Enclosure 27

Response to Request for Additional Information

Westinghouse Nuclear Fuel Columbia Site Evaluation Report March 1975 Section 2

SECTION 2.0
THE SITE

This section presents the basic information concerning the physical, biological and human characteristics of the regional environment that might be affected by the operation of the Westinghouse Nuclear Fuel Division manufacturing plant near Columbia, South Carolina.

2.1 SITE LOCATION AND LAYOUT

The Nuclear Fuel Columbia Site (NFCS) is located in the central part of South Carolina in Richland County. It is approximately 8 miles southeast of the Columbia city limits and is easily reached by South Carolina Highway 48. Nearby towns, industrial plants, public facilities, the Congaree River and transportation links are shown in Figure 2.1-1.

The site is bounded by Route 48 to the north, the Vestal Lumber Manufacturing Company property to the east, the Liberty Life Insurance Company property to the south and the Burrel Manning property to the west.

The manufacturing plant facilities are located in the center of approximately 1158 acres of already disturbed agricultural land. The fuel fabrication facilities, holding ponds, parking lot and landscaped grounds occupy approximately 60 acres. Figure 2.1-2 shows the plant boundary and adjacent properties.

Figure 2.1-2 also depicts the elevations of the site. The plant floor is located at 142 feet above mean sea level. Plant site drainage flow follows original drainage patterns to Sunset Lake, Mill Creek and the Congaree River.

The area around the site is primarily flat and semi-rural to the north and flat, rural and swampy in the other directions. Intentions are to leave most of the unused site (approximately 1098 acres) in its natural state.

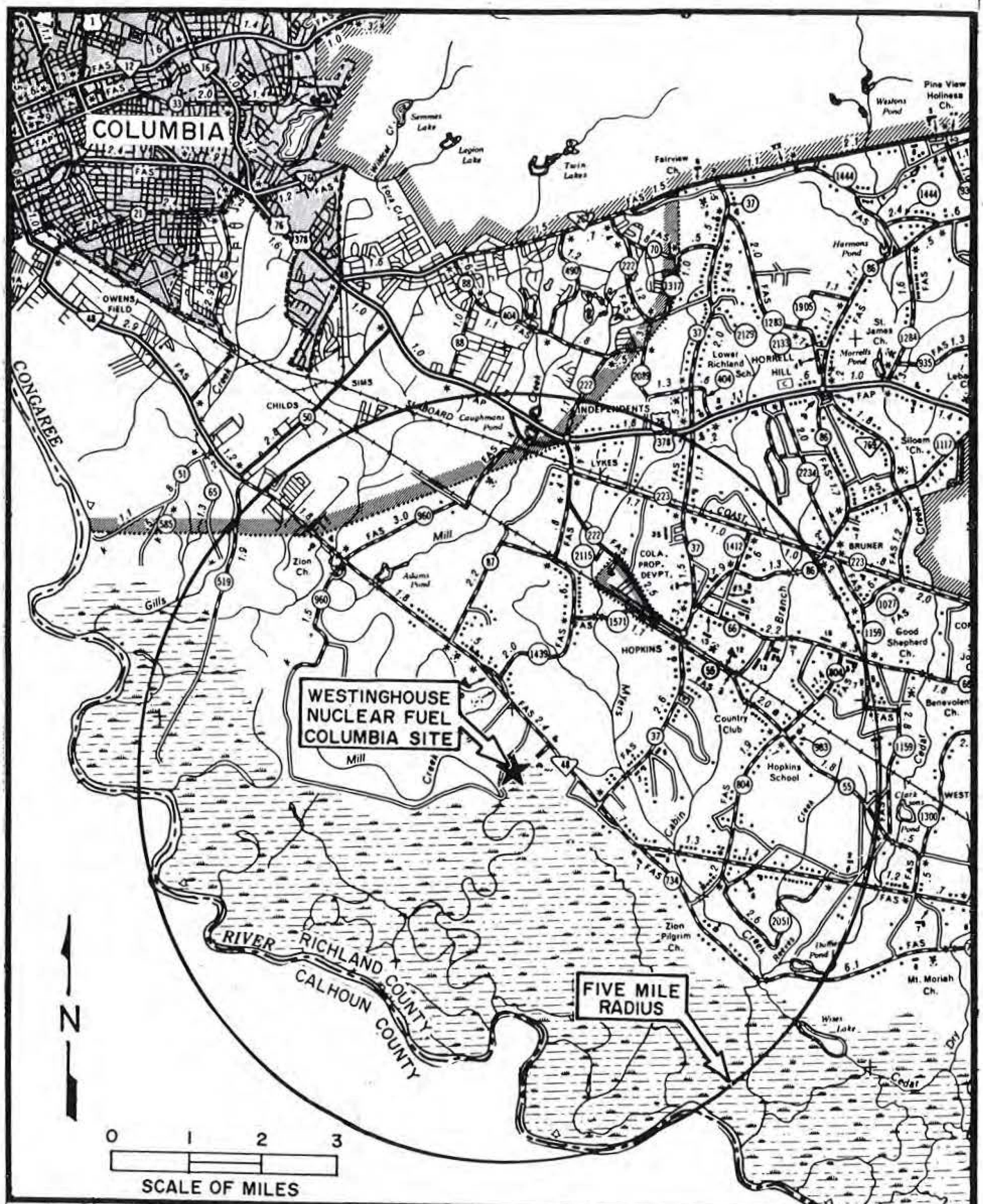

Figure 2.1-1. NFCS Location

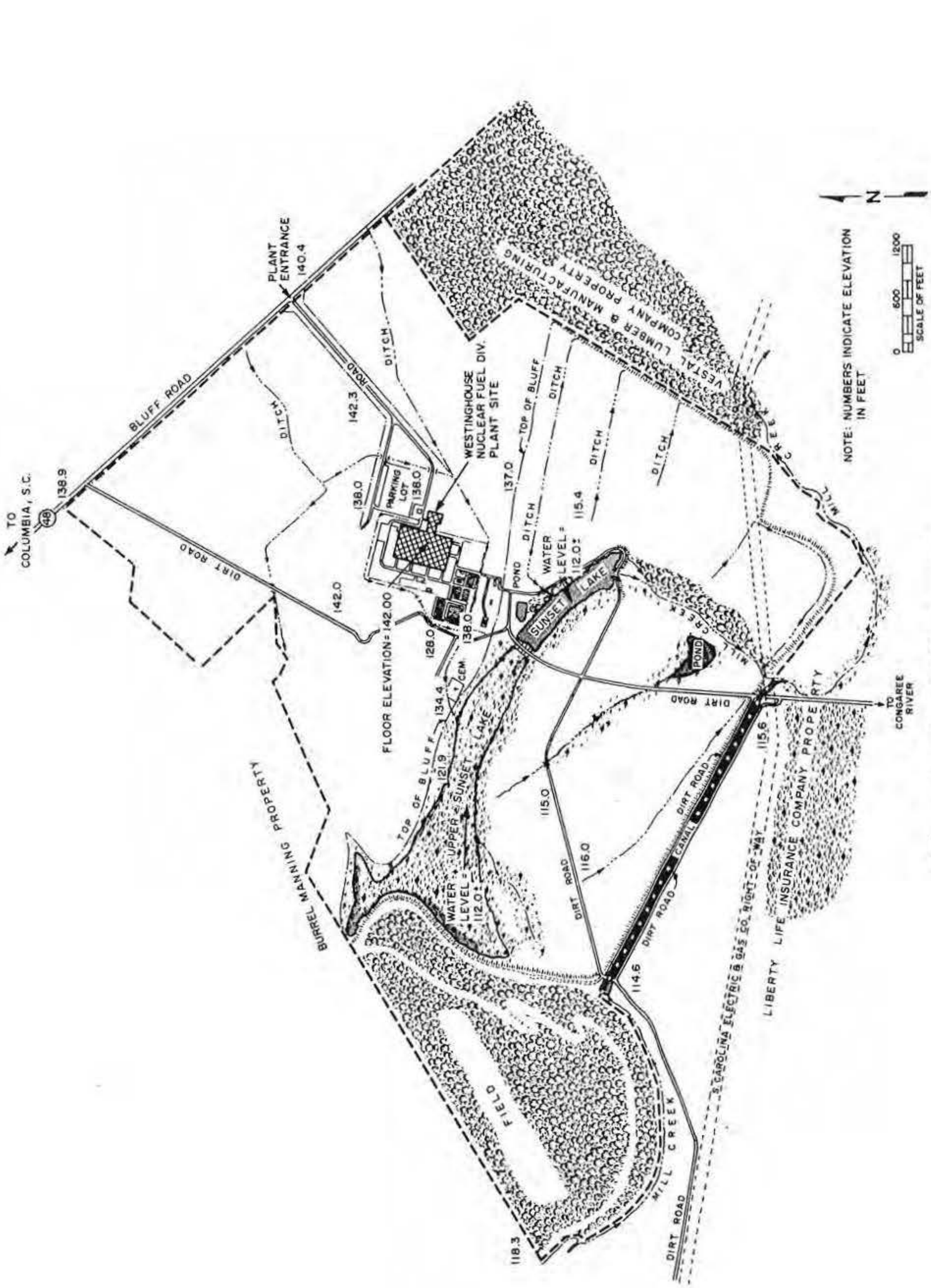

Figure 2.1-2. NFCS Property

2.2 REGIONAL DEMOGRAPHY AND LAND AND WATER USES

2.2.1 REGIONAL DEMOGRAPHY

Figure 2.2-1 indicates the location of all population centers within a 5-mile radius of the Westinghouse Nuclear Fuel Columbia Site. A detailed breakdown of the 1960, 1970 and projected 1980 and 1990 population densities within this 5-mile radius is provided in Figures 2.2-2, 2.2-3, 2.2-4 and 2.2-5, respectively. Also, an assessment of the impact of the transient population on the resident population within the 78.5 square miles under consideration is presented and discussed.

2.2.1.1 RESIDENT POPULATION WITHIN 5 MILES

Figure 2.2-1 shows the population centers within a 5-mile radius of the plant where a detailed analysis of the resident population distribution was performed. The area of 78.5 square miles under consideration was divided into sixteen 22.5 degree azimuthal sectors centered on the 16 cardinal compass points with outer radial increments of 1, 2, 3, 4 and 5 miles as shown in Figure 2.2-2. The 1960 and 1970 population densities within each of the sectors formed by these concentric circles and radial lines were estimated from census data[1,2,3] and United States Geological Survey (USGS) topographic maps. The results of these analyses are presented in Figures 2.2-2 and 2.2-3.

The total 1960 and 1970 populations within a 5-mile radius of the plant are 4116 and 5310, respectively. Figures 2.2-2 and 2.2-3 show that the maximum population densities occur in the sectors NW through ESE.

Population densities within this area were also projected for 1980 and 1990. These projections which are based on data published by the Central Midlands Regional Planning Council[4] are presented in Figures 2.2-4 and 2.2-5. The total projected populations for the area under study are 6953 for 1980 and 16,501 for 1990. These projections indicate an estimated

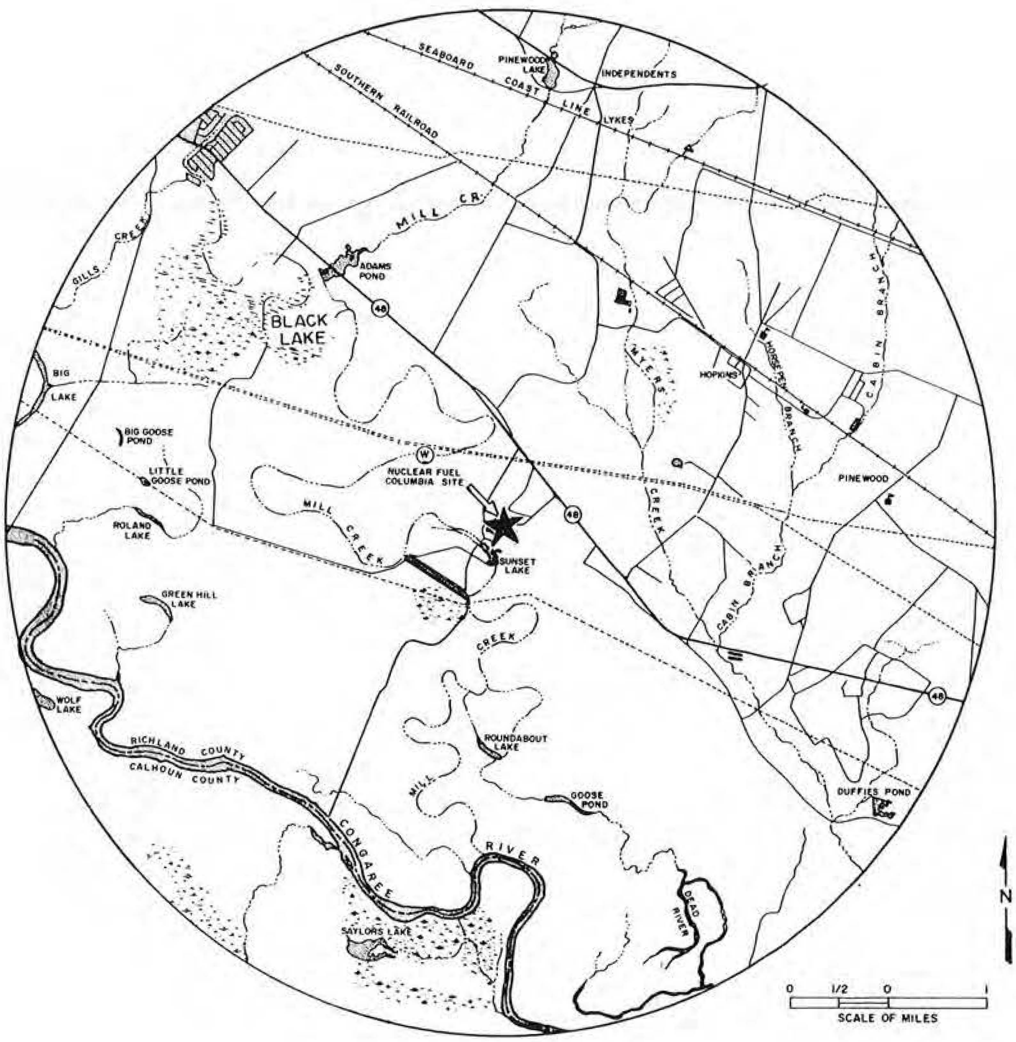

Figure 2.2-1. Population Centers Within 5-Mile Radius of the Westinghouse Nuclear Fuel Columbia Site

