State Water Plan

SCWRC Report No. 140

South Carolina
State Water Assessment

South Carolina Water Resources Commission
3830 Forest Drive, P. O. Box 4440
Columbia, South Carolina 29240

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South Carolina

STATE WATER ASSESSMENT

Report No. 140

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September 1983

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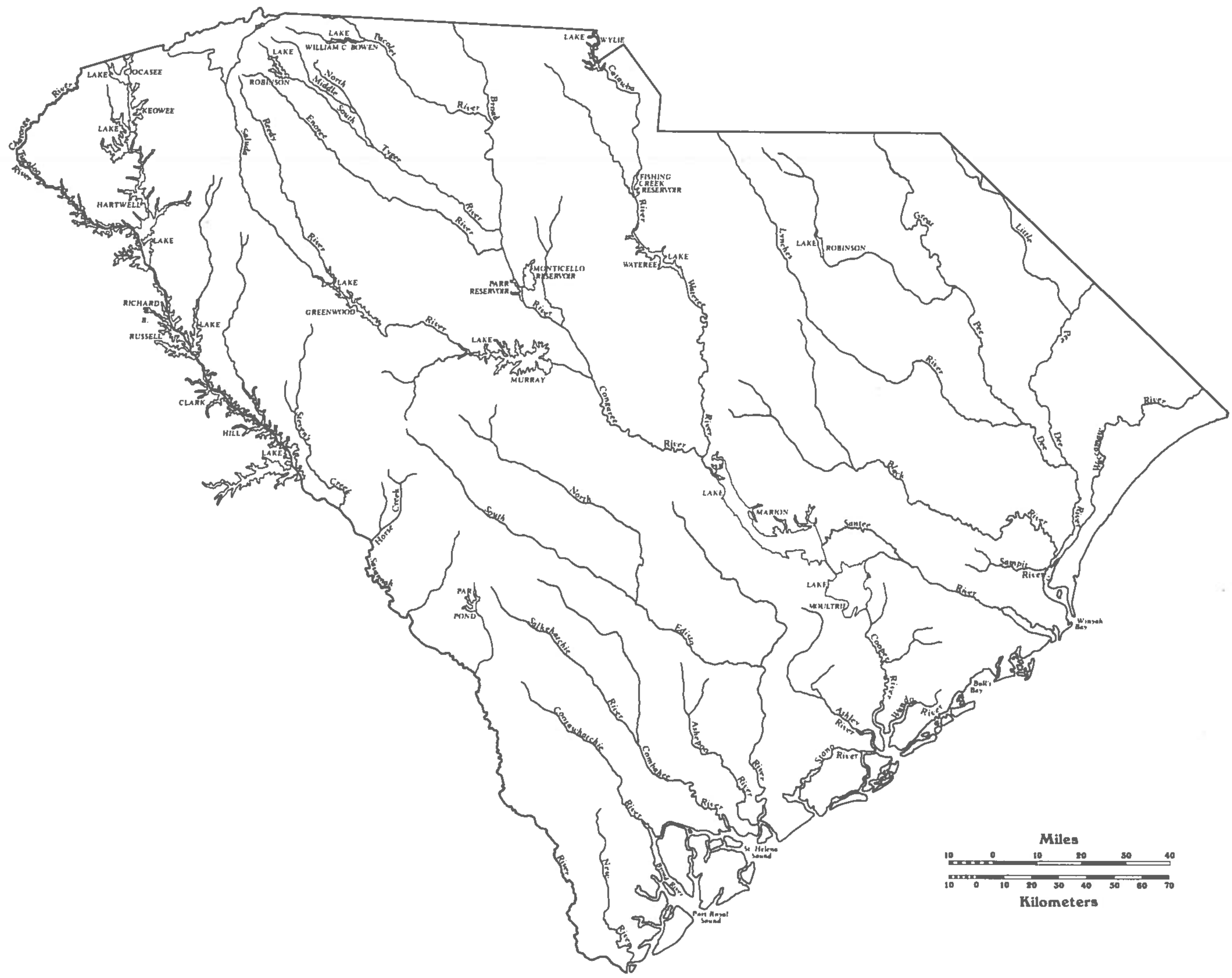
Preface

This report constitutes South Carolina's first statewide water resource assessment and was prepared under the direction of the South Carolina Water Resources Commission with assistance from various State and Federal agencies. The report is intended to provide a basic foundation for the development of a state water plan. It is also hoped that this report will serve as an initial reference document for those searching for information about South Carolina's water resources. Statewide information and more specific sub-basin information is easily accessed and summarized in tables and clearly presented in figures when appropriate. A county/sub-basin cross-reference is also provided following the Table of Contents to aid the reader in locating information. To the extent possible, care was taken to explain water resource principles and terminology and study methodologies, assumptions, interpretations, and other technical reasonings. As a further aid to the reader, several Supplemental Information Boxes are strategically located throughout the report, providing explanations of technical terms and interpretations (see List of Supplemental Information Boxes).

The base year for all data in this report, unless otherwise noted, was 1980. The reader should keep in mind that hydrologic, water use, and water quality data can vary from year-to-year, season-to-season, and even day-to-day. The data presented in this document are generally average or trend-line data and in some cases specific for the base year. If more up-to-date or specific information is needed, the reader is urged to contact the appropriate government agency.

Projections were made for population and water use growth for 1990, 2000, 2010, and 2020. The population projections were made using preliminary 1980 U. S. Census county data and in some cases may vary from the finalized 1980 population figures.

Because of the varying accuracy of reported water use from a variety of sources, water use values are generally rounded to three significant figures. Also, partial water use values presented in tables may not sum to totals because of partial rounding.



Major rivers and lakes in South Carolina.

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Summary

South Carolina's average streamflow is about 33 billion gallons per day. This water, along with the water stored in surface reservoirs and underground aquifers, must be properly managed to meet the State's current and future water needs. Good water availability data, water quality data, and water use data are necessary for responsible water resource management. In addition, the proper legal and institutional framework must be in place to utilize these data. Currently, the quality and extent of South Carolina's water data base varies considerably with the type and source of the data and the geographic location of the resource. Utilization of these data for planning and management purposes is also difficult.

Water law in South Carolina is relatively undeveloped; lacks a coherent policy in regards to water resource management; and is widely dispersed throughout State and Federal constitutions, statutes, regulations, and common law. The riparian reasonable use doctrine is the basis for surface-water law and is inappropriate in many respects for settling water use conflicts. Some of the more consistent water law concerns include: 1) insecurity of riparian rights; 2) limitations on water use (interbasin transfer); 3) protection of the resource for public interests; and 4) adequate legislation for responsible water management during droughts and other water crises. To date, no law has defined the extent of riparian lands or the authority to make interbasin transfers of water. Except for the Ground Water Use Act of 1969, South Carolina has no statutory or case law delineating ground-water rights.

Examination of water availability data reveals several broad trends. Both surface and ground-water availability correlate with the general physiography and geology of South Carolina. Streams in the Blue Ridge and Upper Coastal Plain Provinces tend to have well-sustained base flows with only moderate variability; streams in the lower Piedmont and Lower Coastal Plain generally have poorly sustained base flows and are highly variable. Ground-water yields in the Blue Ridge and Piedmont Provinces are usually low except along poorly identified fracture zones; however, well yields throughout the Coastal Plain are good to excellent with variable water quality.

The State's surface-water data base is relatively good. However, ground-water data are extremely limited throughout the Blue Ridge and Piedmont, the northern Pee Dee area, and some Upper Coastal Plain counties. This problem is compounded by the lack of coordination among agencies which collect ground-water data and the need to compile and analyze the large quantity of raw data already collected. Only portions of Horry, Beaufort, Jasper, Barnwell, and Aiken Counties have a sufficient data base to permit meaningful ground-water management efforts.

The quality of our waters is relatively good. An estimated 84 percent of the State's major river miles meet Federal water quality goals and 86 percent meet State water quality standards most of the time. The most widespread water quality problem is fecal coliform bacteria contamination with 74 percent of the State's water quality monitoring stations indicating unacceptable levels. This problem has caused the closing of 33 percent of the State's estuarine shellfishing waters. Other water quality problems include low dissolved oxygen concentrations in Coastal Plain streams, high suspended solids levels in Piedmont streams, and elevated nutrient levels and eutrophic conditions in lakes throughout South Carolina.

Between 1970 and 1980, gross water use in South Carolina almost doubled to its present 5,780 mgd. About 437 mgd, or 7.6 percent, of this water is consumed (not returned to available supplies). The largest gross use is for cooling water in the production of thermoelectric power (4,370 mgd or 75.6 percent), followed by self-supplied industry (905 mgd or 15.7 percent) and public supply (380 mgd or 6.6 percent). Ninety-six percent of the State's water needs are supplied by surface waters. Excluding the large use by thermoelectric power plants, surface water still supplies 85 percent of the State's total water needs. The largest consumer of water is self-supplied industry which accounts for 38 percent of total consumption, followed by public supply (24 percent) and agricultural irrigation (13 percent).

Statewide gross water use is projected to increase 48 percent to about 8,550 mgd by 2020. The largest increases are expected in agricultural irrigation and thermoelectric power production. These two uses, particularly irrigation, are also expected to play a significant role in a projected 300 percent increase in consumptive water use. Irrigated cropland is expected to increase from its present 120,000 acres to about 600,000 acres by 2020.

Various regional and local water problems exist, or have the potential to occur, throughout the State. All current and projected surface-water needs may not be adequately met by surface-water supplies during low flows in the Saluda, Catawba-Wateree, and Combahee-Coosawhatchie River Sub-basins. Heavy ground-water withdrawals are causing water level declines in the vicinities of the cities of Florence, Darlington, Sumter, Georgetown, Myrtle Beach, Charleston, and Beaufort, South Carolina and Savannah, Georgia. Projected large increases in ground-water use for agricultural irrigation may strain currently productive aquifer systems and cause water level declines in the counties of Dillon, Marion, Florence, Orangeburg, and Aiken. In addition, without proper management, saltwater could contaminate all coastal aquifer systems.

The Saluda River Sub-basin exhibits the most numerous and widespread water resource problems of all sub-basins in the State. Current surface-water demand periodically exceeds available supplies and rapidly growing water demands coupled with limited surface and ground-water availability indicate potential water use conflicts in the future. Variable and frequently low streamflows in the Saluda River below Lake Greenwood restrict navigation, fish migration, and fish habitat. Surface water quality problems are widespread with high levels of fecal coliform bacteria, nutrients, biochemical oxygen demand, and turbidity the major contributors. Lake Greenwood has been identified as the most eutrophic lake in the State. The Little Saluda River and Reedy River exhibit poor water quality and have been identified as two of the worst water quality problem areas in South Carolina. Hydrogeologic knowledge for most of the sub-basin is at the field data level. In general, ground-water yields in the Saluda River Sub-basin are limited. Ground-water quality problems exist in numerous wells due to high levels of iron, copper, and lead. In the vicinity of Leesville, water from the Tertiary Sands Aquifer System contains naturally-occurring radioactivity at levels in excess of acceptable drinking water standards.

Hydroelectric power comprises about 25 percent of total generating capacity and provides seven percent of all electricity in South Carolina. In 1980, this non-withdrawal use used about 63,200 mgd; more than ten times all withdrawal uses combined. Numerous potential hydropower sites have been identified in the State with most occurring in the Broad River Sub-basin. Although hydroelectric power is important to current and future development in South Carolina, permanent impoundment of low-lying lands and highly fluctuating discharges may adversely impact the environment and some water and land use activities.

Commercial navigation, once existing practically statewide, is now limited to coastal waters. Heavy shoaling in harbors and inlets due to shifting sands and sedimentation requires continuous and costly dredging. In addition, suitable dredge material disposal sites are few and decreasing in number.

The maintenance of sufficient instream flow enhances water quantity and quality and benefits fish and wildlife populations and instream uses such as navigation, hydropower generation, and recreation. Minimal discharges from hydroelectric power facilities on the Saluda and Catawba-Wateree Rivers and heavy irrigation water withdrawals on the Edisto River and tributaries of the Salkehatchie River cause occasional low flows which restrict some water use activities. Projected increases in water use coupled with a general lack of recognition and understanding of minimum flow requirements, may increase instream flow problems in the future.

Large quantities of sediment enter South Carolina's surface waters each year filling navigation channels and lakes. Excessive sedimentation impairs municipal, industrial, and recreational water use; destroys aquatic habitat; and adversely impacts desirable aquatic organisms. Over 18 million tons of soil are eroded each year in South Carolina and contribute to the sedimentation problem. Agriculture, silviculture, mining, and construction activities increase soil erosion. Agriculture contributes about 85 percent of total soil loss. Most erosion in the State occurs in the Piedmont. While "best management practices" have been developed to control erosion caused by several land use activities, implementation is primarily voluntary and adequate legislation to properly control erosion and sedimentation has not been developed.

Large populations of noxious aquatic plants infest about 50,000 acres of rivers and lakes throughout the State and are especially troublesome in Coastal Plain waters. These nuisance weeds are able to out compete desirable native species and can interfere with almost all withdrawal and instream water use activities. Hydrilla, an extremely prolific and difficult to control submersed aquatic plant, was recently discovered in Lake Marion and poses a serious threat to all waters of the State. Control of aquatic weeds in public waters is coordinated and funded through the South Carolina Aquatic Plant Management Council. However, sufficient funds are not available to properly control the spreading aquatic weed problem in South Carolina.

South Carolina's coastal waters are an important and increasingly popular resource for municipal, industrial, and recreational uses. Increased development in coastal areas has resulted in limited available waterfront space, increased point and non-point sources of pollution, limited access points to public waterfront areas, and development in unstable erosion-prone beachfront areas. The South Carolina Coastal Council has developed and implemented a Federally approved Coastal Zone Management Program to protect and manage coastal resources.

Numerous lakes, rivers, and coastal waters provide a wide variety of water-based recreational opportunities with the coastal Grand Strand area being the most popular followed by other coastal areas and the major lakes. The Santee-Cooper Lakes, Lake Murray, and Lake Wylie are the most popular major lakes in the State. Fecal coliform bacteria contamination, high levels of PCB's, extremely low streamflows, aquatic weed infestations, and limited public access restrict recreational use of some public water bodies in the State.

Rivers or portions of rivers with outstanding scenic, recreational, geological, fish and wildlife, historical, or cultural values can be protected under the State Scenic Rivers Program or the National Wild and Scenic Rivers Program. The Chattooga River in Oconee County is the State's only National Wild and Scenic River and a five-mile stretch of the Middle Saluda River in Greenville County is the only State Scenic River. Portions of the Congaree, Little Pee Dee, and Ashley Rivers are eligible for inclusion in the State Scenic Rivers Program, and a portion of the lower Saluda River is under study. The inclusion of an eligible river in the State Scenic Rivers Program is primarily dependent on the voluntary granting of scenic easements by riparian landowners. This factor has probably limited the number of State Scenic Rivers.

Wetlands are important natural areas which help maintain water quality, modify flooding, and act as feeding, nesting, and nursery areas for fish and wildlife. Most wetland areas in South Carolina are in the Coastal Plain and an unknown quantity of these important areas are lost each year due to increased development. Some unique wetland areas have been identified and are protected under the South Carolina Wildlife and Marine Resources Department's Heritage Trust Program. However, the extent of wetland loss, the rate at which it is taking place, and the possible consequences to the State's ecology and economy are not known.

Water use in South Carolina is projected to increase substantially, reducing available supplies and increasing competition. Use of water conservation measures can save water; reduce water, energy, and treatment costs; and reduce water use conflicts. Numerous water saving devices and methods are now available for residential, municipal, agricultural, and industrial water uses.

While 213 communities in South Carolina have identified flood prone areas, 166 of these communities participate in the National Flood Insurance Program. The U.S. Geological Survey, U.S. Army Corps of Engineers, and the Federal Emergency Management Agency provide flood insurance studies to local communities. The Federal Emergency Management Agency monitors construction activities in flood plains to ensure local government compliance with Flood Damage Reduction Ordinances. Most flood related programs in South Carolina are run by Federal agencies and no comprehensive statewide flood-plain management program currently exists. The State government has severely limited authority over flood-plain management and other flood related matters and the need for increased State involvement has not been fully assessed.

Acknowledgements

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Special appreciation is extended to the U.S. Army Corps of Engineers, Charleston District, for providing much of the flooding, hydropower, and navigational information contained in this document; and to the U.S. Geological Survey for assisting in the development of the hydrographs and providing streamflow data. Other agencies also provided assistance in specialized areas: U.S. Fish and Wildlife Service assisted in addressing instream flow needs, the S.C. Department of Health and Environmental Control in reviewing and editing water quality sections, the S.C. Coastal Council in identifying coastal concerns, and the Soil Conservation Service in assessing sedimentation problems. Other State and Federal agencies provided technical and review assistance: S.C. Land Resources Conservation Commission, Governor's Office, S.C. Department of Parks, Recreation, and Tourism, State Forestry Commission, S.C. Wildlife and Marine Resources Department, and U.S. Army Corps of Engineers, Savannah District.

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Introduction

"On a major low country stream, three proposals are being considered at present.

(a) A municipality anticipates eventually using about one third the flow of a stream for domestic consumption.

(b) A proposed group irrigation project involving upwards of 35,000 acres would need to use a substantial portion of the streamflow.

(c) A farmer owning about 7,500 acres would also like to develop an irrigation program from the same stream.

There may be many other water users similarly situated above these. How can the needs of these interests best be met? By what legal means can each of them be assured a dependable water right to protect his supply? If there isn't enough for all, what rights, if any, are superior to others."

-The Beneficial Use of Water
in South Carolina, 1952

These words, written over thirty years ago (Busby, 1952) and based on an actual situation, could just as easily have been in yesterday's newspaper. The facts may be different, but the questions would be the same. What are our water rights in South Carolina? Can investors in our water resources be assured of an adequate yield for their investment? Who has priority of water use? Many other questions surely come to mind to the large water user. South Carolina is still operating under the same principles of water law that guided our decisions 30 years ago, and a hundred years before that.

You may be assured, however, that although our basic water laws have not changed, our water usage has. In 1955 South Carolina used about 950 million gallons of water per day (mgd). By 1980 the figure had grown six-fold to almost 5,800 mgd, earning the State the dubuous title of the "second fastest growing water use state in the Nation", second only to Florida (Viessman and Demoncada, 1980). During almost the same period (1960-1980), water consumption increased over 200 percent.

South Carolina is not running out of water. The State is faced, however, with the task of supplying rapidly increasing numbers of municipal, industrial, recreational, electric power, and agricultural water users with the required quantity and quality of water at the right time and right place. Moreover, this must be accomplished with an uncodified legal framework which originated under circumstances far different than today's acute demands on our natural resource base. The State can no longer afford to allow our unguided momentum to carry us into the future. Rather, South Carolina must have an established water resource policy and plan, based on current data and backed by adequate laws, to guide our progress through the upcoming decades.

This report represents the first of two phases in the development of a State Water Plan for South Carolina. Phase I is an inventory of South Carolina's water resources. Water quantity and quality, current uses, future demands, and problems and opportunities are assessed. Phase II will develop a State program to address known and potential problems and opportunities.

This report has five major sections. The first is a brief socio-economic and physical environmental overview of South Carolina. The second is a discussion of South Carolina's water law which points out specific problems and advantages in the State's current legal framework. The third is a statewide hydrologic overview addressing water availability and use within the State. The fourth is a detailed hydrologic description which analyzes the water supply and demand for each of the State's fifteen river sub-basins. The fifth section discusses special water resource topics including navigation, water conservation, hydropower production, aquatic weeds, water-based recreation, and scenic rivers.

Many regional and local water resource studies have been completed in South Carolina. Background studies have been completed by the South Carolina Water Resources Commission and the U.S. Department of Agriculture for the Ashley-Combahee-Edisto River Basin and Santee River Basin and both a background study and management plan have been developed for the Pee Dee River Basin. A comprehensive master water plan has been prepared for the Savannah River Basin by the U.S. Army Corps of Engineers. Water quality management plans have been developed for all major river basins by the South Carolina Department of Health and Environmental Control. Ground-water management plans have been developed and implemented by the South Carolina Water Resources Commission in Beaufort, Colleton, Jasper, Horry, and Georgetown Counties and a portion of Marion County. In addition, there have been many studies and plans addressing site-specific water resource concerns. However, a need existed to coalesce these many diverse and often independent studies to provide a better statewide perspective of South Carolina's water resources. This document attempts to meet that need. More specifically, this study attempts to increase the State's water resource management capabilities by:

- Assessing State water law.
- Assessing the surface- and ground-water resources of the State.
- Projecting future water resource use and demands.
- Identifying statewide and regional water resource problems and opportunities.

AUTHORITY

The South Carolina Water Resources Planning and Coordination Act of 1967 contains broad policies and goals with respect to water resource planning, development, and use. The General Assembly found in part:

> ...that it is in the interest of the public welfare that a coordinated, integrated state water resources policy be formulated and means provided for its enforcement, that plans and programs for the development and enlargement of the water resources of the State be devised and promoted and that other activities designed to encourage, promote, and secure the maximum beneficial use and control of such water resources be coordinated by a commission which, in carrying out its functions, shall give proper and adequate consideration to the multiple aspects of the beneficial use and control of such water resources with an impartiality of interest except that which is designed to best protect and promote the public welfare generally (Act 62, Section 2(b), 1967 Acts and Joint Resolutions).

The Act established the South Carolina Water Resources Commission and made that agency responsible for implementing the policies declared in the Act, including the development and coordination of State water policy. In addition, several other State agencies have statutory responsibilities in specific areas of State water policy, including the Department of Health and Environmental Control, the Coastal Council, the Land Resources Conservation Commission, and the Wildlife and Marine Resources Department. Other State and Federal agencies have interests in the State's water resources and have been consulted during the preparation of this document.

CONDUCT OF THE PROJECT

The State Water Assessment was prepared under the general guidance of the South Carolina Water Resources Commission, which is composed of 18 members. Ten of the members are appointed by the Governor for staggered three year terms: three members representing agriculture, three representing industry, three representing municipalities, and one representing saltwater interests. The remaining eight members of the Commission represent the executive offices of various State agencies and institutions: Department of Agriculture, Clemson University, Department of Health and Environmental Control, Department of Highways and Public Safety, Forestry Commission, Development Board, Land Resources Conservation Commission, and the Wildlife and Marine Resources Department.

A State Water Plan Policy Committee was appointed by the Commission to work more directly with the project staff to establish direction and resolve issues. The Committee was composed of four appointed Commissioners and a representative each from the Land Resources Conservation Commission and the Department of Health and Environmental Control. The project staff consisted of a project manager and of water resource professionals and technicians from the staff of the South Carolina Water Resources Commission.

Assisting the Policy Committee and the project staff was a Technical Advisory Committee composed of representatives from the following State and Federal agencies with interests in water resources planning and management:

S.C. Coastal Council
S.C. Wildlife and Marine Resources Department
S.C. Department of Health and Environmental Control
S.C. Land Resources Conservation Commission
Governor's Office
State Development Board
State Forestry Commission
Clarks-Hill Russell Authority
S.C. Department of Agriculture
U.S. Geological Survey
U.S. Army Corps of Engineers
Soil Conservation Service
U.S. Fish and Wildlife

South Carolina in Perspective

SOCIO-ECONOMIC ENVIRONMENT

Geography has always played an important role in the growth of South Carolina's population and economy. Archaeological investigations indicate early Indian inhabitants evidently found the climate well-suited for their hunting, gathering, and later agricultural economies. Early Spanish, French, and English explorers found South Carolina harbors and inland river systems provided easy ingress to the New World. The soon-to-follow settlers took advantage of the natural amenities to develop an economy based on indigo and rice production that endured for almost two hundred years, only to give way to new and expanded agricultural demands. In more recent times, South Carolina has been identified as part of the "Sun Belt," a band of southern states which have mild, warm climates with only moderate seasonal variations in temperature. The "Sun Belt" has become an attractive region for family and industrial relocation, particularly in this era of rising energy costs. The combination of the suitable climate, sufficient natural resources, and low-cost work force contributed to an economic and demographic revival during the 1970's.

Population

Since 1790, South Carolina's population has increased almost thirteen fold, from slightly greater than 249 thousand to over 3.1 million in 1980. Although the increasing population trend has been continuing, it has not been steady. The decades of greatest growth followed the American Revolution and the Civil War, when growth rates reached over 40 percent. More moderate growth, yet higher than the average 14 percent per decade, occurred during the 1800's, 1810's, and 1970's with rates exceeding 20 percent. Periods of low growth occurred during the 1830's and 1920's with 2.3 and 3.3 percent growth respectively, and completly bottomed out during the Civil War with a 10 year increase of only 0.3 percent.

The past two decades have witnessed extremes in South Carolina's population growth. The decade of the 1960's, with a growth rate of 8.7 percent had the second lowest growth rate since the Civil War. During this period, nearly half of the counties in South Carolina recorded a net loss in population. At the other extreme, the 1970's witnessed a growth rate of 20.5 percent, the greatest since the post Civil War boom. Only one county experienced a loss during this period. Planners project that population growth will continue near its present growth rate through the 1980's (Table 1) and then begin a gradual decline.

One of the more apparent demographic changes occurring in South Carolina is the rural to urban population shift. Table 2 shows the changes in the rural-urban residents from 1930 to 1980. These changes reflect the increasing importance of urban economic opportunities and a change in the State's employment characteristics over time. The statewide trend toward urban concentration is reflected in the increased proportion of the population living in cities or towns exceeding 2,500, with 54.1 percent of South Carolina's 1980 population classified as urban. Although the population of South Carolina as a whole has become more urban, there is wide variation among the counties. Over three-fourths of the 1980 population residing in Charleston, Greenville, and Richland Counties is classified as urban, while Calhoun, Jasper, and McCormick Counties have no urban population.

The major concentrations of population are located within seven Standard Metropolitan Statistical Areas. Together these areas had a 1980 population of 1,865,359 and accounted for nearly 60 percent of the State's total population. The Standard Metropolitan Statistical Areas in South Carolina are centered around the major urban centers of Charleston-North Charleston, Columbia, Greenville-Spartanburg, Anderson, Florence, Rock Hill, and Aiken-Augusta.

The 1980 population of South Carolina was estimated at 3,132,400. By the year 2020 the State's population is expected to reach 5,150,000, an increase of 64.4 percent (Table 1). The counties that are expected to exhibit the most growth during this period are: Dorchester (245 percent), Berkeley (191.5 percent), Lexington (148.4 percent), Horry (142.7 percent), and Pickens (123.2 percent). All of these counties, with the exception of Horry County which possesses a major coastal attraction for tourists, are adjacent to major urban areas. The only county expected to lose population between 1980 and 2020 is McCormick.

Economy

During the period 1880 to 1980, the State's economy underwent a steady shift from rural-agricultural to urban-industrial. Changes in the economic base began to occur in the 1880's as the textile industry moved from the industrial Northeast to the South, concentrating in the Piedmont of South Carolina. Textiles were quickly established as a sister

Table 1.
Current and projected county populations in South Carolina, 1970-2020.

	Population (in thousands)					
County	*1970*	*1980*	*1990*	*2000*	*2010*	*2020*
Abbeville	21.1	22.7	24.5	25.4	26.1	26.4
Aiken	91.0	105.6	123.7	136.3	146.7	152.3
Allendale	9.8	10.7	11.8	12.4	12.8	13.0
Anderson	105.5	133.2	170.1	204.6	236.0	254.0
Bamberg	16.0	18.2	20.8	22.4	23.7	24.4
Barnwell	17.2	19.9	23.2	25.5	27.4	28.4
Beaufort	51.1	65.3	84.4	102.8	119.6	129.4
Berkeley	56.2	94.7	138.4	190.5	244.0	279.0
Calhoun	10.8	12.2	13.9	15.0	15.8	16.3
Charleston	247.7	277.0	313.3	332.6	347.0	360.0
Cherokee	36.7	41.0	46.2	49.0	51.1	52.3
Chester	29.8	30.2	30.7	30.9	31.1	31.2
Chesterfield	33.7	38.2	43.7	46.9	49.6	51.0
Clarendon	25.6	27.5	29.7	30.8	31.7	32.1
Colleton	27.7	31.8	36.7	39.9	42.5	44.0
Darlington	53.4	62.7	74.3	82.8	90.0	94.0
Dillon	28.9	31.1	33.8	35.4	36.2	36.8
Dorchester	32.3	58.8	89.6	129.9	173.0	203.2
Edgefield	15.7	17.6	19.8	20.9	21.8	22.3
Fairfield	20.0	20.7	21.6	22.0	22.3	22.4
Florence	89.6	110.2	136.8	159.9	180.3	192.0
Georgetown	33.5	42.5	54.4	65.7	75.9	81.8
Greenville	240.8	287.9	347.7	395.2	436.0	459.0
Greenwood	49.7	57.8	68.0	75.2	81.1	84.3
Hampton	15.9	18.2	21.0	22.8	24.2	25.0
Horry	69.0	101.4	139.7	181.5	222.0	248.0
Jasper	11.9	14.5	17.9	20.8	23.3	24.7
Kershaw	34.8	39.0	44.2	47.1	49.4	50.6
Lancaster	43.3	53.4	66.4	77.8	87.8	93.5
Laurens	49.7	52.2	55.3	56.7	57.8	58.4
Lee	18.3	18.9	19.7	20.1	20.3	20.5
Lexington	89.0	140.4	195.2	255.7	315.0	351.7
McCormick	8.0	7.8	7.7	7.6	7.6	7.7
Marion	30.3	34.2	39.0	41.7	43.9	45.1
Marlboro	27.1	31.6	37.2	41.2	44.5	46.2
Newberry	29.3	31.2	33.3	34.4	35.3	35.7
Oconee	40.7	48.6	58.6	66.5	73.2	77.0
Orangeburg	69.8	82.3	98.0	109.7	119.6	125.0
Pickens	59.0	79.3	106.5	134.9	162.0	178.1
Richland	233.9	269.7	309.6	336.4	358.3	371.0
Saluda	14.5	16.2	18.1	19.1	19.8	20.2
Spartanburg	173.7	201.9	236.1	260.0	280.0	290.5
Sumter	79.4	88.2	98.9	104.0	108.3	110.4
Union	29.3	30.8	32.6	33.5	34.2	34.5
Williamsburg	34.3	38.2	43.1	45.6	47.5	48.6
York	85.2	106.7	135.0	161.0	184.2	198.0
Total	2590.7	3121.8	3770.0	4330.0	4840.0	5150.0
Change	1970-1980 20.3%	1980-1990 20.35%	1990-2000 14.9%	2000-2010 11.8%	2010-2020 6.4%	

Source: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1982.

Table 2.
South Carolina urban and rural population, 1930 - 1980[a].

Year	Total Number of Inhabitants	Urban		Rural	
		Number of Inhabitants	Percent of Total	Number of Inhabitants	Percent of Total
1930	1,738,765	371,080	21.3	1,367,685	78.7
1940	1,899,804	466,111	24.5	1,433,693	75.5
1950[b]	2,117,027	777,921	36.7	1,339,106	63.3
1960	2,382,594	981,386	41.2	1,401,208	58.8
1970	2,590,713	1,250,725	48.3	1,339,791	51.7
1980	3,121,833	1,689,253	54.1	1.432,580	45.9

[a] By U.S. Census definition, the urban population is composed of persons living in densely populated areas and in places of 2,500 or more outside urbanized areas. All persons living outside urbanized areas of less than 2,500 or in the open countryside are classified as rural.
[b] 1950-1980 based on current urban definition.

Source: S.C. Division of Research and Statistics, 1981.

enterprise to agriculture and resulted in a dual economic system in the South. From this initial impetus, diversification and expansion continued, leading to healthy economic growth during the second half of this century. Agriculture is still a major economic force in the State, but has slowly declined in importance relative to the State's economic health which is now dominated by manufacturing. However, although nonagricultural jobs are a major segment of the State's employment, average income compared to other states remains low.

In 1979, South Carolina ranked 17th nationally for total nonagricultural employment, with 1,177,800 employees. The percentages by type of employment were: manufacturing, 33.9 percent; government, 19.4 percent; wholesale and retail trade, 18.9 percent; services and mining, 13 percent; construction, 6.2 percent; transportation and public utilities, 4.5 percent; and finance, insurance and real estate, 4 percent.

Mining, manufacturing, and public utilities produced almost $22 billion worth of products during fiscal year 1978-79. Of this, textiles alone accounted for $6.6 billion, or 30.8 percent of the total.

In 1979, South Carolina ranked among the lowest in the country in per capita personal income with an average of $7,057, which was 19 percent below the national average. Much variation occurred between counties, from a high of $8,720 in Beaufort County to a low of $4,117 in Clarendon County. The 1980 median household income in South Carolina was $16,509. Those counties containing or adjacent to urbanized areas tended to exhibit higher median household incomes. The more rural, agricultural counties tended to fall below the State average, with Clarendon County reporting $9,640, the lowest median household income.

Agriculture has traditionally been a major economic activity in South Carolina and although it has declined in relative importance over the past century, it is still an important source of income and employment for a number of people in the State. Between 1969 and 1974, the number of farms in the State decreased by 26 percent, while total farmland acreage decreased by 11.7 percent.

Although agricultural production has steadily increased, yearly output is still subject to environmental and economic consequences. Between 1979 and 1980, corn production dropped by almost one-half. Decreased production also occurred for barley, sorghum, soybeans, peanuts, andcotton. However, winter wheat, peach, and tobacco production increased, although tobacco yields per acre were down. The total value of production for agricultural products in the State dropped from $732.9 million in 1979 to $634.3 million in 1980. Cash receipts from farm marketings dropped nearly $11 million for crops from 1979 to 1980, but increased by more than $36 million for receipts from livestock and livestock products. Government payment for farm products doubled during this time.

Soybeans were South Carolina's leading cash crop in 1980 with 19.4 percent of the State's total cash crop receipts from farm marketing and tobacco was second with 16.1 percent.

Horry County ranked first for cash crop receipts from farm marketing in 1979, and Newberry County ranked first for receipts from livestock and livestock products. The major income in the State for crop receipts was from the Upper Coastal Plain counties.

Land Use

Land use information has been developed by various groups and agencies over the years. The data gathered through the Natural Resources Inventory of 1977 (U.S. Department of Agriculture, 1980a) using sample point units is one of the more recent attempts to identify and address each of the major land use categories in the State. The results are presented in Table 3.

The predominent land use category in South Carolina is forest land, covering over 61 percent of the State's land area. Forest land is defined as any land with at least 25 percent tree canopy cover or land stocked by forest trees of any size. Cropland includes lands used primarily for growing row crops, close grown field crops, hayland, and orchards and represents 17 percent of the State's land use. Urban and builtup lands have witnessed a continuing

Table 3.
Land use in South Carolina.

Category	*Acres (1,000)*	*Percent of Total*
Forest Land	12,224	61.5
Cropland	3,378	17.0
Urban and builtup areas	1,410	7.1
Pastureland	1,250	6.3
Other or miscellaneous land	1,012	5.1
Large water areas	596	3.0
	19,870	100.0

Source U.S. Department of Agriculture, 1980a.

increase and are calculated at slightly over seven percent. The urban and builtup land use category includes units of land 10 acres or more in size which are used for residences, industrial sites, commercial sites, utility facilities, transportation facilities, roads and small parks and recreation facilities. The category also includes all roads and railroads outside of urban and builtup areas. Pastureland comprises over six percent of the State's land use and large water bodies about three percent. Also included in the land use inventory is a miscellaneous category which includes farmsteads, feedlots, broiler and layer houses, greenhouses and nurseries, strip mines, quarries, gravel pits, borrow pits, coastal marshes and dunes, mines, water bodies less than 40 acres, streams less than one-eighth mile wide, and small builtup areas less than 10 acres in size. Miscellaneous land use represents about five percent of the State's total area.

PHYSICAL ENVIRONMENT

South Carolina is located in the southeastern United States between North Carolina and Georgia. Extending from the Blue Ridge Mountains to the Atlantic Ocean, the State encompasses approximately 31,055 square miles and includes a variety of unique ecological, geological, and morphological characteristics.

Climate

South Carolina is a state of plentiful rainfall and a mild climate. Several factors responsible for this include the relatively low latitudinal location and a strong moderating influence from warm Gulf Stream waters along the coast. Also of importance are the Blue Ridge Mountains to the north and west which help block or delay the movement of cold air masses from the northwest.

Precipitation

The State's average annual precipitation is slightly over 48 inches. The greatest precipitation falls in the mountains where about 80 inches per year falls near Caesars Head (Fig. 1). Moist air in this area of the State is forced up the mountains to higher and cooler elevations where condensation and precipitation are initiated. Another area of high rainfall is located about 20 miles inland along the entire coast where yearly normal rainfall is about 50 inches. This heavy coastal precipitation is due to the upward movement of moist ocean air as it moves inland on hot summer days. Records indicate the driest area of the State to be Kershaw County, where an average of 44 inches of precipitation falls yearly (National Oceanic and Atmospheric Administration, 1974).

There is little difference in monthly rainfall distribution for the months of December through March, with the exception that the monthly totals for March are somewhat higher than the previous three months. During March, rainfall along the coast begins to increase and by May the normal for the southern coast is over five inches. At the same time, the central part of the State is only receiving about three inches of rain while over five inches is the average for the mountains. From June through September, the most important features of the summer rainfall are the heavier amounts in the mountains and near the coast. During this period, the coastal maximum rainfall migrates north along the coast. During September, the greatest coastal rainfall occurs just northeast of Georgetown. This is due to the passage of tropical storms and hurricanes which are frequent at this time of year. During the fall months, September through November, precipitation is at a minimum throughout the State. Heavy precipitation during this period is often the result of a hurricane or early winter storm (National Oceanic and Atmospheric Administration, 1974).

The greatest documented 24 hour rainfall was 13.25 inches observed at Effingham, Florence County, July 1916. The highest annual total precipitation occurred in 1932 at Caesars Head where over 100 inches of precipitation was recorded. In 1954, the beginning of South Carolina's record drought, only 26 inches of precipitation fell at Parr near Jenkinsville in Fairfield County to set the record annual low for the State.

Snow and sleet occur periodically during the winter

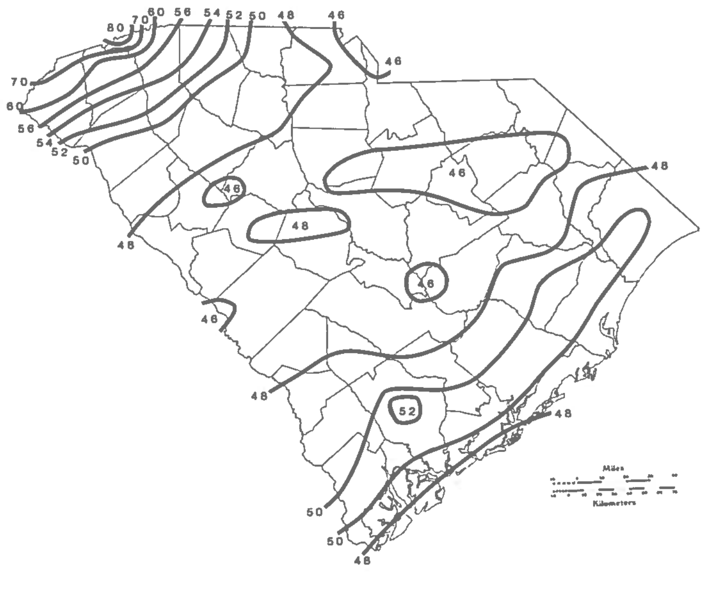

Figure 1.
Average annual precipitation in South Carolina.

months of December through February. Snow generally occurs from one to three times per winter and seldom do accumulations remain except in the mountains. Freezing rain also occurs periodically during winter in the northern half of the State.

Several areas in the State show unusually low annual precipitation of only 38 to 40 inches. Most of these are extremely localized and are usually located east of the larger inland lakes. Because this appears to be a local phenomenon, these areas usually are not indicated on annual normal precipitation maps.

Severe droughts occur about once every 15 years with less severe and less widespread droughts about once every seven years. However, during more than half of the summers, there are periods without sufficient rainfall for many crops.

Severe weather in the form of violent thunderstorms, hurricanes and tornadoes occurs occasionally. Thunderstorms are common in the summer months, but violent storms usually accompany squall lines and cold fronts in the spring. These storms are usually characterized by lightning, hail, and high winds and sometimes spawn tornadoes. Most tornadoes occur from March through June with April being the peak month. Historically, hurricanes are more frequent in late summer and early fall; however, tropical cyclones have affected South Carolina as early as May and as late as November.

Temperature

The State's annual average temperature is about 61°F. This varies from 55.2°F at Caesars Head in the mountains to 66.2°F along the southern coast at Beaufort (Fig. 2).

Elevation, latitude, and distance from the coast are the main influences on temperature. In the mountains, temperature variation above 1,000 feet is due almost entirely to changes in elevation. The State's record low of -20°F was recorded at Caesars head on January 6, 1940. Along the coast, ocean waters show very small daily and annual changes in temperature when compared with the land surface. The air over coastal waters is cooler than the air over land in summer and warmer than the air over land in winter, thus providing a moderating influence on temperatures at locations on or very near the coast. Records show maximum temperatures along the coast to average 4°F to 5°F lower than maximum temperatures in the central part of the State. In July, the daily range in temperatures along the coast is about 13°F, and about 21°F in central areas of the State. The daily range along the coast in January is 16° and about 23° in the center of the State (National Oceanic and Atmospheric Administration, 1974). The lack of any moderating influence in the interior of South Carolina has resulted in higher daily maximum temperatures. The record high temperature, 111°F, has occurred in central South Carolina three times within the past 60 years; at Calhoun Falls on September 8, 1925; Blackville on September 4, 1925; and Camden on June 28, 1954. January is the coldest month with monthly normal temperatures ranging from 39.0°F at Caesars head to 51.4°F at Beaufort. July is the hottest month with monthly normal temperatures ranging from 71.5°F at Caesars Head to 81.5°F at Charleston.

The growing season varies from 201 days at Caesars Head to 294 days at Charleston. In the central region of the State, the average date of the last freezing temperature in spring ranges from March 10 in the south to April 1 in the north. Fall frost dates range from late October in the north to November 20 in the south. Minimum temperatures of less than 32°F occur on about 70 days in the upper portion of the State and on 10 days near the coast. The central part of the State has maximum temperatures of 90°F or more on about 80 summer days. There are 30 such days along the coast and 10 to 20 in the mountains. The percent of possible sunshine received across South Carolina varies from 50 to 60 percent in the winter to 60 to 70 percent in the summer, with the dry periods in the spring and fall receiving 70 to 75 percent of possible sunshine (National Oceanic and Atmospheric Administration, 1974).

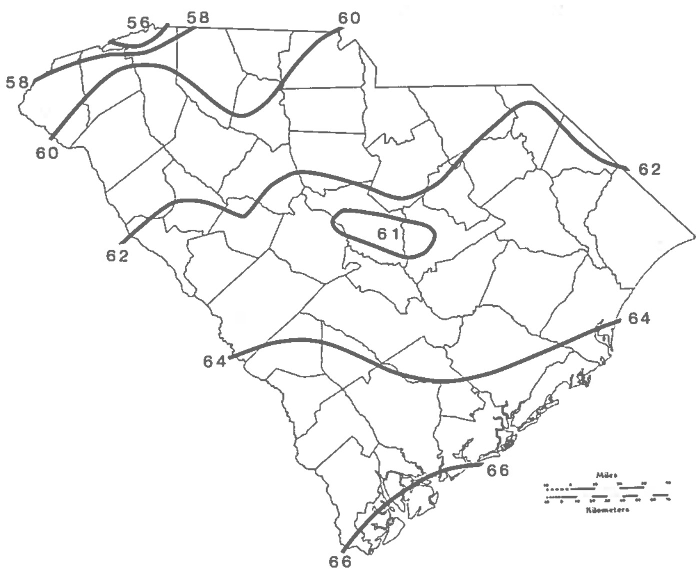

Figure 2.
Average annual temperature in South Carolina.

Relative Humidity

Relative humidity varies more with time of day than it does between days or months. Highest values, about 90 percent, are reached early in the morning, while the lowest values, 45 to 50 percent, occur around noon. Summertime values are about 10 percent greater than those of winter.

Winds

Winds are predominantly southwesterly and northeasterly over most land areas. Along the coast, the wind direction is distributed fairly evenly in all directions. Average wind speeds are 6 to 10 mph.

Natural Resources

South Carolina's abundant natural resources contribute much to the State's scenic beauty, economy, and recreational opportunities. Agricultural and silvicultural enterprises are sustained by fertile soils and vast forest lands. In addition, a variety of minerals on and beneath the land's surface supports a diversified minerals industry, while an abundance of fish and wildlife share and contribute to the State's natural riches.

Soils

The Soil Conservation Service has divided the State into six land resource areas based on soil conditions, climate, and land use (U.S. Department of Agriculture, 1978a). These are the Blue Ridge Mountains, Southern Piedmont, Carolina-Georgia Sandhills, the Southern Coastal Plain, the Atlantic Coast Flatwoods, and the Tidewater Area (Fig. 3). While these land resource areas are similar to the physiographic provinces, they are based on different criteria. These land resource areas are distinguished by soil characteristics which provide a basis for identifying potential types of land use.

Blue Ridge Mountains. The Blue Ridge Mountains Land Resource Area is located in the northwestern corner of the State and consists of dissected, rugged mountains with narrow valleys. Local elevation ranges from 1,000 to over 3,500 feet. Most soils are moderately deep to deep on sloping to steep ridges and side slopes. The underlying material consists mainly of weathered schists, gneisses, and phyllites. Seventy percent of the area is forested with a mixture of oak-hickory and pine. Small farms take up 10 percent of the area and primarily produce truck crops, hay, and corn.

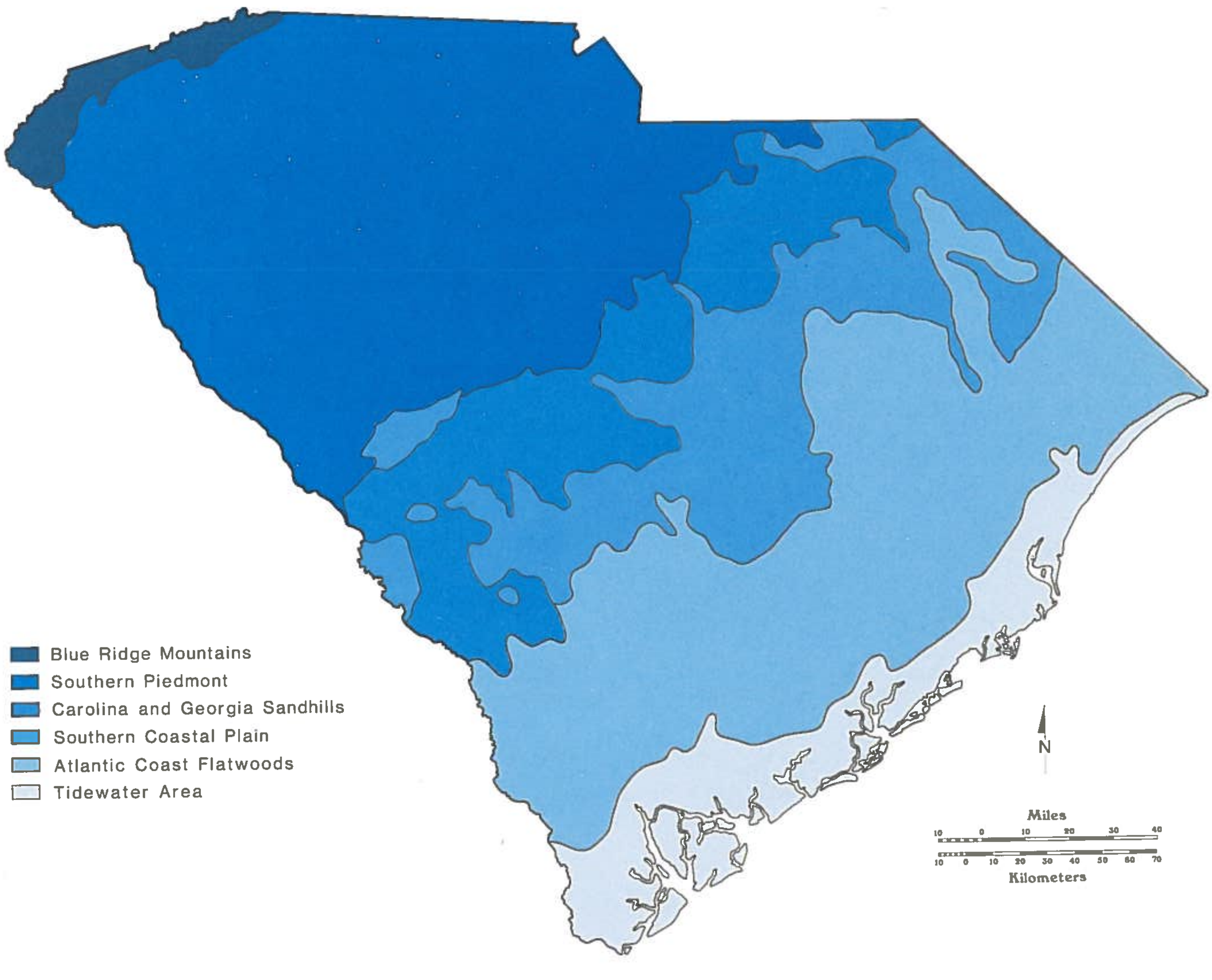

Figure 3.
Land resource areas in South Carolina (U.S. Department of Agriculture, 1983).

Southern Piedmont. The Southern Piedmont Land Resource Area is an area of gently sloping to moderately steep slopes with broad to narrow ridge tops and narrow stream valleys. Local elevation varies from about 375 to 1,000 feet. The region is covered with strongly acid, firm clayey soils formed mainly from gneiss, schist, mica schist, phyllite and Carolina slate. Large areas of land centered near Chester and York Counties have moderately acidic to moderately alkaline soils and were formed mainly from diorite gabbro and hornblende schist. Similiar soils occur in less widespread areas of Abbeville, McCormick, and Greenwood Counties. Approximately two-thirds of the area is forested with mixed hardwoods and various pines, with nearly 30 percent used for farming. Cotton, corn, and soybeans are the major crops.

Carolina-Georgia Sandhills. The Carolina-Georgia Sandhills Land Resource Area is characterized by sloping to strongly sloping uplands with elevations ranging from 250 to 450 feet. The sandy soils are underlain with sandy or loamy sediments. They are mostly well to excessively drained. About two-thirds of the Sandhills region is covered with a wide range of forest types. Cotton, corn, and soybeans are grown within this land resource area.

Southern Coastal Plain. The Southern Coastal Plain Land Resource Area is a region of gentle slopes with increased dissection and moderate slopes to the northwest. Elevation ranges from about 100 to 450 feet. The loamy and clayey soils of the region are well suited for farming. These soils are underlain primarily by loamy, clayey, and sandy sediments. Many soils in the Coastal Plain are poorly drained except for sandy slopes and ridges which are excessively drained.

Atlantic Coast Flatwoods and Tidewater Area. The Atlantic Coast Flatwoods Land Resources Area and the Tidewater Area are products of recent geological processes. Elevation ranges from sea level to about 125 feet. Four general groups of soil are found in this region of nearly level coastal plain dissected by broad valleys with meandering streams. Loamy and clayey soils of the wet lowlands are predominant. These areas are underlain mostly with clayey sediments and some soft limestone. Wet sandy soils of broad ridges can be found in strips near the coast and extensively in Hampton County. These soils are underlain by sandy and loamy sediments. Well-mixed soils underlain by clayey and loamy sediments are found in the floodplains of the numerous rivers. The salt marshes and beaches of the coast consist of clayey and sandy sediments, respectively. Approximately two-thirds of the region is forested. Truck crops, corn, and soybeans are the major farm crops.

Minerals

In 1981, South Carolina's mineral commodities production ranked nationally second for kaolin and vermiculite, third for flake mica (sericite), eighth for fuller's earth and tenth for common clays. South Carolina produced $115 million worth of nonfuel minerals in 1981 (Table 4). Stone, clays, and sand and gravel were the major contributors to the total production value. Mining was reported in 41 of South Carolina's 46 counties (Table 5). Aiken County led the State with 34 operating mines, followed by Cherokee County with 25 and Lexington County with 22.

Stone production ranked first in value and tonnage for 1981. Rock types quarried and crushed to be used as aggregate in concrete, macadam, and road construction materials include granite, gneiss, anorthosite, limestone, and coquina. Granite is also quarried as dimension stone in

Table 4.
Nonfuel mineral production in South Carolina [a].

Minerals	*1980* Quantity (Thousand short tons)	*1980* Value (Thousand dollars)	*1981* Quantity (Thousand short tons)	*1981* Value (Thousand dollars)
Clays[b]	2,211	25,169	1,779	28,323
Gem stones	NA[c]	5	NA	5
Manganiferous ore	20	W[d]	W	W
Sand and gravel	5,556	22,855	5,400	24,800
Stone:				
Crushed	16,107	49,207	14,294	47,662
Dimension	12	703	12	703
Combined value of clays (fuller's earth) mica (scrap), vermiculite, and manganiferous ore.	XX[e]	9,601	XX	13,524
Total	XX	107,540	XX	115,012

[a] Production as measured by mine shipments, sales, or marketable production (including comsumption by producers).
[b] Excludes fuller's earth; value included in "Combined value" figure.
[c] NA indicates not available.
[d] W indicates withheld to avoid disclosing company proprietary data; value included in "Combined value" figure.
[e] XX indicates not applicable.

Source: U.S. Bureau of Mines, 1982.

Table 5.
Mineral commodities mined in South Carolina in 1980.

County	C	Cc	CQ	FE	G	Gcs	Gds	K	LSag	LSc	LScs	MSH	P	S	S/C	SE	SH	V
								Minerals[a]										
Abbeville	-	-	-	-	-	-	-	-	-	-	-	-	-	X[b]	-	-	-	-
Aiken	-	-	-	-	X	-	-	X	-	-	-	-	-	X	X	-	-	-
Allendale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anderson	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Bamberg	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Barnwell	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beaufort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Berkeley	-	-	-	-	-	-	-	-	X	-	X	-	-	X	X	-	-	-
Calhoun	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Charleston	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-
Cherokee	X	-	-	-	-	X	-	-	X	-	X	X	-	X	-	X	X	-
Chester	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Chesterfield	-	-	-	-	X	X	-	-	-	-	-	-	-	X	-	-	-	-
Clarendon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colleton	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	-
Darlington	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-
Dillon	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Dorchester	-	X	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-
Edgefield	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fairfield	-	-	-	-	-	X	X	-	-	-	-	-	-	X	X	-	-	-
Florence	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-
Georgetown	-	-	-	-	-	-	-	-	-	-	X	-	-	X	X	-	-	-
Greenville	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-
Greenwood	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-
Hampton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horry	X	-	X	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-
Jasper	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Kershaw	-	-	-	-	-	-	X	X	-	-	-	-	-	X	-	X	X	-
Lancaster	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	-
Laurens	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Lee	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Lexington	-	-	-	-	-	X	-	X	-	-	-	-	-	X	X	-	X	-
McCormick	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marion	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marlboro	X	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	X	-
Newberry	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oconee	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Orangeburg	-	X	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-
Pickens	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-
Richland	-	-	-	-	-	X	-	X	-	-	-	-	-	X	X	-	X	-
Saluda	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spartanburg	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X
Sumter	X	-	-	X	X	-	-	-	-	-	-	-	-	X	X	-	-	-
Union	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Williamsburg	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
York	X	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-

[a] C-Clay, Common; Cc-Clay, cement; CQ-Coquina; FE-Fullers Earth; G-Gravel; Gcs-Granite, crushed stone; Gds-Granite, dimension stone; K-kaolin; LSag-Limestone, agricultural; LSc-Limestone, cement; LScs-Limestone crushed stone; MSH-Manganiferous schist; P-Peat; S-Sand; S/C-Sand/Clay; SE-Sericite; SH-Shale; V-Vermiculite

[b] X indicates mineral mined.

Source: S.C. Division of Research and Statistical Services, 1982.

Fairfield and Kershaw Counties, and limestone is also mined in Dorchester and Orangeburg Counties for the manufacture of cement and in Cherokee and Berkeley Counties as a source of agricultural lime.

Clays ranked second in production value and third in tonnage. Common clay is utilized in the manufacture of bricks and cement. Fuller's earth, clay with a high absorptive capacity after it is calcined at high temperatures, is marketed as an oil, grease, and odor absorbant. Kaolin, a high-value clay, is mined extensively in Aiken County. Processed kaolin is used considerably in the rubber, paint, paper, fertilizer, and pesticide industries. Unprocessed kaolin is utilized in manufacturing refractories, bricks (as a colorant), and cement. Clays are mined by 24 companies at 50 sites in 17 counties.

The third most commercially valuable mineral commodity is sand and gravel. Its production in tonnage ranked second. Sand and gravel production is the most widespread mining activity in South Carolina with 66 companies operating 75 pits in 32 counties. Sand and gravel is mainly used as aggregate in concrete and asphalt and as fill. Industrial quality sand is also processed for glassmaking, sandblasting, foundry, and filtration applications.

Other mineral commodities mined in South Carolina are vermiculite, manganiferous schist, flake mica (sericite), and peat. Vermiculite's principal uses are as a soil conditioning additive; as lightweight aggregate in concrete, plaster, and fireproofing; and as loose and block insulation. Flake mica is used in electronics and as an inert filler in paint and expansion-joint cement. Manganiferous schist is used for gray coloration in bricks. Peat is mined and sold commercially as a soil conditioner.

Presently, no metal ores are mined in South Carolina. However, gold, silver, lead, manganese, copper and tin were mined formerly, with most of the production occurring during the second half of the nineteenth century. Recently, several companines have expressed renewed interest in the old gold mining districts of South Carolina because of the high price of gold.

Phosphate is an important mineral commodity which is no longer mined in South Carolina. Of worldwide importance as a source of cheap and abundant fertilizer during the 1870's and 1880's, South Carolina's phosphate was mined from 1867 to 1913 in the Lower Coastal Plain from Charleston to Beaufort. In 1938, reserves in the area were estimated at nine million tons; however, mining and production costs presently make the deposits economically marginal.

Oil and gas exploration has occurred in South Carolina since 1920. However, the exploration has been very limited and unproductive. Present exploration projects are concentrating on the Triassic basins buried beneath the Coastal Plain, but no test wells have been drilled.

Forestry

South Carolina has a rich forestry heritage. The production of timber has been an important industry since the late 1600's. Today the forest products industry is the third largest manufacturing industry in the State, behind textiles and chemicals. However, the forests provide more than economic advantages. The extensive forests provide habitat for wildlife; sites for outdoor activities ranging from hunting to birdwatching; and enhancement of environmental quality including scenic beauty, improved water quality, and prevention of soil erosion. Monetary values are difficult to place on such benefits.

Today 12.5 million acres, representing 65 percent of the land area in South Carolina, are devoted to timber production (Table 6). The total value of forestry production in 1977 was $1.9 billion or 9.5 percent of the total economy. In 1981, the total value of production reached $2.5 billion. Over the last ten years, the value of forestry products has increased by 221 percent, while the value of all other products to the economy has grown by 175 percent. At the same time, the number of forestry employees has increased by 35 percent compared to a 17 percent increase for other industries in the State. Some aspect of forestry, whether growing, harvesting, or manufacturing, occurs in every county (Fig. 4) and benefits local, county, and regional economies.

Quantity-wise, pulpwood is the leading timber product in South Carolina. In 1980, pulpwood accounted for 50 percent of total product output. Sawlogs, both hardwood and softwood, accounted for 40 percent of total product output during the same time. Ten percent of total product

Table 6.
Acreage of commercial forest land by forest type and ownership in South Carolina, 1978.

Forest Type	*Acreage*		
	Public	*Private*	*Total*
Softwood types: White pine-hemlock	4,632	8,742	13,374
Longleaf pine	116,492	354,620	471,112
Slash pine	61,345	450,792	512,137
Loblolly pine	384,801	3,018,917	3,403,718
Shortleaf pine	53,693	602,184	655,877
Virginia pine	4,632	173,389	178,021
Eastern redcedar	-	22,764	22,764
Pond pine	25,326	276,223	301,549
Spruce pine	724	7,011	7,735
Pitch pine	4,633	-	4,633
Total	656,278	4,914,642	5,570,920
Hardwood types: Oak-pines	129,053	1,589,491	1,718,544
Oak-hickory	148,698	2,545,694	2,694,392
Chestnut oak	-	4,405	4,405
Southern scrub oak	24,524	221,933	246,457
Oak-gum-cypress	108,098	1,882,656	1,990,754
Elm-ash-cottonwood	24,176	253,258	277,434
Total	434,549	6,497,437	6,931,986
All types	1,090,827	11,412,079	12,502,906

Source: U.S. Department of Agriculture, 1979.

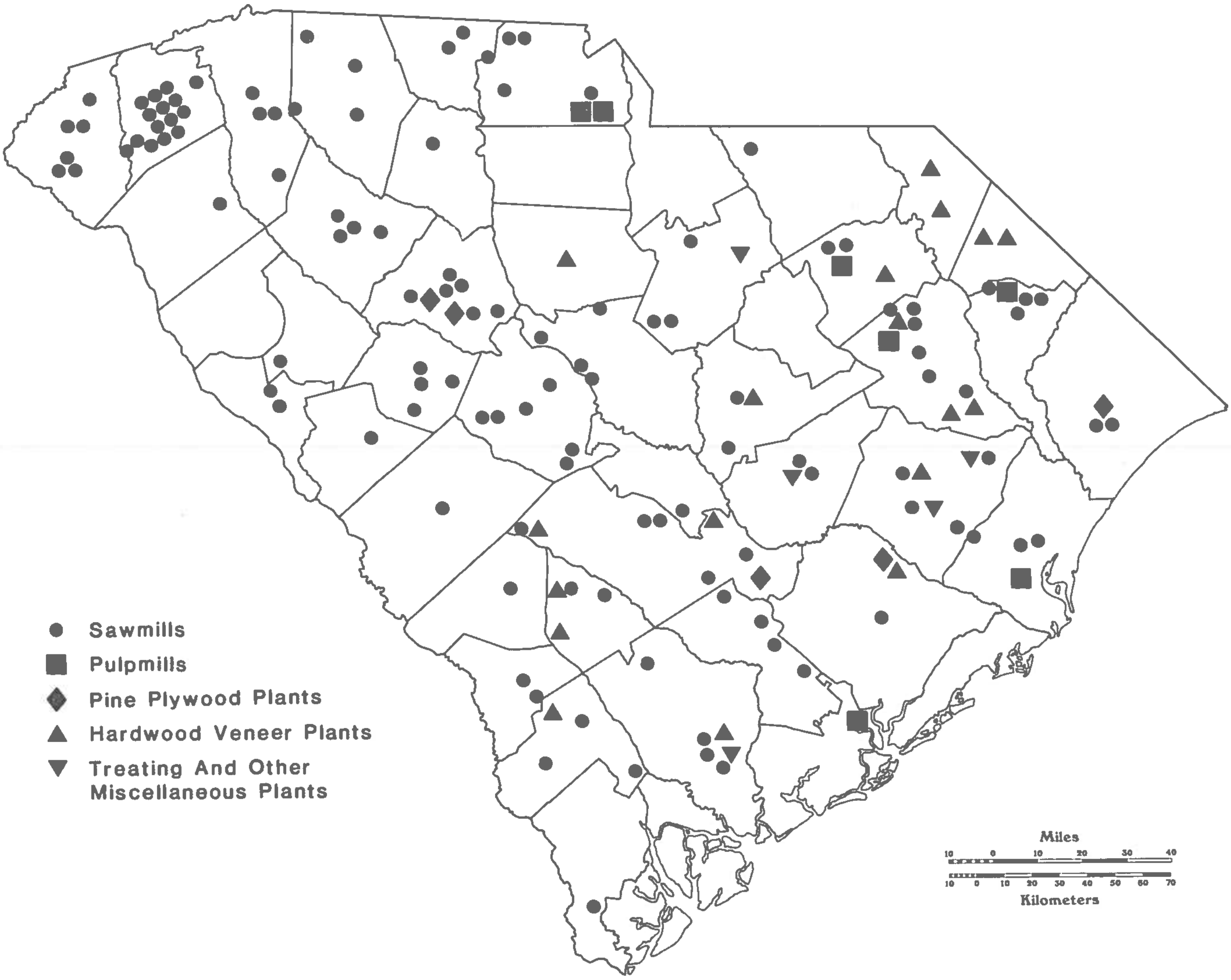

Figure 4.
Primary wood using industries in South Carolina (U.S. Department of Agriculture, 1979).

output came from peeler logs (used mainly for plywood), poles, piling, posts, particleboard furnish, and other miscellaneous products. In 1980, 21 percent of all timber removal was hardwood, while 79 percent was softwood. In the last ten years, much more efficient use has been made of harvested timber allowing a 26 percent increase in total output with only a 12 percent increase in total harvest. This is significant because data indicate the amount of land used for production of forest products has reached a peak and will begin to decline in future years.

The primary species featured in timber management in South Carolina is the loblolly pine. It grows on a wide range of soils and is indigenous to all but the extreme northwestern counties. Shortleaf pine, longleaf pine, and slash pine are the second, third, and fourth leading species, respectively. Various oak species are the primary hardwoods harvested.

About 73 percent of private commercial forest land in the State is owned by individuals, while the forest industry holds 18 percent. Nine percent of commercial forests are publicly owned with most areas located in the national forests.

Fish and Wildlife

A diversity of habitat in South Carolina supports a wide variety of animal life. Over 400 species and subspecies of birds can be found in the State. Although few of these birds are endangered, many are considered significant enough to warrant management efforts, particularly waterfowl, turkeys, and birds of prey. Mammals are also widespread and several, mainly the large game species and furbearers, are the target of management efforts. Amphibians and reptiles are also widespread and diverse with several endangered species present. These include the alligator, the bog turtle, and the sea turtle. The wide variety and abundance of freshwater and marine fishes support an important commercial fish industry in the State and provide anglers with exciting recreation. Fish species are diverse and include trout from the cold water streams in the Blue Ridge region, the famous land locked striped bass of the Santee-Cooper Lakes, and marine game fish such as cobia, bluefish, and swordfish.

South Carolina can be divided into six major types of habitat: forested; grassland, cropland and brush; coastal wetlands; riverine wetlands; aquatic; and beach (U.S. Army Corps of Engineers, 1972).

Forested. The forests of the State, exclusive of swamplands, can be separated into three types: deciduous, evergreen, and mixed. A major factor affecting the species located in these areas is the density of vegetative growth.

The deciduous forests have a denser growth and tend to support a greater number of species than do the other two types. Numerous birds are found here, including wild turkey, mourning dove, bobwhite, ruffed grouse, red-tailed hawk, and the great horned owl. Mammals common to this forest type include raccoon, oppossum, gray squirrel, southern flying squirrel, chipmunk, eastern cottontail, white-tailed deer, and bear. The eastern box turtle, black rat snake, eastern hognose snake, copperhead snake, and various salamander species are representative of different amphibians and reptiles preferring the type of vegetation common to the hardwood forests.

The evergreen forests provide less cover to animals living there, thus there are fewer species and individuals as compared to the hardwood forests. In addition, the pine forests often become dry and hot during the summer months causing many species to move into other types of forest. Numerous birds are found, including woodpeckers, chickadees, wrens, and warblers. The Red-Cockaded Woodpecker, an endangered species, makes its home in pine forests. It prefers to live in old and diseased pine trees. However, with modern forest management techniques, trees meeting these requirement are becoming increasingly rare and harder for the bird to find.

Generally only smaller mammals, such as the cottontail rabbit and gray squirrel, are found in evergreen forests. Reptiles and amphibians found here include the copperhead snake, hognose snake, northern black racer, eastern box turtle, and various lizard species.

The mixed forests have a wide variety of animal species common to both hardwood and evergreen forests. Many animal species have no difficulty changing to different forest types as conditions and seasons change.

Grassland, Cropland, and Brush. These types of habitat areas consist mostly of agricultural lands but also include grasslands of improved and unimproved pasture and fields which have converted to brush. Also included in this group are the parks and other vegetated zones of urban and suburban areas.

Generally only small birds and mammals are found near the fields and croplands, although larger mammals and birds of prey may hunt here. Birds such as meadowlarks and sparrows are common as is the cottontail rabbit which is extremely widespread.

Coastal Wetlands. Both tidal and freshwater marshes make up this habitat. The freshwater marshes are the most important to waterfowl, although the salt marshes are used extensively by feeding ducks and geese. The Clapper Rail, a significant game bird, is common in the salt marshes from Savannah to Murrells Inlet. Dabblers, diving ducks, and coot winter in the coastal area. Other important waterfowl include the Canada Goose, Blue Goose, Snow Goose, and Whistling Swan. Coastal wetlands are also important as nesting areas for numerous bird species including osprey and Southern Bald Eagle. Aquatic furbearers are found throughout this habitat, including muskrat, mink, and otter. The endangered American Alligator is found in the marshes and is reestablishing itself due to protective measures.

Riverine Wetlands. This habitat consists mainly of wooded swamps along rivers and streams. Significant examples of this habitat are the Santee Swamp, Four Hole Swamp, and Congaree Swamp. These areas are often flooded which provides nourishment to the bottomland hardwoods and cypress trees characteristic of this habitat area.

This rich habitat supports an abundance and diversity of fauna and flora. A tremendous number of bird species may be found here including owls, hawks, and wild turkeys. Bachman's Warbler, an extremely rare songbird, has been sighted in this habitat. It is believed that if the Ivory Billed Woodpecker is not extinct, it may be found in the Santee Swamp. With the exception of the wood duck, waterfowl do not nest in these areas.

Small game and furbearing mammals are numerous and include rabbits, squirrels, oppossums, raccoons, foxes, muskrat, mink, and otter. Beaver colonies are found statewide and especially along the Savannah River. Larger mammals include deer, bobcat, and black bear.

Aquatic. This habitat includes both marine and freshwater. The marine habitat is extensive along the entire coast and is found in many forms such as bays, sounds, inlets, and creeks. Approximately 160 species of saltwater fish are found in this area, of which most are inshore species. A few of the species found in this group are flounder, sheepshead, and striped bass. Some of the offshore migratory species include tuna, mackerel, jacks, and bluefish. Some examples of offshore bottom fish are black sea bass, snappers, and porgies. Oysters, shrimp, and blue crabs are the most important commercial shellfish of the marine habitat. Numerous shorebirds live in this area and include the American Oyster-Catcher and osprey.

Freshwater fish habitats of South Carolina include the cold water streams of the mountains, warm water inland lakes, and blackwater streams of the South Carolina Coastal Plain. Brook, rainbow, and brown trout are stocked annually in many areas where water temperatures are sufficiently cool. These streams are generally above 1,400 feet. Warm water fish, including bass, bream, catfish, and crappie, may be found in rivers, lakes, and ponds across the State. The Santee-Cooper Lakes are the site of South Carolina's famous striped bass (rock fish) fishery. These fish are managed extensively and are shipped to many other lakes in the country. The Santee-Cooper Lakes are also important waterfowl habitat.

Beach. Beach is the least extensive of all habitat in South Carolina. Beaches north of North Inlet are heavily developed and used for recreational purposes and provide little wildlife habitat. Southward beaches are less developed and provide important habitat to the Loggerhead Turtle and the Brown Pelican, two endangered species which lay their eggs in the sand.

Physiography and Geology

South Carolina has a diversity of water-related natural beauty including mountain waterfalls, inland swamps, Carolina Bays, and tidal creeks. Much of this diversity is related to the occurrence of three distinct physiographic provinces, the Blue Ridge, Piedmont, and Coastal Plain, which exhibit variations in topography, geology, and vegetation (Fig. 5). These regional variations greatly influence the availability and quality of the State's water resources.

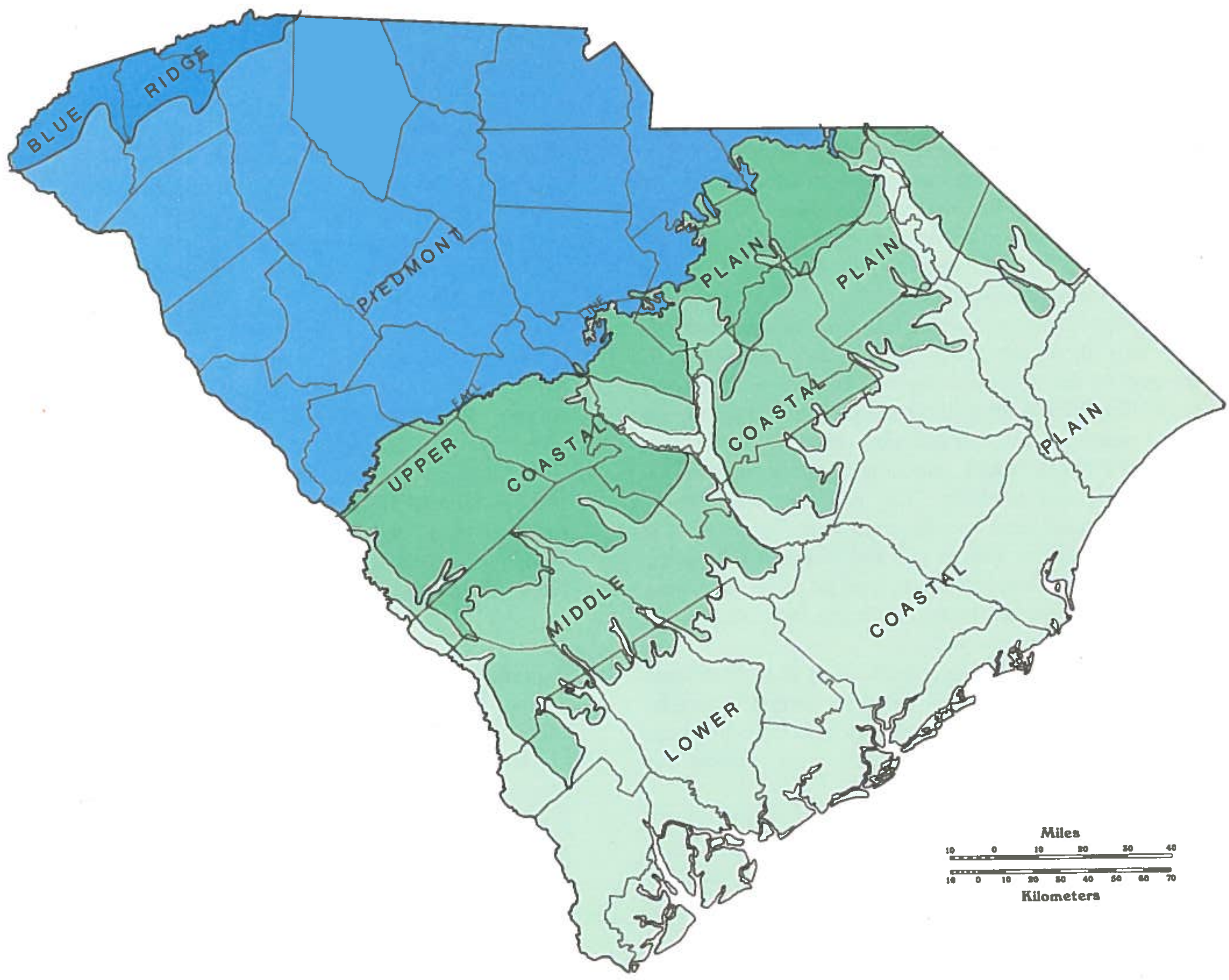

Figure 5.
Physiographic provinces in South Carolina (Adapted from Cooke, 1936 and Siple, 1967).

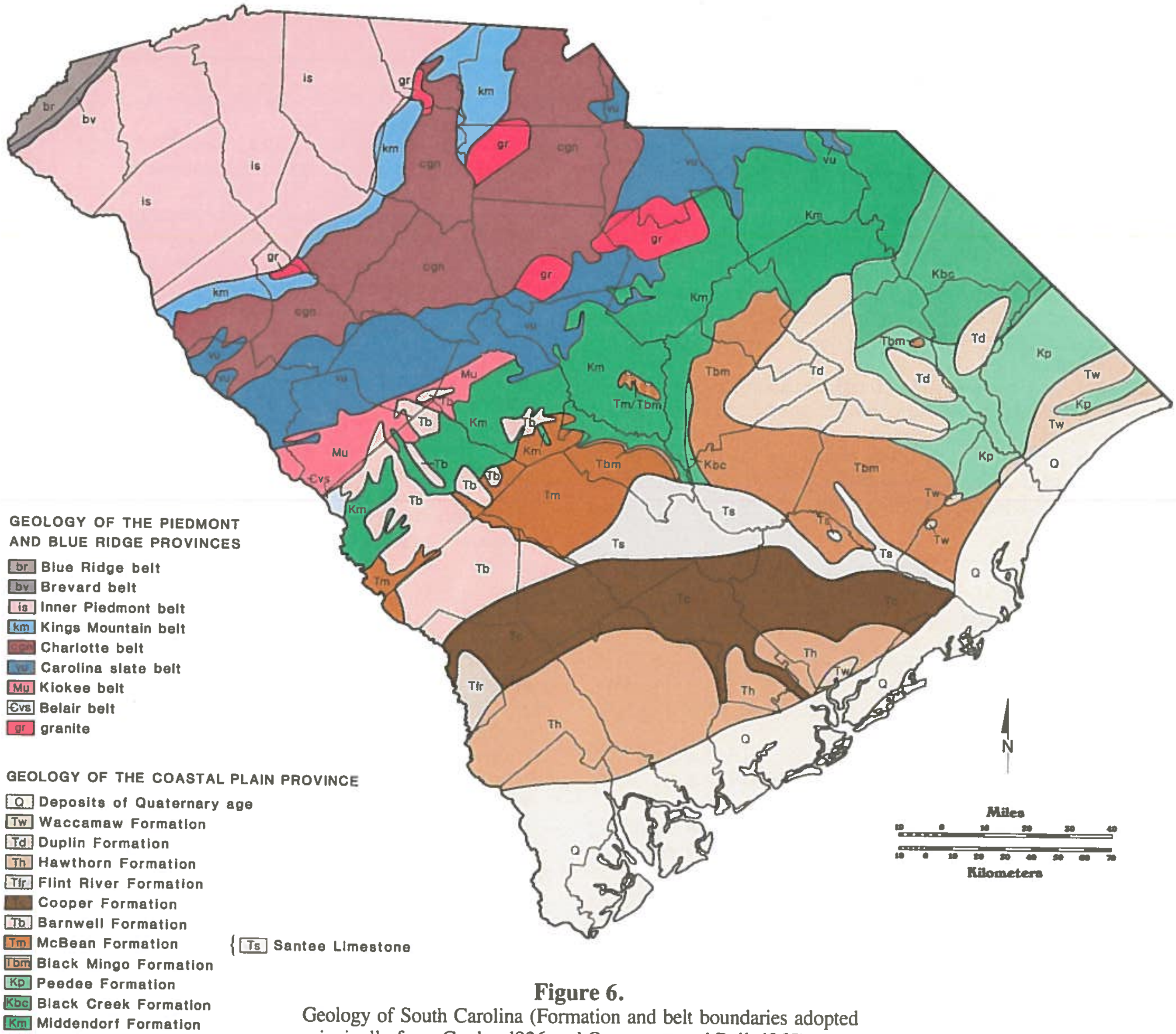

Figure 6.
Geology of South Carolina (Formation and belt boundaries adopted principally from Cooke, 1936 and Overstreet and Bell, 1965).

Historical Overview

The geology of South Carolina is characterized by two principal rock types, the crystalline rocks of the Blue Ridge and Piedmont and the unconsolidated sediments of the Coastal Plain (Fig. 6)*. The crystalline rocks have been classified into seven geologic belts, the Blue Ridge, Inner Piedmont, Kings Mountain, Charlotte, Carolina slate, Keokee, and Belair belts which were derived from ancient sedimentary, volcanic, and igneous rocks (Overstreet and Bell, 1965). These rocks were metamorphosed to their present form during the collision of the North American and African Plates in the Ordovician to Mississippian Periods about 345 to 500 million years ago (Hatcher, 1972).

The current structure and arrangement of these geologic belts were formed when layers of ancient unmetamorphosed rock were pushed together end-to-end by the colliding continental plates. The force of this collision transformed the once flat rock layers into several folded layers, much like a rug folds when pushed from opposite ends.

During the latter part of this plate collision, the folded rock layers were faulted and subsequently intruded by igneous rocks. It is theorized that after this period of collision, the continents separated, opening the present Atlantic Ocean Basin and causing the development of minor basins, such as the northeast trending Triassic Basin underlying the Savannah River Plant (Siple, 1967).

Subsequent erosion of the crystalline rock exposed the

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* The geologic map used in this report (Figure 6) has been adopted principally from the widely accepted formation boundaries described by Cooke (1936) and Overstreet and Bell (1965). The authors recognize that changes to the precise location and/or name of units of pre-Pleistocene age have been suggested for large portions of the Coastal Plain (Siple, 1959; Renfro and Ferry, 1970) as well as more limited Coastal Plain areas (Maulde, 1959; Pooser, 1965; Colquhoun, 1965, 1969; Siple, 1967a, 1975). Changes to the lithology, structure, age, and seismicity of individual rock units in the Blue Ridge and Piedmont have also been suggested (Daniels, 1974; Smoke, 1978; Prowell, 1978).

Supplemental Information Box 1.

Geology Terminology

alluvium (alluvial deposits) – unconsolidated material such as silt, sand, and/or gravel deposited during comparatively recent geologic time by a stream or other body of flowing water.

amphibolite – a metamorphic rock consisting mainly of amphibole minerals but little quartz; amphibole minerals are dark-colored and elongated.

aquifer – a geological formation consisting of permeable material which yields water to wells and springs.

argillaceous – clayey sediments, such as shale or marl; rocks formed by compaction of these sediments are called argillites.

argillite – a compact rock, derived from mudstone or shale, that has undergone higher degree of hardening.

blastomylonite – a mylonitic rock in which some recrystallization has taken place.

biotite – a black or dark green form of mica which is commonly a constituent of crystalline rock.

breccia – a coarse-grained clastic rock composed of large angular broken rock fragments.

calcareous – containing or consisting of calcium carbonates.

cataclastic rocks – rocks that have undergone breakage or crushing during mountain-building periods.

chert – a hard, extremely dense, sedimentary rock made up chiefly of very fine grained quartz and other silica minerals.

clastic – composed principally of broken fragments derived from preexisting rocks.

conglomerate – a coarse-grained , clastic sedimentary rock composed of rounded to subangular fragments larger than two millimeters in diameter set in a fine grained matrix of sand, silt, or clay.

coquina – a type of limestone made up of cemented shell debris.

crystalline rocks – a general term for rocks formed below the earth (igneous or metamorphic) in which mineral crystals form.

diorite – a common dark colored igneous intrusive rock.

Fall Line – generally considered the boundary between the Piedmont and Coastal Plain; actually a zone where rapids or falls occur along streams which pass from the rocks underlying the Piedmont to the unconsolidated sediments underlying the Coastal Plain.

fault – a fracture or break in rock along which some movement has taken place; usually occurs in parallel sets referred to as a fracture zone.

feldspar – one of the most widespread rock-forming minerals; occurs in all types of rocks; are usually white, pink, or transparent; their decomposition is the derivation of most soil clays.

fluvial – of or pertaining to a river and the action of a stream or river.

formation – any sedimentary bed or consecutive series of beds or groups of rock sufficiently homogeneous or distinctive to be considered a unit.

fuller's earth – a fine pure clay of largely hydrated aluminum silicates which has the quality of absorbing oils.

gabbro – a coarse-grained igneous rock which is low in silica and high in magnesium and calcium.

glauconitic – containing or having properties of glauconite—a phosphate-type clay.

gneiss – a fairly coarse-grained, moderately high grade, metamorphic rock with a banded appearance.

granite – a general name for intrusive rock bodies, commonly coarse-grained and usually composed of quartz, feldspar, and mica. Also a specific name for an igneous rock of specific chemical and mineralogic composition.

hornblende – a mineral common in metamorphic and igneous rocks, usually dark in color and elongated.

intrusion – refers to igneous rock which has forced its way into pre-existing rocks by some path like a joint or fault or by deforming or cross-cutting the older rocks to form narrow dikes or large batholiths.

kaolin – a relatively pure white or nearly white non-plastic clay, derived from the complete weathering of minerals like feldspar in granite.

lignite – a brownish-black coal that is intermediate in coalification between peat and subbituminous coal.

limestone – general term for sedimentary rocks containing greater than 50 percent calcium carbonate.

mafic – a general term used to describe dark-colored iron-magnesium minerals or igneous rocks which have as their major constituent one or more of these dark-colored minerals.

marble – hard crystalline limestone.

marl – an old term used to describe an unconsolidated sedimentary rock formed from limy mud sediments.

metamorphism – the process by which minerals and structure of existing rocks are changed by heat and pressure below the surface of the earth; regional metamorphism and intrusion of igneous rock occurs during mountain-building periods.

mica – a general term for sheet silicate minerals such as muscovite and biotite.

migmatite – a composite rock composed of igneous or igneous-looking and/or metamorphic minerals, usually formed during the highest grade of regional metamorphism.

muscovite – a mineral of the mica group, usually colorless, whitish, or pale brown which is common in metamorphic rocks and in most light colored igneous rocks, such as granite.

pebble – small rounded stone, worn smooth as by the action of water, having a diameter between 4-64 millimeters.

pegmatite – mineralogically, a coarse-grained igneous rock, usually of granite-type composition and usually found as irregular dikes, lenses, or veins. Texturally the term is used in combination with other mineral names to indicate unusually large grain size, e.g. gabbro-pegmatite.

phosphatic deposits – sedimentary rock containing phosphate minerals.

phyllites – a fine grained schistose rock resulting from more advanced regional metamorphism than slate.

phyllonite – a rock similar in appearance to phyllite but is formed by mechanical grinding or crushing of initially coarser rock (e.g. granite)

pyrite – a common, pale-bronze mineral composed of iron sulfide (fool's gold).

quartzite – a metamorphic rock composed of restructured quartz; also a very hard but unmetamorphosed sandstone consisting chiefly of quartz grains that have been extremely well cemented together.

saprolite – a layer of thoroughly decomposed bedrock formed in place by chemical weathering.

scarp (escarpment) – a line of cliffs or a break in slope separating surfaces of different levels.

schist – a metamorphic rock in which the mineral grains are arranged in a parallel fashion which tends to have an undulating surface when broken; often named by major mineral constituent, such as mica-schist.

sillimanite – a brown, grayish, or white mineral which occurs in long slender, needle-like crystals often found as fibrous aggregates in gneisses or schists; it forms at the highest temperatures and pressures of regional metamorphism.

slate – shale that has undergone a low grade of metamorphism so that it becomes harder and more brittle but still retains its fine-grained platy nature.

stratigraphy – the study of stratified rocks (mainly sedimentary, but not excluding igneous and metamorphic) in terms of rock characteristics, sequence in time, and correlation of beds.

trough – any long depression, as between two ridges.

unit (stratigraphic) – a stratum or strata recognized as a unit for classification with regards to rock characteristics for the purpose of description, correlation, or mapping.

volcanic – of or relating to materials from volcanoes in the form of lava flows (molten rock) or volcanic ejected material, such as rock, cinder, or ash.

various rock types apparent today. Erosion of up-bulging folds exposed deeply formed rocks, such as in the Blue Ridge, Inner Piedmont, and Charlotte belts. Erosion of down-buckled folds exposed only upper-layer rocks, such as in the Kings Mountain and Carolina slate belts. The rock units of these seven geologic belts represent varying degrees of metamorphism as well as differing rock types. The Inner Piedmont belt is believed to represent the most metamorphosed region (Hatcher, 1972) with the degree of metamorphism progressively decreasing eastward.

During the more recent past, from the Cretaceous to Quaternary periods, the Coastal Plain sediments were deposited on the surface of the crystalline rocks. These sediments were derived from erosion of the Blue Ridge and Piedmont rocks as well as from marine deposits when the oceans were at a much higher level.

The land surface of South Carolina slopes southeasterly toward the ocean with local relief also decreasing in that direction. The physiographic provinces, which lie perpendicular to this slope, exhibit distinct land surface and geologic characteristics.

Blue Ridge Province

The Blue Ridge Province occupies only two percent of the State's land area and is located in the extreme northwest portion of South Carolina. This mountainous region has elevations ranging from 1,000 feet in the foothills to 3,554 feet at Sassafras Mountain, the highest point in South Carolina.

The Blue Ridge belt and the Brevard fault zone are the major geological features of this province. These features were created when a unit of folded and metamorphosed rock was thrust up from under the Piedmont rocks approximately 250 million years ago during the late stages of continental plate collision (Hatcher, 1972). Rocks of the Blue Ridge belt include schist, gneiss, and granite. Rocks of the Brevard fault zone consist of phyllonite, derived from the shearing and crushing of gneisses and schists along the fault, and blastomylonite which is partially recrystallized phyllonite.

Piedmont Province

The Piedmont Province covers roughly 35 percent of the State and lies between the Blue Ridge and Coastal Plain Provinces. The rolling hills of the Piedmont range in elevation from 1,000 feet near the mountains to about 400 feet at the Fall Line. This land surface represents an ancient erosional plain which has been uplifted and moderately dissected to an advanced stage of erosion. Most of this province is mantled by a layer of chemically weathered bedrock called saprolite, which varies considerably in thickness depending on location.

The bedrock of this province is comprised of the metamorphic rocks of the Inner Piedmont, Kings Mountain, Charlotte, Carolina slate, Kiokee, and Belair belts. The Inner Piedmont belt contains rocks of medium to high metamorphic grade which include granitic gneiss, mica schist, sillimanite schist, and amphibolite. Rocks of the Kings Mountain belt are of lower metamorphic grade than are those of surrounding belts. Rocks typical of this belt are sericite schist, hornblende schist, quartzite, and marble. Charlotte belt rocks are of medium to high metamorphic grade and include gneiss, schist, and amphibolite. The Carolina slate belt rocks are of low metamorphic grade including argillite, slate, and exposed basement rocks such as muscovite schist and gneiss. The Kiokee belt is of similar metamorphic grade to the Charlotte belt, and consists of primarily granitic gneiss, biotite-muscovite schist, and microdine gneiss. The Belair belt closely resembles the Carolina slate belt in metamorphic grade, and is composed mainly of faulted argillite.

Coastal Plain Province

The Coastal Plain Province occupies approximately the southeastern two-thirds of the State. The Fall Line defines the irregular division between this province and the Piedmont Province. The Coastal Plain is subdivided into three physiographic regions, the Upper, Middle, and Lower Coastal Plain. These regions are differentiated by topographic and geomorphic features formed millions of years ago when ocean levels were much higher than at present.

The Upper Coastal Plain extends southeast from the Fall Line to the Citronelle Escarpment (Doering, 1960). This ancient sand dune region includes the Carolina Sand Hills and is characterized by moderately sloped, irregularly shaped, and generally rounded terrain. The Middle Coastal Plain lies between the Citronelle and Surry escarpments, while the Lower Coastal Plain lies between the Surry escarpment and the present coastline (Fig. 5). These latter two regions exhibit moderate to low relief and are marked by several terraces (Brandywine, Coharie, Sunderland, Wicomio, Penholoway, Talbot, Pamlico, and Recent), each representing former sea levels (Cooke, 1936).

Metamorphic and igneous rocks similar in type and age to those in the Blue Ridge and Piedmont underlie the sediments of the Coastal Plain as an irregular surface that dips to the south and southeast (Fig. 7). These rocks include granite, diorite, chlorite, hornblende schist, quartz-feldspar gneiss, and hornblende gneiss of Pre-cambrian to Permian age. Subsurface data indicate several major structural features of the basement rock, the most prominent of which is the Cape Fear Arch. This structure is a southeastward plunging basement anticline with an axis roughly paralleling the North Carolina-South Carolina border and intersecting the North Carolina coast at Cape Fear. Buried saprolite of variable thickness separates the crystalline rock from the overlying sedimentary rocks throughout the Coastal Plain. The saprolite layer in the southwestern portion of the Coastal Plain ranges from 40 to 80 feet thick. Several troughs composed of Triassic sediments have been identified in the crystalline bedrock beneath Coastal Plain sediments. One trough, the Dunbarton Basin, is located beneath the Savannah River Plant in Aiken and Barnwell Counties (Siple, 1967; Marine and Siple, 1974). The sediments in this basin consist of clastic red siltstone, sandstone, and some limestone pebbles and are overlain by Coastal Plain deposits (Fig. 7).

Coastal Plain deposits consist of consolidated and unconsolidated sediments of alluvial and marine origin which thicken from a few feet at the Fall Line to over 4,000 feet at the coast near Beaufort (Fig. 8 and Table 7).

Three formations of late Cretaceous age are recognized over a large part of the Coastal Plain--the Middendorf*, Black Creek, and Peedee Formations.

The Black Creek Formation is composed of two members, the upper Snow Hill Marl member and the lower member which has not been named. The Snow Hill Marl is composed of light gray sand interbedded with dark gray marine clays and some green sands. The lower member is composed of dark gray to black laminated clays with white to gray phosphatic, lignitic, and glauconitic sand. The formation is exposed along Black Creek a few miles above Darlington. Elsewhere in the northwestern Coastal Plain the formation lies buried beneath thin (1 to 30 feet) deposits of Pleistocene age. The Black Creek Formation near Sumter occurs between the elevations of approximately 50 feet above mean sea level to 200 feet below mean sea level. In Orangeburg, the Black Creek Formation lies between approximately 300 to 550 feet below mean sea level. Its maximum thickness elsewhere ranges from about 600 to 800 feet. The formation dips generally to the southeast (Fig. 7).

The Peedee Formation is the youngest of the Upper Cretaceous formations in South Carolina. This formation crops out in Florence, Williamsburg, Horry, and Georgetown Counties with the best exposures along the Pee Dee River. The Peedee Formation consists of dark gray clay interbedded with fine to medium micaceous and glauconitic sand and streaks of hard shelly limestone and siltstone. The top of the formation ranges from about 100 feet below mean sea level in the Orangeburg area to more than 1,600 feet below mean sea level in Beaufort County. The thickness of the formation ranges from a few feet near the updip limit to 600 feet in the Beaufort area. In the Charleston area, data indicate that the thickness is 500 to 700 feet.

Due to limited available data, the Ellenton Formation is of uncertain age and geographical extent. When first described in 1967, this formation was thought to be of Late Cretaceous age based on its stratigraphic position (Siple, 1967a). Subsequent investigations indicate that this formation is possibly of Early Paleocene age, equivolent to deposits of Midway age extending from Aiken County to the coast (David Prowell, U.S. Geological Survey, Atlanta, Georgia, personal communications, February 1983). The Ellenton Formation consists of dark gray to black mica-

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* In previous reports of the S.C. Water Resources Commission, the name Tuscaloosa was preferred over that of the Middendorf, principally because the former was the more widely recognized and accepted name and because of inconsistent assumptions offered in support of the latter. However, the type section of the Middendorf Formation located in Chesterfield County, South Carolina does not include lithic units typical of the Tuscaloosa Formation in the southern and western parts of the southeastern Coastal Plain, including in part the Hamburg beds of Sloan (1904, 1908). Therefore, the authors of this report recognize the Middendorf as a distinct formation similar to, but different from, the more widespread Tuscaloosa Formation. Formations and aquifer systems in South Carolina identified as the Tuscaloosa in earlier reports are synonymous to the Middendorf as used in this report. In addition, in down-dip areas near the coast, deposits older than Middendorf (i.e. Early and Late Cretaceous age) are included in the Middendorf for purposes of ground-water analysis.

The Middendorf Formation is composed of light-colored crossbedded kaolinitic sands with lenses of white, tan, red, and purple kaolinitic clays exposed at the surface in South Carolina in Marlboro, Chesterfield, northern Darlington, northern Lee, Kershaw, western Sumter, Richland, northern Calhoun, eastern Lexington, and northern Aiken Counties. The thickness of the Middendorf Formation ranges from a few feet at the Fall Line to 1,500 feet in Beaufort County. The top of the unit occurs at a depth of about 50 to 100 feet below land surface in the northern part of the Coastal Plain to 2,500 feet below land surface in Beaufort County. This indicates a coastward dip and general thickening of the sediments from northwest to southeast across the Coastal Plain.

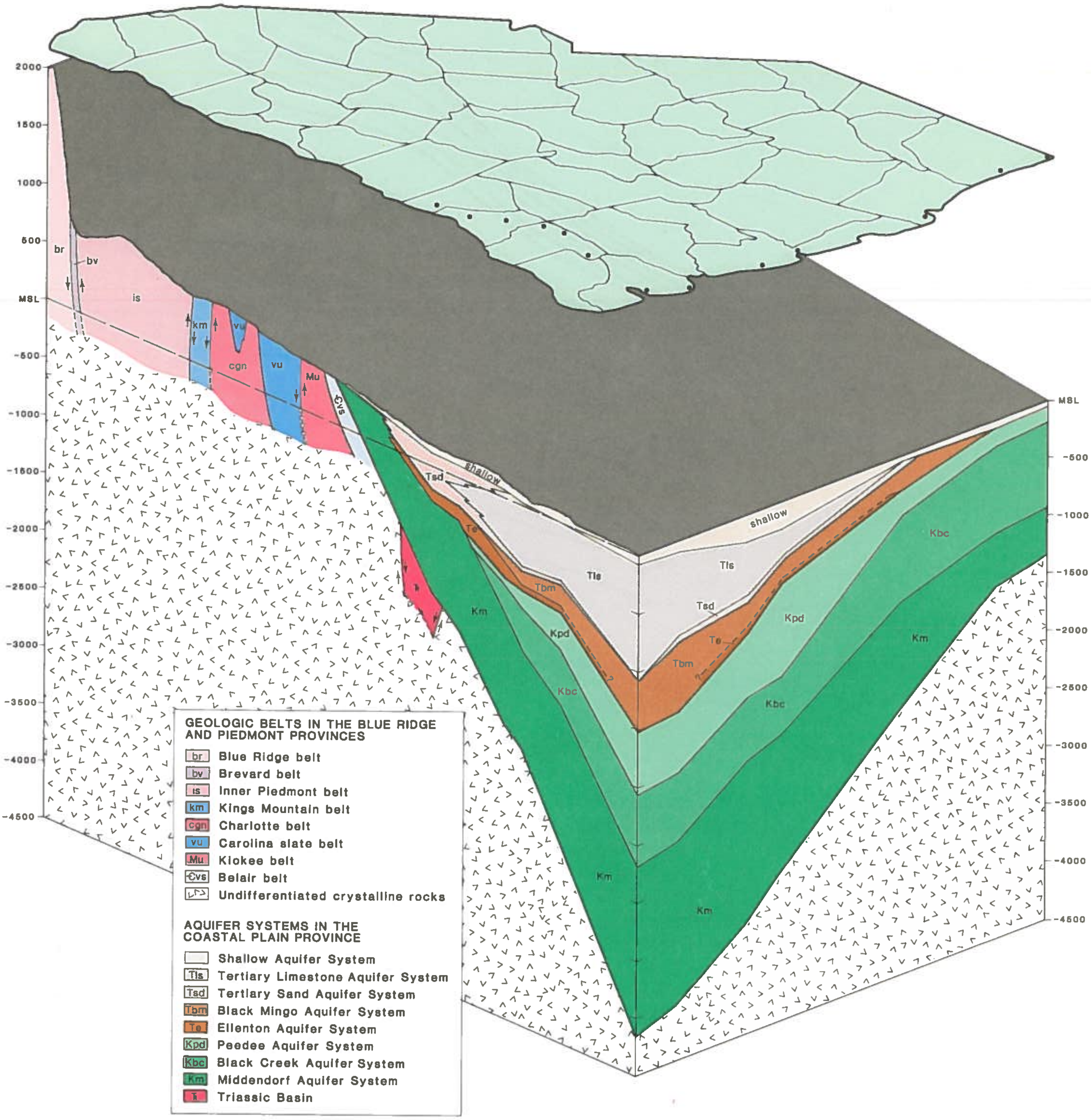


Figure 7.
Generalized structure of formational units and aquifer systems in South Carolina.

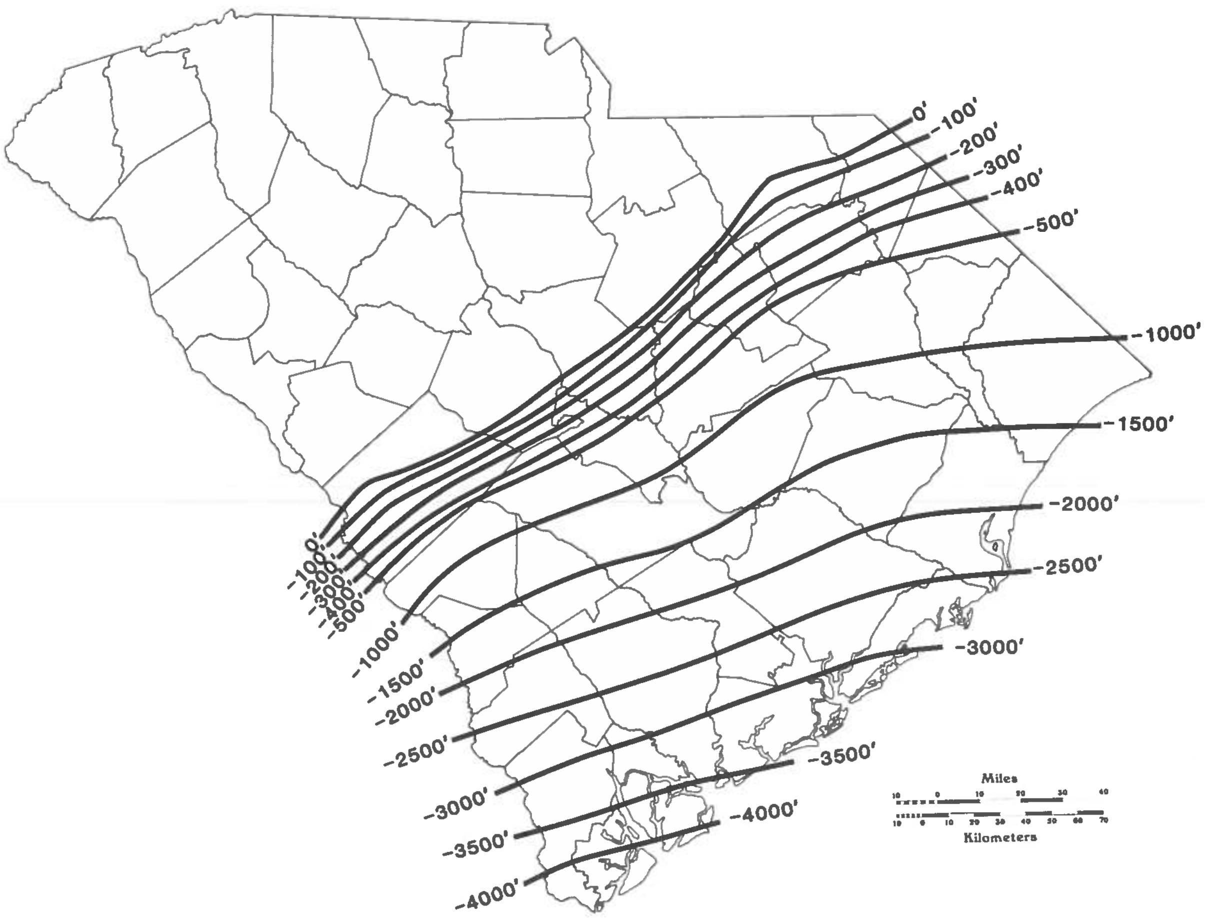


Figure 8.
Generalized contours of the surface of pre-cretaceous rocks in South Carolina (Siple, 1959).

ceous, gypsiferous, carbonaceous clays interbedded with medium to coarse quartz sand and gravel. It occurs in the subsurface in the Savannah River Valley and extends indeterminate distances to the south and east. In Barnwell and Aiken Counties the top lies from 150 to 300 feet below land surface and the formation is approximately 80 feet thick. Its elevation in the area ranges from 0 to 100 feet below mean sea level.

The overlying Tertiary sediments consist of the Black Mingo Formation of Early Eocene to possibly Paleocene age overlain by the Congaree, Warley Hill Marl, McBean, Santee Limestone, and Barnwell Formations of Middle and Late Eocene age. Younger units include the Cooper Formation of Oligocene age, and the Hawthorne Formation of Miocene age. The Tampa Formation of Miocene age may be present in lower Beaufort County. Deposits of Pliocene age are represented by the Duplin and Waccamaw Formations.

The Black Mingo Formation is composed of fine sand, silty clay, sandstone, fuller's earth, and beds of fossiliferous limestone interbedded with gray shale. The lower unit is primarily black shale. The Black Mingo Formation is exposed along the Black River in Clarendon County. Sediments of the Black Mingo underlie the central part of the Coastal Plain. The similarity in the lithology between the black clays and interbedded fine sand in the Tertiary and Upper Cretaceous deposits makes it difficult to distinguish between the two.

The Congaree Formation includes shells, well to poorly sorted sands, sandstone layers, siltstone, and gray to green shale exposed south and west of the Congaree River and in northern Orangeburg, Calhoun, Lexington, Aiken, and Barnwell Counties.

The Warley Hill Formation includes fine green to yellow glauconitic sand overlain by yellow to reddish-yellow sandy clay at exposures in Calhoun County at Cave Hall and Poplar Creek. It is recognized in areas in the northern parts of Orangeburg and Calhoun Counties.

The McBean Formation consists of interbedded brown, yellow, and light green clays, quartzose fossiliferous sands, and siltstone; it contains abundant microfauna and macrofauna. Deposits have been found on both sides of the Savannah River and north of the area between the Santee and Wateree Rivers. The McBean Formation overlies the Warley Hill, Congaree, and Black Mingo Formations and

Table 7.

Description of geologic formations in the Coastal Plain.

SYSTEM	SERIES	GROUP	FORMATION	DESCRIPTION OF FORMATION	AQUIFER SYSTEM NAME	DESCRIPTION OF AQUIFER POTENTIAL AND WATER CHARACTERISTICS
Quaternary	Recent		Recent	Light-gray and tan fine to coarse lenticular sand and interbedded clay of marine and continental origin.	Shallow Aquifer System (in Lower Coastal Plain)	Water occurs primarily under water-table conditions and semi-confined conditions locally of minor importance as an aquifer. Water may be high in iron, sulfate, or nitrate, but is generally soft. High yields from river terrace deposits may be developed. Usually this unit supplies ground water to shallow (-100 feet) drilled and dug wells primarily in rural areas for domestic use. Minor to limited ground-water source.
	Pleistocene		Pamlico Talbot Penholoway Wicomico Sunderland Coharie Brandywine	Light-gray, tan, orange, red and black clay, interbedded with sand and gravel. Deposits form a thin cover over a large portion of the Coastal Plain.		
Tertiary	Pliocene		Waccamaw	Blue-gray to yellow and brown sandy shell marl and fine sand.		Supplies ground water to shallow (less than 100 ft.) wells for domestic use in the rural areas in the northeastern part of the State. Poor to minor ground-water source.
			Duplin Marl*	Buff sandy, friable shell marl occurring in isolated patches in lower half of Coastal Plain.		Minor ground-water source because of its limited extent and thickness. Water is moderately hard and may be high in iron.
	Miocene		Hawthorne	Hard brittle shale resembling silicified fuller's earth, with fine sandy phosphatic marl and soft limestone.		Because of its low permeability is not considered a major aquifer. However, it does provide sufficient water for domestic purposes and for limited industrial use. Water is hard. Minor ground-water source.
	Oligocene		Cooper	Light-brown to grayish-green phosphatic marl, heavily microfossiliferous, with fine grained sand. Basal part may be Jackson in age.		Principally a confining bed. The lower section acts as a poor aquifer in the southeastern part of the State. Water is quite hard and high in iron low in fluoride. Minor ground-water source.
	Eocene	Jackson	Barnwell	The Barnwell consists typically of deep-red to brown fine to coarse massive sandy clay and clayey sand. It appears to represent a residuum derived from solution of a sandy limestone.	Tertiary Sand Aquifer System	Does not yield large quantities of water. Can be used for domestic needs where the sand is sufficiently coarse and free from silt and clay. Water is soft. Minor ground-water source.
		Claiborne (Upper)	Castle Hayne Limestone	Buff-gray tough or crumbly fossiliferous limestone underlain by soft fine-grained granular limestone. Equivalent in down-dip areas to the Ocala Formation in extreme southern S.C., along with Georgia and Florida.	Tertiary Limestone Aquifer System	A major source of water in Beaufort and Jasper Counties. Yields of 500 to 2000 gpm. Water is moderately hard, low in iron and chloride. Water from lower part of of aquifer may be high in chloride.
		Claiborne (Middle)	McBean	The McBean Formation consists of fine to medium grained massive greenish-yellow and red quartz sand, green glauconitic marl, silicified beds of coquina, and clayey sand interbedded with red, brown, ochre, and yellow clay laminae. Littoral to neritic environment gradational with some estuarine or continental.	Tertiary Sand Aquifer System / Tertiary Limestone Aquifer System	The beds of sands and limestone in the lower part in Aiken and Barnwell Counties are fairly permeable and yield moderate quantities of water to industrial and municipal wells. Water is soft but may be high in iron content. Moderate to major ground-water source.
			Santee Limestone	The Santee limestone is a nearly pure white to creamy-yellow fossiliferous and partly glauconitic limestone containing numerous Bryozoa.		In the southeastern part of the State yields 500 gpm in eastern Colleton County to 2000 gpm in western Hampton, Jasper, and western Beaufort Counties. Water is moderately hard to hard with pH 7.1-7.9; salt water intrusion is thought to be occurring at places near the coast. Major ground-water source.
			Warley Hill Marl	Fine green to yellow glauconitic sand overlain by yellow to reddish-yellow sandy clay.	Tertiary Sand Aquifer System	Minor to poor ground-water source because of its small extent and low permeability.
		Claiborne (Lower)	Congaree	Well to poorly sorted sand, fuller's earth, brittle siltstone, and light-gray to green shale alternating with thin-bedded fine-grained sandstone.		The Congaree is the basal, and most productive unit of the Orangeburg Group (including the Barnwell, McBean, and Wharly Hill formations, northwest of the Citronelle Scarp). Yields range from 100 to 600 gpm, and the water is generally soft high in iron, low in fluoride with a pH between 4.0 and 7.9
		Wilcox	Black Mingo	Partly indurated fine white to yellow sand and sugary sandstone or bioclastic limestone. Cement is white and calcareous to siliceous. Underlain by gray to black laminated shales containing numerous macro-fossils in some areas. Basal beds may be Midway in age.	Black Mingo	Yields are uncertain, but some permeable layers may produce up to 200 gpm in Clarendon, Williamsburg and Berkeley Counties. Mainly a confining bed. Water is moderately to very hard and low in iron, chloride, fluoride and the pH is 7.3 to 7.7 Limited to minor ground-water source.
	Paleocene	Midway	Ellenton	Dark-gray to black sandy lignitic micaceous clay containing disseminated crystals of gypsum. Medium to coarse sand and gravel.	Ellenton	Geographic distribution not fully mapped. Known to occur from Savannah to Edisto basins and southeast Allendale County. Water is generally high in sulfate and iron. Moderate to major ground-water source.
Cretaceous	Upper Cretaceous	Navarro	Peedee	Dark-green to gray micaceous, glauconitic, argillaceous sand interbedded with impure limestones and massive dark clays. Deposited under open marine conditions probably at depths of not less than 100 fathoms.	Peedee	Several hundred gpm'have been reported around the City of Orangeburg. In the Low Country, yields up to 500 gpm have been reported. Water is generally soft, but high in iron and sulfate. Limited to moderate ground-water source.
		Taylor	Black Creek — Snow Hill Marl	Light-gray sand and dark clays interbedded with green sand and marine clay. Transitional zone between the deeper marine Peedee Formation and the more shallow marine Black Creek deposits.	Black Creek	This is a major aquifer of public and industrial supply within Orangeburg, Florence, eastern Marion, Clarendon, Williamsburg, Horry, and Georgetown Counties. Yields range from 400 to 1100 gpm. Water is soft with an excess of iron. Excessive fluoride is present in the coastal region. Excessive chlorides are present in the lower part of the Black Creek Aquifer System, along the coast. Major ground-water source.
		Austin	Black Creek — Unnamed	Dark-gray to black laminated lignitic clays interbedded with white to gray phosphatic, glauconitic sand. Deposited in shallow marine estuarine, and paludal environment.		
		Eagleford to Woodbine	Middendorf (Tuscaloosa)	Gray, buff and red arcosic cross-bedded sand and gravel, interbedded with lenses of white and purple clay and kaolin. Mixed continental and marine environment characterized by fluvial, deltaic, and littoral deposits.	Middendorf (Tuscaloosa)	A potential source of large quantities of water in the coastal plain. The permeability is relatively high and yields up to 3400 gpm can be obtained from individual wells. Water is soft and low in total solids in Aiken, Barnwell, Richland, Sumter, Florence, Marion, and Dillon Counties. In the Low Country area it is covered by 2000 to 2600 ft. of younger formations. The water is higher in total dissolved solids near the Coast, more than 1000 mg/L, and fluoride, more than 4.0 mg/L. In the Coastal regions of the State the water becomes excessively salty. Extensive major aquifer.

* Previously considered as Miocene in age.

in some areas overlies Cretaceous deposits.

The creamy yellow to white fossiliferous and calcarious Santee Limestone crops out in a belt approximately 25 miles wide, extending from Allendale County on the Savannah River, eastward to the Santee River and the northern part of Charleston County. The limestone is soft in some places, but in weathered exposures it forms recalcified rock. In the northern part of the outcrop area, the formation contains numerous caves, caverns, sinkholes, and other features related to karst topography.

The Castle Hayne Limestone, recognized and described by Cooke and MacNeil (1952) in Calhoun and Orangeburg Counties, is difficult to differentiate in the field from the Santee Limestone. Similar limestone beds occurring in Jasper and Beaufort Counties are from Middle Clairborne to Jackson in age. The formation is composed of a buff to gray, crumbly fossiliferous limestone overlying a finer-grained granular limestone.

The Barnwell Formation, characteristically exposed in the uplands in Aiken and Barnwell Counties, consists of massive fine to coarse red and yellow clayey sand extending southeastward to the western part of Allendale County. Its thickness ranges from 40 to 90 feet. The formation transgresses northwestward across older deposits of Tertiary and Cretaceous age and the crystalline rocks of the Piedmont.

The Congaree, Warley Hill, McBean, and Barnwell Formations comprise the Orangeburg Group northwest of the Citronelle escarpment.

The Cooper Formation of Oligocene age consists of light brown to grayish green phosphatic marl which is more important as a confining bed than as an aquifer. The lower part of the formation may be Late Eocene in age. The deposit is exposed along Goose Creek and the Cooper, Ashley, and Edisto Rivers.

The Hawthorne Formation is separated by an erosional unconformity from overlying and underlying deposits. In most places it lies within a few feet of the surface and extends to a depth of about 30 feet below land surface. The most distinctive kinds of rock in the Hawthorne Formation are hard brittle shale, sandy phosphatic marl, and soft limestone. The more marine parts of the Hawthorne Formation extend from Hampton County to the eastern part of Berkeley County. Updip equivalents are recognized in Aiken, Barnwell, Allendale, and Lexington Counties.

The Duplin Marl Formation of Pliocene age (may be Yorktown Formation as referred to in North Carolina) consists of deposits of shell hash, sand, clay, and marl that extend as scattered errosional remnants over a large part of the Coastal Plain. The largest concentration of the Duplin is located between the cities of Darlington, Sumter, and Johnsonville. This formation is generally less than 50 feet thick.

The Waccamaw Formation of Pliocene age consists of blue-gray to yellow and brown sandy shell marl. This formation occurs in a belt which parallels the coast and extends from the North Carolina boundary through Horry County and part of Georgetown County. The Waccamaw Formation is also recognized in Berkeley County near the Cooper River and Goose Creek. Available data indicate that the Waccamaw Formation is generally less than 10 feet thick.

At the surface, Pleistocene and Recent Formations, consisting chiefly of sand, clay, and shell, form a thin blanket over the deeper Coastal Plain sediments. Most of these are correlated with seven progressively higher terraces (either marine or fluvial) occurring between 25 and 270 feet above present mean sea level (Cooke, 1936; MacNeil, 1952).

South Carolina Water Law

Water law is a prime candidate for the most misunderstood and, thus threatening, body of law in South Carolina. Many factors contribute to this situation. The purpose of this section is to briefly chart the course of water law development in South Carolina and provide a brief overview of existing State and Federal laws bearing upon water use within this State.

In reviewing water law several considerations must be identified at the outset in order to adequately appreciate the application of law. First, water law is not neatly contained in any one combined set of statutes which one can quickly and easily review. Rather, the law must be gleaned from a broad range of sources, including but not necessarily limited to the constitutions of the United States and South Carolina, Federal and State statutes, Federal and State regulations, and the common law of this State. Second, both the Federal government and the State of South Carolina exercise jurisdiction over waters that flow through and around South Carolina. In many instances the jurisdiction overlaps and is concurrent, but in other situations the jurisdiction is reposed in only one level of government. Third, the matter of ownership of water must be considered. In most situations, water is not subject to ownership; instead, water is common property, enuring to the benefit of the citizenry in general. Water, however, is subject to ownership under various circumstances and in most instances is available for reasonable use without actual ownership. Fourth, water is generally limited in value to anyone unless it is of adequate quantity and quality; therefore, the effects of laws relating to pollution control must be borne in mind. Finally, the very nature of water must be considered. Traditionally, water has been broken down into classifications, such as surface water, ground water, and diffused surface water; however, water, in reality, must be viewed as part of a single hydrologic cycle. Thus, consideration of a problem that superficially appears to be one of surface water may directly affect ground water. As water use and consumption continues to increase, this relationship will become increasingly important in water law.

SURFACE WATER[1]

The basic law of surface water in South Carolina is the riparian doctrine. The doctrine has evolved over the years since its adoption; however, the two broad theories of natural flow and reasonable use have been and continue to be part of the doctrine. Undoubtedly, the reasonable use doctrine is the most important aspect of the riparian doctrine today, and an understanding of both theories is fundamental to the comprehension of South Carolina water law.

The South Carolina Supreme Court first applied the riparian doctrine in 1835 despite the court's misquotation of a passage from Kent's Commentaries on the subject.[2] In *Omelvany v.Jaggers* the court rejected the contention that the first person to erect a mill on a water course acquired a superior right by a prior occupancy to the use of the water course. The court, in quoting only a portion of Kent, set forth what appeared to be the natural flow theory of riparian rights:

> Every proprietor of lands on the banks of a river, has naturally an equal right to the use of the water which flows in the stream adjacent to his lands, as it was wont to flow . . . without diminution or alteration. No proprietor has a right to use the water to the prejudice of other proprietors above or below him, unless he has a prior right to divert it, or a title to some exclusive enjoyment. He has no property in the water itself, but a simple use of it while it passes along . . . . Without the consent of the adjoining proprietors, he cannot divert or diminish the quantity of water which would otherwise descend to the proprietors below, nor throw back the water upon the proprietors above, without a grant, or an uninterrupted possession of twenty years, which is evidence of it.[3]

By 1901[4] the court clearly had rejected the natural flow theory in favor of a form of the reasonable use doctrine, at least to the extent that a riparian owner had no absolute right to have a flow of a stream maintained in its natural volume or purity, stating:

> But as between different proprietors on the same stream, the right of each qualifies that of the other, and the question always is not merely whether the

lower proprietor suffers damage by use of the water above him, or whether the quantity flowing on is diminished by the use, but whether, under all of the circumstances of the case, the use of the water by one is reasonable and consistent with a correspondent enjoyment by the other.[5]

While reasonable use considerations have been applied in a series of earlier cases involving detention of water to the detriment of upstream riparians,[6] the court in *White v. Whitney Mfg. Co.* viewed the reasonable use doctrine as a settled proposition of law.[7] The court has referred to its statement in *White* in subsequent cases,[8] such that the decision must be considered the leading South Carolina case on the riparian, reasonable use doctrine.

