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THE SAVANNAH RIVER PLANT SITE

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Savannah River Laboratory

Aiken, South Carolina

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by

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January 1973

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AIKEN, S. C. 29801

CONTRACT AT(07-2)-1 WITH THE
UNITED STATES ATOMIC ENERGY COMMISSION

FOREWORD

On June 20, 1972, the Atomic Energy Commission designated nearly 200,000 acres of land near Aiken, South Carolina, as the nation's first National Environmental Research Park. The designated land surrounds the AEC Savannah River Plant production complex. The site, which borders the Savannah River for 22 miles, includes swampland, pine forests, abandoned town sites, a large man-made lake for cooling water impoundment, fields, streams, and watersheds.

This report is a description of the geological, hydrological, meteorological, and biological characteristics of the Savannah River Plant site and is intended as a source of information for those interested in environmental research at the site. It is also intended as a reference for those preparing reports about aspects of operation of production and support facilities at the Savannah River Plant.

Much of the information in this document was extracted from the references listed at the end of the report.

ABSTRACT

The Savannah River Plant is located in western South Carolina along the Savannah River about 25 miles southeast of Augusta, Georgia. The plant lies on the Atlantic Coastal Plain and is underlain by a sequence of unconsolidated and semiconsolidated Upper Cretaceous, Tertiary, and Quarternary sediments, deposited on an eroded basement of Precambrian and/or Paleozoic igneous and metamorphic rock. Basement rocks consist of gneiss and schist, and are at a depth of about 900 ft at the Savannah River Plant. A large Triassic deposit in a basin of the crystalline rock underlies the southeastern portion of the plant.

The plantsite has numerous streams, basins, marshes, artificial impoundments, and canals. Surface water in the plant area is very low in dissolved solids and iron; it is very soft. The chemical composition of ground water varies with the different aquifers. The principal aquifer on the plantsite is the Tuscaloosa Formation. Water from this aquifer is low in dissolved solids and iron, is very soft, and has a pH of 4.4 to 6.9.

The climate in the Savannah River area is relatively temperate, with mild winters and long summers. The average winter temperature in Augusta is 48°F, the average summer temperature is 80°F, and the annual average temperature is 65°F. The annual average rainfall at the Savannah River Plant is 47 inches. The average hourly wind velocity for Augusta is ~6.4 mph, and the wind frequently shifts as much as 180° from day to day throughout the year.

Hurricanes occasionally occur along the coasts of South Carolina and Georgia; however, the Savannah River Plant is 100 miles inland, so wind velocities at ground level would not be expected to exceed 60 mph. Occasional tornadoes occur in the Savannah River Plant area. The probability of a tornado striking a given spot in the area is once in 1600 years. No damage to facilities has resulted from a tornado during the existence of the Savannah River Plant.

On the basis of three centuries of recorded history of earthquakes, an earthquake above the intensity of VIII on the Modified Mercalli scale would not be expected at the Savannah River Plant. The region is accumulating stresses relatively slowly and tends to relieve these stresses by relatively frequent earthquakes of small intensity.

Soils on the plantsite are mostly sandy and low in fertility. The forests contain pine and bottomland hardwood. Wildlife populations have increased on the plantsite since the plant was closed to the public in 1952. From the viewpoint of wildlife management, habitat conditions are considered as fair-to-excellent over the plant.

Natural background radiation, which includes that from cosmic rays, external terrestrial radiation, and internal natural radiation, amounts to an annual dose per person of about 120 mrem.

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INTRODUCTION

The Savannah River Plant, operated for the United States Atomic Energy Commission by E. I. du Pont de Nemours and Company, was established in 1950 to produce nuclear materials for national defense. Nuclear materials are produced at this site by transmutation of elements in large nuclear reactors that are moderated and cooled by heavy water. Support facilities extract heavy water from natural water, fabricate nuclear fuel and targets, dissolve the irradiated materials, and separate nuclear products from the intensely radioactive byproducts (Figure 1). Chemical processing of irradiated materials produces radioactive liquid waste that requires continuous management to prevent contamination of the plant environs.

Many nuclidic products can be made efficiently in Savannah River reactors. Plutonium-239 and tritium were the first nuclear products; the product list has since been expanded to include uranium-233, plutonium-238, curium-244, polonium-210, cobalt-60 of high specific activity, and, most recently, californium-252.

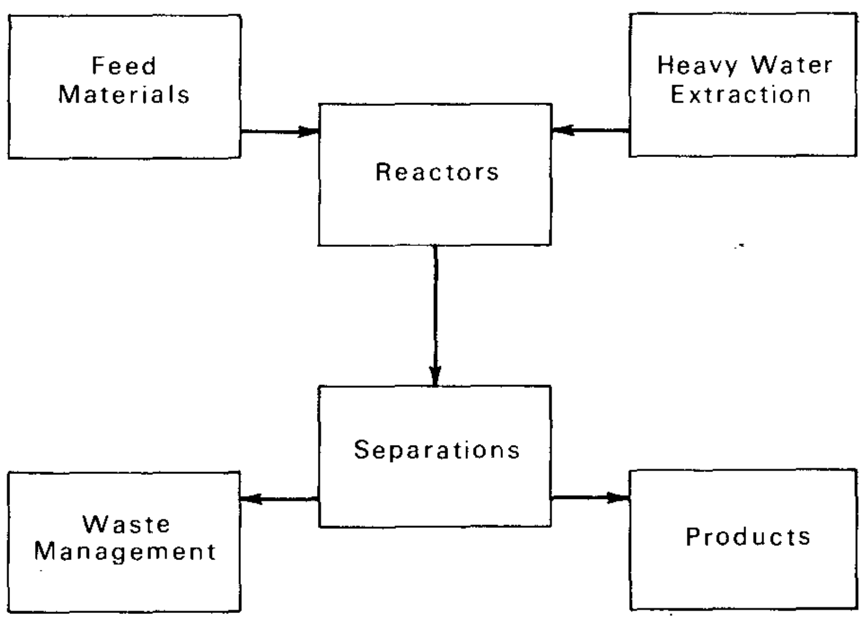

FIGURE 1. The Savannah River Production Complex

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LOCATION

The Savannah River Plant (SRP) occupies an approximately circular site in South Carolina of about 300* square miles bounded on the southwest by the Savannah River and centered approximately 25 miles southeast of Augusta, Ga. Figure 2 shows the location of the site relative to population centers and geographic features within a 150-mile radius. The distribution of population within 100 km (∿63 miles) from the center of the plant is shown in Figure 3. According to the 1970 census, major population centers within about 25 miles of the center of the plant are:

City	Distance, miles	Direction From Plant	Population
Augusta, Ga.	25	Northwest	59,864
N. Augusta, S. C.	25	Northwest	12,883
Aiken, S. C.	20	North	13,436
Williston, S. C.	15	Northeast	2,594
Barnwell, S. C.	15	East	4,439
Allendale, S. C.	26	Southeast	3,620
Waynesboro, Ga.	28	Southwest	5,530

The plantsite has an elevation between 90 and 400 ft above mean sea level, and all operating areas drain toward the Savannah River. The floor level elevations of reactors at the Savannah River Plant are: C Reactor, 287 ft above mean sea level; K Reactor, 271 ft; P Reactor, 317 ft; L Reactor, 251 ft; and R Reactor, 291 ft. The elevation of the Savannah River on the plant is ∿84 ft above mean sea level. The plant lies on the Atlantic Coastal Plain physiographic province, and is underlain by the Tuscaloosa aquifer from which wells supply water to several operating areas.

The locations of the production areas are shown in Figure 4 along with the general drainage pattern for run-off water from the site. Spent cooling water containing heat from reactors is discharged to a cooling impoundment, Par Pond, or through a series of streams and swamps that drain to the Savannah River.

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* The original plantsite area was 200,831 acres (∿314 square miles). Portions of the original site have been deeded to Barnwell County (2,487 acres) and excessed to the General Services Administration for recreational purposes under the administration of the U. S. Forest Service (6,021 acres). The original site boundary is shown in Fig. 4. The shaded areas are no longer part of the plantsite. The plantsite (in 1972) now consists of 192,323 acres (∿300 square miles).

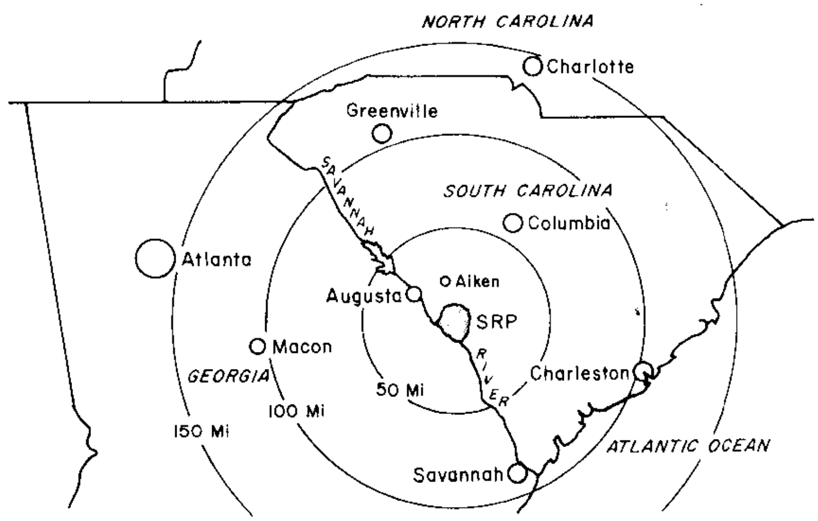

FIGURE 2. Location of SRP Relative to Surrounding Population Centers

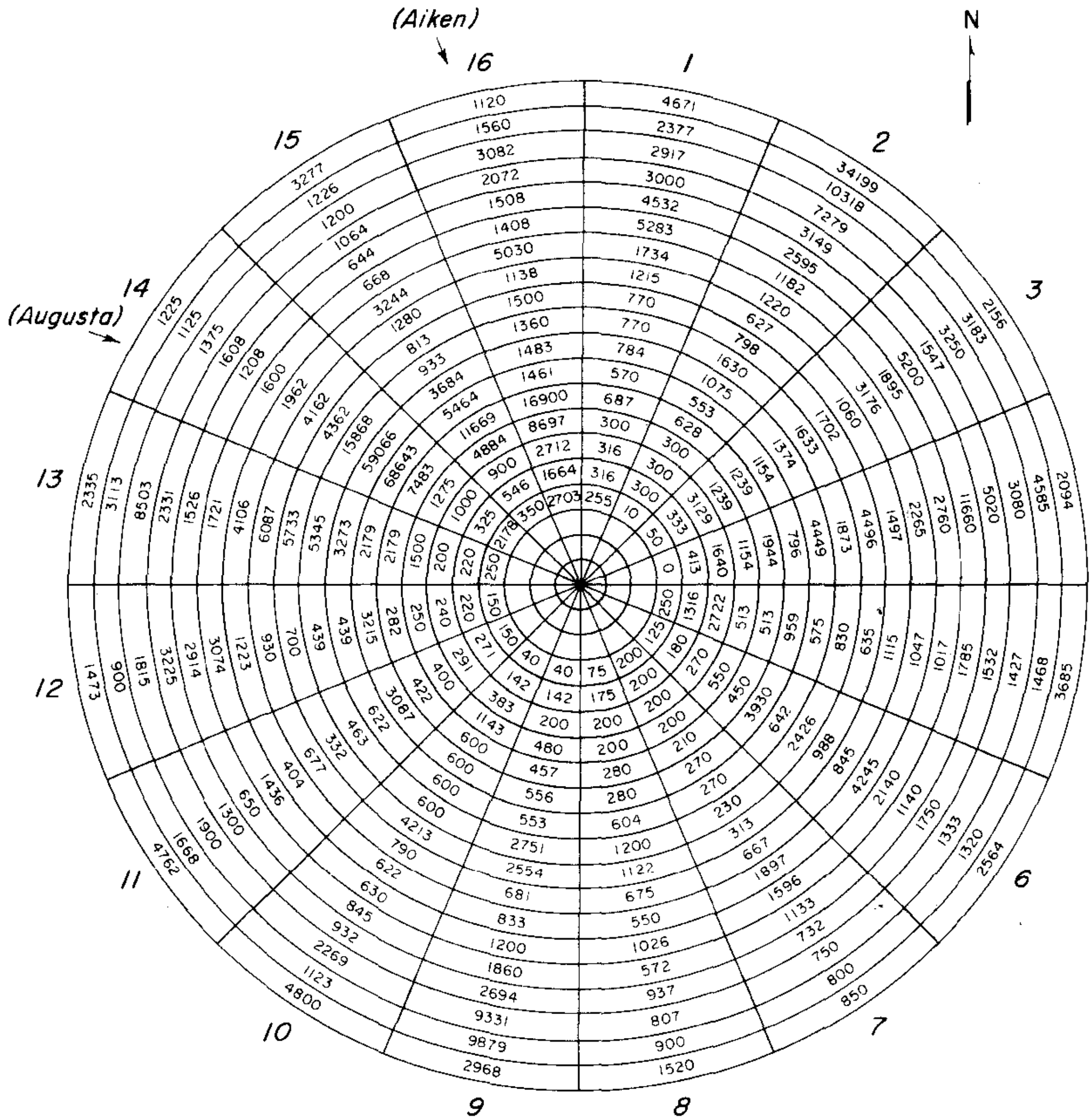

FIGURE 3. Distribution of Population in Region Surrounding the Plant
(Radial Increments = 5 km, 22.5° Sector)
1970 Census

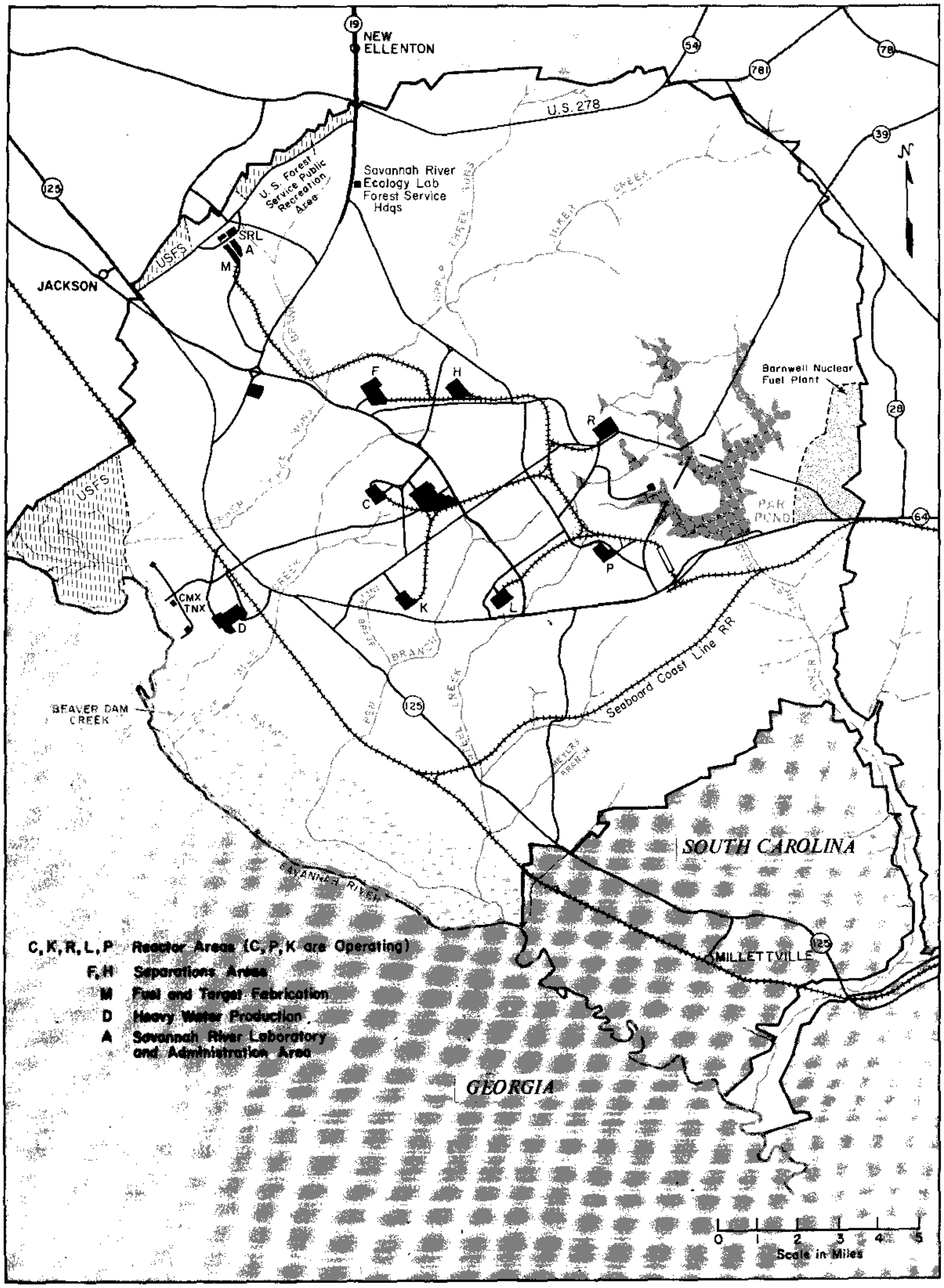

FIGURE 4. The Savannah River Plant Site

GEOLOGY

The Savannah River Plant is located on the upper Atlantic Coastal Plain in South Carolina. (A description of terms in the geologic time scale is given in Appendix A.)

GEOLOGIC STRUCTURE OF SOUTH CAROLINA

South Carolina is divided into two main geologic provinces: (1) The Piedmont Plateau, which is underlain by igneous and metamorphic rock, and (2) the Atlantic Coastal Plain, which is characterized by flat, mostly unconsolidated sediments of Cretaceous age or younger. The relatively soft sediments of the Coastal Plain are more easily eroded than the hard crystalline rocks of the Piedmont Plateau, and for this reason, the boundary between the two provinces is called the Fall Line. The Fall Line is not a sharp line of contact but a zone of transition from the typical land forms of one province to those of the other. It is difficult to determine from the ground surface where the Piedmont Plateau ends and the Coastal Plain begins. However, in river beds the distinction is noticeable, as the change in rock formations causes waterfalls or rapids.

TOPOGRAPHY OF THE SAVANNAH RIVER PLANT

The plantsite is located on the upper Coastal Plain in Aiken and Barnwell counties, South Carolina. The 300-square-mile area is bordered on the southwest by the Savannah River. On the site, two distinct physiographic subregions are represented (Fig. 5), the Pleistocene Coastal Terraces (below 270 ft in elevation) and the Aiken Plateau (above 270 ft and rising to 400 ft on the northwest boundary).

At least three terraces are recognizable within the coastal terraces subregion (Fig. 5).[1] The lowest terrace (Wicomico, 100 ft) is the very broad floodplain of the Savannah River; it is largely covered with a dense swamp forest. The higher terraces (Sunderland, 170 ft, and Brandywine, 270 ft) have a level-to-gently-rolling topography and were extensively cultivated before the establishment of SRP in those areas where soils and drainage were favorable.

The Aiken Plateau was once a relatively smooth, gently sloping area with a regional slope to the southeast. However,

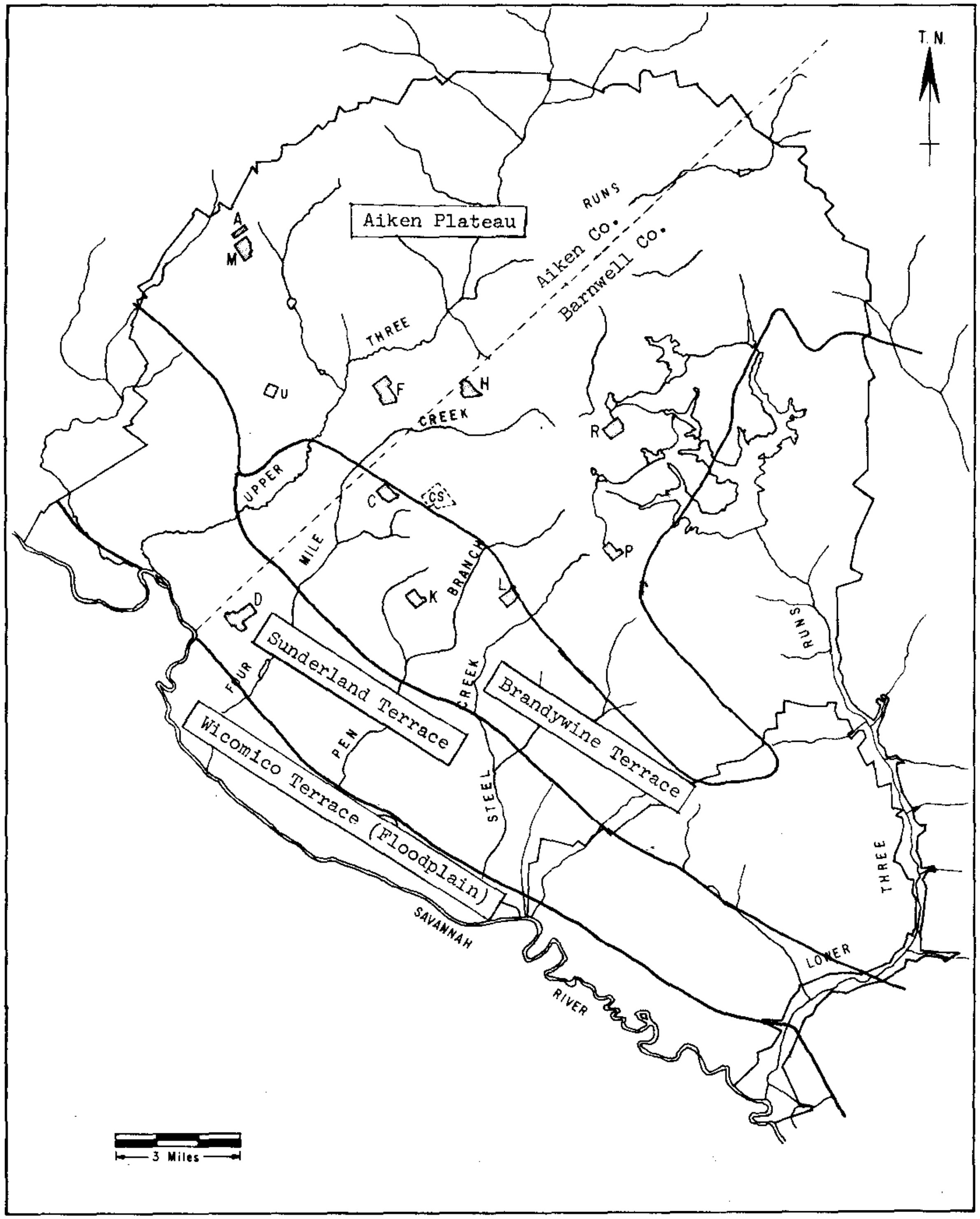

FIGURE 5. Coastal Terraces on the Savannah River Plant

the plateau has been deeply eroded by numerous drainage tributaries. Those interstream areas underlain exclusively by Cretaceous sediments are characterized by gently rolling hills and few, if any, undrained areas. Those interstream areas with a thin cover of Tertiary sediments are characterized by plateaus with steep ravines and numerous undrained "sinks" or "Carolina Bays." (See page 33.)

GEOLOGIC FORMATIONS BENEATH THE SAVANNAH RIVER PLANT

The Savannah River Plant is underlain by a sequence of unconsolidated and semiconsolidated upper Cretaceous, Tertiary, and Quarternary sediments,* deposited on an eroded basement of Precambrian and/or Paleozoic igneous and metamorphic rocks (Figure 6 and Table I). These basement rocks consist of gneiss and schist, and are at a depth of about 900 ft at the Savannah River Plant. They are part of the crystalline rock formations that outcrop at the Fall Line and dip 36 ft/mi to the southeast underneath the Coastal Plain sediments.

The sediments form a wedge ranging in thickness from a few feet at the Fall Line to more than 1200 ft on the southeastern or downdip side of the plantsite. They strike in an average direction of N60°E and dip from 6 to 36 ft/mi to the southeast. The sediments are unbroken by large displacement faults or severe unconformities.

A large Triassic deposit in a basin of the crystalline rock underlies one-third of the plant area and is located in the southeastern section of the site. This deposit consists of sedimentary material formed into sandstones, siltstones, and mudstones.

The geologic formation that immediately overlies the basement rock is called the Tuscaloosa Formation and is 500 to 600 ft thick. This formation consists of sand and clay and contains several prolific water-bearing beds, which supply over 5,000 gallons per minute of water at 70°F to plant wells.

Overlying the Tuscaloosa Formation are several formations of the Tertiary Period that range in age from about 10 million to about 50 million years. These formations have a combined thickness of about 350 ft in the central part of the plant.

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* Tertiary sediments include the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs. Quarternary sediments include the recent Pleistocene epoch.

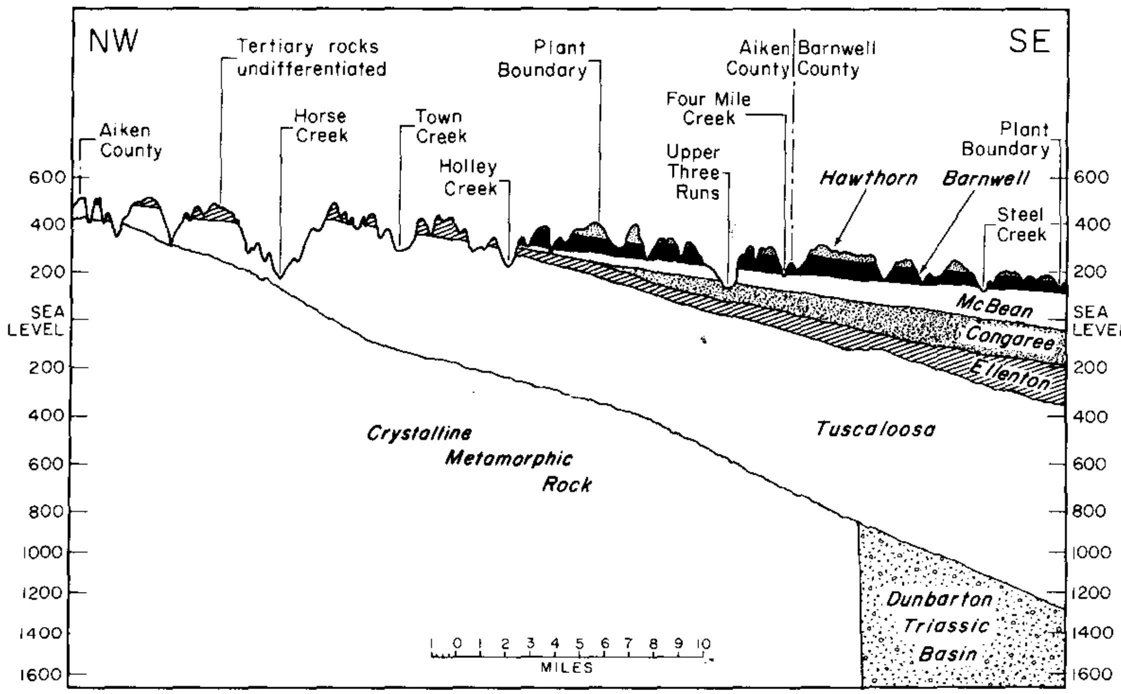


FIGURE 6. Profile of Geologic Formations Beneath the Savannah River Plant

TABLE I

Geologic Formations Underlying the Savannah River Plant Area

Formation	Geologic Age	Exposure	Description	Water Content	Thickness, ft
Alluvium	Recent Epoch		Fine to coarse sand, silt, and clay	Very little	0-30
Terrace Deposits	Pleistocene Epoch	In flood plains and terraces of stream valleys	Tan to gray sand, clay, silt, and gravel with blanket deposits of coarse gravel on higher terraces	Moderate to none	0-30
Alluvium	Pliocene Epoch		Gravel and sandy clay	Little or none	0-20
Hawthorn	Miocene Epoch	Large part of ground surface	Tan, red, and purple sandy clay with numerous clastic dikes	Small to moderate amounts	0-80
Barnwell	Eocene Epoch	Large part of ground surface near streams	Red, brown, yellow, and buff, fine to coarse sand and sandy clay	Limited quantities that are sufficient for domestic use	0-90
McBean Congaree	Eocene Epoch	In banks of larger streams	Yellow-brown to green, fine to coarse, glauconite quartz sand, intercalated with green, red, yellow, and tan clay, sandy marl, and lenses of siliceous limestone	Moderate to large amounts. Quality likely to be harder and of higher iron than other ground waters.	100-250
Ellenton	Upper Cretaceous Epoch	Not exposed on plant	Dark-gray to black sandy lignitic micaceous clay containing disseminated crystalline gypsum and coarse quartz sand	Moderate to large amounts. Higher sulfate and iron content than water from other formations.	5-100
Tuscaloosa	Upper Cretaceous Epoch	Not exposed on plant	Tan, buff, red, and white; crossbedded, micaceous quartzitic and arkosic sand and gravel interbedded with red, brown, and purple clay and white kaolin	Large amounts available with up to 2,000 gpm yields from 8- to 12-inch gravel-pack wells. Soft and low in total solids	0-600
Newark Series "Red Beds"	Triassic Period	Not exposed on plant	Gray, dark-brown, and brick-red sandstone, siltstone, and claystone with included sections of fanglomerate containing gray calcareous pebbles. Rocks identified in only one piezometer and areal extent unknown.	Low yields typical of this type rock in other areas	Unknown
Basement Rocks of the Slate Belt and Charlotte Groups	Precambrian and Palezoic Eras	Not exposed on plant	Hornblende gneiss, chlorite-hornblende schist, lesser amounts of quartzite. Covered by saprolite layer 75 ft thick derived from basement rock.	Small amounts	Many thousands

They consist predominantly of compact clayey sand and sandy clay with a few beds of sand and a few beds of hard clay. At depths ranging from about 100 to 180 ft, there is a zone in which the sandy deposits include calcareous cement, small lenses of limestone, and some shells. At scattered discontinuous localities, slowly circulating ground water has removed this calcareous material and left these lenses less consolidated than the sedimentary rock surrounding them.

At some places on the Savannah River Plant, the rocks of the Tertiary Period are overlain by more recent terrace deposits of alluvium. These deposits are usually thin in the upland areas, but are of significant thickness in the valleys of the Savannah River and some of its larger tributaries.

The ion exchange capacities of the various unconsolidated sediments are low except for the clays of the McBean Formation (Fig. 7).

A more detailed description of the geologic formations underlying the Savannah River Plant appears in Appendix B.

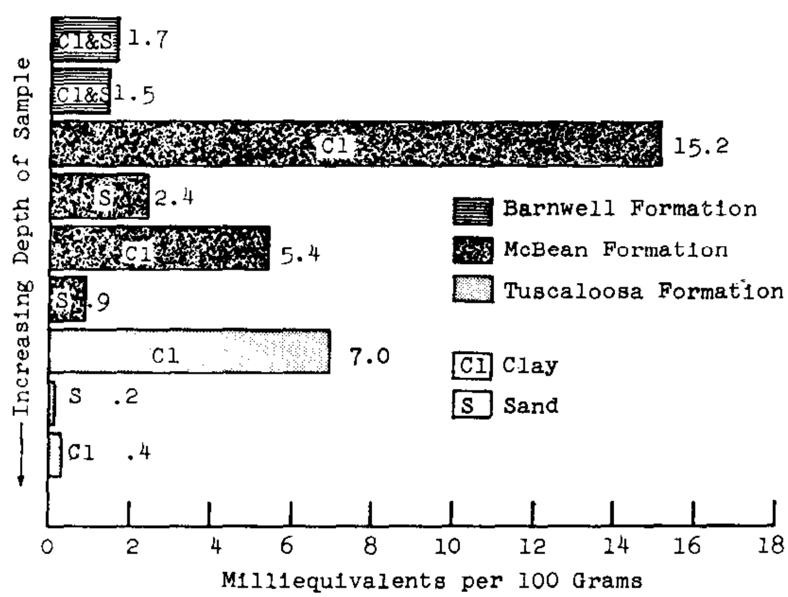


FIGURE 7. Ion Exchange Capacities of SRP Sands and Clays

HYDROLOGY

SURFACE WATER

Almost all of the Savannah River Plant site is drained by tributaries of the Savannah River. Only one small stream in the northeastern sector of the site drains to the Salkehatchie River to the east. Each of the tributaries is fed by small streams; therefore, no location on the site is very far from a continuously flowing stream.

In addition to the flowing streams, surface water is held in over 50 artificial impoundments covering a total of over 3,000 acres. The largest of these, Par Pond, has an area of 2,640 acres. Water is held intermittently in marshes and over 200 natural basins, called Carolina Bays. A large swamp bordering the Savannah River is crossed by several of the streams.

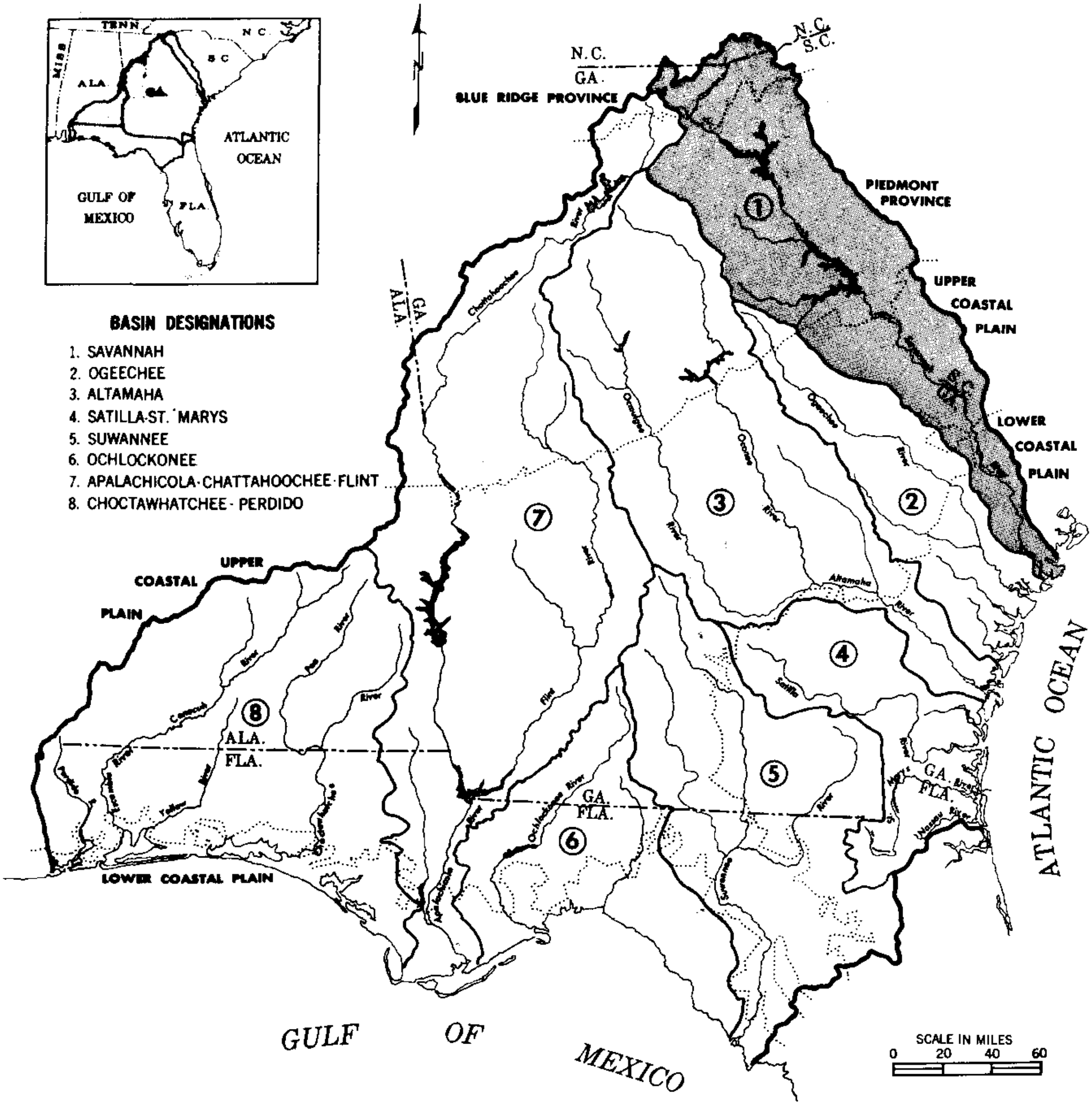
The source of most of the surface water on the plantsite is either natural rainfall or water pumped from the Savannah River to cool the nuclear reactors. The cooling water is discharged to the streams to flow back to the river. Additional small amounts are discharged from other plant processes to the streams.

Savannah River

The Savannah River Plant adjoins the Savannah River, which flows between Georgia and South Carolina. The headwaters of the river are in the Blue Ridge Mountains of North Carolina, South Carolina, and Georgia. Formed at the junction of the Tugaloo and Seneca rivers near Hartwell, Georgia (100 miles upstream from SRP), the river flows southeasterly about 300 miles and empties into the Atlantic Ocean near Savannah, Georgia.

The Savannah River basin is one of the major river basins in the southeastern United States (Figure 8). It has a surface area of 10,579 square miles, of which 8,160 are above the Savannah River Plant (Figure 9).

Two large reservoirs upstream of the Savannah River Plant provide power, flood control, and recreational areas. Clark Hill Reservoir, completed in 1952, is 35 miles (70 river miles) upstream. Hartwell Reservoir, completed in 1961, is 95 miles upstream. Operation of these reservoirs stabilizes the river flow in the vicinity of the plant to a yearly average flow of



Plan for Development of the Land and Water Resources of the Southeastern River Basins, Savannah Basin, Appendix I to Report of the United States Study Commission, Southeast River Basins, 1963, 88th Congress, Session 1, Senate Document No. 51, U. S. Government Printing Office, Washington, D. C. (1963).

FIGURE 8. Southeastern River Basins

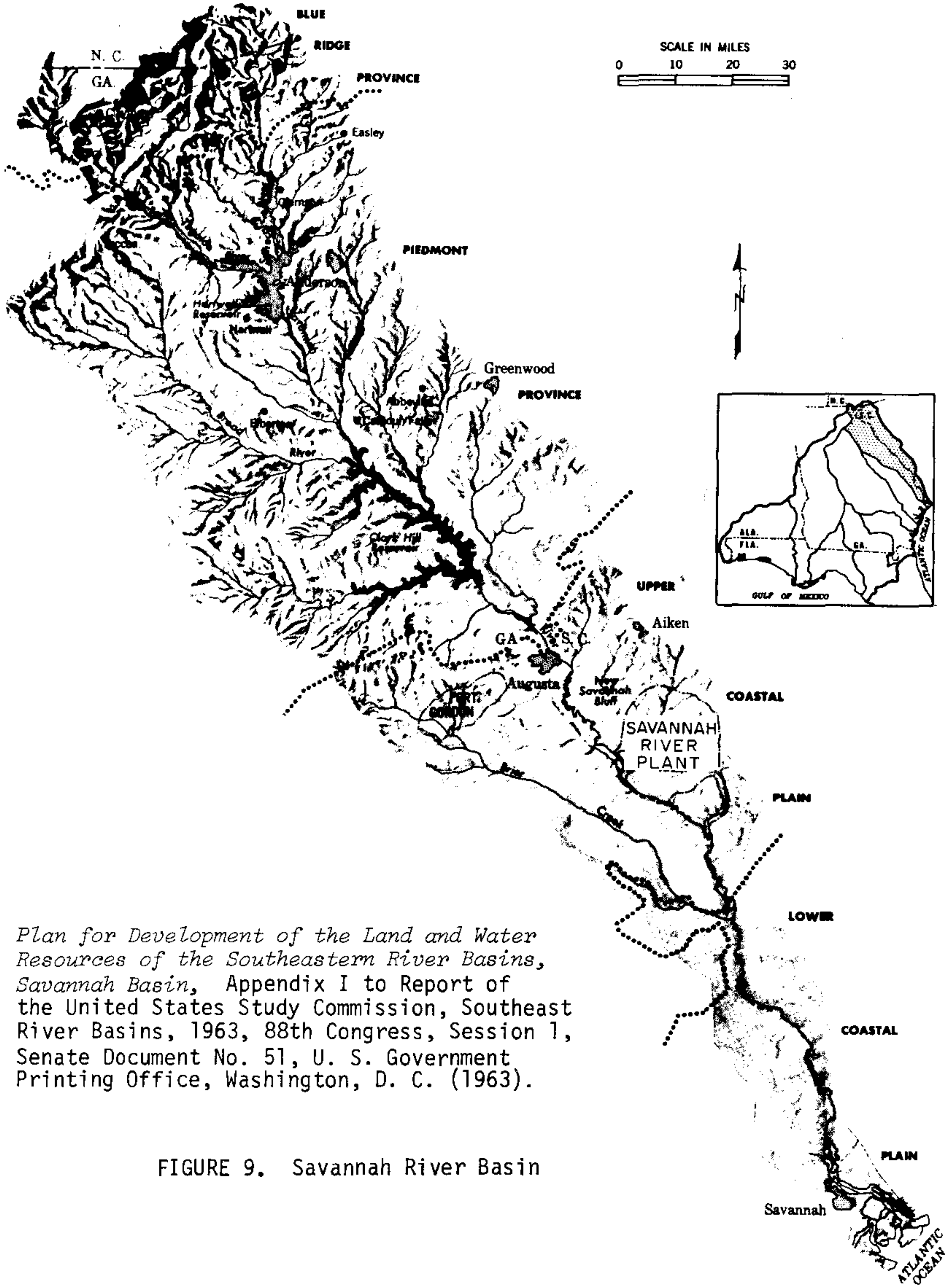


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FIGURE 9. Savannah River Basin

10,400 ±2,900 ft³/sec during 1961 to 1970. The minimum daily flow during this period was 6,000 ft³/sec. Figure 10 shows monthly average flows for 1960 to 1970 for three locations on the river: at U. S. Highway 301 crossing (about 23 miles below SRP), at the SRP boat dock, and at Augusta (at New Savannah Bluff Lock and Dam).

The monthly average temperature of the river water measured at the SRP boat dock since July 1955 ranged from 6.8 to 26.8°C (Table II). The daily river temperature has reached as high as 25.5°C only during the months of June through September. Since 1955, daily temperatures have exceeded 27.5°C on only seven days: four consecutive days in August 1955 and three consecutive days in August 1959.

As the river flows by the Savannah River Plant, its nominal level drops from 84 to 80 feet above mean sea level.

At the Savannah River Plant, water is pumped from the river through concrete pipes to the production reactor areas, where it is used as the secondary coolant to remove heat generated by nuclear fission. Also, 65 to 130 cfs is pumped to the heavy water production plant for process and power plant uses.

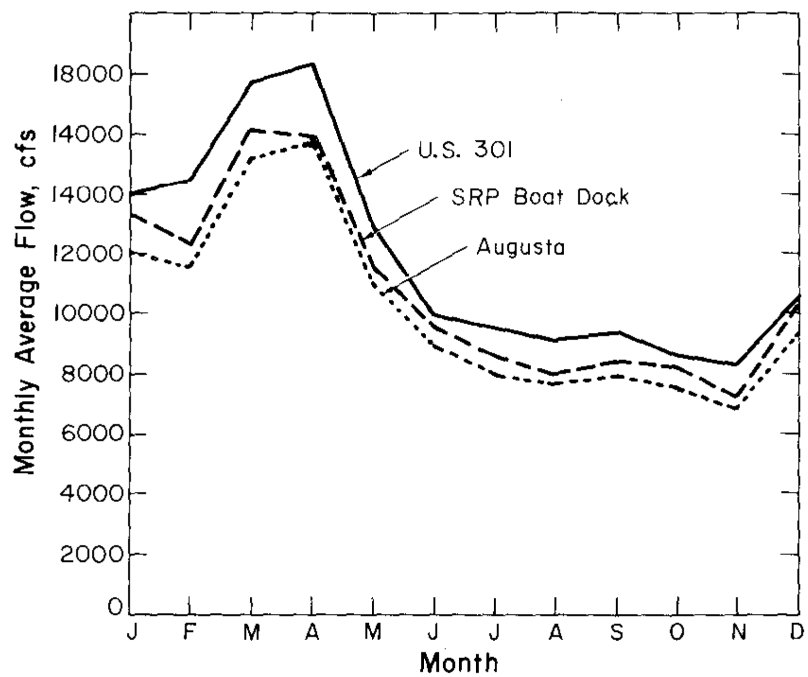

FIGURE 10. Savannah River Average Monthly Flows for 1960-1970

TABLE II

Monthly Average River Temperatures at Jackson, °C

(SRP Boat Docks)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Yearly Average
1955							25.6	26.8	25.2	21.4	15.7	11.2	
1956	8.8	11.7	13.5	16.2	19.9	21.9	23.9	24.1	22.7	19.5	15.5	12.5	17.5
1957	10.2	12.6	13.0	17.6	19.5	22.6	24.2	24.9	25.0	19.2	15.8	11.2	18.0
1958	8.2	6.8	9.4	13.6	18.1	21.8	23.5	24.9	25.4	21.1	17.4	11.1	16.8
1959	9.6	11.2	12.8	17.7	20.9	21.8	25.3	26.3	24.9	22.3	16.3	11.7	18.4
1960	9.9	9.0	8.6	15.0	18.2	22.1	23.5	24.2	24.7	22.0	16.5	10.3	17.0
1961	8.4	9.3	12.7	14.4	19.5	22.1	22.5	22.9	22.6	19.6	17.8	12.7	17.0
1962	8.6	10.2	10.7	14.1	20.2	21.5	23.8	23.7	22.5	20.0	15.1	10.5	16.7
1963	8.4	7.5	11.0	16.7	17.5	20.8	22.4	23.6	21.8	20.1	16.4	9.6	16.3
1964	7.1	7.3	12.0	14.1	17.7	22.5	21.9	22.6	22.3	18.5	16.4	12.5	16.2
1965	9.8	9.6	10.5	14.4	18.4	19.3	21.8	22.0	22.1	20.2	17.8	13.7	16.6
1966	9.3	8.3	10.3	15.5	17.2	20.0	22.9	22.9	21.9	20.3	17.0	12.2	16.5
1967	9.5	9.7	13.1	16.6	18.4	18.7	22.2	22.9	21.7	19.9	15.6	12.7	16.7
1968	8.0	8.2	11.2	15.1	17.3	20.0	22.7	23.4	21.7	19.7	15.0	10.2	16.0
1969	7.8	7.9	9.8	15.2	19.3	21.9	23.2	22.3	21.9	20.6	15.0	11.5	16.4
1970	8.5	9.7	12.8	16.6	19.7								
MONTHLY AVERAGES													
	8.8	9.3	11.4	15.5	18.8	21.2	23.3	23.8	23.1	20.3	16.2	11.6	
											OVERALL AVERAGE		16.9
STANDARD DEVIATIONS													
	0.9	1.6	1.5	1.3	1.1	1.2	1.1	1.4	1.4	1.0	0.9	1.1	
1935-1950 AVERAGE													
	11.5	10.0	14.0	19.0	23.5	26.0	28.5	28.5	26.5	21.5	16.0	12.0	19.7

River Tributaries

The five main streams on the plantsite are Savannah River tributaries. They arise on the Aiken Plateau and descend 100 to 200 feet before discharging to the river. On the plateau, the streams are clear except during periods of high water. Rainfall soaks into the ground, and seepage from the sandy soil furnishes the streams with a rather constant supply of water throughout the year.

In addition, four of the streams have received reactor cooling water discharges. These discharges, many times the natural stream flows, cause the streams to overflow their original banks along much of their length. Because of the temperature of these discharges, fish cannot survive in the streams from the discharge point to the lower reaches of the streams.

The five tributaries are Upper Three Runs, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs.

Upper Three Runs

Upper Three Runs, the longest of the plant streams, differs from the other four streams in two respects: it is the only one with headwaters arising outside the plantsite, and it is the only one that has never received heated discharges of cooling water from the production reactors.

Upper Three Runs drains an area of about 190 square miles. Its significant tributaries are Tinker Creek, a rather lengthy headwaters branch, and Tims Branch, which receives industrial wastes from the fuel fabrication facilities (M Area) and the Savannah River Laboratory and flows through an impoundment, Steeds Pond. The M Area effluent flow averages about 1 cfs. In July 1972, Tims Branch flowed at 1.6 cfs below Steeds Pond and 4 cfs just before discharge into Upper Three Runs.

The flow and temperature of Upper Three Runs has been monitored at the Highway 125 crossing. Fourteen flow rate measurements between 1960 and 1966 ranged from 193 to 529 cfs and averaged 265 cfs. Flows measured in June and July 1972 were 345 and 195 cfs, respectively. The average temperature for 1959 to 1966 was 16.9°C, with a maximum monthly average of 23.0°C in July.

Four Mile Creek

Four Mile Creek follows a generally southwesterly path to the Savannah River for a distance of about 15 miles. In the swamp along the river, part of the creek flow empties into Beaver Dam Creek, a much shorter stream that discharges into the river. The remainder of the Four Mile Creek flow discharges through an opening in the levee between the swamp and river, seeps through the levee into the river, or flows down the swamp and mixes with Steel Creek and Pen Branch.