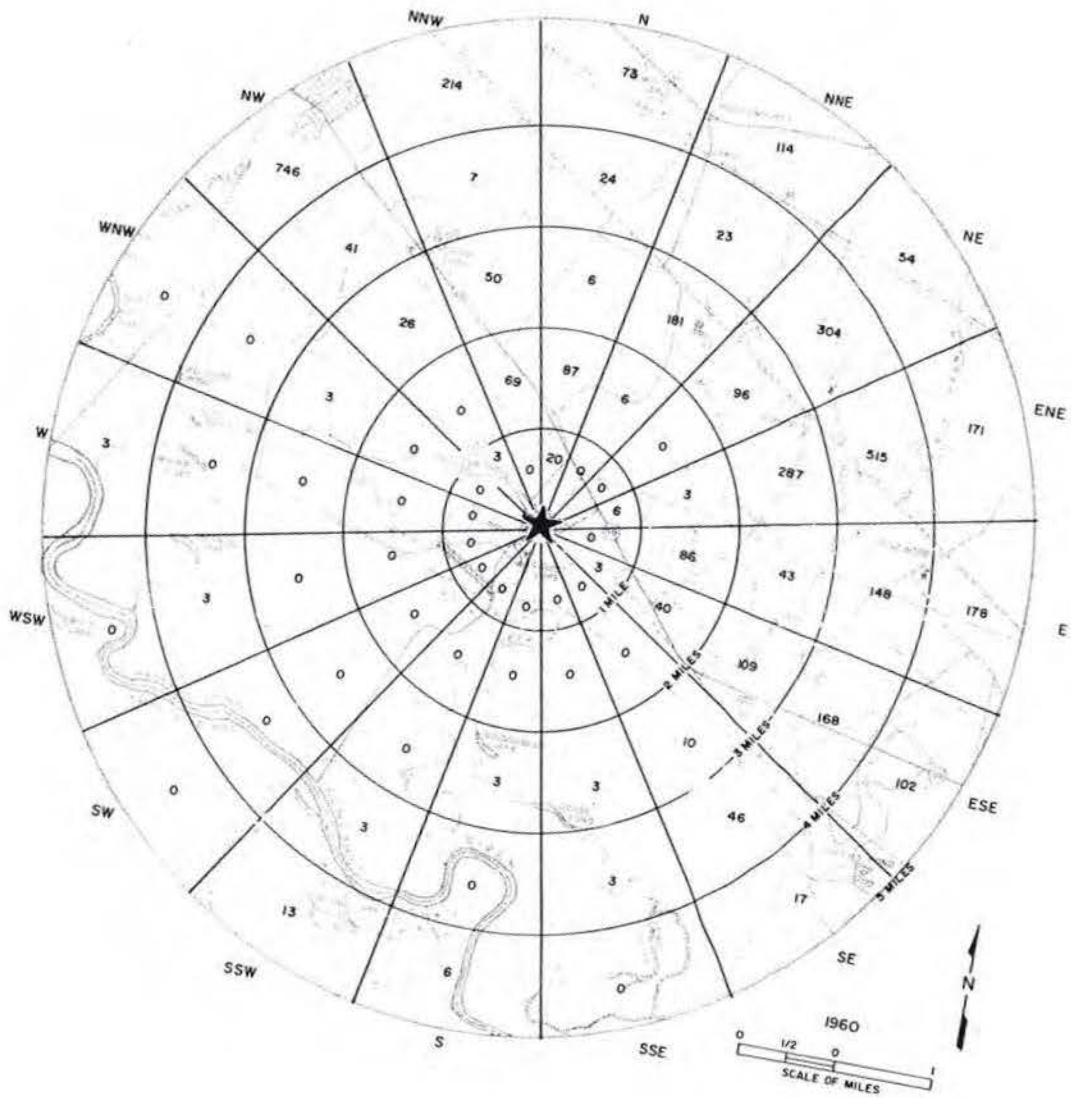

Figure 2.2-2. Population Distribution For 1960

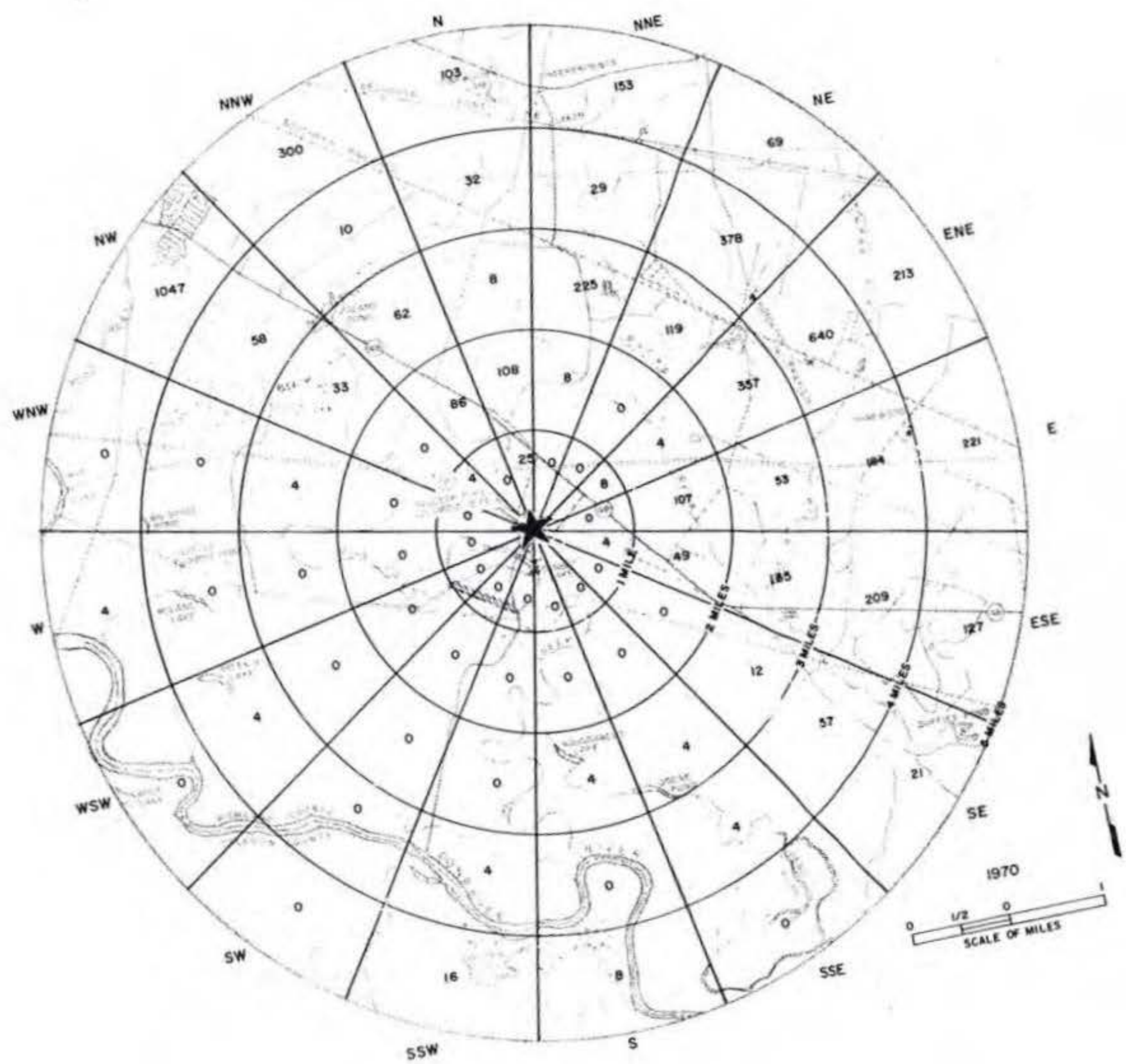

Figure 2.2-3. Population Distribution For 1970

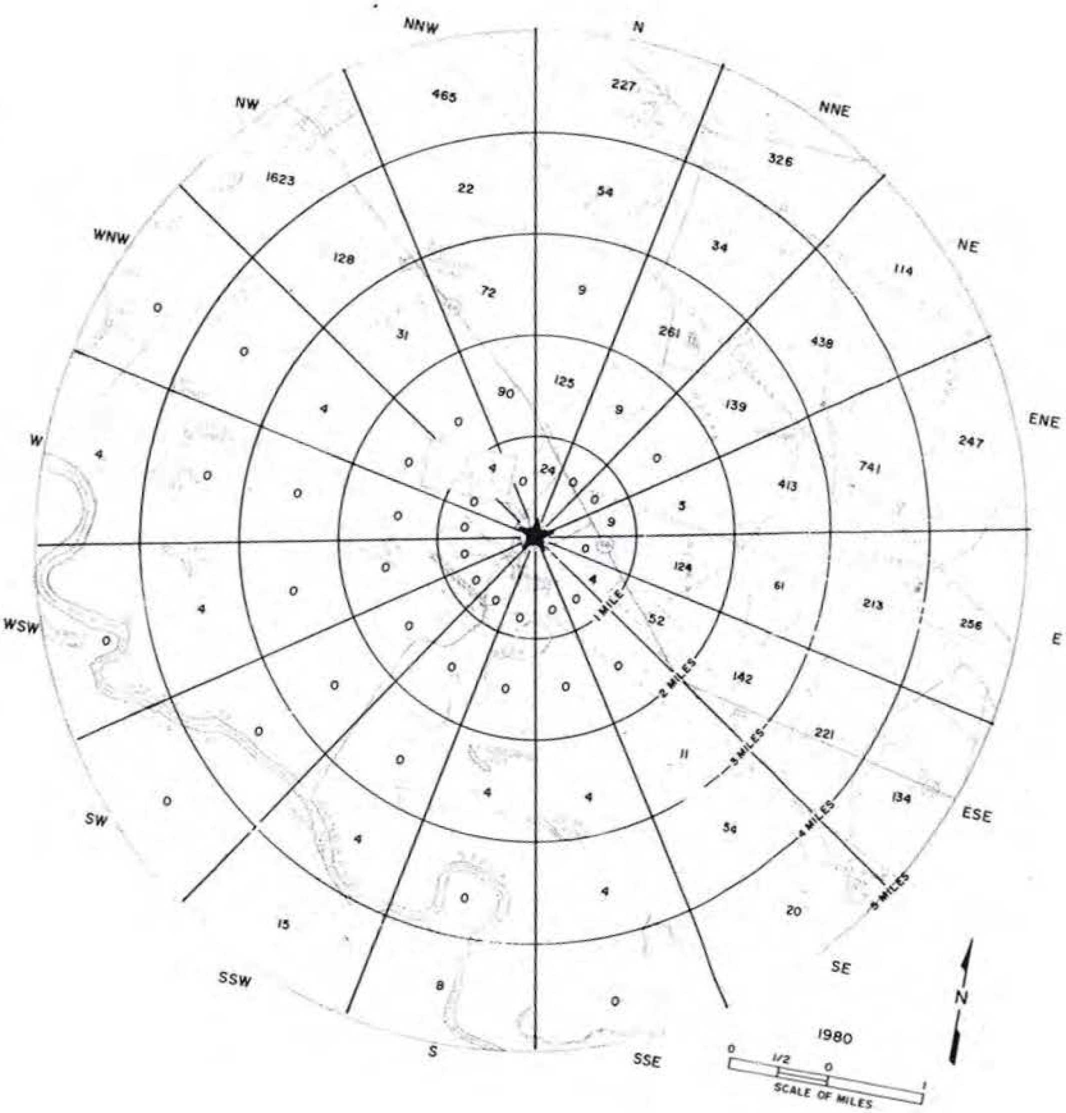

Figure 2.2-4. Population Distribution For 1980

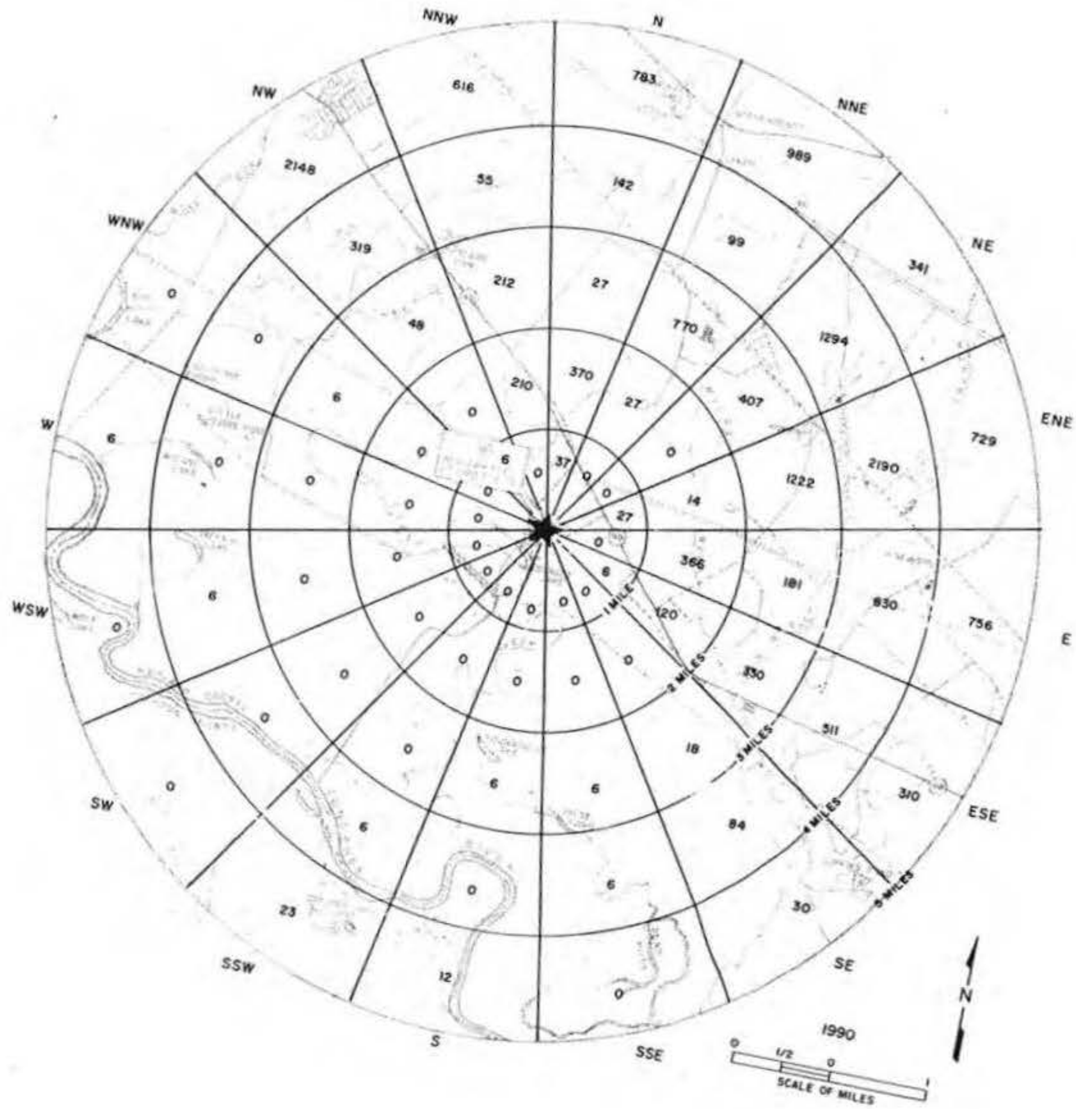

Figure 2.2-5. Population Distribution For 1990

+30.9 percent change in population from 1970 to 1980 and a +211 percent change from 1970 to 1990 for the 78.5-square-mile area under consideration.

2.2.1.2 TRANSIENT POPULATION

An analysis of the size of the transient population within a 5-mile radius of the plant was performed to determine the impact of the transient population on the total population within the study area. This transient population analysis was based on the available population and visitor statistics of neighboring schools, hospitals, plants and recreational facilities within the 78.5-square-mile study area. Results of this analysis are summarized in Table 2.2-1 and the sources of transient population are discussed in Sections 2.2.1.3 through 2.2.1.5.

The public and private schools within the study area are listed in Table 2.2-2. The total enrollment of these schools is 2466 and the total resident population within the considered area is 5310 based on 1970 census data.[1,2] Since the expected student-to-resident ratio is approximately one-third, it is assumed that two out of three students are permanent residents of the area. Thus the total student population of the three schools listed in Table 2.2-2 represents a 15.5 percent increase in the total population of the study area each day that the schools are in session.

The total professional staff of these schools is 114 which represents a 1.4 percent increase in the total population each day that the schools are in session, assuming that one out of three teachers is a resident of the area.

There are no hospitals within a 5-mile radius of the plant.

For all industrial and business facilities with more than five employees within a 5-mile radius of the plant, the total number of employees is 2026 (Table 2.2-3). If all these employees reside outside the study area, a conservative assumption, the total work force represents a 38.2 percent increase

TABLE 2.2-1

ESTIMATED CHANGE IN TOTAL POPULATION CAUSED BY TRANSIENTS WITHIN A 5-MILE RADIUS OF THE PLANT

Source of Transient Population	Estimated Numbers	Resident Population*	Estimated % Increase
School students and	822**	5310	15.5
professional staff	76**	5310	1.4
Industrial workers	2026†	5310	38.2
Totals	2924		55.1

*Based on 1970 census data

**Assumes that two out of three students and one out of three teachers are permanent residents of the area

†Assumes total work force resides outside the area

TABLE 2.2-2

SCHOOLS WITHIN 5 MILES OF THE WESTINGHOUSE NUCLEAR FUEL
COLUMBIA SITE

Name	Distance and Direction From Plant	Grade	Professional Staff	Students
Hopkins Junior High	3-4/5 miles E	8-9	70	1350
Hopkins Elementary	3-1/3 miles ENE	Kindergarten through 5	27	996
Hopkins Head Start	3-1/4 miles ENE	Pre-School	17	120
Totals: 3 Schools			114	2466

TABLE 2.2-3

INDUSTRIES AND BUSINESSES WITHIN 5 MILES OF THE WESTINGHOUSE NUCLEAR FUEL COLUMBIA SITE*

Name	Type of Business	Employees	Distance and Direction From Plant
Columbia Container Co.	Garbage containers	20	4-3/4 miles NW
Columbia Plastering Co.	Plastering	70	4-1/2 miles NW
Dan Dee Specialties	Picture frames	30	4-1/5 miles NW
Southco	Supplies for gift shops	10	4-1/5 miles NW
Roadway Express Inc.	General freight handling	24	4-1/5 miles NW
Power's Dairy	Milk	10	2-1/4 miles NNW
Richman & Associates (field office)	Construction of EHV lines	100	3-miles NE
Columbia Eggs Division of Farmers Cooperative Exchange	Egg grading and packaging	35	3-miles ENE
Square D Company	Manufacture heavy industrial motor controls	930	4-2/3 miles NNE
Palmetto Metal Products, Inc.	Steeldoor frames, window walls, louvers	15	4-4/5 miles NNW
Wallace Concrete Products, Manhole Division	Manholes	12	4-4/5 miles NNW
McGregor's Dairy	Milk	7	4-4/5 miles NNE
Carolina Eastman	Man-made fibers	763	4-3/4 miles W
Totals: 13 Facilities		2026	

* Only industries and businesses with more than five employees are included.

in the total population within the study area. It was assumed that all facilities employing five or fewer employees would tend to employ local residents and therefore would not create a significant transient population.

There are two local county parks within the study area with a combined annual attendance of 109,592 persons (Table 2.2-4). Because of both the favorable year-round climate of the area and the indoor facilities at both of these community parks, it was assumed that this annual attendance of 109,592 would result in an average daily attendance of 300 persons. It was further assumed that all persons using these parks lived within the local community due to the size and community nature of the parks and therefore produced no increase in the total population of the area.

This analysis indicates that the transient population could effectively increase the total population of the area within a 5-mile radius of the plant by 55.1 percent. The future increase in total population by the transient population through 1990 is expected to decrease since the increase in employment, the major source of transients in the study area, based on statistics for Richland County,[5] is not projected to increase at as great a rate as the increase in resident population.

2.2.1.3 SCHOOLS AND HOSPITALS

All schools within a 5-mile radius of the plant are listed in Table 2.2-2. These three schools have a combined enrollment of 2466 pupils and a total professional staff of 114.

A thorough investigation of the 78.5-square-mile study area indicated that there are no hospitals within 5 miles of the plant.

2.2.1.4 INDUSTRIES AND BUSINESSES

The major industries and businesses within a 5-mile radius of the plant are concentrated in the sectors W through ENE. Table 2.2-3 lists all facilities

TABLE 2.2-4

RECREATIONAL PARKS AND SPORTS FACILITIES WITHIN A
5-MILE RADIUS OF THE PLANT

Name	Distance and Direction From Plant	Total Annual* Attendance
Bluff Rd. County Park	3-4/5 miles NW	63,380**
Hopkins County Park	1-3/4 miles E	46,212
Totals: 2 parks		109,592

* For the period 7/1/73 to 6/30/74

** Bluff Rd. County Park did not open until 1/1/74. Therefore attendance figures for 1/1/74 to 6/30/74 were doubled to give an estimate of total annual attendance.

within the study area that employ more than five persons. The combined work force of these 13 facilities is 2026. Industries with five or less employees were not included since it was assumed that these facilities would tend to employ mostly local residents living within the study area and therefore not add to the total population of the area.

There are no other users of licensed nuclear materials within the 78.5-square-mile study area.

2.2.1.5 RECREATIONAL AND SPORTS FACILITIES

The recreational parks and sports facilities within the study area are listed in Table 2.2-4. There are no state parks or commercial sports stadiums within the 5-mile radius of the plant.

2.2.2 LAND USE

Virtually all of the land within 5 miles of the NFCS is in Richland County. Less than 10 percent of the 78.5 square miles within this 5-mile reach is in Calhoun County and except for the Carolina Eastman Plant and some scattered farms under cultivation, this land is largely uninhabited forest and forested swamp. Therefore, the thrust of this description will be toward land use in Richland County.

An examination of aerial photographs and topographic maps of the land within 5 miles of the NFCS (the study area) makes it clear that approximately 70 percent of the land is forest or forested swampland. The forest cover varies throughout the study area, being densest in the southern portions and thinning out to cleared fields in the northern portions.

There are essentially three forest community types in the study area. The first of these, the Water Tupelo-Sweet Gum type, is associated with areas of poor drainage and is generally found in the flats along the Congaree

River and throughout the swamps to the north and south of it. Where the drainage is somewhat improved and soils trend toward sandy loams, the Swamp Chestnut-Cherrybark Oak type may be found. This type is commonly observed in the area from the northern swamp reaches of the Congaree into the northern portions of the study area across Route 48. Finally, where relief and soil characteristics present drier sites, the Loblolly Pine-Hardwood type is evidenced. This type is found most often in the northern portions of the study area. It should be noted that despite the extent of forest cover found in the study area, there is no significant ongoing lumbering activity present.

Agricultural land occupies approximately 20 percent of the study area and most of it is in the northern and eastern portions. The primary crops grown here are soybeans, corn, hay, cotton and to a lesser degree, wheat and oats. A number of pecan orchards exist near the eastern border of the study area.

In general, the farmers here are full-time farmers. South Carolina as a whole has followed the national trend toward fewer but larger, more efficient farms.(6) This requires the farmer to put more time as well as more capital (in the form of renting or purchasing mechanized equipment) into his efforts to compete effectively. Thus, the part-time commercial farmer is, to an increasing degree becoming a thing of the past in this area.

Livestock production in the study area is not especially significant. Egg production was noted to be important locally as evidenced by the presence of the Columbia Egg Division of FCX, Inc. in Hopkins. Beef cattle were observed at a number of farms, though not in any great quantity. Other livestock such as broilers, hogs and sheep were not observed.

The number of dairy producers as well as the total number of cows milked in Richland County continue to decline.(6) At present, there are only four active dairy farms in the entire county, two of which are within the study area. Leon Powers' Dairy is located 2.2 miles northwest of the NFCS on the north side of Route 48. Powers presently milks approximately 400 cows, but has a capacity for 700. Sam McGregor's Dairy is located at the north-northeast extremity of the study area along the east side of a small county road that connects with U.S. Routes 76 and 378, south of Lower Richland High School. McGregor presently milks approximately 150 cows.

Approximately 5 percent of the study area is estimated to be residential land. Much of this land is occupied by single-family dwellings and mobile homes on individual lots which are not part of any particular housing development. There are, however, a number of relatively recent housing developments in the study area occupied by single-story brick homes. Three of these are in the northwest portion of the study area along Route 48, while two others are in the area north and east of Hopkins. Despite the quality of the homes in these developments, there is an abnormally high vacancy rate. (In one, almost 50 percent of the homes are boarded up.) These vacant homes are now owned by the U.S. Government, as their original purchase was financed through the Federal Housing Administration guaranteed 235 Program housing loans which were later defaulted. The 235 Program is no longer in operation, and at present the Federal Housing Administration is attempting to resell these homes but has met with little success.

The amount of industrial land within the study area is less than 1 percent of the total land area. Excluding the NFCS, there are only two major industrial facilities which occupy an extensive amount of land. The first is Square D Corporation, a builder of controls for heavy industrial electrical motors, which is located on the south side of U.S. Routes 76 and 378. The second is the Carolina Eastman Division of Eastman Kodak, Inc., a manufacturer of polyester fibers, which is located on the east side of U.S. Route 21 in Calhoun County. The former facility employs approximately 925 persons and the latter 422 persons.

Other facilities within the study area are considered light industrial -- warehousing, shipping, packing, metal fabrication, etc. -- and generally employ less than 40 persons. There are, however, two industrial activities which could be considered medium in size. One is the field office of Richman and Associates which employs approximately 100 persons and is concerned with the construction of extra high voltage (EHV) electric transmission lines. The second is Wallace Concrete Products, Manhole Division which employs approximately 40 persons and is a producer of reinforced concrete pipe and precast concrete bridges.

There are at present only two public recreational areas within the study area: Hopkins Park and Bluff Road Park. These parks were created by the Richland County Recreation Commission. Hopkins Park has an indoor community center for various activities and a softball field. Bluff Road Park is the more developed of the two, having a community center which includes a full indoor basketball court, weight-exercise room, ceramics room and other rooms for more general use along with two outdoor tennis courts, a softball field and a football field (under construction).

There are also two private country clubs in the study area. One is the Sherwood Country Club located 0.2 mile northwest of Hopkins Junior High School along State Route 55. The only facility is a clubhouse. Pinewood Country Club is located on the south shore of Pinewood Lake which is just south of U.S. Routes 76 and 378. This club has some land adjoining its clubhouse as well as private lake frontage.

An area of 17,000 to 21,000 acres located primarily along the north bank of the Congaree River is being considered by the National Park Service for designation as a national monument. It should be noted that a portion of the study area (approximately 570 acres at the very southeastern extremity) would be within the boundaries of the proposed Congaree Swamp National Monument. A study done by the National Park Service in 1963 concluded that: "...the forest within the study area exists in near virgin state. This magnificent forest of "specimen" trees is a rare remnant of what was once typical of southern river bottom lands."(7)

The National Park Service plans a restudy of the area in the near future to update its knowledge, and until this study is completed, the status of the designated lands will remain undecided.

2.2.3 WATER USE

Surface and groundwater uses are discussed in this section. The information was provided by a group of geohydrologists from the University of South Carolina at Columbia headed by Dr. D. Colquhoun.[8]

2.2.3.1 SURFACE WATER

The city of Columbia uses 42 cfs (815 million gallons per month) of the Broad River waters for municipal uses. There are no industrial or municipal water users of the Congaree River along its course from its confluence with the Saluda and Broad Rivers to its joining with the Wateree River to form the Santee River. Projected water consumption by the NFCS facility at the expanded capacity of 1600 metric tons of uranium per year (MTU/yr) is 10.6 million gallons per month, which will be obtained from the city of Columbia.

The Congaree River (average flow of 9166 cfs) receives untreated municipal discharges from the city of Columbia, the city of Cayce and industrial discharges currently less than 0.2 cfs from the NFCS plant. Approximately 1 million gallons per day of untreated municipal discharges enter the Congaree River at the junction with Congaree Creek.[9] The city of Cayce obtains its waters from Congaree Creek.

Impact from these municipal discharges is reflected in high concentrations of bacteria in the waters of the Congaree River (see Tables 2.5-1 through 2.5-4). Thus, both the city of Columbia and the city of Cayce are presently constructing treatment facilities for their municipal liquid discharges.

Discharges from the NFCS will increase to approximately 0.30 cfs (5.76 million gallons per month) at ultimate capacity. Such an increase is not anticipated to affect the quality of the waters of this river (Section 4.2.2). In addition, the NFCS is planning to improve the existing sanitary system (Section 4.2.4) which will also reduce discharges of bacteria to the river.

2.2.3.2 GROUNDWATER

A well survey was conducted in April 1974 by the South Carolina Health Department, at the request of the NFCS plant. The results of this survey reveal that more than 700 wells used for domestic and agricultural purposes are located within 5 miles of the NFCS plant.[10] Within this area there are approximately eleven "public wells". A "public well" is defined as a well used by more than two families.[11]

As discussed in Section 2.5.2, Groundwater Hydrology, all wells are located updip from the NFCS facility and there are no wells that draw groundwater downdip towards the Congaree River from this plant.

2.2.4 REFERENCES

1. U.S. Department of Commerce, Bureau of Census, Census Tracts, 1970 Census of Housing and Population, Columbia, South Carolina, SMSA, PHC(1)-48, April 1972.

2. U.S. Department of Commerce, Bureau of Census, Block Statistics, 1970 Census of Housing, Columbia, South Carolina, Urbanized Area, 1970 Census of Housing, HC(3)-213, September 1971.

3. U.S. Department of Commerce, Bureau of Census, Number of Inhabitants, 1970 Census of Population, South Carolina, PC(1)-A42 S.C., June 1971.

4. Central Midlands Regional Planning Council, Population Projections of the Central Midland Region (Fairfield, Lexington, Newberry, Richland), Columbia, South Carolina, August 1, 1974.

5. Economy and Population Central Midlands Region of South Carolina, Volume II - Technical Appendix, Hammer, Greene, Siler Associates, June 1972.

6. U.S. Department of Agriculture, Statistical Reporting Service, South Carolina Crop and Livestock Reporting Service, South Carolina Crop Statistics, State and County Data, Columbia, South Carolina, 1974.

7. U.S. Department of the Interior, National Park Service, Southeast Region, Specific Area Report: Proposed Congaree Swamp National Monument, South Carolina, Richmond, Virginia, 1963.

8. Colquhoun, D. J., "Regional and Local Physiography, Ecology, Seismology, Soils and Hydrology of the Westinghouse Plant Site, Richland County, South Carolina," Report to Westinghouse Environmental Systems Department, November 1974.

9. Colquhoun, D. J., Letter to Roffman, H., Westinghouse Environmental Systems Department, November 27, 1974.

10. Mattox, W. A., Field Technician, III, Environmental Health Division, Health Department, Richland County, South Carolina, Columbia, South Carolina, letter to Bibbs, R., Health Physicist, Westinghouse Nuclear Fuel Division, Columbia, South Carolina, April 30, 1974.

11. Sadler, M., South Carolina Department of Sanitation, Columbia, South Carolina, letter to Bibbs, R., Health Physicist, Westinghouse Nuclear Fuel Division, Columbia, South Carolina, April 1974.

2.3 REGIONAL HISTORIC, SCENIC, CULTURAL AND NATURAL LANDMARKS

An examination of information acquired from federal and state sources relating to regional historic, scenic, cultural and natural landmarks led to the conclusion that the only adverse effects of NFCS construction and operation on such landmarks within a 5-mile radius of the plant site may have been to subsurface archaeological relics or remains on the plant site itself. The extent of any damage to these resources will, of course, remain unknown. There have been no known adverse effects to other landmarks in the vicinity of the plant since it began operation in 1969 and on that basis, none are anticipated as a result of future operation.

2.3.1 HISTORIC AND CULTURAL LANDMARKS

Considering the area encompassed by a 5-mile radius from the NFCS, the number of officially recognized historic sites is relatively small. A search of the National Register of Historic Places yielded no nationally recognized sites in this area.(1) However, the South Carolina Department of Archives and History considers five sites within 5 miles of the plant to have historic import. These sites are:

1. Raiford's Mill Creek (Mill Creek) - 18th Century
2. Cabin Branch (John Hopkins, Jr. Plantation House) - circa 1796
3. Claytor House - 1887
4. Chappell Cabin Branch (Hicks Plantation House and Garden) - 1781
5. Hopkins Overseers' Dwellings - 19th Century(2)

A more detailed description of each of these sites is contained in Appendix 2.A.

The archaeological resources within the study area are believed to be abundant, as prehistoric settlements in the lands around Mill Creek and the Congaree River were numerous. The following is a list of those archaeological sites known to the Institute of Archaeology and Anthropology at the University of South Carolina:

1. Greenhill Mound. Lamar site in the Congaree Swamp, below Columbia on the Congaree River. Mound 1/4 of a mile long and 200 yards wide, 20 feet high, in three layers. Sherds, daub, bone, glass, historic ceramics, brick, points, gorget, beads, flakes, axe, shell ring, nails, vessels, celts, spade, knives, pestle, dipper found. This site has not been investigated by the Institute so its exact location is uncertain.

2. Duffies Pond. Woodland site located on east side of Duffies Mill Pond north of Pine Bluff Road.

3. Adams Cemetery. Black cemetery located on east side of Cedar Creek north of Mt. Moriah Church and south of South Carolina Route 48 bridge over Cedar Creek.

4. Archaic and Early Woodland site south of Columbia on Congaree River.

5. Early Woodland site located east of Bluff Road near Columbia.

6. Pole Bridge Creek. Field southwest of dirt road crossing Pole Bridge Creek between South Carolina Route 48 and South Carolina Route 46 near Hopkins. This site has not been investigated by the Institute so its exact location is uncertain.

7. Site on northwest bank of Cedar Creek and northeast bank of Congaree River, near their confluence near Adams Pond. This site has not been investigated by the Institute so its exact location is uncertain.

8. Zion Pilgrim Church. Site northeast of Zion Pilgrim Church between South Carolina Route 48 and Pole Bridge Creek near Hopkins. This site has not been investigated by the Institute so its exact location is uncertain.[3]

Unlike historical sites (which are most often readily apparent), archaeological resources are generally removed from notice by overlaying soils. Thus, except for the activities of plowing and excavation, the extent of archaeological resources in a given area can never be fully known. However, an appraisal of such resources can usually be made by a professional archaeologist and measures can be taken to insure their preservation before construction of a facility. In the case of the NFCS, the facility is already in existence and operating, and it is most probable that any archaeological relics or remains were disturbed or destroyed during the processes of subsurface excavation and construction. The likelihood of adverse impact on extant archaeological resources by the planned 50,000 square foot expansion at NFCS is small considering the earlier disruption of this land by the construction of the main plant.

The facility poses no threat to the historic sites listed earlier. However, close monitoring of plant discharges is essential to the preservation of the abundant archaeological resources of the Congaree Swamp and Mill Creek.

2.3.2 NATURAL AND SCENIC LANDMARKS

There are no areas listed in the National Registry of Natural Landmarks(4) within 5 miles of the NFCS. However, a large part of the Congaree Swamp is being considered for designation as a national monument by the National Park Service, as mentioned in Section 2.2, and will be considered as a natural and scenic landmark herein.

The Congaree Swamp possesses a great variety of river bottom hardwoods and relatively unspoiled fauna. Although the swamp is by most standards relatively inaccessible, there are a few narrow unpaved roads which lead back into it. The present opportunities for recreation other than hunting or boating within the confines of the swamp are minimal, and the area is most valuable for its unique natural beauty and its scientific worth. As mentioned earlier, close monitoring of effluents from the NFCS is essential to the preservation of the intrinsic natural value of the Congaree Swamp.

2.3.3 REFERENCES

1. U. S. Department of the Interior, National Park Service, "National Register of Historic Places," Federal Register, Volume 39, Number 34, U. S. Government Printing Office, Washington, D. C., February 19, 1974.

2. Personal communication, Lee, C. E., State Historic Preservation Officer, South Carolina Department of Archives and History, 1430 Senate Street, Columbia, South Carolina to Pangburn, G. C., Westinghouse Environmental Systems Department, Pittsburgh, Pennsylvania, October 2, 1974.

3. University of South Carolina, Institute of Archaeology and Anthropology, Archaeological Site Listing: Richland County, 1973.

4. U. S. Department of the Interior, National Park Service. National Registry of Natural Landmarks, U. S. Government Printing Office, Washington, D. C., 1973.

