CHAPTER 3

AFFECTED ENVIRONMENT

This chapter describes the existing environment of the Savannah River Plant (SRP) and the nearby region that would be affected by the following modifications considered in this environmental impact statement (EIS):

- Implementation of remedial and closure actions at hazardous, low-level radioactive, and mixed waste sites.
- Establishment of new onsite disposal facilities for hazardous, low-level radioactive, and mixed wastes.
- Potential changes in the discharge of disassembly-basin purge water from C-, K-, and P-Reactors to seepage basins.

3.1 GEOGRAPHY

3.1.1 LOCATION

The Savannah River Plant is located in southwestern South Carolina and occupies an almost circular area of approximately 780 square kilometers (192,700 acres). Figure 3-1 shows the SRP location in relation to major population centers in South Carolina and Georgia. The major physiographic feature is the Savannah River, which forms the southwestern boundary of the Plant and is also the South Carolina-Georgia border. The Plant occupies parts of three South Carolina counties (Aiken, Barnwell, and Allendale).

3.1.2 SITE DESCRIPTION AND LAND USE

The U.S. Government established the SRP area in the 1950s for the production of nuclear materials for national defense. The Plant is a controlled area with limited public access. The facilities, which can be characterized as heavy industry, occupy less than 5 percent of the SRP area.

Figure 3-2 shows the locations of major SRP facilities. P-, K-, and L-Reactors are operating; R-Reactor is in standby status; and C-Reactor is in an extended shutdown. The facilities for fabricating fuel and the target elements to be irradiated in SRP reactors are in M-Area. Two chemical-separations areas (F and H) process irradiated materials. One centrally located site, the Burial Ground, is used to dispose of solid low-level radioactive and mixed wastes; it occupies approximately 200 acres between F- and H-Areas. The Savannah River Laboratory (SRL), adjacent to A-Area, is a process-development laboratory that supports production operations. Other facilities include a heavy-water extraction and recovery plant (D-Area) in standby condition since 1982; production-design test facilities (CMX-TNX Area); central shops (CS-Area) for support; administration areas (A-Area); and a Heavy Water Control Test Facility (U-Area). TC

In addition, the U.S. Department of Energy (DOE) is constructing two facilities near the chemical-separations areas. The Defense Waste Processing Facility (DWPF) will immobilize high-level radioactive waste into a solid, nonleachable borosilicate glass waste form. The Naval Reactor Fuel Material Facility (FMF) will produce nuclear fuel for the U.S. Navy.

Present and previous land use characteristics of the SRP are described in Dukes, 1984.

3.1.3 SOCIOECONOMIC AND COMMUNITY CHARACTERISTICS

DOE produced a comprehensive description of socioeconomic and community characteristics for the area around the Savannah River Plant in 1981 (ORNL, 1981) and in 1984 (DOE, 1984a). Additional information on the topics presented in this section can be found in the updated report.

3.1.3.1 Study Area

TC Approximately 97 percent of SRP employees reside in a 13-county area around the Plant, 9 in South Carolina and 4 in Georgia. The operating and construction force on the Plant has averaged 7500, ranging from a low of 6000 in the 1960s to about 15,600 in September 1987. About 97 percent of this total are employed by E. I. du Pont de Nemours and Company and its subcontractors; the remainder are employed by the U.S. Department of Energy, the University of Georgia, the U.S. Forest Service, and Wackenhut Services, Inc.

TC Aiken County, the City of Aiken, and the small towns immediately around the SRP site have felt the greatest impact of the Savannah River Plant. SRP workers and families comprise roughly one-half of the City of Aiken's nearly 18,000 population (1986) and account in large measure for the high median family incomes in Aiken County.

The greatest percentage of employees reside in the six-county area of Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. Together, these six counties house approximately 89 percent of the total SRP work force. DOE chose these six counties as the study area for the assessment of potential socioeconomic and community effects of the proposed waste management alternatives because the percentage of employees residing in them has remained essentially the same since the early 1960s.

3.1.3.2 Demography

Table 3-1 lists the 1980 populations in the study area for counties and places of more than 1000 persons. The largest cities in the study area are Augusta, Georgia, and Aiken, North Augusta, and Barnwell, South Carolina. Of the 31 incorporated communities in the study area, 16 have populations under 1000 persons, and 11 have populations between 1000 and 5000 persons. Aiken, Columbia, and Richmond Counties, which comprise the Augusta Standard Metropolitan Statistical Area (SMSA), have a total population of about 327,400; however, most of this population resides outside cities or towns. About two-thirds of the total six-county population reside in rural or unincorporated areas.

In 1980, the estimated population in the 80-kilometer area around the Savannah River Plant was approximately 563,300 persons. The estimated population for the year 2000 in this area is 852,000 persons. This estimate was calculated

Table 3-1. 1980 Population for Counties and Places of 1000 Persons or More[a]

Location	1980 population
Aiken County, South Carolina	105,625
City of Aiken	14,978
Town of Jackson	1,771
City of North Augusta	13,593
City of New Ellenton	2,628
Allendale County, South Carolina	10,700
Town of Allendale	4,400
Town of Fairfax	2,154
Bamberg County, South Carolina	18,118
Town of Bamberg	3,672
City of Denmark	4,434
Barnwell County, South Carolina	19,868
City of Barnwell	5,572
Town of Blackville	2,840
Town of Williston	3,173
Columbia County, Georgia	40,118
City of Grovetown	3,384
City of Harlem	1,485
Richmond County, Georgia	181,629
City of Augusta	47,532
Town of Hephzibah	1,452
Study area total	376,058

[a]Adapted from Bureau of the Census, 1982a,b.

using the 1970-to-1980 growth rate of each county in the 80-kilometer area and assuming the same growth rates would continue in the future. For counties that experienced a negative population growth rate between 1970 and 1980, the calculation assumed that continued population decline would not occur. This total county population estimate for the year 2000 is approximately 12 percent higher than the estimates prepared by the States, based on a comparison with projections prepared by Georgia and South Carolina (ORNL, 1981).

3.1.3.3 Land Use

In the study area near SRP, less than 8 percent of the existing land use is devoted to urban and built-up uses. Most such uses are in and around the Cities of Augusta and Aiken. Agriculture accounts for about 21 percent of total land use; forests, wetlands, water bodies, and unclassified lands that are predominantly rural account for about 70 percent.

The projected future land uses of the study area are similar to existing land-use patterns. Developed urban land is projected to increase by 2 percent in the next 20 years. The largest percentage of this growth is expected to occur in Aiken and Columbia Counties as a result of the expansion of the Augusta metropolitan area (ORNL, 1981).

3.1.3.4 Public Services and Facilities

The study area has nine public school systems. Each county has a county-wide school district except Bamberg, which has two districts, and Barnwell, which has three. In 1982, these districts could accommodate an estimated 3642 new students.

Of the 120 public water systems in the study area, 30 county and municipal systems serve about 75 percent of the population. The other 90 systems are generally smaller and serve individual subdivisions, mobile home parks, or commercial and industrial enterprises. All but four of the municipal and county water systems - the Cities of Aiken, Augusta, and North Augusta, and Columbia County - obtain their water from deep wells. Aiken obtains some of its water from Shaws Creek and Shiloh Springs, while Columbia County and the Cities of Augusta and North Augusta obtain water from the Savannah River upstream of SRP. Restrictions in system capabilities for municipal and county water systems that use groundwater as their supply are due primarily to storage and treatment capacity rather than availability of groundwater.

