3 AFFECTED ENVIRONMENT

3.1 General Site Description

The Mixed Oxide (MOX) Fuel Fabrication Facility (the proposed MOX facility) and its support facilities, the Pit Disassembly and Conversion Facility (PDCF) and the Waste Solidification Building (WSB), are proposed for construction at the U.S. Department of Energy's (DOE's) Savannah River Site (SRS). The SRS is located in the southwestern portion of the state of South Carolina, as shown in Figure 3.1. The SRS is adjacent to the Savannah River, along the state border with Georgia, approximately 20 km (12 mi) southeast of Aiken, South Carolina, and 24 km (15 mi) east of Augusta, Georgia (Arnett and Mamatey 2001b). The U.S. Government owns the SRS, which was set aside in 1950 for the production of nuclear materials for national defense. Since the end of the Cold War in 1991, national priorities have shifted, and the site's priorities are now focused on waste management, environmental restoration, technology development and transfer, and economic development. The SRS covers approximately 803 km^2 (310 mi^2) in an approximately circular tract of land within Aiken, Barnwell, and Allendale Counties in South Carolina. Public access to the SRS is limited according to DOE security regulations.

The proposed facility sites are located adjacent to the north-northwest edge of F-Area near the center of the SRS (see Figure 1.2). F-Area contains facilities for chemical separations, including F Canyon, which is the main processing facility, and waste storage, which includes 20 of the 49 active liquid high-level (radioactive) waste (HLW) tanks on the SRS.

3.2 Geology, Seismology, and Soils

This section summarizes the geology, seismology, and soil conditions of the SRS and discusses site-specific conditions at F-Area. Geologic resources include mineral ores, fossil fuels, and aggregate (sand and gravel) materials that can have significant economic value. The value of soil resources depends upon the soil's ability to grow plants. Certain soils are classified by the U.S. Department of Agriculture, Natural Resources Conservation Service, as prime farmland or other important farmlands. The Farmland Protection Policy Act (*United States Code*, Title 7, Section 4201 *et seq.* [7 U.S.C. 4201] *et seq.*) and its implementing regulations (*Code of Federal Regulations*, Title 7, Part 658 [7 CFR Part 658]) require federal agencies as part of the National Environmental Policy Act (NEPA) process to consider the extent to which federal projects and programs contribute to the unnecessary conversion of important farmlands to nonagricultural uses. The site's geology and soil conditions are important in evaluating how water and potential contaminants move through the subsurface, in evaluating erosion impacts, and in predicting subsidence or landslides. Seismology is important in determining potential impacts from earthquakes.

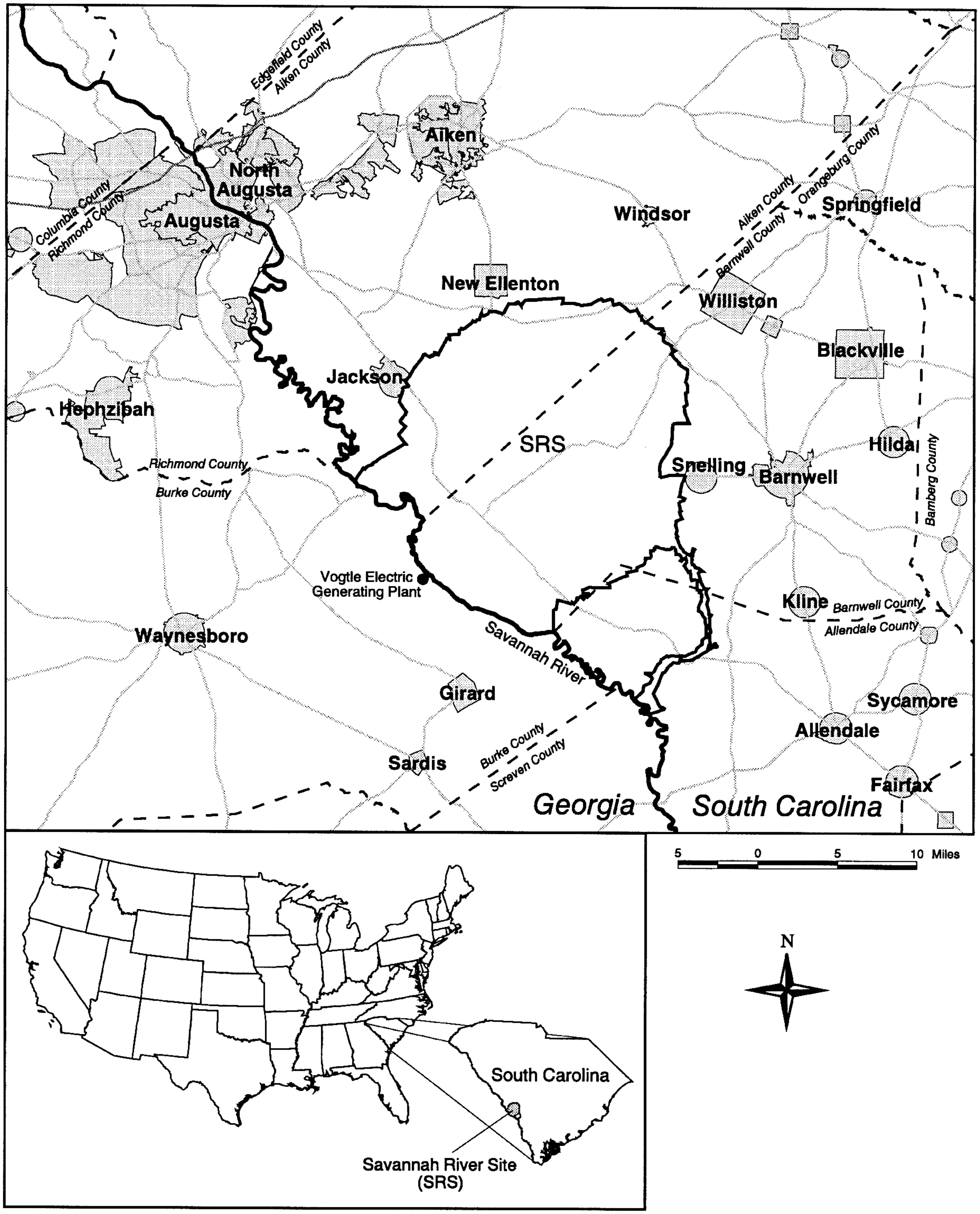

Figure 3.1. Regional location of the SRS.

3.2.1 Geology

The SRS is located in the Aiken Plateau portion of the Upper Atlantic Coastal Plain approximately 32 km (20 mi) east of the Fall Line. The Fall Line is a major physiographic and structural feature that separates the Piedmont and Coastal Plain physiographic provinces in southeastern South Carolina (DOE 1996). Soils within the Piedmont are predominantly derived from the weathering of bedrock. In contrast, soils within the Coastal Plain are predominantly sediments deposited by water. The Coastal Plain sediments are located above bedrock that consists of Paleozoic-age crystalline rock (such as granite) and Triassic-age sedimentary rock (such as siltstone) of the Dunbarton Basin. These sediments thicken from near zero at the Fall Line to about 1,220 m (4,000 ft) at the South Carolina coast (DCS 2003c). In general, the sediments have a regional dip (slant of the top surface) to the southeast. The Aiken Plateau is highly cut by narrow, steep-sided valleys separated by broad, flat areas.

Above the bedrock, the first layer of sediments at the SRS consists of about 210 m (700 ft) of Upper Cretaceous-age quartz sand, pebbly sand, and kaolinitic clay. The next ascending layer (known as the Tinker/Santee Formation) consists of 18 m (60 ft) of Paleocene-age clayey and silty quartz sand, and silt (DCS 2002). Within this layer, there are occasional beds of clean sand, gravel, clay, or carbonate. Deposits of pebbly, clayey sand, conglomerate, and Miocene- and Oligocene-age clay occur at higher elevations. This layer is noteworthy because it contains small, discontinuous, thin calcareous sand zones (i.e., sand containing calcium carbonate) that are potentially subject to dissolution by water. These “soft-zone” areas have the potential to subside, causing settling of the ground surface (WSRC 2000a; DCS 2003c). These areas were encountered in exploratory borings in F-, S-, H-, and Z-Areas of the SRS at depths between 33 and 45 m (100 and 150 ft) (DOE 1995).

The upper sediment layer in F-Area consists of primarily shallow marine quartz sand containing sporadic clay layers (known as the Barnwell Group) (DOE 1999). This layer is about 21 m (70 ft) thick near the western boundary of the SRS and about 52 m (170 ft) thick near the eastern boundary.

There are 11 deep boreholes at the SRS. The closest deep borehole is located just north of an unnamed tributary of Upper Three Runs Creek. The remaining 10 deep boreholes are not located in the vicinity of F-Area.

In 2000, 13 exploratory borings and 63 cone penetration test (CPT) holes were used to identify subsurface conditions at the proposed MOX facility site (DCS 2002). The CPT holes ranged from about 19.5 m (64 ft) to 42.7 m (140 ft) below the existing grade. Some soft zones related to past dissolution and deposition activity were identified at depth. The CPT holes were used to define the limits of the soft zones. The planned locations of heavily loaded structures, such as the MOX Fuel Fabrication Building and the Emergency Diesel Generator Building, were changed to minimize the potential impact of these underlying soft zones.

Except for some small gravel deposits, no economically viable geologic resources occur in the vicinity of F-Area (DOE 1995).

3.2.2 Seismology

On the basis of previous studies at the SRS and elsewhere, there are no known faults capable of producing an earthquake (referred to as capable faults) within the 320-km (200-mi) radius of the site that influence the seismicity of the region, except for poorly constructed faults associated with the Charleston seismic zone (DCS 2003c).

> **Capable Fault**
>
> A fault is described as capable if it has had movement at or near the ground surface at least once within the past 35,000 years, or recurrent movement within the past 500,000 years.

Several faults have been identified from subsurface mapping and seismic surveys beneath the SRS. The largest of these is the Pen Branch Fault. It passes through the SRS in a northeast-southwest direction and is located about 5.6 km (3.5 mi) southeast of F-Area (WSRC 2000a). Because there is no evidence of movement along this fault within the last 38 million years, the Pen Branch Fault is considered not capable.

Two large earthquakes have occurred within 300 km (186 mi) of the SRS. The larger of these was the Charleston earthquake of 1886. The Charleston earthquake is the most damaging earthquake known to have occurred in the southeastern United States and one of the largest historic shocks in eastern North America. This earthquake had an estimated Modified Mercalli Intensity of X (USGS 2001); it damaged or destroyed many buildings in the old city of Charleston, killed 60 people, and produced structural damage up to several hundred kilometers from its epicenter. At the SRS, this earthquake had an estimated Richter Scale magnitude ranging from 6.5 to 7.5. The SRS area experienced an estimated peak ground acceleration[1] of 0.10 g (1/10 the acceleration of gravity — 9.81 m/s/s [32.2 ft/s/s]) during this event (DCS 2002).

> **Modified Mercalli Intensity Scale**
>
> The Modified Mercalli Intensity (MMI) Scale is a measure of the shaking strength of an earthquake at different locations in the region where an earthquake is felt. Earthquake intensities are characterized in terms of how the shaking affects people and buildings. The MMI Scale was originally developed in Italy nearly a century ago and includes 12 degrees of shaking. It was modified for use in the United States in 1931.

Three earthquakes have occurred at the SRS during recent years. They occurred on June 8, 1985, August 5, 1988, and May 17, 1997. These earthquakes were small, shallow events and were probably the result of strain release near intrusive bodies or the edges of metamorphic belts, typical of South Carolina Piedmont type seismic

> **Richter Scale**
>
> The magnitude of an earthquake is a measure of the energy released during the event. It is often measured on the Richter Scale, which runs from 0.0 upwards, with the largest earthquakes recorded having a magnitude of 8.6. The Richter Scale is logarithmic; a quake of magnitude 5 is 10 times more destructive than a quake of magnitude 4. Earthquakes greater than magnitude 6.0 can be regarded as significant, with the likelihood of damage and loss of life (Press and Siever 1982).

1 Peak ground acceleration is the maximum acceleration amplitude (change in velocity with respect to time) measured by a seismic recording of an earthquake (called a strong motion accelerogram).

activity (WSRC 2000a). None of these earthquakes were associated with major faults (e.g., the Pen Branch Fault) in the area. Rather, these earthquakes are inferred to have seismic sources in the lower Paleozoic platform rock at a depth of about 12 km (7.5 mi) (DCS 2001a). These earthquakes had Richter Scale magnitudes of 3.2 or less and had epicenters that were within the SRS boundaries. Earthquakes of this magnitude are not felt, but do register on seismic instruments (Kirkham and Rogers 1981). Seismic alarms at the SRS reactor buildings were not triggered by any of these events (WSRC 2000a).

An earthquake with an average peak ground of 0.20 g is estimated to have an annual probability of exceedance of 1 in 10,000 (1×10^{-4}) at the SRS (DCS 2002, 2003b).

3.2.3 Soils

As discussed in Section 3.2.1, the surface soils at the SRS consist of Coastal Plain sediments. The surface soils are primarily sands and sandy loams with sporadic clay layers (DOE 1999). Currently, a stockpile of soils removed from the Actinide Packaging and Storage Facility (APSF) site on the SRS is mounded up to 15 m (50 ft) thick on the central portion of the proposed facility site in the F-Area. These soils are similar in texture to the natural soils at the site and would be removed from the site during construction.

The majority of soils in F-Area are classified by the U.S. Department of Agriculture, Natural Resources Conservation Service, as the Fuquay-Blanton-Dothan Association. These soils are nearly level to sloping and are well drained. Soils along stream floodplains are classified as the Troup-Pickney-Lucy Association. Both of these soil associations are subject to erosion. Slope stability, however, has not been a significant regional issue.

The surface soils allow precipitation to drain rapidly. Because of their sandy texture and drainage characteristics, some soil units at the SRS meet the requirements as prime farmland. However, the U.S. Department of Agriculture, Natural Resources Conservation Service, does not identify these areas as prime farmlands because they are not available for agricultural use.

Soil sampling was performed in the area of the proposed MOX facility and support buildings as part of a preconstruction baseline environmental monitoring survey conducted between September 2000 and March 2002 (SRS 2002). Fifty locations were identified for sampling by using a statistically based sampling grid. Samples were obtained from depths of between 0 and 30.5 cm (12 in.). Samples were analyzed for metals and radionuclides. None of the metal concentrations exceeded industrial use standards, and all of the radionuclides were well below SRS-developed scenario-specific radionuclide limits.

3.3 Hydrology

This section discusses the hydrologic environment of the SRS and the proposed site for the facilities. Hydrology deals with the properties, distribution, and circulation of water, particularly surface water and groundwater. The surface waters emphasized in this section are the

Savannah River and on-site streams, including treated effluent and runoff discharges to them. Groundwater resources are waters that occur within aquifers (e.g., water-bearing strata that can store and transmit water in significant quantities). These resources are discussed in relation to their use and potential contamination.

3.3.1 Surface Water

The principal surface water feature at the SRS is the Savannah River (see Figure 3.2). It borders the southwest boundary of the site for 32 km (20 mi) (DOE 1996). Six major streams flow through the SRS and discharge to the Savannah River: Upper Three Runs Creek, Beaver Dam Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek. Upper Three Runs Creek has two named tributaries, Tims Branch and Tinker Creek. Pen Branch has one tributary, Indian Grave Branch. Steel Creek also has one tributary, Meyers Branch. None of these bodies of water are federally designated as Wild and Scenic Rivers (DCS 2002). In the vicinity of the F-Area, Upper Three Runs Creek has two unnamed tributaries (see Figure 3.3) that flow to the northwest.

Two man-made lakes are located at the SRS: L Lake, which discharges to Steel Creek, and Par Pond, which discharges to Lower Three Runs Creek (DCS 2002). There are also about 50 other small man-made ponds and about 300 natural Carolina bays (closed depressions capable of holding water) at the SRS. The Carolina bays do not receive any direct effluent discharge; however, they do receive storm-water runoff.

The SRS withdraws surface water from the Savannah River mainly for industrial cooling. In 2000, the SRS withdrew about 49.7 billion L (13.1 billion gal) of water from the river. Most of this water is returned to the river through various discharges (DOE 1999).

The average flow in the Savannah River is 269 m^3/s (9,493 ft^3/s). The 7-day low flow, 10-year recurrence (referred to as “7Q10") flow is 123 m^3/s (4,332 ft^3/s) (WSRC 2000a). This flow is the lowest flow recorded over any 7 consecutive days within any 10-year period. Three large upstream reservoirs (Hartwell, Richard B. Russell, and Strom Thurmond/Clarks Hill) regulate flow in the Savannah River. This regulation is done to lessen the impacts of drought and flooding downstream. Several communities in the area use the Savannah River as a source for domestic water. The closest downstream water intake to the SRS is that of the Beaufort-Jasper Water Authority at Hardeeville, South Carolina, about 130 river miles downstream of the SRS (WSRC 2000a), which withdraws about 340 L/s (5,390 gpm) of water to service a population of 51,000 people.

Treated effluent is discharged to the Savannah River from upstream communities and from treatment facilities at the SRS. The average annual volume of flow discharged by the sewage treatment facilities at the SRS is about 700 million L (185 million gal). These effluents are released under National Pollutant Discharge Elimination System (NPDES) permits. The SRS has five NPDES permits, two (SC0000175 and SC0044903) for industrial wastewater discharges, two (SCR000000 and SCR1000000) for general storm-water discharges, and one (ND0072125) for land application (DOE 1999). Permit SC0000175 regulates 76 outfalls

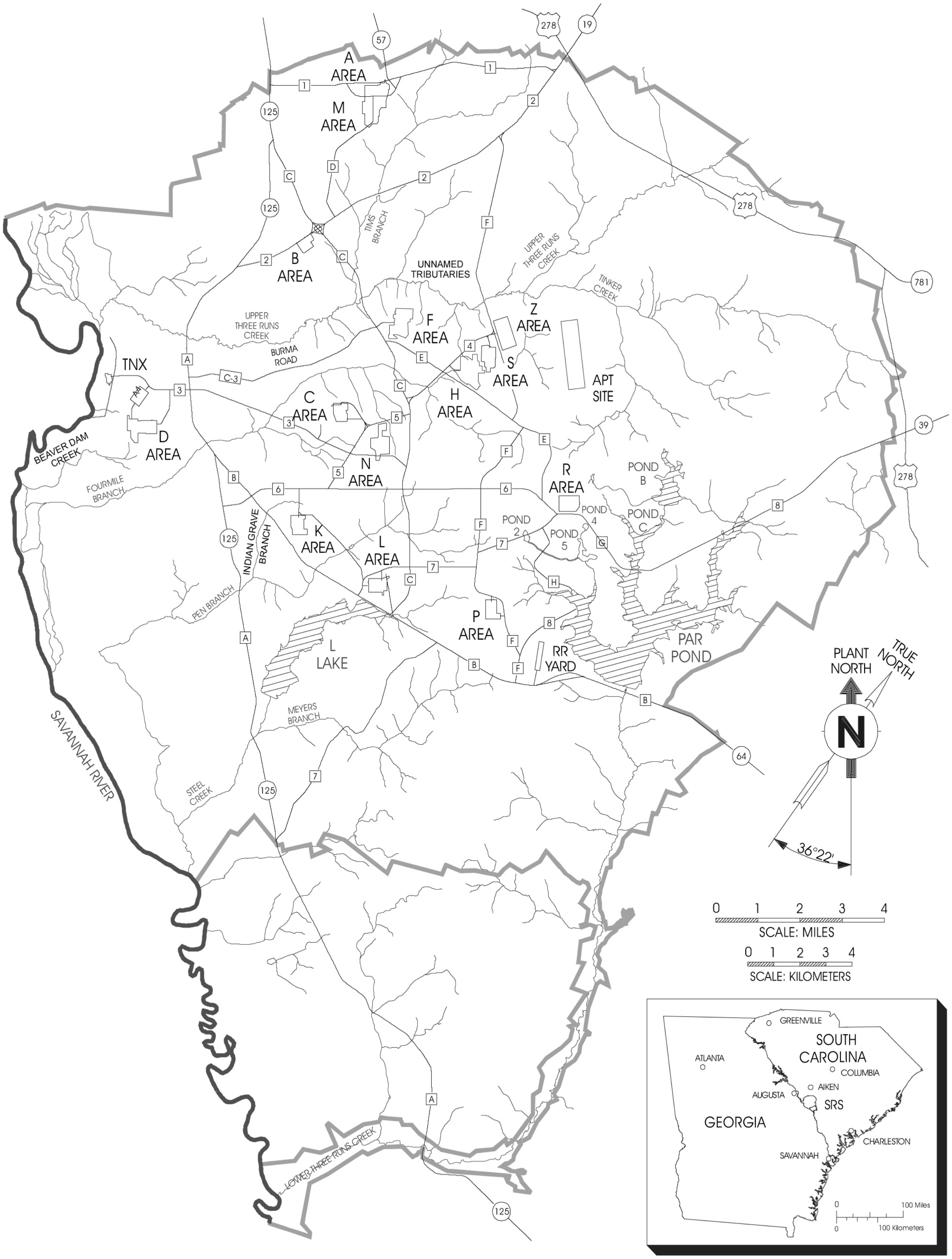

Figure 3.2. Locations of principal surface water features at the SRS (*Source*: DCS 2002).

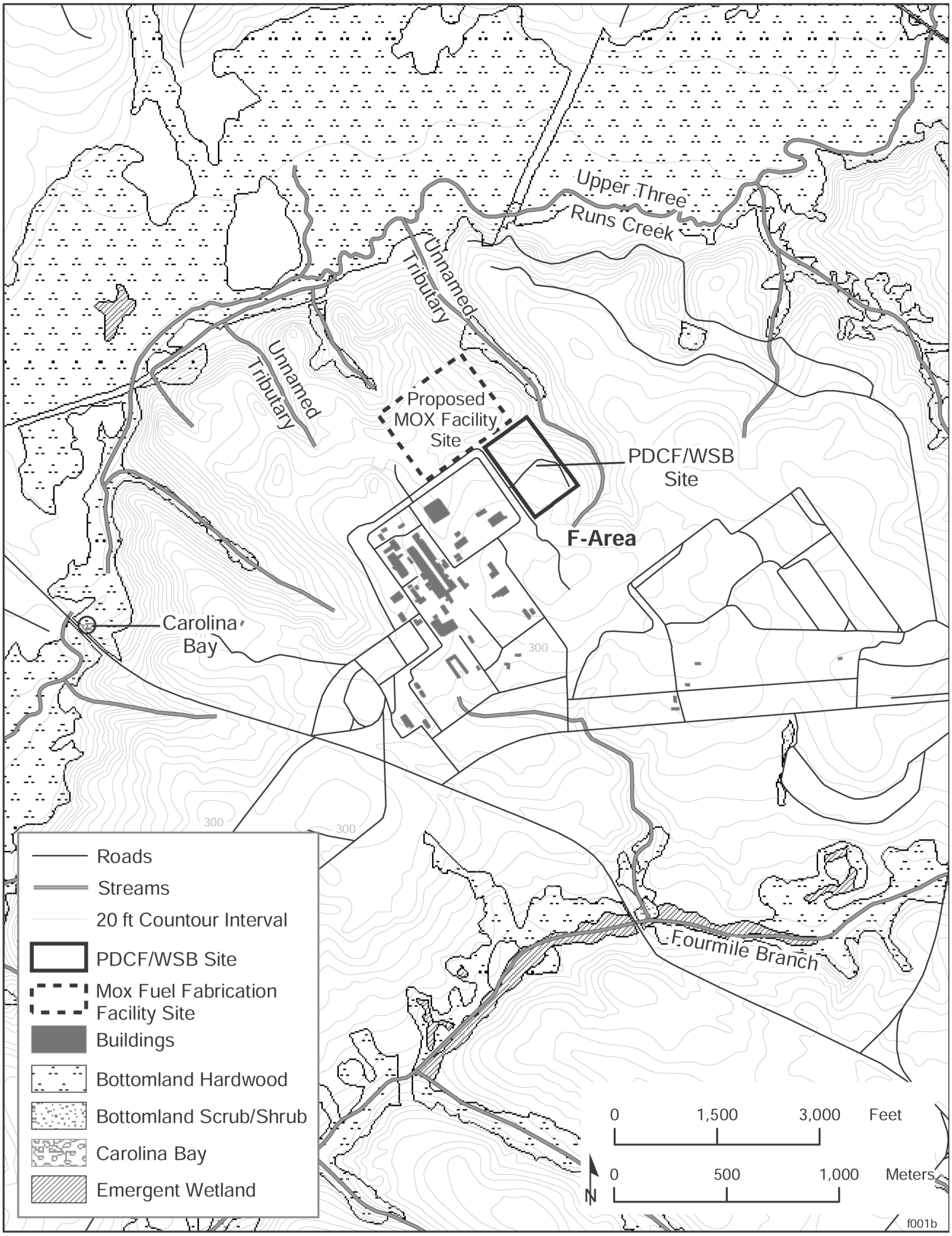

Figure 3.3. Locations of surface water and wetlands in the F-Area (*Source*: Modified from DCS 2002).

