expected that there would be no water demands during the post-closure period. Because of the low infiltration rates and deep water table, groundwater would not likely become contaminated with radionuclides for more than 50,000 years for all three disposal methods.

Human health. The worker impacts from operations would mainly be those from the radiation doses associated with handling and disposing of the wastes. The annual radiation dose would be 2.6 person-rem/yr for boreholes, 4.6 person-rem/yr for trenches, and 5.2 person-rem/yr for vaults. These worker doses are not expected to result in any LCFs (Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (of 2 rem/yr) for site operations. It is expected that the maximum dose to any individual workers over the entire project would not exceed a few rem.

The worker impacts from accidents would be associated with the injuries and illnesses during disposal operations and possible fatalities that could occur from construction and waste handling activities. The annual number of lost workdays due to injuries and illnesses would range from 1 (for boreholes) to 2 (for trenches and vaults), and no fatalities would occur from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those that are expected to occur in any construction project of this size.

For the general public, no measurable doses are expected to occur during waste disposal at the site during operations, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. The highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire impacting an SWB) is estimated to be 7.5 rem and would not result in any LCFs. The total dose to the affected population from such an event is estimated to be 7.0 person-rem (see Table 11.2.4-1). Groundwater contamination is not projected to reach a nearby hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility within the first 10,000 years, so this individual would receive no incremental radiation dose from disposal of these wastes from this potential exposure pathway.

Ecology. Initial loss of shrub-dominated sand dune habitat, followed by the eventual establishment of low-growth vegetation on the disposal site, is not expected to create a long-term reduction in the local or regional ecological diversity. No aquatic habitats occur within the immediate vicinity of the GTCC reference locations at the WIPP Vicinity; hence, impacts on aquatic biota are not expected. No endangered, threatened, and other special-status species have been observed in the WIPP Vicinity area (DOE 1997). However, favorable habitat for the lesser prairie-chicken (*Tympanuchus pallidicinctus*), a federal candidate species, does occur within the WIPP Vicinity area (BLM 2008).

Socioeconomics. Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and up to 152 additional indirect jobs (vault method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce up to $11.7 million in income in the peak construction year (vault method). Up to 127 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 2% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating up to 51 direct jobs annually (vault method) and up to 38 additional indirect jobs (vault method) in the ROI. The disposal facility would produce up to $4.8 million in income annually during operations.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be

significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. The GTCC WIPP Vicinity Section 27 reference location is located within the WIPP LWB and is therefore subject to the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) requirements. WIPP Vicinity Section 35 reference location is located within a multiple use area and contains oil and gas leases. A loss of 0.2% of a 22,493-ha (55,581-ac) grazing allotment would occur, and a portion of Section 35 would be altered to a waste disposal area.

Transportation. Shipment of all waste to the WIPP Vicinity by truck would result in approximately 12,600 shipments involving a total distance of 36 million km (23 million mi). Shipment of all waste by rail would involve 5,010 railcar shipments totaling 14 million km (9 million mi) of travel. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur. For comparison, since starting operations in 1999, WIPP has received more than 8,500 truck shipments of defense TRU waste.

Cultural resources. The majority of the impacts on cultural resources are expected to occur during the construction phase. On the basis of previous research in the region, it is expected that some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the project area. One known prehistoric site is within the WIPP Vicinity reference location and has yet to be evaluated for listing on the NRHP. If additional archaeological sites were identified, they would require evaluation for listing on the NRHP. Section 106 of the NHPA would be followed to determine the impacts of disposal facility activities on significant cultural resources, as needed. Local tribes would be consulted to ensure that no traditional cultural properties were affected by the project.

Waste management. The wastes that might be generated from the construction and operations of the land disposal methods could be sent off-site for disposal as commercial waste management facilities became available.

11.4 CUMULATIVE IMPACTS

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. Section 5.4 presents the methodology for the cumulative impacts analysis. The analysis provided below begins with a description of reasonably foreseeable future actions at the WIPP Vicinity locations, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 11.1). Impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions.