Most municipal and county wastewater-treatment systems have the capacity to treat additional sewage. Some rural municipalities in Allendale, Bamberg, and Columbia Counties and the City of Augusta in Richmond County have experienced problems in treatment-plant capacities. Programs to upgrade facilities are under way or planned in most of these areas.

3.1.3.5 Housing

Since 1970, the largest increases in the number of housing units have occurred in Columbia, Richmond, and Aiken Counties. Columbia County has grown the fastest, more than doubling its number of housing units. Between 1970 and 1980, Aiken and Richmond Counties both experienced about a 36-percent increase in the number of housing units. In Aiken County, one-fourth of this increase resulted from the high growth rate in the number of mobile homes.

The vacancy rate for owner-occupied housing units for the six-county area in 1980 was 2.3 percent. Individual county rates ranged from 3.6 percent in Columbia County to 0.8 percent in Barnwell County. Vacancy rates for rental units in 1980 ranged from 14.8 percent in Columbia County to 7.1 percent in Bamberg County; the rate in 1980 for the study area was 10.5 percent.

3.1.3.6 Economy

The results of the 1980 Census of Population indicate, between 1970 and 1980, a 35-percent increase in total employment, from 75,732 to 102,326, in establishments with payrolls in the six-county area. Service sector employment increased at these establishments by 65 percent, mirroring a national trend toward a service-based economy. Employment in manufacturing increased by 27 percent, adding more than 9000 employees. Most of the overall expansion in the number of employment positions occurred in Richmond and Aiken Counties.

About 31 percent of the workforce in the six-county area in 1980 was employed in the service sector, and 27 percent in the manufacturing sector. Retail trade was the third largest category, accounting for 15 percent of the workforce. The remaining 25 percent of the workforce was distributed among the seven additional categories of employment reported by the Census. In 1980, fewer than 2 percent of workers in the study area were employed in the category of agriculture, forestry, and fishing, while nearly 4 percent were employed in that category in 1970.

Employed residents of Richmond and Aiken Counties accounted for about 77 percent of the study area's employed population in 1980. The largest sectors of employment for these counties were services and manufacturing. The three counties with the smallest populations and workforce numbers (Allendale, Bamberg, and Barnwell) are also more rural and had a higher proportion of workers engaged in agriculture. In these three counties, however, agriculture employs 11 percent or less of the workforce, while the service and manufacturing sectors employ relatively large percentages of the workforce.

The study area's per capita income level increased from 22 percent below the national average in 1969 to 18 percent below in 1979. Of the six counties, all but Richmond showed a gain in per capita income relative to the national average during the 10-year period.

3.1.4 HISTORIC AND ARCHAEOLOGICAL RESOURCES

As of February 1986, 76 sites in the six-county study area were listed in the National Register of Historic Places. Richmond County had the largest number of sites (27), most of which are in the City of Augusta. Thirty-five National Register sites are in Aiken and Allendale Counties. The remaining 14 sites are scattered throughout the remaining three-county area.

A recent effort undertaken for this environmental impact statement (EIS) involved an intensive archaeological and historical survey of 82 waste sites, which was conducted from October 1985 through January 1986. This survey discovered one prehistoric site (38BR584), represented by an isolated, Early Archaic hafted biface from an area adjacent to the P-Area Burning/Rubble Pit. Due to its limited extent and disturbed context, this site is not considered to be potentially eligible for the National Register of Historic Places. DOE has requested concurrence with its determination of "no effect" on any archaeological or historic resources resulting from activities associated with the proposed closure of the 77 waste sites to the State Historic Preservation Officer (Brooks, 1986). Concurrence of "no effect" was received by DOE on October 6, 1986. TC Q-1

3.2 METEOROLOGY AND CLIMATOLOGY

This section describes of the meteorology of the Savannah River Plant, based on data collected at the SRP and at Bush Field, Augusta, Georgia (Du Pont, 1980a, 1982a; Hoel, 1983; NOAA, 1985). Meteorological tapes for 1975 through 1979 from the onsite meteorological program provided additional data for this characterization.

3.2.1 REGIONAL CLIMATOLOGY

The SRP has a temperate climate, with mild winters and long summers. The region is subject to continental influences, but it is protected from the more severe winters in the Tennessee Valley by the Blue Ridge Mountains to the north and northwest. The SRP and the surrounding area are characterized by gently rolling hills with no unusual topographical features that would significantly influence the general climate.

Winters are mild and, although cold weather usually lasts from late November to late March, less than one-third of the days have a minimum temperature below freezing.

3.2.2 LOCAL METEOROLOGY

3.2.2.1 Average Wind Speed and Direction

The average wind speed measured in Augusta from 1951 to 1981 was 3.0 meters per second. The average recorded at a height of 10 meters on the WJBF-TV tower near Beech Island, about 15 kilometers northwest of the SRP, from 1976 to 1977, was 2.5 meters per second. Table 3-2 lists the average monthly wind speed for Augusta, Georgia, along with the prevailing wind direction for each month. This table also lists the monthly and annual average wind speeds for three levels of the television tower.

On an annual basis, the predominant wind direction is west-northwest to east-southeast, with a secondary maximum of east-northeast to west-southwest. In general, seasonal transport is as follows: winter, northwest to southeast; spring, west to east; summer, toward the southwest through north to northeast; and autumn, toward the southwest and southeast. Because pollutant dispersion depends on atmospheric stability, annual wind roses are available for each SRP tower for seven Pasquill-type stability classes; seasonal wind roses are also available (Hoel, 1983).

3.2.2.2 Precipitation

The average annual rainfall at the SRP from 1952 through 1982 was about 122 centimeters (Table 3-3). The average rainfall at Augusta's Bush Field from 1951 to 1980 was about 112 centimeters (NOAA, 1985). The maximum monthly precipitation was about 31.3 centimeters, recorded in August 1964. Hourly observations in Augusta show that the intensity of rainfall is normally less than 1.3 centimeters per hour.

3.2.3 SEVERE WEATHER

3.2.3.1 Extreme Winds

The strongest winds in the SRP area occur in tornadoes, which can have wind speeds as high as 116 meters per second. The next strongest surface winds occur during hurricanes. During the history of the SRP, only Hurricane

Table 3-2. Average Monthly Wind Speed for Bush Field, Augusta, Georgia, 1951-1981, and WJBF-TV Tower, 1976-1977[a]

	Bush Field		WJBF-TV Tower elevation (m)		
Month	Mean speed (m/sec)	Prevailing direction	10	36	91
Jan.	3.2	W	3.0	4.5	6.1
Feb.	3.4	WNW	2.9	4.6	5.8
Mar.	3.6	WNW	3.3	4.5	5.9
Apr.	3.4	SE	2.8	4.2	5.4
May	2.9	SE	2.5	3.7	5.0
June	2.8	SE	2.4	4.0	4.8
July	2.6	SE	2.0	3.1	4.4
Aug.	2.5	SE	2.1	3.2	4.3
Sept.	2.5	NE	2.1	3.3	4.7
Oct.	2.6	NW	2.4	4.1	5.6
Nov.	2.8	NW	2.4	4.1	5.6
Dec.	3.0	NW	2.7	4.4	6.3
Annual	3.0	SE	2.5	3.9	5.3

[a]Source: Du Pont, 1983a.