That what constitutes a reasonable use is a question of fact for a jury determination may be taken as a settled proposition. Such has been held in cases involving detention of natural flow,[9] detention of freshet and normal flow,[10] detention of flow generally,[11] pollution from mine tailings,[12] and pollution from sewage.[13] In considering these matters, the juries were instructed to examine all the circumstances surrounding the alleged damage, including: (l) the capacity of the stream, (2) the adaptation of machinery to the stream, and (3) the general usage and custom in the area.[14] At least one author views these factors as rather elementary in comparison to other jurisdictions where the reasonable use doctrine has been more fully developed.[15]

The extent of the right to use water, based upon the reasonable use doctrine, has not been explored sufficiently in South Carolina decisions to provide a reliable basis for judging the merits of contemporary water use controversies.[16] Serious riparian litigation has been dormant in state courts since 1920.[17] However, several very general observations can be made concerning the extent of the reasonable use doctrine from the limited number of reported cases.

The majority of riparian actions in South Carolina involve private versus commercial users; half involve pollution. Domestic, agricultural, or irrigation uses have been accorded no special preference over other uses, there being no decisions in these areas.[18]

Apparently, the discharge of waste, mine tailings, or pollution is not considered unreasonable *per se* under the South Carolina decisions. In *United States v. 531.13 Acres of Land,* [19] the court of appeals quoted approvingly from an earlier state case on the subject:

> Owners of land on the banks of a stream are entitled to the reasonable use of a stream; that they can use the stream for their own purposes to a reasonable extent; that while it is true that a stream must not be polluted, still this does not mean that nothing can be put in the stream; but that nothing can be put therein that will deprive the landowners below to the reasonable use of the stream.[20]

Nonetheless, such uses have consistently been held unreasonable and subject to injunction.[21] Several cases, however, demonstrate the tendency of the court and the bar to avoid reasonable use determinations, relying instead on the more customary nuisance doctrines.[22] Taken as a whole, the South Carolina decisions involving pollution by upstream riparians indicate rather uniformly that juries find such use unreasonable.

Many of the cases in which quantity issues were in conflict, as the right to detain and release water or to flood lands above or below, also found uses to be unreasonable. In *White v. Whitney Mfg. Co.*,[23] the detention of water by an upstream riparian for power generation was held unreasonable. The court, in *McMahon v. Walhalla Light and Power Co.*,[24] held as a construction of law that downstream riparians are under no obligation to pond waters in such a way as to put them to beneficial use as a condition of the rights afforded them under the reasonable use rule. In this case, the defendant constructed a dam above plaintiff's mill for the purpose of power generation. Waters were detained and released but not diverted. The court refused the defendants charge that lower proprietors must use due care in the construction and operation of their mill in, ". . such a manner as would be adopted by a man of ordinary reason, diligence and judgment in such matters, before he can be heard to complain of the use of the waters of the stream for a like purpose by persons above him."[25] In a 1915 decision, the court held that a lower riparian who owned both banks of a non-navigable stream was entitled to use a ford without interference from the detention and release of waters from an upstream power dam.[26] The foregoing series of cases have been cited as protecting natural flow rights, reasonable use notwithstanding.[27]

To reemphasize an earlier point, the number and vintage of reasonable use cases recorded in South Carolina prohibit a reliable assessment of what may or may not constitute reasonable uses today. In general, the cases have considered pollution and detention for power production unreasonable uses of water under a variety of circumstances. More than one writer has considered the differences between natural flow and reasonable use theories in South Carolina to be somewhat exaggerated, if existent.[28] It has further been charged, in the application of the reasonable use doctrine in South Carolina, that, ". . . the use of water is spread so thinly among so many people that, generally speaking, no one can beneficially use it."[29]

Several other fundamental limitations on riparian rights, as practiced in South Carolina, should be mentioned. A riparian right originates by reason of ownership of land abutting or contiguous to a natural watercourse. Existence of a watercourse, and the definition of it, distinguishes the field of law dealing with diffused surface waters and the field of riparian rights.

While not free from apparent inconsistent decisions,[30] the court has provided a definition of "watercourse" which has been applied in the most recent diffused surface water controversies:

> To constitute a watercourse, there must be a stream usually flowing in a particular direction, though it need not flow continually. It may sometimes be dry. It must flow in a definite channel, having a bed, sides, or

banks, and it naturally discharges itself into some other stream or body of water. It must be something more than mere surface drainage over the entire face of a tract of land, occasioned by unusual freshets or other extraordinary causes . . . . It is essential to the existence of a watercourse that there should be a well-defined bed or channel, with banks. If these characteristics are absent, there is no watercourse, within the legal meaning of the term. Hence natural depressions in the land through which surface water from adjoining lands naturally flows are not watercourses.[31]

Overflow from the banks of a watercourse caused by flood or freshet is considered part of the watercourse if the waters return to the watercourse upon recession of the flood or freshet.[32]

Whether a watercourse is navigable or non-navigable appears to have little, if any, bearing on the existence of riparian rights in South Carolina.[33] No cases seem to draw such a distinction. Although subject to the State's navigational servitude or ownership of the beds of navigable watercourses to the mean or ordinary high water lines, the fastland owners adjacent to navigable watercourses are not deprived of access or other riparian rights.[34]

While well established that riparian rights accrue to the owner of lands contiguous to a watercourse, no South Carolina decision has further explored the limitations on the extent of riparian ownership. It might be assumed that riparian ownership would be confined to the watershed of origin; however, no case has addressed such limit. Other questions pertaining to the acquisition or transfer of riparian rights also remain unanswered. The "chain of title" or "unity of title" theories, though of doubtful application, have not been argued.[35] Nor has the severability of riparian lands or title been tested.[36]

The acquisition of rights to use water by prescription has been addressed in one early case, establishing that an adverse use of water for twenty years against successive owners of the servient soil is sufficient to establish a prescriptive right.[37] The case is more interesting because the claimant established a prescriptive right to the entire flow of the watercourse in question.

Although the statement of the reasonable use doctrine applied since *White v. Whitney Mfg. Co.* [38] includes a requirement that water diverted from a watercourse be returned, after reasonable use, to the watercourse before leaving the riparian's property, no case clearly confirms the common law prohibition of interbasin, or interwatershed, transfer. Absent such decision, interbasin transfers presumably would result in actionable violation of downstream riparian rights.[39] Despite this uncertainty, the General Assembly of South Carolina has enacted several local acts, dealing with particular municipal water supply problems, which purport to authorize the diversion of water from one watershed to be used and discharged into another watershed.[40] Generally the diversions are by nonriparians for use on nonriparian lands. Some of the acts specifically recognize the right of the riparians to the water being diverted and inferentially allow suit to be brought against the diverting municipality or industry.[41] Others are silent as to the rights of riparians.[42]

Despite the apparent ease in obtaining such legislative recognition, in general, municipalities have planned or implemented interbasin transfers with little regard to the possible consequences. It is quite common and often most practical for a waterworks system to withdraw water from one watershed, process it, and distribute it to another watershed for use, treatment, and discharge.[43] No reported case has considered either the enactment and results of the above acts or any municipal interbasin transfer for water supply purposes. Whether interbasin transfer for public purposes constitutes a reasonable use, when such waters are used on nonriparian lands, has not been determined.[44]

Due to the abundance of surface water in many areas of South Carolina, even large withdrawals, unreasonably used, might not produce injury of sufficient substance to justify suit. The court, in the case of *Chalk v. McAlily,* [45] cautioned riparians not to complain of insubstantial injury and stated that a legal injury does not arise absent "appreciable damage."[46]

With the exception of certain statutes affecting ground water, as will be discussed later, few legislative enactments alter or tend to alter riparian doctrines in South Carolina. The State's pollution laws,[47] however, could exert substantial influence in a riparian's choice of remedies in a water use controversy involving pollution caused by upstream proprietors. In addition to the regulatory activities of the State in setting the quantity and quality of discharges,[48] the pollution statute provides its remedies in addition to remedies afforded a riparian under the reasonable use doctrine:

> It is the purpose of this chapter to provide additional and cumulative remedies to abate the pollution of the air and waters of the State and nothing herein contained shall abridge or alter rights of action in the civil courts or remedies existing in equity or under the common law or statutory law, nor shall any provision in this chapter be construed as estopping the State, persons or municipalities, as riparian owners or otherwise, in the exercise of their rights under the common law, statutory law or in equity to suppress nuisance or to abate any pollution.[49]

Apparently, a riparian would have a cause of action based upon the "reasonableness" of a discharge, despite such discharge being permitted or otherwise not in violation of State water quality standards.

Several statutes limit or regulate the erection of dams or the backing up or overflowing of water dams.[50] Other provisions prohibit obstruction of navigable waters and require land owners to clean obstructions from streams.[51] The latter statutes have been wholly unenforced in recent times and are riddled with, possibly, unconstitutional local exceptions.[52]

Beyond Federal permitting requirements, the State regulates construction activities, although not water withdrawals, in the navigable waters and wetlands of South Carolina.[53] Occasionally, low-flow discharge conditions are imposed upon permits for impoundments in navigable waters. No other State enactments appear to have regulated instream flows.

Several laws provide general emergency powers to the South Carolina Department of Health and Environmental Control and the Governor.[54] Whether such statutes are broad enough to be used to allocate waters in time of shortage and emergency is doubtful, such statutes having been untested in court.

The foregoing discussion outlines the state of the riparian doctrine in South Carolina as it applies to surface waters. Any discussion of the riparian doctrine as it may be applied in a contemporary water use controversy in South Carolina entails much speculation. Many important aspects of the reasonable use doctrine and limitations on riparian ownership have not been addressed in State decisions. The principle unanswered questions appear to be:

(1) What is the extent of riparian ownership? Is it confined to the watershed of origin? Is the right severable?

(2) Is the interbasin transfer of water, with or without legislative sanction, a violation per se of riparian rights? Can an interbasin use of water be acquired by prescription?

(3) Given the tendency of the court to protect natural flow rights, what industrial or irrigation uses of water might be found reasonable? Is a public use of water out of the watershed a reasonable use?

DIFFUSED WATERS

Since 1893,[55] South Carolina has adhered to the common enemy rule in dealing with diffused surface waters. In adopting the common enemy rule, the court rejected theories requiring reasonable use considerations, stating:

> Under the common law rule, surface water is regarded as a common enemy, and every landed proprietor has the right to take any measure necessary to the protection of his own property from its ravages, even if in doing so he throws it back upon a coterminous proprietor to his damage . . . .[56]

The application of the common enemy rule to diffused surface water was reaffirmed by the court six years later in the case of *Baltzeger v. Carolina Midland Ry.*,[57] the leading case on the subject. The rule applies only to controversies involving diffused waters, not to natural watercourses.

The distinguishing features of a watercourse, so as to separate it from diffused water, are that it must flow in a definite channel; have a bed, sides, or bank; usually flow in a particular direction; and naturally discharge itself into some other stream or body of water. A more detailed definition was discussed previously.[58]

The application of a strict common enemy rule to diffused water controversies is extreme and often has been criticized.[59] The rule in South Carolina, however, has been modified to some extent. One exception to the strict common enemy doctrine in South Carolina is that a landowner must not deal with his diffused surface water in a manner so as to constitute a nuisance. The court in *Baltzeger*[60] found the right of a landowner to deal with diffused waters:

> . . . is subject to the general law in regard to nuisances, if its accumulation has become a nuisance *per se*, as for example, whenever it has become dangerous at all times and under all circumstances to life, health or property.[61]

The court further indicated that even if a nuisance *per se* was not established, recovery could be based upon private as opposed to public nuisance. This required a showing of special damage, different in kind and degree from damage that would be sustained by the public generally. The fact situation of the case, however, showed the rather limited availability of the nuisance exception. The defendant railroad constructed an embankment causing the ponding and subsequent stagnation of water on the railroad's property. The ponded water allegedly emitted gases which poisoned the air, leading to the death of the plaintiff's daughter. The court found the allegations insufficient to show nuisance *per se* because the stagnant water was not within the above quoted rule, and the fact that the plaintiff's daughter had died because of the noxious gases was not a kind of special damage which might not be expected to be sustained by the public as a whole.[62]

Three subsequent cases, all involving flooding by diffused waters, seem to confirm the inability of landowners to show damages sufficient to fall within the nuisance exception.[63] Two more recent cases have sustained verdicts based upon the nuisance exception, however, on rather narrow grounds, such that the practical availability of the nuisance exception is still in question.[64]

Another exception to the common enemy rule is that diffused water cannot be collected into an artificial channel and cast upon another's land in concentrated form.[65] The exception seems to rest on the premise that diffused water becomes the property of the owner and that he may not dispose of his property to the injury of another.[66] As one author points out, however, the exception seems to reverse several basic elements of the common enemy rule, i.e., that diffused water is an intruder, not subject to ownership, and that the upper proprietor may fight off the intruder in any effective way.[67]

While the court in *Branderberg v. Zeigler*[68] drew a distinction between casting water upon another's land and preventing the flow of diffused water upon your own land, at least one other case suggests the application of the exception to a lower landowner who would dam the flow of diffused water and thus throw it back upon his upper neighbor.[69]

While some cases suggest the applicability of negligence or reasonable use considerations in dealing with diffused water controversies,[70] the overwhelming majority of cases reject negligence and reasonable use concepts.[71] The rejection of these doctrines and of the restricted availability of the nuisance and "casting in concentrated form" exceptions leave the common enemy rule relatively intact in South Carolina.[72]

Municipalities, due to their sovereign status are governed by different principles. While municipalities and other governmental agencies are immune from suit in many situations, the General Assembly has chosen to remove sovereign immunity with regard to drainage of diffused surface waters. A general statute[73] authorizes the institution of a civil action against a municipality for actual damages sustained by causing surface water to be drained from public streets across private property. The statute requires the landowner to demand that the municipality provide proper drainage before such landowner may bring suit; moreover, the statute authorizes municipalities to condemn private property if the necessary drains cannot be maintained along or under the public street.

A good example of the operation of the statute is found in *Hall v. City of Greenville*,[74] wherein the Court reversed the lower court's granting of a nonsuit (essentially, a dismissal for failure to prove the allegations of the complaint), to the city and ordered a new trial. In *Hall*, the city made various street improvements uphill of several property owners in the Meadow Bottom area near the Reedy River. The property in question was situated in a lowlying area and was periodically subjected to flooding by the river during heavy rains. Several large drainage ditches or canals ran around and through the area to the river, some of which were natural drains while others had been intentionally relocated. The case was further complicated by the City Board of Health in ordering the affected residents to vacate certain houses after finding them unfit for human habitation.

The Supreme Court held that sufficient facts were presented so that a jury could have decided whether the city's improvements to the area's streets were the cause of increased drainage over the landowners' property and the cause of water to overflow the drainage ditches. The landowners had also presented evidence that the Board of Health's action was the result of increased flooding from the City's street improvements. Finally, and perhaps most important, the Court held that proof of negligence by a municipality is not necessary in order to recover damages. Municipalities, by virture of the statute discussed above, are generally held to higher standards of care than private persons in matters of surface-water drainage connected with street construction and improvement.

GROUND WATER

Research has revealed no reported cases governing the use or ownership of ground water in South Carolina. Some writers have speculated that the English concept of absolute ownership might be applied by the South Carolina Supreme Court, at least in a private ground-water controversy.[75] However, given the total absence of decisional law, the court could adopt a qualified English rule or a doctrine based upon reasonable use or correlative rights.[76] Any distinction in the rules of law applying to underground streams as opposed to percolating water has not been explored.

Prompted by fears of water level declines and saltwater intrusion in the coastal areas of the State, the South Carolina General Assembly enacted the Ground Water Use Act of 1969.[77] Based upon a similar North Carolina statute,[78] the act requires that the water resources of the State be put to beneficial use, subject to regulation to conserve, provide, and maintain conditions which are conducive to the development and use of water resources.[79]

The act authorizes the South Carolina Water Resources Commission to establish, after required studies, a "capacity use area." In such an area, permits are required to withdraw ground water in excess of 100,000 gallons per day for any purpose.

A capacity use area is defined as any area where the Commission finds that the aggregate uses of ground water in or affecting the area:

(1) Have developed or threaten to develop to a degree which requires coordination and regulation, or

(2) Exceed or threaten to exceed or impair the renewal or replenishment of the ground water.[80]

The wording appears sufficiently broad to include both areas of immediate concern and recharge areas within a single capacity use area.

Upon the evidence of an investigation and if the facts so justify, the Commission may adopt an order establishing a capacity use area.[81] Notice and hearings are required prior to effective declaration.[82] After such a declaration, regulations are promulgated—again after notice and hearings—applying to the area declared.[83] The act directs the Commission to consider regulations specifying:

(1) Water use reporting requirements;

(2) Timing of withdrawals;

(3) Provisions to protect against or abate saltwater encroachment;

(4) Provisions to protect against or abate unreasonable adverse effects on other water users in the area; and

(5) Well depth and spacing, pumping levels, and maximum pumping rates.[84]

Water use permits are required in capacity use areas for withdrawals in excess of 100,000 gallons per day.[85] If the use is non-consumptive, a permit may be issued without a hearing.[86] Virtually all uses would be consumptive uses; however, non-consumptive use is defined as:

> . . . water withdrawn from a groundwater system or aquifer in such a manner that it is returned to the groundwater system or aquifer from which it was withdrawn without substantial diminution in quantity or substantial impairment in quality at or near the point from which it was withdrawn.[87]

In determining whether a use is consumptive, the Commission may take into consideration whether the applicant has adequately compensated other water users in the area who have sustained injury by reason of the reduction of water pressure in the aquifer.[88]

In considering permit applications, the Commission is required to consider:

(1) The number of persons using an aquifer and the object, extent and necessity of their respective with-

drawals or uses;

(2) The nature and size of the aquifer;

(3) The physical and chemical nature of any impairment of the aquifer, adversely affecting its availability or fitness for other water uses (including public use);

(4) The probable severity and duration of such impairment under forseeable conditions;

(5) The injury to public health, safety or welfare which result if such impairment were not prevented or abated;

(6) The kinds of businesses or activities to which the various uses are related;

(7) The importance and necessity of the uses claimed by permit applicants, or of the water uses of the area and the extent of any injury or detriment caused or expected to be caused to other water uses (including public use);

(8) Diversion from or reduction of flows in other water courses or aquifers; and

(9) Any other relevant factors.[89]

Procedures for permit administration are provided, including provisions for notice, hearings, and judicial review.[90] Penalties and injunctive relief are provided.[91]

Taken as a whole, the Ground Water Use Act suggests a reasonable use doctrine imposed through state-issued ground water use permits. In addition to the requirement that the Commission protect against unreasonable effects of water use by one person against others,[92] the agency must take into consideration the extent to which water use, prior to the declaration of capacity use, was "reasonably necessary" to meet the users' needs.[93] The Commission may also consider any prior investment of users in obtaining ground water in the issuance of a permit.[94]

The act recognizes the interrelationship between surface water and ground water; however, it provides contradictory authorities regarding regulation in this area. A required consideration in regulation drafting and permit decisions is the impact of the proposed withdrawal on the diversion from or reduction of flows in other watercourses or aquifers.[95] Elsewhere, the act provides:

> Nothing contained in this chapter shall change or modify existing common or statutory law with respect to the rights of the use of *surface water* in this State [Emphasis added].[96]

Presumably, ground-water withdrawal which affects surface supplies is within the scope of the act. Regulation of surface waters which might impact a capacity use area, or the users in such an area, is apparently prohibited. Problems of saltwater encroachment or intrusion from overdevelopment or improperly located, designed, or abandoned wells are addressed.[97]

As noted in the introduction to this section, water law is much misunderstood, and probably no aspect of water law is more misunderstood than that applicable to ground water. The Ground Water Use Act is a commendable first step in establishing ground-water law; however, further delineation and clarification is warranted to avoid possible social disruption due to uncertainty in the law.

NAVIGABLE WATERS

A common right or servitude in the public to freely use the navigable waters of South Carolina is well established; however, what constitutes navigable waters is less clear. The right is declared and protected both in the South Carolina Constitution[98] and in legislative enactment.[99] Such a servitude exists regardless of the ownership of the banks or bed of a navigable stream, whether public or private.[100] The public right of navigation, as well as the right of fishing[101] in navigable waters, is superior to any rights that might be possessed by the riparian owners.[102]

The extent of the servitude embraces not only that which is actually used, but that which is susceptible to use for navigation in its ordinary state.[103] Navigable, though artificial, canals connected to, or improving navigation on, otherwise navigable waters may be impressed with the public servitude over those waters.[104]

Obstruction of navigable waters may be abated as a public or private nuisance.[105] Early South Carolina decisions provided that absent a showing of special or peculiar damage, differing in kind to that which all others in common might suffer, the remedy for removal of an obstruction on a navigable waterway was by indictment only.[106] The court in *State* v. *Water Power Co.* apparently reversed earlier decisions, commenting that the remedy at law by indictment is always available for the abatement of a public nuisance, but is not always exclusive or adequate and that an action in the court of equity for injunction is appropriate.[107] In this case the court upheld the use of injunctive relief against a permanent obstruction to a navigable canal, stating:

> The State, as a sovereign, holds the property right of unobstructed navigation of the navigable waters of the State in trust for the people of the State and of the United States. This is a property right of great value. It is well established that an individual has a right to injunction against threatened, repeated, or continued injury to his property rights. For a greater reason has the State, as trustee for the people, a right to the intervention of the Court to protect the valuable right of navigation.[108]

The construction of a dam across a navigable waterway is not a nuisance *per se* if authorized by the legislature.[109] The legislature, while having the power to authorize the construction of an impoundment across a navigable stream by a private person, has no power to release that person from liability for damages created by a nuisance.[110] Whoever constructs a dam or bridge in or over a stream must exercise reasonable and prudent care and must consider the natural flow of the stream and its usual freshets and occasional "great floods."[111] The owner of a dam is required to exercise ordinary care in the operation and maintenance of the dam to avoid injury to those upstream and downstream.[112]

The court has extensively reviewed the powers of the State to take, use, or modify the navigable waters of South Carolina for public purposes:

> The waters of the ocean and its bays, and of public

watercourses and lakes, so far as they lie within the jurisdiction of a state, are part of the public domain, and the state may authorize the diversion of such waters for any purpose it deems advantageous to the public, without providing compensation to riparian proprietors injuriously affected. Such diversion is not a taking of private property by eminent domain, but a disposition by the public of the public property.[113]

The powers of the State in the exercise of the navigation servitude coincide with those of the Federal government, and although the rights and powers of the Federal government with respect to waters subject to interstate commerce are paramount, the powers of the State remain in full force and effect, unless and until Congress acts upon the subject.[114] These powers exist regardless of ownership:

The right of the sovereign, in the exercise of the navigation servitude, to take or damage or destroy private property without obligation to compensate therefore extends to the bed of the navigable stream, i.e., to mean high water mark on either bank—and no farther; for damage beyond that boundary the Constitution requires just compensation.[115]

What constitutes a navigable waterway so as to raise a servitude or easement in the public in South Carolina is not completely free from doubt. The court recognized in an early decision that the, ". . . term navigable is equivocal,"[116] although subsequent cases lend little assistance in clarifying what is navigable.

The Code of Law of South Carolina, 1976 provides that all streams which are capable or can be made capable of being navigated by "rafts of lumber or timber" by removal of accidental obstructions and all navigable watercourses or cuts are declared navigable waters of the State.[117] Although in a 1903 Federal decision the circuit court held this statute to be declarative of existing law,[118] it seems by no means clear what law the court considered it declarative of. Nonetheless, the statute, as the only legislative pronouncement on the subject, has been used by the State both in determining the extent of public navigation for permit purposes[119] and in determining ownership of the beds of non-tidal navigable waters.[120]

The Federal test for determining the navigable waters of the United States subject to the paramount powers of Congress has been rejected by the South Carolina Supreme Court in cases involving local issues.[121] The strict conception of the common law test, i.e., tidal influence, has likewise been rejected by the court as a test of navigability.[122]

In the 1894 case of *Heyward* v. *Farmer's Mining Co.* [123] the court extensively reviewed the various doctrines determining which waters may be considered navigable-in-fact, finding that a stream should have sufficient depth and width of water to float useful commerce;[124] that neither the character of the craft nor the relative ease or difficulty of navigation are tests of navigability;[125] that the test is navigable capacity and surroundings have no bearing on the question;[126] that if water is navigable for pleasure boating it is navigable;[127] and that the purpose of navigation is not a subject of inquiry but the fact of the capacity of the water for use in navigation establishes navigability.[128] While both the "log raft" test under the statute and the navigation-in-fact tests as pronounced by the court are somewhat subjective and are questions to be determined by the trier of fact, in practical application it would be difficult to distinguish between the tests.

Another line of cases, however, offers an additional test of which waters are considered navigable based upon the individual declarations of navigability made by the legislature. Apparently, those streams which have been declared navigable by act of the General Assembly and made or kept navigable by expenditure of public moneys are recognized as navigable by the courts,[129] at least to the extent that they are viewed as public highways.[130] Whether such legislative declarations would find favor in contemporary litigation is not known.

OWNERSHIP OF SUBMERGED LANDS

The issue of tidelands ownership represents a most significant and difficult water-oriented area of litigation in South Carolina. The claim of the State to those lands lying between the mean high and mean low water lines on the coast, an area of perhaps a half million acres, has been hotly contested by coastal landowners. While public ownership of tidelands and submerged lands appears to have been a well-settled common law doctrine, vast areas of the coast throughout the eighteenth century were cultivated for growing rice. While rice cultivation ceased many years ago, the tidal areas are still considered valuable for waterfowl habitat, by maintaining old rice impoundments or constructing new impoundments. The tideland cases, typically actions to clear title, are initiated primarily to establish whether the use of the tidelands is exclusive or public.

Because of the great amount of literature devoted to the subject,[131] the complexity of issues, and the view that tidelands ownership is governed by property rather than water law doctrines, only a brief summary of existing case law will be presented here. The leading case in South Carolina is *Cape Romain Land Imp. Co.* v. *Georgia-Carolina Canning Co.*,[132] a trespass action to determine whether the plaintiff or defendant had the right to harvest oysters on a large tract of land between the high and low water lines of tidal and navigable waters. The plaintiff, claiming title, relied upon several grants from the State—the defendant on oyster leases granted by the State. The court, in holding for the defendant, stated:

The title to land below the high water mark on tidal navigable streams, under the well settled rule, is in the State not for purpose of sale, but to be held in trust for public purposes.[133]

Any doubt as to the applicability of the rule has been eliminated by its subsequent reaffirmation.[134]

The *Cape Romain* decision does not stand for the proposition, however, that tidelands are not capable of private ownership. If a grant to such lands from the State, or the State's predecessors in title (the King of England or Lords

Proprietors) can be produced and traced in a direct and unbroken chain to the claimant, private ownership can be made out.[135] Because virtually all of the coastal area of South Carolina was settled, and thus granted, prior to Independence, most tidelands claimants can produce a royal or proprietory grant of some nature. The more recent tidelands cases involve the construction of such grants.

Because of the nature and public importance of tidelands, submerged lands, and lands beneath navigable waters, they are held by the State in trust, in a fiduciary rather than proprietary capacity.[136] As such, grants purporting to convey such lands are construed strictly in favor of the State and against the grantee.[137]

The State comes to court with a presumption of title, that it did not grant away public domain lands:

> A deed or grant by the State of South Carolina is construed strictly in favor of the State and general public and against the grantee . . . . The (State) comes into court with a presumption of title and if the appellant is to prevail she would have to recover upon the strength of her own title of which she must make proof.[138]

General words will convey lands only to the mean high water line:

> Under well settled rules of construction naming such boundaries ("inlet," "sound or creek") will convey land only to the high water mark in the absence of specific language, either in the grant or upon a plat showing that it was intended to convey land below the high water mark.[139]

The location of the mean high water line is a question of fact for jury determination.[140] As such, the method of determining and presenting evidence of this line to the trier of fact is often critical in tidelands litigation. Doctrines pertaining to the applicability of adverse possession or presumption of grant to the tidelands are not settled.

The tidelands cases involve the ownership of tidally-influenced lands, whether fresh or salt.[141] No authoritative decision can be cited as to the ownership of the beds of non-tidal navigable rivers. From the tidelands cases, it is unclear whether the public is presumptively the owner of the beds of navigable waters or merely tidal waters. One recent case, however, affirmed on other ground a lower court holding that the State is the owner of the beds of non-tidal navigable streams.[142]

The ownership and use of tidelands and lands beneath navigable waterways are issues which continue to generate controversy. The State Attorney General has consistently held that filling for private purposes below the mean or ordinary high water lines in tidal and navigable streams constitutes an alienation or taking of public properties for private use. These issues will undoubtedly result in future action by the courts and, perhaps, the General Assembly.

PUBLIC ACCESS

Public ownership of tidelands assures public use on those areas between the mean high and mean low water lines. However, such public ownership does not necessarily imply a right in the public to cross highlands to gain access to the tidelands or navigable waters.[143]

Beyond those access points owned by or clearly dedicated to the public, acquisition of public access rights by prescription has been difficult based upon prevailing South Carolina decisions.[144] Beyond the required use for the statutory period, the public, to acquire a prescriptive right for access, must do so adversely. The court in several cases apparently presumed any public use of a landing or access road was with the permission of the landowner, thus strictly viewing the requirement for adverseness.[145]

More recent decisions, however, indicate that the court is more receptive to the public's claim of right, either by prescription or implied dedication, especially when the use is customary or well known.[146]

STATUTORY AND ADMINISTRATIVE MECHANISMS AFFECTING WATER

State[147]

S.C. Water Resources Planning and Coordination Act

The South Carolina Water Resources Planning and Coordination Act,[148] enacted in 1967, established a committee (later amended to Commission) with the overall responsibility of formulating and establishing a comprehensive water resources policy. The Commission of eighteen members is structured to represent a broad cross-section of water interests. Ten members are appointed by the Governor, as follows: three represent agriculture; three represent industry; three represent municipalities; and one represents saltwater interests. The remaining eight members serve in an *ex-officio* capacity, representing the following state agencies: Department of Agriculture, Department of Health and Environmental Control, Wildlife and Marine Resources Commission, State Forestry Commission, Land Resources Conservation Commission, State Development Board, Department of Highways and Public Transportation, and Clemson University Water Resources Research Institute.

The authority of the Commission is noteworthy, in addition to specific regulatory functions, because of the broad latitude granted the Commission to advise and assist the Governor and General Assembly in virtually every aspect of State water concern. The Commission's general, non-regulatory powers include:

The Commission shall advise and assist the Governor and the General Assembly in:

(1) Formulating and establishing a comprehensive water resources policy for the State, including coordination of policies and activities among the State departments and agencies;

(2) developing and establishing policies and proposals designed to meet and resolve special problems of water resource use and control within or affecting the

State, including consideration of the requirements and problems of urban and rural areas;

(3) reviewing the actions and policies of state agencies with water resource responsibilities to determine the consistency of such actions and policies with the comprehensive water policy of the State and to recommend appropriate action where deemed necessary;

(4) reviewing any project, plan or program of Federal aid affecting the use or control of any waters within the State and to recommend appropriate action where deemed necessary;

(5) developing policies and recommendations to assure that the long range interests of all groups, urban, suburban, and rural, are provided for in the State's representation on interstate water agencies;

(6) recommending to the General Assembly any changes of law required to implement the policy declared in this act; and

(7) such other water resources planning, policy formulation and coordinating functions as the Governor and the General Assembly may designate.[149]

Ground Water Use Act of 1969

The Ground Water Use Act of 1969[150], administered by the Water Resources Commission, has for its primary goal the protection of the present and future integrity of ground-water supplies throughout South Carolina. The primary tool of the Act is the creation of capacity use areas in response to existing or potential threats to ground-water availability. To date, only two capacity use areas have been declared. The Waccamaw Capacity Use Area includes Horry and Georgetown Counties and the Brittons Neck area of Marion County. The Low Country Capacity Use Area includes Beaufort, Colleton, and Jasper Counties and Edisto Island in Charleston County. Within these areas, no person may withdraw an excess of 100,000 gallons of ground water a day without first obtaining a permit from the Commission. Regulations are developed individually for each capacity use area.

S.C. Water Use Reporting and Coordination Act

The South Carolina Water Use Reporting and Coordination Act[151], enacted in 1982, requires every user of 100,000 gallons of water or more a day to file a water use report with the Water Resources Commission. Reports, to be filed annually by agricultural water users and quarterly by all others[152] include the following types of information: (1) identification of sites or facilities where water is used, obtained, and discharged; (2) location of water wells; (3) capacity of withdrawal pumps or structures; (4) total amount of water used; (5) water storage and treatment capacity; (6) method used to determine the amount of water used; and (7) general nature of the use made of the water. The general purpose of the program as specified in the Legislative findings in the Act is to establish a systematic coordinated program to collect information on ground and surface-water use to enable State agencies to provide services to both private and public sectors of the State.[153] In addition to water use information, the Act requires submission of a drillers well log to the Commission for any new water well constructed, having a casing diameter of four inches or greater.[154] Regulations implementing the program became final on May 19, 1983, following review by the General Assembly.[155]

Dams and Reservoirs Safety Act

The Dams and Reservoirs Safety Act[156] declares its purpose as follows;

> It is the purpose of this article to provide for the certification and inspection of certain dams in South Carolina in the interest of public health, safety and welfare in order to reduce the risk of failure of such dams; to prevent injuries to persons and damage to property; and to confer upon the Land Resources Conservation Commission the regulatory authority to accomplish such purposes.[157]

While a dam or reservoir owner remains solely responsible for maintaining his dam or reservoir in a safe condition, the Land Resources Conservation Commission, following appropriate investigation, may order a dam or reservoir owner to undertake maintenance, alteration, repair, or removal as necessary upon the dam or reservoir if unsafe and dangerous to life or property. Dams which are under twenty-five feet in elevation or impound less than fifty-five acre feet of water are not ordinarily regulated except where the dam has a hazard potential that may cause loss of human life in the event of dam failure or improper reservoir operation.[158]

S.C. Coastal Council

The South Carolina Coastal Council was created in 1977 to coordinate, review, and regulate certain activities within the State's coastal areas.[159] The Council is required to develop a comprehensive coastal management program and then to enforce and administer the program. In developing the program, the Council is required to: (1) consider all lands and waters in the coastal zone; (2) consider present land uses and coastal resources; (3) consider present and potential uses and conflicts and uses of coastal resources; (4) inventory areas of critical State concern; (5) conduct studies and surveys as necessary; (6) develop a streamlined and simplified permitting process; (7) review all State and Federal permit applications; and (8) consider and review, along with the Department of Health and Environmental Control, water quality standards and classifications. The Council exercises broad regulatory authority, as indicated in the following statute: "Ninety days after July 1, 1977, no person shall utilize a critical area for use other than the use the critical area was devoted to on such date unless he has first obtained a permit from the Council." Further, the Council is authorized to review all State and Federal permit applications for activities in the coastal zone[160] to certify consistency with the coastal management plan.

Navigable Waters Permit

Construction, dredging, filling, or alterations in State navigable waters require a permit from the State Budget and Control Board. The Board's permitting program is based upon statutes declaring a state navigational servitude and control of vacant State lands.[161] While permits are issued by the Board, the South Carolina Water Resources Commission has been designated as the coordinating agency for the program, assigned the duty of obtaining and reviewing comments from the public and interested State agencies, and recommending appropriate action to the Board on each application. In carrying out its responsibilities, the Commission, with the advice of the Attorney General, makes determinations as to the navigability of rivers and streams.[162] The Board's regulations allow for a comprehensive environmental review of each project in terms borrowed from the National Environmental Policy Act,[163] stating:

(1) The environmental impact of the proposed action on public lands or waters;
(2) Any adverse environmental effects which cannot be avoided should the proposal be implemented;
(3) Alternatives of the proposed actions;
(4) The relationship between local short-term uses of the public property and the maintenance and enhancement of long-term productivity;
(5) Any irreversible or irretrievable commitments of public resources which would be in the proposed action should it be implemented;
(6) Whether the activity is the kind of activity, assuming some environmental disruption, that would result in long-term benefit.[164]

Drainage

Title 49 of the *Code of Laws of South Carolina, 1976*, contains no less than four chapters concerned with drainage matters. The purpose of retaining so many apparently duplicative statutes in the present Code of Laws is not clear; moreover, the present day utility of the statutes is questionable in light of a separate body of statutes authorizing soil and water conservation districts.

Rights-of-way for Drainage. Sections 49-13-10 through 49-13-80[165] purport to authorize a land owner requiring drainage off his property to construct a waterway or ditch over adjoining lands to the nearest waterway. The statutes provide, in cases of refusal of adjoining owners to allow drainage, for notice to the adjoining owners, a board of referees, action by the board, compensation, damages, and appeal to the circuit court. These statutes or ones similar to them have been in existence since 1891; however, the statutes presently found in the 1976 Code of Laws were declared unconstitutional by the South Carolina Supreme Court in 1973,as authorizing the taking of private property for private use.[166]

Sanitation and Drainage Commissions. Sections 49-15-10 through 49-15-90[167] authorize the creation of sanitary and drainage commissions in any county, "To have and exercise exclusive control outside of the limits of incorporated cities and towns of and over all public drainage canals, ditches, drains, trunks, culverts, and similar works and the care and management thereof...."[168] The county commissions are also authorized to make surveys, alter and improve drains, utilize the county chain gang, condemn lands, and recover expenses from non-complying land owners.

Drainage or Levee Districts Under 1911 Act. Sections 49-17-10 through 49-17-1830[169] provide a comprehensive scheme for the creation of drainage or levee districts to accomplish the following legislative public interest declarations:

> It is hereby declared that the drainage of swamps, drainage of surface water from agricultural lands and the reclamation of tidal marshes shall be considered a public benefit and conducive to the public health, convenience, utility and welfare.
>
> * * *
>
> The provisions of this chapter shall be liberally construed to promote the leveeing, ditching, draining, and reclamation of wet and overflowed lands.[170]

The 1911 Act requires an extensive series of actions to establish a drainage district, including petitions to the Clerk of Court, boards of viewers, public hearings, appeals, surveys, assessments of damage, appointment of drainage commissioners, and construction of improvements. Basically, the Act taxes land owners who will benefit from the improvements for the cost of planning, constructing, and maintaining any such improvements.

Drainage Districts Under 1920 Act. Sections 49-19-10 through 49-19-2680[171] seek to accomplish goals similar to those in the 1911 Act; however, the 1920 Act pursues the goals in a slightly less cumbersome but more detailed fashion. Apparently, the Legislature intended the two acts not to conflict with one another as indicated in the first two sections of the 1920 Act:

> This chapter is declared to be remedial in character in purpose and shall be liberally construed in carrying out this legislative intent and purpose.[172]
>
> * * *
>
> This chapter shall be construed to be cumulative to the other laws of this State relating to the organization or incorporation of levee or drainage districts.[173]

The 1920 Act is short on declarations of intention and purpose but long on details as to the proper procedures by which a district is to undertake its business. Apparently, the purposes and goals of the 1920 Act are essentially identical to those of the 1911 Act.[174]

S.C. Water Pollution Control Act

The South Carolina Pollution Control Act[175] is South Carolina's basic law with regard to control of pollution of air and water resources. The purpose of the Act is stated in the following Legislative declaration:

> It is declared to be the public policy of the State to maintain reasonable standards of purity of the air and water resources of the State, consistent with the public health, safety and welfare of its citizens, maximum employment, the industrial development of the State, the propagation and protection of terrestrial and marine flora and fauna, and the protection of physical property and other resources. It is further declared that to secure these purposes and the enforcement of the provisions of this chapter, the Department of Health and Environmental Control shall have authority to abate, control and prevent pollution.[176]

The Act directs the Department of Health and Environmental Control to adopt standards indicating polluted conditions in water and air, which standards are part of the extensive regulations promulgated by the Department. Broad powers have been granted to the Department in order to carry out the fundamental purposes of the Pollution Control Act, including, but not limited to: (1) holding of public hearings; (2) assessment of penalties; (3) making, revoking, or modifying orders to discontinue the discharge of various wastes into State waters; (4) institution of court proceedings to acquire compliance with the Pollution Control Act; (5) issuance, denial, ratification, and suspension, of permits to discharge various wastes; and (6) implementation of the Federal Water Pollution Control Act in South Carolina. The Act makes the discharge into the environment of this State of various polluting substances unlawful, unless accomplished in compliance with the Department of Health and Environmental Control permitting standards.[177]

State Safe Drinking Water Act

The State Safe Drinking Water Act[178] seeks to protect the quality of the State's drinking water supplies. Two mechanisms are provided in an attempt to accomplish this goal. First, construction, expansion, or modification of public supply waterworks systems must be accomplished pursuant to a permit obtained from the Department of Health and Environmental Control.[179] Additionally, the Act provides the following standards and requirements to protect drinking water quality:

> In general, the design and construction of any public water supply shall be in accord with modern engineering practices for such installations. The Board (South Carolina Board of Health and Environmental Control) shall establish such rules, regulations, procedures or standards as may be necessary to protect the health of the public and to insure proper operation and function of public water supplies and water works systems.[180]
>
> * * *
>
> Any public water supply shall be adequately protected and maintained so as to continuously provide safe and potable water in sufficient quality and pressure and free from potential hazards to the health of the consumers.[181]

Second, the Act seeks to protect ground-water supplies through the regulation of all types of wells.[182] The Board is authorized to promulgate regulations, ". . . to insure that underground sources of drinking water are not contaminated by improper well construction and operation. . . ." The Act provides for an "Advisory Committee" to the Board, which committee is to develop standards for well construction, maintenance, operation, and abandonment.[183] The committee, which is composed of five well contractors, a registered professional engineer, a consulting hydrogeologist, a farmer, and three *ex officio* members, representing the Department of Health and Environmental Control, Water Resources Commission, and Land Resources Conservation Commission,[184] may recommend standards for all wells except those regulated by the Ground Water Use Act of 1969, statutes regulating oil and gas production, and the Water Use Reporting Act. The Act states, "For such excepted wells, the Board is authorized to adopt regulations as developed with the Water Resources Commission."[185] As of June 1, 1983, no final regulations have been approved pursuant to Advisory Committee recommendation; however, regulations do exist applying to public supply system water wells, promulgated prior to creation of the Advisory Committee.[186]

Soil and Water Conservation Districts Law

The Soil and Water Conservation Districts Law[187] declares its purpose, in part:

> And it is further declared to be the policy of the General Assembly to provide for the conservation of the soil and water resources of this state and for the control and prevention of soil erosion, and the prevention of floodwater and sediment damages, and for furthering the conservation, development, utilization, and disposal of water, and thereby to preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist and maintain the navigability of rivers and harbors, preserve wildlife, promote recreational development, provide water storage for beneficial purposes, protect the tax base, protect public lands and protect and promote the health, safety and general welfare of the people of this state.[188]

The goals of the Soil and Water Conservation Districts Law are carried out through the operation of the South Carolina Land Resources Conservation Commission, an agency with statewide responsibilities, and local soil and water conservation districts. The Commission is composed of five members, one each appointed by the Governor upon recommendation of the South Carolina Association of Soil and Water Conservation District Commissioners for five areas of the State specified in the law.[189] Generally, the powers of the Commission, among others, include the following: (1) assist local soil and water conservation districts in local programs; (2) provide information to local districts as to activities and experience in other districts; (3) coordinate all programs; (4) "coordinate the development of a statewide flood plain lands area inventory and to formulate guidelines for the conservation, protection and use of flood plain lands excluding tidelands and marshlands . . . ."; and (5) "coordinate the development of a statewide irrigable land inventory and to formulate guidelines for the conservation, protection and use of such lands. . . ."

The law further provides a detailed procedure for the creation of local soil and water conservation districts, including provisions for petitioning for the creation of such districts, hearings on such petitons, determination of need for such districts, referendum on establishment, and final establishment of the district. The powers of local districts are broad, encompassing many of the duties and powers of drainage districts as discussed hereinbefore.[190] The powers of local districts include, among others: (1) surveying and investigating soil erosion, flood water damage and preventive controls needed; (2) carrying out demonstration projects; (3) implementing preventive and control measures for flood prevention and disposal of water; (4) constructing and operating structures necessary to carry out all duties; and (5) developing comprehensive plans for soil and water resources conservation.[191]

Local districts are also authorized to formulate local land-use regulations which may be given the force and effect of law after proper promulgation, including a local referendum on proposed regulations.

Watershed Conservation Districts Law

Title 48, chapter 11, Code of Laws of South Carolina, 1976, provides for the creation of watershed conservation districts, which, when created, are political subdivisions of the State.[192] A watershed conservation district may be established within one or more soil and water conservation districts, following procedures similar to those for the establishment of local soil and water conservation districts. These procedures include petition for formation of a district, hearing, determination of commissioners, and a referendum.[193] The primary purpose of watershed conservation districts is to, ". . . construct, reconstruct, repair, enlarge, improve, operate, and maintain such works of improvement as may be necessary or convenient for the performance of any of the operations authorized by this chapter . . . ." Additionally, a watershed conservation district may acquire lands, easements, or rights-of-way through purchase, lease, gift, or condemnation. The district may borrow money, sue and be sued, and levy annual taxes.[194] The aforementioned powers may be used to develop and execute a program for, ". . . control and prevention of soil erosion, flood prevention, or the conservation, development and utilization of soil and water resources, and the disposal of water."[195]

Federal

Neither the United States Constitution nor the laws enacted by Congress directly attempt to dictate water rights in South Carolina, but the effect of court interpretations and actual application of both the Constitution and various statutes play a significant role in water resources considerations in South Carolina. The primary purpose of this water assessment is not to review and propose modification in Federal law; however, the multitude of Federal provisions ranging from grants for sewer construction to impoundment of significant rivers for hydroelectric power generation cannot be ignored. Federal activities may often carry implications beyond the intended purpose or scope of a particular action. For instance, the Federal government will shortly complete the impoundment of the entire Upper Savannah River in three major reservoirs, constructed for the primary purpose of power production. Even though the Federal government makes no overt attempt to allocate water in South Carolina, the total dominion over the Upper Savannah River by Federal authorities seriously impacts the ability of individuals, industries, agriculture, and municipalities to draw upon the vast water supply in the Upper Savannah Region for future development and growth.

The Federal government exercises numerous opportunities to involve itself in decision making regarding surface waters, primarily those waters affected by the Commerce Clause in the United States Constitution.[196] To date, none of the three branches of Federal government have sought to exercise control over ground water in any degree approaching involvement in surface water. However, recent decisions of the United States Supreme Court and a Federal District Court clearly state that, under appropriate circumstances, ground water may be covered by the Commerce Clause, providing the Federal government a sufficient basis to regulate ground-water use.[197]

With the above in mind, no attempt will be made to identify each Federal program or activity that affects water law and administration in South Carolina; rather, several Federal programs will be briefly discussed, which may be the Federal programs with the greatest present impact on water use decisions.

Federal Water Power Act

The Federal Water Power Act,[198] originally enacted in 1920, provides a comprehensive Federal scheme for the development of water power. Finding its power under the commerce clause of the Constitution, the authority of the Federal government in regard to water power on Federally navigable waterways preempts state authority within the same area. Powers which were formally exercised by the Federal Power Commission are now exercised by the Federal Energy Regulatory Commission, which is empowered to issue licenses for the construction and operation of power generating facilities on waterways subject to Federal jurisdiction. While the Commission possesses broad regulatory authority, in order to grant such a license the Commission must adhere to the following standard in reviewing proposed projects:

> Best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water-power development, and for other beneficial public uses, including recreational purposes.[199]

In reviewing proposed projects, the Commission will attempt to balance cost versus benefits, considering power production, aesthetic values, fish and wildlife, and recreation. The activities of the Federal Energy Regulatory Commission are very important in South Carolina, for the reason that licenses may be issued for periods up to fifty years, and South Carolina has a number of licensed projects in existence and numerous sites potentially subject to development.

Federal Water Pollution Control Act

Congress enacted the Federal Water Pollution Control Act[200] in 1972, subject in part to the following goals and policies:

> The objective of this act is to restore and maintain the chemical, physical, and biological integrity of the nations waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this act—
>
> (1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;
>
> (2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides recreation in and on the water be achieved by July 1, 1983;
>
> (3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;
>
> It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of states to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the administrator in the exercise of his authority under this act.
>
> * * *
>
> It is the policy of Congress that the authority of each state to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this act. It is the further policy of Congress that nothing in this act shall be construed to supersede or abrogate rights to quantities of water which have been established by any state. Federal agencies shall co-operate with state and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

The Water Pollution Control Act, extensively amended by the Clean Water Act in 1977[201] provides a comprehensive scheme to upgrade and protect the nation's water. While a thorough understanding of all parts of the act are necessary to realize the full impact of this law on activities in South Carolina, this assessment will restrict itself to briefly reviewing three important programs created by the act.

Section 401.[202] Section 401 is contained in Title IV of the act, dealing with permits and licenses. Section 401(a)(1) states the fundamental requirement of the section:

> Any applicant for a Federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may result in any discharge into the navigable waters, shall provide the licensing or permitting agency a certification from the State in which the discharge originates or will originate, or, if appropriate, from the interstate water pollution control agency having jurisdiction over the navigable waters at the point where the discharge originates or will originate, that any such discharge will comply with the applicable provisions of Sections 301, 302, 303, 306, and 307 of this Act.

Sections 301-307 state applicable standards and provide for enforcement under the act, including effluent limitations. Section 401 is very important in South Carolina, for the activities described above must first be approved by a state agency, the South Carolina Department of Health and Environmental Control, before the relevant Federal agency may issue its permit or license. Thus, a 401 water quality certification is required, for example, for many activities for which a permit from the Army Corps of Engineers is necessary prior to undertaking any activities within the waters of the United States. The 401 certification can be seen as an important attempt on the part of Congress to comply with its own declaration of policy in placing primary responsibility with the states to prevent, reduce, and eliminate pollution.

Further, because the Section 401 certification is a state program conducted pursuant to state as well as Federal authority, the State of South Carolina has included a requirement for 401 certification in State permits, issued by the Budget and Control Board, for various activities in State navigable waters.[203]

Section 402.[204] Section 402 creates the "National Pollutant Discharge Elimination System", requiring a permit for the point source discharge of pollutants into the waters of the United States. The NPDES program is one of the primary tools for maintaining water quality. In South Carolina, the program is implemented by the South Carolina Department of Health and Environmental Control, pursuant to the broad authority granted the department in the Pollution Control Act.[205] Even though the NPDES program is administered by the State of South Carolina, the United States Environmental Protection Agency retains various oversight and approval authority for procedures and standards in the program.

Section 404.[206] Section 404 prohibits the discharge of dredged or fill material into the waters of the United States without first obtaining a permit. This Federal program is the responsibility of the Secretary of the Army, administered through the Chief of Engineers of the United States Army Corps of Engineers.[207] As with other programs under the Federal Water Pollution Control Act, the Section 404 program is designed to maintain the physical and chemical integrity of the waters of the United States; however, the program differs from others under the act in two important respects. First, the Secretary of the Army is authorized to, ". . . issue general permits on a state, regional, or nationwide basis for any category of activities involving discharges of dredged or fill material if the Secretary determines that the activities in such category are similar in nature, will cause only minimal adverse environmental affects when performed separately, and will have only minimal cumulative adverse effect on the environment." Second, a wide range of activities are excepted from the general permitting requirement under appropriate circumstances. The excepted activities include, among others: (l) normal farming, silviculture, and ranching activities; (2) maintenance or emergency reconstruction of damaged dikes, dams, levees, and transportation structures; (3) construction or maintenance of farm or stock ponds; and (4) construction or maintenance of farm or forest roads. While administration of the Section 404 program has not been delegated to the State of South Carolina, the comments of the State are solicited by the Corps of Engineers on all applications, many of which overlap State permitting jurisdiction;[208] moreover, prior to issuance of a Section 404 permit, the applicant must obtain a Section 401 water quality certification.[209]

PROBLEMS AND NEEDS RELATED TO WATER LAW

The single greatest problem in water law in South Carolina is uncertainty as to the law itself, primarily common law, which leads to to uncertainty and questionable security of rights to use water. While specific problems related to water are identified elsewhere in this Assessment, the focus here will be upon the riparian rights doctrine. Four issues seem to present the most consistent source of concern: (l) insecurity of a riparian right; (2) limitations on where water may be used; (3) inadequate protection of the resource and public interest in the resource; and (4) inability of states to manage the resource in times of crisis.

Insecurity of Riparian Rights

A riparian owner has a right to a reasonable use of water as it flows by his land. There is no guarantee to a specific amount, even if the use is reasonable; moreover, no protection exists based upon the date reasonable use commenced. Three separate concepts are involved in evaluating security of water rights: (1) legal certainty, the protection of law (the predictability of what the law is and how it will be applied); (2) physical certainty, the protection against variation in the quantity of water available for use; and (3) tenure certainty, protection against the loss of the water right through the exercise of lawful acts of others.[210]

A civil action is the sole mechanism for enforcing and maintaining a riparian right. Given the history of riparian litigation in South Carolina,[211] which of several lines of authority a judge would follow and how that law is applied to a contemporary water use conflict is, at best, speculative. The difference in theories under the riparian doctrine is so substantial as to permit total consumption of a stream in one case and spread the use of water so thinly between so many riparians that no beneficial use can be made in another.[212]

The riparian right is a right held commonly—the right of each riparian is coequal. New water users compete on equal footing with older users. In practice, all reasonable uses of water are permitted, regardless of the amount of water consumed and the date the use started, with reasonableness being measured either by the lack of damage to others or by the significance of the damage versus the significance of the use. The various potential reasonable uses defy any quantitative determination as to where, when, under what circumstances, and how much water each riparian is entitled to use or will remain available for use. Theoretically, all reasonable uses of water are threatened with physical uncertainty equally, both as to time and amount, and users would suffer a pro rata shortage. While such an equality of right has an appealing and democratic sound, an equal share of an insufficient supply does not damage all users equally and, of course, does not allocate or devote remaining supplies to the highest and best uses.

As for certainty of tenure of water rights the riparian right is acquired by land ownership and not lost by nonuse. The acquisition and continued maintenance of a right is, therefore, certain, but a particular use of the right is always subject to future determinations of its reasonableness in view of later needs for the water, and even if the use is reasonable, the right gives no guarantee of a certain quality of water, as others with equal rights later demand a share.[213] What is considered as reasonable also varies with supply conditions, such that what is reasonable in good water years may become unreasonable in times of drought.[214]

Water rights acquired by prescription are no more secure than water rights acquired by ownership of riparian land. Further, prescriptive rights are extremely difficult to establish under the riparian reasonable use theory, as they only come into existence when unreasonable harm is done to other riaparian rights. Not only must an injury be sustained but it must be of a continuous nature, not merely during unusually dry years. The chances are small that a riparian would suffer harm in silence for a twenty year period.[215]

Water use is increasing, as is the cost to obtain water. Providing a more secure and stable form of water right would benefit all water using sectors of the economy, and of course, is a keystone in any state water policy.

Limitations on Water Use

Perhaps the most prominent criticism of riparian law is the limitation, or outright illegality, of water use on nonriparian lands by nonriparians. A corresponding limitation is the requirement that the use must be within the watershed or the stream from which the water was taken. These territorial limitations are founded on several concepts, such as reserving water for the sole use of the owner based upon an alleged real property right or as a protection against diminishing the quantity of water for downstream users.

Use by nonriparians or by riparians beyond the watershed of origin or by interbasin transfer exists and is common in South Carolina in spite of riparian law. Above the Fall Line, many municipal water supply systems transfer water from one watershed to serve customers in another watershed. Along the coast, much of the population is served by ground water with three significant exceptions involving municipal interbasin transfers: (1) the City of Beaufort from the Savannah River; (2) the City of Charleston from the Edisto River; (3) the City of Georgetown from the Great Pee Dee River. Interbasin transfer of water for industrial and agricultural use, however, is not widespread at present.

The frequency of interbasin transfer by municipal suppliers is based on simple expediency, for few cities lie wholly within one watershed. Further, limiting distribution of publicly supplied water to a single watershed would not be practical in most cases. The limited number of cases against municipal suppliers by injured riparians in the past has produced a lack of knowledge, or concern, about the watershed limitation.

In that court cases in this state have not clarified the problem, it must be assumed that the territorial limitations inherent in the riparian law remain in effect. The requirement that water be used only in the watershed of origin, from a water development standpoint, is an excessively burdensome limitation and one that would lead to absurd results should it be a mandatory provision of a state water policy. Interbasin transfer should not be viewed as a *per se* good or *per se* bad but should be judged on the merits of each proposed transfer.

Protection of the Resource for Public Interests

The ultimate public interest in any system of water law is to discourage waste and foster the best possible use of the resource. Beyond the interest in providing security to beneficial private uses, a public interest exists in the protection of the resource in general. Such public interests include the maintenance of minimum streamflow for protection of water quality, fishery resources, navigation, recreation, and esthetics. The riparian system does not provide protection to these public interests.

Under the riparian doctrine, water use is a private concern, limited to those owning riparian land, and enforced in law suits brought in the nature of individual property actions. The adversary process rivets the court's attention to the particular parcel of land in dispute and is based on particular individual damages. This method of enforcement is not designed to reach conclusions regarding social policy and the public interest. Another major defect in the administration of riparian law is that it is *ex post facto*, in that law suits do not ordinarily arise until both competing uses are in operation.[216] The practical policy implication of riparian law is that water must be used without damage to others as opposed to a public policy that water be used wisely and beneficially.

No riparian law mechanism is available to protect minimum streamflow, that is, to establish a base flow for planning and regulatory purposes beyond which water consumption will be discouraged in the public interest. Unlike some western states where all water in streams is allocated to an active use, South Carolina is at an advantageous position to protect minimum streamflows and still provide for continued development.

Adequate Drought Management

The lack of comprehensive water management or water use laws in the eastern United States is not surprising, especially in South Carolina. Rainfall is generally abundant and catastrophic drought does not occur frequently. Not unexpectedly, the riparian laws operate most effectively in surplus water situations and least effectively in shortage situations.

Because a riparian right cannot be qualified either as to time or amount, it is apparent that there can be little supervised distribution or administration of rights or uses by a public agency. Enforcement of a particular right proceeds on a case-by-case basis through the judicial system—a method which is time consuming and costly. The system operates to limit the perspective of the court to the merits of an individual case, not to the broad basinwide allocation problems associated with drought. The increased riparian use of water from streams, which inevitably occurs as a result of drought, prohibits any broad and stable allocation of water to best uses by court. In short the riparian system does not provide adequate and efficient procedures for ajudicating water rights, especially in times of drought.

Previous Water Law Reviews and Findings

No shortage of investigations and reports into the adequacy of water law exists in South Carolina.[217] Three efforts in particular deserve mention. Due to increased water usage following World War II, concerns as to the adequacy of the State's water laws were raised in the early 1950's. particularly by the agricultural community. The efforts of many concerned individuals resulted in a comprehensive report to the South Carolina Soil Conservation Committee, entitled, "The Beneficial Use of Water in South Carolina - A Preliminary Report."[218] The report, presented in June, 1952, analyzed the State's water uses and needs, reviewed water law existing at the time, and suggested changes in the law. Recognizing that demands for water would increase to the point of conflict, the report proposed that South Carolina radically amend its law, adopting a statewide appropriation system, modeled after systems commonly found in the western United States.

No immediate legislative action was taken on the aforementioned proposal; however, as a result of the report and other concerns, the General Assembly by joint resolution in 1953,[219] authorized appointment of a water study committee, which submitted its report, entitled "A New Water Policy for South Carolina," to the Legislature in 1954. The "New Water Policy" adopted the 1952 Busby recommendation and proposed a law incorporating the doctrine of prior appropriation, concluding that the following benefits would result:

> What will adoption of such a law mean to South Carolina? The Committee believes the principal benefits will be two:
>
> (1) Orderly and legal development of water and land resources with greater security of investment in such development;
>
> (2) Better and more complete use of our abundant water supply.
>
> With the authority granted under the proposed law, the Water Control Board can establish a priority of rights to the water in any stream or lake. A new user then will know the maximum amount of water he can take under normal supply conditions. In the event of reduced stream flow he knows in advance how many users have earlier claims to the available supply. He is aware of his risk before he makes his investment. Such a system should lead to the development of every surface water resource to its fullest potential.[220]

After extensive debate, the General Assembly failed to enact the Committee's proposal.

In recent years, water supply, water quality, and water law are again topics of concern. The most recent review of State water law was undertaken by the State Water Law Review Committee, created and appointed by Governor Riley in 1982. The Committee was directed to review water law in this and other states and, ". . . make recommendations for proposed changes that clarify or amend existing law, regulation or administrative mechanism in this state. . . .", in two particular areas:

(l) The adequacy of existing law and state government administrative mechanisms to minimize economic and social disruptions during a period of drought; and

(2) The adequacy of existing law and state government administrative mechanisms to manage and resolve conflicts among water users in periods of normal water supply as well as drought.[221]

The Committee, composed of fourteen members representing a broad range of interests in water,[222] concluded that existing State laws and administrative mechanisms are inadequate, making the following specific findings:

> (1) The Committee recommends that the State's role in water resources be recognized so that water, in all its forms, be be viewed as subject to a public trust. To that end, the Committee recommends that a comprehensive State water policy be enacted.
>
> (2) To protect the public interest, the State must be made aware of, and if appropriate, intervene in, actions affecting water rights. To this end, the committee recommends that a notice/intervenor statute be adopted.
>
> (3) Withdrawals of surface water, regardless of quantity, are not currently regulated in South Carolina and many large withdrawals of surface water are occurring or contemplated. The impact of these withdrawals is and will be significant. Therefore, the committee recommends that the State analyze and review such withdrawals, and develop a State policy to regulate them.
>
> (4) A minimum amount of water should be maintained to support in-stream needs in rivers, streams, and lakes. The State should, giving due consideration to existing uses, determine in-stream flow needs and consider those needs in reviewing present and future development.
>
> (5) The State's fundamental problem with regard to ground water is lack of information. Therefore, the committee recommends that a more comprehensive effort be undertaken to investigate, inventory, sample, and map South Carolina's ground-water resources.
>
> (6) The Ground Water Use Act of 1969 is a significant start in responding to potential as well as actual threats to ground-water problems addressed in the act. The committee has endorsed several amendments to the act.
>
> (7) Sound water management requires planning a response to drought. Many states have prepared a drought response plan to alleviate economic, agricultural, and social hardship caused by drought. No such plan exists in South Carolina. Therefore, the committee recommends that a detailed drought response plan be developed.[223]

Adoption of the Committee's recommendations would undoubtedly go a long way toward meeting present and future water law concerns. Clarification of water rights through a comprehensive modern system of water law should promote the, "Orderly and legal development of water and land resources with greater security of investment . . . .", one of the principal benefits of an updated water law identified by planners in the early 1950's.

Most of the Water Law Review Committee's individual recommendations require little, if any, explanation; however, viewed as a whole, the recommendations tend to emphasize the lack of development of water law in South Carolina. With a relatively abundant water supply and sparse population, this lack of development in law has created few serious problems as yet, but the experiences of other eastern states should provide a signal to South Carolina that law tailored for the nineteenth century will not fit the twentieth, and certainly not the twenty-first centuries.

With the exception of the limited application of the Ground Water Use Act of 1969,[224] South Carolina has no statutory or case law delineating rights with regard to ground water. As to surface waters, no law exists in this State identifying the exact extent of riparian lands and authority to make interbasin transfers of water. These and other questions are sure to arise as demand for water increases. An important question raised by this situation is whether South Carolina will choose to anticipate these problems and provide sound solutions, regarding the rights of all parties potentially involved, or will South Carolina choose to treat these problems on a case-by-case basis in the courts, settling questions between only the litigants involved, possibly ignoring broader and equally important issues and interests. A review of this section quickly reveals the antiquated nature of South Carolina's common law of water, and further indicates, with limited exception, the lack of a coherent policy in the treatment of water resources and development of statutory and administrative systems for water management.

FOOTNOTES

[1] The portions of this chapter discussing the law of surface water, ground water, diffused surface water, tidelands, and public access are drawn largely from a paper authored by William C. Moser (formerly Legal Counsel, South Carolina Water Resources Commission), entitled, "Water Law in South Carolina," published in *Legal and Administrative Systems for Water Allocation and Management,* Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1978. Mr. Moser's contribution is probably the most complete recent survey of water law in South Carolina.

[2] *Omelvany v. Jaggers,* 2 Hill 634, 640 (S.C. 1835): "Though he may use the water while it runs over his land, he cannot reasonably detain it or give it another direction. . . ." The error is serious, substituting "reasonably" for "unreasonably"; however the mistake was noted and corrected in the later case of *White v. Whitney Mfg. Co.,* 60 S.C. 254, 266, 38 S.E. 456 (1901).

[3] *Omelvany, supra,* note 1, p. 640.

[4] *White, supra,* note 1.

[5] *Id.,* at 267, citing *Dumont v. Kellogg,* 29 Mich. 420, 18 Am. Rep. 102. Of the *Omelvany* decision the court said, "the quotation from the case of *Omelvany v.Jaggers. . .* is misleading, as it takes no notice of the limitation or qualification of the general rule . . . ."*Id.,* at 270.

[6] *See, Garrett v. McKie,* 1 Rich. 444, 44 Am. Dec. 263 (1845); *Chalk v. McAlily,* 11 Rich. 153 (1857); *Hines v. Jarrett,* 26 S.C. 480, 2 S.E. 383 (1887).

[7] *White, supra,* note 1, pp. 266-67, citing 3 Kent's Com., 353:

Streams of water are intended for the use and comfort of man; and it would be unreasonable and contrary to the universal sense of mankind to debar every riparian proprietor from the application of the water to domestic, agricultural and manufacturing purposes, provided the use of it be made under the limitations which have been mentioned, and there will, no doubt, evidently be, in the exercise of a perfect right to the use of water, some evaporation and decrease of it, and some variations in the weight and velocity of the current; but *de minimis nos curat lex,* and a right by the proprietor below, would not necessarily flow from such consequences, but would depend upon the nature and extent of the complaint or injury, and the manner of using the water. All that the law requires of the party, by or over whose land a stream passes; is, that he should use the water in a reasonable manner, and so as not to destroy or render useless, or materially diminish or affect the application of the water by the proprietor below on the stream; he must not shut the gates of his dams and detain the water unreasonably, or let it off in unusual quantities, to the annoyance of his neighbor.

[8] E.g., *Mason v. Apalache Mills,* 81 S.C. 554, 62 S.E. 399 (1907); *Griffin v. National Light & Thorium Co.,* 79 S.C. 351, 60 S.E. 702 (1908); *Lowe v. Ottaray Mills,* 93 S.C. 420, 77 S.E. 135 (1913); *McMahon v. Walhalla Light & Power Co.,* 102 S.C. 57, 86 S.E. 194 (1915).

[9] *White, supra,* note 1. *See also,* Busby *The Beneficial Use of Water in South Carolina,* (South Carolina Soil Conservation Committee, 1953).

[10] *Mason, supra,* note 8.

[11] *McMahon, supra,* note 8.

[12] *Griffin, supra,* note 8.

[13] *Lowe, supra,* note 8.

[14] *See, Mason, supra,* note 8.

[15] Busby, *supra,* note 9, p. 24.

[16] *See,* to same effect, Dewsnup et al., *A Summary-Digest of State Water Laws,* (National Water Commission, 1973), p. 667.

[17] However, one recent federal decision explored the reasonable use doctrne of South Carolina, *United States v. 531.13 Acres of Land,* 366 F. 2d 915 (1966).

[18] The case of *Jordan v. Lang,* 22 S.C. 159, 37 S.E. 69 (1885), did involve the use of waters for irrigating rice, the downstream riparian complaining of the quantity being used. The case was decided, however, on prescription rather than reasonable use.

[19] *United States, supra,* note 17.

[20] *Id.,* at 919, citing *Duncan v. Union-Buffalo Mills Co.,* 110 S.C. 302, 96 S.E. 522, 524 (1917).

[21] E.g., *Griffin, supra,* note 8; *Williams v. Haile Gold Mining Co.,* 85 S.C. 1, 66 S.E. 117 (1910); *Mason, supra,* note 8; *Threat v. Brewer Mining Co.,* 49 S.C. 95, 26 S.E. 970 (1897).

[22] *Williams, supra,* note 21; *Threat, supra,* note 21.

[23] *White, supra,* note 2.

[24] *McMahon, supra,* note 8.

[25] *Id.,* p. 59.

[26] *Fewell v. Catawba Power Co.,* 102 S.C. 452, 86 S.E. 947 (1915).

[27] Busby, *supra,* note 9, p. 23. Busby views the *Fewell* decision as subjecting the use of an entire drainage system to one lower proprietor's right to ford a stream. *Id.,* p. 23, footnote 44.

[28] Dewsnup, *supra,* note 16, p. 667.

[29] E. Guerard, "The Riparian Rights Doctrine in South Carolina," 21 *S.C. L. Rev.* 757, 770 (1969).

[30] *See, Lowe, supra,* note 8; *Rivenbark v. Atlantic Coast Line R.R.,* 124 S.C. 136, 117 S.E. 206 (1923).

[31] *Johnson v. Williams,* 338 S.C. 623, 634, 121 S.E. 2d 223 (1961), quoting from *Lawton v. South Bound R.R.,* 61 S.C. 548, 552-53, 39 S.E. 752 (1901).

[32] *Jones v. Seaboard Air Line R.R.,* 67 S.C. 181, 45 S.E. 188 (1903).

[33] Dewsnup, *supra*, note 16, p. 668. But *see* Guerard, *supra*, note 29, pp. 760-62.

[34] In *Jones, supra*, note 32 the defendant railroad caused, in the construction of a bridge, the flooding of plaintiff's land. The court found that the plaintiff was entitled to access to the watercourse, saying at p. 194:

> The right which the plaintiff says the defendant invaded was not the right of navigation, or any other right which he held in common with the public, but the right to the unimpaired use of his land on the banks of the river. The fact that the stream was navigable does not affect this question.

[35] *See*, Dewsnup, *supra*, note 16, p. 669.

[36] *See*, Guerard, *supra*, note 29, p. 762.

[37] *Jordan, supra*, note 18.

[38] *White, supra*, note 2.

[39] *See*, C.E. Hill, "Limitation on Diversion from the Watershed: Riparian Roadblock to Beneficial Use," 23 *S.C. L. Rev.* 63 (1971), for a full discussion of interbasin transfer in South Carolina.

[40] A comprehensive list of these statutes is found in Hill, *id.*, pp. 59-60. Most of these acts have been removed from the *Code of Laws of South Carolina, 1976*, as local legislation.

[41] *Id.*, at 59. *See*, Section 70-471, *Code of Laws of South Carolina, 1962*.

[42] *See*, Section 70-491, *Code of Laws of South Carolina, 1962*.

[43] *See*, Hill, *supra*, note 38. Hill, while deploring the effect of the common law limitation on interbasin transfer, attributes the rather indiscriminate transfer of water to the state's abundant supply and a "carefree cavorting" caused by plentiful water. (p. 59).

[44] *See*, Hill, *supra*, note 39, pp. 57-58.

[45] *Chalk, supra*, note 6.

[46] *Id.*, p. 161. Defendant dammed and backed water upon plaintiff's lands, two inches in height for a distance of 100 to 200 feet. The court stated at p. 163:

> Actions like this ought not to be encouraged upon complaints of fanciful injury done to sublimated notions of exclusive territorial dominion . . . . Such actions sometime proceed from rival interests or envious malignity.

[47] "Pollution Control Act," Section 48-1-10, *et seq.*, *Code of Laws of South Carolina, 1976*.

[48] "NPDES Permits," R. 61-9, Vol. 24, *Code of Laws of South Carolina, 1976; see* note 204, *infra*.

[49] Section 48-1-240, 1976 *Code of Laws of South Carolina, 1976*.

[50] *See*, Sections 49-11-10 and 49-11-20, *Code of Laws of South Carolina 1976*, prohibiting the overflow of lands of another by dams; Section 49-11-110, *et seq.*, 1976 *Code of Laws of South Carolina, 1976* as amended, "The Dams and Reservoirs Safety Act," requiring approval of dam construction and design; *see* note 156, *infra*.

[51] Sections 49-1-10, 20, 30, 40, *Code of Laws of South Carolina, 1976*.

[52] *See* notes after Sections 49-1-20, 30, *Code of Laws of South Carolina, 1976*.

[53] "Permits for Construction in Navigable Waters," R. 19-450, *et seq.*, *Code of Laws of South Carolina, 1976* as amended, requires permits for construction activities in the navigable waters of South Carolina below the mean or ordinary high water lines of such waters. A recent coastal zoning act, Section 48-39-10, *et seq.*, *Code of Laws of South Carolina, 1976*, as amended, requires permits for any construction or alteration in the saline waters and tidelands of the state. This permit replaces the above permit in the coastal area and is broader in its jurisdiction over wetlands, beaches, and sand dunes. The act also requires that a coastal management plant be drafted and submitted to the Governor and General Assembly.

[54] *See* Section 48-1-290, *Code of Laws of South Carolina, 1976*, authorizing emergency action by the Department of Health and Environmental Control to protect public health or property. Section 25-1-440, *Code of Laws of South Carolina, 1976*, as amended, places responsibility for the safety, security and welfare with the Governor during times of emergency as defined in the statute. However, a relatively recent opinion of the Attorney General questions the scope of application and utility of the above statutes, as well as the authority of the Water Resources Commission, to respond to water shortages. The conclusion to that opinion, authored by John P. Wilson, Senior Assistant Attorney General, dated August 26, 1981, succintly sums up the current situation:

> Under existing law there is no comprehensive statutory scheme for the management and control of the State's water resources. As discussed above, the South Carolina Water Resources Commission possesses limited regulatory authority under somewhat cumbersome procedures as to Ground Water only. The South Carolina Department of Health and Environmental Control's regulatory authority under the State Safe Drinking Water Act (§§44-55-10. *et seq.*, Code of Laws of South Carolina [1976], as amended) is likewise limited to a "public water supply" as therein defined.
>
> At present, neither agency has statutory authority to promulgate regulations by which to effectively cope with or respond to emergency conditions brought about by severe water shortages. While the Governor's emergency powers are sufficiently broad to insure an adequate response, such are of limited duration (fifteen days without consent of the General Assembly). Under these circumstances, attention and study towards further legislation in this area is recommended.

[55] *Edwards v. Charlotte, Columbia & Augusta R.R.*, 39 S.C. 472, 18 S.E. 58 (1893).

[56] *Id.*, p. 475.

[57] *Baltzeger v. Carolina Midland Ry.*, 54 S.C. 242, 32 S.E. 358 (1899).

[58] *See* W.T. Toal, "Surface Water in South Carolina," *23 S.C. L. Rev.* 82, 84 (1971) and Busby, *supra*, note 9 pp. 29-32 for a more complete discussion.

[59] Toal, *supra*, note 58, p. 83.

[60] *Baltzeger, supra*, note 57.

[61] *Id.*, p. 247.

[62] Toal, *supra*, note 58, p. 86, states of the decision:

> Thus the plaintiff's allegation was insufficient as a nuisance per se because the pond was not dangerous to everyone and was insufficient as a private nuisance because it was as dangerous to everyone as it was his daughter. This case formed a formidable precedent against recovery on the nuisance theory.

[63] *See, Johnson v. Southern Ry.*, 71 S.C. 241, 50 S.E. 775 (1905); *Rivenbark, supra*, note 30; *Banks v. Southern Ry.*, 126 S.C. 241, 118 S.E. 923 (1923).

[64] *See, Deason v. Southern Ry.*, 142 S.C. 328, 140 S.E. 575 (1927); *Bowlin v. George*, 239 S.C. 429, 123 S.E. 2d 528 (1962); *See* also Toal, *supra*, note 58, pp. 87-88, for discussion.

[65] *Brandenberg v. Zeigler*, 62 S.C. 18, 39 S.E. 790 (1901); *Rivenbark, supra*, note 30; *Garmany v. Southern Ry.*, 152 S.C. 205, 149 S.E. 765 (1929).

[66] Toal, *supra*, note 65, p. 88.

[67] *Id.*, pp. 88-9.

[68] *Brandenberg, supra*, note 65, p. 22.

[69] *See, Slater v. Price*, 96 S.C. 245, 80 S.E. 372 (1913).

[70] *Deason, supra*, note 64; *Touchberry v. Northwestern R.R.*, 88 S.C. 47, 70 S.E. 424 (1911).

[71] Toal, *supra*, note 58, p. 89.

[72] *Id.*

[73] Section 5-31-450, *Code of Laws of South Carolina, 1976.*

[74] *Hall v. City of Greenville*, 227 S.C. 375, 88 S.E. Ed 246 (1955).

[75] *See*, G. Dukes and J. Stepp, *South Carolina Laws, Policies and Programs Pertaining to Water and Related Land Resources* (WRRI, Clemson Univ., 1968), p. 20.

[76] *See*, R. Cross, "Ground Waters in the Southeastern States," 5 *S.C. L.Q.* 149 (1953), for more complete discussion of these doctrines.

[77] Section 49-5-10, *et seq.*, *Code of Laws of South Carolina, 1976.*

[78] Section 143-215.11, *et seq.*, *Gen. Stat. of North Carolina.*

[79] Section 49-5-20, *Code of Laws of South Carolina, 1976.*

[80] Section 49-5-40(b), *Code of Laws of South Carolina, 1976.*

[81] Section 49-5-40(a), *Code of Laws of South Carolina, 1976.*

[82] Section 49-5-40(c), *Code of Laws of South Carolina, 1976.*

[83] Section 49-5-50, *Code of Laws of South Carolina, 1976.*

[84] Section 49-5-50(a)(1-4), *Code of Laws of South Carolina, 1976.*

[86] Section 49-5-60, *Code of Laws of South Carolina, 1976.*

[86] Section 49-5-60(b), *Code of Laws of South Carolina, 1976.*

[87] Section 49-5-30(4)(i), *Code of Laws of South Carolina, 1976.*

[88] Section 49-5-30(4)(ii), *Code of Laws of South Carolina, 1976.*

[89] Section 49-5-60(h), *Code of Laws of South Carolina, 1976.*

[90] Section 49-5-60(a-g), *Code of Laws of South Carolina, 1976.*

[91] Section 49-5-110, *Code of Laws of South Carolina, 1976.*

[92] Sections 49-5-50(a)(2) and 49-5-70(e)(f), *Code of Laws of South Carolina, 1976.*

[93] Section 49-5-70(e), *Code of Laws of South Carolina, 1976.*

[94] Section 49-5-70(f), *Code of Laws of South Carolina, 1976.*

[95] Section 49-5-60(h)(8), *Code of Laws of South Carolina, 1976.*

[96] Section 49-5-120, *Code of Laws of South Carolina, 1976.*

[97] Sections 49-5-50(a) and 49-5-60(h), *Code of Laws of South Carolina, 1976.*

[98] Art. 14, Section 4, *Constitution of South Carolina*, 1895, as revised, states:

> All navigable waters shall forever remain public highways free to the citizens of the State and the United States without tax, impost or toll imposed; and no tax, toll, impost or wharfage shall be imposed, demanded or received from the owners of any merchandise or commodity for the use of the shores or any wharf erected on the shores or in or over the waters of any navigable stream unless the same be authorized by the General Assembly.

[99] Section 49-1-10, *Code of Laws of South Carolina, 1976.*

[100] *Rice Hope Plantation v. S.C. Public Service Authority*, 126 S.C. 500, 528 59 S.E. 2d 132 (1950).

[101] *Id.*, 524.

[102] *See, State ex rel. Lyon v. Columbia Water Power Co.*, 82 S.C. 181, 63 S.E. 884 (1909).

[103] *Id.*, p. 187.

[104] *Id.*, pp. 186-87.

[105] Section 49-1-10, *Code of Laws of South Carolina, 1976*, recites:

> All streams which have been rendered or can be rendered capable of being navigated by rafts of lumber or timber by the removal of accidental obstructions and all navigable watercourses and cuts are hereby declared navigable streams and such streams shall be common highways and forever free, as well to the inhabitants of this State as to citizens of the United States, without any tax or impost therefor, unless such tax or impost be expressly provided for by the General Assembly. If any person shall obstruct any such stream otherwise than as in this Title provided, such person shall be guilty of a nuisance and such obstruction may be abated as other public nuisances are by law.

[106] *South Carolina Streamboat Co. v. Wilmington, Columbia, and Augusta R.R.*, 46 S.C. 327, 333, 24 S.E. 337 (1895): "There can be no doubt than an obstruction of any highway is a public nuisance, which, ordinarily, can only be redressed by indictment." *See* also *Drews v. Burton*, 76 S.C. 362, 57 S.E. 176 (1907).

[107] *State v. Water Power Co.*, 82 S.C. 181, 191-3, 63 S.E. 884 (1909)

[108] *Id.*, p. 193.

[109] *Free v. Parr Shoals Power Co.*, 111 S.C. 192, 196, 97 S.E. 243 (1918).

[110] *McDaniel v. Greenville-Carolina Power Co.*, 95 S.C. 268, 273, 78 S.E. 980 (1913).

[111] *Jones, supra,* note 32, p. 197.

[112] *Key Sales Co. v. South Carolina Electric & Gas Co.*, 290 F. Supp. 8 (D.C.S.C. 1968).

[113] *Rice Hope Plantation, supra,* note 100, p. 529. Apparently the public purposes referred to include navigation, power production, health betterment, flood control, and reforestation of watersheds. *See, Clarke v. S.C. Public Service Authority,* 117 S.C. 427, 440, 181 S.E. 481 (1935).

[114] *Rice Hope Plantation, supra,* note 100, pp. 527-29.

[115] *Early v. S.C. Public Service Authority,* 228 S.C. 392, 407, 90 S.E. 2d 472 (1955).

[116] *Shands v. Triplet,* 5 Rich. Eq. 76, 77-78 (S.C. 1852). *See,* E.W. Wald, "Navigability--Its Meaning and Application in South Carolina," 23 *S.C. L. Rev.* 28 (1971), for a more detailed discussion of this subject.

[117] Section 49-1-10, for full citation *see* note 105 herein. The present wording dates back to 1853.

[118] *Manigault v. Ward* 123 F. 707, 714 (1903), affirmed in 199 U.S. 473, 26 S. Ct. 127, 50 L. Ed. 274 (1905).

[119] *See,* "Permits for Construction in Navigable Waters," R. 19-450, *et seq., Code of Laws of South Carolina, 1976,* as amended.

[120] *County of Darlington v. Perkins,* 269 S.C. 572, 239 S.E. 2d 69 (1977), affirmed, on other grounds, a lower court decision which held that the state owned the beds of a non-tidal, navigable, ox-bow lake.

[121] *See, Heyward v. Farmer's Mining Co.*, 42 S.C. 138, 152, 19 S.E. 963 (1894); *State ex rel. Lyon v. Columbia Water Power Co., supra,* note 102 pp. 188-89. Actually the federal test of navigation, the so-called "commerce clause test," has apparently never been applied by the State courts. Two federal decisions, *Manigault, supra,* note 118, and *Chisolm v. Caines,* 67 F. 285 (1894), examples of pre-*Erie Railroad* application of a federal common law, are not considered binding on local decisions.

[122] *State v. Pacific Guano Co.*, 22 S.C. 50, 76-77 (1884); *Heyward, supra,* note 121, p. 150.

[123] *Heyward, supra,* note 121.

[124] *Id.*, p. 150.

[125] *Id.*, p. 151.

[126] *Id.*

[127] *Id.*, p. 155.

[128] *Id.*

[129] *State v. Thompson,* 2 Strob. 12 (S.C. 1847).

[130] *Carey v. Brooks,* 1 Hill 365 (S.C. 1833). *See* also *State v Cullum,* 2 Spears 581 (S.C. 1844); *State v. Hickson,* 5 Rich. 447 (S.C. 1852); *McDaniel, supra,* note 110. From the mid-eighteenth to the mid-nineteenth century, dozens, if not hundreds, of declarations of navigability were made by the legislature.

[131] *See,* B.W. Wyche, "The Law of Tidelands in South Carolina," appearing in *Environmental Law in South-Carolina: Selected Topics* (Univ. of S.C. Environvmental Law Society, 1977); C. Leavell, *Legal Aspects of Ownership and Use of Estuarine Areas in Georgia and South Carolina* (Inst. of Government, Univ. of Georgia, 1971); Clineburg and Krahmer, *The Law Pertaining to Estuarine Lands in South Carolina* (Univ. of South Carolina School of Law, 1969); Logan and Williams, "Tidelands in South Carolina: A Study in the Law of Real Property," 15 *S.C. L. Rev.* 288 (1962).

[132] *Cape Romain Land Imp. Co. v. Georgia-Carolina Canning Co.*, 148 S.C. 428, 146 S.E. 434 (1928).

[133] *Id.*, p. 438. The court viewed the law as settled that in *navigable streams,* ownership below the high water mark was in the sovereign unless specifically conveyed. *Id.*, pp. 437-38. The dissent criticized the decision based upon the fact that of the 34,000 acres alleged to have been granted by the State, only 6.2 acres were above the high water line, thus leaving the plaintiff title to very little land.

[134] *Rice Hope Plantation, supra,* note 100; *Lane v. McEachern,* 251 S.C. 272, 162 S.E. 2d 174 (1968); *State v. Hardee,* 259 S.C. 535, 193 S.E. 2d 297 (1972); *State v. Yelsen,* 265 S.C. 78, 216 S.E. 2d 876 (1975); *State v. Griffith,* 265 S.C. 43, 216 S.E. 2d 765 (1975).

[135] *See, Lane, supra,* note 134.

[136] *See, Cape Romain,* supra, note 132; *Heyward, supra,* note 121; *State v. Pinckney,* 22 S.C. 484 (1884); *State v. Pacific Guano Co., supra,* note 122.

[137] In addition to the cases cited in note 136 above, *see Coosaw Mining Co. v. South Carolina,* 144 U.S. 550, 125. Ct. 689, 36 L. Ed. 537 (1892); *Hardee, supra,* note 131; *Griffith, supra,* note 134; *Yelsen, supra,* note 134.

[138] *Hardee, supra,* note 134, p. 499.

[139] *Yelsen, supra,* note 134, p. 82.

[140] *See, State v. Yelsen,* 257 S.C. 401, 185 S.E. 2d 897 (1972).

[141] *See, Lane, supra,* note 134.

[142] *County of Darlington, supra,* note 120.

[143] *See,* P. Lader, "Legal Aspects of Public Access to Beaches," appearing in *Report of Conference on Marine Resources of the Coastal Plains* (Coastal Plains Regional Commission, 1975), for a more complete discussion of public access.

[144] *See, State v. Randall,* 1 Strob. 110, 47 Am. Dec. 548 (1846).

[145] *See, State v. Miller,* 130 S.C. 152, 125 S.E. 298 (1924); *Savannah River Lumber Corp. v. Bray,* 189 S.C. 237, 200 S.E. 760 (1939); *Tyler v. Guerry,* 251 S.C. 120, 16 S.E. 2d 889 (1968).

[146] *See, County of Darlington, supra,* note 120 but, *see State v. The Beach Club,* 271 S.C. 425, 248 S.E. 2d 115 (1978).

[147] References to water in the *Code of Laws of South Carolina, 1976,* are about as abundant as water within the State. No attempt will or feasibly could be made to identify each reference to water in South Carolina law. The statutes identified and discussed represent only the most major and comprehensive mechanisms affecting water. Numerous other statutes must be reviewed in order to completely cover the topic; however, such

statutory systems as those covering fishing have not been included in that they do not directly affect water use *per se*.

[148] Section 49-3-10, *et seq., Code of Laws of South Carolina, 1976. See* Act No. 61, *Acts and Joint Resolutions of South Carolina, 1967,* for full legislative findings.

[149] Section 49-3-40, *Code of Laws of South Carolina, 1976.*

[150] Section 49-5-10, *et seq., Code of Laws of South Carolina, 1976; see* notes 77-97, *supra.*

[151] Section 49-4-10, *et seq., Code of Laws of South Carolina, 1976,* as amended.

[152] Section 49-4-30, *Code of Laws of South Carolina, 1976,* as amended.

[153] Section 49-4-40, *Code of Laws of South Carolina, 1976,* as amended.

[154] Section 49-4-60, *Code of Laws of South Carolina, 1976,* as amended.

[155] *South Carolina State Register* (Vol. 7, Issue No. 5, May 27, 1983).

[156] Section 49-11-110, *et seq., Code of Laws of South Carolina, 1976,* as amended.

[157] Section 49-11-130, *Code of Laws of South Carolina, 1976,* as amended.

[158] Section 49-11-120(4)(a), *Code of Laws of South Carolina, 1976,* as amended.

[159] Section 48-39-1, *et seq., Code of Laws of South Carolina, 1976,* as amended.

[160] Section 48-39-10(J) states, "'Critical area' means any of the following: (l) coastal waters, (2) tidelands, (3) beaches and (4) primary ocean front sand dunes."

[161] Section 49-1-10, *Code of Laws of South Carolina, 1976,* addresses navigability; *see* note 105 *supra.* Section 1-11-70, *Code of Laws of South Carolina, 1976,* provides, "All vacant lands and lands purchased by the former land Commissioners of the State shall be subject to the directions of the State Budget and Control Board." The Board is specifically authorized to charge a fee to applicants for permits pursuant to Section 1-11-75, *Code of Laws of South Carolina, 1976,* as amended.

[162] R.19-450.1(B)(2), *Code of Laws of South Carolina, 1976,* as amended.

[163] P.L. 91-190, § 102; 42 U.S.C. § 4332.

[164] R.19-450.5(F), *Code of Laws of South Carolina, 1976,* as amended.

[165] Section 49-13-10, *et seq., Code of Laws of South Carolina, 1976.*

[166] *Clemson University v. First Provident Corp.,* 260 S.C. 640, 197 S.E. 2d 914 (1973).

[167] Section 49-15-10, *et seq., Code of Laws of South Carolina, 1976.*

[168] Section 14-15-50, *Code of Laws of South Carolina, 1976.*

[169] Section 49-17-10, *et seq., Code of Laws of South Carolina, 1976.*

[170] Sections 49-17-10 and 49-17-20, *Code of Laws of South Carolina, 1976.* These statutes present an interesting obvious conflict in state policy. Section 49-17-10 calls for drainage of swamps, which would encompass wetlands; whereas, Section 48-39-10, *et seq.,* call for the protection of wetlands. *See* notes 159, 160, *supra.*

[171] Section 49-19-10, *et seq., Code of Laws of South Carolina, 1976.*

[172] Section 49-19-10, *Code of Laws of South Carolina, 1976.*

[173] Section 49-19-20, *Code of Laws of South Carolina, 1976.*

[174] Section 49-17-10, *Code of Laws of South Carolina, 1976,* provides, "It is hereby declared that the drainage of swamps, the drainage of surface water from agricultural lands and the reclamation of tidal marshes shall be considered a public benefit and conductive to the public health, convenience, utility and welfare."

[175] Section 48-1-10, *et seq., Code of Laws of South Carolina, 1976.*

[176] Section 48-1-20, *Code of Laws of South Carolina, 1976.*

[177] Section 48-1-90(a), *Code of Laws of South Carolina, 1976.*

[178] Section 44-55-10, *et seq., Code of Laws of South Carolina, 1976,* as amended.

[179] Section 44-55-40(a), *Code of Laws of South Carolina, 1976,* as amended.

[180] Section 44-55-30, *Code of Laws of South Carolina, 1976,* as amended.

[181] Section 44-55-40(d), *Code of Laws of South Carolina, 1976,* as amended.

[182] Section 44-55-20(h), *Code of Laws of South Carolina, 1976* as amended, declares, "'Well' means a cored, drilled or driven shaft, or a dug hole, whose depth is greater than the largest surface dimension, from which water is extracted or injected. This shall include, but not be limited to, wells used for water supply for irrigation, industrial and manufacturing processes, or drinking water, wells used for underground injection of waste for disposal, storage, or drainage disposal, wells used in mineral or geothermal recovery, and any other special process wells."

[183] The South Carolina Board of Health and Environmental Control may promulgate only such regulations as have been recommended by the Advisory Committee. *See* No., Ops. of the Attorney General, March 14, 1983 (Opinion from Richard P. Wilson, Assistant Attorney General to Alfred H. Vang, Executive Director, Water Resources Commission).

[184] Section 44-55-45, *Code of Laws of South Carolina, 1976,* as amended.

[185] Section 44-55-40(m), *Code of Laws of South Carolina, 1976,* as amended.

[186] *See* R. 61-58, *et seq., Code of Laws of South Carolina, 1976.*

[187] Section 48-9-20, *Code of Laws of South Carolina, 1976.*

[188] Section 48-9-20(3), *Code of Laws of South Carolina, 1976.*

[189] Sections 48-9-210 and 48-9-220, *Code of Laws of South Carolina, 1976.*

[190] *See* notes 165-174, *supra.*

[191] Section 48-9-1270, *Code of Laws of South Carolina, 1976.*

[192] Section 48-11-10, *et seq.*, *Code of Laws of South Carolina, 1976.*

[193] Sections 48-11-20 and 48-11-70, *Code of Laws of South Carolina, 1976.*

[194] Section 48-11-110, *Code of Laws of South Carolina, 1976.*

[195] Section 48-11-20, *Code of Laws of South Carolina, 1976.*

[196] Article I, §8, Constitution of the United States.

[197] *See, Sporhase v. Nebraska, U.S.*, 102 S. Ct. 3456, L. Ed. 2d (1982); and *City of El Paso v. Reynolds* (Cir. No. 80-730 HB, D.C. N. Mex., filed January 17, 1983).

[198] 16 U.S.C. §791, *et seq.*

[199] 16 U.S.C. §803

[200] P.L. 92-500; 33 U.S.C. §1251, *et seq.*

[201] P.L. 95-217.

[202] P.L. 92-500; 33 U.S.C. 1341.

[203] R.19-450.7, *Code of Laws of South Carolina, 1976*, as amended.

[204] P.L. 92-500; 33 U.S.C. 1342.

[205] Section 48-1-50(16), *Code of Laws of South Carolina, 1976.*

[206] P.L. 92-500; 33 U.S.C. 1344.

[207] 33 U.S.C. 1344(d).

[208] R.19-450.2(H), *Code of Laws of South Carolina, 1976*, as amended.

[209] *See*, notes 202, 203 *supra.*

[210] Trelease, "A Model State Water Code For River Basin Development", 22 Law and Contemporary Problems (Vol. 2) 301, Duke Univ. School of Law (1957).

[211] Moser, "Water Law In South Carolina," *supra*, note 1.

[212] *See*, Guerard, *supra*, note 29.

[213] Trelease, *supra*, note 210.

[214] Trelease, *supra*, note 210.

[215] Restatement (2d) of Torts (1979), Section 856.

[216] Trelease, *supra*, note 210.

[217] *See, e.g.*, 5 *S.C.L. Rev.* 103-181 (1952), ("Special Issue On Water Law"); 21 *S.C.L. Rev.* 757 (The Riparian Doctrine in South Carolina); 23 *S.C.L. Rev.* 43 (Limitation on Diversion From the Watershed: Riparian Roadblock to Beneficial Use); 23 *S.C.L. Rev* 82 (Surface Water in South Carolina); Dukes and Stepp, "South Carolina Laws, Policies and Programs Pertaining to Water Related Land Uses," (Report No. 3, Water Resources Research Institute, Clemson, S.C., 1968); Randall, "Legal Aspects of Water Use and Control in South Carolina, Part A, Legal Considerations Relating to A New Water Resources Law for South Carolina," (Report No. 20, Water Resources Research Institute, Clemson, S.C., 1971); and Means, "Legal Aspects of Water Use and Control in South Carolina, Part B, South Carolina Lakes and Ponds: A Study of Public and Private Rights Therein," (Report No. 21, Water Resources Research Institute, Clemson, S.C., 1971).

[218] Mr. Busby, an employee of the Soil Conservation Service, United States Department of Agriculture in California, was on loan as consultant to the Committee at the time he prepared his report, fully entitled, "The Beneficial Use of Water in South Carolina, A Preliminary Report for the South Carolina Soil Conservation Committee on the Historical, Physical, and Legal Aspects of Water Problems in the State."

[219] Act No. 377, *Acts and Joint Resolutions of South Carolina, 1953.*

[220] "A New Water Policy for South Carolina," at p. 33.

[221] Executive Order No. 82-54, November 4, 1982.

[222] The fourteen member committee was appointed to represent the following interests: at large (2, including the chairman); Joint Legislative Water Resources Study Committee (1); Agricultural Interests (1); Recreational Interests (1); Local Government (2); South Carolina Chamber of Commerce, Industrial Interests (1); Hydroelectric Generators (1); Water Resources Commission (1); Department of Health and Environmental Control (1); Public Service Commission (1); and Wildlife and Marine Resources Commission (1).

[223] "Report and Recommendations-Governor's State Water Law Review Committee," December 31, 1982.

[224] Section 49-5-10, *et seq.*, *Code of Laws of South Carolina, 1976.*

South Carolina's Water Resources

In order to develop a basic understanding of South Carolina's water resources, one needs to know five important aspects: where the water is located, how much is available, how good is the water, how much is currently used, and how much do we expect to use in the future. This section addresses these aspects from a statewide perspective. In addition, a brief overview of the water cycle is presented for the benefit of those readers who might not be fully familiar with the daily hydrological processes taking place in our physical environment.

THE WATER CYCLE

The earth has an abundant yet limited supply of water which is constantly in motion on, under, and above its surface. Energy from the sun causes water to evaporate from water bodies and soil and plants transpire water into the atmosphere. This atmospheric water concentrates into cloud formations, and under proper meteorologic conditions, precipitates to earth. Once on the earth's surface, water may flow into streams, lakes, and oceans; infiltrate into the subsurface and enter ground-water storage; or evaporate or transpire into the atmosphere. This continuous interchange of both the geographical position and physical state of water is known as the hydrologic or water cycle. Although a worldwide process, this cycle is modified by local geographical and meteorological factors. Regional variation in the water cycle affects vegetation, topography, and climate and results in landscapes ranging from deserts to rain forests. However, the cycle consists of four basic processes: precipitation, evapotranspiration, ground-water infiltration, and surface runoff (Fig. 9).

Precipitation

The air contains varying amounts of water vapor. Warm air is able to hold a greater concentration of water molecules than cool air. Winds, temperature variations, and physical and meteorological obstructions (hills, mountains, colder or slower moving air masses) cause air and associated water vapor to rise into the atmosphere. As air rises in altitude, atmospheric pressure decreases and the air expands, cools, and loses its moisture holding ability. When this cooling air reaches its saturation point, the gaseous water molecules condense to a liquid. Clouds are the visible manifestation of moisture laden air reaching saturation. Initially, water droplets are extremely small and are kept aloft by air currents. As these droplets coalesce around ice and dust particles, larger drops are formed which fall to earth when of sufficient size. Depending on the surrounding air temperatures and atmospheric conditions, these drops may fall as liquid or solid precipitation or even evaporate before reaching the earth.

Evapotranspiration

Upon reaching the earth's surface, most precipitation is returned directly to the atmosphere through the combined processes of evaporation and transpiration, termed evapotranspiration.

Evaporation is the process by which water changes from the liquid state to the vapor or gaseous state. The most important environmental factors affecting evaporation are temperature, humidity, and wind. Energy from the sun is the driving force behind the hydrologic cycle and is especially important in the process of evaporation. Solar radiation increases air and water temperatures at different rates. Water molecules on the surface of soil, water, and plants heat faster than air molecules. This temperature difference

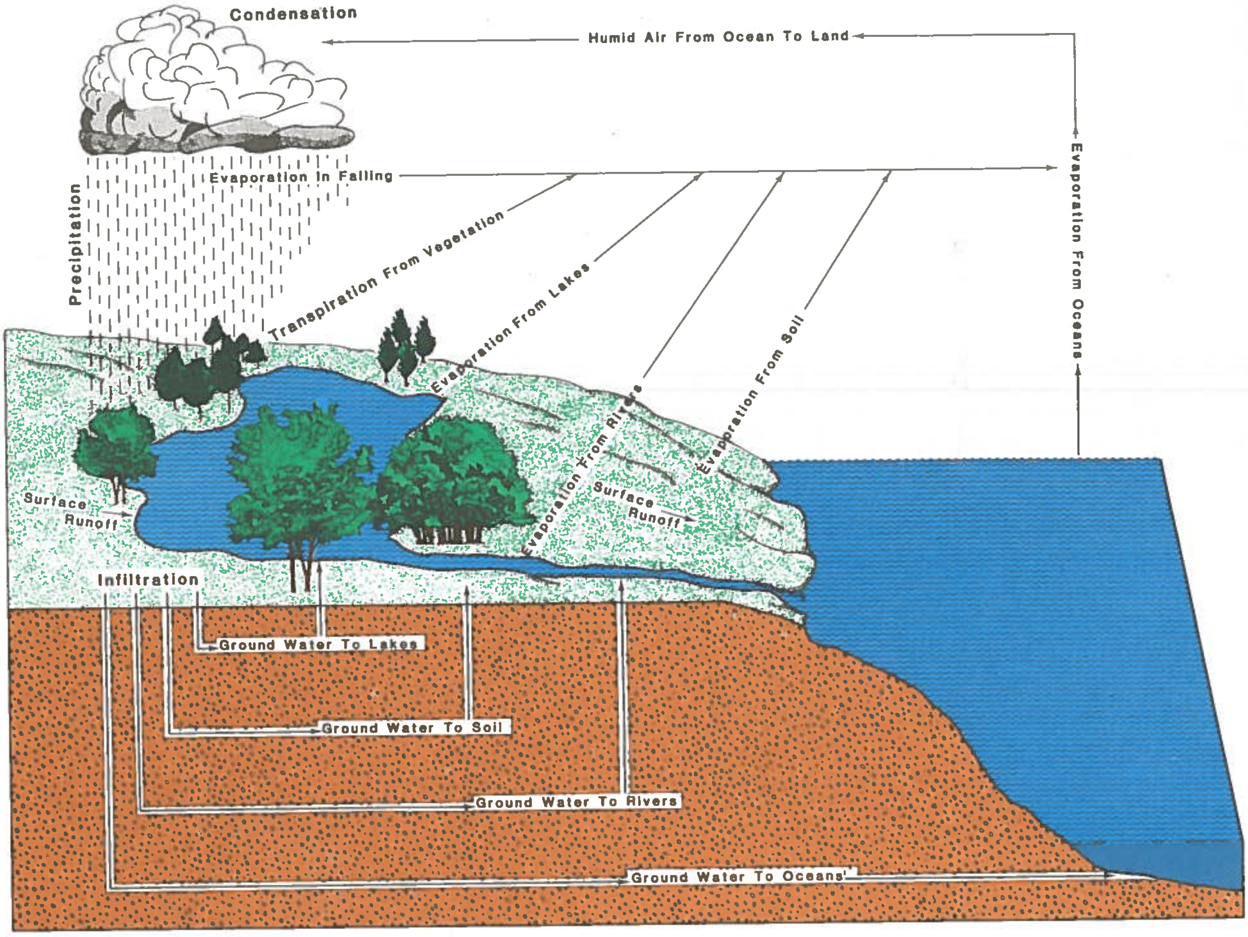


Figure 9.
The water cycle.

results in higher vapor pressure in the water than in the air, and to equalize the pressure, liquid water vaporizes and moves into the atmosphere. In general, the greater the vapor pressure differential, the greater the rate of evaporation.

Evaporation rates are also affected by the moisture content of air, a measure which is known as relative humidity. This is merely the ratio of water vapor in the air to that amount needed for saturation at a particular temperature, expressed as a percentage. At a given temperature, air is capable of absorbing and holding only a certain amount of water vapor. Therefore, as vaporized water molecules gradually saturate the air near the site of evaporation, relative humidity increases and the rate of evaporation decreases. When the relative humidity reaches 100 percent, evaporation stops.

The mixing influence of the wind can greatly accelerate evaporation. If the saturated layer of air above an evaporating body of water is disturbed by wind and is replaced with drier air, then evaporation can continue.

Another important process by which water is lost to the atmosphere is transpiration, the loss of water from plants. Plants require large quantities of water for the transport of nutrients and food (sugars), plant cell formation, photosynthesis, and gas exchange. Water enters plants through the root system, moves through the plant to the leaves, and is then transpired into the atmosphere through tiny openings on the underside of leaves.

Transpiration is a much more variable process than evaporation because water molecules must pass through living organisms before entering the atmosphere. Not only are these water molecules subject to the same physical factors as in evaporation (temperature, wind, and humidity), but they are also subject to the numerous chemical and biological processes within the plant. Transpiration rates are dependent also on the plant species, time of day, and season.

Ground-water Infiltration

A portion of precipitation not lost by evapotranspiration infiltrates the earth's crust and contributes to soil moisture and ground-water reserves. The rate of ground-water infiltration is dependent on soil characteristics and moisture content, type and extent of vegetative cover, and geomorphological characteristics. Not all water that enters the soil recharges deep ground-water reserves; a large portion of this water is retained near the surface as soil moisture. Soil moisture is readily lost to the atmosphere by direct evaporation and transpiration by plants and must be replaced regularly to substain surface vegetation. In addition, soil moisture affects infiltration to deeper more permanent ground-water reserves.

Water in aquifers eventually discharges into streams, lakes, and oceans. Ground-water movement, however, is extremely slow, on the order of tens of feet per year. Therefore, this resource may require hundreds of years to cleanse itself through natural recharge, if contaminated.

Surface Runoff

Precipitation that is not subject to evapotranspiration or ground-water infiltration is available for surface runoff. When the rate of rainfall exceeds the ability of soil to absorb or store the water, the excess pools on the soil surface and runs off to surface streams. The amount of surface-water runoff entering a stream is dependent on rainfall intensity and duration, type and extent of vegetative cover, slope of the land surface, and soil conditions.

SURFACE-WATER RESOURCES

South Carolina's surface waters have played a vital role in the history, development, and economy of the State. Historically, the State's numerous rivers served as transportation routes, fishing and hunting grounds, and drinking water for native Americans and Europeans settling along their shores. Later these flowing waters were also developed to irrigate extensive rice plantations, power grist and textile mills, and transport people and goods. More recent water development includes hydroelectric and thermoelectric power plants, flood control projects, and increases in withdrawals for established uses such as public supply, industry, and irrigation. Presently, surface water is used to meet most of the water demand in the State.

River Systems

Based on hydrologic drainage characteristics the State contains all or parts of four major river basins: the Pee Dee, Santee, Ashley-Combahee-Edisto (ACE), and Savannah (Fig. 10). The U.S. Water Resources Council, in cooperation with the U.S. Geological Survey, has subdivided these major basins into several hydrologic units (U.S. Geological Survey, 1974). The 15 sub-basins discussed in this report were derived from these hydrologic units and are presented in Figure 10 and listed below under their respective major drainage basins.

Pee Dee River Basin
- Pee Dee River Sub-basin
- Lynches River Sub-basin
- Little Pee Dee River Sub-basin
- Black River Sub-basin
- Waccamaw River Sub-basin

Santee River Basin
- Broad River Sub-basin
- Saluda River Sub-basin
- Catawba-Wateree River Sub-basin
- Congaree River Sub-basin
- Lower Santee River Sub-basin

Ashley-Combahee-Edisto (ACE) River Basin
- Ashley-Cooper River Sub-basin
- Edisto River Sub-basin
- Combahee-Coosawhatchie River Sub-basin

Savannah River Basin
- Upper Savannah River Sub-basin
- Lower Savannah River Sub-basin

Monitoring Program

Streamflow in South Carolina has been monitored routinely since the late 1800's by the U.S. Geological Survey. This Federal agency is the only agency in the State directly responsible for collecting streamflow data for public waters. Continuous gaging stations are located throughout the State and periodically stations are added or deleted as data needs change. During 1980, 67 continuous recording stations monitored streamflow in South Carolina. Data have also been collected in the past at 45 discontinued sites (Fig. 11).

The U.S. Geological Survey identifies each streamflow gaging station using an eight digit number. The number reflects the down-stream order position of the station in relation to the main stream and other gaging stations. The complete eight digit number, such as 02175000, includes the two digit hydrologic part number (02) plus the six digit downstream order number (175000) (U.S. Geological Survey, 1980). The gaging station numbers used in this report are the accepted abbreviated version of the complete eight digit number used by the U.S. Geological Survey. In general, the first two digits (02) refering to South Atlantic Slope Basins were deleted, and the last two digits were deleted if equal to zero but follow a decimal point if greater than zero (02172020 becomes 1720.2).

Figure 10.
Major river basins and sub-basins in South Carolina.

The South Carolina Department of Health and Environmental Control periodically measures streamflow at 68 primary water quality sampling stations where flow is not measured by the U.S. Geological Survey. These data, which are used to help determine waste load allocation for streams, are available to the public upon request.

Factors Affecting Streamflow

South Carolina has an abundance of surface water; unfortunately, the availability of this natural resource is not geographically and temporally uniform throughout the State. Streamflow is influenced by natural and man-induced conditions. Physiographic characteristics of the watershed, which affect the seasonal, yearly, and geographical variation in precipitation and evaporation, greatly affect flow. Man's modification of watercourses for hydroelectric power generation, navigation, flood control, and water withdrawal also impacts streamflow.

Physiography

Characteristics of the land surface greatly affect local and regional hydrology. Generally, the land surface of South Carolina is divided three major physiographic provinces: Blue Ridge, Piedmont, and Coastal Plain. The Coastal Plain is further divided into the Upper Coastal Plain, Middle Coastal Plain and Lower Coastal Plain (Fig. 5). Streams located within each of these provinces exhibit flow characteristics representative of the respective region. Streams flowing through more than one province exhibit flow characteristics of each province. The following sections describe general surface water characteristics in each of these provinces.

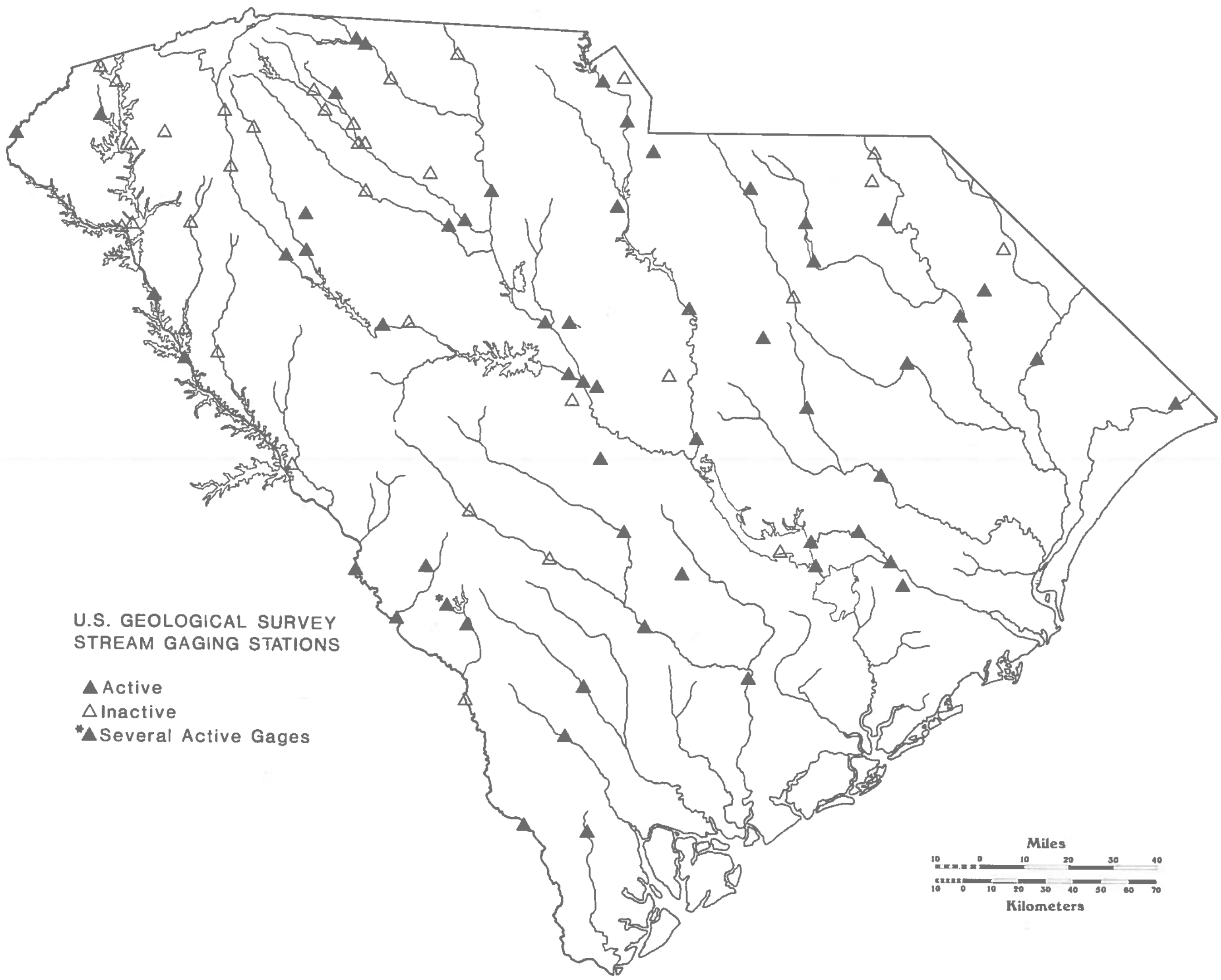


Figure 11.
Active and inactive U.S. Geological Survey streamflow gaging stations in South Carolina.

Blue Ridge Province. This mountainous region of the State has steep terrain with some stream gradients greater than 250 feet per mile (Bloxham, 1979). The geology of this region significantly affects surface-water flow. Surface fractures in crystalline rock provide channels for runoff. Because of this, stream channels are often angular and local drainage patterns are often rectangular (Acker and Hatcher, 1970). These fractures also provide avenues for ground-water flow and storage. As the deeply incised streams of this region intercept these crystalline rock aquifers, relatively large quantities of ground-water contribute to the streamflow. Overlying the crystalline rock is a layer of weathered bedrock or saprolite. This layer of relatively course semipermeable material stores ground water for release later to crystalline rock aquifers and streams. Although some rainfall infiltrates the saprolite layer, the steep terrain and semipermeable soils in this region cause much of the rainfall to run off rapidly into stream channels. Blue Ridge Province streams, therefore, typically exhibit rapidly fluctuating flows dependent on rainfall and ensuing runoff but have well-sustained base flows due to substantial ground-water discharge.

Piedmont. The rolling hills of the Piedmont range in elevation from 1,000 feet near the mountains to 400 feet at the Fall Line. Stream gradients range from 60 feet per mile in the mountain foothills to about five feet per mile in the lower portion of this province near the Fall Line (Bloxham, 1981). Bedrock in this province is jointed and fractured similarly to that in the Blue Ridge Province, but groundwater storage and base flow generally decrease downslope across the Piedmont for two reasons: (1) saprolite permeability decreases from the upper Piedmont to the lower Piedmont, retarding rainwater infiltration and causing more surface-water runoff, and (2) stream channels are less deeply incised than in the Blue Ridge Province which

Supplemental Information Box 2.

Surface Water Hydrology Terminology

average daily streamflow – the arithmetic average of all daily flows recorded during the period of record for the gaging station listed.
90 percent flow – streamflow which has been equalled or exceeded 90 percent of the time at a particular gaged site.
7Q10 flow – the lowest average flow expected during seven consecutive days on the average of once in 10 years. This low flow value is frequently used to assess reliability of streamflow during low rainfall periods. The seven day period is used to minimize effects of daily fluctuations and short term events.
low flow of record – the lowest daily average flow to be measured at a gaging station. Instantaneous measurements may be lower.
maximum flow of record – the highest instantaneous flow recorded at a gage.
unit discharge (unit average discharge, unit 7Q10 discharge) – streamflow per square mile, derived by dividing streamflow (often average daily or 7Q10) by the drainage area at a gaged site. Provides a common streamflow unit for basin comparison.

decreases the number of intercepted fracture zones available to support base flow. Piedmont streamflow is, therefore, highly dependent on rainfall and runoff with little ground-water support. Zero-flow conditions during summer and fall months are not uncommon on smaller streams, especially in the lower Piedmont region, while basins of several hundred square miles may experience zero flow under extreme conditions.

Upper Coastal Plain. The Upper Coastal Plain extends southeast from the Fall Line to the Citronelle Escarpment (Cooke, 1936) and is characterized by moderately sloped, irregularly shaped, and rounded terrain. Stream gradients range from 5 to 20 feet per mile (Bloxham, 1979). This region includes outcrop portions of the Middendorf, Barnwell, and McBean Formations which are comprised of loosely consolidated sediments overlain by coarse sand to sandy loam soils. Streams deeply incise these porous materials, resulting in shallow ground-water aquifers above stream level. These aquifers discharge into streambeds to support flow, especially during periods of low rainfall. In addition, these shallow aquifers absorb large quantities of rainfall, thus reducing peak runoff to streams. Upper Coastal Plain streamflows are, therefore, supported primarily by discharge from ground-water storage and typically exhibit less variable flow year round with well-sustained base flow.

Middle and Lower Coastal Plain. The Middle and Lower Coastal Plain extend from the Citronelle Escarpment to the coast, an area approximately 80 miles wide. This region has moderate to low relief, shallow stream incisement, stream gradients of about 3.5 feet per mile (Bloxham, 1979), and extensive swamplands associated with large portions of the river systems. Middle and Lower Coastal Plain streams are more dependent on rainfall and runoff to support flow rather than groundwater discharge. The highly permeable soils in this region are similar to those of the Upper Coastal Plain which readily absorb rainfall and retard runoff to stream channels. Streamflows, therefore, rise and fall gradually. The low relief and shallow stream incisement of this region allows little ground-water storage area above stream channels. Therefore, ground water provides less support than in the Upper Coastal Plain, and these streams typically have poorly sustained base flows. Zero-flow conditions in the Middle and Lower Coastal Plain are not uncommon during dry periods.

Precipitation and Evapotranspiration

South Carolina is located in the humid, subtropical region of the nation and experiences cool winters, relatively long, hot summers, and moderately high annual precipitation, mostly in the form of rain. Rainfall varies according to geographic location, season, and year. Evaporation also varies geographically and seasonally, but is fairly consistent year after year.

Average annual rainfall is greatest in the Blue Ridge Province (80 inches), decreases to 40 to 48 inches over most of the Piedmont and Coastal Plain regions, and increases again to about 52 inches near the coast (Purvis and Lovingood, 1970). Rainfall amounts vary seasonally with peaks generally occurring during the winter and summer months and lows during the fall (Fig. 12).

The potential evapotranspiration rate, which is at a maximum when all controlling factors are at optimum conditions, increases from north to south. These annual rates range from 29.6 inches near Spartanburg to 46.6 inches at Savannah, Georgia. The rate of evapotranspiration is controlled mostly by air temperature but is modified by relative humidity and wind speed. Marked seasonal variation occurs, with the highest monthly rates during the summer (3.5-4.9 inches per month) and the lowest during the winter (0.35-1.0 inches per month) (Fig. 12).