Four Mile Creek and Beaver Dam Creek together drain about 35 square miles and receive discharges from four plant areas. Four Mile Creek receives effluents from F and H separations areas and the reactor cooling water discharge from C reactor. The average flow upstream of any plant discharge is less than 0.5 cfs and is increased by F and H effluents and drainage to about 20 cfs just above the confluence with the C reactor discharge. After the junction with the C reactor cooling water, the creek flows about seven miles before entering the river swamp. Beaver Dam Creek receives 65 to 130 cfs of effluent from the heavy water production process and the associated power generating plant in D Area.

Pen Branch

Pen Branch follows a path roughly parallel to Four Mile Creek until it enters the river swamp. The only significant tributary is Indian Grave Branch, which flows into Pen Branch about 5 miles above the swamp. Pen Branch enters the swamp about 3 miles from the river, flows directly toward the river for about 1.5 miles, and then turns and runs parallel to the river for about 5 miles before discharging into Steel Creek about 0.5 mile from its mouth.

Pen Branch with Indian Grave Branch drains about 35 square miles above the swamp. Indian Grave Branch receives the effluent cooling water from K reactor. Above the K Area discharge, Indian Grave Branch flow averages only about 1 cfs; above Indian Grave Branch, Pen Branch is also a small stream averaging 5 to 10 cfs.

Steel Creek

Steel Creek flows southwesterly for about 4.5 miles, then turns to flow almost due south for about 5.5 miles, and enters the river swamp 2 to 3 miles from the river. In the swamp, it is joined by Pen Branch.

The drainage area of Steel Creek and its main tributary, Meyers Branch, is about 35 square miles. Steel Creek has received the cooling water discharges from two reactors, but it currently receives only about 15 cfs of water at about natural temperature from P Area. The discharge of cooling water effluent from P reactor to Steel Creek was discontinued in 1963 when this reactor was switched to cooling with recirculated water from Par Pond; L reactor discharge ceased in 1968 when the reactor was shut down and placed in standby condition. Flow rates measured in Steel Creek at the Highway 125 crossing in June and September 1972 were 30 cfs.

Lower Three Runs

Lower Three Runs has the second largest drainage area (about 180 square miles) of the plant streams. Near its headwater a large impoundment, Par Pond (see below), has been formed by an earthen dam. The three main arms of the pond follow the stream bed and drainage areas of the upper reaches of Lower Three Runs and its tributaries, Poplar Branch and Joyce Branch. From the dam, Lower Three Runs flows in a southerly, then southwesterly course for about 20 miles to the Savannah River. An arm of the plant follows the stream to the river. Several small tributaries arising off the plantsite flow into the creek in its lower reaches.

Before construction of Par Pond, effluent cooling water from R reactor was discharged via Joyce Branch to Lower Three Runs. Since the pond filled in 1958, the overflow to Lower Three Runs has varied, depending on the utilization of the pond cooling water system by R and P reactors. In 1964, R reactor was shut down and placed in standby condition. Even when both R and P reactors were utilizing the pond, the temperature of the pond overflow water was about natural. During periods of no dam overflow, about 5 cfs seeps through and under the dam to enter Upper Three Runs. When the pond is thermally stratified (primarily during the warmer months), this seepage is usually several degrees cooler than the surface water in the pond.

Par Pond

The Par Pond cooling water impoundment was formed in 1957-1958 by damming Lower Three Runs. The impoundment covers 2,640 acres to an average depth of about 20 feet. The maximum depth near the dam is about 55 feet. A 140-acre portion is separated from the main body by a dam to form the "precooler," which is now considered part of the P reactor effluent canal system. There are three major arms in Par Pond (Figure 11): the north or upper arm, the middle arm, and the south or lower arm.

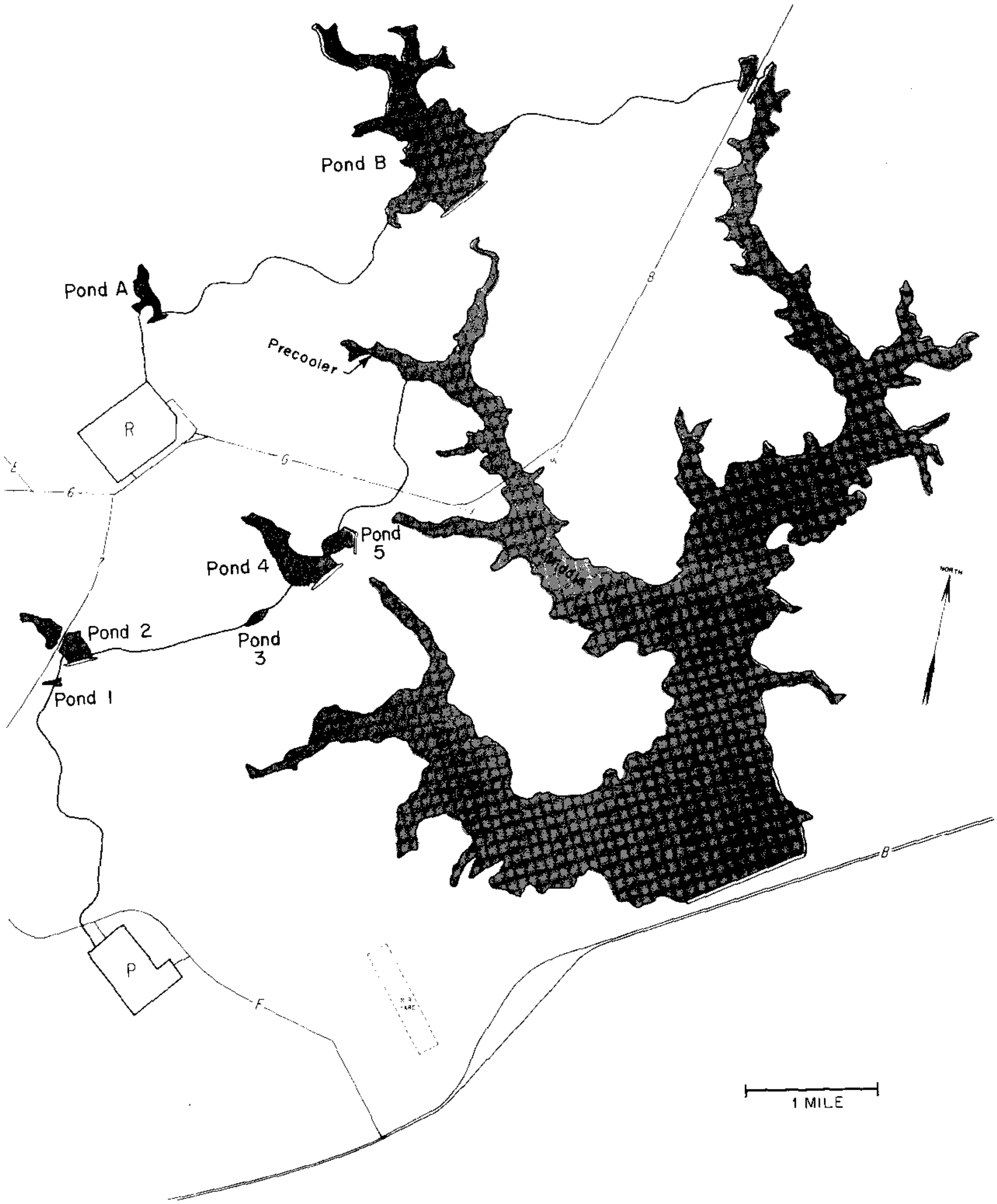

FIGURE 11. Par Pond and Effluent Canals

The canal systems for conducting the effluent cooling water from P and R reactors to Par Pond are also shown in Figure 11. The P canal system is currently in use, but the R system has not received thermal discharges since 1964. From P reactor there are 4-1/4 miles of canals and 5 small impoundments. The largest impoundment besides the 140-acre precooler covers 36 acres; the total surface area of the small impoundments and canals is 227 acres. The now-unused R canal system consists of about 3.5 miles of canals and two impoundments, 7.4 and 260 acres in size, respectively. The total surface area of the system is 285 acres.

River Swamp

On the plantsite, a swamp lies in the floodplain along the Savannah River for a distance of about 10 miles and averages about 1.5 miles wide. A small embankment or natural levee has built up along the north side of the river from sediments deposited during periods of flooding. Next to the levee, the ground slopes downward, is marshy, and contains stands of large cypress trees and other hardwoods. During periods of high river level, river water overflows the levee and stream mouths and floods the entire swamp area, leaving only isolated islands. When flow subsides, stagnant pools of water remain, but even with the pools and meandering channels, much of the land in the swamp is nearly dry.

Three significant breaches in the natural levee allow discharge of creek water to the river - the mouths of Beaver Dam Creek, Four Mile Creek, and Steel Creek. The Beaver Dam Creek discharge contains the effluent from the D Area heavy water plant plus part of the Four Mile Creek flow, carrying the C reactor effluent cooling water. During swamp flooding, the water from these streams flows through the swamp parallel to the river and combines with the Pen Branch flow. Pen Branch does not discharge directly to the river, but flows through the swamp and joins Steel Creek about 0.5 miles above its mouth.

Carolina Bays

Carolina Bays are peculiar shallow natural depressions or craters found on the plantsite and on the Coastal Plain province of North and South Carolina and Georgia; thousands of these bays have been identified from aerial photographs, soil surveys, topographic maps, and studies from the ground.

The origin of the bays is still a subject of scientific controversy, although these depressions have been known and studied for a long time. They were first seriously studied by Glenn,[2] who theorized that they might be the result of ocean waters readvancing up stream valleys. Later, Melton and Shriever[3] proposed the hypothesis of meteoritic origin, which gained worldwide attention, but this has been subsequently seriously challenged. A more recent study by Johnson[4] concluded that the craters were the result of artesian waters rising upward through breaks in the overlying rock layer. A crater was washed out in the surface sand, some of the surface materials were dissolved, and then a combination of wave and wind action formed the characterisitic sand rims. This theory, although answering many of the criticisms of earlier explanations, is not accepted by many geologists as the final complete solution to the problem. Siple[5] favors the hypothesis that the depressions originated with a subsidence following solution of underlying calcareous material (limestone, marl, or shell mixed with sand). In addition to the authors mentioned above, many others have contributed to the literature on the origin of Carolina Bays.

Some of the physiographic features that are common to most bays and that make them so interesting geologically are:

- These depressions are frequently ovoid or elliptical in shape with smooth undissected curves forming the margin of the depression.
- They show a remarkable degree of parallelism in the direction of orientation of their longer axis; they extend generally in a northwest-southeast direction.
- The depressions are often rimmed by low sandy ridges, which are more noticeable on the southeast quadrant.

The depressions are only a few feet below the surrounding terrain, and the length varies from a few hundred feet to four miles. In the bays on the Savannah River Plant site, the vegetation is sufficiently different from that of the adjacent land that the presence of the bay can be determined easily. Although some bays are overgrown by a dense thicket of trees and shrubs, many are open and covered by herbaceous plants. The amount of water in the bays is variable; some appear to be wet throughout the year, while others are completely dry during months of low precipitation.

Chemical Composition of Surface Water

Surface water on the plant and surrounding areas (Figure 12) is very low in dissolved solids and iron and is very soft (Table III).[6] All surface water, except that from the Salkehatchie River near Barnwell, has pH values between 6 and 7; the pH of water from the Salkehatchie River is 7.3. Water from this river is also the hardest. The area around Barnwell is underlain by calcareous deposits; therefore, seepage to the surface stream is characterized by the analogous chemical composition of water in the aquifer. Similarly, the composition of water from Holley Creek is characterized by the chemical composition of the water in the Tuscaloosa aquifer underlying this area.

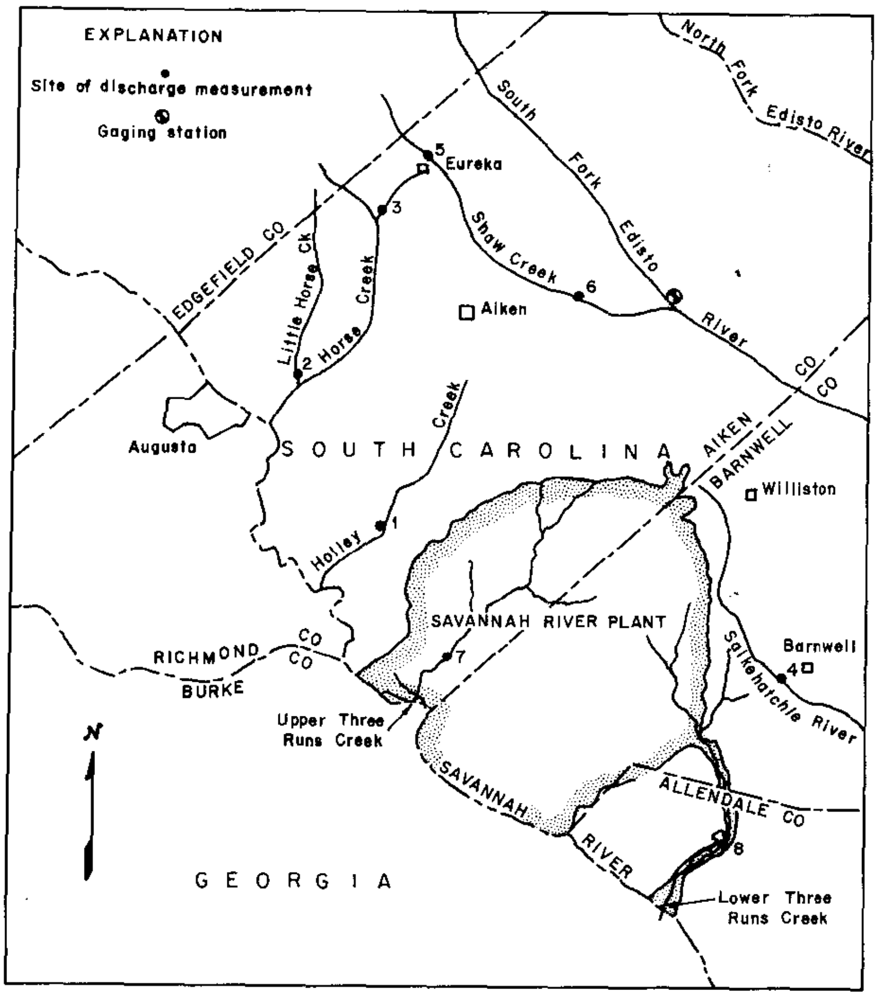

FIGURE 12. Locations of Stream Discharge Measurements

TABLE III

Chemical Analysis of Surface Water in SRP Area

Location (Fig. 12)	SiO_2	Total Iron	Calcium	Magnesium	Potassium plus Sodium	HCO_3^-	SO_4^{2-}	Cl^-	F^-	NO_3^-	Dissolved Solids	Hardness, $CaCO_3$	Specific Conductance (25°C), μmho	pH
	ppm													
1	6.7	0.14	0.6	0.4	2.4	3	1.7	2.5	0.1	0.5	17	3	15.5	6.4
2	5.4	0.14	1.0	0.5	2.2	4	1.4	2.5	0.1	1.0	18	5	21.2	6.3
3	4.9	0.06	0.6	0.3	2.2	3	1.0	2.1	0.1	0.9	13	3	14.7	6.4
4	8.9	0.05	8.8	0.6	2.0	27	1.1	3.4	0.1	0.5	48	24	63.6	7.3
5	6.3	0.20	1.3	0.7	4.8	7	1.2	5.1	0.1	2.7	28	6	34.8	6.8
6	6.6	0.31	0.8	0.5	3.6	5	1.5	3.6	0.1	1.2	23	4	24.5	6.8
7	2.0	0.30	0.5	3.0	2.0	35	0.8	0.8	–	0.5	12	13	25.0	6.5
8	1.4	0.30	3.0	7.0	10	17	3.0	1.3	–	0.5	50	37	60.0	6.9

GROUND WATER

Ground water is defined as that part of the water beneath the land surface that is free to move by gravity. It occurs in the zone of saturation, in which all the interconnected openings or pores in the rocks of the earth's crust are filled with water under hydrostatic pressure. The top of the zone of saturation is the water table, except where that surface is formed by impermeable material. The number, size, and shape of the openings in porous rocks and sediments and the degree of their interconnection determine the amount of water that can be stored in the openings and the effectiveness of any saturated geologic formation to yield water to wells. A water-bearing bed or stratum of permeable rock, sand, or gravel capable of yielding considerable quantities of water to wells or springs is called an aquifer. Geologic formations that are adjacent to but less permeable than aquifers are called confining beds because they tend to restrict or retard the movement of ground water.

Within the zone of saturation, ground water occurs under either water-table or artesian conditions. Under water-table conditions the ground water is not confined, and the upper surface of the saturated zone is free to rise and fall. Under artesian conditions the ground water is confined between an upper and lower confining bed, and the piezometric surface of the aquifer is above the top of the aquifer. The piezometric surface is an imaginary surface that coincides with the level to which the confined water rises in wells. If the artesian reservoir is penetrated by a well, the water rises in the well above the bottom of the upper confining bed.

Normal Water Table of Plant Area

The normal water table has not been well defined north of Upper Three Runs Creek. The highest recorded elevation south of Upper Three Runs is 286 ft above mean sea level recorded near H Area on March 30, 1965. Along the Savannah River at the southeast corner of the plant, the elevation must be no more than 80 ft above mean sea level.* Local levels in the water table are modified by elevations of the drainage courses and variation in the permeability of the subsoil. In some areas, the water table and creek flow are sustained both by artesian water rising from the Tuscaloosa formation and by rainfall.

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* At the Savannah River Plant, the nominal level of the river varies from about 84 feet above mean sea level near the upper plant boundary to about 80 feet at the lower boundary.

Characteristics of Ground Water

Chemical Composition

The ground water from all aquifers in the area has a chemical composition within limits for potable water defined by the U. S. Public Health Service. However, some samples have very high concentrations of iron. The temperature of ground water from all aquifers is between 65.5 and 71°F. Table IV[6] compares the chemical compositions of characteristic ground water samples from different aquifers.

TABLE IV

Properties of Ground Water for Different Aquifers in the SRP Area

Number of Analyses		Iron (ppm)	Calcium (ppm)	Magnesium (ppm)	Sodium and Potassium (ppm)	Bicarbonate (ppm)	Sulfate (ppm)	Chloride (ppm)	Fluoride (ppm)	Nitrate (ppm)	Dissolved Solids (residue on evaporation at 180°C) (ppm)	Hardness as $CaCO_3$ (ppm)	pH
TUSCALOOSA FORMATION													
13	Maximum	0.77	1.4	0.9	6.7	17	4.8	4.0	0.1	8.8	28	7	6.9
	Median	0.16	0.9	0.5	2.1	3	1.4	2.2	0.0	0.6	19	5	5.4
	Minimum	0.00	0.3	0.0	0.9	0	0.5	0.8	0.00	0.0	14	2	4.4
ELLENTON FORMATION													
16	Maximum	4.1	8.7	1.3	4.2	23	27	6.0	0.2	0.9	54	30	6.8
	Median	1.1	6.4	1.0	2.7	12	11	2.1	0.1	0.0	41	19	5.9
	Minimum	0.10	3.9	0.4	1.5	4	7.4	1.5	0.0	0.0	36	10	4.4
McBean LIMESTONE													
15	Maximum	1.0	47	9.4	19	171	14	4.5	0.5	6.2	192	132	7.6
	Median	0.25	27	2.0	1.7	94	4.3	2.8	0.1	0.2	95	72	7.1
	Minimum	0.00	17	0.3	0.4	55	0.8	0.4	0.0	0.0	75	50	6.8
McBean and Congaree													
9	Maximum	1.84	8.7	4.2	2.4	17	9.3	4.0	0.3	2.3	29	15	6.1
	Median	0.16	1.5	0.7	2.1	5.5	1.9	2.7	0.1	1.3	21	8	5.5
	Minimum	0.04	0.5	0.3	0.4	1	0.8	1.5	0.00	0	20	4	4.2

Water from the Tuscaloosa Formation. The Tuscaloosa Formation (Figure 13) is the principal aquifer in the SRP area and is under artesian pressure over much of the area. The aquifer is recharged predominantly through the Tertiary cover in the high areas around Aiken. Water movement in the aquifer at the plantsite is toward the piezometric low along the Savannah River downstream from Augusta. Outcrop areas along the Savannah River and deeply incised stream valleys near the SRP site are generally areas of discharge.

Water from the Tuscaloosa Formation is generally soft, acidic, and low in dissolved solids. The concentration of alkaline ions (sodium and potassium) is about equal to that of the alkaline earths (calcium and magnesium), and the number of sulfate, chloride, and nitrate ions exceed the number of bicarbonate ions. Although little fluoride ion is found, it does occur in some locations in concentrations up to 0.1 ppm. Water from the Tuscaloosa is corrosive to most metal surfaces because of the very low concentration of dissolved solids and low pH. This is especially true where the water contains appreciable amounts of dissolved oxygen and carbon dioxide. Such water causes iron pipe to deteriorate rapidly and discolors the water flowing through it.

Water from the Ellenton Formation. Wells screened in the Ellenton Formation generally do not have the capacity to yield as much water as the permeable materials in the underlying Tuscaloosa Formation. Because there is no continuous bed of clay separating the two formations, they act as one aquifer.

Water from the Ellenton Formation generally has a low concentration of dissolved solids, a low hardness, a high content of iron, and a comparatively high proportion of sulfate among the ions. The ratio of sulfate ion concentration to total anion concentration ranges from 35 to 65%. The dissolved silica is a relatively constant 22 to 28 percent of the total dissolved solids. The concentration of calcium ions is in excess of the concentration of bicarbonate ions; this may be caused by scattered crystals of gypsum (calcium sulfate) in the Ellenton Formation.

Water from the McBean and Congaree Formations. The McBean and Congaree Formations consist of 1) fine-to-medium sand, 2) green glauconitic marl and clayey sand, 3) laminated beds of red-brown or yellow semiplastic to nonplastic clay, 4) impure beds of soft fossiliferous limestone or marl, and 5) lenses of silicified limestone.

The fine-to-medium sand sections and the limestone section are water bearing and yield moderate-to-sizeable quantities of water to industrial and municipal wells in the area near SRP. Next to the Tuscaloosa Formation, the McBean and Congaree Formations are the most prolific aquifers in the area.

These formations are recharged in the topographically higher regions of SRP and discharge into the major drainageways on the SRP site such as Upper Three Runs, Four Mile Creek, and Steel Creek. Some water also discharges to the Savannah River and some migrates downdip to discharge by upward vertical leakage to overlying formations. Artesian conditions prevail over the greater part of the aquifer's extent, and wells in the southern and southeastern part of the SRP site flow quite freely from the calcareous beds of the formation.

Water from the sandy parts of the McBean and Congaree aquifers is similar in chemical composition to that from the Tuscaloosa Formation. In general, the water is acidic and low in dissolved solids. Water circulating through limestone beds in the McBean

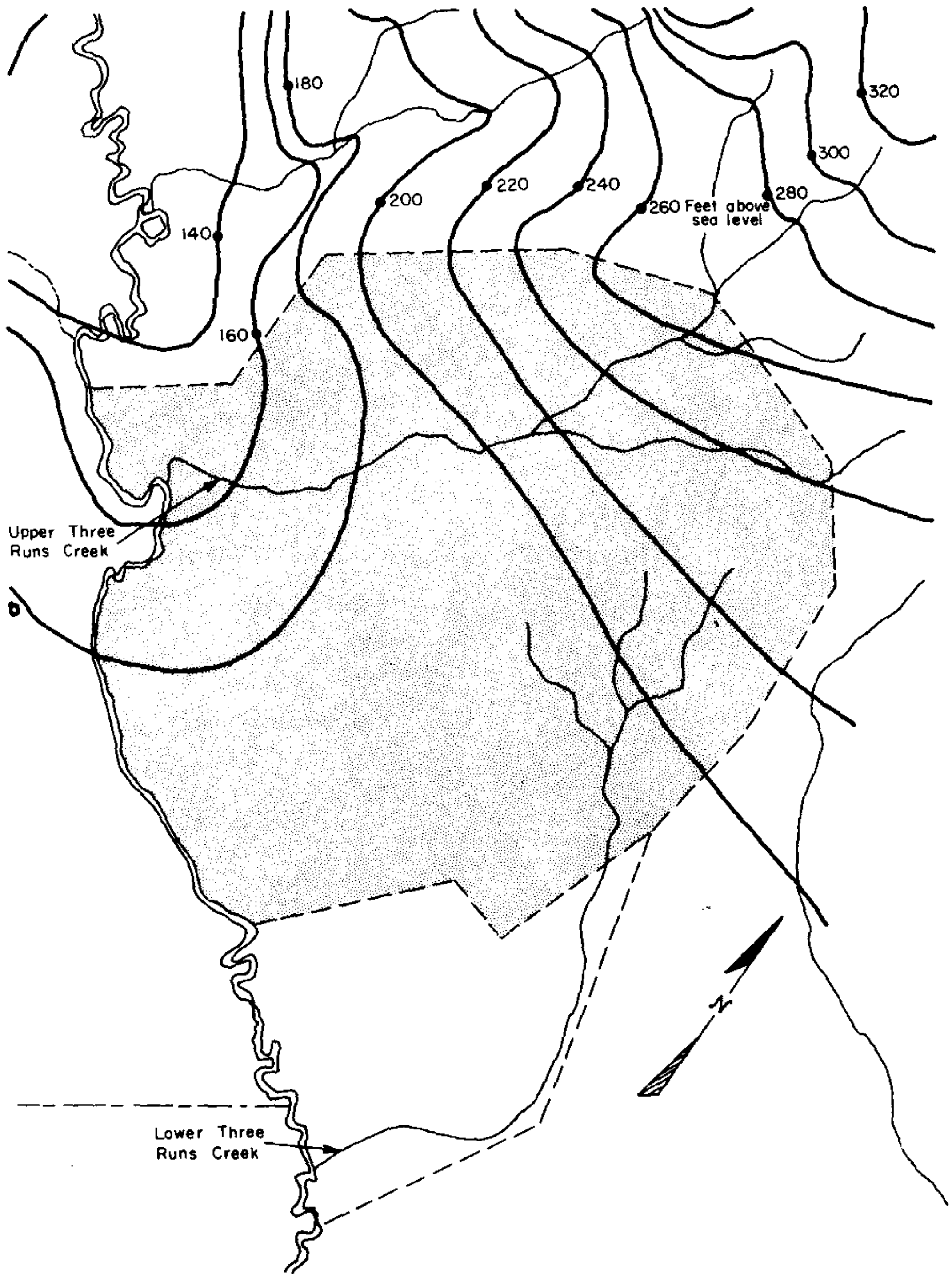

FIGURE 13. Peizometric Map of Artesian Aquifer of Tuscaloosa Formation

Formation contains more dissolved solids and has a higher hardness than any other formation at the SRP site. The water from the McBean limestone beds contains alkaline earth metals in excess of the alkali metals, and the bicarbonate ion is in excess of the total concentration of other anionic constituents. This composition is commonly found in waters circulating through deposits made up predominantly of calcium carbonate. This water also contains higher concentrations of silica than water from any other formation at SRP.

Water from the Barnwell Formation. The Barnwell Formation of Eocene age is a deep-red fine-to-coarse clayey sand and compact sandy clay. Parts of the formation contain mottled-gray or greenish-gray sandy clay and ledges of ferruginous sandstone. Small quantities of water are obtained from the Barnwell Formation at some locations, but ordinarily, large supplies of water are not to be expected.

Natural Radioactivity

The radium content and beta-gamma activity of water from wells in the SRP area are given below.[6]

Natural Radioactivity of Ground Water in SRP Area

Well	Location	Beta-Gamma Activity of Residue, pCi/ℓ	Radium,[a] pCi/ℓ
AL-9	Allendale County Hospital	<50	0.20
AL-8	Sycamore, South Carolina	<50	72
S-377	Ellenton, South Carolina	<50	26
BW-2	Barnwell, South Carolina	<50	1
S-348A	3 miles northwest from Ellenton, South Carolina	<50	30
BW-22	Barnwell, South Carolina	<50	13
AL-16	About 1 mile north from Martin, South Carolina	<100	49
AK-146	About 1 mile west from Town Creek along State Highway 145	<12	0.4
AK-337	14 miles northeast of Aiken, South Carolina	<13	2.0

a. Radium determination was made by the National Bureau of Standards. All other determinations were made by the U. S. Geologic Survey.

HYDROLOGY OF SELECTED REGIONS OF PLANT

Chemical Separations Areas (F and H)

The chemical separations facilities, burial ground, and seepage basins are located between Upper Three Runs on the north and Four Mile Creek on the south. Because Upper Three Runs is more deeply incised, the water table divide is off-set toward Four Mile Creek. Water movement is complex because of great variations in permeability. In general, water moves slowly away from the ground water divide and then at an accelerating rate down the gradient to outcrop at the springs, swamps, and beds of the two streams. Drainage from the burial ground and seepage basins is to Four Mile Creek.

The highest elevation of the water table,* the lowest elevation of the water table, and the depth to the water table for the chemical separations areas during the period 1961 and 1966 are given in Figure 14.

F Area seepage basins are characterized by a perched water table extending southward from Basin 3. Detailed contours on the normal water table (Figure 15) indicate a pronounced downgradient deflection of the contours, which may be explained by:

- The perched water table transports a large quantity of basin water in a southerly direction before it drops down to the normal water table.

- Basins 1 and 2 contribute small ground water mounds that add to a much larger mound from Basin 3 to cause the pronounced downgradient (south) deflection of the contours.

- F Area seepage basins have a relatively flat hydrologic gradient compared to H Area basins (Figure 16) because F Area is closer to the regional watershed divide and is composed of more porous and permeable soils.

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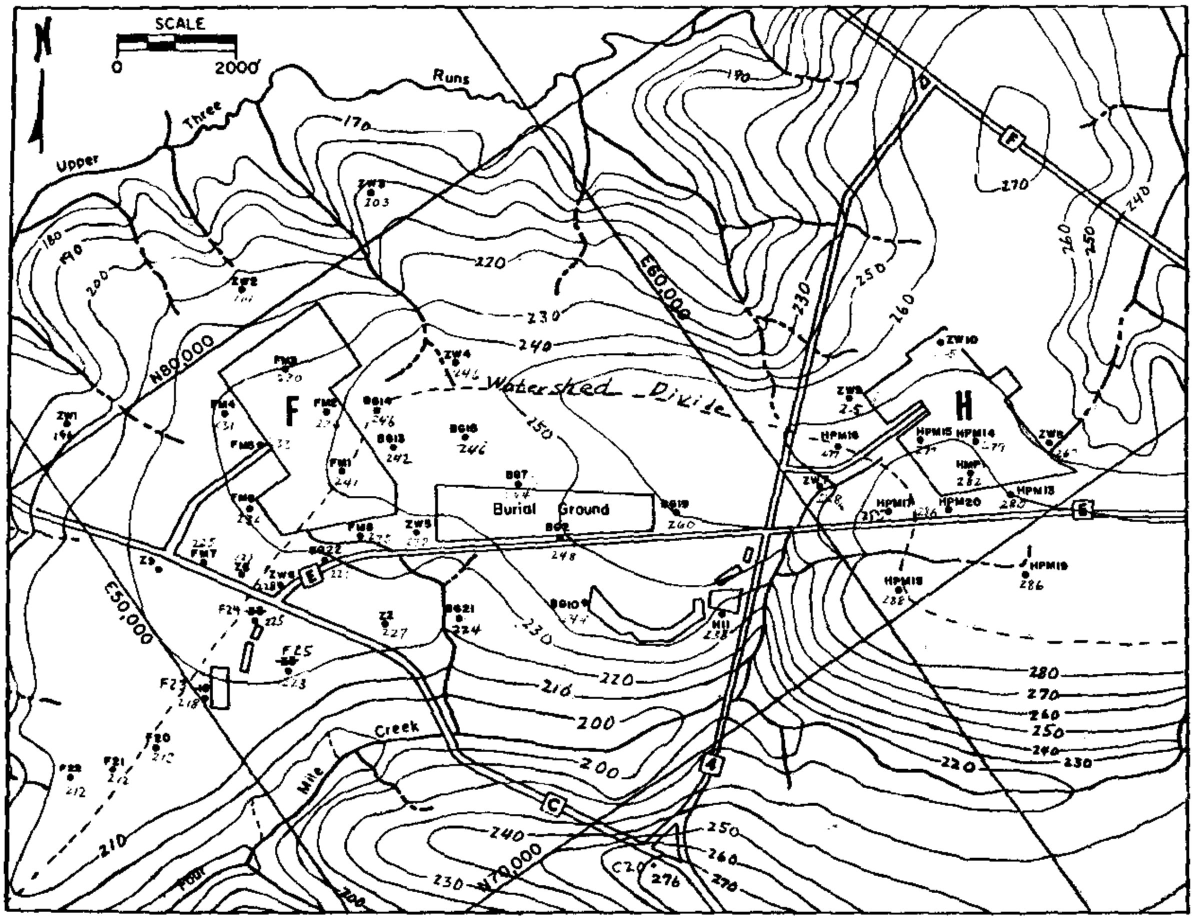
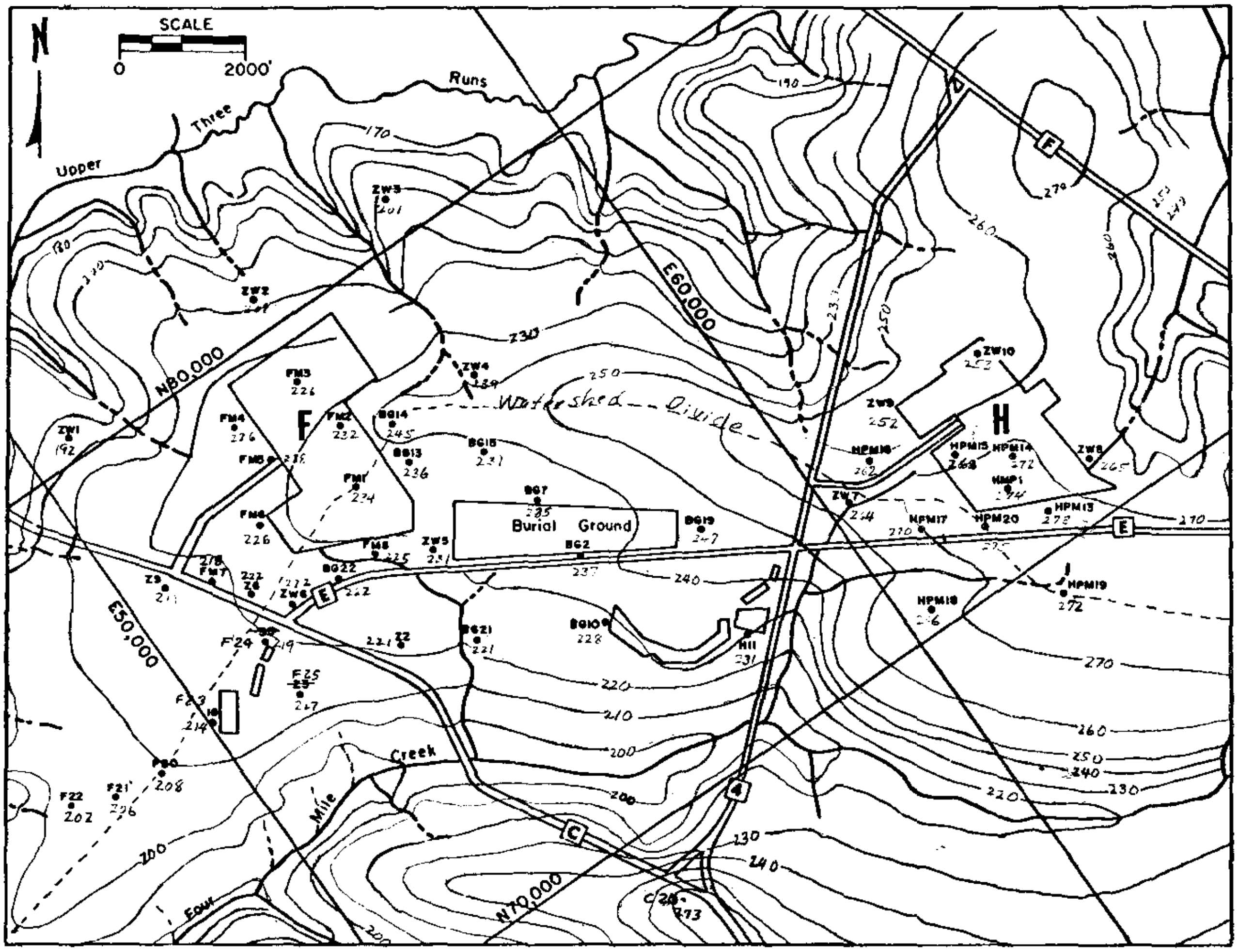
* The water table maps shown in this report were drawn using water level observation wells along the upper slopes and tops of hills and seep lines along flowing streams. The accuracy of the elevations of the 10-ft contours drawn on the water table is within two feet within the area covered by the observation wells. Down slope from the observation wells to the seep line, the accuracy varies between five and two feet of the given 10-ft contour interval, but is more accurate near the seep line.



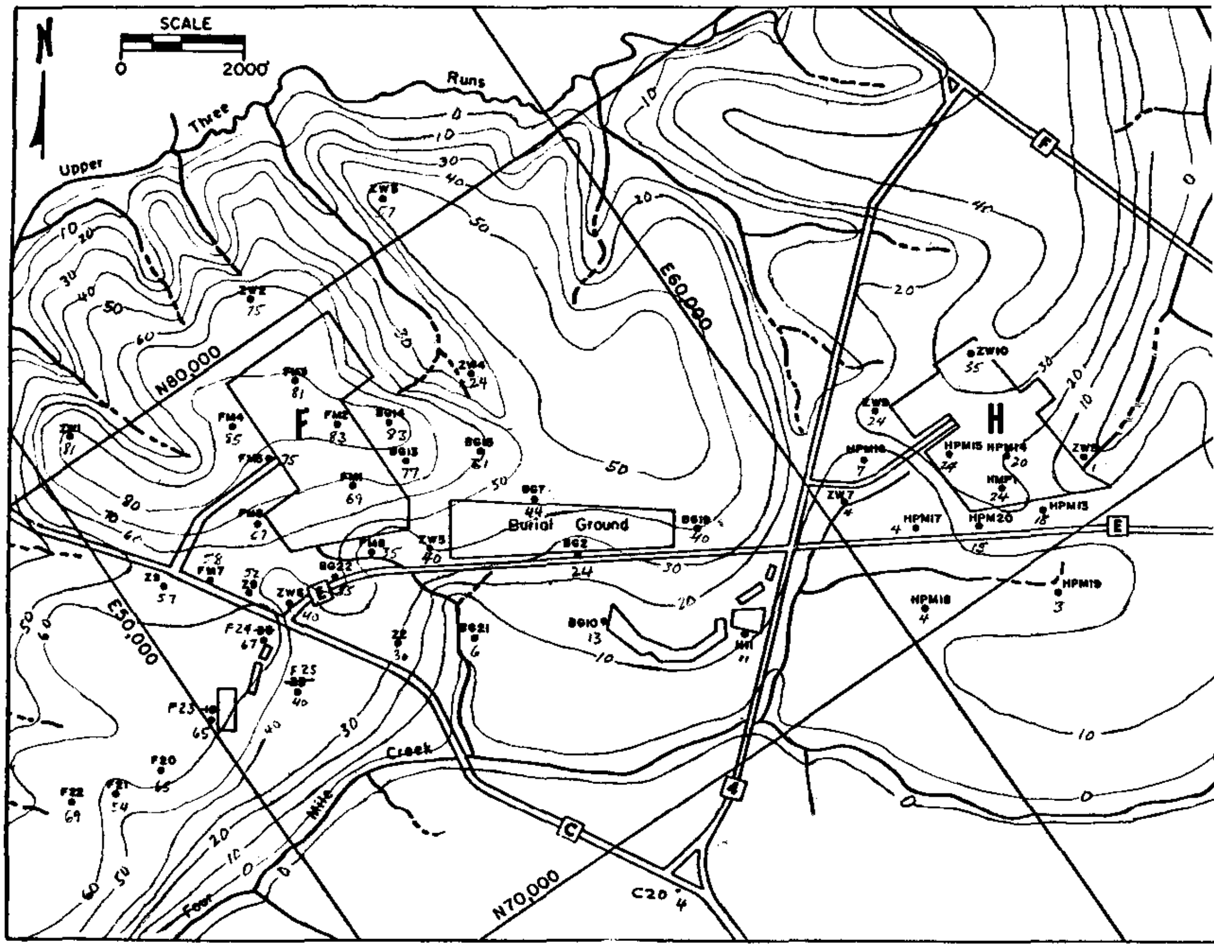
a. Highest Elevation (March 30, 1965)

FIGURE 14. Water Table of Separations Areas



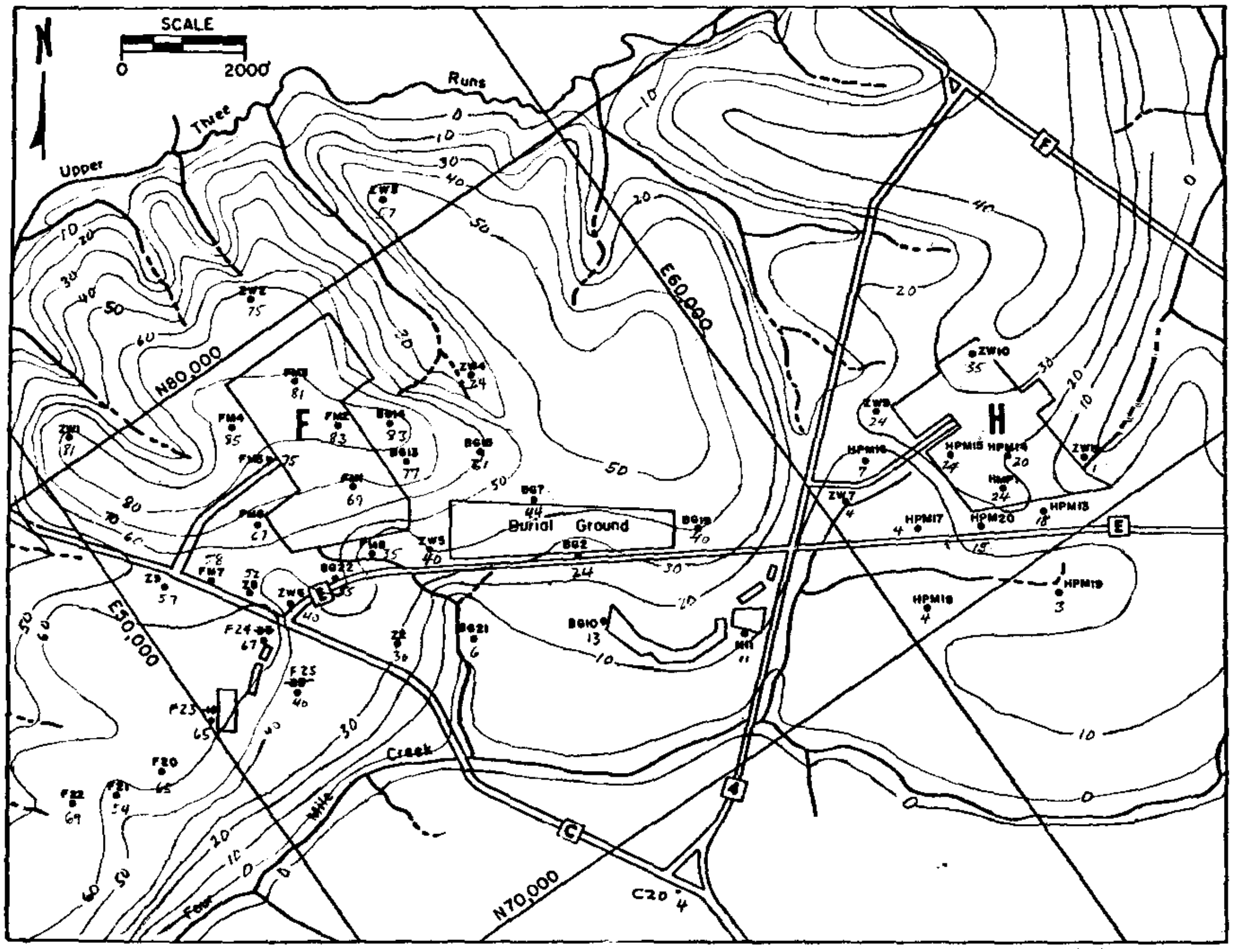
b. Lowest Elevation (During Period 1961-1966)

FIGURE 14. Continued



c. Depth to Water Table

FIGURE 14. Continued



c. Depth to Water Table

FIGURE 14. Continued

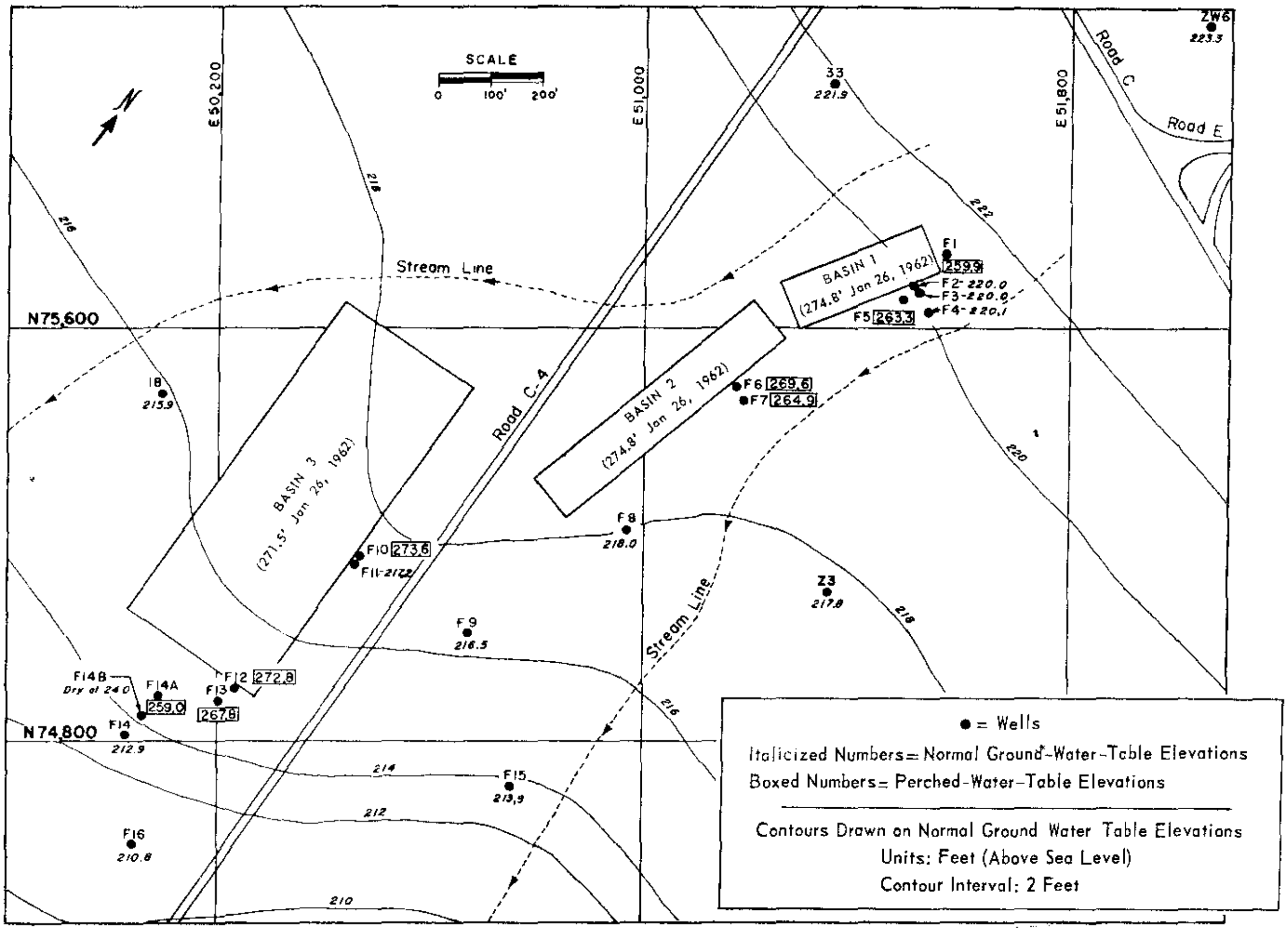


FIGURE 15. Water Table Map of F Area Seepage Basins (February 21, 1962)

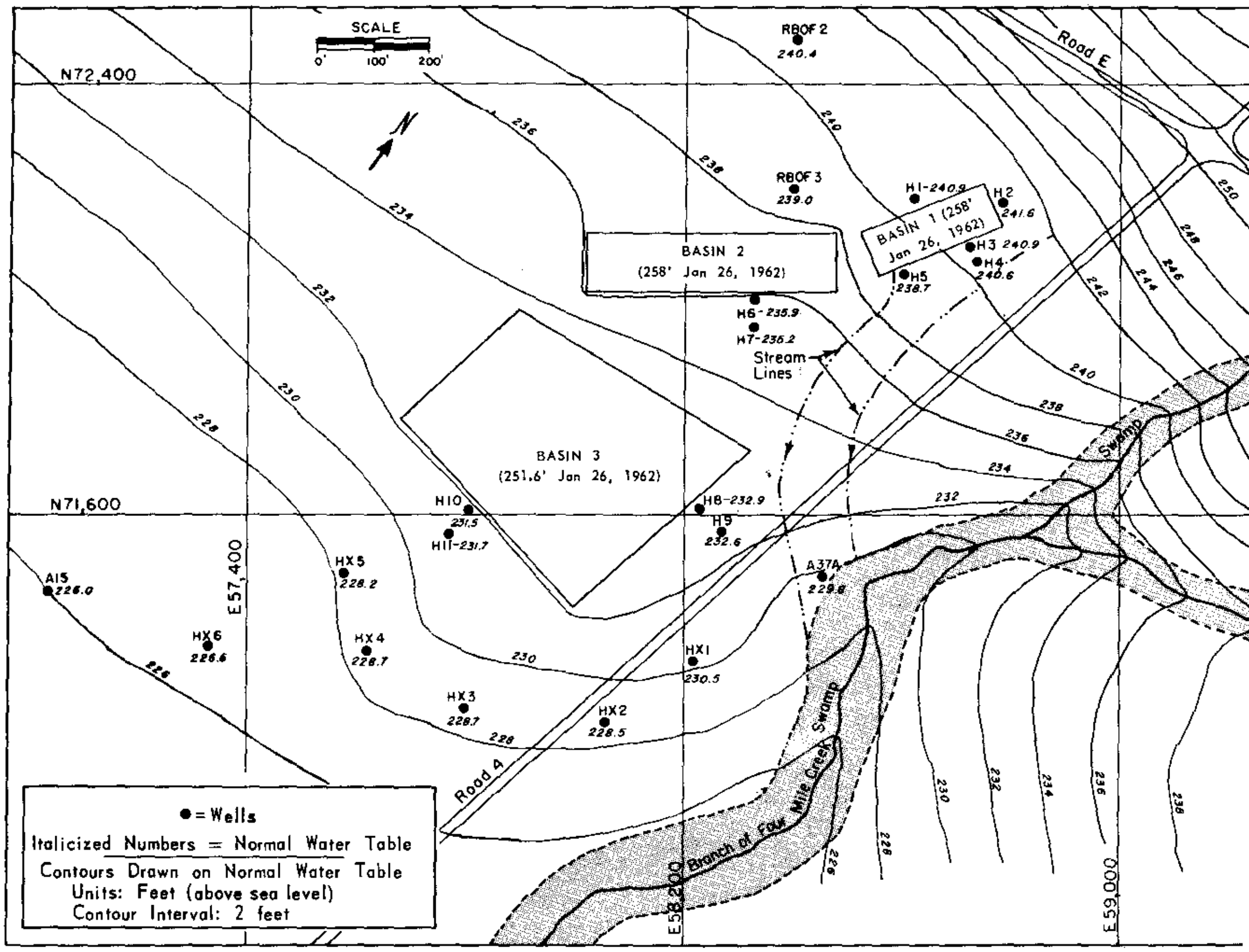


FIGURE 16. Water Table Map of H Area Seepage Basins (February 20, 1962)

H Area seepage basins are not underlain by perched water. The normal water table is only 15 to 25 feet below ground surface. The soils contain a high percentage of clay and have a relatively low permeability except for certain very narrow zones of extremely high permeability. At certain places between these zones, flow is so slow as to be almost imperceptible.