Table 3-3. Precipitation at Savannah River Plant, 1952-1982[a]

	Monthly precipitation (cm)		
Month	Maximum	Minimum	Average
Jan.	25.5	2.3	10.7
Feb.	20.2	2.4	11.2
Mar.	27.8	3.8	13.0
Apr.	20.8	1.4	9.1
May	27.7	3.4	10.6
June	27.7	3.9	11.2
July	29.2	2.3	12.5
Aug.	31.3	2.6	11.8
Sept.	22.1	1.4	10.2
Oct.	27.6	0.0	6.2
Nov.	16.4	0.5	6.2
Dec.	24.3	1.2	9.5
Annual			122.2

[a]Source: Du Pont, 1983a.

Gracie, in September 1959, had winds in excess of 34 meters per second. Winter storms with winds as high as 32 meters per second have been recorded occasionally (Du Pont, 1982a). Thunderstorms can generate winds as high as 18 meters per second and even stronger gusts. The highest 1-minute wind speed recorded at Augusta between 1951 and 1984 was 28 meters per second. Table 3-4 lists the extreme wind speeds for 50- and 100-year return periods for three locations about equally distant from the SRP (Simiu, Changery, and Filliben, 1979).

Table 3-4. Extreme Wind Speeds for SRP Area (meters per second)[a]

Station	Return period	
	50-Year	100-Year
Greenville, S.C.	35	38
Macon, Ga.	30	31
Savannah, Ga.	35	39

[a]Adapted from Simiu, Changery, and Filliben, 1979.

3.2.3.2 Thunderstorms

There is an average of 54 thunderstorm days per year at the SRP. The summer thunderstorms occur primarily during the late afternoon and evening; they may be accompanied by strong winds, heavy precipitation, or, less frequently, hail (NOAA, 1985). Summer thunderstorms are attributable primarily to convective activity resulting from solar heating of the ground and radiational cooling of cloud tops. Thunderstorm activity in the winter months is attributable mainly to frontal activity.

3.2.3.3 Tornadoes

In the Southeastern United States, most tornadoes occur in early spring and late summer, with more than 50 percent occurring from March through June. In South Carolina, the greatest percentage of tornadoes occurs in April and May, about 20 percent (Pepper and Schubert, 1978) in August and September. The latter are spawned mainly by hurricanes. One or two tornadoes can be expected in South Carolina during April and May, with one expected each in March, June, July, August, and September (Purvis, 1977).

Weather Bureau records show 278 tornadoes in Georgia over the period from 1916 to 1958 and 258 in South Carolina for the period from 1950 to 1980 (Table 3-5) (Hoel, 1983). The general direction of travel of confirmed tornado tracks in Georgia and South Carolina is southwest to northeast.

Table 3-5. Tornado Occurrence by Month[a]

	Georgia (1916-1958)		South Carolina (1950-1980)	
Month	Number	Percent	Number	Percent
Jan.	24	8.6	6	2.3
Feb.	23	8.3	14	5.4
Mar.	49	17.6	26	10.1
Apr.	93	33.5	40	15.5
May	20	7.2	53	20.5
June	14	5.0	20	7.8
July	5	1.8	17	6.6
Aug.	10	3.6	25	9.7
Sept.	8	2.9	23	8.9
Oct.	2	0.7	8	3.1
Nov.	15	5.4	11	4.3
Dec.	15	5.4	15	5.8
Total	278		258	

[a]Source: Hoel, 1983.

Occasional tornadoes occur in the SRP area. Investigations of tornado damage near the SRP in 1975 and 1976 indicated wind speeds varying from 45 to 78 meters per second (Du Pont, 1980b). The most recent occurrence of a tornado striking the SRP was on April 23, 1983 (Garrett, 1983).

3.2.3.4 Hurricanes and High Winds

Thirty-eight damaging hurricanes have occurred in South Carolina during the 272 years of record (1700 to 1972); the average frequency was one storm every 7 years. These storms occurred predominantly during August and September. At the SRP, 160 kilometers inland, hurricane wind speeds are significantly lower than those observed along the coast. Winds of 34 meters per second were measured on the 61-meter towers only once during the history of the SRP, when Hurricane Gracie passed to the north on September 29, 1959 (Du Pont, 1982b).

3.2.3.5 Precipitation Extremes

Heavy precipitation can occur in the SRP area in association with either localized thunderstorms or hurricanes. The maximum 24-hour total was about 15.2 centimeters, which occurred during August 1964 in association with Hurricane Cleo.

3.2.4 ATMOSPHERIC DISPERSION

3.2.4.1 Atmospheric Stability

The transport and dispersion of airborne material are direct functions of air movement. Transport direction and speed are governed by the general patterns of airflow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. The atmosphere in the SRP region is unstable approximately 25 percent of the time, it is neutral 25 percent of the time, and it is stable about 50 percent of the time.

3.2.4.2 Air Quality

The States of South Carolina and Georgia have established air-quality-sampling networks. The SRP operates an onsite sampling network. These networks monitor suspended particulates, sulfur dioxide, and nitrogen dioxide. In 1984, ambient concentrations of these pollutants near the SRP were below the local air-quality standards in effect at that time (Du Pont, 1985a).

3.3 GEOLOGY AND SEISMOLOGY

This section describes the important geologic features in the region surrounding the SRP. These features include the regional geologic setting, seismology, and geologic hazards. Appendix A contains more detailed information.

3.3.1 REGIONAL GEOLOGIC SETTING

3.3.1.1 Tectonic Provinces

The North American continent is divided tectonically into foldbelts of recent or ancient deformation, and into platform areas where flat-lying or gently tilted rocks lie on basements of earlier foldbelts (King, 1969). The Southeastern United States contains two platform areas, the Cumberland Plateau province and the Coastal Plain province, and three foldbelts, the Blue Ridge province, the Valley and Ridge province, and the Piedmont province (Figure 3-3).

The SRP is located in the Aiken Plateau physiographic division of the Upper Atlantic Coastal Plain province of South Carolina (Cooke, 1936; Du Pont, 1980a). The center of the Plant is about 40 kilometers southeast of the Fall Line (Davis, 1902) that separates the Atlantic Coastal Plain tectonic province from the Piedmont tectonic province. Crystalline rocks of Precambrian and Paleozoic age underlie a major portion of the gently seaward-dipping Coastal Plain sediments of Cretaceous and younger age. Sediment-filled basins of Triassic and Jurassic age (exact age is uncertain) occur within the crystalline basement throughout the coastal plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of the Plant (Marine and Siple, 1974; Du Pont, 1980a; Stephenson, Talwani, and Rawlins, 1985).