The amount of runoff contributing to streamflow is basically equal to total rainfall minus the amount subject to evapotranspiration and ground-water infiltration. Where ground-water infiltration is negligible, such as in the Piedmont, the interaction of rainfall and evapotranspiraion are major factors affecting streamflow. Streamflow characteristics in the Piedmont and Lower Coastal Plain, where flow is primarily dependent on rainfall and runoff, reflect seasonal variation in precipitation and evapotranspiration (Fig 13). Where ground-water base flow is significant, such as in the Upper Coastal Plain and Blue Ridge Provinces,

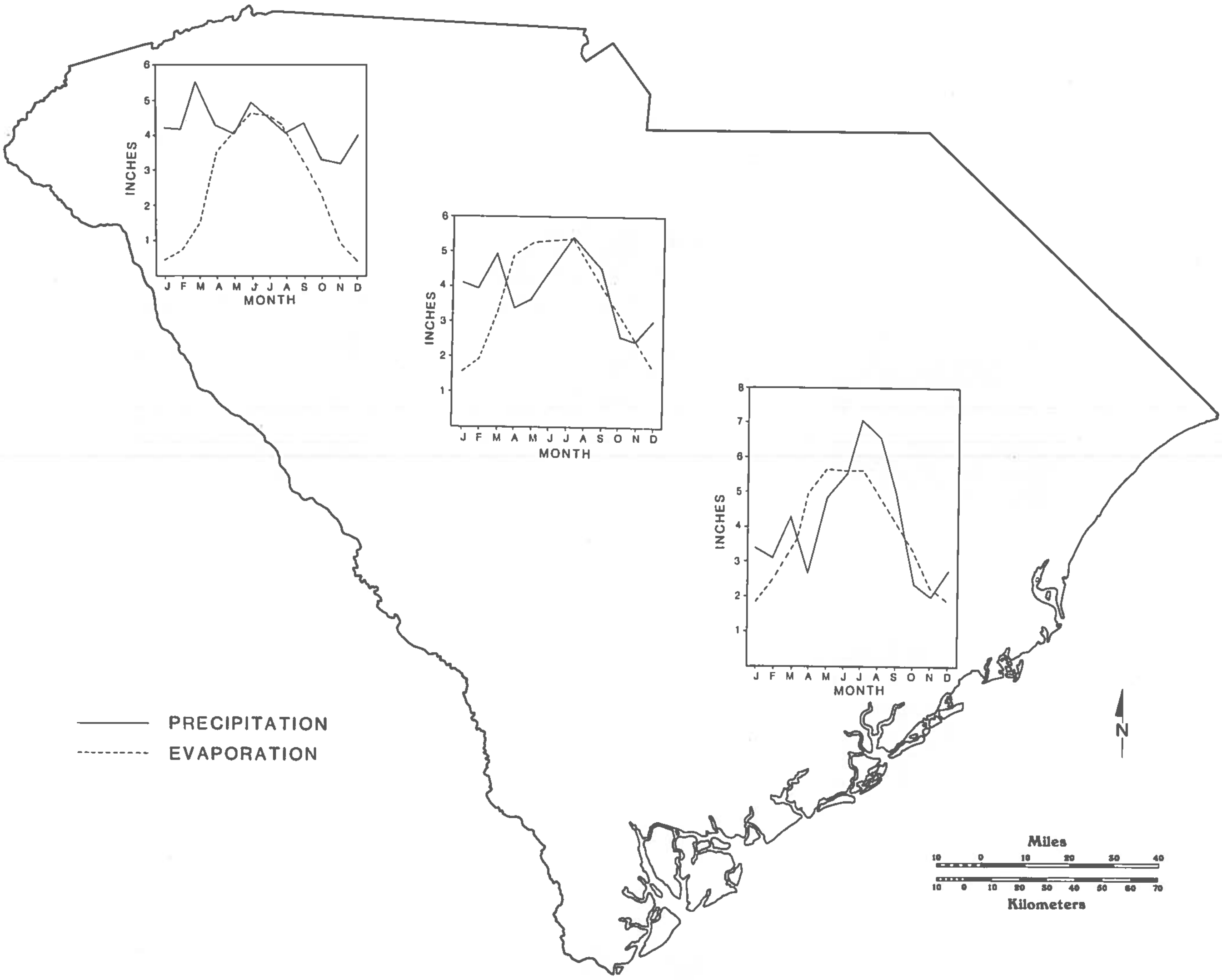


Figure 12.
Average monthly precipitation and evaporation rates in South Carolina.

flows are much more regular throughout the year. The interaction of rainfall and evapotranspiration and the resulting runoff are modified by the porous soil and substratum in these regions. Average annual streamflow may vary considerably from year to year as Figure 14 illustrates; but this is primarily due to differences in yearly precipitation.

Surface-Water Development

Since the settlement of South Carolina by Europeans in the 1600's the State's surface waters have been modified to better serve its citizens. Numerous lakes have been constructed to store water and generate power; streams have been cleared and dredged to improve navigation; and numerous watersheds have been modified to minimize the effects of floods. Many of these developments also provide stillwater habitat for fish and wildlife and provide sites for recreational activities such as swimming, boating, and fishing.

Thirty-five hydroelectric power projects of varying generating capacity and reservoir size are located in South Carolina. Eighty percent of these existing projects and most of all identified potential hydropower sites occur in the Piedmont region of the State. The relatively high relief and steep stream gradients of this province are naturally suited for reservoir development. Few reservoirs are located in the Coastal Plain region. Impoundments in this region are typically large and shallow. The 15 largest reservoirs in the State are listed in Table 8 by storage capacity.

Numerous hydroelectric dams and power plants have been constructed on several of the State's major rivers, including the Savannah, Saluda, Broad, Catawba-Wateree, and Santee. Controlled releases from these facilities above the licensed minimum releases are dependent on electric power demand and may be highly variable. Generally, extreme maximum and minimum flows are modified by these facilities. However, in some instances (Wateree River, Santee River, Saluda River, Broad River), low-flow condi-

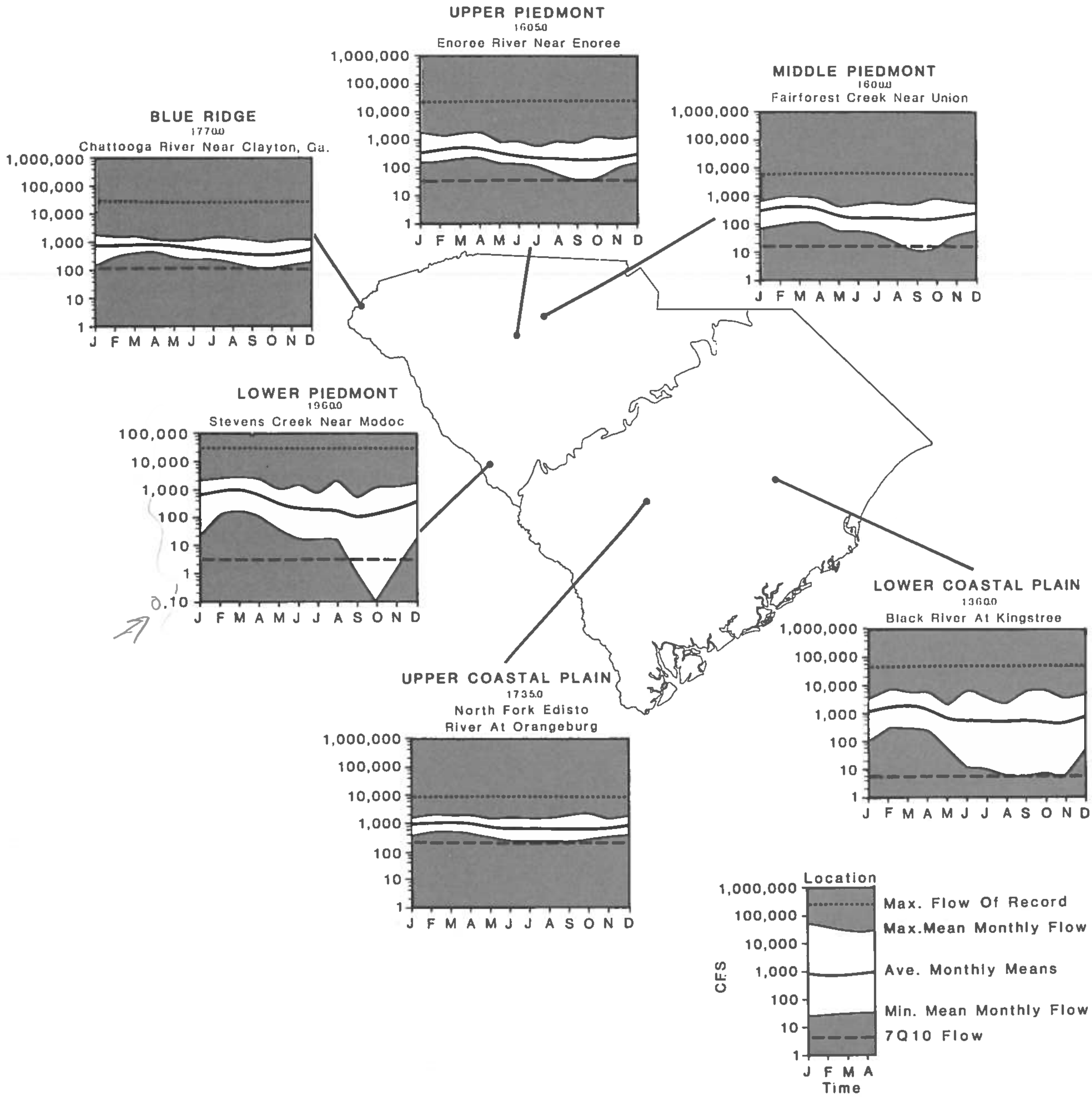


Figure 13.
Representative hydrographs for physiographic provinces in South Carolina.

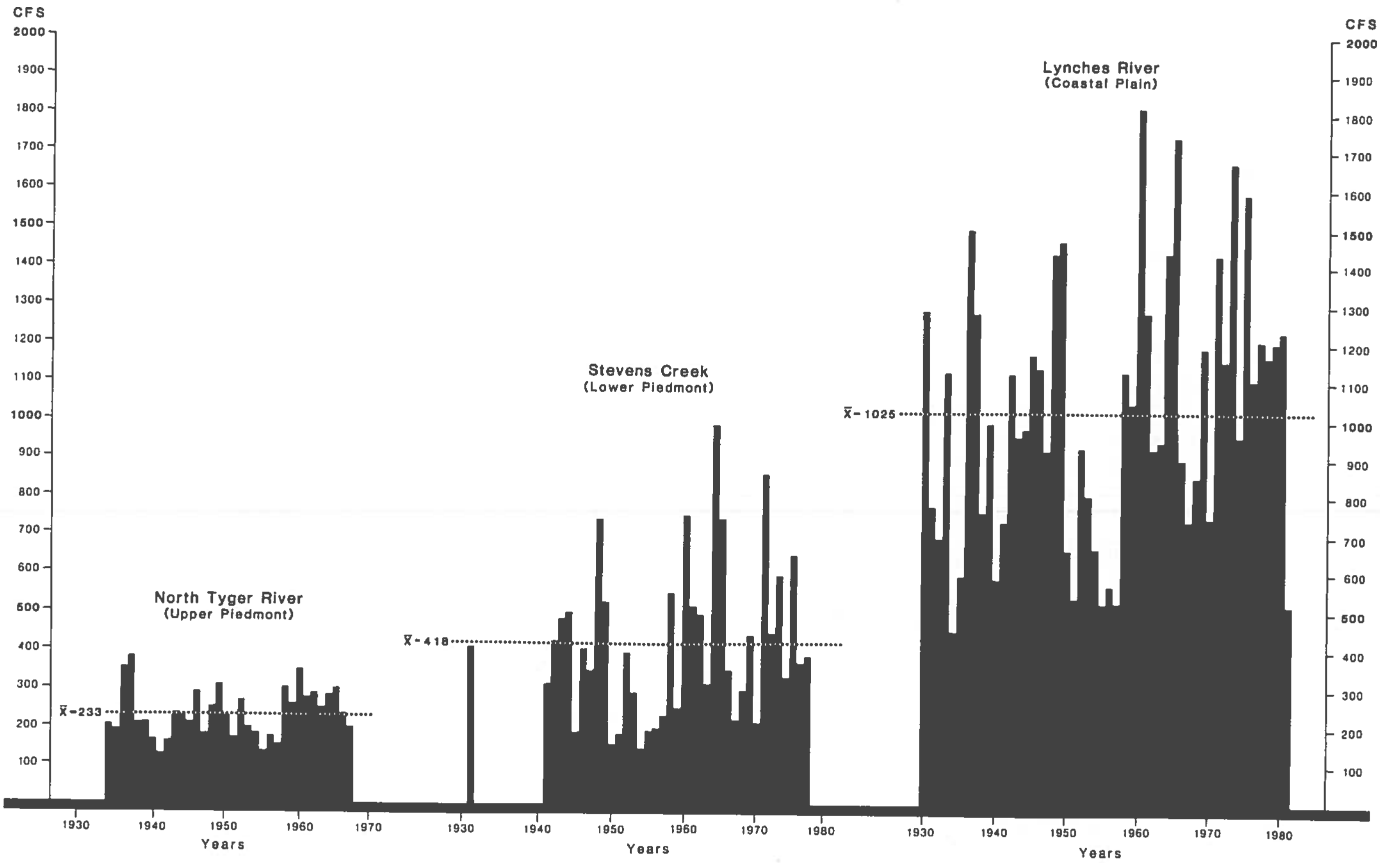


Figure 14.
Yearly streamflow variation of streams in the Piedmont and Coastal Plain of South Carolina.

Table 8.
Largest lakes in South Carolina by storage capacity.

Rank (by capacity)	*Name*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Use*[a]
1	Hartwell Lake	56,000	2,549,000	P,R,Ws
2	Clarks Hill Lake	70,000	2,510,000	P,R,M,Fc
3	Lake Murray	51,000	2,114,000	P,R,Ws
4	Lake Marion	110,600	1,400,000	P,R.
5	Lake Moultrie	60,400	1,211,000	P,R,Ws
6	Lake Jocassee	7,565	1,185,600	P,R
7	Richard B. Russell Lake	26,650	1,026,000	P,Fc,R
8	Lake Keowee	18,372	1,000,000	P,R,M
9	Lake Monticello	6,800	431,050	P,R
10	Wateree Lake	13,710	310,000	P,R,Ws
11	Lake Wylie	12,455	281,900	P,R
12	Lake Greenwood	11,400	270,000	P,R,Ws,M
13	Fishing Creek Reservoir	3,370	80,000	P,R,Ws
14	North Saluda Reservoir	1,080	76,108	M
15	Par Pond-SRP	2,700	54,000	I

[a]P- Power
R- Recreation
M- Municipal
Fc- Flood control
Ws- Water supply
I- Industrial

Supplemental Information Box 3.

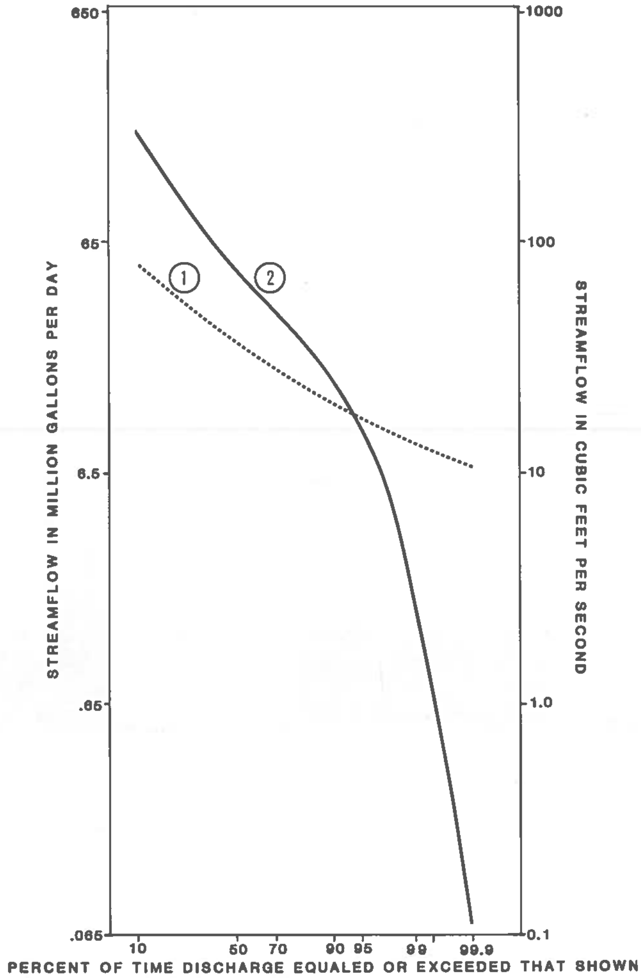
Interpretation of Streamflow Graphics

In each surface water hydrology section, several types of data analysis techniques and graphical representations are used repeatedly to illustrate various aspects of streamflow. Two graphics in particular which are frequently used are flow duration curves and monthly mean streamflow graphs.

Flow Duration Curves

Flow duration curves show the percentage of time that streamflow has been equalled or exceeded at a particular site for the period of gaging record. Reliability of streamflow can be derived from the curves and since the graphs have the same scales, different streams are directly comparable.

The vertical position of the curve indicates amount of flow and the slope indicates reliability of flow. Curves of moderate slope (curve 1) reflect relatively stable streamflows, while steeply sloped curves (curve 2) indicate more variable flows.

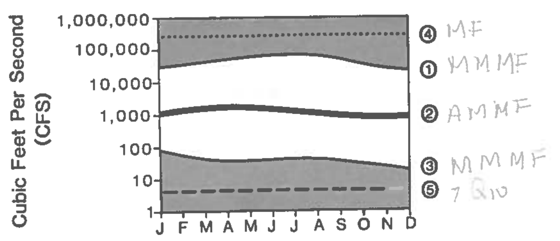


Monthly Mean Flow Graphs

Monthly streamflow graphs illustrate the annual range of flow for each month that has occurred at a particular site for the period of gaging record. Five flow characteristics are used to define the flow range, (1) maximum mean monthly flow, (2) average of monthly means, (3) minimum mean monthly flow, (4) maximum flow of record, and (5) 7Q10 flow.

Since the logrithmic scales for each graph are the same, flow characteristics of different stream sites are comparable.

The vertical position of the curves reflect the quantity of flow, while the range between mean maximum and minimum flows indicate the degree of variability. Seasonal variation, low flow periods, and high flow periods are also graphically depicted by vertical fluctuations of the maximum, average, and low mean flow curves.



tions may be aggrevated due to insufficient discharge while reservoir supplies are replenished or power demand is low.

Approximately 2,000 miles of river channel have been cleared and dredged for navigation during the State's history. However, maintenance on about three-quarters of these channel miles has been discontinued for various reasons. Currently, about 500 miles of navigation channel are actively maintained by the U.S. Army Corps of Engineers. Most of these navigation projects occur in the Lower Coastal Plain region of the State and include the Intracoastal Waterway, Charleston Harbor, Winyah Bay, and the Savannah River between Savannah and Augusta, Georgia.

Modification of watersheds for flood control may entail diking, straightening, clearing, dredging, and damming of stream channels. About 50 flood control projects and 20 studies are in various stages of progress in the State. Most of these projects are located in the Piedmont Province where relatively impermeable soils cause rapid runoff and subsequent flooding during heavy rainfall. Numerous flood control projects also occur in the Middle and Lower Coastal Plain Provinces where the low relief results in poor drainage and pooling of rain water.

State Surface-Water Hydrology Overview

Average streamflow in South Carolina is about 33 billion gallons per day. The Santee River in its original state had the highest average streamflow in South Carolina with 18,700 cfs. This discharge was the third largest on the east coast with only the Susquehanna (37,190 cfs) and Hudson (19,500 cfs) Rivers discharging more water to the Atlantic Ocean. Currently, most of the Santee River flow, about 15,000 cfs, is diverted to the Cooper River. Upon completion of the Cooper River Rediversion Project in 1984, discharge from the Santee River will increase to about 13,000 cfs. Other major rivers in the State are the Pee Dee River with a discharge of 15,600 cfs and the Savannah River which discharges about 12,100 cfs at its mouth.

Streamflow varies seasonally, geographically, and yearly due to physiography and the change in the interaction between rainfall and evapotranspiration. Throughout the State, streamflow is generally highest during late winter and early spring and lowest during late summer and fall. While minimum flows generally occur only during the summer and fall, maximum flows may occur any time during the year.

Streams located in the Blue Ridge and Upper Coastal Plain Provinces, generally exhibit greater flow per square mile of drainage area, and well-sustained base flows (Fig. 13, 15 and 16). High average rainfall with little variation year round and substantial ground-water reserves ensure reliable flows in Blue Ridge streams. Reliable streamflows in the Upper Coastal Plain region are attributed primarily to discharge from substantial ground-water storage. Lower Piedmont and Lower Coastal Plain streams exhibit highly variable flows, small flow per square mile of drainage area, and poorly sustained low flow. Seasonal streamflow variation in these streams is substantial due to the dependence on rainfall and runoff. Dry conditions during late summer and fall result in minimum flow conditions with some streams periodically experiencing zero-flow conditions.

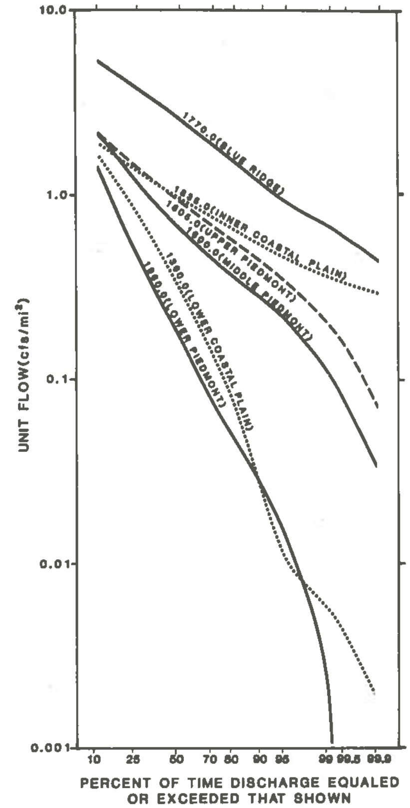


Figure 15.
Unit flow duration (flow duration/square mile) for streams representative of the physiographic provinces in South Carolina.

Surface Water Quality

An important element of any water resource assessment is the quality of the resource. The chemical, physical, and biological integrity of surface water greatly affect man's use of this important resource. While waters of high quality are suitable for all water use activities including swimming, fishing, and drinking (after treatment), less pure waters may safely serve only industrial and agricultural needs. The maintenance of a healthy community of aquatic organisms requires a suitable chemical and physical environment. The introduction of toxic substances or the presence of essential constituents outside acceptable ranges may adversely alter existing aquatic populations and in turn adversely impact human water use activities.

Factors Affecting Water Quality

Generally, water pollution occurs when chemical, physical, or biological constituents are present at levels detrimental to human use or aquatic life. Sometimes these contaminants are of natural origin and enter surface waters by precipitation or runoff from adjacent watershed lands. The impact of this non-point source pollution is dependent upon the amount of precipitation, watershed characteristics, type of pollutant, and the assimilative capacity of the water body. Man's modification of watershed lands for agriculture, silviculture, mining, waste disposal, and other activities can significantly contribute to non-point source pollution. Typical non-point source pollutant materials include sediments, organic materials, nutrients, metals, pesticides, oil and grease, and acids. In the Coastal Plain watersheds, tannins from naturally decomposing swamp vegetation stain the waters of many streams. The dark brown color is a natural characteristic of the State's blackwater streams and is not a water quality problem.

Pollutant materials also originate from industrial, municipal, and domestic wastewater discharges. The impact of these point source pollutants is dependent upon the volume and composition of the discharged effluent and the assimilative capacity of the water body. The uncontrolled release of a wide variety of toxic and non-toxic chemical sub-

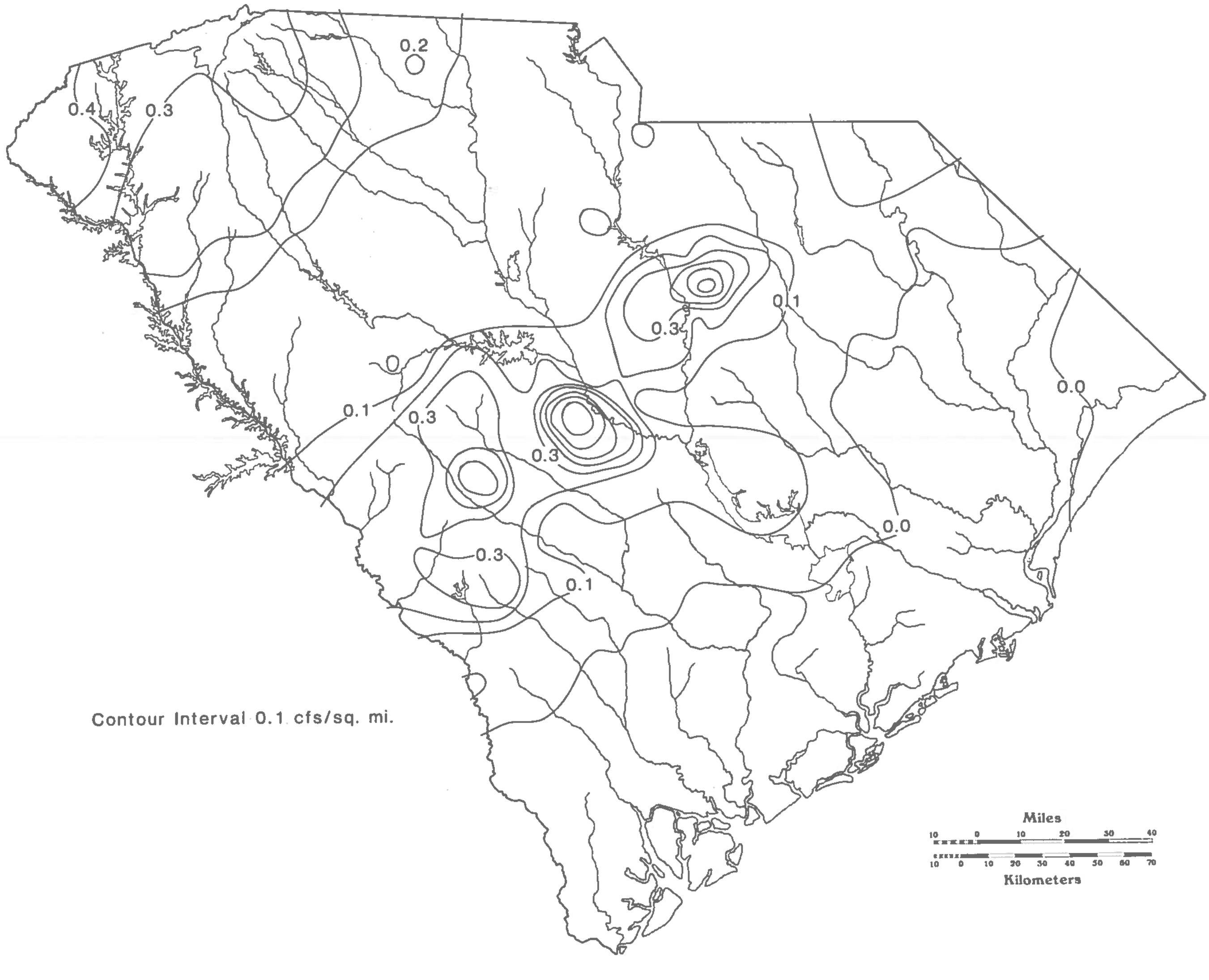


Figure 16.
Unit 7Q10 flow (7Q10/square mile) distribution for drainage areas in South Carolina.

stances, nutrients, oxygen demanding substances, and waste heat from these point source discharges could severely impact the State's valuable surface waters.

Water Quality Management

The objective of the Federal Water Pollution Control Act, as amended in 1972, is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." In order to achieve this objective, two goals were established: (1) the elimination of pollutant discharges into the Nation's navigable waters by 1985, and (2) wherever attainable, water quality suitable for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water by July 1, 1983.

It is the policy of the State of South Carolina to maintain public waters at reasonable standards of purity consistent with public health, safety, and welfare; maximum employment and industrial development; propagation and protection of fish and wildlife; and protection of physical property and other resources (S.C. Pollution Control Act, Section 48-1-20, South Carolina Code of Laws, 1976). The agency primarily responsible for protecting and maintaining the quality of South Carolina's water resources is the S.C. Department of Health and Environmental Control. In pursuit of the National goals and in accordance with State and Federal regulations, the S.C. Department of Health and Environmental Control has established a water classification and standards system, a statewide water quality monitoring network, and several water quality control programs.

Other local, State, and Federal agencies which have interests and programs involving water quality protection include the S.C. Water Resources Commission, S.C. Wildlife and Marine Resources Department, S.C. Land Resources Conservation Commission, S.C. Coastal Council, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Geological Survey, the regional planning councils, and city and county governments.

Classification and Standards

The surface-water classification and associated quality standards system developed by the S.C. Department of Health and Environmental Control (1981a) is designed to maintain suitable water quality for the following designated uses.

1. CLASS AA - Freshwaters which constitute an outstanding recreational or ecological resource and those waters suitable as a source for drinking water supply purposes with treatment levels as specified by the Department of Health and Environmental Control. Suitable also for uses listed in Class A and Class B.
2. CLASS A-TROUT- Freshwater suitable for supporting reproducing trout populations and/or essential to trout reproduction, growth, and survival. Suitable also for uses listed in Class A and Class B.
3. CLASS A - Freshwaters suitable for primary contact recreation. Also suitable for uses listed in Class B.
4. CLASS B - Freshwaters suitable for secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with requirements of the Department of Health and Environmental Control. Suitable for fishing, survival and propagation of fish, and other fauna and flora. Suitable also for industrial and agricultural use.
5. CLASS SAA - Tidal saltwaters which constitute an outstanding recreational or ecological resource and/or waters suitable for uses that require the absence of pollution. Suitable also for uses listed in Class SA, Class SB, and Class SC.
6. CLASS SA - Tidal saltwaters suitable for harvesting of clams, mussels, or oysters for market purpose or human consumption except within buffer zones designated by the Department of Health and Environmental Control. These buffer zones are consistent with this classification. Suitable also for uses listed in Class SB and Class SC.
7. CLASS SB - Tidal saltwaters suitable for primary contact recreation. Suitable also for uses listed in Class SC with the same exception.
8. CLASS SC - Tidal saltwaters suitable for secondary contact recreation, crabbing, and fishing, except harvesting of clams, mussels, or oysters for market purposes or human consumption. Also suitable for the survival and propagation of marine fauna and flora.

All waters of South Carolina fall within one of the preceding classes and must meet associated quality standards. However, some classified waters are identified by name, while all other waters assume the classification of the water body into which they flow. Currently, over 400 water bodies or portions of water bodies in South Carolina have been officially classified by name (S.C. Department of Health and Environmental Control, 1980a). These classified waters include four Class AA, no Class A-Trout, 105 Class A, 266 Class B, no Class SAA, 43 Class SA, 13 Class SB, and 10 Class SC. Locations of these classified waters are presented in the water quality section of each sub-basin assessment.

In general, the quality of the State's waters cannot be lowered to a point which interferes with or harms existing uses and no degradation is allowed in high quality waters (Class AA and Class SAA) (S.C. Department of Health and Environmental Control, 1981a). To maintain existing quality conditions and ensure that waters are suitable for designated uses, quality standards are established for each class (Appendix A). These standards set specific numerical limits for dissolved oxygen, fecal coliform bacteria, pH, temperature, and sometimes turbidity, while providing general specifications for other parameters. The impacts of the individual water quality parameters on water use are discussed in Supplemental Information Box 4. In addition to State standards, Federal water quality criteria are also used as a guide to better manage surface waters. While Federal criteria are not legally binding, unlike State standards, they include quality parameters which do not have specific limits in the State standards and serve as an important management tool.

Monitoring Programs

The surface waters of South Carolina are routinely monitored for various water quality constituents by the S.C. Department of Health and Environmental Control. Data collected through this program include physical and chemical analyses of water, chemical analyses of sediments, and assessment of aquatic biological communities. Much of this information is compiled from a network of fixed monitoring stations including 173 primary stations (Fig. 17) and 414 secondary stations (S.C. Department of Health and Environmental Control, 1981b). Water samples from primary sampling stations are collected and analyzed for a wide range of parameters at monthly intervals year round, while samples from secondary sampling stations are collected at monthly intervals only from May through October and analyzed for fewer constituents. Selected primary and secondary stations are also sampled annually for sediment analyses and biological assessment (S.C Department of Health and Environmental Control, 1981b).

The U.S. Geological Survey also routinely collects water quality data and currently maintains 29 water quality

Supplemental Information Box 4.

Water Use Impacts Of Common Water Quality Constituents

Dissolved Oxygen

The concentration of oxygen dissolved in water is important to sustain a healthy and aesthetically pleasing aquatic environment. Dissolved oxygen levels are variable and influenced by several physical, chemical, and biological factors in a water body. Adequate oxygen levels are necessary to maintain biological metabolism, aquatic life, and a balanced biotic community. Insufficient dissolved oxygen concentrations may result in fish kills, anaerobic decomposition of organic material, and subsequent production of noxious gasses and floating sludge (U.S. Environmental Protection Agency, 1976a). These undesirable conditions adversely impact recreational water use. While high dissolved oxygen levels enhance palatability and treatment of drinking water, these same levels accelerate corrosion of metal pipes and equipment.

Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is the amount of oxygen consumed by aerobic biological processes in the decomposition of organic material. BOD levels are influenced by any source of organic material which may include municipal and industrial waste discharges and influx of organic material from the surrounding watershed. While BOD is dependent upon many environmental factors, generally an increase in organic material results in increased BOD and decreased dissolved oxygen. If BOD is not offset by reaeration, dilution, or photosynthesis, dissolved oxygen depletion may result and interfere with water use. The effects of BOD on water use are the same as those for dissolved oxygen depletion.

Fecal Coliform Bacteria

Microbes from domestic and agricultural wastewater have been linked to ear, eye, nose, throat, and intestinal ailments in man. Bacteria of the coliform group are used as the primary indicators of water-borne fecal contamination (U.S. Environmental Protection Agency, 1976a).

Consumption of contaminated shellfish or inadequately treated drinking water may lead to intestinal diseases such as gastroenteritis and typhoid fever. Elevated levels of fecal coliform bacteria also adversely affect food handling industries by causing unwanted fermentation, taste changes, and/or spoilage (McKee and Wolf, 1963). While results from human health studies vary, it is generally recommended that recreational activities such as swimming be avoided in waters with high concentrations of fecal coliform bacteria.

Metals

Metals include a large group of elements which when present, alone or in combination with other substances, can adversely affect the suitability of surface waters for man's use and aquatic life. Some of the more important metals include cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc. Many metals occur naturally in low concentrations in surface waters; however, many of man's activities (mining, urban runoff, industrial wastewater effluent) elevate normal levels.

When consumed in abnormally high concentrations, most metals are toxic to man and aquatic organisms. Some metals, such as cadmium, lead, and mercury, accumulate in the body and cause chronic illness. The toxicity of metals to aquatic life depends on water temperature, pH, hardness, alkalinity, dissolved oxygen concentration, the presence of other substances, and the species affected. High metals concentrations in domestic water supplies are toxic to consumptive users, cause undesirable taste, and stain plumbing fixtures and laundered clothes. Several metals are injurious to some crops when present in high concentrations in irrigation water. Excess metal concentrations in industrial process water adversely affect product quality in several industries including food-processing, textile, and metal-plating (McKee and Wolf, 1963).

Nutrients

Nutrients are all substances essential for the maintenance, growth, and reproduction of living organisms. Two of the most important nutrients affecting aquatic biological systems are phosphorus and nitrogen. Phosphorus is a major component of living cells and is essential to many metabolic processes such as respiration and photosynthesis. Nitrogen is a major constituent of proteins and genetic material and is especially important for bacterial decomposition of organic matter. These nutrients are normally present in limited quantities and restrict biological productivity. However, when present in large amounts, nutrients increase aquatic plant and algal growth and accelerate eutrophication, the natural aging process of water bodies. At advanced stages of eutrophication decomposing organic material and elevated respiration rates deplete dissolved oxygen in the water resulting in fish kills and other noxious conditions indicative of poor water quality. Many nutrients enter surface waters from natural sources; however, man's domestic, agricultural, and industrial activities often directly or indirectly contribute excessive amounts. While elevated nutrient levels may increase fish production to some extent, excessive nutrient loads encourage advanced eutrophic conditions which impair water quality, aesthetic appeal, and the recreational value of a water body.

pH

The pH of water is a measure of the hydrogen ion activity and is indicative of the intensity of acidic conditions. Standard pH units range from 0 to 14. A pH value of 7.0 is neutral; lower values are progressively more acidic and higher values are more basic. The solubility of many compounds and toxicity of some substances are influenced by pH. Changes in pH can occur from organic material, industrial wastes, acid rain, and other factors.

In domestic supply waters, pH values outside the normal range affect taste, corrosivity, and the efficiency of treatment processes such as chlorination and coagulation. Various industrial processes require a limited pH range. Low pH values increase corrosion to equipment and concrete. Crop yields are affected by the pH of irrigation water; however, the optium pH value is dependent on the type of crops and physical and chemical properties of the soil (McKee and Wolf, 1963). pH values greater than 9.5 and less than 5.0 may directly harm aquatic organisms. Deleterious effects on aquatic life may occur at more subtle changes in pH due to enhanced toxic effects of aqueous substances such as metals and pesticides.

Suspended Solids (Turbidity)

Suspended solids, in natural waters, normally consist of silt, organic detritus, and plankton. However, man's activities have modified this composition through construction activities, agricultural and urban runoff, and the addition of domestic and industrial wastes (McKee and Wolf, 1963).

Elevated levels of suspended solids directly and indirectly affect aquatic organisms by killing fish, shellfish, and their food source; preventing successful development of eggs, larvae, and young; destroying spawning beds and benthic habitat; modifying natural fish movements and migration; decreasing resistance to disease; and promoting and maintaining the development of noxious conditions (U.S. Environmental Protection Agency, 1976a; McKee and Wolf, 1963). Highly turbid waters reduce the aesthetic value of a water body and its recreational use. Suspended solids may also interfere with municipal and industrial treatment processes.

Temperature

Water temperature affects water quality by influencing the rate of chemical interactions, solubility of materials, and physiological and behavioral activity of aquatic organisms. Water temperatures are primarily controlled by climatic conditions; however, discharges from thermoelectric power facilities and industries artificially increase surface-water temperatures and deep-water discharges from hydroelectric facilities can significantly decrease downstream temperatures.

Water temperatures above 15°C (59°F) in domestic water supplies stimulate objectionable taste and odor-producing organisms and affect treatment processes. Industrial processes and cooling systems often require uniform water temperatures and temperatures below a maximum level. Warm water temperatures may accelerate corrosion in pipe lines and cooling systems. Elevated water temperatures in irrigation canals encourage aquatic weed growth (McKee and Wolf, 1963). In addition to metabolic and behavioral affects on aquatic organisms, high water temperatures may cause death and alter community composition, adversely affecting man's recreational use of the resource.

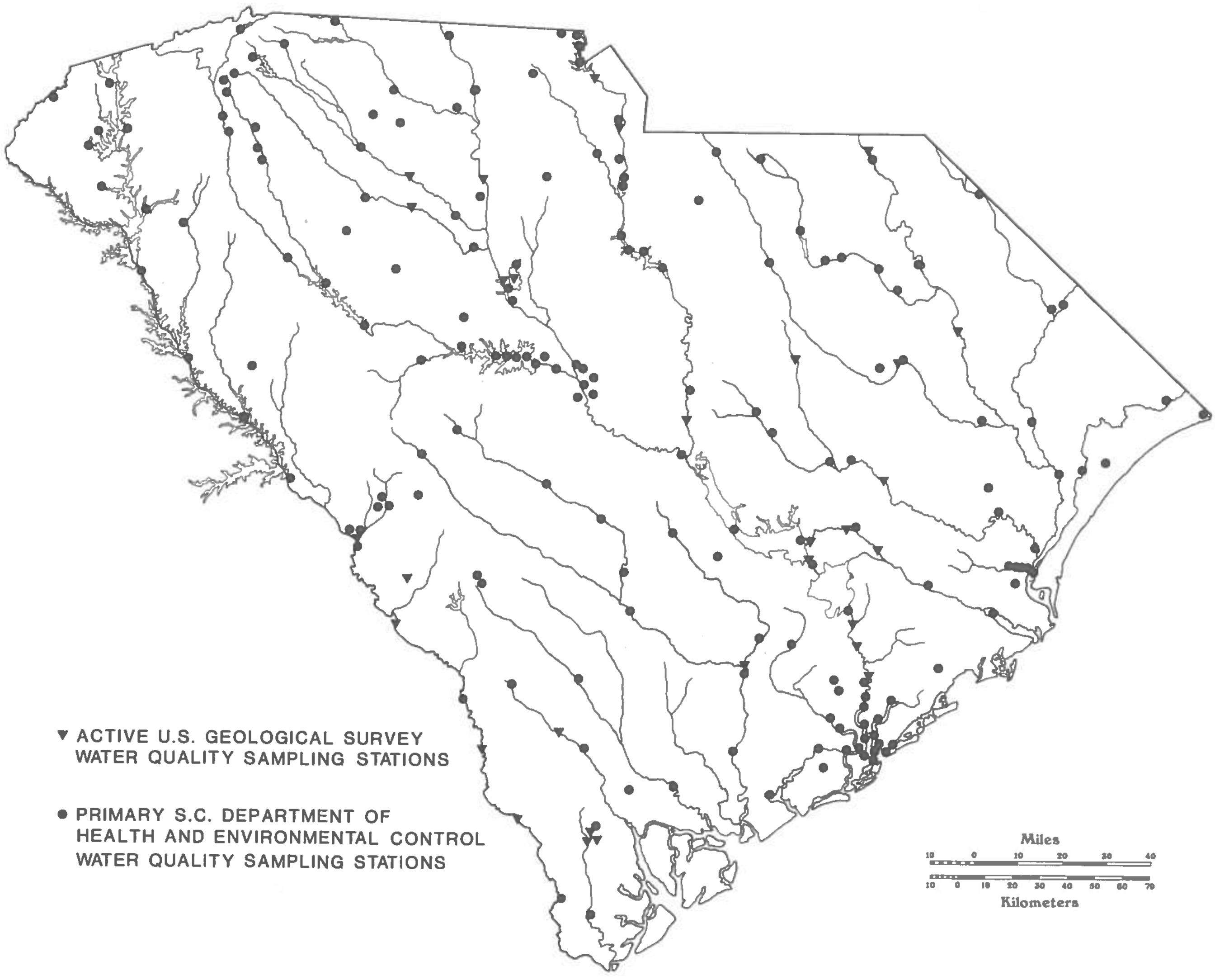


Figure 17.
S.C. Department of Health and Environmental Control (1981a) and U.S. Geological Survey (1981) fixed water quality monitoring stations in South Carolina.

sampling stations in South Carolina (Fig. 17). Over half of these stations are monitored monthly for a wide range of physical, chemical, and microbiological parameters. The remaining stations are monitored continuously and recorded daily for temperature, pH, specific conductance, and dissolved oxygen. Data collected through this monitoring program are published yearly in "Water Resources Data for South Carolina."

In addition to data collected from established routine monitoring stations, water quality data are also collected during special water quality surveys and studies conducted on lakes and streams throughout the State by Federal, State, and local governmental agencies and private entities.

Point Source Management

The discharge of pollutants from point sources is controlled by several programs administered by the S.C. Department of Health and Environmental Control (Table 9). These water quality management programs help to control impacts on the State's surface waters from agricultural, industrial, municipal, and domestic wastewater discharges through planning, permitting and certification, compliance and enforcement, and pollution response and investigation activities.

The control program which most directly regulates point source discharges is the National Pollutant Discharge Elimination System (NPDES). The permit issued by this program limits the type and amount of materials that may be discharged and establishes monitoring requirements. Discharge limits are based on Federal guidelines and on treatment needs to prevent contravention of State water quality standards. NPDES permit requirements for oxygen demanding substances, ammonia, and phosphorus are determined by evaluating the water quality and assimilative capacity of the receiving water in relation to State water quality standards (S.C. Department of Health and Environmental Control, 1979). Potential receiving waters are designated "effluent limited" or "water quality limited", depending on the level of waste treatment required to maintain State standards for dissolved oxygen. While the application of secondary treatment technology or Best Practicable Treatment is sufficient for effluent discharging into effluent limited waters, discharges to water quality limited waters require more advanced treatment technology. There are currently over 200 water quality limited segments in the State. Of these, 66 occur in the Pee Dee River Basin, 79 in the Santee River Basin, 49 in the ACE River Basin, and 21 in the Savannah River Basin (S.C. Department of Health and Environmental Control, 1979). Precise locations of these waters are presented in the water quality section of each sub-basin assessment.

Table 9.
Water quality management programs administered by the S. C. Department of Health and Environmental Control (1981b).

Program	*Function*
1. 208 Water Quality Management Planning.	Plan comprehensive areawide water quality management activities addressing point and non-point source pollution.
2. 201 Facilities Planning.	Plan for areawide control of pollution from wastewater treatment facilities.
3. Municipal Construction Grants.	Review plans and specifications for municipal wastewater treatment projects and administer and allocate Federal funding for facility construction.
4. State Construction Permit.	Regulate the design, construction, and modification of new or existing wastewater transmission and/or treatment facilities.
5. National Pollutant Discharge Elimination System (NPDES) Permit.	Regulate the kinds and quantities of materials discharged into State waters by industrial, municipal, domestic wastewater dischargers to prevent violation of State water quality standards.
6. 401 Certification.	Ensure that Federally permitted activities in State waters meet appropriate State and Federal treatment technology, water quality, and toxic and hazardous material control requirements.
7. Compliance Review and Enforcement.	Ensure that all industrial, municipal, and domestic dischargers comply with wastewater discharge restrictions imposed by the National Pollutant Discharge Elimination System permits.
8. Shellfish Water Quality Management.	Protect and maintain coastal waters for shellfishing through State and local water quality management activities.
9. Fish Kill.	Investigate fish kills and report findings, take appropriate legal action, and suggest recommendations to prevent future fish kills.
10. Spill Prevention Control and Countermeasures.	Prevent and respond to oil spills into State public waters from non-transportation related onshore and offshore facilities.

Non-point Source Management

The control and abatement of surface-water contamination due to runoff from large diffuse areas is often more difficult than from well-defined discharge sites and is primarily dependent on effective land use practices. The S.C. Department of Health and Environmental Control (1978) in conjunction with several other State agencies and entities developed management strategies to abate non-point source pollution from several types of land uses including agriculture, silviculture, and mining, and hydrologic modifications. Currently, use of recommended non-point source pollution control techniques is strictly voluntary. The S.C. Land Resources Conservation Commission is presently developing legislation to implement more comprehensive programs and guidelines to better control erosion and sedimentation from all land uses. Solid waste, hazardous waste, and air quality control programs of the S.C. Department of Health and Environmental Control, in addition to local zoning and water and land management programs of other local, State, and Federal agencies (Table 10), also help to control non-point sources of pollution.

Table 10.
State and Federal management programs, other than those of the S.C. Department of Health and Environmental Control, influencing surface water in South Carolina.

Program	*Agency*	*Purpose*
404 Permit	U.S. Army Corps of Engineers	Regulate the discharge of dredged or fill material into navigable waters and associated wetlands.
State Navigable Waters Permit	S.C. Budget and Control Board and S.C. Water Resources Commission	Protect public lands and waters subject to hydrologic modification in navigable waters.
Coastal Zone Management	S.C. Coastal Council	Protect the quality of the coastal environment and promote economic and social improvement.
Surface Mining Permit	S.C. Land Resources Conservation Commission	Protect and restore lands and waters involved in mining activities.
State Scenic Rivers	S.C. Water Resources and S.C. Wildlife and Marine Resources Department	Preserve selected unique rivers or segments of rivers for present and future generations.
Dams and Reservoirs Safety	S.C. Land Resources Conservation Commission	Regulate and ensure the safety of dams and reservoirs.

State Surface Water Quality Overview

Water quality conditions are influenced by many natural and man-induced factors. Therefore, water quality is variable and can change yearly, seasonally, and even daily depending on the type and location of the water body, naturally occuring conditions, and human activity within the watershed. Water quality conditions and problems identified below and in the individual sub-basin assessments represent documented conditions at the writing of this report; however, these conditions are not static and may change. The S.C. Department of Health and Environmental Control routinely monitors the quality of the State's surface waters and periodically publishes State water quality assessments and results of special studies. The most current water quality conditions of surface waters can be obtained from the S.C. Department of Health and Environmental Control.

The quality of surface waters in South Carolina is generally adequate for most water use needs. The S.C. Department of Health and Environmental Control (1980b) estimates that 84 percent of the State's major river miles meet the 1983 Federal goal of "fishable/swimmable" waters and 86 percent meet State water quality standards most of the time. Trends of improving overall quality have been detected in several waters statewide including the Pocotaligo River, Black Creek, Lake Robinson, Catawba-Wateree River, Reedy River, North Pacolet and Pacolet Rivers, North Fork Edisto River, and Four Hole Swamp (S.C. Department of Health and Environmental Control, 1980b). However, while water quality conditions meet or exceed most Federal and State criteria and significant improvements have been observed, problem conditions in waters throughout the State still impair some water use activities.

The most widespread water quality problem in South Carolina is fecal coliform bacteria contamination. This problem primarily impairs shellfish harvest and recreational water use activities and is typically associated with municipal wastewater discharges and non-point source runoff from urban and agricultural areas. Approximately 72,000 acres (33 percent) of the State's estuarine waters are closed to shellfish harvesting (Luke Hause, S.C. Department of Health and Environmental Control, written communication February 1982) and 74 percent of the State water quality monitoring stations indicate potential problem conditions due to elevated fecal coliform bacteria levels (S.C. Department of Health and Environmental Control, 1979).

Regional physiography greatly influences the quality of surface waters. Surface waters in the Coastal Plain region of the State commonly experience widespread contraventions of certain State standards during the summer months due to natural conditions. Many of the freshwaters in this region are associated with extensive swamplands. Decomposition of large quantities of organic matter in swamp waters, coupled with little or no streamflow, and high summer water temperatures, often result in poor quality water characterized by low dissolved oxygen concentrations, low pH, and sometimes high nutrient levels.

Piedmont waters exhibit somewhat different water quality problems attributed to natural conditions. High topographic relief and relatively impermeable soils in this region of the State contribute to rapid runoff resulting in high levels of suspended solids and turbidity and fecal coliform bacteria contaminiation.

Although natural conditions affect water quality statewide, it is generally man's activities which adversely impact surface waters to the point of impaired use. Elevated fecal coliform bacteria, temperature, nutrient, and biochemical oxygen demand levels and toxic substances have all been attributed to industrial and municipal wastewater discharges. These same problem parameters in addition to high turbidity, low pH and dissolved oxygen levels, and high pesticide concentrations in sediments have been attributed to non-point sources of pollution which are often influenced by man's alteration of the watershed. Water quality analysis of the four major river basins (Pee Dee, Santee, ACE, Savannah) reflect these natural regional influences and man's impact.

Approximately 85 percent of the major river miles in the Pee Dee River Basin meet State water quality standards and the 1983 Federal goal (S.C. Department of Health and Environmental Control, 1980b). Results from biological monitoring support the chemical/physical water quality analysis by indicating generally good to fair water quality conditions throughout the basin (S.C. Department of Health and Environmental Control, 1980b). The most frequent problems in the basin include high levels of fecal coliform bacteria, nutrients, and metals and low dissolved oxygen concentrations and pH. Although low dissolved oxygen, low pH, and high fecal coliform bacteria occur during the summer months and are due to the drainage of poor quality swamp water, wastewater discharges and runoff from major urban areas (Sumter, Hartsville, Darlington, Florence, and Myrtle Beach) greatly impact the major problem areas in this basin. Specific water quality problem areas in the Pee Dee River Basin include Lake Robinson, Black Creek near Hartsville and Darlington, Pocotaligo Swamp near Sumter, the Waccamaw River near Conway, the Intracoastal Waterway, the Sampit River near Georgetown, Murrells Inlet, and coastal waters near Myrtle Beach.

The S.C. Department of Health and Environmental Control (1980b) estimates that about 80 percent of the major river miles in the Santee River Basin meet the 1983 Federal goal and 83 percent meet State water quality standards, although biological monitoring data indicate generally fair to poor water quality conditions. Problem water quality conditions include elevated levels of fecal coliform bacteria, nutrients, turbidity, biochemical oxygen demand, and metals; low dissolved oxygen levels and pH; and nuisance aquatic plant infestations. Fecal coliform bacteria and nutrients are the major problems in this heavily developed basin. Municipal wastewater discharges from large urban areas (Columbia, Greenville, Spartanburg, Rock Hill, and Charlotte), rapid runoff from highly developed watershed lands, and numerous lakes contribute to these problem. Specific problem areas in the Santee Basin include the Reedy River, Lake Greenwood, the Little Saluda River, Fishing Creek Reservoir, Wateree Lake, Sugar Creek, the Congaree River, tributary streams near Columbia, and the headwaters, dead-end canals, and some tributary streams of Lake Marion.

About 81 percent of the surface waters in the ACE River Basin meet the 1983 Federal "fishable/swimmable" goal and 82 percent meet State water quality standards (S.C. Department of Health and Environmental Control, 1980b). Biological data indicate generally good water quality basinwide. Water quality conditions which may impair water use activities include fecal coliform bacteria contamination, depressed dissolved oxygen concentrations, noxious aquatic plant populations, and elevated metals concentrations. These problem conditions are evident in the basin in Foster Creek, Back River Reservoir, Ashley River, Cooper River, North Fork Edisto River below Orangeburg, and isolated locations in coastal waters.

The Savannah River Basin appears to have the best overall water quality in the State. Approximately 94 percent of the surface waters in the basin meet State water quality standards and the 1983 Federal goal of "fishable/swimmable" waters (S.C. Department of Health and Environmental Control, 1980b). Data from biological monitoring support the chemical/physical analysis by indicating generally good quality water basinwide. Problem water quality conditions include elevated levels of fecal coliform bacteria, metals, biochemical oxygen demand, nutrients, polychlorinated biphenyls (PCB), and salinity and low levels of dissolved oxygen and pH. Specific problem areas include Lake Hartwell, Lake Secession, Rocky River, Horse Creek near North Augusta, and Savannah River near Savannah.

GROUND-WATER RESOURCES

Principles of Ground-Water Occurrence

Ground water is defined as that water beneath the land surface that is free to move by gravity. It occurs in the zone of saturation, where interconnected openings and pores in the earth's crust are filled with water under hydrostatic pressure. The number, size, and shape of the rock openings, and their degree of interconnection determine the rock's ability to store and transmit water. Rocks that transmit useful quantities water to wells or springs are called aquifers. Less permeable rocks that prevent or retard the movement of ground water are called confining beds.

Ground water within an aquifer may occur under unconfined (water table) or confined (artesian) conditions. Where unconfined conditions occur, the surface of the saturated zone is open to the atmosphere and is free to rise and fall. The water level in a well penetrating an unconfined aquifer defines the water table, the surface of which is at atmospheric pressure. Unconfined aquifers are directly recharged by precipitation infiltrating downward to the water table.

Confined conditions occur where aquifers are overlain and underlain by confining beds. Ground water in such aquifers is under hydrostatic (artesian) pressure and the water level in a well completed in a confined aquifer will rise above the bottom of the overlying confining bed. This water level, in addition to the static water levels of other wells completed in the same aquifer, define the potentiometric surface of that aquifer. If the potentiometric surface is above ground level, the well will flow freely. Confined aquifers receive recharge from precipitation on outcrop areas and from leakage through adjacent confining beds.

Ground-water occurence and availability is directly related to the geology of a region. In South Carolina, ground-water availability and yields are significantly different between the Blue Ridge/Piedmont region and the Coastal

Plain region. Aquifers within the Blue Ridge and Piedmont regions are comprised of igneous and metamorphic rocks and, therefore, have low primary permeability. Wells developed in these rock aquifers generally have relatively low yields. Only in areas of fracturing, where the secondary permeability has been developed, do wells yield significant amounts of water. Fractures consist of joints, faults (commonly including brecciated zones), and partings along bedding and cleavage planes. In order to locate potentially high-yield well sites, it is necessary to map these fracture zones in detail.

Well yields from crystalline rock aquifers depend on the number of fracture zones intercepted by a well, the thickness of the saprolite layer, and the topographical location of a well. Valleys usually represent areas of intense fracturing and generally exhibit higher ground-water yields than topographically high areas, such as hills, divides or upper slopes, which are commonly underlain by harder rocks of lesser permeability.

Aquifers in the Coastal Plain consist of limestone and unconsolidated sand, shell, and gravel. Ground water in limestone aquifers is stored in and moves through a diffuse network of small fractures or through a localized network of channels developed by solution. Most limestone aquifers in the State are confined and the ground water is under pressure.

Unconsolidated sand and gravel aquifers exist throughout the Coastal Plain as part of the Shallow, Tertiary Sand, and Cretaceous Aquifer Systems. Ground water in these unconsolidated aquifers is stored in and moves through pore spaces between particles of sand and gravel. These aquifers are recharged by precipitation on outcrop areas and by leakage from adjacent aquifers or confining beds.

Ground water in Coastal Plain aquifers generally moves from the northwest to the southeast toward the Atlantic Ocean, following the gentle dip (5 to 20 feet per mile) of the sedimentary formations. Near the ground surface where aquifers are unconfined, ground water occurs under water table conditions and is subject to atmospheric pressure. Water levels in these shallow aquifers are, therefore, variable. Most Coastal Plain ground water, however, occurs in confined aquifers under artesian pressure. Water levels in wells constructed into these aquifers remain fairly steady.

Several properties such as porosity, permeability, and thickness affect the capability of Coastal Plain aquifers to supply water to wells. The porosity and the degree of interconnection of pore spaces in the sediments affects the ability of an aquifer to transmit water. If water is transmitted with relative ease, then the sediments are considered to be permeable. If pore spaces are small, as in clay, water is transmitted slowly and the sediment is considered to be relatively impermeable. The thickness of an aquifer directly affects the volume of water transmitted to wells. Thicker aquifers transmit more water than do thinner aquifers of the same material.

Supplemental Information Box 5.

Ground Water Hydrogeology Terminology

hydraulic conductivity – the capacity of an aquifer to transmit water, expressed in feet per day; equals permeability coefficient.

hydrology – the science dealing with the waters of the earth, their distribution on the surface and underground, and the cycle of evaporation, precipitation, flow to the seas, etc.

specific capacity of well – the rate of discharge from a pumped well divided by drawdown in water level after a specified period of time and expressed as gpm per foot.

storage coefficient – volume of water an aquifer releases from storage per unit surface area of the aquifer per unit change in head. It is a dimensionless term.

transmissivity – the rate at which ground water is transmitted through a unit width of an aquifer under a unit hydraulic gradient multiplied by aquifer thickness, and is expressed in ft^2 per day or gpd per foot.

turbidity — the degree of opaqueness of the water due to the amount of fine matter in suspension.

Several mathematically derived formulae are used to quantify ground-water availability in Coastal Plain aquifers: hydraulic conductivity, specific capacity, storage coefficient, and transmissivity. These terms are defined in Supplemental Information Box 5.

Ground-Water Programs and Data Base

Monitoring Programs

The U.S. Geological Survey has been conducting basic ground-water monitoring in South Carolina since 1945. These programs have included the establishment of a network of observation wells across the State, the systematic analysis of water samples, and the collection and evaluation of well records. The majority of effort has been expended in the Coastal Plain portion of the State.

The S.C. Water Resources Commission and the S.C. Department of Health and Environmental Control conduct periodic ground-water monitoring in accordance with management programs and special studies.

Management Programs

Water Quality Management. The S.C. Department of Health and Environmental Control and the S.C. Water Resources Commission are the agencies responsible for protecting the quality of ground-water resources of the State.

The S.C. Department of Health and Environmental Control programs include: 1) review and permitting of all public supply wells for proper design and construction, 2) regulation of the water-well drilling industry to ensure compliance to minimum well construction standards, and 3) regulation of all sites of potential ground-water contimaination, such as pits, ponds, lagoons, feedlots, and injection wells, for compliance with proper monitoring and clean up activities.

The S.C. Water Resources Commission's management program is authorized by the Ground Water Use Act of 1969. This program is designed to protect the aquifers in designated Capacity Use Areas by regulating the proper design, construction, abandonment, and spacing of wells to reduce the impact of saltwater intrusion and interaquifer flow.

Water Quantity Management. Under the Ground Water Use Act of 1969, the S.C. Water Reosurces Commission has the authority to regulate ground-water withdrawals within designated Capacity Use Areas. The program is primarily designed to minimize the effects of heavy, localized pumpage. All persons withdrawing ground water in excess of 100,000 gallons per day must obtain a permit from the S.C. Water Resources Commission and must report monthly water use on a quarterly basis.

Technical Assistance Programs

Ground-water data and technical assistance are provided to existing and prospective ground-water users by the S.C. Water Resources Commission, S.C. Department of Health and Environmental Control, and U.S. Geological Survey. These programs serve to promote the economical and beneficial use of the State's ground-water resources by increasing public awareness of local problems, and eliciting public support and cooperation in protecting the resources. Assistance typically consists of providing information concerning local geology, maximum possible well yields, ground-water quality, and any local ground-water problems.

Research Programs

The U.S. Geological Survey, S.C. Water Resources Commission, S.C. Department of Health and Environmental Control and, to a limited degree, several academic institutions, conduct research activities throughout the State. These research programs are designed primarily to further develop an understanding of ground-water resources. The types of studies undertaken have ranged from state-wide or multi-county resource evaluations, to site-specific problem investigations. The S.C. Department of Health and Environmental Control is primarily responsible for protecting aquifers from the introduction of foreign materials, and the S.C. Water Resources Commission and U.S. Geological Survey are responsible for describing the geologic framework and evaluating aquifer potentials.

Ground-Water Data Base

The quantity of ground-water information in South Carolina varies considerably according to geographic location and aquifer. Generally, ground-water information is much more extensive in the Coastal Plain region than in the Piedmont and Blue Ridge region of the State (Fig.18). The S. C. Water Resources Commission, for purposes of assessing ground-water study needs, has classified the level of ground-water knowledge in the State by county into four general categories--field data, reconnaissance, evaluation, and development (Fig. 18). These levels of knowledge are based on available data collected by the U.S. Geological Survey, S.C. Department of Health and Environmental Control, S.C. Water Resources Commission, and academic institutions. A more detailed explanation of each level follows:

Field Data (Limited available data). This level is assigned to areas where field data exist for only a few isolated locations, if at all, and ground-water reports are not available. Available data are insufficient to describe the distribution and structural features of aquifers. No extensive ground-water studies have been conducted in these areas. About one-half of all the counties in the State are included in the field data category. Most of these counties occur in the Piedmont Provinces where certain hydrogeologic information is difficult to collect and analyze (Fig. 18).

Reconnaissance (Basic data acquisition). This level is assigned to areas where available well data include well construction, well yield, water quality, and geophysical logs. Geological data include only gross aspects of formational distribution and structural features. General hydraulic characteristics are identified, but the lack of sufficient detail makes specific site analysis imprecise. Reports are available for portions or all of the area, but in insufficient detail to enable comprehensive analysis of ground-water systems. Studies in areas of this level include test-hole drilling and geophysical analysis and are directed toward answering the question, "Where is the resource?"

This level of ground-water knowledge exists in numerous areas of the State including all of Clarendon, Lexington, Oconee, Pickens, Richland, Spartanburg, Williamsburg, and York Counties and portions of Aiken and Barnwell Counties (Fig. 18).

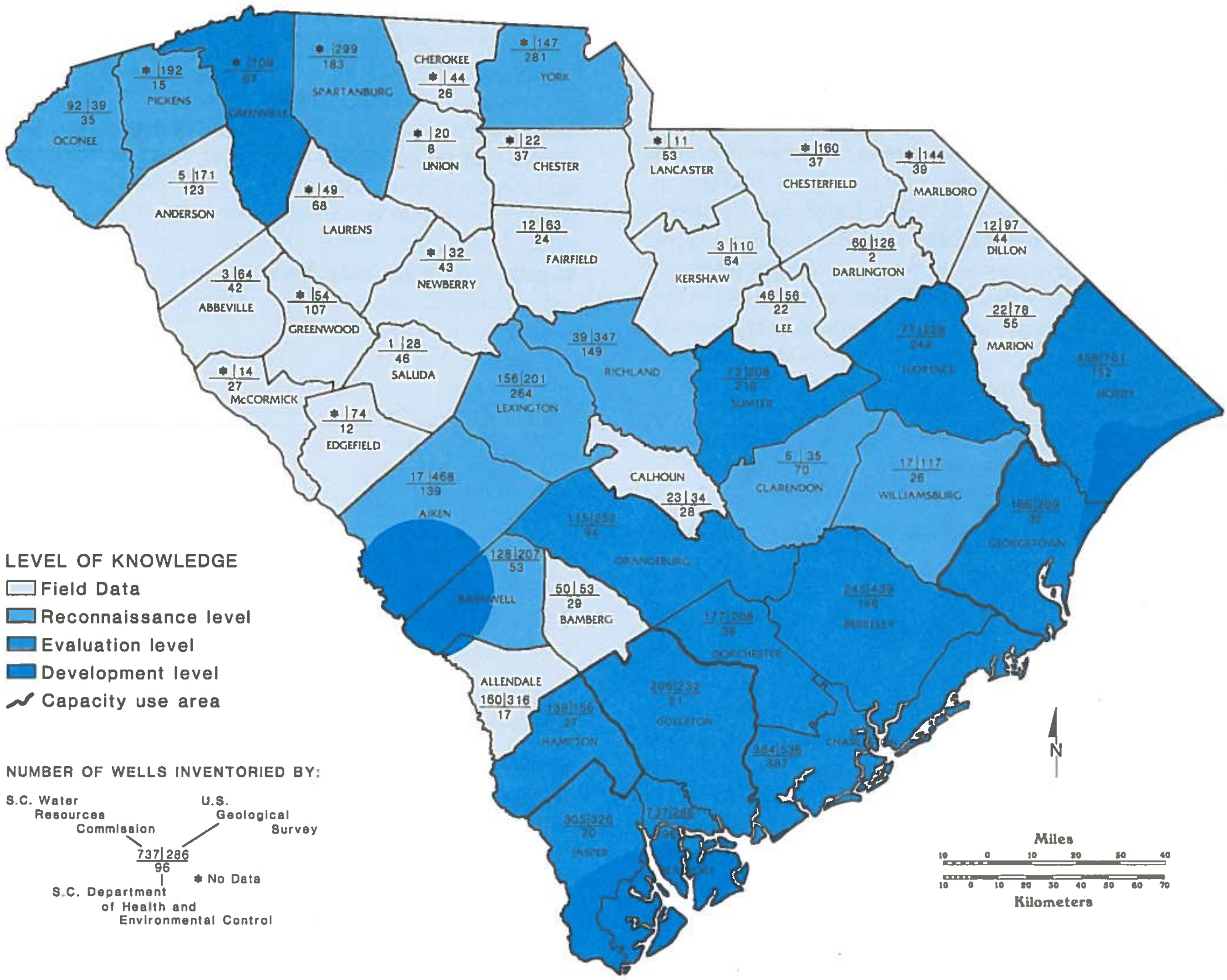


Figure 18.
Level of ground-water knowledge and total number of inventoried wells by county in South Carolina.

Evaluation (Data analysis and interpretation). This level applies to areas where identification of the major aquifer systems have been identified. Hydrologic factors controlling the recharge, movement, availability, and quality of ground water have been identified. The range of well depths, static water levels, and water use have been defined and potentiometric maps have been prepared. Ground-water problems in these areas are described and the additional data requirements to address these problems are estimated. Published or open-file reports are available in sufficient detail to enable a comprehensive analysis of ground-water systems or adequate data are on hand to prepare such an analysis. Studies in these areas attempt to answer the question, "How much of the resource is available?" This level of ground-water knowledge occurs in both the inland and coastal counties where studies have been intense (Fig. 18).

Development (Planning and management). This stage applies to areas where sufficient knowledge of the major aquifers is available such that either a descriptive or computer model can be constructed, if not already prepared. Water balance and yields of the principal aquifers have been defined and specific relationships between surface water and ground water, particularly with respect to problem areas, have been identified. Man-made stresses on the aquifer with respect to effects on hydrologic regimes and water quality have been evaluated. Studies in these areas center on the question: "How is the resource going to be used?"

The Savannah River Plant and vicinity, the Myrtle Beach portion of the Grand Strand, and the lower part of Beaufort and Jasper Counties near Savannah, Georgia, constitute the only areas in the State which currently meet the qualifications defined for a development level of ground-water knowledge (Fig. 18).

Statewide Ground-Water Overview

Vast amounts of water are stored beneath the surface of South Carolina. The availability and quality of this ground water is dependent on the geology and physiography of the region. Highly permeable sedimentary rock formations in the Coastal Plain contain large quantities of water. Because of this, ground water is generally more readily available in the Coastal Plain than in the Blue Ridge and Piedmont Provinces. Ground-water quality in South Carolina is generally good; however, some natural water quality problems are associated with every aquifer system in the State and have varying effects on water use. In addition to naturally occurring problems, man's use of the resource has adversely affected ground-water quality and quantity in some areas of the State.

Blue Ridge and Piedmont Provinces

The crystalline rock aquifers of the Blue Ridge and Piedmont Provinces are composed of highly impermeable igneous and metamorphic rocks. Only limited quantities of ground water can be obtained from the aquifers in this region. The highest yields occur from wells constructed in fracture zones.

In past years, ground water in the Blue Ridge and Piedmont region was developed predominantly from springs and dug wells about two or three feet in diameter. Water in these shallow wells was obtained from the saprolite layers or from the top of the underlying hard rock layer. However, these wells often dried up during periods of drought when the water table fell below the bottom of the well.

In recent years, most ground-water supplies have been developed by drilling 4 to 8 inch diameter wells into rock fractures. Yields from these wells range from less than one gallon per minute to several hundred gallons per minute (Fig. 19). However, yields from individual wells may vary greatly, even when located within several yards of each other. Recharge of these crystalline rock aquifers occurs directly by precipitation or indirectly from ground-water storage in the saprolite layer. Well water levels, therefore, usually rise during winter and spring when rainfall is greater and decline during the summer and early fall months when evapotranspiration is greater.

Because well sites are often chosen on the basis of convenience and economics rather than on hydrogeologic principles, and because most wells are drilled for domestic supplies and penetrate only the upper part of the aquifers, the full ground-water potential for most of the region is not known. Specific aquifer and hydrogeological units currently cannot be delineated throughout the entire Blue Ridge and Piedmont. However, good data bases are available for a few portions of this region, such as in Greenville County and to a lesser extent in Oconee, Pickens, Spartanburg, and York Counties.

The ground-water quality in the Blue Ridge and Piedmont Provinces can be grouped into two general types. The first type includes water from the quartzose, micaceous and light-colored silicate rocks. The water is generally soft with low dissolved solids content. Within this category, water from biotite gneiss and migmatite has the lowest dissolved solids content and lowest specific conductance. The second type includes water from gabbro, hornblende and dark-colored calcic-magnesium rocks. The water is moderately hard to hard with higher dissolved solids content and occasionally higher iron content than water of the first type. Water from gabbro contains the most dissolved solids but is of good quality for most domestic, municipal, industrial, and agricultural uses and meets recommended Federal and State drinking water standards.

Whereas water quality is generally good in crystalline rock aquifers, poor quality ground water occurs in some areas of the Blue Ridge and Piedmont. Excessive concentrations of dissolved solids, iron, and hardness in ground water are fairly widespread and common in crystalline rock aquifers. In York and Chester Counties some ground water is hard, contains excessive amounts of magnesium, is corrosive, and tastes unpleasant. Naturally-occurring radionuclides in excess of recommended drinking water standards are found in bedrock aquifers primarily in Fairfield and York Counties.

Coastal Plain Province

In contrast to the igneous and metamorphic crystalline rocks of the Blue Ridge and Piedmont, the formations of the Coastal Plain region consist of unconsolidated or partially consolidated sediments, including sand, gravel, clay, limestone, marl, coquina, shale, and shell-packed clay. Many of the sedimentary formations of the Coastal Plain are excellent aquifers which are able to store and transmit large volumes of ground water. The aquifer names are often, though not always, synonymous with the geological formations in which the ground water is stored. Figure 7 shows the relative stratigraphic positions of the Coastal Plain aquifer systems. Ground water can be obtained almost anywhere in the region, however, it occurs at different depths in different areas and the aquifer systems are developed to various degrees (Table 11). Water from sedimentary rocks is variable in quality and, in the deep aquifers near the coast, it may be more highly mineralized than in other areas.

Middendorf Aquifer System. The Middendorf Aquifer System overlies the crystalline and Triassic rocks beneath the entire Coastal Plain in South Carolina. This aquifer system contains one or more white or gray sand and gravel aquifers separated by gray, white, red, tan, brown, and blue clays. Ground-water movement in this system is believed to be toward the south and southeast, away from the area of recharge several miles southeast of the Fall Line. This aquifer system yields large quantities of excellent quality water to numerous wells in the upper and middle regions of the Coastal Plain. The Middendorf Aquifer System lies at

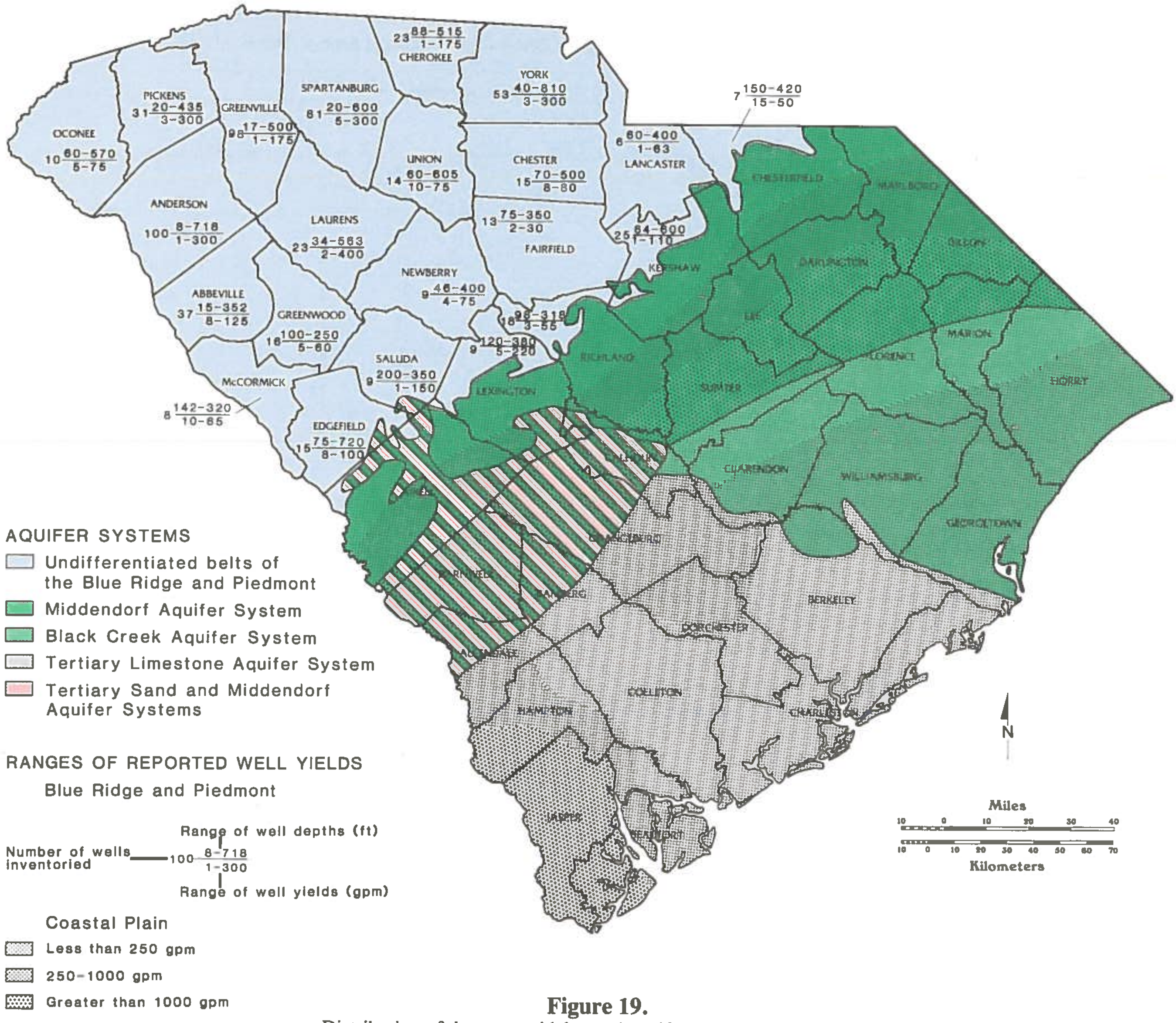


Figure 19.
Distribution of the most widely used aquifer systems in the Coastal Plain, and possible well yields in the Piedmont and Coastal Plain provinces.

or near the surface in Marlboro, Chesterfield, Darlington, Kershaw, Lee, western Sumter, Richland, northern Calhoun, Lexington, and Aiken Counties.

In Sumter and Florence Counties the thickness of the Middendorf Aquifer System ranges from less than 250 feet to more than 600 feet and its surface occurs at an elevation of 50 feet above mean sea level in the Town of Rembert and 670 feet below mean sea level at the Town of Johnsonville. Water levels in wells tapping the Middendorf Aquifer are near or above land surface in most areas of these two counties. Locally, water levels decline in the summer months due to heavier pumpage. Public supply wells in Sumter range in depth from 550 to 670 feet deep and yield from 500 to more than 2,000 gpm. The specific capacities range from 11 to 30 gpm/ft. East of Sumter, the transmissivity decreases and yields of the wells are less than 1,000 gpm with specific capacities of less than 15 gpm/ft. In Florence County, the confining beds comprise a greater percentage of the aquifer system than in Sumter County, thus the transmissivity of the aquifer decreases from 6,200 ft^2/day at Sumter to 950 ft^2/day at Florence.

In the northern part of Horry County, the top of the Middendorf Aquifer System lies at a depth of 600 feet below land surface and the aquifer has a thickness of about 200 feet. It dips south and southeast to a depth of 1,200 feet and has a thickness of about 1,000 feet in the southern part of Georgetown County. In Beaufort, Colleton, Hampton, and Jasper Counties, only a few wells and test holes have penetrated below the Tertiary Limestone Aquifer System and the thickness, lithology, and hydrologic properties of the Middendorf Aquifer System are not well known. The top of the aquifer occurs at an elevation of about 1,100 feet below mean sea level near the City of Hampton and about 2,600 feet below mean sea level in the Beaufort area. In

Table 11.
Distribution and preference of aquifer systems in the Coastal Plain counties of South Carolina.

	Aquifer System and Preference[a]							
County	*Shallow*	*Tertiary Sand*	*Tertiary Limestone*	*Black Mingo*	*Ellenton*	*Peedee*	*Black Creek*	*Middendorf*
Aiken	2	1	—	—	1	—	—	1
Allendale	2	—	1p	—	—	—	1	2
Bamberg	2	1p	1p	—	—	—	1	2
Barnwell	2	1	—	—	1	—	2	2
Beaufort	2	—	1	2	—	—	2	2
Berkeley	2	—	1p	1	—	2	1	2
Calhoun	2	1	2p	1	—	2p	—	2
Charleston	2	—	1	2	—	—	2	
Chesterfield	—	—	—	—	—	—	1	
Clarendon	2	—	1p	1	—	1	1	2
Colleton	2	—	1	1	—	—	1	2
Darlington	2	—	—	—	—	—	—	1
Dillon	2	—	—	—	—	—	1	1
Dorchester	2	—	2	2	—	2	1	2
Florence	2	—	—	2	—	2	1	1
Georgetown	2	—	2p	2	—	1	1	2
Hampton	2	—	1	1	—	—	2	2
Horry	2	—	—	—	—	2	1	2
Jasper	2	—	1	2	—	—	2	2
Kershaw	2	—	—	—	—	—	—	1
Lee	2	—	—	2	—	—	—	1
Lexington	2	1	—	2p	—	—	—	1
Marion	2	—	—	—	—	2p	1	1
Marlboro	2	—	—	—	—	—	—	1
Orangeburg	2	1	1p	1p	1	1p	1	1
Richland	2	—	—	2	—	—	—	1
Sumter	1	—	—	2	—	—	1	1
Williamsburg	2	2	2p	2	—	2	1	1

[a]1 indicates primary or preferred aquifer system for large yields.
2 indicates secondary aquifer system due to limited water yields and/or poor quality.
p indicates aquifer system underlies only part of county.
— indicates aquifer does not extend into county.

Hampton and Colleton Counties, the potentiometric pressure head in the wells is about 160 feet above mean sea level.

Water from the Middendorf Aquifer System is of good chemical quality in the upper part of the Coastal Plain. Along the outcrop where the aquifer is not deeply buried, the water is soft, acidic, and very low in dissolved solids which consequently makes it corrosive to metal surfaces. As a rule, the amount of dissolved solids is relatively low in the recharge areas and increases with depth and distance from recharge areas. In addition, a base-exchange process takes place in which calcium and magnesium ions are exchanged for sodium and potassium ions as water moves down gradient towards the coast. In Sumter and Florence Counties, concentrations of dissolved constituents generally meet State primary drinking water standards although some waters are often high in iron. In most parts of the coastal areas, water is highly mineralized and brackish and can not be used for drinking purposes.

Black Creek Aquifer System. Overlying the Middendorf Aquifer is the Black Creek Aquifer System. This system lies near the surface in Dillon, Marion, Darlington, Florence, western Sumter and Clarendon Counties. The top of the aquifer system in Sumter and Florence Counties ranges from about 50 feet above mean sea level to 175 feet below mean sea level. The thickness increases from a few feet near the Fall Line to about 500 to 700 feet in coastal areas.

The Black Creek Aquifer System is the most important source of ground water in Horry and Georgetown Counties. All present information indicates that the clay between the Black Creek and Middendorf Aquifer Systems hydraulically separates the two systems. In Horry and Georgetown Counties, the top of the Black Creek Aquifer occurs from 150 to 550 feet below mean sea level and has an apparent dip from north to south. The thickness within the two counties increases toward the coast to a maximum of about 750 feet. Wells in this two county area yield approximately 150 to 900 gpm each. The average hydraulic conductivity of the sands of the Black Creek Aquifer ranges from 30 feet/day in Horry County to 10 feet/day in Georgetown County. The transmissivity ranges from 190 to 3,500 ft^2/day, and the specific capacities from 0.7 to 10.7 gpm/ft of drawdown (Zack, 1977).

Continuing ground-water development near the City of Myrtle Beach has caused water levels in the Black Creek Aquifer to decline at rates of up to 9.5 feet per year. If ground-water levels continue to drop at the present rate, the top of the aquifer will be reached in about 10 to 15 years, which could significantly alter the hydrologic regime and potentially reduce ground-water yields.

The chemical quality of water withdrawn from sands of the Black Creek Aquifer System is the best of any ground water available in Horry and Georgetown Counties. Even though concentrations of fluoride (0.5 to 7.0 mg/L) and total dissolved solids (350 to 1,800 mg/L) locally exceed acceptable State primary drinking water standards, the water is relatively soft, low in iron, and sulfate-free. Brackish water in the Black Creek Aquifer near coastal areas is probably the result of ancient geologic processes which took place during or following deposition of these sediments and is not the result of modern day sea water intrusion. Freshwater percolating from recharge areas has flushed the aquifer of ancient saline water as far southeastward as the coast, except for some areas near the flanks of the Cape Fear Arch. The specific location of the freshwater/saltwater interface is not known. In the vicinity of Little River and Calabash, North Carolina, brackish water (chlorides greater than 250 mg/L) occurs at a depth of 120 feet below mean sea level. In the Myrtle Beach area this water occurs at about 800 feet below mean sea level.

Sediments of the Black Creek Aquifer in Jasper and Beaufort Counties dip to the south where they occur at an elevation 1,800 to 2,600 feet below sea level, their greatest depths in the State. In this area the hydrogeologic properties of this aquifer are not well known. Freshwater in the Black Creek Aquifer System becomes more mineralized toward the south or southwest, but data are not available to delineate the boundary between fresh and mineralized water in this aquifer system. Water from a well on Fripp Island, partially screened in the Black Creek Aquifer, contains 1,100 mg/L of chloride. In Allendale and Hampton Counties, however, several wells withdraw large volumes of good quality water from this aquifer system.

Water quality problems associated with the Black Creek Aquifer System along the coast include high sodium and turbidity levels. Elevated sodium levels may be due to a natural ion exchange of calcium in the water for sodium in clays of the formation. Highly turbid water occurs in wells from Horry County south to Hampton County. The cloudy water appears to be due to the suspension of aragonite crystals. The problem is generally temporary and decreases with increased pumping time.

Peedee Aquifer System. The Peedee Aquifer System occurs near the surface in Horry, southern Marion, southern Florence, Williamsburg, and Georgetown Counties and is deeper in the southern part of the State. This aquifer system underlies all of central and southern Florence County and Sumter County. The Peedee Aquifer System is composed of dark clayey sands and sandy clays interbedded with shelly limestone and coquina. Its thickness in this area increases from a few feet near its updip limit to approximately 200 feet in southern Florence County. Individual wells may yield 50 to 60 gpm, but specific capacities of less than 5 gpm/ft of drawdown are to be expected. In Clarendon and Williamsburg Counties, wells completed in the Peedee Aquifer System yield 50 to 150 gpm. The Peedee Aquifer in Horry and Georgetown Counties is approximately 300 to 500 feet thick. Even though water from the Peedee Aquifer System contains low concentrations of chloride and fluoride, it is rarely used because of objectionable amounts of iron and hydrogen sulfide. Thin and fine grained sands in the Peedee Aquifer of the southern coastal counties are not conducive to the development of large well yields and probably contain local pockets of mineralized water.

Ellenton Aquifer System. The Ellenton Aquifer extends from the Savannah River eastward to the Congaree River and southward to the coast (David Prowell, U.S. Geological Survey, Atlanta, Georgia, personal communication, February 1983). In the coastal area near Charleston it is probably equivalent to the Beaufort Formation in North Carolina. It functions as a moderate to highly productive aquifer system. In some areas, it acts as a single hydrologic unit with the upper portions of the Middendorf Aquifer. The thickness of this aquifer ranges from a few feet to about 100 feet in western Allendale County. Well yields range up to 600 gpm or more. Water quality is generally very good except for high amounts of iron and sulfate. Some open-hole wells completed into the Ellenton Aquifer System in Aiken and Barnwell Counties yield turbid water caused by the suspension of black clay particles. This problem dissipates with continued pumping.

Black Mingo Aquifer System. The Black Mingo Aquifer System has been identified through a large part of the Coastal Plain. However, knowledge of the quantity and quality of water in this aquifer system is rather limited because the aquifer system is difficult to identify and water from this system is often mixed with that of others. For these reasons it is not considered a principal aquifer system. In recent reports covering Sumter and Florence Counties (Park, 1980), and Horry and Georgetown Counties (Zack, 1977), the Black Mingo and Duplin Formations, together with the Pleistocene and Holocene deposits, were designated as the Shallow Aquifer System which contains ground water under confined as well as unconfined conditions.

The Black Mingo Aquifer System is composed of fine sand, silty clay, fuller's earth, and beds of fossiliferous limestone interbedded with dark shales. The lower portion of the aquifer system is composed of mostly black shale, which acts as a confining bed for the underlying aquifers. Six municipal and industrial wells in Sumter County completed in this aquifer system have an average yield of 188 gpm (Siple, 1946). Some sand layers may produce up to 200 gpm in Clarendon and Williamsburg Counties. In the southern coastal counties, the Black Mingo Aquifer includes all sediments between the Ellenton Formation and other deposits of Paleocene age and the overlying Tertiary Limestone Aquifer. The thickness ranges from less than 200 feet in Hampton County, to more than 400 feet in Beaufort and Jasper Counties. The top of the Black Mingo Aquifer in this area ranges from 500 to 1,000 feet below mean sea level. Available lithological and geophysical data show that fine-grained rocks in the Black Mingo Aquifer are a source of moderate supplies of water with some high levels of iron and hydrogen sulfide gas in Colleton and Hampton Counties. High fluoride levels occur in this aquifer system in Charleston, Dorchester, and parts of Berkeley Counties.

Tertiary Sand Aquifer System. The Congaree, Warley Hill, McBean, and Barnwell Formations comprise the Orangeburg group in the Upper Coastal Plain between the Savannah and Congaree Rivers and constitute, in this report, the Tertiary Sand Aquifer System. The most permeable beds in this group are quartzose sands in the Congaree and McBean Formations. The Congaree Formation includes both sandy clays and medium to coarse sands. In lower Barnwell County, the sands are interfingered with limestone. The sand section is very permeable and would be considered a more important aquifer except for its rather limited areal extent. In Barnwell County, the hydraulic conductivity ranges from 100 to 200 ft/day and the transmissivity ranges from 5,600 to 13,400 ft^2/day. Well yields range from 50 to 660 gpm and well depths range from 200 to 300 feet. Water from the limestone may be moderately hard to hard. Sands equivalent in age to the McBean Formation extend from 600 to 900 feet in the deep wells on Parris Island. The average yields of 10 wells penetrating the McBean Formation in Aiken County was 193 gpm. The McBean Formation is relatively permeable in the area between the Savannah and Edisto Rivers. The coefficient of transmissivity in the McBean Formation ranges from 1,000 to 13,300 ft^2/day. The more permeable deposits in the group are the porous limestone unit rather than the sand facies. In northern Orangeburg and Lexington Counties, the sands of the Congaree and overlying McBean Formations are recharged by direct precipitation. In general, water from the McBean Formation is acidic, high in iron, and low in total dissolved solids causing it to be highly corrosive to metal surfaces.

The Warley Hill Formation has only minor significance as an aquifer because of its thinness, limited areal extent, and low permeability. The formation probably functions primarily as a semi-confining bed.

The Barnwell Formation does not yield large quantities of water. It can be used for domestic needs where the sand is sufficiently coarse and free from silt and clay. The water in this formation is soft and contains moderate to high amounts of dissolved iron.

Natural radioactivity in excess of acceptable drinking water standards occurs in isolated areas of Lexington, Orangeburg, and Aiken Counties. This problem has caused some public water suppliers to investigate more advanced treatment technologies and alternate supply sources.

Tertiary Limestone Aquifer System. The Tertiary Limestone Aquifer is composed of several formational units of Eocene to Miocene age but the principal hydrogeological unit or aquifer consists of limestone of Eocene age (Santee and/or Castle Hayne Formation). This aquifer system extends over a wide triangle in the southern part of South Carolina from the western part of Allendale County on the Savannah River to Calhoun County on the north, and Georgetown County on the east (Fig. 19). The Tertiary Limestone Aquifer System crops out in southeastern Calhoun and Orangeburg Counties where it is mapped as the Santee Limestone. In parts of Orangeburg, Dorchester, Berkeley, southwestern Georgetown, and Williamsburg Counties, the aquifer system occurs at or near land surface and is tapped by many wells with depths of about 100 feet. In Orangeburg County, the Tertiary Limestone Aquifer is the second most productive aquifer after the Middendorf, but it is utilized more frequently than any other. In Eutawville, the specific capacities of wells range from 0.2 to 14.6 gpm/ft and the estimated transmissivity ranges from 350 to 5,300 ft^2/day (Siple, 1975). In the Jamestown area of Berkeley County, 5,000 to 10,000 gpm are pumped from the Santee quarry in dewatering operations. The transmissivity at this site averages 16,000 ft^2/day (Siple, 1980). In southern Berkeley, Charleston, and Dorchester Counties, the aquifer system is capped by beds of the Cooper Marl. In the southern coastal counties, the aquifer system again occurs near land surface. Here, numerous wells with depths of 80 to 250 feet tap this aquifer and account for more than 80 percent of the ground water used. Its thickness ranges from 300 feet in Hampton and Colleton Counties to more than 900 feet in Beaufort County and probably more than 1,000 feet in Jasper County. The Tertiary Limestone Aquifer System in the southern coastal area is subdivided (Hayes, 1979) into three principal permeable units. This aquifer is capable of yielding from 200 to more than 2,000 gpm of good quality water. However, areas along the coast have experienced saltwater contamination problems resulting from either heavy pumpage or incomplete flushing of the aquifer. Elevated flouride levels occur in this aquifer system in Charleston, Dorchester, and Berkeley Counties. Although water from this aquifer system is hard to moderately hard and may interfere with certain domestic and industrial uses, effective treatment is available and routinely used.

Shallow Aquifer System. Deposits of Miocene, Pliocene, Pleistocene, and Recent age are herein grouped into one hydrogeological unit, generally less than 100 feet thick, designated the Shallow Aquifer System.

The Hawthorne Formation in this system underlies the eastern parts of Hampton County and occurs in portions of Colleton, Jasper, Dorchester, Berkeley, and Charleston Counties. The maximum thickness is 160 feet in these areas where the formation functions both as an aquifer and as a confining bed. The Hawthorne Formation in Aiken and Barnwell Counties is used almost exclusively for domestic supply (Siple, 1967a). Water from this formation in the Lower Coastal Plain is probably hard and the unit is not an important aquifer in this area.

Quartzose sand interbedded with clay or marl in the Duplin Formation (Pliocene age) constitute a fairly permeable aquifer less than 50 feet thick in the northeastern part of Sumter County, and in parts of Florence, Lee, Darlington, Marion, Williamsburg, and Clarendon Counties. These sands constitute a local source for domestic and light industrial water use.

The Waccamaw Formation unconformably overlies the Peedee Formation in Horry and eastern part of Georgetown County. This formation, along with Pleistocene terrace deposits, yields water sufficient for small domestic usage at depths of 15 to 100 feet.

The water-bearing characteristics of the Pleistocene and Holocene (Recent) deposits are not well known. Although their thickness is generally less than 25 feet, many shallow domestic wells obtain water from these deposits. Water yield and quality vary considerably with location. Water quality and aquifer yields of wells in the coastal area were described by the S.C. Department of Health and Environmental Control (Glowaz and others, 1980).

Large quantities of ground water may be available to infiltration wells developed in the alluvial deposits of the Wateree, Black, and Pee Dee River flood plains. This water is likely to be high in sulfate and iron.

Man-Induced Ground-Water Problems

Sometimes man's unwise use of ground-water resources can cause special types of problems which may impact several aquifers or large geographic areas. Two major man-induced problems are 1) ground water contamination and 2) water level declines.

Approximately 170 sites throughout the State have identified ground-water contamination problems. Pollution of ground-water supplies may be due to leakage from surface runoff through improperly constructed or abandoned wells; mismanagement of wells; undesirable siting of solid waste dump sites, septic tanks, sewage lagoons, and animal feed lots; infiltration of undesirable substances due to heavy pumping; mining operations; leaking water or sewer lines; and misapplication of fertilizers and pesticides. Heavy pumpage along the coast causes saltwater intrusion of some aquifers. When chloride concentrations from saltwater become too high (250 mg/L), ground water becomes undesirable for drinking and other uses. Saltwater intrusion is most severe in the Black Creek Aquifer System in Horry and Georgetown Counties and the Tertiary Limestone Aquifer System in coastal Beaufort County (Fig. 20).

Irrigation practices of completely screening and gravel packing wells from top to bottom, coupled with heavy ground-water withdrawals causes aquifer contamination by surface pollutants and interaquifer mixing of ground water. In addition, heavy irrigation pumpage in areas near animal feed lots, where thin, permeable deposits separate the Tertiary Limestone Aquifer System from the land surface, can cause vertical leakage of waste (nitrates and bacteria) into this and deeper aquifer systems.

In some areas of the State, where large capacity wells are closely spaced and pumpage is heavy, water levels in some aquifers have declined significantly on a local and regional scale. Such water level declines can cause a decrease in well yields; shallower wells to go dry if water levels drop below well pumps or screens; power consumption to increase due to greater pumping requirements; poor quality water to infiltrate the aquifer from adjacent areas; and land surface subsidence or collapse. Two areas of the State are presently experiencing regional water level declines: the coastal Grand Strand area of Horry and Georgetown Counties, and the area surrounding Savannah, Georgia including Beaufort, Jasper, and Hampton Counties. Areas experiencing localized declines are the cities of Sumter, Florence, Marion, and Mullins, and the industrialized area of Berkeley County between Moncks Corner and Charleston.

Land surface subsidence and collapse is a threat in areas where limestone deposits occur at shallow depths and ground-water levels have declined substantially. Documented cases in Georgetown, Berkeley, Dorchester, and Orangeburg Counties are usually associated with large water level declines due to dewatering activities of mining operations.

WATER USE

Many of man's activities, including industrial, domestic, agricultural, and recreational activities, depend directly or indirectly on adequate supplies of freshwater. Often in regions of abundant water supply, such as South Carolina, the use of freshwater is taken for granted and the need to carefully monitor its use is not always apparent. However, an increasing demand on South Carolina's water resources from an expanding economy and growing population has elevated competition for this important resource and conflicts over the appropriate use of the State's water are occurring. Such conflicts are expected to increase in the future along with demand.

Until recently, most water use in South Carolina was not routinely monitored and existing limited information was primarily supplied voluntarily to several different State and Federal agencies. Because a systematic data gathering

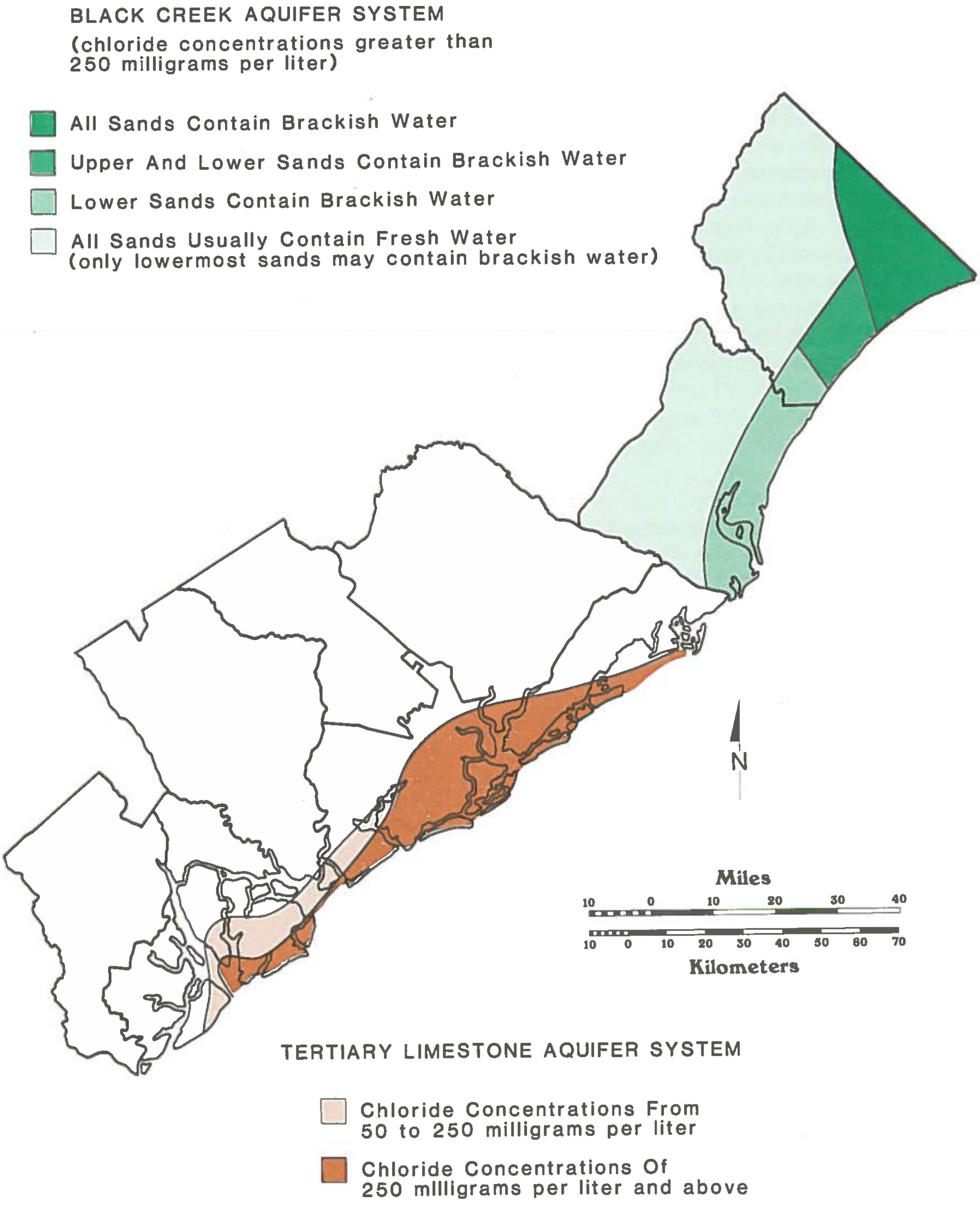


Figure 20.
Chloride concentrations in the coastal aquifers.

program did not exist, current available water use data are generally widely dispersed, incomplete, and of varying quality. Most of the water use information contained in this report was compiled from this tenuous data base. The data base, however, represents the best available information in South Carolina.

More complete and accurate information on water use should be available in the future. On February 24, 1982 Governor Riley signed into law the South Carolina Water Use Reporting and Coordination Act. This Act authorized the S.C. Water Resources Commission to develop a water use reporting program and require water use data from any person and public or private entity using 100,000 gallons per day or more. The information gained from a systematic and coordinated program should greatly enhance the State's water resource planning efforts and help ensure adequate water supplies for an expanding economy and for future generations.

Water Use Methodology

Water use data and projections were compiled for six major water use groups: (1) public supply, (2) self-supplied domestic, (3) agricultural irrigation, (4) agricultural livestock, (5) self-supplied industrial, and (6) thermoelectric power. Water use projections for most user groups were based on projected population growth through the year 2020. Basic population projections through the year 2000 were developed for each county by the S.C. Division of Research and Statistical Services. Using the same trend of gradually declining increase in growth, the S.C. Water Resources Commission extended population projections to 2020. Because surface water is generally examined in hydrologic units which follow natural drainage boundaries and water use projections are based on county population projections, water use data had to be converted from county political boundaries to hydrologic boundaries. The populations of each county were apportioned into the respective hydrologic sub-basins based on estimates prepared by the S.C. Water Resources Commission (1975).

Several regional and national water resource assessments (Murray, 1968; U.S. Water Resources Council, 1968; Murray and Reaves, 1972; Southeast Basins Inter-agency Committee, 1977; U.S. Water Resources Council, 1978) were consulted during the development and final implementation of South Carolina water use projections. Even though these projections are based on accepted growth assumptions and calculation procedures, the projected use is only as good as the original data base. With the aid of more accurate water use data provided by the recently passed Water Use Reporting Act, it will be possible to periodically check and adjust these projections.

All water use is accounted for in the sub-basin of withdrawal, not the sub-basin of use. Since any interbasin transfer is lost to the sub-basin of withdrawal, that amount is regarded as totally consumed within that sub-basin.

Current and projected water use data for the individual water use groups were based on the following sources, calculations, and assumptions.

Public Supply

Public supply includes any public or private utility which distributes water for sale to the public primarily for domestic, commercial, or industrial use.

Public supply water use data were compiled from the following sources:

(1) S.C. Department of Health and Environmental Control, December 1980, Inventory of Public Supply Systems, Part I-- Municipal Water Systems, and Part II--Water Districts;
(2) S.C. Department of Health and Environmental Control, Water Supply Monthly Report Forms, Number 1972;
(3) S.C. Water Resources Commission, 1980 public supplier survey data; and
(4) S.C. Water Resources Commission, Ground Water Division files.

Approximately 10 percent of gross use is assumed to be consumed while the remainder is returned to surface waters.

Projected public supply use is based on statewide population growth projections and the following assumptions:

(1) Public supply water use will generally grow in proportion to population growth;
(2) The percentage of the population served by public suppliers will not increase as in the past due to a reduction in Federal assistance for the construction of large public supply systems;
(3) Although ground-water and surface-water use will increase, the percentage supplied by each source will remain constant;
(4) Consumptive use will remain constant at 10 percent of gross use through 2020; and
(5) Purchasing industrial use will increase, but will still represent the same portion of public supply use in 2020.

Self-supplied Domestic

Self-supplied domestic water use was determined by applying estimated per capita water use rates (80 gallons per day per person) to the population not served by public supply systems. Unless otherwise noted, withdrawals are assumed to come solely from ground-water sources. Estimated consumption rates for self-supplied domestic water use vary in the southeast from five to 100 percent (Murray and Reaves, 1977). Regional differences in geology and source of ground-water supply affect consumption rates in South Carolina. For the purposes of this report consumptive use was assumed to be 85 percent of gross use.

Projected self-supplied domestic water use was based on statewide population growth rates and the following assumptions:

(1) Self-supplied domestic water use will continue to be an important user group;
(2) Statewide self-supplied domestic water use will grow proportionally to population growth;
(3) Ground water will continue to be the primary supply source; and
(4) Consumption will remain constant at 85 percent of gross use.

Self-supplied Industrial

Current self-supplied industrial water use data was compiled from voluntary responses to water use questions included on the 1979-1980 S.C. Department of Labor annual survey report. Responses were collected from over 1,100 industrial establishments throughout the State, of which 351 were self-supplied users.

Projected self-supplied industrial water use was based on statewide population growth and the following assumptions:
(1) Industrial water use will continue to increase due to projected industrial growth in South Carolina;
(2) Although ground-water and surface-water use by self-supplied industry will increase, the percentage supplied by each source will remain constant; and
(3) Consumptive use will increase from the present rate of 18 percent of gross use to 40 percent of gross use by 2020 due to increased recycling and reuse of withdrawal water.

While the S.C. Department of Labor survey does not include all industries in the State, the reported water use is thought to include all major water users and is believed to represent the majority of self-supplied industrial use. Analysis of total reported municipal and industrial water discharges indicates that reported water use for public supply and industry approximates that discharged plus estimated consumptive loss. Therefore, reported water use is believed to closely approximate actual water use.

Agricultural Irrigation

Irrigation water use was calculated by applying an estimated average water application rate to reported irrigated acreage. Reported irrigated acreage was obtained from annual agricultural irrigation surveys conducted by the Clemson Extension Service and the S.C. Water Resources Commission.

Irrigation occurs generally from late March through August, approximately 150 days per year (C.W. Privette, Clemson University, personal communication, December, 1981). For an average year, approximately 10 inches of water are applied per acre of crop (Interagency Task Force on Irrigation Efficiencies, 1979). For purposes of comparing average water use for all user categories, and determining a State water use total, a 12-month average irrigation water use was calculated. The 12-month average use rate is roughly 40 percent of the actual rate that occurs during the growing season which statistically lessens the impact of irrigation water use on available water supplies during peak irrigation usage. Therefore, the 150 day (five month) average water use figure is presented in the statewide analysis and in each sub-basin water use discussion in addition to the annual average.

Projected water use for irrigation was based on estimated increases in irrigated acreage in South Carolina. This increase was anticipated to be about 12,000 acres per year and is expected to total 600,000 acres by the year 2020 (C.W. Privette, Clemson University, personal communication, January, 1982; Irrigation Work Group, Soil Conservation Service, personal communication, January, 1982). Because the greatest growth in irrigation is expected to occur in the Coastal Plain region where ground-water reserves are plentiful, ground-water use for irrigation is expected to increase from 26 percent of total use in 1980 to 38 percent in 2020.

Agricultural Livestock

Livestock water use was determined from population estimates of cattle, hogs, and chickens provided by the S.C. Crop and Livestock Reporting Service (1980). These livestock populations were applied to livestock consumption rates reported by MacKichan and Kammerer (1961). Withdrawals were assumed to be made equally from ground-water and surface-water sources, and consumptive use was assumed to be 100 percent of gross use.

Thermoelectric Power

Current water use data for thermoelectric power facilities were obtained directly from electric utility companies operating in South Carolina.

Projected thermoelectric water use was based primarily on the operation of existing and planned thermoelectric power plants and on projections of the Second National Water Resources Assessment (U.S. Water Resources Council, 1978). Thermoelectric power water withdrawals in South Carolina were projected to increase 36 percent by 2020. Due to anticipated increases in cooling water recycling systems and resultant evaporation loss, consumptive water use is projected to increase about thirteenfold by 2020.

Statewide Water Use Overview

In 1980, gross water withdrawals in South Carolina were estimated to be 5,780 mgd (Tables 12 and 13), representing an 96 percent increase during the past decade (2,944 mgd use in 1970; S.C. Water Resources Commission, 1971). Approximately 437 mgd, or about eight percent of gross water use in 1980 was consumed. By far the largest use was for the production of thermoelectric power (75.6 percent), distantly followed by self-supplied industry (15.7 percent) and public supply (6.6 percent).

Table 12.
Gross water use in South Carolina by source and type use, 1980.

Type Use	Source Of Water: Ground Water (mgd)	Source Of Water: Surface Water (mgd)	Total Use (mgd)	Percent Of Total State Use
Public Supply	82.2	298	380	6.6
Self-Supplied Domestic	57.3	——	57.3	1.0
Agricultural Irrigation	14.8	41.3	56.1	1.0
Agricultural Livestock	5.52	4.56	10.1	0.2
Self-Supplied Industry	46.4	858	905	15.7
Thermoelectric Power	—	4,370	4,370	75.6
Total	206	5,570	5,780	

Table 13.
Gross and consumptive water use in South Carolina by type use, 1980.

Type Use	Gross Use (mgd)	Consumptive Use (mgd)	Percent Consumptive Use: Of Use Category	Percent Consumptive Use: Of Statewide Consumptive Use
Public Supply	380	102.6	27.0	23.5
Self-Supplied Domestic	57.3	48.7	85.0	11.1
Agricultural Irrigation	56.1	56.1	100.0	12.8
Agricultural Livestock	10.1	10.1	100.0	2.3
Self-Supplied Industry	905	167	18.5	38.1
Thermoelectric Power	4,370	53.5	1.2	12.2
Total	5,780	437	7.6	

Figure 21 illustrates current ground-water and surface-water use by user group in each sub-basin. Total water use is greatest in the Upper Savannah (2,080 mgd), Pee Dee (845 mgd), and Catawba-Wateree (560 mgd) Sub-basins. The smallest amount of use (10.3 mgd) occurs in the Little Pee Dee Sub-basin. The Edisto Sub-basin showed the largest consumptive use (94.7 mgd) primarily due to municipal withdrawals of about 65.7 mgd by the City of Charleston located in the Ashley-Cooper Sub-basin. The largest percentage of consumptive use occurs in the Lower Santee (85.6 percent) and Little Pee Dee (58.9 percent) Sub-basins.

Surface water serves as the major source of water in South Carolina, supplying 96 percent of total water needs (Table 12). Most of this surface water, however, is used for cooling purposes in thermoelectric power generation. Excluding this large use, surface water still provides 85 percent of the State's gross water withdrawals. While ground water is used to some extent in every sub-basin, this source is most heavily utilized in the Coastal Plain region. Several large aquifers in this region provide large quantities of generally high quality water.

By the year 2020, statewide gross withdrawals are projected to grow by 48 percent to 8,550 mgd (Table 14). Consumptive water use is projected to increase about 300 percent from 1980 levels to almost 1,760 mgd by 2020. This large growth is attributed to projected large increases in agricultural irrigation and higher consumptive rates by thermoelectric power use due to implementation of cooling water recycling systems.

Agricultural irrigation is projected to show the greatest percentage increase by 2020 (670 percent). The greatest volume increases are expected to be made by thermoelectric power (1,560 mgd) and self-supplied industry (525 mgd). Thermoelectric power facilities will continue to make the largest total withdrawals (5,940 mgd) in 2020.

Gross water use is anticipated to increase in all sub-basins, however, the greatest growth will probably occur in the Broad Sub-basin (924 mgd, 716 percent) (Fig. 22). The Upper Savannah Sub-basin should continue to experience the greatest total water use (2,400 mgd) of all the sub-basins, while the least demand should occur in the Little Pee Dee (29.0 mgd) and Lynches (34.6 mgd) Sub-basins.

Public Supply

Public supply includes any public or private utility which distributes water for sale to the public primarily for domestic, commercial, and industrial use. The most widespread use of public supply water is to meet domestic water demands. In South Carolina, public supply systems are primarily public owned and associated with municipalities, counties, or rural water districts.

The number of individual public supply systems in an area is dependent on many factors including population, source of water, and system capacity. Nearly 290 public supply systems provide water to over three-fourths of all South Carolinians and nearly 750 industries. The largest number of public supply systems (38) are located in the Combahee-Coosawhatchie Sub-basin, while the fewest (7) occur in the Congaree and Lower Santee Sub-basins.

Water use by public supply systems (380 mgd) currently accounts for almost seven percent of total gross use and 23 percent (103 mgd) of consumptive use in the State. The Broad (92.9 mgd), Edisto (78.3 mgd), and Saluda (70.7 mgd) Sub-basins experience the greatest total public supply use (Fig. 21).

Local geological and hydrological conditions, in addition to withdrawal and treatment costs, determine the source of public supply water. Large ground-water reserves in the Coastal Plain region of the State provide a source of

Table 14.
Current and projected water use in South Carolina, 1980 - 2020.

Year	Gross Use (mgd): Ground Water	Gross Use (mgd): Surface Water	Gross Use (mgd): Total Water	Consumptive Use (mgd)
1980	206	5,570	5,780	437
1990	280	6,910	7,190	733
2000	354	7,290	7,650	1,020
2010	423	7,670	8,090	1,340
2020	484	8,060	8,550	1,760

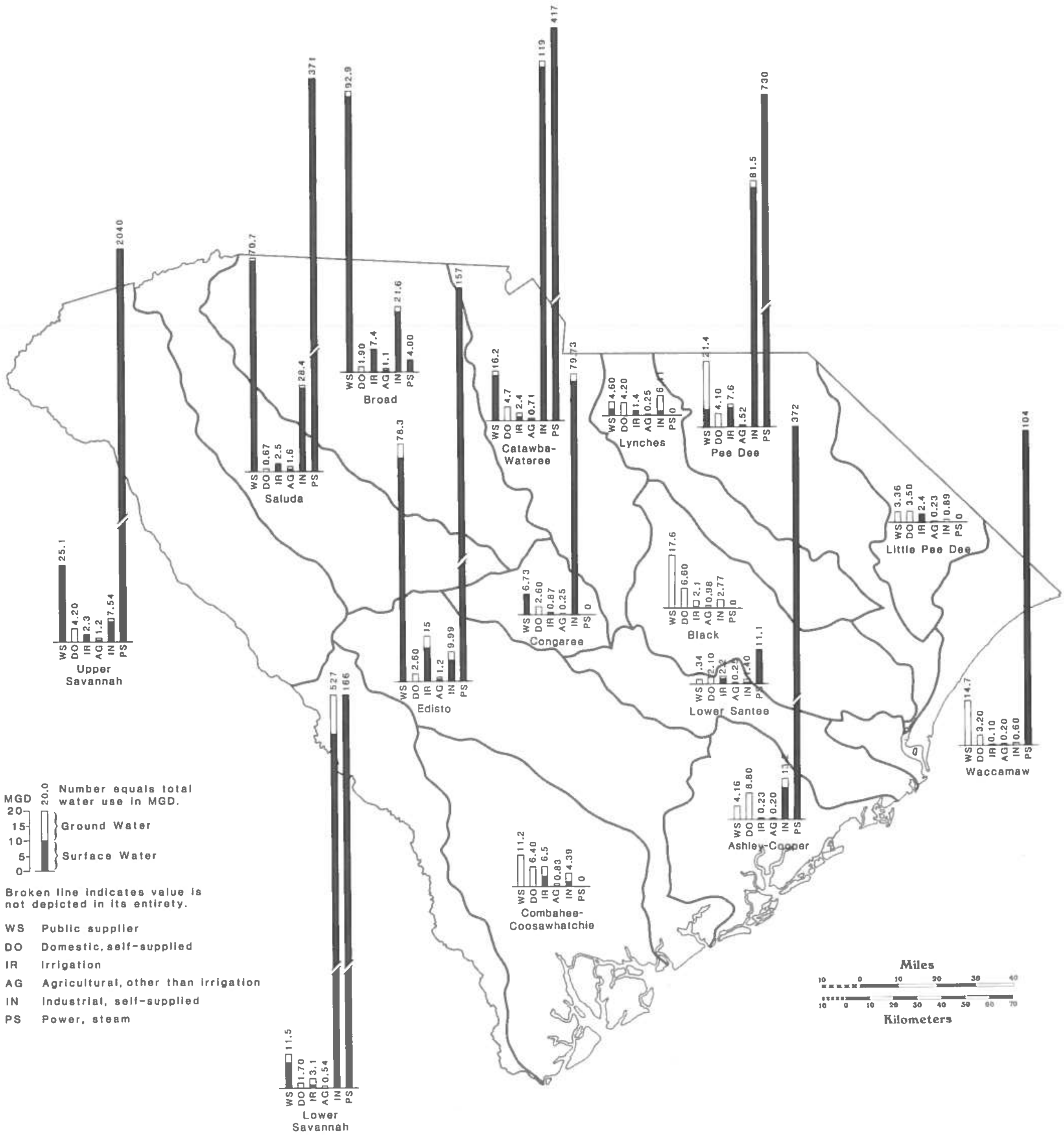


Figure 21.
Current ground-water and surface-water use in South Carolina by sub-basin.

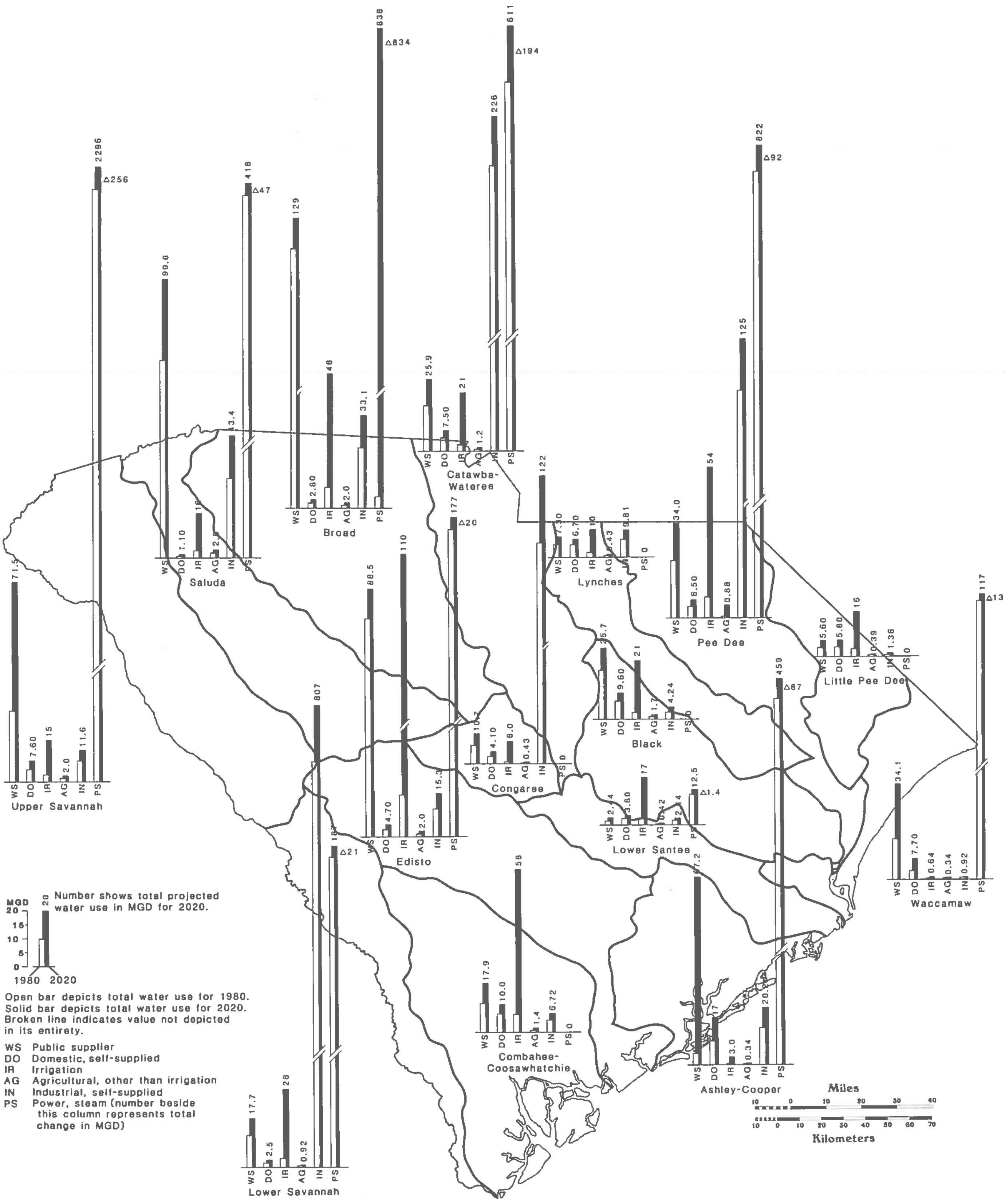


Figure 22.
Current and projected (2020) water use in South Carolina by sub-basin.

generally high quality water. As Figure 21 illustrates, ground water is the major source of public supply water in this area of the State, especially in the Pee Dee and Waccamaw Sub-basins. The upper portion of the State, on the other hand, depends primarily on surface-water sources.