Basement Rock Borings

The ground beneath a 3-mi^2 area between F and H Areas was explored to determine the hydrology of the basement rock. Seven deep rock borings were drilled through 1000 ft of overburden and ∿1000 ft into the basement rock, and water samples were taken. The hydrology of the crystalline rock has been studied extensively.[7-11]

Two separate hydrologic systems exist at this site: the rock system and the overburden system. At the upper surface of the crystalline rock, there is a layer of residual clay about 50 ft thick formed by weathering of the crystalline rock before it was buried by the overlying sediments. This residual clay, called saprolite, effectively separates the water in the fractured crystalline rock from that in the granular material above. Thus, the chemical composition of the water just above the saprolite is quite different from that below. For example, the total dissolved solids in water in the overburden is 34 ppm, whereas that for the water below is 6200 ppm. The water in the crystalline rock contains a dissolved gas with as high as 6 mol % helium; water in the overburden rock contains very little helium. The specific conductance of water from basement rocks exceeds 10,000 μmho, while that from the overburden is generally less than 100 μmho.

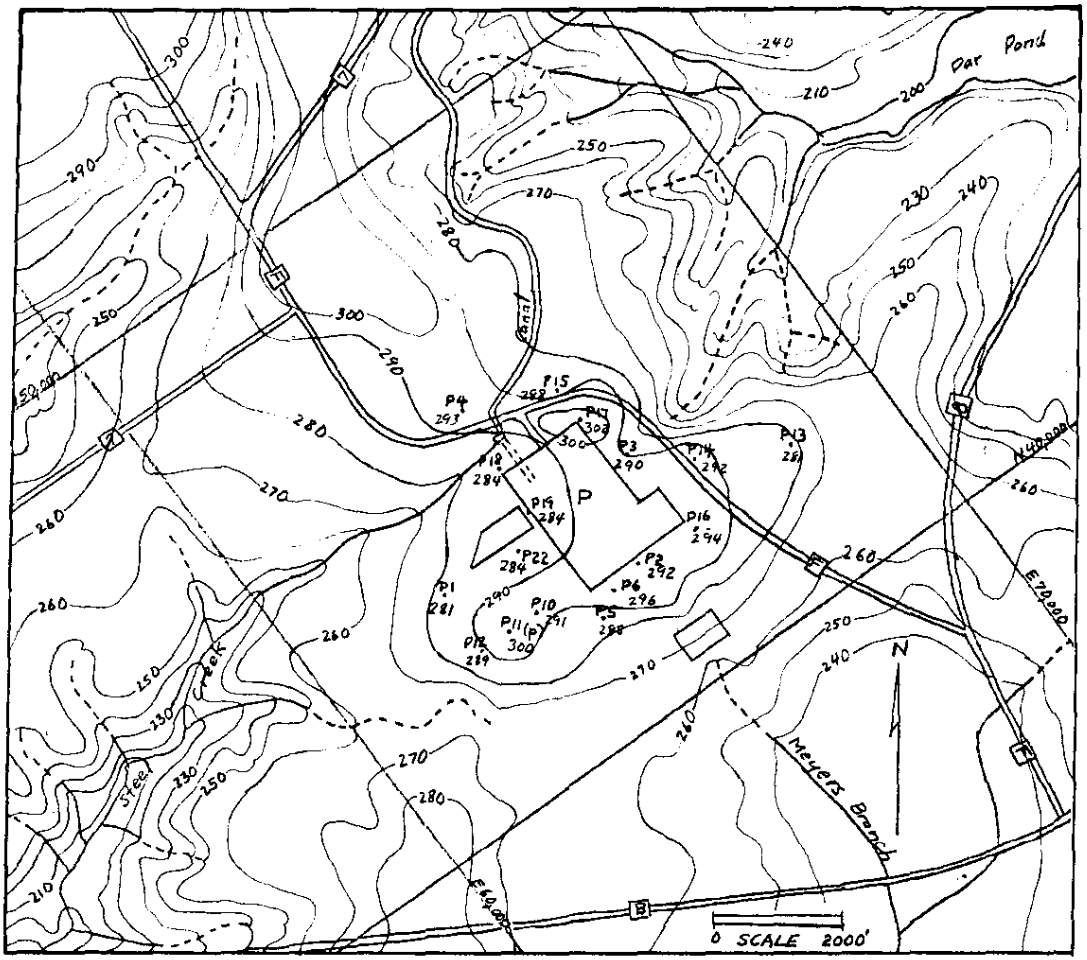
Water occurs under confined conditions in the small fractures within the crystalline rock. The nature of the fractures has been studied,[9-11] and two types of fractures were found to exist in the crystalline rock. The first type consists of small fractures that pervade the entire rock mass, but transmit water extremely slowly. These small fractures link the crystalline rock mass into a single hydraulic system. Rock consisting only of this type of fracture is virtually impermeable. The other type of fracture is restricted to definite zones and consists of larger openings that transmit water at a faster rate. These fractures occur in vertically restricted, but laterally extensive, zones.

Most of the crystalline rock consists of virtually impermeable rock with an average apparent permeability of ∿0.003 gpd/ft^2. A few zones of interlacing fractures occur within the

rock; these zones have an overall coefficient of transmissibility
of ~160 gpd/ft and an average apparent permeability of 1 gpd/ft^2.
Within the zones of interlacing fractures, a few sections have
transmissibilities as high as 120 gpd/ft. The transmissibilities
cannot be converted into values of apparent permeability because 11
the separation and wall conditions of the fractures are not known.

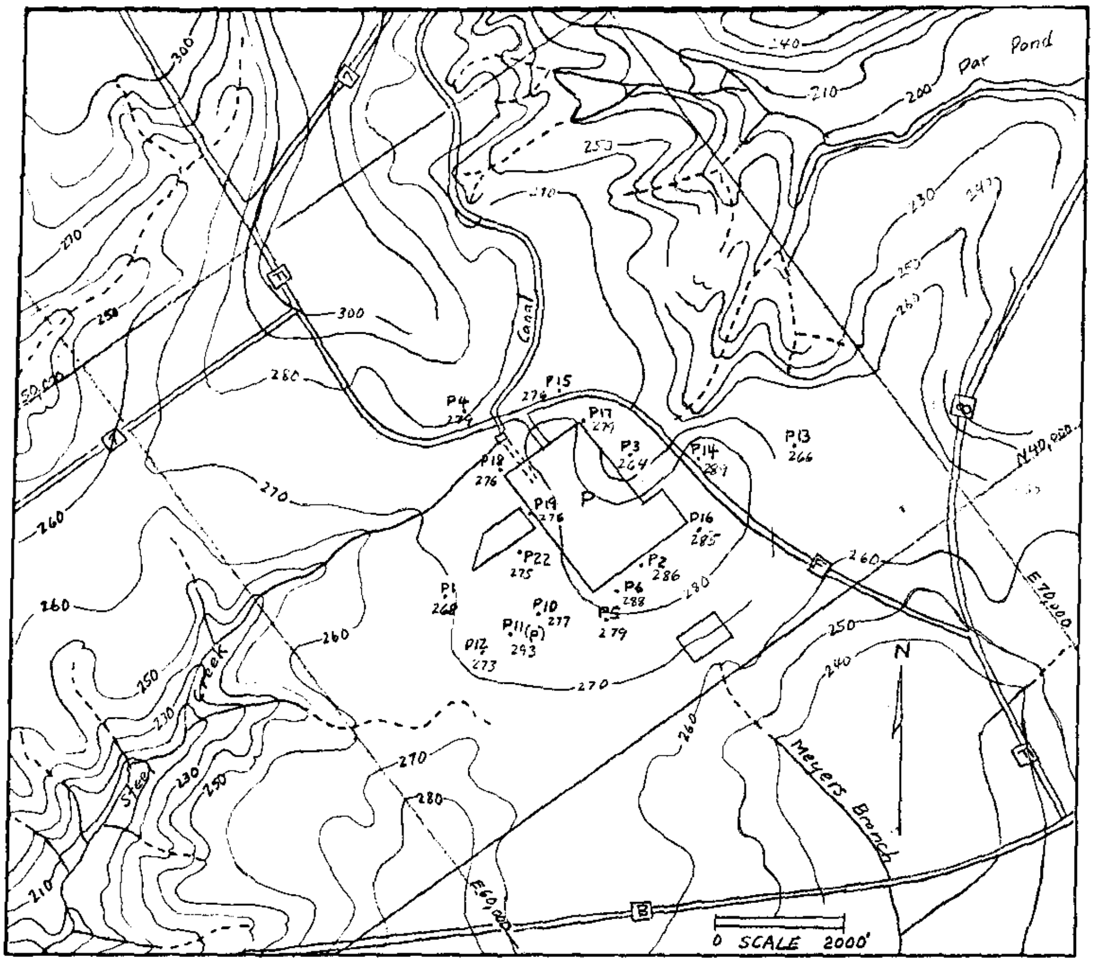
REACTOR AREAS

Water table elevation and depth to water for areas surrounding P, K, C, L, and R reactors are shown in Figures 17 through 21.



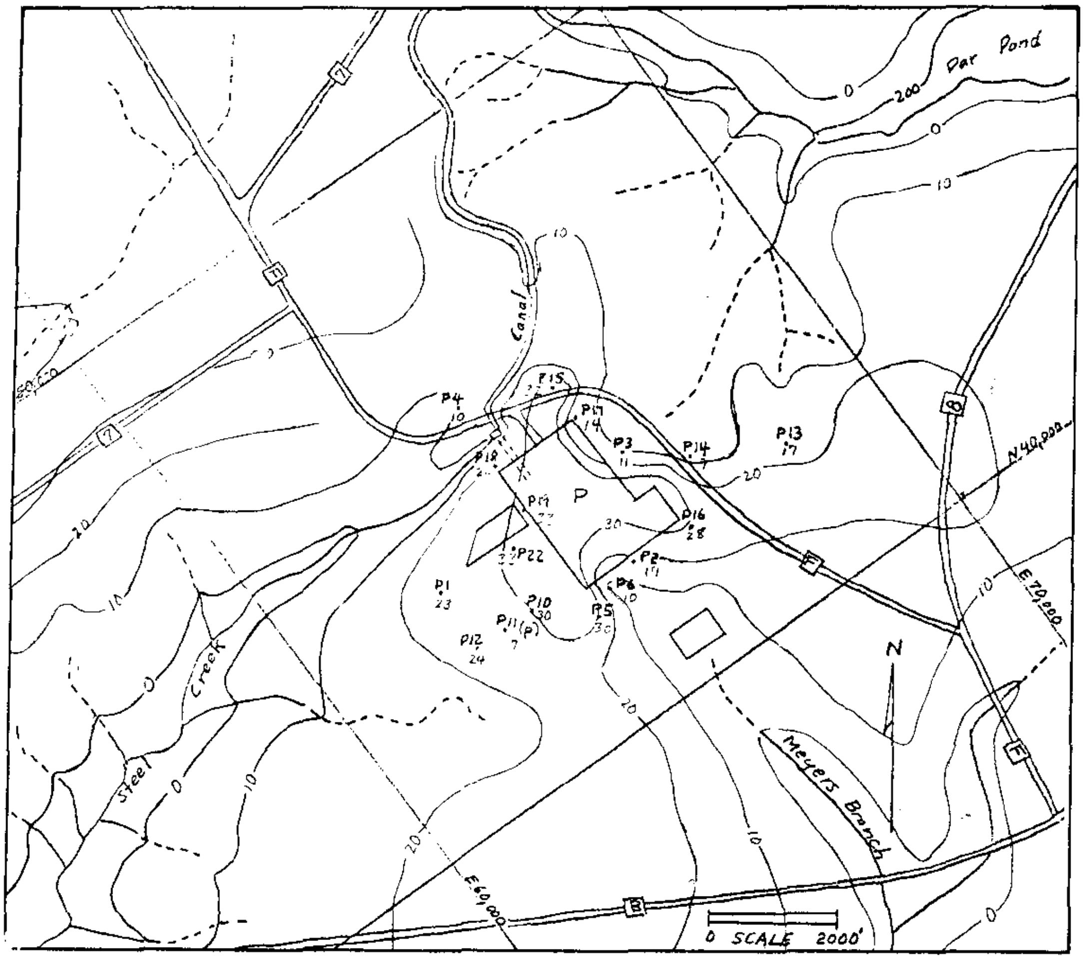
a. Highest Elevation (April 21, 1965)

FIGURE 17. Water Table for P Area



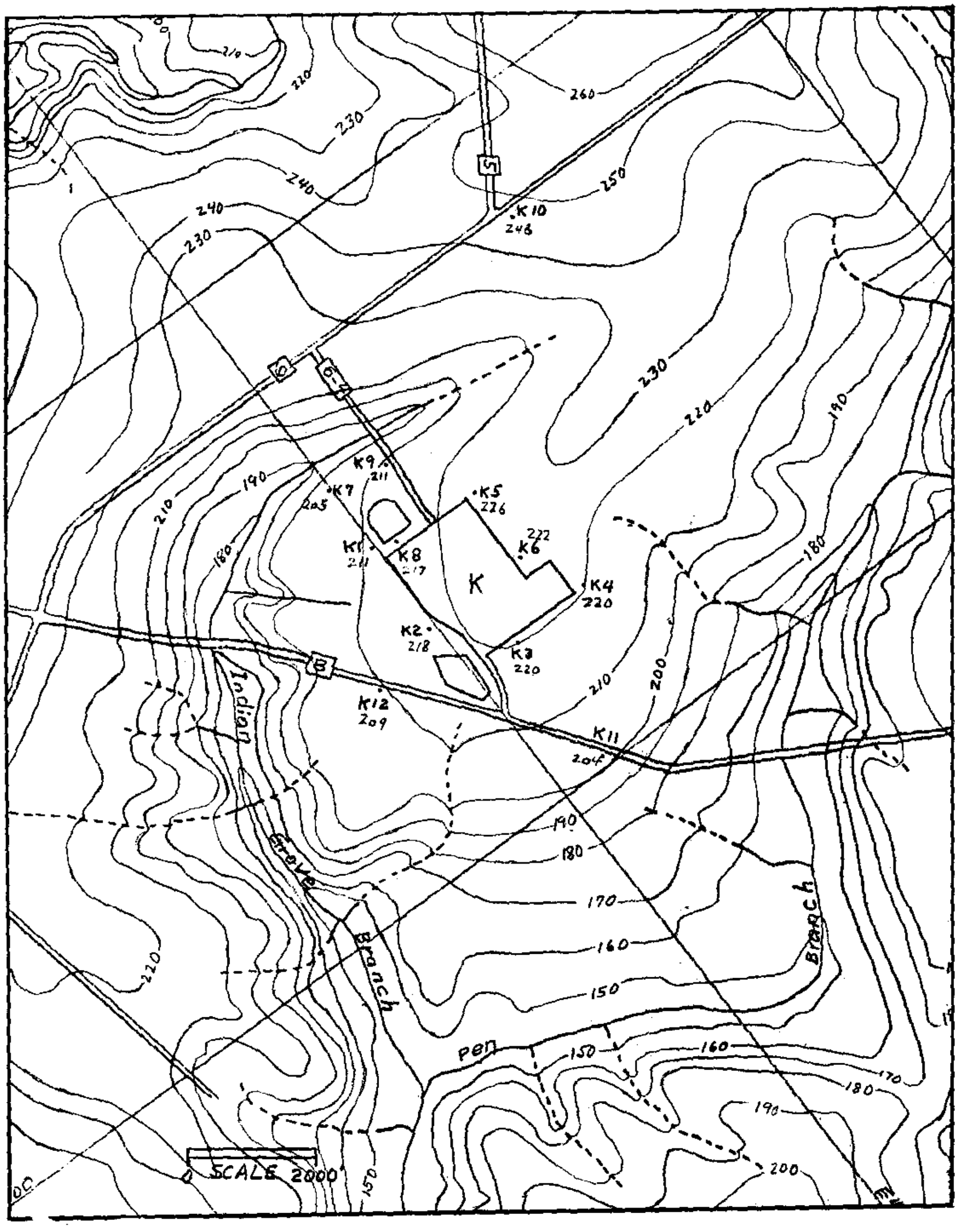
b. Lowest Elevation (December 19, 1963)

FIGURE 17. Continued



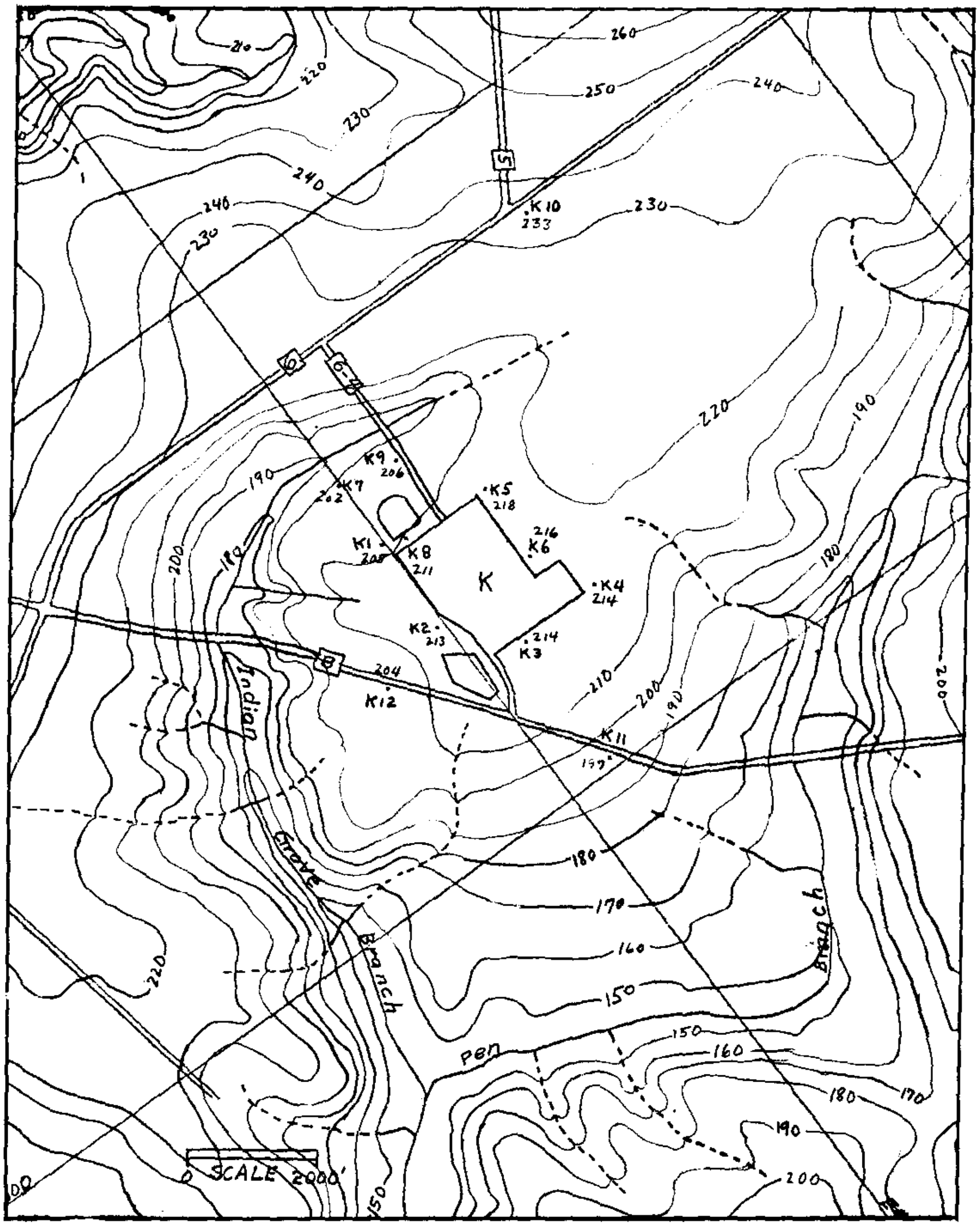
c. Depth to Water Table (April 21, 1965)

FIGURE 17. Continued



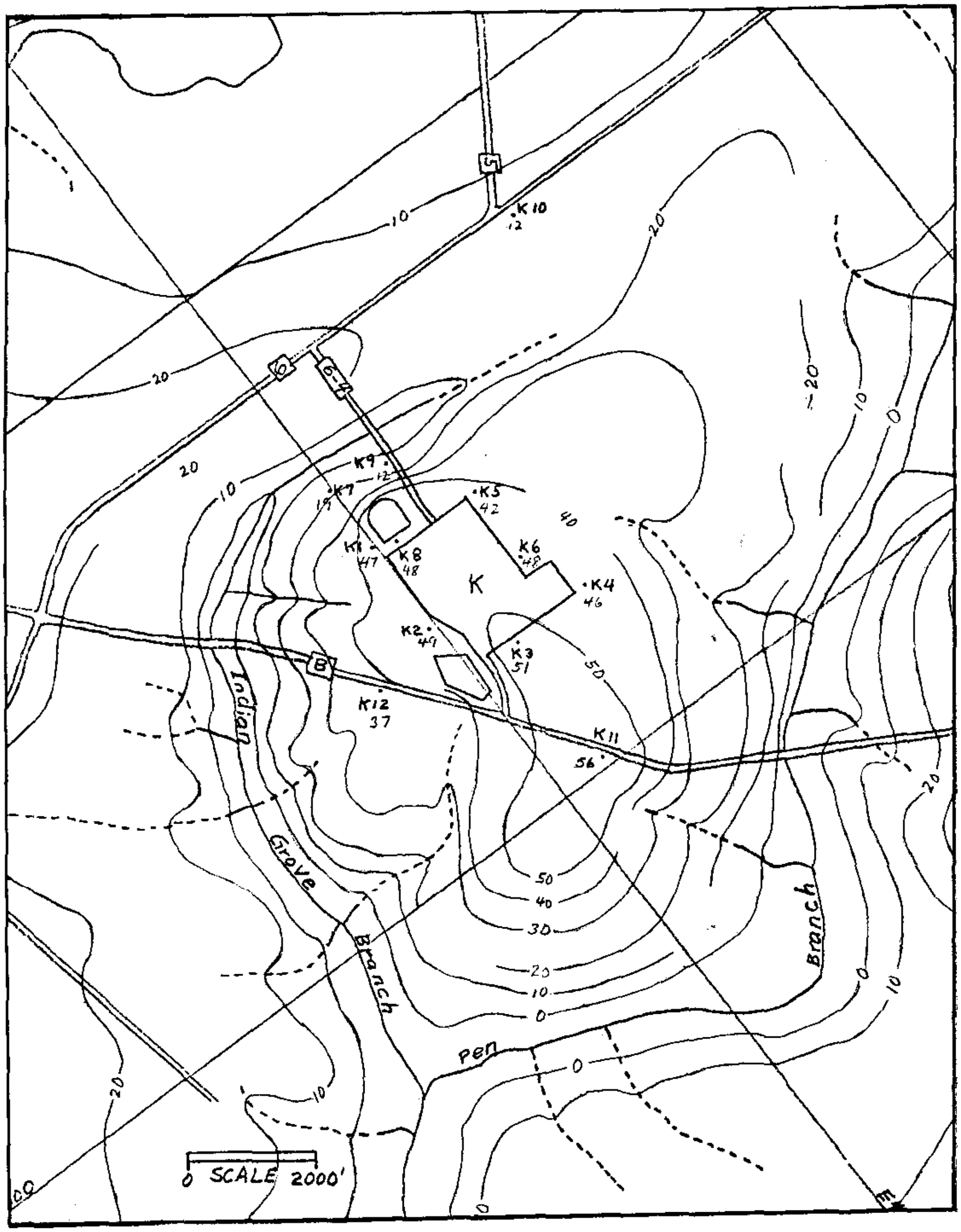
a. Highest Elevation (April 21, 1965)

FIGURE 18. Water Table for K Area



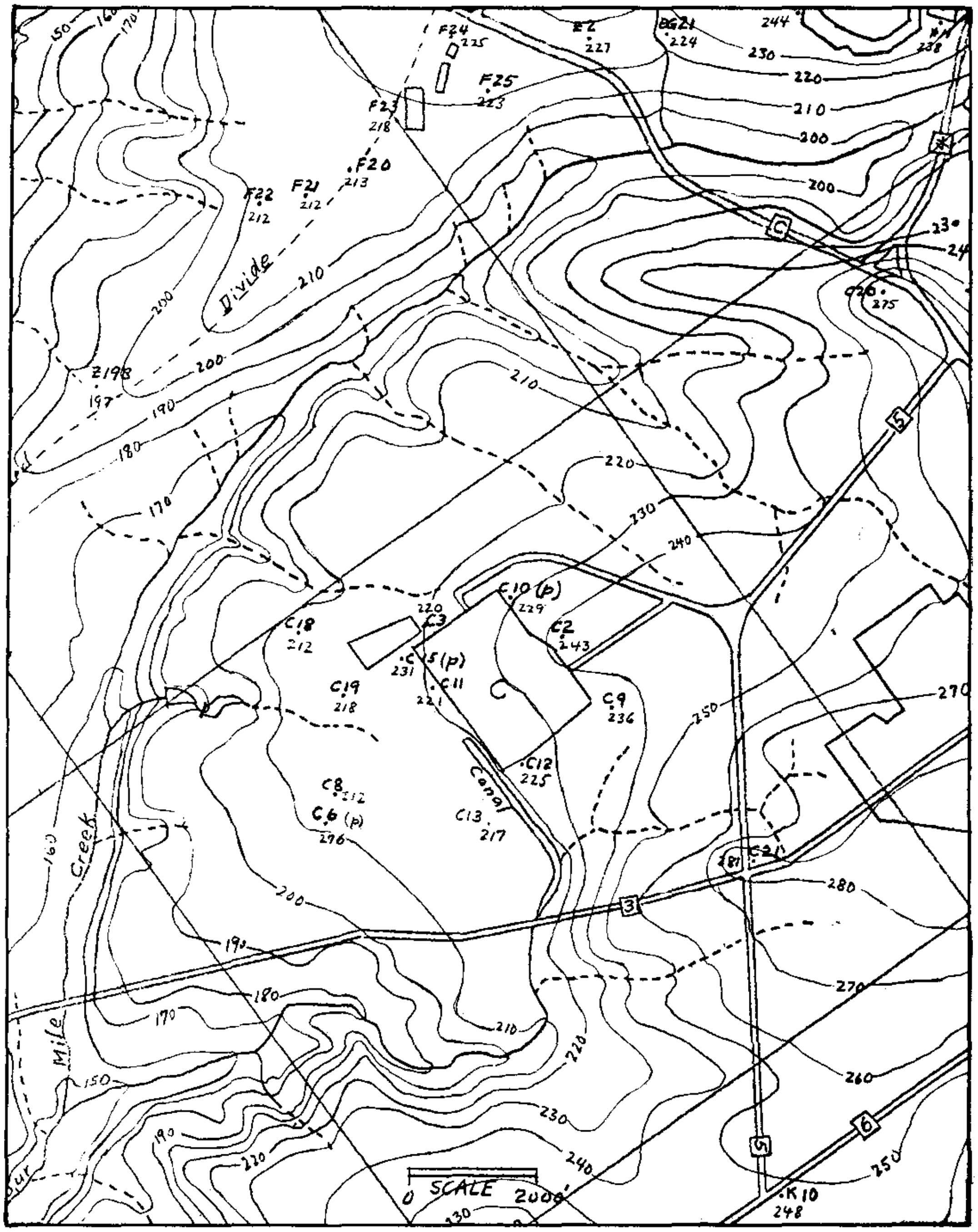
b. Lowest Elevation (December 19, 1963)

FIGURE 18. Continued



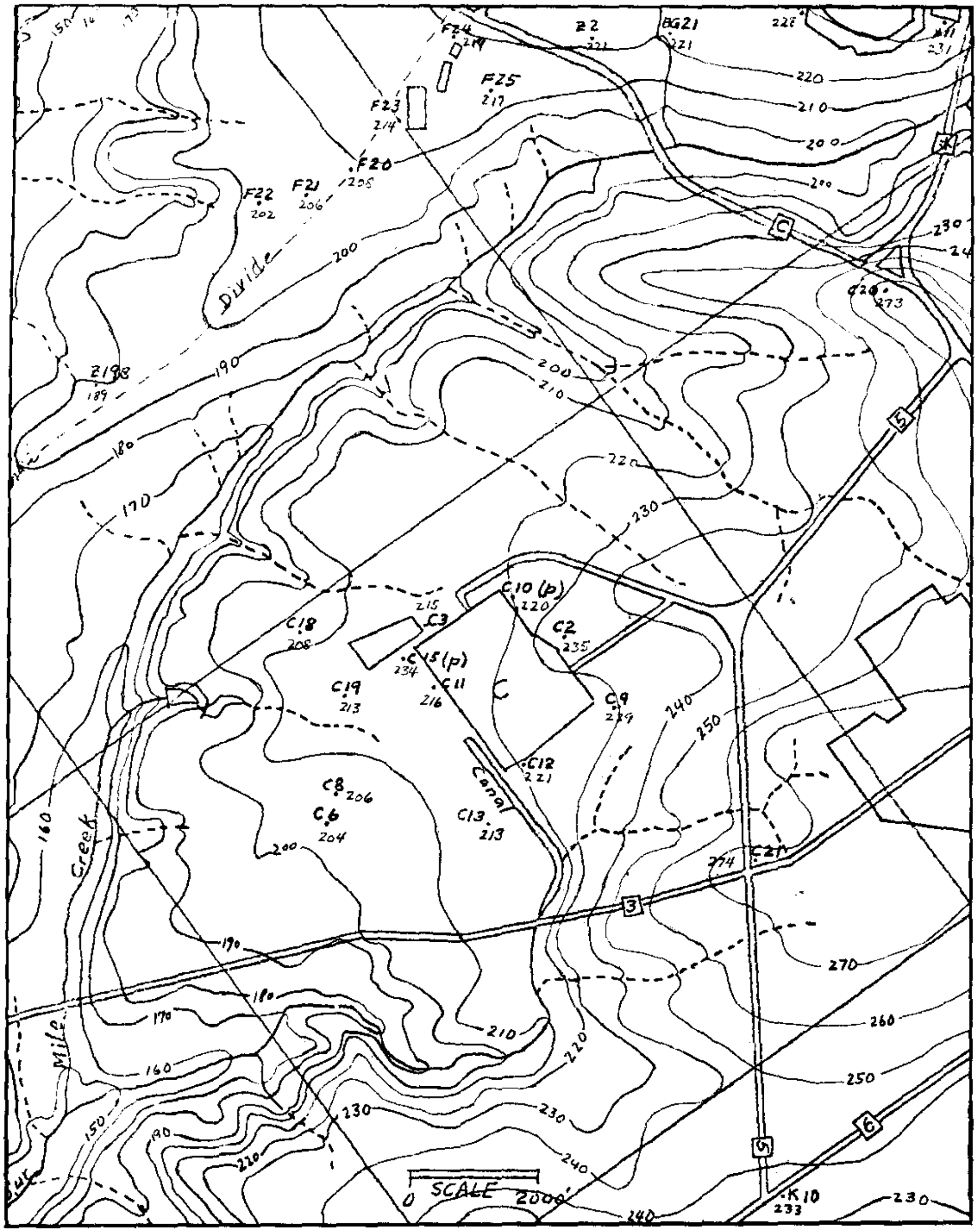
c. Depth to Water Table (April 21, 1965)

FIGURE 18. Continued



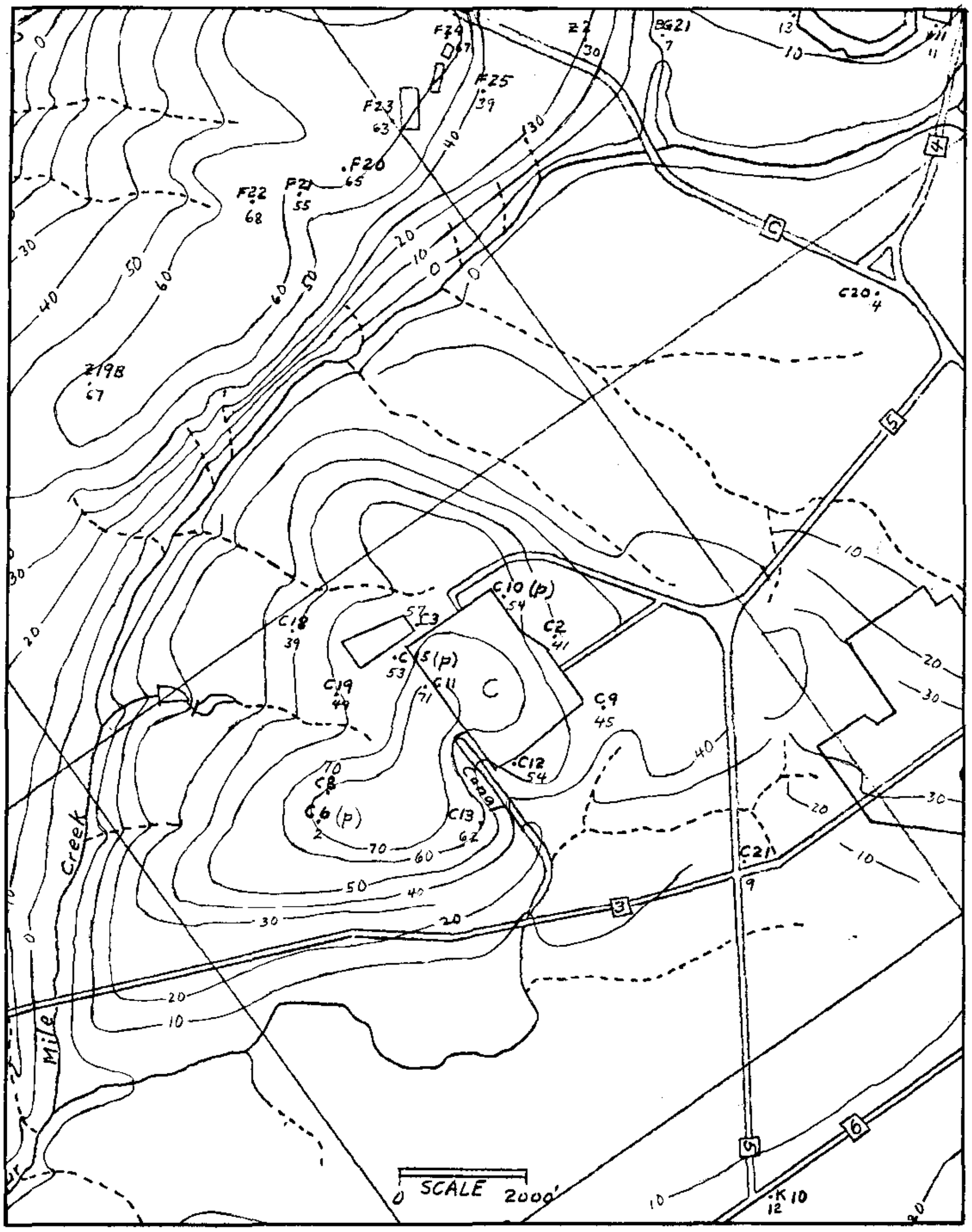
a. Highest Elevation (April 21, 1965)

FIGURE 19. Water Table for C Area



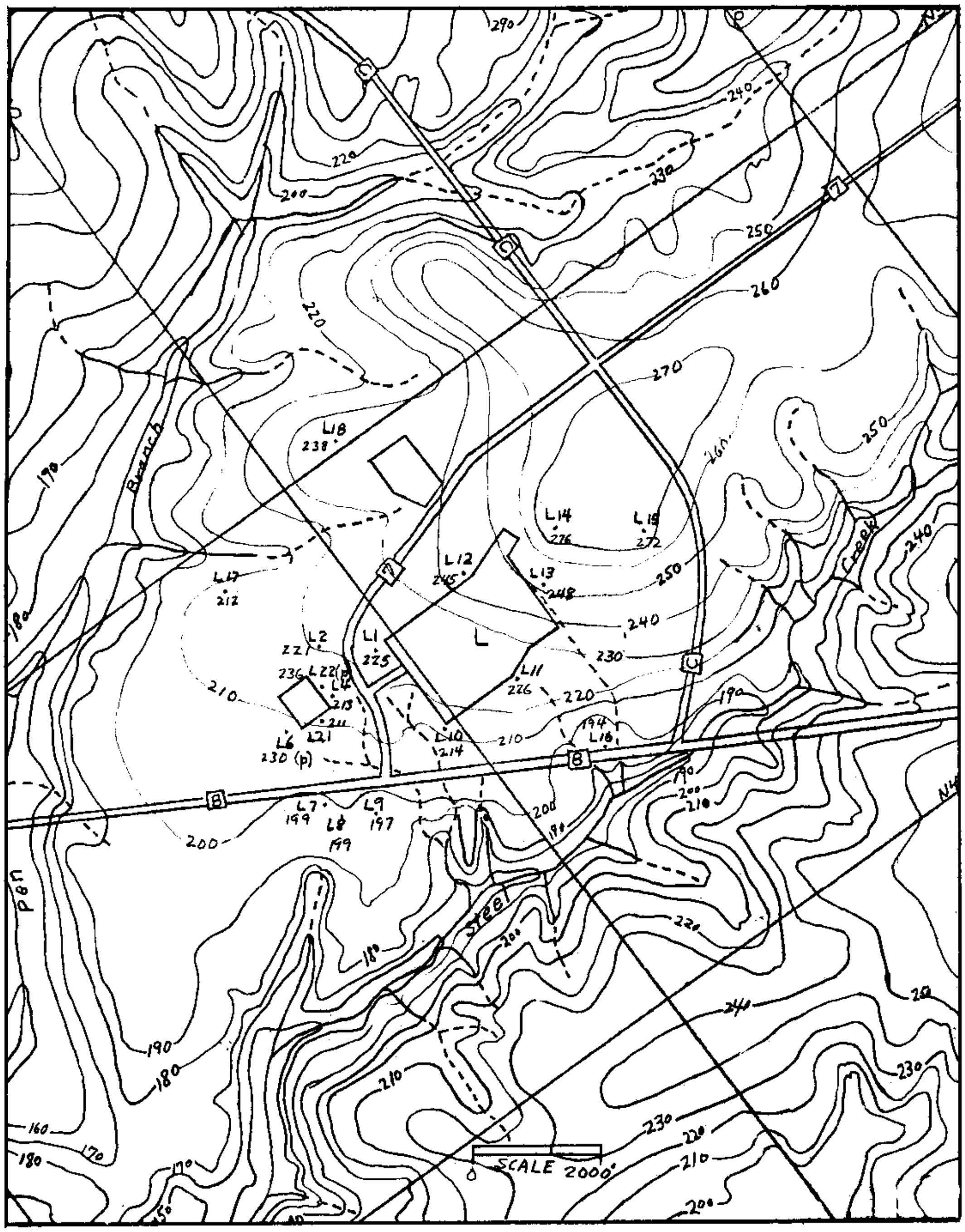
b. Lowest Elevation (December 20, 1963)

FIGURE 19. Continued



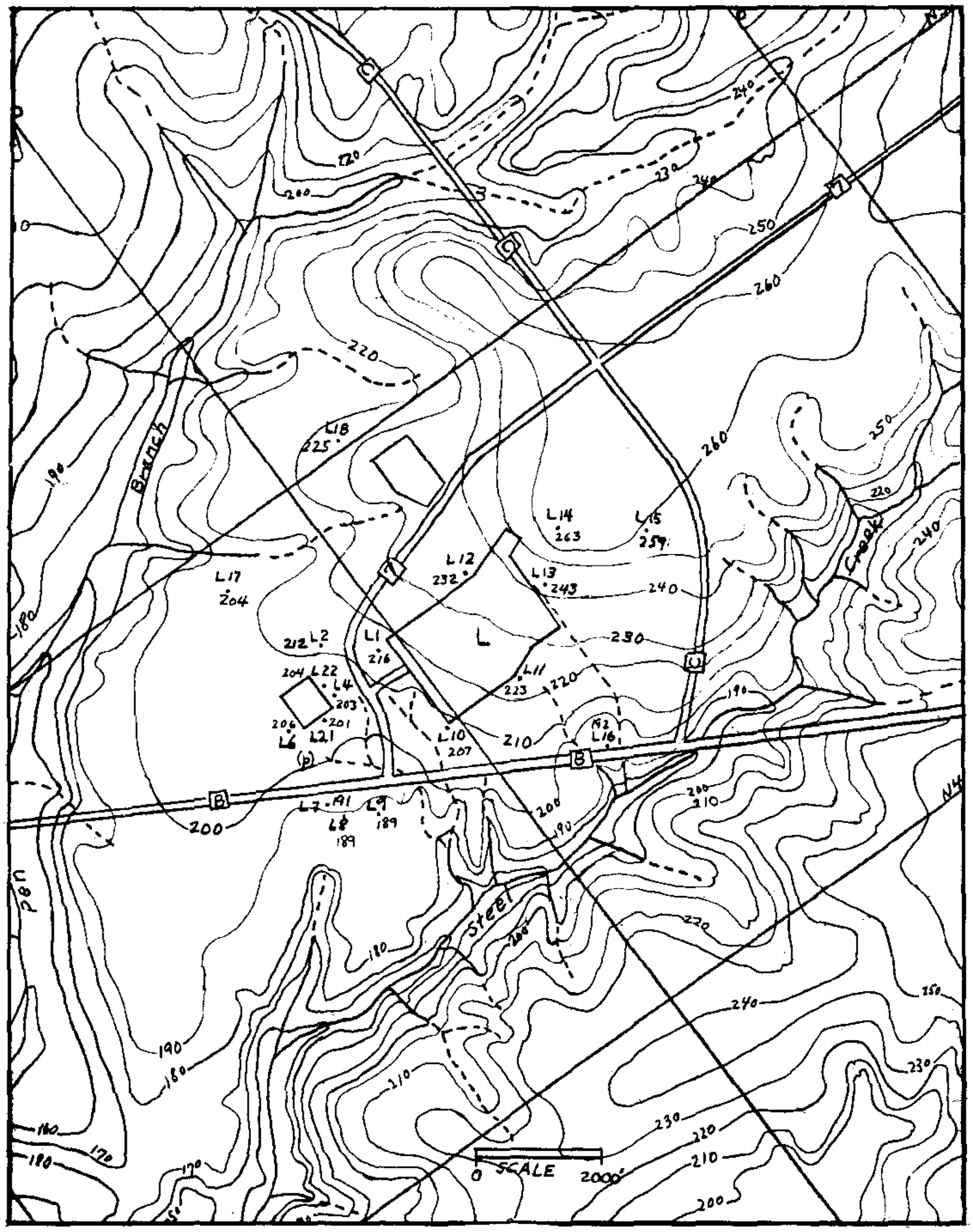
c. Depth to Water Table (April 21, 1965)

FIGURE 19. Continued



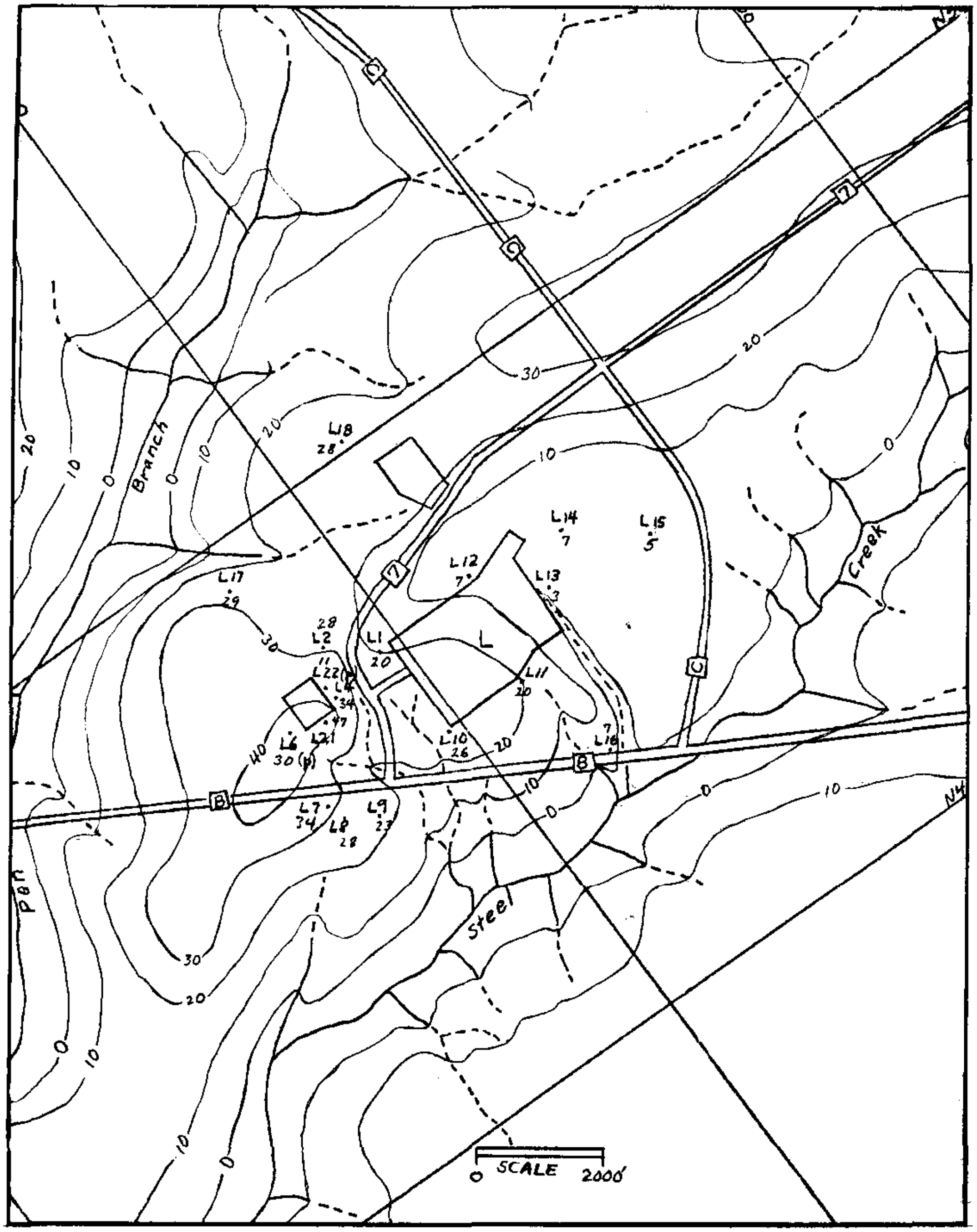
a. Highest Elevation (April 21, 1965)