2.4 GEOLOGY

Major emphasis was placed on the geology and the geohydrology because the NFCS facility employs on-site lagoons for liquid and sanitary treatment. Accurate knowledge of the geologic conditions can provide the ability to evaluate the impact of these holding ponds. A group of highly qualified geologists and geohydrologists from the University of South Carolina headed by Dr. D. Colquhoun have provided most of the information found in this section as well as Section 2.5, Hydrology.(1)

Physiography, geology, seismology and soils are discussed in this section.

2.4.1 PHYSIOGRAPHY

South Carolina is divided into two major physiographic provinces: the Piedmont and the Coastal Plain. The Fall Line separates the igneous and metamorphic Piedmont rocks from the unconsolidated to semi-consolidated Coastal Plain sediments. Major physiographic features of both provinces as well as the subprovinces are shown in Figure 2.4-1.

The NFCS plant is located within the Coastal Plain physiographic province which is characterized by gently to steeply rolling hills and generally well drained mature valleys emptying through the middle Middle Coastal Plain subprovince into the Congaree River. Rejuvenation of valleys resulting in headward migrating youthful incisements is occurring today in nearly all of the local valley systems. The boundaries between the headward lying mature valley floors and the zones of youthful incisements are usually quite sharp. Small earthen dams are generally constructed above the juncture to form broad shallow ponds or lakes in the headward regions. Five or six of these dams have been constructed across Mill Creek and on its tributaries. Mill Creek flows approximately 0.5 mile northwest of the plant site.

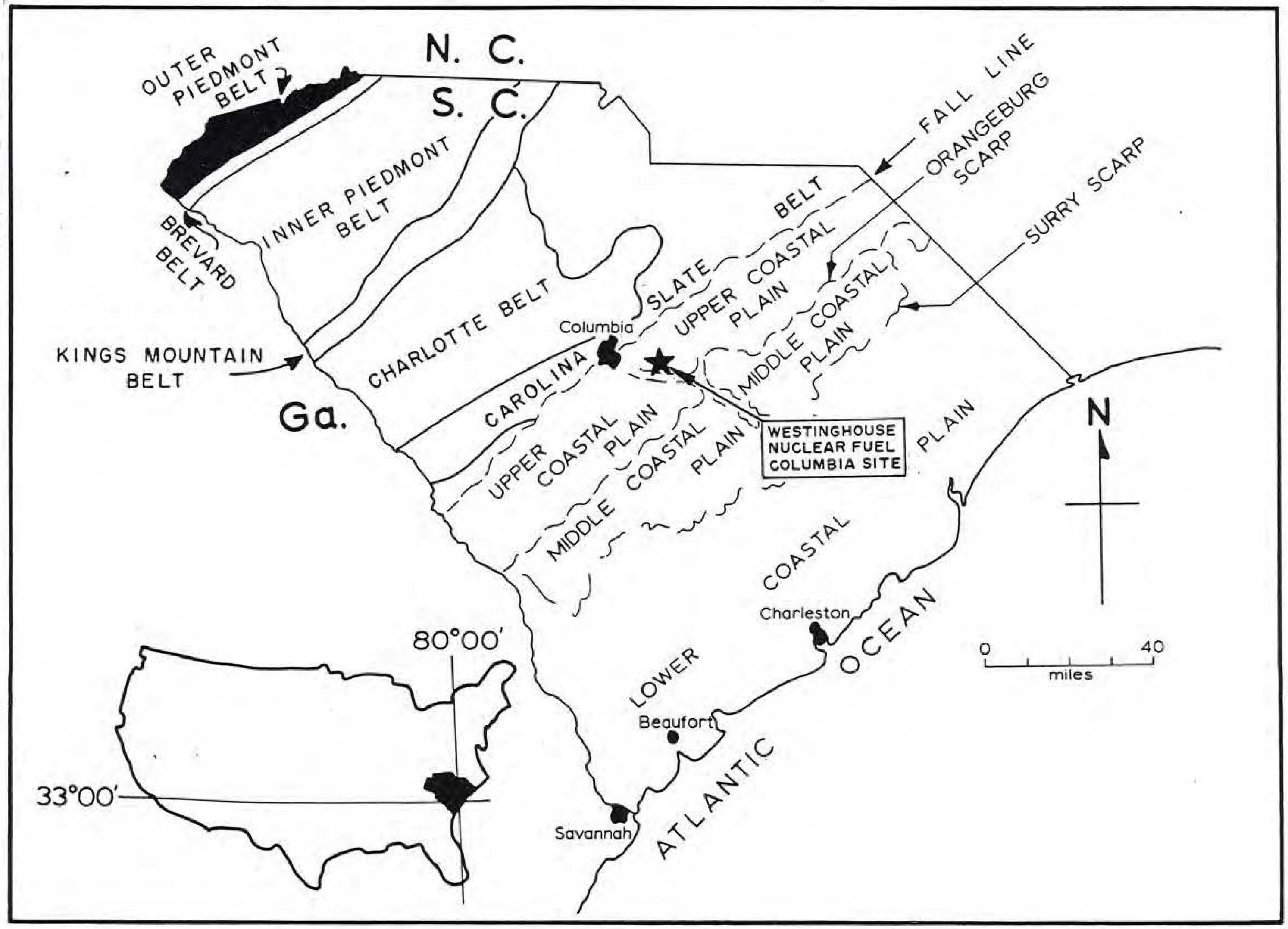

Figure 2.4-1. Physiographic Provinces and some Subprovinces of the State of South Carolina.[1]

Drainage patterns can be characterized as being dendritic for the smaller tributaries which feed into the major creeks draining into the Congaree River. The major creeks, however, have apparently developed as a response to former geomorphology in an adverted fashion. Many of these valleys are undergoing recent rejuvenation within the Upper Coastal Plain subprovince.

The Orangeburg Scarp marks the topographic boundary between the Upper Coastal Plain and the Middle Coastal Plain subprovince. In divided areas in the vicinity of the plant site, relief on the Orangeburg Scarp is quite abrupt, on the order of 200 feet, with a gradient of up to 50 feet per mile. Middle Coastal Plain subprovince topography occurs between the Orangeburg Scarp and the Recent floodplain of the Congaree River, a belt of land 4 to 5 miles in width along which three Middle Coastal Plain terraces and two Lower Coastal Plain terraces are clearly expressed. The Middle Coastal Plain terraces are: (1) the Hazelhurst terrace lying immediately adjacent to the Orangeburg Scarp at elevations of up to 270 feet above mean sea level (MSL), (2) the Coharie terrace, riverward of the Hazelhurst with a maximum elevation of 215 to 220 feet above MSL and (3) the Sunderland terrace with maximum elevation of 170 to 190 feet above MSL. The two Lower Coastal Plain terraces are: (1) the Okefenokee terrace lying adjacent to the Sunderland, and on which the plant is sited, with a maximum elevation of 140 to 150 feet above MSL, and (2) the Wicomico terrace lying riverward of it with a maximum elevation of 100 to 120 feet above MSL. The latter terraces, toward the east, are separated from one another by the Surry Scarp.

All of these terraces decrease very gently in elevation proceeding from the Orangeburg Scarp toward the Congaree River. The lower terraces decrease in elevation parallel to the river in a downstream direction on the order of 1 to 2 feet per mile. The terraces are separated by a scarp where the regional gradient of the land surface increases from 1 to 2 feet per mile to 20 to 30 feet per mile.

Drainage within the Middle and Lower Coastal Plain subprovinces stands in marked contrast to the Upper Coastal Plain. Valleys penetrating these subprovinces lie at only a few feet below their adjacent divide areas. In general, the streams that occupy these valleys have a very low gradient, and broad dense swamps are frequently present. Flooding within these valleys as well as the associated Congaree River floodplain can be a major problem and is not uncommon.

The divide areas are also poorly drained, with regional relief of only a few feet per mile. Incipient drainage patterns, reflecting ancient meander scars or other deltaic-fluvial environments, as well as the frequent occurrence of broad oval-shaped depressions of a few feet relief called "Carolina Bays", create standing water bodies during periods of high rainfall and for several days thereafter.

2.4.2 GEOLOGY OF THE AREA

The Coastal Plain Province at which the NFCS Plant is located is underlain by a wedge of sediments thickening in a seaward direction. Beginning at the Fall Line, these strata attain thicknesses of over 1100 feet at the coast adjacent to North Carolina and over 3700 feet at the coast adjacent to Georgia. The oldest rocks, at the base, are of Late Cretaceous age (approximately 100 million years). The youngest, at the surface include recent river and shoreline facies. A summary of regional investigations indicates that the Late Cretaceous sediments dip seaward at rates of up to 36 feet per mile, Early Tertiary (approximately 70 million years old) at 6 to 8 feet per mile and Late Miocene to Recent (approximately 50 million years to present age) strata appear to be essentially stable, and are not appreciably inclined.

2.4.2.1 SITE SURFACE GEOLOGY AND STRATIGRAPHY

Detailed geologic description of the NFCS based on new field mapping, records of holes drilled in 1965, 1968 and 1972 and applicable published data[2,3,4,5] is given in Appendix 2.B.

New mapping within the NFCS area is illustrated in Figure 2.B-1 in Appendix 2.B, a geologic map which comprises approximately 60 square miles. This area is divided by the Upper, Middle and Lower Coastal Plain and contains nine major stratigraphic units. Figure 2.B-2 in Appendix 2.B gives a stratigraphic cross section of the area. These maps are the result of thorough field investigations and the subsurface conditions were explored by drilling and compiling test borings. Appendix 2.B describes in detail the formations found in the area.

Results of these studies indicate that the Piedmont surface lies close to 25 feet below MSL at the NFCS and the Tuscaloosa Formation, which is a tough semi-consolidated kaolinitic complex, is over 150 feet in thickness. The foregoing Upper Coastal Plain stratigraphic unit is then succeeded by the Middle Coastal Plain Hazelhurst Formation, consisting of basal cobbley gravel, overlain by fine to medium-grained angular clayey sand, with a maximum thickness of 20 feet. The basal gravel is overlain by the Orangeburg red or brown sandy soil or clay.

Farther riverward, the Coharie, Sunderland and the Okefenokee Formations were encountered, lying on the Tuscaloosa subcrop. Each of these formations is not more than 25 feet in thickness.

Local water tables lie within 25 feet of the ground surface. Only within the marine-phase of the Tuscaloosa Formation and undifferentiated Tertiary units that occur near the top of the divide area does the water table lie at significantly lower depths. Such areas are recharge units for downdip aquifers, but they do not occur at the NFCS. The closest area to the site at which they would be found is about 1 mile south under the Congaree floodplain.(1)

Water-bearing formations within the Tuscaloosa Formation described to be found about 14 miles east of the NFCS,(5) have been removed by erosion at the site itself. Based on that lithologic description,(5) the two units corresponding to the Tuscaloosa alluvial unit are generally of very low permeability because of the presence of kaolinitic clayey matrix within the associated sands and occasional gravels.

The aquifer mostly yielding wells used by private dwellings within the NFCS area are the terrace formations deposited upon the Tuscaloosa. Such wells are shallow in depth, up to 50 feet, and actually draw from shallower horizons. The Okefenokee Formation on which the NFCS occurs has been examined at three localities where it has been used to provide fill material. In general, each of these cuts showed an upper portion in which clays had been accumulated through soil forming and weathering processes and a less clayey lower portion of sands and fine gravels with a relatively higher permeability.

In summary, predictable high permeability at the NFCS would be confined to the Okefenokee Formation at depths above approximately 110 feet above MSL. Holes drilled below this depth would encounter the alluvial phase of the Tuscaloosa Formation, which in outcrop is generally of low permeability. Local zones of higher permeability are possible, but not predictable. Such zones, should they occur, would be between the above depth and approximately 25 feet below MSL where Piedmont rocks are encountered. While fracture porosity is possible in the Piedmont lithologies, which are unknown at this site, actual production of water from these lithologies would be fortuitous.

The NFCS is not connected hydrologically with land areas toward the northeast, or east in Richland County, since it lies in a different hydrologic area and does not possess the aquifers generally encountered in those areas. At the NFCS area, those aquifers have been eroded. The principal aquifer used in these other areas would be found in the subsurface approximately one mile due south of the plant site, under the Congaree floodplain.

2.4.2.2 TECTONICS

Major tectonic features are involved in the deposition of the Coastal Plain wedge in the southeastern United States. The Great Carolina Arch extending from well out on the continental shelf landward, in the general vicinity of the North Carolina-South Carolina line, was developed subsequent to Late Cretaceous and prior to Middle Eocene times. Its uplift affects the nature of sediments deposited during this time as well as the thickness of the Coastal Plain wedge within its area of occurrence.

Within the southeastern region of South Carolina, and within the eastern portion of Georgia, tectonic activity which is probably associated with tensional faulting is apparent and affects the strata of Oligocene, Early and possibly Middle Miocene age (approximately 50 million years). Within South Carolina, the surface of carbonate shelf deposits of that age have been shown to be distorted. A northeast-southwest high, or anticline, from which sediments of this age were stripped is found in Beaufort and Jasper Counties, while toward the northwest and southeast sediments of this age are present in excessive thickness. Presently there is no evidence at the surface expressing the subsurface distortion of these sediments except from solution topography at the crest of this anticline. Apparently whatever activity was present ceased prior to the Late Pleistocene (approximately 2 million years ago) when the surface of these older sediments was scoured by wave action.

Between the northeasterly lying Great Carolina Arch and the southeasterly occurring East Georgia embayment, there occurs a region, the Marion shelf, in which the Coastal Plain sedimentary wedge generally thickens in a seaward direction without distortion, and in which the older sediments are relatively steeply inclined (up to 36 feet per mile) and the younger sediments tilt at lesser angles. The NFCS lies within this region.

2.4.3 SEISMOLOGY

More than 700 earthquakes have occurred between 1754 and 1970 in a region located between latitude 30° and 40° north and longitude 75° to 88° west. Included are the states of Alabama, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia and eastern portions of Kentucky and Tennessee.[6] Over two-thirds of these earthquakes are associated with the great Charleston earthquake of August 1886.[7]

Earthquake epicenters in the southeastern United States are shown plotted in Figure 2.4-2. Based on spatial patterning of these epicenters along with geodetic information and tide gage data the activity is interpreted to occur in four seismic zones both parallel and transverse to the regional Appalachian structures: (1) Southern Appalachian, (2) Northern Virginia-Maryland, (3) Central Virginia and (4) South Carolina-Georgia.

Three significant earthquakes were recorded in 1971: two in the Bowman area southeast of Orangeburg and one near Seneca on the northwestern corner of South Carolina. The Bowman earthquakes were assigned modified Mercalli (MM) intensity values of III and IV, while the Seneca earthquake was assigned an intensity value of IV.[8] The Mercalli Intensity Scale and expected damage from each intensity as well as the Richter Magnitude Scale and the approximate Mercalli Intensity Scale equivalent are given in Appendix 2.C. Further evidence of seismic activity in the Bowman area was provided by a magnitude 4.6 earthquake on the Richter Scale in February 1972[9] and microearthquake activity in 1973.[10] The most recent event in the Bowman area occurred on May 28, 1974.

The Summerville - Charleston area has been the most seismically active region in the state, accounting for over 90 percent of all earthquakes. In 3 months of microearthquake monitoring in the Charleston area during the summer of 1971, sixty-one earthquakes were recorded.[8]

The USGS established a five station microearthquake net in the Summerville-Charleston area and during 7 months of operation in 1973, twenty-two local earthquakes were detected.[11] Epicenters of eight well-recorded earthquakes with magnitudes ranging from 1 to 2 were located within a radius of 20 km from the epicenter of the Charleston 1886 shock.

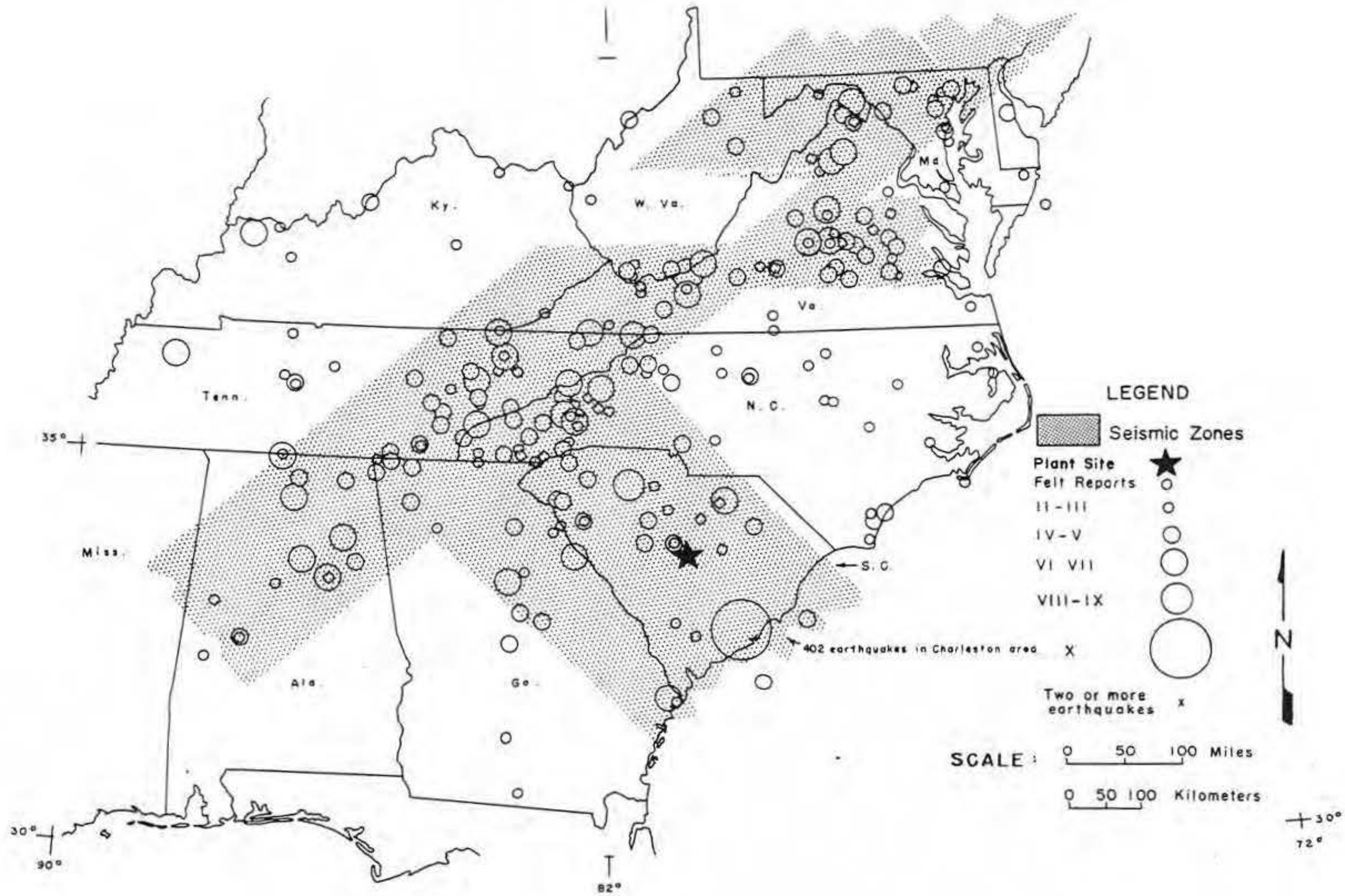

Figure 2.4-2. Seismicity of Southeastern United States, 1754-1970.(6)

During the past two decades, there has been an apparent shift of seismic activity away from the coastal Charleston-Summerville area to the interior parts of the state. The central part of the Coastal Plain region, near Orangeburg has a record of at least one earthquake per year since 1971. Another earthquake was felt in the Pelion-Gaston area, to the south of Columbia on March 28, 1973. These together with the continuing activity in the Summerville-Charleston area seem to support a NW-SE trending seismically active zone.(6,8)

The magnitude 4.3 earthquake on August 2, 1974 seems to have triggered intense seismic activity in the central and western sections of the Piedmont.(12) This early morning earthquake was followed by nearly 1000 aftershocks, while there was no seismic activity in the 3 months preceding the earthquake.(13) Two recent earthquakes in this area occurred in Edgefield County on October 28, 1974 and in McCormick County on November 4, 1974.

Due to the devastating earthquake of 1886, the southeastern part of South Carolina has been classified as earthquake risk zone 3.(14) This classification is based on the fact that the region within this zone suffered intensity Modified Mercalli VII-X damage. No other earthquake in South Carolina has caused such damage. Figure 2.4-3 shows zone 3 and all South Carolina earthquakes. This figure indicates that no earthquakes have occurred within 10 km of the NFCS.

Intensity of damage at the site associated with the 1886 earthquake which is the maximum known to have occurred at the site is Modified Mercalli VII. Such a magnitude corresponds approximately to an epicentral acceleration of 0.15 g.(16)

Other known earthquakes to have caused an effect characterized as being I-IV MM (corresponding to less than 0.01g) at the site are listed in Table 2.4-1.

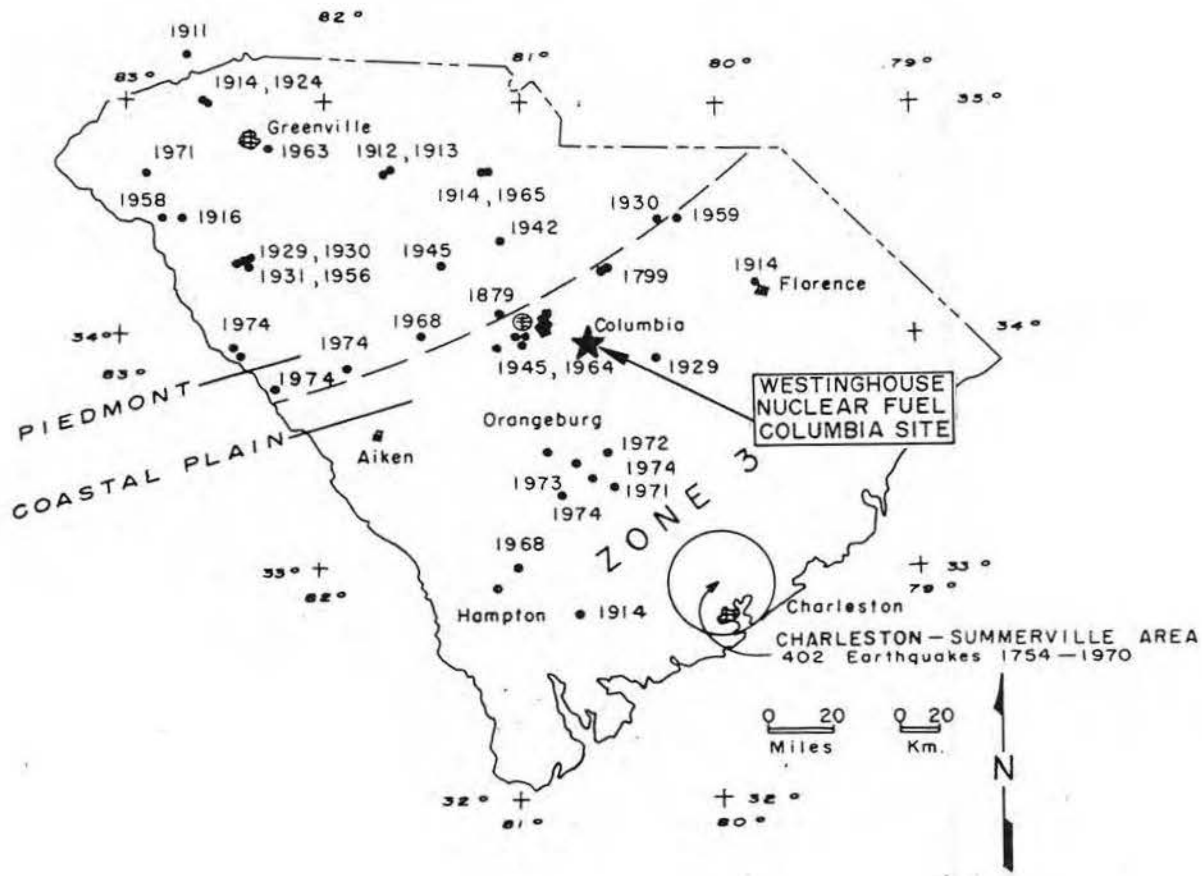

Figure 2.4-3. Seismicity Map of South Carolina. Year is Given by Each Epicenter.[6] Map is Updated to Include Earthquakes through 1974.[1] Map Also Includes Seismic Risk Zone 3.[15]

TABLE 2.4-1

EARTHQUAKES CAUSING AN INTENSITY I-IV EFFECT AT SITE

Location	Date
Union County	January 1, 1913
Charleston area	August 3, 1959
Charleston area	March 12, 1960
Bowman area	May 19, 1971
Bowman area	February 3, 1972
S. of Columbia	March 28, 1973
Summerville	November 22, 1974

2.4.4 SOILS

Soils within 5 miles of the NFCS trend in a southeasterly direction from their contact with Piedmont clayey soils near the confluence of the Broad and Saluda Rivers at Columbia, along the north side of the Congaree River Valley. Highest in elevation and oldest in age is the Magnolia-Marlboro Association consisting of gently sloping to sloping, well drained soils with fine textured subsoils that usually occur between approximately 230 and 300 feet above MSL. Next occurs the Norfolk-Orangeburg Association of nearly level to gently sloping well drained soils with medium textured subsoils generally found between altitudes of 230 and 160 feet above MSL. The Craven-Leaf-Johns Association, on which the NFCS is located occurs next, is a relatively narrow 1- to 2-mile-wide band adjacent to the Congaree River floodplain. This association is characterized by nearly level, well to poorly drained soils. The Congaree-Chewacla Association of well drained and somewhat poorly drained soils occurs between the latter association and the Congaree River.