3.3.1.2 Stratigraphy*

Coastal Plain sediments in South Carolina range in age from Cretaceous to Quaternary; they form a seaward-dipping, thickening, mostly unconsolidated wedge. Near the center of the Plant at H-Area, these sediments are approximately 280 meters thick (Siple, 1967). The base of the sedimentary wedge rests on a Precambrian and Paleozoic crystalline basement, which is similar to the metamorphic and igneous rocks of the Piedmont, and on the siltstone, claystone, and conglomerates of the down-faulted Dunbarton Triassic Basin. Immediately overlying the basement is the Middendorf/Black Creek (Tuscaloosa) Formation (175 meters thick), which is of the Upper Cretaceous age, and which is composed of water-bearing sands and gravels separated by prominent clay units. Overlying the Middendorf/Black Creek is the Ellenton Formation, which is about 18 meters thick and consists of sands and clays interbedded with coarse sands and gravel. Four of the formations shown in Figure 3-3, the Congaree, McBean, Barnwell, and Hawthorn (formation terminology after Siple, 1967), comprise the Tertiary (Eocene and Miocene) sedimentary section, which is about 85 meters thick and consists predominantly of clays, sands, clayey sands, and sandy marls. A calcareous zone in the lower portion of the McBean Formation is associated with void spaces in locations south and east of Upper Three Runs Creek (COE, 1952). The near-surface sands of the Barnwell and Hawthorn Formations generally are loosely consolidated; they can contain thin, sediment-filled fissures (clastic dikes) (Siple, 1967; Du Pont, 1980a). Quaternary alluvium is found at the surface in floodplain areas and as terrace deposits.

3.3.1.3 Geomorphology

The SRP is on the Aiken Plateau (Cooke, 1936), which slopes from an elevation of approximately 200 meters at the Fall Line to an elevation of about 75 meters to the southeast. The surface of the Aiken Plateau, which is highly dissected, is characterized by broad, interfluvial areas and narrow, steep-sided valleys. Because of SRP's proximity to the Piedmont region, it has somewhat more relief than the near-coastal areas, with onsite elevations ranging from 27 to 128 meters above sea level. Relief on the Aiken Plateau is as much as 90 meters locally (Siple, 1967). The plateau is generally well-drained although small, poorly drained depressions occur; these depressions are similar to Carolina bays.

The Aiken Plateau has several southwest-flowing tributaries to the Savannah River. These streams commonly have asymmetrical valley cross-sections, with

*The accepted names for stratigraphic units have evolved over the years as additional information on the age of the units and their correlation with similar units in other areas has surfaced. This is reflected in the different names used by authors to identify subsurface units. The stratigraphic nomenclature used in this document is the same as the usage of the various authors whose works have been referenced. Therefore, different portions of the text might use different names for the same geologic units. Similarly, the same name might be used for geologic units or portions of units that are otherwise different. Figure 3-4 shows the correlation of the units used by the various authors. The terminology used in this document is largely that of Siple (1967).

the northwest slope gentler than the southeast slope. This is caused by stream courses that generally parallel the strike of the Coastal Plain formations. Erosion by the water course results in gentle dip slopes on the northwest, or updip, sides of the valleys. The land forms produced by these geomorphic processes are gentle cuestas.

3.3.2 SEISMOLOGY AND GEOLOGIC HAZARDS

The down-faulted Dunbarton Triassic Basin, which underlies the Savannah River Plant, contains several interbasinal faults. However, the sediments overlying these faults show no evidence of basin movement since their deposition during the Cretaceous Period (Siple, 1967; Marine, 1976; Du Pont, 1980a). Other Triassic-Jurassic basins have been identified in the Coastal Plain tectonic province of South Carolina and Georgia; these features can be associated with the South Georgia Rift (Du Pont, 1980a; Popenoe and Zietz, 1977; Daniels, Zietz, and Popenoe, 1983). The Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces, which are associated with Appalachian Mountain building, are northwest of the Fall Line (Figure 3-3). Several fault systems occur in and adjacent to the Piedmont and the Valley and Ridge tectonic provinces; the closest is the Belair Fault Zone, about 40 kilometers from the Plant, which is not capable of generating major earthquakes (Case, 1977). Surface mapping, subsurface boring, and geophysical investigations at the Plant have not identified any faulting of the sedimentary strata that would affect SRP facilities.

Two major earthquakes have occurred within 300 kilometers of the Savannah River Plant: the Charleston earthquake of 1886, which had an epicentral modified Mercalli intensity (MMI) of X, and which occurred about 145 kilometers away; and the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII to VIII, and which occurred approximately 160 kilometers away (Langley and Marter, 1973). An estimated peak horizontal shaking of 7 percent of gravity (0.07g) was calculated for the site during the 1886 earthquake (Du Pont, 1982c). DOE has published site intensities and accelerations for other significant earthquakes (DOE, 1984b).

On June 8, 1985, a minor earthquake with a local magnitude of 2.6 (maximum intensity MMI III) and a focal depth of 0.96 kilometer occurred at the Plant. The epicenter was just to the west of C- and K-Areas. The acceleration produced by the earthquake was less than 0.002g (Stephenson, Talwani, and Rawlins, 1985). Appendix A contains a detailed discussion of earthquakes and other geologic hazards.

3.4 GROUNDWATER RESOURCES

This section discusses the groundwater resources at SRP in terms of the hydrostratigraphy and groundwater hydrology. Appendix A contains more detailed discussions of groundwater resources. Appendix A describes relationships between groundwater and surface water.

3.4.1 HYDROSTRATIGRAPHY

Three distinct hydrogeologic systems underlie the SRP: (1) the Coastal Plain sediments, where groundwater exists in porous sands and clays; (2) the crystalline metamorphic rock beneath the Coastal Plain sediments, where groundwater exists in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton Basin within the crystalline metamorphic complex, where groundwater exists in intergranular spaces in metamudstones and sandstones. The latter two systems are relatively unimportant as groundwater sources near the Plant. Figure 3-4 shows the lithology and water-bearing characteristics of the hydrostratigraphic units underlying the SRP. Appendix A contains additional detail.

In the central part of the SRP, the McBean Formation (formation terminology after Siple, 1967; see Figure 3-4) is separated from the underlying Congaree Formation by a layer known as the "green clay" (Figure 3-4). This layer, which exhibits a low permeability, is continuous over most of the SRP and thickens towards the southeast. The green clay unit is significant hydrogeologically because it supports a large head differential between the McBean and Congaree Formations. North and west of Upper Three Runs Creek, the green clay is discontinuous and is effective only locally as an aquitard (hydrogeologic confining unit).

In the central part of the SRP, the water table aquifer is separated from the underlying confined aquifer by a thin layer known locally as the "tan clay" (Figure 3-4). The tan clay is discontinuous in F- and H-Areas and, where present in the vicinity of M-Area, is not an important hydrogeologic unit. TC

The lack of continuous aquitard units in the Barnwell, McBean, and Congaree Formations north and west of Upper Three Runs Creek suggests that groundwater in these three units is interconnected hydraulically. However, the clay at the base of the Congaree and the upper clay layer of the Ellenton Formation together form a confining unit that appears to be continuous under the entire SRP. This confining layer provides what is believed to be an effective barrier to downward migration into the sands of the Ellenton-Black Creek (upper Cretaceous Sediments) aquifer. However, current data indicate that volatile organic compounds are present in the Black Creek aquifer in the A/M-Area, suggesting some leakage between the Congaree and the Black Creek. F-16

The South Carolina Hazardous Waste Management Regulations (SCHWMR) and the Resource Conservation and Recovery Act (RCRA) require that the hydrogeologic zones that are most susceptible to impacts from waste management units be determined. These zones have been defined as the unsaturated zone, the uppermost aquifer, the principal confining unit, and the principal confined aquifer (shallowest confined aquifer beneath the SRP). Figure 3-4 shows the relationship of these zones to one another and the correlation of these zones with other stratigraphic nomenclature. The following paragraphs summarize each hydrogeologic zone. The formational terminology used in this discussion is largely that of Geological Consulting Services (Geological Consulting Services, 1986).