Ground water is used by nearly 41 percent of the State's population for domestic water needs. Over one-half of this groundwater use is self-supplied by users, representing 24 percent of the State population. The remainder of the domestic ground-water use is supplied to 17 percent of the State population by 226 (78 percent) public supply systems. Surface water supplies the remaining 59 percent of the State population through 63 public supply systems.

Statewide water use by public supply is projected to increase 68 percent from current levels to about 637 mgd in 2020 (Table 15). The greatest increase by volume and percentage is expected to occur in the Ashley-Cooper Sub-basin (67.2 mgd, 1,500 percent) (Fig. 22). This large increase is due to the development of a new large surface-water supply source by the City of Charleston.

Table 15.
Current and projected public supply water use in South Carolina, 1980 - 2020.

	Gross Use (mgd)			
Year	*Ground Water*	*Surface Water*	*Total Water*	*Consumptive Use (mgd)*
1980	82.2	298	380	103
1990	100	360	460	124
2000	117	416	534	143
2010	132	459	591	157
2020	141	495	637	171

Self-supplied Domestic

Often water for domestic use is obtained by individual homeowners from private wells or through small subdivision or trailer court supply systems. These self-supplied users are assumed to be evenly distributed over South Carolina. The use, while apparently small, is very difficult to estimate and may be significantly greater than currently assessed. About 15 percent of gross water withdrawals are assumed returned to ground and surface waters through septic tank systems.

Self-supplied domestic use represents one percent of gross use (57.3 mgd) but about 11 percent (48.7 mgd) of total consumptive use. It is estimated that over 700,000 people in the State use private water sources. The greatest use currently occurs in the Ashley-Cooper (8.80 mgd), Black (8.60 mgd), and Combahee-Coosawhatchie (6.40 mgd) Sub-basins (Fig. 22). The least self-supplied domestic use (0.67 mgd) occurs in the Saluda River Sub-basin. Ground water is assumed to be the only source to supply this demand.

Table 16.
Current and projected self-supplied domestic water use in South Carolina, 1980 - 2020.

	Gross Use (mgd)			
Year	*Ground Water*	*Surface Water*	*Total Water*	*Consumptive Use (mgd)*
1980	57.3	0.0	57.3	48.7
1990	69.5	0.0	69.5	59.4
2000	80.7	0.0	80.7	68.8
2010	91.0	0.0	91.0	77.7
2020	97.1	0.0	97.1	82.1

By 2020, self-supplied domestic use is anticipated to increase by almost 70 percent to about 97 mgd (Table 16). However, this user group will remain one of the smallest, surpassing only agricultural livestock. Projected increases should be evenly distributed throughout the State and ground water will continue to be the preferred source of supply.

Agricultural Irrigation

Crops transpire large amounts of water from farmlands throughout the State. If not replenished, crop growth is impaired and yields per acre diminished. Natural precipitation is often highly variable and uncontrollable, resulting in fluctuating crop yields from year to year. Controlled irrigation of croplands, however, ensures successful harvests year after year and helps to stabilize farm income. Due to this stabilizing effect and improved irrigation technology, irrigation systems have become more cost effective and their use in South Carolina has increased substantially.

Crop irrigation occurs throughout the State from peach and apple orchards in the upper Piedmont to tobacco, corn, and soybean fields in the Lower Coastal Plain. Currently over 722 identified systems irrigate about 75,600 acres in South Carolina. The largest concentrations occur in the Edisto (148 systems), Broad (99 systems), and Pee Dee (83 systems) Sub-basins, while the fewest (10 systems) occur in the Waccamaw Sub-basin.

Agricultural irrigation does not occur year round but only during critical periods of the growing season when soil moisture is low. Irrigation water use, therefore, is seasonal and may vary from year to year depending on the distribution of annual precipitation. In South Carolina, irrigation generally occurs from April to September with peak application during June and July.

Water used for irrigation is usually either taken in by the plants, evaporated, or soaked into the soils; little if any of the water is returned to a usable source. Therefore, unlike most other water use groups, all irrigation withdrawals are considered totally consumed. Although water use for irrigation is limited to a few months out of the year, the demand is so large that this represents a major use during the growing system, particularly because of its consumptive nature.

Agricultural irrigation currently withdraws and consumes about 56.1 mgd of water in South Carolina. This amount is one percent of total gross use and 13 percent of total consumptive use. When averaged over the five-month growing season, irrigation use is 137 mgd, comprising two percent of gross use and 26 percent of consumptive use in the State. Most irrigation water use occurs in the Edisto Sub-basin (14.8 mgd), followed by the Pee Dee (7.6 mgd), Broad (7.4 mgd), and Combahee-Coosawhatchie (6.5 mgd) Sub-basins. The least amount of irrigation occurs in the Waccamaw Sub-basin (0.1 mgd).

Surface water is the major supply source for irrigation providing about 74 percent of all demand through about 570 surface-water systems. About 150 ground-water systems supply the remaining demand.

Agricultural irrigation is expected to become more widespread in the future. By the year 2020, irrigation is anticipated to increase by almost 670 percent to about 1,050 mgd during the growing season and to about 430 mgd for the year (Table 17). This increase represents the largest percentage increase of all user groups and will make irrigation the third largest water use in the State. While surface water will continue to be the primary source, ground-water use should increase to meet about 38 percent of demand. Large increases in water use for irrigation are expected all over the State, however, growth is anticipated to be greatest in the Combahee-Coosawhatchie, Edisto, and Pee Dee Sub-basins where irrigation water use is expected to grow by 790 percent, 660 percent, and 620 percent, respectively.

Table 17.
Current and projected agricultural irrigation water use in South Carolina, 1980 - 2020.

Year	*12-Month Gross Use (mgd)* Ground Water	Surface Water	Total Water	*Consumptive Use (mgd)*
1980	14.8	41.3	56.1	56.1
1990	51.3	113	165	165
2000	90.2	170	260	260
2010	127	221	348	348
2020	165	266	431	431
	5-Month Gross Use (mgd)			
1980	36.1	101	137	137
1990	125	276	401	401
2000	220	413	633	633
2010	309	539	848	848
2020	401	647	1,050	1,050

Agricultural Livestock

Domestic farm animals such as cattle, hogs, sheep, chickens, and turkeys require water for sanitation and drinking needs. Although water use by this category is small, it is important.

Agricultural livestock currently use less than one percent (10.1 mgd) of total withdrawals. Use is greatest in the Saluda (2.8 mgd) and Edisto (2.0 mgd) Sub-basins and least (0.34 mgd) in the Waccamaw and Ashley-Cooper Sub-basins (Fig. 22).

Supplies are fairly evenly provided from ground-water (55 percent) and surface-water (45 percent) sources.

This user group is anticipated to show a moderate percentage increase (70 percent) by 2020, when demand should be about 17.2 mgd (Table 18). Livestock water use will continue to be the smallest water use group. Increases should be similar throughout the State and ground water will continue to be the slightly preferred source.

Table 18.
Current and projected agricultural livestock water use in South Carolina, 1980 - 2020.

Year	*Gross Use (mgd)* Ground Water	Surface Water	Total Water	*Consumptive Use (mgd)*
1980	5.52	4.56	10.1	10.1
1990	6.29	5.18	11.5	11.5
2000	7.17	5.97	13.1	13.1
2010	8.18	6.73	14.9	14.9
2020	9.41	7.80	17.2	17.2

Self-supplied Industrial

Industry requires water for manufacturing processes, cooling and condensing, steam production, sanitation, drinking, and other purposes. Process water, which becomes part of, or comes in direct contact with, the final product during the manufacturing process, must often be of high quality and available in sufficient quantity from a reliable source. Large volumes of water are required for industrial cooling and condensing to effectively dissipate heat. Surface water is generally the primary source for this large demand.

South Carolina industries purchase water from public supply systems and/or supply their own water needs. Self-supplied industries may in turn sell water to other industrial water users and in some cases supply local domestic needs. In 1980, total industrial gross water use was 993 mgd. Of this use, about 91 percent (905 mgd) was self-supplied, while nine percent (88.7 mgd) was supplied by utilities.

Self-supplied industrial water use represents almost 16 percent of gross use and 38 percent (167 mgd) of statewide consumptive use. The greatest self-supplied industrial water use occurs in the Lower Savannah (527 mgd), Catawba-Wateree (119 mgd), and Pee Dee (81.5 mgd) Sub-basins (Fig. 22). The least use occurs in the Waccamaw Sub-basin (0.60 mgd).

Surface water currently supplies 95 percent of total demand, but only about 28 percent of all industries (65) use this as a sole source. Ground water is used by more industries (201) but in smaller volumes. About 18 industries use both surface and ground-water sources.

Table 19.
Current and projected self-supplied industrial water use in South Carolina, 1980 - 2020.

Year	Gross Use (mgd) Ground Water	Surface Water	Total Water	Consumptive Use (mgd)
1980	46.4	858	905	167
1990	52.9	1,010	1,067	229
2000	58.3	1,120	1,180	252
2010	64.1	1,230	1,300	278
2020	71.1	1,360	1,430	306

Water use by this group is anticipated to increase by 58 percent from current levels to 1,430 mgd in 2020 (Table 19). Industry will remain the second largest user group in 2020, accounting for about 17 percent of total gross use. The greatest increase by volume is expected to occur in the Lower Savannah (280 mgd), Catawba-Wateree (107 mgd), and Pee Dee (43.9 mgd) Sub-basins.

Thermoelectric Power

Thermoelectric power generation comprises about 80 percent of the State's total electric generating capacity (Public Service Commission of S.C., 1981). This electrical energy potential of 7,740 megawatts (MW) is provided by two nuclear plants (3,245 MW), ten coal plants (3,695 MW), three fuel oil plants (772 MW), and one waste heat plant (28 MW).

Electricity is produced in these plants by superheating water to steam and passing the steam under pressure through steam-turbines attached to electric generators. As the generators rotate, electric energy is produced. This steam must then be condensed to the liquid state and large volumes of cooling water are used for this purpose. Thermoelectric power plants are generally located on large rivers and impoundments which provide ample cooling water supplies to help remove waste heat.

Water use for thermoelectric power production represents by far the largest use in South Carolina, totaling 4,370 mgd or about 76 percent of statewide gross use. While this user group requires large withdrawals, actual consumption is only about one percent (53.5 mgd) of the total withdrawal, and about 12 percent of statewide consumptive use. This use occurs in all but five sub-basins, the Lynches, Congaree, Black, Little Pee Dee, and Combahee-Coosawhatchie (Fig. 22). The greatest withdrawals (2,040 mgd) currently occur in the Upper Savannah Sub-basin at the Oconee nuclear steam plant. This facility is well supplied by Lake Keowee.

Due to the large volumes of water required by these facilities, surface waters are the only supply source. Many of these sources are large impoundments. The large storage capacity of impoundments provides a reliable supply of water to electric power facilities and allows withdrawals greater than the average flow of the impounded stream.

Water use for thermoelectric power generation is projected to increase by 36 percent above current levels to about 5,940 mgd in the year 2020 (Table 20). This user group will continue to be the largest user of South Carolina's water resources, accounting for almost 73 percent of total gross use. Increased withdrawals are expected throughout the State, however, the largest increase (834 mgd, 2,000 percent) is projected to occur in the Broad Sub-basin (Fig. 22), due to the completion of the Virgil C. Summer Nuclear Station Unit One and the possible completion of Cherokee Nuclear Station.

Table 20.
Current and projected thermoelectric power water use in South Carolina, 1980 - 2020.

Year	Gross Use (mgd) Ground Water	Surface Water	Total Water	Consumptive Use (mgd)
1980	0.0	4,370	4,370	53.5
1990	0.0	5,420	5,420	146
2000	0.0	5,580	5,580	286
2010	0.0	5,750	5,750	464
2020	0.0	5,940	5,940	758

WATER USE VERSUS AVAILABILITY

The following section of this document provides an assessment of the water resources for each of the State's 15 sub-basins. At the end of each sub-basin assessment, surface and ground-water supplies are compared to current and projected surface and ground-water demand to determine potential surpluses or deficits in sub-basin water availability. Such analysis is essential to any water resource study and provides important insight for water resource planning and development. The means in which these analyses are conducted greatly affects the results. The following is an explanation of the analysis methodologies employed in this report.

Surface-Water Methodology

Availability of flowing water is difficult to assess since streams by nature have fluctuating flows dependent on geological, morphological, and meteorological factors. Flow-duration values provide a good indication of water availability at a particular stream site and, when plotted graphically along with water use totals, provide easy comparison of water use versus availability.

The amount and frequency of water surpluses and shortages can be estimated based on the position of water use demand lines in relation to the flow-duration curve. Surplus water is apparent when the water use line falls below the flow-duration curve. When these lines intersect, water shortages may occur, resulting in potential water use conflicts. Apparent water shortages for consumptive use are more significant than for gross use because consumed water is not returned to the water source and is no longer available for reuse as is water for gross use. Thus, the intersection of the "consumed" line with the flow-duration curve is a more accurate comparison.

Ideal use versus availability analysis would require flow-duration measurements at the site of withdrawal for each user. Since this method is not possible for various reasons, a more generalized approach was used in this report. Sub-basin surface-water availability as represented by flow duration at the most downstream main stem gaging station was compared to current and projected (2020) total gross and consumed surface-water use in the sub-basin. While this method of analysis is generally accepted and reliable, some problems are associated with it.

One of the most obvious problems is that most surface-water users are spread throughout the sub-basin and withdraw from tributary streams which have substantially less flow and different flow-duration characteristics than the main stem river. Therefore, water shortages may occur in several areas within a sub-basin but may not be indicated by the general basin-wide analysis method.

Another problem associated with this analysis method is the lack of streamflow records in some sub-basins because of the poor availability and location of gaging stations. This is especially true in the coastal sub-basins. Gaging stations are non-existent in the Ashley-Cooper Sub-basin and are located far upstream in the Waccamaw, Black, Lower Santee, and Combahee-Coosawhatchie River Sub-basins. Surface-water availability data in these sub-basins are incomplete and, when analyzed with surface-water demand, may indicate water shortages when ample water may actually be available.

A third problem associated with this methodology is that gaging station records, even when adequate to define flow characteristics of a sub-basin, do not always reflect total surface-water availability. Gaged streamflow as indicated by the flow-duration curves reflects available surface water plus unconsumed ground-water discharges minus upstream consumptive use. Since consumptive use of surface water and unconsumed ground-water discharges have generally increased during the period of streamflow record, their precise impact on flow duration is unknown. In some sub-basins, their individual effects may negate any net effect on streamflow. This would be especially true in the Coastal Plain region where ground-water use is greatest. However, in other sub-basins where just consumptive surface-water use is high, actual available streamflow may be greater than the flow-duration curve indicates Although flow-duration curves already reflect water withdrawals and consumption, the lower end of the flow-duration curves (low flow data) may reflect more natural water availability conditions because it is based on records from the mid-1950's before the occurrence of large surface-water withdrawals.

Ground-Water Methodology

In the following sections describing each sub-basin, the availability of ground water to meet present and projected groundwater needs is calculated by two different methods: 1) main stem river base flow analysis and 2) average well yield analysis.

The first method involves an analysis of the surface water flow-duration curve of the most downstream gaging station on the main stem stream draining the sub-basin. The base flow of the stream is considered to be made up almost entirely of ground-water discharge to the stream. One method of defining this quantity of discharge is to assume that the minimum flow for large percentages of time, as selected from the flow-duration curve, represents ground-water discharge or potential recharge to the aquifer. The minimum flow level selected is dependent on the geology and topography of the sub-basin. In sub-basins of low topographic relief and/or composed largely of rocks or clayey weathered rock (saprolite), the surface-water component of streamflow will be large in comparison to the ground-water contribution. But in sub-basins of moderate relief and highly permeable unconsolidated sands, the ground-water contribution is comparatively large, the slope of the duration curve is relatively flat, average and minimum monthly flows are relatively constant, and the maximum and minimum discharge rates are within comparatively narrow ranges. The ground-water contribution to base flow is estimated to occur between 75 to 99 percent of the time, depending upon the hydrogeology of the sub-basin. The higher percentile (numerically) is associated with those basins where the ground-water contribution is low. This method of analysis is applied to sub-basins such as the Broad River Sub-basin because records are available from the gaging station located at the extreme downstream end and thus represent conditions throughout the entire basin.

There are a number of qualifications to the use of this type of analysis and the results obtained. One of these is that availability of ground water may not be distributed proportionally throughout the sub-basin. Another problem is that discharge values may not reflect the potential ground-water supply since the deeper and more productive aquifers do not discharge wholly (or even partially in many instances) to the stream. This occurs in sub-basins located wholly or partially in the Middle to Lower Coastal Plain. Potential recharge to the deeper and more productive aquifers can only be extrapolated where streamflow measurements are obtained in the recharge (or discharge) areas of the aquifer. Another problem occurs when gaging stations are located up basin. In these cases there are no representative data for the area of the basin below the gaging station. Other problems associated with use of the flow-duration curve are itemized in the preceding discussion on surface water.

Taking these limiting factors into consideration, the resultant ground-water availability values should be considered more as measures of magnitude rather than exact amounts. Although there is additional water in storage within the aquifer, in a practical sense the availability may be somewhat less than the rejected recharge indicates. In addition, when a stream is subject to hydroelectric and flood control, the statistical analysis is affected and the resultant values may not be representative of potential yields. Because of the limitations indicated above, the method of determining availability by flow-duration curve analyses is used for only five of the 15 sub-basins.

The second method of estimating ground-water availability is to calculate the approximate number of average-yield wells required to supply the projected future demand. Average yield was estimated as a well pumping 600 gpm for 6 hours each day. It is recognized that in several areas this yield may exceed that potentially obtainable, but in others it may be less than currently available. In addition, many wells are pumped for longer periods each day. The total number of wells required to meet ground-water demands throughout the sub-basin was indicated, plus the density of their distribution, as expressed by the number of square miles per single well. These numbers must be considered approximate since all areas within the sub-basin are not accessible or amenable to well development. The estimated potential ground-water availability should be used in a general sense rather than applicable to site specific situations.

Supplemental Information Box 6.

Water Use Terminology

water use — the utilization of water by man for any purpose including use at the source in its natural form (stream or lake), known as an instream or non-withdrawal use, and utilization after the water has been removed from its source, known as a withdrawal use.

surface water — encompasses all water bodies located on the land surface, including streams, ponds, lakes, and man-made reservoirs. For practical purposes, ocean water is excluded unless expressly mentioned.

ground water — water which is located in the zone of saturation below the earth's surface, including spring seeps and artisan flow. Ground water is stored in porous space in sub-surface, gravel, clay, fractures, and rocks; these water-bearing formations are termed aquifers.

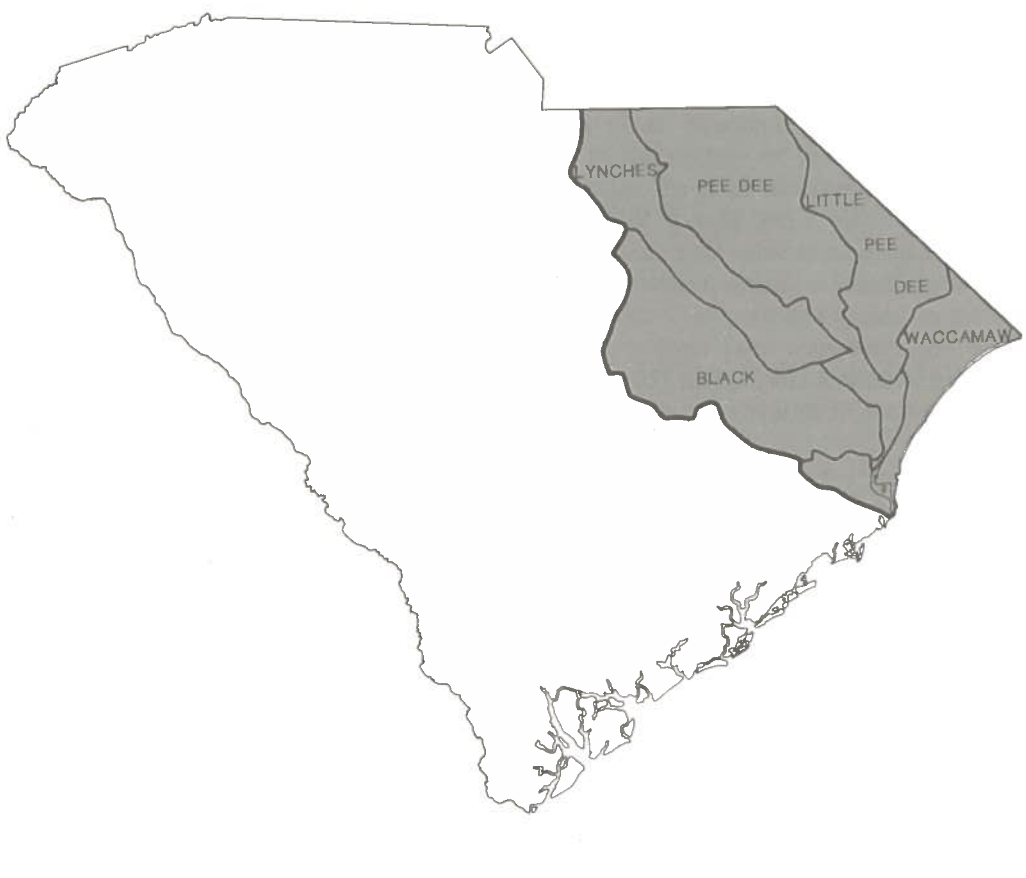
water source — the naturally occurring location of the water being utilized, such as a stream, reservoir, or aquifer.

gross water use — the amount of water withdrawn from a water source. Some or all of the withdrawn water may be eventually returned to the source after its use.

consumptive water use — the difference between the amount of water withdrawn from a source and the amount directly returned to a source. Water is consumed by evaporation, incorporation into a manufactured product, absorption by soil, transpiration by plants, and many other ways.

million gallons per day (mgd) — a common unit of water use measure used to express large water quantities. For example, the average person may require 100 gallons of water per day for their normal use, which can be expressed as 0.0001 mgd. On the other extreme, the City of Columbia may require 60,000,000 gallons of water per day during peak summer usage, which is expressed as 60 mgd.

Sub-basin Analyses: Pee Dee River Basin



Pee Dee River Sub-basin

GENERAL OVERVIEW

The Pee Dee River Sub-basin comprises the majority of the Pee Dee region of the State. The sub-basin extends from the North Carolina border southeast to Winyah Bay and encompasses portions of eight South Carolina counties, including most of Chesterfield, Darlington, Florence, and Marlboro Counties, approximately half of Marion County, and smaller portions of Dillon, Georgetown, and Williamsburg Counties (Fig. 23). The areal extent of the sub-basin is approximately 2,350 square miles, 7.6 percent of South Carolina's land area.

Population

The 1980 sub-basin population was estimated at 202,400, which is almost seven percent of the State's total population (Table 21). By the year 2020 the population in the sub-basin is expected to reach almost 310,000, an increase of 53 percent. The counties expected to exhibit the largest population increases from 1980 to 2020 are Georgetown, with an increase of 92 percent, and Florence, with a 73 percent increase.

Except for Florence County, the counties included in the Pee Dee River Sub-basin are predominately rural in character and population. Over one-half of the population in Florence County is classified as urban. The sub-basin's urban population nearly doubled in the 1970's. The major 1980 population centers within the sub-basin are Florence (30,145), Bennettsville (8,841), Darlington (7,978), Marion (7,622), Hartsville (7,616), and Cheraw (5,681).

Economy

The 1979 per capita income in the sub-basin counties ranged from a low of $5,097 in Marlboro County, which ranked 39th out of the 46 counties in South Carolina, to $6,898 in 14th ranked Florence County. The 1979 per capita income in South Carolina averaged $7,056. Median household income for 1980 ranged from $11,725 in Marion County to $16,059 in Florence County, all below the State median household income of $16,509.

The 1979 annual average employment of non-agricultural wage and salary workers in the sub-basin was approximately 93,800. Percentage breakdown by type of employment was: manufacturing, 41 percent; wholesale and retail trade, 18 percent; government, 16 percent; services and mining, 13 percent; construction, 5 percent; transportation and public utilities, 4 percent; and finance, insurance, and real estate, 3 percent.

In the sectors of manufacturing, mining, and public utilities, the combined annual product value for fiscal year 1978-79 was $2,368.7 million, or 11 percent of South Carolina's total value of products manufactured.

Agricultural activity is intense in this section of the State. Florence County ranked second in the State for cash crop receipts from farm marketings in 1979, with a total of nearly $57 million, and four of the remaining seven counties in the sub-basin ranked in the top ten of reported county

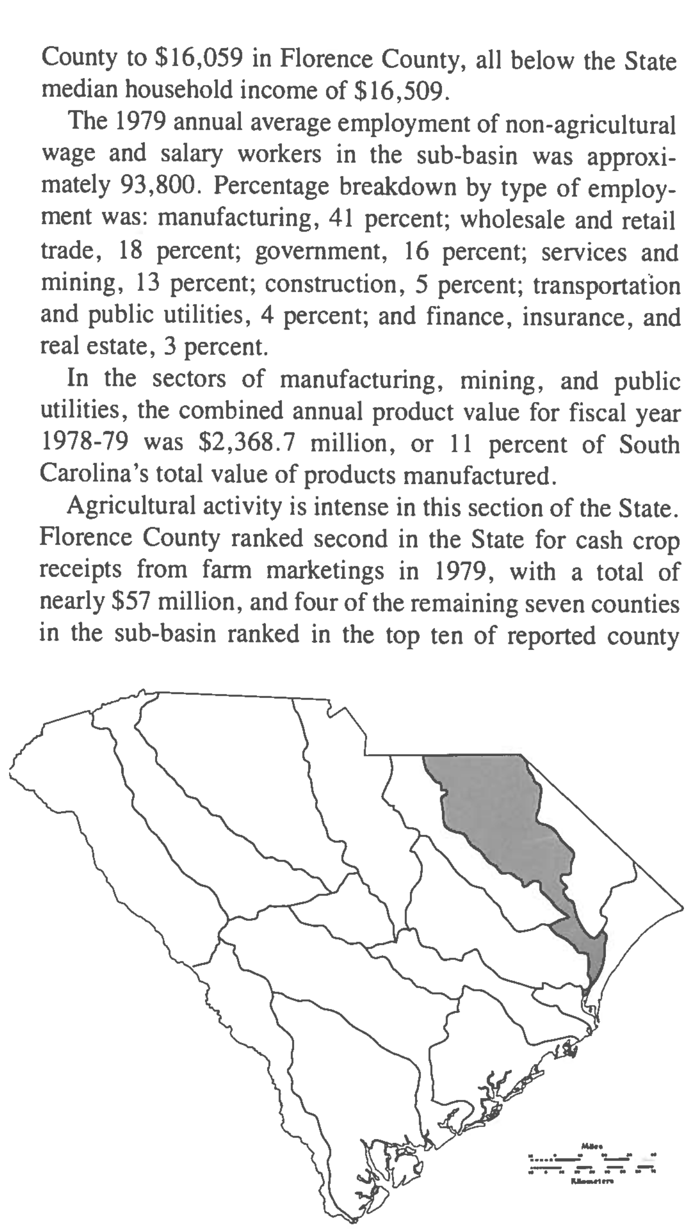


Figure 23.
Location of the Pee Dee River Sub-basin in South Carolina.

Table 21.
Current and projected population for the Pee Dee River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands) 1980	1990	2000	2010	2020	% Change 1980-2020
Chesterfield	83.3	31.9	36.4	39.1	41.3	42.5	33.2
Darlington	80.6	50.7	59.9	66.8	72.5	75.6	49.1
Dillon	8.9	2.8	3.0	3.1	3.2	3.3	17.9
Florence	64.2	71.1	87.8	102.7	115.7	123.1	73.1
Georgetown	5.9	2.5	3.2	3.9	4.5	4.8	92.0
Marion	50.0	17.1	19.5	20.9	21.9	22.5	31.6
Marlboro	79.9	25.4	29.7	32.9	35.5	36.9	45.3
Williamsburg	2.4	0.9	1.0	1.1	1.1	1.2	33.3
Total		202.4	240.5	280.4	295.8	309.9	53.1

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

cash crop receipts. In 1979, Florence County ranked second in the State for tobacco production, while Marlboro County ranked second in cotton production.

SURFACE WATER
Hydrology

The main stem of the Pee Dee River is the dominant hydrologic feature of the sub-basin. This river originates in North Carolina and receives most of its flow from drainage within that state. Major tributary streams in South Carolina include Black Creek, Catfish Creek, Jefferies Creek, and Thompson Creek. Black Creek, the largest of these tributaries, flows through the more urbanized (Hartsville, Darlington, Florence) portion of the sub-basin. Streams in the upper portion of the sub-basin originate in or traverse the Upper Coastal Plain region. Most streams in this sub-basin are associated with extensive swamp areas and follow indistinct channels which often divide and recombine.

Streamflow data are available for seven monitoring sites, one on the Pee Dee River's main stem and six on tributary streams (Fig. 24). A gaging station on the Pee Dee River outside the sub-basin near Rockingham, North Carolina provides useful flow data. The entire period of record on the main stem reflects regulated flows by hydroelectric power facilities in North Carolina. Black Creek's streamflow is affected by two impoundments, Lake Robinson and Prestwood Lake. Peak flows are also monitored at five crest-stage stations (1304, 1305.5, 1308, 1311.1, 1311.4) located on tributaries. Streamflow statistics for the seven existing gaging stations and one discontinued gaging station are presented in Table 22.

Average annual streamflow of the Pee Dee River at Peedee is 9,850 cfs and can be expected to be at least 3,200 cfs, 90 percent of the time. Streamflow in this river is somewhat steady as indicated by the relatively flat flow duration curve (Fig. 25), relatively constant average and minimum monthly flows (Fig. 24), and moderately wide range between maximum and minimum monthly flows. Flow in the upper portion of the Pee Dee River may be quite variable on a weekly basis due to hydropower discharges upstream in North Carolina. However, discharges from hydropower facilities, in addition to ground-water support from the Upper Coastal Plain, sustain relatively steady long-term flows. The lowest flow of record in South Carolina is 700 cfs and occurred during the 1954 drought, while the highest flow (220,000 cfs) was the result of an unnamed tropical storm in 1945 which caused flooding in much of the eastern portion of the State.

Average annual flows in the gaged tributary streams are 72.5 cfs for Juniper Creek, 97.4 cfs for Cedar Creek, 170 cfs for Black Creek near McBee, 241 cfs for Black Creek near Hartsville, and 27.8 cfs for Catfish Canal. Streamflows in these tributaries equal or exceed 17 cfs, 43 cfs, 56 cfs, 120 cfs, and 3.7 cfs, respectively, 90 percent of the time. Tributaries located in the Upper Coastal Plain, such as Black Creek and Cedar Creek, exhibit steady flows, which are maintained by discharge from ground-water storage particularly during periods of low rainfall. These consistent flows are evidenced by relatively flat flow-duration curves (Fig. 25), uniform average monthly flows (Fig. 24), and narrow ranges between maximum and minimum monthly flows. Lower Coastal Plain streams, such as Catfish Canal, exhibit more variable flows as evidenced by steeply sloped flow-duration curves (Fig. 25), irregular monthly flow patterns especially during the summer and fall (Fig. 24), and comparatively small unit average and 7Q10 discharges (1.01 cfs/mi^2 and 0.0018 cfs/mi^2). These Lower Coastal Plain streams are typically more dependent on rainfall and runoff rather than ground-water discharges to support flows. The lowest recorded tributary flow (0.0 cfs) occurred in Catfish Canal during 1978, while the highest flow (2,010 cfs) occurred in Black Creek near Hartsville in 1971.

The Pee Dee River has a large and well-sustained streamflow year round. This stream provides a reliable source of freshwater for activities requiring large quantities of water. Tributary streams in the Upper Coastal Plain region, such as Black Creek and Cedar Creek, also provide reliable flows although of much lower volume. Catfish Canal and probably other Lower Coastal Plain streams provide somewhat less reliable streamflows and use of these streams may require provisions for water storage to ensure

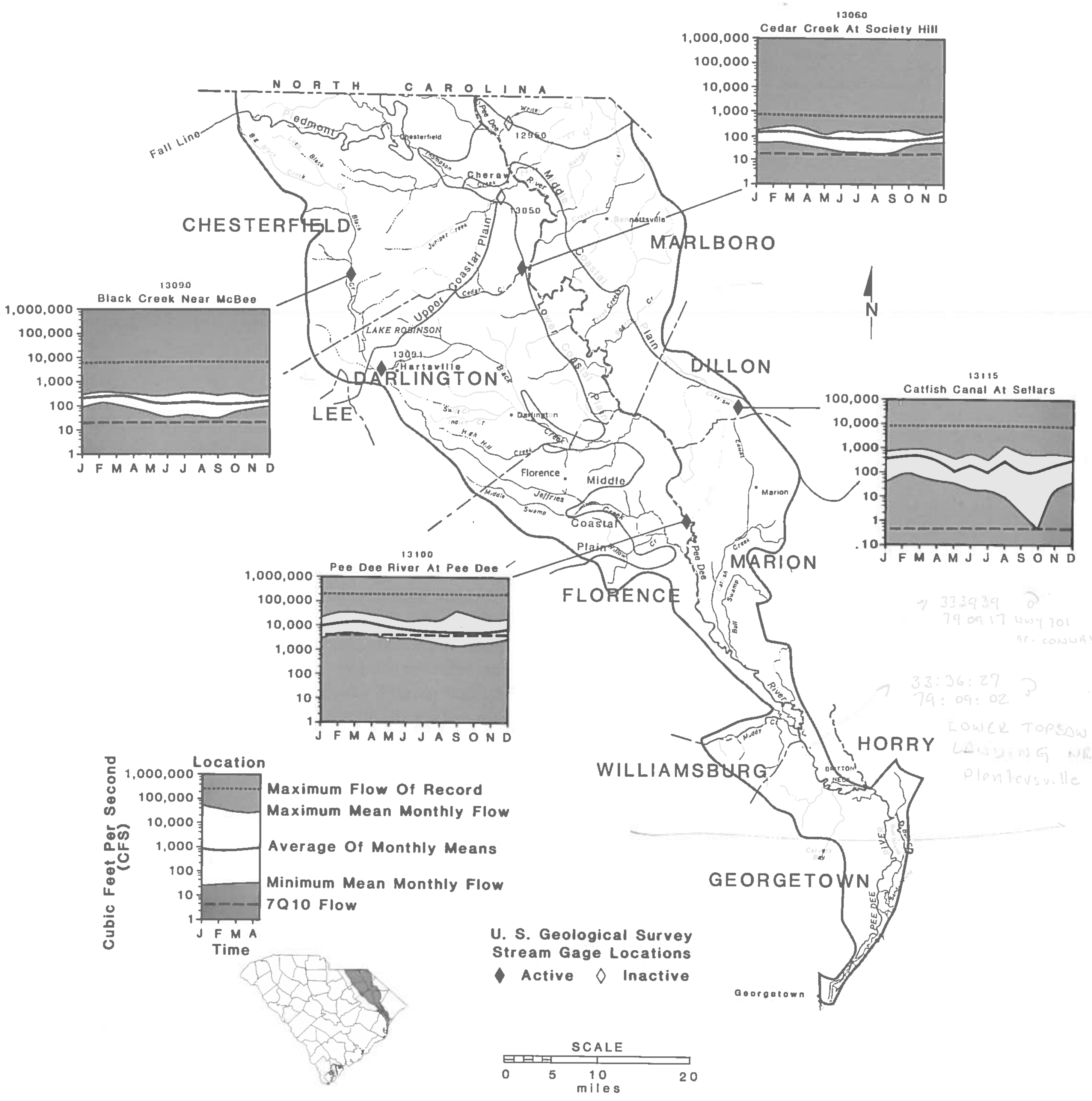


Figure 24.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Pee Dee River Sub-basin, South Carolina.

Table 22.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Pee Dee River Sub-basin, South Carolina.

Gaging Station		*Drainage Area (mi²)*	*Period of Record*		*Average Flow*				
Number	*Name/Location*		*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*90%[a] cfs*	*7Q10[b] cfs*	*7Q10[b] cfs/mi²*
1290	Pee Dee near Rockingham, N.C.	6,863	Aug 1906-Jan 1912, Oct 1927-Present	58	8,089	1.18	2,160	1,100	0.16
1295.9	Whites Creek near Wallace	26.4	Oct 1979-Present	1	37.4	1.42	*[e]	*	*
1305	Juniper Creek near Cheraw	64	May 1940-May 1958	18	72.5	1.13	17	4.3	0.07
1306	Cedar Creek at Society Hill	58.2	Oct 1970-Present	10	97.4	1.67	43	18.5	0.32
1309	Black Creek Near McBee	108	Oct 1959-Present	21	170	1.57	56	22	0.20
1309.1	Black Creek near Hartsville	173	Oct 1960-Present	20	241	1.39	120	67	0.39
1310	Pee Dee River at Peedee	8,830	Oct 1938-Present	42	9,850	1.12	3,200	1,500	0.17
1311.5	Catfish Canal at Sellers	27.4	Nov 1966-Present	13	27.8	1.01	3.7	0.05	0.002

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] * indicates statistic not calculated.

adequate availability during summer and fall low-flow periods.

Development

The Pee Dee River Sub-basin has experienced limited surface-water development consisting primarily of flood control projects. Figure 26 illustrates the extent of surface-water development in the sub-basin.

The one major reservoir in the sub-basin, Lake Robinson, is owned and operated by Carolina Power and Light Company and has a surface area of 2,250 acres and a volume of approximately 31,000 acre-feet (Table 23). Located on Black Creek a few miles northwest of Hartsville, the lake was constructed in 1959 to provide cooling water for the H.B. Robinson fossil fuel generating plant. The H.B. Robinson nuclear generating facility, completed in 1970, also draws cooling water from the lake. The lake also serves industrial and recreational needs. Lake Robinson is the only site identified by the U.S. Army Corps of Engineers within the Pee Dee River Sub-basin having the potential for hydropower development (Table 24). Original construction of the dam did not include hydroelectric generating equipment. In addition, the S.C. Land Resources Conservation Commission has identified three potential small scale hydropower sites with a total potential capacity of 1.5 MW (Long, 1980).

Lakes greater than ten acres in the sub-basin have a total surface area of over 7,000 acres and a total volume of about 57,000 acre-feet. Those lakes greater than 200 acres in size are listed in Table 23.

Presently there are no active U.S. Army Corps of Engineers navigation projects within the sub-basin (Table 25).

The Soil Conservation Service has completed one flood control project on Carter's Branch-Muddy Creek involving 33.3 miles of channel improvement. The U.S. Army Corps of Engineers is presently developing a nonstructural flood control project near Cheraw. The Corps is also in the reconnaissance phase of a comprehensive study of the Pee Dee River identfying primarily flooding and navigation problems. Other flood control problem areas within the sub-basin are identified in Table 26.

Water Quality

The entire main stem of the Pee Dee River and portions of many tributary streams are designated Class B waters, suitable for multiple water use including industrial and agricultural activities (Fig. 27). Portions of several tributary streams are designated Class A waters. Water quality limited streams which require more advanced treatment of wastewater discharges include all of Crooked Creek, Catfish Creek, Bull Swamp, and Muddy Creek and portions of and tributaries to Beach Creek, Swift Creek, and Jefferies Creek (Fig. 28). Water quality throughout the Pee Dee River Sub-basin is generally adequate for most water use needs. Low dissolved oxygen levels during summer months contribute to lower quality conditions. This widespread problem is attributed to the natural conditions of low streamflows, oxygen deficient swamp water drainage, and warm summer water temperatures. More localized water quality problems, including elevated levels of metals and fecal coliform bacteria, are associated with tributary streams receiving wastewater discharges from urban areas. Of these streams, Black Creek exhibits the most widespread and chronic problem conditions.

Physical and chemical water quality data indicate that conditions in the main stem of the Pee Dee River are good to satisfactory (S.C. Department of Health and Environmental Control, 1980b). Problem parameters include occasional elevated levels of mercury and turbidity. While turbid waters have been attributed to non-point source pollution, a source contributing to elevated mercury levels is unknown. Biological studies indicate fair to good quality water in the Pee Dee River with continued improvement since 1975 (S.C. Department of Health and Environmental Control, 1980b). Earlier studies indicate that water quality problems

Table 22. (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
58.0	Dec 2, 1951	275,000	Aug 27, 1908
2.2	Aug 8, 1980	268	Mar 30, 1980
0.0	Many days in 1945, 51, 55, 56	3,910	Sep 18, 1945
9.3	Sep 16, 17, 1980	750	Jun 23, 1973
21.0	Sep 25; Oct 3, 1980	1,770	Jul 15, 1975
51.0	Jul 14, 1970	2,010	Aug 18, 1971
700	Sep 29, 1954	220,000	Sep 22, 1945
0.0	Sep 27-30, 1978 Oct 15-Nov 7, 1978	890	Mar 4, 1971

in this sub-basin were primarily associated with tributary streams draining urban areas. The S.C. Department of Health and Environmental Control (1976) identified contraventions of State standards for dissolved oxygen and fecal coliform bacteria in Jefferies Creek and Catfish Canal which receive point and non-point sources of pollution from the cities of Florence and Marion, respectively. The City of Florence has since upgraded waste treatment capabilities and the City of Marion has constructed a new sewage treatment plant and discharges into a different stream. Impaired recreational water use on Swift Creek due to elevated concentrations of fecal coliform bacteria is attributed to agricultural non-point source pollution (S.C. Department of Health and Environmental Control, 1981c).

Black Creek is the largest tributary to the Pee Dee River and experiences chronic water quality problems. Earlier studies indicate widespread water quality problems including depressed dissolved oxygen concentrations and high levels of fecal coliform bacteria and biochemical oxygen demand (S.C. Department of Health and Environmental Control, 1976). About 84 percent of all contraventions of State standards on this stream were associated with point source discharges in the Hartsville, Darlington, Florence area. All other contraventions were attributed to natural conditions and/or non-point source pollution. More recent evaluations of Black Creek indicate generally satisfactory water quality conditions with a trend toward improved overall quality and lower fecal coliform bacteria concentrations (S.C. Department of Health and Environmental Control, 1980b). Depressed dissolved oxygen levels due to point and non-point source pollution and natural conditions and high zinc levels of unknown origin still indicate degraded water quality in this stream. Recent biological surveys suggest poor to fair conditions evidenced by a poor assemblage of aquatic organisms dominated by pollution tolerant species. Abundant populations of alligatorweed adversely impact recreational use of this river and may also contribute to water quality problems.

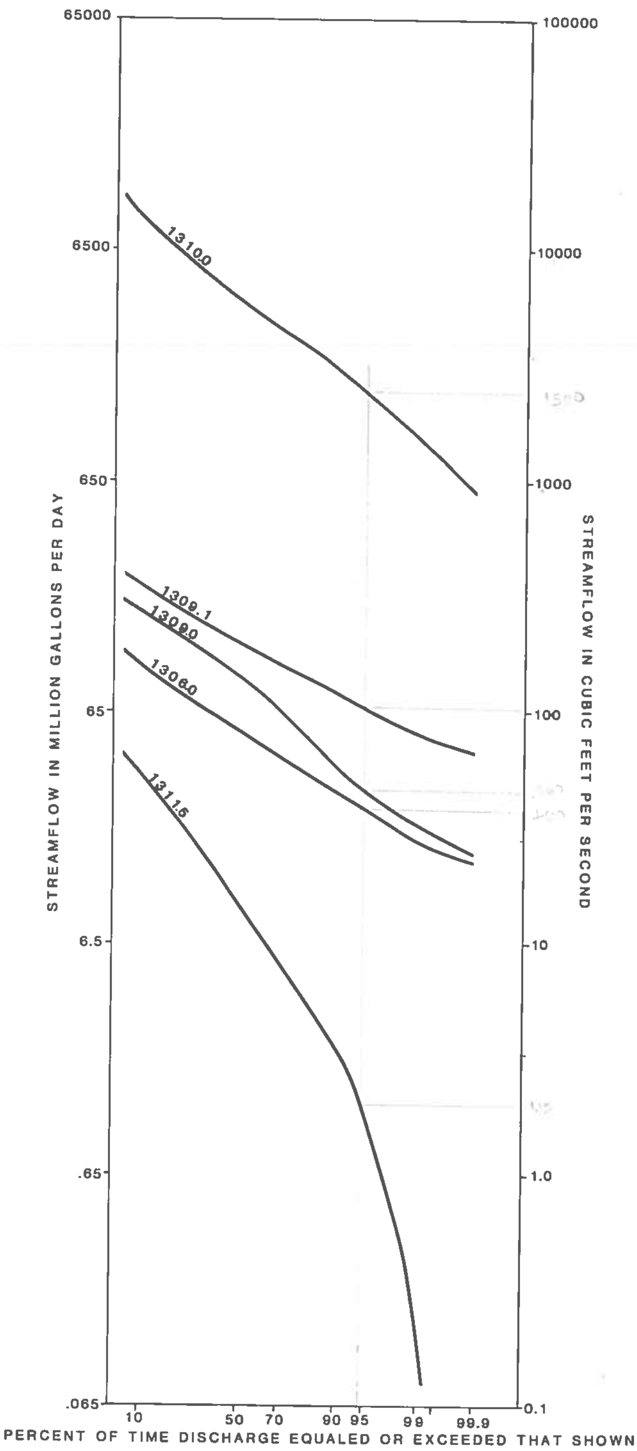


Figure 25.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Pee Dee River Sub-basin, South Carolina.

Table 23.
Existing lakes larger than 200 acres in the Pee Dee River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Lake Robinson	Black Creek	2,250	31,000	Industry Power Recreation
2	Eureka Lake	Sandy River	260	1,660	Recreation
3	Drakes Mill Pond	Three Creeks	250	7,000	Recreation
4	Prestwood Lake	Black Creek	300	1,800	Industry Recreation
5	Unnamed	Flat Creek	400	960	

Source: S.C. Water Resources Commission, 1974.

Table 24.
Existing and potential hydroelectric power development in the
Pee Dee River Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
6	Lake Robinson	Darlington	Black Creek	--[a]	--	1.7	2,250	Potential

[a] -- indicates information not available.

Sources: S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

Table 25.
U.S. Army Corps of Engineers navigation projects in the Pee Dee River
Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
7	Great Pee Dee River	Georgetown Marion Florence Dillon Darlington Marlboro	Charleston	170.0	50	Provides for 9 foot channel from Waccamaw River via Bull Creek to Smith Mills and from there a 3.5 foot channel to Cheraw (mile 172.5). Present head of commercial navigation is mile 73 (approx. 3 feet deep). The project is now discontinued.

Source: U.S. Army Corps of Engineers, 1982b.

Table 26.
Flood control projects and studies in the Pee Dee River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
8	Carters Branch Muddy Creek	Marlboro	SCS	Project completed 1974
9	Big Swamp	Florence	SCS	Recommended Study[b]
10	Wilson's Branch	Chesterfield	COE	Under construction
11	Bennettsville	Marlboro	COE	Recommended Study[c]
12	Polk Swamp	Florence	SCS	Study suspended
13	Catfish Creek	Dillon Marion Marlboro	SCS	Terminated
14	Deep Creek	Chesterfield	SCS	Terminated
15	Smith Swamp	Marion	SCS	Terminated

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.
[b] Non-sponsored study recommended by SCS.
[c] Non-sponsored study recommended by Flood Plain Management Task Group.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

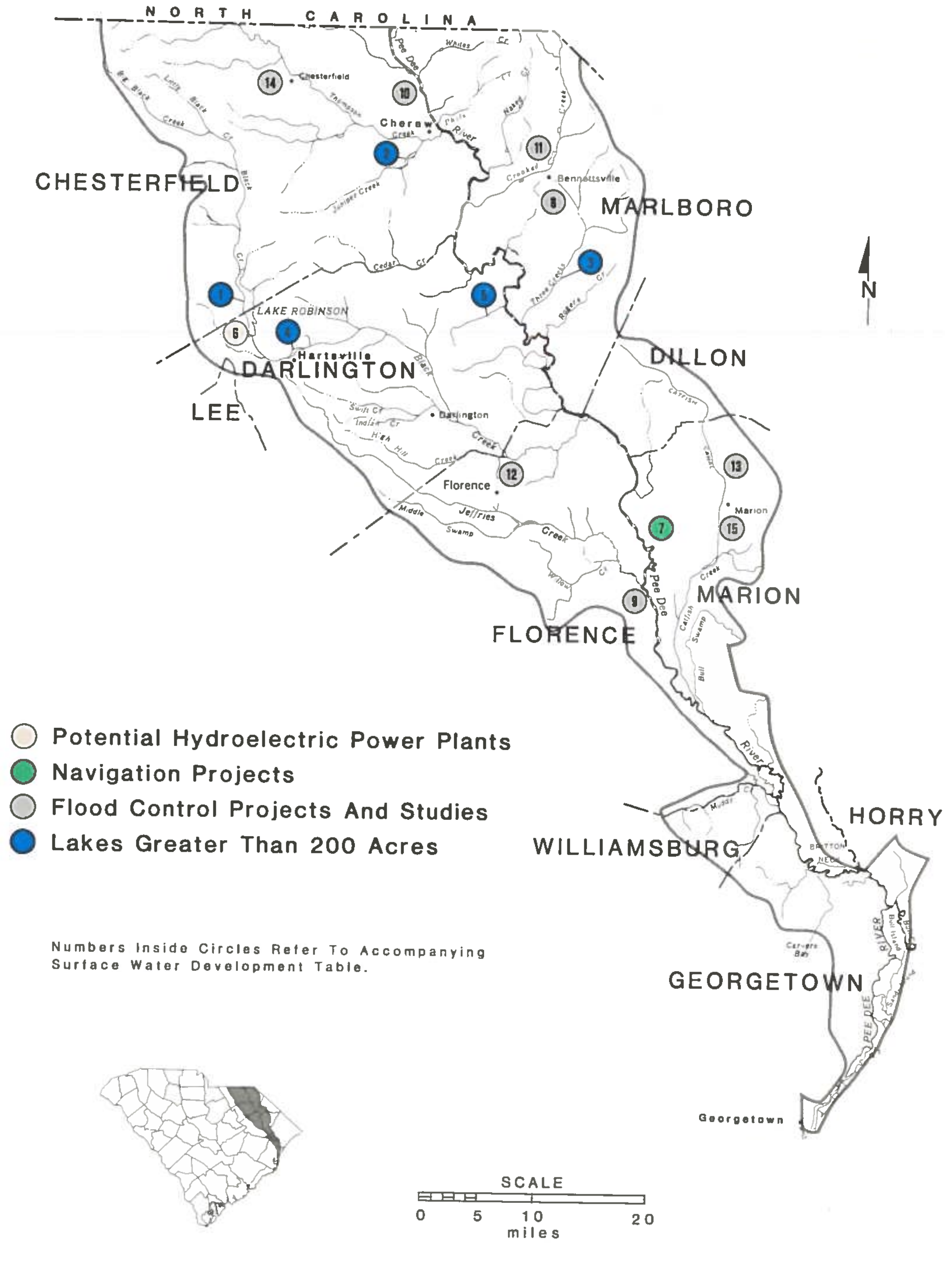


Figure 26.
Surface-water development in the Pee Dee River Sub-basin, South Carolina.

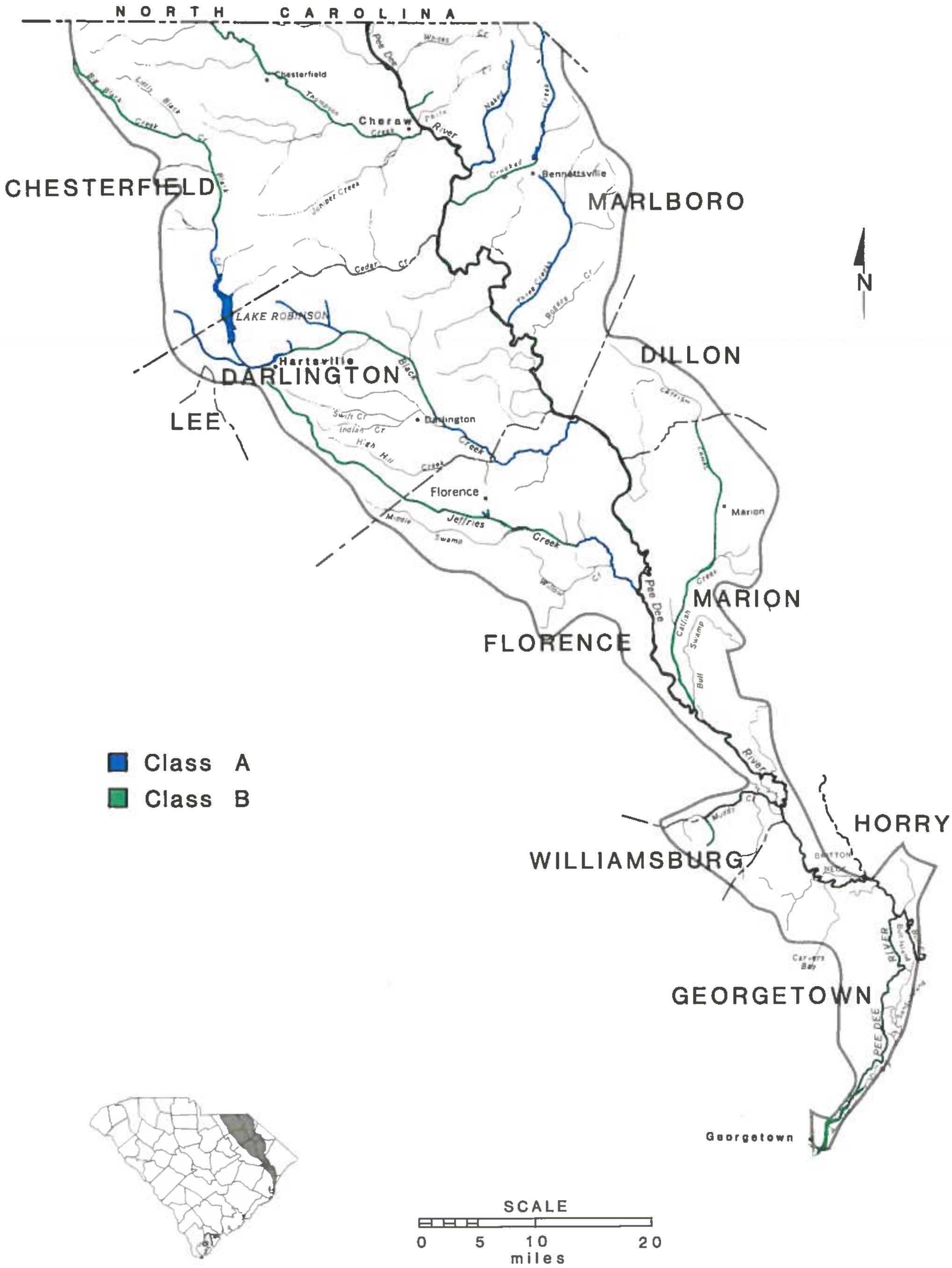


Figure 27.
Surface-water quality classifications in the Pee Dee River Subbasin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

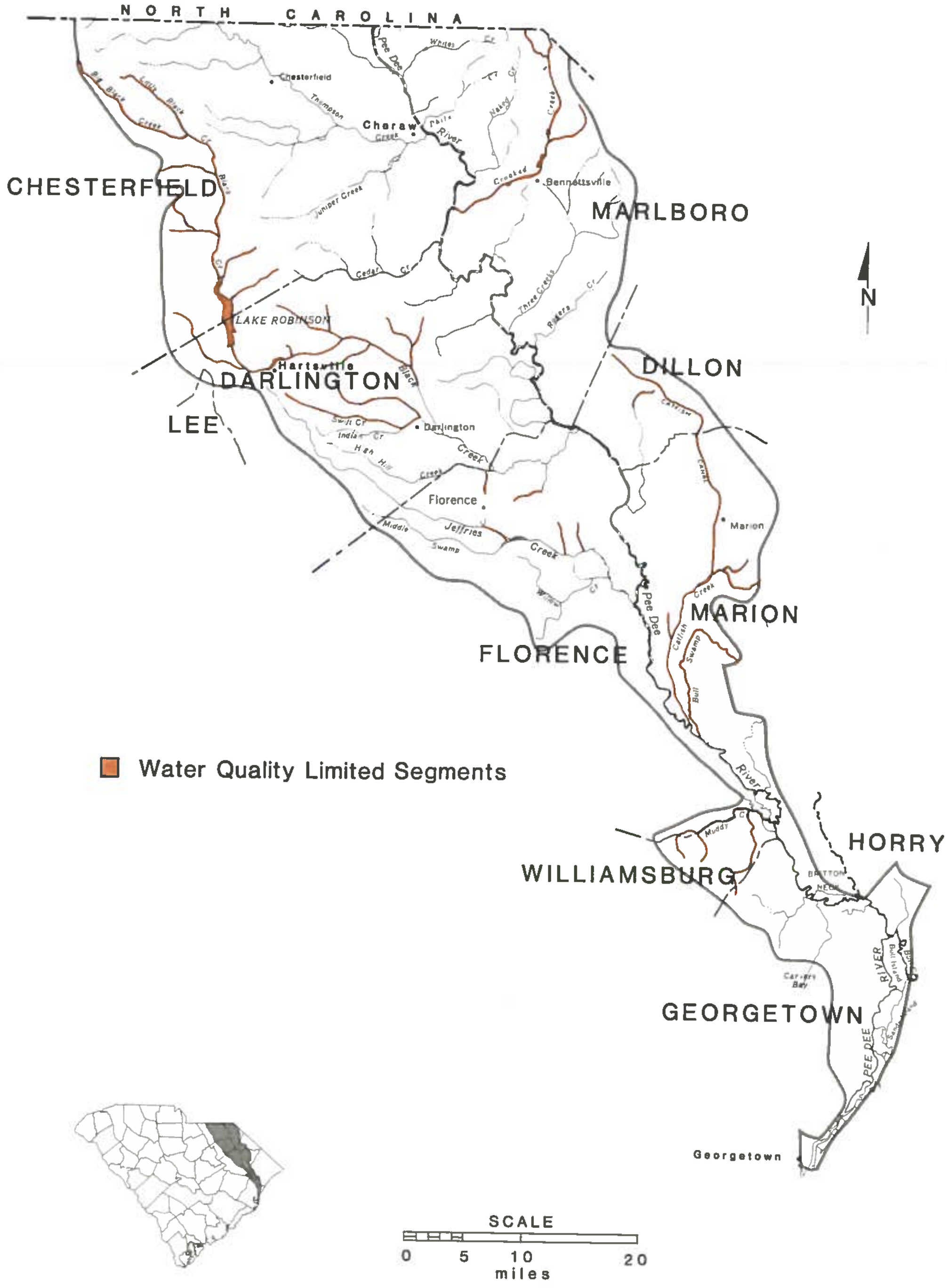


Figure 28.
Water quality limited segments in the Pee Dee River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Upstream from the City of Hartsville, water quality conditions in Black Creek improve somewhat. Lake Robinson has been characterized as mesotrophic and ranked third in trophic quality out of 13 South Carolina lakes surveyed (U.S. Environmental Protection Agency, 1975a). Water quality in the lake is good to satisfactory and has shown signs of improvement during recent years (S.C. Department of Health and Environmental Control, 1980b). However, high water temperatures and low pH levels due to point source discharges and natural conditions indicate degraded water quality conditions in this lake.

Sunfishes in Lake Robinson, Prestwood Lake, and Black Creek exhibit a high occurrence of mouth and/or opercular deformities (Carolina Power and Light Company and Lawler, Matusky, Skelly Engineers, 1981). These deformities are most prevalent in bluegill populations and progressively decrease in occurrence with distance downstream from Lake Robinson. Coincidental with the deformity problem, bluegill populations in Lake Robinson have also experienced a general decline in recent years in total number of fish and young-of-the-year indicating inhibited reproductive ability (Carolina Power and Light Company and Lawler, Matusky, Skelly Engineers, 1981). These problems have been attributed primarily to excess copper concentrations in Lake Robinson due to corrosion of brass condensor tubes in the Carolina Power and Light Company Robinson Steam Plant. Carolina Power and Light Company has recently replaced the brass condensor tubes with stainless steel tubes. This alteration has eliminated copper discharges and improved the fish deformity and reproduction problem.

GROUND WATER

Hydrogeology

Hydrogeologic knowledge throughout the sub-basin ranges from the field data level in the northern and eastern region where data are limited to the evaluation level in the southern region (Fig. 18).

Most of the Pee Dee River Sub-basin lies within the Coastal Plain Province. However, portions of Chesterfield and Marlboro Counties in the upper part of the sub-basin lie within the Carolina Slate Belt of the Piedmont Province where ground water occurs in the overlying mantle of saprolite and in joint systems and fracture zones of crystalline bedrock. Ground-water availability information in this area is currently limited due to the lack of adequate well data. Selected data on well yields are listed in Table 27.

East of the Fall Line, the Coastal Plain sediments reach a maximum thickness of 550 feet along the southern border of Chesterfield and Marlboro Counties. To date, a systematic ground-water study has not been conducted in this part of the sub-basin. However, available data indicate that the area is underlain by the Middendorf Aquifer System, which can yield as much as 1,000 gpm to individual wells. Gravel mines in alluvial deposits along the Pee Dee River and test wells drilled in the Cheraw area by the U.S. Geological Survey indicate a potentially favorable situation for infiltration wells if the water-bearing sands are hydraulically connected to the river. Several wells have been drilled successfully into the alluvial and terrace deposits on the east bank of the Pee Dee River near Wallace.

In the vicinity of Darlington, the Black Creek and Middendorf Aquifer Systems lie beneath a thin veneer of Pleistocene sands and clays and the Duplin Marl. The total thickness of the unconsolidated material overlying the basement rock is estimated to range between 500 and 650 feet.

In Florence County, beneath the Black Mingo and Duplin Formations, the Peedee Aquifer System occurs with a thickness of about 200 feet and reported well yields of about 20 gpm. However, yields from the Peedee Aquifer System elsewhere are normally much higher. Beneath the Peedee Aquifer System, the Black Creek Aquifer System has a thickness of about 250 feet. The principal source of ground water in Florence County is the Middendorf Aquifer System which is the most permeable and productive aquifer in the County. The transmissivity of the Middendorf Aquifer System in the Florence vicinity is about 2,400 ft^2/day with a storage coefficient of about 0.0006 (Park, 1980).

Table 27.
Selected ground-water data for the Pee Dee River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Cheraw	Middendorf	25-150	5-150	--[a]
Bennettsville	Middendorf	200-330	300-700	5-7
Wallace	Pee Dee River Floodplain	60-90	300-800	40 or less
Darlington	Black Creek/Middendorf	250-450	250-1000	--
Florence	Peedee	200 or less	20	--
	Black Creek	200-400	250-500	--
	Middendorf	400-800	500-2000	--
Pamlico	Black Creek	210-300	500	--

[a]-- indicates data not readily available.

Water Quality

The Middendorf and Black Creek are the two most widely used aquifer systems in the sub-basin. Ground water in the Middendorf is generally soft with low total dissolved solids and locally high concentrations of iron, and low pH. The Stiff Diagrams (Fig. 29) show the water quality for this aquifer to be of a sodium bicarbonate type.

Ground water in the Black Creek Aquifer System is also soft, has a low pH, and contains low concentrations of total dissolved solids. Some constituents locally exceed established water quality standards including iron, calcium, magnesium, fluoride, and turbidity. The Stiff Diagrams in Figure 29 show a sodium bicarbonate type of water quality. The total dissolved solids in both aquifer systems tends to increase toward the coast where increasing depth and contact time between the ground water and the host beds facilitate their solution.

WATER USE

While gross water use in the Pee Dee Sub-basin is currently 845 mgd, only about 61.3 mgd are actually lost due to consumption (Table 28). Gross water use in this sub-basin ranks second in the State. The major water use groups in decreasing order are thermoelectric power (730 mgd), self-supplied industry (81.5 mgd), and public supply (21.4 mgd). Major water users by type and supply source are shown on Figure 30.

Surface water serves as the major source of water, supplying about 97 percent of the sub-basin need. Most of this surface-water demand is for cooling water in the production of thermoelectric power. Excluding this major water use group, surface water still provides over 79 percent of total gross use. A large portion of available surface water is lost from this sub-basin through interbasin transfer to the Waccamaw River Sub-basin. This withdrawal (33.2 mgd) occurs at the lower end of the Pee Dee River (Fig. 30) and does not significantly interfere with most water use needs.

Public supply accounts for about two percent of gross water use and three percent of consumptive water use. Most public supply needs (72 percent) are supplied from ground-water sources. This user group is also the largest ground-water user in this sub-basin withdrawing 15.5 mgd.

Self-supplied domestic water use represents less than one percent of gross use and about six percent of consumptive use. This user group is evenly distributed throughout the sub-basin and obtains all water supplies from ground-water sources.

Water use for all agricultural activities comprises one percent of gross use. The vast majority of this use is for irrigation of about 10,230 acres located primarily in Darlington and Marion Counties (Fig. 30). Surface water is the primary source of water (84 percent) for agricultural irrigation, while ground water supplies most (58 percent) livestock needs. When averaged over the five-month growing season, irrigation water use equals 101 mgd comprising two percent of total water use.

Self-supplied industry represents 10 percent of gross water use and 69 percent of consumptive use. Surface water is the primary water source, supplying about 97 percent of all industrial water use needs. Heaviest self-supplied industrial withdrawals occur in the lower portion of the sub-basin. Much of this surface water (33.2 mgd) is transferred out of the Pee Dee River Sub-basin and used in the Black River Sub-basin. This irretrievable loss of water from the sub-basin makes this group the largest consumptive user in the Pee Dee River Sub-basin.

Thermoelectric power is the largest gross water user in the sub-basin accounting for almost 86 percent of total gross use. Although gross use by this group is extremely large, actual consumption is small, eight percent of the sub-basin total. Thermoelectric power also represents the largest use of the sub-basin's surface-water resources and currently withdraws all supply needs from Lake Robinson. The withdrawal and discharge of cooling water into this lake does not significantly affect surface-water availability downstream.

Gross water use in the Pee Dee River Sub-basin is projected to increase by 23 percent from current levels to almost 1,040 mgd in 2020. Total consumptive use is anticipated to increase by 170 percent from current levels to 166 mgd in 2020. Agricultural irrigation shows the largest projected percentage increase in water use between 1980 and 2020 (610 percent), while thermoelectric power shows the largest increase by quantity (92 mgd). Thermoelectric power should continue to be the leading gross water user and surface water should continue to be the major supply source through 2020.

WATER USE VERSUS AVAILABILITY

The current 822 mgd of gross surface-water demand is met 99.5 percent of the time by streamflow (Fig. 31). Consumptive use of 54.3 mgd is adequately supplied by streamflow. The largest surface-water users are the thermoelectric plants on Lake Robinson where an adequate water supply is available. The greatest concentration of surface-water users are found along Catfish Canal where most withdrawals are made for agricultural irrigation (Fig. 30). This high concentration of users may become significant in the future because of the highly variable nature of streamflow in this Lower Coastal Plain stream.

Projected 2020 gross surface-water use of 990 mgd should be met by streamflow 99.1 percent of the time. The 143 mgd projected consumptive use for 2020 should also be met by streamflow. Prior to any future water supply development on tributaries in the Lower Coastal Plain a detailed hydrologic analysis is needed to determine the quantity of streamflow available.

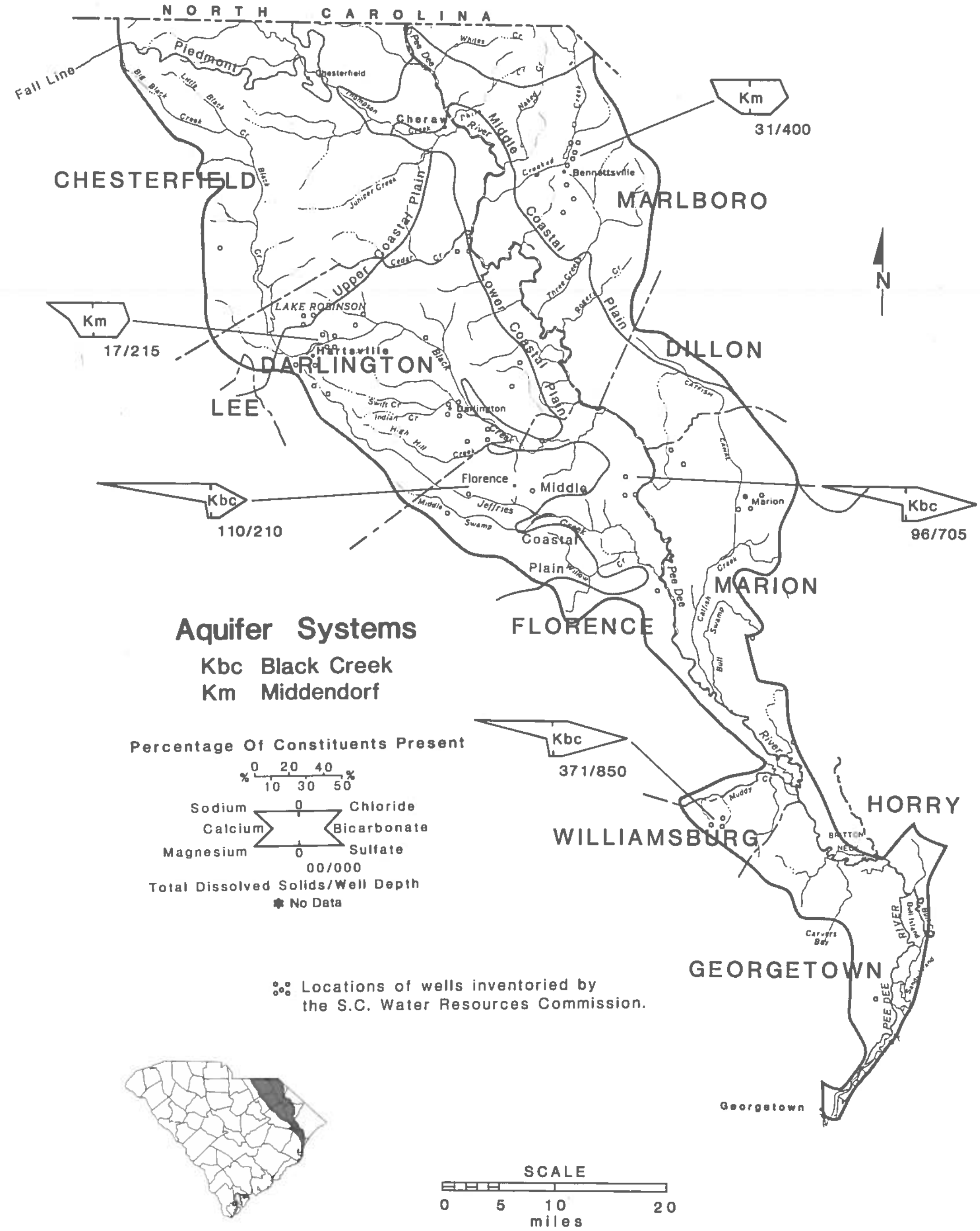


Figure 29.
Ground-water quality of selected aquifer systems and major inventoried wells in the Pee Dee River Sub-basin, South Carolina.

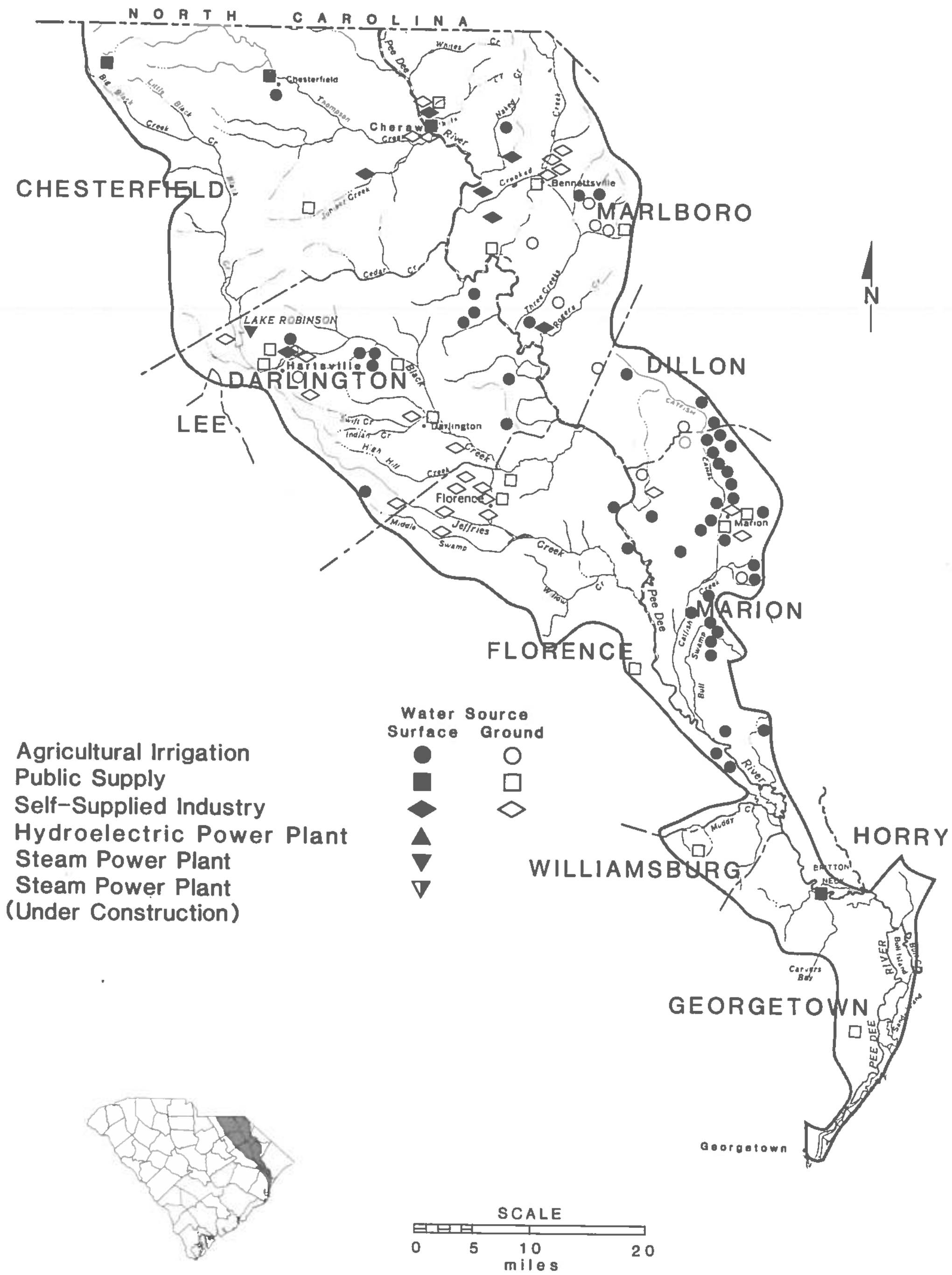


Figure 30.
Location, type, and supply source of water users in the Pee Dee River Sub-basin, South Carolina.

Table 28.
Current and projected water use in the Pee Dee River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			*1990*			*2000*			*2010*			*2020*		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	15.5	5.85	21.4	18.6	7.02	25.6	21.4	8.07	29.5	23.5	8.88	32.4	24.7	9.32	34.0
	Consumed	1.55	0.59	2.14	1.86	0.70	2.56	2.14	0.81	2.95	2.35	0.89	3.24	2.47	0.93	3.40
Self-supplied Domestic	Gross	4.1	---	4.1	4.9	---	4.9	5.7	---	5.7	6.2	---	6.2	6.5	---	6.5
	Consumed	3.5	---	3.5	4.2	---	4.2	4.9	---	4.9	5.3	---	5.3	5.5	---	5.5
Agriculture Irrigation	Gross	1.2	6.4	7.6	4.2	18	22	7.4	26	33	10.3	34	44	13.4	41	54
	Consumed	1.2	6.4	7.6	4.2	18	22	7.4	26	33	10.3	34	44	13.4	41	54
Agriculture Livestock	Gross	0.30	0.22	0.52	0.34	0.25	0.59	0.39	0.29	0.68	0.44	0.33	0.77	0.51	0.37	0.88
	Consumed	0.30	0.22	0.52	0.34	0.25	0.59	0.39	0.29	0.68	0.44	0.33	0.77	0.51	0.37	0.88
Self-supplied Industry	Gross	2.16	79.3	8.15	2.48	91.6	94.1	2.73	101	104	3.01	111	114	3.31	122	125
	Consumed	0.40	42.1	42.5	0.46	48.4	48.9	0.51	52.8	53.3	0.56	58.1	58.7	0.61	63.9	64.5
Thermoelectric Power	Gross	---	730	730	---	752	752	---	774	774	---	798	798	---	822	822
	Consumed	---	5.0	5.0	---	8.25	8.25	---	13.6	13.6	---	22.5	22.5	---	37.1	37.1
Total	Gross	23.2	821	845	30.5	869	899	37.6	909	947	43.5	952	996	44.4	995	1,040
	Consumed	6.95	54.3	61.3	11.1	75.6	86.6	15.3	93.5	109	19.0	116	135	22.5	143	166

Ground-water supplies are much more abundant in the Coastal Plain region than in the Piedmont region of the Pee Dee River Sub-basin. Limited well yields of 15 to 50 gpm in the Piedmont are insufficient to meet present and projected municipal and industrial water use demands. Supplies for rural and suburban domestic needs are sufficiently met throughout the sub-basin by wells utilizing the shallow and intermediate aquifers.

The range of yields for inventoried wells provides a reasonable projection of the average yield for individual wells. These yields range from less than 250 gpm in the Upper Coastal Plain to more than 1,000 gpm in the Middle and Lower Coastal Plain region of the sub-basin. Present total ground-water use (23.3 mgd) can be met by approximately one well per 22 square mile area of sub-basin pumped at a rate of 600 gpm for six hours each day. It would require about 108 such wells to satisfy current demand. The projected requirements for 2020 (48.4 mgd) could be obtained by one well per l0 square mile area of the sub-basin. This demand would require about 224 wells yielding an average of 600 gpm and pumped for six hours each day. Projected ground-water demands in the Coastal Plain part of the sub-basin can be met provided proper hydrogeologic principles are followed in the management of well construction and well spacing.

Figure 31 shows that for 99 percent of the time, the ground-water discharge into the stream equals about 1,000 mgd, or when corrected to the South Carolina portion of the basin (2,350 mi²), about 266 mgd. Since this is estimated to reflect the minimum ground-water contribution to streams, it indicates a potential recharge to the aquifer(s) of about 0.11 mgd per square mile of drainage basin. This constitutes about five times of the calculated ground-water use in the year 2020. But even this is a conservative

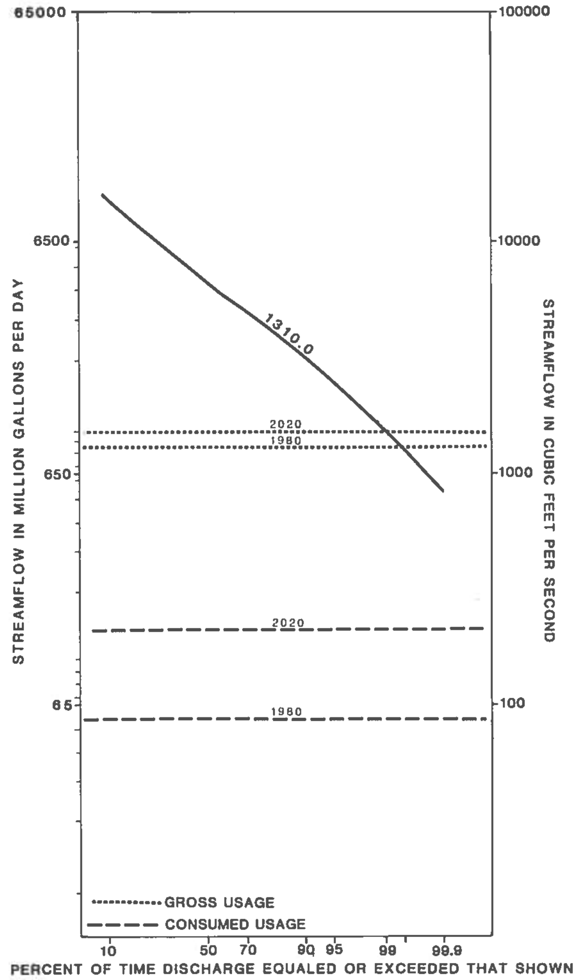


Figure 31.
Water use compared to availability in the Pee Dee River Sub-basin, South Carolina.

estimate and potential ground-water yields may be substantially greater (75 percent) for two reasons. First, the gaging station from which the discharge records were measured is located up basin and thus does not reflect additional ground-water discharge below it. Secondly, the sub-basin is largely underlain by permeable sands and gravels which allow a greater ground-water contribution to streamflow.

Ground-water availability may be limited in certain areas of the sub-basin due to localized problems concerning low aquifer transmissivity and/or heavy pumpage. Heavy pumpage in the Florence Darlington area has reduced the potentiometric head of the Black Creek and Middendorf Aquifer Systems causing some interference between wells. To prevent future reduction of yields in new wells they should be located outside of the present cone of depression. The lower transmissivity of the Black Creek Aquifer System in the southern portion of the sub-basin also represents a problem in that it might cause a reduction in yield for future wells.

Water quality problems may also limit current and projected ground-water use. High iron concentration within the Middendorf Aquifer System in the middle portion of the sub-basin may restrict the use of this water for certain water needs. High concentrations of chloride and fluoride and excessive turbidity in the Black Creek and Middendorf Aquifer Systems near the coast might result in treatment problems for future utilization of this resource.

Ground-water knowledge within the Pee Dee River Sub-basin is limited and the potential for the future development of ground water can be determined only after results of intensive studies identify more precisely the limiting conditions of the aquifer systems.

Major water resource problems and opportunities in the sub-basin are summarized in Table 29.

Table 29.

Major water resource findings in the Pee Dee River Sub-basin, South Carolina.

Opportunities

1. The Pee Dee River is capable of providing large quantities of generally good quality water; projected gross demands can be met 99 percent of the time through 2020.
2. Upper Coastal Plain streams have well-sustained flows year round.
3. Lake Robinson is a potential site for hydroelectric power development.
4. Most wells are currently completed in shallow aquifers; however, high yields from the deeper Middendorf Aquifer System can meet the needs of expanding development.
5. Gravel deposits along the Pee Dee River may provide favorable sites for high yield infiltration wells.

Problems

1. Streamflow in Middle and Lower Coastal Plain streams is not well-sustained year round.
2. Low topographic relief limits major reservoir development.
3. Rapidly increasing surface-water use for agricultural irrigation in Dillon and Marion Counties may result in water use conflicts during low flow periods.
4. Low dissolved oxygen levels occur in some streams during the summer months.
5. Portions of Black Creek experience water quality problems (depressed dissolved oxygen levels, high fecal coliform bacteria and biochemical oxygen demand) due to municipal and industrial wastewater discharges.
6. Recreational use of Swift Creek is impaired due to fecal coliform bacteria contamination from agricultural non-point sources.
7. Lake Robinson experiences high water temperatures and low pH levels; and resident sunfish exhibit mouth and opercular deformities and population declines due to high copper concentrations.
8. Well yields are limited in the Piedmont portion (Chesterfield and Marlboro Counties) and adjacent Coastal Plain portion of the sub-basin.
9. Iron concentrations are high in ground water in the middle portion of the sub-basin (Darlington, Dillon, and Florence Counties).
10. Turbidity, chloride and fluoride in the Black Creek Aquifer System progressively increase downdip toward the coast; chlorides in the Middendorf Aquifer System progressively increase toward the coast.
11. Transmissivity of the Black Creek Aquifer System decreases in the the lower portion of the sub-basin.
12. Heavy ground-water pumping in and around the City of Florence has caused the decline of water levels and the potential exists for similar declines near the City of Darlington.

Lynches River Sub-basin

GENERAL OVERVIEW

The Lynches River Sub-basin is a long, narrow basin transecting the heart of the Pee Dee region of South Carolina. The basin shares a common northern border with North Carolina and encompasses portions of eight South Carolina counties, including Chesterfield, Lancaster, Kershaw, Florence, Lee, Darlington, Sumter, and Williamsburg Counties (Fig. 32). The areal extent of the sub-basin is approximately 1,370 square miles, 4.4 percent of South Carolina's land area.

Population

The 1980 population of the sub-basin was estimated at 83,200, less than three percent of the State's total population (Table 30). By the year 2020, the sub-basin population is expected to exceed 130,000, an increase of 56 percent. The largest increases from 1980 to 2020 are expected in Lancaster (75 percent) and Florence (73 percent) Counties.

The eight counties included in the sub-basin have a predominantly rural population, with the exception of two counties that are classified as being slightly over 50 percent urban. The majority of the urban residents live outside the sub-basin boundary. The major population center within the sub-basin is Lake City (6,739) in Florence County, but the basin boundary is near the urban areas of Florence (30,145) to the south and Lancaster (9,547) to the north.

Economy

In 1979, Florence County had a per capita income of $6,898, slightly below that for the State ($7,056), and ranked 14th out of the 46 counties in South Carolina. The median household income for Florence County was $16,059, also near the State's average ($16,509). Conversely, the per capita income of Lee County was $4,886, ranking 43rd among the counties. The median household income in Lee County was also among the lowest in the State at $10,461.

During 1979, the combined annual average employment of non-agricultural wage and salary workers in Florence and Lee Counties was 44,570. The percentage breakdown by type of employment was: manufacturing, 30 percent; wholesale and retail trade, 22 percent; government, 16 percent; services and mining, 16 percent; construction, 7 percent; transportation and public utilities, 5 percent; and finance, insurance, and real estate, 4 percent.

In the sectors of manufacturing, mining and public utilities, Florence County had an annual product value of $664.3 million during fiscal year 1978-79, and Lee County's annual product value was $80.9 million. Combined, this is less than four percent of the State total ($21,548.4 million).

Agricultural activity is intense in this region of South Carolina. Florence County ranked second in the State in cash receipts from farm marketings in 1979, having a total of nearly $57 million, and Lee County was eighth in cash crop receipts, having $27 million. Of the remaining six counties, three rank in the top ten of reported county cash crop receipts, and three are in the top ten of livestock receipts.

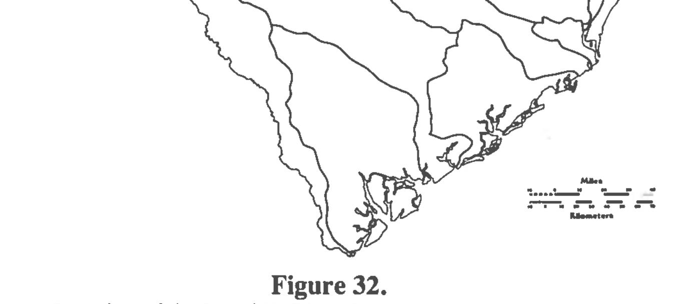


Figure 32.
Location of the Lynches River Sub-basin in South Carolina.

Table 30.
Current and projected population for the Lynches River Sub-basin, South Carolina, 1980-2020.

County	*% Population In Sub-basin*[a]	*Population (in thousands)* 1980	1990	2000	2010	2020	*% Change 1980-2020*
Chesterfield	16.7	6.4	7.3	7.8	8.3	8.5	32.8
Darlington	19.4	12.2	14.4	16.1	17.5	18.2	49.2
Florence	33.7	37.3	46.1	53.9	60.7	64.6	73.2
Kershaw	15.7	6.1	6.9	7.4	7.8	7.9	29.5
Lee	37.5	7.1	7.4	7.5	7.6	7.7	8.5
Sumter	0.3	0.2	0.3	0.3	0.3	0.3	50.0
Williamsburg	7.0	2.7	3.0	3.2	3.3	3.4	25.9
Lancaster	20.8	11.1	13.8	16.2	18.3	19.4	74.8
Totals		83.2	99.2	112.4	123.8	130.1	56.4

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

SURFACE WATER

Hydrology

The Lynches River flows across three physiographic provinces, all of which influence streamflow in both the tributary streams draining these regions and the main river. Headwaters of the Lynches River and the Little Lynches River originate in the lower Piedmont of South Carolina and North Carolina. The dendritic drainage pattern of this river extends through the Upper Coastal Plain but exhibits characteristics of a trellis drainage pattern in the Middle and Lower Coastal Plain Provinces. Three other moderately sized tributary streams in the sub-basin, all in the Lower Coastal Plain, are Bay Swamp, Lake Swamp, and Sparrow Swamp. Most larger stream channels in the Coastal Plain are bordered by swamps, and associated streams break up into braided, indistinct channels.

Streamflow is presently monitored at two gaging stations, one on a Middle Coastal Plain reach of the Lynches River at Effingham and one on Fork Creek at Jefferson in the upper portion of the sub-basin near the Fall Line (Fig. 33). The discontinued Lynches River gage, near Bishopville, was near the boundary of the Upper and Middle Coastal Plain and streamflow reflected the characteristics of the former province. High flows are monitored at four crest-stage stations (1314.6, 1315, 1319.9, 1321) located throughout the sub-basin. No significant streamflow regulation occurs in the sub-basin. Streamflow statistics for the active gages and one inactive gage are presented in Table 31.

Average annual streamflow at gaging stations on the Lynches River varies from 781 cfs near Bishopville to 1,035 cfs at Effingham and does not diverge substantially from these averages throughout the year (Table 31, Fig. 33). Ninety percent of the time, streamflows at these gages equal or exceed 240 cfs and 260 cfs, respectively. Both gages show a drop in discharge from average flow to flow expected 90 percent of the time, but the gage in the Middle Coastal Plain, at Effingham, shows a more marked drop. Typically, Middle and Lower Coastal Plain streams do not have well sustained low flows and have much more variable streamflow than Upper Coastal Plain streams.

Average and above average streamflows in the Lynches River are greatly dependent on direct runoff of rainfall while low flows are well-sustained by discharges from ground-water storage. The steepness of the slope of the flow-duration curves (Fig. 34) and the trend of monthly flows (Fig. 33) illustrate this point. The portion of the flow-duration curve representing flows which occur 70 percent of the time or less is relatively steep. However, the slope of the curve for flows occurring greater than 70 percent of the time flattens out substantially. Well-sustained base flows are also indicated by the relatively constant monthly minimum flows and the narrow range between maximum and minimum flows (Fig. 33).

Because of the influence of the Upper Coastal Plain, the Lynches River near Bishopville exhibits better sustained base flows than farther downstream in the Middle and Lower Coastal Plain regions. This is evidenced by the flow characteristics of the river near Bishopville where the range between monthly maximums and minimums is less than, and the minimum flows greater than those farther downstream at Effingham.

The lowest flows of record on the Lynches River are 125 cfs near Bishopville and 94 cfs at Effingham, and occurred during the 1954 drought. The highest flow of record is 29,400 cfs near Bishopville and was the result of runoff from a tropical storm in September, 1945.

Streamflows in the only gaged tributary stream, Fork Creek, average 29.4 cfs. This creek is located in the Piedmont and Upper Coastal Plain Provinces and probably exhibits a combination of streamflow characteristics of both provinces.

Surface-water availability in the main stem of the Lynches River appears to be reliable. The portion of the river in the Upper Coastal Plain region near Bishopville exhibits especially well-sustained flows due to substantial support from

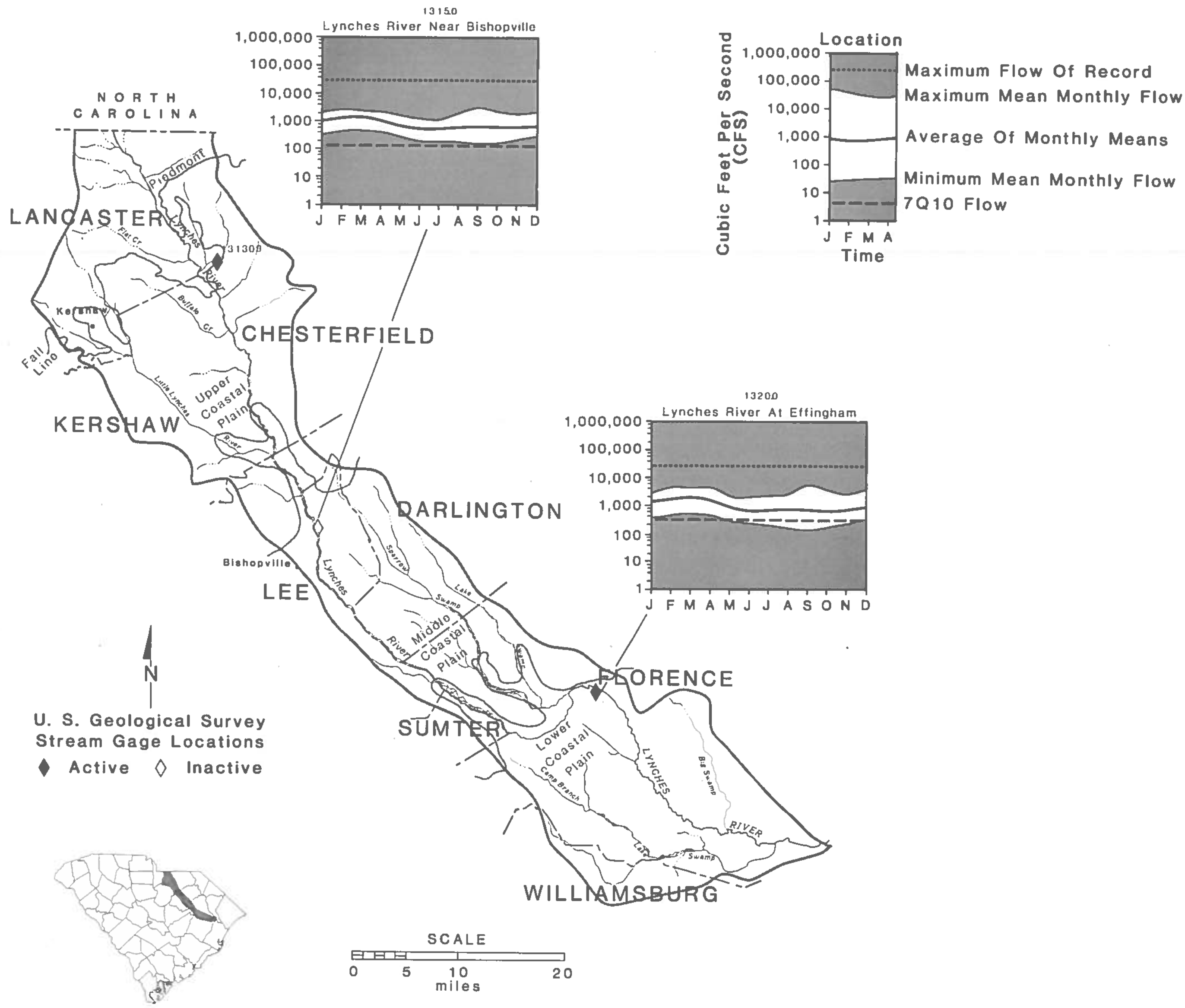


Figure 33.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Lynches River Sub-basin, South Carolina.

Table 31.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Lynches River Sub-basin, South Carolina.

Gaging Station		*Drainage Area*	*Period of Record*		*Average Flow*			*7Q10*[b]	
Number	*Name/Location*	*(mi²)*	*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*90%*[a] *cfs*	*cfs*	*cfs/mi²*
1313.09	Fork Creek at Jefferson	24.3	Oct 1976-Present	4	29.4	1.21	*[e]	*	*
1315	Lynches River at Bishopville	675	May 1942-Aug 1971	29	781	1.16	240	140	0.21
1320	Lynches River at Effingham	1,030	Aug 1929-Present	51	1,035	1.00	260	132	0.13

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] * Indicates statistic not calculated.

ground-water sources. Availability can be expected to be more variable in the upper and lower portions of the river in the Piedmont and Middle and Lower Coastal Plain regions, respectively, due to diminished ground-water influence.

Development

Surface-water development within the Lynches River Sub-basin has been limited and consists of navigation and flood control projects. Figure 35 shows surface-water development in the sub-basin.

There are no major reservoirs within the sub-basin and no potential sites identified for the development of hydropower. The largest lake has a surface area of 150 acres and a volume of 480 acre-feet. The total surface area and volume of all lakes greater than ten acres in size are approximately 1,840 acres and 8,550 acre-feet, respectively. The majority of these lakes are used for recreational purposes; however, some lakes are also used for irrigation.

The U.S Army Corps of Engineers has an active navigation project on the Lynches River from S.C. Highway 41 downstream to Clarks Creek. This project also includes all of Clarks Creek from the Lynches River to the Pee Dee River (Table 32).

The Soil Conservation Service has completed two flood control projects, Hills Creek and Lynches Lake-Camp Branch. The Hills Creek and Lynches Lake-Camp Branch projects included 25.4 miles of channel improvement, one flood water retarding structure, and land treatment practices to reduce erosion and sediment problems. The Soil Conservation Service and the U.S. Army Corps of Engineers have identified other problem areas. These problem areas and projects are listed in Table 33.

Water Quality

The entire main stem of the Lynches River and most tributary streams are designated Class B, suitable for multiple water use activities (Fig. 36). Only a portion of one stream has a Class A water use designation. Water quality limited segments in the sub-basin which require advanced treatment of wastewater effluents include all of Big Swamp, Camp Branch, and Lake Swamp and portions of and/or tributaries to the Lynches River and Sparrow Swamp (Fig. 37). Water quality in the sub-basin is sufficient for designated water use needs.

In general, water quality in the Lynches River is good (S.C. Department of Health and Environmental Control, 1980b). This is evidenced in part by a well-balanced aquatic biological community. Earlier studies indicate the occasional occurrence of contraventions of State standards for dissolved oxygen, fecal coliform bacteria, and pH and elevated levels of biochemical oxygen demand, nutrients, and mercury (S.C. Department of Health and Environmental Control, 1976). Contraventions tended to increase with distance downstream and during the summer months suggesting that primary causes were non-point source pollution and natural conditions.

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge within the sub-basin ranges from the field data level in the northwestern region to the evaluation level in the southeastern region (Fig. 18).

Most of the Lynches River Sub-basin lies within the Coastal Plain Province of South Carolina. Only the northern portion of the sub-basin lies within the Piedmont Province. Almost all of Lancaster County and a portion of Chesterfield County lie within the Carolina slate belt of the Piedmont Province where ground water occurs in fractures and along bedding and cleavage planes of the rocks or in the mantle of overlying weathered rock (saprolite). Due to the conditions of ground-water occurrence in crystalline rock aquifers, it is not unusual to have wells with high yields in close proximity to "dry holes".

The southern part of Lancaster County and the northern half of Kershaw County are underlain by crystalline rock, specifically a coarse-grained granite. Available records on wells in the area are limited, and extrapolation of these data to indicate approximate area well yields is difficult because of the heterogeneity of the ground-water occurrence in crystalline rocks. Selected ground-water data for the sub-basin are presented in Table 34.

The southern portion of the sub-basin is underlain by sediments that range in age from late Cretaceous to Holocene. The top of Middendorf Aquifer System occurs at 250

Table 31 (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
0.44	Sep 17, 1980	1,560	Feb 24, 1979
125	Sep 16, Oct 8, 1954 Sep 21, 1956	29,400	Sep 19, 1945
94	Oct 10, 1954	25,000	Sep 22, 1945

feet below mean sea level in the vicinity of Lynchburg and 440 feet below mean sea level at Lake City. An 800 foot test hole near Lynchburg did not penetrate the entire aquifer system. Well yields up to and possibly exceeding 500 gpm can be expected in this area. Values for transmissivity range from 900 to 9,000 ft^2/day, and hydraulic conductivity is about 19 ft/day (Park, 1980).

The top of the Black Creek Aquifer System is about 50 feet above mean sea level at Lynchburg and 100 feet below mean sea level at Lake City. The thickness of the aquifer increases from about 300 feet to 370 feet between the two sites. Wells with 8 and 10 inch diameters in Florence County yield 250 to 500 gpm with specific capacities of 10 gpm/ft or less. The transmissivity of the Black Creek Aquifer System in Pamplico is estimated at 3,100 ft^2/day. Hydraulic conductivity values in eastern Florence County are within the range of 10 to 50 ft/day.

The Peedee Aquifer System underlies the southeastern part of the Lynches River Sub-basin. Its thickness is estimated to range from 20 feet in Lynchburg to 130 feet in the Lake City area. The aquifer probably yields sufficient water to supply domestic and light industrial needs, with specific capacities of less than 5 gpm/ft.

Because the Black Mingo Aquifer System is at a shallow depth, it has not been differentiated from the Shallow Aquifer System composed of the Duplin Formation and terrace deposits. Specific water-bearing characteristics of this aquifer are unknown in the Lynches River Sub-basin although general well data indicate that yields are sufficient for domestic or light industrial purposes.

Water Quality

Ground water in the Carolina slate belt rocks of the Piedmont Province within the Lynches River Sub-basin is generally soft with low total dissolved solids, iron, and pH. The Stiff Diagrams in Figure 38 show a calcium bicarbonate type water. The Middendorf and the Black Creek are the two most utilized aquifer systems. Ground water in the Middendorf is soft with low total dissolved solids but locally high in dissolved iron. The pH ranges from 5.0 to 7.2. The Stiff Diagrams in Figure 38 show the water quality for this aquifer ranging from a sodium chloride to a calcium bicarbonate type. The ground water in the Black Creek

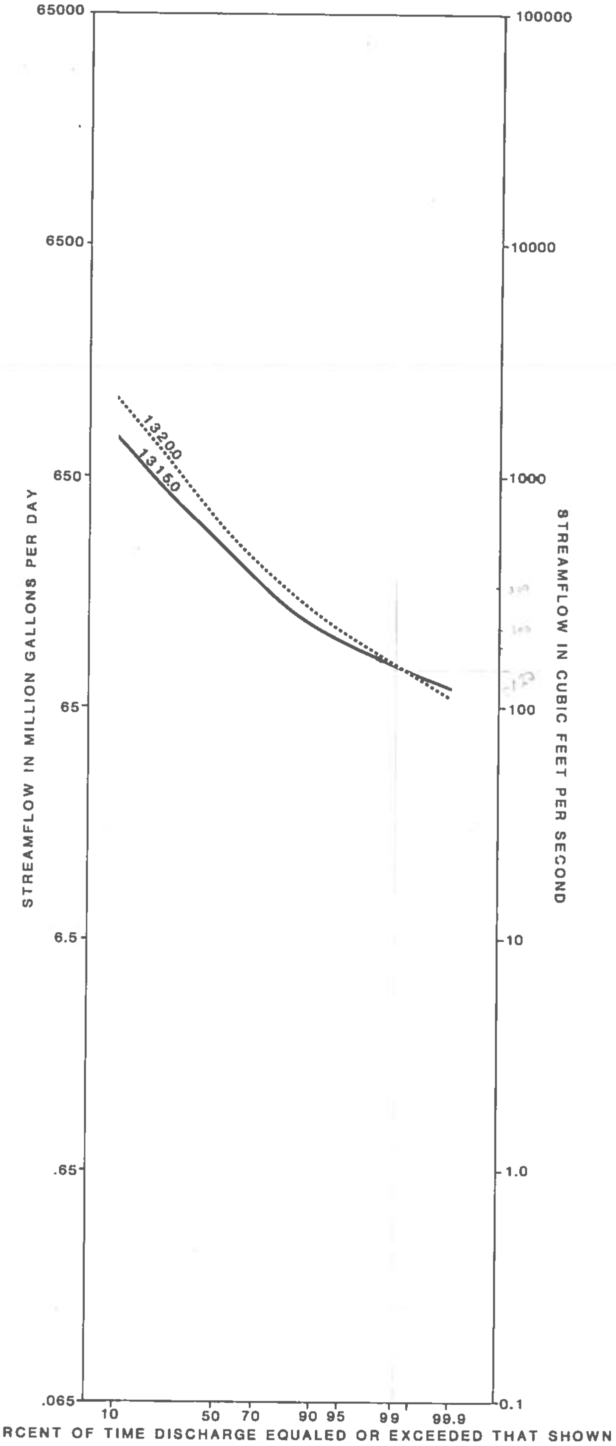


Figure 34.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Lynches River Sub-basin, South Carolina.

Table 32.
U.S. Army Corps of Engineers navigation projects in the Lynches River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
1	Lynches River and Clarks Creek	Florence	Charleston	5.6	50	Project consisted of clearing a channel in Clark Creek to afford outlet for Lynches River. Complete abandonment recommended in 1926. Re-activated in 1979 to Hwy. 41.

Source: U.S. Army Corps of Engineers, 1982b.

Table 33.
Flood control projects in the Lynches River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
2	Hills Creek	Chesterfield	SCS	Project completed 1966
3	Lynches River Basin	Florence Williamsburg Sumter Lee Darlington Chesterfield Lancaster Kershaw	COE	Presently inactive study awaiting funding
4	Salem Community	Florence	SCS	Planning underway
5	Carter Creek	Florence	SCS	Recommended Study[b]
6	Lynches Lake-Camp Branch	Florence	SCS	Completed 1971
7	Little Lynches Creek	Lancaster/Kershaw	SCS	Under construction

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.
[b] Non-sponsored study recommended by SCS.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

Table 34.
Selected ground-water data for the Lynches River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Jefferson	Carolina slate belt	150-420	0-50	--a
Kershaw	Coarse granite	115-281	20-110	--
Bethune	Middendorf	135-230	90-377	--
Olanta	Black Creek	175-220	300	--
Lake City	Black Creek/Middendorf	160-560	750	--

[a]--indicates data not readily available.

Figure 35.
Surface-water development in the Lynches River Sub-basin, South Carolina.

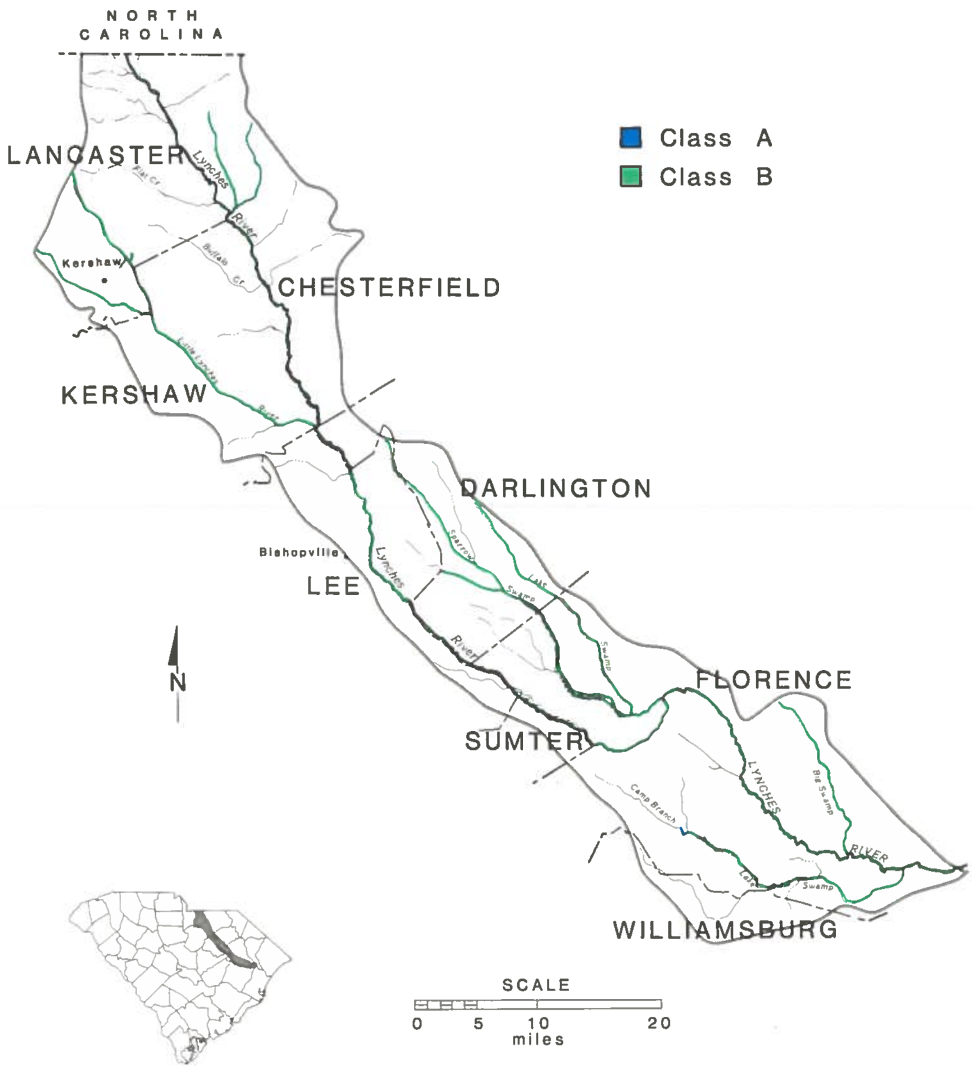


Figure 36.
Surface-water quality classifications in the Lynches River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

Aquifer System is also soft, has a low pH, and low concentrations of dissolved solids. Locally, iron exceeds acceptable water quality standards. The Stiff Diagram in Figure 38 shows a sodium chloride type of water.

WATER USE

Total gross water use in the Lynches Sub-basin is approximately 16.9 mgd with 6.92 mgd lost due to consumption (Table 35). The leading gross water user groups are self-supplied industry (6.41 mgd), public supply (4.60 mgd), and self-supplied domestic (4.2 mgd). Major water users by type and supply source are shown in Figure 39. Water users in this sub-basin rely most heavily on surface-water sources (71 percent) to supply this demand. Ground water supplies the remainder of the total gross water demand. Gross use of the sub-basin's water resources is fairly evenly distributed among user groups, while most consumptive use is due to agricultural irrigation and self-supplied domestic withdrawals.

Public supply comprises 27 percent of the total gross use and about seven percent of consumptive use. Ground-water sources are utilized to meet 54 percent of gross use with the rest drawn from surface-water supplies. The upper Piedmont portion of the sub-basin relies more heavily on surface-water sources for public supply needs than the lower portion of the sub-basin.

Self-supplied domestic use accounts for 25 percent of the sub-basin's gross water demand. This user group is the sub-basin's largest consumer accounting for 52 percent of total consumptive use. Water for self-supplied domestic supplies is drawn exclusively from ground-water sources. This group

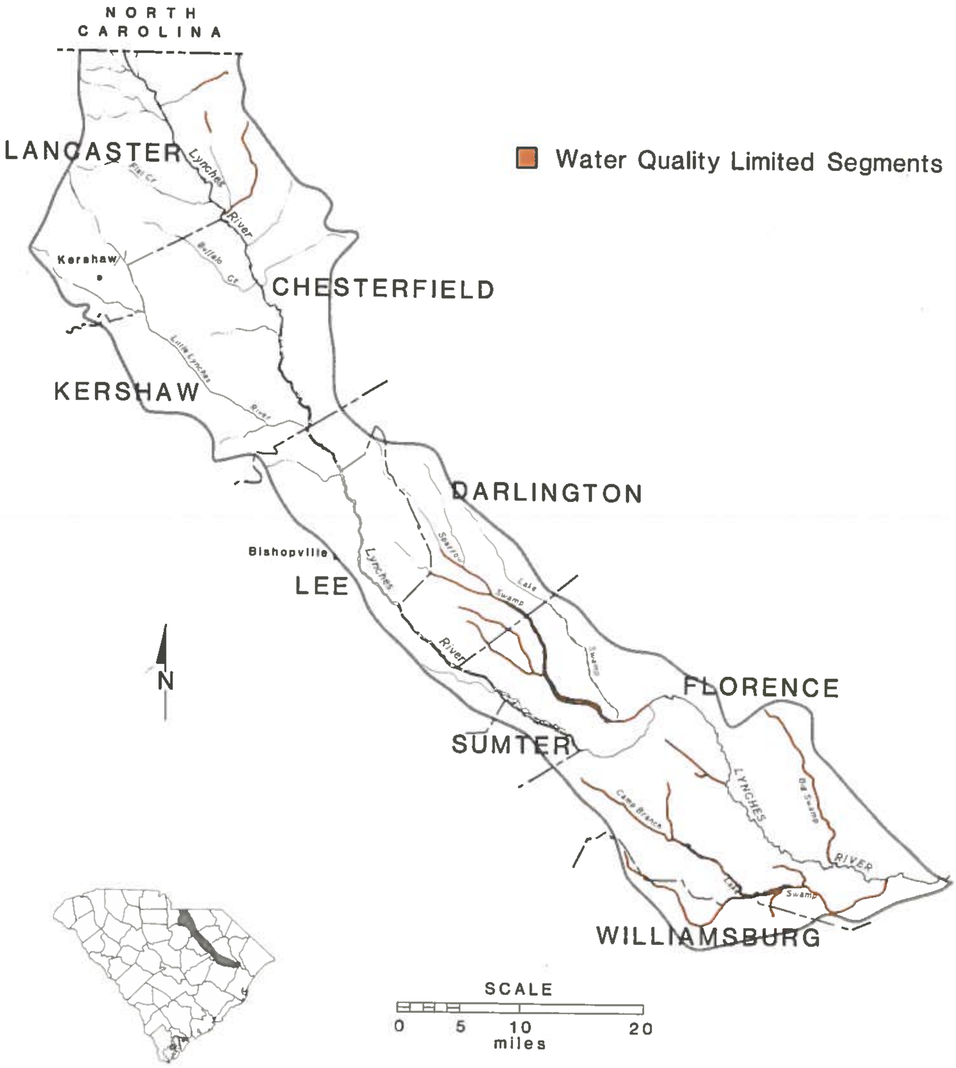


Figure 37.
Water quality limited segments in the Lynches River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

is one of the largest ground-water users requiring 4.2 mgd, equal to 35 percent of all sub-basin ground-water use.

Agricultural activities account for 10 percent of the total gross use in the Lynches River Sub-basin. Most of this use (85 percent) is for irrigation of about 1,900 acres. Irrigation demand represents eight percent of the sub-basin's total gross water demand. This use also accounts for about 21 percent of the sub-basin consumptive use. Most irrigated acreage is in the upper portion of the sub-basin and is supplied primarily (84 percent) from surface-water sources. Irrigation water use averaged over the five-month growing season equals 3.5 mgd comprising 18 percent of total gross use and 39 percent of consumptive use. Water for livestock needs accounts for two percent of gross water demand and is supplied primarily (68 percent) from ground-water sources.

Self-supplied industry is the largest gross water user in the sub-basin. Thirty-eight percent of gross use and 17 percent of consumptive use is by this group. This user category is also the largest ground-water user accounting for 29 percent of all ground-water withdrawals to meet a demand of almost 4.89 mgd. Self-supplied industry withdraws about 76 percent from ground-water and 24 percent from surface-water sources.

Presently no thermoelectric power is generated in the Lynches River Sub-basin.

Gross water use is projected to increase over 105 percent to 34.6 mgd by 2020. Total consumptive use is expected to increase by 175 percent to 19.0 mgd by the year 2020. Agricultural irrigation is projected to show the largest gross water use increase by quantity and percent with 8.9 mgd and 620 percent, respectively. It is anticipated that agricultural irrigation will be the largest gross water user in 2020.

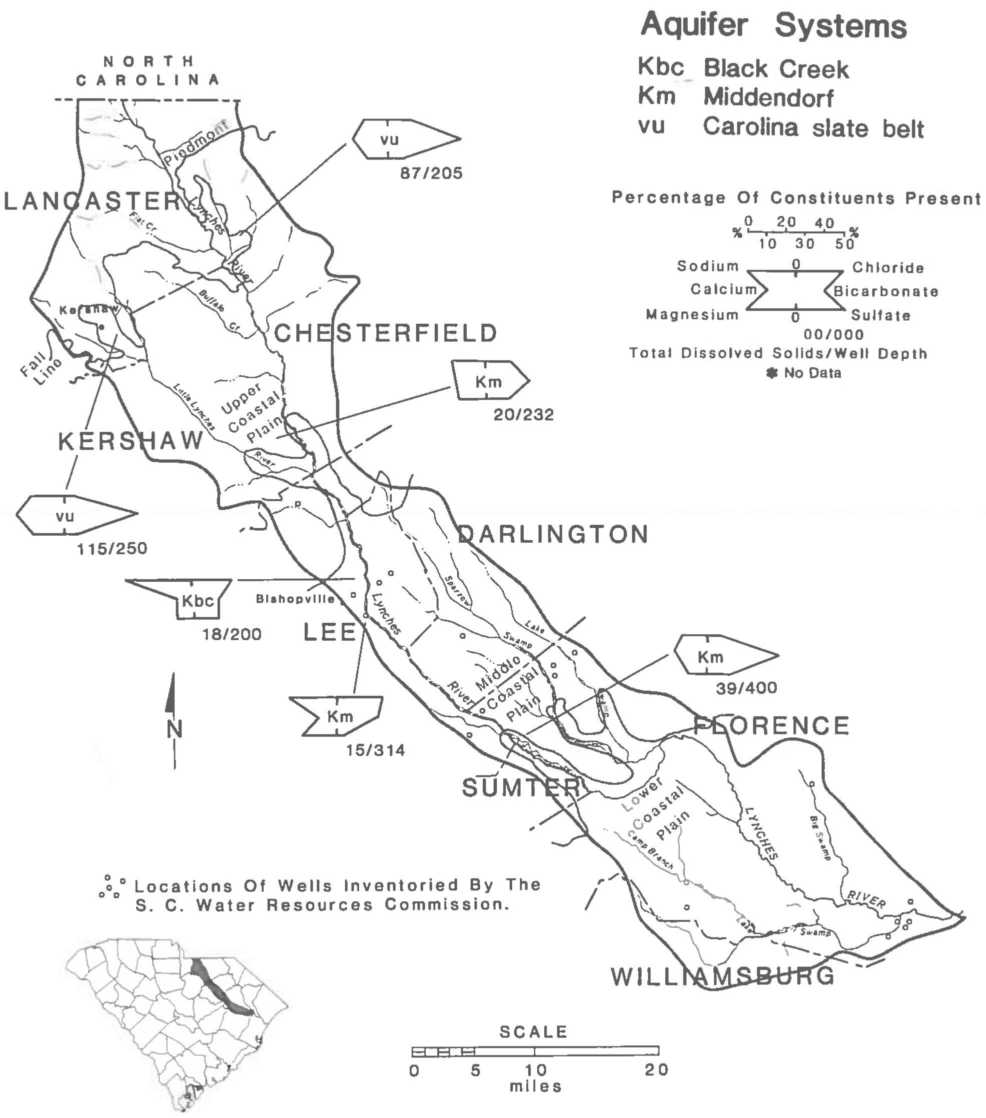


Figure 38.
Ground-water quality of selected aquifer systems and major inventoried wells in the Lynches River Sub-basin, South Carolina.

Although the use of ground water should decrease by 2020, it should continue to be a major supply source for the sub-basin.