(points of discharge); permit SC0044903 regulates another 7 outfalls. The 2000 compliance for these outfalls was 99.7%. The 48 storm-water-only outfalls regulated by the site's storm-water permits are monitored as required. A sediment reduction and erosion plan is required for storm-water runoff from any construction area that exceeds 2 ha (5 acres).

The Savannah River is classified as a freshwater source that is suitable for primary and secondary contact recreation, drinking after appropriate treatment, balanced native aquatic species development, and industrial and agricultural purposes. Primary contact means direct contact with the water, such as while swimming. Secondary contact means having some direct contact with the water but where swallowing is unlikely to occur, such as while fishing. Data from the river's monitoring locations generally indicate that South Carolina's freshwater standards are being met.

Runoff from the land area around F-Area drains to Upper Three Runs Creek and Fourmile Branch (DOE 1999). Runoff from the proposed facilities area drains into unnamed tributaries of Upper Three Runs Creek and flows to the northwest. Runoff from southern portions of the F-Area flow to the southeast into Fourmile Branch. The location for the proposed MOX facility is approximately 670 m (2,200 ft) southeast of Upper Three Runs Creek (WSRC 2000a). An unnamed tributary to Upper Three Runs Creek is located within about 150 m (500 ft) of the proposed MOX facility site (see Figure 3.3). The proposed MOX facility is located about 2,100 m (6,900 ft) north of Fourmile Branch.

Upper Three Runs Creek is a large, cool blackwater stream (i.e., a freshwater stream that has a dark color because of organic debris and tannin-containing compounds) that flows into the Savannah River along the western boundary of the SRS (see Figure 3.2). It drains an area of about 544 km^2 (210 mi^2) and had a mean discharge of 6.9 m^3/s (245 ft^3/s) near its mouth during water year 1995 (WSRC 2000a). A water year is measured from October 1 through September 30. The 7Q10 low-flow is about 2.8 m^3/s (100 ft^3/s). The stream is about 40 km (25 mi) long. It receives water from groundwater aquifer discharges and permitted discharges from several areas at the SRS, including F-Area, S-Area, the Central Sanitary Waste Treatment Facility, and treated industrial wastewater from the Chemical Waste Treatment Facility steam condensate. The stream, however, has never received heated discharges of cooling water from the former SRS production reactors. Flow from the sanitary wastewater discharge averages less than 0.001 m^3/s (0.035 ft^3/s).

Fourmile Branch is a blackwater stream that has been affected by past operational practices at the SRS (DOE 1999). Its headwaters are near the center of the SRS, and it flows southwesterly to the Savannah River. Until June 1985, it received large volumes of hot cooling water from the production reactor in C-Area. While the C-Area reactor was operational, the ambient temperature in Fourmile Branch was 60°C (140°F) (DOE 1999). It has a watershed area of about 54 km^2 (21 mi^2) and receives permitted effluent discharges from F-Area and H-Area. Average flow in the stream is approximately 1.8 m^3/s (64 ft^3/s). The 7Q10 low flow at the same location is about 0.23 m^3/s (8.2 ft^3/s) (WSRC 2000a). In its lower reaches, the stream widens and flows via braided channels through a delta. Downstream of the delta, it reforms into one main channel, with most of the flow discharging into the Savannah River at river mile 152.1; the remainder of the flow enters the Savannah River Swamp.

Under NPDES permit SC0000175, five outfalls discharge effluent to Fourmile Branch. Permitted discharges include 186 basin overflows, cooling water, floor drains, steam condensate, process wastewater, laundry effluent, storm water, sanitary treatment wastewater, ash basin runoff, and lab drains. Within the vicinity of F-Area, there are four permitted outfalls: F2, F3, F4, and F5. Discharge from the F2 outfall averages 0.0048 m^3/s (0.17 ft^3/s). F5 has a flow of 0.0013 m^3/s (0.046 ft^3/s). Outfall F3 is not currently used, but discharges storm water. Outfall F4 is an "administrative outfall" (i.e., an outfall with no pollutant load).

When the Savannah River floods, water from Fourmile Branch flows along the northern boundary of the floodplain and joins with other streams to exit the swamp via Steel Creek instead of flowing directly into the Savannah River. The location for the proposed facilities would not be within the 100-year floodplain of Upper Three Runs Creek (DCS 2002). Similarly, estimated water levels for the probable maximum flood (PMF) for Upper Three Runs Creek are about 15 m (50 ft) below the lowest elevation in F-Area (67 m [220 ft]).

3.3.2 Groundwater

> **Sole Source Aquifer**
>
> - An aquifer that supplies at least 50% of the drinking water to the area above the aquifer.
> - Areas that have no other water supply capable of physically, legally, or economically providing drinking water to local populations.

Several aquifers occur at the SRS (see Figure 3.4). However, no federally designated sole-source aquifers occur there. The uppermost aquifer is known as the Upper Three Runs Aquifer. It occurs at an elevation of about 55 to 67 m (180 to 210 ft) above mean sea level (MSL) in F-Area (DCS 2002). The Upper Three Runs Aquifer lies on top of the leaky Gordon Confining Unit (Green Clay aquitard), which forms a confining layer for the Gordon Aquifer (Congaree Aquifer). The Upper Three Runs Aquifer along with the Gordon Confining Unit and the Gordon Aquifer constitute the Floridan Aquifer System (WSRC 2000a). To the north, the Gordon Confining Unit is not present, and the Gordon and Upper Three Runs Aquifers merge to form the Steed Pond Aquifer. Beneath the Gordon Aquifer is the leaky Crouch Branch Confining Unit (Ellenton aquitard), which, in turn, confines the Crouch Branch Aquifer (Cretaceous Aquifer) (DOE 1999; WSRC 2000a).

Groundwater in aquifers predominantly flows horizontally to points of discharge, such as streams and swamps. In addition, some flow also occurs vertically to either underlying or overlying groundwater aquifers. Groundwater in the Upper Three Runs Aquifer, in general, flows horizontally and discharges to nearby streams. A small portion of the groundwater flows vertically downward to the Gordon Aquifer. Flow in the Gordon Aquifer is mostly horizontal to eventual stream discharge or discharge to the Savannah River, depending on location. Some of the water also flows downward to the underlying Crouch Branch Aquifer. Water in the Crouch Branch Aquifer primarily discharges to Upper Three Runs Creek and the Savannah River. Groundwater beneath the SRS flows slowly at rates that range from inches per year in the clay aquitards that confine the aquifers to several hundred feet per year in the sandy aquifers

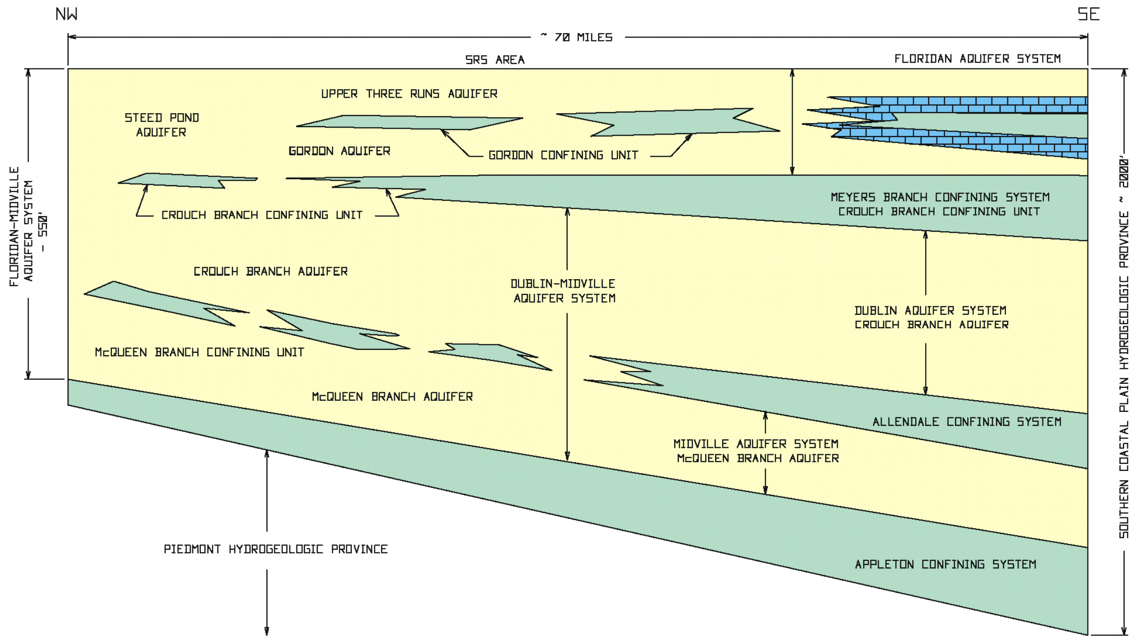

Figure 3.4. Aquifers at the SRS (*Source*: DCS 2001a).

(WSRC 2000c). Average annual recharge to the Upper Three Runs Aquifer is 35.6 cm (14 in.) (WSRC 1997a).

The Crouch Branch Aquifer is an abundant and important water resource for the SRS region. At the SRS, groundwater is the only source of domestic water. All groundwater at the SRS is classified by the U.S. Environmental Protection Agency (EPA) as a Class II water source (i.e., a current and potential source of drinking water). In 2000, the SRS withdrew 7.95 billion L (2.1 billion gal) of groundwater from the Crouch Branch Aquifer in support of site operations. Some nearby towns, such as Aiken, South Carolina, obtain groundwater from the Crouch Branch Aquifer, but most of the rural population draws water from the Gordon, Upper Three Runs, or Steed Pond Aquifers. About 8 billion L/yr (2.1 billion gal/yr) of groundwater is withdrawn from these upper aquifers within a 16-km (10-mi) radius of the site (DCS 2002).

F-Area is located on a groundwater divide between Fourmile Branch and Upper Three Runs Creek. Near-surface groundwater in the southern portion of the F-Area primarily moves laterally and discharges to Fourmile Creek and its tributaries to the south. In the northern portion of the F-Area, including the proposed location of the facilities, near-surface groundwater also primarily moves laterally, but discharges to Upper Three Runs Creek and its tributaries to the north (WSRC 2000c). F-Area is located in a region of groundwater recharge from precipitation.

Beneath the site for the proposed MOX facility, the Upper Three Runs Aquifer is divided into upper and lower zones by the Tan Clay confining unit of the Dry Branch Formation (DCS 2002).

In the area near the proposed MOX facility site, the topography drops sharply to the north toward Upper Three Runs Creek, and the water table occurs in the lower aquifer zone beneath the Tan Clay confining unit. Water table elevation data and computer modeling indicate that shallow groundwater flows away from the Old F-Area Seepage Basin (OFASB) in a north-northwesterly direction and is discharged to a tributary of Upper Three Runs. A small component of this groundwater flows beneath the westernmost corner of the proposed MOX facility site. Depth to groundwater in the area of the OFASB and the proposed MOX facility site ranges from 23.2 to 28.3 m (76 to 93 ft) below the present ground surface. Site preparation for the proposed MOX facility, PDCF, and WSB would involve shallow grading and excavation to a depth of about 12.2 m (40 ft). These activities would not encounter groundwater.

Groundwater varies in quality across the SRS. In some areas, it meets drinking water quality standards; in other areas, such as near waste sites, it does not. The deep Crouch Branch Aquifer is generally unaffected by site operations, except for a location near A-Area, where trichloroethylene contamination has been found. Tritium has been reported in the Gordon Aquifer under the Separation Areas (F- and H-Areas). The Upper Three Runs Aquifer is contaminated with solvents, metals, and low levels of radionuclides near several SRS areas and facilities, including the F-Area.

Groundwater is the only source of domestic water at the SRS. The existing capacity at the SRS is approximately 33.5 billion L/yr (8.9 billion gal/yr). Groundwater rights in South Carolina are associated with the absolute ownership rule. Owners of land overlying a groundwater resource are allowed to withdraw as much water as they desire; however, the state requires users who withdraw more than 138 million L/yr (36.5 million gal/yr) to report their withdrawals. Because the groundwater use at the SRS exceeds this value, DOE is required to report its usage to the state (DCS 2002).

Within F-Area, four groundwater wells are used for process water. Pumping capacities for these wells range from 1,500 to 3,800 L/min (400 to 1,000 gpm). They extract groundwater from the Crouch Branch Aquifer. Two of these wells were formerly used for domestic water supply. The current annual groundwater use at F-Area is 374 million L (98.8 million gal). The estimated capacity of the wells in F-Area is about 4.2 billion L/yr (1.1 billion gal/yr) (DCS 2002).

The F-Area wells are part of a SRS A-Area domestic water loop. The combined capacity of the F-Area and A-Area wells is about 11,360 L/min (3,000 gal/min) (DCS 2003a,b). Water consumption in 2000 averaged 2,850 L/min (754 gal/min). Therefore, an excess capacity of about 8,500 L/min (2,250 gal/min) exists for the A-Area loop. The A-Area loop supplies water to both A-Area and F-Area.

Groundwater quality in F-Area is not significantly different from that of groundwater throughout the rest of the SRS. It is abundant, usually soft, slightly acidic, and low in dissolved solids. F-Area groundwater can exceed drinking water standards for several contaminants. In 1999, 18% of 365 wells sampled at the General Separations and Waste Management Areas (Areas F, E, H, S, and Z) had metal concentrations that exceeded metal drinking water standards; 10% of 471 wells sampled had organic concentrations that exceeded organic drinking water standards; 53% of 483 wells sampled exceeded drinking water standards for tritium; 40% of 372 wells sampled exceeded drinking water standards for other radionuclides; and 31% of 307 wells sampled exceeded drinking water standards for other constituents. The sources of the detected groundwater contamination included burial grounds, waste management facilities, canyon buildings, seepage basins, and saltstone disposal facilities (WSRC 2000c).

Near the F-Area seepage basins and inactive process sewer line, there is widespread radionuclide contamination. Near the F-Area Tank Farm, tritium, mercury, nitrate-nitrite (as nitrogen), cadmium, gross alpha, and lead were detected in concentrations that exceeded drinking water standards in one or more wells. At the Sanitary Sludge Application Site, tritium, specific conductance, lead, and copper values exceeded their drinking water standards in one or more wells. In addition, a subsurface plume of tritium and strontium contamination has recently been found in F-Area. The source of groundwater contamination is from various heavy industrial and nuclear operations over the past 50 years in the F-Area. The contaminant plume appears to originate inside F-Area and extend beneath the MOX facility site, with movement in a fan-like direction of groundwater flow under the proposed MOX facility site.

Contaminated groundwater also exists beneath the OFASB. The OFASB is located about 180 m (600 ft) north of F-Area, immediately adjacent to the western boundary of the proposed MOX facility site. The OFASB has been remediated by filling the basin with clean soil, capping, and stabilizing the contaminated soil within the basin with grout (WSRC 1997a). The results of sampling in the compliance wells for the OFASB indicated that concentrations of several target constituents were above drinking water standards in several wells. These contaminants included iodine-129, nitrate, radium-226, radium-228, strontium-90, tritium, uranium (total), and lead. There is, however, some uncertainty about whether these exceedances are related entirely to OFASB, to upgradient F-Area facilities, or to both. A small component of the contaminant plume from OFASB flows beneath the westernmost corner of the proposed MOX site. Groundwater is monitored on a regular basis with 15 wells. Contaminant fate and transport models predict that the aquifer is expected to return to an uncontaminated state (i.e., a condition in which no maximum contaminant levels are exceeded) within 2 to 115 years, depending on the specific contaminant.

The results of recent groundwater sampling of nine wells distributed uniformly across the proposed MOX facility site indicate that shallow groundwater (i.e., groundwater in the Upper Three Runs Aquifer) is contaminated (SRS 2002). Gross alpha and beta activity, tritium, uranium, and trichloroethylene exceeded maximum contaminant levels for drinking water. Contamination is present beneath the entire MOX site, but is greatest beneath the western edge of the site. The contaminant plume appears to originate inside the F-Area fence and was and is related to F-Area nuclear operations and waste management practices at OFASB.

Groundwater in the Upper Three Runs Aquifer beneath the proposed MOX facility site is contaminated with various heavy industrial and nuclear contaminants. The proposed construction activities will take place at least 9.1 m (30 ft) above the zone of contaminated groundwater.

3.4 Meteorology, Emissions, Air Quality, and Noise

This section discusses the existing meteorology, current airborne pollutant emissions, air quality, and noise environment in the vicinity of the SRS. Section 3.4.1 describes the meteorology, or weather conditions, around the SRS. Meteorology includes the atmospheric conditions that determine where pollutants released into the atmosphere travel and how they are mixed with existing air and become diluted as they travel. Section 3.4.2 describes existing air emissions from the SRS and the surrounding area. Section 3.4.3 describes regional air quality and air quality standards. Air emissions from the proposed MOX facility, the PDCF, and the WSB would combine with existing emissions to affect local and regional air quality. Comparing the resulting combined air quality against the standard levels provides one measure of the facilities' impact on air quality. Section 3.4.4 describes the existing noise environment and applicable regulations. Noise generated by the facilities would combine with existing levels to produce the overall noise impact.

3.4.1 Meteorology[2]

To provide a thorough picture of weather conditions at a given location often requires the use of data from several locations. Different locations that record meteorological data may record different parameters. Data recorded near the site of the proposed action is generally considered most representative of the site. Meteorological data for F-Area (the site of the proposed facilities), H-Area, and Bush Field in Augusta, Georgia, were used to describe meteorological conditions of the affected environment.

Meteorology

Meteorology deals with weather conditions. Air pollution meteorology emphasizes weather conditions that determine how pollutants released into the air travel and mix with the air. The more important weather conditions involved in this process include wind speed and direction and atmospheric stability, a measure of how much mixing is occurring in the atmosphere.

The climate at the SRS is characterized by short, mild winters and long, humid summers (DCS 2002). Mountains to the north and west prevent or delay the approach of many cold air masses (Ruffner 1985).

The annual average wind speed is 2.8 m/s (6.2 mph) at Bush Field, which is located in Augusta, Georgia, about 24 km (15 mi) northwest of F-Area. Wind speed is highest in the spring, averaging 3.1 m/s (7.0 mph). March has the highest monthly average wind speed of 3.4 m/s (7.7 mph) and August the lightest, 2.3 m/s (5.1 mph). The prevailing monthly wind direction is from the west-northwest from November through February and variable for the rest of the year. On the basis of observations for 1995-1999, the highest 2-minute wind speed was 20 m/s

[2] Unless otherwise noted, the information presented in this section is based on meteorological data collected at Bush Field in Augusta, Georgia, about 24 km (15 mi) northwest of F-Area, and summarized by the National Climatic Data Center (NOAA 1999).

(45 mph) from the north-northwest in June 1998, and the maximum gust (5-second wind speed) was 25 m/s (55 mph) from the north-northwest in April 1997.

A wind rose based on data from the 5-year period 1992 through 1996 from the 62-m (200-ft) meteorological tower in H-Area at the SRS is presented in Figure 3.5. The wind rose indicates no strongly predominant prevailing wind direction, but the wind is from the northeast about 10% of the time and from the west-southwest over 9% of the time. Annual average wind speeds ranged from 3.6 to 4.2 m/s (8.0 to 9.4 mph) during the 5-year period (DCS 2002).

Wind Rose

A *wind rose* summarizes wind speed and direction graphically as a series of bars pointing in different directions. The direction of a bar shows the direction *from* which the wind blows. Each bar is divided into segments. Each segment represents wind speeds in a given range of speeds, for example, 6-8 m/s. The length of a given segment represents the percentage of the summarized hours that winds blew from the indicated direction with a speed in the given range.

The driest period occurs during the months of October and November, with rainfall increasing after then to a peak in March. A dry period extends from April through early June, followed by a wet period from late June through early September caused primarily by thunderstorms and showers (Ruffner 1985). Average annual precipitation at Bush Field is 114 cm (44.7 in.). Data from 1967 to 1996 at the SRS show an average annual precipitation of 126 cm (49.5 in.) (DCS 2002). Average monthly precipitation ranges from 6.30 cm (2.48 in.) in November to 11.8 cm (4.65 in.) in March. The greatest amount of precipitation recorded in a single month was 37.6 cm (14.8 in.) in October 1990, and the least amount was in October 1953, when only trace amounts of rainfall were recorded. The greatest amount of precipitation recorded in a 24-hour period was 21.8 cm (8.57 in.) in October 1990. Snowfall occurs only one to three times in the winter and usually remains on the ground for only a short period (Ruffner 1985). Annual snowfall averages 3.3 cm (1.3 in.). The greatest monthly snowfall occurred in February 1973, with 35.6 cm (14.0 in.), and the greatest 24-hour snowfall was 34.8 cm (13.7 in.) in the same month. Freezing rain may occur one to three times per winter (Ruffner 1985).

The average annual temperature at Bush Field is 17.5°C (63.5°F). At the SRS, the average annual temperature is 17.3°C (63.2°F) (DCS 2002). January is the coldest month, with an average temperature of 7.39°C (45.3°F), and July the warmest, averaging 26.7°C (80.1°F). Daily extreme temperatures have ranged from 42.2°C (108°F) in August 1983 to -18°C (-1°F) in January 1985. An average of 309 freeze-free days (days with a minimum temperature greater than 0°C [32°F]) occur per year. There are no freeze days from May through September. Temperatures above 32°C (90°F) occur about 73 days per year, with 56 of them occurring in June, July, and August.