The unsaturated zone is a 10- to 45-meter-thick sandy unit containing clay lenses. This zone is comprised of the Upland Unit and, in some areas of the Plant, the Tobacco Road and Dry Branch Formations. TC

The uppermost aquifer is a 35-meter-thick sandy unit composed of two zones. The upper water-table zone, composed primarily of the clay-rich, fine-grained sands of the McBean Formation (in some areas of the Plant, areas of higher water table) includes portions of the Dry Branch and Tobacco Road Formations. The lower zone is composed of the coarse-grained Congaree Formation and the upper sand and clay of the Ellenton Formation.

Based on an evaluation of hydraulic properties as well as head differences between subsurface zones, the lower three units of the Ellenton Formation are believed to form the principal confining zone beneath the Plant. These units form a section approximately 15 meters thick, composed of two clay beds (middle and lower Ellenton) and the lower Ellenton sand lenses. The sands in these lenses are commonly coarse grained, but generally are supported by a clay matrix that impedes fluid movement. The middle clay is generally a dense, low-permeability clay that can be locally discontinuous or more permeable. The lower clay, however, is an average of 3 meters thick (maximum of 15 meters), is dense, has a low permeability, and is believed to be continuous over the SRP area. Table 3-6 summarizes hydraulic conductivity of the Ellenton Formation.

The confined aquifer is a sandy zone averaging about 30 meters in thickness. This zone is capped by the overlying Ellenton Formation confining unit. In this text, the shallowest confined aquifer will be referred to as the Black Creek aquifer. The aquifer beneath the Black Creek will be referred to as the Middendorf aquifer (see Figure 3-4).

3.4.2 GROUNDWATER HYDROLOGY

Groundwater beneath the SRP generally occurs under confined (artesian) conditions, meaning that the groundwater rises to a potentiometric level above the top of the hydrogeologic unit. The water table in the vicinity of the central portion of the SRP generally occurs in the Barnwell Formation at depths of 5 to 15 meters, whereas it occurs near A- and M-Areas at depths of 30 to 40 meters.

3.4.2.1 <u>Hydrologic Properties</u>

The flow of groundwater in the natural environment depends strongly on the three-dimensional configuration of hydrogeologic units through which flow takes place. The geometry, spatial relations, and interconnections of the pore spaces determine the effective porosity (percentage of void space effectively transmitting groundwater) and the hydraulic conductivity of the hydrogeologic unit. These factors largely control groundwater flow through geologic media. In fact, the velocity of groundwater flow is directly proportional to the hydraulic conductivity and to the hydraulic gradient, and is inversely proportional to effective porosity.

TE TC The Coastal Plain sediments beneath the SRP are heterogeneous and isotropic with respect to the hydrologic properties controlling groundwater flow. One of the most recognized properties, hydraulic conductivity, is typically 10 to 100 times greater in the direction parallel to bedding than in the direction perpendicular to bedding in sedimentary units like these (Freeze and Cherry, 1979). This results in significantly greater groundwater flow laterally within hydrostratigraphic units than between units (see Tables A-4 and A-5).

Table 3-6. Hydraulic Conductivity (cm/sec) of the Ellenton Formation[a,b]

Geologic Unit	Vertical conductivity		Horizontal conductivity	
	Range	Average	Range	Average
Middle Clay	2.2×10^{-9} - 1.4×10^{-5}	1.1×10^{-7}	1.6×10^{-9} - 7.3×10^{-5}	8.61×10^{-5}
Lower Sand	3.5×10^{-9} - 3.9×10^{-4}	4.4×10^{-5}	1.1×10^{-8} - 2.6×10^{-4}	9.39×10^{-5}
Lower Clay	1.8×10^{-8} - 4.0×10^{-7}	1.9×10^{-7}	2.3×10^{-8} - 6.7×10^{-7}	3.12×10^{-7}

[a]Source: DOE, 1987.
[b]Results of laboratory analysis of industrial samples.

3.4.2.2 Head Relationships

The elevation of the free-standing groundwater above a sea-level datum is referred to as the hydraulic head. The heads in the Ellenton and Middendorf/ Black Creek (Tuscaloosa) Formations are higher than those in the Congaree in the central portion of the SRP, thus preventing the downward movement of water from the Congaree to the Ellenton (see Figure A-5). These relationships are general and might not be valid in the vicinity of production wells. Figures 3-5 and 3-6 show the approximate area of upward head differential in 1982 and 1987.

Figures 3-5 and 3-6 describe the head difference between the water in the Black Creek and Congaree Formations. The two maps show a change due to improved data control (more measuring points) and to a lesser extent, show the effects of pumpage on and off the SRP. Had the data control available in 1987 been available in 1982, it is quite likely the maps would have been very
TC similar.

The more recent data (Bledsoe, 1987) are more accurate. The earlier map was based on limited data and was included in the draft EIS because it was the best data available at the time of the publication of the draft EIS.

Parts of the Separations Areas, Burial Grounds, C-Area, and TNX-Area, and the D-Area powerhouse are in the area of upward head differential between the groundwater in the Congaree and that in the Middendorf/Black Creek (Tuscaloosa) Formation. However, A-, M-, K-, and P-Areas are in a region of downward head differential (see Figure 3-6). Because of flow directions and head relationships, the potential for offsite impacts on water quality in the Black Creek aquifer is extremely small. The most important factor for offsite impacts is the prevailing flow direction for water in the Black Creek toward the Savannah River, not toward municipalities that border the Plant. The most important factor for onsite impacts is a significant upward gradient between the Congaree and the Upper Tuscaloosa over some of the SRP (Bledsoe, 1987).

Impacts on the Black Creek aquifer have been confirmed in only one monitoring well cluster on the SRP. This cluster is in the western recharge area (A- and M-Areas), where the clay barrier thins beneath an area where spillage from rail cars and transfer facilities took place during the early days of SRP operation. The migration of these constituents is being defined; their source has been under remediation for nearly 2 years. Data analyzed to date do not define any flow paths for these constituents toward offsite water users. The area of final discharge of the groundwater originating from these sources is the Savannah River. These constituents would require about 150 years to reach
TC the river (DOE, 1987). The pumpage of recovery wells (and supply wells for process water) in A- and M-Areas increases this travel time.

F-18 Other impacts to Black Creek in the A/M-Area are suspected due to supposed leaks along well casings.

Where the upward gradient exists between the Black Creek and the Congaree, water is prevented from flowing into the Black Creek aquifer. An exception occurs in areas where large volumes of water are pumped from the Black Creek; in these areas, pumpage could reverse the upward gradient. The area most susceptible to these impacts is H-Area, where the head differential is relatively small and pumpage is great. A modeling study (Duffield, Buss, and Spalding, 1987) indicates that a maximum head differential (downward potential) of about 1.5 meters has developed in the eastern portion of H-Area (see Figure A-5). Moderate pumpage from the Black Creek also occurs in U-Area, the Central Shops Area, TNX-Area, the Classification Yard, and the U.S. Forest Service offices. The potential for reversing the upward gradient that occurs naturally in these areas is significantly less than that in H-Area. Any contaminants that would be drawn into the Black Creek by this pumpage would flow to the pumping well and, therefore, would not impact offsite areas (Duffield, Bass, and Spalding, 1987). C-46

3.4.2.3 Groundwater Flow

Groundwater moves from areas of high potential energy (usually measured as head) to areas of lower energy. Thus, flow is in the direction of decreasing hydraulic gradient. In general, on the Coastal Plain, the gradient is seaward from the higher areas of the Aiken Plateau toward the shore. Of major significance is the modification of this general southeastward movement caused by the incision of the Savannah River and its tributaries.