WATER USE VERSUS AVAILABILITY

The current 4.94 mgd of gross surface-water demand as well as the 1.77 mgd consumptive surface-water demand are adequately supplied by streamflow (Fig. 40). Most of this use takes place in the upper portion of the sub-basin but flow is still adequate. Projected 2020 gross surface-water use of 13.6 mgd and consumptive surface-water use of 8.61 mgd should also be adequately met. However, small tributary water supply development in the poorly sustained Lower Coastal Plain Province should include site specific hydrologic analysis to determine the quantity of streamflow available, particularly during periods of low rainfall.

Ground-water availability in the Piedmont region of the Lynches River Sub-basin may be limited in some categories of use because well yields are insufficient to meet present and projected large municipal, industrial, and irrigation water use demands.

In the Coastal Plain portion of the Lynches River Sub-basin, wells yield from less than 250 gpm in the Upper Coastal Plain to more than 1,000 gpm in the Middle Coastal Plain. Present and projected ground-water demands in the Coastal Plain can be met where proper well construction, well spacing, and hydrogeologic principles are utilized.

Current ground-water demand (12.0 mgd) can be supplied by approximately one well per 24 square mile area of the sub-basin pumped at a rate 600 gpm for six hours each

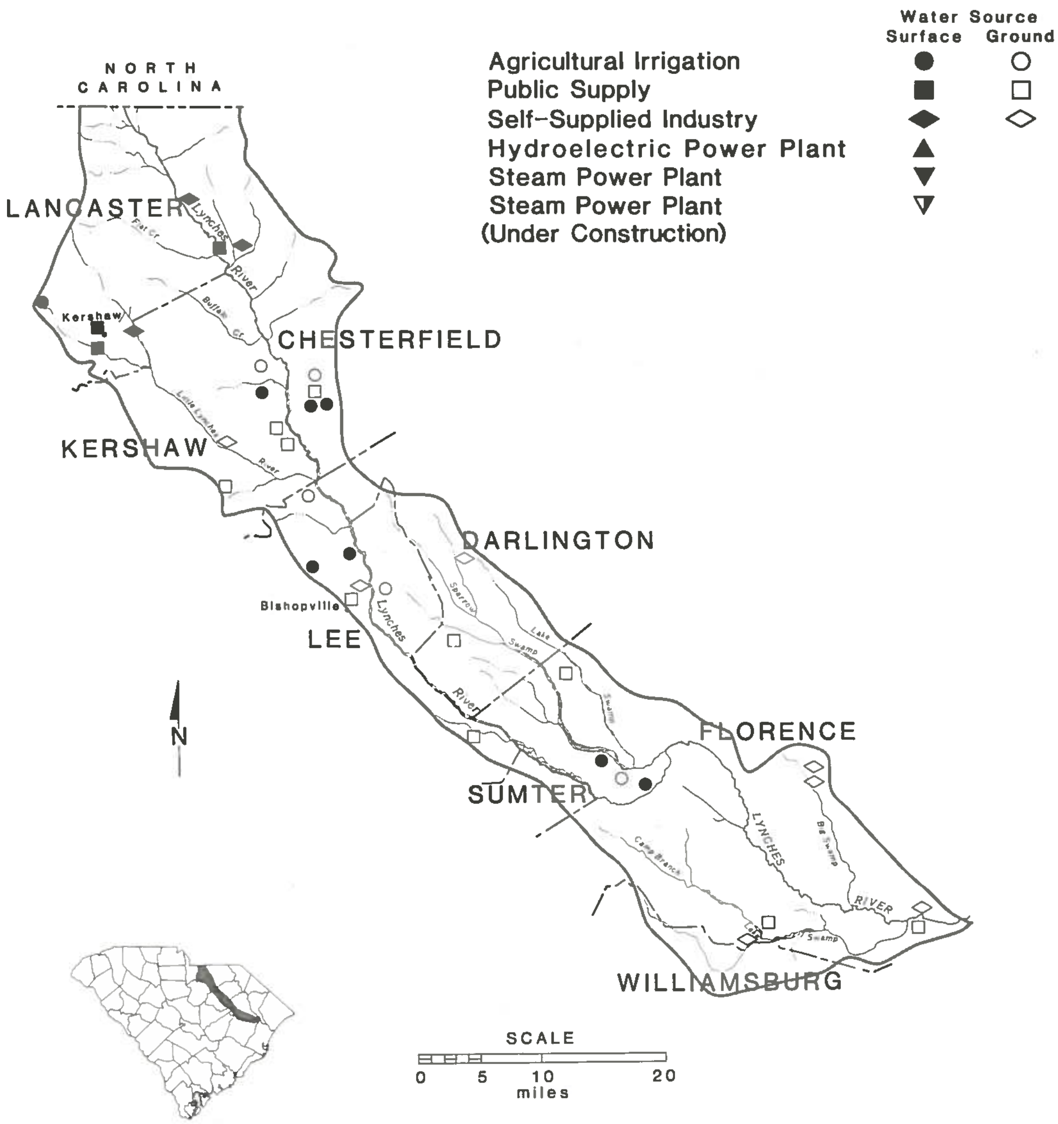


Figure 39.
Location, type, and supply source of water users in the Lynches River Sub-basin, South Carolina.

Table 35.
Current and projected water use in the Lynches River Sub-basin, South Carolina, 1980 - 2020

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water
Public Supply	Gross	2.46	2.14	4.60	2.95	2.57	5.52	3.39	2.95	6.34	3.73	3.25	6.98	3.92	3.41	7.33
	Consumed	0.25	0.21	0.46	0.30	0.26	0.56	0.34	0.30	0.64	0.37	0.33	0.70	0.39	0.34	0.73
Self-supplied Domestic	Gross	4.2	---	4.2	5.0	---	5.0	5.8	---	5.8	6.4	---	6.4	6.7	---	6.7
	Consumed	3.6	---	3.6	4.3	---	4.3	4.9	---	4.9	5.4	--	5.4	5.7	---	5.7
Agriculture Irrigation	Gross	0.23	1.2	1.4	0.81	3.3	4.1	1.4	5.0	6.4	2.0	6.4	8.4	2.6	7.7	10
	Consumed	0.23	1.2	1.4	0.81	3.3	4.1	1.4	5.0	6.4	2.0	6.4	8.4	2.6	7.7	10
Agriculture Livestock	Gross	0.17	0.08	0.25	0.19	0.09	0.28	0.22	0.10	0.32	0.25	0.12	0.37	0.29	0.14	0.43
	Consumed	0.17	0.08	0.25	0.19	0.09	0.28	0.22	0.10	0.32	0.25	0.12	0.37	0.29	0.14	0.43
Self-supplied Industry	Gross	4.89	1.52	6.41	5.62	1.75	7.37	6.19	1.92	8.11	6.80	2.12	8.92	7.48	2.33	9.81
	Consumed	0.90	0.28	1.18	1.04	0.32	1.3	1.15	0.36	1.51	1.26	0.39	1.65	1.38	0.43	1.81
Thermoelectric Power	Gross	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Consumed	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	Gross	12.0	4.94	16.9	14.57	7.71	22.3	17.0	9.97	27.0	19.2	11.9	31.1	21.0	13.6	34.6
	Consumed	5.15	1.77	6.92	6.64	3.97	10.6	8.01	5.76	13.8	9.28	7.24	16.5	10.4	8.6	19.0

day. This would require about 56 total wells in the sub-basin. The projected demand (21.0 mgd) could be met by one well per 14 square mile area of the sub-basin or about 97 total wells yielding an average of 600 gpm and pumped six hours each day.

The projected growth of irrigation use by as much as sixfold by 2020 can put serious stress on the more productive aquifers. This can have a detrimental effect on the normal potentiometric head distributions within or between aquifers, especially when wells are screened from top to bottom. It would also result in interaquifer leakage and as a consequence, may lower the artesian head, yield, and water quality of all wells tapping these aquifers.

Some ground-water quality problems may limit local availability in some areas of the sub-basin. High iron concentrations, particularly in Florence County, may restrict the use of this water for certain needs. Turbidity in the Black Creek Aquifer System in the lower portion of the sub-basin might cause treatment problems for future utilization of this region.

The present extent of ground-water knowledge within the Lynches River Sub-basin is thus considered limited and the potential for future development will depend in a large measure on additional knowledge obtained as a result of intensive ground-water studies.

Major water resource problems and opportunities in the sub-basin are summarized in Table 36.

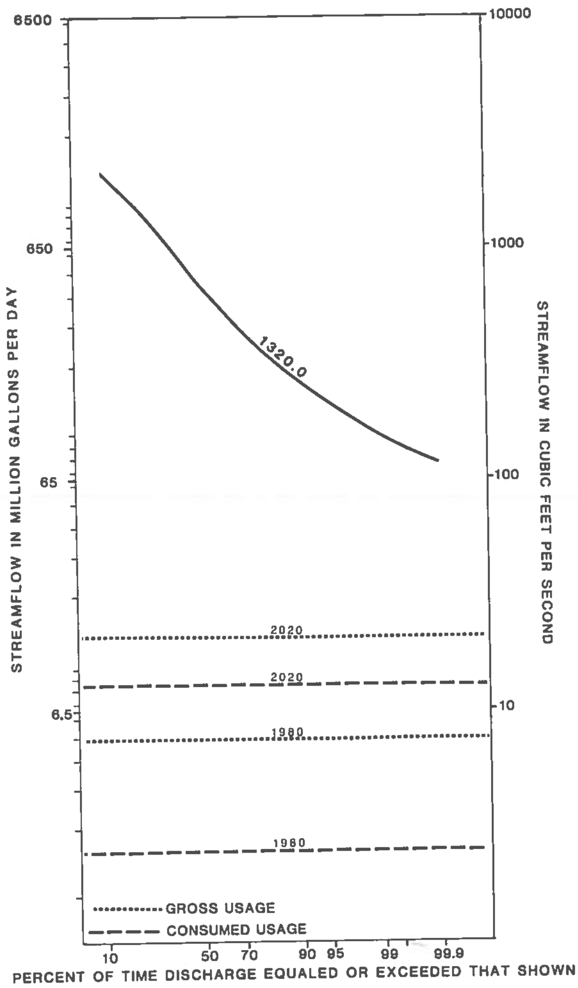


Figure 40.
Water use compared to availability in the Lynches River Sub-basin, South Carolina.

Table 36.
Major water resource findings in the Lynches River Sub-basin, South Carolina.

Opportunities

1. Streamflow in Upper Coastal Plain streams is well-sustained and reliable year round; in general, adequate water is available to meet all projected demands through 2020.
2. Most surface-water development occurs in the Upper Coastal Plain region of the sub-basin where surface-water supplies are adequate for current and projected use needs.
3. Completion of the Little Lynches Creek flood control project should control flooding and provide additional water supply.
4. Resumption of the Lynches River-Clark Creek navigation project should enhance navigation in the project area.
5. The Lynches River is a source of generally good quality water.
6. Yields up to 1,000 gpm can be expected from wells constructed in the Middendorf Aquifer System; this source should be able to supply projected ground-water demands for 2020.
7. The Lynches River floodplain in Kershaw County provides a potentially good site for infiltration wells yielding several hundred gallons per minute.

Problems

1. Piedmont and Lower Coastal Plain streams are characterized by poorly sustained flows year round; site specific hydrologic analysis should be undertaken prior to tributary water supply development.
2. Well yields are generally small in the Piedmont portion of the sub-basin.
3. Dissolved iron concentrations in ground-water, particularly in Florence County, exceed acceptable drinking water standards.
4. High turbidity levels due to dispersed aragonite occur in some wells tapping the Black Creek Aquifer System in the lower portion of the sub-basin.
5. Projected large ground-water use for agricultural irrigation may strain currently productive aquifer systems and cause water level declines.

Little Pee Dee River Sub-basin

GENERAL OVERVIEW

The Little Pee Dee River Sub-basin is located in the northeast portion of the Pee Dee region of South Carolina. This sub-basin shares a common border with North Carolina, and encompasses portions of four South Carolina counties, including Dillon, Marion, Horry and Marlboro Counties (Fig. 41). The areal extent of the sub-basin is approximately 1,100 square miles, 3.5 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 77,600, less than three percent of the State's total population (Table 37). The sub-basin population is expected to reach almost 128,000 by the year 2020, an increase of 65 percent. The largest increases from 1980 to 2020 are expected in the sub-basin population in Horry (142 percent) and Marlboro (48 percent) Counties.

All four counties included in the sub-basin have predominately rural populations, with Dillon County being classified as over 77 percent rural. Although Horry County is 65 percent rural, it exhibited the largest increase in the urban population from 1970 to 1980, with a 71 percent change. However, most of this change occurred outside of the sub-basin boundary. The major centers of population within the sub-basin are Dillon (7,065) in Dillon County and Mullins (6,038) in Marion County. The sub-basin boundary is near the urban areas of Conway (10,219) and Bennettsville (8,841).

Economy

All of the four counties in the sub-basin had a 1979 per capita personal income below that for the State ($7,056). Horry County was closest, with a per capita income of $6,929, ranking 13th among the 46 counties. Dillon County ranked 42nd, with a per capita income of $4,989. The 1980 median household income ranged from $13,687 in Horry County to $11,725 in Marion County, all less than the State average of $16,509.

In 1979, the annual average employment of non-agricultural wage and salary workers in Dillon, Horry, and Marion Counties totaled 57,790. The percentage breakdown of employment was: manufacturing, 27 percent; wholesale and retail trade, 25 percent; services and mining, 21 percent; government, 16 percent; construction, 5 percent; finance, insurance, and real estate, 4 percent; and transportation and public utilities, less than 3 percent.

In the sectors of manufacturing, mining and public utilities, the combined annual product value during fiscal year 1978-79 was $669.6 million, three percent of the State's total.

Agricultural productivity is high in this portion of the State. Horry County ranked first in the State in cash crop receipts from farm marketings in 1979, with a total of $63 million, over nine percent of the State's total. Dillon and Marion Counties also ranked in the top ten of reported cash crop receipts.

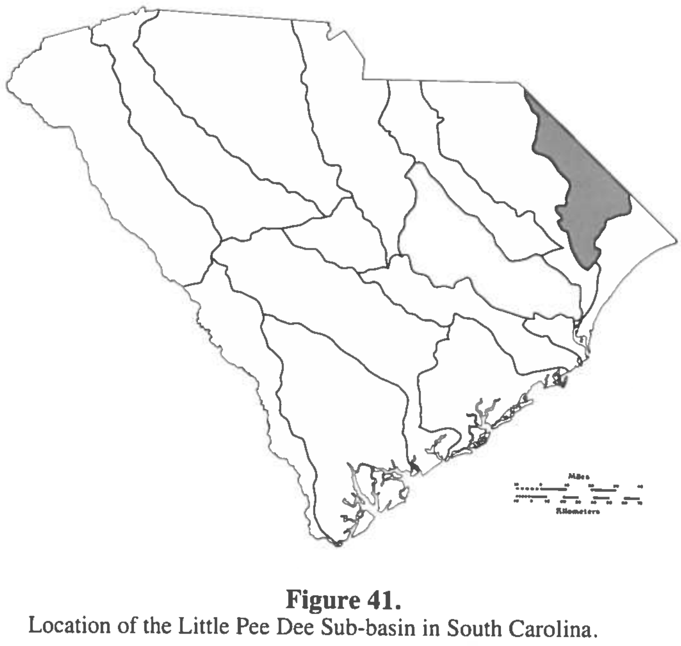


Figure 41.
Location of the Little Pee Dee Sub-basin in South Carolina.

Table 37.
Current and projected population for the Little Pee Dee River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands) 1980	1990	2000	2010	2020	% Change 1980-2020
Dillon	91.1	28.4	30.8	32.0	33.0	33.5	18.0
Horry	25.2	25.8	35.2	45.7	56.0	62.3	141.5
Marion	50.0	17.1	19.5	20.7	22.0	22.5	31.6
Marlboro	20.1	6.3	7.4	8.2	8.9	9.3	47.6
Total		77.6	92.9	106.6	119.9	127.6	64.4

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

SURFACE WATER

Hydrology

The two major watercourses in this sub-basin are the Little Pee Dee River and, a major tributary, the Lumber River. Headwaters for both streams occur in the Sandhill region of North Carolina. Several small to moderately sized tributary streams drain the sub-basin, including Buck Swamp, Bear Swamp, and Lake Swamp. Typical of many Coastal Plain streams, extensive swamplands are associated with much of the main stem river and tributary streams resulting in meandering and often ill-defined stream channels. A 52-mile segment of the Little Pee Dee River, from the confluence with the Lumber River to the confluence with the Pee Dee River, has been determined eligible for the State Scenic Rivers Program.

Streamflow is currently monitored at only one site, Galivants Ferry, on the Little Pee Dee River (Fig. 42). A discontinued streamflow gaging station on the Little Pee Dee River near Dillon presently monitors only crest-stage data. The Lumber River is monitored near Broadman, North Carolina. Streamflow statistics for the three gage sites are presented in Table 38.

Average daily streamflow on the Little Pee Dee River is 577 cfs near Dillon, above the confluence with the Lumber River, and 3,243 cfs at Galivants Ferry, below the confluence. Ninety percent of the time, streamflow at these sites can be expected to equal or exceed 155 cfs and 700 cfs, respectively.

At both sites streamflow characteristics are similar and suggest somewhat variable and potentially limited surface-water availability. The unit average discharges at both gages are nearly equal (Table 38) and similar to the regional unit average discharge. The unit 7Q10 streamflows are identical (0.11 cfs/mi^2) and are relatively low. The moderately sloped flow-duration curves (Fig. 43) and variable mean monthly flows (Fig. 42) indicate that flows are mainly dependent on rainfall and direct runoff with lower streamflows partially supplemented by base flow from ground-water storage. The moderate range between maximum and minimum monthly flows (Fig. 42) suggest some degree of flow variability, especially during the late summer and early fall months. The two lowest flows of record are 24 cfs near Dillon and 155 cfs at Galivants Ferry, both occurred during the drought of 1954. The flood flow of record occurred in 1964 at Galivants Ferry (27,600 cfs) due to runoff from tropical storm Hilda which produced localized flooding.

Streamflow in the Little Pee Dee River is fairly reliable, however, surface-water storage would be needed to ensure adequate water supplies during periodic low-flow conditions. The similarity of streamflow characteristics at the main stem gaging stations suggests similar characteristics for tributary streams in the same physiographic province in the sub-basin.

Development

Surface-water development in the Little Pee Dee River Sub-basin has not been very extensive. Existing development consists of navigation and flood control projects (Fig. 44).

There are no large reservoirs or lakes within the sub-basin. Pages Mill Pond with a surface area of 200 acres and a volume of 640 acre-feet is the largest body of water (Table 39). The total surface area of all lakes larger than ten acres in size is 1,310 acres and the total volume is approximately 4,290 acre-feet.

No potential hydropower sites have been identified in the Little Pee Dee River Sub-basin by the U.S. Army Corps of Engineers; however one potential small scale hydropower site with a potential generating capacity of 0.2 MW has been identified by S.C. Land Resources Conservation Commission (Long, 1980).

There are no active U.S. Army Corps of Engineers navigation projects in the sub-basin (Table 40).

In 1969, the Maple Swamp flood control project, involving 9.8 miles of channel work was completed by the Soil Conservation Service with assistance from local sponsors. Several other problem areas have been identified by both the Soil Conservation Service and the U.S. Army Corps of Engineers. The U.S. Army Corps of Engineers is in the reconnaisance phase of a comprehensive study of the Little Pee Dee River identifying primarily flooding and navigation problems. All flood control projects and studies are presented in Table 41.

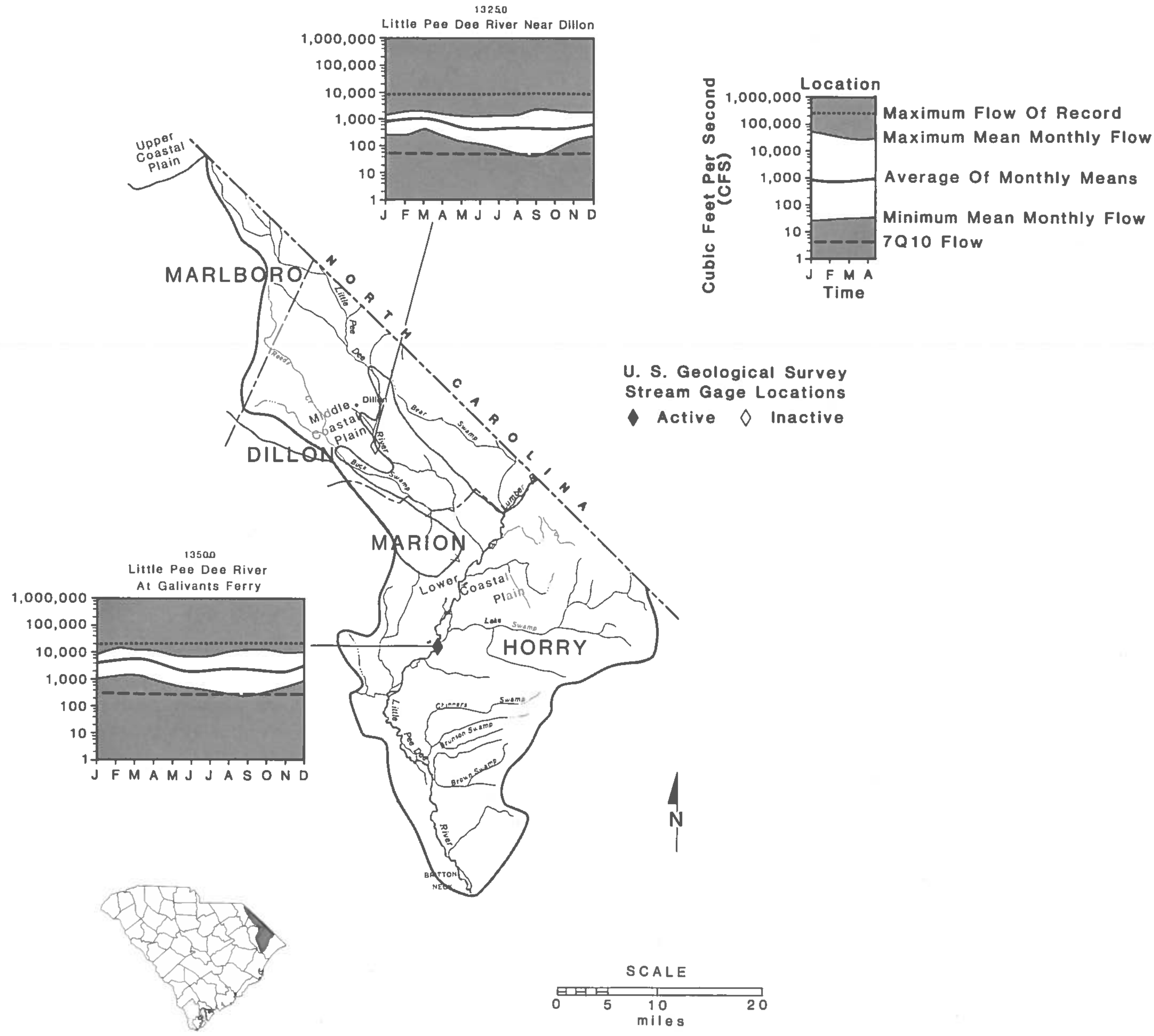


Figure 42.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Little Pee Dee River Subbasin, South Carolina.

Table 38.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Little Pee Dee River Sub-basin, South Carolina.

Gaging Station		Drainage Area	Period of Record		Average Flow				
Number	Name/Location	(mi²)	Dates	Total Years	cfs	cfs/mi²	90%[a] cfs	7Q10[b] cfs	7Q10[b] cfs/mi²
1325	Little Pee Dee near Dillon	524	March 1939-Sep 1971	32	577	1.10	155	57	0.11
1345	Lumber River at Boardman, N.C.	1,228	Sep 1929-Present	51	1,343	1.09	306	149	0.12
1350	Little Pee Dee River at Galivants Ferry	2,790	Oct 1943-Present	39	3,243	1.16	700	315	0.11

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record
[d] Instantaneous maximum flow per period of record.

Water Quality

The entire portion of the Lumber River in South Carolina, Bear Swamp, and most of the Little Pee Dee River are designated Class A water bodies (Fig. 45). A portion of the Little Pee Dee River and some tributary streams are designated Class B. Water quality limited segments requiring advanced treatment of wastewater discharges include a small portion of the Little Pee Dee River and some tributary streams (Fig. 46). Water quality in this sub-basin is generally suitable for most water use needs. Widespread occurrences of low dissolved oxygen and pH levels and relatively high concentrations of fecal coliform bacteria, biochemical oxygen demand, and nutrients are due to impacts from natural swampland drainage and non-point source runoff.

The Little Pee Dee River has generally good water quality although a slight trend of decreasing quality due to problem levels of pH and dissolved oxygen is evident (S.C. Department of Health and Environmental Control, 1980b). Earlier investigations indicate occasional contraventions of State standards for dissolved oxygen, fecal coliform bacteria, and pH and elevated levels of nutrients and biochemical oxygen demand (S.C. Department of Health and Environmental Control, 1976). These problem conditions are widespread and occur primarily during the summer months and in the lower portion of the river. Drainage of low quality swamp water and non-point source runoff are the primary causes of these problem conditions.

A well balanced biological community in the Lumber River indicates good water quality conditions (S.C. Department of Health and Environmental Control, 1980b). Occasional water quality problems in this river include contraventions of dissolved oxygen and fecal coliform bacteria standards and high levels of mercury, nutrients, and suspended solids (S.C. Department of Health and Environmental Control, 1976). These problem conditions occur more frequently during the summer months and are attributed mainly to natural conditions and non-point source pollution.

Elevated concentrations of fecal coliform bacteria impair recreational use in Sweet Swamp in Dillon County (S.C. Department of Health and Environmental Control, 1981c). This water quality problem, in addition to excessive toxaphene concentrations in sediments in Reedy Creek, are attributed to agricultural non-point source pollution.

GROUND WATER

Hydrogeology

The level of the ground-water knowledge throughout the sub-basin ranges from the field data level in the northwestern region, where little data are available, to the evaluation level in the southeastern region, where major aquifer systems have been identified (Fig. 18).

The Little Pee Dee River Sub-basin lies entirely within the Coastal Plain Province. The northwestern part of the sub-basin obtains much of its ground-water supply from the Middendorf and Black Creek Aquifer Systems. Whereas ground-water records are limited, these data indicate that this part of the sub-basin is underlain by approximately 500 feet of unconsolidated sediments, mostly of the Middendorf and Black Creek Formations. Selected ground-water data for the sub-basin are presented in Table 42.

The southeastern portion of the sub-basin is underlain by up to 1,500 feet of sediments, predominately of the Middendorf, Black Creek and Peedee Formations. The Black Creek Aquifer System is used almost exclusively as the ground-water supply for large-capacity wells. In this area the Middendorf is rather deep and increasingly mineralized. The Peedee is generally not a good aquifer, and with the exception of one well in Loris, there are no large-capacity wells in this aquifer system.

Water Quality

The ground water in the Middendorf Aquifer System is generally soft with low concentrations of total dissolved solids and locally high concentrations of iron. Total dissolved solids tend to increase toward the coast. The Stiff Diagram in Figure 47 reflects a sodium chloride type of

Table 38 (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
24.0	Sep 17, 23, 1954	9,810	Sep 20, 1945
66.0	Oct 9, 1968	13,400	Sep 24, 1945
155.0	Oct 12, 13, 1954	27,600	Oct 9, 10, 1964

water for this aquifer. Water in the Black Creek Aquifer System locally contains high concentrations of total dissolved solids and fluoride. The Stiff Diagrams in Figure 47 indicate a predominant sodium bicarbonate type water quality. The Peedee Aquifer System exhibits elevated chloride levels in the vicinity of Loris, causing the town to seek deeper, fresher Black Creek Aquifer water in subsequent drilling efforts.

WATER USE

Gross water demand in the Little Pee Dee Sub-basin is 10.3 mgd (Table 43). This sub-basin has the least amount of water use of all sub-basins in the State. Self-supplied domestic use (3.50 mgd), public supply (3.36 mgd), and agricultural irrigation (2.4 mgd) are the leading gross water users. Major water users by type and source are shown in Figure 48. Consumptive use in the sub-basin is currently 6.09 mgd. Ground water is the major source of water in the sub-basin supplying about 78 percent of demand. Agricultural irrigation is the only use dependent primarily on surface water (93 percent). The heaviest water use occurs in the upper portion of the sub-basin and is dependent primarily upon ground-water supplies.

Water for public supply use accounts for 33 percent of gross use and six percent of consumptive use. Public supply systems depend completely on ground-water sources with over 80 percent of this use occurring in the upper portion of the sub-basin.

Self-supplied domestic use represents over 34 percent of gross water use and over 49 percent of consumptive water use. This user group depends completely on ground-water supplies and is the largest ground-water user (3.50 mgd).

Water use for agriculture accounts for 25 percent of gross use in the Little Pee Dee Sub-basin. Agricultural irrigation represents about 23 percent of gross demand and 39 percent of consumptive use. Water for the 3,230 irrigated acres in this sub-basin is supplied primarily (93 percent) from surface-water sources making this group the largest surface-water user. When averaged over the five-month growing

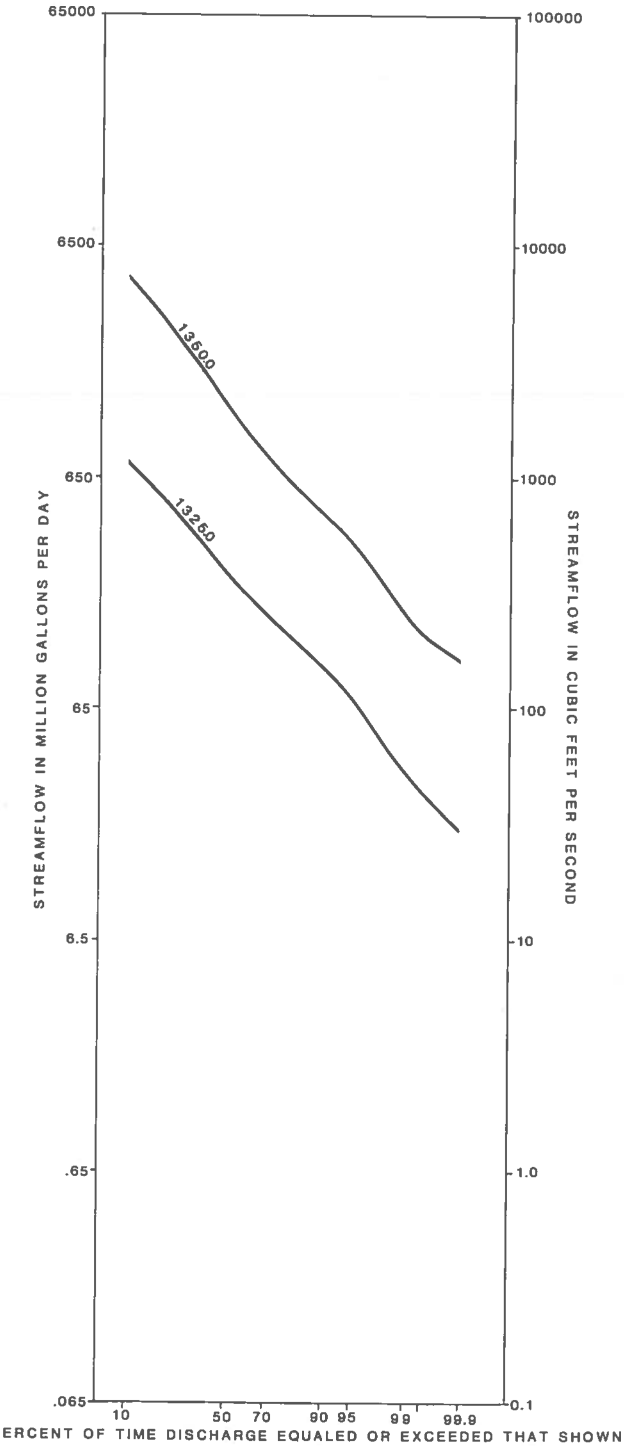


Figure 43.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Little Pee Dee River Sub-basin, South Carolina.

Table 39.
Existing lakes larger than 200 acres in the Little Pee Dee River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Page's Mill Pond	Bear Swamp	200	640	Recreation

Source: S.C. Water Resources Commission, 1974.

Table 40.
U.S. Army Corps of Engineers navigation projects in the Little Pee Dee River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
2	Little Pee Dee	Horry Marion Dillon	Charleston	110.0	--[a]	Project provided for a channel for four foot stream navigation from the mouth to Lumber River and four foot pole boat navigation from there to Little Rock, S.C. Abandonment 1926. Deauthorized 1977.
3	Lumber River	Horry Marion Dillon	Charleston	40.0		Provides for improving river for steamboat use from mouth to Lumberton, N.C. Last work performed 1897. Project deauthorized 1977.

[a] -- indicates information not available.

Source: U.S. Army Corps of Engineers, 1982b.

Table 41.
Flood control projects and studies in the Little Pee Dee River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency[a]*	*Status*
4	Little Pee Dee	Horry Marion Dillon	COE	Study in reconnaissance stage
5	Cartwheel Community	Horry	SCS	Under construction
6	Maple Swamp	Dillon	SCS	Completed 1969
7	Kentyre-Hamer	Dillon	SCS	Terminated
8	Lake Swamp	Horry	SCS	Recommended Study[b]
9	Mitchell Swamp-Pleasant Meadow Branch	Horry	SCS	Terminated
10	White Oak Creek	Marion	SCS	Recommended Study[b]
11	Buck Swamp/Reedy Creek	Marlboro	SCS	Recommended Study[b]
12	Lake View	Dillon	COE	Recommended Study
13	Gapway Swamp	Horry	COE	Completed 1968

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.
[b] Non-sponsored study recommended by SCS.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

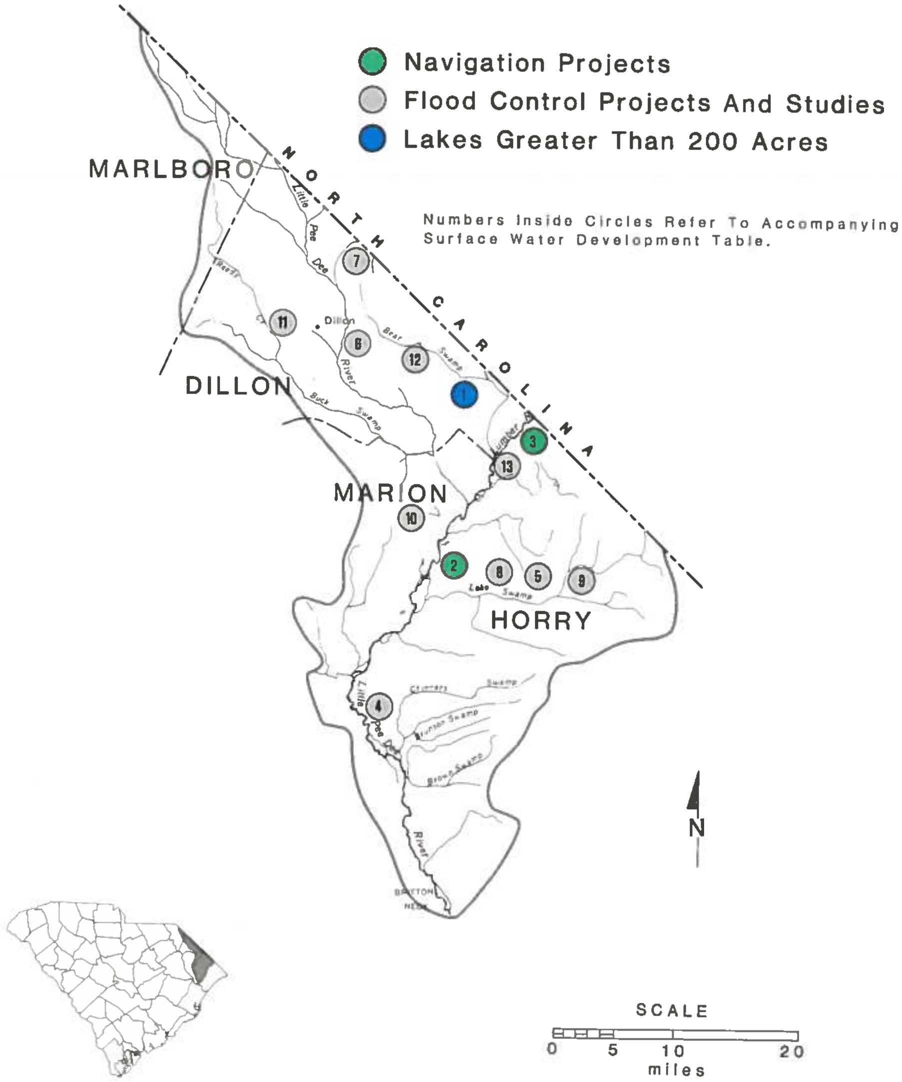


Figure 44.
Surface-water development in the Little Pee Dee River Sub-basin, South Carolina.

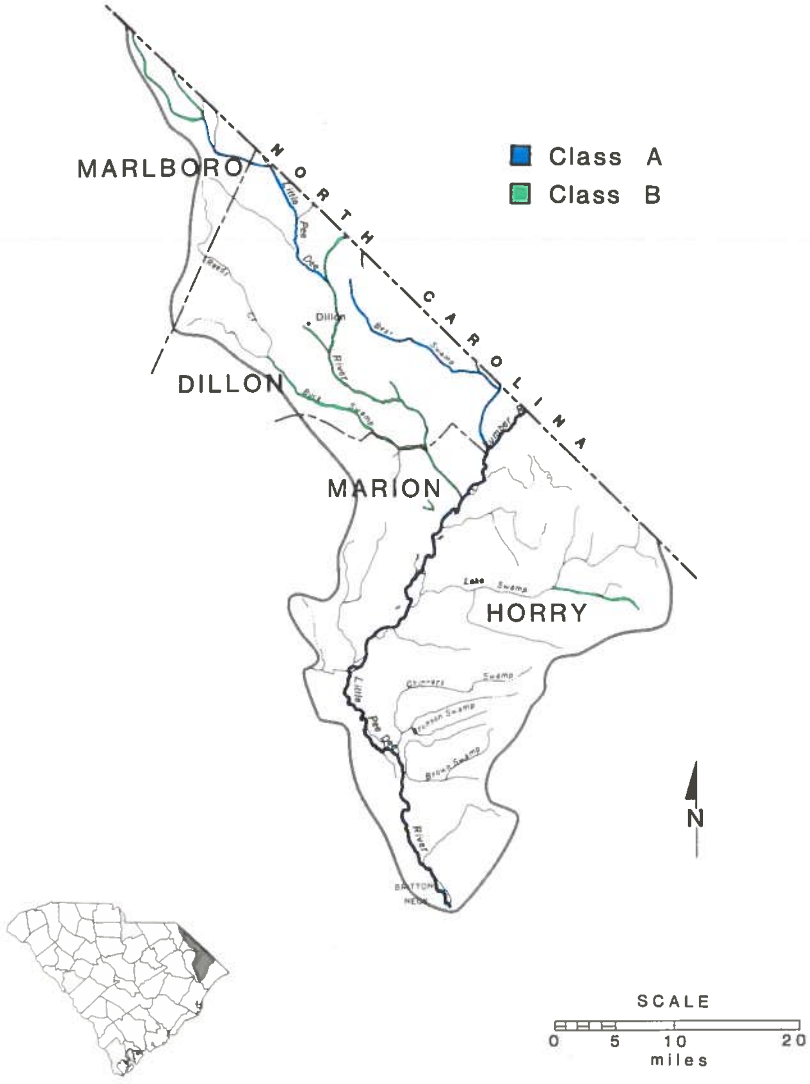


Figure 45.
Surface-water quality classifications in the Little Pee Dee River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

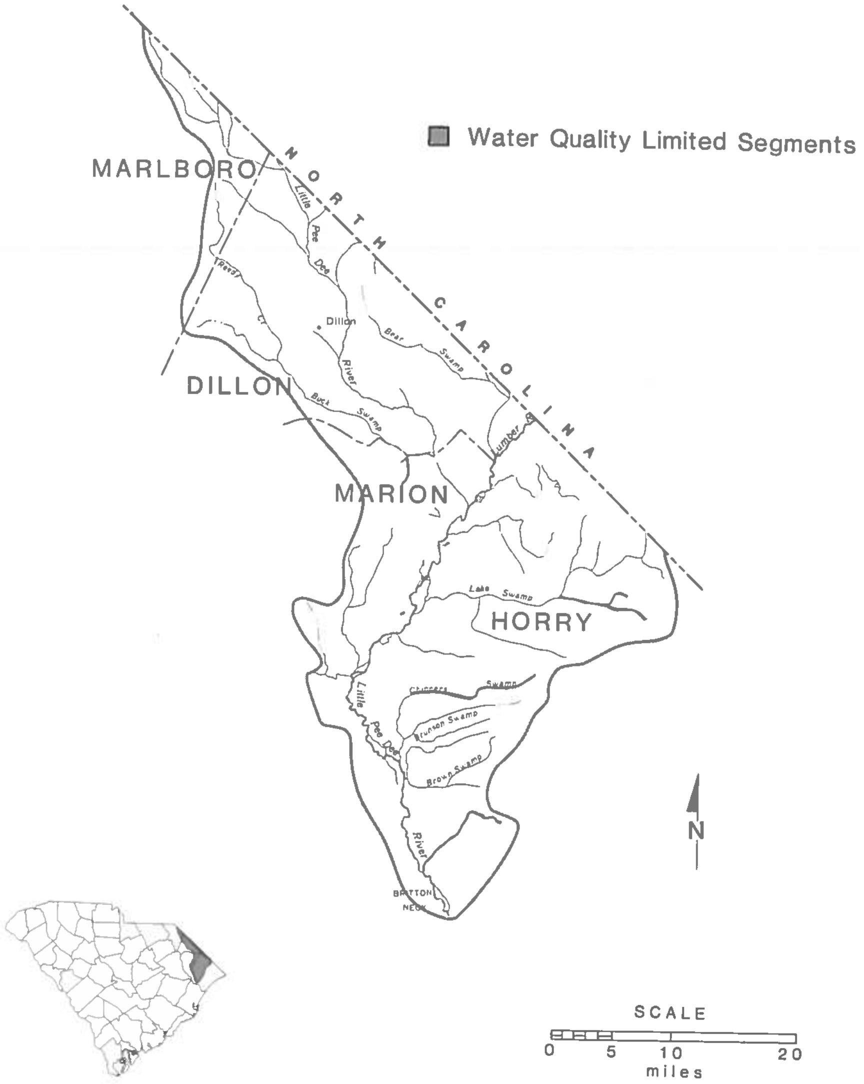


Figure 46.
Water quality limited segments in the Little Pee Dee River Subbasin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

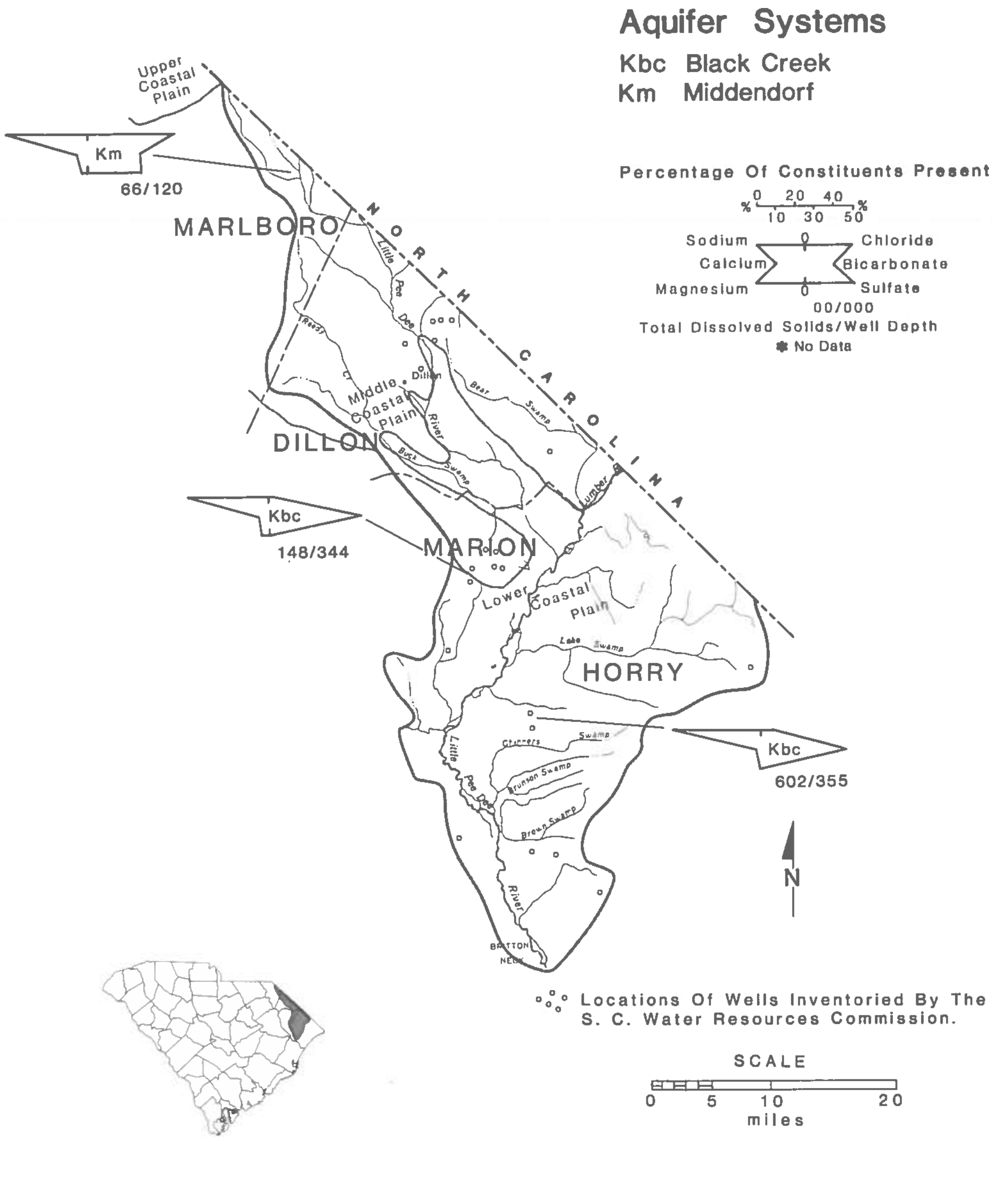


Figure 47.
Ground-water quality of selected aquifer systems and major inventoried wells in the Little Pee Dee River Sub-basin, South Carolina.

Table 42.
Selected ground-water data for the Little Pee Dee River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Dillon	Black Creek/Middendorf	20-290	7-780	--[a]
Mullins	Black Creek	200-460	350-600	3-6
Aynor	Black Creek	300-350	150-250	6-7
Loris	Peedee	60-100	500	35
	Black Creek	280-520	250-500	2

[a]--indicates data not readily available.

season, irrigation water use equals 5.8 mgd, comprising 42 percent of gross use and 61 percent of consumptive use in the sub-basin. Agricultural livestock water use is the lowest in the sub-basin, accounting for two percent of gross use.

Self-supplied industrial water use represents nine percent of gross demand. This user group consumes the least amount of water, accounting for three percent of sub-basin consumptive use. Ground water serves as the only source for industrial water use needs. Nearly all self-supplied industrial use occurs in the upper portion of the sub-basin.

No thermoelectric power water use currently occurs in this sub-basin.

Gross water use is expected to increase by 180 percent from current levels to 29.0 mgd in 2020. Current consumptive use is projected to increase by 260 percent to 21.9 mgd by 2020. The greatest increase in water use is expected to be for agricultural irrigation. This user group is anticipated to increase gross water use by 570 percent to 15.8 mgd in 2020, becoming the major gross water user. Due to these increases and the dependence of irrigation on surface-water supplies, surface water is expected to become the major supply source by 2020.

Current ground-water demand (8.03 mgd) is adequately satisfied and is calculated to be equal to one well per 30 square mile area of sub-basin pumped at a rate of 600 gpm for six hours each day. A total of 37 such wells can satisfy present demand. Projected ground-water use of 14.8 mgd in 2020 will require about 68 wells throughout the sub-basin

Table 43.
Current and projected water use in the Little Pee Dee River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	3.36	---	3.36	4.03	---	4.03	4.64	---	4.64	5.33	---	5.33	5.60	---	5.60
	Consumed	0.34	---	0.34	0.40	---	0.40	0.46	---	0.46	0.53	---	0.53	0.56	---	0.56
Self-supplied Domestic	Gross	3.5	---	3.5	4.2	---	4.2	4.8	---	4.8	5.6	---	5.6	5.8	---	5.8
	Consumed	3.0	---	3.0	3.6	---	3.6	4.1	---	4.1	4.8	---	4.8	4.9	---	4.9
Agriculture Irrigation	Gross	0.16	2.2	2.4	0.56	6.1	6.7	0.98	9.1	10	1.4	12	13	1.8	14	16
	Consumed	0.16	2.2	2.4	0.56	6.1	6.7	0.98	9.1	10	1.4	12	13	1.8	14	16
Agriculture Livestock	Gross	0.12	0.11	0.23	0.14	0.13	0.27	0.16	0.14	0.30	0.18	0.16	0.34	0.20	0.19	0.39
	Consumed	0.12	0.11	0.23	0.14	0.13	0.27	0.16	0.14	0.30	0.18	0.16	0.34	0.20	0.19	0.39
Self-supplied Industry	Gross	0.89	---	0.89	1.02	---	1.02	1.13	---	1.13	1.24	---	1.24	1.36	---	1.36
	Consumed	0.16	---	0.16	0.19	---	0.19	0.21	---	0.21	0.23	---	0.23	0.25	---	0.25
Thermoelectric Power	Gross	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Consumed	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	Gross	8.03	2.31	10.3	9.95	6.23	16.2	11.7	9.24	21.0	13.8	12.2	25.9	14.8	14.2	29.0
	Consumed	3.78	2.31	6.09	4.89	6.23	1.11	5.91	9.24	15.2	7.1	12.2	19.3	7.71	14.2	21.9

pumped at 600 gpm for six hours each day. This is equal to one well per 16 square miles of drainage area. Projected ground-water demands in the sub-basin can be adequately supplied provided proper ground-water management techniques are implemented.

WATER USE VERSUS AVAILABILITY

The current 2.31 mgd gross surface-water demand is adequately supplied by streamflow (Fig. 49). All of this is used for agriculture and livestock purposes, thus consumptive use is also 2.31 mgd. The majority of this use is concentrated in the area between Mullins and Nichols in the Lower Coastal Plain (Fig. 48). This concentration of users may become significant in the future because of the highly variable nature of streamflow in Lower Coastal Plain streams, especially during periods of low rainfall.

Projected 2020 use of 14.2 mgd for both gross and consumptive surface-water use should also be adequately met. However, development of small tributary streams for water supply purposes in the Lower Coastal Plain should include site specific hydrologic analysis to determine the quantity of available streamflow, particularly at low rainfall

Ground-water availability may be limited in certain areas

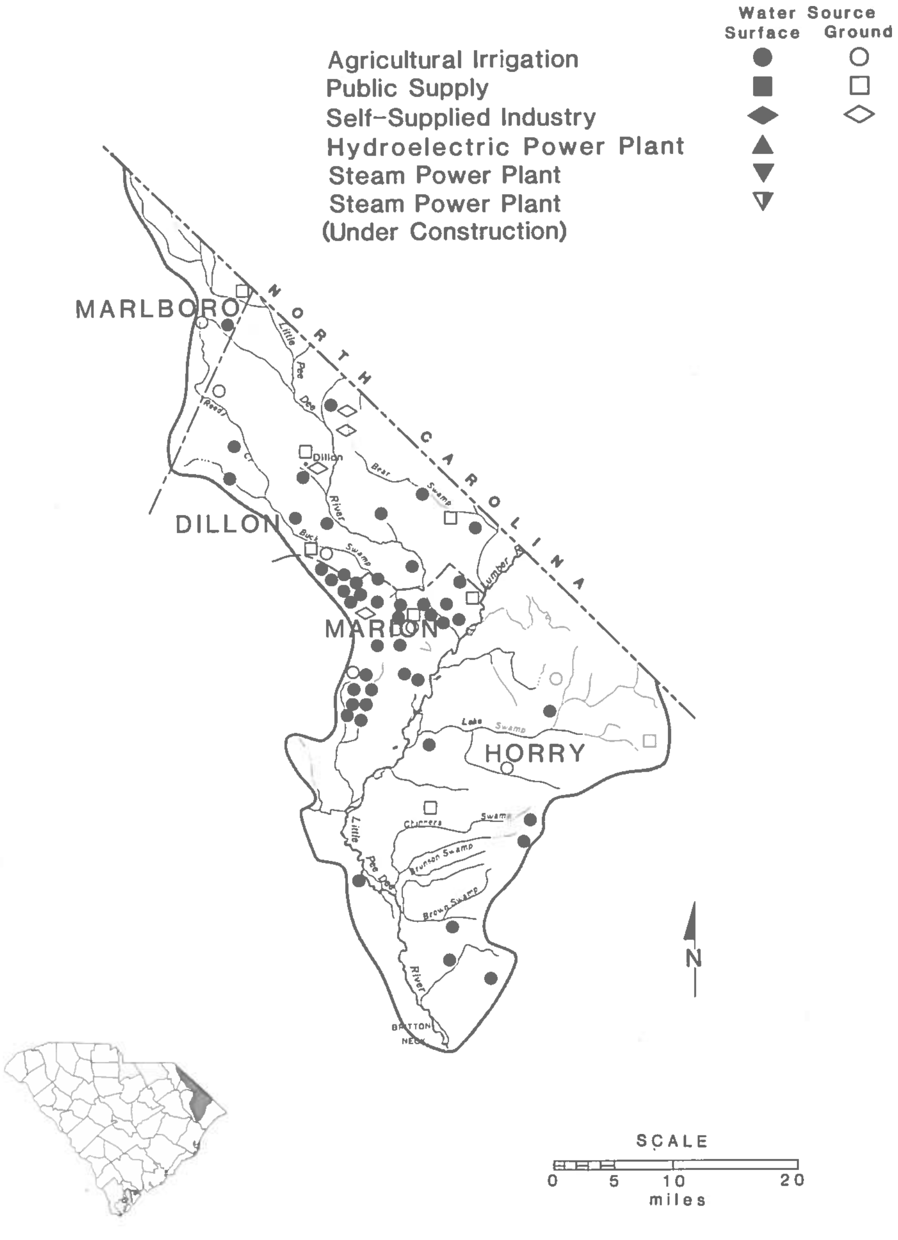


Figure 48.
Location, type, and supply source of water users in the Little Pee Dee River Sub-basin, South Carolina.

of the sub-basin due to the ground-water quality. High iron concentrations may restrict the use of this water for certain needs. Elevated total dissolved solids and fluoride concentration in the Black Creek Aquifer System in areas toward the coast may impair future utilization of this resource. Saltwater movement inland induced by heavy pumpage, as well as the high chloride concentrations already present in the Black Creek Aquifer System in the vicinity of Loris, may cause additional contamination problems between Loris and the coast. Local occurrences of very fine sand in the Black Creek Aquifer System may cause problems in well systems by decreasing the aquifer transmissivity and increasing wear on pumps.

The present extent of ground-water knowledge within the Little Pee Dee River Sub-basin is somewhat limited and the potential for its future development will depend primarily on the results of intensive ground-water studies.

Major water resource problems and opportunities in the sub-basin are summarized in Table 44.

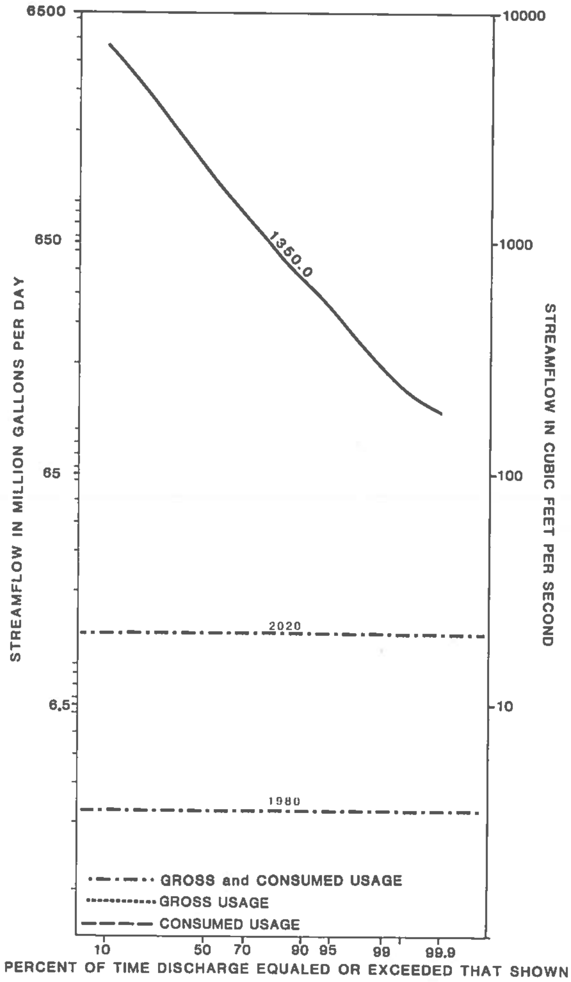


Figure 49.
Water use compared to availability in the Little Pee Dee River Sub-basin, South Carolina.

Table 44.
Major water resource findings in the Little Pee Dee River Sub-basin, South Carolina.

Opportunities

1. The Lumber and Little Pee Dee Rivers have generally good quality water.
2. Projected (2020) surface water use can be adequately met by surface-water supplies.
3. The Middendorf and Black Creek Aquifer Systems are currently underutilized and can provide potentially greater withdrawals to support projected ground-water demands.
4. A 52-mile segment of the Little Pee Dee River is eligible for the State Scenic Rivers Program.

Problems

1. Streamflow in Middle and Lower Coastal Plain streams do not have well-sustained flows and are unreliable sources of surface water.
2. Heavy surface water use for agricultural irrigation in Marion County may cause water use conflicts during periods of low flow.
3. There is a trend of decreasing water quality in the Little Pee Dee River due to problem levels of pH and dissolved oxygen.
4. Natural swamp drainage and non-point source pollution cause depressed dissolved oxygen levels and high nutrient and fecal coliform bacteria levels in the Lumber and Little Pee Dee Rivers.
5. Agricultural non-point source runoff has impaired recreational use of Sweet Swamp due to fecal coliform bacterial contamination and recreational use of Reedy Creek because of high toxaphene levels in the sediments.
6. Limited ground-water data are available in the northwestern portion of the sub-basin.
7. Total dissolved solids and fluoride in the Black Creek Aquifer System progressively increase toward the coast.
8. High chloride concentrations occur in the Black Creek and Peedee Aquifer Systems in the vicinity of Loris.
9. Local occurrence of very fine sand in the Black Creek Aquifer System limits ground-water yields.
10. High iron concentrations occur in the Black Creek Aquifer System in Dillon and Marion Counties as well as in the Shallow Aquifer System in Horry County.

Black River Sub-basin

GENERAL OVERVIEW

The Black River Sub-basin transects the central portion of South Carolina from the western fringe of the Pee Dee region southeast to the upper extent of Winyah Bay. With a northwest-southeast orientation, the sub-basin extends into the western edge of Kershaw County and encompasses portions of six additional counties including Sumter, Williamsburg, Georgetown, Clarendon, Lee, and Florence Counties (Fig. 50). The areal extent of the sub-basin is approximately 2,045 square miles, 6.6 percent of State land area.

Population

The 1980 sub-basin population was estimated at about 154,500, five percent of the State's total population. The population in the sub-basin is projected to reach about 199,000 by the year 2020, an increase of almost 30 percent (Table 45). In contrast, the total population of South Carolina is expected to increase by 64 percent during this period. Georgetown County is expected to exhibit a 90 percent increase in population, with Sumter and Georgetown Counties containing about 60 percent of the sub-basin population by 2020.

The Black River Sub-basin population is predominately rural, with the exception of Sumter County, where slightly over one-half of the residents in the county are classified as urban. Of that one-half, 25 percent live in the City of Sumter.

The major centers of population in the sub-basin are Sumter (24,688), Manning (4,727), Kingstree (4,095), Bishopville (3,466), and Andrews (2,935).

Economy

In the sub-basin, per capita income ranged from $6,108 in Georgetown County, which ranked 30th among the 46 counties, to $4,117 in Clarendon County, the lowest in the State. The 1979 per capita income in South Carolina averaged $7,056. Clarendon County also had the State's lowest median household income with $9,640 in 1980, almost $7,000 lower than the State's median household income of $16,509 for the same year. The upper limit of median household income for the sub-basin was $14,288 in Sumter County, well below that for the State.

The 1979 annual average employment of non-agricultural wage and salary workers for the area totaled approximately 58,800, five percent of the State's total. The percentage breakdown by type of employment was roughly proportional to the State as a whole. Specifically, the sub-basin breakdown was: manufacturing, 35 percent; government, 20 percent; wholesale and retail trade, 19 percent; other services and mining, 13 percent; construction, 6 percent; transportation and public utilities, 4 percent; and finance, insurance, and real estate, 3 percent.

Figure 50.
Location of the Black River Sub-basin in South Carolina.

Table 45.
Current and projected population for the Black River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)* 1980	1990	2000	2010	2020	*% Change 1980-2020*
Clarendon	66.0	18.2	19.6	20.3	20.9	21.3	17.0
Florence	2.1	2.3	2.9	3.4	3.8	4.0	73.9
Georgetown	26.6	11.3	14.2	18.0	20.2	21.6	91.2
Kershaw	3.1	1.2	1.4	1.5	1.5	1.6	33.3
Lee	59.2	11.2	11.7	11.9	12.0	12.1	8.0
Sumter	89.0	78.7	88.0	92.7	96.3	98.3	24.9
Williamsburg	85.5	31.6	35.5	37.6	39.2	40.1	26.9
Total		154.5	173.3	185.4	193.9	199.0	28.8

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

Agricultural activities play a major role in the economy of the sub-basin. With the exception of Georgetown County, every county in the sub-basin ranked in the top ten of 1979 county cash receipts from crops or livestock and livestock products. Williamsburg County was third in the State for cash crop receipts, with a total of over $41 million, and Lee County led the State in cotton production, with 34,000 bales.

SURFACE WATER

Hydrology

The dominant watercourse draining the sub-basin is the Black River, while numerous tributary streams of various sizes also contribute to the hydrology. The principal tributaries draining into the Black River include the Pocotaligo River, Scape Ore Swamp, Pudding Swamp, and Black Mingo Creek. These surface waters eventually discharge directly into Winyah Bay located in the Waccamaw Sub-basin. Most streams are located entirely within the Middle and Lower Coastal Plain region with only Scape Ore Swamp located in the Upper Coastal Plain region. Extensive swamplands border much of the Black River and its tributaries, frequently resulting in ill-defined and meandering stream channels. The cities of Sumter, Manning, and Kingstree make wide use of the surface waters in this sub-basin.

Streamflow is monitored at three sites, as shown in Figure 51. These gaging stations have varying periods of record with the longest (51 years) for the gage on the Black River at Kingstree. High flows are also monitored at two crest-stage stations (1356.2, 1360.1). Streamflow statistics for the three streamflow stations are presented in Table 46.

Average annual streamflow for gaged sites on the Black River ranges from 393 cfs near Gable to 942 cfs at Kingstree. Streamflow at these sites equals or exceeds 35 cfs and 36 cfs, respectively, 90 percent of the time.

Steep flow-duration curves (Fig. 52), widely varying flow extremes (Table 46), highly fluctuating low monthly flows (Fig. 51), and a wide range between monthly flow extremes, indicate highly variable streamflows in the Black River which is dependent primarily on rainfall and ensuing runoff rather than ground-water discharges to maintain flows. Base flows at Kingstree appear to receive some ground-water support, while low flows at Gable receive little or no support from ground-water storage and occasionally reach zero-flow conditions. The lowest flows of record for the Black River were recorded at Gable where zero-flow conditions occurred for several days in 1954, 1956, and 1957. The highest flow of record (58,000 cfs) was recorded at Kingstree in 1973. Occassional high flows in the Black River cause flood damage in the cities of Sumter, Kingstree, and Anderson. Flooding of the Pocotaligo River occassionally impacts the Town of Manning.

Average annual flow on the only gaged tributary, Scape Ore Swamp, is 111 cfs. Streamflow can be expected to be at least 28 cfs, 90 percent of the time. Due to this stream's location in the Upper Coastal Plain, low flows are well-sustained by ground-water reserves. This is evidenced by a moderately sloped flow-duration curve (Fig. 52), moderately variable minimum monthly flows (Fig. 51), and greater 7Q10 and record low-flow values than in downstream Black River (Table 46).

Streamflow in the Black River is highly variable and is not a reliable source of surface water, especially during the summer months. Water storage facilities would enhance surface-water dependent development on this river by providing adequate water supplies year round. While average streamflow in Scape Ore Swamp is less than in the Black River, the reliability of flow is greater. During periods of low rainfall, streamflow in Scape Ore Swamp may exceed that in the main stem river.

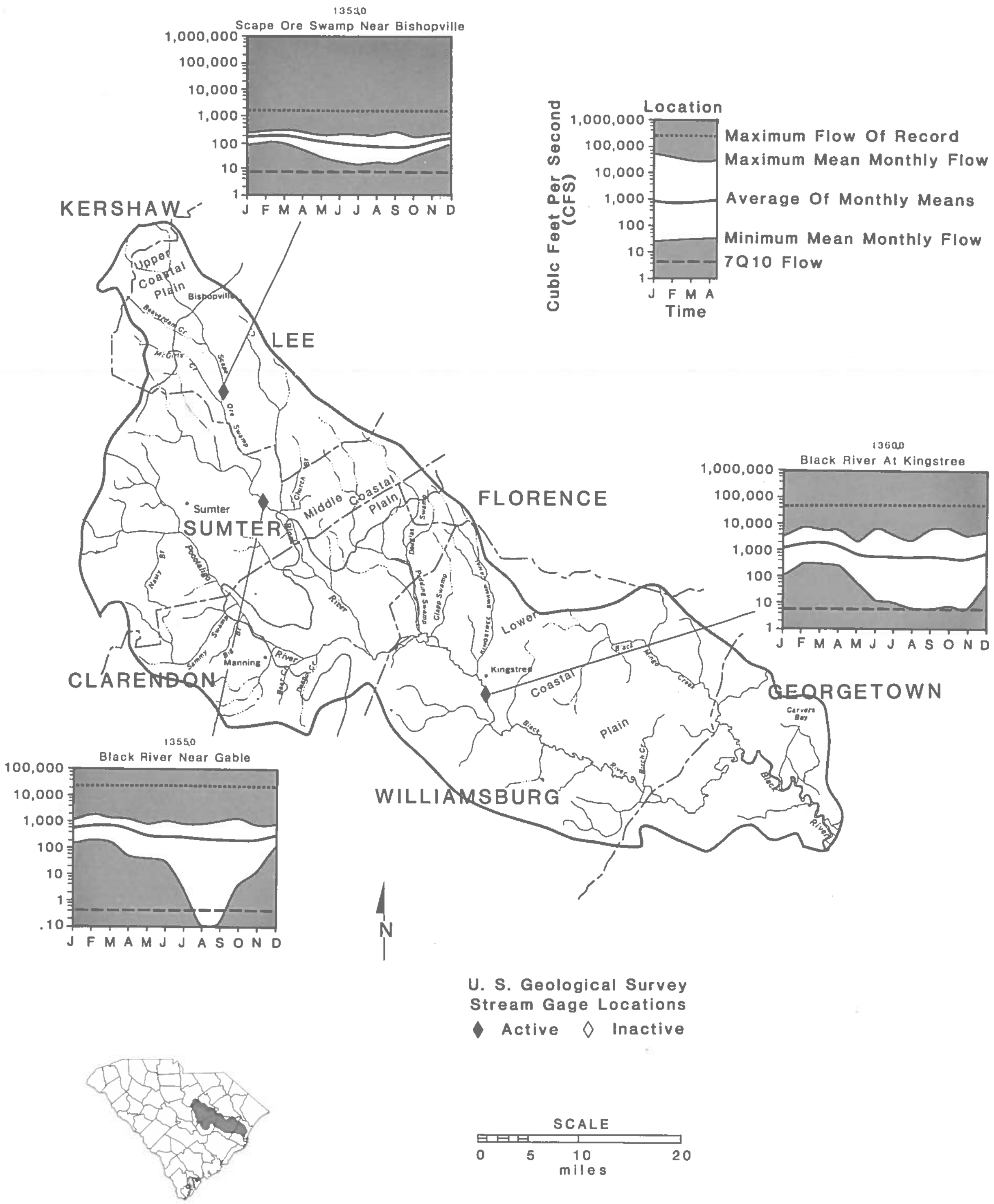


Figure 51.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Black River Sub-basin, South Carolina.

Table 46.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Black River Sub-basin, South Carolina.

Gaging Station		*Drainage Area*	*Period of Record*		*Average Flow*			*7Q10*[b]	
Number	*Name/Location*	*(mi²)*	*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*90%*[a] *cfs*	*cfs*	*cfs/mi²*
1353	Scape Ore Swamp near Bishopville	96.0	Jul 1968-Present	12	111	1.16	28	6.7	0.07
1355	Black River near Gable	401	Jun 1951-Jun 1966 Apr 1972-Present	22	393	0.98	35	0.41	0.001
1360	Black River at Kingstree	1,252	Aug 1929-Present	51	942	0.75	36	5.7	0.005

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.

Development

Limited surface-water development has occurred in the Black River Sub-basin. Existing development consists mostly of flood control projects located throughout the sub-basin. Figure 53 shows surface-water development in the sub-basin.

There are no large reservoirs or lakes within the sub-basin. The largest lake has a surface area of 150 acres and a volume of 600 acre-feet. The total surface area of all lakes larger than ten acres is 1,699 acres and the total volume is about 4,000 acre-feet.

No active navigation projects occur in this sub-basin. An inactive project on Mingo Creek is detailed on Table 47.

The U.S. Army Corps of Engineers has completed three flood control projects (Fig. 53, Table 48). The Shot Pouch Creek Project includes land enhancement and recreation. In addition, numerous flood problem areas have been identified.

Water Quality

Water bodies of several different water use designations occur in the Black River Sub-basin (Fig. 54). While a major portion of the Black River main stem is designated Class A, the upper portion, the entire Pocotaligo River, and other tributary streams have Class B water use designations. A small portion of the Black River near Winyah Bay is designated Class SB. Water quality limited segments in the sub-basin which require advanced treatment of wastewater discharges include all of Nasty Branch, Pudding Swamp, Douglas Swamp, and Kingstree Swamp and portions of and/or tributaries to the Pocotaligo River, and Black River (Fig. 55). Water quality in the Black River Sub-basin is suitable for designated water use needs the majority of the time. However, typical of Coastal Plain sub-basins in South Carolina, water quality is degraded in freshwater streams during the summer months due to drainage of poor quality water from extensive swamplands. Point source discharges from urban areas also adversely impact water quality and water use in the sub-basin.

The Black River exhibits good to satisfactory water quality (S. C. Department of Health and Environmental Control, 1980b). Problem conditions include elevated mercury levels of unknown origin and low dissolved oxygen concentrations due to natural swamp drainage and non-point source pollution. Evaluation of aquatic biological communities indicates good water quality with improved conditions during recent years (S. C. Department of Health and Environmental Control, 1980b). Earlier studies indicate widespread dissolved oxygen and fecal coliform bacteria problems in the Black River occurring primarily during the summer and spring (S. C. Department of Health and Environmental Control, 1976). These degraded conditions were attributed to drainage of poor quality water from the vast swamplands associated with this river, low streamflows, and relatively high summer water temperatures.

The Pocotaligo River has historically exhibited recurrent water quality problems. Early studies indicate contraventions of State dissolved oxygen, fecal coliform bacteria, and pH standards in addition to elevated levels of mercury, biochemical oxygen demand, and nutrients (S. C. Department of Health and Environmental Control, 1976). Water quality violations occurred primarily during summer and spring and many were attributed to point source discharges near the City of Sumter. While there are some indications of improvement, water quality continues to be characterized as satisfactory to poor (S. C. Department of Health and Environmental Control, 1980b). Degraded conditions are evidenced by depressed dissolved oxygen levels, occasional fish kills, an absence of some groups of aquatic organisms, and an abundance of pollution tolerant species. Nuisance aquatic weed infestations in the river and adjacent swamps restrict flow and contribute to degraded conditions.

GROUND WATER

Hydrogeology

The level of the ground-water knowledge ranges from the field data level in the northwestern region to the evaluation level in the southeastern region (Fig. 18).

The Black River Sub-basin lies wholly within the Coastal Plain Province. The part of Lee County lying within the sub-basin is underlain by the Middendorf Aquifer System which is the principal source of ground water in this area. Selected ground-water data for the sub-basin are presented in Table 49.

The estimated coefficient of transmissivity of the Middendorf Aquifer System in the Bishopville area is about

Table 46. (Continued)

Extreme Flows			
Minimum[c]		Maximum[d]	
cfs	*Dates*	*cfs*	*Date*
6.7	Jul 21, 1970	1,700	Sep 7, 1979
	No flow for several days in 1954, 1956, 1957	12,500	Mar 5, 1971
2.0	Sep 12-15; Oct 7, 8, 1954	58,000	Jun 4, 1973

5,300 ft²/day. U. S. Geological Survey records on 56 wells within Lee County indicate a total thickness of sediments overlying the crytsalline rock to be about 600 feet. Development of the Middendorf Aquifer System between 300 and 600 feet would probably produce higher yields than those reported from depths of 150 to 320 feet.

The total thickness of sediments overlying the crystalline rocks in Sumter County is estimated to range from about 500 feet in the northwestern part of the county to about 900 feet on the border with Clarendon County. In the area north and west of Sumter, the top of the Middendorf is recorded at a depth of 100 to 350 feet. Beneath the City of Sumter the top of the Middendorf occurs at a depth of 470 feet. The quantity of water required for municipal use in the City of Sumter is increasing, and water levels in the supply wells are declining. In 1955, the level in an irrigation well four miles northeast of Sumter was measured at several feet above land surface,but in 1977, the water level was six feet below land surface. Water levels in Sumter Water Plant One measured 65 feet below land surface in 1977. Results of aquifer tests conducted at two Sumter Water Plants indicated transmissivity values between 6,200 and 10,700 ft²/day with a storage coefficient of 0.0002 (Park, 1980).

The Black Creek Aquifer System underlies most of Sumter County. The top of the aquifer is about 50 feet above mean sea level and the thickness increases from a few feet in the Rembert area to about 400 feet near Pinewood. Many water systems in Sumter County include wells that tap the Black Creek Aquifer System.

The Peedee Aquifer System also underlies the lower portion of Sumter County but data concerning wells screened in this aquifer are not available because the aquifer is usually not screened exclusively. Rather it is screened in conjuction with one or more other aquifers.

The Shallow Aquifer System in Sumter County supplies domestic wells ranging in depths from 10 to more than 100 feet below land surface. Shallow wells developed in alluvial deposits along the Black River may obtain large amounts of water transmitted from the river through these deposits. There is a definite need for further study of these shallow systems.

Clarendon and Williamsburg Counties, located in the center of the Black River Sub-basin, are entirely underlain by the Middendorf Aquifer System. In the vicinity of

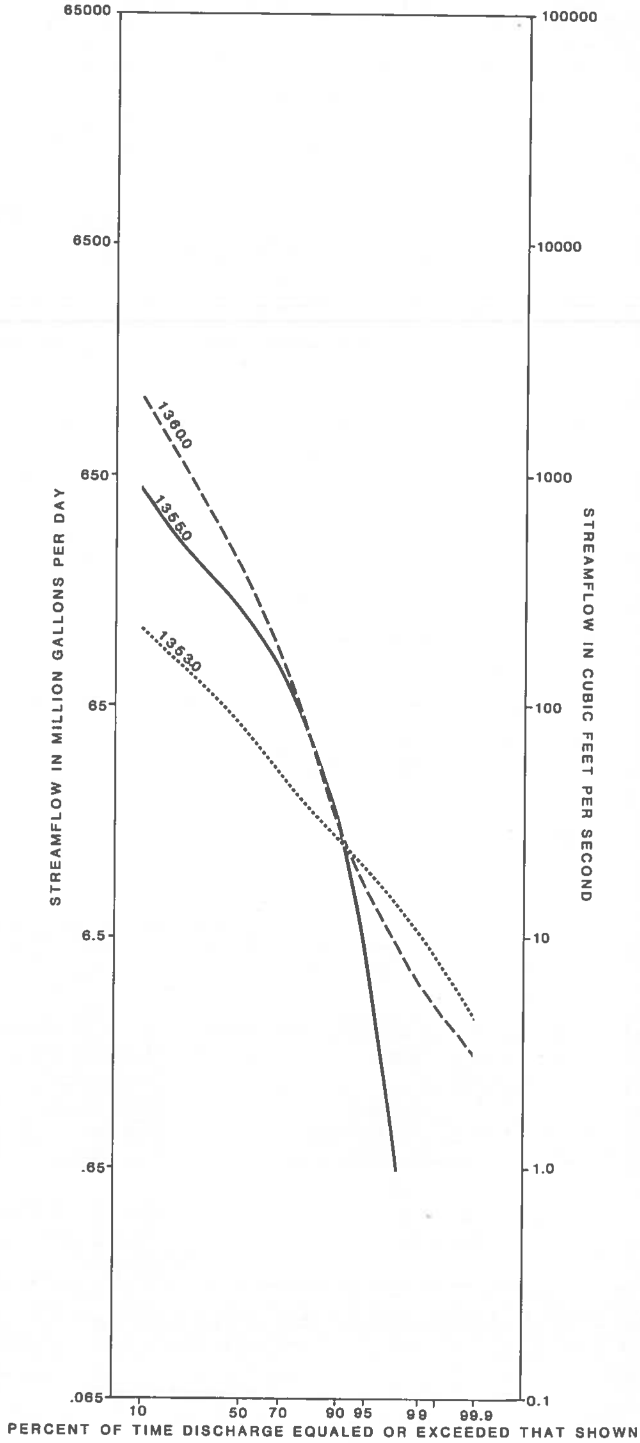


Figure 52.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Black River Sub-basin, South Carolina.

Table 47.
U.S. Army Corps of Engineers navigation projects in the Black River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
1	Mingo Creek	Georgetown	Charleston	11.0	60	Project provides for a channel 60 feet wide, eight feet deep from the mouth to Hemingway Bridge. Last work performed 1945. Project presently inactive.

Source: U.S. Army Corps of Engineers, 1982b.

Table 48.
Flood control projects and studies in the Black River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
2	Kingstree Branch	Williamsburg	COE	Completed 1977
3	Turkey Crreek	Sumter	COE	Completed 1971
4	Shot Pouch Creek	Sumter	COE	Completed
5	Upper Black River	Lee	SCS	Recommended Study[b]
6	Pudding Swamp	Sumter/Lee	SCS	Recommended Study[b]
7	Ox Swamp	Williamsburg	SCS	Recommended Study[b]
8	Stoney Run	Williamsburg	SCS	Recommended Study[b]
9	Black Mingo	Williamsburg	SCS	Recommended Study[b]
10	Kingstree Canal	Williamsburg	SCS	Recommended Study[b]
11	Back Swamp	Lee	SCS	Authorized for planning

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.
[b] Non-sponsored study recommended by SCS.
[c] Non-sponsored study recommended by Flood Plain Management Task Group.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

Table 49.
Selected ground-water data for the Black River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Lee County	Middendorf	150-320	125-1170	up to 28.3
Sumter	Middendorf	550-670	500-2000	11-30
Sumter County	Black Creek	100-250	50-150	<5
Sumter/Mayesville	Shallow	50-60	100-400	--[a]
Clarendon/Williamsburg Counties	Black Creek	350-800	150-500	3-17
Manning	Black Creek/Peedee	270-610	200-250	--
Andrews	Black Creek	--	350-500	2.3-4.5
	Shallow	22-60	150	--

[a]--indicates data not readily available.

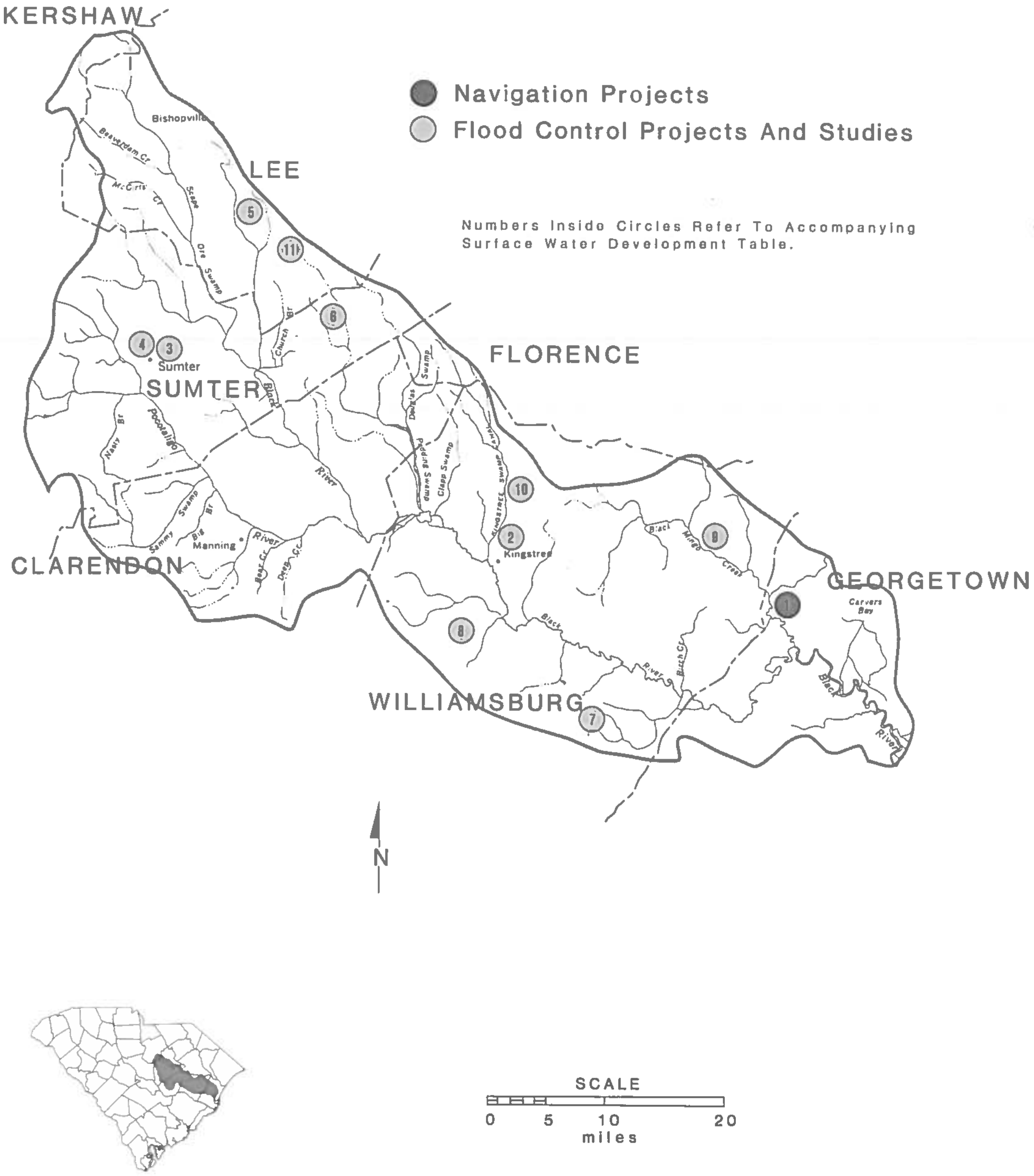


Figure 53.
Surface-water development in the Black River Sub-basin, South Carolina.

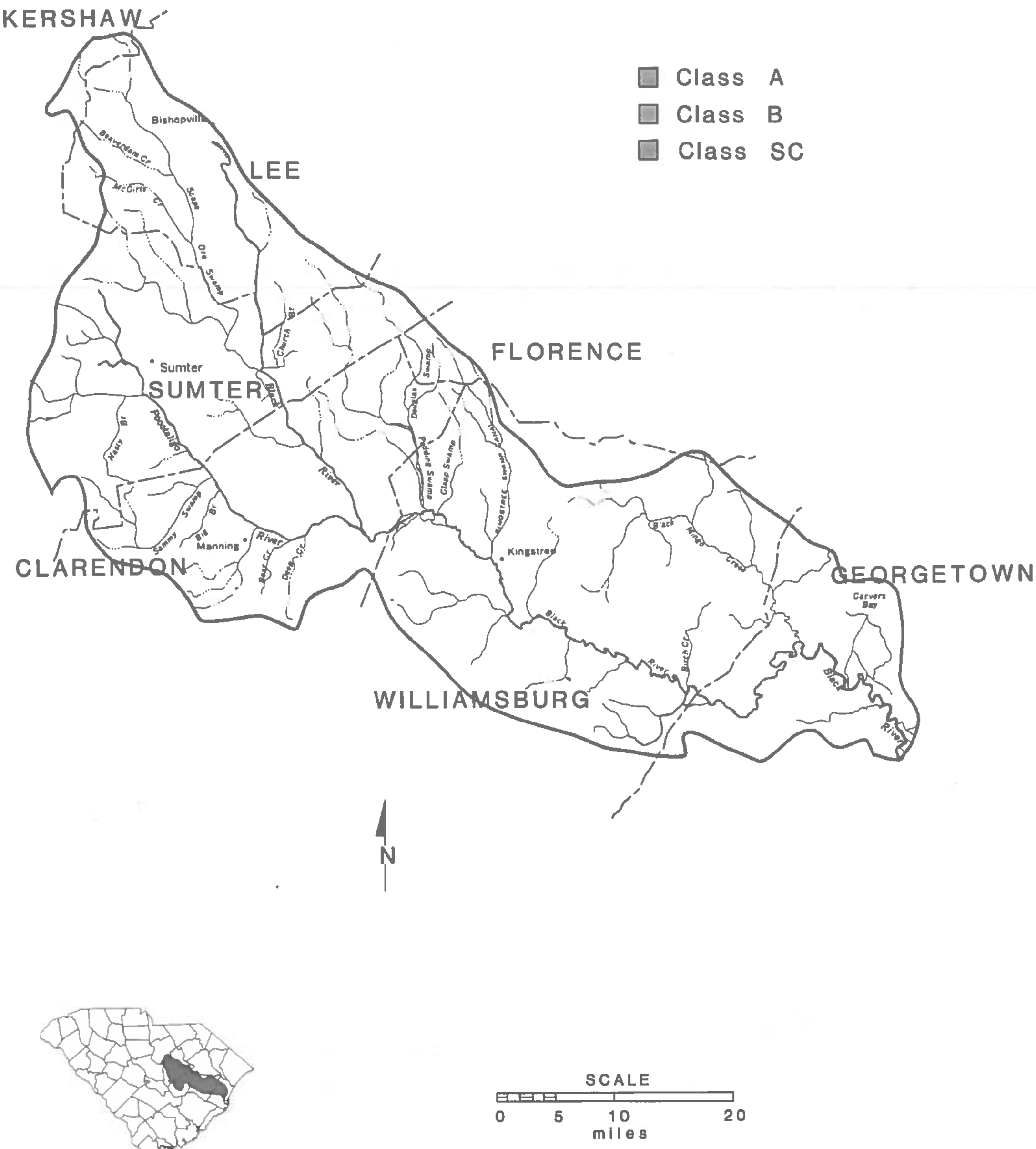


Figure 54.
Surface-water quality classifications in the Black River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

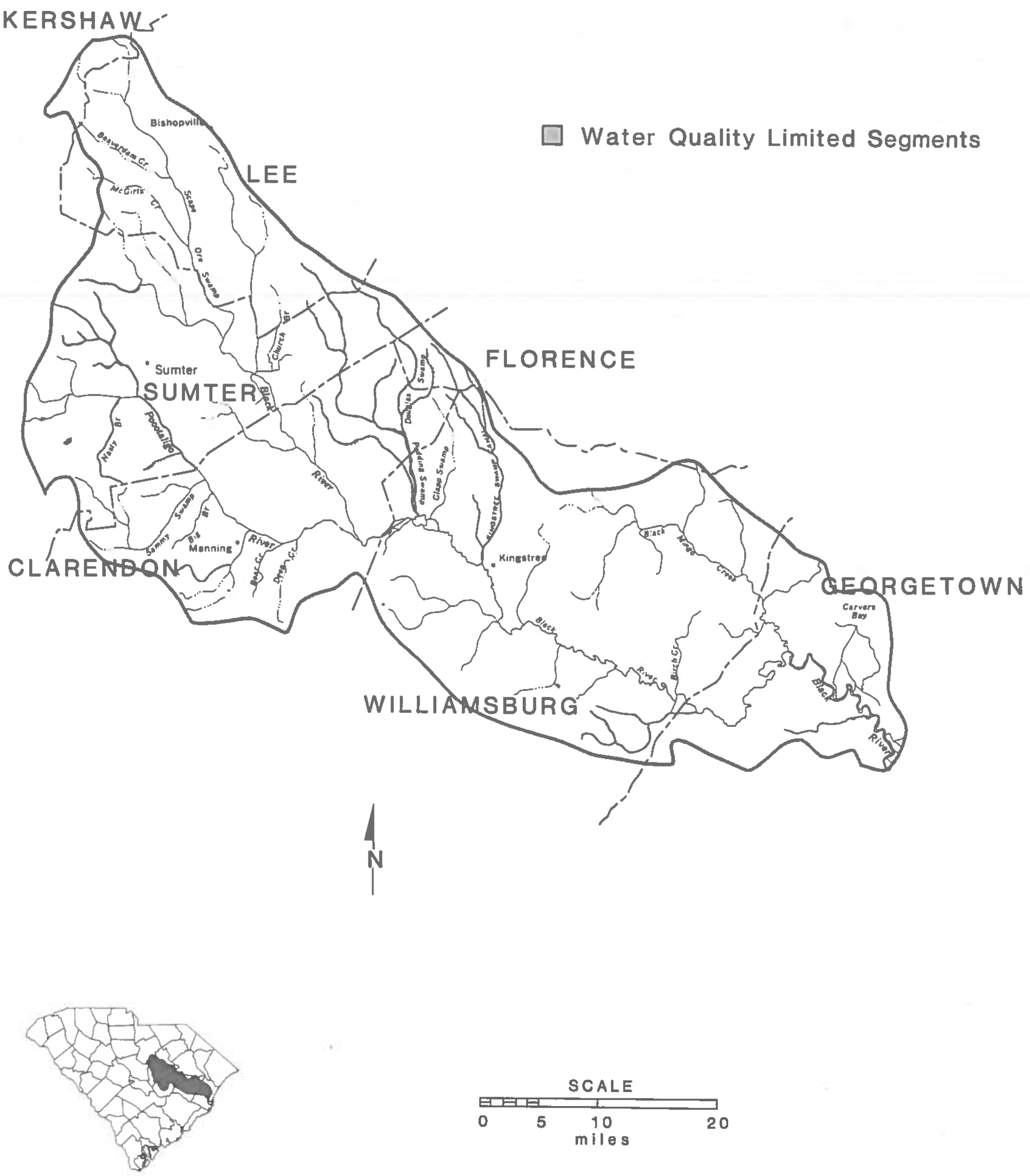


Figure 55.
Water quality limited segments in the Black River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Turbeville, the top of the Middendorf Aquifer System occurs at depths of 550 to 600 feet. Specific characteristics of this aquifer are poorly understood because few wells or test holes penetrate it. The electrical resistivity log from a 1,318 foot test hole near Kingstree apparently shows brackish to salty water at 1,180 feet below land surface. The thickness of the Middendorf Aquifer System is estimated at about 300 to 400 feet in this area. Wells which penetrate the Middendorf Aquifer System are also screened in overlying aquifers, so hydraulic properties of the Middendorf Aquifer System are difficult to identify.

The Black Creek Aquifer System underlying Clarendon and Williamsburg Counties is about 400 to 500 feet thick and lies between the elevations of approximately 250 and 700 feet below mean sea level. Estimates of transmissivity range from 900 to 5,000 ft^2/day (Johnson, 1978). The Peedee Aquifer System above the Black Creek is estimated to be about 250 feet thick with the top of the aquifer occurring about 50 feet below mean sea level. There are no data available concerning ground water in the Shallow Aquifer System in these counties. However, this aquifer system supplies domestic needs in rural areas.

In Georgetown County, the Middendorf Aquifer System lies at depths of 1,000 feet below mean sea level or greater and is not used as a source of ground-water supply. The Black Creek Aquifer System occurs between 400 and 1,000 feet and is tapped by a number of public supply wells, such as those at Andrews. Typical Black Creek wells have screens between 550 and 800 feet, yield 350 to 500 gpm, and have specific capacities between 2 and 5 gpm/ft. Domestic water supplies are obtained from the Shallow and Peedee Aquifer Systems with wells that are less than 100 feet deep. A few shallow wells are known to produce as much as 150 gpm, but yields are usually much smaller.

Water Quality

The Middendorf and Black Creek are the two most intensively used aquifer systems in the sub-basin. In the northern portion of the sub-basin the water in the Middendorf Aquifer System is generally soft and low in pH, chloride, fluoride, and total dissolved solids. Total dissolved solids, pH, and fluoride and chloride concentrations increase with depth and proximity to the coast. A test well in Georgetown County indicates that water at a depth of 1,300 feet is brackish, containing more than 600 mg/L of chloride. The Stiff Diagrams in Figure 56 show water quality types for this aquifer ranging from a sodium chloride to a sodium sulfate type.

The ground water in the Black Creek Aquifer System is soft. The pH ranges from a value of 5 to 6 in Sumter County to 8 and 9 in Georgetown County. Total dissolved solids are about 20 mg/L in the northwestern portion of the sub-basin and increase toward the coast where they exceed acceptable drinking water standards. Chloride and fluoride concentrations increase toward the coast. Chloride concentrations and total dissolved solids also increase with depth.

The Stiff Diagrams indicate a typical sodium bicarbonate water in the Black Creek Aquifer System. In the southeastern portion of the sub-basin, water from some wells has a milky or cloudy appearance that persists even with prolonged pumping. The milky appearance of the water is caused by a colloidal suspension of aragonite, a calcium carbonate mineral.

WATER USE

Total gross water withdrawals are currently estimated at 30.1 mgd; 11 mgd of this is consumed (Table 50). Total use ranks 11th of all sub-basins. The leading gross users are public supply, (17.6 mgd), self-supplied domestic (6.6 mgd), and agricultural irrigation (2.1 mgd). Ground water is the most heavily used source of supply, accounting for 97 percent of the gross usage. Ground-water use in this sub-basin is the largest in the State. Most surface-water withdrawals take place in the upper half of the sub-basin. Major water users by type and source are shown on Figure 57.

Public supply is the leading water withdrawer representing 58 percent of gross use, and the leading ground-water user, with 60 percent of total ground-water withdrawals. However, this use represents only 16 percent of total consumptive use. This sub-basin has the largest ground-water use for public supply for all sub-basins in the State.

Self-supplied domestic water use, (6.60 mgd) makes up 22 percent of gross use, all of which is derived from ground-water sources. This use accounts for over 51 percent of consumptive use. Domestic self-supplied gross and consumptive use is the second largest in the State.

Agricultural demand (3.1 mgd) accounts for 10 percent of gross use. Irrigation withdrawals make up 68 percent of this agricultural use and ground water is the primary source for both irrigation and livestock uses. Most of the irrigated acreage (97 percent) is located in the upper half of the sub-basin. The second largest consumptive use in this sub-basin is agricultural withdrawal, representing 28 percent of the total. Irrigation water use, when averaged over the five-month growing season, is 5.2 mgd, comprising 16 percent of total gross use and 37 percent of consumptive use in the sub-basin.

Only a small amount (2.80 mgd) of self-supplied industrial water use occurs in the Black River Sub-basin, representing nine percent of gross usage. This use represents only five percent of total consumptive use. Ground water supplies 97 percent of the self-supplied industrial demand, which is predominantly located in the central portion of the sub-basin.

No thermoelectric power water use ocurs in this sub-basin.

Gross water use is projected to increase 110 percent to about 62.6 mgd by the year 2020. Ground water should remain the most heavily used source of supply and public supply will remain the leading gross water user. Total consumptive use is projected to increase by 220 percent to 34.6 mgd by the year 2020. Most of this increased consumption will be due to increases in agricultural irrigation demand.

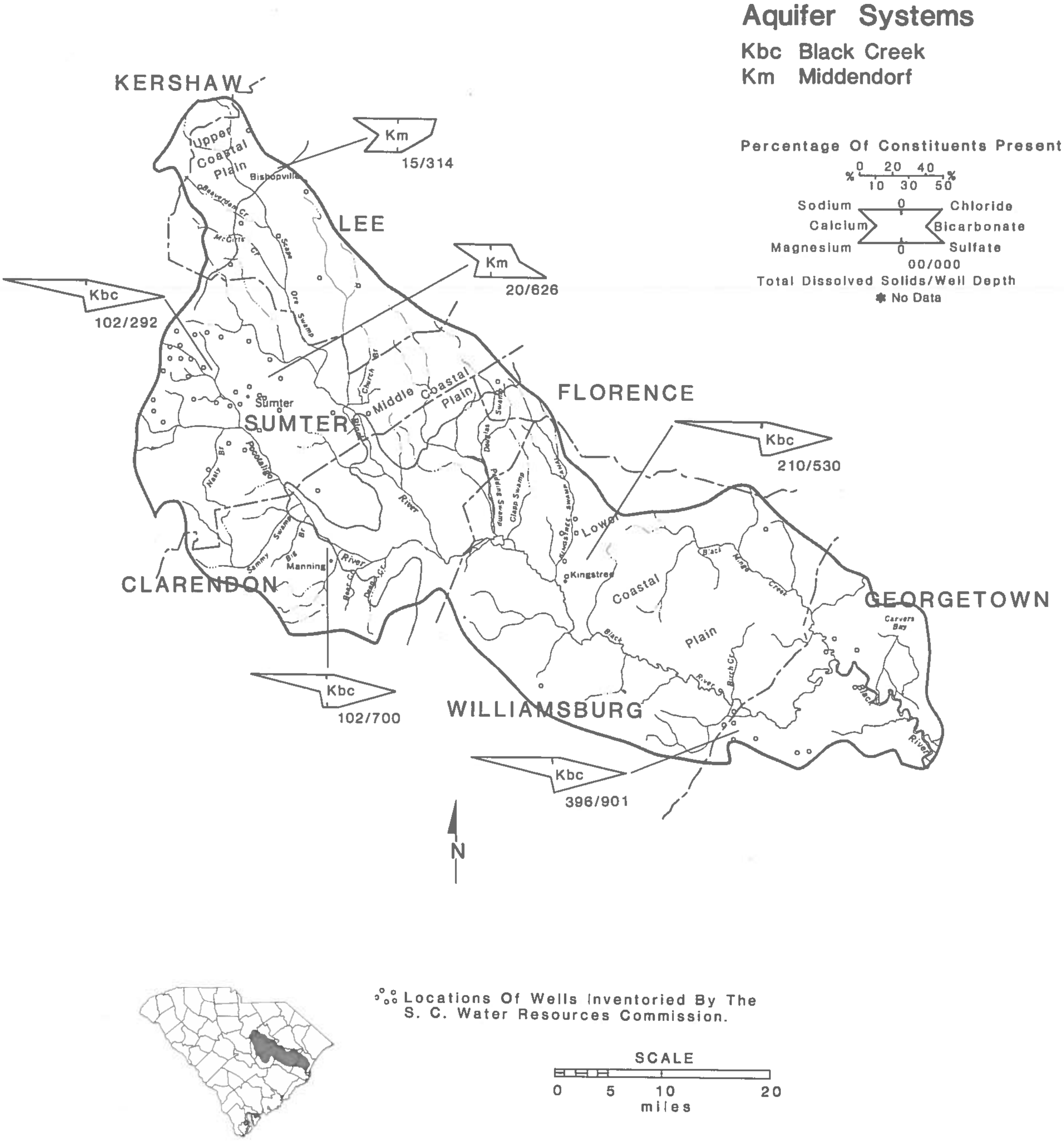


Figure 56.
Ground-water quality of selected aquifer systems and major inventoried wells in the Black River Sub-basin, South Carolina.

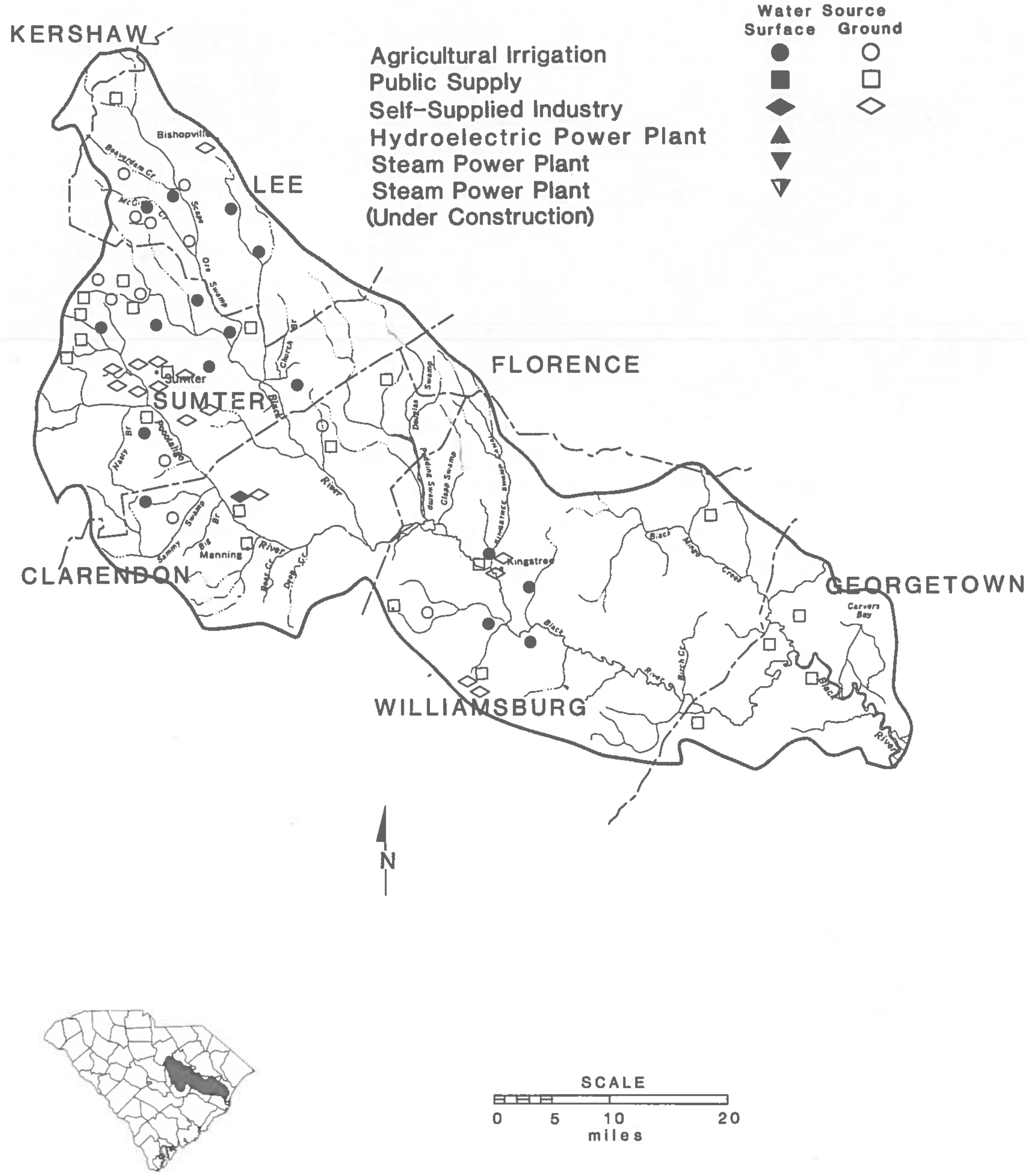


Figure 57.
Location, type, and supply source of water users in the Black River Sub-basin, South Carolina.

Table 50.
Current and projected water use in the Black River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	17.6	---	17.6	20.2	---	20.2	22.3	---	22.3	24.5	---	24.5	25.7	---	25.7
	Consumed	1.76	---	1.76	2.02	---	2.02	2.23	---	2.23	2.45	---	2.45	2.57	---	2.57
Self-supplied Domestic	Gross	6.6	---	6.6	7.6	---	7.6	8.4	---	8.4	9.2	---	9.2	9.6	---	9.6
	Consumed	5.6	---	5.6	6.5	---	6.5	7.1	---	7.1	7.8	---	7.8	8.2	---	8.2
Agriculture Irrigation	Gross	1.6	0.53	2.1	5.6	1.5	7.1	9.8	2.2	12	14	2.8	17	18	3.4	21
	Consumed	1.6	0.53	2.1	5.6	1.5	7.1	9.8	2.2	12	14	2.8	17	18	3.4	21
Agriculture Livestock	Gross	0.70	0.28	0.98	0.80	0.32	1.1	0.91	0.36	1.3	1.0	0.41	1.4	1.2	0.47	1.7
	Consumed	0.70	0.28	0.98	0.80	0.32	1.1	0.91	0.36	1.3	1.0	0.41	1.4	1.2	0.47	1.7
Self-supplied Industry	Gross	2.68	0.09	2.77	3.08	0.10	3.18	3.39	0.11	3.50	3.73	0.13	3.86	4.10	0.14	4.24
	Consumed	0.50	0.02	0.52	0.57	0.02	0.59	0.63	0.02	0.65	0.69	0.02	0.71	0.76	0.03	0.79
Thermoelectric Power	Gross	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Consumed	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	Gross	29.2	0.90	30.1	37.3	1.92	39.2	44.8	2.67	47.5	52.4	3.34	55.8	58.6	4.01	62.6
	Consumed	10.2	0.83	11.0	15.5	1.84	17.3	20.7	2.58	23.3	25.9	3.23	29.2	30.7	3.90	34.6

WATER USE VERSUS AVAILABILITY

The current 0.90 mgd of gross surface-water demand and the 0.83 mgd of consumptive surface-water demand are adequately supplied by streamflow (Fig. 58). Most of this water use occurs in the upper reaches of the sub-basin near Sumter (Fig. 57). Projected 2020 gross surface-water use of 4.01 mgd should be supplied by streamflow 99.2 percent of the time. Consumptive surface-water use is expected to reach 3.90 mgd by 2020.

Future water supply development on small tributaries in the Lower Coastal Plain should include site specific hydrologic analysis to determine the quantity of streamflow available, particularly during dry years.

The historical range of well yields provides a reasonable projection of the average yield for individual wells in future development. These yields range from 250 gpm in the northwest portion to more than 1,000 gpm in central and southeastern parts of the sub-basin. Present ground-water use (29.2 mgd) can be provided by one well per 15 square mile area of the sub-basin pumped at a rate of 600 gpm for six hours each day. This would require 135 such wells throughout the sub-basin. Projected 2020 ground-water demand (58.6 mgd) will require 271 such wells, equal to one well per seven square mile area. Projected ground-water demands in the Black River Sub-basin can be met when proper management, well construction, well spacing, and hydrogeologic principles are applied. The duration curve indicates that discharges in the Black Creek at Kingstree bear little or no relation to the potential ground-

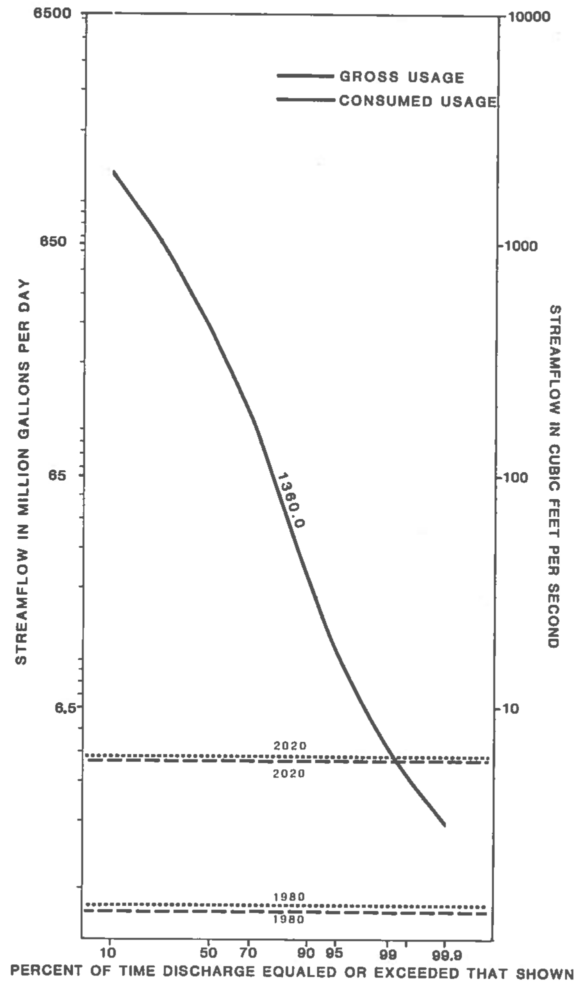


Figure 58.
Water use compared to availability in the Black River Sub-basin, South Carolina.

water availability.

Ground-water availability may be limited in certain areas of the sub-basin because of localized conditions of limited yields. Heavy pumpage in the vicinity of the Sumter and Georgetown areas has reduced the potentometric head of the Black Creek Aquifer System causing some interference between wells. To prevent future reduction of yields, new wells should be located outside of the present cone of depression.

Water quality problems may also limit current and projected ground-water use. High concentrations of chloride, fluoride, total dissolved solids, and a milky appearance due to suspended aragonite in some wells might present problems for the future utilization of water from the Black Creek and Middendorf Aquifer Systems.

Proper management of the ground-water resources within the Black River Sub-basin will require utilization of knowledge obtained through additional ground-water studies.

Major water resource problems and opportunities in the sub-basin are summarized in Table 51.

Table 51.
Major water resource findings in the Black River Sub-basin, South Carolina.

Opportunities

1. Current and projected water use is adequately met by surface-water supplies most of the time.
2. Upper Coastal Plain streams have well-sustained and reliable flows year round.
3. The Black River has generally good quality water and has shown signs of improvement in recent years.
4. Large quantities of ground water can be obtained throughout the sub-basin where three or four principal aquifer systems can be tapped.
5. The Middendorf and Black Creek Aquifer Systems are the most productive aquifer systems in the sub-basin and constitute the best potential sources for future ground-water development.

Problems

1. Most of the sub-basin occurs in the Middle and Lower Coastal Plain where streamflows are highly variable and unreliable.
2. Drainage of poor quality swamp water causes depressed dissolved oxygen levels and elevated fecal coliform bacteria levels during the summer and spring months.
3. The Pocotaligo River exhibits generally poor quality water with contraventions of some State standards occurring during summer and spring.
4. Occassional flooding from the Black and Pocotaligo Rivers adversely impacts the cities of Sumter, Kingstree, Manning, and Andrews.
5. Aquatic weed infestations in portions of the Pocotaligo River and the Black River impair recreational water use activities.
6. Chloride, fluoride, and total dissolved solids concentrations exceed acceptable drinking water standards in ground water near the coast.
7. High turbidity due to dispersed aragonite occurs in some wells.
8. Cretaceous aquifers near the coast are in part contaminated by saltwater.
9. Heavy ground-water withdrawals in the City of Sumter have caused water level declines in nearby wells.

Waccamaw River Sub-basin

GENERAL OVERVIEW

The Waccamaw River Sub-basin lies in the northeastern most portion of the State and runs roughly parallel with the coast which forms the eastern border of the basin. Sharing a 30 mile northern border with North Carolina, the basin includes all of Winyah Bay and the City of Georgetown at its southern extreme. The sub-basin emcompasses most of Horry County and a portion of Georgetown County (Fig. 59). Within the boundary of the basin is the popular seashore vacation area known as the Grand Strand. This coastal strip is comprised of a series of towns extending from Cherry Grove near the North Carolina border to Pawleys Island near Georgetown, South Carolina. The areal extent of the sub-basin is approximately 995 square miles, 3.2 percent of State land area.

Population

The 1980 population of the sub-basin was estimated at 102,100, about three percent of the State's total population (Table 52). By the year 2020 the sub-basin population is expected to reach about 236,300, an increase of about 130 percent. This is a rapidly growing region, with Horry County projected to increase by 150 percent from 1980 to 2020, and Georgetown County by almost 86 percent.

Horry County has a predominately rural population. Although the population classified urban increased by 71 percent from 1970 to 1980, the majority of the population resided in rural areas.

The major centers of population within the sub-basin are Georgetown (10,115) in Georgetown County and Myrtle Beach (17,351) and Conway (10,219) in Horry County. The transient population of the coastal Grand Strand area of Horry County increases dramatically during the summer months. The population in Myrtle Beach alone increases over tenfold during peak tourist season.

Economy

The 1979 per capita income was $6,108 in Georgetown County and $6,929 in Horry County, which ranked 13th among South Carolina's 46 counties. Per capita income in the State during this period was $7,056. The 1980 median household income in Horry County was $13,687, which was almost $3,000 below the State's average of $16,509.

In 1979, the annual average employment of non-agricultural wage and salary workers in Horry County was 38,300. The percentage breakdown by type of employment was: wholesale and retail trade, 28 percent; services and mining, 25 percent; manufacturing, 19 percent; government, 15 percent; construction, 6 percent; finance, insurance, and real estate, 4 percent; and transportation and public utilities, 3 percent. The relatively large percentage of employment in wholesale and retail trade, and other services, compared to that of the State, emphasizes the importance of tourist-oriented trade in this sub-basin.

Figure 59.
Location of the Waccamaw River Sub-basin in South Carolina.

Table 52.
Current and projected population for the Waccamaw River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)* 1980	1990	2000	2010	2020	*% Change 1980-2020*
Georgetown	62.8	27.7	34.0	41.3	47.7	51.4	85.6
Horry	74.8	74.4	104.5	135.8	166.2	184.9	148.5
Total		102.1	138.5	177.1	213.9	236.3	131.4

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

Inland of the coastal Grand Strand area, is a flourishing agricultural economy in Horry County. This county ranked first in the State for cash crop receipts from farm marketings in 1979 with a total of $63 million, over nine percent of the State's total.

SURFACE WATER

Hydrology

The Waccamaw River, Intracoastal Waterway, Sampit River, and Winyah Bay comprise the sub-basin's major waterbodies. Much of this sub-basin is covered by cypress and hardwood swamps and small tributary streams. The Waccamaw River is located entirely in the Lower Coastal Plain Province and has its headwaters and over half of its drainage area originating in North Carolina. The Waccamaw River and Sampit River flow directly into Winyah Bay. This large and important estuary also receives freshwater inflow directly from the Black and Pee Dee Rivers. The cities of Georgetown and Conway rely heavily on these surface waters for commercial transportation.

Only one gaging station on the Waccamaw River near Longs currently monitors streamflow in the sub-basin (Fig. 60). A gaging station also exists on the Waccamaw River outside of the sub-basin at Freeland, North Carolina. No crest-stage stations are located in this sub-basin. Streamflow statistics for the North Carolina and South Carolina gaging stations are presented in Table 53.

Average annual flow in the Waccamaw River near Longs is 1,223 cfs. Streamflow at this location equals or exceeds 47 cfs, 90 percent of the time. The steep slope of the flow-duration curve (Fig. 61), highly variable average and minimum monthly flows (Fig. 60), wide range between minimum and maximum monthly flows, and extremely low flow values (Table 53) indicate highly variable streamflows. Such poorly sustained streamflows are typical of streams in the Lower Coastal Plain due to diminished base flow support from shallow ground-water sources.

The lowest flow of record at Longs is 1.0 cfs and occurred during the drought of 1954. The record flood flow (16,000 cfs) was the result of tropical storm Dennis in 1981 which caused extensive flood related damage to developed areas near Conway. Occasional high flows on the Waccamaw River and poor drainage cause flooding in the vicinity of Conway.

Surface-water availability in the Waccamaw River is variable and generally unreliable as a major source. Adequate surface-water supplies can be guaranteed only if provisions for storage are developed.

Development

Typical of most of the State's Coastal Plain, surface-water development in the Waccamaw River Sub-basin is somewhat limited. Development in this sub-basin consists of numerous navigation and flood control projects (Fig. 62).

There are no large reservoirs within the sub-basin and the largest lake, Busbee Lake, has a surface area of only 400 acres and a volume of 1,100 acre-feet. The lake is used for recreation and supplies cooling water to the Grainger Steam Plant owned by the S.C. Public Service Authority. All lakes greater than ten acres in size have a total surface area of 625 acres and a volume of 1,225 acre-feet. Those lakes greater than 200 acres in surface area are shown in Table 54.

No hydropower facilities exist within the sub-basin nor have potential sites been identified.

The U. S. Army Corps of Engineers has a continuing navigation project in Georgetown Harbor where a channel is maintained from the ocean through Winyah Bay into the Sampit River. The Murrells Inlet navigation project was completed by the U.S. Army Corps of Engineers in 1980, while two other projects are active and a third is under study. Details of these projects are shown in Table 55.

The U.S. Army Corps of Engineers has completed five flood control projects in the sub-basin since 1957. In addition, several problem areas have been identified by both the U.S. Army Corps of Engineers and the Soil Conservation Service. These areas and their status are listed in Table 56.

Water Quality

Water bodies within the Waccamaw River Sub-basin include a wide range of water use designations (Fig. 63). The majority of fresh surface waters are designated Class A, suitable for swimming, fishing, and uses requiring water of lesser quality. Only the upper portion of the Sampit River is designated Class B. The entire ocean front area from Winyah Bay north to the North Carolina-South Carolina border, including Murrells Inlet, is designated Class SA.

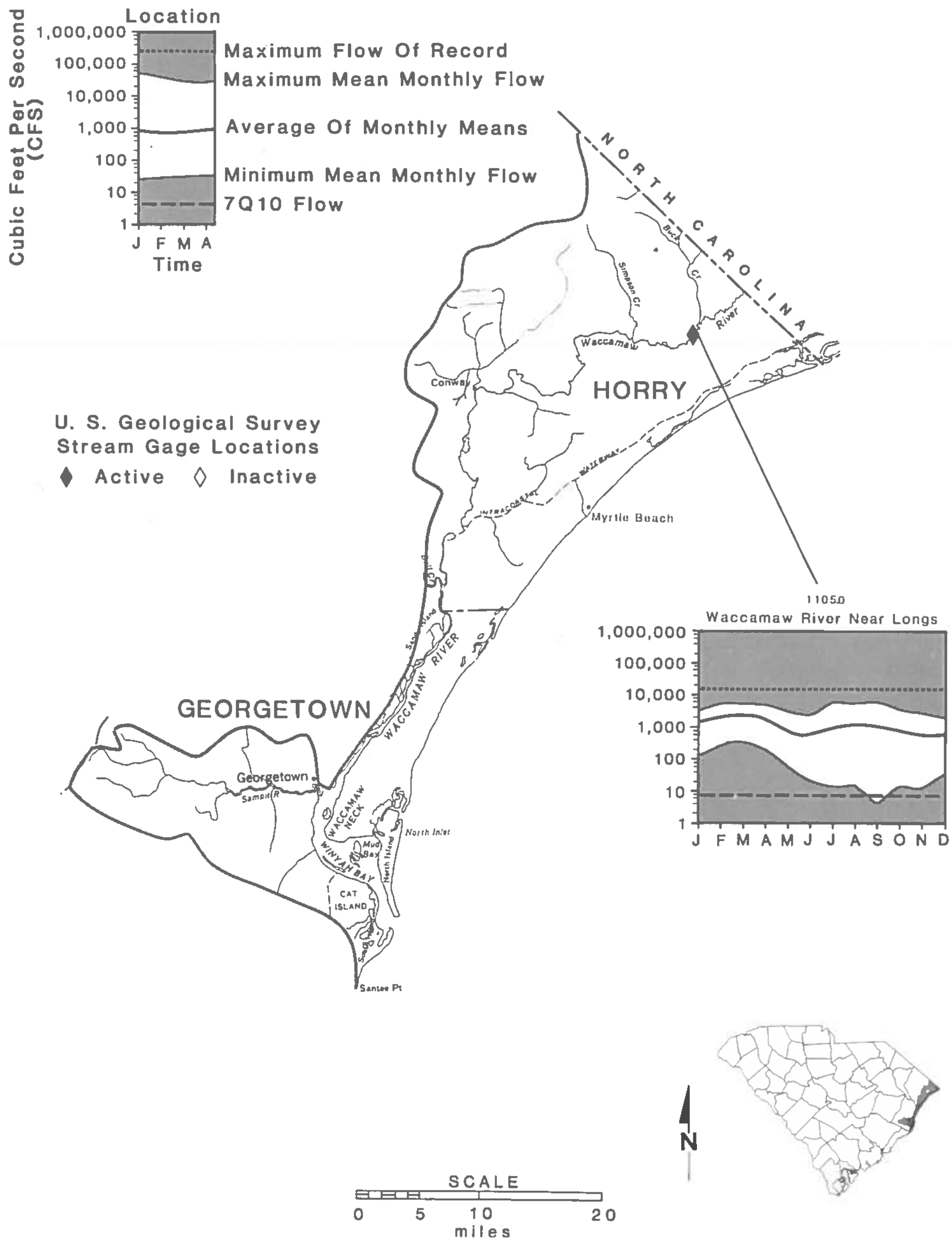


Figure 60.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Waccamaw River Subbasin, South Carolina.