Figure 2.4-4 shows the location of the soils found at and in the vicinity of the NFCS. A summary of these soil associations indicating the type of

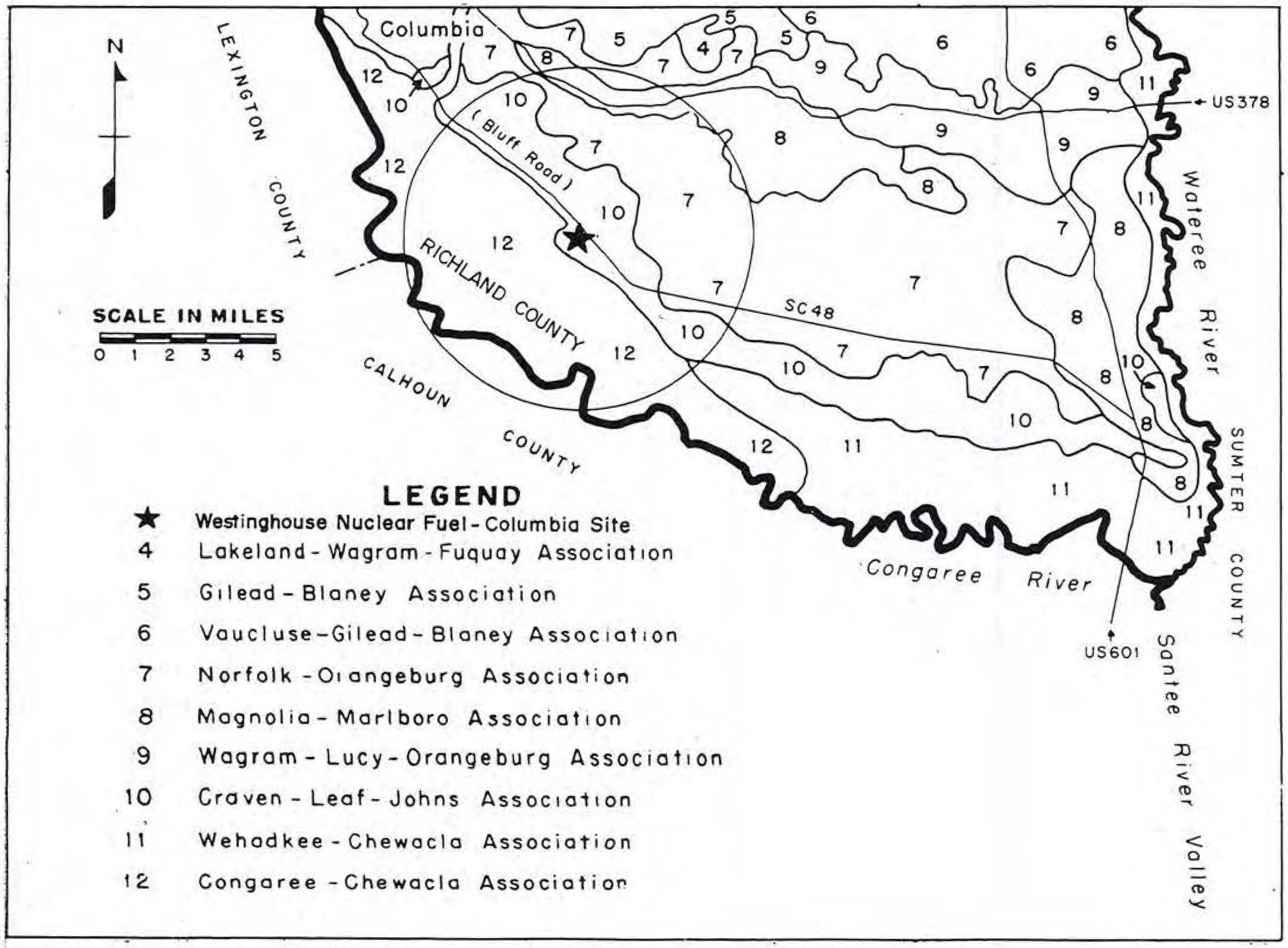

Figure 2.4-4. Generalized Soils Associations of Southern Richland County, South Carolina.[1]

soil, type of location, range in characteristics, drainage and permeability, use and typical vegetation distribution and extent, chemical and physical properties, suitability of soil as a resource material and degree of limitation for selected uses follows.

The NFCS is established on the Orangeburg Series, a deep, well drained soil type, consisting typically of a dark grayish-brown loamy sand surface layer about 7 inches thick, and a red, friable, sandy clay loam, thick subsoil. Such soil types have several degrees of limitations affecting their use: corrosivity to both uncoated steel and concrete construction is moderate because of acidity. Slight limitations are present with respect to dwellings, septic tank absorption fields, sewage lagoons, local roads and streets, light industry and sanitary land fields because slopes present within the area are less than 8 percent. Moderate limitation exists with respect to pond reservoir areas because of moderate permeability and the fact that the depth to the seasonal high water table is greater than 60 inches.

The NFCS is surrounded by soil series which impose even further degrees of limitations. The Leaf Series which lies north and east of the site, is a poorly drained soil type, consisting of a very dark gray silt loam surface layer and a gray mottled silty clay subsoil. Such soil types have three limitations: (1) very high corrosivity to uncoated steel and high to moderate corrosivity to concrete, (2) severe wetness and flooding potential to dwellings because of the seasonal high water table, shrink-swell potential and (3) severe limitation to septic tank field absorption because of the permeability class and depth to seasonal high water table.

To the west of the site Craven Series soils occur which are moderately well drained, having nearly level to sloping Coastal Plain soils. They have a grayish-brown loam surface layer and a light olive-brown and yellowish-brown clay subsoil that is very firm and slowly permeable. Gray mottles occur below about 18 inches. Subhorizons are gray clayey sediments with lenses of sandy material. This series has severe limitations for use as septic tank absorption fields because of low permeability; sewage lagoons because of wetness; sanitary landfills because of wetness; steel and concrete emplacement because of high corrosivity; small commercial buildings because of wetness and drainage because of low permeability.

To the south of the plant site on the Congaree River floodplain and adjacent to incised meanders of Mill Creek, occur the Congaree, Chastain and Chewacla Series. These are all alluvial or bottomland soil types, the Congaree being well drained; the Chastain poorly drained, and the Chewacla somewhat poorly drained. All types have severe limitations toward use for dwellings, septic tank filter fields, sewage lagoons, local roads and streets, sanitary landfills of either area or trench type or light industry, all because of flooding. All are moderately corrosive to concrete emplacement, while corrosion to uncoated steel is very high for the Chastain, high for the Chewacla and low for the Congaree Series.

With respect to soil type, it appears that the NFCS is well located for construction purposes. There exist, however, moderate limitations for pond reservoirs because of moderate permeability and because the depth to seasonal high water table is greater than 60 inches. The Orangeburg Series is developed on the Okefenokee Formation, which is the principal aquifer of this section of Richland County (Section 2.5). Groundwater within this aquifer is expected to pond on top of the Tuscaloosa alluvial phase beds lying below the aquifer at approximately 110 feet above MSL and discharge into Mill Creek or onto the Congaree River floodplain to the southwest. Because of the gradient of the surface water table, migration within this aquifer will not occur toward the northeast, or north, nor is it likely to penetrate into the Sunderland Formation.

2.4.5 REFERENCES

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2.5 HYDROLOGY

Local surface and groundwater systems are described in this section. As with Section 2.4, the information found in this section is based on the comprehensive study conducted by the geologists and geohydrologists of the University of South Carolina headed by Dr. D. Colquhoun.[1]

2.5.1 SURFACE WATER

The Congaree River Valley extends seaward from the confluence of the Saluda and Broad Rivers at Columbia, about 10 miles upstream from the NFCS area, to its confluence with the Wateree River approximately 10 miles below. For approximately 1 mile below the confluence at Columbia, the river flows over Piedmont granites and schists before entering the Coastal Plain Province of sands, silts and muds. The river valley within the Coastal Plain Province is exceptionally wide, extending over 8 miles from the terraced northeastern to the scarped southwestern valley walls. The northeastern terraced wall is approximately 4 miles wide from the Orangeburg Scarp to the present floodplain. The floodplain extends approximately 4 miles to the southwestern valley wall which is, in general, not terraced but expresses frequent scarps or cliffs and land gradients of 400 to 500 feet per mile. Figure 2.5-1 shows the surface water features in the close vicinity of the NFCS.

The Congaree River generally occupies the southwestern portion of the floodplain, flowing in a meandering pattern. At no place does the river occupy the northeast half of the floodplain, and it is probably for this reason that the terraces on the northeast valley wall have remained so well preserved over such a long period of geologic time.

Principle tributaries to the Congaree include Gills Creek at Columbia, Mill Creek which flows in the vicinity of the NFCS and Beaver Creek which flows to the southeast in the vicinity of Hopkins, South Carolina.

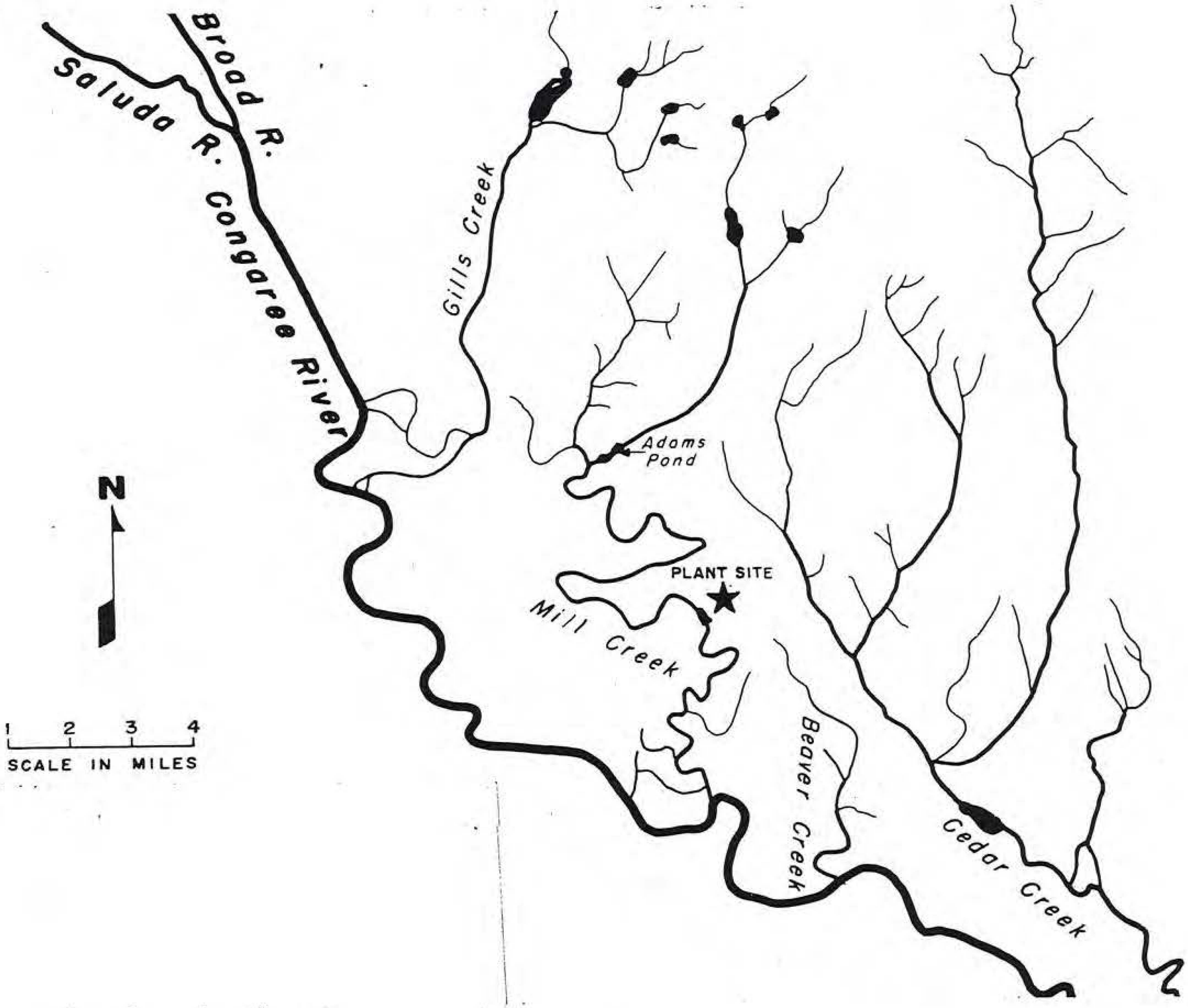

Figure 2.5-1. General Surface Water Features in the Vicinity of the NFCS[1]

All of these streams arise on the northeast valley wall several miles above the Orangeburg Scarp, within the Upper Coastal Plain subprovince. Dendritic in pattern near their headwaters, they flow in a south-southwesterly direction to become meandering in the vicinity of and within the present Congaree River floodplain. All of these small streams show evidence of cutting into a former "more mature" drainage pattern. Near their headwaters this is expressed as a narrow somewhat deeper "V"-shaped valley cutting into a broader, flatter floodplain, where recreational and stocked fish ponds are often constructed to take advantage of the wider stream valleys.

2.5.1.1 CONGAREE RIVER GRADIENT AND FLOW

Figure 2.D-1 in Appendix 2.D shows the gradient of the Congaree River between Columbia and Gaston as reported by the U. S. Geological Survey, Water Resources Division at Columbia, South Carolina.(2) Discharges and gage heights for this river at Columbia during the period between 1892 and 1973 are listed in Table 2.D-1, Appendix 2.D.(3) Since 1892, the highest stage attained at Columbia was the flood of August 27, 1908 when the stage reached 35.8 feet and the discharge was 364,000 cfs. Constraining factors on the flow include total regulation of flow in the Saluda River at Lake Murray and Lake Greenwood and to some extent by power plants on the Broad River. The city of Columbia diverts about 42 cfs of water for its municipal supply. Since construction of regulating hydroelectric sites on the Saluda River the maximum flow was 231,000 cfs on April 10, 1964, at which time the gage height attained was 33.34 feet.

The flood history of the Congaree River can be studied by means of the peak data listed in Table 2.D-1 and Figure 2.D-1. The earliest peak was noted in September 1852, at which time a gage height of 34.4 feet was noted but not the discharge. Maximum peak and discharge for the entire period occurred on August 27, 1908, when the gage height stood at 35.8 feet and discharge was 364,000 cfs. Comparing the Congaree River slope with the stage at Columbia curve indicates a slope of approximately 1.3 feet per mile. The NFCS is approximately 12 miles below the Columbia gaging station which indicates a 15.6 foot difference in elevation between that station and the plant site portion of the Congaree River Valley, or a water stand of 128.6 feet above MSL. Since the plant site is located at an elevation of approximately 140 feet, it can be concluded that no flooding of the plant site has occurred in the last 73 years and possibly in the last 123 years.

This is further substantiated by the 100-year flood line maps of the Congaree River Valley constructed by the U. S. Army Corps of Engineers as shown in Figure 2.5-2. In this map, the line separating flood prone and approximate areas occasionally flooded from higher land areas is drawn at 130 feet in the vicinity of the NFCS.

2.5.1.2 WATER QUALITY

Water quality records for the years 1969 through 1974 were obtained from the South Carolina Pollution Control Authority.(4) Yearly means for years with available data were computed from the computer printouts for five stations: four along the Congaree River and one on Mill Creek above the site at Adams Pond. Two of the Congaree River stations are above the NFCS and two are below it. Locations are indicated in Tables 2.5-1 through 2.5-5, which list concentrations of analyzed chemical parameters.

Comparison of these records indicates no unusual trends in concentrations of chemicals between stations above and below the site for the twenty-two chemical parameters, nor are there any significant differences with time.

Effects of municipal discharges discussed in Section 2.8.3.1 are reflected in high bacteria counts. Both coliform and fecal coliform counts exceeded the South Carolina water quality standards for Class B, which applies to these surface water bodies. As a result, both the city of Columbia and the city of Cayce are presently constructing treatment facilities for their municipal liquid discharges.

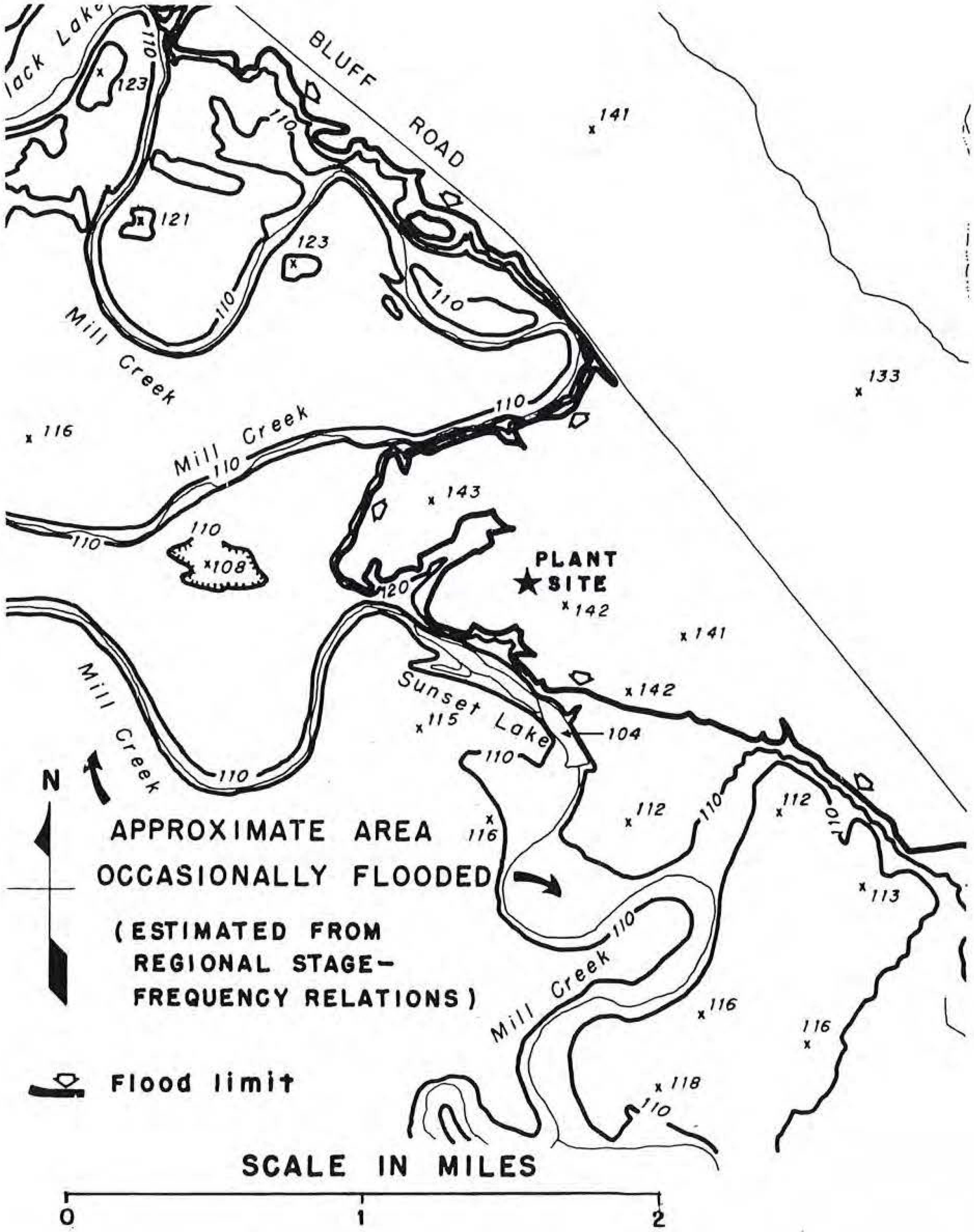

Figure 2.5-2. Map of Flood-Prone Areas in the Vicinity of the NFCS[1]

TABLE 2.5-1

YEARLY MEANS OF WATER QUALITY OF CONGAREE RIVER JUST ABOVE LEXINGTON-CALHOUN COUNTY LINE[4]

(APPROXIMATELY 6 RIVER MILES UPSTREAM FROM THE NFCS DISCHARGE POINT)

Concentration in mg/l Or As Indicated

Parameter	1971	1972	1973
Water temp. °C	23.5	17.4	22.5
Turbidity, Jackson Units	90.6	29.0	x
Turbidity as SiO_2	13.75	9.0	23.0
Color PT-CO Units	120.0	69.2	50.0
DO Probe	x	x	8.0
DO	7.4	8.86	x
DO % of saturation	86.6	89.3	x
BOD	1.23	2.10	7.0
pH (pH Units)	x	x	6.8
Lab pH (pH Units)	6.84	6.05	6.10
Total $CaCO_3$	23.5	21.7	22
Total N	0.04	x	x
NO_3 - N	0.05	0.346	x
NO_3 and NO_2- N, total	0.05	0.32	0.4
Ortho PO_4	0.043	0.063	0.15
Total Hardness as $CaCO_3$	27.0	x	x
Chloride	6.0	x	x
Cadmium	x	x	0.030
Chromium	x	x	0.100
Copper	x	x	0.050
Iron, Total	x	x	0.484
Lead	x	x	0.100
Total Coliform MFI M-ENDO/100 ml*	60333	x	x
Fecal Coliform MPN-EC-MED/100 ml	16475	1030	x
Fecal Coliform MPN-MFCBR/100 ml	16475	2398	1000
Total Coliform MPN-PRES/100 ml	60333	x	x
Ammonia	13	x	x
Mercury µg/l	x	0.05	0.05

* MFI M-ENDO = Membrane filter incubation procedure using M-ENDO medium
MPN-EC-MED = Most probable number using EC medium
MPN-MFCBR = Most probable number using M-FC broth
MPN-PRES = Most probable number, presumptive test

TABLE 2.5-2

YEARLY MEANS OF WATER QUALITY OF CONGAREE RIVER 2-1/4 MILES BELOW LEXINGTON-CALHOUN COUNTY LINE[4]

(APPROXIMATELY 3.75 RIVER MILES UPSTREAM FROM THE NFCS DISCHARGE POINT)

Concentration in mg/l Or As Indicated

Parameter	1971	1972	1973
Water temp. °C	22.75	23.66	21.0
Turbidity, Jackson Units	69.0	26.0	x
Turbidity (as SiO_2)	19.0	10.5	15.0
Color PT-CO Units	160.0	56.0	50.0
DO Probe	x	x	7.9
DO	7.23	8.68	x
DO % of saturation	83.66	86.0	x
BOD	0.9	1.62	2.8
pH (pH Units)	x	x	6.5
Lab pH (pH Units)	6.95	6.38	6.2
Total $CaCO_3$	24.0	21.1	26.0
Total N	0.06	x	x
NO_3 - N	0.05	0.32	x
NO_2 and NO_3 - N, total	0.05	0.34	0.4
Ortho PO_4	0.06	0.15	0.06
Total Hardness as $CaCO_3$	24.5	x	x
Chloride	5.6	x	x
Cadmium	x	x	0.030
Chromium, total	x	x	0.100
Copper	x	x	0.050
Iron, total	x	x	0.870
Lead	x	x	0.100
Total Coliform MFI M-ENDO/100 ml*	106333	x	x
Fecal Coliform MPN-EC-MED/100 ml	49250	946.6	x
Fecal Coliform MPN-MFCBR/100 ml	49250	3088	1000L
Total Coliform MPN-PRES/100 ml	109666	x	x
Ammonia	0.66	x	x
Mercury μg/l	x	0.04	0.5K

* MFI M-ENDO = Membrane filter incubation procedure using M-ENDO medium
MPN-EC-MED = Most probable number using EC medium
MPN-MFCBR = Most probable number using M-FC broth
MPN-PRES = Most probable number, presumptive test

TABLE 2.5-3

YEARLY MEANS OF WATER QUALITY OF CONGAREE RIVER AT MOUTH OF MILL CREEK[4]

(APPROXIMATELY 2.6 RIVER MILES DOWNSTREAM FROM NFCS DISCHARGE POINT)

Concentration in mg/l Or As Indicated

Parameter	1971	1972	1973
Water temp. °C	22.0	16.25	21.0
Turbidity, Jackson Units	72.5	33.0	x
Turbidity (as SiO_2)	17.0	11.25	11.0
Color PT-CO Units	152.5	56.0	50.0
DO	7.2	8.61	x
DO % of saturation	82.1	84.8	x
BOD	0.95	1.7	2.4
pH (pH Units)	x	x	6.5
Lab pH (pH Units)	6.85	6.45	6.1
Total $CaCO_3$	24.0	20.8	20.0
Total N	0.04	x	x
NO_3 - N	0.05	0.41	x
NO_2 and NO_3 - N, total	0.05	0.38	0.4
Ortho PO_4	0.04	0.096	0.10
Total Hardness as $CaCO_3$	22	x	x
Chloride	6.0	x	x
Cadmium	x	x	0.030
Chromium, total	x	x	0.100
Copper	x	x	0.050
Iron	x	x	232
Lead	x	x	0.100
Total Coliform MFI M-ENDO/100 ml*	43000	x	x
Fecal Coliform MPN-EC-MED/100 ml	40250	1650	x
Fecal Coliform MPN-MFCBR/100 ml	40250	6473.0	1000
Total Coliform MPN-PRES/100 ml	43000	x	x
Ammonia	0.11	0.36	x
Mercury ug/l	x	0.03	0.5