FIGURE 20. Water Table for L Area



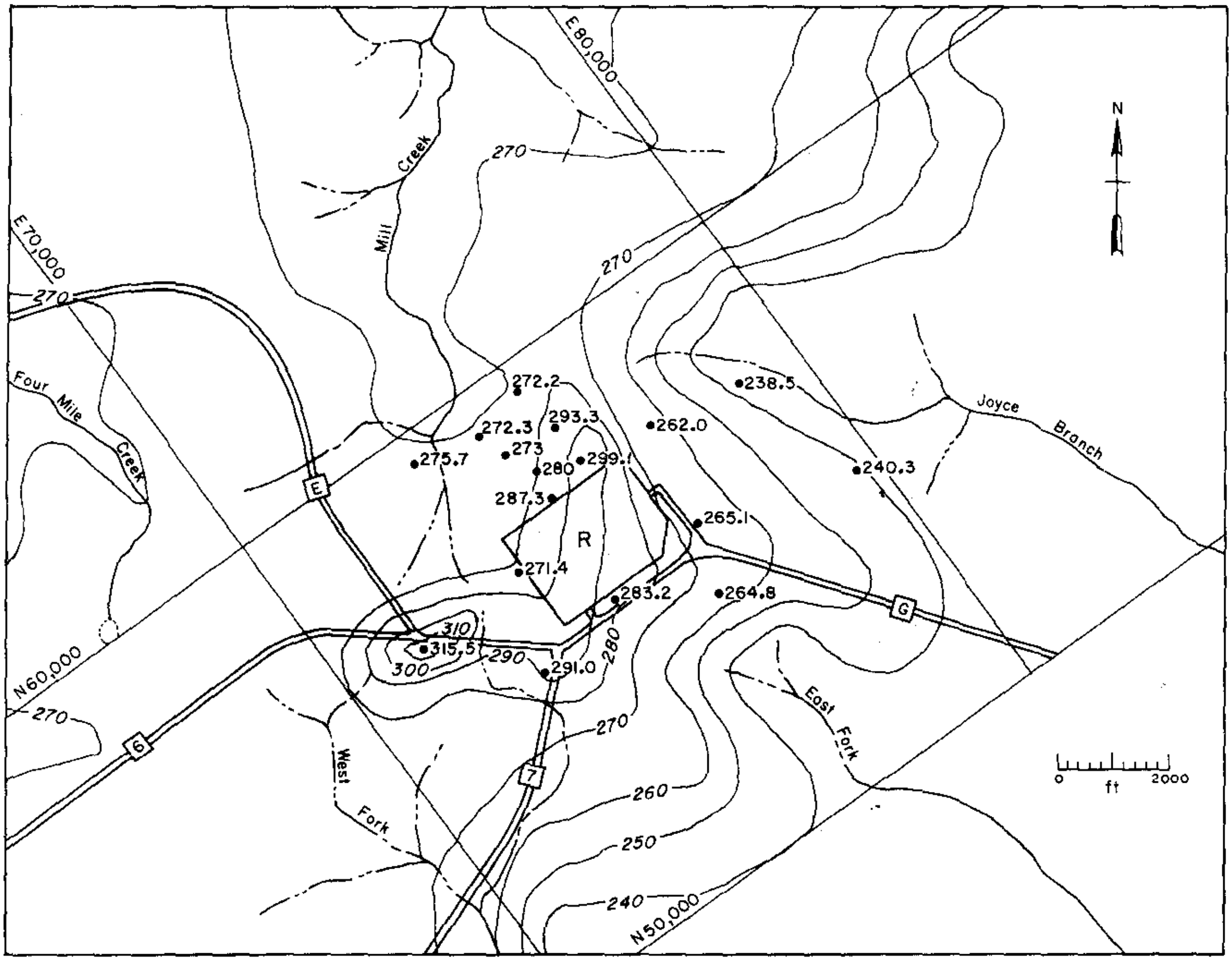
b. Lowest Elevation

FIGURE 20. Continued



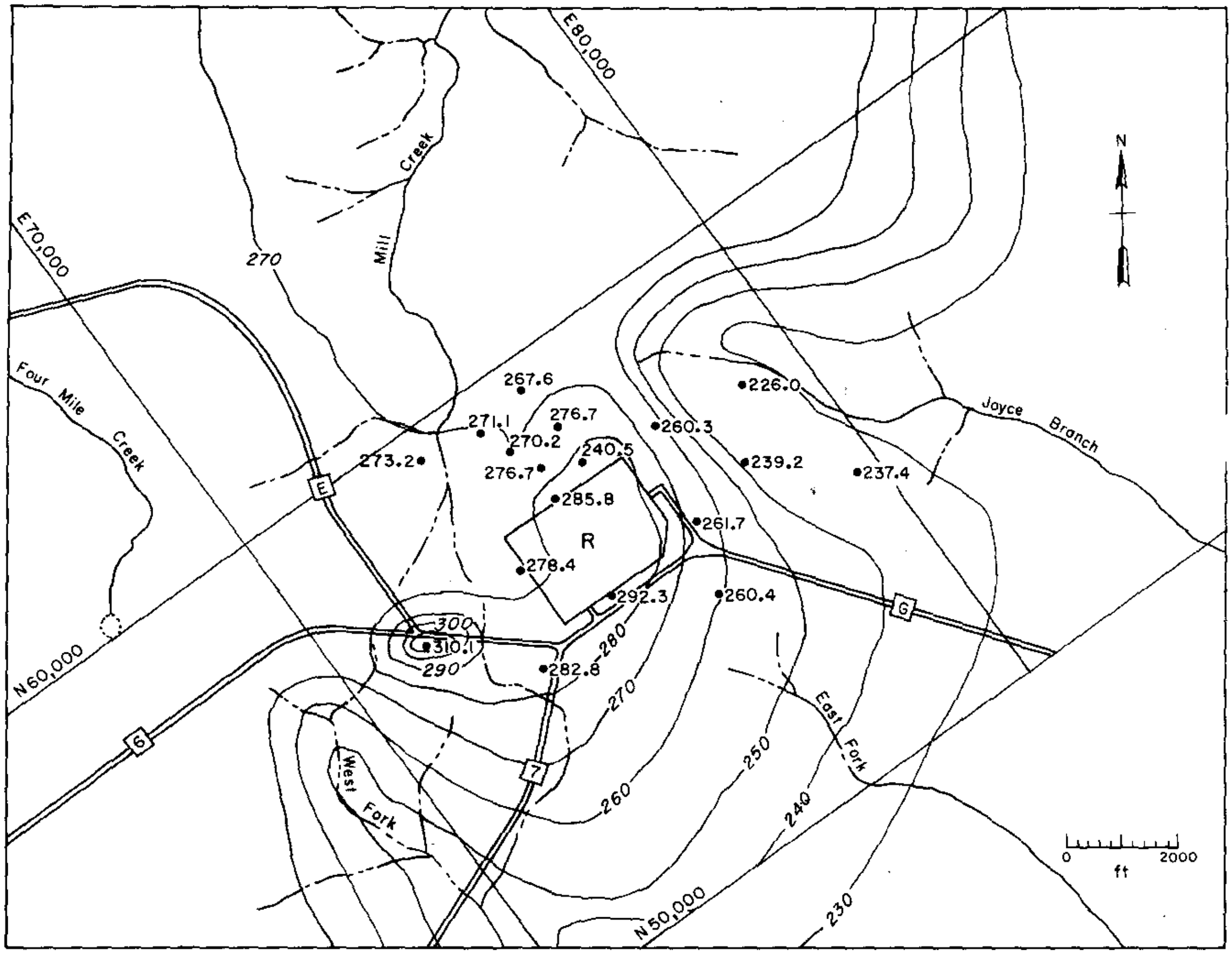
c. Depth to Water Table

FIGURE 20. Continued



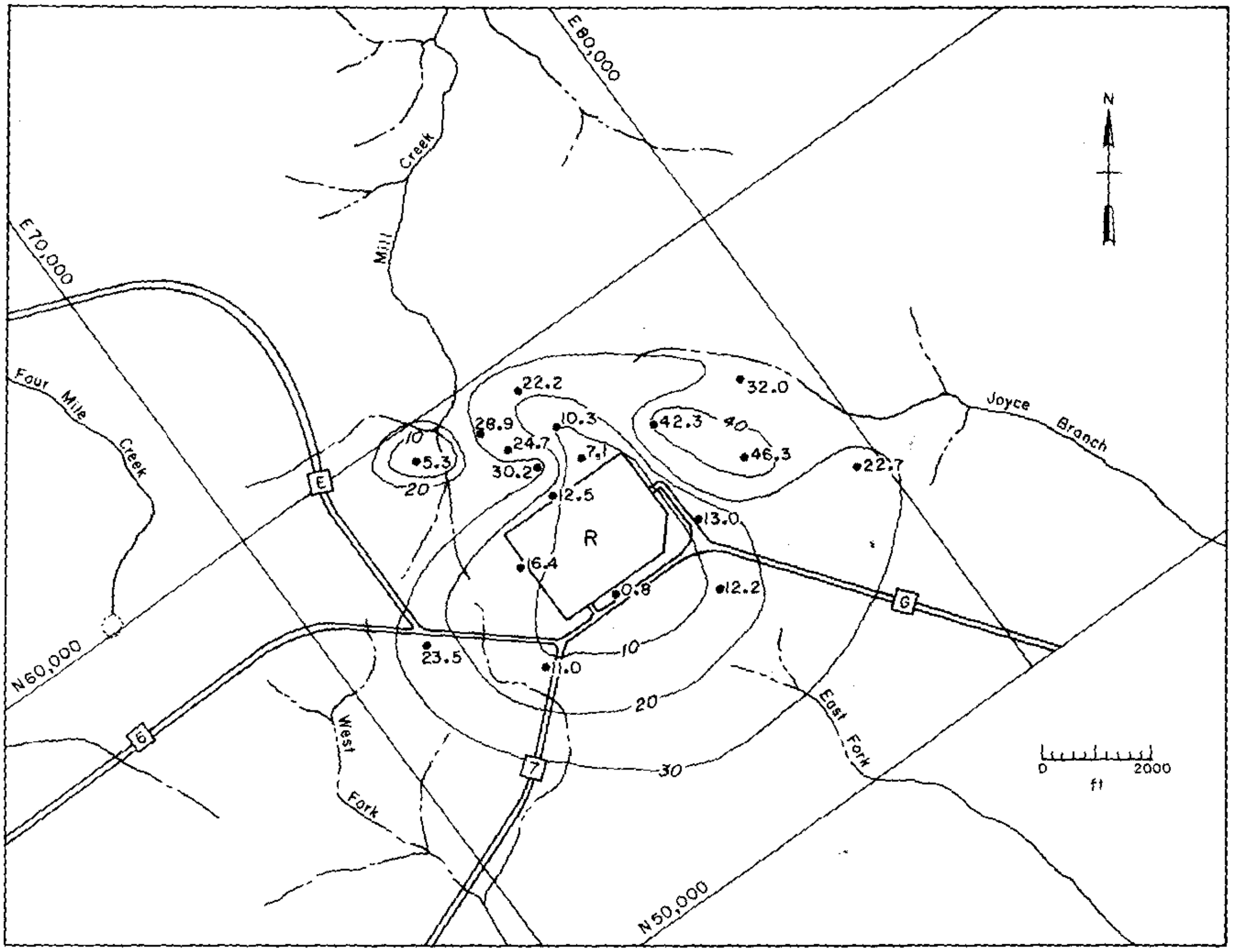
a. Highest Elevation (March 14, 1965)

FIGURE 21. Water Table for R Area



b. Lowest Elevation (December 18, 1965)

FIGURE 21. Continued



c. Depth to Water Table (March 14, 1965)

FIGURE 21. Continued

CLIMATE

The climate in the Savannah River area is relatively temperate, with mild winters and long summers. This area, while subject to continental influences, is protected by the Blue Ridge Mountains from the more vigorous winters prevailing in the Tennessee Valley.

TEMPERATURE AND HUMIDITY

The average Augusta winter temperature is 48°F, the average summer temperature is 80°F, and the annual average is 65°F. The average daily temperature variation is about 20°F. Additional temperature data covering a 77-yr period are given in Table V*.

TABLE V

Temperature and Relative Humidity in Augusta, Ga.

Month	Average Temperature, °F			Extreme Temp, °F		Average Relative Humidity, %			
	Daily Maximum	Daily Minimum	Monthly Average	Record Maximum	Record Minimum	1 am	7 am	1 pm	7 pm
January	57.4	38.5	47.9	84	6	75	84	59	69
February	59.8	39.9	49.9	84	3	72	82	56	63
March	67.3	46.7	56.7	93	14	72	80	57	59
April	75.2	53.1	64.1	94	29	74	77	48	56
May	83.4	61.7	72.6	100	40	78	77	48	59
June	89.4	68.9	79.3	105	46	82	79	51	64
July	90.9	71.9	81.5	105	55	86	83	55	69
August	89.7	71.2	80.5	105	58	87	87	56	71
September	85.5	66.5	76.0	106	41	84	85	55	71
October	76.2	55.0	65.5	94	29	79	84	50	70
November	65.8	44.3	55.0	86	11	77	84	53	67
December	57.9	38.6	48.3	81	7	77	84	58	70

*Meteorological data for Augusta, Ga., cited in this report was obtained from a series of annual reports published by the United States Dept. of Commerce entitled, "Local Climatological Data, Annual Summary with Comparative Data, Augusta, Georgia."

The highest, lowest, average high, average low, and average temperature at SRP* for the years 1961 through 1972 are given in Figure 22. Observed temperature extremes measured at Augusta and SRP are listed in Table VI.

TABLE VI

Observed Temperature Extremes

	Temperature, °F	Observation Date
Lowest SRP	4	January 1970
Lowest Augusta	3	February 1899
Highest SRP	105	June 1970
Highest Augusta	106	July 1952

The average relative humidity for Augusta is 70%. Table V summarizes, by month, observations of relative humidity for about 50 years.

Winters

The average minimum temperature and the total time that the temperature is <32°F in Augusta are listed in Table VII for the years 1966 through 1971.

TABLE VII

Winter Weather in Augusta

Year	Time at <32°F, hours	Average Minimum Temperature, °F
1966-1967	212	28.2
1967-1968	268	29.1
1968-1969	278	29.3
1969-1970	497	26.4
1970-1971	422	26.2
1971-1972	133	27.2

Summers

The highest, average high, average, average low, and lowest temperatures at SRP for the months of June, July, and August for the years 1961 through 1972 are given in Figures 23 through 25.

* SRP temperature and humidity data were obtained from instruments located in the SRP Administration Area.

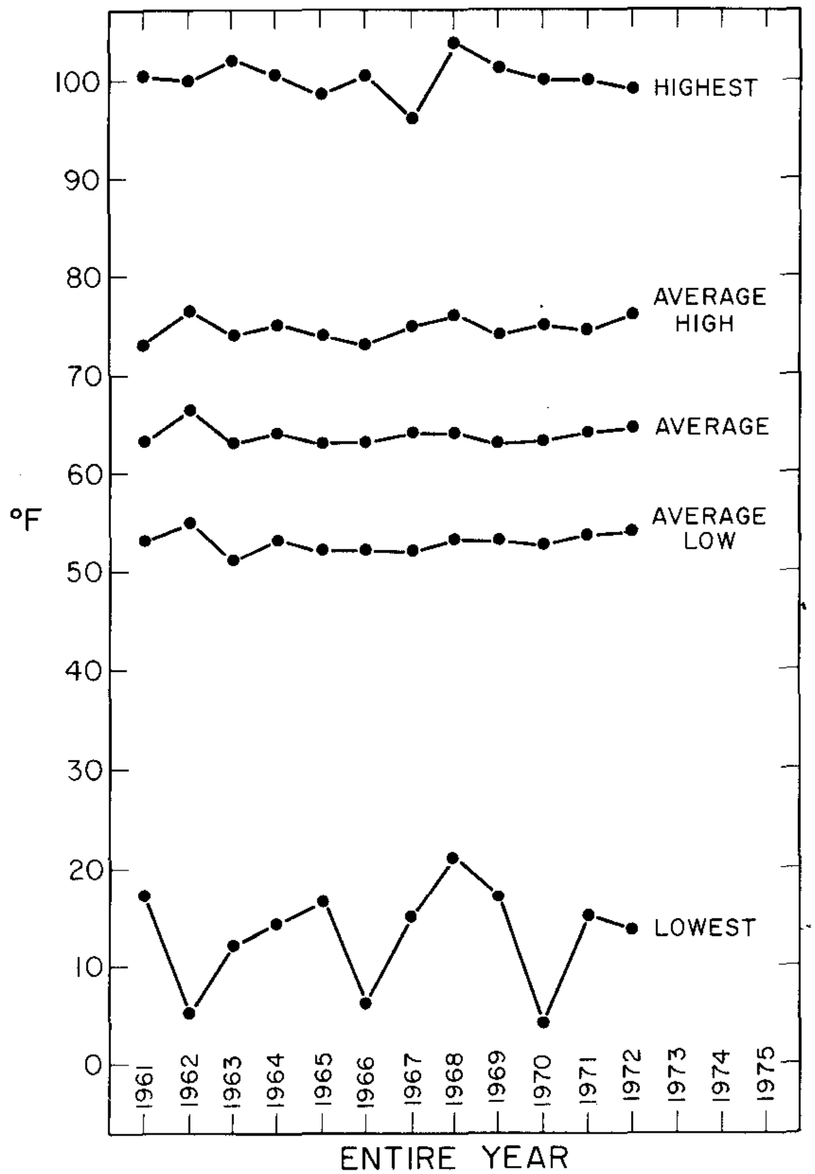


FIGURE 22. Summary of Temperatures at SRP from 1961 to 1972

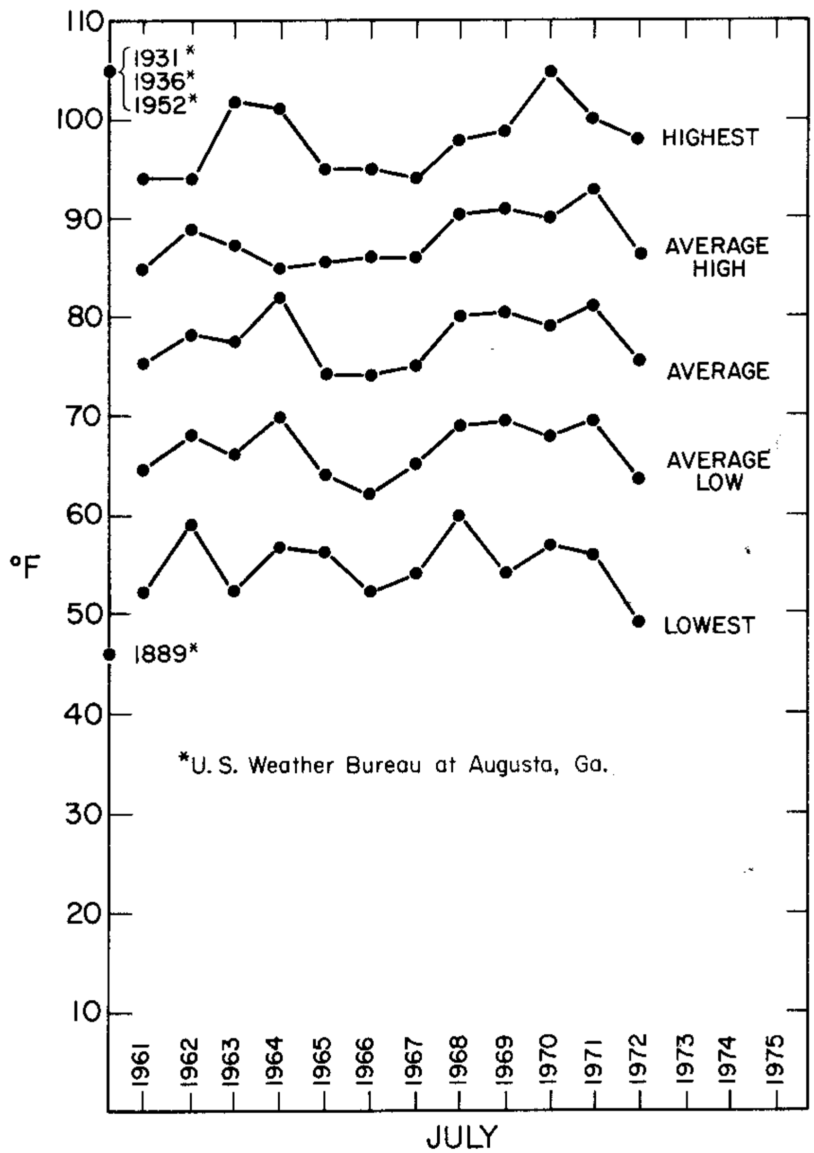


FIGURE 23. Summary of Temperatures at SRP During June for 1961 to 1972

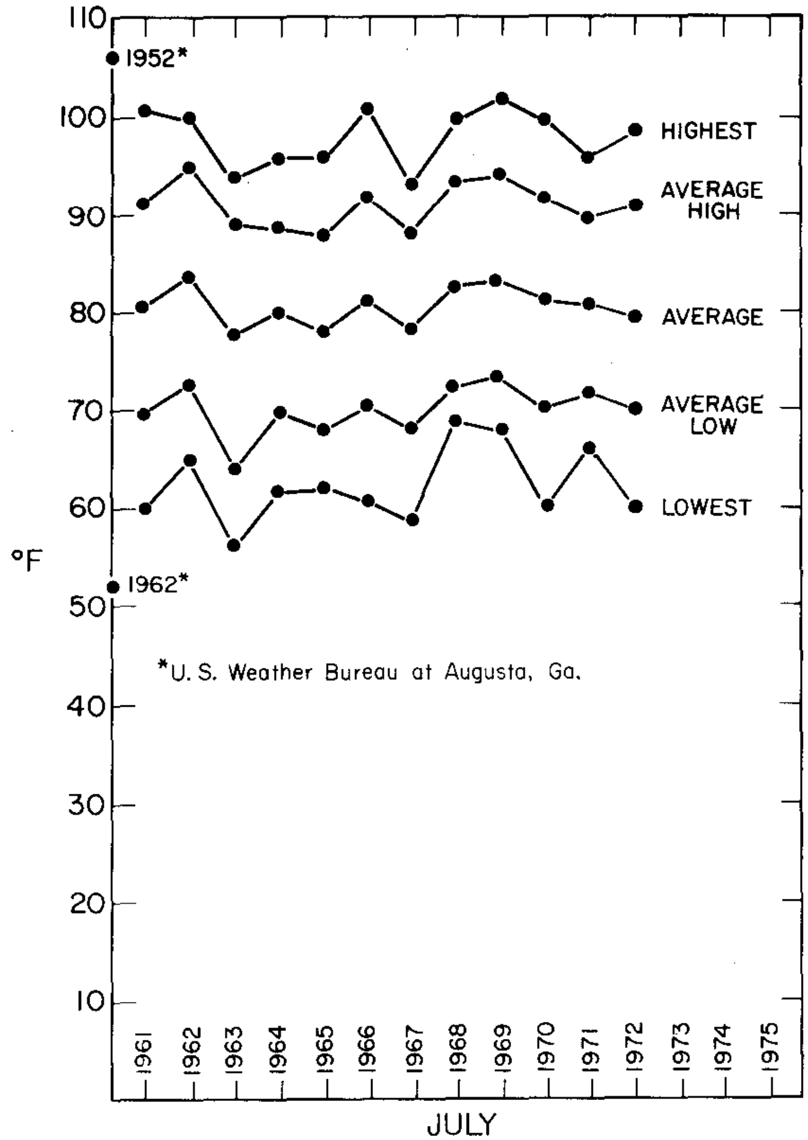


FIGURE 24. Summary of Temperatures at SRP During July for 1961 to 1972

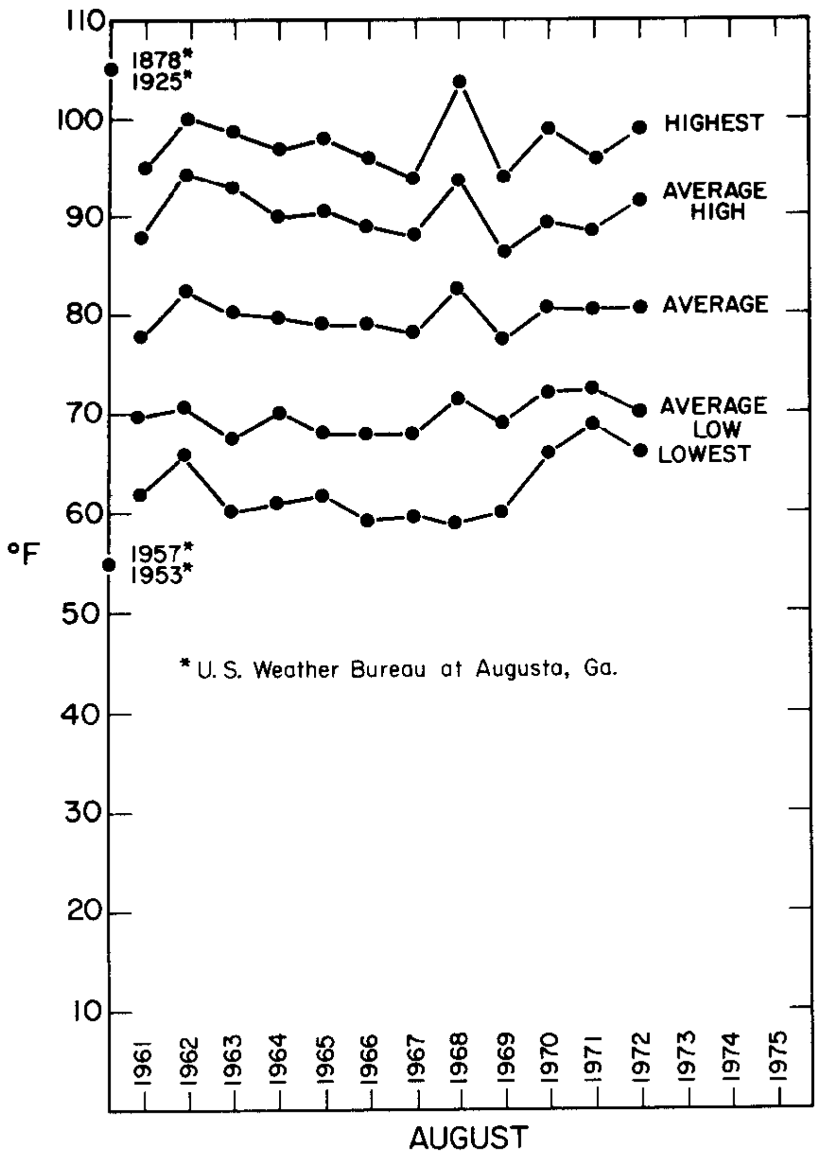


FIGURE 25. Summary of Temperatures at SRP During August for 1961 to 1972

PRECIPITATION

The average annual rainfall at SRP is 47 in. for the years 1952 through 1972. Total annual rainfall measured at SRP for 1952 to 1972 is given in Figure 26. The recorded maximum annual precipitation in Augusta occurred in 1929 (73.82 in.); the recorded minimum, 1933 (28.05 in.). The observed rainfall for 1971 and 1972 at different locations on the plant is given in Figure 27.

On the average, rainfall is greatest in March and least in November (Table VIII). Hourly observations at Augusta indicate that the intensity of rainfall is usually less than 0.5 in./hr for each month, except in the summer when the rate may reach 2.0 in./hr.

Snowfall and freezing rain are infrequent during the winter months in the SRP area, and any that does fall does not cover the ground for more than a few days.

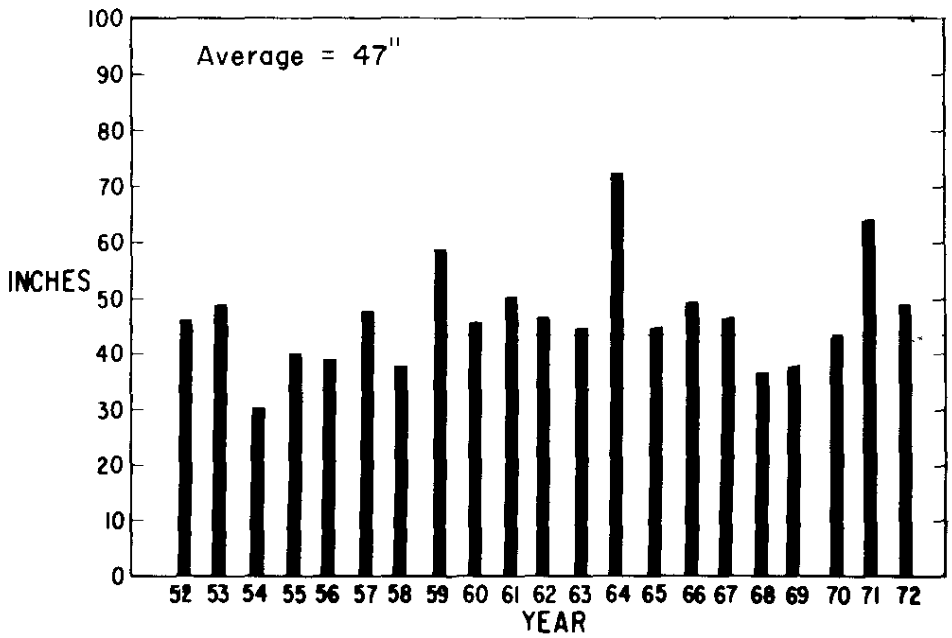


FIGURE 26. Annual Rainfall at SRP for 1952 to 1972

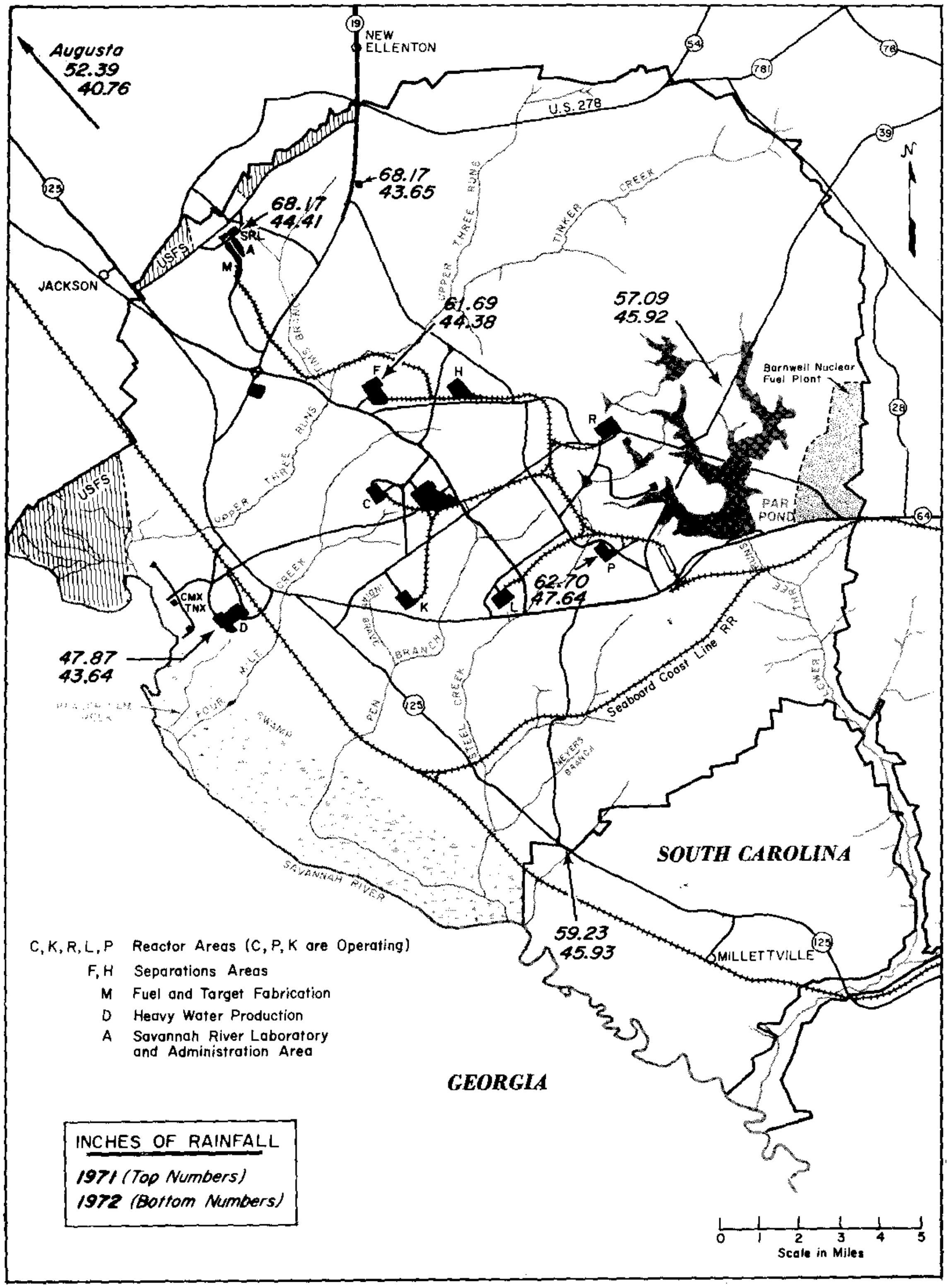


FIGURE 27. Total Rainfall at Different Locations on SRP for 1971 and 1972

TABLE VIII

Savannah River Plant Precipitation Summary

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1952	2.07	3.23	6.55	3.12	5.56	5.67	2.82	5.98	3.34	1.36	2.86	3.99	46.55
1953	2.69	5.48	3.83	2.96	4.42	5.38	3.63	3.61	8.53	0.11	1.04	7.51	49.19
1954	1.26	1.64	2.95	2.50	2.89	2.91	2.03	4.10	1.43	1.29	2.94	2.88	28.82
1955	4.75	2.62	2.21	5.57	4.53	3.31	3.94	5.07	3.42	1.32	2.93	0.46	40.13
1956	1.67	7.94	4.84	3.21	3.07	2.34	4.34	3.18	4.56	1.83	0.93	2.05	39.96
1957	2.05	1.58	4.29	2.75	8.02	4.17	3.51	2.41	5.04	6.12	6.46	2.24	48.64
1958	4.01	4.38	4.96	5.63	2.07	2.50	5.32	2.76	1.12	0.96	0.21	4.42	38.34
1959	3.54	6.06	6.44	2.03	3.81	4.06	5.80	2.93	8.71	10.86	1.97	3.54	59.75
1960	6.91	5.81	5.76	5.07	1.96	3.66	5.27	2.81	4.84	0.97	0.83	2.93	46.82
1961	3.59	5.76	7.23	8.20	3.88	3.01	3.09	7.15	1.00	0.07	1.83	5.60	51.41
1962	4.64	5.14	6.52	4.03	3.50	4.41	2.56	3.43	5.55	2.27	3.50	2.20	47.75
1963	5.96	3.64	3.34	3.70	2.98	8.42	3.18	1.04	5.37	0.00	3.68	4.47	45.78
1964	7.79	6.00	5.79	5.94	3.62	4.50	10.42	12.34	5.68	6.13	0.88	4.38	73.47
1965	2.00	6.39	8.67	2.43	1.33	5.04	8.04	1.94	2.83	2.59	2.17	1.41	44.84
1966	7.18	5.96	4.43	2.53	5.51	4.66	4.11	5.23	3.64	1.25	1.05	3.40	48.95
1967	3.66	3.80	5.68	2.82	5.01	3.74	7.52	7.32	1.70	0.64	2.51	3.13	47.53
1968	3.98	0.94	1.49	2.12	3.46	6.20	3.88	4.27	2.24	3.00	3.39	2.73	37.70
1969	2.00	2.46	3.38	4.09	3.02	3.95	2.71	5.42	4.56	1.16	0.40	4.19	37.34
1970	2.79	2.69	7.36	1.38	4.16	3.46	4.85	3.79	1.71	5.01	1.68	4.92	43.80
1971	5.11	4.16	8.68	2.92	2.98	5.92	10.53	8.76	3.80	5.95	2.31	2.89	64.01
1972	8.91	4.42	2.82	0.57	4.72	6.57	2.64	6.05	1.47	1.20	3.56	5.23	48.26
Average	4.12	4.29	5.10	3.50	3.83	4.47	4.77	4.74	3.83	2.57	2.24	3.60	47.09

TEMPERATURE INVERSIONS

Temperature inversions (air temperature increases with height above the ground) inhibit atmospheric turbulence and hence are associated with small rates of atmospheric diffusion. Temperatures, as a function of height, are obtained routinely twice a day at a number of weather stations in the United States by the use of balloon-borne sensors. These "radiosonde" observations are collected and summarized by the National Weather Service. The closest observation stations to SRP are at Atlanta, Ga., and Charleston, S. C. A summary of data for these two stations from 1942 through 1947[12] is shown in Figures 28 and 29. The time of balloon release in the 1940's was 10:00 AM and 10: PM, EST.

From the frequency of inversions at 10 AM and 10 PM given in Figure 28, the general pattern is for an inversion based on the ground to establish itself in the evening and to break up the following morning.

Figure 29 compares the frequency of all inversions based below 1500 ft with the frequency of such inversions when more than 0.01 in. of rain fell between 8 and 12 AM or PM.

Figures 28 and 29 can only be considered as gross indicators of the inversion structure in the SRP area because of the somewhat distant location of measurement, the observations being taken only twice a day, and the coarse vertical resolution (a radiosonde balloon rises at about 1000 ft/min).

More detailed temperature inversion data are available from instruments on a television transmission tower within 15 miles of the center of SRP. Summaries for the lapse rate (the rate of change of atmospheric temperature with height) at 260 and 70 m (850 and 230 feet) above ground are presented in Table IX. The SIGA (the standard deviation of the horizontal wind direction) is a measure of the dispersive ability of the atmosphere. These data show that stable conditions exist 30 to 32% of the time. From a thermal stability sense, more of the data lie in the lapse rate range of 0 to 1°F/100 ft.

A fumigation event* is considered to have occurred if the lapse rate at the elevation of interest changes from some positive value to a negative value of at least 1°F/100 ft. This condition occurs very infrequently at both heights.

* Shortly after the sun comes up on a clear morning, an existing ground-based inversion begins to dissipate and is slowly replaced by an unstable layer that begins at ground level and works its way upward. At some time after sunrise, if an inversion is pre-

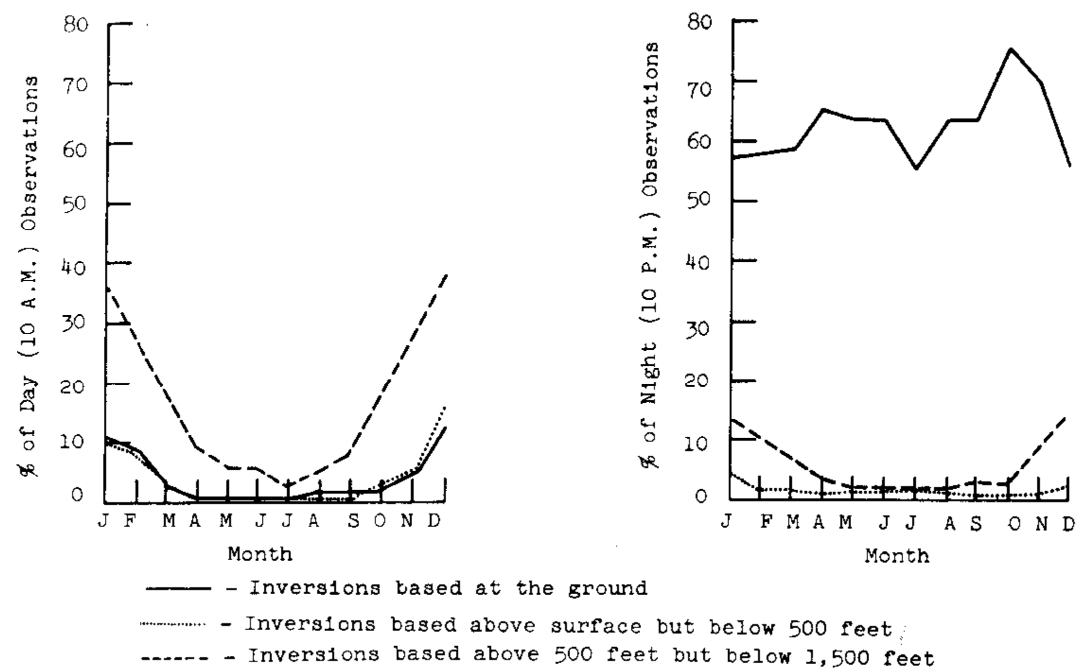
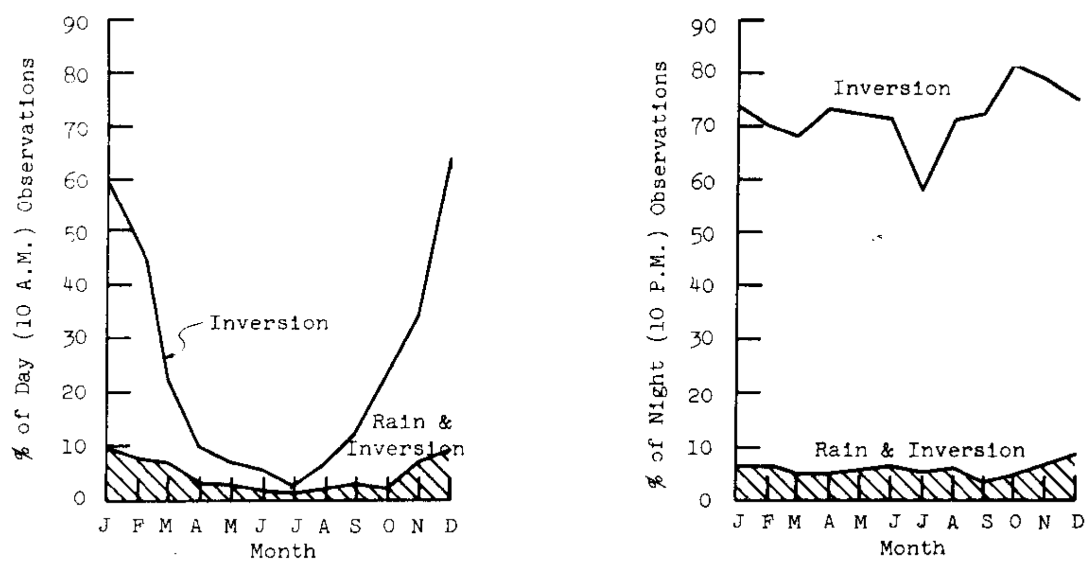


FIGURE 28. FREQUENCY OF INVERSIONS IN THE GEORGIA - SOUTH CAROLINA AREA



Frequency of Inversions in Lowest 1,500 feet and Frequency of Such Inversions with Rain

FIGURE 29. Frequency of Inversions with Rain in the Georgia - South Carolina Area

TABLE IX

Stability Analysis of Lapse Rates

(2 Years Data From March 1966 to March 1968)

260-m Analyses

Lapse Rate, °F/100 ft	Stable		Unstable[a]		Unstable[a]		Unstable[a]		Unstable[a]	
	Events	%	SIGA <15	%	SIGA <30	%	SIGA <45	%	SIGA >45	%
0 to 1	77311	30.37	162690	63.92	11866	4.66	1391	0.55	1183	0.46
1 to 2	29	0.01	22	0.01	2	0.00	0	0.0	0	0.0
2 to 3	15	0.01	8	0.00	0	0.0	0	0.0	0	0.0
3 to 4	6	0.00	1	0.00	0	0.0	0	0.0	0	0.0
4 to 5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Over 5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	77361	30.39	162721	63.93	11868	4.66	1391	0.55	1183	0.46

70-m Analyses

Lapse Rate, °F/100 ft	Stable		Unstable		Unstable		Unstable		Unstable	
	Events	%	SIGA <15	%	SIGA <30	%	SIGA <45	%	SIGA >45	%
0 to 1	80716	31.68	147306	57.81	21892	8.59	2341	0.92	2351	0.92
1 to 2	64	0.03	44	0.02	15	0.01	0	0.0	2	0.00
2 to 3	30	0.01	18	0.01	1	0.00	1	0.00	0	0.0
3 to 4	13	0.01	5	0.00	0	0.0	0	0.0	1	0.00
4 to 5	11	0.00	1	0.00	0	0.0	0	0.0	0	0.0
Over 5	1	0.00	0	0.0	0	0.0	0	0.0	0	0.0
Total	80835	31.72	147374	57.84	21908	8.60	2342	0.92	2354	0.92

Unstable at 260 ft (Inversion Below Lapse)

°F/100 ft	Events	%
0 to 1	49516	19.45
1 to 2	802	0.32
2 to 3	38	0.01
3 to 4	33	0.01
4 to 5	11	0.00
Over 5	15	0.01
Total	50415	19.81

Unstable at 70 ft (Inversion Below Lapse)

°F/100 ft	Events	%
0 to 1	11580	4.54
1 to 2	206	0.08
2 to 3	10	0.00
3 to 4	22	0.01
4 to 5	6	0.00
Over 5	14	0.01
Total	11838	4.65

Number of Potential Fumigation Events at 260 m = 31 or 0.01% of 254,524 Samples

Number of Potential Fumigation Events at 70 m = 74 or 0.03% of 254,813 Samples

a. SIGA = standard deviation of the horizontal wind direction.

WIND

Wind data are obtained from two locations in the vicinity of SRP, the National Weather Service in Augusta, Ga., and an instrumented television tower within 15 miles of the center of SRP. Differences in the data are expected due to differences in height above ground level from which the data were obtained and topographical differences. The National Weather Service instruments are located at the Bush Field Airport in Augusta, Ga. This is in the Savannah River valley at an altitude of about 130 ft msl. Wind channeling effects from being in the valley cause bias from the northeast direction. The television tower at Beach Island is at a higher altitude (380 ft msl) and, therefore, should be relatively free of directional bias due to local topography.

There are also surface effects with respect to measured wind velocity. The velocity generally increases as a logarithmic function of height near the ground surface. Departures from the logarithmic function occur due to variations in atmospheric stability.

The average hourly wind velocity for Augusta, Ga., was 6.4 mph (measured at a height of 20 ft) for the years 1950 to 1955. The distribution of hourly wind velocities for each quarter during 1950 to 1955 is shown in Figure 30. Calms and wind speeds below 3 mph (poor dispersion conditions) occur about 33% of the time, mostly during late evening and early morning hours.

The frequency of wind speed as a function of height on the television transmission tower near SRP is given in Table X. These data show that at 120 feet above the ground speeds of less than 2 m/sec (∿4 mph) occur 15% of the time with frequency decreasing with elevation. That this is so much less than indicated for Augusta, Ga., is due to two reasons: more-sensitive instruments on the television tower and greater height above the ground. The most-frequent wind speed at 120 ft above the ground is 2 to 5 m/sec.

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sent just above the top of an exhaust stack, it acts as a lid as the progressively developing convective eddies mix the effluent plume within the shallow unstable layer of air next to the ground. This condition can cause large concentrations of stack-released material over short periods of time because of the high inversion-like concentrations brought rapidly to the ground. This event can occur at distances up to several kilometers from the stack.