Table 53.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Waccamaw River Sub-basin, South Carolina.

Gaging Station		Drainage Area	Period of Record		Average Flow				
							90%[a]	7Q10[b]	
Number	Name/Location	(mi^2)	Dates	Total Years	cfs	cfs/mi^2	cfs	cfs	cfs/mi^2
1095	Waccamaw River at Freeland, N.C.	680	Jul 1939-Present	41	710	1.04	47	6.8	0.01
1105	Waccamaw River near Longs	1110	Mar 1950-Present	30	1,223	1.10	23.2	0.99	0.001

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.

These tidal saltwaters are suitable for harvesting of clams, mussels, or oysters for human consumption and uses requiring waters of lesser quality. All of Winyah Bay and the lower reaches of the Sampit River are designated Class SC. These saltwaters are suitable for crabbing fishing, boating and the survival and propagation of marine animals and plants. Water quality limited segments which require advanced treatment of wastewater effluents include portions of the Waccamaw River, Intracoastal Waterway, and Sampit River and some of their tributary streams and several tidally influenced coastal waters between Myrtle Beach and North Inlet including Murrells Inlet (Fig. 64). While water quality in this sub-basin is adequate for most water use needs, several designated water use activities requiring high quality water are restricted or prohibited. Widespread fecal coliform bacteria contamination due to point and non-point source pollution poses the greatest threat to recreational water use and harvesting of shellfish.

The Waccamaw River exhibits good to satisfactory water quality (S. C. Department of Health and Environmental Control, 1980b). Occasional problem conditions include low dissolved oxygen concentrations and pH levels due to non-point source runoff and natural conditions. A slight improvement in fecal coliform bacteria levels has been evident during recent years. Earlier studies indicate widespread contraventions of fecal coliform bacteria and dissolved oxygen standards along this river and its tributaries (S. C. Department of Health and Control, 1976). These problem conditions occurred primarily during the spring and summer and were attributed mainly to industrial and municipal point source discharges near Conway.

The Intracoastal Waterway experiences frequent and widespread water quality violations which impact some water use activities. Problem conditions include depressed dissolved oxygen concentrations and elevated levels of fecal coliform bacteria (S. C. Department of Health and Environmental Control, 1976; Moore, Gardner and Associates Inc., undated). These problem conditions are attributed to point source discharges and non-point sources of pollution. Drainage water from adjacent swamplands also significantly impacts the quality of the Intracoastal Waterway. Fecal coliform bacteria contamination has restricted shellfishing in that portion of the Waterway near Little River Inlet (Fig. 64).

Water quality in the tidally influenced coastal waters is generally good (S. C. Department of Health and Environmental Control, 1976). However, occasional high levels of fecal coliform bacteria and some heavy metals from non-point sources adversely impact some water use activities (Moore, Gardner, and Associates, Inc., undated). Occasionally, shellfish harvesting in Murrells Inlet (Georgetown County) and Cherry Grove Inlet (Horry County) is prohibited due to fecal coliform bacteria contamination. This problem condition in Murrells Inlet in addition to frequent high levels of mercury and lead are attributed to septic tank seepage and highway runoff (Moore, Gardner, and Associates, Inc., undated). Stormwater runoff from the highly developed Myrtle Beach area adversely impacts recreational use of associated coastal waters due to elevated levels of fecal coliform bacteria and lead (Moore, Gardner, and Associates, Inc., undated).

The Sampit River, which receives municipal and industrial wastewater from Georgetown, exhibits only satisfactory water quality (S. C. Department of Health and Environmental Control, 1980b). Problem conditions include low dissolved oxygen and pH levels and high water temperatures. Water quality trends in this river are mixed with improving quality in terms of fecal coliform bacteria and decreasing quality in terms of dissolved oxygen and aesthetics. Shellfish harvests are prohibited from portions of this river due to poor water quality conditions (Fig. 64). The Waccamaw Regional Planning and Development Council identified the Sampit River as one of six major water quality problem areas in the Horry, Georgetown, Williamsburg County region (Moore, Gardner, and Associates, Inc., undated).

Water quality of Winyah Bay is generally suitable for Class SC water use needs. The bay, however, is heavily impacted by non-point source pollutants from the Black, Pee Dee, and Waccamaw Rivers and by industrial and municipal wastes from the Sampit River (Mathews and others, 1980). Fecal coliform bacteria contamination has closed shellfishing in most of the bay since 1964 and heavy sediment loading from influent streams requires frequent

Table 53 (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
1.0	Oct 14, 1954	16,000	Aug 1981
0.1	Aug 1930; Sep 9, 10, 28; Oct 4-14, 1954	10,200	Sep 25, 1955

dredging and causes dredge spoil disposal problems (Moore, Gardner, and Associates, Inc., undated). Data from sampling stations in the upper portion of Winyah Bay indicate generally satisfactory water quality (S. C. Department of Health and Environmental Control, 1980b). Problem conditions in this area include low dissolved oxygen and pH levels. The Waccamaw Regional Planning and Development Council has identified this important estuary as a major water quality problem area in the Horry, Georgetown, Williamsburg County region (Moore, Gardner, and Associates, Inc., undated).

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge in the sub-basin ranges from the evaluation level in most of the sub-basin to the development level in the coastal Grand Strand area (Fig. 18). Due to the capacity use designation of this area under the authority of the Ground Water Use Act, ground-water use within the sub-basin is managed. The S.C. Water Resources Commission requires permits and water use reports for all wells capable of using in excess of 100,000 gallons per day.

The Waccamaw River Sub-basin lies wholly within the Coastal Plain region. Basement rocks lie at a depth of about 1,300 feet below mean sea level at the South Carolina-North Carolina border and dip southwestward to about 2,200 feet in the Winyah Bay vicinity. Sediments of the Middendorf Aquifer System overlie the basement and are about 400 feet thick at the northeastern portion of the sub-basin and about 900 feet thick at the southwestern border of the sub-basin. Above the Middendorf Aquifer System lies the Black Creek Aquifer System which has a thickness of 600 to 750 feet throughout the sub-basin. A continuous clay layer between the Black Creek and the Middendorf hydraulically separates the two aquifer systems. Selected ground-water data for the sub-basin are presented in Table 57.

The Black Creek Aquifer System is the main source of ground water for municipal, industrial, and domestic water supply in Horry and Georgetown Counties. Aquifer tests in the Myrtle Beach area indicate a value of 30 ft/day for the average hydraulic conductivity, 2,700 ft²/day for the trans-

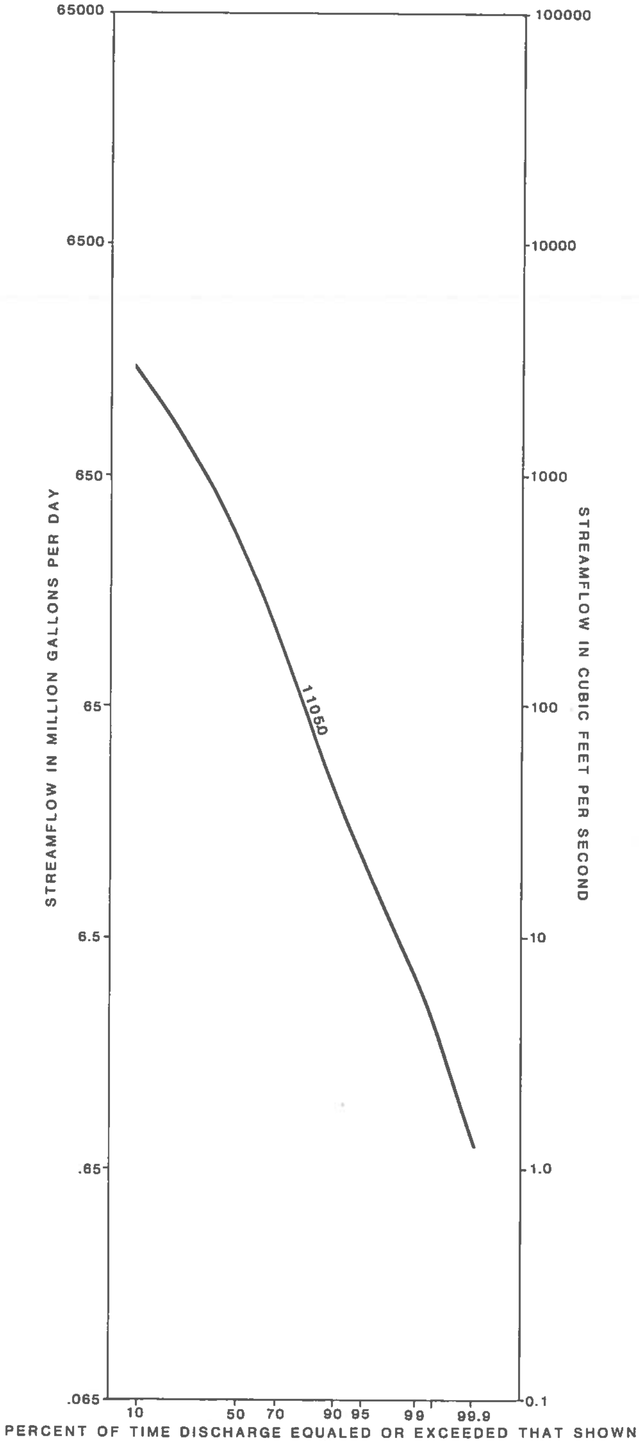


Figure 61.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Waccamaw River Sub-basin, South Carolina.

Table 54.
Existing lakes larger than 200 acres in the Waccamaw River Sub-basin, South Carolina.

Map No.	Name	Stream	Surface Area (acres)	Storage Capacity (acre-feet)	Purpose
1	Busbee Lake	Waccamaw River	400	1,100	Power Recreation
2	Unnamed	Bear Swamp	225	225	Wildlife

Source: S.C. Water Resources Commission, 1974.

Table 55.
U.S. Army Corps of Engineers navigation projects in the Waccamaw River Sub-basin, South Carolina.

Map No.	Project Name	County	Responsible District	Length (miles)	Width (feet)	Status/Remarks
3	Waccamaw River	Georgetown Horry	Charleston	41.5-21.5	80-50	Provides for a channel 18 feet deep, 80 feet wide from the mouth to Conway and then a cleared channel to Lake Waccamaw. Project is inactive except for portion from Georgetown to Conway.
4	Little River Inlet	Horry	Charleston	2.0-1.0	90-300	Authorized in 1972, provides a 12 foot deep channel across the ocean bar and then 10 feet deep to the Atlantic Intracoastal Waterway. Scheduled for completion in 1984.
5	Calabash	Horry	Charleston	1-5	--[a]	Studies underway to determine feasibility of providing channel 10 feet deep from the Atlantic Intracoastal Waterway at Little River, S.C. to Calabash, N.C.
6	Murrells Inlet	Horry	Charleston	3.0-0.6	90-300	Completed 1980
7	Georgetown Harbor	Georgetown	Charleston	17.9	400-600	Provides a 27 foot deep channel from the Atlantic Ocean, through Winyah Bay, to a turning basin in the Sampit River. A continuing project.

[a] -- indicates information not available.

Source: U.S. Army Corps of Engineers, 1982b.

Table 56.
Flood control projects in the Waccamaw River Sub-basin, South Carolina.

Map No.	Project/Watershed Name	County	Responsible Agency[a]	Status
8	Brown-Grier	Horry	SCS	Terminated
9	Waccamaw River	Horry/Georgetown	COE	Study completed 1981
10	White Oak Swamp	Horry	SCS	Recommended Study[b]
11	Myrtle Beach	Horry	COE	Recommended study of Intracoastal Waterway tidal flooding[c]
12	Socastee	Horry	COE	Unserviced or inactive
13	Buck Creek	Horry	COE	Completed 1969
14	Cowpen Swamp	Horry	COE	Completed 1959
15	Crabtree Swamp	Horry	COE	Completed 1966, additional study recommended
16	Simpson Creek	Horry	COE	Completed 1957
17	Todd Swamp	Horry	COE	Completed 1963
18	Georgetown Hurricane Study	Georgetown	COE	Recommended Study[c]

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.
[b] Non-sponsored study recommended by SCS.
[c] Non-sponsored study recommended by Flood Plain Management Task Group.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

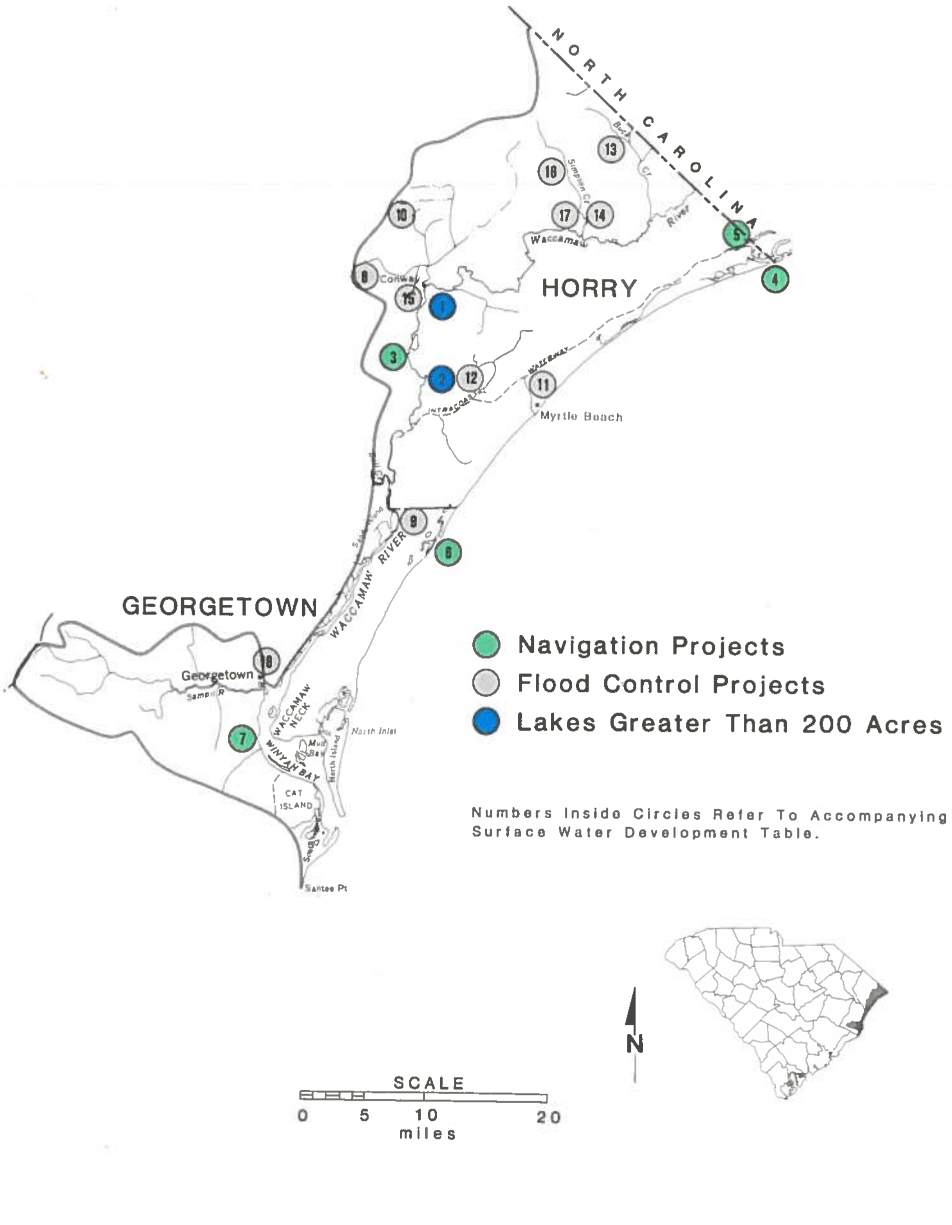


Figure 62.
Surface-water development in the Waccamaw River Sub-basin, South Carolina.

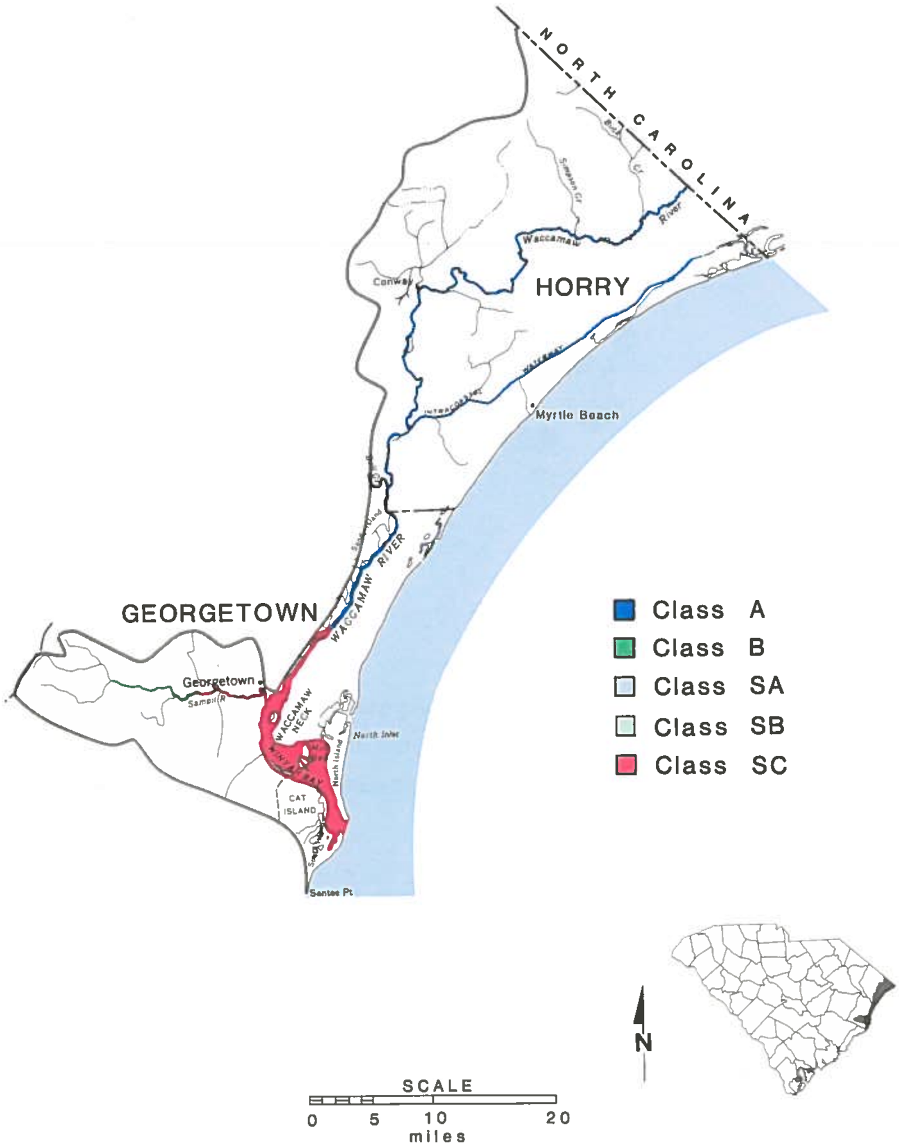


Figure 63.
Surface-water quality classifications in the Waccamaw River Subbasin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

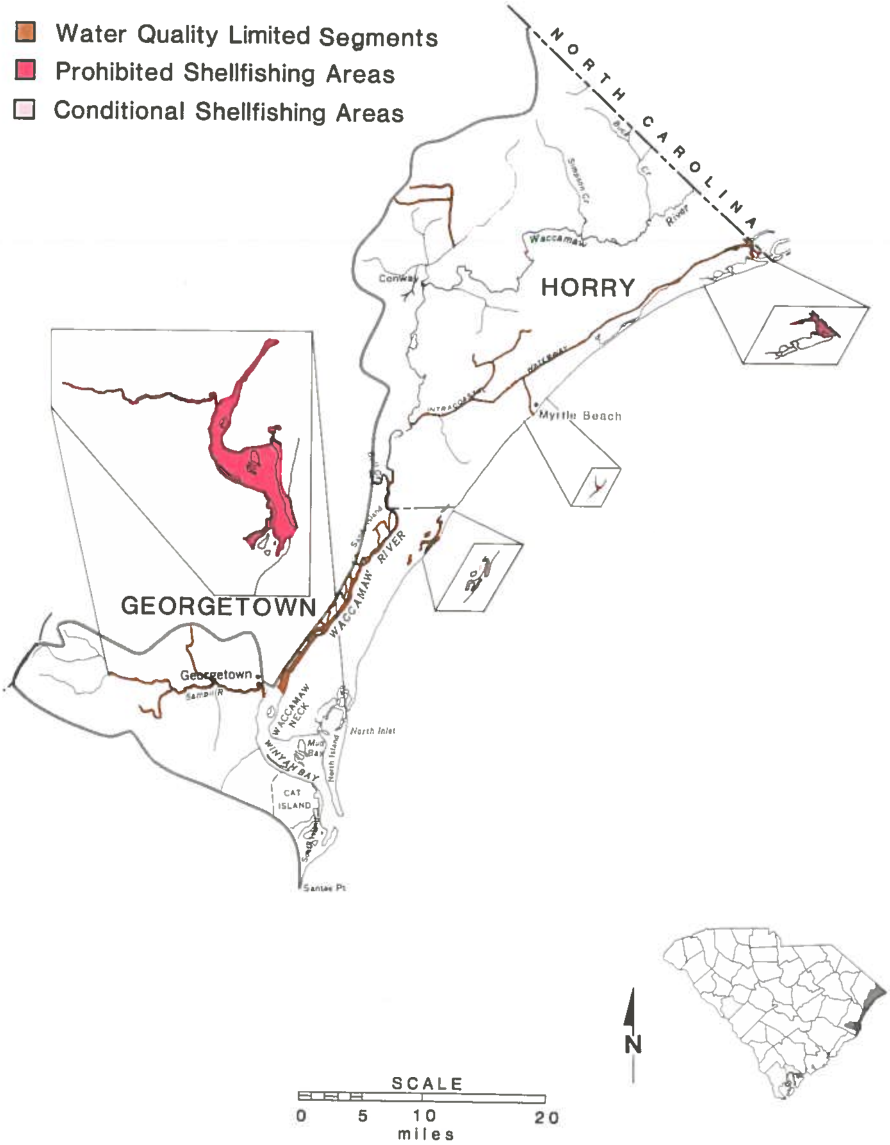


Figure 64.
Water quality limited segments and prohibited and and conditional shellfishing areas in the Waccamaw River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Table 57.
Selected ground-water data for the Waccamaw River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Myrtle Beach	Black Creek	265-880	350-620	4-7
Bucksport	Black Creek	380-590	200	--[a]
Georgetown	Black Creek	700-884	150	1.2-2.7

[a] -- indicates data not readily available.

missivity and 0.00026 for the storage coefficient (Zack, 1977). In the Bucksport area, wells screened opposite the Black Creek Aquifer System indicate a transmissivity of 1,300 ft²/day. Wells at Georgetown range from 690 to 1,344 feet deep and are usually screened at 700 to 884 feet.

The Peedee Aquifer System overlies the Black Creek Aquifer System and ranges in depth from 0 to 130 feet in the northwestern portion of the sub-basin and 200 to 500 feet in the southwestern part. Because of a large percentage of clay and fine-grained sand, the permeability of this aquifer is rather low, but is sufficient to meet domestic requirements by use of small-diameter wells.

Throughout the Waccamaw River Sub-basin thin beds of fine clayey sand, fine calcareous sand and coquina of Tertiary age overlie the Peedee Aquifer System. This shallow aquifer system is used for domestic water supply wherever the contained water is of good quality.

Water Quality

The greatest problem in developing ground-water supplies in coastal South Carolina and specifically in the Waccamaw River Sub-basin, is the occurrence or intrusion of brackish to salty water into the freshwater aquifers. The quality of water in the Middendorf Aquifer System is unacceptable as a water supply source in most of the sub-basin for this reason.

In the City of Georgetown, a well screened in the Middendorf at about 1,300 feet has leaked brackish water and contaminated shallower aquifers. This contamination increased chloride concentrations from 70 mg/L to 430 mg/L in a nearby well. After uncapping the contaminating well, which relieved the pressure and leakage of contaminated water, the chloride levels in the contaminated well returned to original levels (70 mg/L). Elevated chloride and hardness values at shallower depths (445-465 feet) west of Georgetown (Table 58) are currently unexplainable. More specific water sampling and chemical analyses will be required to obtain a better understanding of the water quality within the region.

The chemical quality of ground water from the Black Creek Aquifer System is the best available in the area, even though concentrations of total dissolved solids, fluoride, and in the coastal area chloride exceed acceptable drinking water standards. In water from municipal wells at Myrtle Beach, total dissolved solids range from 790 to 922 mg/L and the fluoride content ranges from 3.3 to 4.4 mg/L. In the vicinity of North Myrtle Beach-Little River, connate seawater, which has been trapped in the sediments since their formation, has not been completely flushed from the Black Creek Aquifer System on the flanks and summit of the Cape Fear Arch. The interface between the freshwater and the brackish water in the area between Myrtle Beach and Calabash, North Carolina occurs within the Black Creek Aquifer System (Table 59). The precise location of this interface is unknown, because existing wells are usually equipped with multiple screens and the water represents a composite from various depths. In the North Myrtle Beach vicinity, water from 119 to 695 feet deep contains over 1,000 mg/L of total dissolved solids. Fluoride content ranges from 4.2 to 5.2 mg/L, and the chloride concentration is about 300 mg/L. The Stiff Diagrams in Figure 65 show a sodium bicarbonate type of water quality. The increased pumpage from the Black Creek Aquifer System that created a general decline of water levels in wells in Horry and Georgetown Counties may also change the hydrologic properties and water quality characteristics of all aquifers in the coastal areas of this sub-basin. The possibility exists that the saltwater-freshwater interface has moved inland in response to heavy ground-water withdrawals.

The chemical quality of water in the Peedee Aquifer System is quite variable and generally poor. Throughout most of the area, water from this aquifer contains low concentrations of chloride and fluoride, but relatively high concentrations of iron and sulfate.

The U. S. Geoloical Survey test holes drilled into the Shallow Aquifer System at North Myrtle Beach indicate some saltwater contamination. In February, 1977, the S.C. Water Resources Commission conducted a study of the chemical quality of the Shallow Aquifer System in the Loris, Longs, and Red Bluff areas. The depths of the study wells ranged from 22 to 300 feet. Most of these shallow wells (30 to 38 feet deep) contained water with excessive amounts of iron. The total hardness ranged from about 130 to 250 mg/L, fluoride from 0 to 0.18 mg/L, and chloride from 3 to 108 mg/L.

Table 58.
Availability and quality of ground water at different depths near Georgetown.

Screen Type/Depth (ft)	*Yield (gpm)*	*Specific Capacity (gpm/ft)*	*Chloride (mg/L)*	*Hardness (mg/L)*	*Iron (mg/L)*	*Sulfate (mg/L)*	*Flouride (mg/L)*
Temporary Screen							
445-465	4	0.034	535	108	1.4	76	1.0
617-668	37.5	0.45	71	20	0.1	19	0.9
744-788	60	0.052	130	32	0.6	9	0.8
854-879	12	0.052	162	24	0.4	7	1.1
Permanent Screen							
625-655/ 770-790	75	0.62	92	18	0.9	15	0.9

Table 59.
Ground-water quality from various intervals in a test hole (6T-b2) at the Air Force Base, Myrtle Beach, Horry County.

Depth (ft)	*Chloride (mg/L)*	*Hardness (mg/L)*	*Iron (mg/L)*	*Sulfate (mg/L)*	*Fluoride (mg/L)*	*pH*	*Total Dissolved Solids (mg/L)*
321-340	108	55	0.35	0.0	1.8	7.6	524
376-407	60	9.0	0.8	0.0	4.0	9.4	624
450-463	42	25	1.2	0.0	---	8.5	758
540-560	67	7.0	1.0	0.0	2.9	8.6	734
695-700	96	7.0	0.8	0.0	3.0	8.8	792
770-790	118	6.0	0.2	0.0	3.0	8.7	830
840-860	380	23.0	0.3	0.0	7.0	8.5	1,582
890-910	590	22	0.65	12	4.6	8.7	1,881
1044-1054	1,330	50	0.74	4	2.1	7.6	3,278
1545-1554	1,280	51	0.75	0.0	1.1	7.9	3,290

WATER USE

Gross water use is currently estimated at 122.8 mgd of which 8.10 mgd is consumed (Table 60). This sub-basin gross usage is the ninth largest in the State. Thermoelectric power water use (104 mgd) is the leading water use, public supply use (14.7 mgd) is second, and self-supplied domestic use (3.20 mgd) is third. The major water users by type and supply source are shown in Figure 66. Surface water is the most heavily used source of water, supplying 85 percent of the demand. Excluding steam power use, ground water is the leading water source, supplying 99 percent of the remaining demand. Most of the ground-water withdrawals occur along the Grand Strand (Fig. 66) and are highly variable due to tourist influx in the summer. Most of this discharged ground water does not add to streamflow.

Public supply accounts for 12 percent of total gross use and 18 percent of consumptive use. Ground water is the only source utilized for public supply. This use is the largest gross use of ground water in the sub-basin.

Self-supplied domestic water use accounts for three percent of gross use and 33 percent of consumptive use. Ground water is the only source of supply utilized for self-supplied domestic purposes.

Agricultural water use is very limited in this sub-basin (0.30 mgd), comprising less than one-half of one-percent of the total gross use and four percent of total consumptive use. Irrigation withdrawals (0.10 mgd) come solely from surface water sources, while withdrawals for livestock come evenly from ground and surface-water sources. When averaged over the five-month growing season, irrigation water use is 0.24 mgd, comprising 0.2 percent of total sub-basin water use.

Approximately 33.2 mgd of surface water is diverted into this sub-basin from the lower portion of the Pee Dee River Sub-basin via a large canal. This interbasin transfer of water provides for 98 percent of all self-supplied industrial water use in the Waccamaw River Sub-basin and is accounted for in the Pee Dee River Sub-basin. Water obtained from within the Waccamaw Sub-basin boundary for use by self-supplied industry (0.60 mgd) accounts for less than one percent of total sub-basin gross use and about one percent of total consumptive use.

Water use for thermoelectric power generation is the largest gross water use (85 percent), consumptive water use, (44 percent), and surface-water use in the sub-basin. This water is taken solely from a reservoir built for this purpose and the impact of this large water withdrawal on downstream users is minimal.

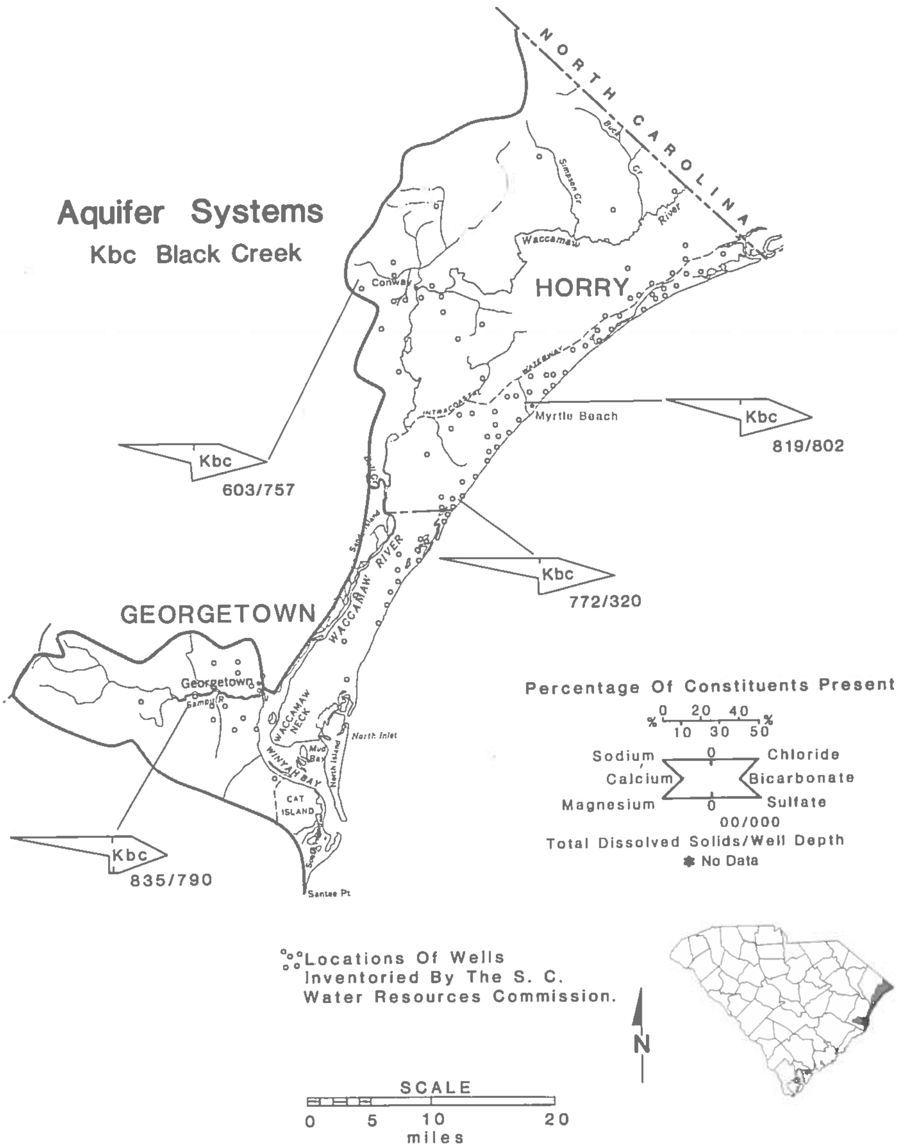


Figure 65.
Ground-water quality of selected aquifer systems and major inventoried wells in the Waccamaw River Sub-basin, South Carolina.

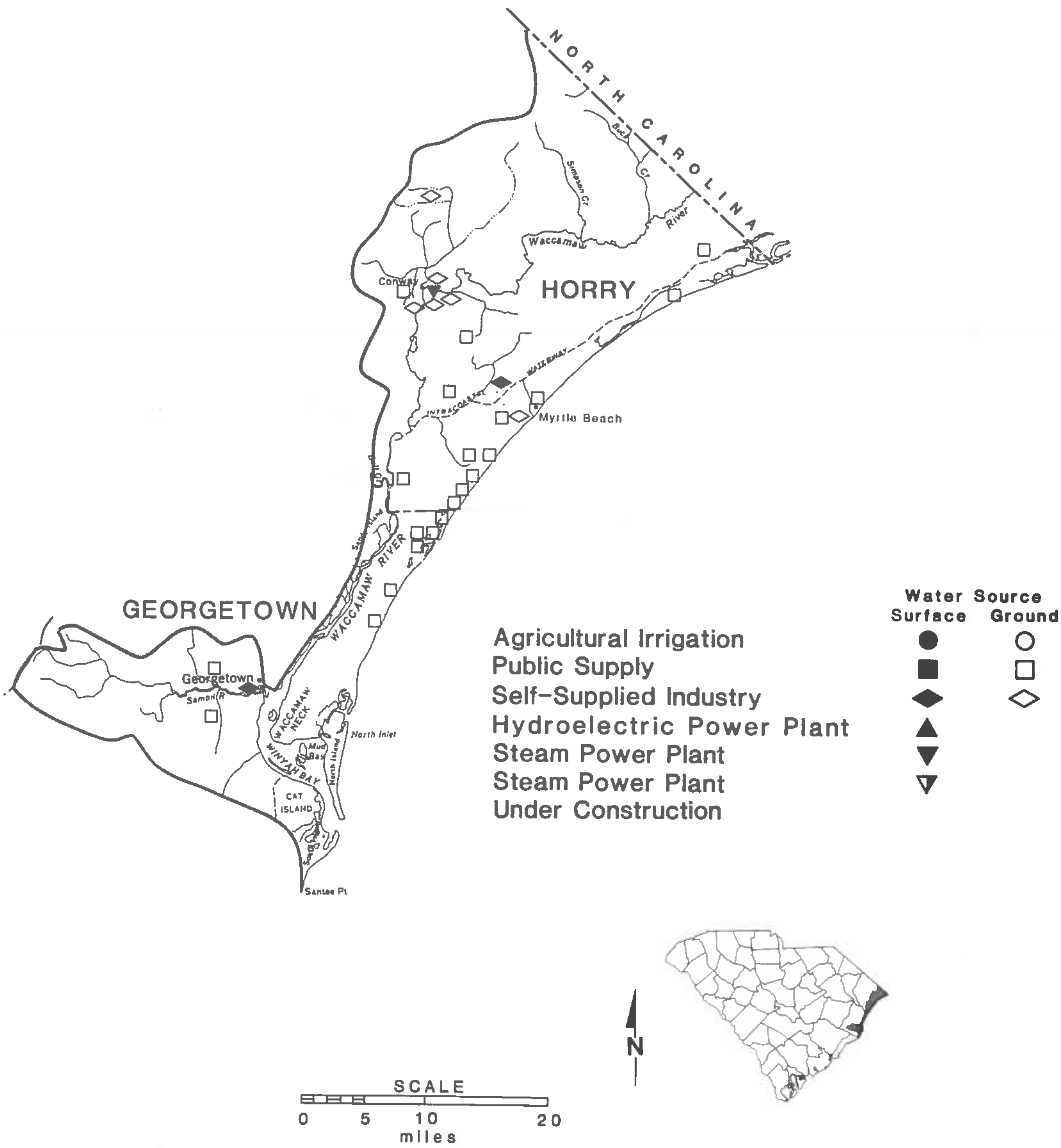


Figure 66.
Location, type, and supply source of water users in the Waccamaw River Sub-basin, South Carolina.

Table 60.
Current and projected water use in the Waccamaw River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water
Public Supply	Gross	14.7	---	14.7	19.9	---	19.9	25.8	---	25.8	31.0	---	31.0	34.1	---	34.1
	Consumed	1.47	---	1.47	1.99	---	1.99	2.58	---	2.58	3.10	---	3.10	3.41	---	3.41
Self-supplied Domestic	Gross	3.2	---	3.2	4.3	---	4.3	5.6	---	5.6	6.7	---	6.7	7.4	---	7.4
	Consumed	2.7	---	2.7	3.7	---	3.7	4.8	---	4.8	5.7	---	5.7	6.3	---	6.3
Agriculture Irrigation	Gross	---	0.1	0.1	---	0.28	0.28	---	0.41	0.41	---	0.54	0.54	---	0.64	0.64
	Consumed	---	0.1	0.1	---	0.28	0.28	---	0.41	0.41	---	0.54	0.54	---	0.64	0.64
Agriculture Livestock	Gross	0.11	0.09	0.20	0.13	0.10	0.23	0.14	0.12	0.26	0.16	0.13	0.29	0.19	0.15	0.34
	Consumed	0.11	0.09	0.20	0.13	0.10	0.23	0.14	0.12	0.26	0.16	0.13	0.29	0.19	0.15	0.34
Self-supplied Industry	Gross	0.56	0.04	0.60	0.64	0.05	0.69	0.71	0.05	0.76	0.78	0.06	0.84	0.86	0.06	0.92
	Consumed	0.10	0.01	0.11	0.12	0.01	0.13	0.13	0.01	0.14	0.14	0.01	0.15	0.16	0.01	0.17
Thermoelectric Power	Gross	---	104	104	---	107	107	---	110	110	---	114	114	---	117	117
	Consumed	---	3.52	3.52	---	5.81	5.81	---	9.58	9.58	---	15.8	15.8	---	26.1	26.1
Total	Gross	18.6	104	123	25.0	107	132	32.3	111	143	38.6	115	153	42.6	118	160
	Consumed	4.38	3.72	8.10	5.94	6.20	12.1	7.65	10.1	17.8	9.10	16.5	25.6	10.1	26.9	37.0

Gross usage is projected to increase about 31 percent to over 160 mgd in 2020. Thermoelectric steam power use should remain the leading gross and consumptive water use. Agricultural irrigation should show the greatest gross use increase, estimated at nearly 540 percent.

WATER USE VERSUS AVAILABILITY

The current 104 mgd gross surface-water demand is adequately supplied by streamflow 76 percent of the time (Fig. 67). However, almost all of this use occurs at the Grainger thermoelectric plant which is well supplied by 400 acre Busbee Lake. When this is taken into consideration streamflow is adequate to meet demands. Surfacewater consumption within the sub-basin is 3.72 mgd.

Projected 2020 gross surface-water demand is 118 mgd while consumptive surface-water demand is 26.9 mgd. Streamflow should be able to adequately meet these needs 99.8 percent of the time after water use for thermoelectric power (117 mgd gross, 26.1 mgd consumed) is omitted.

Any future surface water supply development in the poorly sustained Lower Coastal Plain Province should include site specific hydrologic analysis to determine the quantity of streamflow available, particularly at low rainfall times.

Present and projected ground-water demands in the Waccamaw River Sub-basin can be met when proper management, well construction, well spacing, and hydrogeologic principles are mantained. Probably a large percentage of the Middendorf Aquifer System contains brackish water and no wells in this sub-basin withdraw ground water from this aquifer. Large capacity wells completed in

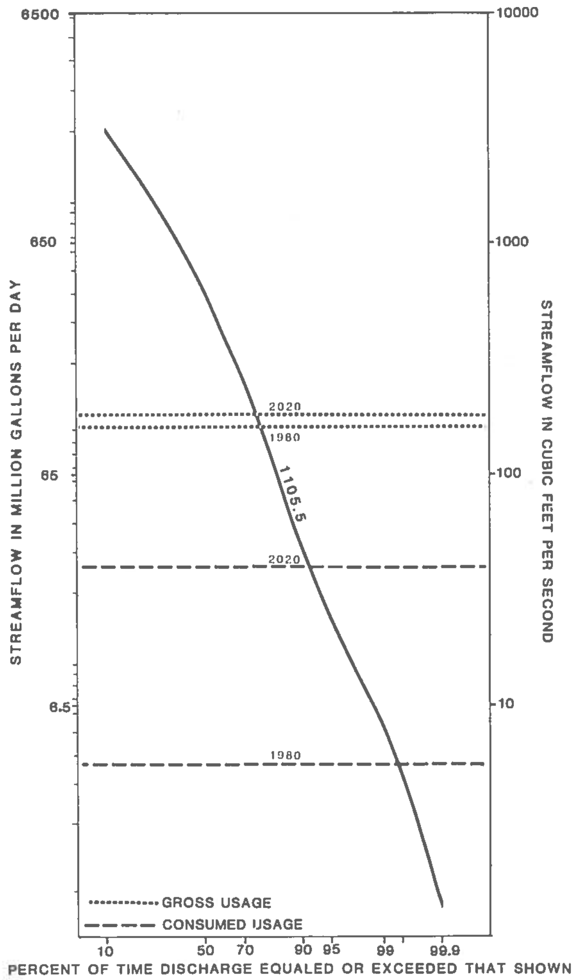


Figure 67.
Water use compared to availability in the Waccamaw River Sub-basin, South Carolina.

freshwater sands of the Black Creek Aquifer System, ranging in depth from less than 400 feet in the northern part of the sub-basin to approximately 900 feet in the southern portion and may range in yield from 250 to 500 gpm.

Present ground-water demand (18.6 mgd) can be supplied by approximately one well pumped at a rate of 600 gpm for six hours each day per 11 square mile area of the sub-basin. It would require a total of 86 such wells to meet current demand. Projected groundwater use requirements for 2020 (42.6 mgd) could be satisfied by 197 such wells throughout the sub-basin which is equal to one per five square miles.

Ground-water availability may be limited in localized areas of the sub-basin. The potential for contamination by saltwater encroachment and intrusion has been documented within the Black Creek Aquifer System (Siple, 1967b; Zack, 1977; Spigner and others, 1977). Heavy pumpage in the Myrtle Beach area during the past five years has caused excessive regional water level declines in the Black Creek Aquifer System. A lower transmissivity in the Black Creek Aquifer System in the southern portion of the sub-basin represents one of the major problems resulting in reduced well yields.

Continued ground-water management through the State permit system for construction of wells and reporting of ground-water use is expected to provide a framework for the reasonable and flexible development of this important resource.

Major water resource problems and opportunities in the sub-basin are summarized in Table 61.

Table 61.
Major water resource findings in the Waccamaw River Sub-basin, South Carolina.

Opportunities

1. Commercial navigation channels are maintained in Winyah Bay and the Sampit River with shallow draft navigation in the Waccamaw River from Georgetown to Conway.
2. Completion of the Little River Inlet project in 1984 will allow safe navigation to and from the ocean.
3. Completion of the Murrels Inlet project allows safe navigation to and from the ocean.
4. The Waccamaw River exhibits generally good quality water.
5. Projected ground-water demands can be supplied if proper management techniques are employed.
6. The Black Creek Aquifer System is underutilized in the upper portion of the sub-basin.
7. The Shallow Aquifer System can provide additional ground-water supplies in the upper portion of the sub-basin.

Problems

1. The entire sub-basin occurs in the Lower Coastal Plain where streamflows are poorly sustained year round.
2. Low topographic relief limits major reservoir development.
3. Severe beach erosion occurs in the vicinity of Myrtle Beach.
4. High flows in the Waccamaw River and poor drainage cause flood damage in the vicinity of Conway.
5. Fecal coliform bacteria contamination in the Intracoastal Waterway impairs recreational water use and shellfish harvesting.
6. High fecal coliform levels in Murrells Inlet and Cherry Grove Inlet occasionally restrict shellfish harvesting.
7. Stormwater runoff from the City of Myrtle Beach adversely impacts localized ocean quality due to temporary high lead and fecal coliform bacteria levels.
8. The Sampit River has generally degraded water quality due to heavy industrial and municipal wastewater discharges; shellfishing is prohibited in this river.
9. Winyah Bay has generally satisfactory water quality but is adversely impacted by non-point and point source pollutants; shellfish harvesting is prohibited from these waters.
10. Heavy sediment loading of Winyah Bay requires frequent dredging to maintain commercial navigation and causes dredge spoil disposal problems.
11. Infestations of the aquatic weed reedcane (Phragmites) in waterfowl management ponds, tidal marshes, and dredge spoil disposal sites impairs use of these areas.
12. Regional water level declines have occurred in the Black Creek Aquifer System, especially along the coast.
13. Saltwater can potentially contaminate all Cretaceous aquifer systems in coastal areas.
14. Portions of all aquifer systems exhibit localized high concentrations of total dissolved solids, chlorides, and fluorides.
15. High turbidity due to dispersed aragonite occurs in the Black Creek Aquifer System in the lower portion of the sub-basin.
16. Transmissivity of the Black Creek Aquifer System decreases in the lower portion of the sub-basin.

Sub-basin Analyses: Santee River Basin

Broad River Sub-basin

GENERAL OVERVIEW

The Broad River Sub-basin dominates the central Piedmont section of the South Carolina. Sharing a long northern border with North Carolina, the basin tapers in a southeasterly direction and terminates at the confluence with the Saluda River near Columbia. The sub-basin encompasses all or portions of 11 South Carolina counties, including all of Cherokee, Spartanburg, and Union Counties and portions of Chester, Fairfield, Greenville, Laurens, Lexington, Newberry, Richland and York Counties (Fig. 68). This is the largest sub-basin in the State, representing 12.2 percent of the land area, approximately 3,800 square miles.

Population

The sub-basin is the most populated of all sub-basins in the State with an estimated 1980 population in excess of 477,000, over 15 percent of the State's total population (Table 62). The sub-basin population is expected to reach approximately 665,000 by the year 2020, an increase of nearly 40 percent. The largest population increases during this time period are expected to occur in Greenville (59 percent) and Spartanburg (44 percent) Counties, while Chester County will exhibit the lowest growth rate (3 percent).

The northwest portion of the sub-basin contains the major urbanized centers, with the cities of Spartanburg and Greenville comprising part of the industrialized Interstate 85 corridor traversing the sub-basin. The remainder of the sub-basin is predominantly rural with an agricultural-based economy.

The major centers of population within the sub-basin are Spartanburg (43,507), Gaffney (13,209), and Union (10,541). Laurens (10,365) and Clinton (7,979) in Laurens County lie on the western boundary, and York (6,338) in York County is located on the eastern border of the sub-basin. The basin boundary is near the urban areas of Greenville (58,190) in the north and Columbia (96,237) in the south.

Economy

Per capita income in the sub-basin ranged from $6,114 in Union County to $8,201 in Greenville County, with a mean of $6,942, less than the State average of $7,056. Per capita income of Greenville and Spartanburg Counties ranked among the top ten counties in South Carolina. The 1980 median household income ranged from $16,000 in Newberry County to $18,996 in Greenville County, with four other counties having a median household income above the State's average of $16,509.

During 1979 the combined annual average employment of non-agricultural wage and salary workers was approximately 308,500, 26 percent of the State total. The percentage breakdown by type of employment was: manufacturing, 43 percent; wholesale and retail trade, 18 percent; government, 13 percent; services and mining, 12 percent; con-

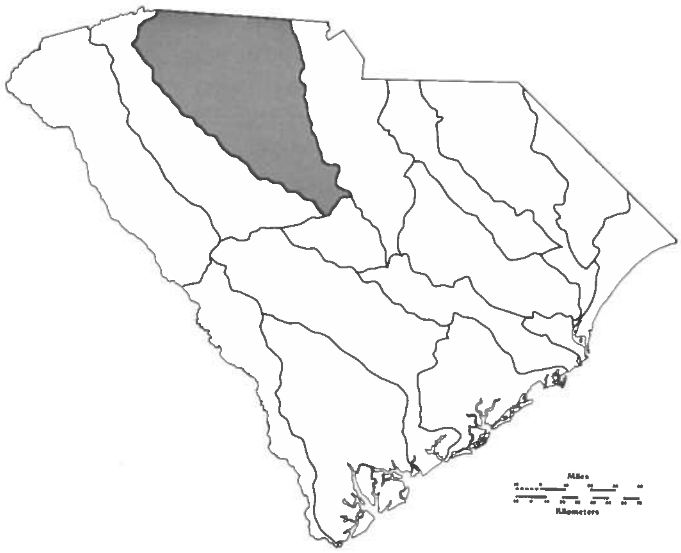


Figure 68.
Location of the Broad River Sub-basin in South Carolina.

Table 62.
Current and projected population for the Broad River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands)					% Change 1980-2020
		1980	1990	2000	2010	2020	
Cherokee	100.0	41.0	46.2	49.0	51.1	52.3	27.3
Chester	47.6	14.4	14.6	14.7	14.8	14.8	2.7
Fairfield	65.5	13.6	14.1	14.4	14.6	15.6	14.7
Greenville	29.1	84.1	101.2	115.0	126.8	133.3	58.5
Laurens	32.6	17.0	18.0	18.5	18.9	19.0	11.8
Lexington	0.2	0.3	0.4	0.5	0.6	0.7	133.3
Newberry	39.7	12.4	13.2	13.7	14.0	14.2	14.5
Richland	18.5	49.7	57.3	62.2	66.3	68.4	37.6
Spartanburg	100.0	202.2	239.1	260.0	279.8	290.5	43.7
Union	100.0	30.8	32.6	33.5	34.2	34.5	12.0
York	11.0	11.8	14.9	17.7	20.3	21.7	83.9
Total		477.4	551.6	599.2	641.4	665.0	39.3

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

struction, 6 percent; transportation and public utilities, 5 percent; and finance, insurance, and real estate, 3 percent.

The sector of manufacturing, mining and public utilities had an average annual product value of $6,326.4 million during fiscal year 1978-79, representing 29.4 percent of the State total.

Manufacturing is the economic focus of this portion of the State, with agriculture playing a minor role in the generation of income. Only Spartanburg ranked in the top 30 counties for cash receipts from farm marketing in 1979.

SURFACE WATER

Hydrology

The Broad River, with its headwaters originating in North Carolina, comprises the main stem of this large drainage system. Three large tributaries, the Pacolet, Tyger, and Enoree Rivers, originate primarily in South Carolina and discharge into the main stem river. Other smaller streams tributary to the Broad River or its major tributaries include Lawson Fork Creek, Fairforest Creek, Bullock Creek, Turkey Creek, Sandy River, Little River, and Cedar Creek. The entire drainage lies within the Piedmont Province except for the extreme headwater streams of the Pacolet and Tyger Rivers which occur in the Blue Ridge Province. Several urban areas including Spartanburg, Columbia, Greer, Gaffney, Union, York, and Winnsboro utilize these flowing waters.

Streamflow is presently monitored at eight gaging stations, two on the Broad River, one each on the Pacolet, South Pacolet, North Tyger, Tyger, and Enoree Rivers, and one on Cedar Creek (Fig. 69). Historic streamflow data are available from nine discontinued streamflow gaging stations and presented in Table 63. Streamflow data for the Broad River near Boiling Springs, North Carolina is also presented. Eight crest-stage stations (1537.5, 1563, 1575, 1596, 1600, 1601.3, 1605, 1608) record peak high-flow data. Lake gages on Lake William C. Bowen and Lake Monticello monitor surface elevation. Several small water supply and hydropower reservoirs located on the Broad, Pacolet, and Enoree Rivers generally have little effect on streamflow except during low-flow conditions. These developments were built prior to streamflow monitoring.

Average annual streamflow in the Broad River in South Carolina varies from 2,470 cfs near Gaffney, to 4,090 cfs near Carlisle, to 6,250 cfs north of Columbia. Streamflows at these sites are at least 960 cfs, 1,220 cfs, and 1,900 cfs, respectively, 90 percent of the time. This main stem river reflects streamflow characteristics typical of Piedmont streams which depend primarily on precipitation and surface runoff to support flows. In the upper portion of this river near Gaffney (Station 1535) where annual rainfall is highest (60 inches) and ground-water discharges are more significant, flows are well-sustained and moderately variable as reflected in the gently sloped flow-duration curve (Fig. 70), relatively narrow range between average and minimum monthly flow (Fig. 69), and fairly even minimum monthly flow year round. With distance downstream, flow becomes progressively more variable as rainfall and ground-water support in this lower portion of the sub-basin decreases. The increasing steepness of the flow-duration curve for the Broad River near Carlisle is probably due to influences from three upstream hydroelectric facilities and the paucity of tributary stream inflows. Low flows of record in the main stem occurred during the mid 1950's. The lowest flow of record (44 cfs) was recorded near Carlisle. The highest flow of record (228,000 cfs) occurred north of Columbia (Station 1615) in 1929.

Average annual streamflow in the three major tributaries is 488 cfs on the Pacolet River near Clifton, 465 cfs on the Tyger River near Woodruff, and 433 cfs on the Enoree River near Enoree. Ninety percent of the time, flow at these sites equals or exceeds 175 cfs, 150 cfs, and 135 cfs, respectively.

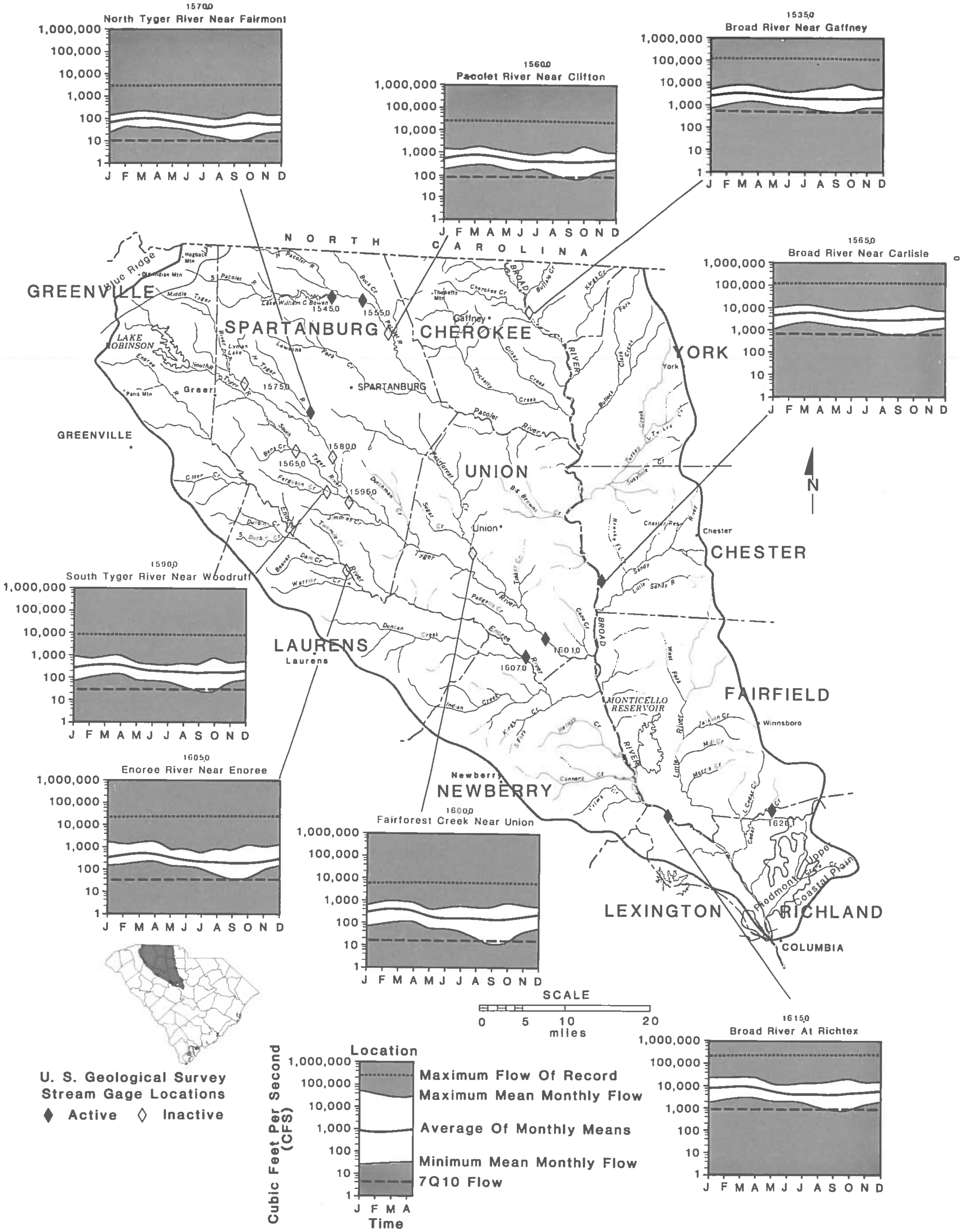


Figure 69.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Broad River Sub-basin, South Carolina.

Table 63.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Broad River Sub-basin, South Carolina.

Gaging Station		*Drainage*	*Period of Record*		*Average Flow*				
		Area		*Total*			*90%[a]*	*7Q10[b]*	
Number	*Name/Location*	*(mi²)*	*Dates*	*Years*	*cfs*	*cfs/mi²*	*cfs*	*cfs*	*cfs/mi²*
1515	Broad River near Boiling Springs N.C.	864	Jun 1925-Present	55	1,522	1.76	550	318	0.37
1535	Broad River near Gaffney	1,490	Oct 1938-Sep 1971	33	2,470	1.65	960	540	0.36
1545	North Pacolet River at Fingerville	116	Oct 1929-Present	51	215	1.84	81	43	0.37
1555	Pacolet River at Fingerville	212	Oct 1929-Present	51	488	1.66	125	61	0.29
1560	Pacolet River near Clifton	320	Oct 1939-Sep 1971	32	488	1.53	175	83	0.26
1565	Broad River near Carlisle	2,790	Oct 1938-Present	42	4,090	1.47	1,220	740	0.27
1570	N. Tyger River near Fairmont	44.4	Oct 1950-Present	30	67.1	1.51	24	10	0.23
1575	Middle Tyger River at Lyman	68.3	Oct 1937-Jan 1968	30	103	1.51	35	18	0.25
1580	N. Tyger River near Moore	162	Oct 1933-Jan 1968	34	233	1.44	76	36	0.22
1585	S. Tyger River near Reidville	106	Apr 1934-Dec 1967	33	160	1.51	22	17	0.16
1590	S. Tyger River near Woodruff	174	Oct 1933-Sep 1971	38	235	1.35	70	29	0.17
1595	Tyger River near Woodruff	351	Oct 1929-Sep 1956	27	465	1.32	150	71	0.20
1600	Fairforest Creek near Union	183	Jun 1940-Sep 1971	31	212	1.16	52	16	0.09
1601.05	Tyger River near Delta	759	Oct 1973-Present	7	1,240	1.63	*[c]	*	*
1605	Enoree River near Enoree	307	Aug 1929-1976	47	433	1.41	135	58	0.19
1607	Enoree River at Whitmire	444	Oct 1973-Present	7	648	1.46	*	*	*
1615	Broad River at Richtex	4,850	Oct 1925-Present	55	6,250	1.29	1,900	970	0.20
1620.1	Cedar Creek near Blythwood	48.9	Nov 1966-Present	13	50.5	1.03	4.3	0.5	0.01

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record
[d] Instantaneous maximum flow for period of record.
[e] * Indicates statistic not calculated.

Streamflow characteristics in the tributary streams are similar to those of the main stem. Flow is least variable in streams that drain the upper portion of the sub-basin where rainfall and groundwater support is greatest, while flow in streams that drain the lower portion of the sub-basin near Columbia shows the greatest variability. The most well-sustained flows occur in the North Pacolet River at Fingerville (Station 1545) as evidenced by the gently sloped flow-duration curve and high unit average discharge (1.84 cfs/mi²) and unit 7Q10 discharge (0.37 cfs/mi²). The most variable gaged flows occur in Cedar Creek near Blythewood (Station 1620.1) as indicated by the steeply sloped flow-duration curve and low unit average discharge (1.03 cfs/mi²) and unit 7Q10 discharge (0.01 cfs/mi²).

The lowest flows of record for tributary streams occurred primarily during the drought of 1954 - 1956. Flood flows of record are attributed primarily to three major storm events occurring in 1929, 1940, and 1976. Storm events producing peak flows appear to impact only limited areas of the sub-basin.

The Broad River provides reliable quantities of surface water along its entire length, although low flows are more well-sustained in the upper reaches. Reliable sources of surface-water supplies also occur in tributary streams in the upper portion of the sub-basin such as the Pacolet, Tyger, and Enoree Rivers. Streams that originate in the lower portion of the sub-basin near Columbia, such as the Little River and Cedar Creek, require storage to provide reliable water supplies year round.

Development

Surface-water development has been extensive within the Broad River Sub-basin. Most of this development has been for the production of hydroelectric power although several reservoirs have been built to provide municipal water supplies. Figure 71 shows the extent and distribution of development in the sub-basin.

Three major reservoirs exist within the sub-basin, Lake William C. Bowen, Lake Monticello, and Parr Reservoir (Table 64).

Lake William C. Bowen is located northwest of Spartanburg on the South Pacolet River. Having a surface area of 1,600 acres and a volume of 24,550 acre-feet, it is used by the City of Spartanburg as a municipal water supply and recreational area.

Lake Monticello and Parr Reservoir are located adjacent to each other approximately 26 miles northwest of Columbia, on Frees Creek and Broad River, respectively. Parr Reservoir, constructed in 1914 to provide water for hydroelectric production, has a surface area of 4,400 acres and a volume of 32,533 acre-feet. The lake currently provides cooling water for steam electric generating facilities located there and during the 1960's provided cooling water to the experimental Parr Nuclear Power Plant. In 1976 the dam was raised nine feet to be used in conjunction with the newly formed Lake Monticello to provide water for the Fairfield Pumped Storage facility located on Lower Frees Creek. Lake Monticello has a surface area of 6,800 acres and a volume of about 431,000 acre-feet. Built in 1977, the lake is intended to supply cooling water to the V.C. Summer

Table 63. (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
105	Oct 10, 1954	73,300	Aug 16, 1928
224	1954	119,000	Aug 14, 1940
28.0	Oct 6, 7, 1954	12,500	Aug 14, 1940
32.0	Oct 6, 7, 1954	22,800	Aug 14, 1940
17.0	Oct 19, 1942	26,800	Aug 14, 1940
44.0	Sep 2, 1956	123,000	Oct 10, 1976
7.0	Sep 19, 1954	3,610	May 26, 1959
5.0	Sep 24, 1955	4,800	Aug 14, 1940
16.0	Oct 3, 1954	12,300	Aug 14, 1940
5.5	Jun 6, 1941	6,420	Oct 7, 1949
12.0	Sep 23, 1955	9,510	Apr 6, 1936
29.0	Oct 4, 1954	28,000	Oct 2, 1929
4.5	Oct 8, 1954	7,720	Apr 8, 1964
262	Sep 16, 1980	30,300	Oct 11, 1976
20.0	Oct 2-4, 7, 1954	30,000	Oct 2, 1929
108	Sep 17, 1980	19,700	Oct 10, 1976
149	Oct 13, 1935; Sep 2, 1957	228,000	Oct 3, 1929
0.66	Oct 5, 6, 1968	4,870	Jul 4, 1968

Nuclear Unit and be the upper storage reservoir of the Fairfield Pumped Storage facility. During periods of peak electrical demand, water is drained from Lake Monticello into Parr Reservoir through turbines, generating electricity. At night when the demand for electricity is low, a portion of the Summer station's output will be used to provide the power necessary to pump water back up to Lake Monticello. The maximum drawdown of Lake Monticello will be five feet, while Parr Reservoir will fluctuate nine feet. Although heavily involved in the production of electricity, the waters of Parr Reservoir and Lake Monticello also serve recreational needs of local citizens.

Lakes more than ten acres in size have a total surface area of approximately 15,400 acres and a total volume of about 570,000 acre-feet. All lakes with a surface area greater than 200 acres are listed in Table 64.

Numerous sites have been identified within the sub-basin for potential hydropower development. However, it would not be possible to construct dams at all these sites as construction at some locations would preclude other potential and existing hydropower sites. All present and potential hydropower sites in the sub-basin are listed in Table 65. In addition, the S.C. Land Resources Conservation Commission has identified 26 potential small scale hydropower sites with a total potential capacity of 26.5 MW (Long, 1980).

There are no active navigation projects within the sub-basin and the only inactive one is the Columbia Canal. Constructed to provide a navigable route around the rapids at the confluence of the Broad and Saluda Rivers, the Columbia Canal was heavily used by barge traffic during the mid-1800's. After the introduction of the railroad,

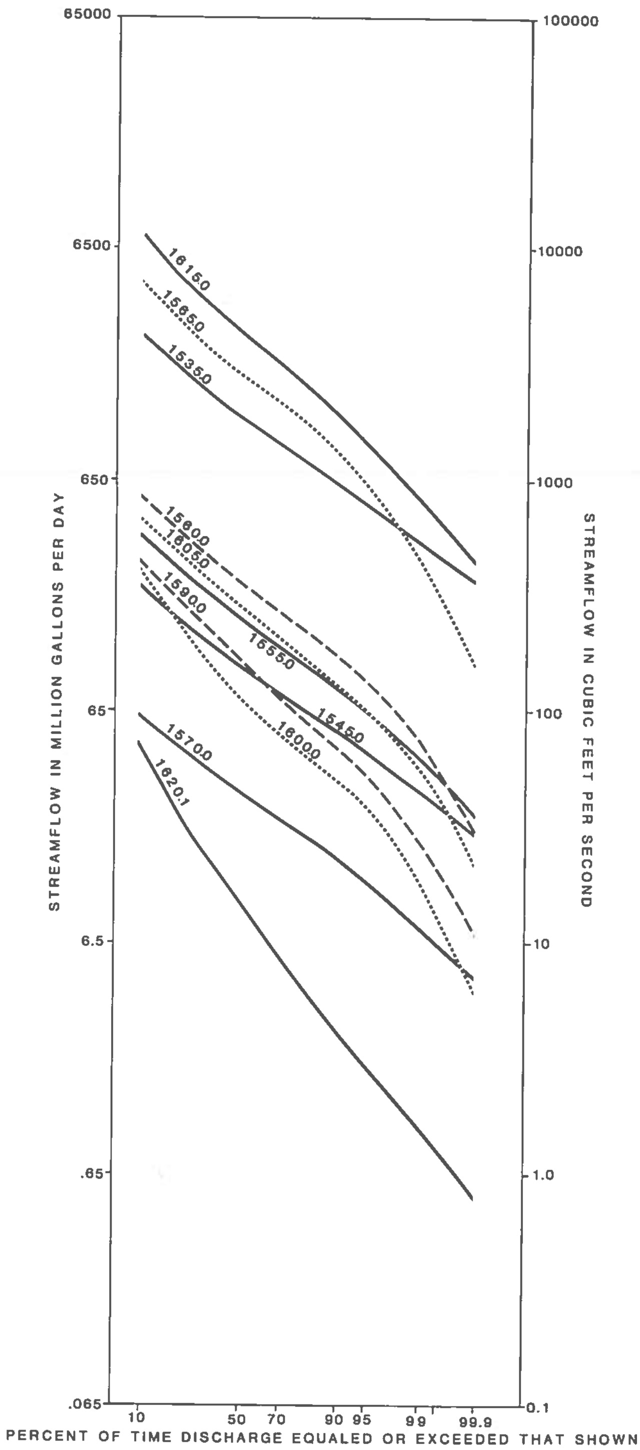


Figure 70.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Broad River Sub-basin, South Carolina.

Table 64.

Existing lakes larger than 200 acres in the Broad River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Parr Reservoir	Broad River	4,400	32,533	Power Recreation
2	Lake Monticello	Frees Creek	6,800	431,050	Power Recreation
3	Lake William C. Bowen	South Pacolet River	1,600	24,550	Water Supply Recreation Flood Control
4	Lake John A. Robinson	South Tyger River	802	14,490	Recreation Water Supply Sediment Storage
5	99 Islands	Broad River	885	19,000	Power Recreation
6	Gaston Shoals (Rainbow Lake)	Broad River	250	4,000	Power Recreation
7	Spartanburg Reservoir #1	South Pacolet River	301	2,920	Recreation Water Supply
8	Lockhart	Broad River	300	2,400	Power
9	Neal Shoals	Broad River	600	6,000	Power Recreation
10	Lyman Lake	Middle Tyger River	500	6,200	Industry Power
11	Lake Cunningham	South Tyger River	250	2,200	Recreation Water Supply

Sources: Federal Power Commission, 1970.
S.C. Electric and Gas Company, 1973.
S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1983a.

Table 65.

Existing and potential hydroelectric power development in the Broad River Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
12	Gaston Shoals	Cherokee	Broad	Duke Power Co.	5	9.1	250	Const. 1908
13	99 Islands	Cherokee	Broad	Duke Power Co.	7	19.7	885	Const. 1910
14	Columbia	Richland	Broad	SCE&G[a]	7	10.6	265	Const. 1894
15	Pacolet	Spartanburg	Pacolet	Milliken Co.	1	0.8	--[b]	Const. 1937
16	Lockhart	Union	Broad	Lockhart Power Co.	1	12.8	300	Const. 1920
17	Neal Shoals	Union	Broad	SCE&G	4	5.2	600	Const. 1905
18	Parr Shoals	Newberry	Broad	SCE&G	6	14.9	4,400	Const. 1914
19	Fairfield[c]	Fairfield	Frees Cr.	SCE&G	8	511.0	6,800	Const. 1977
20	Frost Shoals	Richland	Broad	--	--	177.0	8,900	Potential
21	Blairs	Fairfield	Broad	--	--	109.0	36,900	Potential
22	Spartanburg	Spartanburg	South Pacolet	City of Spartanburg	2	1.0	--	Const. 1925
23	Lyles Ford[d]	Fairfield	Broad	--	--	25.0	3,270	Potential
24	Blairs A[d]	Fairfield	Broad	--	--	63.1	9,224	Potential
25	Greater Lockhart	York	Broad	--	--	149.6	51,150	Potential
26	Greater Lockhart[e]	York	Broad	--	--	284.0	58,600	Potential
27	Greater Lockhart PS[c,e]	York	Broad	--	--	1,000	58,600	Potential
28	Greater Cherokee Falls	Cherokee	Broad	--	--	15.0	470	Potential
29	Greater Gaston Shoals	Cherokee	Broad	--	--	115.8	16,300	Potential
30	Trough	Spartanburg	Pacolet	--	--	6.9	1,340	Potential
31	Clifton #3	Spartanburg	Pacolet	--	--	2.6	29	Potential
32	Pacolet River	Spartanburg	Pacolet	--	--	6.6	1,050	Potential
33	W.C. Bowen Res.	Spartanburg	South Pacolet	City of Spartanburg	--	1.5	1,516	Potential
34	Whitmire[d]	Union	Enoree and Tyger	--	--	20.4	17,310	Potential
35	Tyger River	Union	Tyger	--	--	21.2	13,190	Potential
36	Burnt Factory	Spartanburg	Tyger	--	--	9.5	1,460	Potential
37	Print Crash	Spartanburg	Middle Tyger	--	--	1.1	32	Potential
38	Berry Shoals	Spartanburg	South Tyger	--	--	2.1	70	Potential

[a] SCE&G indicates S.C. Electric and Gas Company.
[b] -- indicates information not available.
[c] Pumped storage facility.
[d] Alternative to Blairs development.
[e] Alternatives to Greater Lockhart development.

Sources: Federal Power Commission, 1970.
S.C. Electric and Gas Company, 1973.
S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

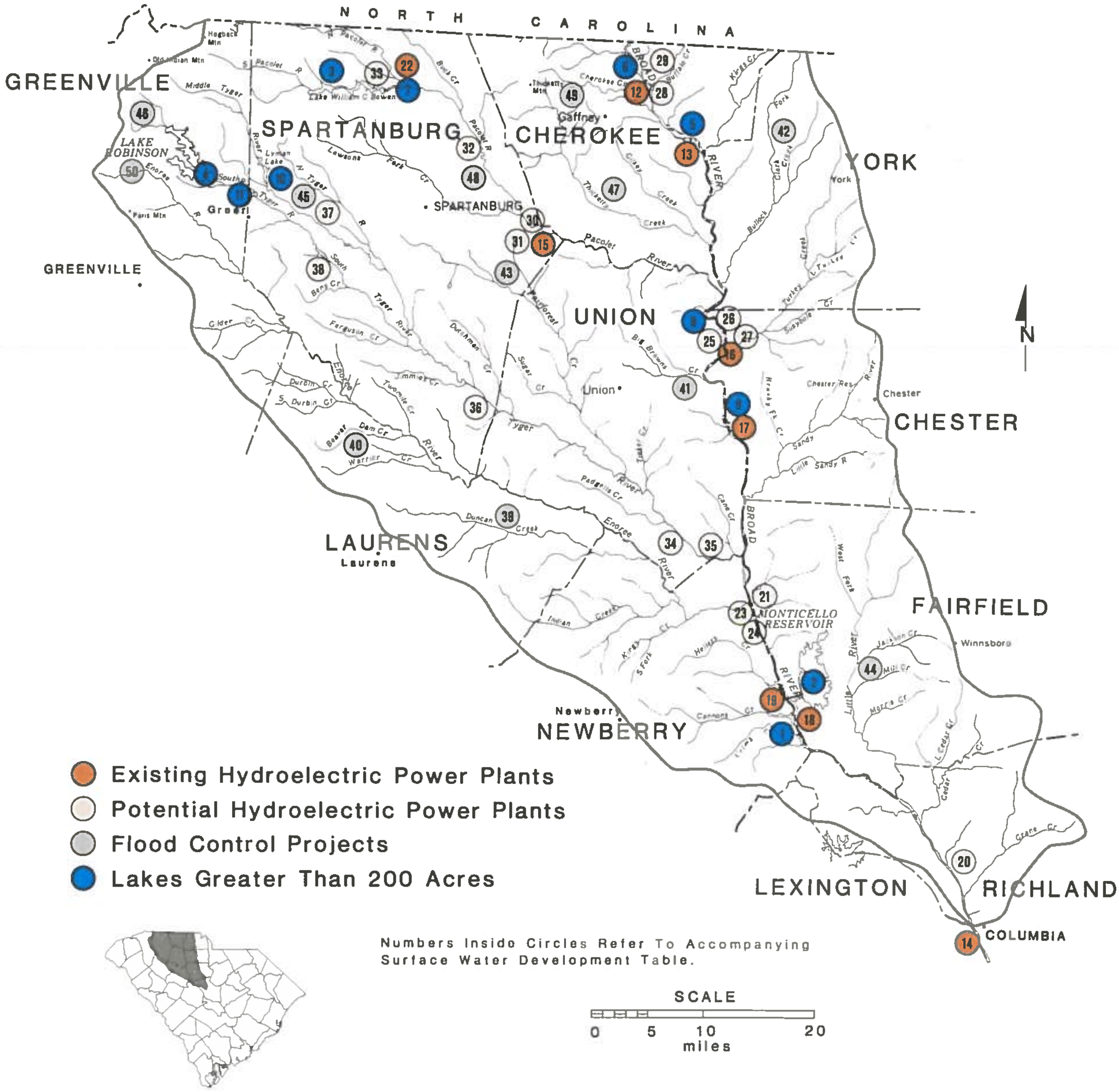


Figure 71.
Surface-water development in the Broad River Sub-basin, South Carolina.

Table 66.
Flood control projects in the Broad River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
39	Duncan Creek	Laurens	SCS	Completed 1974
40	Beaverdam-Warrier Creeks	Laurens	SCS	Completed 1982
41	Brown's Creek	Union	SCS	Under construction
42	Clarks Fork-Bullocks Creek	York	SCS	Under construction
43	Fairforest Creek	Union/Spartanburg	SCS	Under construction
44	Jackson-Mill Creeks	Fairfield	SCS	Complete 1982
45	North Tyger River	Spartanburg	SCS	Under construction
46	South Tyger River	Greenville	SCS	Under construction
47	Thicketty Creek	Cherokee/Spartanburg	SCS	Completed 1981
48	Pacolet River	Spartanburg/Greenville	SCS	Terminated
49	Will Camp Memorial	Cherokee	SCS	Terminated
50	Brushy Creek	Greenville	COE	Inactive

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.

Source: U.S. Department of Agriculture, 1980.

traffic on the canal decreased and the canal fell into disrepair. In the 1890's, the canal was repaired and a hydroelectric facility was constructed near its southern end. The canal and hydroelectric plant are still in use today. The City of Columbia also uses the canal as a source of municipal water supply.

The Soil Conservation Service has assisted in the planning and installation of flood control projects in the subbasin (Table 66). Out of the 40 floodwater retarding structures that were planned, 26 have been completed, including 9.7 miles of channel improvement. Land treatment for erosion control and sediment damage reduction was included in each of the projects. Five other projects are under construction and will include 19 floodwater retarding structures and 2.6 miles of channel improvement.

Water Quality

The Broad River mainstem and most tributary streams in this subbasin have Class B water use designations (Fig. 72). Water quality limited segments which require advanced treatment of wastewater discharges include all of Lake William C. Bowen, Timber Creek, Jackson Creek, and Crane Creek and several minor tributary streams throughout the sub-basin (Fig. 73). While water quality problems occur near urbanized areas of the sub-basin, water quality conditions generally meet designated standards for Class B waters.

Water quality in the Broad River is characterized as generally good (S.C. Department of Health and Environmental Control, 1977, 1980b). However, biological data, in addition to elevated levels of biochemical oxygen demand, fecal coliform bacteria, metals, phosphorus, and low dissolved oxygen, indicate somewhat poorer conditions in the lower reaches of the river near Columbia (U.S. Geological Survey, 1981; S.C. Department of Health and Environmental Control, 1980b; Central Midlands Regional Planning Council, 1979). Reduced water quality conditions in this portion of the river may be partially attributed to influent water from Crane Creek. This stream exhibits elevated levels of fecal coliform bacteria due to municipal wastewater discharges and urban stormwater runoff (S.C. Department of Health and Environmental Control, 1975a).

The Enoree River exhibits generally satisfactory water quality conditions. Occasional contraventions of State standards for dissolved oxygen; elevated levels of fecal coliform bacteria, turbidity, and metals; and sparse macroinvertebrate populations indicate some quality degradation (S.C. Appalachian Council of Governments, 1979; S.C. Department of Health and Environmental Control, 1980b; and U.S. Geological Survey, 1981). These problem conditions are attributed to municipal and industrial point source discharges and non-point source runoff from urban areas. Macroinvertebrate populations have been adversly affected by two 1979 oil spills which occurred in tributary streams (Carlson, 1979).

Water quality in the Tyger and South Tyger Rivers is good to satisfactory (S.C. Department of Health and Environmental Control, 1980b). These rivers drain a heavily urbanized area where industrial and municipal wastewater discharges, in addition to urban stormwater runoff, contribute to occasional elevated levels of fecal coliform bacteria, turbidity, biochemical oxygen demand, and metals (S.C. Appalachian Council of Governments, 1979; S.C. Department of Health and Environmental Control, 1980b).

The Pacolet and North Pacolet Rivers exhibit satisfactory and occasionally less than satisfactory water quality conditions (S.C. Department of Health and Environmental Control, 1980b). Fecal coliform bacteria contamination, high levels of turbidity, isolated pH problems, and significant quantities of metals from point and nonpoint sources all contribute to degrade water quality in these rivers (S.C. Department of Health and Environmental Control, 1975a; S.C. Appalachian Council of Governments, 1979). In recent years water quality has improved somewhat in terms of fecal coliform bacteria and overall quality.

Lake William C. Bowen has been classified as a mesotrophic lake indicating moderate nutrient imput. The U.S.

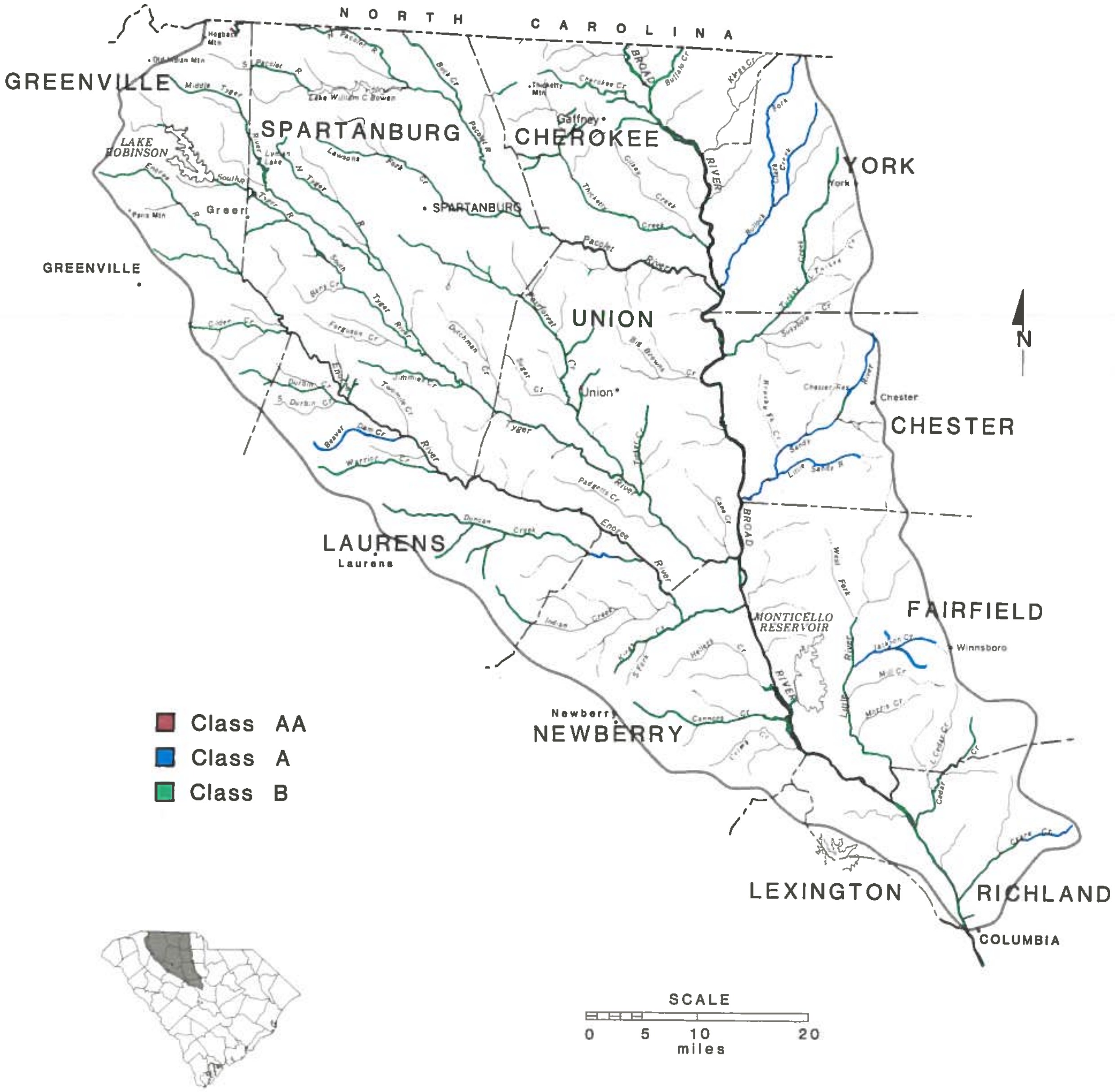


Figure 72.
Surface-water quality classifications in the Broad River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

Figure 73.
Water quality limited segments in the Broad River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Environmental Protection Agency (1976b) ranked this lake seventh in trophic quality out of 13 South Carolina lakes surveyed. That same agency also determined that 76 percent of the phosphorus entering the lake was due to non-point sources. About three-fourths of the shoreline is infested with the aquatic weed slender naiad (*Najas minor*) which impairs recreational and municipal water supply use of the lake (S.C. Aquatic Plant Management Council, 1982).

Water quality in Monticello Reservoir does not impair current water use activities. This recently impounded lake experiences depressed dissolved oxygen levels in deep waters during summer months (U.S. Geological Survey, 1981; Dames and Moore, 1981). While a fish kill of about 2,000 shad in August, 1980 was partially attributed to low dissolved oxygen concentrations, this condition is not unusual for stratified lakes of this type and aquatic organisms are generally unaffected.

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge in the sub-basin ranges from the field data level over most of the area to the evaluation level in Greenville County (Fig. 18).

The Broad River Sub-basin lies almost entirely within the Piedmont Province where ground water occurs principally in fractures formed by fault and joint systems and in the saprolite. The Coastal Plain sediments extend into the extreme southern portion of the sub-basin and constitute a shallow sandy aquifer. The Inner Piedmont belt underlies all of Greenville and Spartanburg Counties and parts of Laurens and Cherokee Counties. Included within the Kings Mountain belt are the middle portion of Laurens County, western Union County, and the western half of York County. Central Chester County, northern Fairfield County, and northwestern Richland County are underlain by the Carolina slate belt.

Saprolite in some areas is as much as 100 feet thick and serves as a medium for the collection of rainfall and recharge of ground water to fractures in the underlying rocks. The greatest water yields usually occur in areas where saprolite cover is the thickest. The number and size of fractures usually diminish with increasing depth and most wells do not exceed 300 feet. The supply of water from wells penetrating these rock units is reliable but limited and well yields are usually less than 50 gpm. Wells located on fracture zones in crystalline rock can produce 100 to 300 gpm, while other wells located in the same vicinity produce only 2 to 50 gpm. Topography can also have a significant impact on well yields. Valleys provide large areas for aquifer recharge and usually indicate areas of rock weakness where greater numbers of fractures occur. Wells located in valleys usually tend to have larger yields than wells in topographically high areas. The type of rocks encountered seem to have minor significance in determining well yields. At the present time, the complete ground-water potential is not known for much of this region and specific aquifer or hydrogeologic units are not delineated.

Generally, ground water within the sub-basin is somewhat limited and is available in quantities suitable only for domestic use. The average yield of wells is about 20 gpm. Although some wells are as much as 600 feet deep, 75 percent of all wells recorded are less than 250 feet. The available data indicate optimum depths for maximum yields range from 100 to 250 feet. Ground water within the basin is derived from precipitation with generally less than a third of the average annual rain fall available to recharge the ground water. Recharge is affected by downward infiltration of rainfall as it moves to discharge areas of lower elevation in springs, rivers, lakes or wells.

U.S. Geological Survey records for Greenville County include 709 wells with yields up to 200 gpm obtained from the crystalline rock and saprolite (Koch, 1968). Wells drilled to obtain maximum yields range in depth from 150 to 300 feet. The average yield from these wells is 17 gpm, while wells drilled into schist and gneiss have average yields of 15 to 20 gpm.

Ground water in Spartanburg County occurs in fractured igneous and metamorphic rocks and saprolite within the Inner Piedmont belt. The average discharge from wells drilled to obtain maximum yields is 53 gpm (Siple and Cummings, 1970). From a total of 299 wells inventoried by the U.S. Geological Survey, 75 percent are less than 250 feet deep.

Well records in Newberry County are sparse, however, U.S. Geological Survey records include information concerning 32 wells ranging from 20 to 400 feet deep with yields of 2 to 75 gpm. An engineering report (Barbot, 1977) includes information on 20 wells used by the Newberry County Water and Sewer Authority. The wells discussed in this report are 240 to 350 feet deep and yield 10 to 150 gpm. The specific capacity of these wells is only about 0.3 gpm/ft.

Data on 147 wells in York County indicate a range in well yields from 3 to 300 gpm and average about 50 gpm (Butler and Siple, 1966). U.S. Geological Survey records for Laurens County include 49 wells with recorded depths ranging from 34 to 563 feet and yields of 2 to 400 gpm.

In Cherokee County, fairly complete hydrologic data are available on 44 wells, concentrated mainly in the Gaffney-Blacksburg area. These wells range from 36 to 500 feet deep and yield 1 to 175 gpm.

Records available from the U.S. Geological Survey contain data on nine wells in the Broad River Sub-basin vicinity of Chester County. These wells range in depth from 60 to 500 feet. The yield per well ranges from 5 to 80 gpm.

Data for Fairfield County include information on 63 wells which range from 30 to 360 feet deep and yield 1 to 600 gpm.

Ground-water data are very limited in Union County although information concerning 18 wells is fairly complete. Wells located in the Jonesville vicinity, range in depth from 36 to 600 feet and yield 3 to 75 gpm.

The northwest portion of Richland County in the Broad River Sub-basin is underlain mostly by argillite of the

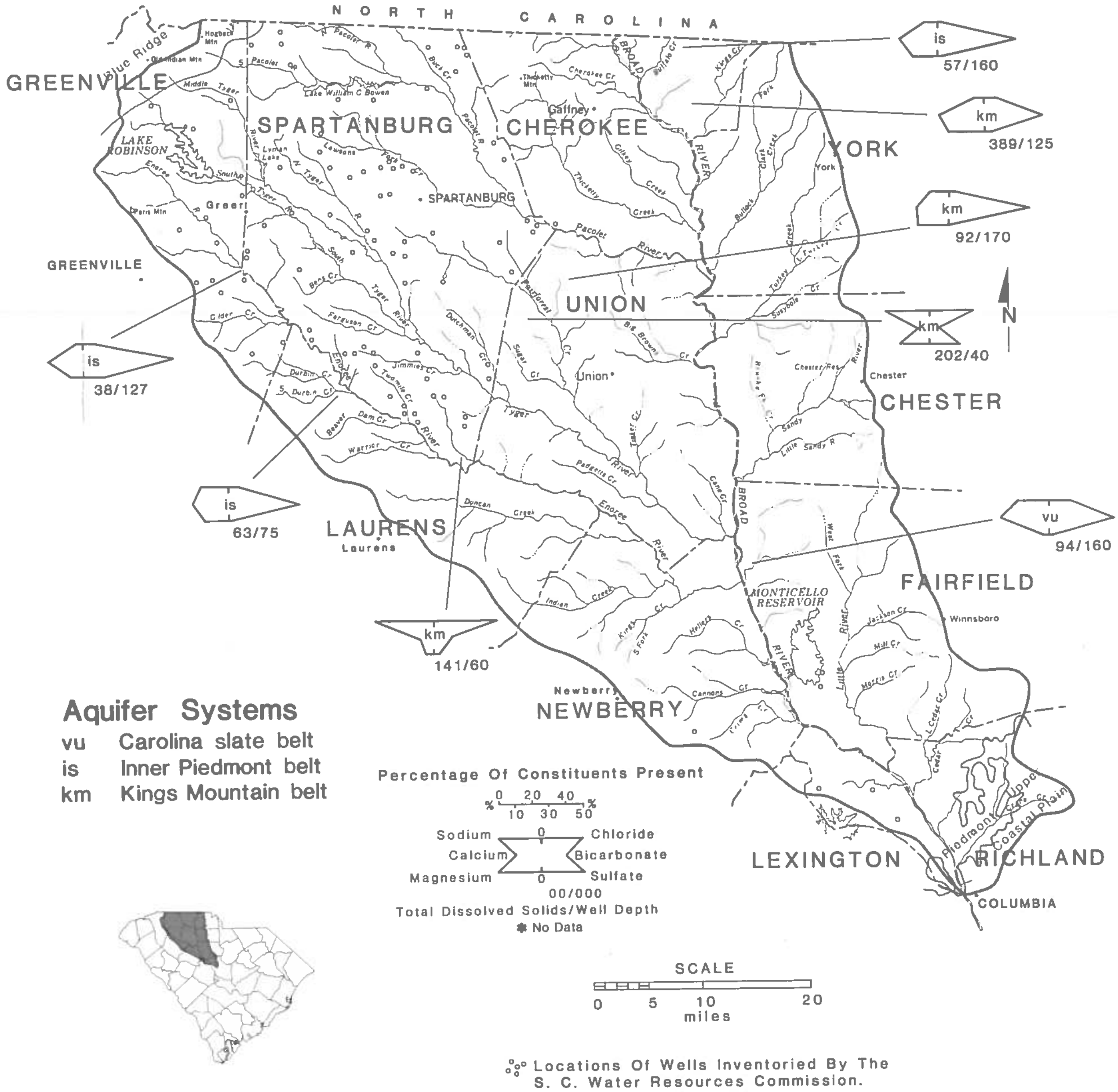


Figure 74.
Ground-water quality of selected aquifer systems and major inventoried wells in the Broad River Sub-basin, South Carolina.

Carolina slate belt. The extreme southeastern edge of the sub-basin is underlain by approximately 50 feet of unconsolidated sands, gravels, and clays of the Middendorf Aquifer System which were deposited over the Carolina slate belt. Data from the U.S. Geological Survey include information on 347 wells. The depths of 20 wells in Richland County within the Broad River Sub-basin range from 26 to 300 feet and yields range from 2 to 50 gpm. Available data in the vicinity of Ballentine, Blythewood, and Killian indicate that most wells are used primarily for domestic purposes, and maximum yields have not been developed. Therefore, data are considered inadequate to determine potential yields of the two aquifer systems in this area.

Water Quality

Chemical quality of the ground water from wells within the Broad River Sub-basin is generally very good, although in some areas water is rather hard. Water from the light-colored acidic rocks such as granite, granite-gneiss and mica schist, is soft, slightly acidic, and contains low levels of dissolved minerals. Water from rocks such as hornblende gneiss or schist, diorite, gabbro, and diabase, is slightly alkaline, fairly hard, and relatively high in dissolved solids. This water might also contain high amounts of dissolved iron. Chemical analyses of ground water from Newberry County indicate total dissolved solids ranging from 155 to 195 mg/L, total hardness of 100 mg/L, dissolved iron from 0 to 0.1 mg/L, chlorides from 9 to 12 mg/L, fluoride from 0.1 to 0.3 mg/L, and pH from 6.1 to 7.3. Radiochemical analyses indicate that the Ra-226 and Pb-214 (radioactive isotopes of radium and lead) concentrations in two wells located in Jenkinsville, Fairfield County, exceed acceptable drinking water standards. These wells penetrate rocks of the Charlotte belt. One of these wells is 265 feet deep and has a Ra-226 content of 6 pCi/L (picocuries per liter), while the other is 355 feet deep and has a Ra-226 content of 4 pCi/L. Both wells have been disconnected from the public supply system. The Stiff Diagrams (Fig. 74) show water quality for this sub-basin ranging from a sodium chloride type to a calcium bicarbonate type.

WATER USE

Gross water use in the Broad River Sub-basin is currently 129 mgd and consumptive use is 23.5 mgd (Table 67). Total gross water use in this sub-basin is the eighth largest in the South Carolina. Public supply (92.9 mgd), self-supplied industry (21.6 mgd), and agricultural irrigation (7.4 mgd) are presently the largest gross water user groups. The major users by type and supply source are shown in Figure 75.

Surface-water sources supply 96 percent of all water use needs, while ground water is a major supply source for only self-supplied domestic needs. This sub-basin has the greatest surface-water use and total water use by public supply systems in the State.

Public supply withdrawals represent 72 percent of gross demand and 40 percent of consumptive use, making this user group the largest gross and consumptive water user in the sub-basin. This user group is also the largest surface-water user (91.2 mgd) in the sub-basin, withdrawing 98 percent of supply needs from this source. This sub-basin has the largest surface-water and total water use for public supply of all sub-basins in the State.

Self-supplied domestic use accounts for two percent of gross use and seven percent of consumptive use. This small user group depends completely upon ground-water supplies

Table 67.
Current and projected water use in the Broad River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water
Public Supply	Gross	1.72	91.2	92.9	1.98	103	105	2.18	112	114	2.39	115	117	2.51	126	129
	Consumed	0.17	9.12	9.29	0.20	10.3	10.5	0.22	11.2	11.4	0.24	11.5	11.7	0.25	12.6	12.9
Self-supplied Domestic	Gross	1.9	---	1.9	2.2	---	2.2	2.4	---	2.4	2.6	---	2.6	2.8	---	2.8
	Consumed	1.6	---	1.6	1.9	---	1.9	2.0	---	2.4	2.2	---	2.2	2.4	---	2.4
Agriculture Irrigation	Gross	0.04	7.4	7.4	0.14	20	20	0.25	31	31	0.34	40	40	0.45	48	48
	Consumed	0.04	7.4	7.4	0.14	20	20	0.25	31	31	0.34	40	40	0.45	48	48
Agriculture Livestock	Gross	0.52	0.62	1.1	0.59	0.71	1.3	0.68	0.81	1.50	0.77	0.92	1.7	0.88	1.1	2.0
	Consumed	0.52	0.62	1.1	0.59	0.71	1.3	0.68	0.81	1.50	0.77	0.92	1.7	0.88	1.1	2.0
Self-supplied Industry	Gross	1.63	20.0	21.6	1.87	23.0	24.9	2.06	25.3	27.4	227	27.8	30.1	2.49	30.6	33.1
	Consumed	0.30	3.70	4.0	0.35	4.26	4.61	0.38	4.68	5.06	0.42	5.14	5.56	0.46	5.66	6.12
Thermoelectric Power	Gross	---	4.00	4.00	---	767	767	---	790	790	---	814	814	---	838	838
	Consumed	---	0.02	0.02	---	8.43	8.43	---	66.5	66.5	---	110	110	---	181	181
Total	Gross	5.81	123	129	6.78	914	920	7.57	959	967	8.37	998	1,010	9.13	1,040	1,050
	Consumed	2.63	20.9	23.5	3.18	43.7	46.9	3.53	114	118	3.97	168	172	4.44	248	253

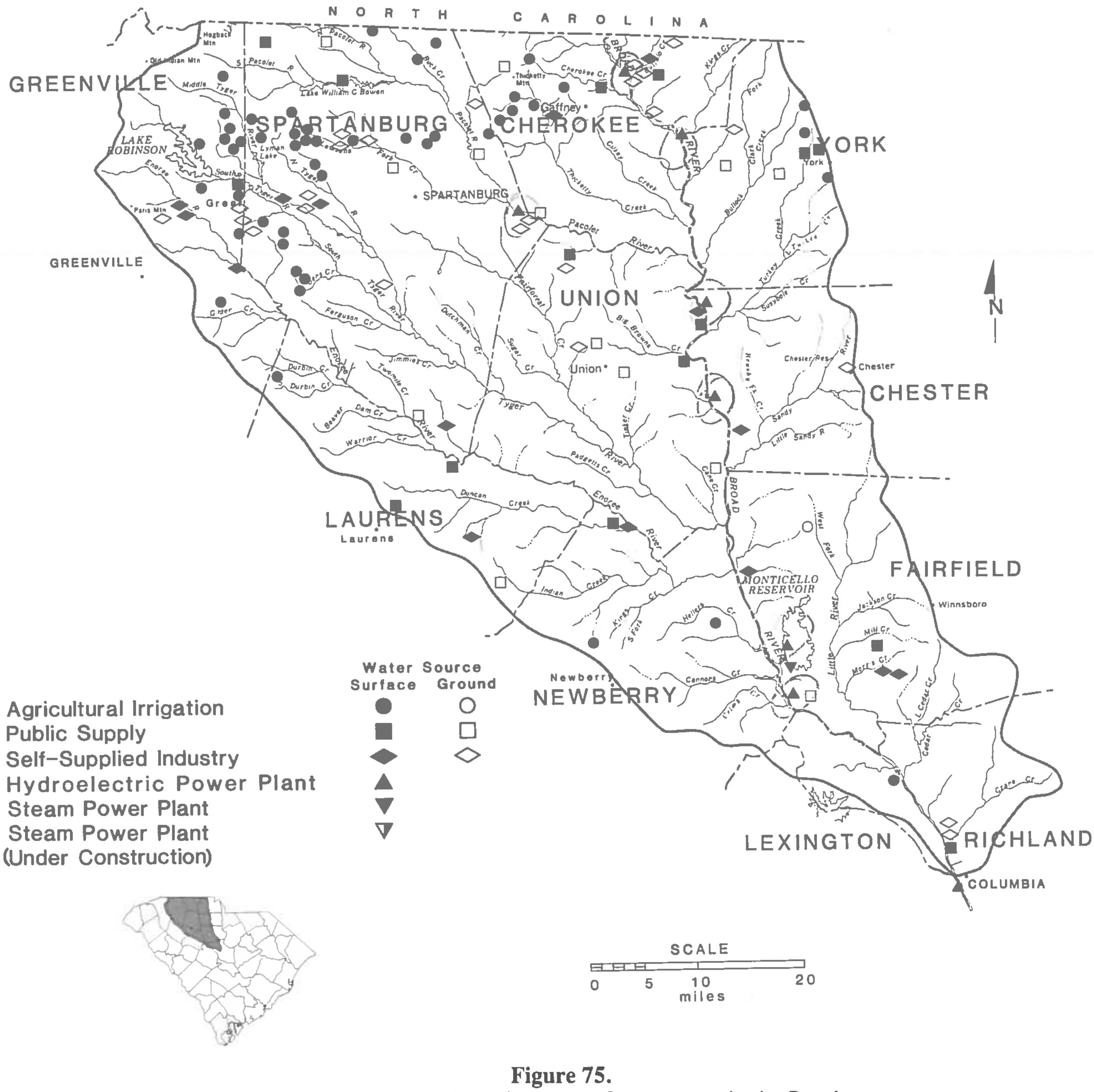


Figure 75.
Location, type, and supply source of water users in the Broad River Sub-basin, South Carolina.

and is consequently the largest ground-water user (1.90 mgd) in the sub-basin.

Water use for agricultural activities comprises almost seven percent of total gross use. Irrigation of over 10,000 acres in the sub-basin accounts for six percent of gross use and 25 percent of consumptive use. Virtually all irrigation water (99 percent) is withdrawn from surface-water sources. When averaged over the five-month growing season, irrigation water use equals 18 mgd and comprises 13 percent of total sub-basin use. Water use for livestock represents about one percent of gross use and five percent of consumptive use. Approximately one-half of livestock water is obtained from ground-water and half from surface-water sources.

Self-supplied industry accounts for about 17 percent of gross demand and about 17 percent of consumptive use. Most industrial water use occurs in the upper portion of the sub-basin and is heavily dependent (93 percent) upon surface-water sources.

Currently, thermoelectric power production represents almost three percent of gross and less than one percent of consumptive use. However, two power plants under construction are anticipated to substantially increase demand by this user group. All cooling water for these facilities will come from surface-water sources.

Total gross use is expected to increase from current levels by 720 percent to 1,050 mgd in 2020. Consumptive use is projected to increase by 980 percent to 253 mgd in 2020. These especially large increases in total water use are due primarily to large projected increases in surface-water withdrawals by proposed thermoelectric power facilities. These electric power plants that are expected to be in operation by 1990 and 2000, should cause gross use by this group to increase from the current 4 mgd to 838 mgd in 2020, a 200 fold increase. Thermoelectric power should become the largest water user in 2020 and surface water should remain the major supply source.

WATER USE VERSUS AVAILABILITY

The current 123 mgd gross surface-water demand and 20.9 mgd consumptive surface-water demand are adequately supplied by streamflow (Fig. 76). Use of surface water occurs throughout the sub-basin but the greatest concentration of users occurs in the Spartanburg/ Greenville area (Fig. 75). Projected 2020 gross surface demand of 1,040 mgd can be supplied by streamflow 93 percent of the time. Most of this projected use, however, is due to proposed thermoelectric power plants located on impoundments of ample water to supply their withdrawal needs. When this water use is omitted from the total projected use, streamflow should adequately meet demand. Consumptive demand of 248 mgd should be adequately met by streamflow.

An estimate or projection of the feasibility of meeting future demands for ground water in the Broad River Sub-basin can be determined only after an intensive program of test well drilling has been evaluated. The range of well yields for those wells currently inventoried is too large to provide a reasonable projection of the average yield for individual wells, beyond the generalized categories included in Figure 19 (one to 300 gpm). Construction of wells in the most favorable physiographic areas, i.e. draws and valleys, increases the probability of obtaining higher yields. Based on the existing data, ground-water yields in this sub-basin are insufficient to meet the larger municipal and industrial requirements. While some irrigation demands may exceed available ground-water supplies, rural or suburban domestic needs are adequately met by shallow or intermediate aquifers.

Present records indicate comparatively low yields for individual wells and full potential yields have not yet been determined since most wells are not drilled to obtain maximum yield. If the base flow of the Broad River is analyzed, it indicates a fairly favorable potential for ground-water availability. Figure 76 shows the flow of the Broad River at Richtex, near Columbia, to be at least 555 mgd for 99 percent of the time. If this is minimum base flow of the

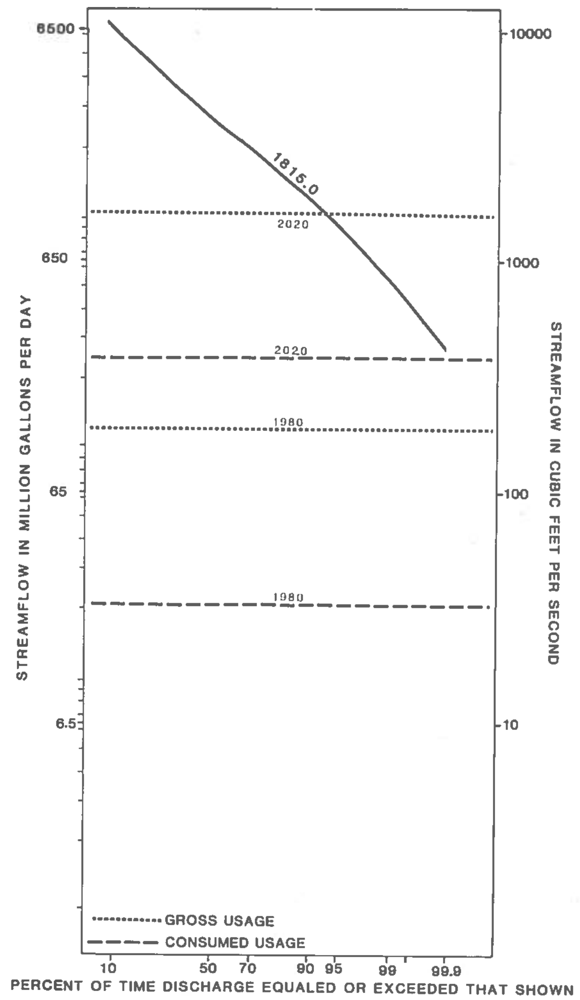


Figure 76.
Water use compared to availability in the Broad River Sub-basin, South Carolina.

stream, it is assumed to represent total ground-water contribution and indicates that ground-water discharge is about 0.114 mgd per square mile of basin area. This calculated ground-water discharge adjusted to the South Carolina area of the drainage basin (435 mgd) exceeds the projected ground-water demand in the year 2020 by about 50 times. There may be additional ground water in storage within the aquifer, but withdrawals exceeding the calculated recharge rate would dry up some streams and constitute mining of the ground-water resource. As a practical matter, the retrievable portion of the ground-water recharge estimate is somewhat less than the figures indicate. Projected ground-water needs for the year 2020 appear to be more than adequately met by the estimated supply.

Ground-water availability may be limited in certain areas of the sub-basin due to ground-water quality. Locally, high iron concentrations may restrict the use of this water for certain activities. Excessive hardness, magnesium, and a taste problem in York and Chester Counties and excessive naturally-occurring radionuclides (radium, radon, and lead) in York and Fairfield Counties may also restrict the use of ground water in these areas.

Major water resource problems and opportunities in the sub-basin are summarized in Table 68.

Table 68.

Major water resource findings in the Broad River Sub-basin, South Carolina.

Opportunities

1. Current and projected surface-water use is adequately met by surface-water supplies.
2. Streams in the upper Piedmont portion of the sub-basin have generally well sustained flows year round.
3. Numerous potential hydroelectric power development sites have been identified in the sub-basin.
4. The upper portion of the Broad River exhibits generally good quality water.

Problems

1. Streamflows in unregulated Piedmont streams are somewhat variable and highly dependent on rainfall; reliability of streamflow decreases from the upper to the lower portion of the sub-basin.
2. High flows on Brushy Creek cause occasional flood damage to adjacent watershed development.
3. The quality of the Broad River near Columbia is adversely impacted by point and non-point source urban pollution.
4. Streams throughout the sub-basin exhibit high turbidity levels, especially following rainstorm events.
5. Point and non-point sources of pollution from the highly developed upper sub-basin area adversely impact major streams draining this area.
7. Limited well yields occur throughout the sub-basin and large municipal and industrial uses may not be met by ground-water supplies.
8. High iron concentrations occur in aquifers throughout the sub- basin.
9. Some ground water in York and Chester Counties exhibits taste problems and has high levels of hardness and magnesium.
10. Some ground water in York and Fairfield Counties has high naturally occurring radionuclides (radium, radon, and lead).
11. Ground-water data are generally insufficient to accurately assess the resource.

Saluda River Sub-basin

GENERAL OVERVIEW

The Saluda River Sub-basin is a long, narrow basin transecting the Blue Ridge and Piedmont regions of South Carolina, and extending southeast to the Fall Line in the central portion of the State. With a northwest-southeast orientation, the sub-basin shares a common northern border with North Carolina and encompasses portions of 12 South Carolina counties, including most of Greenville, Greenwood, Laurens, Newberry and Saluda Counties; and smaller portions of Abbeville, Aiken, Anderson, Edgefield, Lexington, Pickens, and Richland Counties (Fig. 77). The areal extent of the sub-basin is approximately 2,505 square miles, 8.1 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 429,600, which was 13.7 percent of the State's total (Table 69). The sub-basin population is expected to reach about 713,000 by the year 2020, an increase of 66.1 percent. The greatest amount of growth during this period is anticipated in Lexington County (148.3 percent) in the south and Pickens County (123.2 percent) in the north.

This basin is a mixture of urban and rural populations, with Greenville and Lexington Counties having over half of their populations classified as urban, while 80 percent of Saluda County's population is rural.

The major cities and population centers include: Greenville (58,190), Greenwood (21,568), Easley (14,345), Laurens (10,365), Newberry (9,776), Simpsonville (9,012), and Mauldin (8,258). In addition, there are numerous smaller towns within the sub-basin boundary. The major urban center of Columbia lies immediately outside the eastern boundary.

Economy

There are four sub-basin counties with a 1979 per capita income above the State's average of $7,056. These include Greenville, Greenwood, Lexington, and Newberry Counties. The average per capita income for the region was $7,099, slightly above that for the State. The 1980 median household income ranged from $18,996 in Greenville County to $14,213 in Saluda County. The majority of counties in the sub-basin have median household incomes above the State average of $16,509.

During 1979, the combined annual average employment of non-agricultural wage and salary workers in the sub-basin averaged 272,700. The percentage breakdown by type of employment was: manufacturing, 40.4 percent; wholesale and retail trade, 19.1 percent; government, 14.0 per-

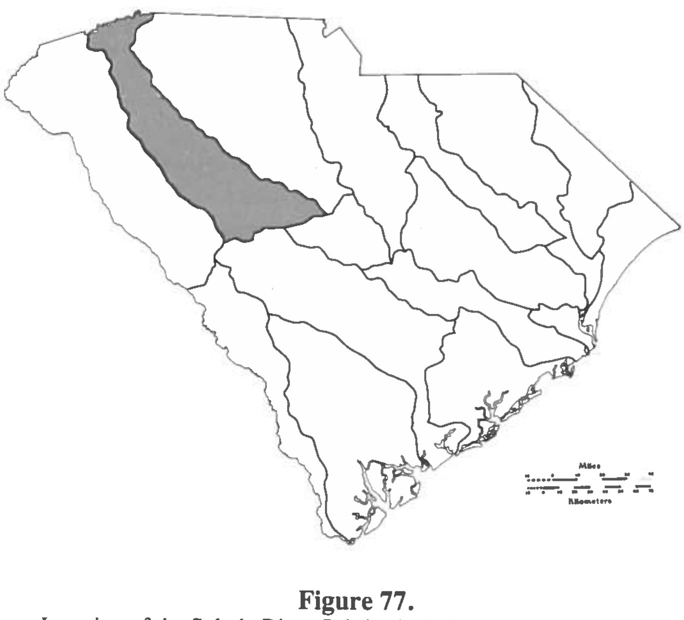


Figure 77.
Location of the Saluda River Sub-basin in South Carolina.

Table 69.
Current and projected population for the Saluda River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)* 1980	1990	2000	2010	2020	*% Change 1980-2020*
Abbeville	9.0	2.0	2.2	2.3	2.3	2.4	16.6
Aiken	0.1	0.1	0.1	0.1	0.1	0.2	66.0
Anderson	18.6	24.9	31.6	38.1	43.9	47.2	89.4
Edgefield	2.3	0.4	0.5	0.5	0.5	0.5	27.0
Greenville	70.9	205.0	246.5	280.2	308.9	324.8	58.5
Greenwood	80.4	46.7	54.7	60.4	65.2	67.8	45.3
Laurens	67.4	35.2	37.3	38.2	39.0	39.4	11.7
Lexington	38.5	54.3	75.1	98.4	121.3	135.4	148.3
Newberry	60.3	18.8	20.1	20.8	21.3	21.5	14.6
Pickens	27.2	21.7	29.0	36.7	44.0	48.4	123.2
Richland	2.1	5.6	6.5	7.1	7.5	7.8	37.7
Saluda	90.5	14.7	16.4	17.3	18.0	18.3	25.0
Total		429.6	520.0	599.6	672.1	713.7	66.1

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

cent; services and mining, 12.2 percent; construction 6.7 percent; transportation, 4.2 percent; and finance, insurance, and real estate, 3.4 percent.

In the sector of manufacturing, mining and public utilities, the average annual product value of the area was $5,490.4 million during fiscal year 1978-79, 25.5 percent of the State's total.

Manufacturing is the primary economic activity, with agriculture playing a relatively small role in the region's economy. Newberry County ranked first in the State from 1979 farm marketing receipts for livestock and livestock products. Three other sub-basin counties also ranked in the top ten of reported livestock receipts.

SURFACE WATER

Hydrology

The Saluda River is the major watercourse in the sub-basin. This stream has its headwaters in the Blue Ridge Province in South Carolina and it flows southeasterly across the Piedmont Province before joining with the Broad River to form the Congaree River near Columbia. Major tributaries include the Reedy River, Rabon Creek, Little River, Bush River, and Little Saluda River. These flowing surface waters serve water use needs for the cities of Greenville, Greenwood, and Laurens.

A five mile segment of the Middle Saluda River in Greenville County is protected under the State Scenic Rivers Program. In addition, a 10 mile segment of the Saluda River downstream of Lake Murray is under consideration as a possible scenic river. This portion of the lower Saluda River offers whitewater canoeing, trout and smallmouth bass fishing, and an aesthetic shoreline, all within a population center of 400,000 people.

Streamflow is presently monitored at five sites, three on the Saluda River, and two on tributary streams (Fig. 78). Streamflow data are also available for four discontinued gaging stations. Streamflow statistics for these nine streamflow gaging stations are presented in Table 70. Surface-water data are also available from four crest-stage stations (1630, 1653.5, 1672, 1677.5) and two lake stations on Lakes Greenwood and Murray. Streamflow in the upper portion of the Saluda River has been affected for the entire period of record by two small water supply reservoirs, Table Rock Reservoir and North Saluda (Poinsett) Reservoir. Controlled releases from Lake Murray and Lake Greenwood have modified streamflows in the lower portion of the Saluda River since 1930 and 1940, respectively.