* MFI M-ENDO = Membrane filter incubation procedure using M-ENDO medium
MPN-EC-MED = Most probable number using EC medium
MPN-MFCBR = Most probable number using M-FC broth
MPN-PRES = Most probable number, presumptive test

TABLE 2.5-4

YEARLY MEANS OF WATER QUALITY OF CONGAREE RIVER AT MOUTH OF BEAVER CREEK[4]

(APPROXIMATELY 9.7 RIVER MILES DOWNSTREAM FROM THE DISCHARGE POINT)

Concentration in mg/l Or As Indicated

Parameter	1971	1972	1973
Water temp. °C	21.25	15.83	20.0
Turbidity, Jackson Units	74.5	33.0	x
Turbidity (as SiO_2)	15.0	9.0	11.0
Color PT-CO Units	132.5	55.0	50.0
DO Probe	x	x	8.1
DO	7.6	8.7	x
DO % of saturation	83.66	84.83	x
BOD	0.725	1.64	2.2
pH (pH Units)	x	x	6.2
Lab pH (pH Units)	6.875	6.316	6.1
Total $CaCO_3$	23.5	21.83	20
Total N	0.035	x	x
NO_3 - N	0.060	0.396	x
NO_2 and NO_3 - N, total	0.01	0.38	0.4
Ortho PO_4	0.035	0.103	0.0
Total Hardness as $CaCO_3$	40.5	x	x
Chloride	6.0	x	x
Cadmium	x	x	0.030
Chromium, total	x	x	0.100
Copper	x	x	0.050
Iron	x	x	0.374
Lead	x	x	0.100
Total Coliform MFI M-ENDO/100 ml*	118666	x	x
Fecal Coliform MPN-EC-MED/100 ml	24050	2193	x
Fecal Coliform MPN-MFCBR/100 ml	24050	3596	1000
Total Coliform MPN-PRES/100 ml	118666	x	x
Ammonia	x	x	x
Mercury µg/l	x	0.03	0.05K

* MFI M-ENDO = Membrane filter incubation procedure using M-ENDO medium
MPN-EC-MED = Most probable number using EC medium
MPN-MFCBR = Most probable number using M-FC broth
MPN-PRES = Most probable number, presumptive test

TABLE 2.5-5

YEARLY MEANS OF WATER QUALITY OF MILL CREEK AT ADAMS POND (BLUFF ROAD)[4]

(APPROXIMATELY 9 RIVER MILES UPSTREAM FROM SUNSET LAKE)

Concentration in mg/l Or As Indicated

Parameter	1969	1971	1972	1973	1974
Water temp. °C	x	25.75	23.81	25.33	24.0
Turbidity, Jackson Units	x	28.00	x	28.00	x
Turbidity (as SiO_2)	x	11.0	4.0	14.75	x
Color PT-CO Units	x	317.5	67.5	69.0	120
DO Probe	x	x	x	7.91	6.1
DO	x	6.5	7.22	x	x
DO % of saturation	x	77.58	85.17	x	x
BOD	x	5.05	2.32	5.36	5.10
pH (pH Units)	x	x	x	6.52	6.20
Lab pH (pH Units)	x	6.05	5.92	6.24	6.20
Total $CaCO_3$	x	8.5	6.83	10.0	8.0
Total N	x	x	x	x	x
NO_3 - N	x	x	0.120	x	x
NO_2 and NO_3 - N, total	x	x	0.22	0.184	x
Ortho PO_4	x	0.01	0.15	0.45	x
Total Hardness as $CaCO_3$	x	15	x	x	x
Chloride	x	9	x	0.03	x
Cadmium	x	x	x	0.100	x
Chromium, total	x	x	x	0.100	x
Copper	x	x	x	0.050	x
Iron	x	x	x	0.845	x
Lead	x	x	x	0.200	x
Total Coliform MFI M-ENDO/100 ml*	x	1445	x	x	x
Fecal Coliform MPN-EC-MED/100 ml	52	60	60	x	x
Fecal Coliform MPN-MFCBR/100 ml	52	60	23	43.6	90
Total Coliform MPN-PRES/100 ml	x	1445	x	x	x
Ammonia	x	0.05	x	x	x
Mercury µg/l	x	x	x	0.366	x

* MFI M-ENDO = Membrane filter incubation procedure using M-ENDO medium
MPN-EC-MED = Most probable number using EC medium
MPN-MFCBR = Most probable number using M-FC broth
MPN-PRES = Most probable number, presumptive test

2.5.2 GROUNDWATER

Groundwater production from the portion of the Coastal Plain of Richland County within which the NFCS is located is indicated in Figure 2.5-3. The principal aquifers include several terrace formations: the Okefenokee, Sunderland, Coharie and the Tuscaloosa Formation. Geographically, production from shallow holes is possible within any of the terrace formations. Predictable production within the Tuscaloosa, however, is confined to the area east of the subcrop of the Ktm aquifer illustrated in Figure 2.5-3.

2.5.2.1 OKEFENOKEE AND OTHER TERRACE FORMATION AQUIFERS

Most wells drilled or dug within the region produce water at shallow depths of up to 30 to 40 feet from within the various terrace formations. The cross-sectional shape of the various terrace formations is illustrated in Figure 2.B-2 in Appendix 2.B.

In the higher terraces, the Tuscaloosa Formation is scoured below those sediments, such that the Tuscaloosa surface dips with decreasing gradient away from the landward scarp boundary of the terrace and toward the river, flattening within a short distance at a depth some 20 to 30 feet below the terrace surface. Depressions in the form of channels carved by streams prior to the deposition of the terrace sediments occur within the Tuscaloosa surface, and in these areas depth from the surface to the Tuscaloosa subcrop may be up to 50 feet. The Tuscaloosa subcrop may lie very close to the surface in certain areas, particularly in the vicinity of the various scarps separating the terraces where it may be exposed or lie only a few feet below ground surface. In such areas, production of water from the surficial aquifers is unlikely, although natural springs during rainy periods are not uncommon.

In the lower terraces, the Sunderland and the Okefenokee, the actual shape of the Tuscaloosa subcrop is not known precisely because of a general lack of exposure. However, limited drill holes in the area indicate that this

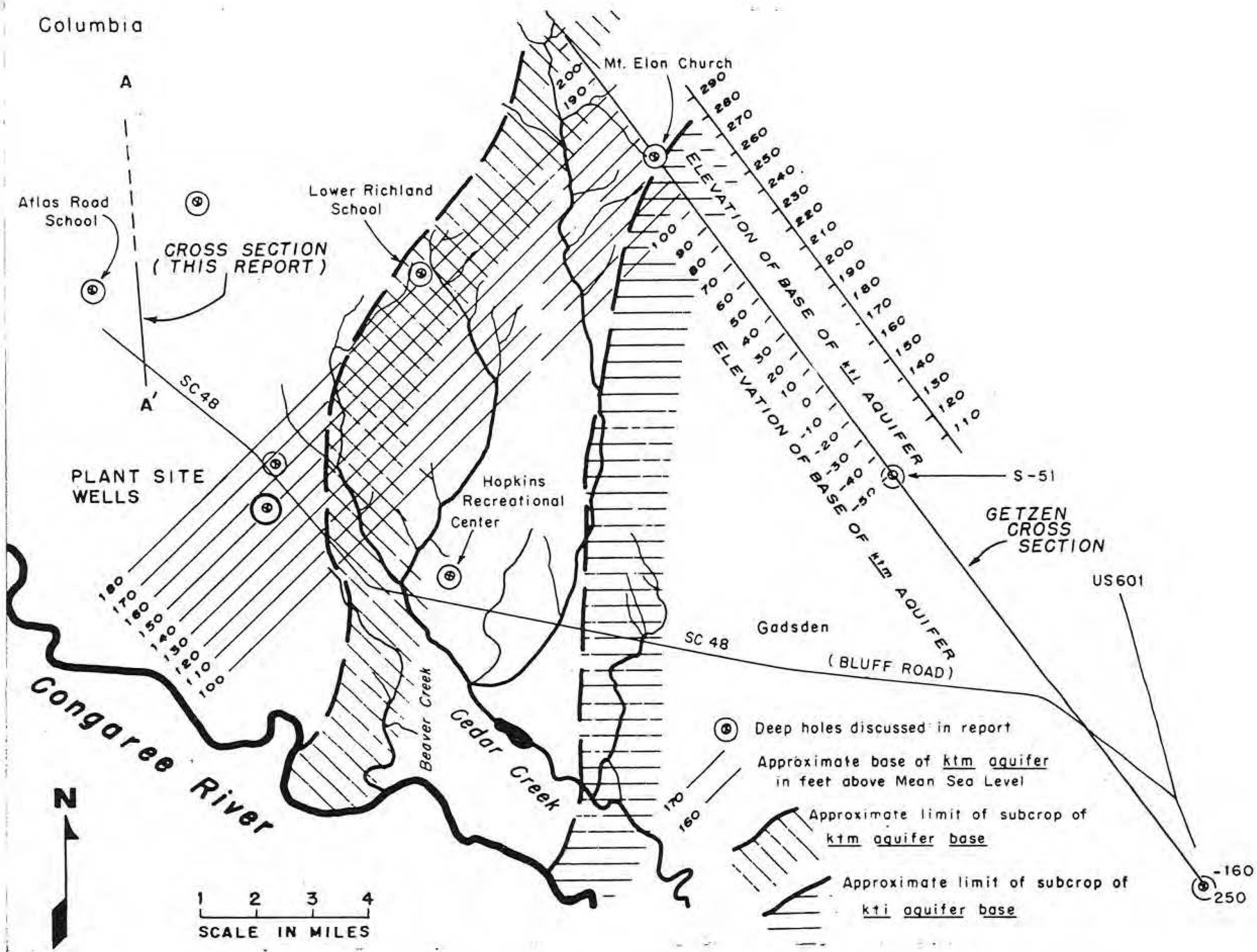

Figure 2.5-3. Principle Deep Aquifer in the Vicinity of the NFCS(1)

formation is not at variance with the more detailed picture noted above for the higher terraces.

In summary, the lower boundary to the surficial aquifers is a generally planar surface in a riverward direction at a depth of 20 to 30 feet below the surface of the ground. Irregularities in the form of scoured channels may occur on this surface such that thicknesses of up to 50 feet are possible between the surface of the terrace and the Tuscaloosa subcrop.[(1)]

Static water level in nearly all holes drilled into the surficial aquifers lies within 10 or at the most 15 feet of the ground surface. This was the case for all holes drilled through terrace sediments illustrated in Figure 2.B-1, Appendix 2.B, and the twenty holes drilled to shallow depths (19 feet) within the NFCS property by Froehling and Robertson, Inc. Such water levels were also found in holes located within the NFCS property such as the holes constructed for a farm irrigation system which existed before plant construction and the original well which served the old Burnside property.

2.5.2.2 LOWER TUSCALOOSA FORMATION AQUIFERS

The basal units of the Tuscaloosa Formation alluvial phase are generally of low permeability or impermeable. Deep holes producing from the Tuscaloosa alluvial phase include two wells drilled on the NFCS property. Both encountered beds of no or low permeability below the generally productive terrace formation aquifer present to 30 feet below ground surface. The first well was drilled in 1963 to supplant the 30 foot deep hole supplying the old Burnside property. Gray clay, which was cased off, occurred below the surface aquifer to 105 feet below the ground surface. Production from below 105 feet came from packed sand. The well produced 107 gallons per minute with a drawdown of 15 feet. The static water level was 22 feet below ground surface. The second deep well on the NFCS property was drilled during construction of the plant. It encountered gray clay to 71 feet below ground surface and packed sand from that depth to 140 feet. The top 71 feet were cased off and unmeasured production was obtained from below.

A third deep well was constructed 1 mile northwest of the NFCS on private property at a point along Route 48. The terrace aquifer at this hole produced only black mud and black water at a depth of 15 to 20 feet. From 20 feet to 200 feet below the ground surface only impermeable clays were encountered, but at 200 feet a porous sand was found. Water from this level filled the hole and finally rested about 10 feet below the ground surface.

A fourth deep well was attempted about 5 miles northwest of the plant site at Atlas School to supplement a 22 foot deep well which had been drilled previously, producing from the terrace units. This well encountered generally impermeable to low permeability clays below 25 feet to 115 feet and little water was produced. The well was abandoned.

To the north-northwest of the plant site a hole 136 feet deep was drilled near the intersection of Routes 88 and 76. This hole encountered 10 feet of permeable sand underlying clays and produced 30 gallons of water per minute.

The number of deep wells penetrating the Tuscaloosa alluvial phase is limited. The wells are confined to that portion of Richland County lying west of the Ktm aquifer illustrated in Figure 2.5-3. Since good water production to the east of the Ktm line on Figure 2.5-3 would be encountered above the alluvial phase, there would be little point in deepening the holes. In all cases, production from the alluvial phase occurred very low in the stratigraphic sequence, and in all cases there was no production from the higher beds because of the general occurrence of impermeable to low permeability clay. The amount of water obtainable from the alluvial phase of the Tuscaloosa is not predictable. At least one hole did not yield water and was abandoned. There is general reason to believe that the upper beds of the alluvial phase of the Tuscaloosa may be regarded as an aquiclude with respect to the lower aquifers and the overlying Okefenokee and Sunderland Aquifers. This reasoning is based on two facts: (1) the upper portion of the alluvial phase exists as an impermeable to low permeability section composed of clays and clayey sands within the five wells quoted above, as well as in other published data[3] and (2) within the NFCS the static water level of the Tuscaloosa alluvial phase aquifer stood at 22 feet below ground surface, while several holes utilizing the Okefenokee Aquifer had static water level surfaces of less than 15 feet. Since ground elevations of the drill sites were almost the same, approximately 140 feet above MSL, this would indicate that two aquifers separated by an aquiclude were encountered.

2.5.2.3 UPPER TUSCALOOSA FORMATION AQUIFERS

Production of groundwater from deep wells, as opposed to surficial aquifers, to the northeast and east of the NFCS occurs from the Tuscaloosa marine phase. These aquifers dip in the same direction as the underlying aquifers and they flow in a southeastward direction.[1]

2.5.2.4 ON-SITE WELLS

The three NFCS monitoring wells draw their water from the Okefenokee Terrace. Section 2.4.2.1, Site Surface Geology and Stratigraphy, describes the relation of the water-bearing formations at the NFCS and the rest of Richland County. The exact location of the monitoring wells which were on-site as part of the existing irrigation project before the NFCS facility was constructed is illustrated in Figure 6.1-2. Water levels are given in Table 2.5-6. These wells are monitored for their radiological content as well as for fluorides, ammonia and pH.

TABLE 2.5-6

WATER LEVELS OF MONITORING WELLS ON NFCS PROPERTY*

Well No.**	Depth to Bottom of Well (ft)	Depth to Water Level (ft)
1	Could not be obtained†	
2	26.6	13.3
3	24	7

* Data was supplied by NFCS Health Physicists

** Locations of wells are illustrated in Figure 6.1-2

† Probably less than 35 feet

2.5.2.5 GROUNDWATER QUALITY

Groundwater quality records have been obtained from the offices of the U. S. Geological Survey and the South Carolina Pollution Control Authority for a number of wells in the area between Columbia and Eastover along Bluff Road and between that area and Route 76 which lies to the north. No attempt was made by these sources to identify either the top or the base of the producing horizons, the positioning of screens or casing, nor the name of the driller who constructed the well in the first place. Thus, although the water quality was monitored rather frequently, assigning the analysis to a particular aquifer is not possible. None of the core holes discussed in Sections 2.4 and 2.5 have been monitored for their water quality.

Table 2.5-7 lists groundwater quality within 5 miles of the NFCS for aquifers Kti, Ktm and the surface aquifer.

2.5.2.6 SUMMARY

This summary indicates the following important facts.

1. The NFCS is underlain by the Okefenokee surficial aquifer. The base of this aquifer lies at approximately 110 feet above MSL and tilts at a very low angle toward the Congaree River floodplain. The upper surface of this aquifer lies at about 132 feet above MSL and because of incision of Mill Creek to depths below 110 feet tilts more steeply toward the Congaree River floodplain.

2. The surficial aquifer is separated from deeper aquifers by an aquiclude of relatively impermeable sandy clay at least 40 feet in thickness.

3. A deep aquifer, or aquifers, of unknown regional nature and unpredictable production is present below 70 feet above MSL. This aquifer dips southeast in a downriver direction with groundwater flowing in that direction.

TABLE 2.5-7

GROUNDWATER QUALITY[4]

Concentrations in mg/l Or As Indicated

	Surface Aquifer	Kti* Aquifer (Probable)	Ktm* Aquifer (Probable)
Station No.	335815081002500	335425080475000	335410080473500
Date	Dec. 12, 1962	Jan. 18, 1968	Jan. 18, 1967
Depth to top of Sample, (ft)	--	65	119
Depth to bottom of Sample, (ft)	--	70	127
Color, (platinum cobalt units)	33	4	5
Specific Conductance ($\mu\Omega$/cm)	399	39	42
pH, pH Units	4.4	5.5	6.7
CO_2	--	15	6.1
HCO_3	--	3	19
Alkalinity (as $CaCO_3$)	--	2	16
Hardness(Ca, Mg)	112	5	6
Non-Carbonate Hardness	112	2	0
Ca	20	1.0	1.4
Mg	12	0.6	0.4
Na	21	5.1	2.1
K	6.6	0.3	0.2
Ce	36	2.5	2.5
SO_4	118	0.4	0.6
F	2.6	0.2	0.2
PO_4	--	--	0.1
Dissolved NO_3-N	1.8	2.7	0.38
Dissolved NO_3	8.0	12	1.7
Total NO_3	8.0	--	--
SiO_2	18	4.6	3.8
Dissolved Fe	1.1	--	--
Dissolved Mn	0.5	--	--
Total Mn	--	0.01	0.1
Al	1.9	--	0.1
Total Dissolved Solids, (TDS)	258	34	27

* For location of these aquifers see Figure 2.5-3.

4. The principal deep aquifers of this region of Richland County lie to the east of the NFCS and dip in the same direction as the underlying aquifers. The piezometric surface of these aquifers also indicates flow in a southeastward direction.

5. As a result of these facts, accidental discharge of industrial wastes into the surficial aquifer underlying the NFCS holding ponds would be confined to the aquifer and would not migrate to the lower aquifer as long as present casings in the deep holes remain effective to migration of fluid (static level of surface aquifer about 130 feet above MSL-static level of lower aquifer 122 feet above sea level).

6. Most logically, discharges of the groundwater in the surficial aquifer would occur toward the river itself, probably discharging into the waters of Mill Creek, and the configuration of the surficial aquifer would contraindicate groundwater flow in any other direction.

2.5.3 REFERENCES

1. Colquhoun, D. J., et al., "The Regional and Local Physiography, Geology, Seismicity, Soils and Hydrology at the Westinghouse Plant Site, Richland County, South Carolina," Report to Westinghouse Environmental Systems Department, November 1974.

2. U. S. Department of the Interior, Geological Survey, Water Resources Division, Peak Stages and Discharges, Congaree River, South Carolina, U. S. Government Printing Office, 1974.

3. U.S. Geological Survey, Water Resources Division, 1974.

4. South Carolina Pollution Control Authority, Water Quality Data, 1969 Through 1973.

2.6 METEOROLOGY AND CLIMATOLOGY

This section describes the climatological features and the severe weather potential for the NFCS and evaluates the atmospheric dispersion characteristics relevant to the transport of gaseous effluents from the facility.

A summary of local climatological features for the U. S. Weather Bureau Station at Columbia Metropolitan Airport(1) located about 16 miles northeast of the site is given in Table 2.6-1 which includes temperature, relative humidity, wind, precipitation and mean annual number of days of climatological events.

This weather station provides data that approximately represents the site's meteorological features because of the proximity of this station to the site. One year's diffusion climatology data is also available from on-site measurements.

Detailed climatological and diffusion meteorology data are presented in Appendix 2.E.

2.6.1 REGIONAL CLIMATOLOGY

Columbia is located on the Congaree River near the confluence of the Broad and Saluda Rivers in central South Carolina. The Fall Line between the Piedmont and Coastal Plain is near Columbia and as a result, the soil in the vicinity ranges from sand to clay loams. The terrain varies in elevation from about 350 feet above mean sea level in northern Columbia to about 200 feet in the southeastern part of the city.

The weather in the region of the Columbia site reflects a temperate climate with high relative humidity, moderate rainfall throughout the year, moderate winds and normal diurnal temperature changes. Winters are mild with rare cold waves accompanied by temperatures of zero or below. Freezing temperatures (< 32°F) occur on an average of 65 days per year, generally during the months of November through March.

TABLE 2.6-1

CLIMATOLOGICAL DATA FROM COLUMBIA METROPOLITAN AIRPORT[(1)]*

Parameter	
Temperature, °F	
Annual average	63.5
Maximum	75.4
Minimum	51.5
Record high	107
Record low	-2
Degree days	2598
Relative Humidity, %	
Annual average	73
Wind	
Annual average speed, mph	7.0
Prevailing Direction	SW
Fastest mile:	
speed, mph	60
direction	W
Precipitation, in.	
Annual average	46.36
Monthly maximum	16.72
Monthly minimum	Trace
24-hr maximum	7.66
Snowfall, in.	
Annual average	1.9
Monthly maximum	16.0
24-hr maximum	15.7
Mean Annual - No. of Days	
Precipitation ≥ 0.1 in.	110
Snow, sleet, hail ≥ 1.0 in.	1
Thunderstorms	53
Heavy fog	27
Maximum temperature ≥ 90°F	65
Minimum temperature ≤ 32°F	65

* Data based on 7 to 30 years of record

However, long summers are prevalent with the warm weather usually lasting from sometime in May into September. A typical summer has about 6 days of 100°F or more. Temperatures of above 90°F occur on an average of 65 days each year, mostly during June through August. Fall is the most pleasant time of the year. Rainfall during late fall is at an annual minimum while the sunshine is at a relative maximum. About 20 percent of the annual rainfall is recorded during the fall. Spring is the most changeable season of the year. The temperature varies from an occasional cold snap in March to generally warm and pleasant in May.

Total annual precipitation averages nearly 46 inches. Precipitation is well distributed throughout the year with summer being the rainiest season, contributing about 33 percent of the annual total. In summer, the southwesterly flow around the offshore Bermuda high pressure area supplies the necessary moisture for the many thunderstorms occurring during this season. Thundershower activity shows an increase during summer, decreasing about the first week of September. The wettest recorded month for Columbia was August 1949, with a total of 16.72 inches of rainfall. The most rainfall in a 24-hour period (7.66 inches) occurred in August 1949. Annual precipitation of snow and ice pellets for the Columbia area averages about 2 inches. Calculated maximum rainfall values for a period of 24 hours are 6.61 inches for a 25-year return period and 7.42 inches for a 50-year return period.[(2)] Winds are generally moderate (7.0 mph) with prevailing direction from the southwest. In spring, winds may briefly become strong enough to cause damage to trees and buildings.

Average relative humidity varies slightly throughout the year with an annual average of about 73 percent. The diurnal variation shows that it is lowest in the afternoons and highest at night. The incidence of heavy fog (1/4 mile or less visibility) varies slightly around South Carolina. Typical values are 27 days at Columbia, 31 days in Greenville-Spartanburg and 29 days in Charleston. Four months have an average fog frequency of 3 or more days.

2.6.2 SEVERE WEATHER

Severe weather considerations are discussed in the subsequent sections. Under discussion are snow and glaze storms, thunderstorms and hail and tornadoes and hurricanes.

2.6.2.1 SNOW AND GLAZE STORMS

The winter weather in the central part of South Carolina is largely made up of polar air outbreaks that reach this area in a modified form. Only on rare occasions do arctic air masses push southward as far as Columbia and cause some of the coldest temperatures. During a 10-year period, 10 to 30 days of freezing rain or drizzle were reported in central South Carolina. The site can expect a day of more than one inch of snowfall in one out of five winters. Disruption of activities from snowfall is unusual. Variations over a period of 26 years show that February 1973 experienced a total of 16 inches of snow with 15.7 inches falling in a single day. Normal snowfall for February is 0.9 inch.

In the Columbia area, three to six glaze storms have been reported in 28 years. In central South Carolina, glaze ice of 0.25 inch or more occurred three to five times and 0.5 inch or more, occurred one to two times in a period of 9 years.[3] However, the river gorge area near Columbia is known to receive thick glaze more frequently than the surroundings. Based on 20 years of data, it is known that one medium sleet storm occurred in the area at least every 3 years.

2.6.2.2 THUNDERSTORMS AND HAIL

In the Columbia area, thunderstorms occur on an average of 53 days per year with the majority, an average of 32, occurring in summer months of June, July and August. The months of October through February each show only one day of thunderstorms. Damaging hail infrequently falls during thunderstorms. Hail of up to 1/2 inch in diameter has been observed on rare occasions. The hail damage index in central South Carolina is less than 5 whereas this index is 50 near Denver, Colorado.[4] Therefore, geographically, the site is situated in a region where hail is not a significant damaging factor.

2.6.2.3 TORNADOES AND HURRICANES

In South Carolina severe tornadoes occur almost every year, most often in the spring. During the interval 1956 through 1973, 172 tornadoes were reported in this state. Data from Richland County, where the site is located, shows that over the past 24 years (1950-73) nine tornadoes have been reported. Thom[5] developed an empirical formula to compute the mean recurrence interval for a tornado striking any location by approximating the location with a geometrical point. Based on the mean path area of a tornado, the number of tornadoes per year and the area over which tornadoes may occur (Richland County), the probability of a tornado striking any location within Richland County, which includes the site, is once in more than 700 years.