The groundwaters in the regions of the river and onsite streams are diverted toward hydraulic head lows caused by natural discharge to the surface water. Each stream dissects the hydrogeologic units differently; the smallest streams become natural discharge points for groundwater in the Barnwell Formation, and the Savannah River does the same for groundwater in the deeper formations. Thus, discrete groundwater subunits are created, each with its own recharge and discharge areas. Appendix A describes natural aquifer recharge and discharge areas and water budgets at the SRP.

3.4.3 GROUNDWATER QUALITY

3.4.3.1 Regional Groundwater Quality

The water in the Coastal Plain sediments is generally of good quality, suitable for industrial and municipal use with minimal treatment. It is characterized as soft, slightly acidic, and low in both dissolved and suspended solids (Table 3-7).

3.4.3.2 Groundwater Monitoring Results

A substantial amount of groundwater monitoring data has been generated from SRP monitoring wells over the past several years. Data from groundwater sampling since 1982 were reported in the Technical Summary of Groundwater Quality Protection Program at Savannah River Plant (Christensen and Gordon, 1983), the SRP Environmental Reports for 1985 and 1986 (Zeigler, Lawrimore, and Heath, 1986; Zeigler, Heath, Taus, and Todd, 1987), and in the 26 environmental information documents (EIDs) prepared for this EIS, referenced in Appendixes B and F. TC

This section of the EIS characterizes the affected groundwater environment (e.g., groundwater at the waste site monitoring wells based on the data reported and compiled into a single summary to provide a general understanding of waste site groundwater quality related to applicable standards or criteria. TC

Table 3-7. Average Chemical Analysis of Groundwater From Coastal Plain Formations at the Savannah River Plant[a]

Chemical properties/ chemical constituent[b]	Barnwell Formation	McBean Formation	Congaree Formation	Middendorf/Black Creek (Tuscaloosa) Formation
pH (standard units)	5.6	6.5	6.3	5.4
Total dissolved solids	25.0	46.8	71.0	21.0
Specific conductance (micromhos)	27	57	130[c]	30
Calcium	2.9	8.2	19.6	0.6
Magnesium	0.2	2.5	0.3	2.1
Potassium	0.9	1.2	0.8	1.8
Sodium	2.3	4.2	1.5	4.0
Iron	0.2	0.1	0.2	0.1
Silicon	4.6	5.9	10.1	0.6
Aluminum	0.7	0.6	1.0	NM[d]
Manganese	<0.1	<0.1	<0.1	0.5
Bicarbonate	12.7	31.0	57.4	4.3
Chlorine	3.5	2.8	3.4	0.7
Nitrate (as N)	3.1	0.1	0.1	0.1
Phosphate (as P)	0.1	0.3	0.1	0.2
Fluoride	TR[e]	<0.1	0.1	NM

[a]Adapted from Du Pont, 1983b. Formational terminology after Siple, 1967; see Figure 3-4.
[b]Units are milligrams per liter (except pH and specific conductance).
[c]Only one analysis.
[d]NM - No measurement.
[e]TR - Trace.

Groundwater is monitored at potentially hazardous and mixed waste sites. Parameters analyzed at these sites include heavy metals, nutrients, pesticides, organic solvents, and radiological parameters. Table 3-8 summarizes the results of 39 groundwater-quality parameter measurements related to applicable standards or criteria. For example, 672 tests for silver were reported, none of which exceeded the National Interim Primary Drinking Water Standard of 50 micrograms per liter. Table 3-8 lists the number of values exceeding a standard or criterion (if any) and the number of values not exceeding the standard. In addition, this table lists the maximum value reported for comparison with the standard.

The summary indicates that many groundwater constituents analyzed do not exceed the applicable standard or criterion. On the other hand, several constituents are shown to exceed groundwater standards or criteria at one or more waste site well locations on the SRP.

Exceedance of a standard or criterion does not always indicate contamination from a waste disposal site or operation. Certain constituents can occur naturally at concentrations that exceed standards. Also, contamination associated with a particular site can occur in the wells of another site located hydraulically downgradient. A site-specific evaluation of the data using comparisons of upgradient versus downgradient wells is necessary to determine the constituent contributions of a waste site. Such comparisons are described in detail (in the 26 waste site EIDs and in Looney et al., 1987) for the purposes of selecting waste site modeling parameters and comparing appropriate alterna- TC
tive actions for specific waste sites.

In addition, exceedance of a standard or criterion does not automatically indicate a risk to human health or the environment. For example, the standard for iron of 300 micrograms per liter is a secondary drinking-water standard established for aesthetic purposes and is not health-related. Thus, the origin of the standard or criterion listed is important.

Finally, the results of groundwater monitoring to date are considered preliminary because of indications that some earlier results (1982-1984) might have been questionable. In 1984, improvements were made in the procedures for obtaining and preserving samples. Where manual bailing had been used, pumps now ensure adequate flushing of the wells before a sample is taken; also, C-50
samples for dissolved metal analyses are filtered to remove suspended solids before preservatives are added (EPA, 1984). In addition, wells constructed of galvanized casings were removed from service and replaced with wells constructed of PVC plastic. These problems (now corrected) are thought to have been responsible for excessively high concentrations of several metals, including zinc, cadmium, lead, and iron, in earlier samples (Zeigler, Lawrimore, and Heath, 1986).

Table 3-9 summarizes recent groundwater monitoring data for radiological constituents for the SRP; it provides the total number of samples reported and the maximum and minimum values for 12 radiological parameters.

Table 3-8. Summary of SRP Groundwater Monitoring Data[a]

Parameter	Units	Standard or criterion (S/C)	Values reported	Values exceeding S/C	Values not exceeding S/C	Maximum value	
pH-acid	units	6.5[b]	1018	955	63	2.3	
pH-alkaline	units	8.5[b]	1018	23	995	12.5	
Silver	mg/L	0.05[c]	672	0	672	(d)	
Arsenic	mg/L	0.05[c]	654	0	654	(d)	
Barium	mg/L	1[c]	597	4	593	2.3	TC
Beryllium	mg/L	0.011[e]	568	29	539	0.31	
Cadmium[f]	mg/L	0.010[c]	704	84	620	0.15	
Chromium	mg/L	0.050[c]	874	51	823	6.3	TC
Copper	mg/L	1[b]	527	0	527	(d)	
Iron[f]	mg/L	0.3[b]	750	302	448	280	
Mercury	mg/L	0.002[c]	817	54	763	3.1	
Manganese	mg/L	0.05[b]	714	218	496	91.	
Lead[f]	mg/L	0.05[e]	781	115	666	4.9	TC
Selenium	mg/L	0.01[c]	653	2	651	.054	
Zinc[f]	mg/L	5[b]	616	32	584	50.	
Chloride	mg/L	250[b]	835	0	835	(d)	
Fluoride	mg/L	1.4[c]	680	1	679	2	
Nitrate-N	mg/L	10[c]	734	127	607	370	
Sulfate	mg/L	400[g]	752	1	751	765	
Hydrogen sulfide	mg/L	0.002[h]	465	1	464	3.0	
Cyanide	mg/L	0.20[b]	200	0	200	(d)	
Phenol	mg/L	3.5[i]	631	0	631	(d)	
TOH	mg/L	0.0007[j]	846	706	140	94.	
Endrin	mg/L	0.0002[c]	580	0	580	(d)	
Lindane	mg/L	0.004[c]	580	1	579	0.01	TC
Methoxyclor	mg/L	0.1[c]	580	0	580	(d)	
Toxaphene	mg/L	0.005[c]	580	0	580	(d)	
2,4-D	mg/L	0.1[c]	592	4	588	0.74	

Footnotes on last page of table.