Average annual streamflow in the Saluda River varies from 647 cfs near Greenville to 2,929 cfs near Columbia. Ninety percent of the time, flow at these sites equals or exceeds 240 cfs and 430 cfs, respectively. Streamflows in the Blue Ridge portion of the sub-basin are relatively steady and have well-sustained base flow supported by ground-water discharges from exposed fracture zones. High rainfall and runoff in this region also contributes significantly to flow. Streamflow in the upper reaches of the Saluda River is well-sustained throughout the year. The relatively steady flow at the upper gage sites (Station 1625 and 1630) is reflected in a more moderately sloped flow-duration curve (Fig. 79), narrower range between maximum and minimum monthly flows (Fig. 78), more regular minimum monthly flow pattern, higher low flows of record (Table 70), and higher unit average and 7Q10 discharge values than at downstream stations. Streamflow in the Saluda River becomes increasingly more variable in the Piedmont region with distance downstream, due to hydropower facilities and progressively decreasing annual precipitation and ground-water support in watersheds away from the mountains. Decreasing contribution to streamflow is reflected in the unit average and 7Q10 discharge values which are highest

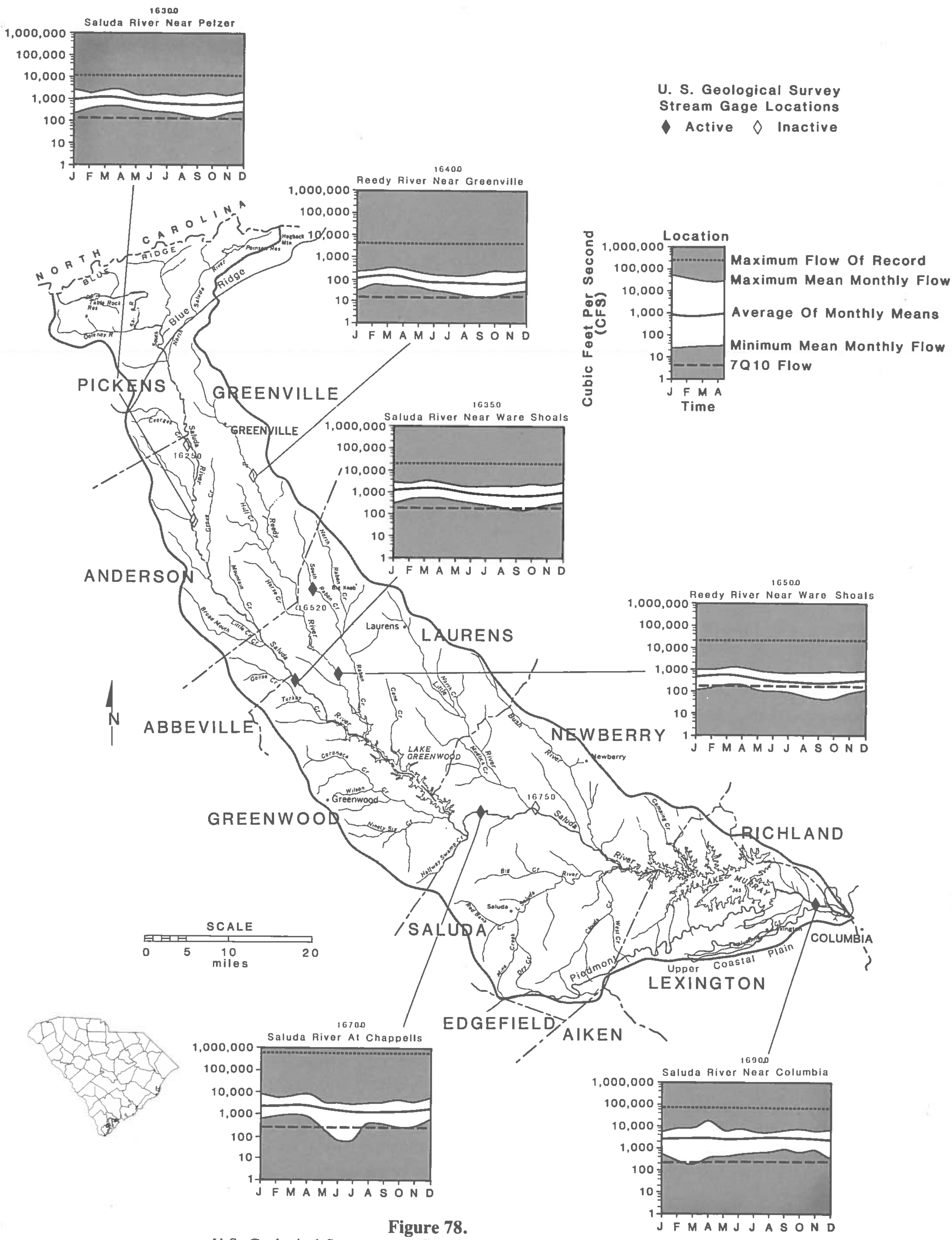


Figure 78.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Saluda River Sub-basin, South Carolina.

Table 70.

Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Saluda River Sub-basin, South Carolina.

Gaging Station			*Period of Record*		*Average Flow*				
		Drainage Area		*Total*			*90%[a]*	*7Q10[b]*	
Number	*Name/Location*	*(mi^2)*	*Dates*	*Years*	*cfs*	*cfs/mi²*	*cfs*	*cfs*	*cfs/mi²*
1625	Saluda River near Greenville	295	Oct 1941-Sep 1978	37	647	2.19	240	130	0.44
1630	Saluda River near Pelzer	405	Sep 1929-Sep 1971	42	783	1.93	290	168	0.41
1635	Saluda River near Ware Shoals	581	Oct 1938-Present	42	1,040	1.79	330	190	0.33
1640	Reedy River near Greenville	48.6	Oct 1941-Sep 1971	30	83.0	1.71	28	16	0.33
1650	Reedy River near Ware Shoals	236	Mar 1939-Present	41	354	1.50	70	36	0.15
1652	S. Rabon Creek near Gray Court	29.5	Jan 1967-Present	13	41.4	1.40	16	6.4	0.22
1670	Saluda River at Chappells	1,360	Oct 1926-Present	54	1,991	1.46	600	320	0.24
1675	Saluda River near Silverstreet	1,620	Oct 1926-Jun 1966	39	2,227	1.37	710	355	0.22
1690	Saluda River near Columbia	2,520	Aug 1925-Present	55	2,929	1.16	430	260	0.10

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.

near Greenville (2.19 cfs/mi², 0.44 cfs/mi²) and lowest near Columbia (1.16 cfs/mi², 0.10 cfs/mi²). The increasing slope of the flow-duration curves and increasing range between minimum and maximum monthly flow for gaging sites downstream graphically depicts increased streamflow variability.

The most variable flows in the Saluda River occur immediately below Lake Greenwood where regulated discharges from the Buzzard's Roost Hydroelectric Plant greatly influence flow. Use of this facility only during periods of peak electric demand results in highly fluctuating flows downstream with frequent periods of extreme low flow. These low-flow conditions limit navigation, fish migration, and suitable fish habitat.

Tributary streams are subject to the same flow controlling factors as the main stem river. However, most tributaries do not benefit from headwaters in regions of high rainfall and ground-water discharge to partially sustain streamflows during periods of low rainfall. Streamflow characteristics of the Reedy River indicate the same main stem trend of increased flow variability with progression downstream. Average annual streamflow in the Reedy River is 83 cfs near Greenville and 354 cfs near Ware Shoals. Streamflow at these sites is at least 28 cfs and 70 cfs, 90 percent of the time. The other gaged tributary stream, South Rabon Creek, averages 41.4 cfs and exceeds 16 cfs, 90 percent of the time.

The lowest flow of record on the Saluda River is 8 cfs and occurred at Chappells in 1939. Record flood flows were primarily due to three storms occurring in 1929, 1949, and 1973. The peak flow on the Saluda River (83,800 cfs) was recorded near Silverstreet in 1929.

In general, available streamflows in the upper portion of the sub-basin are well-sustained and provide a reliable surface-water supply source. While flow is more variable in the lower portion of the Saluda River, minimum flow still provides a substantial supply. Tributaries in the lower portion of the sub-basin may experience significant low-flow conditions during periods of low rainfall and if used as a water source may require storage facilities to ensure a reliable year-round water supply.

Development

To meet the needs of industry and municipalities within the Saluda River Sub-basin, extensive development of surface water has been necessary. Figure 80 illustrates the extent of surface-water development in the sub-basin which consists of widespread hydroelectric and flood control projects.

Three major reservoirs exist within the sub-basin, Lake Murray, Lake Greenwood, and North Saluda (Poinsett) Reservoir. All three are located on the Saluda River.

Lake Greenwood, located 18 miles east of Greenwood, is owned by the Greenwood County Electric Power Commission, but operation of both the lake and the hydroelectric plant (Buzzard's Roost) is controlled by Duke Power Company. Constructed in 1940 for the production of hydroelectric power, the lake also serves as a municipal water supply and is used for recreation. With a surface area of approximately 11,400 acres, and a volume of about 270,000 acre-feet, Lake Greenwood ranks 10th in surface area among lakes in the State.

Lake Murray ranks fifth in surface area and third in volume with 51,000 acres and 2,114,000 acre-feet, respectively. Located 11 miles west of Columbia, Lake Murray is owned and operated by South Carolina Electric and Gas Company. The lake was constructed in 1930 for the production of hydroelectric power, but it also provides recreational opportunities and is expected to supply water to portions of the City of Columbia by mid-1983.

North Saluda (Poinsett) Reservoir is owned by the City of Greenville and is used solely as a municipal water supply. It has a surface area of 1,080 acres and a volume of about 76,000 acre-feet.

The total surface area of all lakes larger than ten acres is approximately 66,000 acres and total volume is nearly 2,500,000 acre-feet. All lakes larger than 200 acres are listed in Table 71.

Four potential hydroelectric sites have been identified within the sub-basin. These sites are listed in Table 72. In addition, S.C. Land Resources Conservation Commission has identified 10 potential small scale hydropower sites

Table 70. (Continued)

Extreme Flows

Minimum[c]		Maximum[d]	
cfs	*Dates*	*cfs*	*Date*
70.0	Oct 16, 1954	11,000	Oct 7, 1949
57.0	Oct 17, 1954	13,600	Oct 7, 1949
11.0	Oct 12, 19, 1941	20,700	Sep 14, 1973
4.6	Oct 11, 1966	4,050	Mar 6, 1963
4.8	Sep 9, 1973	11,000	Sep 14, 1973
6.9	Aug 29, 31, 1980	4,100	Sep 14, 1973
8.0	Oct 29, 1939	63,700	Oct 2, 1929
49.0	Jul 4, 1940	83,800	Oct 3, 1929
12.0	Jul 13, 1930	67,000	Oct 2, 1929

with a total potential generating capacity of 8.0 MW (Long, 1980).

There are no navigation projects within the sub-basin.

Extensive measures have been taken by the Soil Conservation Service to prevent flooding and soil erosion. The sub-basin was the site of some of the earliest flood control projects within the South Carolina. Five projects have been completed since 1958. These projects involved nearly 30 miles of channel improvement and 19 floodwater retarding structures. Other identified problem areas are in various stages of construction or study. Four projects currently under construction consist of nine floodwater retarding structures. All flood control projects and studies are listed in Table 73.

Water Quality

Streams draining the Saluda River Sub-basin are designated primarily Class B waters (Fig. 81). All the major lakes and a few small streams have Class A water use designations and short stretches of the North and South Saluda Rivers are designated Class AA. Water quality limited segments which require advanced treatment of wastewater discharges include all of Lake Greenwood, Lake Murray, Wilson Creek, North Creek, Camping Creek, Clouds Creek, and West Creek; portions of Reedy River, Goose Creek, Bush River, and Twelvemile Creek; and several minor tributary streams (Fig. 82). While several water quality problem areas occur in this sub-basin, most water bodies meet their designated water use classification quality standards.

Overall water quality in the Saluda River is good but decreases to satisfactory during portions of the year. Although high levels of fecal coliform bacteria, suspended solids, and metals occur, due to point source discharges and non-point source runoff, State standards and criteria are rarely contravened (S. C. Appalachian Council of Governments, 1979; S. C. Department of Health and Environmental Control, 1980b).

The Reedy River exhibits poor to satisfactory water quality. This recognized water quality problem stream

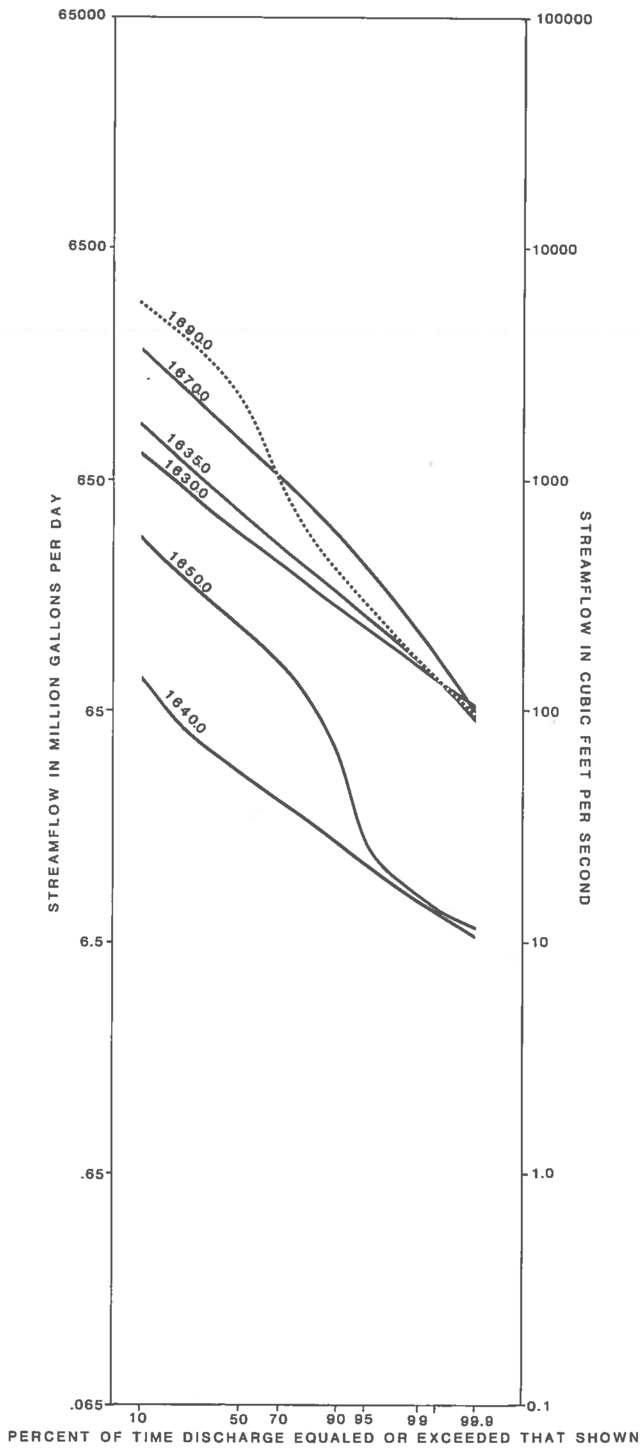


Figure 79.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Saluda River Sub-basin, South Carolina.

Table 71.
Existing lakes larger than 200 acres in the Saluda River Sub-basin, South Carolina.

Map No.	Name	Stream	Surface Area (acres)	Storage Capacity (acre-feet)	Purpose
1	Lake Murray	Saluda River	51,000	2,114,000	Power Recreation
2	Lake Greenwood	Saluda River	11,400	270,000	Power Recreation Water supply
3	N. Saluda Reservoir (Poinsett Res.)	N. Saluda River	1,080	76,108	Water supply
4	Table Rock Cove	N. Saluda River	500	29,154	Water supply
5	Saluda Lake	Saluda River	475	7,228	Industry Power Water supply
6	Boyd's Mill Pond	Reedy River	246	2,184	Power Recreation
7	Holidays Bridge	Saluda River	465	1,152	Power Water supply

Source: S.C. Water Resources Commission, 1974.

Table 72.
Existing and potential hydroelectric power development in the Saluda River Sub-basin, South Carolina.

Map No.	Facility/Site Name	Facility/Site Location County	Facility/Site Location River	Owner	No. of Units	Total Capacity (MW)	Surface Area (acres)	Status
8	Saluda	Greenville	Saluda	Duke Power Co.	4	2.4	475	Const. 1905
9	Piedmont	Greenville	Saluda	J.P. Stevens Co.	1	1.0	--[a]	Const. 1937
10	Upper Pelzer	Anderson	Saluda	The Kendall Co.	1	2.0	--	Const. 1920
11	Lower Pelzer	Anderson	Saluda	The Kendall Co.	1	3.3	--	Const. 1895
12	Holidays Bridge	Greenville	Saluda	Duke Power Co.	4	3.5	465	Const. 1906
13	Ware Shoals	Greenwood	Saluda	Riegel Textile	1	5.0	--	Const. 1906
14	Boyds Mill	Laurens	Reedy	Duke Power Co.	2	1.0	246	Const. 1909
15	Buzzard's Roost	Greenwood	Saluda	Greenwood Co.	3	15.0	11,400	Const. 1940
16	Saluda Hydro	Lexington	Saluda	SCE&G[b]	5	198	51,000	Const. 1930
17	Fork Shoals	Greenville	Reedy	--	--	2.0	51	Potential
18	The Forks	Greenville	Saluda	--	--	18.3	7,652	Potential
19	Upper Ware Shoals	Abbeville	Saluda	--	--	20.2	1,720	Potential
20	Lower Saluda	Lexington	Saluda	--	3	18.0	1,424	Potential

[a] -- indicates information not available.
[b] SCE&G indicates S.C. Electric and Gas Company.

Sources: Federal Power Commission, 1970.
S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

Table 73.
Flood control projects and studies in the Saluda River Sub-basin, South Carolina.

Map No.	Project/Watershed Name	County	Responsible Agency[a]	Status
21	Big Creek	Anderson	SCS	Completed 1962
22	Bushy Creek	Pickens/Anderson	SCS	Completed 1958
23	George's Creek	Pickens	SCS	Completed 1964
24	Huff Creek	Greenville	SCS	Completed 1957
25	Broadmouth Creek	Anderson	SCS	Completed 1959
26	Saluda River	Pickens/Anderson	COE	Completed 1962
27	Hollow Creek	Lexington/Saluda	SCS	Under construction
28	Oolenoy River	Pickens	SCS	Under construction
29	Rabon Creek	Laurens/Greenville	SCS	Under construction
30	Little River	Laurens	SCS	Under construction
31	Wilson Creek	Greenwood	SCS	Terminated
32	Bush River	Laurens/Newberry	SCS	Terminated
33	Scotts Creek	Newberry	COE	Study reactivated
34	Reedy River	Greenville	COE	Inactive
35	Langston Creek	Greenville	COE	Inactive

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.

Sources: U.S. Department of Agriculture, 1980.
U.S. Army Corps of Engineers, 1982c.

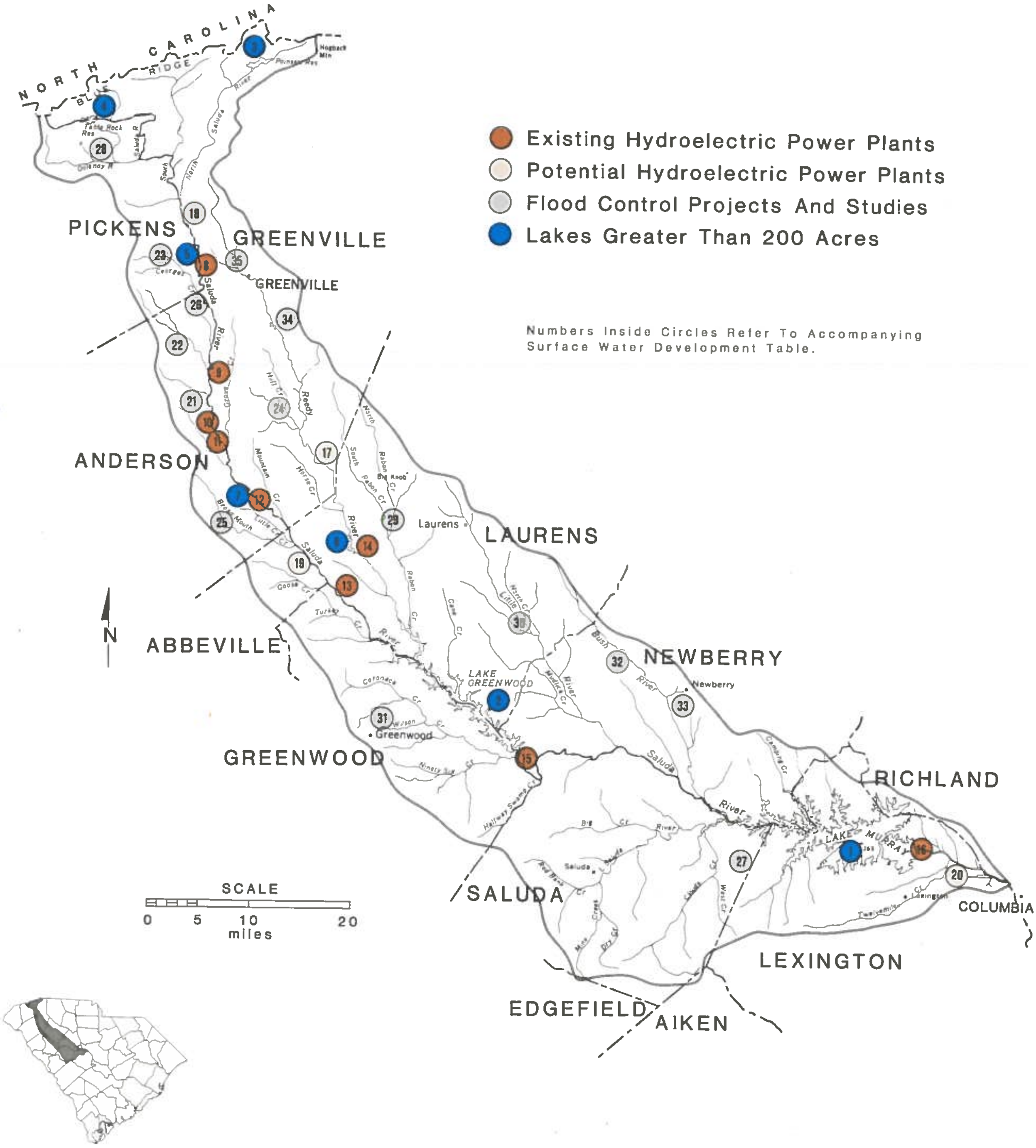


Figure 80.
Surface-water development in the Saluda River Sub-basin, South Carolina.

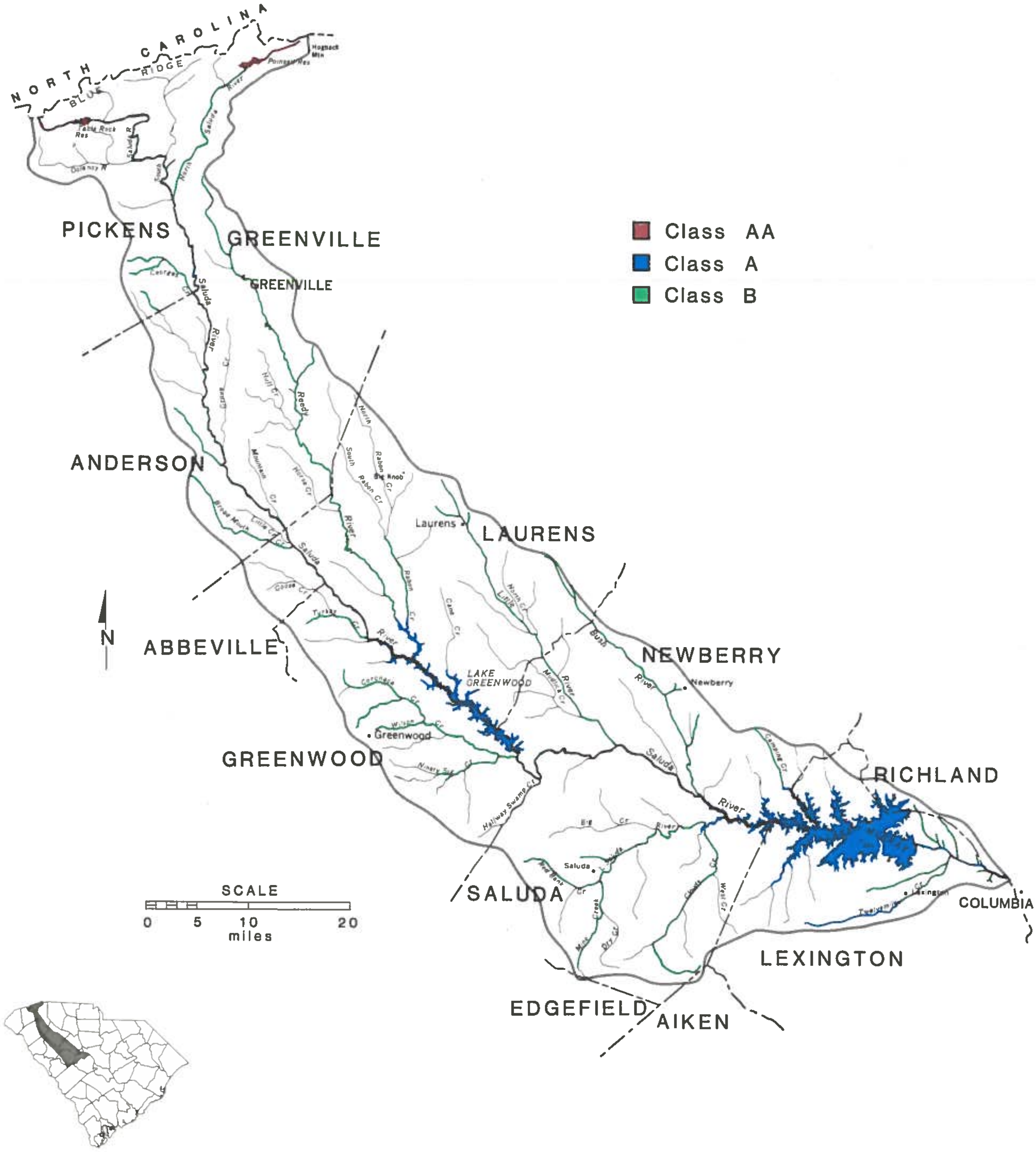


Figure 81.
Surface-water quality classifications in the Saluda River Subbasin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

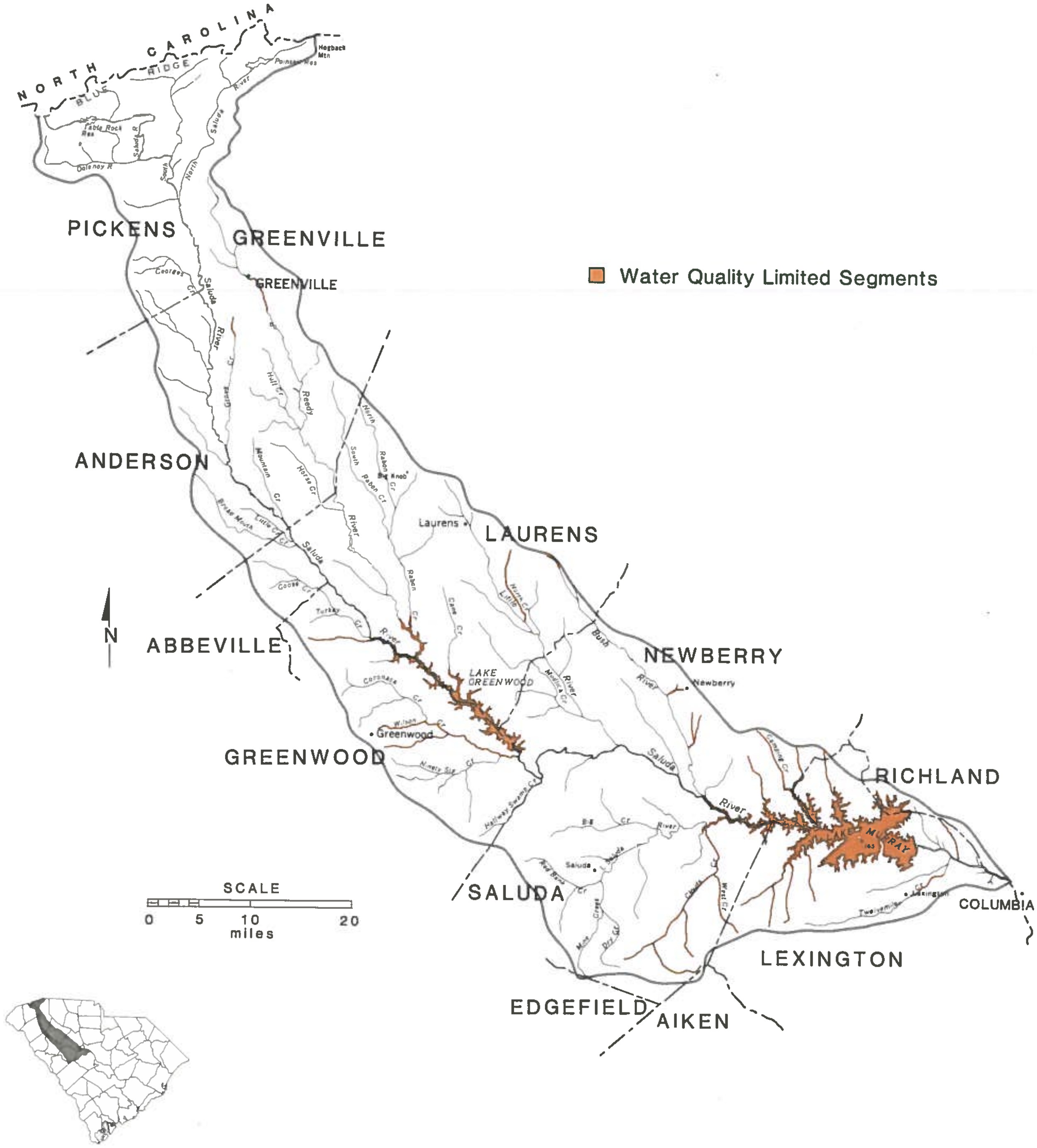


Figure 82.
Water quality limited segments in the Saluda River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

experiences frequent contraventions of Class B standards for fecal coliform bacteria and elevated levels of nutrients, biochemical oxygen demand, and turbidity. In addition, biological data indicate a low diversity of aquatic organisms dominated by pollution tolerant species (S. C. Appalachian Council of Government, 1979; S. C. Department of Health and Environmental Control, 1980b). Problem conditions in this river are attributed primarily to wastewater discharges from the Mauldin Road Sewage Treatment Plant which serves the Greenville metropolitan area. This facility currently discharges treated wastewater into the Reedy River at a rate equal to 50 percent of the river's average streamflow at the plant site (S. C. Appalachian Council of Governments, 1979). Discharge rates are expected to increase to about 71 percent of the Reedy River streamflow by 1995. To help improve water quality conditions in this river the S. C. Department of Health and Environmental Control has required limits on the discharge of phosphorus (nutrients) and imposed additional restrictions on oxygen demanding substances discharged from the Mauldin Road Treatment Plant. Color of the effluent must also be routinely monitored.

The Little Saluda River exhibits satisfactory to poor water quality. This river was identified as the most severe water quality problem area in the State with only 14 percent of the river meeting State and Federal standards and criteria (S. C. Department of Health and Environmental Control, 1980b). Water quality problems include depressed dissolved oxygen and pH values and elevated levels of fecal coliform bacteria, nutrients, and turbidity. Primarily municipal point source discharges contribute significantly to contraventions of State standards for dissolved oxygen and fecal coliform bacteria (S. C. Department of Health and Environmental Control, 1975a, 1980b).

Lake Greenwood has been identified as the most eutrophic lake in South Carolina, resulting from extremely high nutrient loading (U. S. Environmental Protection Agency, 1976c). Water quality conditions in the lake are characterized as generally satisfactory but with a trend of decreasing quality in terms of pH and temperature (S. C. Department of Health and Environmental Control, 1980b). Water quality problems impacting the lake include low pH levels, elevated turbidity and nutrient levels, and ammonia concentrations potentially toxic to aquatic life. While no major algal blooms and consequent fish kills have been documented, the lake experiences regular minor localized algal problems and the potential for severe algal problems exists (Inabinet and Pearce, 1981). The primary nutrient impacting Lake Greenwood is phosphorus. Studies indicate that the majority of phosphorus loading (76 percent) originates from the Mauldin Road Treatment Plant on the Reedy River (U. S. Environmental Protection Agency, 1976c; Inabinet and Pearce, 1981). This municipal facility has recently been required by the State to limit discharges of total phosphorus to help improve water quality conditions in the Reedy River and Lake Greenwood.

Lake Murray has been classified as mesoeutrophic and ranked sixth out of 13 lakes surveyed in the State for trophic quality (U. S. Environmental Protection Agency, 1975b; Environmental Research Center, Inc., 1976). This trophic classificiation indicates moderate to high nutrient loading. Water quality conditions in Lake Murray are generally good with indications of improving quality in terms of nutrients and aesthetics (S. C. Department of Health and Environmental Control, 1980b). Overall conditions are adequate for this lake's Class A water use designation. Adverse water quality impacts occur primarily in the many small coves and in the upper reaches of the lake. Biological data indicate fair to poor quality conditions in the headwater area (S.C. Department of Health and Environmental Control, 1980b). These areas have also experienced relatively high nutrient concentrations and fecal coliform bacteria contamination (Environmental Research Center, Inc., 1976). Localized degraded water quality conditions have been attributed to both point and non-point sources of pollution entering the lake from the Saluda River and smaller influent streams draining local basin areas (U. S. Environmental Protection Agency, 1975b; Environmental Research Center, Inc., 1976; Hydrocomp, Inc., 1978).

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout the sub-basin ranges from the field data level in the southwestern region to the evaluation level in the northwestern region within Greenville County (Fig. 18).

The Saluda River Sub-basin lies almost entirely within the Piedmont Province. The extreme southern portion of the basin lies within the Coastal Plain Province. The sub-basin is transversed by four geologic belts trending northeast and southwest. From north to south these belts are the Inner Piedmont belt, Kings Mountain belt, Charlotte belt, and Carolina slate belt. Ground-water availability in the sub-basin is typically limited and restricted to zones of high fracturing and deep saprolite layers. Well records for the sub-basin counties are sparse, however, data from Greenville County indicate well depths ranging from 150 to 300 feet with yields of 15 to 20 gpm. Laurens County wells range in depth from 20 to 400 feet and yield 2 to 75 gpm, while wells in Newberry County range from 34 to 563 feet deep and yield 2 to 400 gpm. More detailed information concerning ground-water availability in these three counties is presented in the Broad River Sub-basin assessment.

Johnson and others (1968) investigated the hydrogeology of Pickens County. Recorded wells in the county range from 15 to 435 feet deep and yield from 1 to 500 gpm.

Some basic hydrologic and geologic data are available for Anderson County. U. S. Geological Survey records include information on 171 wells which range in depth from 18 to 718 feet and yield 140 to 175 gpm.

Geologic maps show that major rocks in Pickens and Anderson Counties include mica schist, granitoid and biotite gneiss, amphibolite and some igneous rocks. Previous tectonic studies also indicated that rocks of this region are highly folded and some rather large-scale faults occur in the two counties (Secor and others, 1978). Fractures in the rocks are attributed to faults and joints. Fault zones range in length from less than 1 mile to 10 miles and widths range from 15 feet to about 1,200 feet. These zones are highly fractured. While most of the original fractures are filled with quartz, remaining openings offer excellent opportunities for the transmission and storage of water.

A recent report (Boyter, 1979) discusses data obtained from an inventory of 58 wells and maps more than 100 linear fracture zones in portions of Oconee, Pickens and Anderson Counties. Wells drilled within fracture zones yield from 10 to 500 gpm, whereas well yields outside of fracture zones are about 1 gpm or less. Wells situated in linear features in valley bottoms have a greater probability of higher yields. The metamorphic and igneous rock fracture zones offer the best opportunity for obtaining maximum well yields.

U. S. Geological Survey has some limited hydrologic data on 64 wells in Abbeville County. Their depths range from 15 to 352 feet and yields range from 1 to 125 gpm. The S. C. Water Resources Commission has information on three recently drilled wells ranging in depths from 165 to 320 feet. These wells have a maximum yield of 50 gpm. The data for Abbeville County are considered inadequate for an interpretation of the ground-water occurrence in the area.

U. S. Geological Survey files for Greenwood County consist of partial hydrologic data concerning 54 wells. The depths of these wells range from 42 to 300 feet and yields range from 2 to 50 gpm. Information concerning the occurrence and quality of water is scarce, therefore, an evaluation of the ground-water potential is not possible at this time.

Available records for Saluda County include information on 28 wells ranging in depth from 28 to 350 feet and yielding from 5 to 150 gpm. The area is underlain by an argillite unit and a muscovite unit. Based on available information, wells can be expected to have moderate yields depending upon the amount of cleavage or foliation present in the rock and the number of fractures intercepted by the well. Eight test wells drilled on the north side of the Saluda River, 5 miles east of Chappells, contained approximately 10 feet of medium to coarse sand at an elevation below the river level. Aquifer tests of these alluvial deposits indicate a transmissivity value of 16,040 ft^2/day. This appears to be the most promising site in the State for developing ground water by infiltration.

Ground water is the source of public supply for Chapin, Leesville, Gilbert, and Summit in the northern portion of Lexington County. Ground water in the area occurs in two distinct zones: the shallow sedimentary aquifer system (about 100 feet thick) and the deeper bedrock aquifer, composed of fractured igneous and metamorphic rocks. In the towns of Gilbert and Summit there are four wells completed to bedrock (300 to 400 feet) that produce about 40 gpm each. The most recent hydrologic data was obtained from a series of nine test wells drilled at the new Michelin Tire Plant. Pumping tests indicate that wells tapping the sand aquifer beneath this site are able to deliver about 40 to 60 gpm. The general area north of U. S. Highway 1 is underlain by bedrock units rather than sand aquifers. Wells drilled in this area commonly yield a few gallons per minute with some wells delivering up to 100 gpm. Well yields are generally sufficient for domestic and light industrial use. U. S. Geological Survey records for Lexington County include information on about 57 wells in the area within the Saluda River Sub-basin. Their depths range from 88 to 450 feet and yields range from 1 to 150 gpm.

Water for the Leesville municipal supply system is supplied by five wells producing a total of 495 gpm. Over 65 test holes and wells have been drilled within the limits of the City of Leesville since the early 1950's (Siple and Paradeses, 1964). These wells range from 88 to 125 feet deep and produce about 50 to 150 gpm. In one well drilled into bedrock (265 feet deep) the yield was reported to be 30 gpm. The subsurface sedimentary units, composed of alternating zones of sand, clay and gravel of Eocene to Miocene age (Tertiary Sands Aquifer System), range in thickness from 60 to 100 feet. The only source of recharge to this aquifer is precipitation and is estimated at about 1.1 mgd. The transmissivity for this aquifer system is estimated 670 ft^2/day and the storage coefficient ranges from 0.02 to 0.05 (Stevens, 1976).

Water Quality

In the rock aquifers of Oconee, Pickens, and Anderson Counties, pH of ground water ranges from 5.1 to 7.5, hardness ranges from 3.9 to 118.6 mg/L, and the total dissolved solids range from 2 to 464 mg/L. Thirty-one percent of wells sampled in this area exceeded acceptable iron levels with concentrations as high as 72.5 mg/L. Water from five wells contained more than the recommended limit of copper, and there are 11 wells containing excessive amounts of lead. To prepare a comprehensive interpretative study of the chemical characteristics of ground water in that vicinity, additional water quality data are needed for inventoried wells and for approximately 200 to 300 additional wells. Adequate quantities of ground water could be developed which meet Federal drinking water standards.

Radiochemical analyses of ground water from the Tertiary Sand Aquifer System in the Leesville vicinity of Lexington County indicate that ground water contains naturally high concentrations of gross alpha particle activity (up to 45 pCi/L) and Radium-226 (3.56 to 23.0 pCi/L). These levels locally exceed acceptable drinking water standards for gross alpha particle activity and combined Radium-226 and Radium-228 (Moore, 1980). The source of the radium, a disintegration product of thorium, is thought to be the granitic rocks cropping out near the Fall Line and its occurrence appears to be concentrated in the crystalline rocks or sediments adjoining the Fall Line in a rather narrow zone.

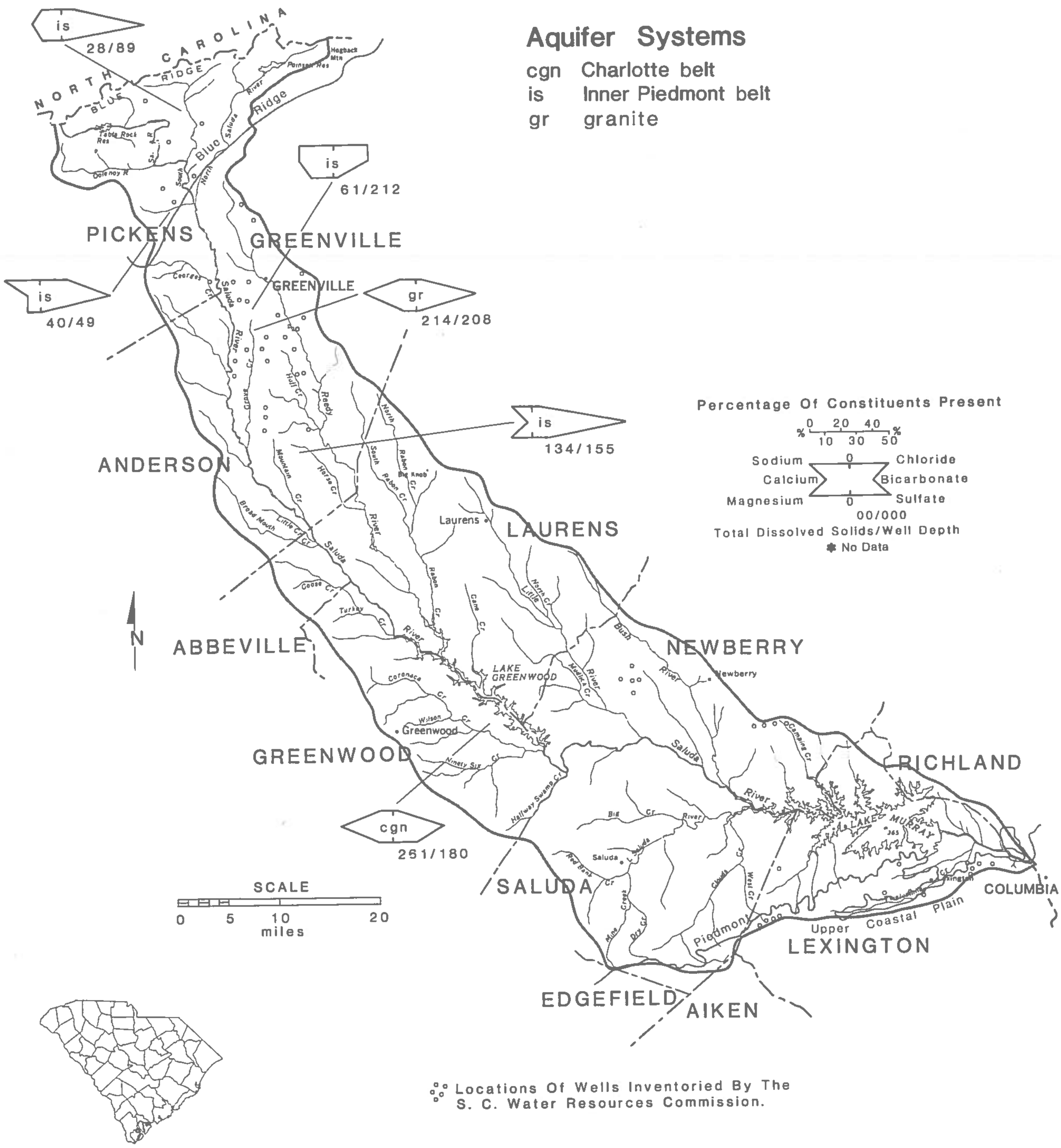


Figure 83.
Ground-water quality of selected aquifer systems and major inventoried wells in the Saluda River Sub-basin, South Carolina.

Stiff Diagrams in Figure 83 show water quality types for rock aquifers ranging from a calcium bicarbonate type to sodium bicarbonate and sodium chloride types.

WATER USE

Total gross water use averages 475 mgd with four percent of that use (19.5 mgd) being consumed (Table 74). This use ranks fifth in the State. The leading water users are thermoelectric power (371 mgd), public supply (70.7 mgd), and self-supplied industry (28.4 mgd). The major water users by type and supply source are shown in Figure 84.

Surface-water withdrawals make up 99 percent of the gross use and also supply 97 percent of the gross use other than thermoelectric power water use. Water use is heaviest in the lower and upper ends of the sub-basin. Ground-water, surface-water, and total gross water withdrawals for livestock in this sub-basin are the greatest in the State.

Public supply gross use accounts for 15 percent of the sub-basin total, while consumptive use is 36 percent of the total water use. Surface water is used to supply 99 percent of the demand with over 63 percent of the withdrawals occurring in the upper end of the sub-basin. The ground-water withdrawal for this use is the largest in the sub-basin. Construction is underway to increase public water supply for the City of Greenville and vicinity. The city plans to withdraw water from Lake Keowee in the Upper Savannah River Sub-basin and transport the water about 30 miles for use and final discharge in the Saluda River Sub-basin. The project is scheduled to go on-line in 1985 with water rights to an initial average use of 5 mgd. Water use rights will increase in periodic increments to an average of 90 mgd in 2020.

Self-supplied domestic use accounts for less than one percent of the total gross use and for three percent of the consumptive use. Ground water is the only source of supply utilized to meet this demand.

Agricultural water use represents less than one percent of total gross use but 21 percent of consumptive use. Surface water supplies 80 percent of all agricultural water. Irrigation water demand represents almost 60 percent of this use, with surface water as the major (96 percent) source utilized. When irrigation water use is averaged over the five-month growing season, it equals 6.0 mgd or one percent of total sub-basin use. Livestock use (1.63 mgd) depends on surface water for 55 percent of its supply. The Saluda River Sub-basin has the largest total livestock demand in the State.

Self-supplied industrial use of 28.4 mgd represents six percent of the total gross use and 27 percent of total consumptive use. Surface water supplies almost 96 percent of the demand. Almost 78 percent of this use occurs in the lower end of the sub-basin.

A single thermoelectric power plant withdraws 371 mgd, or 78 percent of the total gross use. Consumptive use at this plant represents 13 percent of the total sub-basin consumptive use. Surface water is the only source utilized and represents the largest surface-water withdrawal in the sub-basin.

Total gross use is projected to grow 22 percent to 581 mgd by 2020. Consumptive use is projected to grow almost 270 percent to 72.5 mgd by 2020. Most of the growth in consumptive use is due to the projected growth in public supply and thermoelectric power. Surface water should remain the leading source of supply and thermoelectric power should remain the leading water user.

Table 74.
Current and projected water use in the Saluda River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water
Public Supply	Gross	1.03	69.7	70.7	1.24	79.2	80.4	1.42	87.8	89.2	1.56	94.4	96.0	1.64	98.0	99.6
	Consumed	0.10	6.97	7.07	0.12	11.8	11.9	0.14	16.2	16.3	0.16	19.5	19.7	0.16	25.8	26.0
Self-supplied Domestic	Gross	0.67	---	0.67	0.80	---	0.80	0.92	---	0.92	1.0	---	1.0	1.1	---	1.1
	Consumed	0.57	---	0.57	0.68	---	0.68	0.78	---	0.78	0.85	---	0.85	0.94	---	0.94
Agriculture Irrigation	Gross	0.10	2.4	2.5	0.35	6.6	7.0	0.61	9.9	11	0.86	13	14	1.1	15	16
	Consumed	0.10	2.4	2.5	0.35	6.6	7.0	0.61	9.9	11	0.86	13	14	1.1	15	16
Agriculture Livestock	Gross	0.74	0.89	1.6	0.84	1.0	1.8	0.96	1.2	2.2	1.1	1.3	2.4	1.3	1.5	2.8
	Consumed	0.74	0.89	1.6	0.84	1.0	1.8	0.96	1.2	2.2	1.1	1.3	2.4	1.3	1.5	2.8
Self-supplied Industry	Gross	0.98	27.4	28.4	1.13	31.5	32.6	1.24	34.7	35.9	1.36	38.1	39.5	1.50	41.9	43.4
	Consumed	0.18	5.07	5.25	0.21	5.83	6.04	0.23	6.42	6.65	0.25	7.05	7.30	0.28	7.75	8.03
Thermoelectric Power	Gross	---	371	371	---	382	382	---	394	394	---	405	405	---	418	418
	Consumed	---	2.52	2.52	---	4.16	4.16	---	6.86	6.86	---	11.3	11.3	---	18.7	18.7
Total	Gross	3.52	471	475	4.36	500	505	5.15	528	533	5.88	552	558	6.64	574	881
	Consumed	1.69	17.9	19.5	2.20	29.4	31.6	2.72	40.6	43.3	3.22	52.2	55.4	3.78	68.8	72.5

Figure 84.
Location, type, and supply source of water users in the Saluda River Sub-basin, South Carolina.

WATER USE VERSUS AVAILABILITY

The current surface-water demand of 471 mgd is only met 79 percent of the time by streamflow (Fig. 85), while consumptive surface-water demand is more than adequately supplied all the time. One of the largest surface-water users, McMeekin thermoelectric plant, obtains ample water supplies from Lake Murray. When this use (164 mgd) is omitted from total sub-basin demand, streamflow meets demand 88 percent of the time.

The largest water user in the sub-basin, Lee thermoelectric plant, withdraws cooling water from the Saluda River near the Town of Williamston in Anderson County. Although this plant withdraws from a small impoundment, available supplies are primarily dependent on river flow. Streamflow in this portion of the river is insufficient to meet this demand 15 percent of the time. These periods of low flow may restrict this use and others.

Projected 2020 gross surface demand of 574 mgd should be adequately supplied by streamflow 72 percent of the time. Projected 2020 consumptive surface demand of 68.8 mgd should be adequately supplied by streamflow.

Future development of ground water in the Saluda River Sub-basin will be determined only after the results of additional test-well drilling have been evaluated. The range of well yields for those wells inventoried to date is too large to facilitate an accurate projection of the average yield for individual wells, beyond the generalized categories included in Figure 19 (one to 400 gpm). Constructing wells in the most favorable physiographic areas, such as draws and valleys, increases the probability of obtaining higher yields. Based on the nature and quantity of data obtained to date, ground-water yields in this sub-basin are insufficient to meet large municipal or industrial requirements. Some irrigation demands may also exceed available ground-water supplies, however, rural and suburban domestic needs are adequately met by shallow and intermediate aquifers.

Typical of crystalline rock aquifer areas, well yields in this sub-basin are relatively low, however, since most wells are not constructed to obtain maximum yields, full potential yields per well have not been determined. The base flow of the major stream provides a fairly reliable indicator for ground-water availability. Discharge of the Saluda River near Columbia is 106 mgd, 99 percent of the time. This flow is assumed to be the minimum base flow of the stream and represents total ground-water contribution. Ground-water recharge, therefore, is about 0.04 mgd per square mile of sub-basin area and exceeds projected ground-water demand in the year 2020 by a factor of 16. In general, comparison of projected ground-water needs for the year 2020 appear to be more than adequately met by the estimated supply.

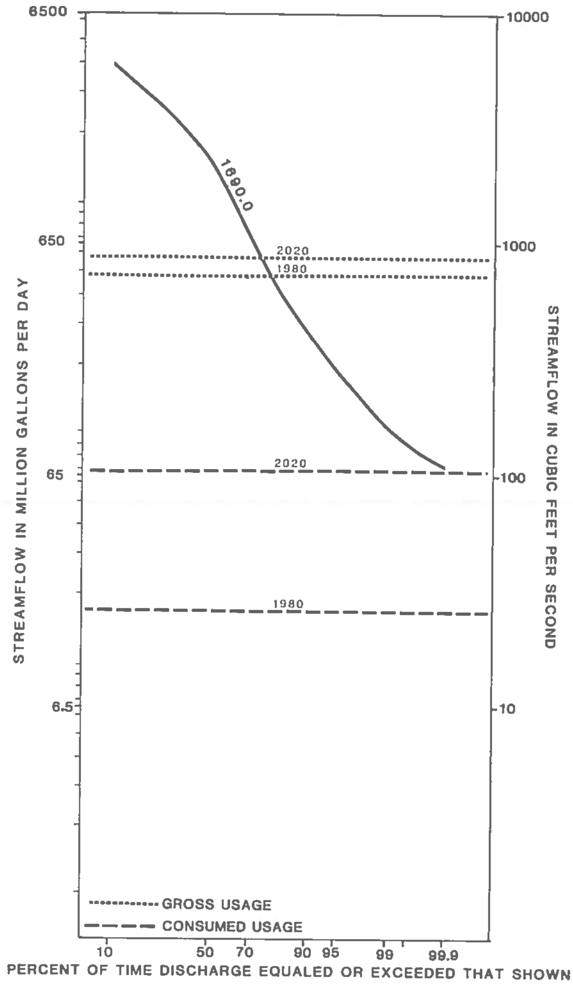


Figure 85.
Water use compared to availability in the Saluda River Sub-basin, South Carolina.

Ground-water availability may be limited in certain areas of the sub-basin due to localized well yield problems. Water quality problems may also limit current and projected ground-water use. High iron concentrations in many places, excessive naturally occurring radionuclides (radium, radon) in the Leesville area, and high copper and lead concentrations in Pickens and Anderson Counties may restrict the use of this water for certain activities.

Major water resource problems and opportunities in the sub-basin are summarized in Table 75.

Table 75.

Major water resource findings in the Saluda River Sub-basin, South Carolina.

Opportunities

1. Streams in the upper portion of the sub-basin have generally well-sustained and reliable flows.
2. Four potential hydroelectric power development sites have been identified in the sub-basin.
3. Lake Murray has generally good quality water, with signs of improvement in recent years.
4. The lower Saluda River downstream of Lake Murray represents a unique resource which is being considered for protection under the State Scenic Rivers Program.

Problems

1. Streamflows in unregulated Piedmont streams are somewhat variable and dependent on rainfall; reliability of streamflow decreases from the upper to the lower portion of the sub-basin.
2. Surface-water supplies may be inadequate to meet projected 2020 water use all of the time.
3. Regulated hydropower discharges cause flows in the Saluda River immediately below Lake Greenwood to be highly variable with frequent periods of very low flow; low flows limit navigation, fish migration, and fish habitat.
4. Occasional high flows on the Reedy and Langston Creek near Greenville cause flood damage to developed watershed areas.
5. Large wastewater discharges from the Mauldin Road Sewage Treatment Plant cause poor water quality conditions in the Reedy River and Lake Greenwood.
6. The water quality of the Little Saluda River is poor and contravenes some State standards due to municipal wastewater discharges.
7. Ground-water yields are generally limited from Piedmont aquifers.
8. High iron concentrations occur locally in aquifers throughout the sub-basin.
9. Ground water in the Leesville area contains excessively high naturally-occurring radionuclides (radium, radon).
10. Some wells in Pickens and Anderson Counties contain high copper and lead concentrations.
11. Ground-water data are insufficient to adequately assess the resource.

Catawba-Wateree River Sub-basin

GENERAL OVERVIEW

The Catawba-Wateree River Sub-basin bisects the north-central portion of South Carolina. The sub-basin parallels the course of the Catawba-Wateree River from the North Carolina border south to the confluence with the Congaree River. Portions of eight South Carolina counties are within the sub-basin boundaries, including most of Chester, Kershaw, Lancaster and York Counties, the eastern third of Fairfield County, and small portions of Sumter, Lee, and Richland Counties (Fig. 86). The areal extent of the sub-basin is approximately 2,315 square miles, 7.5 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 207,000, nearly seven percent of the State's total population (Table 76). By the year 2020 the sub-basin population is expected to reach about 334,000, an increase of 61.1 percent. The largest population increases during this period are anticipated in York and Lancaster Counties. This portion of the sub-basin encompasses the metropolitan areas of Rock Hill, York, and Lancaster and is influenced by Charlotte, North Carolina.

In general, the upper portion of the Catawba-Wateree Sub-basin is well-developed and urbanized, while the lower portion is relatively sparsely populated and rural. The major centers of population in the sub-basin are Rock Hill (35,087), Lancaster (9,547), Camden (7,465), Chester (6,762), and York (6,338).

Economy

The 1980 average median household income for the sub-basin was approximately $16,824, over $300 greater than the State average, and ranged from $12,566 in Fairfield County to $19,120 in Lancaster County. Mean per capita income for the area in 1979 was slightly less than the State per capita income of $7,056.

Combined annual average employment of non-agricultural wage and salary workers in 1979 was 91,200. The percentage breakdown by type of employment reflects the dominance of manufacturing in this area: manufacturing, 48.9 percent; wholesale and retail trade, 13.9 percent; government, 13.9 percent, services and mining, 8.8 percent; transportation and public utilities, 6.3 percent; construction, 5.6 percent; and finance, insurance, and real estate, 2.4 percent.

In the sectors of manufacturing, mining and public utilities, the sub-basin had an annual product value of about $2,292.4 million during fiscal year 1978-79, which was 10.6 percent of that for the State.

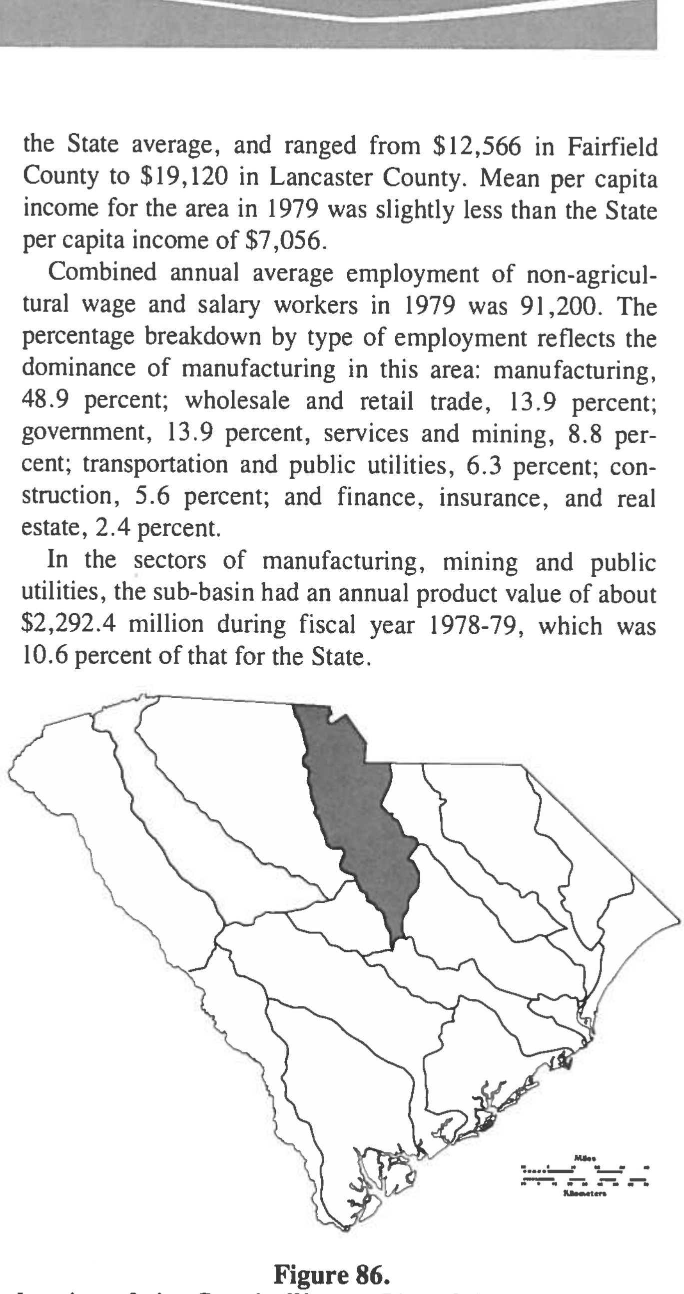


Figure 86.
Location of the Catawba-Wateree River Sub-basin in South Carolina.

Table 76.
Current and projected population for the Catawba-Wateree River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)* 1980	1990	2000	2010	2020	*% Change 1980-2020*
Chester	52.4	15.8	16.1	16.2	16.3	16.3	3.3
Fairfield	34.5	7.1	7.4	7.6	7.7	7.7	8.3
Kershaw	81.2	31.8	36.0	38.3	40.2	41.2	29.4
Lancaster	79.2	42.5	52.6	61.6	69.6	74.1	74.4
Lee	3.3	0.6	0.7	0.7	0.7	0.7	8.0
Richland	2.0	5.4	6.2	6.7	7.2	7.4	37.7
Sumter	9.5	8.4	9.4	9.9	10.3	10.5	24.8
York	89.0	95.5	120.2	143.3	164.0	175.8	84.2
Total		207.2	248.5	284.3	315.8	333.7	61.1

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

Agricultural activities, although found throughout the area, are not as intense as in other areas of the State. The sub-basin area is in the lower one-third of reported county cash crop receipts. Kershaw County was fifth in the State for livestock receipts in 1979, with nearly $21 million.

SURFACE WATER

Hydrology

The major watercourse draining this sub-basin is the Catawba-Wateree River. The headwater streams and much of the drainage area of the Catawba River occur in North Carolina. At its confluence with Big Wateree Creek near the middle of the sub-basin, the Catawba River changes in name to the Wateree River. Major tributary streams in the upper Piedmont portion of the sub-basin include Fishing Creek, Rocky Creek, Big Wateree Creek and Wateree Creek, Sugar Creek, and Cane Creek. Streams draining the Upper Coastal Plain region below Wateree Lake include Spears Creek, Colonels Creek, and Swift Creek.

Streamflow is currently monitored at six gaging stations, four of which are located on the Catawba-Wateree River main stem and two on tributary streams (Fig. 87). Streamflow is monitored on Twelve Mile Creek immediately across the state border near Waxhaw, North Carolina (Table 77). Surface-water data are also collected at three lake stations located on Lake Wylie, Fishing Creek Reservoir, and Wateree Lake; three stage stations; and one crest-stage station. Streamflow at all main stem river stations has been subject to regulated releases for most of the period of record due to numerous hydroelectric power facilities in North and South Carolina. The gaging station on the Wateree River below Eastover accurately monitors streamflow only below 10,000 cfs, while the full range of flow is monitored at all other gaging stations.

Average annual flow of the Catawba-Wateree River ranges from 4,614 cfs near Rock Hill to an estimated 7,090 cfs near Eastover (Table 77). Streamflow can be expected to equal or exceed 1,000 cfs near Rock Hill, Catawba, and Camden and 2,200 cfs near Eastover, 90 percent of the time. Controlled releases from five hydroelectric power plants along the river greatly affect streamflow. This high degree of regulation probably results in less variation between monthly flows than would otherwise occur and is evident at all main stem gaging stations, which indicate only slight seasonal variation. In addition, the relatively narrow range between maximum and minimum monthly flows and the moderately sloped flow-duration curves (Fig. 88) for the main stem gaging stations indicate moderate flow variability. Daily streamflows near Camden are more variable than elsewhere along the river due to fluctuating releases from the Wateree Hydroelectric Plant. The lowest recorded flow on the main stem (143 cfs) occurred at Camden and low flows can be expected to occur more frequently here than elsewhere along the river. The highest flood flow of record (400,000 cfs) was also recorded at Camden and occurred prior to extensive hydroelectric power development upstream.

Unlike the main stem, tributary streams are largely unregulated. Average annual streamflow of the gaged tributary streams ranges from 47 cfs at Colonels Creek to 196 cfs at Rocky Creek (Table 77). Flow in these streams should equal or exceed 23 cfs and 17 cfs, respectively, 90 percent of the time. Differing geomorphological characteristics of two major physiographic provinces greatly influence streamflow in these and other tributaries. Colonels Creek is located in the Upper Coastal Plain region, where highly permeable soils, subsurface sediments, and deeply incised streams result in well-sustained flows during periods of low rainfall. These reliable flows at Colonels Creek are evidenced by the moderately sloped flow-duration curve (Fig. 88), nearly constant mean and minimum monthly flows year round (Fig. 87), and narrow range between maximum and minimum monthly flows for this stream. Rocky Creek

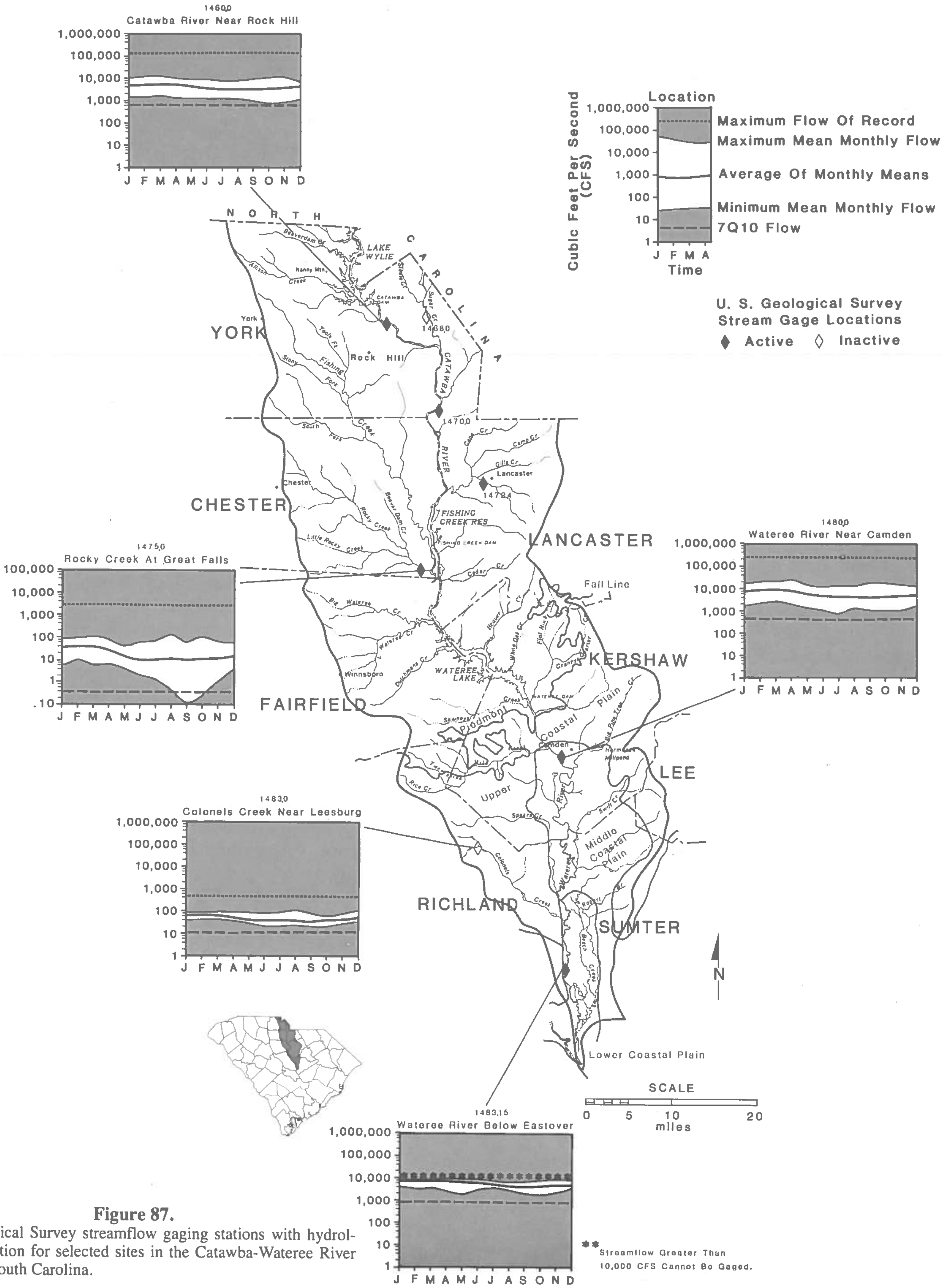


Figure 87.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Catawba-Wateree River Sub-basin, South Carolina.

Table 77.

Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Catawba-Wateree River Sub-basin, South Carolina.

Gaging Station		Drainage Area	Period of Record		Average Flow				
							90%[a]	7Q10[b]	
Number	Name/Location	(mi^2)	Dates	Total Years	cfs	cfs/mi^2	cfs	cfs	cfs/mi^2
1460	Catawba River near Rock Hill	3,050	Sep 1895-Sep 1903; Apr 1942-Present	46	4,614	1.51	1,000	710	0.23
1468	Sugar Creek near Fort Mill	262	Jan 1974-Sep 1979	6	461	1.76	98	*[c]	*
1469	Twelve Mile Creek near Waxhaw, NC	76.5	Oct 1960-Present	20	72.1	0.94	2.2	0	0
1470	Catawba River near Catawba	3,530	Oct 1968-Present	12	6,060	1.72	1,300	900	0.25
1472.4	Bear Creek at Lancaster	66.6	Oct 1978-Present	2	61.1	0.92	*	*	*
1475	Rocky Creek at Great Falls	194	Feb 1951-Present	29	196	1.01	17	1.8	0.01
1480	Wateree River near Camden	5,070	Oct 1904-Sep 1910 Oct 1929-Present	57	6,444	1.27	1,000	490	0.10
1483	Colonels Creek near Leesburg	38.1	Sep 1966-Sep 1980	14	47.1	1.24	24	11.5	0.30
1483.15	Wateree River below Eastover	5,590	Jul 1968-Present	12	7,000[f]	*	2,200	800	0.14

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] * indicate statistic not calculated.
[f] Sum of discharge of waters at Camden and estimated tributary inflow downstream.
[g] Streamflow greater than 10,000 cfs, gage height 16.71 feet.

is located in the Piedmont region where high relief and impermeable soils result in rapid runoff and limited ground-water storage. This and other Piedmont streams are, therefore, characterized by highly variable flows dependent primarily on rainfall and runoff rather than discharge from ground-water storage. Unreliable flows of Rocky Creek are reflected in the steeply sloped flow-duration curve (Fig. 88), large range between flood flow of record and low flow of record (Table 77), highly variable mean and minimum monthly flows during the year (Fig. 87) and wide range between maximum and minimum monthly flows.

Streamflow in the upper portion of the Catawba-Wateree River is well-sustained throughout the year and provides a reliable source of supply. While surface-water availability in the portion of the river below Wateree Dam is relatively constant year round, daily fluctuations and resultant low flows may limit some water use activities. Large water users may require storage facilities in this lower stretch of the river to help ensure more reliable surface-water supplies.

Tributary streams in the Upper Coastal Plain, such as Colonels Creek, support relatively constant streamflows year round and provide a reliable surface-water flow if adequate in volume. However, tributary streams in the Piedmont are not reliable water supply sources due to widely fluctuating flows and low flows during periods of low rainfall. Unregulated Piedmont streams require provisions for storage to ensure sustained surface-water availability.

Development

The Catawba-Wateree River Sub-basin may be the most intensely developed drainage basin in South Carolina. Surface-water development consists primarily of dams and reservoirs for hydroelectric power production but also includes several flood control projects. Figure 89 shows the extent of surface-water development in the sub-basin.

The three largest reservoirs are Wateree Lake, Lake Wylie and Fishing Creek Reservoir. All are owned and operated by Duke Power Company. In surface area, Wateree Lake and Lake Wylie are the eighth and ninth largest lakes in the State, respectively. Wateree Lake is the tenth largest in the State by volume.

Wateree Lake is located eight miles northwest of Camden on the Wateree River. Constructed in 1919 and enlarged in 1925, it is used for power generation, municipal water supply, and recreation. This lake has a surface area of 13,710 acres and a volume of approximately 310,000 acre-feet. Lake Wylie is located on the North Carolina-South Carolina border, five miles north of Rock Hill. Constructed in 1905, this lake is one of the oldest major impoundments in the State. Lake Wylie was later enlarged to its present capacity in 1925, covering an area of 12,455 acres with a volume of approximately 282,000 acre-feet. It was constructed for the generation of hydroelectric power and also serves recreational needs.

Fishing Creek Reservoir was built for the production of hydroelectric power in 1916. In addition to power generation, it is used as a municipal water supply and for recreation. The lake has a surface area of 3,370 acres and a volume of 80,000 acre-feet.

The total surface area of all lakes greater than ten acres within the sub-basin is approximately 34,400 acres with an approximate volume of 734,800 acre-feet. Lakes larger than 200 acres are listed in Table 78.

Only two potential hydropower sites have been identified by the U.S. Army Corps of Engineers within the sub-basin. Located at Sugar Creek and Courtney Island, these sites would utilize the 88.5 feet of head between Lake Wylie and Fishing Creek Reservoir. If these additional hydroelectric power facilities are constructed, the Catawba River would become the most developed river in South Carolina. Existing and potential hydroelectric sites are listed in Table 79.

Table 77. (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
490	Oct 21, 1954	151,000	May 23, 1901
24	Aug 25, 1979	22,700	Oct 9, 1976
No flow	Oct 6, 1968; Oct 7-15, 1970	7,700	Apr 1, 1973
755	Sep 17, 1980	73,600	Oct 9, 1976
0.80	Sep 16, 22, 1980	3,610	Mar 29, 1980
0.04	Oct 6-13, 1954	31,300	Aug 23, 1967
143	Sep 28, 1980	400,000	Jul 18, 1916
11	Jul 12-14, 1970	494	Jun 10, 1973
702	Sep 3, 1968	-[g]	Dec 14, 1969

In addition, one potential small scale hydropower site has been identified by the S.C. Land Resources Conservation Commission (Long, 1980) with a total potential capacity of 0.3 MW.

The Wateree River has been the site of the only U.S. Army Corps of Engineers project within the sub-basin (Table 80). In the late 1800's and early 1900's, a four-foot navigation channel was maintained from the mouth of the river to Camden. However, for economic reasons the project was recommended for abandonment in 1915 and is no longer active.

The Soil Conservation Service has completed two flood control projects, Fishing Creek in York County and Wateree Creek in Fairfield County, and has two other projects under construction. These projects include 18.3 miles of channel improvement, 29 floodwater retarding structures and land treatment for erosion control and sediment reduction. Details of these and other flood control projects are listed in Table 81.

Water Quality

The Catawba-Wateree Sub-basin is composed of a large number of Class A water bodies suitable for swimming, fishing, and other uses requiring high quality waters (Fig. 90). All major lakes and all or parts of many tributary streams are of this water use class. The main stem and some tributaries have been designated Class B waters. Water quality limited segments in this sub-basin which require advanced treatment of wastewater discharges include all or portions of Lake Wylie, Fishing Creek Reservoir, Beaver Creek, Hermitage Millpond, Swift Creek and several minor tributary streams throughout the sub-basin (Fig. 91). Water use in the sub-basin generally is not inhibited by water quality conditions. However, some streams draining highly urbanized areas of the sub-basin are sufficiently degraded

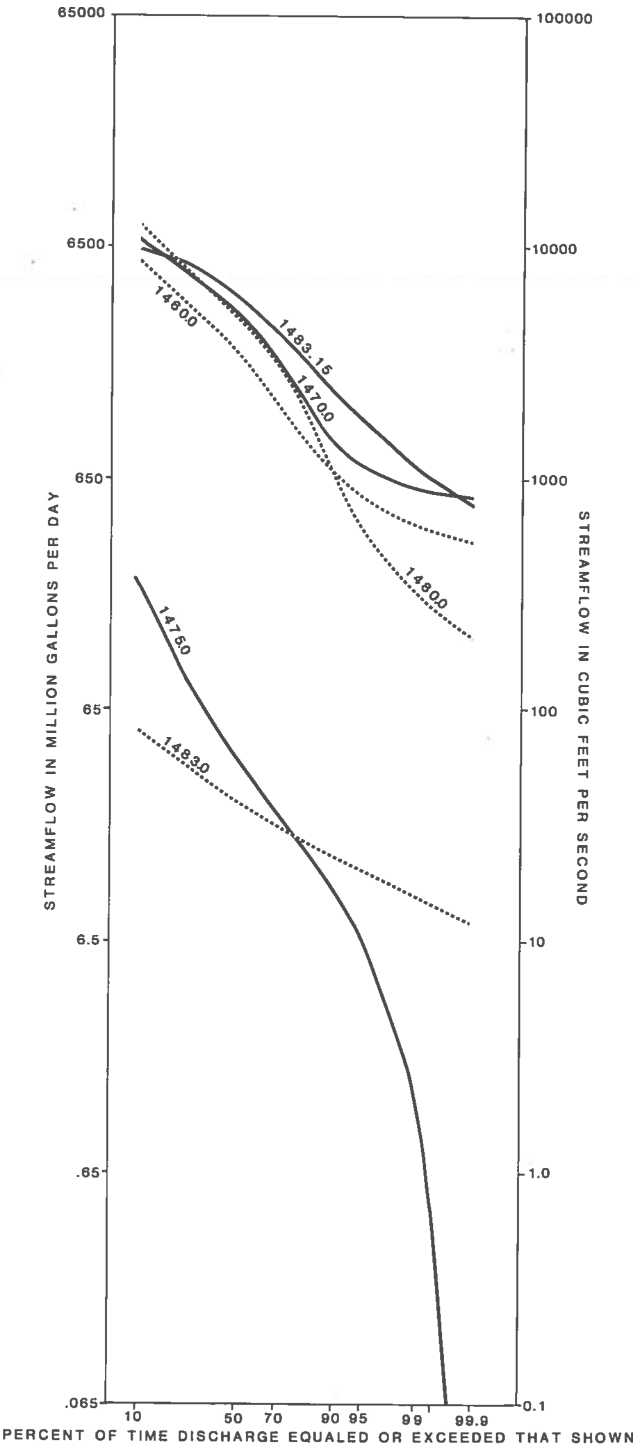


Figure 88.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Catawba-Wateree River Sub-basin, South Carolina.

Table 78.

Existing lakes larger than 200 acres in the Catawba-Wateree River Sub-basin, South Carolina.

Map No.	Name	Stream	Surface Area (acres)	Storage Capacity (acre-feet)	Purpose
1	Lake Wylie	Catawba River	12,455	281,900	Power Recreation
2	Wateree Lake	Wateree River	13,710	310,000	Power Recreation
3	Fishing Creek Reservoir	Catawba River	3,370	80,000	Power Recreation Water Supply
4	Rocky and Cedar Creek Reservoirs	Catawba River	800	23,000	Power Recreation
5	Dearborn, Great Falls Reservoir	Catawba Creek	450	16,000	Power Recreation
6	Hermitage Mill Pond	Big Pine Tree Creek	600	1,800	Industry Power Recreation Water Supply
7	Murray's Pond	Colonel's Creek	200	600	Recreation

Source: S.C. Water Resources Commission, 1974.

Table 79.

Existing and potential hydroelectric power development in the Catawba-Wateree River Sub-basin, South Carolina.

Map No.	Facility/Site Name	Facility/Site Location County	Facility/Site Location River	Owner	No. of Units	Total Capacity (MW)	Surface Area (acres)	Status
8	Wylie	York	Catawba	Duke Power Co.	4	60.0	12,455	Const. 1925
9	Fishing Creek	Lancaster	Catawba	Duke Power Co.	5	36.0	3,370	Const. 1916
10	Great Falls/ Dearborn	Chester	Catawba	Duke Power Co.	12	73.0	800	Const. 1907
11	Rocky Creek/ Cedar Creek	Chester	Catawba	Duke Power Co.	12	73.0	800	Const. 1909
12	Wateree	Kershaw	Wateree	Duke Power Co.	5	60.0	13,710	Const. 1919
13	Sugar Creek	York	Catawba	--[a]	--	26.4	2,500	Potential
14	Courtney Island	Lancaster	Catawba	--	--	50.6	5,400	Potential

[a] -- indicates information not available.

Sources: Federal Power Commission, 1970.
S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

Table 80.

U.S. Army Corps of Engineers navigation projects in the Catawba-Wateree River Sub-basin, South Carolina.

Map No.	Project Name	County	Responsible District	Length (miles)	Width (feet)	Status/Remarks
15	Wateree River	Sumter Richland Kershaw	Charleston	67.0	--[a]	Project provided for safe and unobstructed 4 foot navigation for steamers from the mouth to Camden, S.C. Recommended for abandonment in 1915, the project is inactive.

[a] -- indicates information not available.
Source: U.S. Army Corps of Engineers, 1982b.

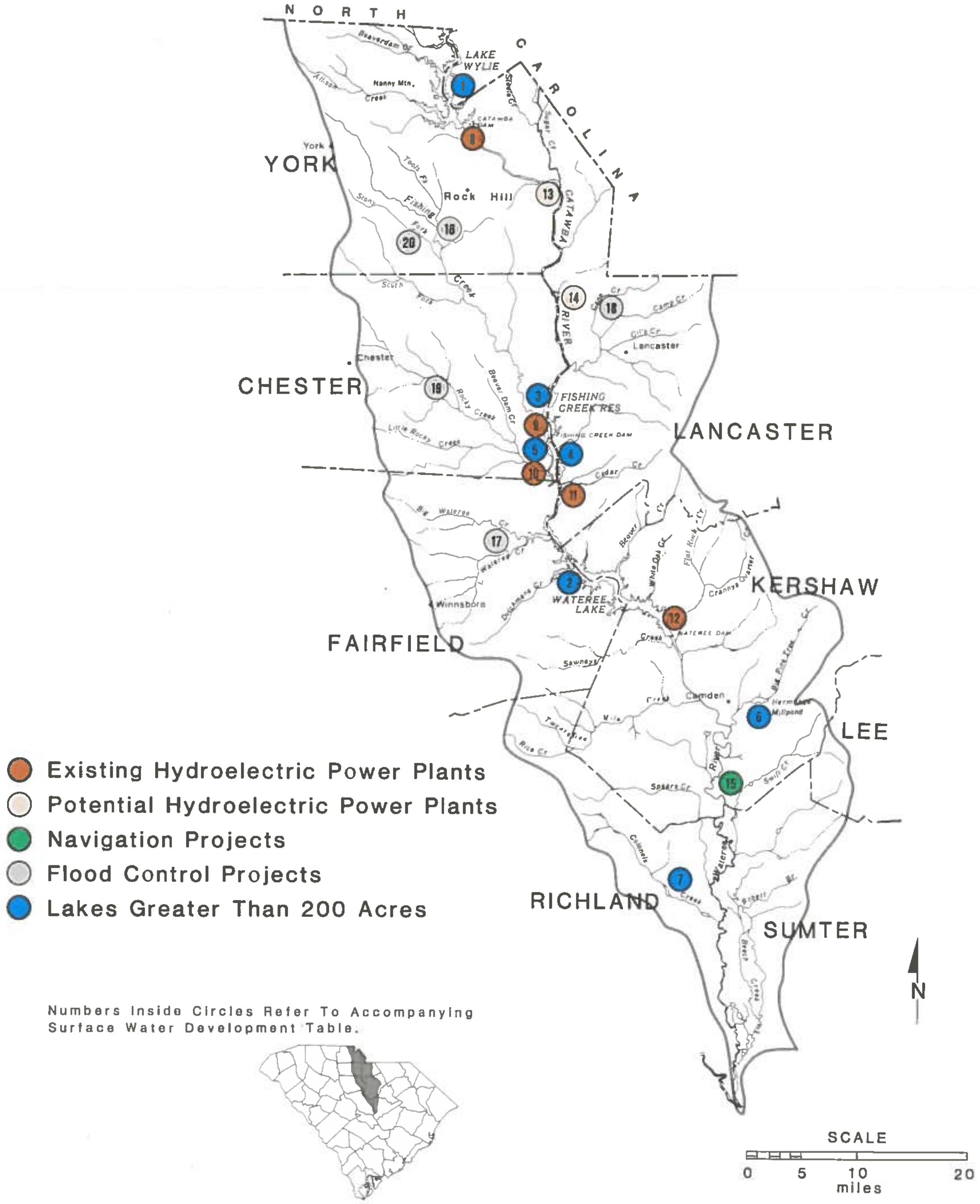


Figure 89.
Surface-water development in the Catawba-Wateree River Sub-basin, South Carolina.

Table 81.
Flood control projects in the Catawba-Wateree River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
16	Fishing Creek	York	SCS	Completed 1974
17	Wateree Creek	Fairfield	SCS	Completed 1966
18	Cane Creek	Lancaster	SCS	Under construction
19	Rocky Creek	Chester/Fairfield	SCS	Under construction
20	Stony Fork	York	SCS	Terminated

[a] SCS indicates Soil Conservation Service.

Source: U.S. Department of Agriculture, 1980.

to restrict some water use activities and potential water use problems may occur in the lakes if present nutrient loading continues.

Water quality in the Catawba and Wateree Rivers is generally good but decreases during portions of the year (S.C. Department of Health and Environmental Control, 1980b). Trends in recent years indicate increasing quality in terms of temperature, dissolved oxygen, and aesthetics and decreasing quality in terms of inorganic toxicity. Due to greater development, the portion of the sub-basin above Wateree Lake exhibits poorer overall water quality than the portion below the lake. Much of the degraded conditions in the Catawba River, which are evidenced by high levels of fecal coliform bacteria, biochemical oxygen demand, and nutrients, are attributed to inflow from Sugar Creek. This Class B stream which receives municipal wastewater from the City of Charlotte, North Carolina exhibits poor water quality with violations of State quality standards (Johnson and de Kozlowski, 1981).

Elevated fecal coliform bacterial levels due to agricultural non-point source pollution may impair limited recreational use of Tools Fork Creek and Allison Creek (S.C. Department of Health and Environmental Control, 1981c).

Lake Wylie has been classified as eutrophic, indicating fairly high nutrient loading (U.S. Environmental Protection Agency, 1975c). The U.S. Environmental Protection Agency (1975c) ranked this lake eighth in trophic quality out of 13 South Carolina lakes studied. Water quality is generally good to fair with some evidence of nutrient loading (S.C. Department of Health and Environmental Control, 1980b). Approximately 60 percent of the phosphorus entering this lake comes from non-point sources.

Fishing Creek Reservoir is one of the most eutrophic lakes in the State ranking tenth out of 13 lakes surveyed for trophic conditions (U.S. Environmental Protection Agency, 1975d). High organic and nutrient concentrations, in addition to a predominance of pollution tolerant organisms indicate fair to poor water quality conditions (S.C. Department of Health and Environmental Control, 1980b; Johnson and de Kozlowski, 1981). While water use on this lake has not yet been adversely affected, the potential for future restrictions due to increased water quality problems exists due to continued high nutrient loading.

Wateree Lake is the most eutrophic major lake in this sub-basin and has been ranked 12th in trophic quality out of 13 South Carolina lakes surveyed (U.S. Environmental Protection Agency, 1975e). The majority of the heavy nutrient load entering the lake is from point source discharges located upstream along the Catawba River. While chemical and physical parameters indicate generally good quality water, biological studies suggest fair to poor water quality due to an abundance of pollution tolerant organisms (S.C. Department of Health and Environmental Control, 1980b; Johnson and de Kozlowski, 1981). Water quality in this lake, as in Fishing Creek Reservoir, has not significantly affected current water use; however, the potential for adverse water use impacts due to continued nutrient loading is present.

GROUND WATER

Hydrogeology

Knowledge of ground-water resources in the Catawba-Wateree River Sub-basin ranges from the field data level in the middle part to the evaluation level in the southeastern region (Fig. 18).

The Catawba-Wateree River Sub-basin lies partially in the Piedmont Province and partially in the Upper Coastal Plain, creating wide variations in ground-water availability and yield. Selected ground-water data for the sub-basin are presented in Table 82.

The Piedmont portion of the sub-basin includes parts of York, Chester, and Fairfield Counties predominately underlain by Charlotte belt rocks. Lancaster and Kershaw Counties are underlain by rocks of the Carolina slate belt. Both belts are generally oriented northeast-southwest with the Charlotte belt transecting the northernmost part of the sub-basin. Because of a limited data base, little information can be presented concerning ground-water occurrence in the Piedmont counties of the basin. There appears to be little difference between yields from the two crystalline rock

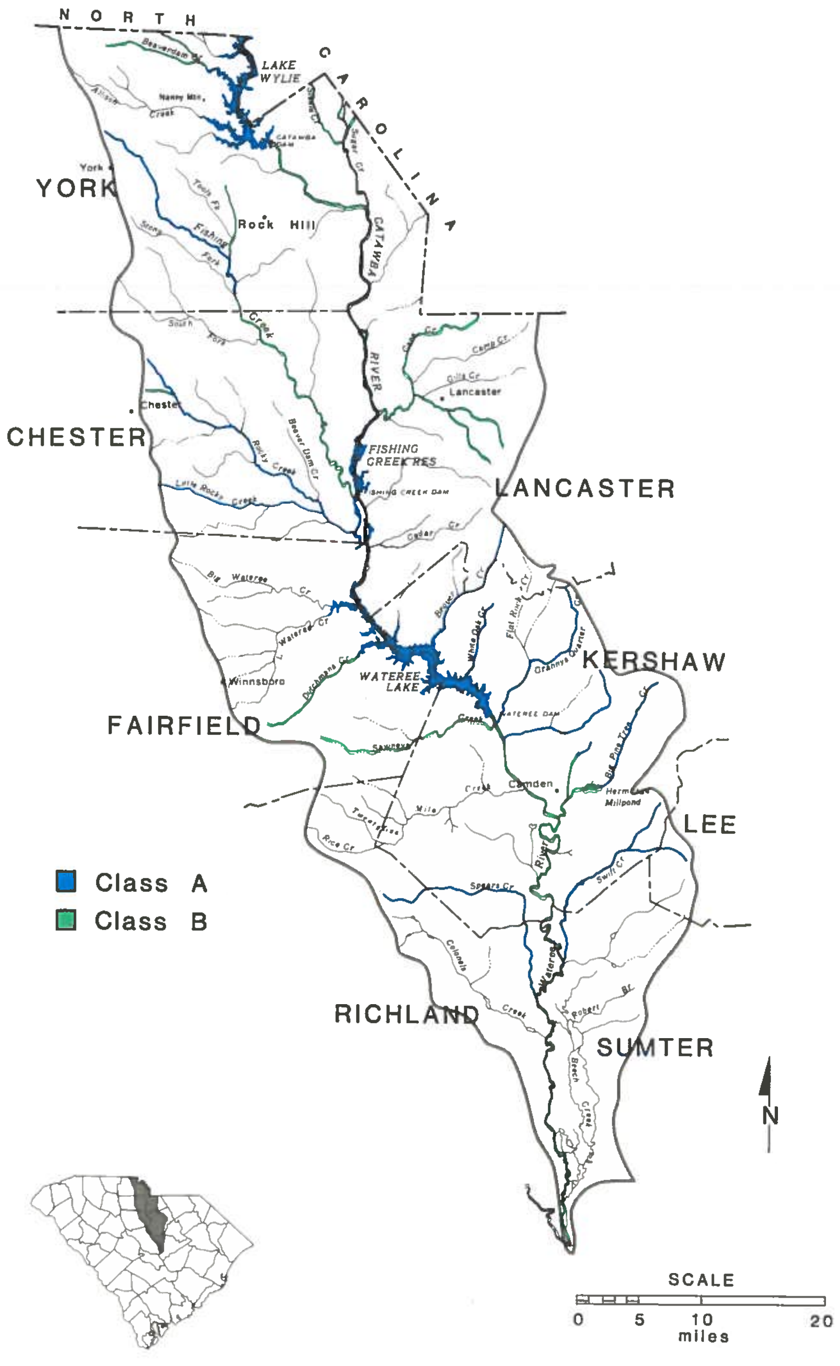


Figure 90.
Surface-water quality classifications in the Catawba-Wateree River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

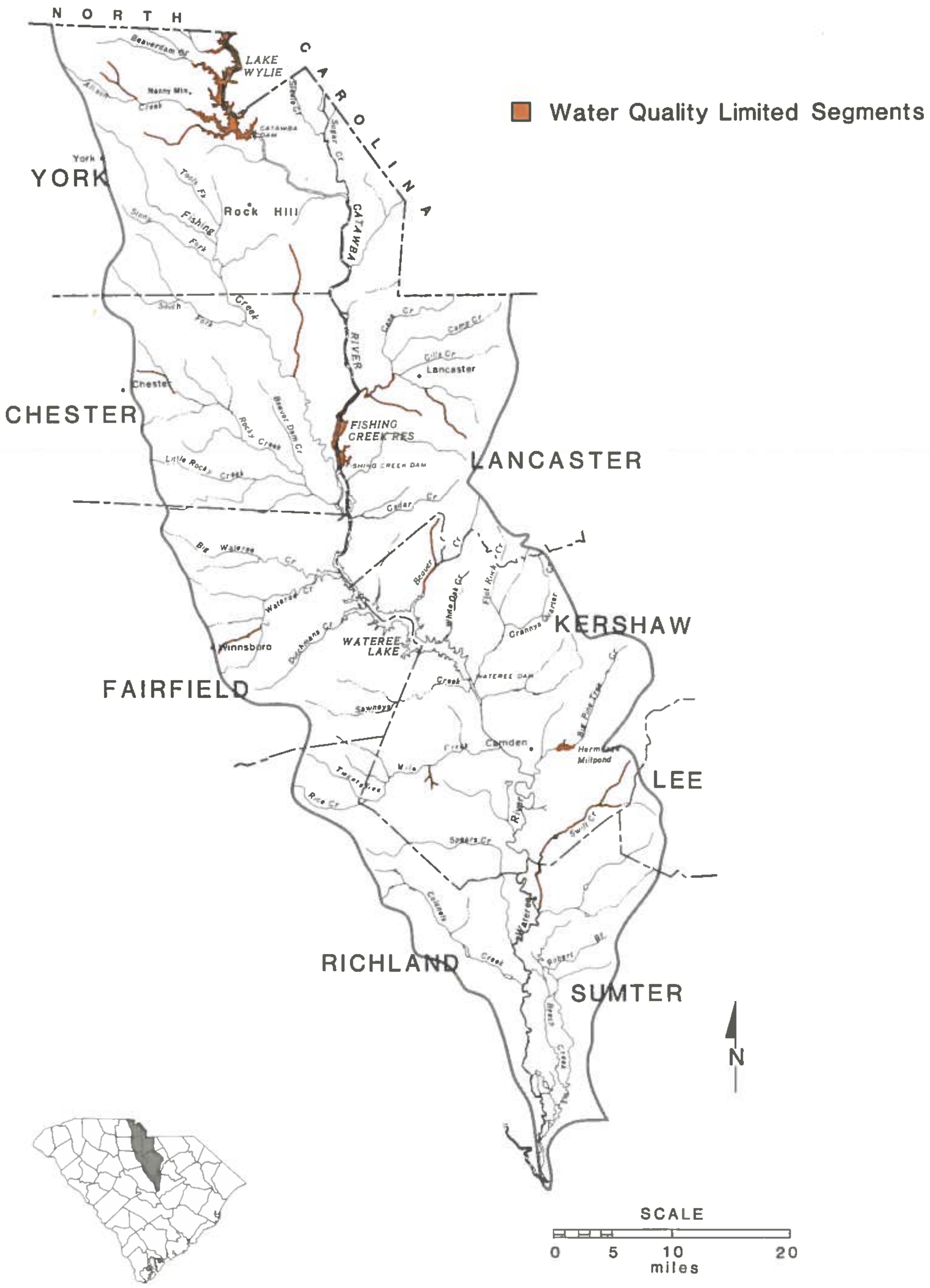


Figure 91.
Water quality limited segments in the Catawba-Wateree River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Table 82.
Selected ground-water data for the Catawba-Wateree River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Camden	Middendorf	26-130	2-50	--[a]
Lugoff	Middendorf/crystalline	200-500	5-120	--
Cassatt	Middendorf	61-92	264	--
Eastover	Middendorf	500-610	2000-2500	30
Rembert	Middendorf	139-161	55-60	3.2-4.2
Hagood	Middendorf	145-318	1212	35
Elgin	Middendorf	115-150	150	--
Wedgefield	Black Mingo/Black Creek	74-238	100-200	2.4
Wateree River at Lugoff	Shallow sand and gravel deposits in flood plain	50	100-400	--

[a]--indicates data not readily available.

belts traversing the region. The supply of ground water in the Piedmont counties appears to be limited. Average well yields are usually about 20 gpm with maximum yields approaching 300 gpm in a few instances. A substantial number of residential wells have yields of less than 10 gpm.

Butler and Siple (1966) discussed data concerning 147 wells in York County. The data indicate a range in well yields from 3 gpm to more than 300 gpm and an average of about 50 gpm. The largest user of ground water in York County is the City of Clover, where the average use approximates 0.12 mgd (83 gpm).

The U.S. Geological Survey records of Chester County contain data on five wells located in the Catawba-Wateree River Sub-basin. Depths of these wells range from 70 feet to 156 feet and yields range from 8 to 40 gpm.

U.S. Geological Survey data for Fairfield County include information on 63 wells. Their depths range from 30 to 360 feet and the yields range from 11 to 60 gpm.

Southeast of the Fall Line, in Richland, Kershaw, and Sumter Counties, the sedimentary deposits of the Upper Coastal Plain provide a good source of ground water. This portion of the sub-basin is underlain by the Middendorf, Black Creek, and Black Mingo Aquifer Systems which dip southeastward and thicken to about 650 feet near the lower boundaries of the sub-basin.

A recent analysis of well data near the Town of Wateree in Richland County indicates a total thickness of sedimentary deposits of about 650 feet. The Middendorf Aquifer System occurs between the depths of 350 to 650 feet and directly overlies the bedrock. From 250 to 350 feet lies a series of sand and clay beds which possibly represent the Black Creek Aquifer System. The Black Mingo Aquifer System overlies the Black Creek and is the principal source of water for most domestic and small municipal wells. The transmissivity of the Middendorf Aquifer System near Eastover has been calculated to be about 10,000 ft^2/day and the storage coefficient is approximately 0.00013 (Crum, 1979; Pelletier, 1982).

In Sumter County, the area around Rembert and Hagood is underlain by alluvial deposits of sand, silt, clay and gravel along the Wateree River, and by the Middendorf Aquifer System elsewhere. Wells located in the Wedgefield area are used primarily for domestic purposes. Well depths in this area range from 47 to 247 feet and yields range from 2 to 200 gpm. No data are available on yields of wells drilled in the alluvium, but 8 to 10 inch diameter wells developed in the sands of the Middendorf Aquifer System should yield from 500 to 600 gpm.

Water Quality

In the Piedmont portion of the Catawba-Wateree River Sub-basin, water locally contains high iron and magnesium concentrations, excessive hardness, and has taste problems. The Stiff Diagram in Figure 92 shows a calcium bicarbonate type water for the ground water occuring in the Charlotte and Carolina slate belts and a calcium sulfate type for the Kings Mountain belt.

Water from depths of 70 to 150 feet in the Coastal Plain sediments of Sumter County contains excessive amounts of dissolved iron. Water from the Middendorf Aquifer System is soft and has a total dissolved solids content of less than 30 mg/L and a pH of from 4.5 to 6.0; the water is corrosive and tends to shorten the life of wells, pumps, and piping. Water from a depth of 434 to 544 feet, in one well near the Town of Wateree in Richland County has very good quality with a total dissolved solids content of 75.0 mg/L, total hardness of 23 mg/L, dissolved iron of 0.17 mg/L, chloride content of 12.3 mg/L, and no detectable fluoride. In another well screened from 452 to 563 feet in the same vicinity, the water contains excessive amount of iron (1.29 mg/L). The Stiff Diagram shows a sodium bicarbonate water quality type for the Middendorf Aquifer System.

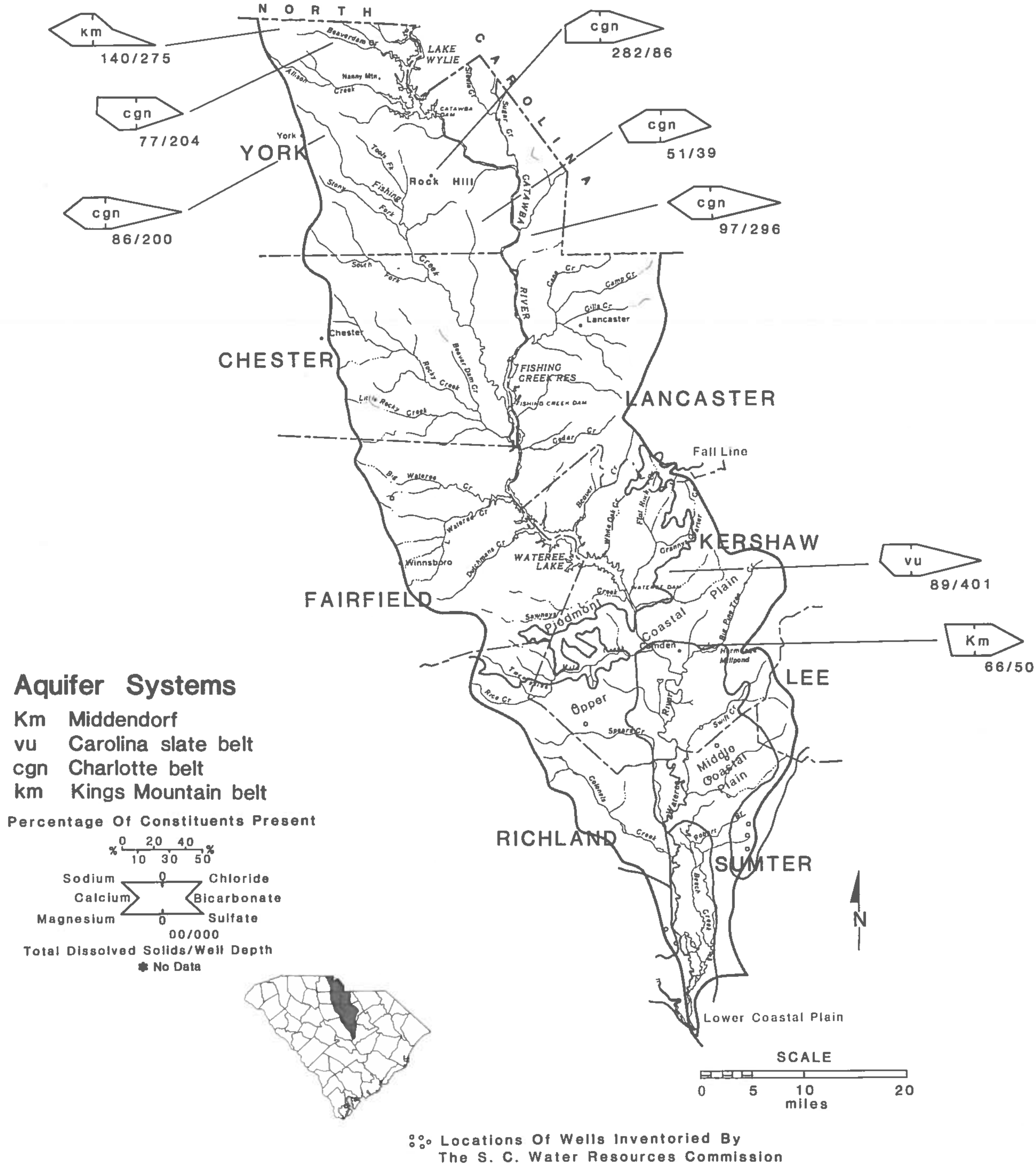


Figure 92.
Ground-water quality of selected aquifer systems and major inventoried wells in the Catawba-Wateree River Sub-basin, South Carolina.

Table 83.

Current and projected water use in the Catawba-Wateree River Sub-basin, South Carolina, 1980 - 2020.

		Water Use(mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	1.44	14.8	16.2	1.73	17.8	19.5	1.99	20.4	22.4	2.19	22.5	24.7	2.30	23.6	25.9
	Consumed	0.14	1.48	1.62	0.17	1.78	1.95	0.20	2.04	2.24	0.22	2.25	2.47	0.23	2.36	2.59
Self-supplied Domestic	Gross	4.7	---	4.7	5.6	---	5.6	6.5	---	6.5	7.1	---	7.1	7.5	---	7.5
	Consumed	4.0	---	4.0	4.8	---	4.8	5.5	---	5.5	6.0	---	6.0	6.4	---	6.4
Agriculture Irrigation	Gross	1.2	1.2	2.4	4.2	3.3	7.5	7.4	5.0	12	10	6.4	16	13	7.7	21
	Consumed	1.2	1.2	2.4	4.2	3.3	7.5	7.4	5.0	12	10	6.4	16	13	7.7	21
Agriculture Livestock	Gross	0.39	0.32	0.71	0.44	0.36	0.80	0.51	0.42	0.93	0.58	0.47	1.1	0.66	0.54	1.2
	Consumed	0.39	0.32	0.71	0.44	0.36	0.80	0.51	0.42	0.93	0.58	0.47	1.1	0.66	0.54	1.2
Self-supplied Industry	Gross	1.99	117	119	2.19	161	163	2.52	184	187	2.77	202	205	3.05	223	226
	Consumed	0.37	21.7	22.1	0.41	29.8	30.2	0.47	34.0	34.5	0.51	37.4	37.9	0.56	41.3	41.9
Thermoelectric Power	Gross	---	417	417	---	543	543	---	559	559	---	576	576	---	611	611
	Consumed	---	0.97	0.97	---	25.5	25.5	---	42.1	42.1	---	69.4	69.4	---	115	115
Total	Gross	9.72	550	560	14.2	725	740	18.9	769	788	22.6	807	830	26.5	866	892
	Consumed	6.1	25.7	31.8	10.0	60.7	70.8	14.1	83.6	97.6	17.3	116	133	20.9	167	188

WATER USE

Gross water use in the Catawba-Wateree Sub-basin currently averages 560 mgd of which 31.8 mgd is lost due to consumption (Table 83). This sub-basin ranks fourth in the State for total gross use. Major water users include thermoelectric power (417 mgd), self-supplied industry (117 mgd), and public supply (14.8 mgd). Major water users by type and supply source are shown in Figure 93.

Surface water is the sub-basin's major source of supply, meeting about 98 percent of total demand and 93 percent of demand other than thermoelectric power. While most public supply and industrial use occurs in the upper portion of the sub-basin, thermoelectric power and agricultural irrigation use are more predominant in the portion of the sub-basin below Wateree Dam.

Public supply represents three percent of gross use and five percent of consumptive use. Surface water supplies almost 91 percent of public supply needs in this sub-basin.

Water for self-supplied domestic use accounts for less than one percent of gross use and 13 percent of consumptive use. This user group is the largest ground-water user in the sub-basin withdrawing all supply needs (4.70 mgd) from this single source.

Agricultural water use comprises less than one percent of gross demand. While withdrawals for irrigation account for less than one percent of gross use, they represent eight percent of total sub-basin consumption. When averaged over the five-month growing season, irrigation water use equals 5.8 mgd, comprising one percent of total sub-basin use. One-half of the sub-basin's 3,245 cultivated acres are irrigated from surface-water sources. Livestock water use represents 0.1 percent of gross use and two percent of consumptive use. This user group obtains 55 percent of water supplies from ground-water sources.

Self-supplied industrial withdrawals make up 21 percent of gross demand. This user group is the largest consumptive user in the sub-basin accounting for 68 percent of total consumptive use. Most industrial water use occurs in the upper portion of the sub-basin and is heavily dependent (98 percent) upon surface-water sources.

Thermoelectric power is the sub-basin's largest gross water user (75 percent) and surface-water user (417 mgd). While this user group requires large amounts of water for cooling purposes, actual consumption by this group is very small, representing only three percent of total consumptive use. The one electric power facility comprising this group is located in the lower portion of the sub-basin and withdraws all supply needs from the Wateree River.

Total gross water use is projected to increase by 59 percent to over 892 mgd by 2020. Consumption is expected to increase by 490 percent to 188 mgd by 2020. By 2020, thermoeletric power should show the largest increase by volume (194 mgd), and agricultural irrigation should show the largest percentage increase (760 percent). Thermoelectric power will continue to be the major user group and surface water the major supply source.

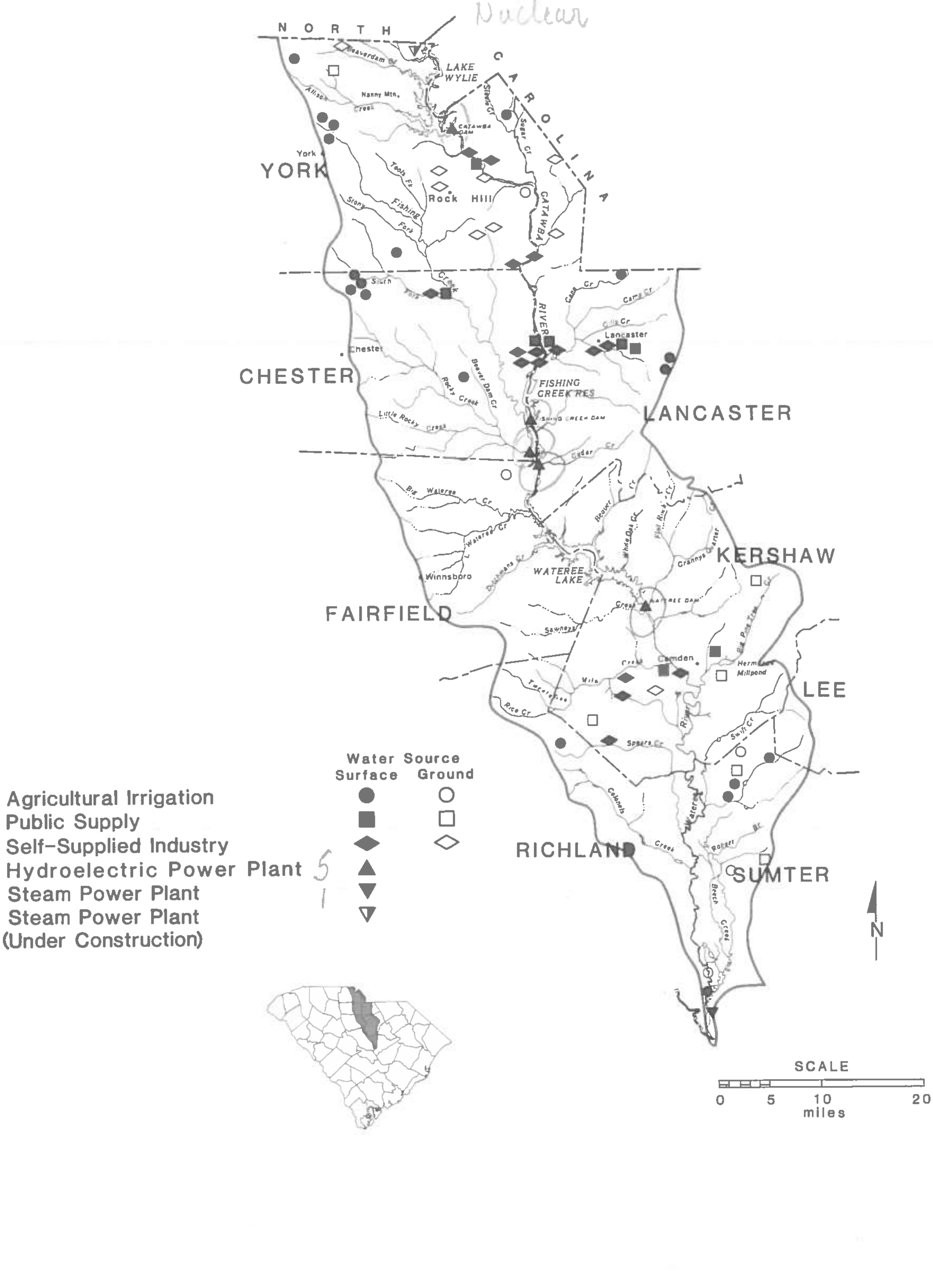


Figure 93.
Location, type, and supply source of water users in the Catawba-Wateree River Sub-basin, South Carolina.

WATER USE VERSUS AVAILABILITY

Streamflow in the Catawba-Wateree River is sufficient to meet current and projected gross surface-water demands most of the time. During periods of low flow, basinwide availability is less than total demand. Total basin flow meets current gross surface-water use (550 mgd) approximately 99.7 percent of the time (Fig. 94). The projected gross demand for the year 2020 (866 mgd) is expected to be supplied by streamflow about 98 percent of the time. Sufficient supplies of surface water should be more than adequate to fulfill current and projected consumptive use.

In the upper portion of the study area, between Lake Wylie and Wateree Lake where the number of surface-water users is greatest (Fig. 93) minimum flows are more than sufficient to meet demands. Tributary streams in this part of the study area are not reliable supplies due to low base flows during periods of low rainfall. Unregulated streams in the Piedmont Province will require provisions for storage to ensure sustained surface-water availability. Since most of the upper basin area is relatively close to the Catawba River main stem, pumping water from the river is an alternative to withdrawals from unreliable tributaries.

The supply-demand relationship is more critical in the downstream portion of the study area. Due to periodic minimal releases from Wateree Lake, low flows are smaller and more frequent in the Wateree River than in the upstream Catawba River. Coincident with the lower flows is a greater surface-water demand. The 7Q10 flow at the Eastover gaging station is equivalent to current maximum lower basin demand.

Streamflow conditions in the lower portion of the main stem could severely limit future development in the area. It may become necessary for future water users to provide for surface-water storage, rely more heavily on ground water, or utilize tributary streamflow.

Ground-water supplies are much more abundant in the Coastal Plain region than the Piedmont region of the Catawba-Wateree Sub-basin. The range of well yields in the Piedmont portion is too large (from one to 300 gpm) to provide a reasonable projection of the average yield for individual wells, beyond the generalized categories included in Figure 19. The potential for future ground-water development in the Piedmont portion of the sub-basin can be determined only after an intensive program of test-well drilling has been evaluated.

Generally, based on the existing data, ground-water yields in the Piedmont region are insufficient to meet large municipal and industrial requirements. However, if the base flow of the major stream is analyzed, it shows a fairly good potential for ground-water availability. Figure 94 shows that the flow of the Wateree River is 684 mgd 99 percent of the time. This flow is assumed to represent the total ground-water contribution to the stream and indicates ground-water discharge to be about 0.12 mgd per square mile area of the sub-basin. This base flow discharge, adjusted to the South Carolina area of the drainage basin (278 mgd), exceeds the projected ground-water use for the year 2020 by about 10 times.

Ground-water availability in some areas of the sub-basin may be limited because of localized conditions of low well yields. Water quality problems may also limit current and projected ground-water use. High iron concentrations, excessive hardness, and magnesium, and taste problems in some rock aquifers may restrict the use of water for certain purposes.

Major water resource problems and opportunities in the sub-basin are summarized in Table 84.

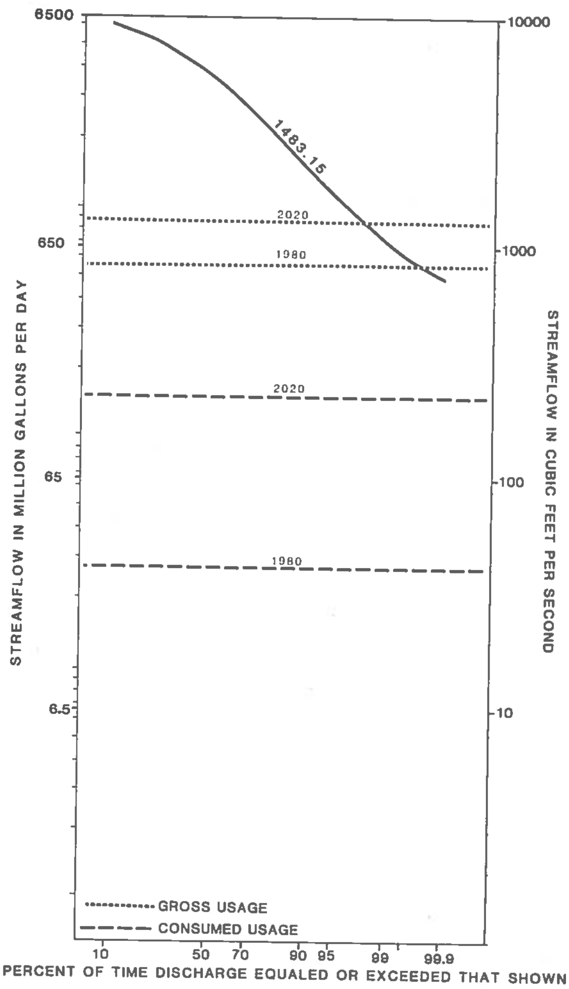


Figure 94.
Water use compared to availability in the Catawba-Wateree River Sub-basin, South Carolina.

Table 84.

Major water resource findings in the Catawba-Wateree River Sub-basin, South Carolina.

Opportunities

1. Streamflow in the Catawba-Wateree River is sufficient to meet current gross surface-water demand 99.6 percent of the time and projected gross use 98 percent of the time.
2. The upper portion of the Catawba-Wateree River exhibits well-sustained and reliable flows.
3. Upper Coastal Plain streams have well-sustained and reliable flows.
4. Two potential hydroelectric power sites, Courtney Island and Sugar Creek, have been identified in the sub-basin.
5. Water quality in the Catawba-Wateree River and Lake Wylie is generally good.
6. Ground-water supplies in the Coastal Plain region of the sub-basin are largely undeveloped and offer a good source for future development.

Problems

1. During periods of low flow, surface-water supplies are not adequate for current and projected gross surface-water use.
2. Regulated releases from Wateree Dam cause highly fluctuating flows downstream which may result in water use conflicts in the lower portion of the sub-basin during low-flow periods.
3. Current heavy withdrawals from the Wateree River will severely limit any future surface-water dependent development along this river.
4. Unregulated Piedmont streams have highly variable flows and are unreliable sources of surface water.
5. Point and non-point sources of pollution from the highly developed upper portion of the sub-basin have adversely impacted the quality of streams in this area.
6. Municipal wastewater discharges from the City of Charlotte, N.C. have caused poor water quality conditions in Sugar Creek as evidenced by frequent violations of State dissolved oxygen and fecal coliform bacteria standards in addition to other problem conditions.
7. Poor water quality in Sugar Creek adversely impacts the quality of portions of the Catawba River.
8. Fishing Creek Lake and Wateree Lake are highly eutrophic with fair to poor water quality and have the potential for adverse water use impacts.
9. Ground-water yields are limited in the Piedmont portion of the sub-basin and are not adequate to meet large municipal and industrial use needs.
10. High iron and magnesium concentrations, excessive hardness, and taste problems occur in ground water from some rock aquifers in the Piedmont region.
11. Ground-water data are insufficient to accurately assess the resource in the Piedmont region.

Congaree River Sub-basin

GENERAL OVERVIEW

Located in the geographical center of the State, the Congaree River Sub-basin is the smallest of the 15 designated sub-basins in South Carolina. It encompasses portions of Richland, Lexington, and Calhoun Counties (Fig. 95). The areal extent of the sub-basin is approximately 705 square miles, 2.3 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at approximately 280,000, which was nine percent of the State's total population (Table 85). The sub-basin population is expected to reach 464,000 by the year 2020, an increase of 65.2 percent. The largest population increase is anticipated in Lexington County, which is expected to increase by 148.3 percent during this time period.

The southeastern portion of the sub-basin is predominantly rural, while the northwestern portion is one of the most densely populated areas of the State. The regional focus and main center of population in the sub-basin is Columbia (96,237). Other major urban areas are Cayce (12,135), West Columbia (10,240), and Forest Acres (5,923), all of which are adjacent to Columbia.

Economy

The 1979 per capita personal income for the sub-basin ranged from $8,294 in Richland County, which ranked second among the State's 46 counties, to $6,782 in Calhoun County, which ranked 16th. Median household income in 1980 ranged from $19,798 in Lexington County, the highest in the State, to $11,174 in Calhoun County, which was about $5,000 less than the State's median household income.

Annual average employment of non-agricultural wage and salary workers in the sub-basin totalled 181,200 in 1979. The percentage breakdown by type of employment was: government, 30.3 percent; wholesale and retail trade, 21.2 percent; manufacturing, 16.6 percent; services and mining, 14.6 percent; transportation and public utilities, 5.2 percent; finance, insurance, and real estate, 7.5 percent; and construction, 4.9 percent. Because the State capital is Columbia, the number of government employees is disproportionately high in the region, compared to the State as a whole.

In the sector of mining, manufacturing and public utilities, the sub-basin had an annual product value of approximately $1,930.4 million during fiscal year 1978-79. This was nine percent of the State's total product value for this period.

Figure 95.
Location of the Congaree River Sub-basin in South Carolina.

Table 85.
Current and projected population for the Congaree River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands)					% Change 1980-2020
		1980	1990	2000	2010	2020	
Calhoun	25.0	3.1	3.5	3.7	4.0	4.1	32.7
Lexington	49.4	70.0	96.4	126.3	155.7	173.7	148.3
Richland	77.4	208.0	239.6	260.4	277.3	286.3	'37.7
Total		281.1	339.5	390.4	437.0	464.1	65.2

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

Agricultural productivity is high in Calhoun and Lexington Counties, with the majority of agricultural income in Calhoun County resulting from crops, and Lexington County receiving most of its agricultural income from livestock and livestock products. Lexington County ranked third in South Carolina for 1979 livestock receipts. About 87.1 percent of Richland County's population is classified as urban, and agriculture plays a minor role in the county's economy.