Hurricanes or tropical storms affect the State of South Carolina about one year out of two. Most of the hurricanes affect only the outer Coastal Plains. A few of them do come far inland but they decrease in intensity partly because of greater frictional effects on land compared to water, but mainly due to the loss of their source of moisture which supplies the energy in the form of latent heat of condensation which acts as a driving force. Consequently these hurricanes usually lose their destructive winds by the time they reach the central part of the state. It is reported that hurricanes inflicting major damage to the state have occured at the rate of one every 10 years based on a record dating back to 1886.[6] More recent information indicates that over a period of 30 years (1941 - 1970) 4 to 5 North Atlantic hurricanes penetrated into Central-South Carolina out of a total of 31. There was no severe damage due to winds but flash floods caused damage to farmlands and public utilities in the Columbia region from all these storms.[6,7] The fastest wind recorded in the Columbia region is 60 mph and the calculated fastest mile of wind expected to occur in a 100-year period is 100 mph.[8]

2.6.3 ATMOSPHERIC DISPERSION

High air pollution potential is caused by low mixing heights and light winds.[9] Holzworth's data on the frequency of high air pollution potential (designated by HAPP) indicated that from 1960 to 1965 the Columbia region experienced no HAPP cases of low mixing heights and light winds. Mixing heights of less than 1000 meters coupled with winds of less than 4 meters/second lasting 2 days or more occurred only once in autumn in the 5-year period. Similar conditions lasting 5 days or more did not occur at all. These data indicate that central South Carolina is in a region of extremely favorable dispersion.

2.6.3.1 DIFFUSION CLIMATOLOGY

The annual and seasonal summary of the joint wind stability frequency is obtained from on-site meteorological data collected at NFCS from August 1, 1972 through July 31, 1973 using the STAR program.[10] The results are presented in Table 2.E-18 in Appendix 2.E. The stability data indicates that stable conditions (E, F, G) exist 47 percent of the time, neutral conditions (D) occur about 43 percent of the time and unstable atmospheric conditions (A, B, C) prevail only about 10 percent of the time.

Seasonal stability distribution for the various stability classes indicates that spring experiences the greatest number of hours (310) of unstable conditions as well as slightly stable conditions (412 hours); winter, the greatest number of hours (1047) of neutral conditions and summer, the greatest number of hours (984) of stable conditions.

2.6.3.2 SHORT-TERM (ACCIDENT) DIFFUSION ESTIMATES

Estimates of atmospheric dilution factors (χ/Q) representative of post-accident time periods up to 8 hours for the 50 percent and 95 percent confidence levels are presented in Table 2.6-2 for downwind distances as far as 20 miles from the proposed site, assuming a ground-level release. Estimates of χ/Q representative of post-accident time periods up to 30 days are presented in Appendix 2.E.

2.6.3.3 LONG-TERM (ROUTINE) DIFFUSION ESTIMATES

Estimates of atmospheric dilution factors (χ/Q) on an annual basis at downwind distances up to 50 miles in 16 compass directions at the 50 foot level are provided in Table 2.6-3 assuming ground-level release. The basis for estimating these dilution factors is presented in Appendix 2.E, Basis for Estimates. The highest χ/Q values occur in the northeast sector and lowest values in the southern sector.

TABLE 2.6-2

ATMOSPHERIC DILUTION FACTORS
FOR 95 AND 50 PERCENT WESTHER*
χ/Q (Sec/m^3)
(0 TO 8 HOUR PERIOD)

Distance In Miles	95% Confidence Level** "G"; $\bar{u}$ = 0.1 m/sec	59% Confidence Level** "F"; $\bar{u}$ = 1.5 m/sec
0.071†	3.949×10^{-1}	6.733×10^{-3}
0.1	1.087×10^{-1}	3.269×10^{-3}
0.2	3.263×10^{-2}	9.974×10^{-4}
0.3	1.661×10^{-2}	5.239×10^{-4}
0.34††	1.444×10^{-2}	4.786×10^{-4}
0.5	7.280×10^{-3}	2.973×10^{-4}
0.7	4.977×10^{-3}	2.188×10^{-4}
1.0	3.666×10^{-3}	1.454×10^{-4}
2.0	1.792×10^{-3}	6.392×10^{-5}
5.0	6.477×10^{-4}	2.066×10^{-5}
10.0	2.841×10^{-4}	8.674×10^{-6}
20.0	1.306×10^{-4}	3.874×10^{-6}

* Data taken from August 1, 1972 through July 31, 1973

** Includes correction for building wake effects as given in Table 2.E-23

† Exclusion distance (114m = 374 ft)

†† Nearest site boundary 1800 feet or 0.34 mile

TABLE 2.6-3

ESTIMATES OF ATMOSPHERIC DILUTION FACTORS FOR NFCS
ANNUAL AVERAGE X/Q VALUES

Data in Sec/m^3

Direction from Plant Location

Distance Downwind Miles	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
.07*			3.61E-4													
0.1	1.11E-4**	1.21E-4	2.62E-4	2.18E-4	1.90E-4	1.46E-4	1.11E-4	9.83E-5	8.99E-5	1.15E-4	1.57E-4	1.72E-4	1.86E-4	1.49E-4	1.46E-4	1.17E-4
0.2	3.18E-5	3.44E-5	7.51E-5	6.27E-5	5.47E-5	4.21E-5	3.19E-5	2.84E-5	2.60E-5	3.33E-5	4.54E-5	5.00E-5	5.39E-5	4.32E-5	4.21E-5	3.36E-5
0.3	1.54E-5	1.66E-5	3.62E-5	3.03E-5	2.65E-5	2.04E-5	1.55E-5	1.38E-5	1.26E-5	1.62E-5	2.20E-5	2.43E-5	2.62E-5	2.10E-5	2.05E-5	1.63E-5
0.5	6.22E-6	6.71E-6	1.47E-5	1.23E-5	1.08E-5	8.32E-6	632E-6	5.63E-6	5.15E-6	6.59E-6	8.97E-6	9.90E-6	1.07E-5	8.58E-6	8.35E-6	6.64E-6
0.8	2.76E-6	2.97E-6	6.52E-6	5.48E-6	4.80E-6	3.70E-6	2.81E-6	2.51E-6	2.29E-6	2.93E-6	3.99E-6	4.41E-6	4.77E-6	3.83E-6	3.72E-6	2.95E-6
1.0	1.89E-6	2.04E-6	4.49E-7	3.78E-6	3.31E-6	2.55E-6	1.94E-6	1.73E-6	1.58E-6	2.02E-6	2.75E-6	3.04E-6	3.29E-6	2.64E-6	2.56E-6	2.03E-6
1.5	9.80E-7	1.05E-6	2.34E-6	1.97E-6	1.72E-6	1.33E-7	1.01E-6	9.00E-7	8.24E-7	1.05E-6	1.43E-6	1.59E-6	1.72E-6	1.38E-6	1.33E-6	1.06E-6
2.5	4.42E-7	4.76E-7	1.07E-6	9.03E-7	7.87E-7	6.03E-7	4.58E-7	4.10E-7	3.76E-7	4.79E-7	6.53E-7	7.28E-7	7.87E-7	6.30E-7	6.07E-7	4.80E-7
3.5	2.65E-7	2.85E-7	6.49E-7	5.47E-7	4.76E-7	3.64E-7	2.76E-7	2.47E-7	2.27E-7	2.89E-7	3.94E-7	4.41E-7	4.77E-7	3.82E-7	3.67E-7	2.90E-7
4.5	1.82E-7	1.96E-7	4.49E-7	3.79E-7	3.29E-7	2.51E-7	1.90E-7	1.71E-7	1.57E-7	1.99E-7	2.72E-7	3.06E-7	3.31E-7	2.64E-7	2.53E-7	1.99E-7
7.5	8.69E-8	9.38E-8	2.19E-7	1.84E-7	1.59E-7	1.21E-7	9.12E-7	8.21E-8	7.55E-8	9.59E-8	1.31E-7	1.48E-7	1.61E-7	1.28E-7	1.22E-7	9.55E-8
10.0	5.78E-8	6.25E-8	1.47E-7	1.24E-7	1.07E-7	8.07E-8	6.08E-8	5.48E-8	5.05E-8	6.41E-8	8.77E-8	9.97E-8	1.08E-7	8.60E-8	8.14E-8	6.36E-8
15.0	3.16E-8	3.41E-8	8.07E-8	6.80E-8	5.85E-8	4.44E-8	3.34E-8	3.01E-8	2.78E-8	3.52E-8	4.82E-8	5.49E-8	5.95E-8	4.74E-8	4.49E-8	3.50E-8
20.0	2.20E-8	2.39E-8	5.79E-8	4.86E-8	4.14E-8	3.10E-8	2.32E-8	2.11E-8	1.95E-8	2.47E-8	3.38E-8	3.98E-8	4.21E-8	3.34E-8	3.13E-8	2.43E-8
25.0	1.66E-8	1.82E-8	4.48E-8	3.75E-8	3.17E-8	2.36E-8	1.76E-8	1.60E-8	1.49E-8	1.88E-8	2.58E-8	2.99E-8	3.23E-8	2.55E-8	2.37E-8	1.84E-8
30.0	1.32E-8	1.46E-8	3.64E-8	3.04E-8	2.56E-8	1.89E-8	1.40E-8	1.28E-8	1.19E-8	1.50E-8	2.07E-8	2.41E-8	2.60E-8	2.05E-8	1.90E-8	1.47E-8
35.0	1.09E-8	1.21E-8	3.06E-8	2.54E-8	2.13E-8	1.56E-8	1.16E-8	1.06E-8	9.91E-9	1.25E-8	1.72E-8	2.01E-8	2.17E-8	1.71E-8	1.57E-8	1.21E-8
40.0	9.28E-9	1.03E-8	2.63E-8	2.18E-8	1.82E-8	1.33E-8	9.82E-9	9.02E-9	8.44E-9	1.06E-8	1.47E-8	1.72E-8	1.85E-8	1.46E-8	1.33E-8	1.03E-8
45.0	8.03E-9	8.93E-9	2.30E-8	1.91E-8	1.59E-8	1.15E-8	8.50E-9	7.82E-9	7.34E-9	9.22E-9	1.27E-8	1.50E-8	1.61E-8	1.27E-8	1.15E-8	8.89E-9
50.0	7.06E-9	7.88E-9	2.04E-8	1.69E-8	1.41E-8	1.02E-8	7.47E-9	6.88E-9	6.47E-9	8.13E-9	1.12E-8	1.32E-8	1.43E-8	1.12E-8	1.01E-8	7.82E-9
.568†			1.21E-5													

* Exclusion Distance 374 feet

** 1.11E-4 = 1.1 x 10^{-4} (Typical)

† 3000 feet

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2.7 ECOLOGY

2.7.1 TERRESTRIAL ECOLOGY

The biotic components of the Westinghouse nuclear fuel fabrication facility site are influenced principally by the presence of the nearby Congaree River and the associated woodlands of its floodplain. Species diversity around the site is extremely complex due to favorable climate, location and limited commercial development. Wooded areas surrounding the site are interrupted by limited agricultural development.

The consideration of the terrestrial impacts resulting from utilization of the facility is based on the following general description of soils, vegetation and wildlife. Soils are described in Section 2.4.4. The undisturbed soils are nearly level, moderately well to poorly drained soils.(1)

2.7.1.1 VEGETATION

A vegetation survey was completed for the site and adjacent areas during the late April and early May 1974 period. Observations were made in each of the four major cover types to determine the approximate density and species composition of each. The survey revealed the presence of diverse flora throughout much of the site and adjacent areas with the exceptions being cultivated fields and land disturbed by plant construction (Table 2.F-1, Appendix 2.F).

The forest cover type that illustrated the greatest diversity was the Swamp Chestnut Oak--Cherrybark Oak type. This cover type was perhaps the most commonly observed in the area and is a common association throughout southern alluvial forests.(2) Predominant species within this cover type included: swamp chestnut, cherrybark and white oak (Quercus michauxii, Quercus falcata and Quercus alba) with associate species including: white ash (Fraxinus americana), shagbark, mockernut, shellbark and bitternut hickory (Carya ovata, Carya tomentosa, Carya laciniosa, Carya cordiformis), sweet gum (Liquidambar styraciflua), American and winged elm (Ulmus americana, Ulmus alata), red maple (Acer rubrum), yellow poplar, (Liriodendron tulipifera), American beech (Fagus grandifolia), southern red, white and willow oak (Quercus falcata, Quercus alba and Quercus phellos).

Of all cover types surveyed, this type illustrated the greatest density of woody plant species. In many areas the canopy was closed, thereby limiting light penetration and restricting herbaceous ground cover. Woody ground cover did persist in some areas with common species including poison ivy (Rhus radicans), Japanese honeysuckle (Lonicera japonica), greenbrier (Smilax sp), trumpet vine (Campsis radicans) and Virginia creeper (Parthenocissus quinquefolia).

In areas of drier sites, the Swamp Chestnut Oak--Cherrybark Oak type was replaced by the Loblolly Pine-Hardwood type. Although the major component here was loblolly pine (Pinus taeda), the species itself was seldom abundant. Loblolly pine was generally scattered throughout the cover comprising approximately 25 to 30 percent of the total stand.

Associate species commonly observed within this cover type included American elm, yellow poplar, black locust (Robinia pseudoacacia), red maple, white and scarlet oak (Quercus alba and Quercus coccinea). Shrubby species and woody ground cover included poison ivy, Japanese honeysuckle, Virginia creeper, cross vine (Bignonia capreolata), smooth sumac (Rhus glabra), blackberry (Rubus sp), lead bush (Amorpha fruticosa), redbud (Cercis canadensis) and greenbrier.

A third major cover type abundant throughout much of the lake area was the Water Tupelo--Sweet Gum type. The most dominant tree species included water tupelo (Nyssa aquatica), sweet gum, red maple and Carolina ash (Fraxinus caroliniana). This cover is characteristic of poorly drained soils and deep swamp areas throughout the south. The DBH (diameter at breast height) of many of the trees range from 24 to 36 inches. Much of the canopy was closed, however occasional openings permitted sun flecks. The surface of the water was nearly covered with an extensive growth of water meal (Spilodella sp) and duckweed (Lemna sp). Much of the lake area was found to be typical of many southern swamps.

Old fields and cultivated fields comprised a fouth major community type. These areas showed signs of secondary succession with woody invaders species including black locust, black cherry (Prunus serotina), poison ivy and Japanese honeysuckle. Herbaceous species reached their greatest development here with common species including: wild onion (Allium sp), smartweed (Polygonum pennsylvanicum), broom sedge (Andropogon virginicus), great mullen (Verbascum thapsus), sheep sorrel (Rumex hastatulus) and Queen Anne's lace (Daucus carota). Cultivated fields adjacent to the site also show evidence of secondary succession; however, most of these fields are planted yearly in soybeans and thereby limit invasion of herbaceous species.

2.7.1.2 WILDLIFE

2.7.1.2.1 AVIFAUNA

Bird observations were made on site and throughout adjacent areas during late April and early May 1974. Identification was primarily based on three criteria: call, song and actual sightings. Population densities appeared relatively high in all areas surveyed. Passerine (perching) species were observed in woodlots, fields and swamp areas with most warblers occurring throughout the tree tops. Bobwhite quail (Colinus virginianus) and several species of sparrows were commonly found in fields and brushy areas. Raptors (hawks, owls and vultures) were observed in flight over many open areas of the site. The red-tailed hawk (Buteo jamaicensis) and red-shouldered hawk (Buteo lineatus) appeared to be the most common raptors.

It was found that a home range preference exists for most species found within the site area. The greatest population density and species diversity appeared to be along the borders of old fields and woodlots (Table 2.F-2, Appendix 2.F). Most commonly observed species in these areas included indigo bunting (Passerina cyanea), cardinal (Richmondena cardinalis), Carolina wren (Thryothorus ludovicianus) and catbird (Dumetella carolinensis).

The second most preferred home range appeared to be swamp edge areas (Table 2.F-3, Appendix 2.F). Avifauna most abundant in these areas included red-winged blackbird (Agelaius phoeniceus), red and white eyed vireos (Vireo olivaceus) and Vireo griseus) northern parula warbler (Parula americana), Carolina wren and prothonotary warbler (Protonotaria citrea).

The third most preferred habitat area appeared to be cultivated and old fields (Table 2.F-4, Appendix 2.F). Commonly observed species in these areas included chipping, song and savannah sparrows (Spizella passerina, Melospiza melodia and Passerculus sandwichensis) and red-winged blackbirds.

Lists of observed avifauna species endemic to their particular habitats are included in Appendix 2.F, Tables 2.F-2, 2.F-3 and 2.F-4. A total of 67 species were recorded during all avifauna observations and appear in Appendix 2.F, Table 2.F-5.

2.7.1.2.2 MAMMALS

A mammalian survey was also performed during the spring of 1973 to determine species diversity and habitat utilization. Critical survey work was performed on the site while general observations were made throughout adjacent areas. Species identification was determined by track, scat analysis and visual observations. A literature review was then conducted to support all finds and to provide a list of additional species suspected to occur in the area.

Habitat preferences were shown to exist for most mammalian species. Shorelines of lakes and rivers were most preferred while secondary preference was given to edge areas of old fields and woodlots. Grassy areas and open fields were least preferred by mammalian species. These latter areas provided only limited escape and resting cover accounting for the restricted utilization.

Appendix 2.F, Table 2.F-6 lists all mammals actually observed on site with additional listings of species possibly occurring there. Tables 2.F-7 through 2.F-9 in the appendix also list mammalian species endemic to each major habitat mentioned above.

The most important game mammals observed on site were the white-tailed deer (Odocoileus virginianus), gray squirrel (Sciurus carolinensis), red squirrel (Tamiasciurus hudsonicus) and the eastern cottontail (Sylvilagus floridanus). The white-tailed deer and cottontail are found throughout the site while the red and gray squirrel are limited to forested areas.

Other important mammals include the opossum (Didelphis marsupialis), raccoon (Procyon lotor), gray fox (Urocyon cinereoargenteus), bobcat (Lynx rufus), golden mouse (Peromyscus nuttalli) and white-footed mouse (Peromyscus leucapus). Other species may be relatively abundant on site but were not identified during the 1974 survey.

2.7.1.2.3 HERPETOFAUNA

General observations for herpetofauna were conducted concurrently with the avifaunal and mammalian surveys. Identification was determined by calls and visual observation. When possible, animals were captured, aged, sexed and later released. Evening surveys were conducted for calling males with special attention given to frog and toad species.

The greatest population density and species diversity appeared to occur in aqueous habitats. Daily observations revealed that the most commonly observed species included the yellow-bellied turtle (Pseudoemys scripta scripta) and the red-bellied water snake (Natrix erythrogaster erythrogaster).

Many of the female turtles were preparing nest sites or actually engaged in egg laying. Snake species were abundant throughout the lake area canals.

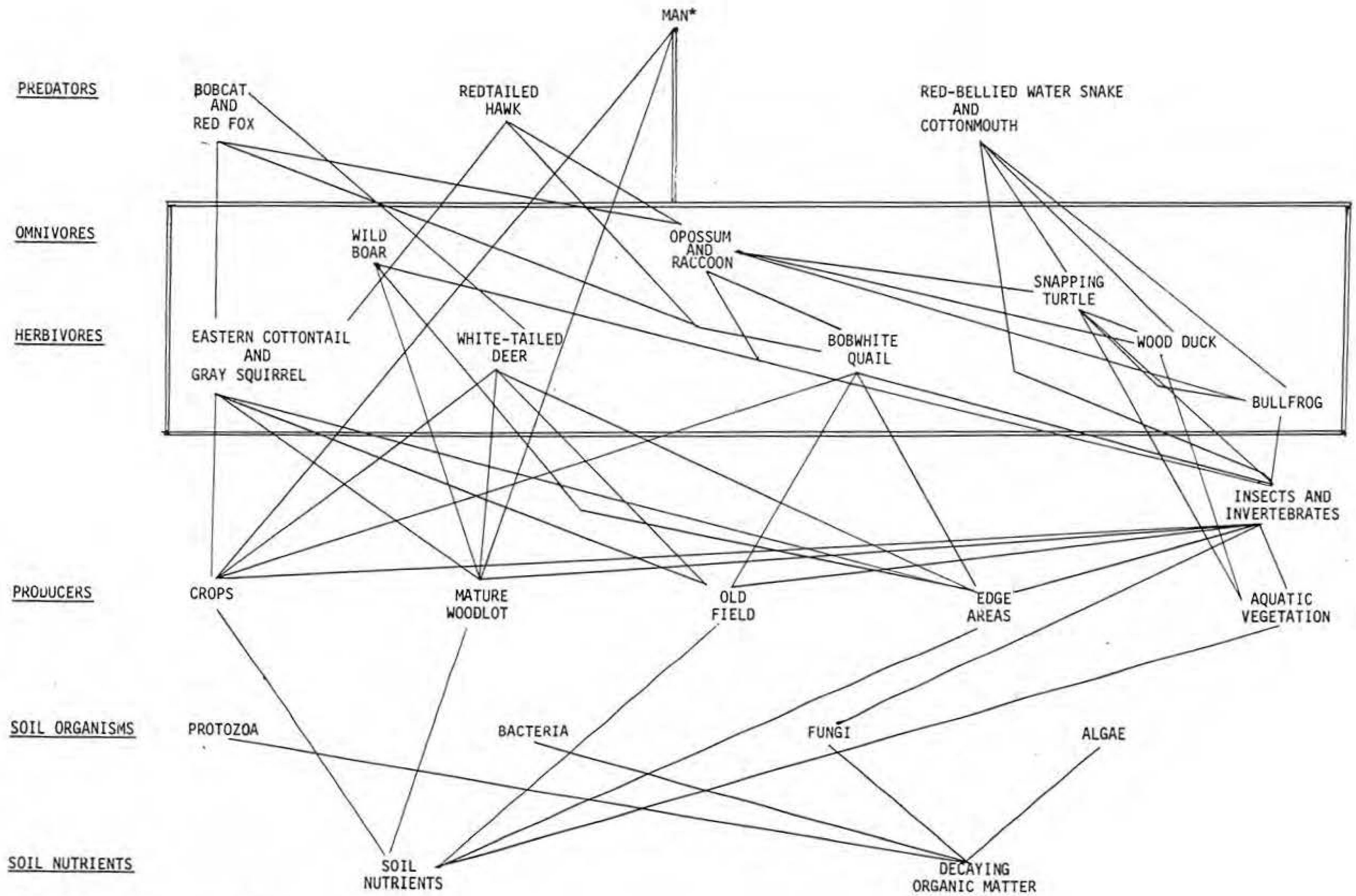
Evening surveys revealed that the tree frog (Rana clamitans) and southern cricket frog (Acris gryllus gryllus) were heard most commonly. Call analysis, actual sightings and a literature review indicate a diverse herpetofaunal community. A list of all observed herpetofauna appears in Appendix 2.F, Table 2.F-10.

2.7.1.2.4 FOOD WEB RELATIONSHIPS

A food web was constructed to show the relationships between some of the common species on the site. The web illustrates possible pathways for uptake and concentration of pollutants in the food chain. This food web includes man as a consumer of several species which could be harvested primarily by hunting (see Figure 2.7-1).

2.7.1.2.5 THREATENED AND ENDANGERED SPECIES

Although several threatened or endangered species are known to occur in South Carolina (Appendix 2.F, Table 2.F-11), few, if any, are likely to be found in the immediate site area.[3] Of the endangered species the Southern bald eagle (Haliaeltus leucocephalus leucocephalus) and American peregrine falcon (Falco peregrinus anatum) may occasionally visit the site but such occurrences would be rare. The endangered red-cockaded woodpecker (Dendrocopus borealis) and threatened Eastern brown pelican (Pelicanus occidentalis), both present in South Carolina, are birds of restricted habitats and their occurrence on site is doubtful.[4] The endangered Bachman's warbler (Vermivora bachmanii) may occur in the swampy-riverbottom habitat on the site; however, their presence was not detected. No Eastern cougars (Felis concolor), either resident or transient, are expected on site. American alligators (Alligator mississippiensis) may have occurred on site at one time but it is believed they have been exterminated in recent years.



*All animals within double line may be consumed by man.

Figure 2.7-1. Generalized Food Web of Columbia Site

2.7.2 AQUATIC ECOLOGY

2.7.2.1 INTRODUCTION

Aquatic ecosystems occurring in the vicinity of the NFCS facility include the Congaree River, Mill Creek and Sunset Lake (Figure 2.7-2).

The Congaree River is a typical South Atlantic Piedmont stream characterized by high levels of suspended solids, sandy bottom and sand beaches.(5) The Congaree is formed by the confluence of the Broad and Saluda Rivers at Columbia, South Carolina and flows in a general southeast direction for approximately 60 miles until its confluence with the Wateree River and ultimate discharge into Lake Marion near Fort Motte, South Carolina. The flow of the Congaree River averages 9166 cubic feet per second and is regulated by Lake Murray and Lake Greenwood on the Saluda River and to some extent by power plants on the Broad River.(6)

Presently, the NFCS facility continuously discharges a small amount (less than 0.2 cfs) of treated waste effluent into the Congaree River at a point 3.4 miles southwest of the plant. At this discharge point the Congaree River is approximately 500 feet wide and 9 feet or less deep. Physical and chemical characteristics during the sampling of two river transects in this area are shown in Appendix 2.G, Table 2.G-1. Chemical characteristics of the Congaree River and the NFCS discharge are discussed in Sections 2.5.1.2 and 6.2.2.