Average annual relative humidity at Bush Field ranges from 83% in the early morning to 51% in the afternoon. In July and August, the early morning relative humidity averages 90%, with afternoons averaging 55-56%. At the SRS, comparable values for August are 97% and 50% (DCS 2002). Dew point temperatures at Bush Field range from 1.33°C (34.4°F) in January to 21.0°C (69.7°F) in July. Heavy fog with visibility less than 0.40 km (0.25 mi) occurs on an

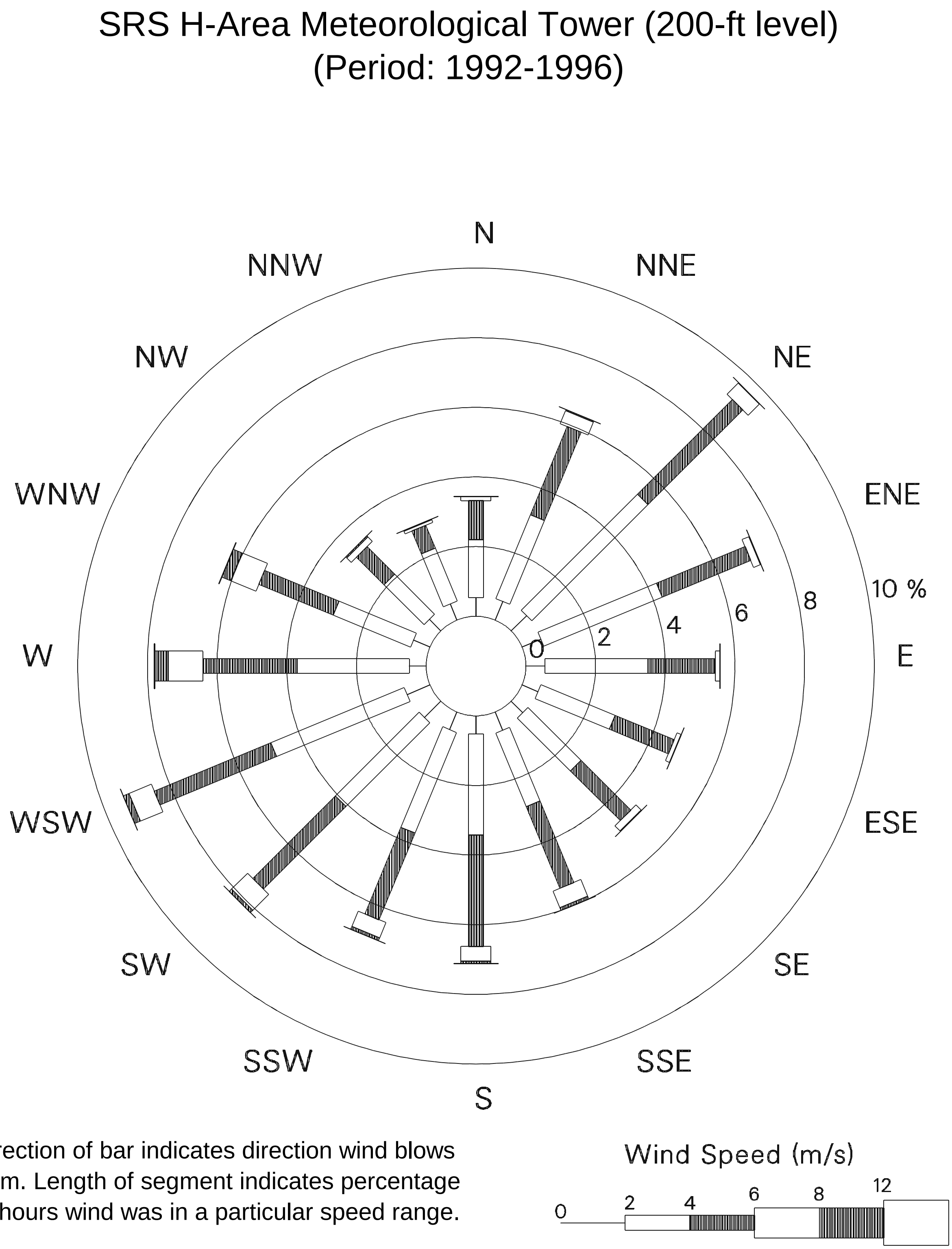

Figure 3.5. Annual wind rose for the SRS (*Source*: Arnett and Mamatey 2000a, Table 31).

average of about 32 days per year. Heavy fog occurs throughout the year but is most likely in November and December.

Thunderstorms, tornadoes, and hurricanes provide occasional severe weather to South Carolina (Ruffner 1985). Thunderstorms occur on an average of 53 days per year at Bush Field. July averages 12.6 thunderstorm days, December 0.7. More than 70% of the thunderstorms occur in the four-month period from May through August. They are most common in the summer months, but the more violent storms generally occur along active cold fronts in spring (Ruffner 1985). Hail with thunderstorms is infrequent and occurs about once every 2 years on the average (DCS 2002).

Tornadoes are rare in South Carolina. Most that do occur are during the period March through June. April is the peak month for tornadoes, with a smaller peak in August and September (Ruffner 1985). For the 49-year period of 1950-1998, an average of 11 tornadoes per year occurred in South Carolina (Storm Prediction Center 2001). Between 1880 and 1995, a total of 17 significant tornadoes were reported in Aiken and Barnwell Counties, South Carolina, and Burke County, Georgia. Nine tornadoes have caused damage on the SRS, one with estimated wind speeds as high as 67 m/s (150 mph). None have caused damage to buildings on the SRS (DCS 2002).

Tropical storms or hurricanes affect South Carolina about once every 2 years. Most do little damage and affect only the costal areas, decreasing in intensity as they move inland. Those that do move far inland can cause considerable flooding (Ruffner 1985). Thirty-six hurricanes caused damage in South Carolina between 1700 and 1989, and the interval between them has ranged from 2 months to 27 years. About 80% have occurred in August and September. Between 1886 and the present, 17 storms (10 hurricanes and 7 tropical storms) have passed within 64 km (40 mi) of the proposed MOX facility site. All the hurricanes had been downgraded to tropical storms or tropical depressions before reaching SRS (Weather Site, Inc. 2003). The only hurricane-force winds measured at the SRS were associated with Hurricane Gracie on September 29, 1959, when wind speeds of 34 m/s (75 mph) were measured at F-Area (DCS 2002).

3.4.2 Emissions

The SRS is classified as a “major source” (of airborne pollutant emissions) under the Clean Air Act (CAA), with potential emissions of more than 227,000 kg/yr (250 tons/yr). The SRS has construction and operating permits from the South Carolina Department of Health and Environmental Control (SCDHEC), Bureau of Air Quality, for about 199 point sources. Thirty-eight of these sources are permitted for air toxics. During 2000, 137 sources operated at least part of the year, and 62 were on cold standby or under construction.

Significant sources of criteria air pollutants[3] or their precursors and toxic air emissions at the SRS include coal-fired powerhouse boilers (two in A-Area and three in H-Area) and No. 2 oil-fired package steam generators (two in K-Area and two portable units). Other facilities emitting nonradiological emissions include 128 pieces of equipment powered by diesel engines, the Defense Waste Processing Facility, groundwater air strippers, the Consolidated Incineration Facility, and controlled burning. During 2000, the SRS continued to be in compliance with permitted emission rates and special conditions (Arnett and Mamatey 2001b).

SRS point source emissions for 1999 are compared with point source and total emissions within the four surrounding counties — Aiken, Allendale, and Barnwell Counties in South Carolina and Burke County in Georgia — in Table 3.1. The SRS contributed less than 6% of the four-county point source emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter less than 10 μm and less than 2.5 μm in diameter, (PM_{10} and $PM_{2.5}$, respectively) in 1999. The SRS contributed about 17% of the four-county area point source emission of carbon monoxide (CO). However, CO is generated primarily by mobile sources, and the SRS emitted only about 0.20% of the total point and nonpoint CO for the four-county area. Arnett and Mamatey (2001a) provide an inventory of about 200 toxic air pollutant emissions from the SRS for 1999. Table 3.2 lists the emissions that exceeded 0.9 MT (1 ton) per year.

3.4.3 Air Quality

The SRS is located in the Augusta-Aiken Interstate Air Quality Control Region (AQCR) #53, which comprises 6 counties in South Carolina and 13 in Georgia (see Figure 3.6) (EPA 1972). Both South Carolina and Georgia have adopted State Ambient Air Quality Standards (SAAQS) identical to the federal National Ambient Air Quality Standards (NAAQS) for the criteria pollutants (see adjacent text box). In addition, South Carolina has retained the annual standard for total suspended particulates (TSP) and adopted an additional standard for gaseous fluorides (SCDHEC 2000; GDNR 2000).

Air Quality Terms

Particulate matter (PM) is dust, smoke, other solid particles, and liquid droplets in the air. The size of the particulate is important and is measured in micrometers (μm). A micrometer is 1 millionth of a meter (0.000039 in.).

Total suspended particulate (TSP) is PM with a diameter less than 30 μm. PM_{10} is PM with a diameter less than 10 μm and $PM_{2.5}$ is PM with a diameter less than 2.5 μm. The U.S. Environmental Protection Agency (EPA) has set standards for PM_{10} and $PM_{2.5}$ designed to protect human health and welfare.

Criteria pollutants are pollutants for which the EPA has prepared documents detailing their health and welfare impacts and set standards specifying the air concentrations that avoid these impacts. The criteria pollutants are sulfur oxides, nitrogen dioxide, carbon monoxide, PM_{10}, $PM_{2.5}$, lead, and ozone.

Volatile organic compounds (VOCs) are organic vapors in the air that can react with other substances, principally nitrogen oxides, to form ozone. The reactions are energized by sunlight.

Background is a concentration value, usually based on measured pollutant data, that accounts for the impacts of emission sources not included explicitly in the air quality model.

3 "Criteria" air pollutants are common air pollutants for which federal standards have been established.

Table 3.1. Estimated emissions from four counties around the SRS and SRS point sources in 1999[a]

	Four-county area emissions (tons/yr)[b]		SRS emissions		
				As percentage (%) of four-county area	
Pollutant[c,d]	**Point**	**Total**	**Total (tons/yr)**	**Point**	**Total**
CO	712	62,300	124	17	0.20
NO_x	6,800	17,700	337	5.0	1.9
SO_2	14,600	15,400	346	2.4	2.3
PM_{10}	1,250	1,747	54.5	4.4	3.1
$PM_{2.5}$	696	1,120	37.9	5.4	3.4
VOCs	1,770	8,330	7.45	0.42	0.089

[a]Four SRS border counties: Aiken, Barnwell, and Allendale, South Carolina; and Burke, Georgia. "Point" values are for all point sources. "Totals" are for all sources, including point, area, and mobile.

[b]To convert tons to kilograms, multiply by 907.2.

[c]The reference does not include lead. Lead emissions have been lowered by reductions in the lead content of gasoline.

[d]Ozone is not emitted directly and is not listed in this table. It is formed in the air by chemical reactions involving VOCs and NO_x.

Source: EPA (2001).

South Carolina is currently designated as being in attainment (i.e., in compliance with standards) for all criteria pollutants (40 CFR 81.341). Georgia is designated as in attainment except for the 13-county area around Atlanta, which is designated as nonattainment for the 1-hour ozone standard (40 CFR 81.311). A list of the ambient standards and the high and low ambient concentrations at air quality monitoring stations within 80 km (50 mi) of the proposed MOX facility site is shown in Table 3.3. The regulations for Prevention of Significant Deterioration (PSD) of air quality (40 CFR 52.21) place limits on the total

National Ambient Air Quality Standards (NAAQS)

The EPA sets NAAQS for criteria pollutants (sulfur oxides, PM_{10}, $PM_{2.5}$, carbon monoxide, nitrogen dioxide, lead, and ozone). The primary NAAQS specify maximum ambient (outdoor air) concentrations of the criteria pollutants that would protect public health with an adequate margin of safety. Secondary NAAQS specify maximum concentrations that would protect public welfare. If both a primary and a secondary standard exist, the lower (more restrictive) standard is normally used for assessment purposes. Some of the NAAQS for an averaging time of 24 hours or less allow the standard values to be exceeded a limited number of times per year.

Table 3.2. Toxic air pollutant emissions at the SRS in 1999

Pollutant[a]	CAS number[b]	Emissions (tons/yr)[c]
Benzene	71-43-2	4.16
Chloroform	67-66-3	6.30
Formaldehyde	50-0-0	1.28
Formic acid	64-18-6	3.45
Hexane	110-54-3	1.14
Hydrochloric acid	7647-1-0	1.73
Hydrogen sulfide	7783-6-4	5.71
Methoxychlor	67-56-1	1.46
Nitric acid	7697-37-2	1.04
Sodium hydroxide	1310-73-2	1.32
Tetrachloroethylene	127-18-4	2.17
Toluene	108-88-3	1.87
Trichloroethylene	79-1-6	5.53
Xylenes	1330-20-7	4.96

[a]Only pollutants with emissions of more than 1 ton are listed.

[b]Chemical Abstract Services (CAS) number — a number assigned to a specific chemical by CAS. The number avoids the ambiguity associated with multiple names for the same chemical and also avoids problems associated with name differences between languages.

[c]To convert tons to kilograms, multiply by 907.2.

Source: Arnett and Mamatey (2001a, Table 45).

increase in ambient pollution levels above established baseline levels for SO_2, NO_2, and PM_{10}. Under those regulations, the allowable increases are smallest in Class I areas (national parks and wilderness areas). The rest of the country is subject to PSD II increments. States can choose a less stringent set of Class III increments, but no states have chosen to do so. The Cape Romain National Wildlife Refuge, the PSD Class I area closest to the SRS, is about 160 km (100 mi) to the east. The facilities at the SRS have not been required to obtain PSD permits (DCS 2002).

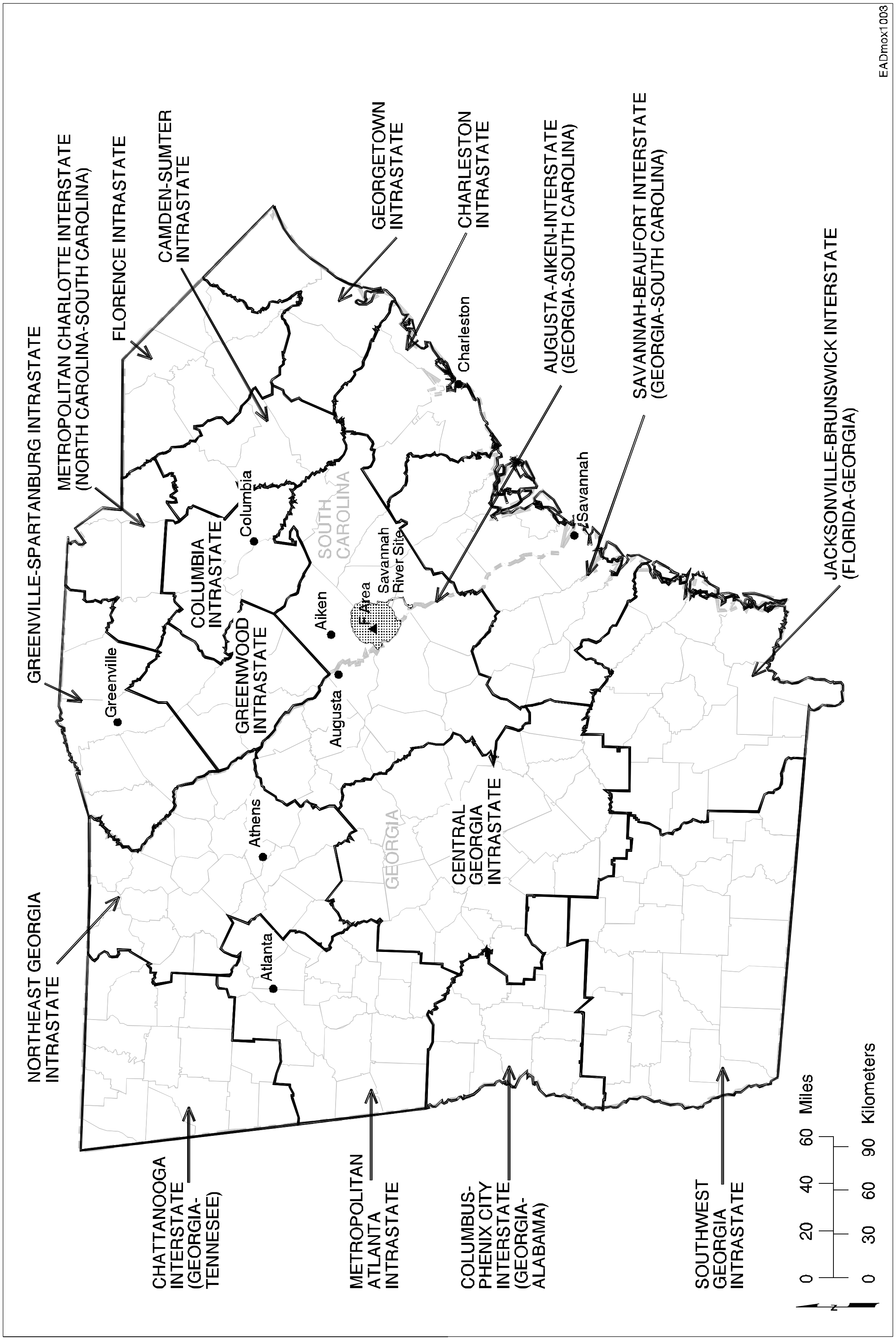

Figure 3.6. Air quality control regions, South Carolina and Georgia.

Table 3.3. Ambient air quality standards and range of pollutant levels in the vicinity of the SRS

Pollutant	Averaging time	Ambient standard ($\mu g/m^3$)[b,c]	Highest/lowest levels in vicinity of SRS[a]		
			Concentrations ($\mu g/m^3$)	Locations (city, county, state)	Years
SO_2	3 hours	1,300[d]	180	–, Barnwell, SC	1999
			58	–, Barnwell, SC	1997
	24 hours	365[e]	55	Augusta, Richmond, SC	1997-2000
			13	–, Barnwell, SC	1997-1998
	Annual	80[e]	5.2[f]	–, Aiken, SC/ Augusta, Richmond, GA	1999/ 1997-2000
			2.6[f]	–, Aiken, SC/ –, Barnwell, SC	1996-1998/ 1997-2001
NO_2	Annual	100[g]	9.4	–, Aiken, SC	1997-2000
			5.6	–, Barnwell, SC	1999, 2001
CO	1 hour	40,000[e]	–[h]		–
	8 hours	10,000[e]	–[h]		–
O_3	1 hour	235[g]	233[i]	Augusta, Richmond, SC/ –, Edgefield, SC	1998/1998
			165[i]	–, Edgefield, SC	2001
	8 hours[j]	157[g]	194[k]	Augusta, Richmond, SC	1998
			145[k]	–, Barnwell, SC	2001
PM_{10}	24 hours	150[g]	165[i]	–, Lexington, SC	1997
			36[i]	–, Aiken, SC	2001
	Annual	50[g]	29	–, Lexington, SC	1999
			17	–, Aiken, SC	2001

Table 3.3. Continued

Pollutant	Averaging time	Ambient standard (μg/m³)[b,c]	Highest/lowest levels in vicinity of SRS[a]: Concentrations (μg/m³)	Locations (city, county, state)	Years
$PM_{2.5}$	24 hours[j]	65[g]	42[l]	Augusta, Richmond, GA	1999
			17[l]	–, Colleton, SC	2000
	Annual[j]	15[g]	19.9	Augusta, Richmond, GA	1999
			11.2	–, Colleton, SC	2000
Pb	Calendar Quarter	1.5[g]	0.04	–, Lexington, SC	1999
			0.00	Multiple	1997-2001
TSP[m]	Annual	75[e]	41[n]	–, Aiken, SC	1998
			26[n]	–, Lexington, SC	2001

[a]Based on available data for 1997 through 2001 unless otherwise noted. The vicinity of the SRS was taken to be the area within 80 km (50 mi) of the proposed MOX facility and includes all or part of Aiken, Bamberg, Barnwell, Colleton, Edgefield, Hampton, Lexington, and Orangeburg Counties in South Carolina and Burke, Columbia, Jenkins, Richmond, and Screven Counties in Georgia. The listed concentrations are not always directly comparable to the ambient standards. Except for 13 counties around Atlanta, Georgia, that are nonattainment for 1-hour O_3, both South Carolina and Georgia have been designated as in attainment for all implemented standards. Footnote b summarizes criteria for determining standard attainment.

[b]Unless otherwise noted, South Carolina and Georgia SAAQS are the same as NAAQS. South Carolina has additional standards for gaseous fluorides that are not shown because they are not emitted by the proposed facility.

Footnotes continued on next page.

Table 3.3. Continued

[c]Methods of determining whether standards are attained depend on pollutant and averaging time. The 3-hour and 24-hour SO_2 standards and the 1-hour and 8-hour CO standards are not to be exceeded more than once per calendar year. The annual TSP, SO_2, and NO_2 standards are not to be exceeded in any calendar year. The lead standard is not to be exceeded in any calendar quarter. The 1-hour ozone (O_3) standard is attained when the expected number of days per calendar year with maximum hourly concentrations above the standard is less than or equal to one and applies only in areas designated nonattainment when the 8-hour O_3 standard was adopted in July 1977. The 8-hour O_3 standard is attained when the 3-year average of the annual fourth-highest daily maximum 8-hour concentrations is less than or equal to the standard. The 24-hour PM_{10} standard is attained when the expected number of days per calendar year with a 24-hour average concentration above the standard is less than or equal to one. In areas that meet certain criteria, attainment of the 24-hour PM_{10} standard is based on having the 3-year average of the 99th percentile 24-hour averages less than or equal to the standard. The annual PM_{10} standard is met when the 3-year average of the annual means is less than or equal to the standard. The 24-hour $PM_{2.5}$ standard is met when the 3-year average of the 98th percentile 24-hour averages is less than or equal to the standard. The annual $PM_{2.5}$ standard is met when the 3-year average of the annual means is less than or equal to the standard.

[d]Secondary (welfare-based) standard.

[e]Primary (health-based) standard.

[f]Years 2000 and 2001 data for Aiken County not available; years 1999 and 2000 data for Richmond County not available.

[g]Primary and secondary standard.

[h]No CO data in vicinity of SRS for 1997-2001.

[i]Second highest concentration.

[j]NAAQS only; implementation of the standard has been delayed, and states have not developed attainment plans.

[k]Fourth highest concentration.

[l]98th percentile concentration.

[m]South Carolina standard.

[n]Based on South Carolina data for 1998-2001.

Sources: 40 CFR 50; SCDHEC (2002a-d); EPA (2002, 2003a).

3.4.4 Noise

The *Noise Control Act of 1972* and subsequent amendments (*Quiet Communities Act of 1978,* 42 U.S.C. 2901-4918) delegate the authority to regulate noise to the states. However, South Carolina and Georgia do not have noise regulations. The Aiken County Zoning and Development Standards Ordinance limits noise levels by frequency band (see Table 3.4). The EPA guideline recommends an L_{dn}[4] of 55 dBA[5] to protect the public from the effects of noise in typically quiet outdoor and residential areas (EPA 1974). To protect the general population against hearing loss, the EPA guideline recommends an $L_{eq}(24)$[6] (L_{eq} averaged over 24 hours)

Table 3.4. Aiken County maximum allowable noise levels[a]

Frequency band (Hz)	Nighttime[b] sound pressure level at property boundary (dB)	
	Nonresidential	Residential
20-75	69	65
75-150	60	50
150-300	56	43
300-600	51	38
600-1,200	42	33
1,200-2,400	40	30
2,400-4,800	38	28
4,800-10,000	35	20

[a]This table gives nighttime sound pressure levels (SPLs). Allowable daytime levels are generally louder than nighttime levels.