Table 3-8. Summary of SRP Groundwater Monitoring Data[a] (continued)

Parameter	Units	Standard or criterion (S/C)	Values reported	Values exceeding S/C	Values not exceeding S/C	Maximum value	
2,4,5-TP	mg/L	0.01[e]	592	0	592	(d)	
1,1-dichloroethane	mg/L	4.05[k]	24	0	24	(d)	
1,1,1-trichloroethane	mg/L	0.2[k]	359	4	355	0.26	
Tetrachloromethane	mg/L	0.005[k]	150	6	144	0.14	TC
1,1-dichloroethylene	mg/L	0.007[k]	44	1	43	0.01	
Trans 1,2-dichloroethylene	mg/L	0.27[m]	35	0	35	(d)	
Trichloroethylene	mg/L	0.005[k]	417	187	230	161	
Tetrachloroethylene	mg/L	0.0007[n]	411	146	265	269	
Gross alpha	pCi/L	15[c]	769	104	665	11,500	
Gross beta	pCi/L	0.2[o]	704	476	228	21,000	TC
Radium	pCi/L	5[c]	618	88	530	128	

[a]Data compiled from 26 existing waste site Environmental Information Documents, which reported analytical results for samples taken from 1982 to third quarter 1985.
[b]National Secondary Drinking Water Regulations (40 CFR 143).
[c]National Interim Primary Drinking Water Regulations (40 CFR 141).
[d]All values reported below standard or criterion.
[e]EPA, 1976. (Maximum concentrations for protection of freshwater aquatic life.)
[f]Results of metals analyses performed between 1982 and 1984 might be inaccurate because of problems with well construction and sampling protocol. Actual groundwater concentration levels of these metals were probably somewhat less.
[g]50 FR 46958.
[h]EPA, 1976. (Maximum concentration for protection of freshwater aquatic life; detection limit of analysis procedure was 3 milligrams per liter.)
[i]EPA, 1986a.
[j]No standard or criterion available, conservatively set at standard for tetrachloroethylene (see footnote k below).
[k]EPA, 1986b, 1987 (52 FR 25690). TC
[l]50 FR 48949 (detection limit of analysis procedure was 0.008 milligram per liter).
[m]EPA, 1981.
[n]50 FR 48950 (detection limit of analysis procedure was 0.001 milligram per liter).
[o]*No standard or criterion available, set for comparative purposes at the detection limit of 0.2 picocuries per liter.*

Table 3-9. SRP Groundwater Monitoring Data - Radiological Constituents[a]

Parameter	Units	Number of samples	Maximum	Minimum
Alpha[b]	pCi/L	1,539	360	<DL[c]
Nonvolatile beta	pCi/L	1,539	24,000	<DL[c]
Tritium[d]	pCi/mL	1,379	7,000,000	<DL[c]
Cerium-144	pCi/mL	42	0.18	<DL[c]
Cesium-134	pCi/mL	42	0.07	<DL[c]
Cesium-137	pCi/mL	42	0.02	<DL[c]
Chromium-51	pCi/mL	42	2.4	<DL[c]
Cobalt-60	pCi/mL	42	0.25	<DL[c]
Ruthenium-103	pCi/mL	42	0.10	<DL[c]
Ruthenium-106	pCi/mL	42	0.22	<DL[c]
Antimony-125	pCi/mL	42	0.01	<DL[c]
Strontium-89, -90	pCi/mL	31	140	<DL[c]

[a]Data compiled from Zeigler, Lawrimore, and Heath, 1986.
[b]The National Interim Primary Drinking Water Standard for gross alpha is 15 picocuries per liter (40 CFR 141).
[c]Detection limits.
[d]The National Interim Primary Drinking Water Standard for tritium is 20,000 picocuries per liter (40 CFR 141).

3.4.4 GROUNDWATER USE

3.4.4.1 Important Aquifers

As noted in Section 3.4.1, subsurface waters in the vicinity of the SRP include six major hydrostratigraphic units. The geohydrologic characteristics of these units, their areal configurations, and their recharge/discharge relationships control the vertical and horizontal movement of groundwater at the SRP (see Appendix A).

At present, the SRP does not withdraw groundwater from the crystalline, metasediment basement rocks and overlying saprolite. The Middendorf/Black Creek (Cretaceous Sediments) hydrostratigraphic unit, which is 170 to 250 meters thick at the SRP, is the most important regional aquifer in the vicinity of the SRP. At the SRP, the Middendorf/Black Creek consists of two aquifers separated by a clay layer or aquitard, which impedes movement of groundwater between the two aquifers. The lower aquifer (Middendorf) consists of about 90 meters of medium to coarse sand; the overlying aquifer (Black Creek) consists of about 45 meters of well-sorted medium-to-coarse sand. Beneath the SRP, these two aquifers join only by way of wells that withdraw water from both permeable zones.

The upper Middendorf/Black Creek clay unit and the Ellenton clays form an aquitard over most of the SRP. In some areas, the Ellenton and the sands appear to be connected hydrologically.

The Congaree is another important local aquifer. Locally, only the Middendorf/Black Creek exceeds the Congaree's water-producing potential. The Congaree's intermediate depth also makes it attractive for water wells. An extensive clay layer at the base of this unit forms a confining bed that separates the permeable sands of the Congaree hydrologically from the sands in the underlying Ellenton and Middendorf/Black Creek units. The green clay (Figure 3-4), a marker bed at the top of the Congaree, exhibits very low hydraulic conductivity; therefore, it is a significant aquitard, particularly south and east of Upper Three Runs Creek. The SRP does not withdraw large quantities of groundwater from the McBean, Barnwell-Hawthorn, or stream valley alluvium deposits (formation terminology after Siple, 1967). The McBean, however, becomes increasingly more important as an aquifer to the east of the SRP.

The water table is usually in the stream valley alluvium deposits and in the Barnwell. The McBean is usually under semiconfined conditions. In contrast, groundwaters in the Congaree (to the south and east of Upper Three Runs Creek) and the Middendorf/Black Creek are under confined conditions. Middendorf/Black Creek water wells near the Savannah River (e.g., in D-Area) often flow because the potentiometric level of the groundwater is greater than the elevation of the land surface.