Sunset Lake is a shallow (6 feet maximum depth), artificial impoundment on Mill Creek (Appendix 2.G, Figure 2.G-2) 1/4 mile south of the NFCS facility. The lake originally consisted of two open water areas,(7) an Upper Lake (surface area of 44 acres) and a Lower Lake (surface area of 8 acres). Mill Creek entered the Upper Lake from the north and exited the Lower Lake by passing over a small dam located at the south end of the lake. Mill Creek then meandered through swamplands until discharging into the Congaree River 2.5 miles downstream from the NFCS waste discharge. Flow from Upper

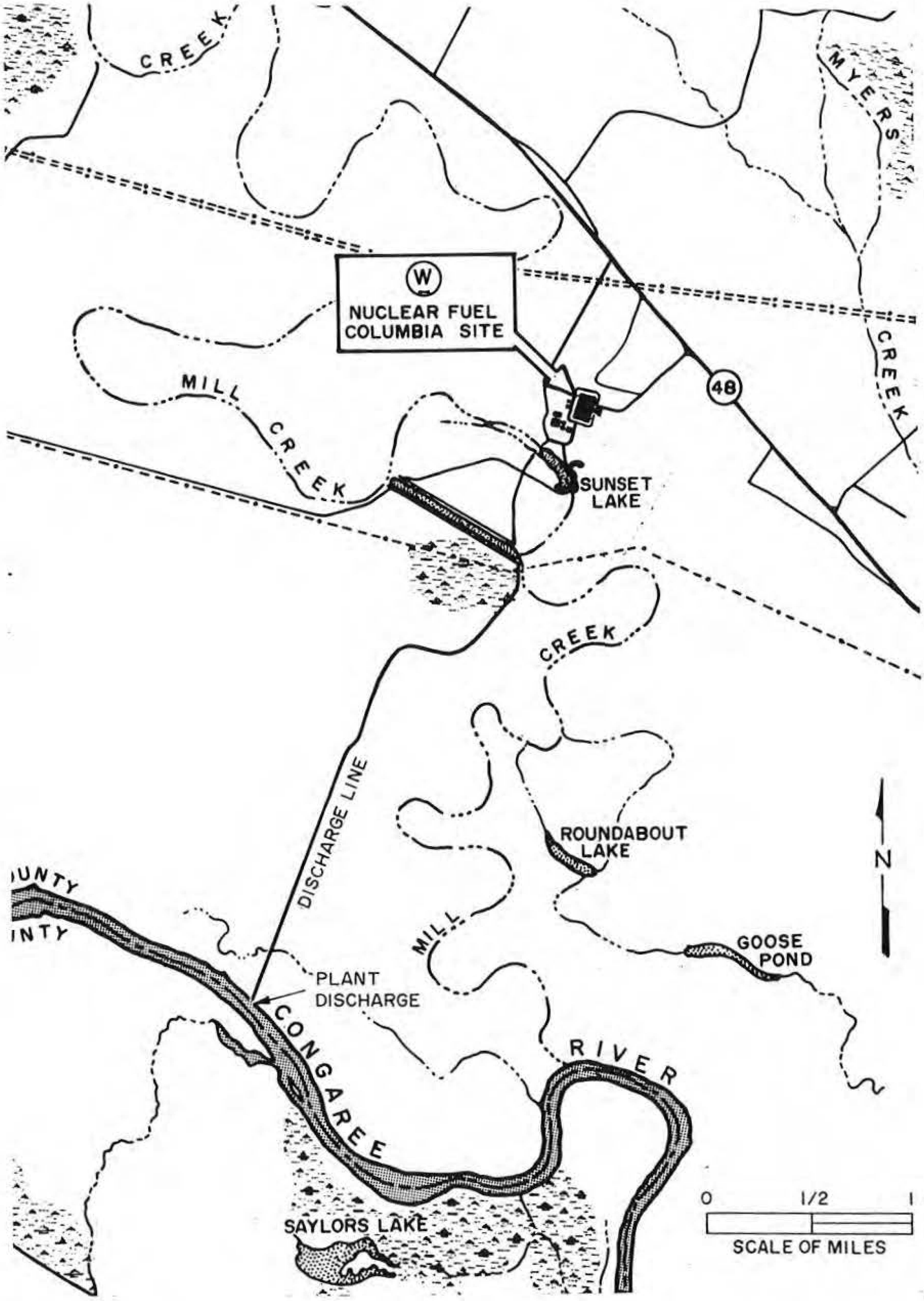


Figure 2.7-2. Surface Waters in the Vicinity of the NFCS Facility

Sunset Lake to Lower Sunset Lake was by way of a narrow channel passing under a causeway.

Presently, the area which originally constituted the Upper Lake is a swamp area (Appendix 2.G, Figure 2.G-2) supporting a mixed stand of swamp tupelo (Nyssa aquatica) and Carolina ash (Fraxinus caroliniana). The water surface is covered by a dense duckweed mat (Spirodela polyrihiza and Lemna minor). Lower Sunset Lake still maintains an open water area although the encroachment of swamp tupelo and macrophyte growth is evident. This small lake exhibits a brown coloration probably due to the presence of humic substances.

Both Sunset Lake and Mill Creek are of interest in that they may receive accidental spillage from the holding ponds at the NFCS facility. These spills enter the swampy region of the former Upper Lake and subsequently enter the Lower Lake and Mill Creek. A historical discussion of these spills and their effects are discussed in Section 5.1.1.2.3.

2.7.2.2 PREVIOUS ENVIRONMENTAL STUDIES

A review of available information on the Congaree River indicates that very little biological survey work had been done in the area. Contacts with state and federal agencies and the University of South Carolina provided minimal information.

2.7.2.3 WESTINGHOUSE ENVIRONMENTAL SYSTEMS DEPARTMENT AQUATIC SURVEY

As a result of the limited biological data on the Congaree River, WESD conducted an aquatic survey of the Congaree River in the vicinity of the NFCS discharge. In addition, Lower Sunset Lake and select areas of Mill Creek were also sampled. This survey was conducted from September 30 to October 4, 1974 and was designed to generally characterize the aquatic biota present in these waters. Parameters sampled included fish, benthic macroinvertebrates, zooplankton, algae and other aquatic plants. Ancillary physical and chemical determinations were recorded during the biological collections.

2.7.2.4 GENERAL DISCUSSION OF AQUATIC BIOTA

2.7.2.4.1 CONGAREE RIVER

FISH

Fifty-two fish species (Appendix 2.G, Table 2.G-3) were collected in the Congaree River drainage area during a study conducted by the University of South Carolina in 1952 and 1953.[8] Most of these specimens, however, were collected in smaller streams and ponds within the drainage basin with relatively few fish being collected in the Congaree River proper. Development of the drainage area since 1953 has probably affected the abundance and distribution of many of these species.

More recent compilations (Appendix 2.G, Tables 2.G-4, 2.G-5 and 2.G-6) of fish species occurring in the counties bordering the Congaree River (Richland, Lexington and Calhoun counties) consist of similar numbers of species although their composition shows some differences.[9] These lists were also accumulated from a variety of waters in each of these counties rather than solely from the Congaree River.

According to the South Carolina Fish and Wildlife Department,[10] major fish species presently inhabiting the Congaree River include striped bass, largemouth bass, smallmouth bass, white bass, bluegill, white crappie, black crappie, bowfin, carp, gar, gizzard shad, bullheads and channel catfish. They also indicate that the Congaree River was considered to be an important area for spawning of striped bass in the early 1960's. Whether the Congaree River is still an important spawning area for striped bass is not known.

Electroshocking (for 3 hours) and gill netting (for 23 hours) of the Congaree River near the NFCS discharge (Appendix 2.G, Figure 2.G-1) on October 2, 1974, yielded only one channel catfish. High flows observed during the collection period (approximately 3.6 ft/sec) may have been responsible for the small catch.

BENTHIC MACROINVERTEBRATES

Ponar dredge samples from the Congaree River above and below the NFCS discharge were collected during October 1974. The bivalve mollusk Sphaerium sp was the predominant organism collected (Appendix 2.G, Table 2.G-8). Chironomids (Chironomini sp), annelid worms (Limnodrilus udekemianus and Naididae sp) and corbiculoid clams (Corbicula fluminea) were also frequently encountered.

ZOOPLANKTON

Zooplankton in tow samples collected from the Congaree River near the NFCS discharge during October 1974 were very sparse. The larval stage of bivalve mollusks (glochidia), nematode worms and the protozoan, Epistilis plicatilis, were the most frequently encountered organisms in the samples (Appendix 2.G, Table 2.G-9). A variety of other protozoans, rotifers, nematodes, oligochaetes, copepods, cladocerans, ostracods, arachnids and a number of aquatic insects (including mayflies, caddis flies, midge flies and beetles) were also present.

PHYTOPLANKTON

Congaree River phytoplankton species observed by the state in 1973 near Fort Motte, South Carolina (Appendix 2.G, Table 2.G-10) were predominately diatoms.[11] Dominant phytoplankton forms were not noted, however, total phytoplankton densities ranged from approximately 700 to 2000 cells per milliliter.

Phytoplankton collected in the Congaree River in the vicinity of the NFCS discharge in October 1974 were predominately the colonial green algae Eudorina elegans (Appendix 2.G, Table 2.G-11). Diatoms, blue-greens and euglenoids were also present. Average cell numbers in the river were approximately 500 cells per milliliter.

PERIPHYTON

Periphyton obtained from a variety of substrates (logs, leaves and rocks) available in the Congaree River during October 1974 were predominately diatoms (Appendix 2.G, Table 2.G-12). Green algae (Ulothrix sp and an unidentified coccoid green) and blue-green (Microcoleus vaginatus and Oscillatoria sp) were infrequently observed. Some of the more abundant diatom forms observed in these qualitative collections were Achnanthes deflexa, Navicula minima, N. mutica v. stigma, N. mutica v. undulata and N. cryptocephala v. veneta.

2.7.2.4.2 SUNSET LAKE

FISH

Twelve fish species were collected by gill netting and electroshocking in Lower Sunset Lake and areas adjacent to the lake (Appendix 2.G, Figures 2.G-2 and 2.G-3) during October 1974. Fish collected in the lake proper included warmouth, flier, golden shiners, black crappie, spotted suckers, bluegill and longnose gar. A total of twenty fish were collected during 23 hours of gill netting with the golden shiners being the species most frequently encountered. Only two fish (a flier and warmouth) were collected in one hour of electroshocking in Lower Sunset Lake. Low dissolved oxygen levels (4.0 ppm or less) observed in the lake would constitute an unfavorable condition for fish in the lake. High temperature, low flow and the decomposition of organic matter in the lake were probably responsible for the low oxygen levels observed.

In the small pool in Mill Creek just below the outflow of Lower Sunset Lake, 94 fish were collected in 4 hours of gill netting. These fish were predominately bluegill but other fish present included golden shiners, black crappie, warmouth catfish, yellow and brown bullheads, flier and spotted suckers. Habitat differences attributable to a stream situation as opposed to a lake were probably responsible for the increased abundance of fish in this small area. Only two fish, a bluegill and bowfin, were collected in 4 hours of gill netting in a small canal fed by Mill Creek.

Although the swampy region of the former Upper Lake was not sampled, it is probable that fish from the Lower Lake and Mill Creek move into this area under suitable environmental conditions. However, the large amounts of organic matter (duckweed and leaf litter) in the Upper Lake region in conjunction with low flow and high temperature would be expected to depress dissolved oxygen levels during warmer months of the year and produce conditions generally unsuitable for fish.

BENTHIC MACROINVERTEBRATES

The only benthic macroinvertebrate collected in Lower Sunset Lake was the phantom-midge, Chaoborus punctipennis. Larval stages were most prominent in the October 1974 collections but pupal stages were also observed. This invertebrate is well suited to exist in waters containing low levels of dissolved oxygen.(12)

ZOOPLANKTON

Zooplankton species in Lower Sunset Lake during October 1974 were quite numerous (Appendix 2.G, Table 2.G-14) and predominated by protozoans (Difflugia lobostoma and Difflugia oblonga) and the rotifer Asplanchna priodonta. Noticeably higher zooplankton numbers were observed at the inflow end of the Lower Lake as opposed to the outflow end. Increased numbers of Difflugia spp at the inflow end may be the result of the stirring up of the bottom by the inflowing of swamp water from the regions of Upper Sunset Lake.

PHYTOPLANKTON

Phytoplankton in the Lower Lake (Appendix 2.G, Table 2.G-15) were quite numerous with densities of approximately 60,000 plankters per milliliter. Predominant phytoplankters in the lake were the colonial green algae Eudorina elegans and an unidentified coccoid green algae. In general, green algae constituted the majority of the phytoplankton community although diatoms, euglenoids, blue-greens and dinoflagellates were also represented.

MACROPHYTES

Aquatic macrophyte growth (Appendix 2.G, Table 2.G-16 and Figure 2.G-5) was also noted in Lower Sunset Lake during the October sampling. A small bed of the yellow water lily (Nuphar advena) was located near the outflow end of the lake. Swamp tupelo (Nyssa aquatica) occurred all around the periphery of the Lower Lake and mixed beds of a variety of species occurred in the immediate areas of the Upper Lake area inflow and outflow of Mill Creek.

Macrophyte growth in the Upper Lake area consisted largely of a mixed stand of swamp tupelo (Nyssa aquatica) and Carolina ash (Fraxinus caroliniana) and dense mat of duckweed (Spirodela polyrihiza and Lemna minor).

2.7.3 REFERENCES

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2.8 BACKGROUND CHARACTERISTICS

2.8.1 BACKGROUND RADIOLOGICAL CHARACTERISTICS

2.8.1.1 GENERAL

To evaluate the significance of future releases of radioactive materials to the environment from expanded operations at the Westinghouse Nuclear Fuel Columbia Site (NFCS), present background radiological characteristics of the plant environs must be determined. The background radiological characteristics presented in this section were developed from selected data obtained from numerous published reports and from the plant's environmental monitoring program. These data include uranium, gross alpha and gross beta levels, where available, as measured in air, water, fallout deposition, soil and vegetation.

An environmental program is presently being initiated to obtain background plutonium levels in the plant environs (Section 6.2). This program will be completed prior to introduction of plutonium fuel rod assembly operations at NFCS presently planned to begin in January 1976.

2.8.1.2 GROSS ALPHA AND GROSS BETA ACTIVITY IN AIR

Table 2.8-1 lists measurements of gross alpha activity in airborne particulates (MDL* = 8.0×10^{-15} μCi/ml) at five on-site air monitoring stations for the period January 3, 1973 to January 2, 1974. The locations of these stations are illustrated in Figure 2.8-1. These data show that for stations 1 and 2 which are both at the site boundary, 3000 feet NE and 2400 feet E, respectively, the average gross alpha activities for 1973 were $\leq (8.4 \pm 1.6) \times 10^{-15}$ and $\leq (8.8 \pm 3.5) \times 10^{-15}$ μCi/ml, respectively, while for stations 3, 4 and 5, which are closer to the plant, 1050 feet SW of the plant, 1950 feet WNW of the plant and 75 feet from the SE corner of the plant, respectively, the average 1973 gross alpha activities were $\leq (1.4 \pm 2.0) \times 10^{-14}$, $\leq (1.4 \pm 1.9) \times 10^{-14}$

* Minimum detectable level

TABLE 2.8-1

AVERAGE GROSS ALPHA AIR CONCENTRATION MEASUREMENTS
FOR YEAR 1973
(UNITS - 10^{-15} μCi/ml)

	Air Monitoring Station No.**				
	1	2	3	4	5
Annual Average ± Std. Dev.*	$\leq 8.4 \pm 1.6$	$\leq 8.8 \pm 3.5$	$\leq 14 \pm 20$	$\leq 14 \pm 19$	$\leq 11 \pm 4.7$
Maximum Permissible Concentration†	4000	4000	100,000	100,000	100,000

* MDL (Minimum Detectable Level) = 8.0×10^{-15} μCi/ml.

** See Figure 2.8-1 for location of stations.

† See Appendix 4.B.

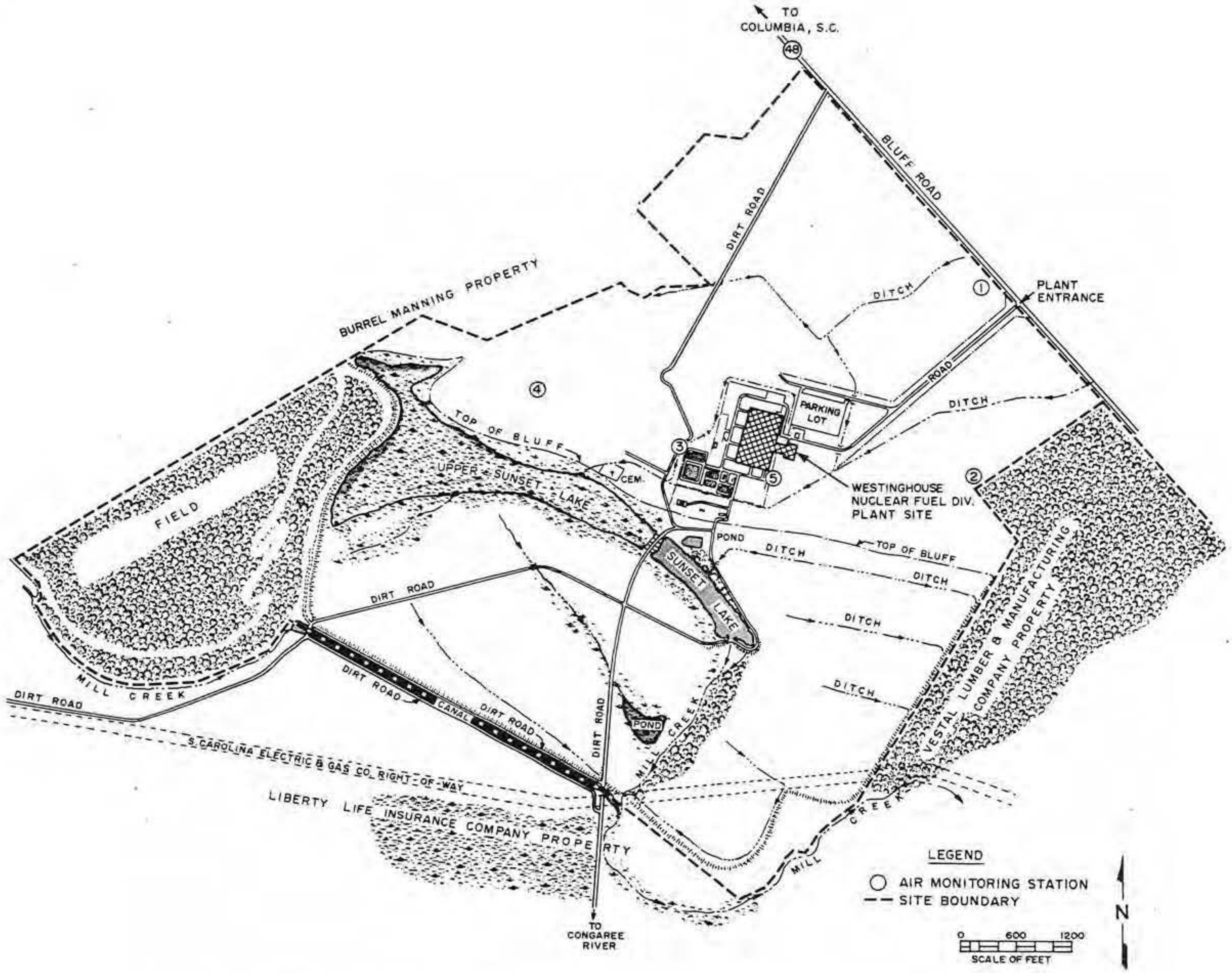

Figure 2.8-1. Locations of Air Monitoring Stations

and $\leq (1.1 \pm 4.7) \times 10^{-14}$ μCi/ml, respectively. Measurements of gross alpha activity taken by the state for the period of June 18, 1973 to December 17, 1973 at four locations in the vicinity of the plant (2250 feet E, 2250 feet NW, 3000 feet NE and 6.5 miles NE of the plant) all show gross alpha activity in airborne particulates to be less than the MDL of 1.0×10^{-15} μCi/ml.[1] These values can be compared with the maximum permissible concentrations (MPC) for uranium in air of 4×10^{-12} μCi/ml at or beyond site boundary (stations 1 and 2) and 1.0×10^{-10} μCi/ml in restricted areas.

Gross beta activity in airborne particulates has not been routinely measured in the past as part of the plant's environmental monitoring program but will be in the future (Section 6.2.1). However, gross beta activity in airborne particulates (MDL = 4.0×10^{-15} μCi/ml) for 1973 measured by the state at the four locations listed above is given in Table 2.8-2.[1] Average gross beta activities of 3.5×10^{-14} μCi/ml at 2250 feet E of the plant, 1.6×10^{-14} μCi/ml at 3000 feet NE, 3.5×10^{-14} μCi/ml at 2250 feet NW and 2.3×10^{-14} μCi/ml at 6.5 miles NE of the plant are reported. These data can be compared with gross beta activity measured in air at Columbia, South Carolina for the period July 1973 through January 1974, given in Table 2.8-3[2] which show an average gross beta activity of 6.4×10^{-14} μCi/ml. No published data could be found concerning uranium concentrations in air in the vicinity of the Columbia plant.

2.8.1.3 GROSS ALPHA, GROSS BETA AND URANIUM CONCENTRATIONS IN SURFACE AND GROUNDWATER

2.8.1.3.1 SURFACE WATER

Table 2.8-4 summarizes weekly water samples from the Congaree River for the period April 25 to December 26, 1973 that were analyzed for total uranium activity as part of the NFCS environmental monitoring program. These data show average total uranium activity to range from $(0.06 \pm 0.29$ to $0.40 \pm 0.31) \times 10^{-9}$ μCi/ml. An extensive literature search revealed no additional monitoring of uranium in the surface waters in the vicinity of the NFCS.

TABLE 2.8-2

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES FOR 1973[1]

Units - 10^{-14} μCi/ml

	Location of Sampling Stations				
Date Collected	2250 Feet E of Plant	3000 Feet NE of Plant	2250 Feet NW of Plant	Date Collected	6.5 Miles NE of Plant
1/73 - 6/73	3 (22 samples)	2 (19 samples)	3 (23 samples)	1/73 - 6/73	2 (24 samples)
6/18/73	2	1	3	6/22/73	1
6/26/73	2	1	2	6/28/73	1
7/9/73	2	<0.4	3	7/5/73	1
7/16/73	4	1	4	7/12/73	1
7/23/73	2	1	3	7/19/73	3
7/31/73	4	1	3	8/9/73	2
8/7/73	2	1	2	8/23/73	3
8/15/73	3	-	2	8/30/73	-
8/21/73	3	-	3	9/6/73	2
8/27/73	3	2	3	9/13/73	2
9/10/73	3	1	3	9/20/73	2
9/17/73	3	-	4	12/7/73	3
9/25/73	2	1	4	12/14/73	7
10/1/73	4	1	4	12/21/73	9
10/8/73	6	1	6	-	-
10/15/73	7	<0.4	7	-	-
10/23/73	5	2	6	-	-
10/29/73	4	1	4	-	-
11/5/73	5	1	4	-	-
11/12/73	4	2	4	-	-
11/19/73	6	5	4	-	-
11/26/73	6	-	5	-	-
12/3/73	6	-	6	-	-
12/10/73	4	1	4	-	-
12/17/73	6	-	5	-	-
Annual Average	3.5	1.6	3.5	-	2.3

TABLE 2.8-3

MEASURED GROSS BETA ACTIVITY IN AIR
AT COLUMBIA, SOUTH CAROLINA[2]
JULY 1973 TO JANUARY 1974

Month	(Units - 10^{-14} μCi/ml)
July	10
August	4
September	8
October	3
November	3
December	8
January	9

TABLE 2.8-4

AVERAGE TOTAL URANIUM ACTIVITY IN CONGAREE RIVER WATER SAMPLES
(APRIL THROUGH DECEMBER, 1973)

(Units - 10^{-9} μCi/ml)

Sampling Locations					
Blossom St. Bridge (Upriver)	500 yd Upriver From Plant Discharge	At Plant Discharge Point	500 yd Downriver From Plant Discharge	1000 yd Downriver From Plant Discharge	Rte. 601 Bridge (Downriver)
0.10 $\pm$ 0.27	0.19 $\pm$ 0.30	0.13 $\pm$ 0.29	0.40 $\pm$ 0.31	0.06 $\pm$ 0.29	$\leq$0.29

Gross alpha and gross beta activity levels in the Congaree River for 1972 and 1973 are given in Table 2.8-5.[1] These yearly average gross beta activities range from (5.1 to 5.4) x 10^{-9} μCi/ml upstream of the plant discharges and from (4.4 to 5.6) x 10^{-9} μCi/ml downstream while the yearly average gross alpha activities range from (0.6 to 1.1) x 10^{-9} μCi/ml upstream of the plant discharges and from (0.5 to 2.0) x 10^{-9} μCi/ml downstream.

Average and maximum measurements of gross alpha and gross beta activity in water samples from Sunset Lake for the period December 1972 to November 1973 are given in Table 2.8-6. These average alpha and beta activity values range from (7.6 to 55.1) x 10^{-9} μCi/ml and from (18.3 to 108) x 10^{-9} μCi/ml, respectively. These values can be compared with the MPC's for uranium and uranium daughters in plant discharge water of 3.1 x 10^{-5} μCi/ml and 2.1 x 10^{-5} μCi/ml for alpha and beta activities, respectively (Appendix 4.B).