[b]Nighttime: 9:00 p.m. to 7:00 a.m.

Source: DOE (1996).

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4 L_{dn} is a 24-hour average sound level that gives additional weight to noise that occurs during the night (10:00 p.m. to 7:00 a.m.).

5 dBA is A-weighted decibels, a unit of weighted sound-pressure level measured by specific methods and using the A-weighting specified by the American National Standards Institute (ANSI). It duplicates the ear's sensitivity to sound.

6 For sounds that vary with time, L_{eq} is the steady sound level that would contain the same total sound energy as the time-varying sound over a given time.

of 70 dBA or less over a 40-year period. The Federal Aviation Administration and the Federal Interagency Committee on Urban Noise have issued land use compatibility guidelines indicating that yearly day-night average sound levels (L_{dn}) of less than 65 dBA are compatible with residential land uses and that, if a community determines it is necessary, levels up to 75 dBA may be compatible with residential uses and transient lodgings (but not mobile homes) if such structures incorporate suitable noise reduction features (14 CFR 150, Appendix A).

Major noise sources in active areas at the SRS include industrial facilities and equipment such as cooling systems, transformers, engines, vents, paging systems; construction and materials-handling equipment; and vehicles. Outside of active operational areas, vehicles and trains generate noise. Most industrial facilities at the SRS are located far enough from the site boundary that the associated noise levels at the boundary would be barely distinguishable from background levels.

Noise impacts to the general public arise primarily from transportation of people and materials to and from the site by vehicles, helicopters, and trains (DCS 2002). A noise survey was conducted in the SRS area in 1989 and 1990 (NUS 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 51 to 70 dBA. Summer 24-hr L_{eq} levels ranged from 60 to 67 dBA; winter values ranged from 54 to 65 dBA.

3.5 Ecology

This section describes the plant and animal resources at the SRS, with emphasis on those components that could be affected by the construction and operation of the proposed MOX facility and associated Pit Disassembly Conversion Facility/Waste Storage Building (PDCF/WSB) complex. Particular attention is given to species and special habitats protected by the federal government under the Endangered Species Act, as well as species of special concern listed by the states of South Carolina (Aiken and Barnwell counties) and Georgia (Burke County). In addition to federal and state regulations, DOE protects plants, animals, and Carolina bays in DOE Research Set-Aside Areas. Unless otherwise cited, the information presented in this section has been abstracted from DCS (2002).

Ecological Resources

Ecological resources include plant and animal species and the habitats on which they depend (e.g., forests, fields, wetlands, streams, and ponds).

3.5.1 Terrestrial

This section describes the native plant communities and wildlife species at the SRS and in the F-Area where the proposed facilities would be constructed. Wildlife habitats, wildlife management areas, and ecological research sites are also described.

3.5.1.1 Vegetation

At the time land for the SRS was purchased by the government in 1950, about 40% of the site was old field, crop land, or developed by the former town of Ellenton. The remainder of the area was forested (WSRC 1994). As the DOE developed the SRS, the vegetation changed over time. Many of the old fields reverted back to forested areas. In addition, this increase in wooded area also resulted from timber and watershed protection management directed by the U.S. Forest Service (WSRC 1994; DOE 1999).

In 1972, the entire SRS was designated as the nation's first National Environmental Research Park (NERP). Thirty specified areas within the SRS are designated as DOE Research Set-Aside Areas that are reserved for ecological research. These areas total 5,672 ha (14,005 acres), or about 7% of the SRS (Davis and Janecek 1997), and are selected and managed by the Savannah River Ecology Laboratory (SREL) (WSRC 1994). They serve as control areas, providing a context for comparisons with other areas on the SRS that may be affected by human activities. The set-aside areas are located in each of the major vegetation communities characteristic of the SRS (DOE 2000b). The closest set-aside area to the proposed facilities is Set-Aside Area No. 13 (Organic Soils), located about 500 m (1,640 ft) northwest of the proposed facilities. Most of this 310.8-ha (767.3-acre) area is located on the north side of Upper Three Runs Creek. Set-Aside Area No. 15 (Whipple/Office of Health and Environmental Research [OHER] Study Site) is located about 1.8 km [1.1 mi] northeast of the proposed facilities, and three other set-asides (No. 1 [Field 3-412/Ellenton Bay], No. 6 [Beech-Hardwood Forest], and No. 14 [Mature Hardwood Forest]) are located more than 3.4 km (2.1 mi) southwest of the facility area. Upper Three Runs Creek borders or runs through these set-aside areas (Davis and Janecek 1997).

In June 1999, the DOE designated a 4,055-ha (10,012-acre) area of the SRS as a biological and wildlife refuge. This area, known as the Crackerneck Wildlife Management Area (WMA) and Ecological Preserve (Crackerneck WMA), is located in the western portion of the SRS. It is bordered by a narrow buffer zone along South Carolina State Route 125 and by Upper Three Runs Creek. The South Carolina Department of Natural Resources (SCDNR) manages this area (DOE 2000b).

Currently, nearly 90% of the land (72,900 ha [180,000 acres]) at the SRS is forested with upland pine, hardwood, mixed (pine and hardwood), and bottomland hardwood forests. The major upland and wetland forest types at the SRS (including major species and coverage) are listed in Table 3.5. Pine forests cover about 65% of the upland areas of the SRS (DOE 1999). These pine forests are managed by the U.S. Forest Service and have displaced much of the upland hardwood communities (DOE 1991a). Natural resource management is actively practiced on more than 80% of the SRS, including about 73,710 ha (182,000 acres) of commercial forests and 4,860 ha (12,000 acres) of nonforest lands (DOE 2000b; WSRC 1994).

Approximately 5% of land at the SRS is developed with industrial and transportation infrastructure and grassland, old fields, or shrub vegetation (WSRC 1994). This land is generally classified as "facility." The industrial and transportation development includes administrative and production facilities, electrical substations, roads, and railroads and occupies

Table 3.5. Major forest types at the SRS

Forest type	Canopy species	Midstory species	Coverage [hectares (acres)]
Upland Forests			
Dry longleaf pine-scrub oak	Longleaf pine (sparse)	Oaks, black cherry, common persimmon (continuous)	3,058 (7,551)
Longleaf pine	Longleaf pine, loblolly pine, water oak	Black cherry, common persimmon, sand hickory, sassafras, water oak	15,533 (38,353)
Mixed yellow pine	Loblolly, slash and/or longleaf pines	American holly, black cherry, common persimmon, sand hickory, sassafras, water oak, sweetgum, red maple, redbay, sweetbay magnolia	27,020 (66,716)
Southern mixed hardwood	Oaks (white, scarlet, laurel, post, southern red, turkey, bluejack, blackjack), hickories (mockernut, pignut), yellow poplar, blackgum, red maple, sweetgum, white ash, pines (loblolly, longleaf)	Sparkleberry, vaccinium, American holly, black cherry, mockernut hickory, white ash, sassafras, dogwood, Georgia hackberry	12,805 (31,618)
Wetland Forests			
Bottomland	Oaks (water, laurel, overcup, willow), southern magnolia, sweetgum, elms (American, winged), red maple, yellow poplar, river birch, tag alder, waxmyrtle, loblolly pine	American holly, redbay, sweetbay magnolia, ironwood, southern hackberry, red buckeye, honeysuckle	12,531 (30,941)
Southern swamp	Bald cypress, water tupelo, sweetgum	Ashes (water, red), sourgum, red maple, American elm	4,285 (10,581)
Total:			75,232 (185,760)

Sources: DOE (1991a, 2000b); Workman and McLeod (1990); WSRC (1994).

about 1,587 ha (3,919 acres). Vegetated areas associated with the developed areas are actively maintained (lawns and landscaped areas). These associated vegetated areas occur primarily on power line rights-of-way, roadsides, some borrow pits, some burial sites, and in forest openings and occupy about 1,345 ha (3,322 acres) (DOE 2000b). Unless managed, most scrub-shrub areas will develop into forest within 5 to 10 years (WSRC 1994). The vegetated areas also include permanent upland meadows, scrub-shrub areas, and SRS wildlife food plots. Controlled burns of 6,075 to 7,290 ha (15,000 to 18,000 acres) of pine-dominated uplands are conducted annually to reduce flammable materials and to enhance the development of fire-tolerant plant communities and improve wildlife habitat. Additionally, improved planting techniques and seedling survival have resulted in conversion of significant areas of loblolly and slash pine forests to young longleaf pine forests over the past 10 years (DOE 2000b).

Habitats in the 16.7-ha (41.3-acre) area proposed for the MOX facility include pine (or evergreen) forest (5.9 ha [14.6 acres]), mixed pine (combination of both pine and deciduous [hardwood] species, with pine trees predominant) (1.4 ha [3.4 acres]), mixed deciduous (0.3 ha [0.8 acre]), grassland (1.6 ha [3.9 acres]), “facility” (developed) (3.6 ha [9.0 acres]), old field (fields formerly used for agriculture but now undergoing natural succession) (1.1 ha [2.7 acres]), spoils (2.8 ha [6.8 acres]), and deciduous (hardwood trees, essentially the southern mixed hardwood forest type of Table 3.5) (0.04 ha [0.1 acre]) (see Figure 3.7). The grassland habitat occurs within the transmission line right-of-way that crosses the proposed MOX site. The spoils habitat originated from the excavation for the Actinide Packaging and Storage Facility (APSF) in the F-Area. Although soil was excavated, the APSF was not constructed. This area is covered primarily with various grass and forb species. The standard seed mixture used to establish a plant cover on such areas includes grass and forb species such as unhulled and hulled common Bermuda grass, browntop millet, and unscarified Appalachian lespedeza (Bowling 2001).

Habitats in the 9.1-ha (22.5-acre) area proposed for the PDCF and WSB include pine forest (0.8 ha [2.0 acres]), deciduous (2.5 ha [6.2 acres]), and facility (5.8 ha [14.3 acres]) (see Figure 3.7).

Forested and facilities areas primarily surround the immediate project area (see Figure 3.7). The forested areas are dominated by loblolly pine with some mixed hardwoods (e.g., sweetgum, turkey oak, and water oak). The sparse understory and shrub layers consist of sparkleberry, dogwood, jasmine, and wax myrtle. Also present are areas dominated by a closed canopy of longleaf pine with sweetgum and willow oak as minor components. Vegetation along the unnamed tributaries to Upper Three Runs Creek include loblolly pine, sweetgum, red oak, and sycamore in the canopy, with black cherry, dogwood, and young individuals of the canopy tree species in the understory (Wike and Nelson 2000). The grassland habitat associated with the transmission line also occurs in this area. The OFASB area located west of the proposed MOX facility site also contains a vegetated cover similar to that over the spoils area within the proposed MOX facility site.

3.5.1.2 Wildlife

Among the numerous wildlife species reported from the SRS are 44 species of amphibians, 59 species of reptiles, 258 species of birds, and 54 species of mammals. The SRS has among the highest biodiversity of herpetofauna (reptiles and amphibians) in the United States because of the area’s warm, moist climate and its wide variety of habitats (DOE 2000b). Snakes that could occur in the project area include eastern hognose snake, eastern garter snake, eastern coachwhip, scarlet king snake, rat snake, corn snake, and pine snake. Lizards could include the green anole, southern fence lizard, several species of skinks, and the eastern glass lizard. Amphibians could include the southern toad and oak toad. The southern leopard frog, bullfrog, and other frogs and toads could occur in the small drainage basins near the site, while

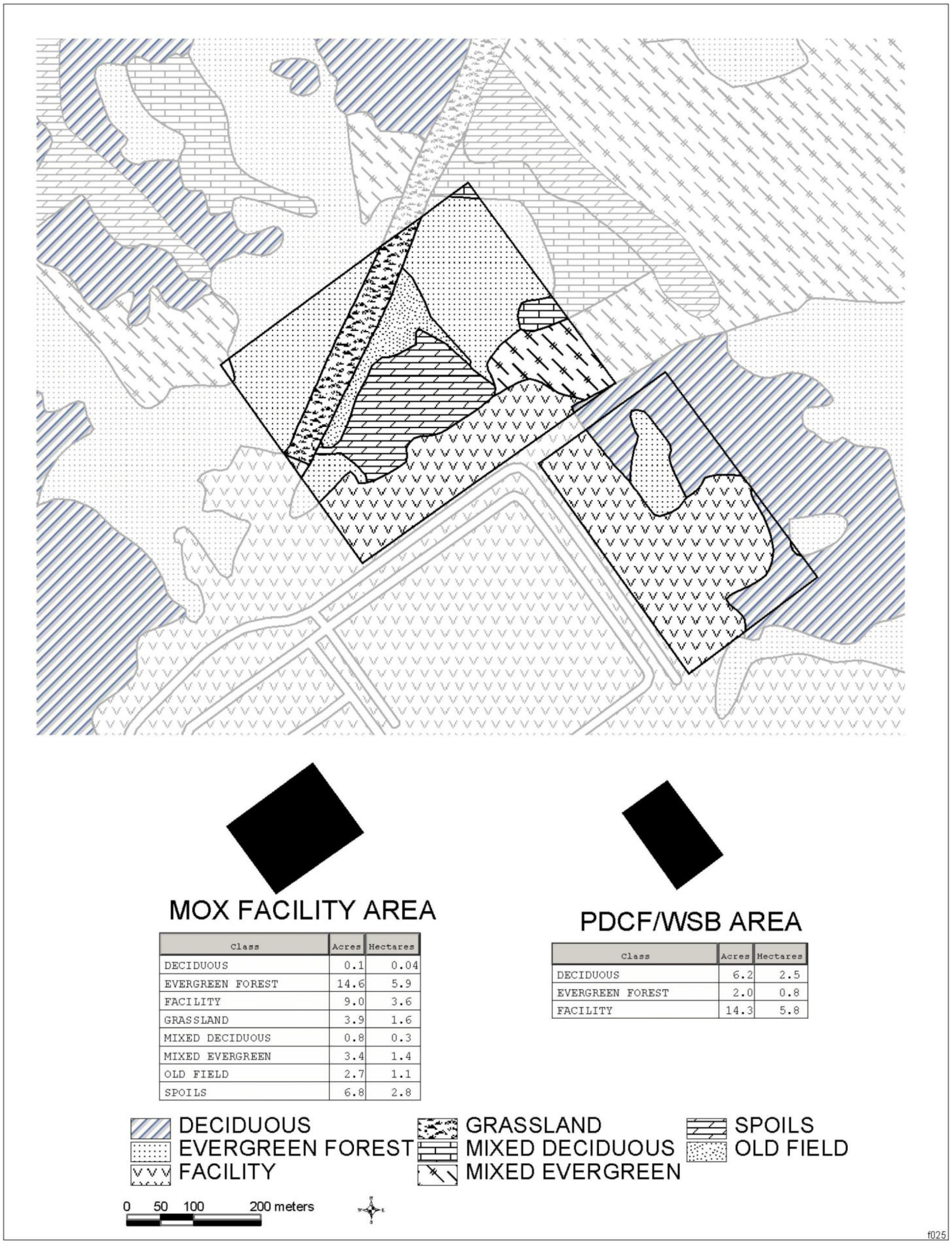

Figure 3.7. Current land cover in the area of the project site.

amphibians such as tree frogs and salamanders could occur within the unnamed tributary to Upper Three Runs Creek (Conant 1958; Mayer and Wike 1997).

Bird species at the SRS that are very common to abundant include black vulture, eastern kingbird, acadian flycatcher, common crow, northern mockingbird, blue-gray gnatcatcher, ruby-crowned kinglet, red-eyed vireo, northern parula, black-throated warbler, ovenbird, northern cardinal, savannah sparrow, white-throated sparrow, and song sparrow (WSRC 1994). As many as 17,000 ducks and coots are winter migrants at the SRS. Most of these congregate on Par Pond, L Lake, and other large ponds and Carolina bays (DOE 1991a). Wood ducks are the only waterfowl species that commonly breed on the SRS (WSRC 1994). Several mammal species can be found in old field/clearcuts, pine plantations, and scrub oak/longleaf pine habitats (these are the generalized habitat types that occur within the vicinity of the facilities). These species include southern short-tailed shrew, Virginia opossum, golden mouse, oldfield mouse, raccoon, eastern cottontail, and white-tailed deer. Other mammals that can occur within two of these habitat types include least shrew, striped skunk, raccoon, eastern harvest mouse, gray and fox squirrels, southeastern shrew, spotted skunk, feral hog, and gray fox. Several bat species also occur in one or more of these habitats (WSRC 1994).

Populations of white-tailed deer, feral hogs, and beaver are controlled through selective harvest strategies (DOE 2000b), which has included public hunts for white-tailed deer and feral hogs (Noah 1995; DOE 1996). The deer herd is estimated at about 3,000, with harvests averaging about 1,580 animals per hunting season. The feral hog population now exceeds 2,500 (DOE 2000b). The feral hogs originated from free-ranging domestic swine abandoned after resident farmers were relocated in 1952. They now occur over about 70% of the SRS (WSRC 1994). The hogs are trapped wherever they are found. Beavers are trapped where they compromise the safety or operations of roads, railroads, culverts, or research plots, or where they are causing significant resource damage. Increasing numbers of coyotes and armadillos may require the SRS to initiate control measures for these species in the future (DOE 2000b). Other commercial and recreational wildlife resources at the SRS are not exploited over most of the SRS because of restricted access and safety concerns. These species include bobcat, gray and red fox, mink, muskrat, Virginia opossum, river otter, eastern cottontail, raccoon, fox and gray squirrels, waterfowl, northern bobwhite, mourning dove, wild turkey, common snipe, and American woodcock (WSRC 1994). Hunting has been allowed for most of these species (except for bobcat, foxes, river otter, and fox squirrel) at the Crackerneck WMA (SCDNR 2000/2001). However, since late September 2001, hunting has been closed to the general public in this area. A controlled hunt was later allowed to help regulate the SRS deer herd.

The developed areas of the SRS include buildings, parking lots, infrastructure, and landscaped areas. Nevertheless, a number of wildlife species have been reported from these areas. A total of 43 species have been reported from the F-Area, including 4 species of amphibians, 12 species of reptiles, 18 species of birds, and 9 species of mammals. Several bird species are abundant: rock dove, common crow, northern mockingbird, American robin, and European starling. Common mammals include Virginia opossum, eastern cottontail, house mouse, feral cat, striped skunk, and raccoon. The densities of most wildlife species are higher in undeveloped areas then in developed areas. Exceptions include the house sparrow, house finch, rock dove, house mouse, Norway rat, and feral cat. Nevertheless, the use of developed areas of the SRS by wildlife is more common than previously reported, and these areas can be expected to contribute to the site's environmental diversity (Mayer and Wike 1997).

3.5.2 Aquatic

Six major streams and several associated tributaries flow through the SRS, and the Savannah River bounds the southwestern border of the SRS. More than 50 man-made ponds also occur at the SRS (DOE 1999). The two largest are L Lake (405 ha [1,000 acres]), which discharges into Steel Creek, and Par Pond (1,069 ha [2,640 acres]), which discharges into Lower Three Runs Creek (Section 3.3.1). These lakes do not have any direct interactions with the F-Area. Altogether, about 2,000 ha (4,940 acres) of open water occurs at the SRS (WSRC 1994).

At least 81 fish species have been identified at the SRS (DOE 2000b). Sport and commercial fishing on the SRS is allowed only within the Crackerneck WMA. Extensive fishing also occurs in the Savannah River. Commercial fish species include the American shad, hickory shad, and striped bass. Recreational species include largemouth bass, chain pickerel, crappie, bream, sunfish, and catfish (DOE 1996; WSRC 1994, 1997b). The man-made ponds support populations of bass and sunfish (DOE 1999).

Some SRS surface waters are classified as Category I resources. These waters are defined by the U.S. Department of the Interior as unique and irreplaceable on a national or eco-regional basis. These areas would include Carolina bays and cypress-tupelo swamps. Any surface waters supporting species of concern and areas containing high-quality wetlands or headwater streams (e.g., portions of Upper Three Runs Creek) would also be considered for Category I status (DOE 2000b).

The F-Area is drained by Upper Three Runs Creek and Fourmile Branch (see Figure 3.3). Upper Three Runs Creek is the most pristine stream at the SRS and would be considered a Category I resource. It contains more than 550 species of aquatic insects and supports about 60 fish species. The more abundant fish species include bowfin, American eel, redfin pickerel, dusky shiner, yellowfin shiner, coastal shiner, flat bullhead, tadpole madtom, mosquitofish, redbreast sunfish, warmouth, spotted sunfish, and blackbanded darter. More than 10 other fish species are common in Upper Three Runs Creek (Bennett and McFarlane 1983). Upper Three Runs Creek is an important spawning area for blueback herring and provides seasonal nursery habitat for American shad, striped bass, and other Savannah River species (DOE 1999). This stream also appears to be an important spawning site for the spotted sucker (WSRC 1994).

About 48 fish species have been collected from Fourmile Branch. Those in the stream's lower reaches include species common to the Savannah River. The only abundant fish species collected from Fourmile Branch are mosquitofish, redbreast sunfish, and spotted sunfish. Common species include longnose gar, bowfin, golden shiner, bluehead chub, creek chub, creek chubsucker, pirate perch, and brook silverside (Bennett and McFarlane 1983).

Water bodies in the vicinity of the proposed facilities include unnamed tributaries to Upper Three Runs Creek (see Figure 3.3) and small drainages and detention basins associated with permitted discharge outfalls. Macroinvertebrate (e.g., aquatic insects, snails, clams, and worms) and fish surveys indicate that Upper Three Runs Creek is unaffected by SRS NPDES-permitted discharges (Specht and Paller 2001).

3.5.3 Wetlands

> **Wetlands**
>
> *Wetlands* are areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions.

More than 20% of the SRS consists of wetlands, including open waters. Most wetlands on the SRS are associated with floodplains, streams, and impoundments. Wetland types on the SRS include bottomland hardwoods, southern swamp (cypress-tupelo), freshwater marshes, and Carolina bays. Areal coverage of forested wetlands is given in Table 3.5. The freshwater marshes total 1,380 ha (3,407 acres), and the Carolina bays total about 785 ha (1,939 acres) (DOE 2000b). The conditions of many wetlands at the SRS are similar to conditions that existed before the government assumed control of the site, except for those wetlands along stream corridors and adjacent portions of the Savannah River swamp that were degraded by thermal releases from reactor operations. These areas have been recovering since cessation of cooling water releases (WSRC 1994).