3.4.4.2 Regional and Local Groundwater Use

The Middendorf/Black Creek (Tuscaloosa) aquifer, which becomes shallower as it approaches the Fall Line, forms the base for most municipal and industrial water supplies in Aiken County. In Allendale and Barnwell Counties, the Middendorf/Black Creek exists at increasingly greater depths. Consequently, the shallower Congaree and McBean aquifers (formation terminology after Siple, 1967), or their limestone equivalents, supply some municipal, industrial, and agricultural users. The Barnwell, McBean, and Congaree Formations are the primary sources for domestic water supplies in the vicinity of the SRP.

DOE has identified 56 major municipal, industrial, and agricultural groundwater users within 32 kilometers of the center of the SRP (Appendix A). The total pumpage for these users is about 135,000 cubic meters per day.

Talatha community, the closest municipal user (about 11 kilometers from the center of the SRP), uses about 480 cubic meters per day. The Town of Jackson, about 16 kilometers from the center of the SRP, pumps about 1070 cubic meters per day. Of the total municipal pumpage (52,605 cubic meters per day), the Middendorf/Black Creek aquifer supplies about 34,270 cubic meters; the remainder (about 18,335 cubic meters per day) comes from the McBean and the Congaree. Total industrial/agricultural pumpage from the Middendorf/Black Creek aquifer is about 71,940 cubic meters per day; this includes 38,550 cubic meters per day drawn by the SRP.

In addition to the large users discussed above, the South Carolina Department of Health and Environmental Control (SCDHEC) lists 25 small communities and mobile home parks, 4 schools, and 11 small commercial interests as groundwater users. Generally, shallow wells equipped with pumps with capacities of 54 to 325 cubic meters per day serve these and other miscellaneous users; thus, they do not draw large quantities of water. The total estimated withdrawal for these 40 users is less than 2000 cubic meters per day (DOE, 1984b).

A number of domestic wells near the SRP also draw from the shallow aquifers. Two South Carolina state parks (Aiken State Park, with seven wells, and Barnwell State Park, with two) are within a 32-kilometer radius of the Plant (DOE, 1984b). Several shallow wells produce small quantities of water for SRP guardhouses.

3.4.4.3 Relationship of Precipitation and Groundwater Use to Water Levels

Figure 3-7 shows hydrographs of five Middendorf/Black Creek (Tuscaloosa) wells and one Ellenton well. Five of these wells are on the SRP. The sixth, AK-183, is 29 kilometers northwest of the center of the SRP in the Middendorf/Black Creek outcrop area; pumpage in the vicinity of the SRP does not influence this well. TE Winter (December, January, and February) precipitation (plotted at the top of Figure 3-7) is the principal source of groundwater recharge. Generally, high water levels occurred in the Middendorf/Black Creek (Tuscaloosa) in 1974, but from then until 1982 these levels declined. Winter precipitation declined from 1972 to 1981, which might account partially for the declining water levels shown by well AK-183; in addition, since 1975 SRP pumping has increased by about 80 percent, from 14.9 to 26.8 cubic meters per minute. Because of higher winter precipitation in 1982 and 1983, groundwater levels have increased.

TE Figure 3-7 shows the total SRP pumping rate; the highest rates are toward the bottom of the plot to facilitate their comparison to water levels in monitoring wells. Calculations show that the decline in water levels at monitoring wells P7A, P54, and P3A is related primarily to increased SRP groundwater withdrawals (DOE, 1984b). TC The drawdowns at these wells reflect adjustments to new pumping regimes rather than net depletion of the aquifer (Du Pont, 1983b). Water levels stabilize quickly (within 100 days) after pumping rates change (Mayer et al., 1973).

Withdrawals from the Middendorf/Black Creek (Tuscaloosa) at SRP could reach TC about 38 cubic meters per minute without diminishing potential water levels from existing (1960) production wells (Siple, 1967). In addition, this aquifer could produce more water with better-designed well fields. In 1960, the SRP pumpage from the Middendorf/Black Creek was about 19 cubic meters per minute (Siple, 1967); currently, the estimated SRP groundwater use is 27 cubic meters per minute.

3.5 SURFACE-WATER RESOURCES

3.5.1 SURFACE-WATER SYSTEMS

The Savannah River is the principal surface-water system near the SRP. It adjoins the Plant along its southwestern boundary. The total drainage area of the river, 27,388 square kilometers, encompasses all or parts of 41 counties in Georgia, South Carolina, and North Carolina. Over 77 percent of the drainage area is upriver of the SRP (Lower, 1985).

On the Plant, a swamp lies in the floodplain along the Savannah River for a distance of about 16 kilometers; its average width is about 2.4 kilometers. A small embankment or natural levee has built up along the north side of the river from sediments deposited during periods of flooding. On the SRP side of the levee, the ground slopes downward, is marshy, and contains large stands of cypress-tupelo forest and bottomland hardwoods.

The SRP is drained almost entirely by six streams: Upper Three Runs Creek, Four Mile Creek, Beaver Dam Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek (Figure 3-2). These streams rise on the Aiken Plateau and descend 30 to 60 meters before discharging to the Savannah River.

3.5.2 SURFACE-WATER HYDROLOGY

Streamflow in the Savannah River is regulated by five large reservoirs upriver of the SRP: Clarks Hill, Russell, Hartwell, Keowee, and Jocassee (DOE, 1984b; Duke Power Company, 1977). The average annual flow has been stabilized by these reservoirs to 288.8 cubic meters per second near Augusta (Bloxham, 1979) and 295 cubic meters per second near the SRP (DOE, 1984b).

TE Natural discharge patterns in the Savannah River are cyclic: maximum river flows typically occur in the winter and spring and the lowest flows occur in the summer and fall (Figure 3-8).

Since 1963, the U.S. Army Corps of Engineers has attempted to maintain a minimum flow of 178.4 cubic meters per second below the New Savannah River Bluff Lock and Dam at Butler Creek (River Mile 187.4, near Augusta, Georgia) (COE, 1981). During the 18-year period from 1964 to 1981 (climatic years ending March 31), the average of the 7-day low flow for each year measured at the New Savannah River Bluff Lock and Dam was 181 cubic meters per second (Watts, 1982), or about 2.3 cubic meters per second less than at the SRP (Ellenton Landing, River Mile 156.8).

3.5.3 SURFACE-WATER QUALITY

In the vicinity of the SRP, the Savannah River is classified as a Class B stream under the State of South Carolina's Water Classification Regulations. Class B waters are broadly defined as suitable for secondary-contact recreation and as a source of drinking water after conventional treatment according to approved regulatory regimes (SCDHEC, 1981).

The onsite streams have not been classified by name. However, the regulations provide that "in any case where streams are not otherwise classified and are tributaries to a classified stream, they shall meet the quality standards of the classified stream" (SCDHEC, 1981). Thus, onsite streams at the SRP that are tributaries to the Savannah River are considered to be Class B streams. Routine analyses of samples from onsite stream locations since 1973 indicate that SRP discharges have complied with Class B water classification standards except for those streams receiving thermal discharges where temperature and occasionally dissolved oxygen standards are exceeded.

A two-year Comprehensive Cooling Water Study was initiated in July 1983 to ascertain the effects of thermal discharges on the Savannah River and onsite stream water quality (Du Pont, 1985b). The discussions that follow provide a summary of the water quality of the Savannah River and six major onsite streams.