Aside from the adjacent operating WIPP repository, the primary use of land within 16 km (10 mi) of the WIPP Vicinity locations is grazing, with lesser amounts of land used for oil and gas extraction and potash mining. Most of this land is managed and owned by BLM. Two ranches are located within 16 km (10 mi) of the WIPP site. The closest town, Loving, New Mexico, is about 29 km (18 mi) away. Most of the land within 50 km (30 mi) of the WIPP Vicinity locations is owned by either the federal government or the State of New Mexico. At the time of the preparation of this EIS, there were no known plans for large actions on BLM land.

The land use described above, in combination with the low potential impacts discussed in Section 11.2, indicate that the contribution from the construction, operations, and post-closure phases of the proposed action to cumulative impacts at the WIPP Vicinity locations and the nearby WIPP geologic repository would be small and would not have a significant cumulative impact on area air quality, geology and soils, water resources, ecology, socioeconomics, environmental justice, cultural resources, and land use. The post-closure performance analysis incorporating the emplacement of the GTCC LLRW and GTCC-like waste at the adjacent WIPP repository (as discussed in Section 4.3.4) indicated that releases to the environment (if any) would be negligible. Combining these releases with the results discussed in Section 11.2.4, which indicates that potential post-closure radionuclide releases to the groundwater in Sections 27 and 35 would also be small, indicates that cumulative human health impacts at the WIPP Vicinity would not be significant.

On June 15, 2005, the NRC staff issued the *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico* (NRC 2005). This facility was constructed and is now in operation. It is located about 60 km (37 mi) east of the WIPP Vicinity reference locations (town of Eunice). The distance from the WIPP Vicinity reference locations – in combination with NRC staff findings (as reported in the EIS for that action [NRC 2005]) that stated that environmental impacts from this enrichment facility would be small to moderate – indicate that cumulative impacts from the possible GTCC LLRW and GTCC-like waste disposal activities at the WIPP Vicinity reference locations in combination with the enrichment facility operations would be small and not result in significant cumulative impacts for all resource areas evaluated (including human health and transportation).

On June 5, 2012 (*Federal Register*, Vol. 77, No. 108), DOE proposed to evaluate two additional locations for a long-term mercury storage facility. These two locations are both near WIPP, but the first is located within and the second is located outside the land subject to the WIPP LWA (P.L. No. 102-579), as amended. The first is located in Section 20, Township 22 South, Range 31 East (across the WIPP access road from the WIPP facility), and the second is located in Section 10, Township 22 South, Range 31 East, approximately 3.5 mi (5.6 km) north of the WIPP facility. The impacts on the various resource areas from construction and operation of a long-term mercury storage facility would range from none to minor, including impacts on land use and visual resources, surface water or groundwater resources, air emissions, engine exhaust emissions from transporting mercury, noise levels, ecological resources, cultural and paleontological resources, the site's waste management infrastructure, human health, socioeconomics, and vehicle trips during construction. There would be minor, short-term (6-month) air quality impacts involving construction of a new storage facility. There would be no disproportionately high and adverse effects on minority or low-income populations.

Transportation accidents are predicted to pose a negligible to low risk to human health. The impacts from the proposed construction and operation of a long-term mercury storage facility discussed above, in combination with the potential impacts summarized in Section 11.2 for the GTCC proposed action, would not have a significant cumulative impact on any of the resource areas evaluated for the WIPP and the WIPP Vicinity.

Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at the WIPP Vicinity reference locations would provide more detailed analyses of site-specific issues, including cumulative impacts.

11.5 STATUTORY AND REGULATORY PROVISIONS RELEVANT TO THE EIS

Siting a vault, trench, or borehole facility for GTCC LLRW and GTCC-like waste inside the WIPP LWB (i.e., Section 27) would be subject to the limits of the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), as discussed for WIPP in Section 4.7; therefore, federal legislation to develop such facilities would be required. Siting a vault, trench, or borehole facility on BLM-administered land outside the WIPP LWB (i.e., Section 35) would require a land withdrawal in accordance with DOI regulations at 40 CFR Part 2300, "Land Withdrawals."

11.6 REFERENCES FOR CHAPTER 11

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