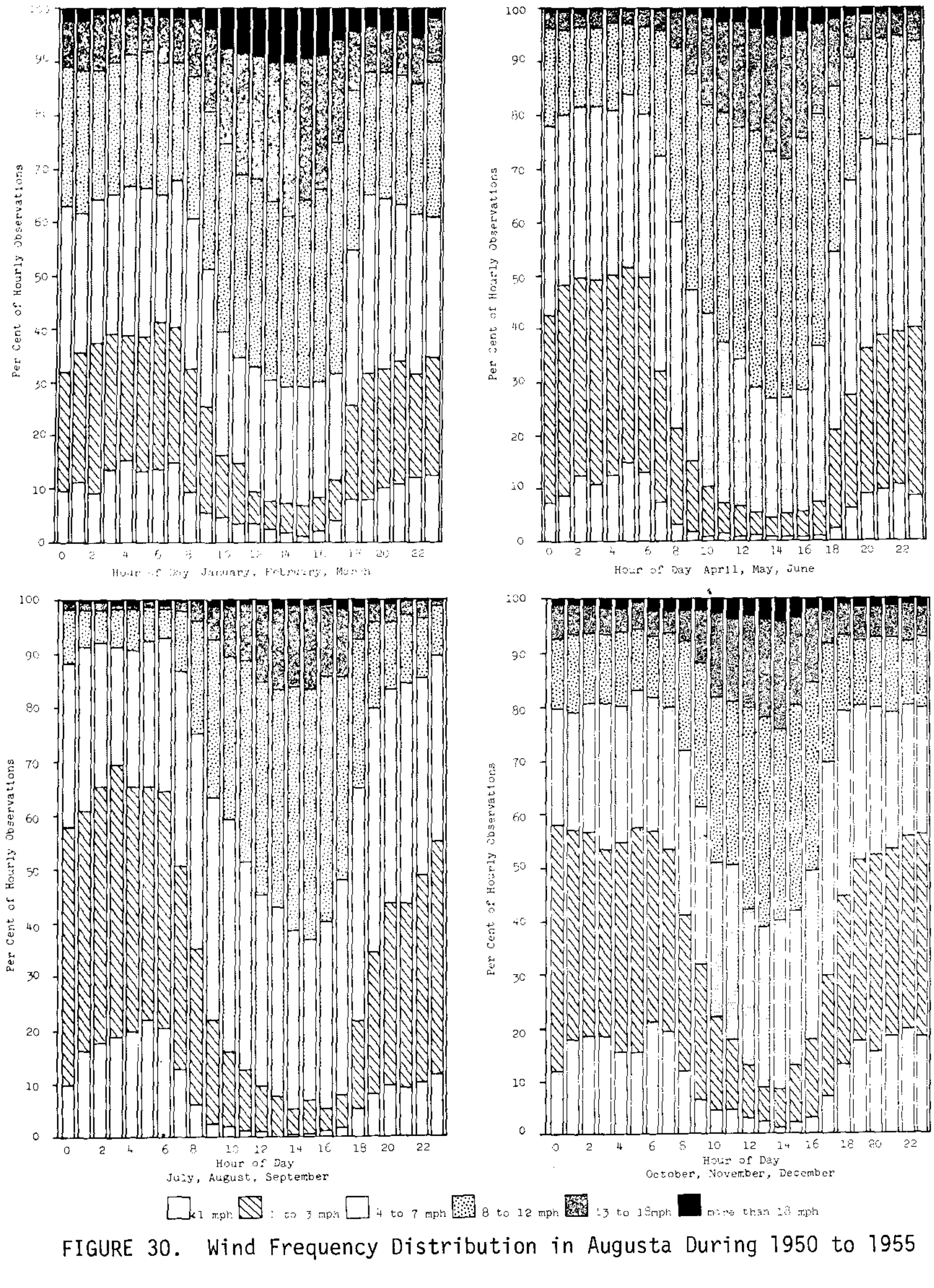


FIGURE 30. Wind Frequency Distribution in Augusta During 1950 to 1955

TABLE X

Frequency of Wind Speed at Various Elevations

(2 Years Data from March 1966 to March 1968)

Wind Speed, m/sec	Frequency at each Elevation (in feet)[a]						Fraction at each Elevation (in feet)						Accum Fraction by Speed by Elevation (in feet)					
	1000	800	600	450	300	120	1000	800	600	450	300	120	1000	800	600	450	300	120
0 to 1	3054	4350	4530	7133	6655	11744	0.02	0.02	0.02	0.03	0.03	0.05	0.02	0.02	0.02	0.03	0.03	0.05
1 to 2	6634	9543	10370	9998	15345	26109	0.04	0.04	0.04	0.05	0.06	0.11	0.06	0.06	0.06	0.08	0.09	0.15
2 to 3	13042	18581	19837	18369	28575	47555	0.09	0.07	0.08	0.09	0.11	0.19	0.15	0.13	0.14	0.16	0.20	0.35
3 to 4	15266	24017	24782	22720	34373	56300	0.10	0.10	0.10	0.11	0.13	0.23	0.25	0.23	0.24	0.27	0.33	0.58
4 to 5	16158	25349	26490	23719	36510	46297	0.11	0.10	0.11	0.11	0.14	0.19	0.36	0.33	0.34	0.38	0.47	0.77
5 to 6	16207	26908	27726	26357	38747	29049	0.11	0.11	0.11	0.12	0.15	0.12	0.46	0.43	0.45	0.50	0.62	0.89
6 to 7	14218	23231	25474	24042	32190	12576	0.09	0.09	0.10	0.11	0.13	0.05	0.56	0.53	0.56	0.61	0.75	0.94
7 to 8	11780	21237	23311	21944	26761	6569	0.08	0.08	0.09	0.10	0.10	0.03	0.63	0.61	0.65	0.72	0.85	0.97
8 to 9	11222	20311	21970	20856	19411	3901	0.07	0.08	0.09	0.10	0.08	0.02	0.71	0.69	0.74	0.81	0.93	0.98
9 to 10	9836	17342	18055	15841	9688	2012	0.06	0.07	0.07	0.07	0.04	0.01	0.77	0.76	0.81	0.89	0.97	0.99
10 to 11	9738	16560	17454	12095	4526	1189	0.06	0.07	0.07	0.06	0.02	0.00	0.84	0.83	0.88	0.94	0.98	0.99
11 to 12	7463	13545	12417	6457	1963	585	0.05	0.05	0.05	0.03	0.01	0.00	0.89	0.88	0.93	0.97	0.99	1.00
12 to 13	5611	10098	8377	3321	992	318	0.04	0.04	0.03	0.02	0.00	0.00	0.92	0.92	0.96	0.99	1.00	1.00
13 to 14	4508	8055	5350	1522	615	165	0.03	0.03	0.02	0.01	0.00	0.00	0.95	0.95	0.98	0.99	1.00	1.00
14 to 15	3006	5093	2548	571	289	86	0.02	0.02	0.01	0.00	0.00	0.00	0.97	0.97	0.99	1.00	1.00	1.00
15 to 16	1940	3240	1194	281	144	41	0.01	0.01	0.00	0.00	0.00	0.00	0.98	0.99	1.00	1.00	1.00	1.00
16 to 17	1118	1826	539	150	82	13	0.01	0.01	0.00	0.00	0.00	0.00	0.99	0.99	1.00	1.00	1.00	1.00
17 to 18	610	879	181	61	43	11	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
18 to 19	316	338	76	32	18	5	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
19 to 20	172	144	36	10	5	1	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Over 20	120	111	41	46	52	65	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Totals	152019	250758	250758	215525	256984	244591												

a. Number of records in this survey = 257292.

Prevailing Wind

The prevailing wind direction, by month, is given in Table XI based on a 9-year record at Augusta, Ga. Wind direction frequency near SRP is shown in Figure 31 as the percent of time the wind was blowing from different directions. This figure represents data obtained at an elevation of 300 ft (supplemented with data from 120 and 450 ft elevations) from the instrumented television tower near SRP over a two-year period (1966-1968).[13] For the period measured there was a preference for winds from the southwestern quadrant with a secondary maximum for winds from the northeastern quadrant.

The daily shift of prevailing wind at Augusta, as shown in Table XII,[14] is as much as 180° from day to day throughout the year. The 1957 monthly average of day-to-day shifts in prevailing wind direction ranged from 42 to 80° per day. In addition, hourly observations at Augusta show that the wind direction was not often constant for 24 hours during the year 1957. In most cases, the wind shifted from one hour to the next.

TABLE XI

Prevailing Wind Direction at Augusta

Month	Prevailing Wind[a]	Time at Given Direction, %
January	Northwest	26
February	Northwest	26
March	Northwest	25
April	Northwest	19
May	Northwest	17
June	South	21
July	South	26
August	South	23
September	East	20
October	Northwest	21
November	Northwest	28
December	Northwest	22

a. Direction from which wind blows

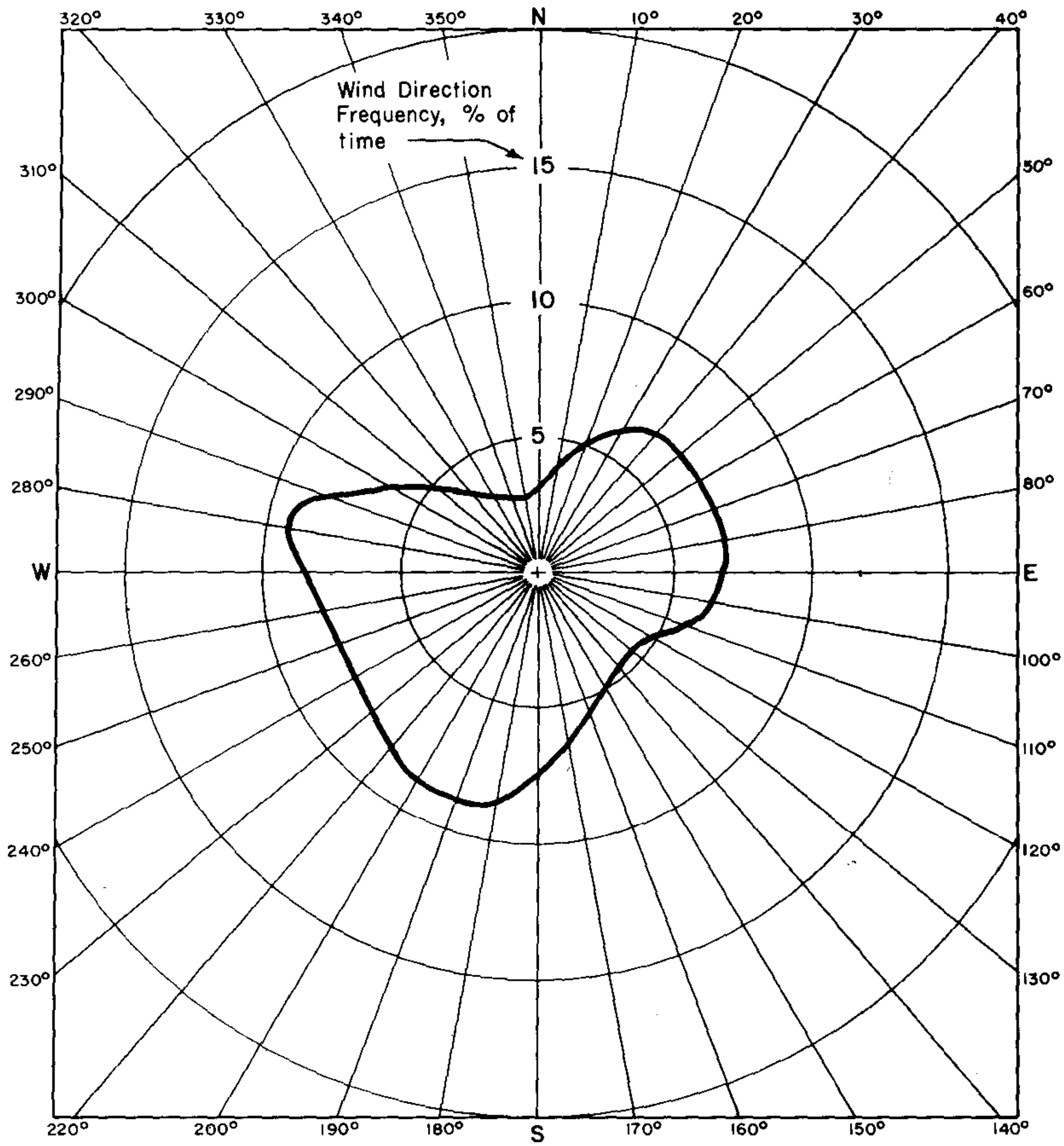


FIGURE 31. Wind Direction Frequency Near SRP at 300 feet

TABLE XII

Daily Shift of Prevailing Wind Direction in Augusta (1957)

Date	Shift, degrees[a]											
	January	February	March	April	May	June	July	August	September	October	November	December
1	NNW	SSW	W	ESE	E	NE	NW	SW	NW	NE	NW	W
2	15	150	30	120	30	75	90	75	180	0	90	45
3	0	120	165	105	75	0	90	0	105	15	105	15
4	165	0	0	0	0	30	45	60	15	60	15	90
5	120	180	0	45	0	135	135	165	75	0	0	15
6	180	45	0	90	90	15	180	0	30	45	90	135
7	180	45	75	60	165	30	135	90	0	0	90	0
8	135	120	150	0	120	30	60	135	45	60	0	0
9	75	90	30	105	150	180	15	135	15	0	165	135
10	30	15	15	75	15	45	165	75	30	45	60	45
11	180	135	165	120	0	135	0	75	15	105	60	30
12	15	30	120	150	75	0	30	105	15	15	15	30
13	135	75	60	30	75	150	90	150	0	45	0	90
14	30	15	30	105	15	120	0	120	0	30	90	60
15	165	180	90	0	60	75	120	45	30	120	45	30
16	45	180	90	75	0	45	30	105	0	0	60	0
17	60	0	45	0	90	135	105	0	30	45	30	135
18	0	180	180	0	60	180	45	75	180	135	60	0
19	150	180	135	15	120	135	30	15	60	30	120	45
20	135	105	30	15	90	30	90	30	60	15	30	60
21	15	0	30	30	105	15	15	60	30	15	120	150
22	180	15	0	0	0	0	45	0	60	30	150	60
23	120	75	165	0	0	15	45	15	165	60	15	30
24	135	165	75	0	105	30	0	45	90	0	90	0
25	0	0	180	15	105	0	165	135	135	120	180	90
26	0	60	15	15	45	90	15	90	45	60	135	150
27	180	30	75	30	60	90	15	75	90	15	60	0
28	0	90	30	0	165	60	15	120	0	0	105	180
29	0	0	45	15	15	60	45	30	45	45	45	120
30	90	0	45	15	0	30	150	120	0	60	90	30
31	105	0	150	0	15	0	150	90	0	150	0	30
Average	83	84	74	42	62	67	71	75	54	45	73	60

a. The change was taken as the smaller angular rotation from the previous day's prevailing wind. The actual change could be greater than indicated if the shift occurred through the larger angular rotation.

Wind Persistence

The duration of the wind blowing from one direction within a given azimuthal angle is called "wind persistence." Figures 32 and 33 show the probability of wind persistence at the Savannah River Plant (1966-1968) for elevations of 300 and 800 feet and several angular widths.[13] These calculations were made by first computing an average direction based on one hour's data and then processing additional data to update the hourly average for each data sample. This process is continued until the updated average deviates more than θ/2 degrees from the initial one-hour averaged direction, where θ is the angular width in degrees. The elapsed time for wind persistence is then computed, and the wind persistence is classified according to duration in hours. The current hourly average is then used as a base, and the process continues as previously outlined. Figure 32 shows the probability for a given wind persistence for sector widths of 45, 30, and 22.5° at 300 ft. Figure 33 is a similar plot at 800 ft. These studies show the probability of the wind persistence at 300 ft for a 10-hr period is 0.07, 0.125, and 0.23 for a 22.5, 30, and 45° sector width, respectively. Results were very similar at 800 ft.

The region surrounding the plant was divided into 16 sectors (Figure 3). The wind persistence was computed for the most populated sector (Sector 14) and is shown in Figure 34 as a function of wind persistence in hours versus probability of occurrence at 300 and 800 ft. The probability of the wind persistence at 300 ft for a 10-hr period in this sector is only 0.025.

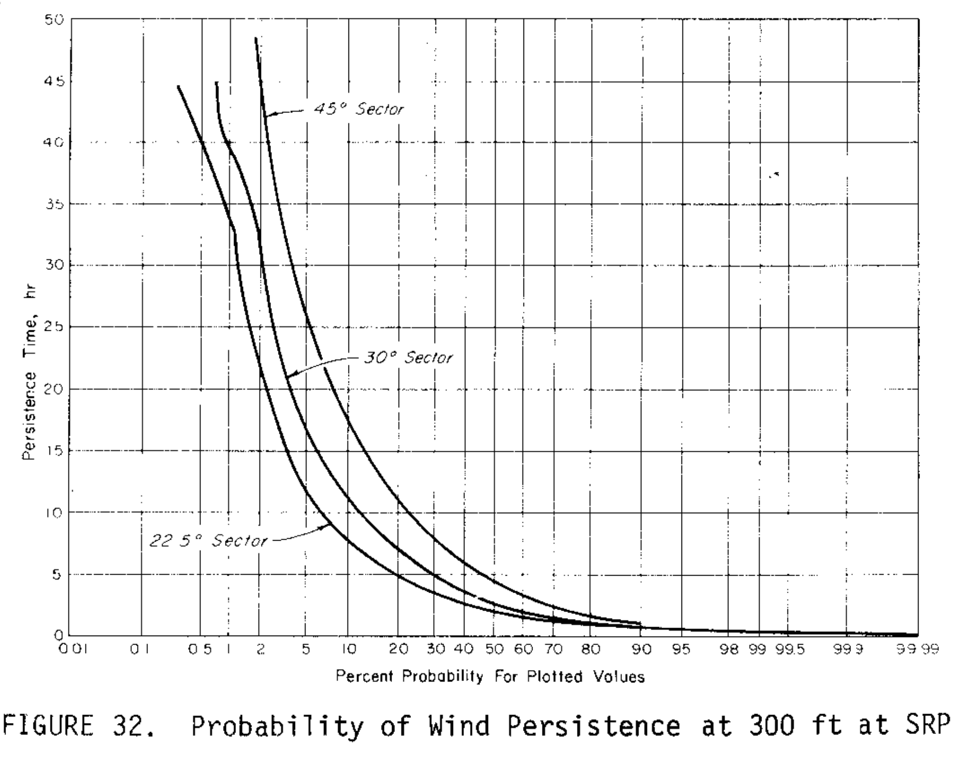


FIGURE 32. Probability of Wind Persistence at 300 ft at SRP

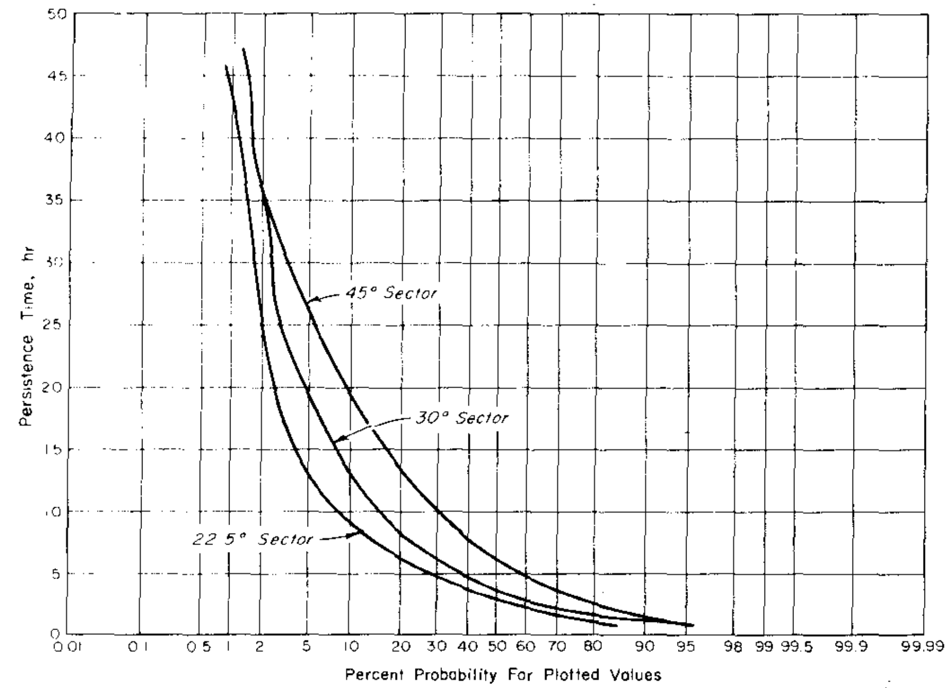


FIGURE 33. Probability of Wind Persistence at 800 ft at SRP

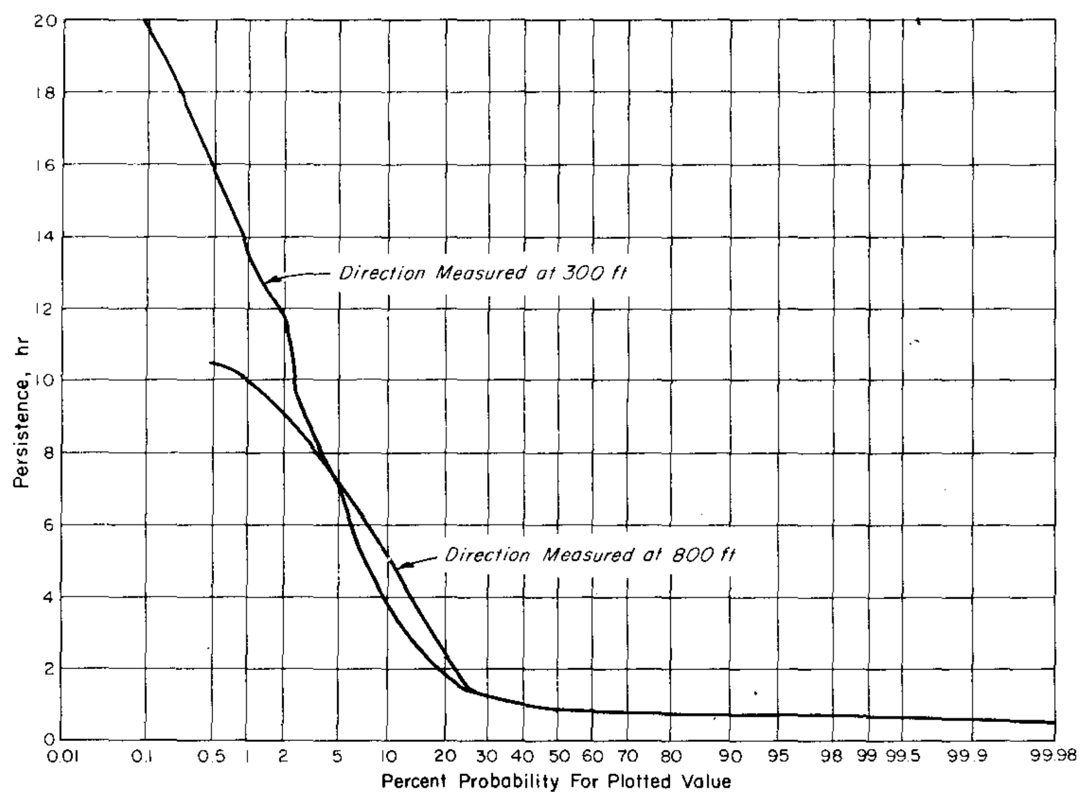


FIGURE 34. Percent Probability versus Wind Persistence from SRP to Augusta, Ga. (22.5° Sector)

STORMS

Hurricanes

Fully mature tropical cyclones, called hurricanes in the Atlantic and typhoons in the Pacific, are large rotating storms of extraordinary violence. They are born over the warm waters of all the tropical oceans except the South Atlantic. Although hurricanes are neither the largest nor the most intense atmospheric storms (they cannot match the concentrated fury of tornadoes or compare in size to winter storms of the middle latitudes), their considerable size and great intensity make them the most dangerous and destructive of all storms. The greatest damage and loss of life arise from storm surges that inundate low-lying coastal areas with wind-driven seawater in which all floating objects act as battering rams, from flooding caused by heavy rains, and from winds that frequently exceed 150 mph. At the outer limits of the hurricane, the winds are light to moderate in velocity and gusty. As the center approaches, they increase gradually, growing to squalls and then to furious gales. Finally, in the fully developed hurricane, the winds immediately surrounding the center blow with indescribable fury (>75 mph).[15] The region of maximum winds, 5 to 10 miles in width, surrounds the eye (a radius ranging from 10 miles for small, intense hurricanes to 40 miles for the larger ones). The eye is the innermost portion of the storm. Winds diminish with amazing rapidity as this region passes but seldom approach absolute calm.[16]

Tropical cyclones which do not mature into hurricanes are called tropical storms (winds <75 mph). A summary of all Atlantic-born tropical cyclones and hurricanes for the years 1959 to 1971 is listed in Table XIII (data assembled by the National Hurricane Center, Miami, Fla.). Many of these storms did not strike land and thus caused little damage.

TABLE XIII

Atlantic Hurricanes and Tropical Storms

	Number of	
Year	Hurricanes	Tropical Storms
1959	6	5
1960	4	3
1961	8	2
1962	3	5
1963	7	2
1964	6	6
1965	4	2
1966	7	4
1967	6	2
1968	4	3
1969	10	3
1970	3	7
1971	5	7
Annual Average	5.6	3.9

Some hurricanes that affect the South Carolina coast originate in the West Indies and Caribbean area and turn northward along the west coast of Florida and thence northeastward, reaching South Carolina either by following a landward track across states to the south, or by an oceanward track which first brings the hurricane across one or more states to the south and thence over the ocean parallel to the Atlantic coast. These storms spread and fill while passing overland, losing much of their force before reaching South Carolina. Storms that enter the Atlantic Ocean after crossing land occasionally regain their strength and lash the coast of South Carolina with full hurricane winds. Most hurricanes that originate far out in the Atlantic or in the West Indies curve away from the coast and stay over the ocean, but some strike the mainland.

Thirty-eight hurricanes affected (caused damage) South Carolina in the 272 years of record (1700-1971) or an average frequency of 1 every 7 years.[17] The hurricanes that affect South Carolina occur predominantly in the months of August and September (Table XIV). Records (Table XV) during the 1700's and 1800's are not complete or totally accurate because of the lack of communications and a systematic method of identifying and tracking hurricanes at that time.[17] Figures 35 and 36[17] show the tracks of hurricanes affecting South Carolina since 1893.

The occurrence of a hurricane along the coastal region does not generally mean that the Savannah River Plant will be subjected to winds of hurricane force. SRP is 100 miles inland, and the high winds associated with hurricanes tend to diminish as the storms move over land. Winds of 75 mph were measured by anemometers mounted at 200 ft only once during the history of SRP, during passage of Hurricane Gracie to the north of the plantsite on September 29, 1959 (Fig. 36).

TABLE XIV

Month of Occurrence of Hurricanes in South Carolina, 1700-1971

Month	Number	% of Total
June	1	2.6
July	1	2.6
August	14	36.8
September	18	47.4
October	4	10.5

TABLE XV

Hurricanes Affecting the
South Carolina Seaboard, 1700-1971

Date	Location of Observed Damage
September 16, 1700	Charleston
September 16, 1713	Charleston
September 14, 1728	Charleston
September --, 1752	Charleston
August 10, 1778	Between Georgetown and Cape Fear
August 10, 1781	Entered coastal Georgia and passed to west of Charleston
October 30, 1792	Charleston
September --, 1797	Charleston
September 7, 1804	Charleston and Atlantic seaboard
August --, 1806	Georgetown
September 10, 1811	Charleston
August 27, 1813	Charleston
September 10, 1820	North of Georgetown
September 27, 1822	Charleston and Coastal South Carolina
June --, 1825	Charleston
August --, 1830	South Carolina coastal areas
September 4, 1834	Georgetown
September 18, 1835	Inland through Georgia and the Carolinas
September 7, 1854	Inland in Georgia and then northeast, paralleling coast
August 27, 1881	Inland in Georgia and South Carolina
August 25, 1885	Coastal areas from Georgia to North Carolina
*August 28, 1893	Georgia and South Carolina coastal areas
*September 27, 1894	Charleston after crossing Florida and going out to sea
*August 28, 1911	Between Savannah and Charleston
*July 13, 1916	North of Charleston
*September 17, 1928	Across lower Florida and northeast along S. C. coast
*August 11, 1940	Between Savannah and Charleston (Beaufort and Edisto Island)
October 20, 1944	Inland north of Savannah after crossing Florida
*October 15, 1947	Across lower Florida, out to sea, inward short distance north of Savannah
*August 30, 1952	"Able" - Beaufort, S. C.
*August 29, 1954	"Carol" - along S. C. coast 140 miles off shore
*October 15, 1954	"Hazel" - along S. C. coast 92 miles off shore at Charleston
*August 11, 1955	"Connie" - off shore along northern S. C. coast, passed 100 miles southeast and east of Wilmington, N. C.
*August 17, 1955	"Diane" - off Georgia and S. C. coast, entering near Wilmington, N. C.
*September 18, 1955	"Ione" - passed by S. C. coast 150 miles east of Myrtle Beach
*September 27, 1958	"Helene" - passed by S. C. coast, 40 miles east of Cape Fear at closest approach to land
*September 29, 1959	"Gracie" - inland to St. Helena Sound and Edisto Island. This is the only hurricane during existence of SRP in which gale winds were experienced at the plantsite
*September 11, 1960	"Donna" - paralleled S. C. coast 50 to 70 miles off shore from Beaufort to northeast

* Hurricane tracks for these hurricanes are shown in Figures 35 and 36.

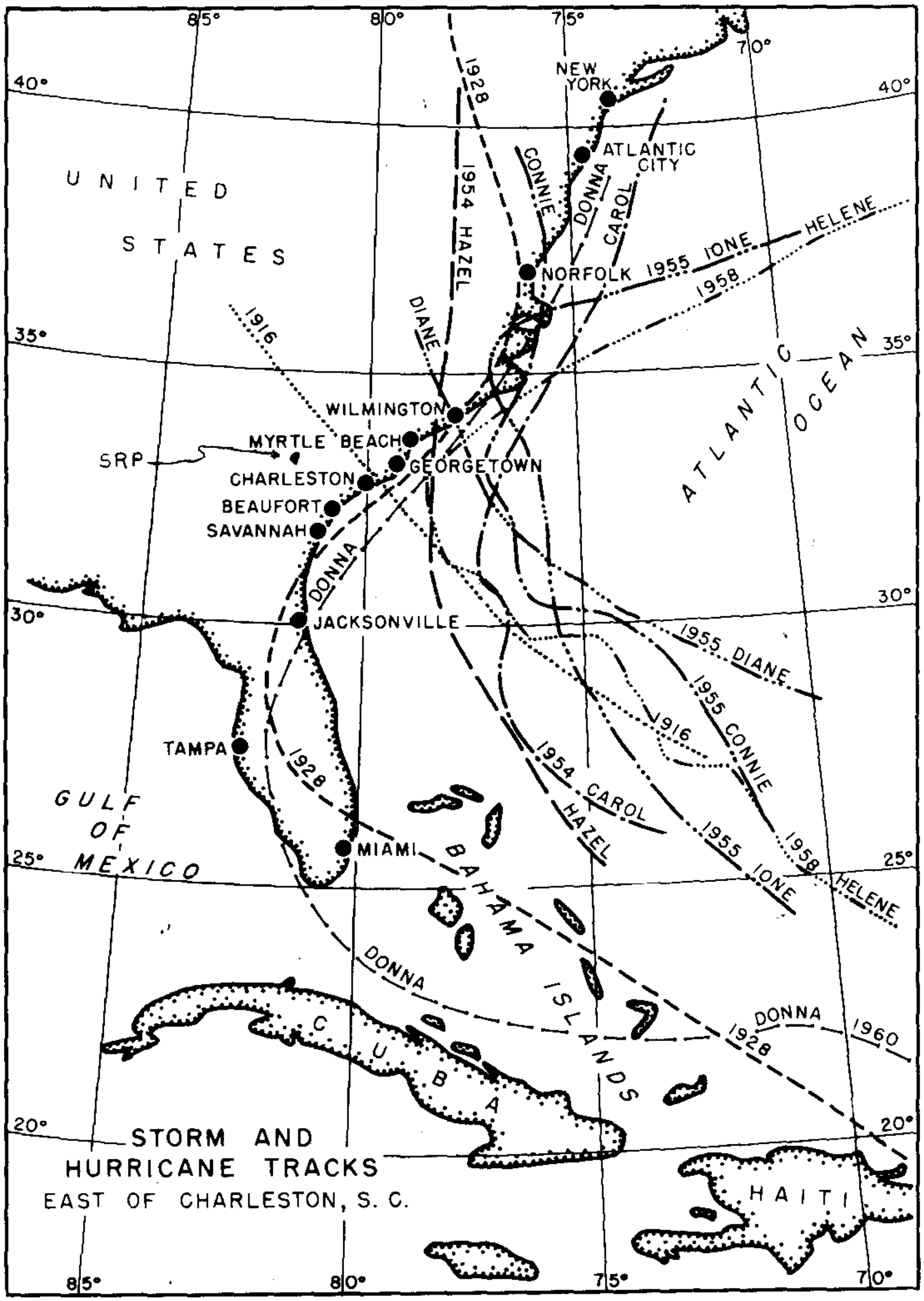


FIGURE 35. Storm and Hurricane Tracks East of Charleston, S. C.

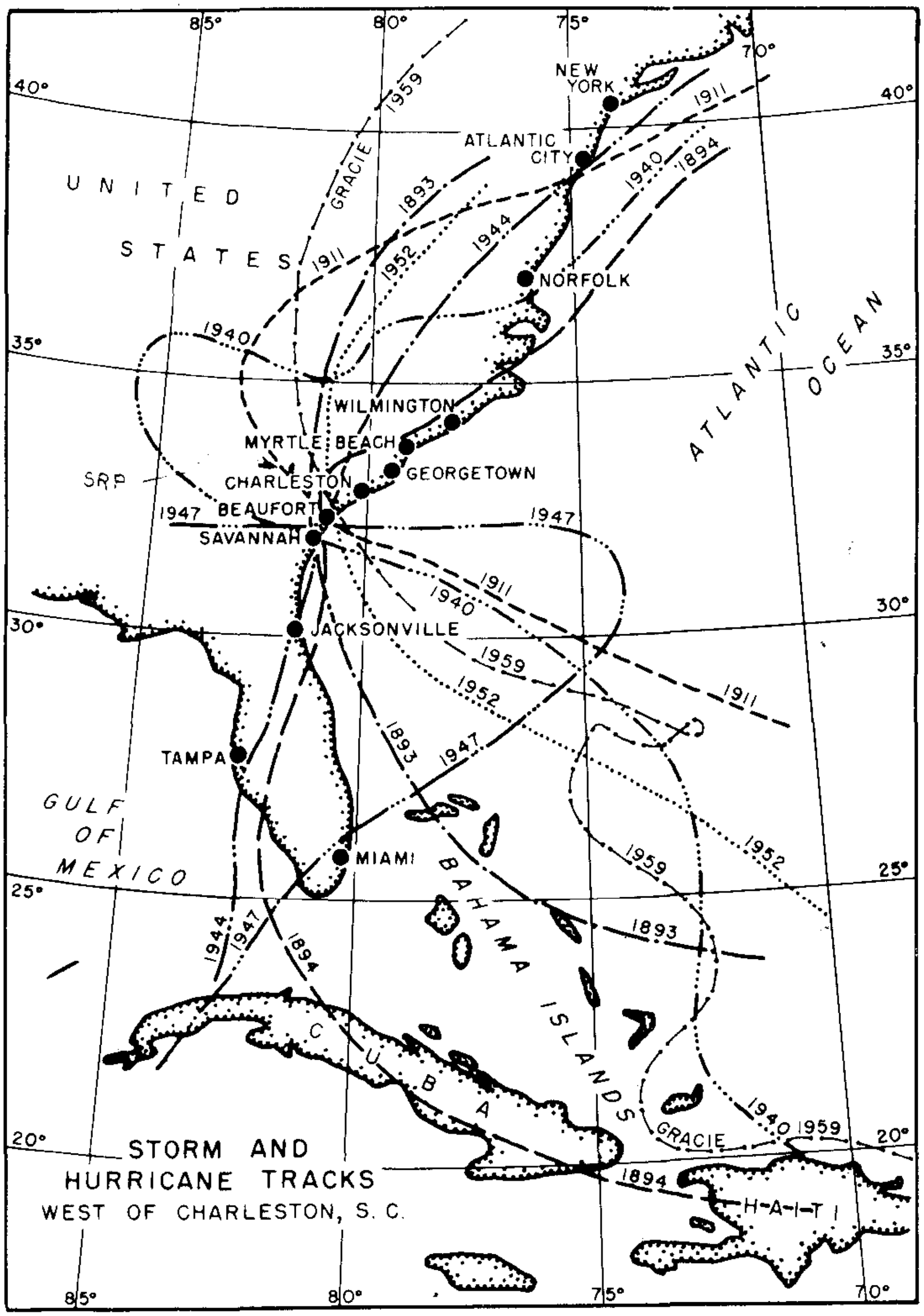


FIGURE 36. Storm and Hurricane Tracks West of Charleston, S. C.

Tornadoes

The tornado, one of the most destructive of storms, is characterized by counterclockwise rotary movement of extremely high-speed winds within a relatively small storm circulation pattern. It frequently leaves great destruction along a narrow path and is usually accompanied by heavy rain and hail, and often by lightning and thunder. A distinguishing feature of the tornado is the funnel-shaped cloud that usually appears to hang from a heavy cumulonimbus cloud aloft. This funnel cloud often rises and falls, turns and swings in various directions before touching the earth's surface.

The Savannah River Plant is in an area where occasional tornadoes are to be expected. Weather Bureau records[18] show 278 tornadoes in Georgia and 154 in South Carolina during the 43-year period 1916-1958. These records cannot be considered complete because it has been only in the two most recent decades that a systematic method of recording tornadoes has been developed. More recent data, 1959 through 1971, show that South Carolina is struck by an average of 10 tornadoes per year. However, the older 1916-1958 data show that most tornadoes occur during the period March through June (see Table XVI) and travel in a generally southwest to northeast direction.

TABLE XVI

Tornado Occurrence by Month, 1916-1958

	Georgia		South Carolina	
	Number	Percent	Number	Percent
January	24	8.6	2	1.3
February	23	8.3	7	4.5
March	49	17.6	19	12.3
April	93	33.5	37	24.0
May	20	7.2	29	18.8
June	14	5.0	20	13.0
July	5	1.8	3	1.9
August	10	3.6	13	8.4
September	8	2.9	13	8.4
October	2	0.7	3	1.9
November	15	5.4	3	1.9
December	15	5.4	5	3.2
Total	278		154	

A statistical study of tornadoes by Thom[19] in Iowa and Kansas between 1953 and 1962 made possible the development of frequency distributions of tornado path width and length and the probability of a tornado striking a point. Since the threshold wind speed of damage is assumed to be 75 mph, the damage path width of a tornado is taken as the diameter where 75 mph winds exist. Also the damage path length is the distance over which the tornado leaves observable damage. Postulating that the statistical distribution of these quantities follows a differential Gaussian distribution, Thom was able to fit correlating parameters to observed data and thereby to arrive at an expression for tornado probabilities. The expectation value for tornado-path area was found to be 2.821 square miles. By the principle of geometrical probability, the chance of a point being hit by a tornado is

$$P = \frac{a\ \bar{m}}{S} = 2.821\ \frac{\bar{m}}{S}$$

where P = probability per year of a point within area S being hit by a tornado

a = average area (square miles) of tornado damage, taken as 2.821 square miles for the United States,[20] assuming parameters found in Iowa and Kansas were applicable

$\bar{m}$ = number of tornadoes expected in area S per year

S = area over which $\bar{m}$ is considered

In studying tornado frequencies in the United States, Thom divides the country into 1-degree-square regions and assigns an annual frequency for each region. The annual frequency in the 1-degree-square region (3,973 square miles) in which SRP is located is 0.9 for the ten-year period, 1953-1962. With these data, the probability of a tornado striking a specific point within the SRP site was calculated to be 6.39×10^{-4} per year. The recurrence interval (1/P) is 1565 years. For the 300 square mile site as a whole, the probability of a tornado striking is 0.071 per year with a recurrence interval of 14.1 years. For the 13,231 acres (20.7 square miles) of land dedicated to specific operational activities (including highways, power lines, major buildings and facilities, etc.), the probability of a tornado striking is 0.005 per year with a recurrence interval of 204 years.

During the 21-year history of SRP, there has been no tornado damage to any production or support facility. However, there have been several unconfirmed sightings in unpopulated areas.

SEISMICITY

The Savannah River Plant is located in an area where moderate damage might occur from earthquakes based on earthquake risk predictions by the U. S. Coast and Geodetic Survey (Fig. 37).[21] On the basis of three centuries of recorded history of earthquakes, an earthquake above the intensity of VII MM would not be expected at the Savannah River Plant. (The Modified Mercalli scale is described in Appendix C.) During the past 100 years, the area within a 100-mile radius of the Savannah River Plant has experienced one shock of intensity X, one shock of intensity VIII, two shocks of intensity VII, and nine shocks of intensity V MM.

The shock of intensity X MM was the great Charleston earthquake of August 31, 1886, which dominated seismic activity in South Carolina for many years. This disturbance had dual epicenters, one at Woodstock (16 miles N 30° W from Charleston) and another 13 miles due west from Charleston. The epicenters were 14 miles apart. Appendix D[22] gives a detailed description of the Charleston earthquake. Although the Charleston quake had an

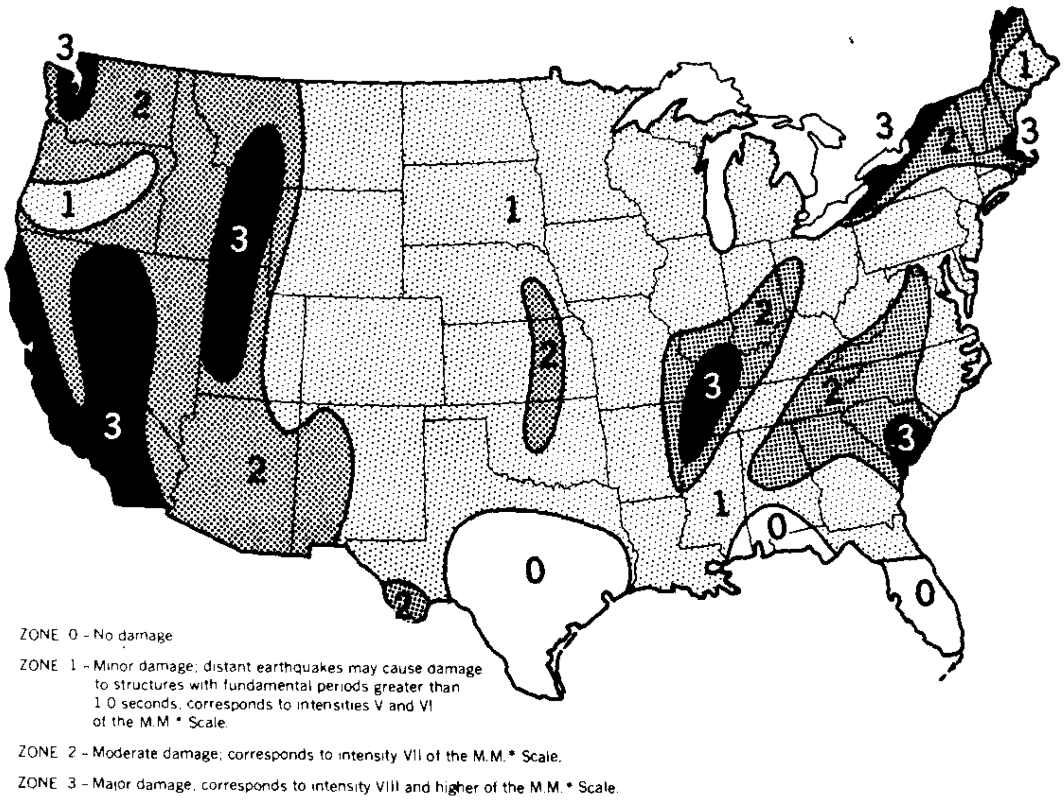


FIGURE 37. Seismic Risk Map for Conterminous United States

intensity of IX-X MM, it was felt 800 to 1000 miles away. An area of about 2,000,000 square miles was affected. In contrast, the 1906 San Francisco earthquake with an intensity of XI MM affected an area of only 373,000 square miles. With only minor exceptions, an earthquake of a given intensity in the eastern United States will be felt at much greater distances than a shock of the same intensity in the western U. S. The radius of perceptibility is four times greater in the eastern U. S. than in the western U. S. For many years it was thought that this effect was observed because the depth of shocks in the East were greater. Now, it appears more likely that the effect is due to the more efficient propagation of certain seismic waves in the more uniform crustal structure of the eastern U. S. The Charleston earthquake caused only minor superficial changes. The epicentral region was broken by many fissures through which water issued, but the fissures seldom attained a width of more than one inch. In contrast, the San Francisco earthquake opened fissures up to 5 feet wide at a distance of 15 miles from the fault, and the fault was exposed at the surface. The Charleston quake was probably caused by a fault movement in basement rock beneath a half-mile thickness of unconsolidated sediments.

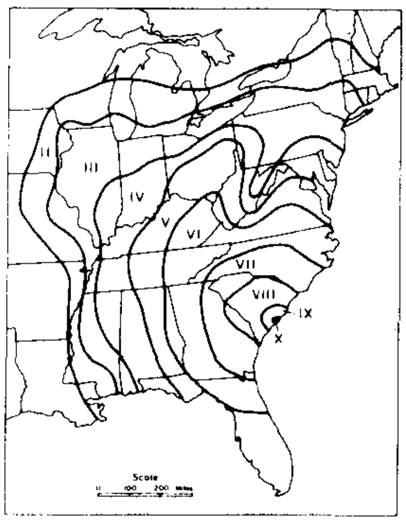
In the vicinity of SRP, ground motion was estimated at an intensity of VIII MM during the Charleston earthquake of 1886. Figure 38 shows an isoseismal map[23] of this earthquake and some of the observed effects in the epicentral region. At Augusta, Ga., just over 100 miles from the epicentral area, 100 chimneys fell, and a dam fissured and broke.

Since the 1886 Charleston earthquake, three earthquakes of intensity VII-VIII have occurred in South Carolina:

- October 22, 1886. Aftershock of August 31 quake
  Intensity: VII
  Epicenter: Summerville, S. C. (20 miles NW of Charleston)
  Strong shocks at Charleston; felt at Augusta, Atlanta, and Richmond. No damage at Augusta.

- June 12, 1912
  Intensity: VII
  Epicenter: Summerville, S. C.
  Felt at Macon, Ga., Greenville, S. C., and Wilmington, N. C.
  No damage except at Summerville.

- January 1, 1913
  Intensity: VII-VIII
  Epicenter: Union County, S. C. (20-22 miles SW of Spartanburg, S. C.)
  Felt at Raleigh, N. C.
  No damage except in epicentral area.



ISOSEISMAL MAP (Rossi-Forel), from Dutton, 1889

Rossi-Forel	X	IX+	VIII+-IX-	VIII	VI-VII	V-VI	IV-V	III	I-II
Mod. Mercalli	X	IX	VIII	VII	VI	V	IV	III	II

Intensity: X   Felt Area: 2 million sq. miles

[1811 New Madrid Eq.: XII, 2 million sq. mi.
1906 San Francisco Eq.: XI, 375,000 sq. mi]

Deaths: ~ 60   Damage: ~ $5 million

Epicentral Effects

- Ground fissures and craterlets
- Water, sand, and mud fountains
- Railroad rails bent, tracks displaced
- Loud earthquake sounds
- Earth and water waves
- Sulfur gas released

Unusual Aspects

- Region essentially free of shocks for preceding 200 yr
- Large felt area
- Dual epicentral points
- West Virginia "low intensity"

FIGURE 38 Isoseismal Map for Charleston, S. C., Earthquake on August 31, 1886

The 1912 and 1913 earthquakes have been analyzed in detail by S. Taber, as was a February 21, 1916 earthquake, centered near Skyland, N. C., on the North Carolina border about 150 miles from the Savannah River Plant site.[24-26] The isoseismal lines for these three earthquakes are plotted in Figure 39.

The seismic activity in the southeastern part of the United States has been low since the Jurassic Period (about 200 million years ago). Recorded seismic activity has remained low during historic times. No severe earthquake shocks had their origin in the area from the time of settlement by colonists in 1671 until the Charleston earthquake in 1886. The only shocks of significance felt in the area during the 200-year period were those connected with the New Madrid, Missouri, disturbance of 1811-1812. These shocks slightly damaged a few brick buildings in Columbia and elsewhere in the state of South Carolina.

Of 439 earthquakes reported to have occurred in South Carolina between 1754 and 1972, 402 have occurred in the Charleston-Summerville area as foreshocks and aftershocks of the great 1886 Charleston quake. In the year following the 1886 main quake, a series of 86 aftershocks were felt. The frequency of aftershocks decreased with time, as is characteristic with aftershock series.