Over 300 Carolina bays (closed depressions capable of holding water) occur on the SRS (DOE 2000b). Carolina bays are characterized by their elliptical or ovoid shape, with a northwest/southeast orientation of their long axis (WSRC 1994). The Carolina bays on the SRS have remained largely undisturbed since 1950 and thus are valuable examples of these regional wetlands (Schalles et al. 1989). The median size of the Carolina bays is about 0.8 ha (2.0 acres), and only 15 exceed 4 ha (10 acres). The Carolina bays have characteristics similar to other wetlands (e.g., shallow marshes, herbaceous bogs, shrub bogs, or swamp forests). They also have a xeric to hydric (dry to moist) gradient from their peripheral sand rim to the center depression (Schalles et al. 1989). More than 135 species of plants have been identified from these wetlands. Most are dominated by grasses and sedges (Schalles et al. 1989; WSRC 1994). Amphibians are the most prevalent vertebrates that utilize the Carolina bays, but many reptiles, birds, and mammals also have been observed at these wetlands (Schalles et al. 1989). Less than 20 of the Carolina bays contain permanent fish populations. Fish species include redfin pickerel, mud sunfish, lake chubsucker, and mosquito fish (DOE 1999). An accelerated program has been initiated at the SRS to restore impacted Carolina bays (DOE 2000b). No Carolina bays occur near the proposed facility sites.

No wetlands occur on the proposed facility sites. Wetland habitat does occur along the unnamed tributary to Upper Three Runs Creek located near the eastern border of the proposed facility site (see Figure 3.3). The dominant species of vegetation in this wetland are yellow poplar, laurel oak, red maple, red bay, and cherrybark oak. Maiden cane also occurs near the wetland boundary (Wike and Nelson 2000).

3.5.4 Protected Species

> **Protected Species**
>
> *Endangered species*. Any species in danger of extinction throughout all or a significant portion of its range.
>
> *Threatened species*. Any species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Table A.1 (Appendix A) lists the threatened, endangered, and other special status species that may be found in the vicinity of the SRS. Appendix A also discusses the federally and state-endangered red-cockaded woodpecker (*Picoides borealis*), which receives special attention at the SRS.

No federal- or state-listed wildlife species have been reported from the proposed project area, but several species may exist in the general vicinity. The American alligator (*Alligator mississippiensis*) is federally threatened (by virtue of its similarity to the endangered American crocodile [*Crocodylus acutus*]). While it is fairly common at the SRS, it has only been recently observed near the F-Area, and its occurrence there is considered uncommon. The federally threatened (state-endangered) bald eagle (*Haliaeetus leucocephalus*) actively nests in the Pen Branch area and in an area south of Par Pond. These areas are 14 km (8.7 mi) and 12 km (7.5 mi) southwest and southeast of the proposed project area, respectively. The closest nesting area of the federally and state-endangered red-cockaded woodpecker to the proposed facility site is about 5 km (3.1 mi) away. The proposed area for the facilities does not occur within red-cockaded woodpecker management areas (see Appendix A). However, all areas containing pines, including those at the proposed sites, provide suitable forage areas for this species. The federally and state-endangered wood stork (*Mycteria americana*) has been observed near the Fourmile Branch delta, about 21 km (13 mi) from the proposed site. The federally endangered (state-endangered) shortnose sturgeon (*Acipenser brevirostrum*) occurs in the Savannah River as far upstream as the SRS.

Walk-through surveys did not reveal any federal- or state-listed wildlife species within the proposed facility area (USFS 2000). The Bachman's sparrow (*Aimophila aestivalis*) is adapted to open meadow and shrubby meadow habitats such as those that occur throughout F-Area. The eastern woodrat (*Neotoma floridana*) could inhabit the transitional areas between the hardwood forest and F-Area facilities, and the moist stream bottom area is suitable for the star-nosed mole (*Condylura cristata*). The upland pine and pine-oak ridge habitats are highly suitable for the southern hognose snake (*Heterodon simus*) and pine snake (*Pituophis melanoleucus*) (USFS 2000). The American sandburrowing mayfly (*Dolania americana*) is a relatively common aquatic insect in Upper Three Runs Creek (WSRC 1994). This species was formerly a candidate species for federal listing, but it is not currently listed by the U.S. Fish and Wildlife Service (USFWS) or State of South Carolina.

More than 1,300 species of plants occur at the SRS (WSRC 1994); however, only 53 species are considered to be sensitive, as determined by state, federal, and global ratings. The smooth coneflower (*Echinacea laevigata*) is the only federally listed (endangered) plant species at the SRS; it is also state endangered. Smooth coneflowers inhabit roadsides and open, sunny areas. The collection of plants from natural populations was a significant factor in the endangerment of the species (Arnold et al. 1998). Three populations of the smooth coneflower have been identified at the SRS. Activities near these known populations are highly restricted (DOE 2000b).

Nearly 300 populations of other sensitive plant species occur at the SRS (DOE 2000b). Included are three populations of the state-listed (species of concern) piedmont azalea (*Rhododendron flammeum*) that have been found along the steep slopes adjacent to the Upper Three Runs Creek floodplain in an area northwest of F-Area (DOE 1999).

Walk-through surveys of the proposed MOX facility site in October 1998 and March 2000 did not reveal any populations of the smooth coneflower (USFS 2000). Because this species is adapted to meadow and open forest habitats, the project area appears to be too disturbed or shady for the coneflower's establishment and successful survival. The survey did indicate that suitable habitat for several rare plant species exists in areas adjacent to the survey site. The hardwood slope provides habitat suitable for leech brush (*Nestronia umbellata*), piedmont azalea, and striped garlic (*Allium cuthbertii*). The moist bottom and lower slope sections are suitable for green-fringed orchid (*Platanthera lacera*) and least trillium (*Trillium pusillum* var. *pusillium*). The upland pine and pine-oak ridge areas are suitable for lance-leaf wild-indigo (*Baptisia lanceolata*) and bearded milk-vetch (*Astragalus villosus*) (USFS 2000).

3.6 Land Use

This section briefly describes land use patterns on and around the SRS. Land use is a classification of parcels of land relative to their suitability for or the actual presence of human activities (e.g., industry, agriculture, recreation, etc.) and natural uses. Natural resource attributes and other environmental characteristics could make a site more suitable for some land uses than for others. Changes in land use may have both beneficial and adverse effects on other resources (e.g., ecological, cultural, geological, and hydrological).

3.6.1 Savannah River Site Land Use

Existing land use at the SRS can be characterized into three main categories: (1) undeveloped/ forest, (2) wetlands/water, and (3) developed. Approximately 73% of the SRS is undeveloped; 22% consists of wetlands, streams, and lakes; and 5% is developed (e.g., facilities, roads, and utility corridors). The forested areas are managed for timber production. The U.S. Forest Service, under an interagency agreement with DOE, harvests approximately 728 ha (1,800 acres) of timber from the SRS each year. Prime farmland soils exist at the SRS, but areas of prime farmland are not identified within the SRS because the land is not available for agricultural activities (DCS 2002). A portion of the SRS is open for fishing, as discussed below for the Crackerneck WMA. Since late September 2001, hunting has been closed to the general public in this area. A limited hunting period was later allowed to control the SRS deer herd.

As discussed in Section 3.5.1.1, the SRS has been designated a National Environmental Research Park by DOE. The scientific community can use the site to study the impacts of human activity on cypress swamp and hardwood forest ecosystems. Approximately 5,700 ha (14,085 acres) of land is set aside at the SRS for nondestructive environmental research (DOE 1999).

The F-Area is generally classified by the SRS land use plan as developed; some areas within F-Area are classified as industrial or heavy industrial.

Future land use at the SRS is determined by the DOE through site development, land use, and future planning processes (DCS 2002). SRS planners have developed a land use zone planning model for the site that is consistent with their past support of a multiple-use planning concept where compatible. Three principal planning zones have been established: Site Industrial, Site Industrial Support, and General Support. The *SRS Long Range Comprehensive Plan* includes the construction and operation of the proposed facilities as part of the plan for its Nuclear Materials Stewardship mission (DOE 2000b). New missions for the SRS in the 21st Century, as stated in the *Savannah River Site Strategic Plan*, include the construction and operation of new facilities for tritium extraction and the storage and disposal of surplus plutonium. In addition to these new facilities, the SRS plans to play an increased role in the advancement of nuclear materials protection, control, and accounting (DOE 2000a).

3.6.2 Off-Site Land Use

Predominant regional land uses in the vicinity of the SRS include urban and residential, industrial, agricultural, and recreational areas. Forest and agricultural land predominantly border the SRS, with only limited urban and residential development. The nearest residences are located to the west, north, and northeast, some within 60 m (200 ft) of the SRS boundary. Farming is diversified throughout the region and includes such crops as peaches, watermelon, cotton, soybeans, corn, and small grains. Incorporated and industrial areas are also present near the site, including textile mills, polystyrene foam and paper plants, chemical processing plants, and a commercial nuclear power plant. Open water and nonforested wetlands occur along the Savannah River Valley. Recreational areas within 80 km (50 mi) of the SRS include Sumter National Forest, Santee National Wildlife Refuge, and Clark's Hill/Strom Thurmond Reservoir. State, county, and local parks include Redcliffe Plantation, Rivers Bridge, Barnwell and Aiken County State Parks in South Carolina, and Mistletoe State Park in Georgia. The Crackerneck WMA, which includes a portion of the SRS along the Savannah River, is open to the public for fishing (DOE 1999).

3.7 Cultural and Paleontological Resources

Cultural resources include archaeological sites and historic structures and features that are protected under the National Historic Preservation Act of 1966, as amended.

Cultural and Paleontological Resources

Cultural resources include archaeological sites, historic structures and features, and traditional cultural properties.

Paleontological resources are the fossil remains of past life forms.

Cultural resources also include traditional cultural properties that are important to a community's practices and beliefs and that are necessary to maintain the community's cultural identity. Cultural resources that meet the eligibility criteria for listing on the *National Register of Historic Places* (NRHP) are considered "significant" resources and must be taken into consideration during the planning of federal projects. Federal agencies are also required to consider the effects of their actions on sites, areas, or other resources (e.g., plants) that are of religious significance to Native Americans as established under the American Indian Religious Freedom Act. Native American graves and burial grounds are protected by the Native American Graves Protection and Repatriation Act.

Paleontological resources are the fossil remains of past life forms. Paleontological resources with significant research potential are protected under the Antiquities Act.

3.7.1 Archaeological Resources

The Savannah River Archaeological Research Program (SRARP) of the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, has been conducting archaeological investigations at the SRS since 1973 (SRARP 1989). The SRARP prepared an archaeological resource management plan for the SRS in 1989. The purpose of the plan is to provide the DOE with a means of addressing future archaeological resource management needs at the SRS and to establish a series of research directions to facilitate better management of these resources. The SRS currently manages its archaeological resources under the terms of a 1990 Programmatic Agreement among the DOE Savannah River Operations Office, the South Carolina State Historic Preservation Officer (SCSHPO), and the Advisory Council on Historic Preservation.

Over a period of more than 25 years, members of the SRARP have been very active in recording more than 850 archaeological sites at the SRS.[7] Although most of these sites have not been formally evaluated for eligibility for listing on the NRHP, 67 sites have been identified as potentially eligible (DOE 1999). In general terms, prehistoric sites within the SRS consist of village sites, base camps, limited-activity sites, quarries, and workshops. Nearly 800 prehistoric sites have been recorded at the SRS (DCS 2002). As detailed below, several prehistoric sites have been recorded within or near the proposed facilities. Two prehistoric sites within the footprints of the proposed facilities and their associated grading area have been determined to be eligible for listing on the NRHP.

Historic sites at the 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. About 400 historic sites have been recorded to date at the SRS (DOE 1999). No historic sites have been recorded within the vicinity of the proposed facilities.

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[7] Of the 850 plus sites that have been recorded at the SRS, some are prehistoric, some are historic, and some have both a prehistoric and historic component. For this reason, the sum of prehistoric sites plus historic sites is much greater than the approximate total of 850 sites.

Archaeological surveys have been conducted in the F-Area in the vicinity of the proposed facilities. Fifteen prehistoric sites have been identified. Nine of these sites were recorded during 1993 and 1994 (Cabak et al. 1996). Four sites were recorded during SRS surveys conducted between 1973 and 1977 (Hanson et al. 1978). One site was recorded in 1983 (as cited in Cabak et al. 1996), and the remaining site was recorded in a 1999 survey covering unsurveyed lands remaining for the proposed location of the surplus plutonium disposition facilities (King and Stephenson 2000).

Four sites are located within the area of direct project disturbance. Two of the four prehistoric sites (38AK546/547 and 38AK757) are eligible for listing on the NRHP. Site 38AK546/547, located within the area of the proposed MOX facility, is eligible because of its potential to provide significant information about the prehistory of the Aiken Plateau, in particular the use of ridge slope settings during the Early Mississippian period (King and Stephenson 2000). Site 38AK757 is located within the boundary of the proposed PDCF facility and is important for learning more about the use of upland settings by prehistoric inhabitants of the area during the Mississippian Period (King and Stephenson 2000). Two sites within the area of the proposed MOX facility, 38AK330 and 38AK548, were determined not eligible in consultation with the SCSHPO, and no further work is required for these two sites (Green 2000, as cited in DCS 2002).

Date Ranges of Prehistoric Time Periods Used by Archaeologists at the SRS

Mississippian	A.D. 1100 - 1450
Late Woodland	A.D. 500 - 1100
Middle Woodland	600 B.C. - A.D. 500
Early Woodland	1000 B.C. - 600 B.C.
Late Archaic	3000 B.C. - 1000 B.C.
Middle Archaic	6000 B.C. - 3000 B.C.
Early Archaic	8000 B.C. - 6000 B.C.

Source: SRARP (1989).

Eleven prehistoric sites are located near the proposed facilities. Five of those sites (38AK106, 38AK155, 38AK563, 38AK564, and 38AK581) have been recommended eligible for listing on the NRHP. Site 38AK106 has been recommended eligible on the basis of its integrity, high density of artifacts, and research potential for providing information on the Early Archaic, Early Woodland, and Late Woodland time periods. Site 38AK155 is eligible because of its potential to yield important information on subsistence strategies and the use of upland streamside settings between 3000 B.C. and A.D. 1450 (between the Late Archaic and Early Mississippian periods). Site 38AK563 is important because it contains cultural deposits ranging from the Early Archaic Period through the Late Woodland Period and has the potential to provide information on the changes in human use of the floodplain over a considerable time range. Site 38AK564 has been recommended eligible because it contains stratigraphically[8] separated evidence of site use from the Early Archaic and Late Archaic/Early Woodland time periods. Site 38AK581 contains evidence of numerous occupations by prehistoric people during the Woodland Period. The site has been recommended eligible on the basis that these

[8] Archaeologists look at the position of artifacts relative to layers of soil and other artifacts to help determine sequences of events. Objects found closer to the surface of an undisturbed site were deposited more recently than objects found below them (i.e., an archaeologist would expect to find Woodland Period artifacts in one or more layers of soil above Archaic Period artifacts in a stratigraphically preserved site).

various occupations appear in a well-defined stratigraphic sequence and potentially contain important information about changes that occurred during that time period (Cabak et al. 1996).

3.7.2 Historic Structures

No architectural inventories have been conducted to date at the SRS. The SRS has a number of nuclear production facilities, including facilities important to tritium and plutonium production, that may have historic value as related to events during the Cold War. Construction of the F-Area began in 1951 under the Atomic Energy Commission. The F-Area was historically used for plutonium recovery during DOE's plutonium production phase (DCS 2002). The areas of construction for the proposed facilities do not contain structures. No existing buildings within the F-Area have been identified for reuse, modification, or demolition related to MOX facility activities.

3.7.3 Traditional Cultural Properties

Traditional cultural properties are places and resources important to traditional American cultures, which include, but are not restricted to, Native American cultures. Village sites, ceremonial locations, burials, cemeteries, and natural areas containing important resources, such as traditional plants, are typical types of properties of concern to Native American cultures. Properties of traditional value to immigrant groups (e.g., from Europe and Africa), such as cemeteries, also can be considered as traditional cultural properties. Native American groups with traditional ties to the area include the Apalachee, Cherokee, Chicksaw, Creek, Shawnee, Westo, and Yuchi (DCS 2002). Many of these groups were relocated to the Oklahoma Territory in the 1800s. However, issues related to the American Indian Religious Freedom Act have surfaced within the central Savannah River valley. Native American representatives have expressed concern over traditional plant resources that could exist at the SRS (DOE 1991b; DCS 2002). None of the identified plant resources is currently known to exist in the F-Area. Consultations with appropriate Native American Tribes, Bands, and Nations are underway regarding the proposed MOX facility (Appendix B).

3.7.4 Paleontological Resources

While some fossil-bearing strata are known to exist at the SRS, none are known within the F-Area. Paleontological resources that have been recorded within the SRS area mostly date to 54 to 39 million years ago during the Eocene Age. Those resources include fossil plants, invertebrate fossils, giant oysters, other mollusks, and bryozoa. Most known paleontological resources in the area are considered common and of low research potential (DOE 1999). The discovery of paleontological resources within the area of the proposed facilities is not anticipated.

3.8 Infrastructure

This section briefly describes the existing infrastructure of the SRS as it pertains to the proposed action. Site infrastructure includes utilities, roads, and railroads needed to support construction and operation of the facilities. A detailed discussion of the SRS infrastructure is provided in the DOE Surplus Plutonium Disposition EIS (DOE 1999).

3.8.1 Electricity

The SRS uses a 115-kV power line system in a ring arrangement to supply electricity to the operations areas. Power is supplied by three transmission lines from the South Carolina Electric and Gas Company. The F-Area receives power from the 200-F power loop supplied by the 251-F electrical substation. The current F-Area power consumption rate is about 63,000 MWh/yr; the F-Area total capacity is about 700,000 MWh/yr (DCS 2002). The total SRS usage of electrical power is 370,000 MWh/yr out of a site capacity of 4,400,000 MWh/yr.

3.8.2 Water

Domestic water supplies at the SRS come from a system composed of several wells and water treatment plants. The system includes three wells and a water treatment plant in the A-Area and two wells and a backup water treatment plant in the B-Area. A 43-km (27-mi) piping loop provides domestic water from the A- and B-Areas to other SRS operations areas, including the F-Area (DCS 2002). Current domestic water usage in F-Area is 378 million L/yr (100 million gal/yr) compared with a capacity of 890 million L/yr (235 million gal/yr).

Within F-Area, four deep groundwater wells are used for process water. Pumping capacities for these wells range from 1,500 to 3,800 L/min (400 to 1,000 gpm), and they extract groundwater from the Crouch Branch Aquifer. Two of these wells were formerly used for domestic water supply. The current annual groundwater use at F-Area is 1.4 billion L (370 million gal) (DCS 2002). The estimated capacity of the wells in F-Area is about 4.2 billion L/yr (1.1 billion gal/yr).

3.8.3 Fuel

Coal and oil are used at the SRS to power steam plants located in A-, D-, H- and K-Areas. The produced steam is distributed across the site in an aboveground pipeline distribution system. Coal is delivered by rail and is stored at coal piles in A-, D-, and H-Areas. Number 2 grade fuel oil is delivered by truck and is used in the K-Area. Natural gas is not used at the SRS.

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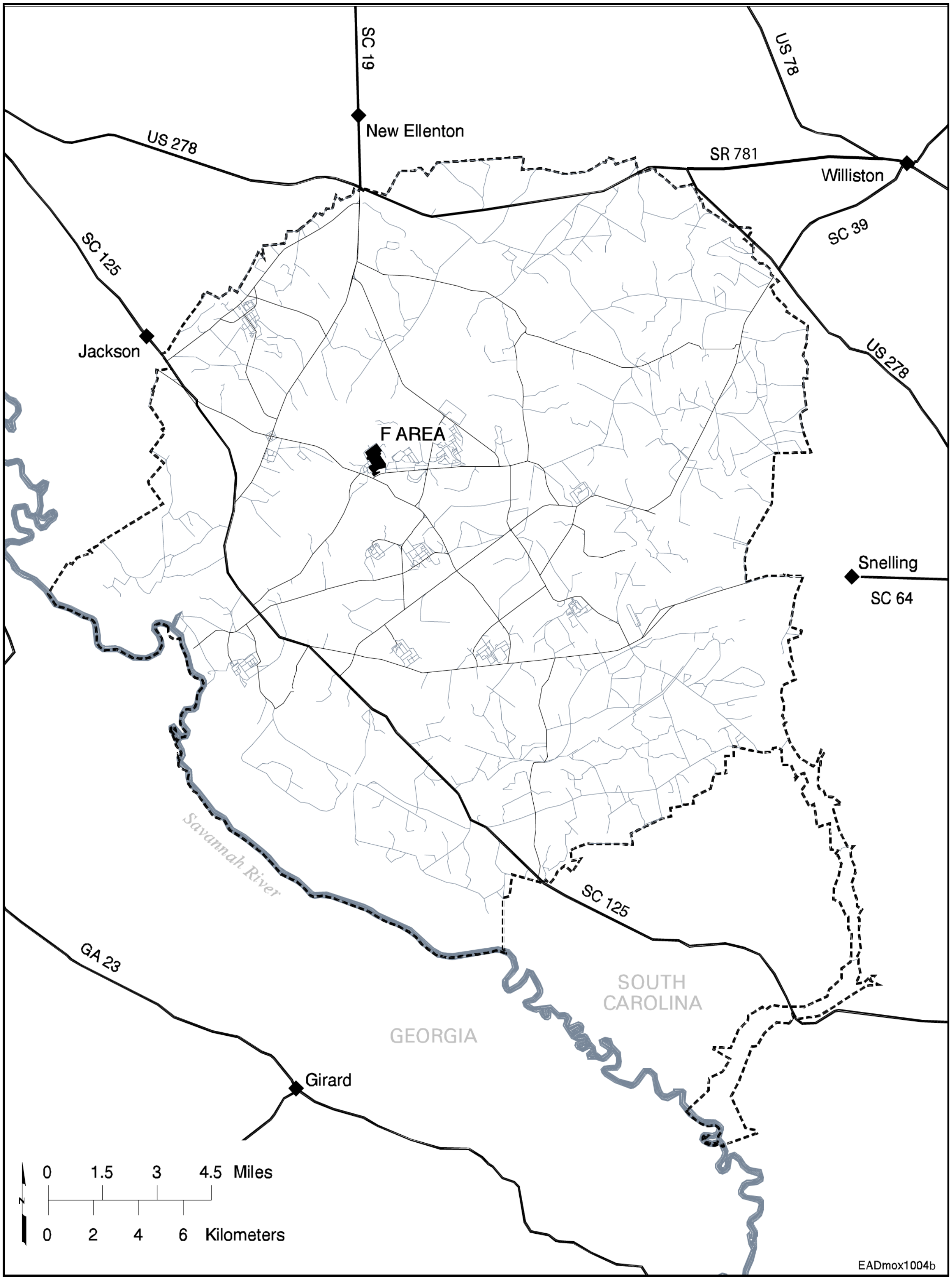

Figure 3.8. Roadways in the vicinity of the SRS.

Current waste generation rates and inventories at the SRS are presented in Table 3.6. Waste management practices at the SRS include minimization, characterization, treatment, storage, transportation, and disposal of waste generated from ongoing site activities. Waste minimization at the SRS is accomplished through source reduction, recycling, and employee participation in pollution prevention programs. Total solid waste volumes have decreased by 70% since 1991.

The types of waste currently managed at the SRS are high-level waste (HLW), transuranic (TRU) waste, mixed TRU waste, low-level waste (LLW), mixed LLW, hazardous waste, and

Table 3.6. Current waste generation rates and inventories at the SRS[a]

Waste type	Generation rate (m^3/yr)	Inventory[b] (m^3)
TRU[c]		
Contact handled	171	6,034
Remotely handled	0.6	1
LLW	8,195	1,616[d]
Mixed LLW		
RCRA	61	7,717
TSCA[e]	<1	3
Hazardous	74	1,416
Nonhazardous		
Liquid	416,100[f]	NA[g]
Solid	6,670	NA

[a]Sources for estimates presented in this table are DOE (1997) for TRU waste, LLW, and mixed LLW; DOE (1996) for hazardous and nonhazardous solid waste; and Sessions (1997) for nonhazardous liquid waste.