2.8.1.3.2 WELL WATER

Table 2.8-7 lists average annual gross alpha and gross beta concentrations in three on-site wells for the period March 21, 1972 to March 13, 1974. The locations of these wells which are 27 to 33 feet deep are illustrated in Figure 6.1-2. These average gross alpha values range from (8.2 to 26) x 10^{-9} μCi/ml while the average gross beta values range from (23.9 to 103) x 10^{-9} μCi/ml. These values can be compared with an off-site well, located $\sim$ 9.5 miles ESE of the NFCS, monitored by the state which showed gross alpha and beta activity levels of (0.6 and 2.8) x 10^{-9} μCi/ml, respectively for the period November 15, 1972 to March 14, 1974.[1]

2.8.1.3.3 DRINKING WATER

Gross alpha and gross beta activities in drinking water from Columbia, South Carolina are listed in Table 2.8-8.[1] These data show average gross alpha and gross beta activities of (<0.5 and 3.4) x 10^{-9} μCi/ml respectively for the period of record (November 30, 1971 to June 8, 1973).

TABLE 2.8-5

GROSS ALPHA AND GROSS BETA ACTIVITY IN THE CONGAREE RIVER[1]

(Units - 10^{-9} $\mu Ci/ml$)

Year	U. S. Route #601 Bridge, Downstream of Plant Discharge		Blossom St. Bridge, Upstream of Plant Discharges	
	Gross Alpha	Gross Beta	Gross Alpha	Gross Beta
1972	2.0	5.6	0.6	5.1
1973	0.5	4.4	1.1	5.4

TABLE 2.8-6

GROSS ALPHA AND BETA ACTIVITY IN SUNSET LAKE
(December 1972 - November 1973)

(Units - 10^{-9} μCi/ml)

	Location of Sampling Point*				
	Road	Entrance	Exit	Causeway	Spillway
Average Gross Alpha Activity	46.0 ± 8.9	7.6 ± 3.4	8.8 ± 3.5	55.1 ± 13.6	22.0 ± 4.9
Maximum Gross Alpha Activity	152.7 ± 16.2	23.8 ± 6.9	22.8 ± 6.8	545.0 ± 48.7	48.2 ± 9.0
Average Gross Beta Activity	108.0 ± 10.0	18.3 ± 7.7	29.9 ± 6.9	31.9 ± 6.5	23.1 ± 5.1
Maximum Gross Beta Activity	812.0 ± 14.9	195.0 ± 9.3	79.7 ± 6.3	177.0 ± 17.1	78.4 ± 6.3

* Road - Drainage culvert from plant storm sewer that enters Sunset Lake
Entrance - Point where Mill Creek enters Sunset Lake
Exit - Point where water from Sunset Lake mixes with water diverted through the canal
Causeway - At dam that separates upper and lower portions of Sunset Lake
Spillway - Point where Sunset Lake enters Mill Creek

TABLE 2.8-7

ANNUAL AVERAGE GROSS ALPHA AND BETA CONCENTRATION IN THREE ON-SITE WELLS

(Units - 10^{-9} μCi/ml)

Year	Well No. 1		Well No. 2		Well No. 3	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1972 (March 21 to December 6)	25.2 ± 8.0	51.6 ± 6.7	8.6 ± 4.0	23.9 ± 3.5	8.2 ± 3.8	103.0 ± 8.5
1973 (January 17 to December 28)	22.8 ± 4.4	53.7 ± 9.3	24.3 ± 5.9	83.0 ± 11.0	20.0 ± 3.9	56.2 ± 9.4
1974 (January 9 to November)	16.0 ± 5.0	33.0 ± 8.0	26.0 ± 5.0	55.0 ± 9.0	12.0 ± 4.0	62.0 ± 10.0

TABLE 2.8-8

GROSS ALPHA AND BETA ACTIVITY IN DRINKING WATER
COLUMBIA, SOUTH CAROLINA[1]

(Units - 10^{-9} μCi/ml)

Date of Sampling	Gross Alpha	Gross Beta
11-30-71	N.D.	2.4
6-14-71	0.7	3.7
2-14-72	N.D.	3.4
8-16-72	N.D.	5.3
9-11-72	N.D.	3.0
1-12-73	1.4	2.2
5-23-73	N.D.	4.4
6- 8-73	0.5	3.4
Maximum	1.4	5.3
Minimum	<0.5	2.2
Average	<0.5	3.4

N.D. - Not Detectable

2.8.1.4 GROSS ALPHA AND BETA ACTIVITY IN FALLOUT DEPOSITION AND PRECIPITATION

Average annual gross alpha and gross beta activity in precipitation at the radiation alert network station in Columbia, South Carolina is given in Table 2.8-9[1] for 1971, 1972 and part of 1973. Average annual gross alpha activity for all three years is consistent (1.5 to 2.1) x 10^{-9} μCi/ml. However, for average annual gross beta activity, 1971 and 1972 (42.5 and 49.5) x 10^{-9} μCi/ml, respectively are in reasonable agreement while 1973 activity is much less (9.0) x 10^{-9} μCi/ml.

Measurements of monthly gross alpha and beta activity in fallout deposition for 1973 taken as part of the NFCS environmental monitoring program are listed in Table 2.8-10. The locations of these fallout stations are shown in Figure 2.8-2. The 1973 annual average gross alpha activity at the eight stations ranges from 0.54 ± 0.28 to 2.0 ± 1.7 nCi/m^2/month while the 1973 annual average gross beta activity ranges from 1.2 ± 1.3 to 5.3 ± 12.5 nCi/m^2/month. Using the average rainfall for 1973 of 5.63 inches per month, these values are equivalent to (3.78 to 13.6) x 10^{-9} μCi/ml annual average alpha activity and (8.74 to 36.9) x 10^{-9} μCi/ml annual average beta activity.

These gross beta data can be compared with measurements of gross beta activity in fallout deposition at Columbia, South Carolina for the period August 1973 to December 1973[4] which show an average gross beta activity of 0.35 nCi/m^2/month.

2.8.1.5 TOTAL URANIUM ACTIVITY IN VEGETATION

Table 2.8-11 lists total uranium activity in eight vegetation samples (five grass and three soybean) analyzed in September 1974. The total uranium activity in these samples ranges from 0.000 ± 0.036 to 0.743 ± 0.032 pCi/gm (dry).

TABLE 2.8-9

ANNUAL AVERAGE GROSS ALPHA AND BETA ACTIVITY
IN PRECIPITATION AT COLUMBIA, SOUTH CAROLINA[1]

Year	Gross Alpha	Gross Beta
	(Units - 10^{-9} μCi/ml)	
1971	2.1	42.5
1972	1.7	44.5
1973 (First 6 months)	1.5	9.0

TABLE 2.8-10

1973 ANNUAL AVERAGE GROSS ALPHA AND BETA ACTIVITY
IN FALLOUT DEPOSITION

(Units - n*Ci/m^2/month)

Fallout Station	Gross Alpha	Gross Beta
1	1.7 ± 1.5	1.8 ± 1.5
2	2.0 ± 1.7	2.0 ± 1.5
3	0.78 ± 1.1	2.7 ± 3.8
4	1.2 ± 1.2	1.7 ± 1.4
5	0.54 ± 0.28	5.3 ± 12.5
6	0.83 ± 0.35	1.2 ± 1.3
7	1.6 ± 1.1	2.6 ± 2.8
8	0.86 ± 0.57	1.3 ± 0.79

* n = nano = 10^{-9}

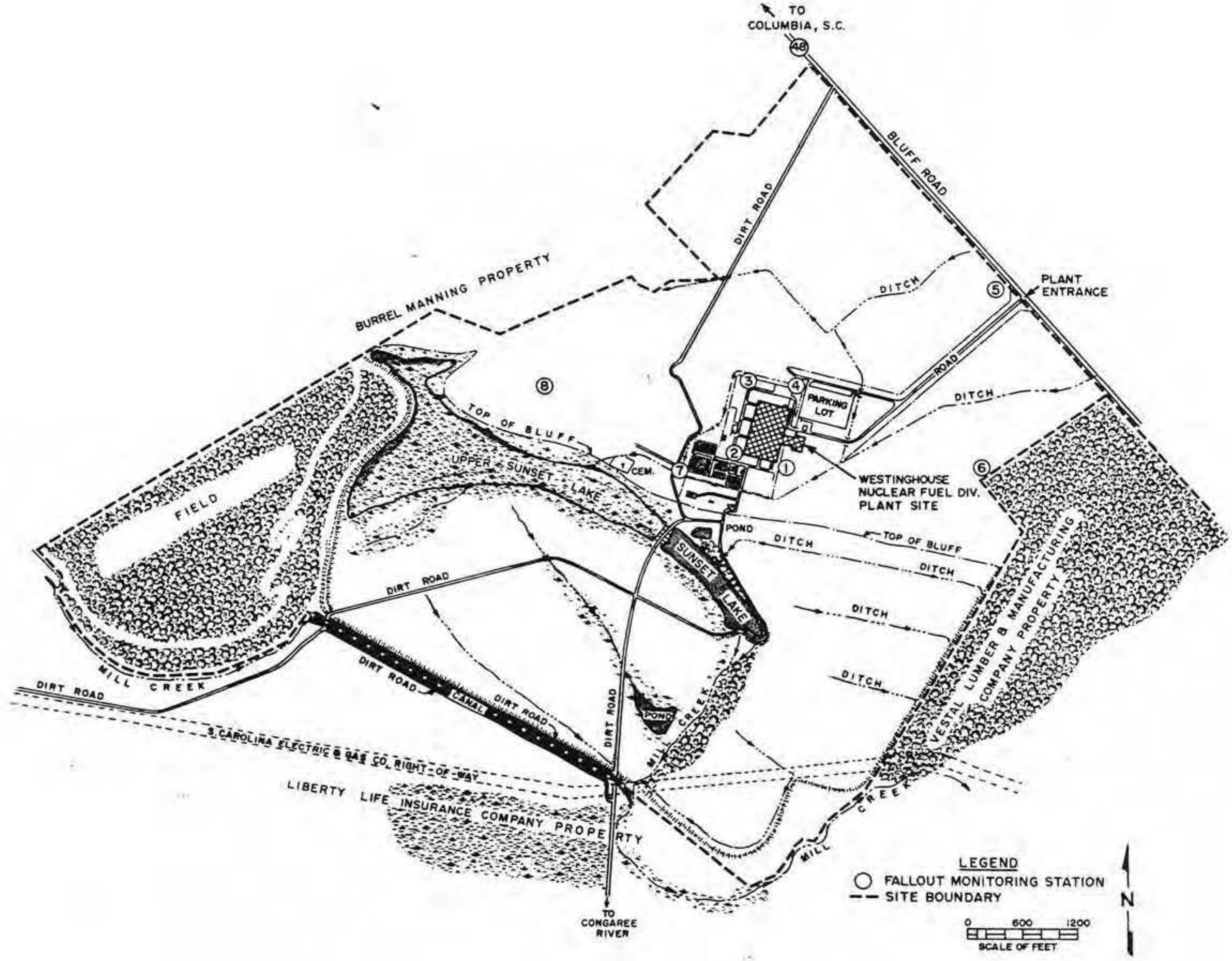

Figure 2.8-2. Locations of Fallout Monitoring Stations

TABLE 2.8-11

TOTAL URANIUM ACTIVITY IN ON-SITE VEGETATION SAMPLES
TAKEN IN SEPTEMBER 1974

Units - pCi/gm (dry)

Location	Type of Sample	Total Uranium
Air Monitoring Station No. 1*	Grass	0.085 $\pm$ 0.027
Air Monitoring Station No. 2	Grass	0.050 $\pm$ 0.032
Air Monitoring Station No. 3	Grass	0.000 $\pm$ 0.036
Air Monitoring Station No. 4	Grass	0.000 $\pm$ 0.036
Air Monitoring Station No. 5	Grass	0.743 $\pm$ 0.032
Weather Tower	Soybeans	0.091 $\pm$ 0.032
North of Crossroads (400 feet S of Sunset Lake)	Soybeans	0.036 $\pm$ 0.032
South of Crossroads (400 feet S of Sunset Lake)	Soybeans	0.396 $\pm$ 0.040

* See Figure 2.8-1 for location of sampling stations

2.8.1.6 GROSS ALPHA, GROSS BETA AND URANIUM ACTIVITY IN SOIL

Gross alpha, gross beta and total uranium activity in on-site soil samples collected in June and September 1974 are listed in Table 2.8-12. These data show a range in gross alpha activity of 1.09 $\pm$ 0.36 to 3.99 $\pm$ 1.16 pCi/gm (dry) and in gross beta activity of 0.75 $\pm$ 0.30 to 4.14 $\pm$ 0.42 pCi/gm (dry). Total uranium activity ranged from $\leq$0.022 to 0.793 $\pm$ 0.036 pCi/gm (dry). This range in total uranium activity can be compared with an average content of uranium in the earth's crust of 1.4 pCi/gm.[5]

2.8.1.7 WHOLE-BODY DOSE RATES

Based on "Estimates of Ionizing Radiation Doses in the U. S. 1960-2000,"[6] the whole-body dose rate from natural background radiation in the vicinity of Columbia is expected to be on the same order as that for South Carolina in general; that is $\sim$ 135 mrem/yr (70 mrem/yr from external terrestrial radiation, 40 mrem/yr from cosmic rays and 25 mrem/yr from internal emitters from terrestrial radiation). This value agrees well with an average of 0.32 mrem/day (or 117 mrem/yr) reported by the state[1] for areas in South Carolina where there are no nuclear facilities.

The above dose rates can be compared with those measured at six locations[1] in the vicinity of the plant. These data which are listed in Table 2.8-13 indicate an average dose rate of 0.31 to 0.45 mrem/day or 113 to 164 mrem/yr.

2.8.1.8 SUMMARY

Based on the data presented in the preceding sections (2.8.1.1 through 2.8.1.7) a summary of present background radiological characteristics typical of the NFCS environs is presented in Table 2.8-14. Because of the variations in reported data, typical ranges rather than specific values are given for some of the parameters discussed.

TABLE 2.8-12

GROSS ALPHA, BETA AND URANIUM ACTIVITY IN SOIL

Units - pCi/gm (dry)

Location	Date Collected	Gross Alpha	Gross Beta	Total Uranium
Air Monitoring Station No. 1*	9/18/74	3.33 ± 0.86	1.68 ± 0.34	0.100 ± 0.033
Air Monitoring Station No. 2	9/18/74	3.99 ± 1.16	1.54 ± 0.34	0.058 ± 0.032
Air Monitoring Station No. 3	9/18/74	1.94 ± 0.71	1.19 ± 0.32	0.040 ± 0.036
Air Monitoring Station No. 4	9/18/74	1.09 ± 0.36	0.75 ± 0.30	0.000 ± 0.040
Air Monitoring Station No. 5	9/18/74	1.14 ± 0.50	4.14 ± 0.42	0.000 ± 0.040
Fallout Monitoring Station No. 1**	6/14/74	-----------	-----------	0.784 ± 0.036
Fallout Monitoring Station No. 2	6/14/74	-----------	-----------	0.793 ± 0.036
Fallout Monitoring Station No. 3	6/14/74	-----------	-----------	0.324 ± 0.036
Fallout Monitoring Station No. 4	6/14/74	-----------	-----------	0.491 ± 0.040
Fallout Monitoring Station No. 5	6/14/74	-----------	-----------	0.279 ± 0.032
Fallout Monitoring Station No. 6	6/14/74	-----------	-----------	0.243 ± 0.027
Fallout Monitoring Station No. 7	6/14/74	-----------	-----------	0.000 ± 0.022
Fallout Monitoring Station No. 8	6/14/74	-----------	-----------	0.000 ± 0.022

* See Figure 2.8-1 for location of air monitoring stations

** See Figure 2.8-2 for location of fallout monitoring stations

TABLE 2.8-13

AVERAGE DIRECT RADIATION MEASUREMENTS WITH TLD'S[1]

(Units - mrem/day)

Location of Stations

Sample Period	10 Miles NW of Plant	3000 ft NE of Plant
1/7/71 to 4/4/71	0.51	--
3/4/71 to 6/8/71	0.37	--
6/8/71 to 8/16/71	0.64	--
8/16/71 to 12/22/71	0.42	--
12/22/71 to 3/21/72	0.16	0.20
3/21/72 to 6/26/72	0.25	0.34
6/26/72 to 9/19/72	0.25	0.33
9/19/72 to 12/7/72	0.14	1.11
12/7/72 to 3/1/73	0.24	0.23
3/1/73 to 6/16/73	0.18	0.18
Average mrem/day	0.31	0.45
Average mrem/yr	113	164

Sample Period	2250 ft E of Plant	2250 ft NW of Plant	7 Miles NE of Plant	9 Miles NNW of Plant
9/22/72 to 12/11/72	0.60	0.49	0.51	0.55
12/11/72 to 3/2/73	0.27	0.28	0.25	0.40
3/2/73 to 6/6/73	0.26	0.25	0.21	0.23
Average mrem/day	0.37	0.34	0.32	0.39
Average mrem/yr	135	124	117	142

TABLE 2.8-14

SUMMARY OF BACKGROUND RADIOLOGICAL CHARACTERISTICS TYPICAL OF THE NFCS ENVIRONS

Measured Parameter	Typical Values and Ranges*		
	Gross Alpha	Gross Beta	Total Uranium
Air	$\leq 1.0\times10^{-15}$ to 5.8×10^{-14} μCi/ml	$(1.6 \text{ to } 6.5)\times10^{-14}$ μCi/ml	---
Surface Water - Congaree River	$(0.5 \text{ to } 2)\times10^{-9}$ μCi/ml	$(4.4 \text{ to } 5.6)\times10^{-9}$ μCi/ml	$(0.06\pm0.29 \text{ to } 0.40\pm0.31)\times10^{-9}$ μCi/ml
- Sunset Lake	$(7.6 \text{ to } 55)\times10^{-9}$ μCi/ml	$(18.3 \text{ to } 108)\times10^{-9}$ μCi/ml	---
Well Water - On-site	$(8.2 \text{ to } 26)\times10^{-9}$ μCi/ml	$(24 \text{ to } 103)\times10^{-9}$ μCi/ml	---
- Off-site	$\sim0.6\times10^{-9}$ μCi/ml	$\sim2.8\times10^{-9}$ μCi/ml	---
Drinking Water	$(<0.5 \text{ to } 1.4)\times10^{-9}$ μCi/ml	$(2.2 \text{ to } 5.3)\times10^{-9}$ μCi/ml	---
Precipitation	$(1.5 \text{ to } 2.1)\times10^{-9}$ μCi/ml	$(9.0 \text{ to } 50)\times10^{-9}$ μCi/ml	---
Fallout Deposition	0.5 to 2.0 nCi/m^2/month	0.35 to 18 nCi/m^2/month	---
Vegetation	---	---	<1 pCi/gm
Soil	1 to 5 pCi/gm	1 to 4.5 pCi/gm	<1 pCi/gm

TLD'S — Whole Body Dose: 110 to 160 mrem/yr

* Based on data presented in Sections 2.8.1 to 2.8.1.7.

2.8.2 BACKGROUND CHEMICAL CHARACTERISTICS

Background concentrations of applicable chemicals found in the air and in water bodies are described in this section.

2.8.2.1 AIR

Fluorides and ammonia are the main chemical discharges of the NFCS plant. These chemicals are monitored within the plant property as described in Section 6.2, Chemical Monitoring. Average effluents of these chemicals at the present maximum load operation of 400 MTU per year are listed in Table 2.8-15.

TABLE 2.8-15

AVERAGE AMMONIA AND FLUORIDE EFFLUENT
FOR 400 MTU/YEAR OPERATION

	Effluent Concentration Per Stack (mg/m^3)	
Chemical	Average	Maximum
Ammonia	390	585
Fluorides	0.36	0.54

2.8.2.2 WATER

In this section background characteristics of surface and groundwater systems in the vicinity of the NFCS facility are discussed.

2.8.2.2.1 BACKGROUND CHARACTERISTICS OF THE CONGAREE RIVER

Water quality of the Congaree River upstream and downstream of the NFCS plant discharge point is discussed in Section 2.5.1.2, Water Quality. The biological characteristics are discussed in Section 2.7.2, Aquatic Ecology.

Water quality of the Congaree River upstream and downstream of the discharge point is also monitored for relevant chemical parameters by the NFCS. The monitoring system is described in Section 6.2, Chemical Monitoring.

2.8.2.2.2 BACKGROUND CHARACTERISTICS OF SURFACE WATER ON THE NFCS PROPERTY

In addition to the Congaree River, water quality of water bodies located on the NFCS property are monitored for relevant chemical parameters. Fluoride, ammonia and pH are monitored on a weekly basis at five stations: (1) entrance to the Westinghouse property at the point where Mill Creek enters Sunset Lake, (2) exit from the Westinghouse property at the point where water from Sunset Lake mixes with water diverted through the canal, (3) causeway station at the dam that separates the upper and lower portions of Sunset Lake, (4) spillway station at the point where Sunset Lake enters Mill Creek and (5) road station, at the drainage culvert from plant storm sewer that enters Sunset Lake. Sunset Lake is described in Section 2.7.2, Aquatic Ecology.

"French drains" located beneath the holding lagoons drain any leaks to the road station, and fluoride and ammonia concentrations at this station are generally higher than at any other monitoring station on Westinghouse premises. Fluoride concentrations under normal conditions ranged during 1973 (a typical full year) between <0.2 to 19.2 mg/l at the road station (average: 4.7 mg/l) while at the entrance station concentrations were usually below 0.2 mg/l and at the other stations they were generally below 1 mg/l. Ammonia concentrations at the road station ranged during 1973 between less than 1 to 60 mg/l (average: 22.4 mg/l) and at the other stations generally less than 1 mg/l except some values that reached up to 18 mg/l. During 1973, pH values at the road station were generally close to 9 (average: 8.6 ± 0.9 pH units) while at the other stations they were generally close to 7.

2.8.2.2.3 BACKGROUND CHARACTERISTICS OF LOCAL GROUNDWATER

Water-bearing formations at the NFCS are described in Section 2.4.2.1, Site Surface Geology and Stratigraphy, and the groundwater characteristics are discussed in Section 2.5.2, Groundwater. Three wells located on the NFCS are monitored for fluoride, ammonia and pH. These wells were at the site as part of the existing irrigation program before the Columbia facility was constructed. Concentrations of fluoride at these wells are generally below 0.2 mg/l, ammonia values are generally below 1.0 mg/l and pH values generally range between 5.8 and 7.4.

2.8.3 EXISTING BACKGROUND CONCENTRATIONS OF POLLUTANTS AROUND THE SITE

To assess the air quality impact of the proposed facility near Columbia on the surrounding area, the background concentrations of existing pollutants must be determined. The usual approach is to identify major existing sources of pollution around the proposed facility and calculate their contributions by using available numerical models. The calculated contributions from the proposed plant are then superimposed on the contributions of the existing sources to determine the additional increase in pollutant levels which will be caused by the proposed facility.

The approach taken in this study utilizes the background concentrations of pollutants obtained by the Air Quality Control Division of the State of South Carolina, Department of Public Health. A summary of background levels of air pollutants obtained away from the site at various places which only approximately represents the background information near the site, is shown in Table 2.8-16. Short-term measurements are available only for SO_2 and fluorides. Highest short-term concentrations of SO_2 recorded are 100 $\mu g/m^3$ for a 1-hour period and 32 $\mu g/m^3$ for a 24-hour period. For fluorides, the highest monthly value recorded is 0.30 $\mu g/cm^2$. Long-term measurements show an annual average of 3.0 $\mu g/m^3$ for SO_2 and a geometric mean of 60 $\mu g/m^3$ for particulates.

A comparison of these background measurements with the calculated ground level concentrations from the proposed facility provides the information to estimate the projected increases in the concentrations of air pollutants from the proposed plant.

TABLE 2.8-16

SO_2, FLUORIDE AND PARTICULATE MATTER BACKGROUND CONCENTRATIONS AROUND THE PROPOSED FACILITY[7]

Pollutant	1-hr max ($\mu g/m^3$)	24-hr max ($\mu g/m^3$)	Monthly mean ($\mu g/cm^2$)	Geometric mean ($\mu g/m^3$)
SO_2	100	32	--	3
Fluorides	--	--	0.3	--
Particulates	--	--	--	60

2.8.4 REFERENCES

1. Williams, E. F., Radiation Surveillance Supervisor, South Carolina Department of Health and Environmental Control, Division of Radiological Health, letter to Woodsum, H. C., WESD, October 19, 1973.

2. Radiation Data and Reports, Volume 14 (1973), No. 11 and 12 and Volume 15 (1974), No. 1, 2, 4, 5 and 6.

3. U.S. Department of Commerce, NOAA, Environmental Data Service, "Local Climatology Data, Columbia, South Carolina," 1973.

4. Radiation Data and Reports, Volume 14 (1973), No. 12 and Volume 15 (1974), No. 1, 2, 4 and 5.

5. Russell, R. S., Radioactivity and Human Diet, Pergamon Press, Great Britain, 1966.

6. U.S. Environmental Protection Agency, Office of Radiation Programs, Division of Criteria and Standards, "Estimates of Ionizing Radiation Doses in the United States 1960 - 2000," Rockville, Maryland, August 1972.

7. State of South Carolina, Department of Public Health, Air Quality Control Division, telephone communication with Rao, R. WESD, December 2, 1974.