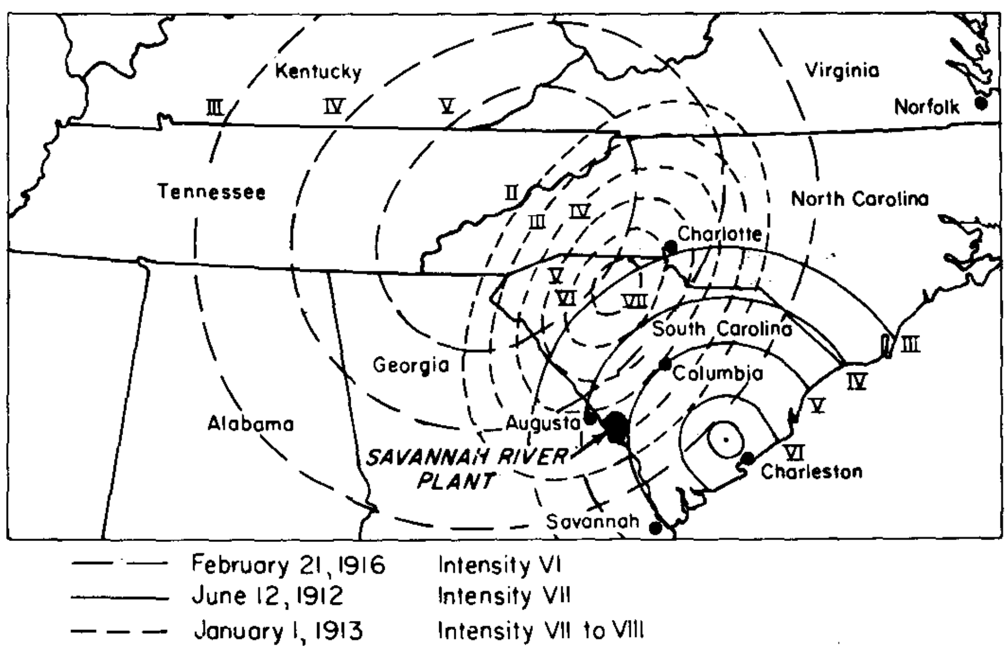


FIGURE 39. Isoseismal Intensities For Three Earthquakes

The spatial distribution of South Carolina earthquakes, with respect to southern Appalachian seismicity, is shown in Figure 40.[23] The central portion of the state was the locale for three of the four 1971 earthquakes (the fourth occurred in the northwest portion of the state) and the February 1972 earthquake. These quakes near Orangeburg had epicenters in the heretofore activity-free central portion of the state (Figure 41). None of these tremors exceeded an intensity of II MM at the SRP site.

The region surrounding the plant generally is one characterized by a relatively slow rate of crustal change. It is near an ancient mountain system, which no longer is undergoing active deformation or faulting. The crust is slowly tilting, perhaps is rising isostatically, but in any case is relatively stable. The region is accumulating stresses relatively slowly and, more importantly, appears to relieve these stresses by relatively frequent earthquakes of small intensity.

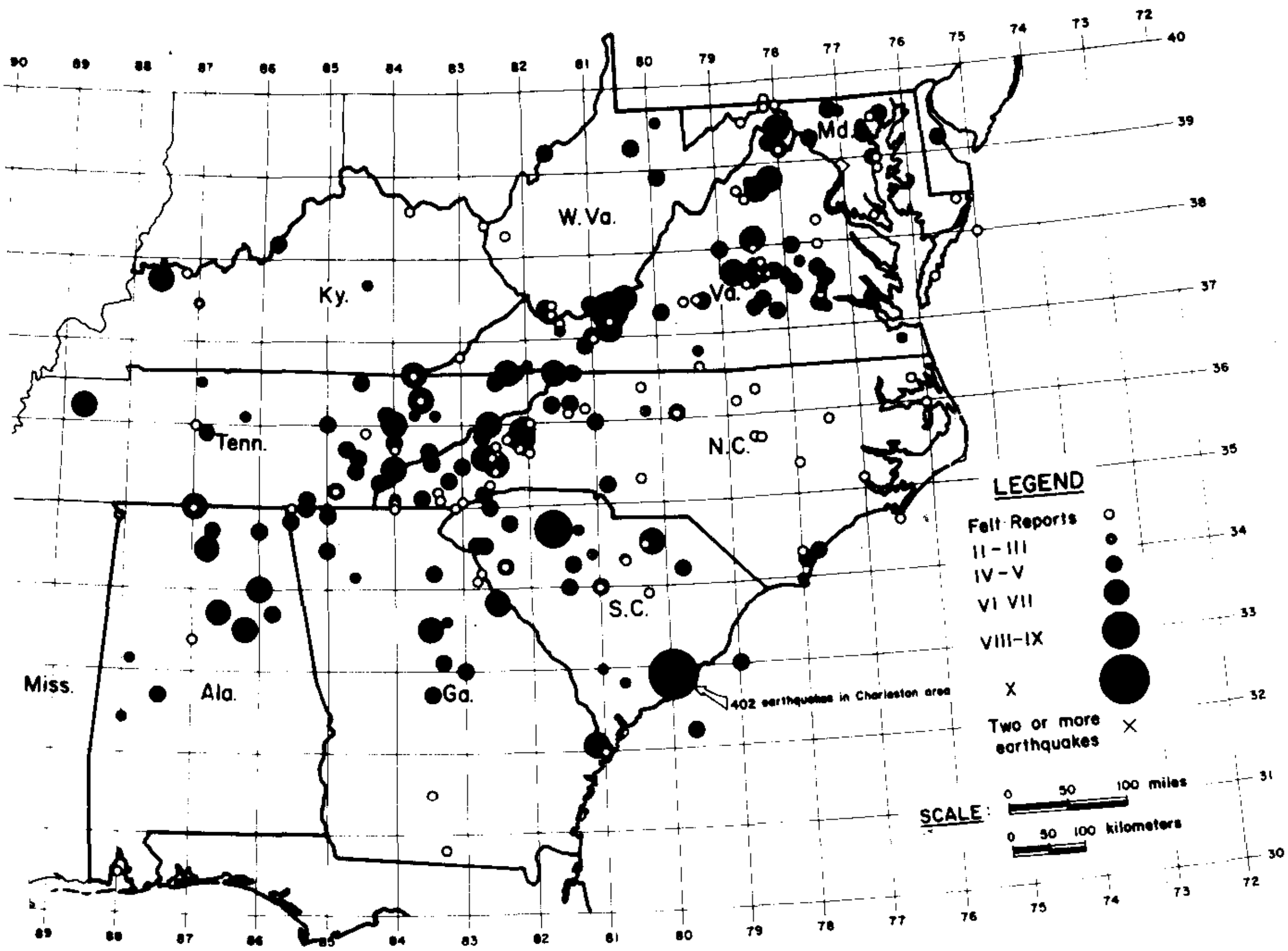


FIGURE 40. Seismic Activity in Southern Appalachian Area Between 1754 and 1970

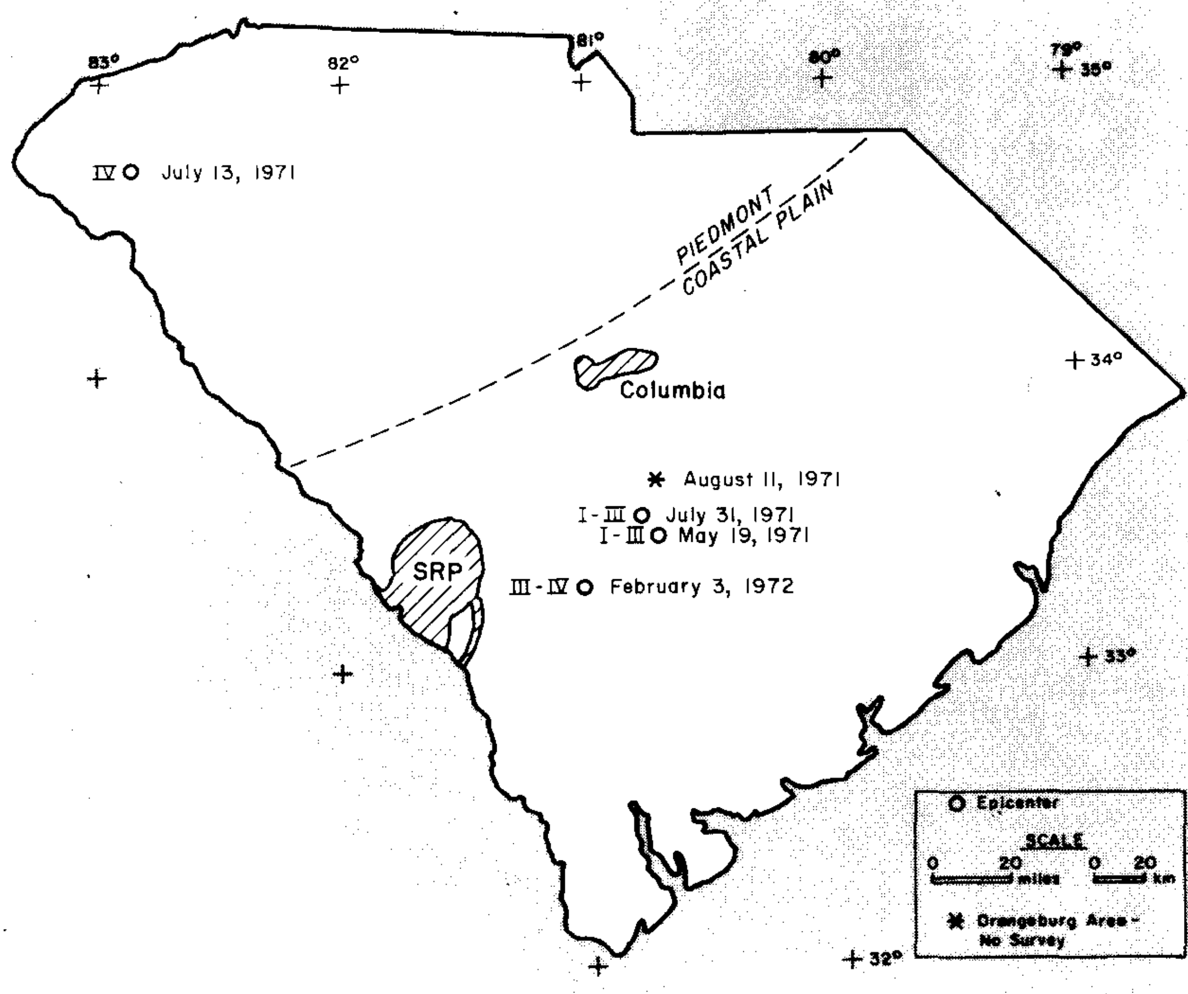


FIGURE 41. Earthquakes in South Carolina during 1971-1972

BIOTA

The plantsite is a natural preserve for biota typical of the southeastern Coastal Plain. The production and support facilities occupy only a small portion of the plantsite, and wildlife is little affected by them. Radioactive releases are limited to low levels in limited areas and have had no significant effect on the wildlife.

BACKGROUND

Before construction of SRP in 1951-52, Ellenton (population 600) and Dunbarton (population 231) were the only towns on the plantsite. The communities of Leigh, Hawthorn, Robbins, and Meyers Mill were isolated aggregates of families. After acquisition of the site by the Government, abandoned houses and towns entered ecological successional stages due to lack of maintenance. Honeysuckle invaded these areas, and fruit trees and ornamentals grew wild. At the time of Government acquisition, about 67% of the land area was forested, and 33% was in croplands and pastures, mostly on the terraces. Cotton and corn were the chief crops. Abandoned fields passed through the annual forb stage (broadleaf vegetation) into the perennial grass stage and gradually became more wooded, mostly with pine.

HABITAT CONDITIONS

From the viewpoint of wildlife management, habitat conditions are considered fair-to-excellent over the plantsite. Carrying capacity for all species is beginning to diminish. Canopy closure in the pine plantations is shading out much of the understory vegetation, and overutilization and advanced succession are beginning in the abandoned town and homesite complexes.

Approximately 30,000 acres in the northern portion of the plantsite are covered with deep infertile sands. Streams and small branches that cross the area and several ponds provide sites for the existing wildlife species.

The Savannah River swamp, particularly that portion subject to periodic flooding, and the dry sandy sites of the north are areas of limited wildlife support. Although the swamp is supporting many wildlife species, the composition and age of vegetational species limit carrying capacity. Proposed hardwood regeneration cuttings in the swamp will substantially increase both quality and quantity of forage species.

The part of the plant between the sandy sites on the north and the Savannah River swamp on the southeast is best suited for most of the wildlife species because of soil fertility and resultant favorable species composition. Much of the area is in young pine plantations. Sawtimber is uncommon. Ecological succession in the area of old townsites has reached the stage of maximum forage production (for deer). Hedgerows, ornamentals, and fruit trees also provide excellent quail and other wildlife habitats. Rabbit and squirrel populations are dense around these areas.

Artificial water impoundments are numerous. Five natural streams drain the site to the Savannah River, the largest being Upper Three Runs and Lower Three Runs. In addition to the normal occurrence of warm water species of fish, these streams provide spawning runs for striped bass, an anadromous species. The Savannah River swamp provides excellent habitat for fish in the numerous stream channels and oxbow lakes.

VEGETATION

The plantsite is about evenly divided between the Coastal Terrace subregion and the Aiken Plateau. The Aiken Plateau is quite hilly and deeply dissected by small streams. There are extensive areas of scrub oak - longleaf pine forest along the ridges, and many of the farms in this region were marginal in agricultural productivity. Soils in the Aiken Plateau are mostly sandy and low in fertility. Most of the soil is too sandy and excessively drained to yield regular, profitable crops.

Sandy loams occur in the Coastal Terraces subregion. Fertility is much greater in this area than on the sandy soils of the Aiken Plateau. Fluvial belts of sandy loams also occur along the streams that cross the SRP site. Farming in this area before construction of SRP was confined to the Sunderland and Brandywine terraces bordering the Savannah River floodplain.

Before Federal acquisition there was very little timber management in the area. Generations of exploitive logging had resulted in poor stands of timber except for hardwoods in the floodplains; timber cutting in the floodplain was not over-exploited because of limited access.

A timber planting program was started late in 1952 by the U. S. Forest Service under a cooperative agreement with the Atomic Energy Commission. By 1972, the site was extensively planted with over 100 million pine trees. The distribution of major types of vegetation is shown in Figure 42.[27] Each symbol on this map represents 40 acres of land.

Almost 35 million board-feet of pine and hardwood sawtimber and over 245,000 cords of pulpwood have been harvested to date. The current land utilization (other than the approximately 13,000 acres of industrial areas and support facilities and 5,600 acres of water) is shown in Table XVII.

TABLE XVII[27]

Land Utilization, acres

Open fields	640
Slash pine	33,800
Longleaf pine	11,080
Loblolly pine	13,880
Pine-hardwood (60% pine)	46,360
Hardwood-pine (60% hardwood)	43,640
Scrub oak	13,400
Upland hardwoods	2,760
Bottomland hardwoods	32,920

Two major subdivisions are described in the SRP Timber Management Plan: commercial and noncommercial forest land. Commercial forest lands are subdivided as follows:

- Nonmodified - those lands existing as stands that are or will be managed under even-aged practice.
- Modified - those lands bordering public access roadways that currently support stands of timber, and will be under modified even-age management to furnish maximum aesthetic values while still furnishing timber products.
- Unregulated - those areas that cannot be predictably managed due to conditions caused by reactor effluents. These include both areas where timber has been killed by hot water and areas normally inaccessible to timber harvest due to excessive flooding.
- Reserved - a 950-acre area reserved to the study of ecological succession by personnel from the University of Georgia and others.

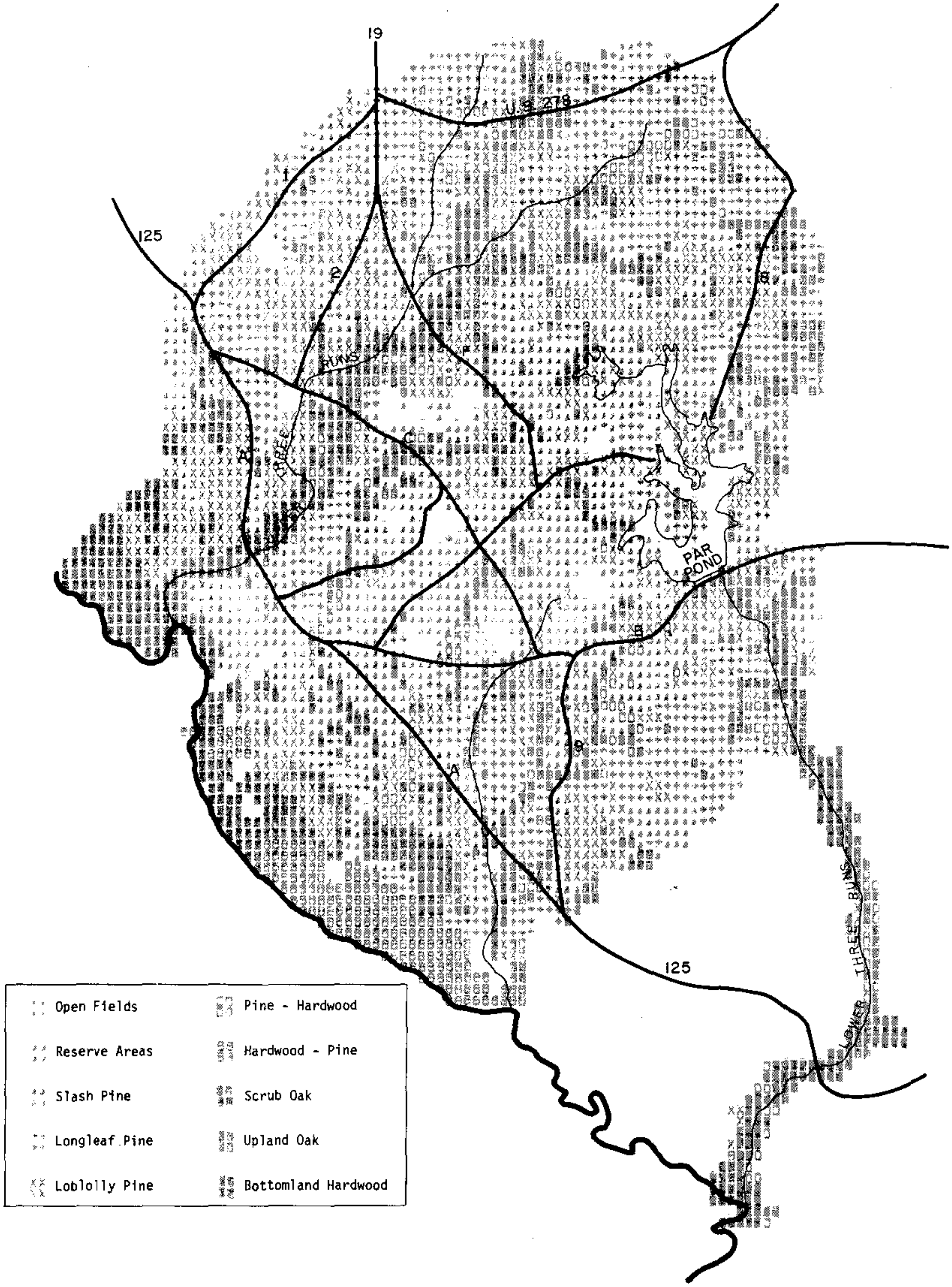


FIGURE 42. Forest Types on the Savannah River Plant

The composition of the naturally seeded forests of the Savannah River Plant site is closely related to the moisture available to the trees. Habitats range from very sandy, dry hilltops to continually flooded swamps. This continuous range is broken into zones characterized by a community of tree species.

The xeric, sandy areas[28] are typically covered with a scrub-oak community dominated by longleaf pine, turkey oak, blue jack oak, black jack oak, and dwarf post oak with ground cover of three awn grass and huckleberry.

On more fertile, dry uplands, oak-hickory hardwoods are prevalent. The most characteristic species are white oak, post oak, southern red oak, mockernut hickory, pignut hickory, and loblolly pine, with an understory of sparkleberry, holly, greenbrier, poison oak, and poison ivy.

On more moist soils, often found along small streams or on old floodplains, the composition is more variable. Trees may include tulip poplar, beech, sweetgum, willow oak, swamp chestnut oak, water oak, loblolly pine, and ash. The understory may include dogwood, *Vibernum*, holly, and red buckeye.

Bottomland hardwood forest[29] borders the Savannah River swamp where it is subject to occasional flooding. Here, small variations in elevation strongly affect the kinds of trees present. Some common trees are sweetgum, swamp chestnut oak, red maple, ash, laurel oak, blue beech, river birch, water oak, willow oak, sycamore, winged elm, and loblolly pine. Palmetto, switch cane, greenbrier, grape, crossvine, and trumpet creeper are common.

In the Savannah River swamp, where standing water is present most of the year, bald cypress and tupelo gum are dominant trees. Black gum, water elm, and water ash are also present.

Examples of habitat types at SRP have been reserved for research purposes. Two of these areas are registered with the Society of American Foresters as Natural Areas for the preservation of forest cover types. These are: Boiling Springs Natural Area - an example of loblolly pine-hardwood (9 acres), and Scrub Oak Natural Area - an example of scrub oak-longleaf pine forest type (52 acres).

Ten areas[30a] are typical of the major ecosystems present on the plantsite:

1. Sandhills - 67 acres
2. Cypress Grove - 22 acres
3. Loblolly Stand - 28 acres
4. Steel Creek Bay - 29 acres
5. Mixed Swamp Forest - 91 acres
6. Beech Hardwood Forest - 118 acres
7. Oak-Hickory Forest - 83 acres
8. Old Fields - 350 acres
9. Risher Pond - 4 acres
10. University of Georgia Laboratory Area - 100 acres of fields and pine woods.

The ages (in 1972) of the major types of vegetation are summarized in Table XVIII and distribution is shown in Figure 43. Each symbol represents 40 acres.

TABLE XVIII

Age of Major Types of Trees[27]

Age, years	Acres
Unclassified	640
1 - 10	21,720
10 - 20	77,080
20 - 30	24,560
30 - 40	15,400
40 - 50	19,560
50 - 60	13,760
60 - 80	17,360
80 +	8,440

Biologists[28-32] have recorded a variety (128 families, 871 species) of vascular plants on the plantsite. These are listed alphabetically by family in Appendix E. Although this is an incomplete listing, it represents most of the more common plants present.

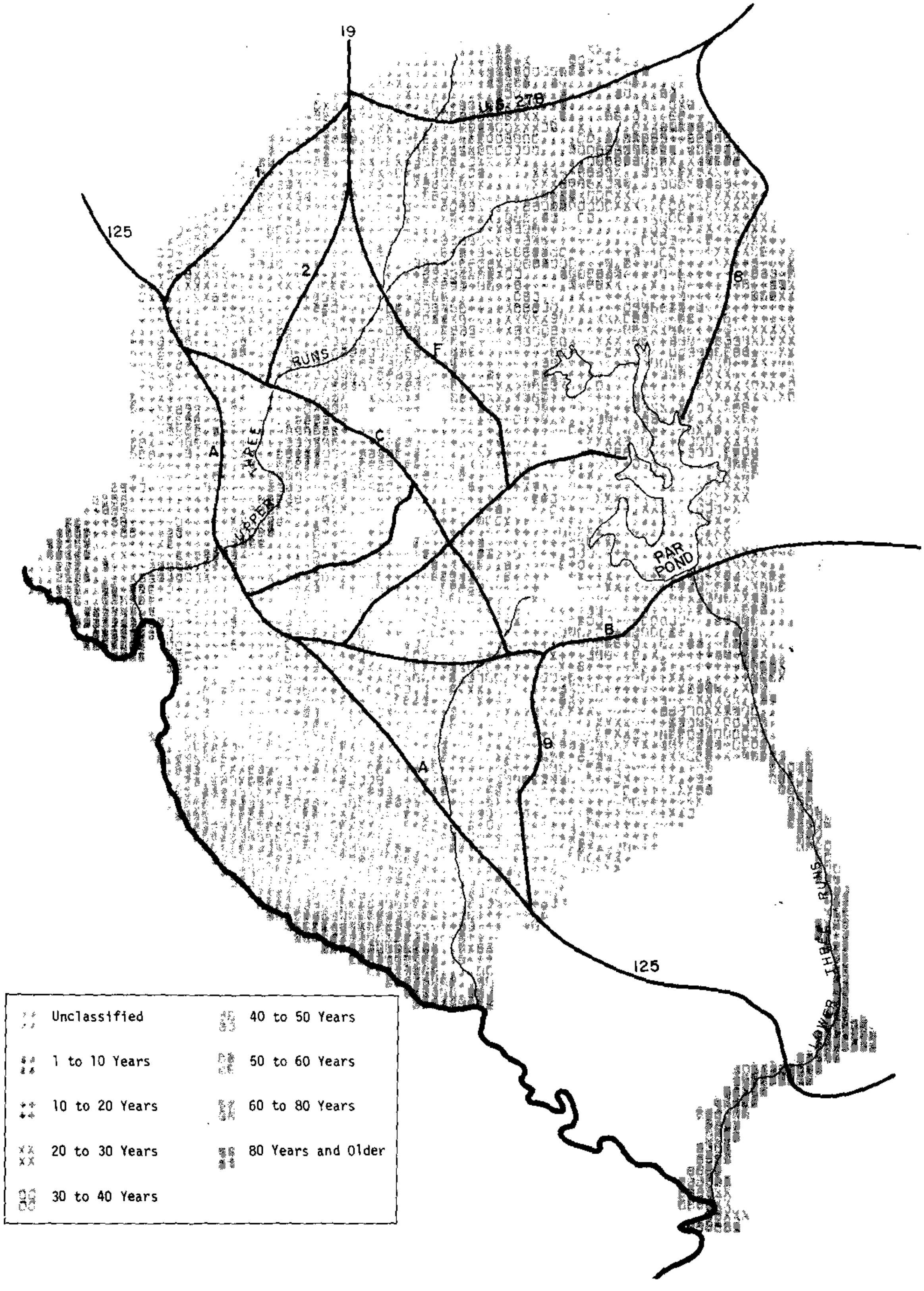


FIGURE 43. Age of Vegetation on the Savannah River Plant

FURBEARERS

The populations of most species of furbearers increased rapidly after the Savannah River Plant was officially closed to the public on December 14, 1952.

Most notable expansion was in the deer herd, which was estimated to be about 10 animals in 1951. A virtual population explosion occurred; the present population is estimated to be 35 deer per square mile or between 10,000 and 11,000 on the plantsite (Figure 44). The greatest population densities occur on the southern and northeastern portions of the plantsite. Under protection, the population expanded so rapidly that by 1960, deer-vehicle collisions were common, and the hazard of range deterioration was apparent. Controlled hunts, open to the public, were instituted in 1965. Approximately 7,000 deer have been killed, 6,000 in public hunts and 1,000 for study purposes.[32a]

Domestic hogs, abandoned in 1952, reverted to the semiwild state and became detrimental to young forest plantations. A control program of hog removal was initially pursued by shooting and trapping. Currently, deer hunters are allowed to shoot the feral hogs, and 62 have been killed since 1970.

Feral dogs are present on the plantsite. Because the threat of rabies is always present, and a few persons were chased by dogs, trapping is practiced, and captured dogs are turned over to the S.P.C.A. for disposition.

With the exception of deer, feral hogs, and feral dogs, there is no wildlife predation by man. Small mammals such as mice, rats, and shrews are common in favorable habitats. Animals that are common (C) or abundant (A) on the plantsite are:

Gray fox	(C)	Opossum	(C)
Racoon	(C)	Cottontail rabbit	(A)
Wildcat	(C)	Gray squirrel	(A)
Red fox	(C)	Fox squirrel	(C)
Striped skunk	(C)		

Uncommon species found in favorable habitats include marsh rabbit, beaver, and otter. Animals considered rare are spotted skunk, cane cutter rabbit, black bear, mink, weasel, muskrat, and cougar.

A table of furbearing animals, listed with scientific name, common name, distribution, and abundance appears in Appendix F. Information for this table was extracted from References 33 through 36.

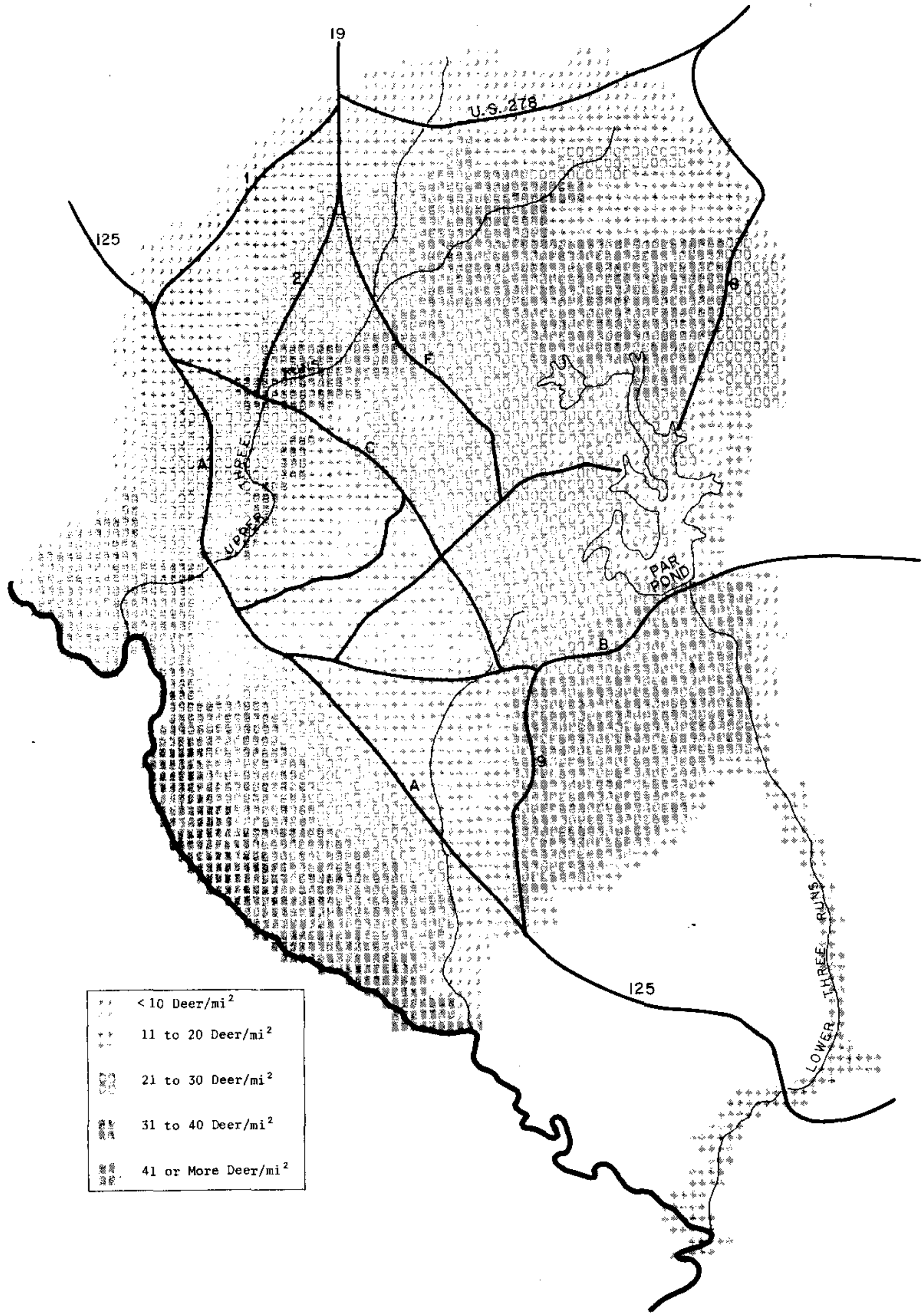


FIGURE 44. Deer Density on the Savannah River Plant

BIRDS

Before acquisition of the plantsite by the Government, game birds, particularly quail and dove, were abundant due to extensive use of land for agriculture. Wild turkey, although present, were of very limited numbers. Waterfowl were present but mainly during winter migrations. Winter waterfowl species increased in number and diversity after construction of Par Pond. An estimated 10,000 ducks and coots spend the winter on the site. Most of these are on Par Pond and several other large ponds and Carolina Bays. Perhaps 2,000 ducks spend the winter in the lower swamps and on the Savannah River. Wood ducks are the only common nesters.

The removal of land from agriculture did not decrease the quail population; in fact, the population increased and probably reached a record high in the early 1960's and has been declining, since ecological succession is reducing carrying capacity of the land.

Endangered species of birds that are protected on the SRP site are the bald eagle and the redcockaded woodpecker.

Biologists[37] have identified 213 species of birds on the plantsite; these are listed in Appendix G. The major habitat types for birds are:

- Bottomland hardwoods, including stands of cypress, tupelo, and black gum in the Savannah River swamp, and stands of oak, sweetgum, black gum, tulip-poplar, red maple, and other trees on swamp ridges, stream bottoms, and flatlands.
- Sandhill pinelands which, at elevations of 150 to 390 ft, are characterized by longleaf pine, although portions are overgrown with scrub oak.
- Abandoned fields, which contain a variety of grasses and nongrassy herbs, or forbs, with heavy growths of broomsedge in long-abandoned fields.
- Aquatic and semi-aquatic habitats, including streams, ponds, and Carolina Bays.

FISH

Aquatic habitats for fish on the plantsite are numerous and diversified. They consist of natural and thermally stressed flowing streams, ambient temperature and thermally stressed reservoirs, Carolina Bays, abandoned farm ponds, swamp channels, and oxbow lakes.

The surface waters are described in more detail in the section "Hydrology"; however, waters of most importance, from the standpoint of SRP operation, and from the standpoint of important environmental research potential, are briefly described below.

Upper Three Runs. This is the largest natural flowing stream on the site. It has never been thermally stressed and is essentially unchanged by plant operations. Fish range throughout.

Four Mile Creek. This stream receives reactor cooling water effluent. Fish inhabit the lower reaches near the Savannah River swamp and backwater pools.

Pen Branch. This stream also receives reactor cooling water effluent. Fish inhabit only the lower reaches and backwater pools.

Steel Creek. This stream received reactor cooling water effluent before 1968 but is currently at ambient temperature and is reverting to its natural state. Fish range throughout.

Lower Three Runs. This stream received reactor cooling water effluent during the period 1953-1958. A 2640-acre reservoir (Par Pond) was constructed on the headwaters of this creek in 1958 to receive reactor cooling water and has been used continuously since that time. Par Pond water is recirculated to an operating reactor, and any water that overflows the earthen dam spillway is within a few degrees of natural ambient temperatures. Lower Three Runs temperature has not been affected by reactor operation since 1958, and fish range throughout.

Par Pond. This large cooling water impoundment has been receiving reactor cooling water since 1958. Temperatures are elevated at one end and near ambient at the cold end. The pond is connected to two reactor effluent streams (one reactor operating, one reactor shutdown since 1964) by a series of canals and smaller pond (Figure 11). Fish range throughout Par Pond and ponds on the canal network. Fish populations peaked during the early 1960's in Par Pond. However, due to the protected nature of the impoundment, populations are becoming unbalanced. Bass populations are excessively high, and bream populations are declining. Major species occurring are largemouth bass, black crappie, bluegill, and redbreasted sunfish.

Recent studies[38-41] have identified 57 species of fish at selected sampling locations in the waters described above. All of the species collected are also found in the Savannah River drainage system in which 102 species have been identified.[42] Species diversity depends on current utilization of the waters. Twenty-eight species have been identified in Par Pond, six species in Pond 2, nine species in Pond B, and twelve species in Pond C. The average water temperature of Pond C is higher than that of Par Pond and Pond 2 is warmer than Pond C (Figure 19). Pond B does not currently receive heated effluents.

Most species not collected from the Par Pond system but reported in Lower Three Runs are those commonly considered to inhabit flowing waters. Two species have been collected from Par Pond but have not been recorded as present in Lower Three Runs. These are *Ictalurus platycephalus* (flat bullhead) and *Alosa aestivalis* (blueback herring). The latter is an anadromous species which commonly migrates up the Savannah River to spawn. An effort is being made to determine if this species is reproducing and is truly landlocked in the reservoir system. Species identifications in streams number 36 in Upper Three Runs, 25 in Four Mile Creek, 16 in Pen Branch, 24 in Steel Creek, and 42 in Lower Three Runs. Appendix H lists scientific and common names of identified species and locations where found. All streams, except Lower Three Runs, were sampled near the Savannah River swamp. Lower Three Runs was sampled 8 miles downstream from the Par Pond Dam. The most common species in reservoirs and impoundments are redbreasted sunfish, bluegill, bream, largemouth bass, and crappie.

REPTILES AND AMPHIBIANS

The SRP site, with its wide diversity of aquatic and terrestrial habitats, supports a diverse population of reptiles and amphibians. Species common to the southeastern Coastal Plain are found. Biologists[43,44] have identified 10 species of turtles, 10 species of lizards, 1 specie of alligator, 34 species of snakes, 15 species of salamanders, and 28 species of frogs and toads. A listing of reptiles and amphibians, with scientific and common names, appears in Appendix I. Alligators, once rare, are now commonly seen in Par Pond and, to a lesser extent, in some of the effluent streams.

BACKGROUND RADIATION

Naturally occurring radiation from both cosmic and terrestrial sources varies with location, but is assumed constant with time within the recorded span of human history.[45] Local penetrating radiation from artificial origins, both fallout from nuclear detonations and prescribed medical exposures, varies primarily with time for the population as a whole, and doses from the latter source vary from one individual to another. External exposure from radioactive fallout appears to be decreasing with time as a result of the nuclear test ban treaty,[46,47] while that from medical sources appears to be increasing as a result of increased use of diagnostic X-rays.[48]

The calculated annual radiation dose received by the average person living in the vicinity of the Savannah River Plant in 1972 is approximately 220 mrem, of which approximately 120 mrem is from natural sources.* Its distribution is shown in Table XIX. The wide range of exposures (excluding those incurred for medical reasons) results primarily from the geologic distribution of naturally radioactive elements near the surface in this region.

In the vicinity of SRP, low concentration placer deposits of uranium and thorium occur in the Atlantic Coastal Plain. Slightly higher concentrations occur in near-surface rocks of the Piedmont Plateau bordering the Coastal Plain on the northwest. These deposits cause substantial local variations in natural background radiation within the region. The radioactivity of these deposits on the plantsite and environs has been described in detail by Schmidt.[49]

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* The dose received by a person living near the plant perimeter from SRP radioactive releases is <1% of that received from natural sources.

TABLE XIX

Background Exposure

	Estimated Whole Body Dose, mrem	
	Average[a]	Range[b]
Natural		
Cosmic Radiation	35	30-40
Terrestrial Deposits		
External	55	6-380
Ingested	27	25-30
Total Natural	117	
Artificial		
Medical Diagnostic	101	*c*
Weapons Fallout		
External	1	
Ingested	4	3-8
Total Artificial	106	
Total Background	223	165-560

a. Central Savannah River Area (within 40 km of SRP perimeter)

b. Within 100 km of SRP perimeter

c. Only the average used in total range because of high individual variability

COSMIC RAY

Cosmic ray contribution to natural background dose varies with both latitude and altitude. SRP and the surrounding area lie between latitudes 33°N and 34°N with an altitude variation between sea level and roughly 300 meters (1000 ft).[50]

The ionizing component of cosmic radiation at sea level varies with latitude in the plantsite area by only about 0.5% of mean value,[51] less than the variation between measurements by different investigators (∿3.7%).[52] The altitude effect on the ionizing component of cosmic radiation (based on doubling of the dose rate for every 1500-meter increase in altitude[53]) causes an increase of from 1.4% to 5.8% over the sea level dose at the roughly 100 to 400 ft elevation of the general area surrounding the Savannah River Plant. The dose rate from this component of cosmic radiation is thus estimated at 29 mrad/yr based on a sea level rate of 28 mrad/yr.[54]

The dose equivalent rate from the neutron component of cosmic radiation is more difficult to estimate because of the wide variations in measurements[55] and the effect of self-shielding and secondary production in the body. Compared with the effects of these variations, the changes with latitude and altitude within the region of concern are negligible. Watt's experimental data[56] corrected for latitude and altitude give a value of 6 mrem/yr at SRP.

Thus, the total dose equivalent attributed to cosmic radiation in the vicinity of SRP is 35 mrem/yr.*

EXTERNAL TERRESTRIAL RADIATION

External terrestrial radiation in the vicinity of SRP is attributed primarily to gamma emitters in the natural radioactive series derived from uranium and thorium with some additional contributions from potassium-40. Variation in the distribution of these minerals in local geologic formations and their inclusion in materials of construction commonly used in urban areas leads to a wide variation with location. Some typical values are shown in Table XX. Because of the wide variation shown, the U. S. mean value of 55 mrem/yr[57] is chosen to represent the average external terrestrial background in the vicinity of SRP. Lowder and Condon[58] cite essentially the same rate, 1 mrem/wk, for the average dose to persons living indoors.

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* mrad is equivalent to mrem for the ionizing component of cosmic radiation and for external terrestrial radiation.

TABLE XX

External Gamma Fields From
Natural Terrestrial Radioactivity

(mrem/yr)

	Aircraft Surveys	Spot Measurements on Ground: SRP Mean (70)	Spot Measurements on Ground: Other
Augusta, Ga.	17- 85 (58)[b]		56 (71)
Waynesboro, Ga.	17- 46 (58)	26	
Aiken, S. C. (Airport)	17- 34 (58)	19	26 (63) 24 (65)
Barnwell[a]	6- 51 (58)	35	
Edgefield[a]	11-154 (58)		23- 95 (63)
Lexington[a]	17-385 (58,63)		20-140 (63)
Columbia	35-385 (63)		80 (58) 70 (71)

a. 10-mile radius

b. Number in parentheses is year of measurement. Source of data is also given.

(58) Reference 49

The aeroradioactivity survey readings reported by Schmidt in counts per second (cps) at 500 ft altitude were corrected for background due to fallout (150 cps) and converted to mrem/yr at 3 ft by the factor 1 mrem/hr at 3 ft = 77,000 cps at 500 ft (Reference 49, p 13). This is considered a better conversion factor than the 1 μrem/hr = 37 cps derived from the correlation curve supplied by Schmidt (Reference 49, p 17) because the latter was based on ground readings in the μrem/hr range which are subject to considerable uncertainty.

Reference 56

(63) References 59 and 60

(65) Reference 61

(70) Reference 62

(71) Lawrence Livermore Laboratory measurements

INTERNAL RADIATION

Internal radiation from natural sources arises primarily from ^{40}K, daughters of ^{226}Ra, ^{14}C, and ^{87}Rb. Contributions from these sources are shown in Table XXI. Whole body dose can be estimated as equal to gonad dose if only the gonad dose has been calculated. No estimate of variation with location is attempted because widespread distribution of fertilizers and foods as well as population mobility has an averaging effect for these natural long-lived radionuclides that produce the internal dose.

TABLE XXI

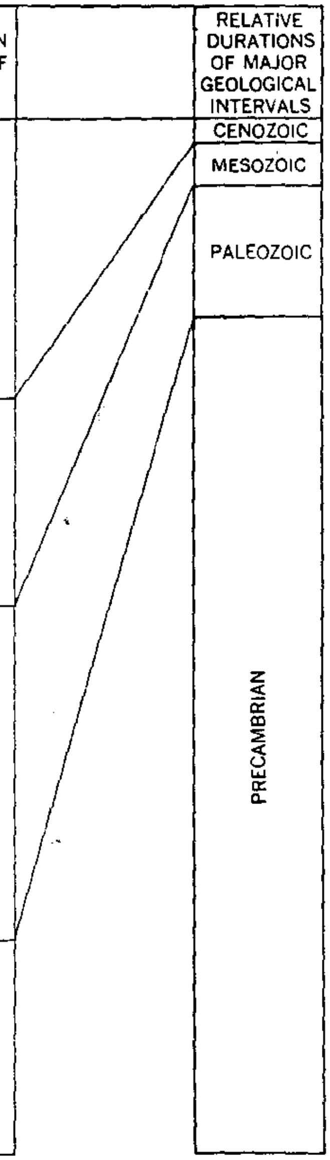
Estimated Average Annual Whole-Body Internal Radiation Dose From Natural Radioactivity

Nuclide	Dose, mrem	Year	Source of Data
^{3}H	<0.01	1962	Reference 63, p 217, paragraph 84
^{14}C	1.0	1962	Reference 63, p 216-216, paragraph 82
^{40}K	19	1962	Reference 63, p 216, paragraph 80
^{87}Rb	0.6	1966	Reference 64, p 27, paragraph 136 (QF^{a} = 2)
^{210}Po	3.0	1966	Reference 64, p 35, Table XVI (QF = 10)
^{222}Rn	3.0	1962	Reference 63, p 212, paragraph 41 (QF = 10)
Total	27.0		

a. Quality factor.

Appendix A
THE GEOLOGIC TIME SCALE[65]

ERA	PERIOD	EPOCH	MILLIONS OF YEARS AGO (APPROX.)	DURATION IN MILLIONS OF YEARS (APPROX.)
CENOZOIC	QUATERNARY	RECENT PLEISTOCENE	0-1	1
	TERTIARY	PLIOCENE	1-13	13
		MIOCENE	13-25	12
		OLIGOCENE	25-36	11
		EOCENE	36-58	6
		PALEOCENE	58-63	
MESOZOIC	CRETACEOUS		63-135	72
	JURASSIC		135-181	46
	TRIASSIC		181-230	49
PALEOZOIC	PERMIAN		230-280	50
	PENNSYLVANIAN		280-310	30
	MISSISSIPPIAN		310-345	35
	DEVONIAN		345-405	60
	SILURIAN		405-425	20
	ORDOVICIAN		425-500	75
	CAMBRIAN		500-600	100
PRECAMBRIAN	UPPER MIDDLE LOWER	Although many local subdivisions are recognized, no world-wide system has been evolved. The Precambrian lasted for at least 2½ billion years. Oldest dated rocks are at least 2,700 million, possibly 3,300 million, years old.		



Appendix B
GEOLOGIC CHARACTER OF FORMATIONS UNDERLYING THE SAVANNAH RIVER PLANT[5]

AIKEN PLATEAU OF RECENT EPOCH

The Aiken Plateau lies between the Savannah and Congaree Rivers and extends southeastward from the Fall Line to the inland margin of the Coastal Terraces. The surface of the plateau is dissected by many streams and has broad interfluvial areas and relatively narrow steep-sided valleys. The interfluvial areas represent an upland plain that slopes gently to the southeast. Its altitude on the northwest edge near the Fall Line is about 650 feet msl, and the slope to the southeast is about 8 feet/mile. Streams draining the upland have cut steep-sided valleys on the plateau and have left a relief of as much as 300 feet in some areas.

Although most of the upland area is well drained, poorly drained sinks or natural depressions are fairly numerous, particularly in those areas underlain by calcareous beds. Many of the smaller depressions represent solution depressions or sinks and have an irregular or circular outline, typical of solution sinks formed elsewhere. Some of these sinkhole depressions have forms that are nearly indistinguishable from the Carolina Bays described elsewhere in this report.

ALLUVIUM OF RECENT EPOCH (QUATERNARY PERIOD)

Alluvium of recent age occurs in the tributary and main channels of the Savannah River. These deposits are generally cross-bedded and heterogeneous in composition and range in thickness from about 5 to 30 feet. The deposits consist of poorly sorted sand, clay, and gravel.

MARINE TERRACE DEPOSITS OF PLEISTOCENE EPOCH (QUATERNARY PERIOD)

The Coastal Terraces extend from the outer or shoreward margin of the Aiken Plateau to the Atlantic Coast, a distance of 80 to 90 miles. The section includes the lowland along the Savannah River. As the name implies, terraces - either alluvial or marine - are the characteristic feature of the area. According to Cooke,[2] the Coastal Terraces mark the position of seven former stands of the sea during which waves cut into the headlands and built offshore bars.

The seven Coastal Terraces and their altitudes are as follows: Pamlico, 25 feet, Talbot, 42 feet; Penholoway, 70 feet; Wicomico, 100 feet; Sunderland, 170 feet; Coharie, 215 feet; and Brandywine (or Hazlehurst), 270 feet. (The Wicomico, Sunderland, and Brandywine terraces have been identified on the SRP site.)

Objections have been raised to the designation of the high (and some intermediate) terraces (which includes the ones present at SRP) as marine features of Pleistocene age because their present physiographic expression is too nebulous for positive correlation as remnants of 1) former marine plains, 2) marine bars, or 3) wave-cut cliffs, or even as remnants of fluvial plains. Whatever their origin, there is fairly distinct evidence of separate terrace deposits in some areas. The terrace deposits consist of surficial porous media containing tan-to-gray sand, silt, and gravel with blanket deposits of coarse gravel on the higher terraces through which water from precipitation must pass to recharge underlying water-bearing beds.

ALLUVIUM OF PLIOCENE EPOCH (TERTIARY PERIOD)

Alluvial deposits of late Tertiary age occur irregularly and discontinuously on the interstream divides or plateaus. They are composed of coarse gravel and poorly sorted sand and are tentatively classified as Pliocene in age, because of their stratigraphic and topographic position above deposits of Eocene and Miocene age. The thickness of the deposits ranges from 5 to 20 feet. Included in this category are the alluvial deposits that occur along the east flank of the Savannah River basin. They probably represent materials reworked from the Tuscaloosa Formation. Generally, the poorly sorted sand and gravel that constitute the alluvial deposits are considerably above the water table and have little importance as a source of ground water for wells. Nevertheless, these deposits are fairly permeable and are capable of storing and transmitting water. For this reason, and because the deposits occur at the ground surface, it is presumed that water from precipitation is absorbed by them at land surface and transmitted to underlying permeable formations.

HAWTHORN FORMATION OF MIOCENE EPOCH (TERTIARY PERIOD)

The Hawthorn Formation crops out in a very large part of the southeastern Atlantic Coastal Plain and probably represents the most extensive surficial deposit of Tertiary age in this region. The area of outcrop extends northeastward from Alabama and Florida across Georgia into South Carolina. In Aiken County, the Hawthorn Formation immediately underlies the land surface in the topographically high areas. Toward the south and east, the Hawthorn Formation occurs at progressively lower altitudes and eventually passes beneath the thin mantle of younger deposits that constitute a series of Coastal Terraces. It thickens from 0 feet in northwestern Aiken County to approximately 80 feet in the vicinity of the Barnwell-Allendale County line.