[b]Inventory projections were as of end of fiscal year 1996 for those presented in DOE (1997).

[c]Includes mixed TRU waste.

[d]LLW is disposed of on-site at the SRS. The estimated inventory shown is less than the generation rate (for FY1996) because it represents only LLW that had not been disposed of as of the end of FY 1996.

[e]TSCA = Toxic Substances Control Act.

[f]416,000 m^3/yr = 416,100,000 L/yr.

[g]NA = not applicable; nonhazardous wastes are not held in long-term storage.

nonhazardous waste. The first five types contain radioactive material. Of the seven waste types currently managed at the SRS, HLW would not be generated by the proposed MOX facility, the PDCF, or the WSB. The proposed MOX facility would generate a liquid high-alpha-activity waste that would be further processed, resulting in the generation of TRU waste and LLW (DCS 2002).

The TRU wastes generated at the SRS include contaminated equipment, protective clothing, and tools. Most of these wastes are stored on concrete pads that are not covered with soil. TRU waste generated before 1986 is stored on five concrete pads and one asphalt pad that have been covered with approximately 1.2 m (4 ft) of soil. TRU waste generated since 1986 is stored on 13 concrete pads that are not covered with soil. These storage pads are located in the Low-Level Radioactive Waste Disposal Facility, which is located in E-Area (DOE 1995). In 1996, it was decided to vent and purge all buried drums; this process was completed in 1999 (Arnett and Mamatey 2000b). A TRU waste characterization and certification facility to prepare TRU waste for treatment and to certify TRU waste for disposal at the Waste Isolation Pilot Plant (WIPP) is planned for 2007. This TRU waste facility would be built to manage other SRS TRU waste and is independent of the proposed action. In the interim, drums that are certified for shipment to WIPP will be stored on concrete pads in E-Area (DOE 1999).

Waste Types

Transuranic (TRU) waste: Refers to radioactive waste that contains more than 100 nanocuries per gram (nCi/g) of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years. Such waste results primarily from the fabrication of plutonium weapons and plutonium-bearing reactor fuel. Generally, little or no shielding is required.

Low-level waste (LLW): Refers to radioactive waste that is not classified as HLW, TRU, or spent nuclear fuel (SNF).

Hazardous waste: Refers to nonradioactive waste materials defined by the Resource Conservation and Recovery Act (RCRA) as hazardous wastes. These wastes are considered to pose potential hazard to human health when improperly treated, stored, disposed of, or otherwise managed because of their quantity, concentration, and physical and chemical characteristics. (Note: hazardous waste mixed with low-level [radioactive] waste or TRU waste is referred to as mixed low-level waste or mixed TRU waste, respectively.)

Liquid and solid LLW types are treated at the SRS. Aqueous LLW streams undergo filtration, reverse osmosis, and ion exchange at the F-and H-Area effluent treatment facility (ETF) to remove the radionuclide contaminants. The treated effluent is discharged to Upper Three Runs Creek.

Treatment residuals are eventually immobilized with grout for on-site disposal. Solid LLW is categorized into four groups: low-activity wastes (those that radiate less than 0.002 Sv/h [200 mrem/h] at 5.1 cm [2 in.] from the unshielded container); intermediate-activity wastes (those that radiate greater than 0.002 Sv/h [200 mrem/h] at 5.1 cm [2 in.]); intermediate-activity tritium waste (intermediate-activity waste with more than 3.7×10^{11} Bq [10 Ci] of tritium per container); and long-lived waste (waste contaminated with long-lived isotopes that exceed the waste acceptance criteria [WAC] for on-site disposal) (DCS 2002). Wastes in the first three categories are stored and disposed of in vaults, and wastes in the fourth category are placed in a waste storage building until treatment and disposal technologies are developed. Located in the E-Area, the vaults are below-grade concrete structures, and the storage building is a metal structure on a concrete pad. Disposal facilities at the SRS are projected to meet solid LLW disposal capacity needs for the next 20 years.

Mixed LLW is stored in various tanks and buildings located in the A-, E-, M-, N-, and S-Areas of the SRS. The current mixed waste program at the SRS primarily involves the safe storage of these wastes until treatment and disposal facilities become available. A site treatment plan (WSRC 2000b) for mixed wastes has been developed, as required by the Federal Facility Compliance Act, that specifies treatment technologies or technology development schedules for all SRS mixed waste. During 1999, plans for all mixed LLW were met in accordance with the site treatment plan (Arnett and Mamatey 2000b).

Hazardous waste is managed at the SRS either by accumulating the waste at the generating facility for a maximum of 90 days or storing it in Resource Construction and Recovery Act (RCRA)-permitted hazardous waste storage buildings or on interim storage pads located in the B- and N-Areas. Most of the waste is shipped off-site to commercial RCRA-permitted facilities. In 1999, 297 m^3 (388 yd^3) of hazardous waste was shipped off-site to commercial disposal facilities (Arnett and Mamatey 2000b).

The treatment of nonhazardous wastewater at the SRS has been centralized since 1994 with the completion and operation of the 2.8 million-L/day (0.75 million-gal/day) Central Sanitary Wastewater Treatment Facility. This facility treats sanitary wastewater by an extended aeration activated sludge process that separates the wastewater into clarified effluent and sludge.

The collection, hauling, and disposal of solid sanitary waste at the SRS is privatized, and the waste is sent to the Three Rivers Landfill southwest of the B-Area. Other nonhazardous waste consists of scrap metal, powerhouse ash, domestic sewage, scrap wood, construction debris, and used railroad ties. These wastes are disposed of by means appropriate to their nature.

3.10 Human Health Risk

Human health can be adversely affected by radioactive and hazardous chemical contaminants in the environment. This section discusses how humans can become exposed to these materials, the potential effects of this exposure, potential human receptors considered in this EIS, and the existing conditions at the SRS and the surrounding area. Methods used to estimate the potential for injuries or fatalities among workers are also discussed.

3.10.1 Hazard Exposure Pathways

3.10.1.1 Pathways for Human Exposure to Radiation and Radioactivity

Radioactivity released from the SRS reaches the environment and people in a variety of ways. The routes that radioactive materials follow to get from an SRS facility to the environment and then to people are called pathways. The primary human exposure pathways for these releases are discussed below:

- *Inhalation exposure pathway*: Individuals in the path of airborne emissions would receive a dose from breathing in the radioactive material. Some of this material also deposits on the ground and over time may become resuspended in the air, at which time it may also be inhaled.

- *Direct radiation from contaminated soil*: Material that is deposited on the ground from passing airborne emissions becomes an external exposure source of direct radiation.

- *Immersion in radioactive clouds*: Individuals in the path of radioactive airborne emissions would receive an external dose during immersion in the passing "cloud" of material.

- *Ingestion exposure pathway*: Radioactive materials can be transported through a variety of routes into the human diet. Airborne radioactive material may deposit directly on food crops or animal feed crops, resulting in potential exposure from human ingestion of the food crops or indirectly from ingestion of contaminated animal products. Material deposited on farmland may also be taken up through the roots by human and animal food crops. Material deposited on surface water or land may reach groundwater. Contaminated surface water or groundwater could be used for irrigating crops or direct consumption by humans. Contaminated surface water could also result in contamination of aquatic species, such as fish, which could subsequently be consumed by humans.

One important pathway of radioactive material released from the SRS in the form of particulate matter is the airborne pathway. After being discharged from a stack, the radioactive particulate matter will be carried by wind downwind of the facility, where it will either be inhaled by individuals or settle on the ground. Radioactivity in the soil will cause direct radiation exposures in individuals located near contaminated soil. Soil contamination may also be resuspended into the air by the wind and then inhaled farther downwind. Food produced on farmlands with contaminated soil will also contain this radioactivity. Precipitation runoff from downwind soil will carry radioactivity to local surface waters, such as lakes, rivers, and streams. Finally, radioactivity in surface water may accumulate in fish or other aquatic life that can be consumed by humans.

Radiation and Radioactivity

Radioactivity or *radioactive decay* is the process by which unstable atoms emit *radiation* to reach a more stable state.

Radiation is the movement of energetic particles or waves through matter and space. Radiation comes from radioactive material or from equipment such as x-ray machines. Radiation may be either ionizing radiation or non-ionizing radiation.

Ionizing radiation is radiation that has enough energy to cause atoms to lose electrons and become ions. For example, the radioactive decay of plutonium produces radiation that can ionize matter (e.g., tissue).

Radiation dose is the quantity of radiation energy that is deposited in a material. The radiation dose to humans is measured in units of sieverts (Sv). The unit of rem is also used. One sievert is equal to 100 rem.

Collective dose is the sum of the individual doses received in a given period of time by a specified population. The unit of collective dose is person-sieverts, or person-rem.

The DOE has determined the critical types of radioactivity and pathways for radioactive materials released from SRS operations. Tritium and cesium-137 are the primary contributors to doses to members of the public. The major pathways for tritium released into air were through breathing air and eating food, whereas the major pathway for tritium and cesium-137 released into site streams were through drinking river water and eating fish from the river (DOE 1999). Pathways or routes by which radioactive material moves through the environment to reach humans can be complex. For example, contaminants can settle on grass that is eaten by cows that produce milk that is consumed by humans. The meat of the cows can also be consumed by humans. Another example, more relevant to the SRS, would be game animals that consume contaminated vegetation and then are eaten by humans. A detailed discussion of the many pathways at the SRS is presented in the annual environmental report (Arnett and Mamatey 2001b).

3.10.1.2 Pathways for Human Exposure to Chemicals

Humans can also be exposed to nonradioactive chemicals released to the environment. The DOE has determined that the critical chemicals among those released from SRS operations to the environment are arsenic and benzene (Arnett and Mamatey 2000b). Exposures may occur primarily through inhaling pollutants released to air, drinking contaminated groundwater or surface water, ingesting contaminants in foodstuffs grown in contaminated soil or irrigated with contaminated groundwater, or ingesting contaminated soil.

3.10.1.3 Physical Hazards

Although not attributable to releases of contaminants to the environment, there is a risk of injuries and fatalities from physical hazards for construction and operation workers at any facility. The U.S. Bureau of Labor keeps statistics on the annual number of injuries and fatalities by industry type. Where possible, these statistics have been used to estimate the extent of physical hazard risk for the no-action and proposed action alternatives.

3.10.2 Receptors

Effects of radiation and chemical exposures for the no-action and proposed action alternatives during normal operations were estimated by first calculating the doses to relevant receptors. The analyses considered three groups of people: (1) members of the public, (2) SRS employees, and (3) facility workers. For purposes of this EIS, these three groups are defined as follows:

- *Members of the Public*: Individuals who live and work outside the SRS within 80 km (50 mi) of the proposed facilities:

  - Might be exposed to trace amounts of radioactive and chemical materials released to the environment through exhaust stacks.

  - Could receive radiation and chemical exposures primarily through inhalation of material in the air, external radiation from deposited radioactive material, and ingestion of contaminated food.

- *SRS Employees*: Individuals employed at the SRS who are not workers at the proposed MOX facility, the PDCF, or the WSB. SRS employees include those workers assigned radiological work at other nuclear facilities within the SRS boundary, as well as those who are not assigned radiological work, such as cafeteria workers or persons in administrative positions:

  - Might be exposed to direct radiation from radioactive materials (although at a great distance) and to trace amounts of plutonium or uranium released to the environment through site exhaust stacks.

  - Could receive radiation and chemical exposures primarily through inhalation of material in the air and external radiation from radioactive material deposited on the ground.

  - Work-related physical hazard risks are present.

  - Estimate of impacts to transient population groups (soda machine vendors, etc.) are bounded by impacts to this group.

- *Facility Workers*: Individuals who work at the proposed MOX facility, the PDCF, or the WSB and who receive a radiation dose in the course of employment in which the assigned duties of the individuals involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation:

- Might be exposed to direct gamma radiation emitted from radioactive materials, such as depleted uranium compounds.

- Could receive small radiation doses from inhaling uranium, plutonium, or other radionuclides compared with the direct radiation doses resulting from enclosed processes; ventilation controls would be used to inhibit airborne emissions in facilities.

- Would be protected by a dosimetry program to control doses below the maximum regulatory limit of 0.05 Sv/yr (5 rem/yr) for workers (10 CFR 20.1201).

- For chemical exposures, facility workers are addressed under separate regulations (e.g., Occupational Safety and Health Act [OSHA]); their exposures are not quantitatively addressed in this FEIS. However, physical hazards (i.e., risks of injury and fatality) are addressed for both construction and operations workers.

Impacts to a maximally exposed individual (MEI) were also evaluated. The MEI is a hypothetical person who, because of proximity, activities, or living habits, could receive the highest possible dose of radiation or of a hazardous chemical from a given event or process. For members of the public, potential locations for an MEI would be at the site boundary, the closest possible public access points near the operations under consideration. For SRS employees not directly involved in facility operations, MEI locations are considered at distances of 100 m (330 ft) or more from a facility. An MEI for radiation exposure is not always considered for facility workers because these workers are monitored, and their exposure is expected to be kept as low as reasonably achievable (ALARA), with workers being rotated into and out of relatively higher exposure job functions. In such cases, an average worker dose was estimated.

3.10.3 Baseline Radiological Dose and Risk

The radiological baseline in the vicinity of the SRS includes background radiation, man-made (anthropogenic) sources, and radiation from ongoing SRS operations. Background radiation comes from natural sources, such as cosmic radiation and naturally occurring radioactive material, and from anthropogenic sources that cannot be controlled, such as global fallout from nuclear testing or nuclear accidents. Anthropogenic sources, including consumer products (e.g. television sets and smoke detectors) and medical procedures, account for additional exposure. Human exposure to radiation is measured in units of sieverts (Sv). Background radiation levels

What Is a Sievert?

A *sievert* is a unit of radiation dose. The effects of radiation exposure on humans depend on the kind of radiation received, the total amount absorbed by the body, and the tissues involved. A sievert (Sv) is calculated by a formula that takes these three factors into account. Another common unit of radiation dose is the rem (1 Sv = 100 rem). The U.S. average individual radiation dose is about 0.0036 Sv (0.36 rem) or 3.6 millisievert (mSv) [360 millirem (mrem)] from natural background and anthropogenic sources.

Latent Cancer Fatality (LCF)

What it is: The primary adverse health effect from the low-level radiation doses received from proposed MOX facility, PDCF, or WSB operations and potential accidents would be the possible induction of latent cancer fatalities (LCFs). LCFs are a measure of the expected number of additional cancer deaths in a population (or people dying of cancer) as a result of exposure to radiation. Death from cancer induced by exposure to radiation may occur at any time after the exposure takes place. However, latent cancers would be expected to occur in a population from one year to many years after the exposure takes place. To place the significance of these additional LCF risks from exposure to radiation into context, the average individual has approximately 1 chance in 4 of dying from cancer (LCF risk of 0.25).

How it is calculated: The U.S. Environmental Protection Agency has suggested (Eckerman et al. 1999) a conversion factor that for every 100 person-Sv (10,000 person-rem) of collective dose, approximately 6 individuals would ultimately develop a radiologically induced cancer. If this conversion factor is multiplied by the individual dose, the result is the individual increased lifetime probability of developing an LCF. For example, if an individual receives a dose of 0.00033 Sv (0.033 rem), that individual's LCF risk over a lifetime is estimated to be 2×10^{-5}. This risk corresponds to a 1 in 50,000 chance of developing a LCF during that individual's lifetime. If the conversion factor is multiplied by the collective (population) dose, the result is the number of excess LCFs. Because these results are statistical estimates, values for expected LCFs can be, and often are, less than 1.0 for cases involving low doses or small population groups. If a population group collectively receives a dose of 50 Sv (5,000 rem), which would be expressed as a collective dose of 50 person-Sv (5,000 person-rem), the number of potential LCFs experienced from within the exposure group is 3. If the number of LCFs estimated is less than 0.5, on average, no LCFs would be expected.

result in a national annual average individual exposure of approximately 3.0 mSv (300 mrem), with an additional 0.60 mSv (60 mrem) from other anthropogenic sources. A more detailed breakdown of these sources is presented in Table 3.7.

Radiation from SRS operations is estimated by analyzing monitoring data. The SRS has an extensive radiological monitoring network both on- and off-site to assess the effects of site operations on air, surface water, groundwater, soil, terrestrial and aquatic food products, and local game animals. These routine environmental surveillance activities include monitoring airborne and liquid effluent discharges from their points of origin at each operating facility on the SRS to determine compliance with applicable exposure standards. The results of the effluent monitoring and environmental surveillance and the potential radiation doses to members of the public in surrounding areas from those effluents are published annually by the Environmental Monitoring Section of Westinghouse Savannah River Company (e.g., Arnett and Mamatey 2001b).

Airborne emissions from the SRS operations for 2000 are summarized in Table 3.8. Liquid releases for 2000 are summarized in Table 3.9. The estimated off-site radiation doses from both airborne and liquid releases were below all applicable radiation exposure standards for humans and aquatic organisms (Arnett and Mamatey 2001b). The estimated exposures and the applicable standard for each exposure are summarized in Table 3.10. The estimated all-pathway dose to an MEI was 0.0018 mSv (0.18 mrem), which is 0.18% of the DOE's 1.0 mSv (100-mrem) all-pathway dose standard for annual exposure. For an NRC-licensed facility, such as the proposed MOX facility, a dose limit of 1.0 mSv/yr (100 mrem/yr) from operations for an individual member of the public is also applicable (10 CFR 20.1301).

Table 3.7. Sources and contributions to the U.S. average individual radiation dose[a]

Source	Effective dose equivalent [mSv/yr (mrem/yr)]
Natural background radiation	
Cosmic radiation	0.27 (27)
Rocks and soil (external)	0.28 (28)
Internal to body	0.40 (40)
Radon (internal/inhalation)	2.0 (200)
Subtotal	≈2.95 (≈295)
Man-made background radiation	
Weapons test fallout	<0.01 (<1)
Consumer products	0.10 (10)
Medical	
Diagnostic X-rays	0.39 (39)
Nuclear Medicine	0.14 (14)
Subtotal	≈0.64 (≈64)
Total	≈3.60 (≈360)

[a]*Source*: Modified from Arnett and Mamatey (2001b) and NCRP (1987).

Workers at the SRS with the potential to be exposed to external radiation or to inhale airborne radioactivity take part in a monitoring program in accordance with 10 CFR 835 ("Occupational Radiation Protection"). In 2000, 3,382 SRS workers had a measurable dose with a combined total effective dose equivalent (TEDE) of 1.632 person-sievert (person-Sv) (163.2 person-rem) for an average TEDE of 0.00048 Sv (0.048 rem) (DOE undated).

The primary health concerns attributed to radiation exposure are the development of cancer and hereditary (genetic) effects. Although radiation-induced genetic effects have been observed in laboratory animals (given very high doses of radiation), no evidence of genetic effects has been observed among the children born to atomic bomb survivors from Hiroshima and Nagasaki. Thus, latent cancer fatalities (LCFs) are the radiological health effect end point used in this EIS as a measure of human health impacts. A conservative assumption in this regard is that any amount of radiation may pose some risk for causing cancer, and that the risk is higher for higher radiation exposures. A linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and the occurrence of cancer. This dose-response model suggests that any increase in dose, no matter how small, results in an incremental increase in risk. For the purposes of this EIS, the risk of a latent cancer fatality (LCF) is taken to be 0.06 LCF per person-Sv (0.0006 LCF per person-rem). (See the text box in this section for a discussion on LCFs.) This LCF risk factor is a gender- and age-averaged value that accounts for differences between male and female receptors from infancy through old age living in the United States (Eckerman et al. 1999). While female receptors were

Table 3.8. Radioactive atmospheric releases from SRS operations for 2000

Radionuclide	Curies[a]	Radionuclide	Curies[a]
Gases and Vapors		***Particulates (cont.)***	
H-3 (oxide)	3.24×10^{4}	Eu-152	4.13×10^{-5}
H-3 (elem.)	1.24×10^{4}	Eu-154	1.64×10^{-5}
H-3 total	4.48×10^{4}	Eu-155	4.02×10^{-6}
C-14	1.33×10^{-1}	Hg-203	2.23×10^{-10}
Kr-85	5.28×10^{4}	Ra-226	1.74×10^{-5}
I-129	1.71×10^{-3}	Ra-228	2.74×10^{-5}
I-131	6.96×10^{-6}	Ac-228	1.80×10^{-6}
I-133	1.18×10^{-4}	Th-228	5.76×10^{-7}
		Th-230	1.74×10^{-5}
Particulates		Th-232	2.58×10^{-6}
Cr-51	1.21×10^{-4}	Th-234	1.04×10^{-4}
Co-57	3.26×10^{-7}	Ba-133	5.4×10^{-10}
Co-58	1.27×10^{-4}	U-233	1.50×10^{-8}
Co-60	8.60×10^{-4}	U-234	3.98×10^{-4}
Ni-59	4.17×10^{-13}	U-235	1.80×10^{-5}
Ni-63	5.09×10^{-6}	U-236	4.16×10^{-11}
Zn-65	2.23×10^{-5}	U-238	5.20×10^{-4}
Sr-89,90	3.89×10^{-3}	Np-237	2.26×10^{-10}
Zr-95	1.68×10^{-5}	Pu-238	3.59×10^{-4}
Zr-85	1.07×10^{-9}	Pu-239	2.05×10^{-3}
Nb-94	3.95×10^{-10}	Pu-240	1.99×10^{-7}
Nb-95	1.13×10^{-4}	Pu-241	4.09×10^{-6}
Tc-99	8.75×10^{-5}	Pu-242	7.03×10^{-9}
Ru-103	4.23×10^{-5}	Am-241	1.46×10^{-4}
Ru-106	1.04×10^{-5}	Am-243	6.02×10^{-6}
Sb-124	5.63×10^{-10}	Cm-242	4.47×10^{-7}
Sb-125	5.34×10^{-5}	Cm-244	7.68×10^{-5}
Sn-113	6.20×10^{-10}	Cm-245	1.04×10^{-13}
Sn-126	6.45×10^{-14}	Cm-246	3.98×10^{-6}
Cs-134	1.31×10^{-4}	Ar-39	3.30×10^{-5}
Cs-137	8.15×10^{-3}	Na-22	7.90×10^{-11}
Ce-141	4.16×10^{-5}	Mn-54	1.30×10^{-10}
Ce-144	1.44×10^{-4}	Se-79	4.47×10^{-9}
Pa-233	2.23×10^{-10}		
Pr-144	3.68×10^{-13}	Alpha	7.35×10^{-4}
Pr-144m	4.43×10^{-15}	Beta-Gamma	3.57×10^{-2}
Pm-147	1.30×10^{-5}		

[a]One curie (Ci) equals 3.7×10^{10} becquerels (Bq). One Bq equals one disintegration per second (dps).

Source: Modified from Arnett and Mamatey (2001b).