The Hawthorn Formation is characteristically composed of fine sandy phosphatic marl or soft limestone and hard brittle shale resembling silicified fuller's earth. In the updip area of Aiken and Barnwell Counties, it consists mainly of tan, reddish-purple, and gray sandy dense clay that contains coarse gravel and limonitic nodules. Small white flecks of kaolinitic material that are commonly disseminated throughout the formation give it a white mottled appearance. Generally, the color pattern of the deep-red to purple clay resembles that of alligator skin. Coarse angular brown pebbles of ferruginous to phosphatic (?) composition occur commonly as a thin deposit over the outcrop area of the Hawthorn Formation.

The most unusual feature of the Hawthorn Formation is the numerous sediment-filled fissures or clastic dikes crisscrossing the clayey sand. This feature is particularly conspicuous in exposures in Barnwell County. The fissures extend to considerable depth, as revealed by excavation, and they are generally filled with a greenish-gray silty to sandy clay. The dike wall, 0.2 to 1.0 inch thick, is generally indurated and consists of an iron-oxide-cemented quartz sand. The enclosing sediments are tan to red or purple coarse sand and clay. There is also a noticeable degree of orientation or lineation of the dikes. Most of those selected for measurement in Barnwell County showed a strike of either N85°E or N5°E and a dip of 45° to 55° in either direction from the line of strike. The consistent alignment of many of the dikes is their most noticeable characteristic and is rather unusual in unconsolidated sediments. Although clastic dikes have been observed elsewhere in the Coastal Plain, they are not so numerous nor so well aligned as those in Barnwell County.

The origin of the dikes may be attributed to several factors: 1) shrinkage resulting from weathering, 2) seismic activity, and 3) relief of compressional stresses by the upward movement of plastic material. Many similar structural features in consolidated sediments elsewhere are generally explained on the basis of the first hypothesis, and the nonoriented or unaligned dikes in this area were probably formed in this manner. However, this hypothesis does not appear to be a completely satisfactory explanation for the formation of the aligned dikes, inasmuch as they are apparently confined to the post-Eocene sediments. Although the second possibility, seismic activity, is a likely causative force, it also seems probable that the dike itself was formed both by means of infilling, at an equal pace, of overlying material and by the mechanism included in hypothesis 3. So far as is known, there is no material present now in a stratigraphically higher position in the geologic section and similar in composition to the fracture fill that might conceivably have worked down into the fissure as it was formed. There is, however, greenish-gray clay in the Hawthorn Formation at downdip localities that could have been present in this area in the geologic past and would be a likely source for such filling. There is also similar clay stratigraphically lower in the geologic section, a fact suggesting that possibly some dikes were injected up through the younger Tertiary rocks. Conceivably this injection may have been brought about by the failure of underlying beds to support compressional stresses. Under such conditions, the weight of the overlying material would cause a failure in the substructure brought about by the ground water solution of the underlying calcareous beds. When these beds could no longer support the overlying formations, fractures would develop as the superstructure collapsed, and clastic material below would migrate up into the fractures. Some corroborative evidence for such an origin is indicated by the large number of solution sinks in the vicinity of the dikes, as for example, the northeastern quarter of the Ellenton quadrangle. Conversely, dike swarms are indigenous to those areas exhibiting other features of solution and collapse.

An interesting speculation concerns the relation, if any, that these fractures may have with the origin of the Carolina Bay structure. Such a fracture system might affect or control the orientation of areas of accelerated solution by circulating groundwater and thereby produce an incipient sink or bay.

BARNWELL FORMATION OF EOCENE EPOCH (TERTIARY PERIOD)

The term Barnwell Formation is used to designate deposits of late Eocene age that unconformably overlie the McBean Formation of middle Eocene age in Aiken and Barnwell Counties.

The Barnwell Formation is exposed in the uplands of most of Aiken and Barnwell Counties, but it has been removed by erosion in the valleys. The formation thickens to the southeast, from 0 feet in the northern part of Aiken County to approximately 90 feet at the southeast boundary of Barnwell County.

The general appearance and lithology of the Barnwell Formation resembles that of a residuum of sandy limestone strata from which most, if not all, the calcareous material has been removed by solution. The deposits are mainly composed of deep-red fine-to-coarse clayey sand and compact sandy clay. Other parts of the formation contain beds of mottled-gray or greenish-gray sandy clay and ledges of ferruginous sandstone that range in thickness from 1 inch to 3 feet. The differences in color of these deposits may be due to differences in the degree of weathering. Nonetheless, the deep-red materials are semiconsolidated and are generally exposed in steep-walled cliffs or bluffs.

At Shell Bluff in Burke County, Georgia, a shell bed containing the oyster *Ostrea gigantissima* Finch crops out along the west side of the Savannah River at an approximate altitude of 170 feet msl. This bed reportedly forms the basal part of the Barnwell Formation.

McBEAN AND CONGAREE (?) FORMATION OF EOCENE EPOCH (TERTIARY PERIOD)

The McBean and Congaree (?) Formations represent equivalents of the Claiborne Group of middle Eocene age of the Gulf Coastal Plain. A complete subdivision of the Claiborne group may be warranted in a detailed interpretation of the stratigraphic section in areas downdip or farther to the east. Such a division appears less warranted in the SRP area where the shoreward faces of each subdivided unit grades into a comparatively thin zone, and the criteria for distinguishing them become doubtful. In view of this difference the deposits of Claiborne age are grouped together for convenience as the McBean Formation generally, and more specifically as the McBean Formation for the upper part, and the Congaree (?) Formation for the lower part.

The deposits of Claiborne age strike about N60°E and dip about 8 to 9 feet/mile toward the south or southeast. Their thickness ranges from 0 feet in the northwestern part of the area to about 250 feet in the southeastern part near the Allendale County line. They overlie the Ellenton Formation in the area southeast of Upper Three Runs and overlap, unconformably, the Tuscaloosa Formation in the northern part of Aiken County and southern Edgefield County.

The deposits of Claiborne age include: 1) fine-to-medium sand (the grains being generally clear, transparent, and highly polished); 2) green glauconitic marl and clayey sand; 3) laminated beds of red, brown, and yellow-colored semiplastic to nonplastic clay (generally of the montmorillonite group but in part kaolinitic); 4) impure beds of soft fossiliferous limestone or marl; and 5) lenses of silicified limestone and a fossiliferous indurated tan-to-gray sandy marl.

A pisolitic clay zone, similar to that occurring in the Gulf Coastal Plain and indicative of the base of the Claiborne deposits in that province, is also present at the base of the Claiborne in South Carolina.

The McBean Formation (restricted) is exposed in the valleys of Upper Three Runs, Holley Creek, Town Creek, Tims Branch, Tinker Creek, Lower Three Runs, and in scattered localities in the central to northern parts of Aiken County.

ELLENTON FORMATION OF UPPER CRETACEOUS PERIOD

The dark lignitic clay and associated coarse sand that occur in the subsurface of the SRP area above the Tuscaloosa Formation and beneath the formations of the Eocene age constitute a separate and distinct lithologic unit. It is named the Ellenton Formation because the unit is traceable and typically occurs in the subsurface in the vicinity of the former town of Ellenton within the SRP area near the junction of the Savannah River and the Aiken-Barnwell County line.

The Ellenton Formation consists of a dark-gray to black sandy lignitic micaceous clay interbedded with medium-to-coarse quartz sand. Some of the quartz grains contain inclusions of pyrite; others are rutilated. Much of the free pyrite appears to be decomposed. Authigenic gypsum crystals are commonly distributed throughout the formation. Generally, the upper part of the formation contains a gray silty to sandy micaceous lignitic clay, with which the gypsum is commonly associated. In some wells the clay zone may be overlain by coarse quartz sand.

The lower part of the Ellenton Formation consists generally of clayey quartz sand of medium-to-coarse texture, which in some areas becomes very coarse and gravelly. The quartz grains are bluish-gray. Lignite and decomposed pyrite or marcasite fragments, muscovite, and aggregates of kaolinite or other very soft minerals are fairly common.

The Ellenton Formation probably is unconformable with the underlying Tuscaloosa Formation and the overlying Tertiary sediments. The lower contact is characterized by a change in color of the clay and a change in the composition of the sand. The dark-gray to black clay of the Ellenton is readily distinguishable from the variegated clay of the Tuscaloosa. Likewise, the quartzose sand of the Ellenton can be generally differentiated from the arkosic sand of the Tuscaloosa. The upper contact is also characterized by a change in the color of the clay above and below the contact. In drilling, the color of the sediments characteristically changes from the red, tan, or mustard-yellow of the basal sand and clay of the Tertiary System to the dark-gray to black of the silty to sandy clay of the Ellenton Formation.

TUSCALOOSA FORMATION OF UPPER CRETACEOUS PERIOD

The Tuscaloosa Formation consists mainly of fluvial and estuarine deposits of crossbedded sand and gravel intercalated with lenses of variegated silt and clay. The Tuscaloosa rests upon the basement rock and dips to the southeast following the slope of the bedrock floor. The Tuscaloosa is overlain conformably by the Ellenton Formation, but near the Fall Line it is overlain unconformably by sediments of Tertiary and Quaternary age.

The Tuscaloosa Formation crops out in a belt that is 10 to 30 miles wide and extends northeastward across South Carolina from Augusta, Georgia, to the North Carolina state line. It is exposed in the vicinity of SRP in the lower parts of the valleys of Horse Creek, Shaw Creek, South Fork Edisto River, Holley Creek, and Town Creek. On the upper slopes of these valleys, the Tuscaloosa is covered with Tertiary and Quaternary deposits that, in places, completely transgress the outcrop area of the Tuscaloosa and rest directly upon the crystalline rocks of the Piedmont. Southeast of the belt of outcrop, the Tuscaloosa Formation is completely covered by younger sediments and occurs at progressively greater depths in the subsurface in the direction of the Atlantic Ocean.

The average strike of the formation is N65°E, and the dip is to the southeast. The average rate of dip near SRP is 30 feet/mile but only 15 feet/mile near the Fall Line where the surface of the Tuscaloosa was probably beveled by the transgressing sea that sorted and deposited the Tertiary sediments.

The thickness of the Tuscaloosa Formation ranges from 0 feet along the Fall Line to approximately 600 feet in the vicinity of Upper Three Runs. Southeast of Upper Three Runs, the thickness of the formation is fairly constant.

In the SRP area, the Tuscaloosa Formation consists of light-gray to white, tan, and buff crossbedded quartzitic to arkosic coarse sand and gravel intercalated with lenses of white, pink, red, brown, and purple silt and clay. Individual beds of coarse and fine sediment are intermixed in no regular sequence and grade laterally into one another or pinch out within comparatively short distances. Ferruginous sandstone concretions are commonly found in nodular or lenticular shapes at the contact of a permeable bed above a less permeable bed, and siderite nodules are scattered throughout some of the silt and clay strata. In addition, numerous addition, numerous lenses of kaolin ranging from 2 to 40 feet in thickness are present in the Tuscaloosa; these are particularly abundant a few miles southeast of the Fall Line.

The predominant rock-forming minerals of the coarse-grained deposits are quartz, partially altered feldspar, and mica. The grains of quartz are angular to subrounded, have a clear to greasy luster, and commonly contain internal fractures and inclusions of rutile grains. Though less abundant than quartz, grains of feldspar are conspicuous in most exposures of the Tuscaloosa not only near the SRP area but also in other parts of the state. Most of the mica in the sand is colorless muscovite, but some of it may be bleached biotite.

Heavy minerals found in the Tuscaloosa include ilmenite, tourmaline, rutile, zircon, monazite, and garnet.

The composition and irregularity of the sediments of the Tuscaloosa Formation suggest derivation from the disintegrated and partially weathered crystalline rocks of the nearby Piedmont and deposition in a fluvial or nonmarine environment. Therefore, it is assumed that the Tuscaloosa Formation was deposited by sediment laden streams that eroded and drained the Piedmont in Late Cretaceous time. Conceivably, the Tuscaloosa sediments accumulated as a series of coalescing deltas that bordered the shoreline of the Late Cretaceous sea.

NEWARK SERIES "RED BED" ROCK OF TRIASSIC PERIOD

One-third of the SRP site in the southeastern section of the area is underlain by pre-Cretaceous rock, interpreted to be Triassic in age on the basis of its lithologic characteristics. The sediments near the center of this basin are brick-red mudstone consisting of silt and clay and pale red or pink poorly sorted sandstone. Gray calcareous nodules of caliche are occasionally embedded in these sediments. Near the basin margins the sediments consist of poorly sorted coarse grained fanglomerate with a silt and clay matrix. No igneous rocks have been found. All of the sediments are extremely low in permeability. The extent of these buried Triassic basins trend in a northeast-southwest direction, and it is highly probable that this is elongated in a similar manner. An airborne magnetometer survey made in 1958 by the U. S. Geologic Survey indicates that the Triassic basin is associated with a correlated area of low gamma* intensity of a roughly elliptical area 6 miles by 30 miles with the longer axis in a northeast-southwest direction. From the

* A unit of magnetic intensity.

From the southeast corner of the SRP site, the area of low magnetic intensity associated with the Triassic basin extends 25 miles to the northeast, but to the southwest, on the Georgia side, it appears to terminate abruptly within about 5 miles of the Savannah River.

During Triassic Period, the earth's crust was broken by large normal faults. These faults formed basins in which Triassic sediments accumulated. The sediments subsequently cemented together to form sandstone, siltstone, or claystone.

BASEMENT ROCK OF PALEOZOIC AND PRECAMBRIAN ERAS

Two-thirds of the SRP site is underlain by basement rock of the Paleozoic and Precambrian eras. The basement rocks are composed predominantly of gray or green chlorite-hornblende schist and hornblende gneiss and of lesser amount of quartzite. These metamorphic rocks are thought to belong primarily to the Carolina slate belt. Calcite and zeolite occur as fillings in some fractures.

The upper surface of the pre-Cretaceous basement rock has been eroded, tilted to the southeast, and buried under overlying sediments. The general plane of the surface strikes N62°E and dips to the southeast at approximately 36 ft/mile.

At the SRP site, the basement rock is immediately overlain by about 50 feet of saprolite, a weathered product of the basement rock. The saprolite separates the basement rock and the overlying Tuscaloosa Formation. The basement rock outcrops at the Fall Line and along the bottoms of deeply incised stream valleys.

Appendix C
MODIFIED MERCALLI SCALE, 1956 VERSION[a]

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed. Average ground motion, 0.23% g; ground motion range, 0.1 to 0.5% g.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake. Average ground motion, 0.31% g; ground motion range, 0.1 to 0.8% g.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak. Average ground motion, 0.93% g; ground motion range, 0.2 to 4.6% g.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters pictures move. Pendulum clocks stop, start, change rate. Average ground motion, 1.33% g; ground motion range, 0.2 to 7.5% g.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle). Average ground motion, 4.0% g; ground motion range, 0.5 to 17.5% g.

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation

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a. Ground motion accelerations were taken from Reference 66.

ditches damaged. Average ground motion, 6.7% g; ground motion range, 1.8 to 14% g.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Average ground motion, 17.2% g; ground motion range, 5.1 to 35% g.

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly. Average ground motion, 25% g.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Masonry A — Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc., designed to resist lateral forces.

Masonry B — Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C — Ordinary workmanship and mortar; extreme weaknesses, such as failing to tie in at corners. Neither reinforced nor designed against horizontal forces.

Masonry D — Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Appendix D
CHARLESTON EARTHQUAKE OF 1886[22]

Time of earthquake.—21:51 and 21:59, with others later.

Epicenter.—Fifteen miles northwest of Charleston, S.C. (32.9° N., 80.0° W.).

Area affected.—Area with radius of 800 miles; strongly shaken to 100 miles.

Description.—The earthquake started with a barely perceptible tremor, then a sound like a heavy body rolling along; the sound became a roar, all movable objects began to shake and rattle, and the tremor became a rude, rapid quiver. There was no break in the increasingly heavy jar. Everyone feared instant death. Finally the earth became quiet, the roar stopped, and various human sounds, such as cries of pain and fear, wailing, and exciting shouts, became audible.

The first shock was at 21:51 and the second 8 minutes later. People immediately began to gather in the large public square in Charleston to escape injury from falling buildings. The period until morning was filled with great anxiety, especially as there were exaggerated rumors of the number killed. Further shocks occurred at about 02 and 04. The utter stillness after each shock, combined with the lack of apparent cause, was appalling. A severe shock occurred at 08:30 which aroused great apprehension, as it was now seen that many of the buildings were either ruined or in dangerous condition. It was also known that about 60 people had been killed in the night and many injured, and it was feared that there were more casualties to come. Further shocks occurred at 13:00, 17:00, and about 20:00. By this time practically all people were in the streets.

There was no serious lack of food, but the means for preparing it were inadequate. Since few houses escaped damage and many were totally destroyed, the amount of debris in the streets was very great and there was only a narrow passage through the middle, which added to the difficulty. Aid from the outside was impossible, as the railroads were badly damaged and the telegraph wires were down. News did not get through until late the following day. As soon as the railroads were repaired many people fled. However, a large number remained and officials of all kinds remained at their posts and helped to organize aid and relief. Fortunately the weather remained fine.

In the vicinity of Charleston special effects were noted. In one place sulphur gas was very evident. There was a wave of some height on the Cooper River. In some places the motion was so great that people were overcome with nausea.

Much of Charleston was built on made land and some of it where a number of creeks had been filled in. In such places it was necessary to use piling. The Government buildings were generally well built, though some were quite old. In addition there were a large number of well-built residences, usually found in a place of considerable wealth, as it had long been a custom of planters to retire and build homes in Charleston. These facts are important in connection with a study of the destruction. The early houses were in many cases built of hand-made brick which had a rougher surface and permitted better adherence of the mortar than later smooth bricks. The mortar used in the early days was excellent, being made of burnt shells. This type of bond used in the earlier buildings, though no stronger than that used later, was better adapted to prevent concealing a lack of sufficient mortar.

The great masonry structures were found to be severely damaged, though in some cases new portions were destroyed while the old remained intact. Brick buildings were found to be more severely damaged than at first thought and in some cases the bricks moved in the mortar. Buildings of three or more stories had diagonal cracks in the walls at the middle stories and vertical cracks near the top. Well-built wooden houses with parts carefully pinned together form a complete and elastic whole which tends to return to its original shape as soon as the disturbance has passed. However, some of the best houses were loosened at the joints so that they were shaken by passing vehicles and they were somewhat out of plumb. Curiously, a family living in a one-story wooden building slept through the earthquake without knowing that it had occurred. Chimneys of at least 14,000 houses were destroyed in Charleston.

Part of the damage was due to aftershocks, and on the whole it was considerable. Fortunately there was no wind, and the fires which started were extinguished without difficulty.

The first shock lasted 35 to 40 seconds and was apparently first vertical and then horizontal. The wave motion was very complex. Pictures were found with faces to the walls. In the cemeteries there was no prevailing direction for the fall of monuments, indicating that the shocks came from many directions, as might be expected so near the origin. Earth waves similar to ground swell were seen and estimated to be 2 feet high. This may have been the case in certain places, but in general, it seems likely they were not more than 4 or 5 inches in height. Such waves explain much of the destruction. Buildings showed both horizontal and vertical displacements. There were 10 severe and numerous moderate to light aftershocks up to September 30, and probably countless others recordable only by instruments. The series of heavy aftershocks undoubtedly helped to weaken the buildings previously damaged.

Careful study of reports indicates that there were two epicentral points, one near Woodstock, 16 miles N30°W from Charleston surrounded by a region of maximum effect about 20 miles in diameter and nearly circular, and the other about 13 miles due west from Charleston, surrounded by an elliptical area with axes 9 and 6 miles, respectively, the major axis lying north-south. These centers were about 14 miles apart. The northern area contained two villages, Summerville and Lincolnville. In the former place, the great earthquake did not come without warning; on both the 27th and 28th there were sounds like heavy explosions. On the 31st, the earthquake had full force. People were tossed from side to side and thrown to the ground. The houses seemed to be receiving heavy blows from below and chimneys fell. In some cases bricks and the chimneys, carrying the fireplaces with them, sank in piles of debris. In some cases the tops of the chimneys snapped off at the roof line and were thrown considerable distances. The indications point to strong vertical motion. The aftershocks had a deep powerful boom followed by a heavy jar. At Lincolnville the shocks were more severe and the vertical motion more pronounced. The rest of this area and the southern area were thinly settled and the points of chief interest were the cracks, craterlets and the effects on the railroads.

Through the epicentral area as defined, and in some regions outside of it, the ground was greatly fissured and in some cases water extruded. The cracks were rarely more than an inch wide but near the streams the movement of the banks toward the stream left wider cracks. Where large quantities of water came up there was a round hole of considerable size with a greater basin at the ground surface. These were of all sizes from very small up to 20 feet in diameter. Much sand was brought up, usually from known beds of quicksand. In some cases the water rose in high jets carrying sand and mud.

The bending of rails and lateral displacement of the tracks were very evident in the epicentral region though not at Charleston. There were severe flexures of the track in places and sudden and sharp depressions of the rail bed. At one place there was a sharp S curve. At a number of places the effect on culverts and other structures demonstrated that there was a strong vertical force in action at the time of the earthquake.

The estimated depth of focus, or depth below the surface at which the earthquake actually occurred, was 12 miles. This was based on the character of waves at different points, though there is some doubt as to the accuracy of this method.

The area of severe effect was large, and the tremors were actually felt over an area with a radius of about 800 miles so that 2,000,000 square miles were affected, including undersea area. Within an area of 100 miles in diameter, the destruction would have been severe except for the character of the country; settlements were few and far between and the prevailing type of building primitive, the log cabin being well designed to resist destruction by earthquakes. Throughout this region it was hard for people to remain on their feet.

The belt from 50 to 100 miles in radius was strongly shaken. This included two cities, Savannah and Columbia, each about 90 miles away. At the former, 300 chimneys were damaged and those poorly constructed were shaken down. Columbia felt the shocks still more strongly. Buildings swayed, plaster fell, and the undulatory movement of the ground made walking difficult. The effect did not vary exactly with distance from epicenter, as geological conditions were an important factor. At Augusta, just over 100 miles from the epicenter, 100 chimneys fell and a dam fissured and broke. The shocks were as severe at Raleigh, 215 miles away, as at Wilmington, 152 miles away. The shock was felt at Boston, Milwaukee, Cuba, and as far east as Bermuda, 1,000 miles away. It was felt sharply at New York. There appears to have been a shadow zone where it was lightly felt, as compared with other places of similar distance, in the Appalachian region of West Virginia, Maryland, and Pennsylvania.

Appendix E
VASCULAR PLANTS OF SRP[28-32]

ACANTHACEAE(Acanthus Family)	
Dryschorista oblongifolia	
Justicia americana	Water Willow
Justicia ovata	Justica
Justicia ovata	Water Willow
Ruellia carolinensis	Ruellia
Ruellia ciliosa	Ruellia
Ruellia humilis	Ruellia
ACERACEAE(Maple Family)	
Acer barbatum	Southern Sugar Maple
Acer negundo	Box Elder
Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
AIZOACEAE(Carperweed Family)	
Mollugo verticillata	Carpetweed
ALISMACACEAE(Water Plantain Family)	
Sagittaria graminea	Duck Potato
Sagittaria latifolia	Common Arrowhead
AMARANTHACEAE(Amaranth or Pigweed Family)	
Amaranthus spinosus	Thorny Amaranth
Froalichia floridana	Cottonweed
AMARYLLIDACEAE(Amaryllis Family)	
Hypoxis hirsuta	Stargrass
Narcissus incomparabilis	
Narcissus jonquilla	Jonquil
Narcissus pseudo-narcissis	Daffodil, Buttercup
Zephyranthes atamasco	Atamasco Lily, Fairy Lily, Cullowhee
ANACARDIACEAE(Cashew Family)	
Rhus copallina	Winged Sumac
Rhus radicans	Poison Ivy
Rhus toxicodendron	Poison Oak
Rhus vernix	Poison Sumac
APIACEAE(Parsley Family)	
Angelica vevenosa	
Apium leptophyllum	Marsh Parsley
Centella asiatica	
Centella erecta	Marsh Pennywort
Chaerophyllum tainturieri	Wild Chervil
Cicuta maculata	Water Hemlock
Cryptotaenia canadensis	Honewort
Daucus carota	Queen Anne's Lace, Wild Carrot
Dausus pucillus	Small Wild Carrot
Eryngium integrifolium	

Hydrocotyle verticulatta	Pennywort
Hydrocotyle umbellata	Marsh Pennywort
Ptiliminium capillacium	Ptilimnion, Marsh Bishop-Weed
Sanicula canadensis	Black Snakeroot
Sanicula smallii	Snakeroot
Spermolepis divaricata	
Thaspium trifoliatum	Meadow Parsnip

APOCYNACEAE(Dogbane Family)

Amsonia ciliata	Blue Dogbane
Amsonia tabernaemontana	Blue Stars
Apocynum cannabinum	Hemp Dogbane
Trachelospernum difforme	Climbing Dogbane
Vinca major	Perriwinkle

AQUIFOLIACEAE(Holly Family)

Ilex coriaceae	Large or Sweet Gallberry
Ilex decidua	Possum-Haw
Ilix glabra	Inkberry
Ilex myrtifolia	Yaupon
Ilex opaca	American Holly
Ilex verticillata	Winterberry
Ilex vomitaria	Yaupon, Christmas-Berry, Cassine

ARACEAE(Arum Family)

Arisaema triphyllum	Jack-In-The-Pulpit, Indian Turnip
Orontium aquaticum	Golden Club

ARECACEAE

Sabal minor	Cabbage Palmetto

ARALIACEAE(Ginsing Family)

Aralia spinosa	Hercule's Club
Hedera helix	English Ivy

ARISTOLOCHIACEAE(Birthwort Family)

Aristolochia serpentaria	Birthwort
Aristolochia serpentaria hastata	Virginia Snakeroot
Hexastylis arifolia	Wild Ginger, Heart Leaf

ASCLEPIADACEAE(Milkweed Family)

Ascerates viridiflora	Green Milkweed
Asclepias amplexicaulis	Sand Milkweed
Asclepias humistrata	Purple-Veined Milkweed
Asclepias perennis	Swamp Milkweed
Asclepias tuberosa	Butterfly Milkweed, Pleurisy-Root
Asclepias variegata	Variegated Milkweed
Asclepial verticillata	Narrow-Leaved Milkweed
Matelea carolinensis	Angle-Pod

ASPLENIACEAE(Spleenwort Family)

Asplenium platyneuron	Ebony Spleenwort

ASTERACEAE(Composite or Aster Family)

Acanthospernum australe	
Achilla millefolium	Common Yarrow, Milfoil
Ambrosia artemisifolia	Common Ragweed
Ambrosia elatior	Ragweed
Antennaria plantaginifolia	Pussy-Toes
Anthemus cotula	Mayweed, Dog Fennel
Arnica acaulis	Leopard's Bane
Aster concolor	
Aster dumosus	
Aster linariifolius	Stiff-Leaved Aster
Aster paternus	White-Topped Aster
Aster pilosus	Whiteheath Aster, Frost Flower
Aster solidagineus	White-Topped Aster
Aster undulatus	
Baccharis halmifolia	Groundsel-Tree, Silverling,Sea Myrtle
Berlandiera pumila	
Bidens bipinnata	Spanish Needles
Bidens mitis	Beggars Ticks
Boltonia asteroides	
Cardus repandus	Thistle
Cardus spinosissimus	Yellow Thistle
Carphephorus bellidifolius	Carpephorus
Chrysogonum virginianum	Green and Gold
Coreopsis basalia	Coreopsis
Coreopsis lanceolata	Coreopsis
Coreopsis major	Coreopsis
Coreopsis major stellata	Coreopsis
Coreopsis rosea	Coreopsis
Echinacea laevigata	Purple Cone-Flower
Elephantopus carolinianus	Elephant's Foot
Elephantopus tomentosus	Elephant's Foot
Erigeron canadensis	Horseweed
Erigeron strigosus	Daisy Fleabane
Erigeron vernus	
Eupatorium album	Dog Fennel
Eupatorium capillifolium	Dog Fennel
Eupatorium coelestinum	Mist Flower, Ageratum
Eupatorium compositifolium	Dog Fennel
Eupatorium fistulosum	Queen-of-the-Meadow, Joe-Pye-Weed
Eupatorium leucolepsis	Dog Fennel
Eupatorium revurvans	Dog Fennel
Eupatorium rotundifolium	Dog Fennel
Facelis retusa	
Gaillardia aestivalis	Daisy
Gnaphalium chilense	Rabbit Tobacco
Gnaphalium obtusifolium	Rabbit Tobacco, Everlasting
Gnaphalium purpureum	Cudweed
Gnaphalium purpureum falcatum	Cudweed
Haplopappus divaricatus	Yellow Aster
Helenium amarum	Bitter-Weed
Helianthus angustifolius	Sunflower
Helianthus annus	Sunflower
Helianthus debilis	Sunflower
Heliopsis helianthoides	Ox-Eye
Heterotheca gossypins	Camphorweed
Heterotheca mariana	Camphorweed
Heterotheca nervosa	Camphorweed
Heterotheca subaxillaris	Camphorweed

Hieracium gronovii	Hawkweed
Hymenopappus scabiosaeus	
Hypochoeris elata	Cat's Ear
Krigia virginica	Dwarf Dandelion
Kuhnia eupatoroides	False Boneset
Lactuca canadensis	Wild Lettuce
Lactuca graminifolia	Grass-Leaved Blazing Star
Liatris elegans	Blazing Star
Liatris regimontis	Blazing Star
Liatris secunda	Blazing Star
Liatris tenuifolia	Blazing Star
Marshallia obovata	Button Flower
Mikania scandens	Climbing Hempweed
Pulchea rosea	Marsh-Fleabane
Polymnia uvedalia	Bear's Foot
Prenanthes serpentaria	Gall-of-the-Earth, Lion's Foot
Pterocaulon pycnostachyum	Black-Root
Pyrrhopappus carolinianus	Carolina False Dandelion
Rudbeckia hirta	Black-Eyed Susan
Sclerolepis uniflora	
Senecio glabellus	Bitterweed
Senecio obovatus	Groundsel
Senecio smallii	Groundsel
Silphium compositum	
Silphium dentatum	
Solidago altissima	Goldenrod
Solidago boottii	Goldenrod
Solidago gigantea	Goldenrod
Solidago microcephala	Tiny-Headed Goldenrod
Solidago nemoralis	Goldenrod
Solidago odora	Goldenrod
Solidago petiolaris	Goldenrod
Solidago stricta	Goldenrod
Sonchus asper	Spiny-Leaved Sow Thistle
Tagetes minuta	Marigold
Tetragonotheca helianthoides	
Trilisa paniculata	Hound's Tongue,Deer's Tongue, Vanilla
Verbesina occidentalis	Yellow Wingstem
Verbesina virginica	
Vernonia altissima	Ironweed
Vernonia angustifolia	Ironweed

BALSAMINACEAE(Jewel Weed Family)

Impatiens capensis	Touch-Me-Not

BERBERIDACEAE(Barberry Family)

Podophyllum peltatum	May Apple

BETULACEAE(Birch Family)

Alnus serrulata	Tag Alder, Smooth Alder
Betula nigra	River Birch
Carpinus caroliniana	Blue Beech, Ironwood
Ostrya virginiana	Hop Hornbean

BIGNONIACEAE(Bignonia or Trumpetcreeper Family)

Anisostichus capreolata	Cross Vine
Campsis radicans	Trumpetcreeper
Catalpa bignonioides	Indian Cigar, Catawba, Catalpa

BORAGINACEAE(Borage Family)

Heliotropium amplexicaule	Heliotrope
Heliotropium indicum	Heliotrope
Lithospermum caroliniense	Puccoon
Onosmodium virginianum	False Gromwell

BRASSICACEAE(Mustard Family)

Arabidopsis thalinia	Mouse Ear Cress
Brassica juncea	Leaf Mustard
Camelina microcarpa	False Flax
Capsella bursa	Shepherd's Purse
Cardamine bulbosa	Bittercress
Descurania pinnata	Tansy Mustard
Draba brachycarpa	
Lepidium virginicum	Pepper Grass
Nasturtium officinale	Water Cress
Rorippa islandica	Yellow Cress
Raphanus raphanistrum	Wild Radish

BROMELIACEAE(Pineapple Family)

Tillandsia usneoides	Spanish Moss

CALYCANTHACEAE(Strawberry-Shrub Family)

Calycanthus floridus	Sweet Shrub, Strawberry Bush, Carolina Allspice

CAMPANULACEAE(Blue-Bell Family)

Lobelia boykinii	Swamp Lobelia
Lobelia cardinalis	Cardinal Flower
Lobelia nuttallii	Slender Lobelia
Lobelia georgiana	Lobelia
Lobelia puberala	Lobelia
Lobelia spicata	Pale-Spike Lobelia
Specularia biflora	Venus Looking Glass
Specularia perfoliata	Venus Looking Glass
Wahlenbergia marginata	

CAPRIFOLIACEAE(Honeysuckle Family)

Lonicera fragrantissima	Sweet Breath of Spring
Lonicera japonica	Japanese Honeysuckle
Lonicera sempervirens	Trumpet Honeysuckle
Sambucus canadensis	Elderberry
Viburnum cassinoides	Withe-Rod
Viburnum dentatum	Arrow-Wood
Viburnum nudum	Possum Haw
Viburnum rufidulum	Southern Black Haw

CARYOPHYLLACEAE(Pink Family)

Agrostemma githago	Corn Cockle
Arenaria caroliniana	Sandwort
Arenaria serpyllifolia	Creeping Sandwort

Cerastium viscosum	Chickweed
Cerastium vulgatum	Mouse-Ear Chickweed
Dianthus ameria	Deptford Pink
Holosteum umbellatum	Jagged Chickweed
Paronychia americana	
Paronychia fastiagiata	Whitlow-Wort
Sagina decumbens	Pearlwort
Saponaria officinalis	Soapwort, Bouncing Wort
Silene angustifolia	Pink
Silene antirrhina	Sleepy Catchfly
Silene caroliniana	Wild Pink
Silene Cucabulus	Bladder Campion
Silene stellata	Starry Campion
Stipulieida setacea	Pine Pink

CELASTRACEAE(Staff Tree Family)

Euonymus americanus	Strawberry Bush

CERATOPHYLLACEAE(Hornwort Family)

Ceratophyllum demersum	Hornwort

CHENOPODIACEAE(Goosefoot Family)

Chenopodium album	Common Lambsquarters
Chenopodium ambrosioides	Mexican Tea, Wormweed
Cycloloma atriplicifolium	Winged Pigweed

CISTACEAE(Rockrose Family)

Helianthemum canadense	Rockrose
Helianthemum rosmarinifolium	Rockrose
Lechia patula	Pinweed
Lechia villosa	Pinweed
Lechia tenuifolia	Narrow-Leaved Pinweed

CLETHRACEAE(White Alder Family)

Clethra anifolia	Summersweet
Clethra tomentosa	White Alder

COMMELINIACEAE(Spiderwort Family)

Commelina virginica	Day-Flower
Tradescantia ohionsis	Spiderwort
Tradescantia rosea	Spiderwort

CONVOLULACEAE(Morning Glory Family)

Bonamia humistrata	
Breweria michauxii	Breweria
Breweria humistrata	Breweria
Breweria tricosanthes	Breweria
Calystegia sepium	Hedge Bindwell
Cuscuta campestris	Field Dodder
Cuscuta compacta	Compact Dodder
Cuscuta pentagona	Dodder
Ipomoea hederacea	Morning Glory

Ipomoea pandurata	Bigroot Morning Glory,Wild Potato Vine
Ipomoea purpurea	Common Morning Glory
Ipomoea trichocarpa	Morning Glory
Jacquemontia tamnifolia	Smallflower Morning Glory
Quamoclit coccinea	Red Morning Glory

CORNACEAE(Dogwood Family)

Cornus amommum	Swamp Dogwood, Silky Cornel
Cornus florida	Flowering Dogwood
Cornus stricta	Stiff Cornel

CRASSULACEAE(Orpine Family)

Penthonum sedoides	Ditch Stonecrop

CUCURBITACEAE(Gourd Family)

Cayaponia boykinii	Cayaponia

CYPERACEAE(Sedge Family)

Bulbostylis stenophylla	
Carex complanata	Carex
Carex festucacea	Carex
Carex folliculata	Carex
Carex glaucescens	Carex
Carex joori	Carex
Carex laxiflora	Carex
Carex lurida	Carex
Carex muhlenbergii	Carex
Carex seorsa	Carex
Carex tribuloides	Carex
Cyperus ovularis	Cyperus
Cyperus retrofractus	Cyperus
Eleocharis melanocarpa	Spike Rush
Eleocharis microcarpa	Spike Rush
Eleocharis obtusa	Spike Rush
Rhynchospora macrostachys	Beak Rush
Rhynchospora globularis	Beak Rush
Rhynchospora sulcata	Beak Rush
Scirpus cyperinus	Bulrush

CYRILLACEAE(Cyrilla Family)

Cyrilla racemiflora	Leatherwood, Titi

DIOSCOREACEAE(Yam Family)

Dioscorea villosa	Wild Yam

DROSERACEAE(Sundew Family)

Drosera brevifolia	Sundew
Drosera intermedia	Sundew

EBENACEAE(Ebony Family)

Diospyros virginiana	Persimmon

EMPETRACEAE(Crowberry Family)

Ceratiola ericoides	Crowberry

ERICACEAE(Heath Family)

Chimophila maculata	Spotted Wintergreen, Pipsissewa
Epigaea repens	Trailing Arbutus
Eubotrys racemosa	Fetterbush
Gaylussacia dumosa	Dwarf Huckleberry
Gaylussacia frondosa	
Kalmia latifolia	Mountain Laurel
Leucothoe axillaris	Dog Laurel
Lyonia ligustrina	Maleberry
Lyonia lucida	Fetterbush
Lyonia mariana	Stagger-Bush
Momotropa hypopithys	Pine-Sap
Monotropa uniflora	Indian Pipe
Oxydendrum arboreum	Sourwood
Rhododendron canescens	Wild Azalea, Hairy Azalea
Rhododendron nudiflorum	Pinkster Flower
Rhododendron speciosa	
Rhododendron viscosum	Swamp Azalea, Swamp Honeysuckle
Vaccinium arboreum	Sparkleberry, Tree Huckleberry
Vaccinium attrococcum	Highbush Blueberry
Vaccinium corymbosum	Highbush Blueberry
Vaccinium cuthbertii	Cuthbert's Blueberry
Vaccinium elliottii	Elliott's Blueberry
Vaccinium stamineum	Squaw-Huckleberry,Gooseberry,Deerberry
Vaccinium virgatus	Blueberry
Vaccinium tenellum	
Zenobia pulverulenta	Zenobia

ERIOCAULACEAE(Pipewort Family)

Lachno caulon	Pipewort

EUPHORBIACEAE(Spurge Family)

Acalypha glacilens	Three-Seeded-Mercury
Acalypha rhomboides	Three-Seeded-Mercury
Acalypha virginica	Three-Seeded-Mercury
Cnidoscolus stimulosus	Tread-Softly
Croton capitatus	Wooly Croton
Croton grandulosus	Croton
Euphorbia corrollata	Flowering Spurge, Tramps Spurge
Euphorbia marginata	Snow-On-The-Mountain
Euphorbia ipecacuanhae	Carolina Ipecac
Euphorbia heterophylla	Painted Leaf
Euphorbia maculata	Spotted Spurge, Wartweed
Euphorbia mercurialina	
Euphorbia preslii	Spurge
Sebastiana ligustrina	Sebastian Bush
Stillingia sylvatica	Queen's Delight
Tragia urens	Tragia

FABACEAE(Legume Family)

Amorpha fruiticosa	Lead Plant, False Indigo
Amphicarpa bracteata	Hog Peanut

Apios americana	Ground Nut
Arachis hypogaea	Peanut
Astragalus villosus	Milk Pea
Baptisia alba	White Wild Indigo
Baptisia lanceolata	Yellow Wild Spurge
Baptisia leucophaea	Cream Wild Indigo
Baptisia microphylla	
Baptisia perfoliata	Cat-Bells
Baptisia tinctoria	Horse-Fly Weed,Yellow Wild Indigo
Cassia nicitans	Wild Sensitive Pea
Cassia fasciculata	Partridge Pea
Cassia obtusifolia	Sicklepod
Cassia occidentalis	Coffee Senna
Cassia tora	Sickle Pod
Centrosema virginianum	Spurred Butterfly Pea
Cercis canadensis	Redbud, Judas Tree
Clitoria mariana	Butterfly Pea
Crotolaria angulata	Rabbit Bells
Crotolaria lanceolata	Crotolaria
Crotolaria mucronata	Crotolaria
Crotolaria sagittalis	Wild Pea
Crotolaria spectabilis	Rattlebox
Daubentonia punica	
Desmodium lineatum	Tick-Trefoil
Desmodiun nudiflorum	Beggar-Ticks
Desmodium paniculatum	Stick-Tights
Desmodium rotundifolium	Beggar's Lice
Desmodium strictum	Beggar's Lice
Desmodium tartvosum	Beggar's Lice
Gleditsia aquatica	Water Locust
Indigofera caroliniana	Indigo Plant
Kuhnistera pinnata	Summer Farewell
Lespedeza angustifolia	
Lespedeza cuneata	Sericea Lespedeza
Lespedeza intermedia	Leafy Bushclover
Lespedeza hirta	Hairy Bushclover
Lespedeza procumbens	Creeping Lespedeza
Lespedeza repens	Creeping Lespedeza
Lespedeza striata	Japanese Clover
Lespedeza stuevei	
Lespedeza virginica	
Lupinus diffusus	Sandhill Lupine
Lupinus villosus	Lupine
Medicago lupulina	Black Medic
Melilotus alba	White Clover
Petalostemum pinnatum	Summer-Farewell
Phaseolus sinuatus	Wild Bean
Phaseolus polystactyus	Bean Vine
Psoralea canescens	Hairy Psoralea
Psoralea psoralioides	Samson Snakeroot, Congo Root
Rhynchosia difformis	Spreading Rhynchosia
Pueraria lobata	Kudzu Vine
Rhynchosia reniformis	Dollar Weed
Rhynchosia Simplicifolia	Dollar Weed
Rhynchosia tomentosa	Upright Rhynchosia
Robinia nana	
Robinia pseudoacacia	Black Locust
Schrankii microphylla	Sensitive Brier

Stylosanthes biflora	Pencil Flower
Stylosanthes riparia	Low Pencil Flower
Strophostyles umbellata	Wild Bean
Tephrosia florida	
Tephrosia spicata	Hoary Pea
Tephrosia virginiana	Goat's Rue, Devil's Shoe String
Trifolium arvense	Clover
Trifolium campestre	Clover
Trifolium pratense	Red Clover
Trifolium procumbens	Hop Clover
Trifolium reflexum	Buffalo Clover
Trifolium repens	White Clover
Vicia angustifolia	Common Vetch
Vicia hirsuta	Hairy Vetch
Wisteria florabunda	Wisteria
Wisteria fruitescens	Wisteria
Zornia bracteata	Zornia

FAGACEAE(Oak Family)

Castanea pumila	Chinquapin
Fagus grandifolia	Beech
Quercus alba	White Oak
Quercus cinerea	Blue-Jack Oak
Quercus falcata	Sourthern Red Oak
Quercus laevis	Turkey Oak, Scrub Oak
Quercus laurifolia	Laurel Oak
Quercus lyrata	Overcup Oak
Quercus margaretta	Dwarf Post Oak
Quercus marilandica	Blackjack Oak
Quercus michauxii	Swamp Chestnut Oak
Quercus nigra	Water Oak
Quercus phellos	Willow Oak
Quercus stellata	Post Oak
Quercus velutina	Black Oak
Quercus durandii	Durand's White Oak

FUMARIACEAE(Fumitory Family)

Corydalis flavula	Yellow Fumewort

GENTIANACEAE(Gentian Family)

Bartonia paniculata	Screw-Stem
Bartonia verna	Bartonia
Gentiana catesbaei	Gentian
Gentiana saponaria	Soapwort Gentian
Gentiana villosa	Gentian
Nymphoides cordata	
Sabatia angularis	Pink
Sabatia calycina	Marsh Pink
Sabatia paniculata	Marsh Pink
Sabatia quadrangula	
Sabatia campanulata	Narrow Leaved Pink

GERANIACEAE(Geranium Family)

Geranium carolinianum	Carolina Geranium,Low Wild Geranium

HALORAGACEAE(Water-Milfoil Family)

Myriophyllum heterophyllum	Water Milfoil
Proserpinaca palustris	Mermaid Weed
Proserpinaca pectinata	Mermaid Weed

HAMMAMELIDACEAE(Witch Hazel Family)

Hamamelis virginiana	Witch Hazel
Liquidambar styraciflua	Sweetgum

HIPPOCASTONACEAE(Buckeye or Horse Chestnut Family)

Aesculus pavia	Dwarf Buckeye, Red Buckeye

HYDROPHYLLACEAE(Waterleaf Family)

Hydrolea quadrivalis	Hydrolea

HYPERICACEAE(St.John's Wort Family)

Hypericum canadense	Hypericum
Hypericum cistifolium	Hypericum
Hypericum denticulatum	Coppery St.John's Wort
Hypericum drummondii	
Hypericum gentianoides	Pineweed
Hypericum gymnathum	
Hypericum hypericoides	St.Andrews's Cross
Hypericum mutilum	Dwarf St.John's Wort
Hypericum setosum	
Hypericum stans	St.Peter's Cross
Hypericum suffruticosum	
Triadenum walteri	Marsh St.John's Wort

IRIDACEAE(Iris Family)

Sisyrinchium albidium	Blue-Eyed Grass
Sisyrinchium angustifolium	Blue-Eyed Grass
Sisyrinchium arenicola	Blue-Eyed Grass

JUGLANDACEAE(Walnut Family)

Carya aquatica	Water Hickory
Carya glabra	Pignut
Carya illinoensis	Pecan
Carya pallida	Pale Hickory
Carya tormentosa	Mockernut
Juglans nigra	Black Walnut

JUNCACEAE(Rush Family)

Juncus biflorus	
Juncus coriaceus	
Juncus debilis	
Juncus dichotomus	
Juncus effusus	
Juncus elliottii	
Juncus polycephalus	
Juncus scirpoides	
Juncus tenuis	Path Rush

LAMIACEAE(Mint Family)

Glecoma hederacea	Gill-Over-The-Ground
Lamium amplexicaule	Henbit, Dead Nettle
Leonotis nepetsefolia	Lion's Ear
Lycopus amplectans	Bugleweed
Lycopus rubellus	Water Horehound
Lycopus uniflorus	Bugleweed
Lycopus virginicus	Bugleweed
Mentha piperita	Peppermint
Monarda fistulosa	Horse-Mint
Monarda punctata	
Nepeta cataria	Catnip
Prunella vulgaris	Heal-All
Pycnanthemum flesuosum	Narrow-Leaved Mint
Pycnanthemum hyssopifolium	Mountain Mint
Pycnanthemum incanum	Mountain Mint
Salvia azurea	Sage
Salvia lyrata	Lyre-Leafed Sage
Salvia utricifolia	Sage
Scutellaria elliptica	Skullcap
Scutellaria integrifolia	Skullcap
Scutellaria laterifolia	Skullcap
Trichostema dichotomum	Bluecurls

LAURACEAE(Bay Family)

Lindera benzoin	Spicebush
Persea borbonia	Smooth Red Bay
Persea palustrus	Swamp Bay
Sassafras albidum	Sassafras

LENTIBULARIACEAE(Bladderwort Family)

Utricularia biflora	Bladderwort
Utricularia fibrosa	Bladderwort
Utricularia gibba	Small Bladderwort
Utricularia inflata	Inflated Bladderwort
Utricularia purpurea	Purple Bladderwort

LILIACEAE(Lily Family)

Aletris farinosa	Colicroot, Stargrass
Allium ampeloprasum	Wild Onion
Allium canadense	Wild Onion
Allium cuthbertii	Wild Onion
Asparagus officinalis	Asparagus
Medeola virginiana	Indian Cucumber Root
Nolina georgiana	
Polygonatum biflorum	Solomon's Seal
Smilacina racemosa	False Solomon's Seal
Smilax ecirrhata	Green Brier
Smilax glauca	Green Brier
Smilax herbacea	Green Brier
Smilax lauraflora	Bamboo
Smilax pumila	Green Brier
Smilax pumila	Green Brier
Smilax rotundifolia	Common Green Brier
Smilax walteri	Green Brier
Yucca filamentosa	Beargrass
Zigadensis densus	Crow-Poison, Black Snakeroot

LINACEAE(Flax Family)

Linum striatum	Wild Flax
Linum medium	Yellow Flax

LOGONIACEAE(Logonia Family)

Cynoctonum mitreola	Mitrewort
Cynoctonum sessifolium	Sessile-Leaved Mitrewort
Gelsemium sempervirens	Yellow Jessamine
Polypremum procumbena	Polypremum
Spigelia marilandica	Pinkroot,Indian Pink,Carolina Pink

LORANTHACEAE(Mistletoe Family)

Phoradendron flavescens	Mistletoe

LYCOPODIACEAE(Club Moss Family)

Lycopodium adpressum	Southern Bog Club Moss

LYTHRACEAE(Loosestrife Family)

Ammania coccinea	Ammania
Decodon verticillatus	Water Willow
Lagerstroemia indica	Crape-Myrtle

MAGNOLIACEAE(Magnolia Family)

Liriodendron tulipifera	Tulip Poplar,Yellow Poplar,Tulip Tree
Magnolia virginiana	Sweetbay
Magnolia grandiflora	Southern Magnolia

MALVACEAE(Mallow Family)

Hibuscus incanus	Silvery Mallow
Hibuscus militaris	Rose Mallow
Hibuscus moscheutos	Rose Mallow, Wild Cotton
Sida rhombifolia	False Mallow

MELASTOMATACEAE(Meadow-Beauty Family)

Rhexis alifanus	Meadow Beauty
Rhexia ciliosa	Meadow Beauty
Rhexia mariana	Pale Meadow Beauty
Rhexia lanceolata	Narrow-Leaved Meadow Beauty
Rhexia mariana exalvida	Pale Meadow Beauty
Rhexia striata	Meadow Beauty
Rhexia virginica	Deer Grass

MELIACEAE(Mohogony Family)

Melia azedarach	China Berry

MENISPERMACEAE(Moonseed Family)

Cocculus carolinus	Red-Berried Moonseed,Carolina Moonseed

MIMOSACEAE(Mimosa Family)

Albizzia julibrisson	Acacia
Schrankia microphylla	Sensitive Brier

MORACEAE(Mulberry Family)

Broussonetia papyrifera	Paper Mulberry
Morus rubra	Red Mulberry
Morus alba	White Mulberry

MYRICACEAE(Bayberry Family)

Myrica cerifera	Wax Myrtle
Myrica pusilla	Dwarf Wax Myrtle

NELUMBONACEAE(Lotus Family)

Nelumbo lutea	Yellow Nelumbo, Pond Nuts

NYMPHACEAE(Water Lily Family)

Nymphaea odorata	Pond Lily, Water Lily
Cabomba caroliniana	Fanwort
Brasenia schreberi	Water Shield
Nuphar advena	Cow Lily

NYSSACEAE(Sour Gum Family)

Nyssa aquatica	Tupelo Gum
Nyssa biflora	Water Gum
Nyssa sylvatica biflora	Black Gum

OLEACEAE(Olive Family)

Chionanthes virginicus	Fringe Tree,Flowering Ash
Forestiera acuminata	Swamp Privet
Fraxinus americana	White Ash
Fraxinus caroliniana	Water Ash
Fraxinus profunda	Pumpkin Ash
Fraxinus pennsylvania	Red Ash
Gasminum nudiflorum	
Ligustrum sinense	Privet
Ligustrum japonicum	Evergreen Privet

ONAGRACEAE(Eveningprimrose Family)

Gaura biennis	
Gaura filipes	
Jussiaea decurrens	Primrose Willow
Ludwigia alternifolia	Seedbox
Ludwigia arcuata	
Ludwigia areolata	Marsh Purslane
Ludwigia hirtella	Hairy Seedbox
Ludwigia glandulosa	Seedbox
Ludwigia leptocarpa	
Ludwigia palustrus	Water Purslane
Ludwigia sphaerocarpa	Round Seedbox
Ludwigia suffruticosa	Woody Seedbox
Ludwigia virgata	Seedbox

Oenothera biennis	Evening Primrose
Oenothera fruticosa	Sundrops
Oenothera laciniata	Low or Cutleaf Evening-Primrose
Oenothera speciosa	Primrose
Oenothera tetragona	Sundrops

OPHIOGLOSSACEAE(Adders Tongue Family)

Botrychium dissectum	Common Grapefern

ORCHIDACEAE(Orchid Family)

Listera australis	Southern Twayblade
Malaxis unifolia	Green Adders Mouth
Spiranthes praecox	Grass-Leaved Ladies Tresses

OROBANCHACEAE(Broomrape Family)

Conopholis americana	Squaw-Root, Cancer-Root
Epithagus virginiana	Beech-Drops

OXALIDACEAE(Wood Sorrel Family)

Oxalis corniculata	Creeping Ladies Sorrel
Oxalis dillenii	Creeping Ladies Sorrel
Oxalis europaea	Tall Yellow Wood Sorrel
Oxalis repens	Creeping Wood Sorrel
Oxalis stricta	Yellow Wood Sorrel
Oxalis violacea	Violet Wood Sorrel

PAPAVERACEAE(Poppy Family)

Argemone alba	Prickly Poppy
Sanguinaria canadensis	Bloodroot

PASSIFLORACEAE(Passion Flower Family)

Passiflora incarnata	Maypop
Passiflora lutea	Yellow Passion Flower

PHRYMACEAE(Lopseed Family)

Phryma leptostachya	Lopseed

PHYTOLACEACEAE(Pokeweed Family)

Phytolacca americana	Pokeberry, Pokeweed

PINACEAE(Pine Family)

Pinus clausa	Sand Pine
Pinus echinata	Shortleaf Pine
Pinus palustris	Longleaf Pine
Pinus taeda	Loblolly Pine
Pinus elliotii	Slash Pine

PLANTAGINACEAE(Plantain Family)

Plantago aristata	Bracted Plantain, Buckhorn
Plantago heterophylla	Small Plantain
Plantago hookeriana	Plantain
Plantago lanceolata	Buckhorn Plantain, English Plantain
Plantago virginica	Field Plantain

PLATANACEAE

Platanus occidentalis	Sycamore

POACEAE(Grass Family)

Agrostis hyemalis	Bent Grass
Andropogon elliottii	Elliott's Broomsedge
Andropogon scoparius	Little Bluestem
Andropogon ternarius	Broomsedge
Andropogon virginicus	Virginia Broomsedge
Anthaenantia villosa	
Aristida lanosa	Three Awn Grass
Aristida longespica	Three Awn Grass
Aristida purpurascens	Three Awn Grass
Aristida tuberculosa	Three Awn Grass
Arundinaria gigantea	Witch Cane
Arundinaria tecta	Switch Cane
Arundo donax	Giant Reed Grass
Briza minor	Quaking Grass
Bromus catharticus	Chess, Brome Grass
Cenchrus echinatus	Sandspurs
Cynodon dactylon	Bermuda Grass
Danthonia sericea	Oat Grass
Digitaria sanguinalis	Large Crabgrass
Echinochloa crusgallii	Barnyard Grass
Eragrostis spectabilis	Love Grass
Erianthus alopecuroides	Plume Grass, Beard Grass
Erianthus giganteus	Plume Grass, Beard Grass
Festuca octoflora	Fescue
Festuca sciurea	Fescue
Glyceria striata	Manna Grass
Gmnopogon ambiguus	Beard Grass
Holcus lanatus	Velvet Grass
Hordeum pusillum	Little Barley
Leersia hexandra	Cut Grass
Leersia oryzoides	Cut Grass
Leptoloma cognatum	Witch Grass
Lolium multiflorum	Rye Grass
Lolium perenne	Rye Grass
Melica mutica	Melic Grass
Muhlenbergia capillaris	Muhly
Oplismenus setarius	
Panicum aciculara	Panicum
Panicum anceps	Panicum
Panicum ashei	Panicum
Panicum boscii	Panicum
Panicum ciliatum	Panicum
Panicum commutatum	Panicum
Panicum dichotomumflorum	Panicum
Panicum hemitomon	Maiden Cane
Panicum laxiflorum	Panicum
Panicum oligosanthes	Panicum
Panicum polyanthes	Panicum
Panicum ravenelii	Panicum
Panicum scoparium	Panicum
Panicum verrucosum	Panicum
Panicum xalapense	Panicum
Paspalum dilatatum	Dallis Grass

Paspalum laeve	Paspalum
Paspalum urvillii	Vaseygrass
Poa annus	Annual Bluegrass
Poa pratensis	Bluegrass
Sacciolepis striata	
Setaria geniculata	Foxtail
Sorghastrum nutans	Indian Grass
Sorghastrum secundum	Indian Grass
Sorghum halepense	Johnson Grass
Sphenopholis nitida	Wedge Grass
Sporobolus clandestinus	Drop Seed
Sporobolus junceus	Drop Seed
Sporobolus poiretii	Smutgrass
Stipa avenacea	Needle Grass
Tridens flavus	Purple Top
Triplasis americana	Sand Grass
Triplasis purpurea	Sand Grass
Tripsacum dactyloides	Gamma Grass
Uniola sessiliflora	

PODOSTEMACEAE(River Weed Family)

Podostemum ceratophyllum	River Weed

POLEMONIACEAE(Phlox Family)

Gilia rubra	Standing Cypress
Phlox amoena	Hairy Phlox
Phlox carolina	Phlox
Phlox drummondii	Cultivated Phlox
Phlox glaberrima	Smooth Phlox
Phlox hentzii	Trailing Phlox
Phlox subulata	Phlox

POLYGALACEAE(Milkwort Family)

Asemeia grandiflora	Candy Weed
Polygala cymosa	Pine-Barren Milkwort
Polygala grandiflora	
Polygala curtisii	Button-Rosy
Polygala incarnata	
Polygala lutea	Orange Milkwort
Polygala polygama	Milkwort
Stillingia sylvatica	Queen's Delight, Queen's Root

POLYGONACEAE(Buckwheat or Smartweed Family)

Brunnichia cirrhosa	Buckwheat Vine
Eriogonum tomentosum	Dog-Tongue, Wild Buckwheat
Polygonella americana	Jointweed
Polygonum aviculare	Common Knotweed
Polygonum hirsutum	Hairy Knotweed
Polygonum hydropiperoides	Water Pepper
Polygonum pensylvanicum	Pinkweed
Polygonum persicaria	
Polygonum punctatum	Knotweed
Polygonum sagittatum	Tearthumb
Polygonum scandens	Climbing Buckwheat,False Buckwheat
Polygonum virginianum	Virginia Smartweed
Rumex acetosella	Red Sorrel
Rumex crispus	Curly Dock, Sour Dock
Tovara virginiana	
Rumex hastatulus	Wild Sorrel

POLYPODIACEAE(Common Fern Family)

Asplenium platyneuron	
Polypodium polypodioides	Resurrection Fern

PONTEDERIACEAE(Pickerel Weed Family)

Pontederia cordata	Pickeral Weed, Wampee

PORTULACACEAE(Purslane Family)

Portulaca parvula	Small Flowered Purslane
Portulaca pilosa	Purslane

POTAMOGETONACEAE(Pondweed Family)

Potamogeton epihydrus	Potamogeton

PRIMULACEAE(Primrose Family)

Hottonia inflata	Feather' Foil
Lysimachia quadrifolia	Whorled Loosestrife
Lysimachia lanceolata	Fringed Loosestrife
Samolus floribundus	Water Pimpernel
Steironema lanceolatum	Narrow Loosestrife
Steironema ciliatum	Loosestrife

RANUNCULACEAE(Crowfoot or Buttercup Family)

Anemonella thalictroides	Rue Anemone
Clematis crispa	Leather Flower
Delphinium ajacis	Buttercup
Ranunculus americanus	Spearwort
Thalictrum revolutum	Meadow Rue

RHAMNACEAE(Buckthorn Family)

Berchemia scandens	Supple-Jack
Ceanothus americanus	New Jersey Tea

ROSACEAE(Rose Family)

Agrimonia pubescens	Agrimony
Amelanchier canadensis	Swamp Shad Bush,Serviceberry,Juneberry
Aronia arbutifolia	Chokeberry
Crataegus flava	Hawthorn
Crataegus marshalii	Parsley Haw
Crataegus uniflora	Dwarf Thorn
Exochorda racemosa	
Fragaria virginiana	Strawberry
Laurocerasus caroliniana	Carolina Cherry
Malus angustifolia	Narrow-Leaved Crab Apple
Potentilla canadensis	Five-Finger
Potentilla recta	
Potentilla simplex	Dwarf Five-Finger
Prunus angustifolia	Chickasaw Plum
Prunus caroliniana	Cherry Laurel
Prunus persica	Peach
Prunus serotina	Chokeberry, Wild Black Cherry
Prunus triloba	
Prunus umbellata	Hog Plum
Pyrus angustifolia	Wild Crab Apple

Pyrus communis	Common Pear
Rosa carolina	Wild Rose
Rosa multiflora	Wild Rose
Rubus betulifolia	Swamp Blackberry
Rubus cuneifolius	Sand Blackberry
Rubus trivialis	Southern Dewberry
Rubus enslenii	Southern Dewberry
Spiraea chamaedryfolia	
Spiraea prunifolia	
Spiraea thunbergii	

RUBIACEAE(Madder Family)

Cephalanthus occidentalis	Button Bush
Diodia teres	Smaller Buttonweed
Diodia virginiana	Larger Buttonweed
Galium circaezans	Wild Licquorice
Galium hispidulum	
Galium obtusum	Bedstraw
Galium pilosum	Cleavers
Galium triflorum	Cleavers
Houstonia longifolia	Houstonia
Houstonia pusilla	Small Bluet
Houstonia purpurea	Houstonia
Mitchella repens	Partridge Berry
Richardia scabra	Florida Purslane, Mexican Clover

SILICACEAE(Willow Family)

Populus alba	White or Silver Poplar
Populus heterophylla	Swamp Cottonwood
Populus nigra	Lombardy's Poplar
Salix nigra	Black Willow

SARRACENIACEAE(Pitcher-Plant Family)

Sarracenia flava	Trumpets
Sarracenia minor	Hooded Pitcher Plant

SAURURACEAE(Lizard's Tail Family)

Saururus cernuus	Lizard's Tail

SAXIFRAGACEAE(Saxifrage Family)

Decumaria barbara	Climbing Hydrangea
Itea virginica	Virginia Willow
Philadelphus inodorus	Mock Orange, Syringa

SCROPHULARIACEAE(Figwort Family)

Agalinia fasciculata	Gerardia
Aureolaria pectinata	Sticky Foxglove
Aureolaria virginica	False Foxglove
Bocopa caroliniana	Blue Water Hyssop
Bocopa monnieri	Water Hyssop
Chelone glabra	White Turtlehead
Gerardia setacea	Gerardia
Gratiola pilosa	Hedge Hyssop
Gratiola ramosa	Hedge Hyssop
Gratiola virginica	Hedge Hyssop
Linaria canadensis	Blue Toad Flax
Lindernia dubia	False Pimpernel
Micranthemum umbrosum	Creeping Pimpernel
Mimulus alatus	Monkey Flower

Penstemon australis	Beard Tongue
Penstemon laevigatus	Beard Tongue
Verbascum blattoria	Moth Mullein
Verbascum thaspus	Mullein, Flannel Plant
Veronica arvensis	Speedwell
Veronica peregrins	Speedwell

SOLANCEAE(Nightshade Family)

Datura stramonium	Jimsonweed
Petunia integrefolia	Petunia
Physalis heterophylla	Ground Cherry
Physalis pubescens	Ground Cherry
Physalis virginiana	Ground Cherry
Solanum americanum	Nightshade
Solanum carolinense	Horsenettle, Nightshade
Solanum nigrum	Black Nightshade

SPARGANIACEAE(Bur-Reed Family)

Sparganium americanum	Bur-Reed

STERCULIACEAE(Chocolate Family)

Firmiana plantanifolia	Japanese Varnish-Tree, China Parasol-Tree

STYRACACEAE(Storax Family)

Styrax americana	Storax
Styrax grandiflora	Storax

SYMPLOCACEAE(Sweet-Leaf Family)

Symplocos tinctoria	Horse-Sugar, Sweet-Leaf, Yellow-Wood

TAXODIACEAE(Cypress Family)

Taxodium distichum	Bald Cypress

TILIACEAE(Linden Family)

Tilia georgiana	Basswood

TURNERACEAE(Turnera Family)

Piriqueta caroliniana

TYPHACEAE

Typha latifolia	Cattail
Typha domingensis	Cattail

ULMACEAE(Elm Family)

Celtis occidentalis georgiana	Hackberry or Nettle Tree
Celtis tenuifolia	Dwarf Hackberry
Planera aquatica	Water Elm, Planer Tree
Ulmus alata	Winged Elm
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm

URTICACEAE(Nettle Family)

Boehmeria cylindrica	False Nettle
Pilea pumilla	Clearweed

VALERINACEAE(Valerian Family)

Valerianella radiata	Corn Salad

VERBENACEAE(Vervain Family)

Callicarpa americana	French Mulberry, Beauty Berry
Lantana camara	Lantana
Verbena bonariensis	Vervain
Verbena canadensis	Verbena
Verbena carnea	Vervain
Verbena hybrida	Verbena
Verbena tenuisecta	Moss Verbena
Verbena urticifolia	Vervain

VIOLACEAE(Violet Family)

Viola cucullata	
Viola esculenta	Edible Violet
Viola lanceolata	
Viola hastata	Halberd-Leaved Violet
Viola macloskeyi	
Viola papilionacea	Blue Violet,Meadow Violet
Viola pedata	Bird-Foot Violet
Viola primulifolia	Primrose-Leaved Violet
Viola rafinesqii	
Viola septemloba	Southern Coast Violet
Viola villosa	Southern Downy Violet
Viola vittata	Strap-Leaved Violet
Viola walterii	Prostrate Blue Violet

VITACEAE(Grape Family)

Ampelopis arborea	Pepper Vine
Parthenocissus quinquefolia	Virginia Creeper
Vitia aestivalis	Summer Grape
Vitis rotundifolia	Muscadine

XYRIDACEAE(Yellow-Eyed Grass Family)

Xyris caroliniana	Yellow-Eyed Grass

Appendix F
FURBEARERS OF SRP[33-36]

Scientific Name	Common Name	Distribution	Abundance
Urocyon cinereoargenteus	Gray Fox	Terraces and plateau	Common
Vulpes Fulva	Red Fox	Plateau	Uncommon
Procyon Lotor	Raccoon	Terraces and Plateau	Common
Lynx Rufus	Bobcat, Wildcat	Terraces and Plateau	Common
Felix concolor	Cougar	Terraces	Rare
Mephitis mephitis	Striped Skunk	Terraces and Plateau	Common
Spilogale putorius	Spotted Skunk	Terraces and Plateau	Rare
Didelphis marsupialis	Opossum	Terraces and Plateau	Common
Sylvilagus floridanus	Cottontail Rabbit	Terraces and Plateau	Abundant
Sylvilagus palustris	Marsh Rabbit	Swamp	Uncommon
Sylvilagus aquaticus	Cane Cutter Rabbit	Swamp	Rare
Sciurus carolinensis	Gray Squirrel	Terraces and Plateau	Abundant
Sciurus niger	Fox Squirrel	Terraces and Plateau	Common
Glaucomys volans	Flying Squirrel	Hardwoods	Common
Canis familiaris	Feral Dogs	Terraces and Plateau	Uncommon
Ursus americanus	Black Bear	Floodplain	Rare
Castor canadensis	Beaver	Ponds and Streams	Uncommon
Lutra canadensis	Otter	Ponds and Streams	Uncommon
Mustela vison	Mink	Not Known	Rare
Mustela frenata	Weasel	Not Known	Rare
Odocoileas virginianus	Whitetail Deer	Terraces and Plateau	Abundant
Sus scrofa	Feral Hogs	Terraces	Common
Ondatra zibethica	Muskrat	Terraces and Plateau	Rare
Peromyscus polionotus	Old-field Mouse	Forbs-Broomsedge	Common
Mus musculus	House Mouse	Forbs-Broomsedge-Hardwoods	Rare
Cryptotis parva	Least Shrew	Forbs-Broomsedge-Vine	Common
Reithrodontomys humulis	Harvest Mouse	Forbs-Broomsedge-Vine	Common
Sigmodon hispidus	Cotton Rat	Forbs-Broomsedge-Hardwoods	Abundant
Neotoma floridana	Eastern Woodrat	Broomsedge-Vine	Uncommon
Peromyscus gossypinus	Cotton Mouse	Hardwoods	Abundant
Ochrotomys nuttalli	Golden Mouse	Hardwoods	Abundant
Oryzomys palustris	Rice Rat	Lowland Hardwoods & Swamp	Common
Pitymys pinetorum	Pine Mouse	Astor-Upland Grass	Common
Blarina brevicauda	Short-tailed Shrew	Forbs-Broomsedge-Pines	Abundant
Sorex longirostris	Southeastern Shrew	-	Common

Appendix G
BIRDS OF SRP[37]

The list of birds sighted on the SRP site and in the near vicinity was extracted from information published in Reference 35. Also, information from persons who made their observations as part of a specific census, or casually, in the pursuit of other duties was used. Some birds were identified from road kills and kills from collision with a nearby television tower. The common and scientific names follow the Fifth Edition of the American Ornithologists' Union Checklist (1957).

Residency status in the table follow these abbreviations:

P.R. - Permanent resident

S.R. - Summer resident - regular, spring to fall; breeding or presumably breeding

S.V. - Summer visitant - nonbreeding

W.V. - Winter visitant - usually regular, fall to spring

T.V. - Transient visitant - spring and/or fall

The location of sighting is the area where the birds are most commonly observed. In some cases, birds were not seen but were identified by their calls and singing. In some instances, the location of sighting is not given for one of the following reasons: • Birds were seen only in migration. • Birds were seen in areas not typical or expected of the species. • Birds were seen only in nearby areas offsite. • Birds were observed only as a result of road kills or kills from collision with a television tower. • Record was not made of location of bird sighting.

Abundance is a qualitative measure since a number of observers contributed to the list. In some cases, specific numbers of sightings are listed; however, in most cases, abundance is expressed in nonquantitative terms such as:

Rare	Very Common
Uncommon	Abundant
Common	Very Abundant

Scientific Name	Common Name	Residency Status	Location of Sighting	Abundance
Gavia immer	Common Loon	T.V.	River Swamp, Par Pond	2
Podiceps auritus	Horned Grebe	W.V.	Ponds	3
Podilymbus podiceps	Pied-Billed Grebe	P.R.	Ponds	Common
Phalacrocorax auritus	Double-Crested Cormorant	W.V.	Near Ponds	7
Anhinga anhinga	Anhinga	S.V.	Ponds, Creeks	3
Ardea herodias	Great Blue Heron	P.R.	Ponds, Carolina Bays, Creeks	Common
Butorides virescens	Green Heron	S.R.	Creeks	Uncommon
Florida caerulea	Little Blue Heron	S.V.	Ponds	Common
Casmerodius albus	Common Egret	P.R.	Carolina Bays, Ponds	Common
Leucophoyx thula	Snowy Egret	S.V.	River Swamp, Ponds	Uncommon
Nycticorax nycticorax	Black-Crowned Night Heron	T.V.	Ponds	2
Nyctanassa violacea	Yellow-Crowned Night Heron	S.V.	River Swamp, Carolina Bays	2
Ixobrychus exilis	Least Bittern	S.R.	Carolina Bays	Common
Botaurus lentiginosus	American Bittern	W.V.	Carolina Bays	Uncommon
Mycteria americana	Wood Ibis	S.V.	Near Creeks	Uncommon
Guara alba	White Ibis	S.V.	River and Carolina Bays	15
Branta canadensis	Canada Goose	W.V.	Ponds	1
Chen hyperborea	Snow Goose	T.V. or W.V.	Carolina Bays	2
Chen caerulescens	Blue Goose	T.V. or W.V.	Carolina Bays	4
Anas platyrhynchos	Mallard Duck	W.V. or S.R.	Carolina Bays	Common
Anas rubripes	Black Duck	W.V.	Carolina Bays	17
Anas acuta	Pintail Duck	W.V.	Carolina Bays	1
Anas carolinensis	Green-Winged Teal	W.V.	Par Pond	Common
Anas discors	Blue-Winged Teal	T.V.	Ponds, Carolina Bays	Common
Mareca americana	American Widgeon	W.F.	Ponds	Uncommon
Spatula clypeata	Shoveler	T.V. & W.V.	Carolina Bays	3
Aix sponsa	Wood Duck	P.R.	River Swamp	Common
Aythya collaris	Ring-Necked Duck	W.V.	Ponds, Carolina Bays	Common
Aythya valisneria	Canvasback	W.V.	Ponds	1
Aythya affinis	Lesser Scamp	T.V.	Ponds	Uncommon
Glaucionetta albeola	Bufflehead	T.V.	Ponds	5
Clangula hyemalis	Oldsquaw	W.V.	Par Pond	1
Erismatura jamaicensis	Ruddy Duck	T.V.	Ponds	Uncommon
Lophodytes cucullatus	Hooded Merganser	W.V.	Ponds, Streams	Uncommon to Common
Cathartes aura	Turkey Vulture	P.R.	Ubiquitous	Common
Coragyps atratus	Black Vulture	P.R.	Ubiquitous	Very Common
Ictinia missippiensis	Mississippi Kite	S.R.	Lower Terraces	Uncommon
Accipiter striatus	Sharp-Shinned Hawk	W.V.	Ubiquitous	Infrequent
Accipiter cooperii	Coopers Hawk	P.R.	Ubiquitous	Common
Buteo jamaicensis	Red-Tailed Hawk	P.R.	Pines, Powerline Poles	Common
Buteo lineatus	Red-Shouldered Hawk	P.R.	River Swamp, Lower Terraces	Common
Buteo platypterus	Broad-Winged Hawk	S.R.	Deciduous Woods	Rare
Haliaeetus leucocephalus	Bald Eagle	T.V.	Near Par Pond	3
Circus cyaneus	Marsh Hawk	W.V.	Old Fields	Common
Pandion haliaetus	Osprey	T.V.	Ponds	16
Falco peregrinus	Peregrine Falcon	W.V.	Near Par Pond	Rare
Falco columbarius	Pigeon Hawk	T.V.	Lower Terrace	Rare
Falco sparverius	Sparrow Hawk	P.R.	Old Field	Common
Colinus virginianus	Bob White	P.R.	Ubiquitous in Ground Cover	Common
Meleagris gallopavo	Turkey	P.R.	Near Streams and Swamp	Rare
Rallus elegans	King Rail	S.R.	Carolina Bays	Common
Rallus limicola	Virginia Rail	T.V.	- -	Rare
Porzana carolina	Sora	T.V.	- -	Uncommon
Porphyrula martinica	Purple Gallinule	S.R.	Carolina Bays	Uncommon
Gallinula chloropus	Common Gallinule	T.V.	Carolina Bays, Ponds	Uncommon
Fulica americana	American Coot	W.R.	Ponds, Carolina Bays	Common
Charadrius vociferus	Killdeer	P.R.	Edges of Ponds, Bays	Uncommon
Philohela minor	American Woodcock	P.R.	- -	Rare
Capella gallinago	Common Snipe	W.R.	Marshes	Common
Actitis macularia	Spotted Sandpiper	T.V.	Edges of Ponds, Streams	Common
Tringa solitaria	Solitary Sandpiper	T.V.	Ponds	Uncommon
Totanus melanoleucus	Greater Yellowlegs	T.V.	Ponds	Uncommon
Totanus flavipes	Lesser Yellowlegs	T.V.	- -	Uncommon
Erolia minutilla	Least Sandpiper	T.V.	- -	Uncommon

Scientific Name	Common Name	Residency Status	Location of Sighting	Abundance
Crocethia alba	Sanderling	T.V.	- -	3
Lobipes lobatus	Northern Phalarope	T.V.	Bays	2
Larus delawarensis	Ring-Billed Gull	W.R.	River, Ponds	5
Larus philadelphia	Bonaparte's Gull	T.V.	Ponds	Rare
Chlidonias nigra	Black Tern	T.V.	Bays	Scarce
Zenaidura macroura	Mourning Dove	P.R.	Fields, Oak Forests	Common
Columbigallina passerina	Ground Dove	-	Par Pond, Streams	5
Coccyzus americanus	Yellow-Billed Cuckoo	S.R.	Flood Plain Forests	Common
Coccyzus erythropthalmus	Black-Billed Cuckoo	T.V.	- -	1
Tyto alba	Barn Owl	P.R.	Terrace Forests	2
Otus asio	Screech Owl	P.R.	Trees	Few
Bubo virginianus	Great Horned Owl	P.R.	Pine Trees	Uncommon
Strix varia	Barred Owl	P.R.	Flood Plain Timber	Common
Asio flammeus	Short-Eared Owl	W.V.	Fields	Common
Caprimulgus carolinensis	Chuck-Will's-Widow	S.R.	Forested Areas	Common
Chordeiles minor	Common Nighthawk	S.R.	Open Pineland	Common
Chaetura pelagica	Chimney Swift	S.R.	River Swamp	Common
Archilochus colubris	Ruby-Throated Hummingbird	S.R.	Broadleaf Forests	Common
Megaceryle alcyon	Belted Kingfisher	P.R.	Ponds, Streams	Uncommon
Colaptes auratus	Yellow-Shafted Flicker	P.R.	Swamp Forests	Common
Hylatomus pileatus	Pileated Woodpeckers	P.R.	River Swamps, Flood Plain Forests	Common
Centurus carolinus	Red-Bellied Woodpecker	P.R.	River Swamps, Flood Plain Forests	Common
Melanerpes erythrocephalus	Red-Headed Woodpecker	P.R.	Power Poles	Common
Sphyrapicus varius	Yellow-Bellied Sapsucker	W.V.	Mixed Forests, Swamps	Common
Dendrocopus villosus	Hairy Woodpecker	P.R.	Dead Timber	Uncommon
Dendrocopus pubescens	Downy Woodpecker	P.R.	Broadleaf and Mixed Forests	Common
Dendrocopus borealis	Red-Cockaded Woodpecker	P.R.	Pine Trees	Rare
Tyrannus tyrannus	Eastern Kingbird	S.R.	Open Country	Abundant
Tyrannus dominicensis	Gray Kingbird	-	- -	1
Tyrannus verticalis	Western Kingbird	-	- -	1
Myiarchus crinitus	Great Crested Flycatcher	S.R.	Broadleaf and Mixed Forests	Common
Sayornis phoebe	Eastern Phoebe	W.V.	Near Water	Common
Empidonax virescens	Acadian Flycatcher	S.R.	River Swamp	Abundant
Empidonax traillii	Traill's Flycatcher	T.V.	- -	1
Empidonax minimus	Least Flycatcher	T.V.	- -	1
Contopus virens	Eastern Wood Pewee	S.R.	Open Mixed Woods	Common
Eremophila alpestris	Horned Lark	W.V.	Open Fields	Uncommon
Iridoprocne bicolor	Tree Swallow	T.V.	- -	2
Riparia riparia	Bank Swallow	T.V.	Stream	1
Stelgidopteryx ruficollis	Rough-Winged Swallow	S.R.	Clay Banks	Common
Hirundo rustica	Barn Swallow	T.V.	- -	Uncommon
Progne subis	Purple Martin	S.R.	Old House Sites	Common
Cyanocitta cristata	Blue Jay	P.R.	Woods	Common
Corvus brachyrhynchos	Common Crow	P.R.	Pines and Mixed Forests	Abundant
Corvus ossifragus	Fish Crow	S.R.	Flood Plain Forests, Bays	Common
Parus caroninensis	Carolina Chickadee	P.R.	Open Wooded Areas	Common
Parus bicolor	Tufted Titmouse	P.R.	Open Wooded Areas	Common
Sitta carolinensis	White-Breasted Nuthatch	P.R.	River Swamp	Uncommon
Sitta pusilla	Brown-Headed Nuthatch	P.R.	Open Pine Forests	Common
Certhia familiaris	Brown Creeper	W.V.	- -	Rare
Troglodytes aedon	House Wren	W.V.	Scrubby Growth	Uncommon
Troglodytes troglodytes	Winter Wren	W.V.	Forest Floor	Common
Thryomanes bewickii	Bewick's Wren	W.V.	Brush, Wood Piles	Common
Thryothorus ludovicianus	Carolina Wren	P.R.	Swamps, Flood Plain Forests	Common
Telmatodytes palustris	Long-Billed Marsh Wren	W.V.	Carolina Bays	Uncommon
Mimus polyglottos	Mocking Bird	P.R.	Trees, Shrubs	Abundant
Dumetella carolinensis	Catbird	W.V.	Swamp Border	Common

Scientific Name	Common Name	Residency Status	Location of Sighting	Abundance
Toxostoma rufum	Brown Thrasher	P.R.	Thickets	Common
Turdus migratorius	Robin	W.V.	Ubiquitous	Common
Hylocichla mustelina	Wood Thrush	S.R.	Flood Plain Forests	Common
Hylocichla guttata	Hermit Thrush	W.V.	Broadleaf and Mixed Forests	Common
Hylocichla ustulata	Swainson's Thrush	T.V.	- -	Uncommon
Hylocichla minima	Gray-Checked Thrush	T.V.	- -	Rare
Hylocichla fuscescens	Veery	T.V.	River Swamp	Common
Sialia sialis	Eastern Bluebird	P.R.	Open Woodlands	Abundant
Polioptila caerulea	Blue-Gray Gnatcatcher	S.R.	Ubiquitous	Abundant
Regulus satrapa	Golden-Crowned Kinglet	W.R.	Broadleafed and Mixed Forest	Common
Regulus calendula	Ruby-Crowned Kinglet	W.R.	Forest Edges, Shrubs	Abundunt
Anthus spinoletta	Water Pipit	W.V.	Old Fields	Common
Anthus spragueii	Sprague's Pipit	W.V.	Fields	Rare
Bombycilla cedrorum	Cedar Waxwing	W.V.	Fruit-Seeking	Common
Lanius ludovicianus	Loggerhead Shrike	P.R.	Open Country	Common
Sturnus vulgaris	Starling	P.R.	- -	Uncommon
Vireo griseus	White-Eyed Vireo	S.R.	Broadleaf Forests	Common
Vireo flavifrons	Yellow-Throated Vireo	S.R.	Broadleaf and Mixed Forests	Common
Vireo solitarius	Solitary Vireo	W.V.	River Swamp	Rare
Vireo olivaceus	Red-Eyed Vireo	S.R.	Broadleaf Forests, Swamp	Abundant
Mniotilta varia	Black-and-White Warbler	T.V.	- -	Uncommon
Protonotaria citrea	Prothomotary Warbler	S.R.	Swamp, Streams	Common
Limnothylpis swainsonii	Swainson's Warbler	S.R.	Swamp, Streams	Common
Helmitheros vermivorus	Worm-Eating Warbler	T.V.	- -	Uncommon
Vermivora chrysoptera	Golden-Winged Warbler	T.V.	- -	Uncommon
Vermivora Pinus	Blue-Winged Warbler	T.V.	Broadleaf Forests	?
Vermivora peregrina	Tennessee Warbler	T.V.	- -	Uncommon
Vermivora celata	Orange-Crowned Warbler	W.V.	- -	Rare
Vermivora ruficapilla	Nashville Warbler	T.V.	- -	Rare
Parula americana	Porula Warbler	S.R.	Broadleaf Forests	Abundant
Dendroica petechia	Yellow Warbler	T.V.	Willow Borders	Uncommon
Dendroica magnolia	Magnolia Warbler	T.V.	- -	Uncommon
Dendroica tigrina	Cape May Warbler	T.V.	- -	Uncommon
Dendroica caerulescens	Black-Throated Warbler	T.V.	- -	Abundant
Dendroica coronata	Myrtle Warbler	W.V.	Waxmyrtle	Common
Dendroica virens	Black-Throated Green Warbler	T.V.	- -	Uncommon
Dendroica cerulea	Cerulean Warbler	T.V.	- -	Rare
Dendroica fusca	Blackburnian Warbler	T.V.	- -	Uncommon
Dendroica dominica	Yellow-Throated Warbler	S.R.	River Swamp, Streams	Uncommon
Dendroica pensylvanica	Chestnut-Sided Warbler	T.V.	- -	Uncommon
Dendroica castanea	Bay-Breasted Warbler	T.V.	- -	Uncommon
Dendroica striata	Blackpoll Warbler	T.V.	- -	Uncommon
Dendroica pinus	Pine Warbler	P.R.	Pinelands	Common
Dendroica kirtlandii	Kirtland's Warbler	T.V.	- -	Rare
Dendroica discolor	Prairie Warbler	S.R.	Open Pine & Scrub Oaks	Common
Dendroica palmarum	Palm Warbler	W.R.	Open Country	Common
Seiurus aurocapillus	Ovenbird	T.V.	Broadleaf Forest	Abundunt
Seiurus noveboracensis	Northern Waterthrush	T.V.	Ponds	Common
Seiurus motacilla	Louisiana Waterthrush	S.R.	Streams	Common
Oporornis formosus	Kentucky Warbler	S.R.	Pond Margins, Broadleaf Forests	Common
Oporornis agilis	Connecticut Warbler	T.V.	- -	Rare
Geothlypis trichas	Yellowthroat	P.R.	Fields, Streams, Bays	Common
Icteria virens	Yellow-Breasted Chat	S.R.	Scrubby Areas, Lower Terraces	Common
Wilsonia citrina	Hooded Warbler	S.R.	River Swamp	Common
Wilsonia pusilla	Wilson's Warbler	T.V.	- -	Rare
Wilsonia canadensis	Canada Warbler	T.V.	- -	Rare
Setophaga ruticilia	American Redstart	T.V.	Broadleaf Forests	Common
Passer domesticus	House Sparrow	P.R.	Industrial Areas	Common
Dolichonyx oryzivorus	Bobolink	T.V.	Fields	Common
Sturnella magna	Eastern Meadowlark	P.R.	Fields	Common
Sturnella neglecta	Western Meadowlark	W.V.	- -	Rare
Agelaius phoeniceus	Red-winged Blackbird	P.R.	Carolina Bays	Common

Scientific Name	Common Name	Residency Status	Location of Sighting	Abundance
Icterus spurius	Orchard Oriole	S.R.	Old Farm Sites	Common
Icterus galbula	Baltimore Oriole	T.V. W.V.	- -	Rare
Euphaeus carolinus	Rusty Blackbird	W.V.	River Swamp	Uncommon
Quiscalus quiscula	Common Grackle	P.R.	Near Bays	Common
Molothrus ater	Brown-Headed Cowbird	W.V.	Fields	Uncommon
Piranga olivacea	Scarlet Tanager	T.V.	Broadleaf Forest	Common
Piranga rubra	Summer Tanager	S.R.	Mixed Forest	Common
Richmondena cardinalis	Cardinal	P.R.	Edge Growth, Hammocks	Abundant
Pheucticus ludovicianus	Rose-Breasted Grosbeak	T.V.	- -	Uncommon
Guiraca caerulea	Blue Grosbeak	S.R.	Grassy Fields	Common
Passerina cyanea	Indigo Bunting	S.R.	Ubiquitous	Common
Passerina ciris	Painted Bunting	S.R.	Lower Terraces	Common
Carpodacus purpureus	Purple Finch	W.V.	Upland Areas	Common
Spinus pinus	Pine Siskin	W.V.	- -	Rare
Spinus tristis	American Goldfinch	P.R.	Lower Terraces	Uncommon to Common
Pipilo erythrophthalmus	Rufous-Sided Towhee	P.R.	Shrub, Pine-Oak Forests	Common
Passerculus sandwichensis	Savannah Sparrow	W.R.	Old Fields	Very Abundant
Ammodramus savannarum	Grasshopper Sparrow	W.V.	- -	Uncommon
Passerherbulus caudacutus	LeConte's Sparrow	W.V.	- -	Rare
Passerherbulus henslowii	Henslow's Sparrow	T.V.	- -	Rare
Pooecetes gramineus	Vesper Sparrow	W.V.	Open Areas	Common
Aimophila aestivalis	Bochman's Sparrow	P.R.	Pine Woods	Common
Junco hyemalis	Slate-Colored Junco	W.V.	Upland Pine-Oak	Common
Spizella passerina	Chipping Sparrow	P.R.	Pine	Common
Spizella pusilla	Field Sparrow	P.R.	Lower Terraces	Common
Zonotrichia albicollis	White-Throated Sparrow	W.V.	Moist Areas	Abundant
Passerella iliaca	Fox Sparrow	W.V.	- -	Rare
Melospiza lincolnii	Lincoln's Sparrow	T.V.	- -	Rare
Melospiza georgiani	Swamp Sparrow	W.V.	Bays, Marshy Areas	Common
Melospiza melodia	Song Sparrow	W.V.	Open, Brushy Areas	Abundant

Appendix H
FISH ON THE SRP SITE[38-41]

Scientific Name	Common Name	Location[(a)] Upper Three Runs	Four Mile Creek	Pen Branch	Steel Creek	Lower Three Runs	Par Pond System
Anguilla rostrata	American Eel	C				A	B
Alosa aestivalis	Blueback Herring		C				B
Amia calva	Bowfin		C			A	B
Aphredoderus sayanus	Pirate Perch	C	C	C	C	A	B
Centrarchus macropterus	Flier	C			C	A	
Lepomis gulosus	Warmouth		C	C	C	A	B
Chologaster cornuta	Swampfish	C				A	
Cyprinus carpio	Carp	C	C				
Dorosoma cepedianum	Gizzard Shad					A	B
Elassoma zonatum	Banded Pygmy Sunfish					A	B
Enneacanthus chaetodon	Blackbanded Sunfish	C					
Enneacanthus gloriosus	Bluespotted Sunfish	C				A	
Erimyzon oblongus	Creek Chubsucker	C			C	A	
Erimyzon sucetta	Lake Chubsucker	C	C	C	C	A	B
Esox americanus	Redfin Pickerel	C	C	C	C	A	B
Esox niger	Chain Pickerel	C			C	A	B
Etheosoma fusiforme	Swamp Darter	C	C	C	C	A	B
Etheosoma nigrum	Johnny Darter	C			C		
Etheosoma olmstedi	Tessellated Darter					A	
Fundulus lineolatus	Lined Top Minnow					A	
Fundulus notti	Starhead Top Minnow						
Gambusia affinis	Mosquitofish	C	C	C	C	A	B
Hybopsis micropogon	River Chub	C					
Hypentelium nigricans	Northern Hogsucker				C		
Ictalurus melas	Black Bullhead		C				
Ictalurus natalus	Yellow Bullhead	C	C		C	A	B
Ictalurus nebulosus	Brown Bullhead	C	C	C	C	A	B
Ictalurus platycephalus	Flat Bullhead						B
Ictalurus punctatus	Channel Catfish		C			A	B
Labidesthes sicculus	Brook Silversides	C				A	B
Lepisosteus oculatus	Spotted Gar	C	C				
Lepisosteus osseus	Longnose Gar	C	C			A	
Lepisosteus spatula	Alligator Gar		C				
Lepomis auritus	Redbreasted Sunfish	C	C	C	C	A	B
Lepomis gibbosus	Pumpkinseed	C	C	C	C		
Lepomis macrochirus	Bluegill	C	C		C	A	B
Lepomis marginatus	Dollar Sunfish	C		C	C	A	B
Lepomis microlophus	Redear Sunfish	C	C	C	C	A	B
Lepomis punctatus	Spotted Sunfish	C	C	C	C	A	B
Micropterus salmoides	Largemouth Bass	C	C	C	C	A	B
Minytrema melanops	Spotted Sucker		C			A	B
Molostoma sp.	Jumprock	C					
Notemigonus crysoleucas	Golden Shiner	C		C	C	A	B
Notropis altipinnis	Highfin Shiner	C					
Notropis chalybaeus	Ironcolor Shiner					A	
Notropis cummingsae	Dusky Shiner			C		A	
Notropis lutipinnis	Yellowfin Shiner				C		
Notropis maculatus	Taillight Shiner	C				A	
Notropis petersoni	Coastal Shiner	C			C	A	B
Noturus gyrinus	Tadpole Mudtom	C				A	
Noturus leptacanthus	Speckled Mudtom					A	
Perca flavescens	Yellow Perch	C				A	B
Percina nigrofasciatus	Blackbanded Darter					A	
Pomoxis annularus	White Crappie					A	
Pomoxis nigromaculatus	Black Crappie	C	C			A	B
Semotilus atromaculatus	Creek Chub	C			C		
Umbra pygmae	Eastern Mudminnow					A	

(a) Fish were identified where the letters A, B and C appear. These letters are used to identify the source of information as follows:

A - References 38, 39, 40
B - J. P. Clugston, University of Georgia, Unpublished Studies
C - Reference 41

Appendix I
REPTILES AND AMPHIBIANS OF SRP[43,44]

Scientific Name	Common Name
Chelonia (Turtles)	
Chelhydra serpentina	Common Snapping Turtle
Sternothaerus odoratus	Stinkpot, Musk Turtle
Kinosternon subrubrum	Eastern Mud Turtle
Kinosternon bauri	Striped Mud Turtle
Clemmys guttata	Spotted Turtle
Terrapene carolina	Eastern Box Turtle
Pseudemys floridana	Florida Cooter
Pseudemys scripta	Yellow-Bellied Turtle
Deirochelys reticularia	Chicken Turtle
Trionyx spinifera	Southern Spiny Softshell
Sauria (Lizards)	
Anolis carolinensis	Carolina Anole, Chameleon
Sceloporus undulatus	Northern Fence Lizard
Ophisaurus attenuatus	Eastern Slender Glass Lizard
Ophisaurus ventralis	Eastern Glass Lizard
Cenemidophorus	Six-Lined Race Runner
Lygosoma laterale	Ground Skink
Eumeces fasciatus	Five-Lined Skink
Eumeces laticeps	Broad-Headed Skink
Eumeces inexpectatus	Southeastern Five-Lined Skink
Crocodilia (Alligator)	
Alligator mississipiensis	American Alligator
Serpentes (Snakes)	
Natrix cyclopion	Florida Green Water Snake
Natrix erythrogaster	Red-Bellied Water Snake
Natrix fasciata	Banded Water Snake
Natrix rigida	Striped Water Snake
Natrix taxispilota	Brown Water Snake
Seminatrix pygaea paludis	Carolina Swamp Snake
Virginia valeriae	Valeria's Snake
Storeria dekayi wrightorum	Midland Brown Snake
Storeria occipitomaculata	Red-Bellied Snake
Thamnophis sauritus	Eastern Ribbon Snake
Thamnophis sirtalis	Eastern Garter Snake
Heterodon platyrhinos	Eastern Hognose Snake
Abastor erythrogrammus	Rainbow Snake
Heterodon simus	Southern Hognose Snake
Diadophis punctatus	Southern Ringneck Snake
Farancia abacura	Eastern Mud Snake
Coluber constrictor	Northern Black Racer, Blacksnake

Scientific Name	Common Name
Serpentes (Snakes) - Continued	
Masticophis flagellum	Eastern Coachwhip
Opheodrys aestivus	Eastern Rough Green Snake
Elaphe guttata	Corn Snake
Elaphe obsoleta	Black Rat Snake
Pituophis melanoleucas	Northern Pine Snake
Lampropeltis getulus	Eastern King Snake
Lampropeltis doliata	Scarlet King Snake
Cemophora coccinea	Scarlet Snake
Tantilla coronata	Southeastern Crowned Snake[(a)]
Micrurus fulvius	Eastern Coral Snake[(a)]
Agkistrodon contortrix	Southern Copperhead[(a)]
Agkistrodon piscivorus	Eastern Cottonmouth[(a)]
Sistrurus miliarius	Carolina Pygmy Rattlesnake[(a)]
Crotalus horridus atricaudatus	Canebrake Rattlesnake[(a)]
Caudata (Salamanders)	
Pseudotriton montanus	Mountain Triton
Pseudotriton ruber	Red Salamander
Notophthalmus viridescens	Red Newt
Eurycea bislineata	Two-Lined Salamander
Eurycea longicauda	Holbrook's Salamander
Manculus quadridigitatus	Dwarf Four-Toed Salamander
Plethodon glutinosus	Slimy Salamander
Ambystoma talpoidem	Mole Salamander
Ambystoma opacum	Marbled Salamander
Ambystoma maculatum	Spotted Salamander
Ambystoma tigrinum	Tiger Salamander
Necturus punctatus	Spotted Mudpuppy
Siren lacertina	Mud Eel, Siren
Siren intermedia	Intermediate Siren
Desmognathus fuscus	Dusky Salamander
Ranidae (Frogs)	
Rana pipiens	Leopard Frog
Rana catesbeiana	Bullfrog
Rana clamitans	Bronze Frog, Green Frog
Rana areolata	Gopher Frog
Rana grylio	Pig Frog, Southern-Bullfrog
Rana palustris	Pickerel Frog
Rana virgatipes	Carpenter Frog
Bufo terrestris	Southern Toad, Carolina Toad
Bufo woodhousei	Woodhouse's Toad
Bufo quercicus	Oak Toad, Dwarf Toad
Scaphiopus holbrooki	Spadefoot
Acris gryllus	Cricket Frog
Pseudacris ornata	Ornate Chorus Frog
Pseudacris brimleyi	Brimley's Chorus Frog
Pseudacris triseriata	Chorus Frog
Pseudacris nigrita	Southern Chorus Frog
Hyla crucifer	Spring Peeper
Hyla gratiosa	Barking Tree Frog
Hyla cinerea	Green Tree Frog
Hyla squirella	Southern Tree Frog, Squirrel Frog
Hyla femoralis	Pine Woods Tree Frog
Hyla avivoca	Bird-Voice Tree Frog
Hyla versicolor	Common Tree Frog, Tree Toad
Hyla ocularis	Little Chorus Frog
Microhyla carolinensis	Narrow-Mouth Toad

(a) Poisonous Snakes

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