Table 3.9. Radioactive liquid releases from SRS operations for 2000 (including direct and seepage basin migration releases)

Radionuclide	Curies[a]
H-3	5.34×10^{3}
Sr-90	5.44×10^{-2}
Co-60	1.62×10^{-3}
I-129	7.82×10^{-2}
Cs-137	8.81×10^{-2}
U-234	2.87×10^{-5}
U-235	6.18×10^{-6}
U-238	1.97×10^{-4}
Pu-238	2.21×10^{-5}
Pu-239	1.68×10^{-5}
Am-241	1.19×10^{-5}
Cm-244	7.01×10^{-6}
Alpha	1.96×10^{-2}
Beta-Gamma	4.44×10^{-2}

[a]One Ci equals 3.7×10^{10} Bq.

Source: Modified from Arnett and Mamatey (2001b).

estimated to have a slightly higher LCF rate than males, and infants a higher LCF rate than adults, the use of this risk factor for estimating collective LCF risks to the public in this EIS should provide a reasonable average based on current understanding of radiological effects in humans. On the other hand, the collective LCF risks to the facility workers and SRS employees evaluated in this EIS may be conservative (overestimated) because the more susceptible receptors, such as infants, considered in determining the LCF risk factor are not present in the SRS employee population.

3.10.4 Baseline Chemical Exposure and Risk

3.10.4.1 Chemical Risk Assessment Background

As stated in Section 3.10.2, human exposure to nonradioactive chemicals in air, water, or soil may occur through ingestion, inhalation, or contact with skin. Methods used to assess hazards associated with chemical exposures may simply involve a comparison of concentrations in air, water, or soil with health-risk based standards or guidelines available from state and federal agencies (see *SRS Baseline Risks* below). More detailed assessments estimate the extent of

Table 3.10. Estimated radiation exposures to the public from SRS emissions in 2000

Pathway/receptor	Dose	Standard
Air		
Maximally exposed individual [mSv (mrem)]	0.0004 (0.04)	0.10 (10)[a]
Collective population [person-Sv (person-rem)]	0.023 (2.3)	NA[b]
Liquid		
Maximally exposed individual [mSv (mrem)]	0.0014 (0.14)	0.04 (4)[c]
Collective population [person-Sv (person-rem)]	0.039 (3.9)	NA
Total		
Maximally exposed individual [mSv (mrem)]	0.0018 (0.18)[d]	1.0 (100)[e]
Collective population [person-Sv (person-rem)]	0.062 (6.2)[d]	NA

[a]Set by the EPA in "National Emission Standards for Hazardous Air Pollutants — Radionuclides," 40 CFR 61 Subpart H, December 15, 1989.

[b]NA = not applicable.

[c]Adopted from the EPA in DOE Order 5400.5 as set forth in "National Primary Drinking Water Standards," 40 CFR Part 141.11, July 9, 1976.

[d]Sum of the air and liquid pathways.

[e]All pathway dose standard from DOE Order 5400.5.

Source: Arnett and Mamatey (2001b).

human exposure due to a particular source and compare that exposure with benchmark levels for noncarcinogenic risks ("hazard index" approach) or benchmarks for carcinogenic risks.

In estimating either noncancer risks (that is, noncancer adverse health outcomes, such as liver damage or developmental impairment) due to chemical exposures or increased lifetime cancer risk, the first step is to estimate the chemical concentration in air, water, and/or soil, either present from natural sources or attributable to anthropogenic sources. The concentration estimate is combined with an estimate of the human intake level to produce a chemical-specific daily intake estimate. (The intake level is usually from the upper end of the expected range of possible intakes in order to make sure risk estimates take individuals who have unusually high intakes into account). Estimated intakes are compared with chemical-specific reference doses or cancer slope factors. The reference doses and cancer slope factors are developed by the EPA for many commonly used chemicals and are based on a broad range of toxicological data. See the text box for further information on risk estimation procedures.

3.10.4.2 SRS Chemical Baseline Risks

Public water supplies in the vicinity of the SRS are monitored and regulated to be in compliance with health-based federal standards, and remediation programs are underway at the SRS to

Concepts in Estimating Risks from Exposures to Chemicals in Air, Water, and Soil

Reference Dose: Intake level of a chemical that is very unlikely to have noncancer adverse effects; measured in units of milligrams per kilogram of body weight per day (mg/kg-d). Different reference doses often apply for oral and inhalation exposures.

Hazard Quotient: a comparison of the estimated intake level or dose of a chemical in air, water, or soil with its reference dose; expressed as a ratio.

> *Example:* If 5 parts per billion (0.005 mg/L) benzene is in groundwater used for drinking and 2 L is ingested daily by a 70-kg (150-lb) person over a period of 10 years, then
> Intake = (0.005 mg/L × 2 L/day)/70 kg = 0.00014 mg/kg-d.
> The reference dose for chronic ingestion of benzene is 0.0003 mg/kg-d.
> The benzene hazard quotient is 0.00014/0.0003 = 0.5. This hazard quotient is less than 1, indicating that the exposure is unlikely to cause adverse noncancer health effects.

Hazard Index: The sum of hazard quotients for all chemicals to which an individual is exposed. Used as a screening tool, a hazard index of less than 1 indicates that adverse health effects are unlikely. However, a hazard index of greater than 1 does not necessarily mean adverse health effects will occur, because different chemicals may react differently in the human body (that is, they may have different, nonadditive kinds of toxicity).

Slope Factor: an upper-bound estimate of a chemical's probability of causing cancer over a 70-year lifetime, based on the extent of intake during the exposure period and given in units of inverse intake [$(\text{mg/kg-d})^{-1}$ or 1/(mg/kg-d)]. For a carcinogen, different slope factors often apply for oral and inhalation exposures.

Increased Lifetime Cancer Risk: an upper-bound estimate of the likelihood that an individual will develop cancer as a result of exposure to a cancer-causing chemical. It is the product of the intake level and the slope factor.

> *Example:* benzene is also a cancer-causing chemical with an oral slope factor of up to 0.055 $(\text{mg/kg-d})^{-1}$.
>
> Assuming 5 parts per billion (0.005 mg/L) in water and calculating intake as above, but averaging over a lifetime of 70 years, the increased lifetime cancer risk for benzene ingestion would be:
>
> 0.00014 mg/kg-d x 0.055 $(\text{mg/kg-d})^{-1}$ x 10-yr exposure/70-yr lifetime = 0.0000011 (also can be stated as 1.1×10^{-6} or 1.1 in 1 million).
>
> This increased risk level would be considered to be small. It is at the lower end of the risk range of 0.000001 (10^{-6}, or 1 in 1 million) to 0.0001 (10^{-4}, or 1 in 10,000) which generally does not require mitigating actions.

control exposure to and eliminate areas of soil contamination. Therefore, the most important potential exposure pathway for workers and the general public would be through inhalation of contaminants released to air from ongoing SRS operations.

The SRS has approximately 200 regulated sources of air emissions. In 1991, the SCDHEC established Air Pollution Control Regulation 61-62.5, Standard No. 8, to regulate hazardous or toxic air pollutant emissions. To demonstrate compliance with this standard, the SRS completed an air emissions inventory and air dispersion modeling for all site sources in 1993, as summarized in Arnett and Mamatey (2001b). An update to the modeling was submitted in 1998 (Dukes 1998). The modeling effort provides estimates of maximum ambient concentrations at or beyond the SRS boundary due to SRS emission sources for about 200 toxic air pollutants (TAPs). The estimated maximum concentrations of the TAPs did not exceed values given in the 2001 version of the SCDHEC standard No. 8 (SCDHEC 2001).

Because regulatory standards are not developed exclusively on the basis of public health considerations, and because the basis for the SCDHEC standard concentrations is not described in available documentation (SCDHEC 2001), the potential for adverse human health impacts was assessed through comparison with health risk-based guideline levels. Specifically, the reported maximum ambient 24-hour average concentrations were modified by a factor of 0.2 to estimate annual average concentrations (based on EPA guidance [EPA 1992]). These estimated annual average concentrations were compared with health risk-based air concentrations developed by the EPA's Office of Air Quality Planning and Standards (OAQPS) (Smith et al. 1999) and with EPA-established reference concentrations for non-cancer effects (EPA 2003b). Although only two TAPs (TCDDs and tetrachloroethylene) exceeded the EPA guideline levels, 10 TAPs had estimated annual average concentrations between the EPA guideline cancer risk level values of 10^{-6} to 10^{-4} (see Table 3.11).

3.10.5 Baseline Physical Hazard Risks

Although worker physical hazard risks (i.e., risks of fatality or injury from on-the-job accidents) can be minimized when workers adhere to safety standards and use protective equipment as necessary, certain rates of accidents have been associated with all types of work. Risks can be calculated on the basis of historical industrywide statistics, as described below.

The expected annual numbers of worker fatalities and injuries for specific industry types are calculated on the basis of rate data from the Bureau of Labor Statistics, as reported by the National Safety Council (NSC 2001), and on the number of annual full-time equivalent (FTE) workers required for manufacturing activities. Employment at the SRS in 2000 was 13,227 people (DCS 2001b). It is assumed that, in general, the types of activities required for these employees would be similar to those for the manufacturing industrial sector, so those fatality and injury rates are used to estimate annual risks. A rate of 3.3 fatalities per 100,000 FTEs and 4.6 injuries per 100 FTEs is used. On the basis of these rates, the estimated annual number of fatalities for SRS workers is less than 1 (specifically, 0.44) per year. The estimated number of injuries is 610 per year (includes only injuries resulting in lost workdays, not including the day of injury). These physical hazard risks represent the baseline risks for existing SRS operations for comparison with impacts under the no-action and proposed action alternatives. However, actual injury and fatality risks over the past 10 years or more have been lower than those predicted on the basis of national statistics.

Table 3.11. Modeled site boundary ambient concentrations of select SRS toxic air pollutant (TAP) emissions in comparison with SCDHEC standards and EPA health risk-based guideline levels

Toxic air pollutant (TAP)	Number of SRS sources	SRS maximum modeled 24-hour average concentration ($\mu g/m^3$)[a]	SRS Estimated Annual Average Concentration ($\mu g/m^3$)[b]	SCDHEC standard ($\mu g/m^3$)	EPA guideline level ($\mu g/m^3$)[c]
TAPs with ambient level exceeding EPA guideline level					
TCDDs	1	0.00002	4×10^{-6}	0	3×10^{-8} to 3×10^{-6}
Tetrachloroethylene	36	99	20	3,350	0.17-17
TAPs with estimated annual ambient level between EPA Guideline 10^{-6} and 10^{-4} cancer risk level					
Arsenic	7	0.05	0.01	1.0	0.00023-0.023
Benzene	118	4.6	0.9	150	0.13-13 (30)
Beryllium	7	0.009	0.0020	0.01	0.00042-0.042 (0.02)
Bis(chloromethyl)ether	1	0.002	0.0004	0.03	2×10^{-5} to 2×10^{-3}
Carbon tetrachloride	16	4.2	0.84	150	0.067-6.7
Dimethyl benzidine	1	0.002	0.0004	NA	0.00038-0.038
Heptachlor	1	0.01	0.002	2.5	0.00077-0.077
Hydrazine	5	0.06	0.012	0.5	0.0002-0.02
Quinoline	1	0.004	0.0008	NA	0.00029-0.029
Trichloroethylene	38	23	5	6,750	0.5-50

[a]SCDHEC Standard No. 8 requires that the standards be compared with modeled maximum 24-hour average concentrations at or beyond the site boundary.

[b]EPA guideline values should be compared with annual average concentrations; these values were estimated as the maximum 24-hour ambient concentrations multiplied by 0.2.

[c]Where a range is given, the range corresponds to a 10^{-6} to 10^{-4} risk level (that is, the concentration that if inhaled for a lifetime would result in an increased individual risk of developing cancer of between 1 in 1 million and 1 in 10,000). Values in parentheses are verified reference concentrations established by the EPA (2003b), also recognized as important guidelines under SCDHEC Standard No. 8.

Sources: Dukes (1998); SCDHEC (2001); Smith et al. (1999, Table 2).

3.11 Socioeconomics

This section discusses existing socioeconomic conditions in the vicinity of the SRS as they relate to the proposed facilities. The socioeconomic data presented for the SRS describe a regional economic area (REA) comprising 15 counties around the site (see Appendix D) and a region-of-influence (ROI) surrounding the site comprising 4 counties — Columbia and Richmond Counties in Georgia and Aiken and Barnwell Counties in South Carolina. The REA is used to assess the potential regional economic impacts of site activities, specifically impacts on employment and unemployment and on personal income. The REA constitutes a broad market area defined by economic linkages between the various sectors in the regional economy.

The ROI was defined on the basis of the current residential locations of full-time SRS workers directly involved in the SRS activities and encompasses the area in which most of these workers spend their wages and salaries. The ROI is used to assess the impacts of site activities on population, housing, community services, and community fiscal conditions. More than 90% of SRS workers currently reside in these counties (DCS 2001b). In the following sections, data are presented for each of the counties in the ROI.

3.11.1 Population

The population of the ROI was at 475,095 in 2000 (U.S. Bureau of the Census 2002a) and was expected to reach 489,000 by 2001, as shown in Table 3.12. In 2000, 30% of the ROI total (142,552 people) resided in Aiken County (U.S. Bureau of the Census 2001), with 25,337 in the city of Aiken. Over the period 1990-2000, population in the ROI as a whole, in Aiken County, and in the city of Aiken grew slightly, with average growth rates of 1.4%, 1.7%, and 2.5%, respectively. Over the same period, population in South Carolina as a whole grew at a rate of 1.4%.

In 2000, 41% of the ROI population (195,182 persons) resided in the city of Augusta/ Richmond County, Georgia, with 19% (89,288) located in Columbia County, Georgia, and 5% (23,478) in Barnwell County, South Carolina (U.S. Bureau of the Census 2000). Growth in Augusta/Richmond County over the period 1990-2000 was slight at 0.3%, relatively high in Columbia County over the same period at 3.1%, and moderate in Barnwell County at 1.5%. Other incorporated places in the immediate vicinity of the SRS are Barnwell (population 5,035 in 2000), Blackville (2,973), Elko (212), Hilda (436), Jackson (1,625), New Ellenton (2,250), North Augusta (17,574), and Willston (3,307) (U.S. Bureau of the Census 2002a).

3.11.2 Employment and Unemployment

Employment in the REA totaled 207,660 people in 2000 and was expected to reach 214,000 in 2002. Employment grew at an annual average rate of 1.6% between 1990 and 2000 (U.S. Bureau of the Census 1992, 2002b). The economy of the REA is dominated by the trade

Table 3.12. ROI population statistics for selected years

Entity	1990[a]	2000[a]	Average annual growth rate (%), 1990-2000	2002 (projected)
Georgia				
Columbia County	66,031	89,288	3.1	95,000
Richmond County/City of Augusta	189,719	195,182	0.3	196,000
South Carolina				
Aiken County	120,991	142,552	1.7	147,000
City of Aiken	19,872	25,337	2.5	27,000
Barnwell County	20,293	23,478	1.5	24,000
ROI Total	415,394	475,095	1.4	489,000
Georgia	6,478,216	8,186,453	2.4	8,580,000
South Carolina	3,486,703	4,012,012	1.4	4,130,000

[a]*Source*: U.S. Bureau of the Census (2002a).

and service industries, with these activities currently contributing almost 63% of all employment in the REA (see Table 3.13). The manufacturing sector is also a significant employer in the REA, with 27% of total REA employment. Employment at the SRS in 2000 was 13,227 people (DCS 2001b).

Unemployment in the REA steadily declined during the late 1990s from a peak rate of 8.0% in 1993 to the 2002 rate of 5.7% (see Table 3.14) (U.S. Bureau of Labor Statistics 2002). Unemployment in Georgia was 4.7% in August 2002; in South Carolina the rate was 5.7% in that month.

3.11.3 Income

Personal income in the REA was $14.8 billion in 2000 and was expected to reach $15.6 billion in 2002. Personal income grew at an annual average rate of 1.8% over the period 1990-1999 (see Table 3.15). Personal income per capita in the REA also rose in the 1990s and was expected to reach $24,700 in 2002, compared with $23,146 at the beginning of the period.

3.11.4 Housing

Total housing in Columbia County grew at an annual rate of 3.5% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 35,400 in 2002, reflecting the relatively high growth in county population. About 9,580 new units were added to the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were expected to be 2,340 vacant housing units in the county in 2002, with 420 expected to be rental units available to construction workers at the proposed facilities.

Table 3.13. REA employment by industry, 2000

Sector	Employment	Percent of REA total
Agriculture[a]	6,250	3.0
Mining	877	0.4
Construction	11,399	5.5
Manufacturing	55,853	27.0
Transportation and Public Utilities	5,028	2.4
Trade	34,389	17.0
Finance, Insurance and Real Estate	7,783	3.7
Services	86,673	42.0
Other	193	0.1
Total	207,660	

[a]1997 data; U.S. Department of Agriculture (1999).

Source: U.S. Bureau of the Census (2002b), except as noted.

Table 3.14. REA unemployment rates

Period	Rate (%)
REA	
1990-2000 average	6.7
2002[a]	5.7
Georgia	
1990-2000 average	5.0
2002[b]	4.7
South Carolina	
1990-2000 average	5.4
2002[b]	5.7

[a]Rate is for July 2002.

[b]Rate is for August 2002.

Source: U.S. Bureau of Labor Statistics (2002).

Total housing in the City of Augusta/Richmond County grew at an annual rate of 0.6% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 82,800 in 2002, reflecting the relatively slow growth in county population. Only 5,000 new units were added to the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were projected to be 8,440 vacant housing units in the county in 2002, with 3,550 of those expected to be rental units available to construction workers at the proposed facilities.

Total housing in Aiken County grew at an annual rate of 2.3% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 64,100 in 2002. Growth in the city of Aiken was 2.9% over this period, with 11,900 total housing units expected in 2002. Almost 12,700 new units were added to the existing housing stock in the county between 1990 and 2000, 2,830 of which were built in the city of Aiken. On the basis of annual population growth rates, there were expected to be 6,610 vacant housing units in the county in 2002, with 1,610 expected to be rental units available to construction workers at the proposed facilities.

Table 3.15. REA personal income (2003 dollars)

Parameter	1990[a]	2000[a]	Average annual growth rate (%), 1990-2000	2002 (projected)
Total personal income ($ millions)	12,426	14,814	1.8	15,600
Personal income per capita ($)	23,146	24,681	0.6	25,300

[a]*Source*: U.S. Department of Commerce (2002).

Total housing in Barnwell County grew at an annual rate of 2.6% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 10,500 in 2002, reflecting the moderate growth in county population. About 2,300 new units were added to the existing housing stock in the county between 1990 and 2000. On the basis of annual population growth rates, there were projected to be 1,210 vacant housing units in the county in 2002, with 300 of those expected to be rental units available to construction workers at the proposed facilities.

Total housing in the ROI as a whole grew at an annual rate of 1.8% over the period 1990-2000 (see Table 3.16), with total housing units expected to reach 202,000 in 2002. About 31,600 new units were added to the existing housing stock in the ROI between 1990 and 2000. On the basis of annual population growth rates, there were projected to be 19,600 vacant housing units in the ROI in 2002, with 5,910 of those expected to be rental units available to construction workers at the proposed facilities.

3.11.5 Community Resources

Construction and operation of the proposed MOX facility, PDCF, and WSB would result in increased revenues and expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues would come primarily from state and local sales taxes associated with employee spending during construction and operation and local property taxes.

Additional revenues would be used to support additional local community services currently provided by each jurisdiction.

Construction and operation of the proposed facilities would result in increased demand for community services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands would also be placed on local medical facilities and physician services.

Tables D.1 and D.2 in Appendix D present information on revenues and expenditures by the various local government jurisdictions in the ROI. Tables 3.17 and 3.18 present data on employment and levels of service (number of employees per 1,000 population) for public safety, general local government services, and physicians. Tables 3.19 and 3.20 provide staffing data for school districts and hospitals.

Table 3.16. City, county, and ROI housing characteristics[a]

Parameter	1990[b]	2000[c]	2002 (projected)
Georgia			
Columbia County			
Owner occupied	17,322	25,557	27,100
Rental	4,519	5,563	5,900
Total unoccupied units	1,904	2,201	2,340
Total units	23,745	33,321	35,400
Richmond County/City of Augusta			
Owner occupied	38,762	42,840	43,100
Rental	29,913	31,080	31,300
Total unoccupied units	8,613	8,392	8,440
Total units	77,288	82,312	82,800
South Carolina			
Aiken County			
Owner occupied	33,491	42,036	43,400
Rental	11,392	13,551	14,000
Total unoccupied units	4,383	6,400	6,610
Total units	49,266	61,987	64,100
City of Aiken			
Owner occupied	5,130	6,804	7,140
Rental	2,619	3,483	3,660
Total unoccupied units	794	1,086	1,140
Total units	8,543	11,373	11,900
Barnwell County			
Owner occupied	5,194	6,810	7,010
Rental	1,906	2,211	2,280
Total unoccupied units	754	1,170	1,210
Total units	7,854	10,191	10,500
ROI Total			
Owner occupied	99,673	123,902	128,000
Rental	49,250	54,016	55,200
Total unoccupied units	16,520	19,116	19,600
Total units	165,443	197,034	202,000

[a]Column entries may not add up due to independent rounding.

[b]*Source*: U.S. Bureau of the Census (1994).

[c]*Source*: U.S. Bureau of the Census (2002a).

Table 3.17. Local public service employment (2001)

Part A: Georgia

	Columbia County		Grovetown		Harlem	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	147	1.8	17	2.8	7	3.9
Fire protection[b]	3	0	4	0.7	1	0.6
General	435	5.3	33	5.4	14	7.7
Total	585	7.2	54	8.9	22	12.1

	Augusta-Richmond County		Blythe		Hephzibah	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	357	1.8	1	1.4	4	1.0
Fire protection[b]	283	1.4	0	0	7	1.8
General	1,673	8.6	1	1.4	4	1.0
Total	2,313	11.9	2	2.8	15	3.9

	State of Georgia level of service[a,c]
Police protection	2.4
Fire protection[b]	1.1
General	52.0
Total	55.4

Part B: South Carolina

	Aiken County		Aiken		Jackson	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	131	1.4	54	2.1	4	2.5
Fire protection[b]	78	0.8	-[d]	-[d]	-[d]	-[d]
General	60	0.6	239	9.4	7	4.3
Total	269	2.8	347	13.7	11	6.8

	New Ellenton		North Augusta		Wagener	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	4	1.8	48	2.7	3	3.5
Fire protection[b]	-[d]	-[d]	6	0.3	-[d]	-[d]
General	5	2.2	125	7.1	5	5.8
Total	9	4.0	179	10.2	8	9.3

Table 3.17. Continued

	Barnwell County		Barnwell		Blackville	
	Number	Level of service[a]	Number	Level of service[a]	Number	Level of service[a]
Police protection	26	2.1	13	2.6	8	2.7
Fire protection[b]	-[d]	-[d]	3	0.6	1	0.3
General	150	12.3	22	4.4	11	3.7
Total	176	14.5	38	7.6	20	6.7

	Williston		State of South Carolina level of service[a,c]
	Number	Level of service[a]	
Police protection	9	2.7	2.5
Fire protection[b]	1	0.3	0.8
General	12	3.6	54.9
Total	22	6.7	58.2

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

[b]Does not include volunteers.

[c]2000 data.

[d]Police and fire services are provided by a combined department.

Sources: Aiken County: Powell (2001); Barnwell County: Aguilar (2001); Columbia County: J. Johnson (2001); Edgefield County: Harling (2001); Richmond County: Colliander (2001); City of Aiken: Rideout (2001); City of Jackson: S. Johnson (2001); Town of New Ellenton: Bledsoe (2001); City of North Augusta (2000); Town of Wagener: Salley (2001); City of Barnwell: Vargo (2001); Town of Blackville: McDonald (2001); Town of Williston: Fowler (2001); Town of Grovetown: Kent (2001) and Capatillo (2001); Town of Harlem: Moore (2001); City of Augusta (1999); Town of Blythe (2000); Town of Hephzibah (2000); U.S. Bureau of the Census (2000).

3.11.6 Traffic

Vehicular access to the SRS is provided from South Carolina SCs 19, 64, 125, 781, and U.S. Highway 278, as shown in Figures 3.1 and 3.8. Highway 19 runs north from the site through New Ellenton towards Aiken; SC 64 runs in an easterly direction from the site towards Barnwell; SC 125 runs through the site itself in a southeasterly direction between North Augusta and Allendale, passing through Beech Island and Jackson. U.S. 278 also runs through the site, in a southeasterly direction between North Augusta and Barnwell. SC 781 connects U.S. 278 with Willston to the northeast of the site. The northern perimeter of the site is about 16 km (10 mi) from downtown Aiken. Table 3.21 shows average annual daily traffic (AADT) flows over these road segments, together with congestion level designations (levels of service). Levels of service designations were developed by the Transportation Research Board (1985) and range from A to F. Designations A through C represent good traffic operating conditions with some minor delays experienced by motorists; F represents jammed roadway conditions.

Table 3.18. Local physicians data (1997)

County	Number of physicians	Level of service[a]
Georgia		
Columbia County	324	4.0
Richmond County	1,189	6.1
South Carolina		
Aiken County	190	1.4
Barnwell County	14	0.6

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

Source: American Medical Association (1999).

Table 3.19. Local school district data (2001)

School district	Number of teachers	Student-to-teacher ratio[a]
South Carolina		
Aiken County	1,486	17.0
Barnwell County		
School District 19	80	14.4
School District 29	70	14.9
School District 45	183	15.3
State total	44,967	15.2
Georgia		
Columbia County	1,064	17.0
Richmond County	2,200	16.0
State total	89,561	16.0

[a]The number of students per teacher in each school district.

Sources: Ferriter (2001); Georgia Department of Education (2000).

Table 3.20. Local medical facility data (2001)

Hospital	Number of staffed beds	Occupancy rate (%)[a]
Aiken Regional Medical Centers	245	56
Barnwell County Hospital	33	37
Georgia Regional Hospital at Augusta	196	79
Medical College of Georgia Hospital	446	56
Select Specialty Hospital	17	NA[b]
St. Joseph Hospital	151	48
University Hospital	553	50
Walton Rehabilitation Institute	58	78
ROI Total	1,699	-

[a]Percent of staffed beds occupied.

[b]NA = not available.

Source: SMG Marketing Group Inc. (Copyright 2001, used with permission).

Table 3.21. Average annual daily traffic (AADT) in the vicinity of the SRS (2000)

Road segment[a]	Traffic volume (AADT)	Level of service[b]
SC 125 in the vicinity of Jackson	13,400	B
U.S. 278 between SC 302 and Barnwell county line	5,400	A
SC 19 in the vicinity of New Ellenton	13,900	B
SC 781 between U.S. 278 and U.S. 78	2,700	A
U.S. 278 to SC 37	2,500	A
SC 64 between SC 20 and Barnwell	6,900	A
SC 125 between SC 17 and Martin	2,100	A

[a]SC = state route (highway); U.S. = U.S. highway.

[b]Level of service designations as developed by the Transportation Research Board (1985). Levels range from A to F, with A representing the best traffic operating conditions and F representing jammed roadway conditions.

Source: McCoy (2001), except as noted.

3.12 Aesthetics

Natural and man-made features give a landscape character and aesthetic quality. The character of a landscape is determined by the elements of form, line, color, and texture; each may influence the character of a landscape to a varying degree. The stronger the influence of any one or all of these elements, and the more visual variety that can successfully coexist in the landscape, the more aesthetic quality present in the landscape

3.12.1 General Description of the Site

The viewshed within the vicinity of the SRS consists principally of agricultural and forested land, with some residential and industrial development. The landscape is characterized mainly by wetland or forest on low mountains and hills with intermittent open land. Vegetation consists of hardwood forests in the low-lying areas and wetland forests, with oak and pine forests on higher ground.

3.12.2 Description of the Location of the Proposed Facilities

Various concrete industrial buildings and other structures, administrative and support buildings, and parking areas are located within the F-Area at the SRS. The largest structures are approximately 30 m (100 ft) high, with some stacks and towers reaching 60 m (200 ft) high. All of the industrial and administrative areas are brightly lit at night and are visible when approached on SRS access roads. The industrial and other developed areas in the vicinity of F-Area, including utility corridors, are generally consistent with a Bureau of Land Management visual resource management (VRM) Class IV designation (activities that lead to major modification of the existing character of the landscape). The remainder of the site fits a VRM Class III (hosting activities which at most only moderately change the existing character of the landscape) or IV designation (DOI 1986a,b).

The closest publicly accessible viewing location is from State Highway 125, about 6 km (4 mi) to the southwest. Public view of F-Area is restricted by the heavily wooded terrain between Route 125 and the site.

3.13 References for Chapter 3

Aguilar, N. 2001. Personal communication from Aguilar (Barnwell County, SC) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

American Medical Association 1999*. Physician Characteristics and Distribution in the U.S*. Chicago, IL.

Arnett, M.W., and A.R. Mamatey (eds.) 2000a. *Savannah River Site Environmental Data for 1999*. WSRC-TR-99-00301. Westinghouse Savannah River Company, Aiken, SC.

Arnett, M.W., and A.R. Mamatey (eds.) 2000b. *Savannah River Site Environmental Report for 1999*. WSRC-TR-99-00299. Westinghouse Savannah River Company, Aiken, SC.

Arnett, M.W., and A.R. Mamatey (eds.) 2001a. *Savannah River Site Environmental Data for 2000.* WSRC-TR-2000-0329. Westinghouse Savannah River Company, Aiken, SC.

Arnett, M.W., and A.R. Mamatey (eds.) 2001b. *Savannah River Site Environmental Report for 2000.* WSRC-TR-2000-00328. Westinghouse Savannah River Company, Aiken, SC.

Arnold, J.E., et al. 1998. *Efforts to Save an Endangered Species* - Echinacea laevigata *(smooth coneflower)*. Horticulture Department, Clemson University, Clemson, SC. Available at http://virtual.clemson.edu/groups/hort/sctop/bsec/bsec-13.htm (last updated July 16).

Bennett, D.H., and R.W. McFarlane 1983. *The Fishes of the Savannah River Plant: National Environmental Research Park*. SRO-NERP-12. U.S. Department of Energy, Savannah River Ecology Laboratory, National Environmental Research Park Program, Aiken, SC. Aug.

Bledsoe, K. 2001. Personal communication from Bledsoe (Town of New Ellenton, SC) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

Bowling, T.J. 2001. E-mail from Bowling (Duke Cogema Stone & Webster, Charlotte, NC) to M. L. Birch (Duke Cogema Stone & Webster, Charlotte, NC). June 6.

Cabak, M.A., et al. 1996. *Distributional Archaeology in the Aiken Plateau: Intensive Survey of E Area, Savannah River Site, Aiken County, South Carolina*. Savannah River Archaeological Research Papers 8.

Capatillo, V. 2001. Personal communication from Capatillo (Town of Grovetown, GA) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

City of Augusta 1999. *City of Augusta Annual Financial Statement*. Augusta, GA. Dec.

City of North Augusta 2000. *City of North Augusta Annual Financial Statements*. North Augusta, SC. Dec.

Colliander, B. 2001. Personal communication from Colliander (Richmond County, SC) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

Conant, R. 1958. *A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian.* Houghton Mifflin Company, Boston, MA.

Davis, C.E., and L.L. Janecek 1997. *DOE Research Set-Aside Areas of the Savannah River Site*. SRO-NERP-25. U.S. Department of Energy, Savannah River Ecology Laboratory, National Environmental Research Park Program, Aiken, SC. Aug.

DCS (Duke Cogema Stone & Webster) 2001a. *Mixed Oxide Fuel Fabrication Facility Construction Authorization Request*. Docket No. 070-03098. Charlotte, NC.

DCS 2001b. *Responses to Request for Additional Information for the Duke Cogema Stone & Webster (DCS) Mixed Oxide (MOX) Fuel Fabrication Facility (FFF) Environmental Report (ER).* Report with letter and attachments on CD-ROM, submitted by P. S. Hastings (DCS, Charlotte, NC) to U.S. Nuclear Regulatory Commission, Washington, DC. July 12.

DCS 2002. *Mixed Oxide Fuel Fabrication Facility Environmental Report, Revision 1 & 2.* Docket Number 070-03098. Charlotte, NC. July.

DCS 2003a. *Mixed Oxide Fuel Fabrication Facility Environmental Report, Revision 3.* Docket Number 070-03098. Charlotte, NC. June.

DCS 2003b. *Mixed Oxide Fuel Fabrication Facility Environmental Report, Revision 4.* Docket Number 070-03098. Charlotte, NC. Aug.

DCS 2003c. *MOX Fuel Fabrication Facility Site Geotechnical Report*. DCS01-WRS-DS-NTE-G-00005-E, Charlotte, NC. June

DOE (U.S. Department of Energy) undated. *DOE Occupational Radiation Exposure 2000 Report.* Assistant Secretary for Environment, Safety and Health, Office of Safety and Health, Washington, DC.

DOE 1991a. *Draft Environmental Impact Statement for the Siting, Construction, and Operation of New Production Reactor Capacity*. DOE/EIS-0144D. Office of New Production Reactors, Washington, DC. April.

DOE 1991b. *American Indian Religious Freedom Act (AIRFA) Compliance at the Savannah River Site*. Prepared by NUS Corporation and RDN, Inc., for Savannah River Operations Office, Environmental Division, Aiken, SC. April.

DOE 1995. *Savannah River Site Waste Management Final Environmental Impact Statement*. DOE/EIS-0217. Savannah River Operations Office, Aiken, SC. July.

DOE 1996. *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*. DOE/EIS-0229. Office of Fissile Materials Disposition, Washington DC. Dec.

DOE 1997. *Integrated Data Base Report — 1996: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*. DOE/RW-0006, Rev. 13. Office of Environmental Management, Washington, DC. Dec.

DOE 1999. *Surplus Plutonium Disposition Final Environmental Impact Statement.* DOE/EIS-0283. Office of Fissile Materials Disposition, Washington DC. Nov.

DOE 2000a. *Savannah River Site Strategic Plan*. Savannah River Site, Aiken, SC. March.

DOE 2000b. *Savannah River Site Long Range Comprehensive Plan.* Savannah River Site, Aiken, SC. Dec.

DOI (U.S. Department of the Interior) 1986a. *Visual Resource Inventory*. BLM Manual Handbook H-8410-1. Bureau of Land Management, Washington, DC. Jan.

DOI 1986b. *Visual Resource Contrast Rating*. BLM Manual Handbook H-8431-1. Bureau of Land Management, Washington, DC. Jan.

Dukes, M.D. 1998. “Savannah River Site (SRS) Air Dispersion Modeling Update.” Letter from Dukes (Environmental Protection Department, Westinghouse Savannah River Co., Aiken, SC) to C.W. Richardson (Director of Bureau of Air Quality, South Carolina Department of Health and Environmental Control, Columbia, SC). Oct. 13.

Eckerman, K.F., et al. 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides, Federal Guidance Report No. 13*. EAP 402-R-99-001. Prepared by Oak Ridge National Laboratory, Oak Ridge, TN, for U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, DC. Sept.

EPA (U.S. Environmental Protection Agency) 1972. *Federal Air Quality Control Regions*. Publication No. AP-102. Office of Air Programs, Rockville, MD. Jan.

EPA 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety.* EPA-550/9-74-004. Washington, DC.

EPA 1992. *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised*. EPA-454/R-92-019. Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC. Oct.

EPA 2001. *National Emission Inventory (NEI) 1999 Version 1 for Criteria Pollutants*. Office of Air Quality Planning and Standards, Research Triangle Park, NC. March 20. Available at ftp://ftp.epa.gov/EmisInventory/net_99.

EPA 2002. *AirData — Reports and Maps*. Office of Air Quality Planning and Standards, Research Triangle Park, NC. Aug. Available at http://www.epa.gov/air/data/reports.html.

EPA 2003a. *Air Data — Reports and Maps*. Office of Air Quality and Standards, Research Triangle Park, NC. June. Available at http://www.epa.gov/air/data/reports.html.

EPA 2003b. "Integrated Risk Information System Database." Available at http://www.epa.gov/iriswebp/iris/index.html. Accessed June 2003.

Ferriter, M. 2001. Personal communication from Ferriter (South Carolina Department of Education) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

Fowler, P. 2001. Personal communication from Fowler (Town of Williston, SC) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

GDNR (Georgia Department of Natural Resources) 2000. *Rules for Air Quality Control.* Chapter 391-3-1. Environmental Protection Division, Air Protection Branch, Atlanta, GA. Dec. 28.

Georgia Department of Education 2000. *1999-2000 Public Education Report Card*. Available at http://accountability.doe.k12.ga.us/report2000.

Hanson, G.T., et al. 1978. "The Preliminary Archaeological Inventory of the Savannah River Plant, Aiken and Barnwell Counties, South Carolina." Research Manuscript Series 134. South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia, SC.

Harling, M. 2001. Personal communication from Harling (Edgefield County, SC) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

Johnson, J. 2001. Personal communication from Johnson (Columbia County, GA) to L. Nieves, (Argonne National Laboratory, Argonne, IL). May.

Johnson, S. 2001. Personal communication from Johnson (Town of Jackson, SC) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

Kent, S. 2001. Personal communication from Kent (Town of Grovetown, GA) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

King, A., and K. Stephenson 2000. *Archaeological Survey and Testing of the Surplus Plutonium Disposition Facilities*. Technical Report Series No. 24. Savannah River Archaeological Research Program, South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia, SC. April.

Kirkham, R.M., and W.P. Rogers 1981. *Earthquake Potential in Colorado.* Colorado Geological Survey Bulletin 43. Department of Natural Resources, Denver, CO.

Mayer, J.J., and L.D. Wike 1997. *SRS Urban Wildlife: Environmental Information Document*. WSRC-TR-97-0093. Westinghouse Savannah River Company, Savannah River Site, Aiken, SC. May.

McCoy, N. 2001. Personal communication from McCoy (South Carolina Department of Transportation) to T. Allison (Argonne National Laboratory, Argonne, IL). May.

McDonald, J. 2001. Personal communication from McDonald (Town of Blackville, SC) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

Moore, D. 2001. Personal communication from Moore (Town of Harlem, GA) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

NCRP (National Council on Radiation Protection and Measurements) 1987. *Ionizing Radiation Exposure of the Population of the United States; Recommendations of the National Council on Radiation Protection and Measurements*. NCRP Report No. 93. Bethesda, MD.

NOAA (National Oceanic and Atmospheric Administration) 1999. *Local Climatological Data: Annual Summary with Comparative Data for Augusta, Georgia (AGS)*. National Climatic Data Center, Asheville, NC.

Noah, J.C. (compiler) 1995. *Land-Use Baseline Report, Savannah River Site*. WSRC-TR-95-0276. Westinghouse Savannah River Company, Savannah River Site, Aiken, SC. June.

NSC (National Safety Council) 2001. *Injury Facts.* 2000 Edition. Itasca, IL.

NUS 1990. *Sound-Level Characterization of the Savannah River Site*. Report No. NUS-5251. NUS Corp. Aug.

Powell, D. 2001. Personal communication from Powell (Aiken County, SC) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

Press, F., and R. Siever 1982. *Earth*. W.H. Freeman and Company, San Francisco, CA.

Rideout, S. 2001. Personal communication from Rideout (City of Aiken, SC) to L. Nieves (Argonne National Laboratory, Argonne, IL). May.

Ruffner, J.A. 1985. *Climates of the States*. Third Edition. Gale Research Company, Book Tower, Detroit, MI.

Salley, T. 2001. Personal communication from Salley (Town of Wagener, SC) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

SCDHEC (South Carolina Department of Health and Environmental Control) 2000. *Air Quality Modeling Guidelines*. Bureau of Air Quality, Columbia, SC. Jan.

SCDHEC 2001. *Air Pollution Control Regulations and Standards, Regulation 61-26.5, Air Pollution Control Standards, Standard No. 8, Toxic Air Pollutants*. Oct. 26. Available at http://www.scdeh.net/eqc/baq/html/regulatory.html.

SCDHEC 2002a. *Ambient Air Quality Data Summary for 1998.* July. Available at http://www.scdhec.net/baq/html/modeling.htm.

SCDHEC 2002b. *Ambient Air Quality Data Summary for 1999.* July. Available at http://www.scdhec.net/baq/html/modeling.htm.

SCDHEC 2002c. *Ambient Air Quality Data Summary for 2000.* July. Available at http://www.scdhec.net/baq/html/modeling.htm.

SCDHEC 2002d. *Ambient Air Quality Data Summary for 2001.* July. Available at http://www.scdhec.net/baq/html/modeling.htm.

SCDNR (South Carolina Department of Natural Resources) 2000/2001. "Hunting Regulations in South Carolina, Wildlife Management Areas Game Zone 3 Aiken, Lexington & Richland Counties." Wildlife Management Offices, New Ellenton, SC. Available at http://water3.dnr.state.sc.us/dnr/etc/rulesregs/img/zone3.pdf.

Schalles, J.F., et al. 1989. *Carolina Bays of the Savannah River Plant.* Savannah River Plant, National Environmental Research Park Program, Aiken, SC. March.

Sessions, J. 1997. "Request for Waste Management Information." Personal communication from Sessions (Westinghouse Savannah River Company, Aiken, SC) to J. Dimarzio (SAIC). Oct. 1.

SMG Marketing Group Inc. 2001. Data downloaded from the web site www.hospitalselect.com and used with permission. Chicago, IL. Nov 20.

Smith, R.L., et al. 1999. *Ranking and Selection of Hazardous Air Pollutants for Listing Under Section 112(k) of the Clean Air Act Amendments of 1990, Technical Support Document*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Available at http://www.epa.gov/ttn/atw/urban/main_txt.pdf (accessed on April 12, 2001).

Specht, W.L., and M.H. Paller 2001. *Instream Biological Assessment of NPDES Point Source Discharges at the Savannah River Site, 2000*. WSRC-TR-2001-00145. Westinghouse Savannah River Company, Savannah River Site, Aiken, SC. May.

SRARP (Savannah River Archaeological Research Program) 1989. *Archaeological Resource Management Plan of the Savannah River Archaeological Research Program*. South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia, SC. Dec.

SRS (Savannah River Site) 2002. *Plutonium Disposition Program (PDP) Preconstruction Environmental Monitoring Report*. ESH-EMS-2002-1141, Rev. 0. Westinghouse Savannah River Company, Aiken, SC. June.

Storm Prediction Center 2001. *Historical Tornado Data Archive, Graphs and Charts on U.S. Tornadoes: 1950-1998 Tornadoes by State*. April 26. Available at http://www.spc.noaa.gov/archive/tornadoes/index.html.

Town of Blythe 2000. *City of Blythe Financial Report*. Blythe, GA. Dec.

Town of Hephzibah 2000. *Town of Hephzibah Financial Report*. Hephzibah, GA. Dec.

Transportation Research Board 1985. *Highway Capacity Manual*. National Research Council, Washington DC.

U.S. Bureau of Labor Statistics 2002. *Local Area Unemployment Statistics*. Washington, DC. Available at ftp://ftp.bls.gov/pub/time.series/la/.

U.S. Bureau of the Census 1992. *County Business Patterns, 1990*. Washington, DC. Available at http://www.census.gov/ftp/pub/epcd/cbp/view/cbpview.html.

U.S. Bureau of the Census 1994. *City and County Data Book, 1994*. Washington, DC.

U.S. Bureau of the Census 2000. *Census of Governments 2000*. Washington, DC. Available at http://www.census.gov/govs/www/cog.html.

U.S. Bureau of the Census 2002a. *U.S. Census American Fact Finder*. Washington, DC. Available at http://factfinder.census.gov/.

U.S. Bureau of the Census 2002b. *County Business Patterns, 2000*. Washington, DC. Available at http://www.census.gov/ftp/pub/epcd/cbp/view/cbpview.html.

U.S. Department of Agriculture 1999. *Census of Agriculture — County Data, 1997*. National Agricultural Statistics Service, Washington, DC. Available at http://www.nass.usda.gov/census/census97/volume1/vol1pubs.htm.

U.S. Department of Commerce 2002. *Regional Accounts Data — Local Area Personal Income*. Bureau of Economic Analysis, Washington, DC. Available at http://www.bea.doc.gov/bea/regional/reis/.

USFS (U.S. Forest Service) 2000. *Threatened, Endangered, and Sensitive Species Survey and Evaluation of F-Area Plutonium Disposition Mission Area at the Savannah River Site.* U.S. Forest Service, Savannah River Institute, Savannah River Site, Natural Resource Management Program, Aiken, SC. March 29.

USGS (U.S. Geological Survey) 2001. *Large Earthquakes in the United States, Charleston, South Carolina.* Available at http://wwwneic.cr.usgs.gov/neis/eqlists/USA/1886_09_01.html, accessed April 15, 2001.

Vargo, K. 2001. Personal communication from Vargo (City of Barnwell, SC) to J. Jackson (Argonne National Laboratory, Argonne, IL). July.

Weather Site, Inc. 2003. *Hurricane* Site dot Com. Available at http://www.hurricanesite.com. May 7.

Wike, L.D., and E.A. Nelson 2000. Memo from Wike and Nelson to J.S. Roberts (Westinghouse Savannah River Company, Aiken, SC). March 30.

Workman, S.W., and K.W. McLeod 1990. *Vegetation of the Savannah River Site: Major Community Types*. SRO-NERP-19. Savannah River Site, National Environmental Research Park Program, Aiken, SC. April.

WSRC (Westinghouse Savannah River Company) 1994. "SRS Ecology Environmental Information Database." CD database prepared for the U.S. Department of Energy by Westinghouse Savannah River Company under Contract No. DE-AC09-89SR18035. May 5.

WSRC 1997a. *Groundwater Mixing Zone Application for the Old F-Area Seepage Basin (U)*. WSRC-RP-97-39, Rev. 1. Savannah River Site, Aiken, SC. March.

WSRC. 1997b. *SRS Ecology Environmental Document*. WSRC-TR-97-0023. Savannah River Site, Aiken, SC.

WSRC 2000a. *Natural Phenomena Hazards (NPH) Design Criteria and Other Characterization Information for the Mixed Oxide (MOX) Fuel Fabrication Facility at Savannah River Site (U)*. WSRC-TR-2000-00454. Savannah River Site, Aiken, SC. Nov.

WSRC 2000b. *Savannah River Site Approved Site Treatment Plan, 2000 Annual Update*. WSRC-TR-0608, Rev. 8. Savannah River Site, Aiken, SC. March.

WSRC, 2000c, *Savannah River Site Environmental Report for 1999.* WSRC-TR-99-00299. Savannah River Site, Aiken, SC.