SURFACE WATER

Hydrology

The major watercourse in the sub-basin is the Congaree River, formed by the confluence of the Saluda and Broad Rivers near Columbia. Several small to moderately sized tributaries discharge into the main stem, the largest of which include Congaree Creek, Gills Creek, Cedar Creek, and Toms Creek. This sub-basin is located mostly within the Upper Coastal Plain with portions of the eastern region in the Middle Coastal Plain. Much of the Congaree River and lower portions of tributary streams are associated with swamplands. The Columbia-West Columbia-Cayce metropolitan area makes extensive use of surface waters in the upper portion of the sub-basin. A 45-mile segment of the Congaree River, from Congaree Creek to the Highway 601 bridge, has been declaired eligible for the State Scenic River Program.

Currently, streamflow is monitored at three sites, the Congaree River, Gills Creek, and Big Beaver Creek (Fig. 96). A streamflow gage on Congaree Creek was discontinued in 1980. Peak high flow is also recorded at one crest-stage station (1695.4). Streamflow on the Congaree River is affected by regulated discharges from hydroelectric power plants on the Saluda and Broad Rivers and several flood control and recreational impoundments along Gills Creek affect natural streamflow in this tributary. Streamflow statistics for the three active and one inactive streamflow gaging stations are presented in Table 86.

Average annual streamflow in the Congaree River at Columbia is 9,425 cfs and should be at least 3,300 cfs, 90 percent of the time. While daily flow may be highly variable due to fluctuating releases from hydroelectric power facilities upstream, mean monthly flow is less variable (Fig. 96). The moderately wide range between maximum and minimum monthly flows (Fig. 96) and the moderately sloped flow-duration curve (Fig. 97) suggest that flow in this river is more variable than the monthly means indicate. The low flow of record (662 cfs) occurred during the 1954 drought, and the flood flow of record (364,000 cfs) occurred in August 1908.

Tributary streams on opposite sides of the Congaree River exhibit different streamflow characteristics. Streams draining the western side of the sub-basin, such as Congaree Creek and Big Beaver Creek, have extremely uniform streamflows. Congaree Creek has the most regular streamflows year round of any gaged stream in the State. This is indicated by the nearly flat flow-duration curve (Fig. 97), extremely narrow range between maximum and minimum monthly flows (Fig. 96) virtually constant mean monthly flows year round, high unit average discharge (1.82 cfs/mi^2), and high unit 7Q10 discharge (0.97 cfs/mi^2) values. The flow-duration curve (Fig.97) and unit discharge values for Big Beaver Creek also indicate well-sustained flow with little significant variation year round.

Streams draining the eastern side of the sub-basin are typical of most Middle Coastal Plain streams which exhibit moderately-sustained flow. This group of streams originates in an area of nearly impermeable, red clayey sand and, therefore, are characterized by limited sustained flow (Bloxham, 1976). Streamflow characteristics of Gills Creek reflect the more variable, less well-sustained flows of these eastern tributaries. Those characteristics include a steeply sloped flow-duration curve (Fig. 97), high unit discharge value, wide range between maximum and minimum monthly flows, and variable seasonal flow pattern (Fig. 96).

The Congaree River provides large quantities of surface water. While daily flow may fluctuate widely, minimum available flow is still significant and reliable year round. Surface-water availability from streams draining the western portion of the sub-basin are highly reliable and provide an excellent source of water supply as long as quantities are adequate for use. Although streams on the east side of the sub-basin are more variable, some base flow support from groundwater reserves should ensure limited surface-water availability year round.

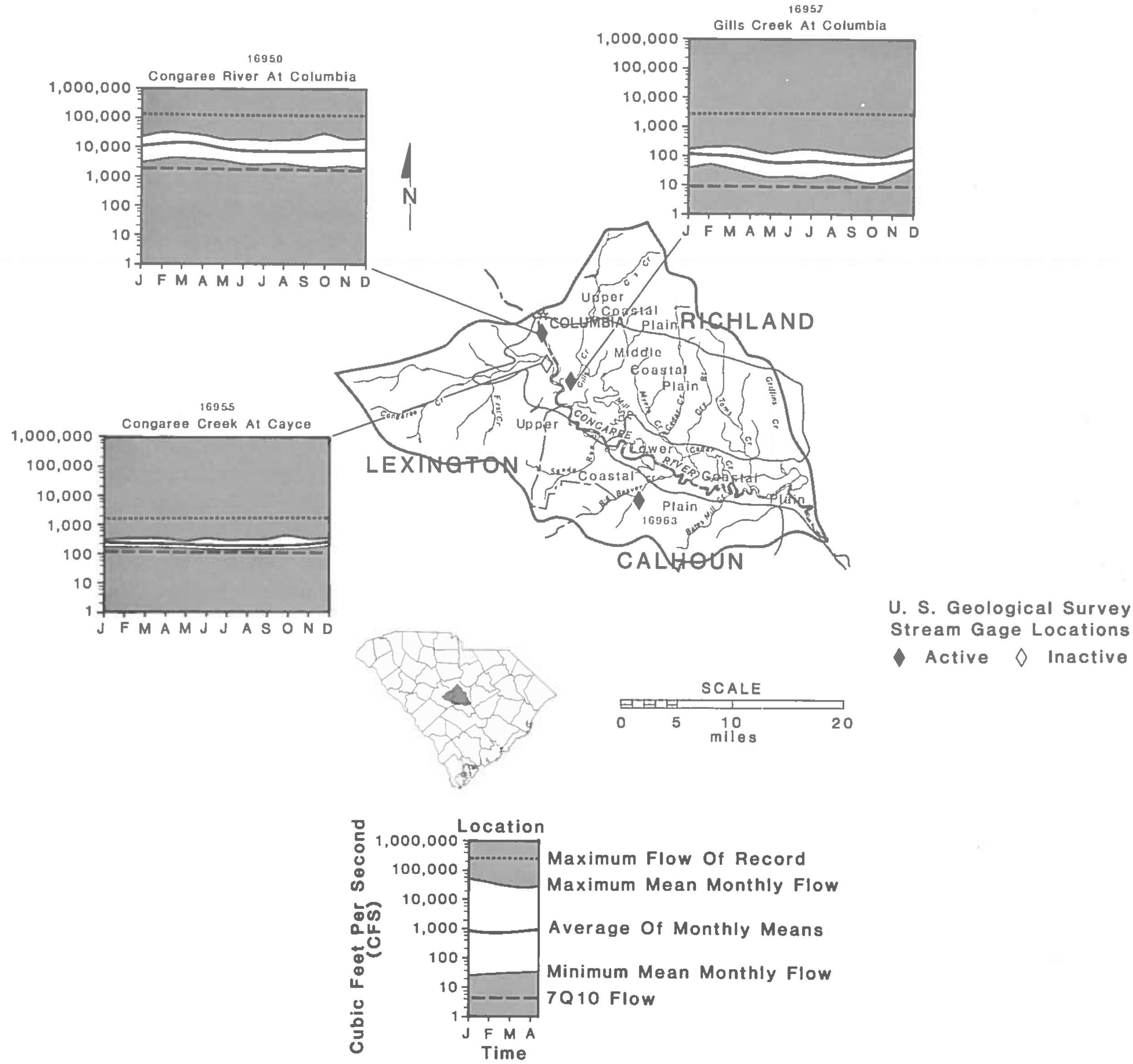


Figure 96.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Congaree River Subbasin, South Carolina.

Table 86.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Congaree River Sub-basin, South Carolina.

Gaging Station		Drainage Area	Period of Record		Average Flow				
							90%[a]	7Q10[b]	
Number	*Name/Location*	*(mi²)*	*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*cfs*	*cfs*	*cfs/mi²*
1695	Congaree River at Columbia	7,850	Oct 1939-Present	41	9,425	1.20	3,300	1,800	0.23
1695.5	Congaree Creek at Cayce	122	Oct 1959-Sep 1980	21	222	1.82	148	118	0.97
1695.7	Gills Creek at Columbia	59.6	Sep 1966-Present	14	77.9	1.31	24	9.8	0.16
1696.3	Big Beaver Creek near St. Matthews	10.0	Jul 1966-Present	14	14.3	1.43	7.4	5.0	0.50

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.

Development

Surface-water development is limited in the Congaree River Sub-basin. Figure 98 shows all known development in the sub-basin which includes one discontinued navigation project and some flood control studies. There are no large reservoirs within the sub-basin. Weston Pond, located within Fort Jackson, is the largest lake with a surface area of 240 acres and a volume of 2,300 acre-feet (Table 87). Lakes larger than 10 acres have a total surface area of 3,045 acres and a total volume of 16,607 acre-feet.

The U. S. Army Corps of Engineers has identified four potential hydropower sites on the Congaree River (Table 88). Three of these dam sites would include locks which would allow navigation from the Santee-Cooper Lakes to Columbia. The fourth site, known as The Reregulator, would be located just downstream of the existing Columbia Hydropower Plant.

The U. S. Army Corps of Engineers has no active navigation projects in the sub-basin. In the past, plans existed to provide for navigation along the entire length of the Congaree River. Approximately 70 percent of the project was completed before it was deauthorized in 1977. Details of the project are presented in Table 89.

Neither the U. S. Army Corps of Engineers nor the Soil Conservation Service have completed flood control projects within the sub-basin, although the Corps is presently conducting studies of identified problem areas (Table 90). Preliminary results indicate potential flooding of structures in the City of Cayce from high flows in the Congaree River and a dam break and potential flooding in the Gills Creek watershed.

Water Quality

Classified streams draining this small sub-basin are primarily Class B waters (Fig. 99). Portions of some tributary streams are designated Class A, suitable for primary contact recreational uses such as swimming. Water quality limited segments which require advanced treatment of wastewater discharges include all of Mill Creek and portions of Gills Creek (Fig. 100). While few published water quality studies exist for this sub-basin, available reports indicate that water quality generally meets standards established for classified waters. Water quality problems in the sub-basin occur primarily in tributaries and the upper portion of the Congaree River associated with the highly developed Columbia metropolitan area.

The Congaree River and its many tributaries have historically exhibited poor water quality, primarily due to elevated levels of fecal coliform bacteria and biochemical oxygen demand. The S. C. Department of Health and Environmental Control (1975a) ranked the upper portion of this sub-basin as the number one water quality problem area in the larger Santee River Basin. Water quality conditions in this river have also been attributed to problem conditions in Lake Marion (Inabinet, 1976). The severity of water quality problems in the Congaree River was attributed to private and public municipal sewage effluents and non-point source runoff from the Columbia metropolitan area (S. C. Department of Health and Environmental Control, 1975). Upgraded wastewater treatment operations have improved quality conditions somewhat by reducing fecal coliform bacteria and associated human health hazards. Except for occasional water quality problems, physical, chemical, and biological water quality data indicate that current conditions in the main stem river are generally good (S. C. Department of Health and Environmental Control, 1980b).

Earlier studies of tributary streams indicate that the upper portion of Mill Creek, the lower portion of Congaree Creek, and the entire reach of Gills Creek experience contraventions of State standards for fecal coliform bacteria (S. C. Department of Health and Environmental Control, 1975a). These problem conditions were attributed to municipal point source discharges and urban runoff.

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout most of the sub-basin is at the reconnaissance level and at the field data level in the southern portion (Fig. 18).

The Congaree River Sub-basin lies within the Coastal Plain Province and is underlain entirely by the Middendorf Aquifer System. In the southern part of Richland and Lexington counties, Black Mingo sediments overlie the Middendorf Aquifer System. Near the Fall Line, the Black

Table 86 (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
662.0	Oct 18, 1954	364,000	Aug 27, 1908
111.0	Jun 20, 1970	1,840	Oct 1, 1959
9.4	Nov 5, 1979	2,880	Feb 24, 1979
4.7	Jul 3, 12, 1970; Aug 4, 1970	1,360	Jul 29, 1971

Mingo is absent and the Middendorf is directly overlain by Tertiary sands of younger age. The Coastal Plain sediments commence at the Fall Line and thicken in a southeasterly direction to 650 feet near Wateree.

At sites located on the Fall Line, ground water is usually obtained from the underlying crystalline rock aquifers of the Carolina slate belt. Whereas well yields are highly variable in this area, numerous wells have been drilled which provide important ground-water availability information. Two wells in West Columbia are 385 feet and 95 feet deep and produce 12 gpm and 56 gpm, respectively. However, these wells were obtained only after three dry holes had been drilled at the same location. Nearby, wells of 240 feet and 400 feet deep yield 150 and 15 gpm, respectively.

The Town of Eastover is supplied by ground water from wells less than 200 feet deep which tap the Black Mingo Aquifer System. This aquifer is separated from the deeper Middendorf Aquifer System by several confining beds composed of clay or silty clay. U.S. Geological Survey file data for wells in the area include 23 wells with depths ranging from 61 to 294 feet and yields ranging from 3 to 387 gpm. Most wells in the area were constructed for domestic purposes and maximum yields have not been developed.

Water Quality

Water from the Middendorf Aquifer System is usually acidic, soft, and low in chloride and fluoride. In some localities, this aquifer may contain iron in concentrations exceeding the drinking water limits of 0.3 mg/L. The Stiff Diagrams (Fig. 101) show water quality in the Middendorf Aquifer System ranging from a sodium chloride and sodium bicarbonate type to a magnesium bicarbonate type. These diagrams also indicate a calcium bicarbonate and calcium chloride water quality type for ground water occurring in the Carolina slate belt.

In the Cayce-West Columbia area of Lexington County, the S.C. Department of Health and Environmental Control has identified isolated wells yielding naturally-occurring radioactive ground water. In some of these wells radiation levels exceed acceptable drinking water standards (5 pcCi/L) and alternate supply sources are being investigated.

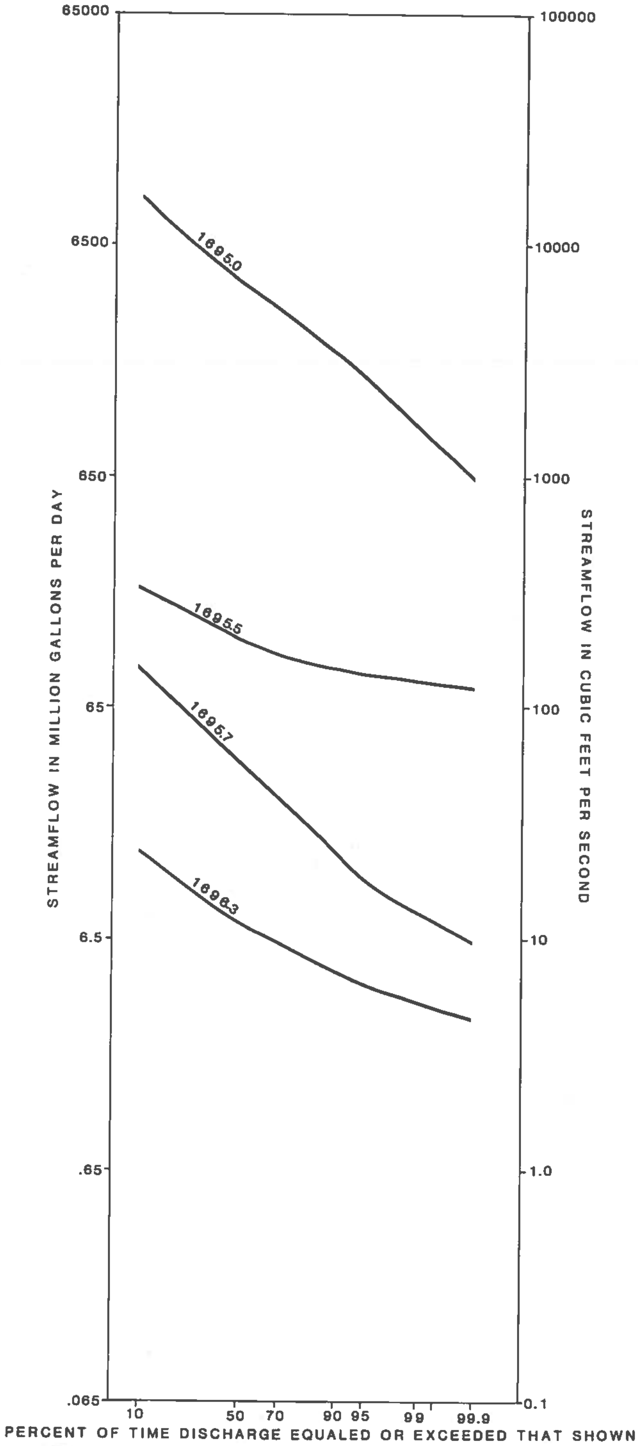


Figure 97.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Congaree River Sub-basin, South Carolina.

Table 87.
Existing lakes larger than 200 acres in the Congaree River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Weston Pond	Cedar Creek	240	2,300	Recreation

Source: S.C. Water Resources Commission, 1974.

Table 88.
Existing and potential hydroelectric power development in the Congaree River Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
2	Lock and Dam #1	Richland	Congaree	--[a]	--	21.5	1,632	Potential
3	Lock and Dam #2	Richland	Congaree	--	--	9.3	1,440	Potential
4	Lock and Dam #3	Richland	Congaree	--	--	19.5	1,648	Potential
5	Reregulator[b]	Richland	Congaree	--	--	56.5	727	Potential

[a] -- indicates information not available.
[b] Would inundate the potential Lower Saluda Site on the Saluda River.

Sources: U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

Table 89.
U.S. Army Corps of Engineers navigation projects in the Congaree River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
6	Congaree River	Richland Calhoun Lexington	Charleston	49.0	--[a]	Project provided for a 4 foot navigable channel over the lower 49 miles of river and for construction of a lock and dam to extend deep water 2 miles further to Columbia, S.C. Project deauthorized in 1977.

[a] -- indicates information not available.

Source: U.S. Army Corps of Engineers, 1982c.

Table 90.
Flood control projects and studies in the Congaree River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency[a]*	*Status*
7	Congaree River	Lexington	COE	Preliminary Flood Investigation
8	Gills Creek	Richland	COE	Current Study

[a] COE indicates U.S. Army Corps of Engineers.

Source: U.S. Army Corps of Engineers, 1982c.

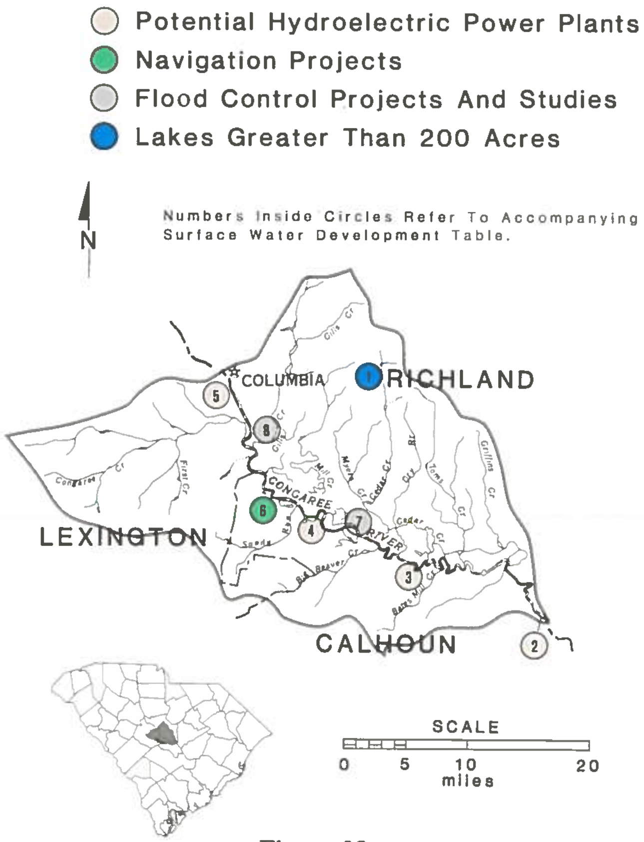


Figure 98.
Surface-water development in the Congaree River Sub-basin, South Carolina.

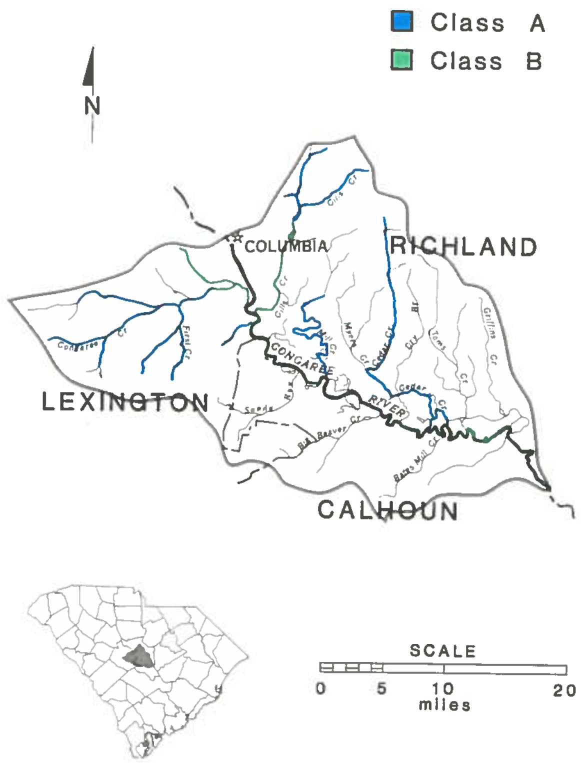


Figure 99.
Surface-water quality classifications in the Congaree River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

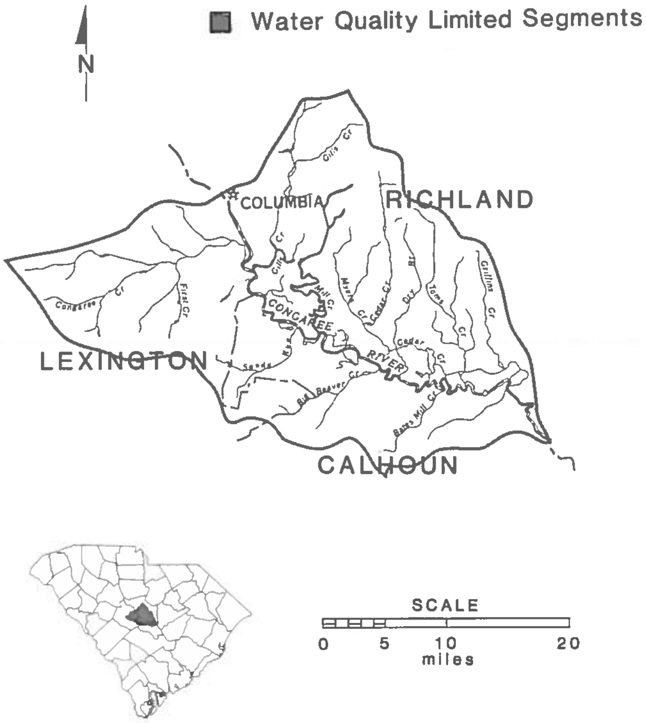


Figure 100.
Water quality limited segments in the Congaree River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

WATER USE

Total gross water use is currently estimated to be approximately 90.2 mgd with 21 percent of that use consumed (Table 91). The leading water users are self-supplied industry (79.7 mgd), public supply (6.73 mgd), and self-supplied domestic (2.6 mgd). The major water users by type and supply source are shown in Figure 102. Total gross use in this sub-basin is the tenth highest in the State. Surface water is used to meet 93 percent of the demand.

Public supply withdrawals account for eight percent of the gross use and four percent of the consumptive use. Surface water supplies approximately 96 percent of the demand.

Self-supplied domestic use represents nearly three percent of the gross use and 12 percent of the consumptive use. Ground water is the only source utilized to meet this demand.

Agricultural uses account for about one percent of the total gross use and six percent of the consumptive use. Ground water is used to meet 64 percent of this use. Irrigation demand accounts for 78 percent of this use and ground water is used to meet 67 percent of this demand. When averaged over the five-month growing season, irrigation use equals 2.1 mgd, comprising two percent of total sub-basin use. Over 56 percent of the livestock use (0.25 mgd) is withdrawn from ground-water sources.

Self-supplied industry is the largest gross user accounting for 88 percent of the gross use. This use is the largest consumer of water representing 79 percent of the consumptive use. Surface water is utilized to meet almost 97 percent of the demand. Both groundwater and surface-water withdrawals for this use are the greatest in the sub-basin.

No thermoelectric power plants are located in this sub-basin.

Total gross use is projected to grow 62 percent to 146

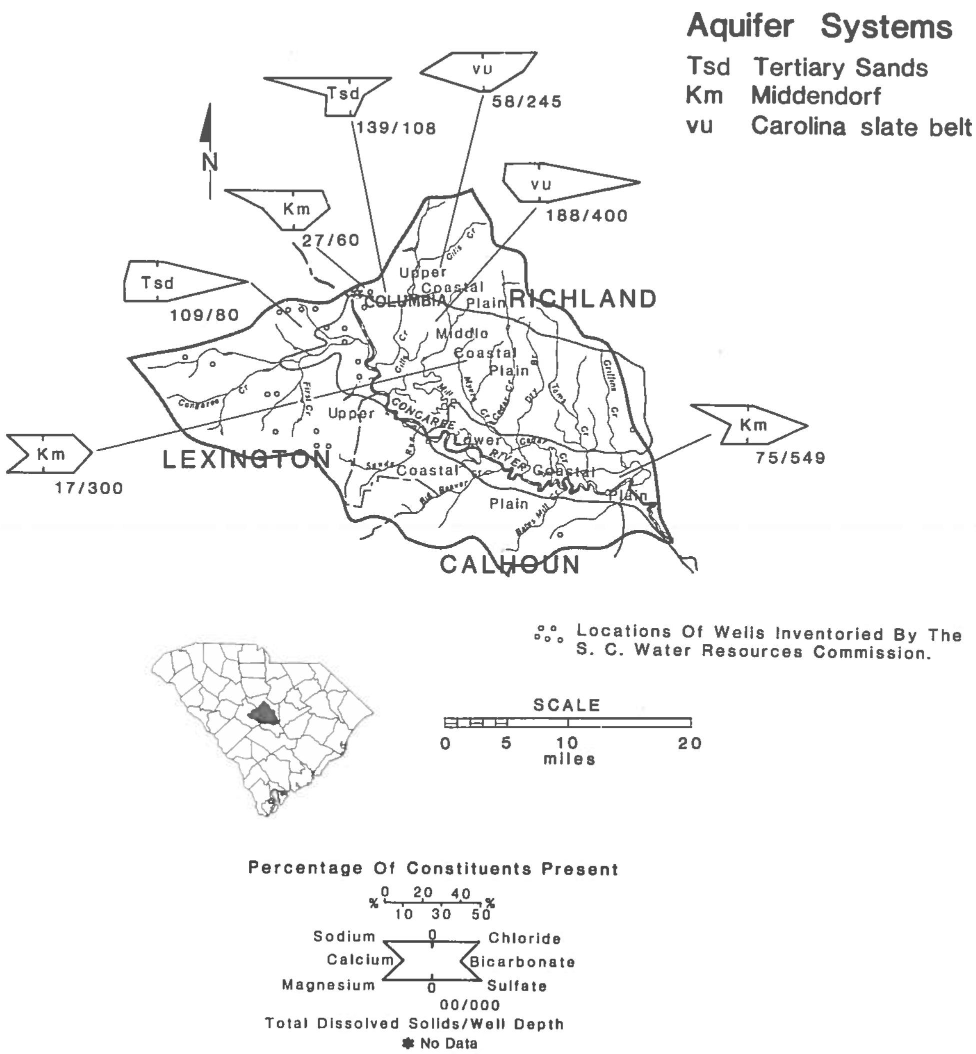


Figure 101.
Ground-water quality of selected aquifer systems and major inventoried wells in the Congaree River Sub-basin, South Carolina.

Table 91.

Current and projected water use in the Congaree River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	0.24	6.49	6.73	0.29	7.79	8.08	0.33	8.96	9.29	0.36	9.85	10.2	0.38	10.3	10.7
	Consumed	0.02	0.65	0.67	0.03	0.78	0.81	0.03	0.90	0.93	0.04	0.99	1.03	0.04	1.03	1.07
Self-supplied Domestic	Gross	2.6	---	2.6	3.1	---	3.1	3.6	---	3.6	4.0	---	4.0	4.1	---	4.1
	Consumed	2.2	---	2.2	2.6	---	2.6	3.1	---	3.1	3.4	---	3.4	3.5	---	3.5
Agriculture Irrigation	Gross	0.58	0.29	0.87	2.0	0.80	2.8	3.6	1.2	4.8	5.0	1.6	6.6	6.5	1.9	8.0
	Consumed	0.58	0.29	0.87	2.0	0.80	2.8	3.6	1.2	4.8	5.0	1.6	6.6	6.5	1.9	8.0
Agriculture Livestock	Gross	0.14	0.11	0.25	0.16	0.13	0.29	0.18	0.14	0.32	0.21	0.16	0.37	0.24	0.19	0.43
	Consumed	0.14	0.11	0.25	0.16	0.13	0.29	0.18	0.14	0.32	0.21	0.16	0.37	0.24	0.19	0.43
Self-supplied Industry	Gross	2.73	77.0	79.7	3.00	88.6	91.6	3.30	97.4	101	3.63	107	111	4.18	118	112
	Consumed	0.51	14.3	14.8	0.56	16.4	17.0	0.61	18.0	18.6	0.67	19.8	20.5	0.77	21.8	22.6
Thermoelectric Power	Gross	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Consumed	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	Gross	6.29	83.9	90.2	8.55	97.3	106.	11.0	108.	119.	13.2	119	132	15.4	130	146
	Consumed	3.45	15.4	18.8	5.35	18.1	23.5	7.52	20.2	27.8	9.32	22.6	31.9	11.1	24.9	36.0

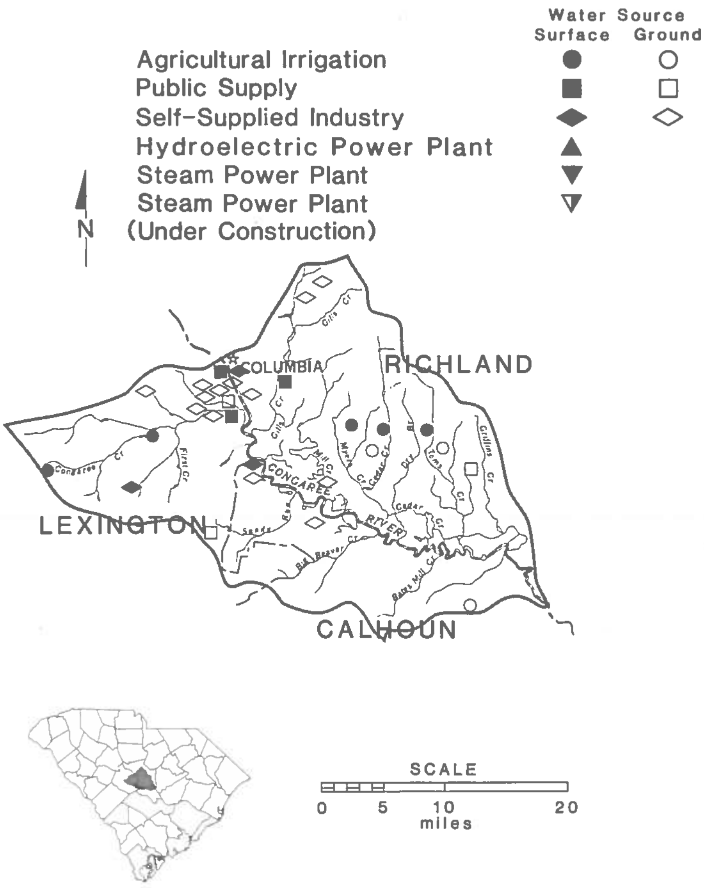


Figure 102.
Location, type, and supply source of water users in the Congaree River Sub-basin, South Carolina.

mgd by 2020. Consumptive use is projected to increase about 91 percent to 36.0 mgd. Most of this growth is accredited to the projected growth in self-supplied industry and agricultural irrigation. Self-supplied industry should remain the leading water user and surface water should still be the most heavily used source of supply.

WATER USE VERSUS AVAILABILITY

The current 83.9 mgd surface-water demand is adequately met by streamflow (Fig.103); of this amount, 15.4 mgd are consumed. This surface-water demand is spread fairly evenly in the sub-basin (Fig. 102). Projected 2020 gross surface-water demand is 130 mgd of which 24.9 mgd should be consumed. This amount should also be adequately met by streamflow.

Present ground-water demands within the Congaree River Sub-basin are estimated to be seven percent of all water used in 1980 (6.29 mgd). Projected 2020 demand for ground water should be 11 percent (15.4 mgd) of the total water demand. Present use can be supplied by approximately one well pumped at a rate of 600 gpm for six hours each day per 24 square mile area of the sub-basin, which would require a total of 29 wells. The projected requirements for 2020 could be satisfied by one well per 10 square mile area or about 71 total wells.

Ground-water availability may be limited in the Fall Line vicinity where sand aquifers are very thin (100-300 feet). Excessive iron in water from the Middendorf Aquifer System near the Fall Line may restrict the use of this water for some uses. In addition, the very low dissolved solids content of this water makes it very corrosive to metal surfaces such as casing, screens, and plumbing fixtures.

Major water resource problems and opportunities in the sub-basin are summarized in Table 92.

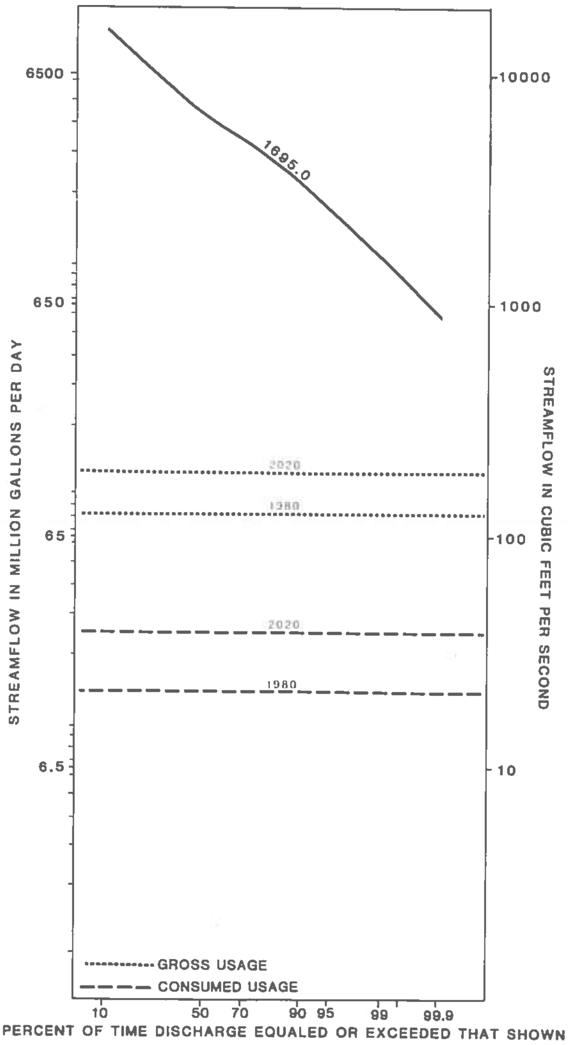


Figure 103.
Water use compared to availability in the Congaree River Sub-basin, South Carolina.

Table 92.
Major water resource findings in the Congaree River Sub-basin, South Carolina.

Opportunities

1. Adequate supplies of surface water are available to meet current and projected surface-water use needs.
2. Four potential hydroelectric power development sites have been identified in the sub-basin.
3. Upper Coastal Plain streams such as Congaree Creek have extremely well-sustained and reliable flows.
4. The Congaree River can be potentially developed to allow commercial navigation from Charleston to Columbia.
5. Large undeveloped quantities of ground water from the Black Mingo and Middendorf Aquifer Systems are available for much of the sub-basin.
6. Vertical and horizontal infiltration wells in the Congaree River flood plain could potentially yield good quantities of water.
7. A 45-mile segment of the Congaree River is eligible for the State Scenic Rivers Program.

Problems

1. Floodwaters from the Congaree River may adversely impact development in the City of Cayce.
2. Studies indicate a dam break and flood potential in the Gills Creek watershed.
3. Point and non-point sources of pollution from the Columbia metropolitan area cause occasional water quality problems (high levels of fecal coliform bacteria and biochemical oxygen demand) in the upper portion of the Congaree River and its tributaries.
4. Ground-water yields are limited from Piedmont wells and wells in the Coastal Plain near the Fall Line.
5. Corrosive water of high iron content occurs in many of the sand aquifers in the Upper Coastal Plain region near the Fall Line.
6. Isolated wells in the Cayce-West Columbia area of Lexington County yield ground water with naturally-occurring radiation levels in excess of acceptable drinking water standards.

Lower Santee River Sub-basin

GENERAL OVERVIEW

The Lower Santee River Sub-basin transects the central Coastal Plain region of the State, extending from the confluence of the Congaree and Wateree Rivers southeast to the coast. With a northwest-southeast orientation, this basin encompasses portions of eight South Carolina counties, including portions of Calhoun, Charleston, Clarendon, Berkeley, Georgetown, Orangeburg, Sumter, and Williamsburg Counties (Fig. 104). The areal extent of the sub-basin is approximately 1,275 square miles, 4.1 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 38,300, which was only 1.2 percent of South Carolina's total population (Table 93). The sub-basin population is expected to reach 67,700 by the year 2020, an increase of 76.8 percent. The largest population increases are expected to occur in the coastal counties of Berkeley (191.6 percent) and Georgetown (91.6 percent). The sub-basin is primarily rural and contains no major urban areas or centers of population, although there are a number of small towns. The largest of these towns with their 1980 population are St. Matthews (3,450), St. Stephens (1,220), and Summerton (1,194).

Economy

Economically, this is one of the poorer sub-basins in South Carolina. The sub-basin's 1979 per capita personal income averaged $5,449, about $1,600 lower than the State average of $7,056. Clarendon County ranked lowest in the State for per capita income and 1980 median household income. The median household income for the region averaged $6,000 less than that for the State ($16,509).

The 1979 annual average employment of non-agricultural wage and salary workers for the sub-basin was approximately 10,500. Dominant employment types were manufacturing 41 percent; government 19 percent; wholesale and retail trade 16 percent; construction 10 percent; services and mining 10 percent; transportation and public utilities 3 percent; and finance, insurance, and real estate 2 percent. Compared to the State as a whole, the Lower Santee area has a greater share of manufacturing and construction employees, a proportionate number of government employees, and less than its share of the remaining categories.

Agricultural activity is intense in sections of the sub-basin, generally becoming less important near the coast. Four of the counties were in the top ten of reported county cash crop receipts in 1979, and two of the counties, Orangeburg and Sumter, were also in the top five of livestock receipts.

Figure 104.
Location of the Lower Santee River Sub-basin in South Carolina.

Table 93.
Current and projected population for the Lower Santee River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands) 1980	1990	2000	2010	2020	% Change 1980-2020
Berkeley	10.9	10.4	15.1	20.8	26.6	30.4	191.6
Calhoun	41.2	5.0	5.7	6.2	6.5	6.7	32.7
Charleston	0.7	1.9	2.2	2.3	2.4	2.5	28.0
Clarendon	34.0	9.4	10.1	10.5	10.8	10.9	16.8
Georgetown	4.7	2.0	2.6	3.1	3.6	3.8	91.6
Orangeburg	6.5	5.4	6.4	7.1	7.8	8.1	51.3
Sumter	1.2	1.1	1.2	1.3	1.3	1.3	24.8
Williamsburg	8.1	3.1	3.5	3.7	3.9	3.9	26.8
Total		38.3	46.7	54.9	62.9	67.7	76.8

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

SURFACE WATER

Hydrology

The Santee River has undergone extensive hydrologic modification during the past 40 years. Formed by the confluence of the Congaree and Wateree Rivers in the Upper Coastal Plain, the Santee River immediately flows into Lake Marion, the State's largest reservoir by surface area. Most of Lake Marion's water is diverted into the adjacent Ashley-Cooper River Sub-basin to form Lake Moultrie and eventually flows into the Cooper River and Charleston Harbor. In the river's original state, periodic flooding nourished extensive swamplands along the entire length. However, much of the upper portion of the Santee River is now inundated and flow in the stretch below the diversion has been considerably reduced. Construction of the Cooper River Rediversion Project by the U.S. Army Corps of Engineers is now underway to redivert a major portion (80 percent) of the previously diverted flow back into the Santee River. This should reduce shoaling problems in Charleston Harbor caused by the increased sediment load which resulted from the diversion of the Santee River's flow down the Cooper River.

Several small tributary streams drain the sub-basin, the largest of these are Halfway Swamp Creek and Wambaw Creek.

Five gaging stations monitor streamflow in the Lower Santee River Sub-basin, three on the Santee River, one on the Lakes Marion-Moultrie diversion canal, and one on Wedboo Creek (Fig. 105). Flows on the Santee River have been affected for the period of record by hydroelectric power operations at Wilson Dam on Lake Marion. Historic streamflow data for the Santee River are available from one discontinued gaging station (1700). Streamflow statistics for these six gaging stations are presented in Table 94. Surface-water data are also collected at six stage recorders, one crest-stage station, and one lake gage on Lake Marion.

Before development of the Santee-Cooper lake system, flow in the Santee River (Station 1700) was well-sustained year round. Average annual streamflow was 15,400 cfs and could be expected to equal or exceed 7,000 cfs, 90 percent of the time.

Currently, average annual streamflow in the Santee River is 2,280 cfs at Pineville and 3,025 cfs below St. Stephens. Ninety percent of the time, flow at these sites should be at least 500 cfs and 550 cfs, respectively. Most streamflow in the lower portion of the Santee River is contributed by discharges from Wilson Dam. Contributions from tributary streams only slightly increase main stem flow downstream. The flow-duration curves for current Santee River gaging stations (Fig. 106) indicate extremely variable high flows and low flows, while moderate flows are regular. This unusual flow-duration pattern is attributed to regulated releases at Wilson Dam. Occasional discharges of large volumes of water help relieve Lake Marion of floodwater inflow from upstream, while withholding discharges retains adequate water levels in Lake Marion for recreation, hydroelectric power, and other uses. These fluctuating releases and subsequent streamflow variations are also evidenced by the variable monthly flow pattern (Fig. 105).

After rediversion, streamflow in the Santee River below the rediversion canal will increase markedly. Average weekly discharge from the hydroelectric facility on the rediversion canal is planned to be 12,000 cfs; however, daily fluctuations in flow are anticipated. Streamflow between Wilson Dam and the rediversion canal will probably not change substantially from current levels.

Since diversion, the lowest flow of record (9 cfs) occurred near Pineville in 1947 due to repair work on the spillway. The flood flow of record (155,000 cfs) was also recorded near Pineville and is attributed to a tropical storm in 1945 which caused extensive flooding throughout the eastern portion of South Carolina.

Average streamflow in the only gaged tributary stream, Wedboo Creek, is 12.2 cfs and flow should equal or exceed 0.35 cfs, 90 percent of the time. This stream exhibits

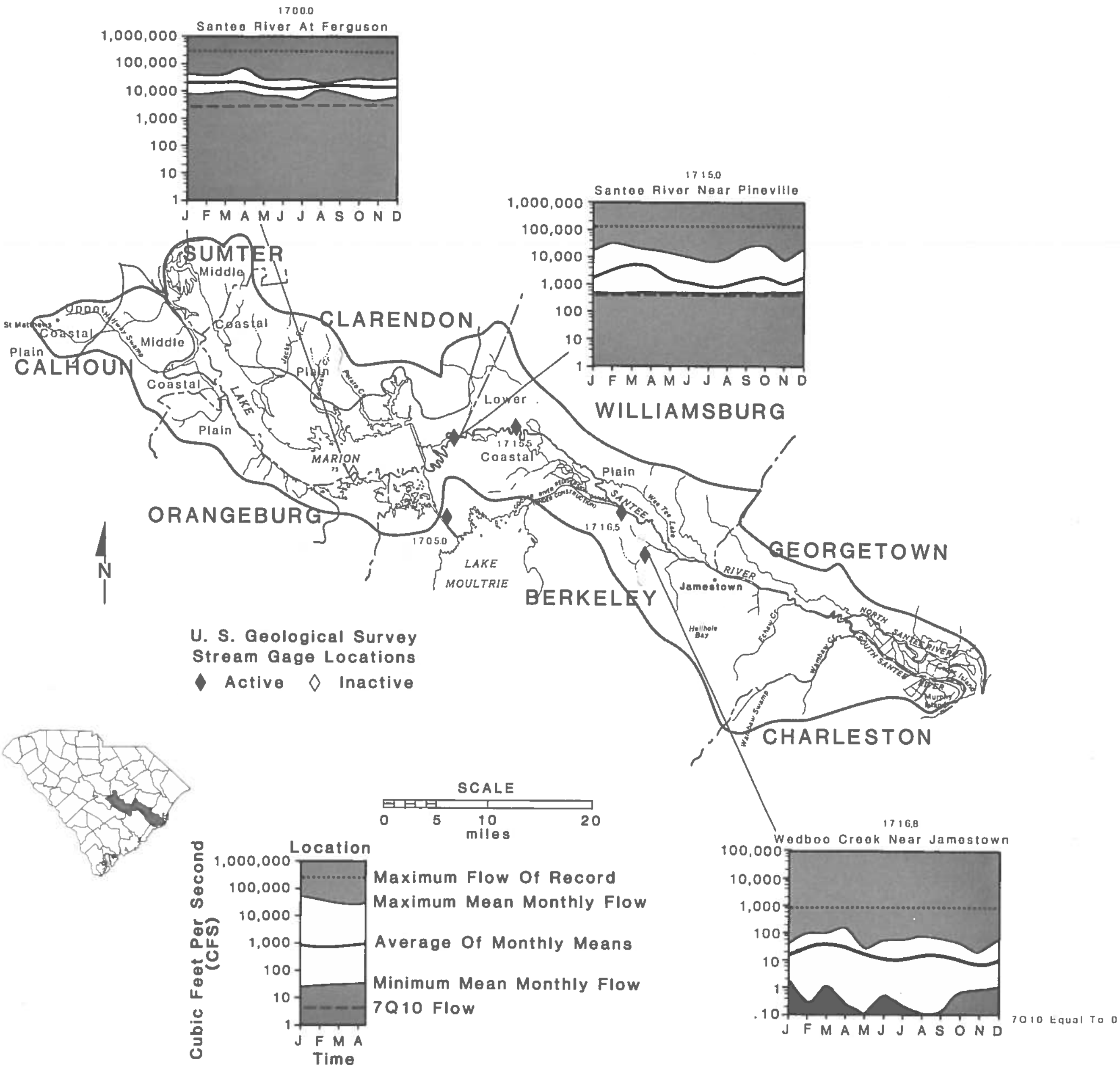


Figure 105.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Lower Santee River Subbasin, South Carolina.

Table 94.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Lower Santee River Sub-basin, South Carolina.

Gaging Station		*Drainage Area*	*Period of Record*		*Average Flow*				
								7Q10[b]	
Number	*Name/Location*	*(mi²)*	*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*90%*[a] *cfs*	*cfs*	*cfs/mi²*
1700	Santee River at Ferguson	14,600	Dec 1907-Sep 1941	33	15,400	1.05	7,000	3,750	0.26
1705	Lake Marion-Moultrie Diversion Canal	*[f]	Oct 1943-Present	37	15,100	*	6,900	2,320	*
1715	Santee River near Pineville	14,700	Apr 1942-Present	38	2,280	0.16	500	420	0.03
1715.6	Santee River near Russellville	14,800	Oct 1979-Present	1	3,144	0.21	*	*	*
1716.5	Santee River below St. Stephens	14,900	Oct 1970-Present	14	3,025	0.20	550	498[c]	0.03
1716.8	Wedboo Creek near Jamestown	17.4	Sep 1966-Feb 1972; Feb 1973-Present	12	12.2	0.70	0.35	0	0

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] Lowest mean value for seven consecutive days for nine-years of record.
[f] * indicates statistic not calculated.

highly variable flow and occasional zero-flow conditions typical of Lower Coastal Plain streams. These highly variable flows are evidenced by the steeply sloped flow-duration curve (Fig. 106), widely fluctuating monthly flow pattern (Fig. 105), and wide range between maximum and minimum monthly flows. Zero-flow conditions have occurred on many days during several years since monitoring began in 1966.

Although flow in the Santee River is somewhat variable, the river still provides, on the average, a good supply of surface water. After rediversion, available surface water downstream of the rediversion canal will increase substantially as streamflow approaches pre-diversion levels. Tributary streams in general are probably an unreliable supply source due to highly fluctuating flows and zero-flow conditions during periods of low rainfall. Streamflow in tributaries in the upper portion of the sub-basin near the Upper Coastal Plain region may be less variable due to ground-water support and provide a more reliable supply source.

Development

While surface-water development in the sub-basin is not extensive, the largest lake in the State by surface area, Lake Marion, occurs here. Figure 107 shows all surface-water development in the sub-basin.

Wilson Dam, located 17 miles south of Manning on the Santee River, contains the waters of Lake Marion which extend 60 miles upstream almost to the confluence of the Congaree and Wateree Rivers. It is the only large lake or reservoir within the sub-basin. The S.C. Public Service Authority owns and manages the lake which was completed in 1941 and operates the hydroelectric plant completed in 1950 at Wilson Dam. Although the largest reservoir in the State with a surface area of 110,600 acres, Lake Marion is rather shallow (average depth 12.5 feet) and only ranks fourth in volume with 1,400,000 acre-feet. Some water from Lake Marion is allowed to pass at Wilson Dam but most of the flow is diverted via a canal to Lake Moultrie. Lake Marion is used for hydropower generation, flood control, recreation and a large portion of the lake incorporates the Santee National Wildlife Refuge.

The total surface area of all lakes greater than ten acres within the sub-basin is about 112,000 acres and the total volume is about 1,405,000 acre-feet. Those lakes larger than 200 acres are listed in Table 95.

There have been no potential hydropower sites identified within the sub-basin and the only existing site is at Wilson Dam (Table 96).

Prior to the construction of Wilson Dam, the U.S. Army Corps of Engineers maintained the entire river for navigation (Table 97). After construction of the dam, direct navigation from the lower reaches of the Santee River to the upper reaches was discontinued.

The Soil Conservation Service has planned a land treatment watershed project in northeast Calhoun County (Table 98).

Water Quality

The two major water bodies comprising the Lower Santee Sub-basin, Lake Marion and the Santee River, have Class A and Class B water use designations, respectively (Fig. 108). Near the coast, the Santee River divides forming the North and South Santee Rivers. These rivers are designated Class SB north of the Intracoastal Waterway and Class SA south of the Waterway. Water quality limited segments requiring advanced treatment of wastewater discharges include Lake Marion and several of its tributaries and all or portions of streams tributary to the Santee River (Fig. 109). Current water quality problems in this sub-basin are few but greatly impact some water uses where they occur. The Cooper River Rediversion Project is expected to greatly impact water quality of the Lower Santee River and affect some water use activities.

Table 94 (Continued)

Extreme Flows			
Minimum[c]		Maximum[d]	
cfs	Dates	cfs	Date
2,630	Sep 2, 1925	368,000	Jul 22, 1916
61.0	Sep 24, 25, 1956	40,200	Mar 10, 1952
9.0	Feb 23, 1947	155,000	Sep 23, 1945
484.	Aug 21, 1980	70,400	Apr 1, 1980
491	Aug 2, 1974	98,900	Mar 21, 22, 1975
0.0	Many days in 1966, 69, 73, 74, 80	928	Aug 26, 1971

Water quality in Lake Marion is generally good with a trend over the past three years of decreasing quality due to declining dissolved oxygen values (S.C. Department of Health and Environmental Control, 1980b). Lake Marion is characterized as eutrophic and has been ranked ninth in overall trophic quality out of 13 major South Carolina Lakes studied (U.S. Environmental Protection Agency, 1976d). High nutrient loading, primarily from headwater streams, has contributed to eutrophic conditions in Lake Marion. These high nutrient levels in addition to other environmental factors have resulted in severe noxious aquatic plant infestations covering over 30,000 acres in the upper portion of the lake. Water dependent recreation has likewise been greatly limited in this area of the lake. The S.C. Aquatic Plant Management Council (1981, 1982) has identified Lake Marion as one of the top aquatic plant problem areas in South Carolina and provided funds for chemical control efforts in 1981 and 1982.

Other water quality problems in Lake Marion have included elevated levels of fecal coliform bacteria in headwater areas and degraded water quality in and around residential dead-end canals (Inabinet, 1978). These problems may inhibit primary contact activities such as swimming and water skiing in waters associated with dead-end canals.

Some streams discharging into Lake Marion exhibit water quality problems which impair recreational water use. Studies by the S.C. Department of Health and Environmental Control (1981c) indicate that elevated levels of fecal coliform bacteria in Warley Creek near St. Matthews (Calhoun County), Halfway Swamp Creek (Calhoun County), and Jacks Creek (Clarendon County) are attributed to agricultural non-point source pollution. High toxaphane and organic nitrogen contrations in the sediments of Halfway Swamp Creek and elevated nutrient levels in Jacks Creek are also due to this source.

Chemical and physical water quality conditions indicate that the quality of the Santee River is generally good with a 1977-1979 trend of decreasing quality in terms of pH and

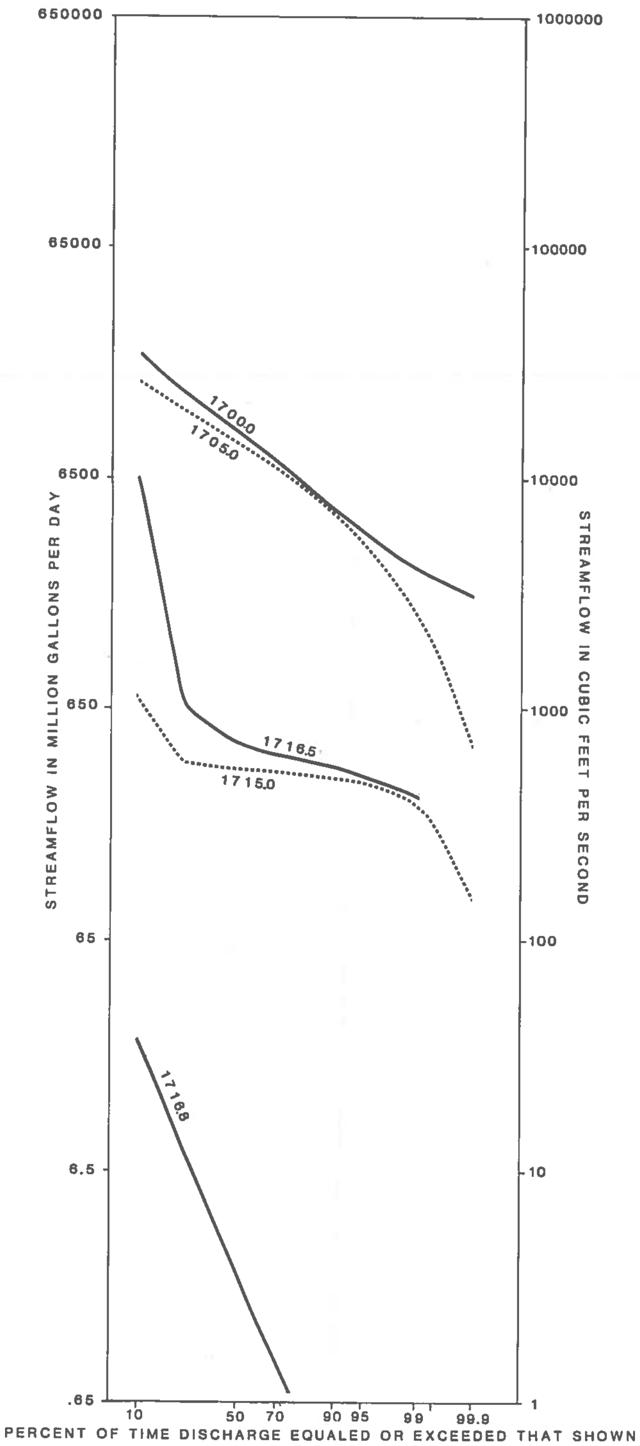


Figure 106.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Lower Santee River Sub-basin, South Carolina.

Table 95.
Existing lakes larger than 200 acres in the Lower Santee River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Lake Marion	Santee River	110,600	1,400,000	Flood control Power Recreation
2	Unnamed	Swamp west of Santee River	400	1,200	Recreation Santee River

Source: S.C. Water Resources Commission, 1974.

Table 96.
Existing and potential hydroelectric power development in the Lower Santee Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
3	Wilson Dam (Spillway)	Berkeley	Santee	SCPSA[a]	1	2.0	110,600	Const. 1950

[a] SCPSA indicates S.C. Public Service Authority.

Sources: Federal Power Commission, 1970. U.S. Army Corps of Engineers, 1982a.

Table 97.
U.S. Army Corps of Engineers navigation projects in the Lower Santee River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
4	Santee River	Georgetown Charleston Berkeley Orangeburg Clarendon Calhoun	Charleston	143.0	--[a]	The original project provided for snagging the entire river. The 1941 construction of Lake Marion closed the river to navigation above mile 87. Presently project is discontinued.

[a] -- indicates information not available.

Source: U.S. Army Corps of Engineers, 1982b.

Table 98.
Flood control projects in the Lower Santee River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
5	Northeast Calhoun	Calhoun	SCS	Under Construction

[a] SCS indicates Soil Conservation Service.

Source: U.S. Department of Agriculture, 1980, 1983.

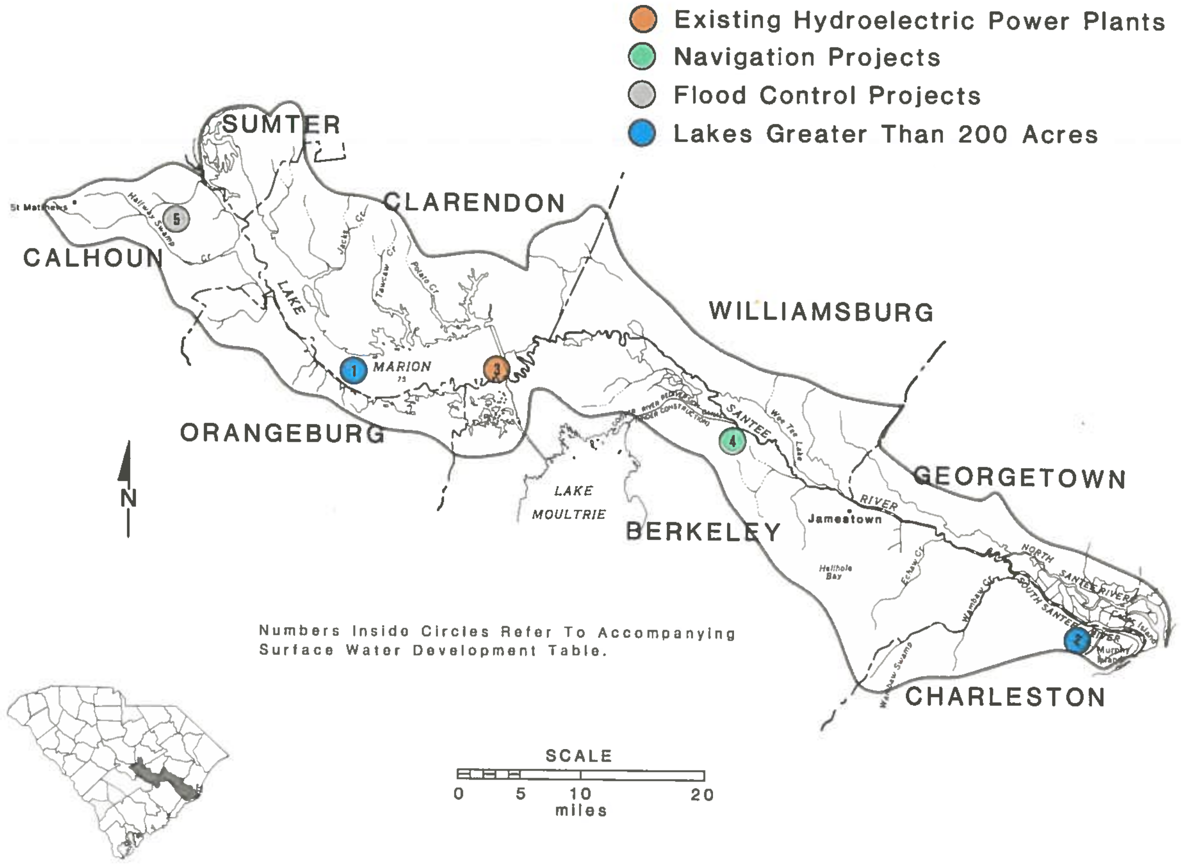


Figure 107.
Surface-water development in the Lower Santee River Sub-basin, South Carolina.

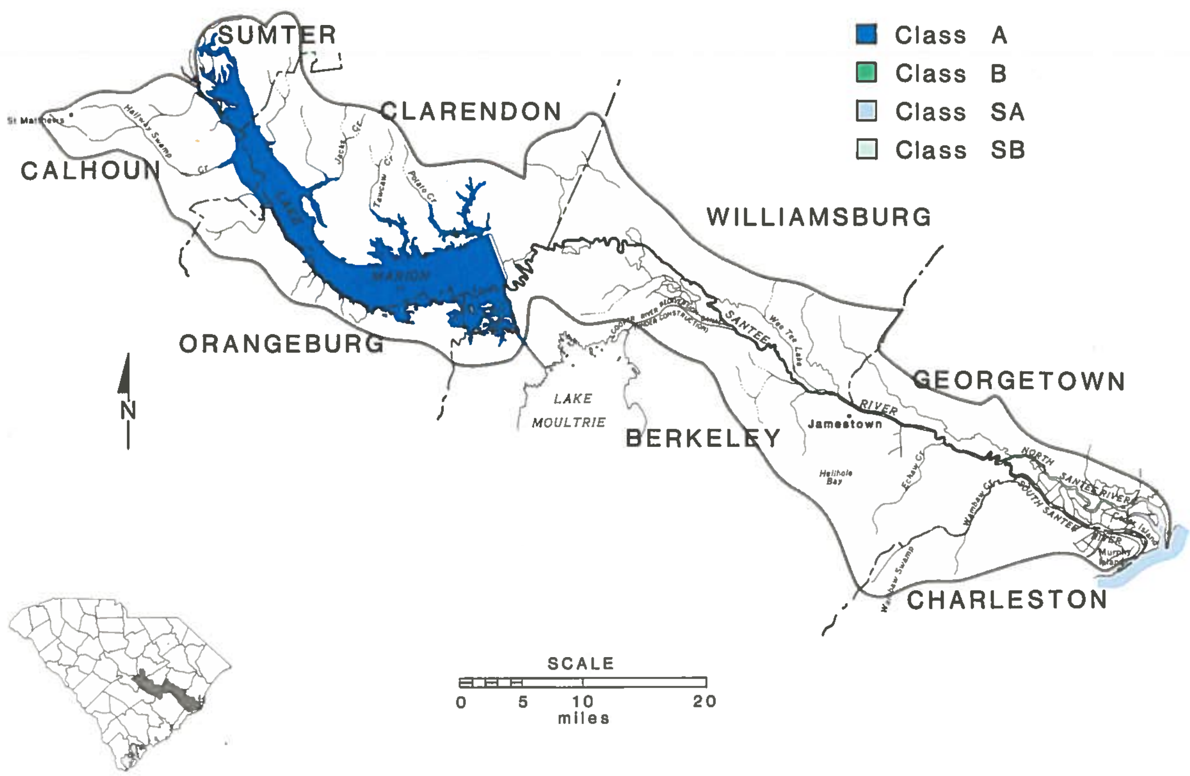


Figure 108.
Surface-water classifications in the Lower Santee River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

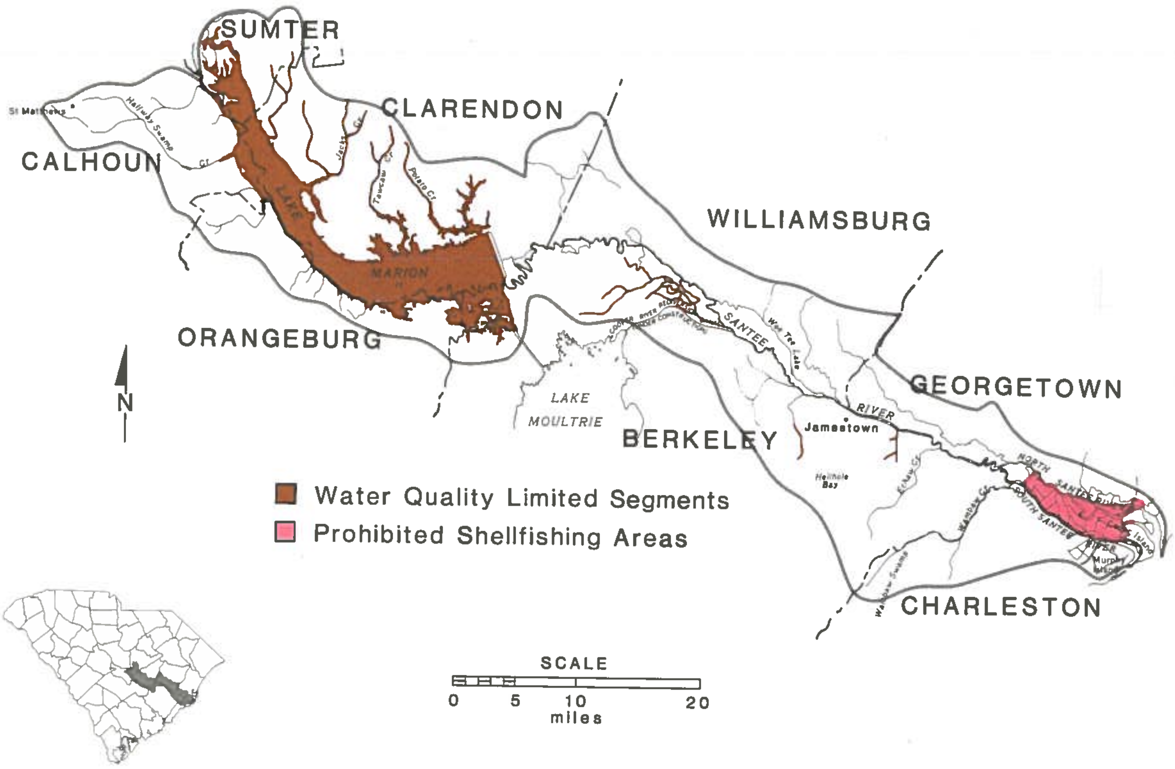


Figure 109.
Water quality limited segments and prohibited shellfishing areas in the Lower Santee River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Table 99.
Selected ground-water data for the Lower Santee River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Clarendon County	Black Creek	250-675	3-675	--[a]
	Peedee	100-250	up to 150	--
Calhoun County	Black Creek/ Peedee/Black Mingo	84-480	30-300	7.2-27
Eutawville	Peedee/Black Mingo	--	35	3.8
	Tertiary Limestone/ Black Mingo/Peedee	179-460	2800	--
Jamestown	Tertiary Limestone	20-80	400	--
	Black Creek	700-900	127-375	0.8-2.3
St. Stephens	Black Creek/ Middendorf	1050-1260	300-400	6-10

[a]--indicates data not readily available.

increasing quality in terms of aesthetics (S.C. Department of Health and Environmental Control, 1980b; S.C. Water Resources Commission, 1976). While current biological data indicate poor to fair water quality, biological data from this river are highly variable due to fluctuating streamflows. Biological data from earlier years indicate fair quality conditions (S.C. Department of Health and Environmental Control, 1980b). Due to inadequate water quality conditions, harvesting of shellfish from a large portion of the North and South Santee River tidal area is prohibited (Fig. 109).

Current water quality and some water use activities may be significantly altered after streamflows are increased in the Santee River due to the Cooper River Rediversion Project. Although impacts from the project are uncertain, the U.S. Army Corps of Engineers (1975) has predicted decreased saltwater intrusion and average salinity in the lower portion of the river, increased dilution capacity for discharged wastewater, increased water levels in Santee Swamp, increased anadromous fish migration, enlarged and relocated brackish water habitat, destruction of some oyster beds, and possible adverse impacts on hard clam populations.

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout the sub-basin ranges from the field data level in the northwestern region to the evaluation level in the southeastern region (Fig. 18).

The Lower Santee River Sub-basin lies within the Middle and Lower Coastal Plain Provinces. The northwestern portion of the sub-basin is underlain by more than 1,000 feet of unconsolidated sediments. The thickness increases to approximately 2,500 feet in the southeastern limit. The Middendorf Aquifer System underlies the entire sub-basin; however it is generally too deep to be considered a potential water source for most users. Little is known of the hydrogeologic characteristics of this aquifer system in the sub-basin. Selected ground-water data for the sub-basin are presented in Table 99.

The Black Creek Aquifer System is the major source of ground water throughout Clarendon, Williamsburg, and Georgetown Counties. The top of this aquifer system is 300 feet deep at Summerton and about 600 feet deep at the mouth of the Santee River. Wells can be expected to yield 500 to 1,000 gpm even though yields of only about 250 gpm have been attained in the eastern part of the basin. Well data for Clarendon County are rather limited.

The top of the Peedee Aquifer System in Clarendon and Williamsburg Counties lies about 100 to 250 feet below land surface.

Surficial deposits combined with the Black Mingo Aquifer System in Clarendon and Williamsburg Counties, extend to a depth of approximately 100 to 250 feet and reportedly produce 20 to 50 gpm.

The Orangeburg County area of the sub-basin is underlain by the Middendorf Aquifer System between depths of approximately 950 to 1,600 feet, the Black Creek Aquifer System between 650 and 950 feet, the Peedee Aquifer System between 375 and 650 feet, the Black Mingo Aquifer System between 250 and 375 feet, and the Tertiary Limestone Aquifer System between 50 and 250 feet (Siple, 1975). The Black Mingo and Tertiary Limestone Aquifer Systems are the most widely used in the vicinity of Eutawville.

In the Jamestown area of Berkeley County, the Black Creek Aquifer System occurs between the depths of approximately 570 to 1,000 feet, the Peedee Aquifer System between 300 and 570 feet, the Black Mingo Aquifer System from 80 to 300 feet deep, and the Tertiary Limestone Aquifer System from 20 to 80 feet. The Pleistocene and Recent sediments comprise the top 20 feet. At St. Stephens, test wells 30 to 150 feet deep were reported to produce up to 150 gpm (Spiers, 1975).

Ground-water studies in the St. Stephens area (Siple, 1968; Spiers, 1975) indicate the presence of several aquifers above the Cretaceous sediments; these are the Black Mingo, Tertiary Limestone, and Shallow Aquifer Systems. The Black Mingo Aquifer System is the most widely used water-bearing aquifer system in northern Berkeley County. The transmissivity of this aquifer ranges from 500 to 8,500 ft^2/day, and the storage coefficient is estimated to be 0.0001. The Black Creek Aquifer System is used for municipal and industrial water supplies in this area.

The Jamestown area in northeastern Berkeley County, like the area south of Lake Marion, exhibits a covered karst topography underlain at shallow depths by the Tertiary Limestone Aquifer System. This aquifer system is the most important source of ground water for domestic use in the area. Ground-water pumpage from two limestone quarries was estimated to be in excess of 25,000 gpm (36 mgd) in 1977, and had caused a water level decline of over 35 feet in the Tertiary Limestone Aquifer System since the summer of 1975. This heavy pumpage also resulted in instances of land surface collapse and water level declines in wells located more than one mile from the center of pumping. Available data indicate that land surface collapse will probably continue to occur as long as the ground-water table remains below a highly weathered cavernous zone in the Tertiary Limestone Aquifer System (Spigner, 1978a,b).

Water Quality

The Black Creek Aquifer System is the most widely used aquifer system within the sub-basin. However, the water is of a sodium bicarbonate type and contains fluoride in amounts exceeding recommended drinking water limits in the eastern portion of Williamsburg and Georgetown Counties (Fig. 110). Excessive turbidity (cloudiness) has been reported in water from several wells completed in this aquifer system. The turbidity is probably due to the presence of micro-crystalline aragonite in the water. It is uncertain whether aragonite crystals are being formed within the well bore due to pressure changes during pumpage or whether they are already present in the aquifer. However, the problem seems to be alleviated with increasing time and use of wells in this aquifer.

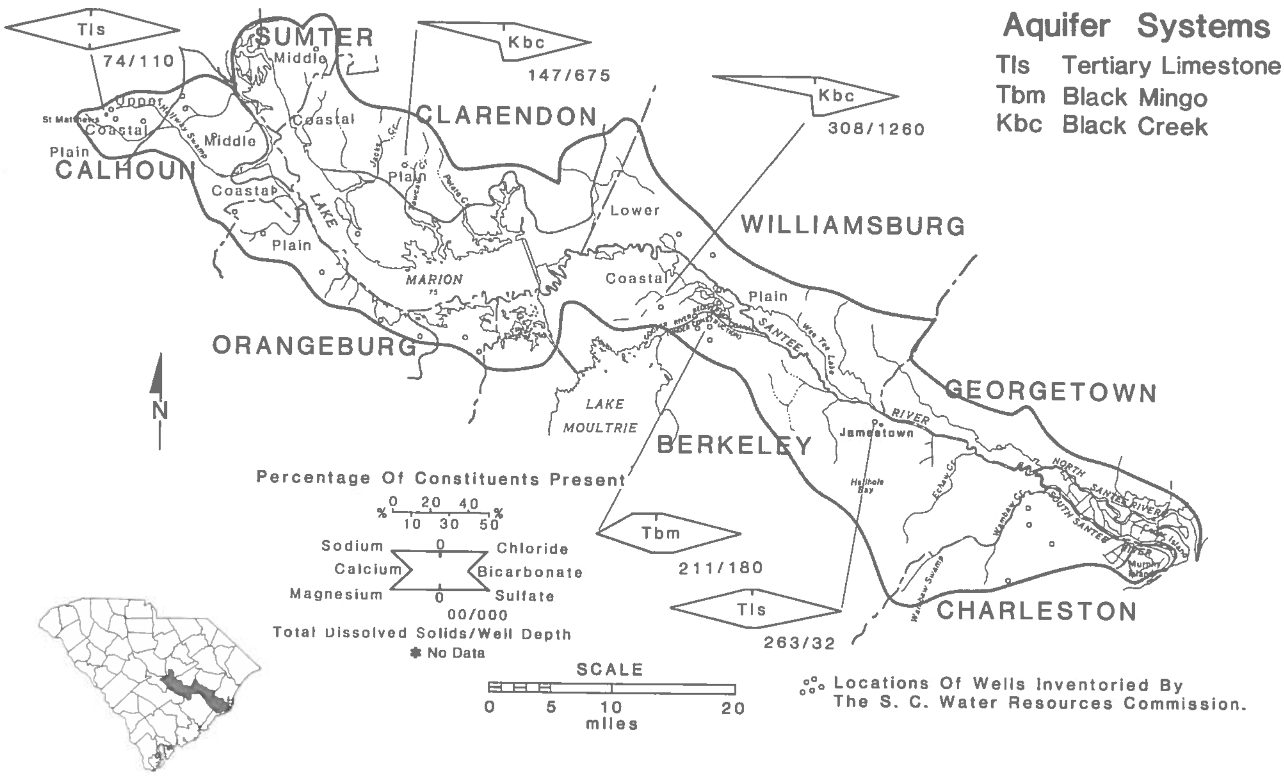


Figure 110.
Ground-water quality of selected aquifer systems and major inventoried wells in the Lower Santee River Sub-basin, South Carolina.

WATER USE

Gross water use is currently estimated at 18.4 mgd with 86 percent of this (15.7 mgd) being consumed (Table 100). The leading water withdrawals are for thermoelectric power (11.1 mgd), agricultural irrigation (2.2 mgd), and self-supplied industry, (1.4 mgd). Major water users by type and supply source are shown in Figure 111.

Surface water supplies 72 percent of the gross demand but ground water supplies 72 percent of the demand of uses other than thermoelectric power. The largest water withdrawal is for thermoelectric power generation and is located in the extreme lower end of the Lower Santee River Sub-basin.

Public supply withdrawals (1.34 mgd) account for seven percent of the total gross use, while consumption is less than one percent of total sub-basin consumed use. Ground water is the only source of supply used. Most of the use occurs in the upper half of the sub-basin.

Self-supplied domestic use represents 11 percent of the total gross use and 11 percent of the consumptive use. This user group is the largest ground-water user in the sub-basin.

Agricultural water use makes up 13 percent of the total gross use. Irrigation accounts for 90 percent of this total use (2.2 mgd) with surface water supplying 82 percent of the demand. All irrigated acreage is located in the upper half of the sub-basin (Fig. 111). When averaged over the five-month growing season, irrigation use equals 5.4 mgd, comprising 25 percent of gross use and 28 percent of consumptive use in the sub-basin. Ground water is used to meet 60 percent of the livestock water needs.

Self-supplied industry uses 1.40 mgd which represents eight percent of the total gross use but accounts for almost two percent of the consumptive use. Ground water is used to supply 90 percent of the demand, which is all located in the lower half of the sub-basin.

A single thermoelectric power plant uses 11.1 mgd from the North Santee River representing 60 percent of the total gross use. The entire 11.1 mgd is transferred for use in the Waccamaw River sub-basin. This use is thus considered totally consumed and represents 70 percent of consumptive use in the Lower Santee Sub-basin. This is the largest surface-water withdrawal in the sub-basin.

Total gross use is projected to grow 105 percent to 37.8 mgd by 2020. Consumptive use is projected to grow 110 percent to 15.7 mgd. Most of the growth in consumptive use is due to the projected increase (650 percent) agricultural irrigation. This should become the leading gross and consumptive water user and surface water should remain the most heavily used source.

Table 100.

Current and projected water use in the Lower Santee River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	1.34	---	1.34	1.61	---	1.61	1.93	---	1.93	2.22	---	2.22	2.44	---	2.44
	Consumed	0.13	---	0.13	0.16	---	0.16	0.19	---	0.19	0.22	---	0.22	0.24	---	0.24
Self-supplied Domestic	Gross	2.1	---	2.1	2.5	---	2.5	3.0	---	3.0	3.5	---	3.5	3.8	---	3.8
	Consumed	1.8	---	1.8	2.1	---	2.1	2.6	---	2.6	3.0	---	3.0	3.2	---	3.2
Agriculture Irrigation	Gross	0.4	1.8	2.2	1.4	5.0	6.4	2.5	7.4	9.9	3.4	9.7	13	4.5	12	17
	Consumed	0.4	1.8	2.2	1.4	5.0	6.4	2.5	7.4	9.9	3.4	9.7	13	4.5	12	17
Agriculture Livestock	Gross	0.15	0.10	0.25	0.17	0.11	0.28	0.19	0.13	0.32	0.22	0.15	0.37	0.25	0.17	0.42
	Consumed	0.15	0.10	0.25	0.17	0.11	0.28	0.19	0.13	0.32	0.22	0.15	0.37	0.25	0.17	0.42
Self-supplied Industry	Gross	1.26	0.14	1.40	1.39	0.16	1.55	1.52	0.18	1.70	1.68	0.19	1.87	1.93	0.21	2.14
	Consumed	0.23	0.03	0.26	0.26	0.03	0.29	0.28	0.03	0.31	0.31	0.04	0.35	0.36	0.04	0.40
Thermoelectric Power	Gross	---	11.1	11.1	---	11.4	11.4	---	11.8	11.8	---	12.1	12.1	---	12.5	12.5
	Consumed	---	11.1	11.1	---	11.4	11.4	---	11.8	11.8	---	12.1	12.1	---	12.5	12.5
Total	Gross	5.25	13.1	18.4	7.07	16.7	23.7	9.14	19.5	28.7	11.0	22.1	33.2	12.9	24.9	37.8
	Consumed	2.71	13.0	15.7	4.09	16.5	20.6	5.67	19.4	25.1	7.15	22.0	29.1	8.55	24.7	33.3

WATER USE VERSUS AVAILABILITY

The current 13.1 mgd gross surface-water demand and the 13.0 mgd consumptive surface-water demand is adequately met by streamflow (Fig. 112). Nearly 100 percent of this use occurs near the mouth of the Santee River (Fig. 111). Projected 2020 demand of 37.8 mgd gross surface-water demand and 33.3 mgd consumptive surface-water demand should be adequately met by streamflow (Fig. 113). Water supply development on tributaries within the sub-basin should include site specific hydrologic analysis to determine the quantity of streamflow available, particularly at low rainfall periods.

It is estimated that ground water supplies about 29 percent of total water use in the Lower Santee River Sub-basin. Projections for the 2020 demand shows that ground-water demand should increase 145 percent from 5.25 mgd to 12.9 mgd and should constitute 34 percent of the total water demand. Present use could be supplied by approximately one well pumped at a rate of 600 gpm for six hours each day per 53 square mile area of the sub-basin. This would require a total of about 24 such wells. Projected requirements for 2020 could be supplied by one well per 21 square mile area which would require about 60 such wells using the same pumping regime.

Some ground-water problems exist at the present time in the Jamestown area where heavy ground-water pumpage from limestone quarries causes the occurrence of land surface collapse.

Ground-water quality problems may also limit availability in the coastal areas of the sub-basin. High iron and fluoride concentrations and an increase in turbidity might cause treatment problems for future utilization of the ground-water resource.

Major water resource problems and opportunities in the sub-basin are summarized in Table 101.

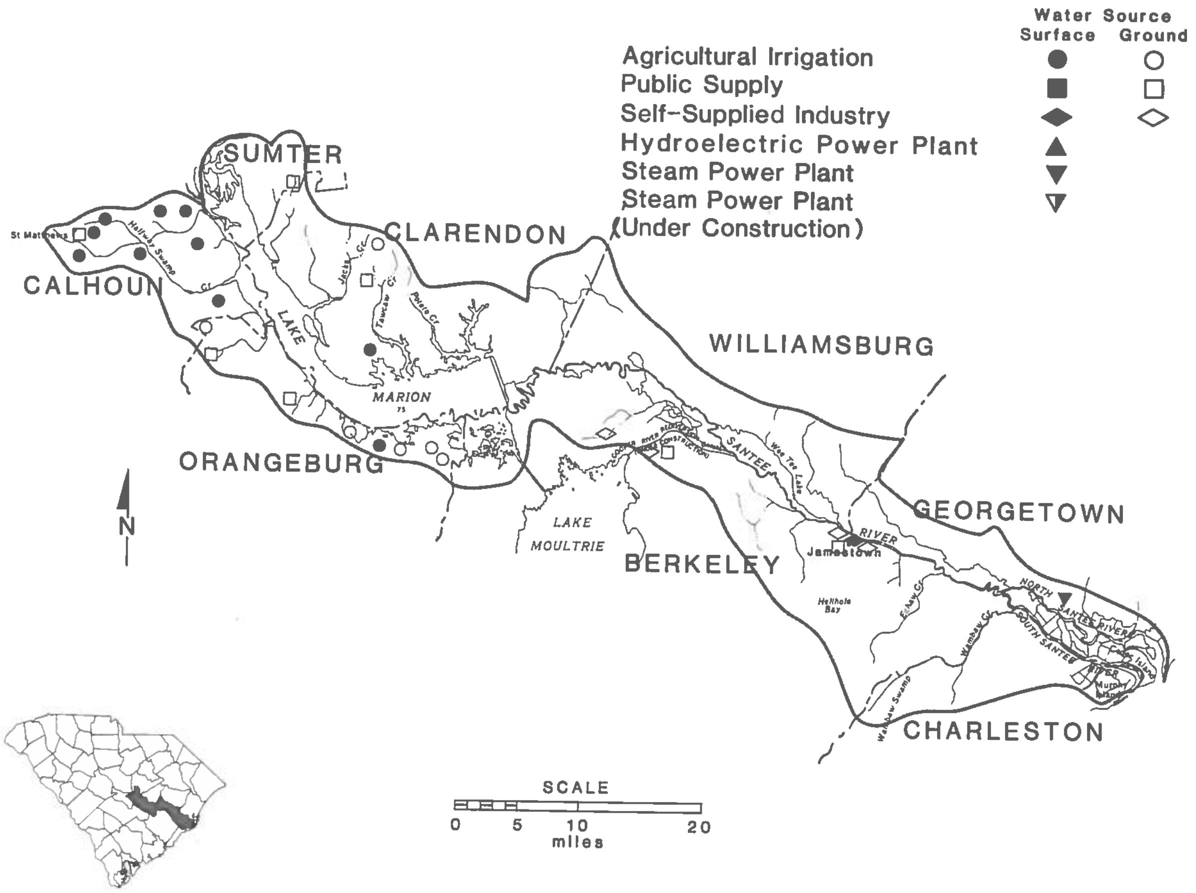


Figure 111.
Location, type, and supply source of water users in the Lower Santee River Sub-basin, South Carolina.

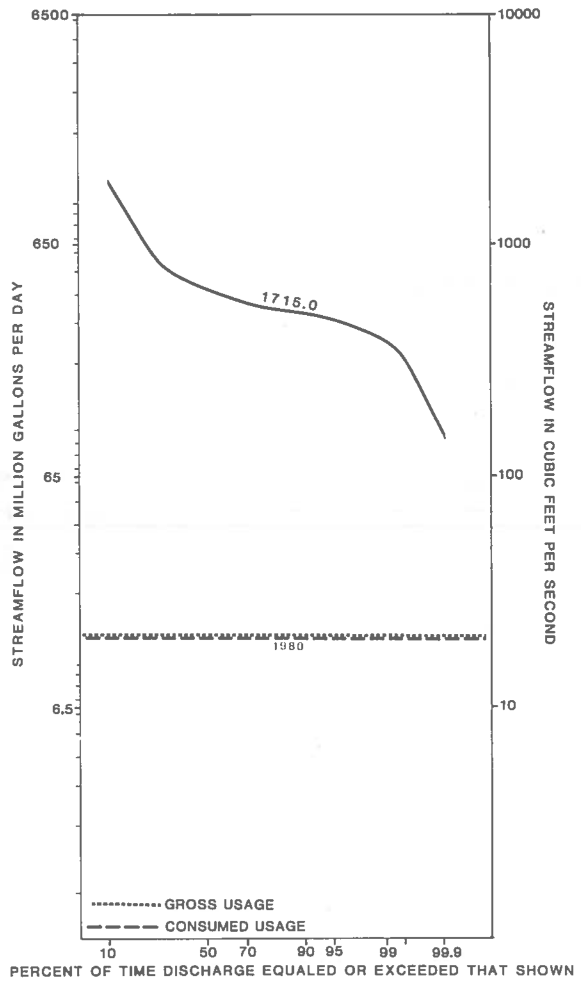


Figure 112.
Water use compared to availability in the Lower Santee River Sub-basin, South Carolina.

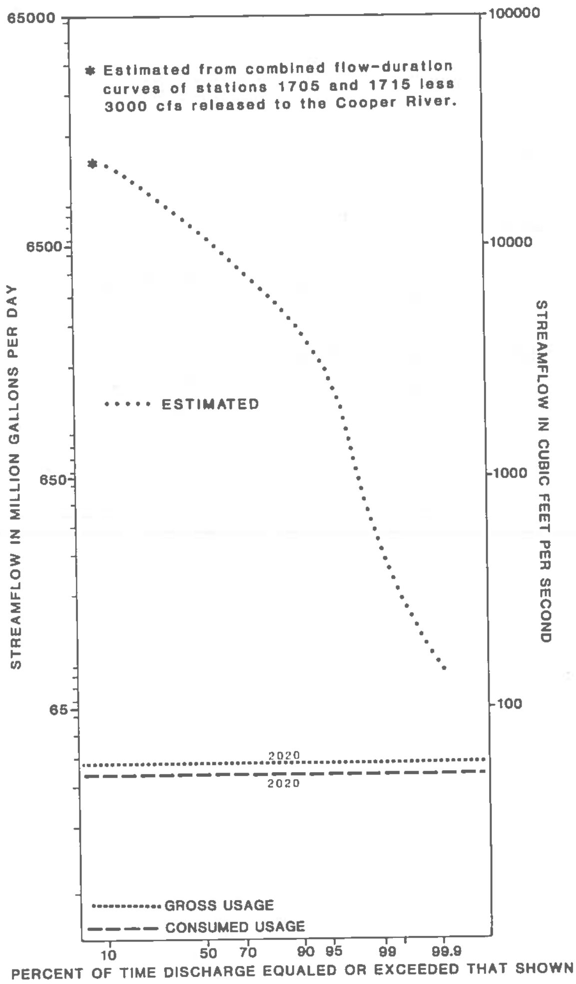


Figure 113.
Projected (2020) water use compared to availability after rediversion in the Lower Santee River Sub-basin, South Carolina.

Table 101.

Major water resource findings in the Lower Santee River Sub-basin, South Carolina.

Opportunities

1. After completion of the Cooper River Rediversion Project, streamflow in the Santee River will increase substantially providing more available surface water for future development and waste assimulation.
2. Current consumptive surface-water use is adequately met by surface-water supplies.
3. Lake Marion and the Santee River exhibit generally good water quality.
4. The Middendorf and Black Creek Aquifer Systems are largely underdeveloped and can supply large quantities of ground water.
5. Additional ground-water development will be possible in the Black Mingo and Tertiary Limestone Aquifer Systems following completion of the Cooper River Rediversion Project due to decreased saltwater intrusion.

Problems

1. Streams in this Middle and Lower Coastal Plain sub-basin exhibit variable and generally unreliable flows.
2. Extensive noxious aquatic plant infestations in upper Lake Marion severely restrict recreational water use activities and contribute to poor water quality conditions.
3. Residential dead-end canals impair local water circulation and cause localized water quality problems.
4. Agricultural non-point source runoff impairs recreational water use of Warley Creek, Halfway Swamp Creek, and Jack's Creek due to high levels of fecal coliform bacteria.
5. Shellfish harvesting is prohibited in the North and South Santee Rivers due to fecal coliform bacteria contamination.
6. High fluoride concentrations occur in the Black Creek Aquifer System in areas southeast of Jamestown.
7. Turbidity levels progressively increase in the Black Creek Aquifer System with distance toward the coast.
8. Heavy ground-water pumpage from the Tertiary Limestone Aquifer System near Jamestown has resulted in water level declines and land surface collapse.

Sub-basin Analyses: ACE River Basin

Ashley-Cooper River Sub-basin

GENERAL OVERVIEW

The Ashley-Cooper River Sub-basin is located in the Lower Coastal Plain in the southeast portion of South Carolina. The sub-basin extends inland for approximately 45 miles to Lake Moultrie at its widest point and encompasses portions of Berkeley, Charleston, and Dorchester Counties (Fig. 114). The areal extent of the sub-basin is approximately 1,710 square miles, 5.5 percent of the State land area.

Population

The 1980 population of the sub-basin was estimated at 381,400, which was 12.2 percent of South Carolina's total population (Table 102). By the year 2020 the sub-basin population is expected to reach 705,100, an increase of 84.9 percent. Dorchester County is expected to have the most rapid rate of growth (244.9 percent) during this period, primarily along an axis of towns extending northwest from the Charleston urbanized area.

The major centers of 1980 population in the sub-basin were Charleston (69,291), North Charleston, including Charleston Heights (55,284), James Island (21,600), Mt. Pleasant (13,715), Hanahan (13,049), St. Andrews (9,202), and Summerville (6,154).

In general, this is an urban region, with the majority of the population in all three counties classified as urban. The urban focus of the region is the City of Charleston.

Economy

The 1979 per capita income in the sub-basin ranged from $5,439 in Berkeley County, which ranked 38th in the State, to $7,652 in Charleston County, which ranked sixth. The mean per capita income for the region was $6,501, which is below the State's average of $7,056. The 1980 median household income in the sub-basin averaged $16,562, slightly above that for the State as a whole. Charleston County led the sub-basin with a median household income of $17,241.

During 1979, the combined annual average employment of nonagricultural wage and salary workers in the three sub-basin counties totaled 145,300. Dominant employment types were, government, 30.8 percent; wholesale and retail trade, 21.7 percent; services and mining, 16 percent; manufacturing, 13.4 percent; construction 7.6 percent; transportation and public utilities, 6.1 percent; and finance, insurance, and real estate, 4.3 percent. Compared to the State as a whole, the Ashley-Cooper area has less than its share of manufacturing employees and a greater proportion of the remaining categories, particularly government employees because of the large number of military installations.

Figure 114.
Location of the Ashley-Cooper River Sub-basin in South Carolina.

Table 102.
Current and projected population for the Ashley-Cooper River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands)					% Change 1980-2020
		1980	1990	2000	2010	2020	
Berkeley	87.1	83.4	120.6	166.0	213.1	243.1	191.5
Charleston	93.8	260.8	294.0	311.9	326.2	333.7	28.0
Dorchester	63.1	37.2	56.5	82.0	109.8	128.3	244.9
Total		381.4	471.1	559.9	649.1	705.1	84.9

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

In the sectors of manufacturing, mining, and public utilities, the region had an annual product value of $1,620.3 million during fiscal year 1978-79, which was 7.5 percent of the State total.

Agricultural activity is not very intense in this section of the State, although Charleston County did rank 12th in the State for cash crop receipts from farm marketings in 1979, with a total of $19,615 million.

SURFACE WATER

Hydrology

The two major freshwater rivers draining this sub-basin are the Ashley River and the Cooper River. These tidally influenced rivers along with several saltwater tidal creeks and rivers discharge into Charleston Harbor. Numerous tidal streams draining developed and undeveloped areas along the coast discharge into the Atlantic Ocean. All streams in the sub-basin are entirely within the Lower Coastal Plain. A segment of the Ashley River from S.C. Highway 165 bridge to the Seaboard Coastline Railroad bridge near North Charleston has been determined eligible for inclusion in the State Scenic Rivers Program. The Charleston metropolitan area makes extensive use of these surface-water resources.

Streamflow data in this sub-basin is somewhat limited. Routine streamflow monitoring by the U.S. Geological Survey is not performed. Special studies, however, have provided some hydrologic information. Streamflow in the Cooper River is regulated by releases from the Pinopolis Hydroelectric Plant. Current weekly average discharge at Pinopolis is 15,600 cfs and is highest during the winter months and lowest in the autumn months (S.C. Water Resources Commission, 1979). The majority of the water discharged at Pinopolis has been diverted from the Santee River into Lake Moultrie. Construction is underway to redivert much of this water back into the Santee River. Upon completion of the rediversion project, planned for 1983, weekly average discharge at Pinopolis will be reduced to 3,000 cfs.

Streamflow within this sub-basin provides a limited source of freshwater and after completion of the rediversion project available supplies will decrease even more. Currently, the impoundment of freshwater streams within the sub-basin and the transfer of water from outside the sub-basin provide most available surface-water supplies.

Development

Most surface-water development in this coastal sub-basin includes navigation projects in and around the Port of Charleston and flood control projects in urbanized areas (Fig. 115). In addition, hydroelectric development has resulted in the creation of one of the largest lakes in South Carolina.

Lake Moultrie is the largest reservoir in the sub-basin (Table 103). The completion of the Pinopolis Dam in 1941 created the lake which is located on the Cooper River north of Moncks Corner and is owned and managed by the S.C. Public Service Authority (Santee-Cooper). It is the fourth largest lake in the State with a surface area of 60,400 acres. A volume of approximately 1,200,000 acre-feet ranks it fifth in that category among lakes in the State. Presently, Lake Moultrie's waters flow down the Cooper River and enter Charleston Harbor. In order to help alleviate a severe silting problem in the harbor, a canal is being constructed near St. Stephens to redivert Lake Moultrie's waters into the Santee River, thereby reducing the average flow of the Cooper River from its present 15,600 cfs to 3,000 cfs. Since this diversion of water will greatly reduce the output of electricity from the Jefferies Hydropower facility at Pinopolis Dam, a new hydropower facility is being constructed on the rediversion canal which will compensate for the loss of hydroelectric production. The expected completion date for the project is 1983. In addition to power production, Lake Moultrie is used for recreation and includes a large portion of the Santee National Wildlife Refuge.

The City of Charleston owns two reservoirs, Back River Reservoir and Goose Creek Reservoir, from which it obtains municipal and industrial water supplies. Originally tidally influenced creeks, the two streams were impounded for the storage of freshwater.

Back River Reservoir receives water primarily from the Cooper River and supplies mainly industrial customers, although it is also used as an alternate municipal supply source. Goose Creek Reservoir is used for recreational purposes and as a back-up municipal supply source. Together the two reservoirs have a total surface area of 1,450 acres and an approximate volume of 13,000 acre-feet.

The total surface area of all lakes larger than ten acres is 66,281 acres. The total volume is approximately 1,250,000 acre-feet. Those lakes larger than 200 acres are listed in Table 103.

No potential hydropower sites have been identified within the sub-basin. Existing sites are presented in Table 104 and Figure 115.

The U.S. Army Corps of Engineers has been involved in numerous navigation projects in the sub-basin. The majority of the work is associated with Charleston Harbor (Table 105).

The U.S. Army Corps of Engineers completed a flood control project on Sawmill Branch in 1971 and is currently involved in several other projects. The Soil Conservation Service has only one project within the sub-basin, the Lower Berkeley flood control project, which is still in the planning stages. All projects and studies are presented in Table 106.

Water Quality

Water bodies of several different water use classifications occur in the Ashley-Cooper River Sub-basin (Fig. 116). Lake Moultrie is the only Class A water body in this sub-basin. All other classified freshwaters have Class B water use designations. Classified saltwater bodies include Class SA, Class SB, and Class SC water use designations. Water quality limited segments which require advanced treatment of wastewater effluents include all of Lake Moultrie, Back River, Goose Creek, and several minor tributary streams (Fig. 117). Water quality conditions in this highly developed sub-basin are generally adequate for most current water use needs. Problem conditions in the Ashley River and altered water quality conditions after completion of the Cooper River Rediversion Project may affect some water use activities in portions of the sub-basin.

The Ashley River has historically exhibited degraded water quality conditions which have limited some designated water use activities. Early studies by the U.S. Department of Health, Education, and Welfare (1965) indicate grossly polluted conditions and frequent fish kills, due to municipal and industrial wastewater discharges. However, more recent studies indicate improved conditions due to more advanced and expanded municipal waste treatment (S.C. Department of Health and Environmental Control, 1975a; CH2M Hill and Betz Environmental Engineers, Inc., 1978). Contraventions of State standards for dissolved oxygen and fecal coliform bacteria in addition to high phosphorus (nutrients) concentrations still occur and are attributed to municipal and industrial point source discharges and non-point source runoff from the highly developed watershed. The taking of shellfish is prohibited from portions of this river due to fecal coliform bacteria contamination (Fig. 117).

Water quality in Lake Moultrie has been good with no observed violations of State standards (S.C. Department of Health and Environmental Control, 1975a; CH2M Hill and Betz Environmental Engineers, Inc., 1978). The U.S. Environmental Protection Agency (1976e) classified this lake as eutrophic and ranked it fifth in trophic quality out of 13 South Carolina lakes surveyed. Trophic quality of this lake was higher than that of upstream Lake Marion. Except for temporary localized turbidity problems during construction, the U.S. Army Corps of Engineers (1975) does not anticipate the Cooper River Rediversion Project to affect water quality conditions in Lake Moultrie. However, concern exists that alteration of flow patterns in the lake after rediversion may aggravate existing nuisance aquatic plant problems and adversely affect drainage of low lying areas around the lake (Howard Roach, S.C. Public Service Authority, personal communication, March 1982).

While the Cooper River exhibits generally good water quality, conditions in the upper portion of the river are better than in the stretch below Back River Reservoir (S.C. Water Resources Commission, 1974; S.C. Department of Health and Environmental Control, 1980b). Water quality conditions in this lower portion of the river are not suitable to allow the harvesting of shellfish (Fig. 117). Abundant nuisance aquatic plant populations along this river, estimated at 4,600 acres, occasionally impact some recreational activities (S.C. Aquatic Plant Management Council, 1981). Water quantity and quality in the Cooper River should be greatly affected by the Cooper River Rediversion Project. This project, expected to be completed in late 1983, will reduce the average streamflow in the Cooper River from the current 15,600 cfs to 3,000 cfs after rediversion. The U.S. Army Corps of Engineers (1975) anticipates that reduced streamflow will decrease waste assimilative capacity of the river, increase saltwater intrusion and salinity levels, decrease biological productivity, increase aquatic plant growth in adjacent rice fields, and reduce anadromous fish migration and resident fish populations in this river. Some questions still exist over the magnitude and extent of saltwater intrusion in the Cooper River and resultant water use impacts after rediversion. Early studies indicate that oceanic saltwater intrusion would not sufficiently penetrate up the river to adversely impact Back River Reservoir, a major freshwater resource for local municipalities and industry (S.C. Water Resources Commission, 1974; Benson and Boland, 1977). However, more recent studies indicate that saltwater may intrude a sufficient distance to occasionally impact water quality and water use in Back River Reservoir (S.C. Water Resources Commission, 1979; Chigges and Taylor, 1981).

Currently, water quality in the main body of Back River Reservoir meets State standards and criteria. Foster Creek,

Table 103.
Existing lakes larger than 200 acres in the Ashely-Cooper River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Lake Moultrie	West Branch Cooper River	60,400	1,211,000	Power Recreation Water supply
2	Back River Reservoir	Back River	850	8,500	Industry Recreation Water supply
3	Goose Creek Reservoir	Goose Creek	600	4,800	Recreation Water supply
4	Unnamed	Jack Creek	500	2,500	Recreation

Source: S.C. Water Resources Commission, 1974.

Table 104.
Existing and potential hydroelectric power development in the Ashley-Cooper River Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
5	Jefferies (Pinopolis)	Berkeley	Cooper	SCPSA[a]	5	132.6	60,400	Const. 1942
6	St. Stephens	Berkeley	Rediversion Canal	SCPSA	--[b]	84.0	60,400	Under const.

[a] SCPSA indicates S.C. Public Service Authority.
[b] -- indicates information not available.

Sources: Federal Power Commission, 1970.
U.S. Army Corps of Engineers, 1982a.

Table 105.
U.S. Army Corps of Engineers navigation projects in the Ashley-Cooper River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
7	Town Creek	Charleston	Charleston	1.0	80	Project provides for a 12 foot entrance channel across the ocean bar; and then a 10 foot channel up Five Fathom Creek to the Intracoastal Waterway. Completed 1974.
8	Beresford Creek	Charleston	Charleston	1.8	60	Project provides for a 6 foot deep Creek channel from deep water in Cooper River via Clouter Creek up Beresford Creek, a distance of 1.8 miles. Project deauthorized in 1977.
9	Charleston Harbor	Charleston	Charleston	25.3	400-1000	Project provides for: 35 foot deep channel from the Atlantic Ocean to mouth of Goose Creek; a 35 foot deep channel through Town Creek; a 10 foot deep channel in Shem Creek to Hwy. 17; two stone entrance jetties. A 40 foot deep channel for defense purposes is proposed. The project is continuing.
10	Shipyard River	Charleston	Charleston	1.2	200-600	Project provides for 30 foot deep channel from deep water in the Cooper River to the Carbide Inc. plant on Shipyard River. The project is complete.
11	Ashley River	Charleston	Charleston	7.4	300	Project provides for a 30 foot deep channel from the mouth to Stowchard Wharf. Project completed in 1940.
12	Folly River	Charleston	Charleston	8.8	80-100	Project provides for: 11 foot deep channel from the ocean to the mouth of Folly River; a 9 foot deep channel from the mouth to Hwy. 171. A 9 foot deep channel within Folly Creek from Hwy. 171 to Folly River. Project completed in 1979.
13	Abbapools Creek	Charleston	Charleston	5.0	60	Project provides a 4 foot deep channel from the mouth on the Stono River to a point 5 miles upstream. Project deauthorized 1975.

Source: U.S. Army Corps of Engineers, 1982b.

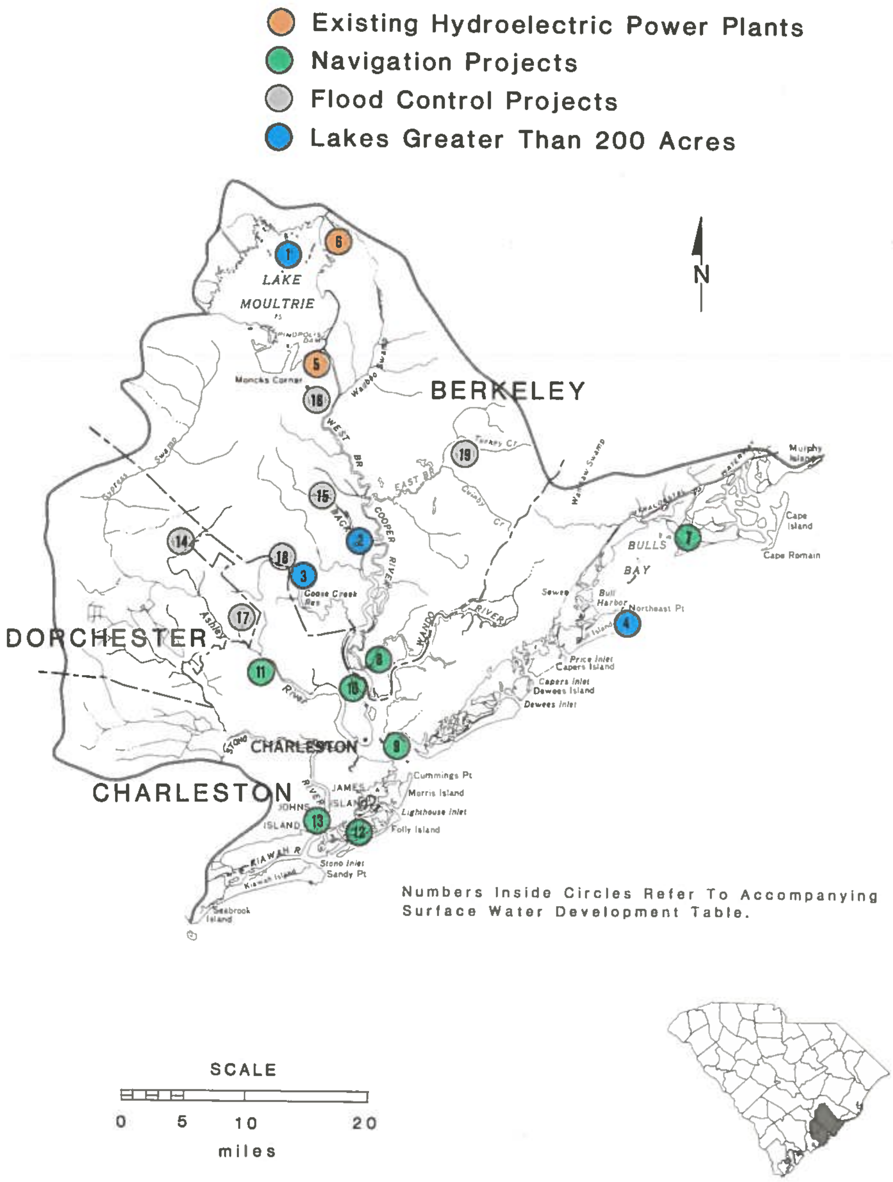


Figure 115.
Surface-water development in the Ashley-Cooper River Sub-basin, South Carolina.

Table 106.
Flood control projects in the Ashley-Cooper River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
14	Sawmill Branch	Dorchester Berkeley Charleston	COE	Completed 1971
15	Lower Berkeley	Dorchester	SCS	Terminated
16	California Branch	Berkeley	COE	Deauthorized 1979
17	Eagle Creek	Dorchester	COE	Project authorized
18	Goose Creek	Charleston/ Berkeley	COE	Study in progress
19	Turkey Creek	Charleston/ Berkeley	COE	Inactive

[a] COE indicates U.S. Army Corps of Engineers
SCS indicates Soil Conservation Service.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

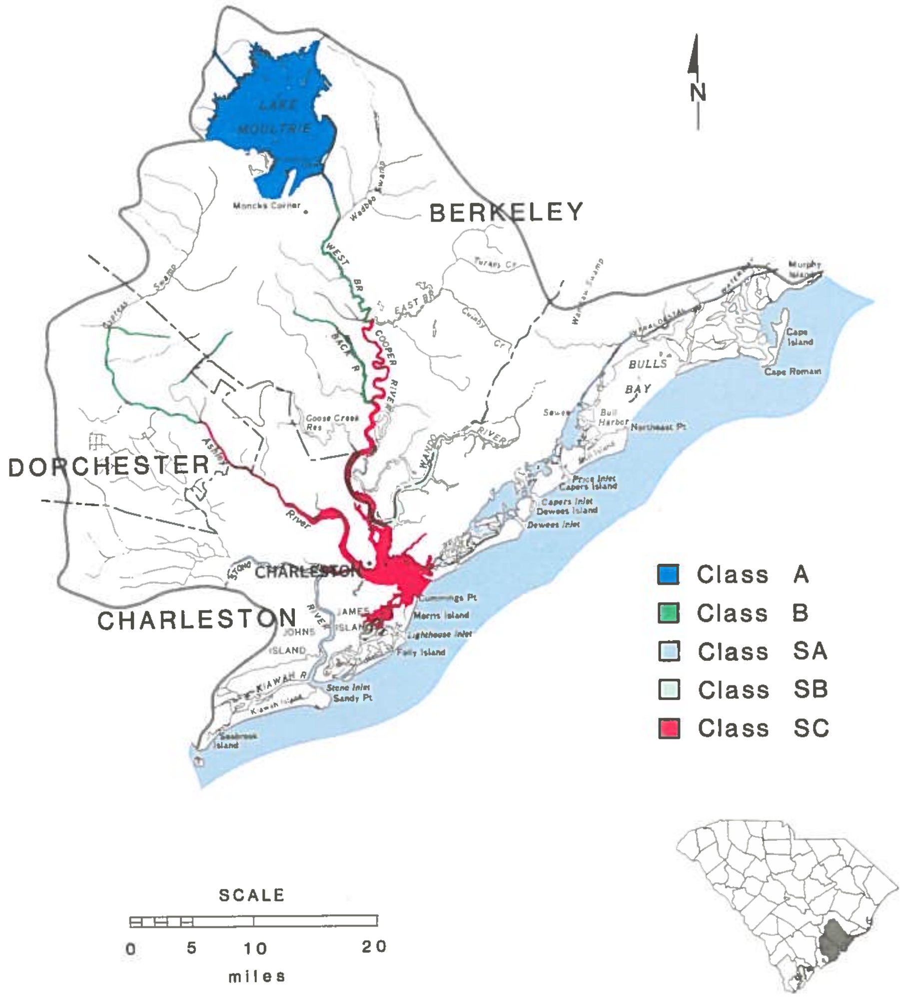


Figure 116.
Surface-water quality classifications in the Ashley- Cooper River Sub-basin, South Carolina (S.C. Department of of Health and Environmental Control, 1980a).

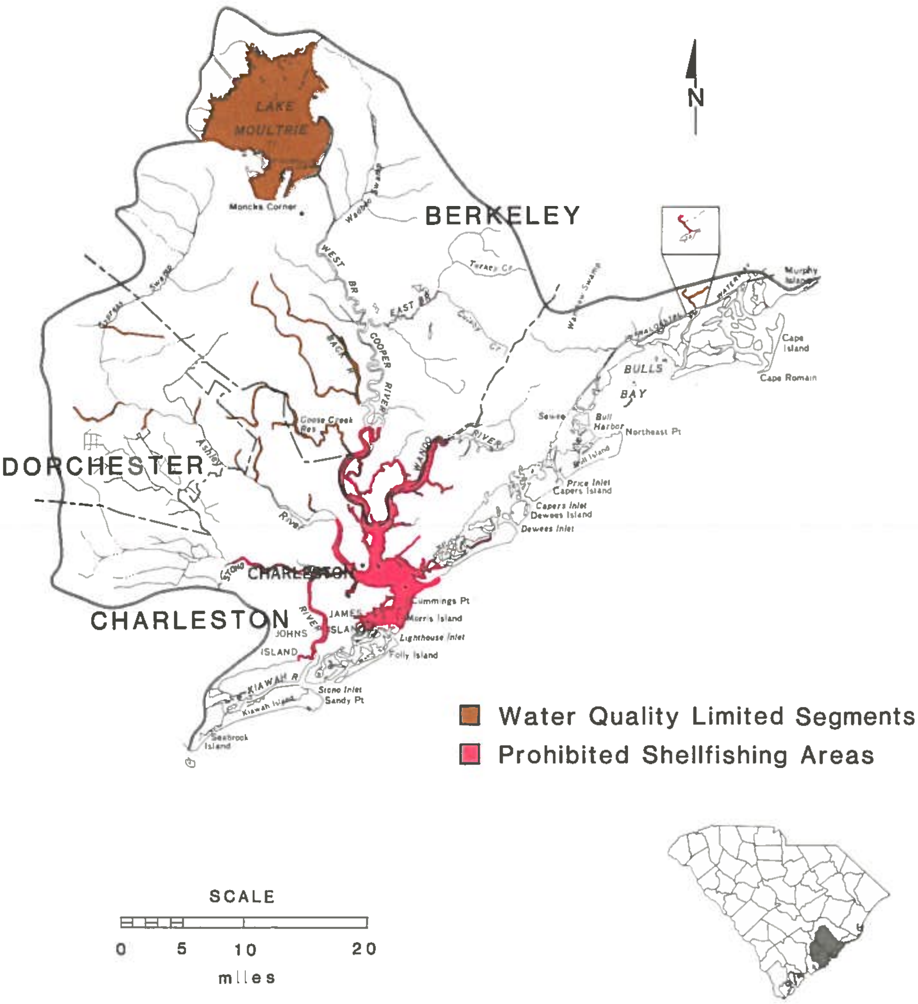


Figure 117.
Water quality limited segments and prohibited shellfishing areas in the Ashley-Cooper River Sub-basin, South Carolina (S. C. Department of Health and Environmental Control, 1979).

a major tributary to the reservoir, exhibits degraded conditions evidenced by contraventions of State dissolved oxygen standards and elevated levels of biochemical oxygen demand, specific conductance, hardness, alkalinity, chlorides, nutrients, and some metals (Lagman and others, 1980). These poor water quality conditions have been attributed to point and non-point sources. Abundant nuisance aquatic plant populations dominated by Brazilian elodea, alligatorweed, and water primrose severely impact numerous water uses in this reservoir. The S.C. Aquatic Plant Management Council (1981, 1982) has identified Back River Reservoir as one of the major aquatic plant problem areas in the State. Although current water quality is generally adequate for most water use needs, possible increases in chloride concentrations in the reservoir after rediversion may disrupt some municipal and industrial water use activities (S.C. Water Resources Commission, 1979; Chigges and Taylor, 1981).

Goose Creek Reservoir, which is used for recreation and serves as a municipal water supply for the City of Charleston, is severely impacted by approximately 300 acres of nuisance aquatic vegetation. This water body has been identified as one of the major aquatic plant problem areas in the State and was provided control funds in 1982 (S.C. Aquatic Plant Management Council, 1981, 1982).

The Wando River exhibits the best water quality of all the major rivers entering Charleston Harbor. Due to impacts from the Cooper River and Charleston Harbor, water quality at the mouth of the Wando River is not as good as farther upstream (S.C. Water Resources Commission, 1973). This lower portion is closed to shellfish harvesting due to unsuitable water quality conditions (Fig. 117). Recent port development on this river is not expected to cause long-term water quality problems (S.C. Water Resources Commission, 1974). Reduced flows in the Cooper River due to rediversion are expected to increase salinity and destroy existing sub-tidal oyster beds in the lower portion of the Wando River (U.S. Army Corps of Engineers, 1975; S.C. Water Resources Commission, 1979).

Water quality conditions in Charleston Harbor are affected by the Ashley, Cooper, and Wando Rivers and the Atlantic Ocean. The harbor has experienced water quality problems in the past. However, while occasional depressed dissolved oxygen levels still occur and shellfish harvesting is still prohibited, water quality conditions have recently improved (CH2M Hill and Betz Environmental Engineers, Inc., 1978). Reduced flow in the Cooper River after completion of the rediversion project is expected to decrease the sediment load entering Charleston Harbor and therefore reduce shoaling. Current stratified conditions due to salinity differences should also change, creating a well mixed estuary. Water quality conditions in the harbor may improve further due to accelerated tidal flushing of wastes (Federal Water Pollution Control Administration, 1966).

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout the sub-basin is at the evaluation level (Fig. 18). A cooperative ground-water study is presently being conducted by the S.C. Water Resources Commission and the U.S. Geological Survey. This study is identified as the Trident Ground-Water Study and encompasses the counties of Charleston, Berkeley, and Dorchester. The study will provide an intensive appraisal of ground-water quality and quantity in the Charleston area. A final report on this investigation is anticipated in 1983.

The Ashley-Cooper River Sub-basin lies wholly within the Lower Coastal Plain Province. Six major aquifer systems underlie the sub-basin and include the Middendorf, Black Creek, Peedee, Black Mingo, Tertiary Limestone, and Shallow Aquifer Systems. The thickness of the sediments ranges from about 1,700 to 3,200 feet. The principal sources of public supply water are the Black Creek Aquifer System, the Black Mingo and Tertiary Limestone Aquifer Systems, and the Shallow Aquifer System. Selected ground-water data for the sub-basin are presented in Table 107.

Although the Middendorf Aquifer System underlies the entire sub-basin, it is not generally used as a ground-water source because of its great depth and brackish water.

The Black Creek Aquifer System underlies all of the Ashley-Cooper River Sub-basin. The top of this aquifer system occurs at 430 feet below mean sea level at St. Stephens near the northern extreme of the sub-basin and dips to approximately 1,000 feet below mean sea level at Mt. Pleasant on the coast. Its thickness ranges from 600 feet in the northern part of the sub-basin to 750 feet at the southern part. This aquifer system is potentially the most productive water bearing unit in the sub-basin, but because of its depth only large municipalities and industries have the financial resources to develop it. For example, 14 major industrial and municipal wells which are screened in the Black Creek Aquifer System have yields ranging from 200 to 500 gpm with specific capacities of less than 10 gpm/ft. The development of well yields of up to 1,000 gpm are thought to be possible in most of the sub-basin.

The Peedee Aquifer System overlies the Black Creek Aquifer System and is about 250 feet thick. Because of its low permeability there are no wells known to be screened in this aquifer within the sub-basin.

Sand, clay, and limestone beds within the Black Mingo Aquifer System lie close to land surface north of Bonneau and thicken from about 200 feet at St. Stephens to 350 feet near Sullivan's Island. Sediments of the Black Mingo Aquifer System dip to the south-southeast at 8 to 12 feet per mile. The Black Mingo Aquifer System underlies the entire Ashley-Cooper River Sub-basin.

The Tertiary Limestone Aquifer System also underlies the entire sub-basin. Its thickness ranges from a few feet at Bonneau to approximately 200 feet at Sullivan's Island. North of Huger and McClellanville, the Tertiary Limestone Aquifer System is highly permeable and adequate water supplies are obtained without drilling into deeper lying

Table 107.
Selected ground-water data for the Ashley-Cooper River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Moncks Corner	Tertiary Limestone /Black Mingo	200	250	Less than 4
Goose Creek-Summerville	Tertiary Limestone /Black Mingo	300-500	250	--[a]
Cypress Gardens	Tertiary Limestone /Black Mingo	--	500-1000	15
Mt. Pleasant	Shallow	40-60	40-175	--

[a]-- indicates data not readily available.

Black Mingo sands. However, most wells penetrate and are open to both aquifer systems.

The Tertiary Limestone and the Black Mingo Aquifer Systems are the most extensively developed ground-water sources south of Moncks Corner, Huger, and McClellanville. Well yields in this area vary with location and depth (Table 107). Water levels in the Tertiary Limestone-Black Mingo Aquifer Systems vary from approximately 80 feet above sea level at Cross, to about 10 feet below sea level at Charleston. Water levels in the Tertiary Limestone and Black Mingo Aquifer Systems have decreased significantly in some parts of the sub-basin. The most notable declines have occurred between Goose Creek and Moncks Corner, where water levels are 5 to 15 feet below those in wells of the surrounding areas and on the Charleston neck, where water levels have been depressed as much as 70 feet below original levels. In the northern section of the sub-basin, ground-water movement in the Tertiary Limestone-Black Mingo Aquifer Systems is controlled by the topography of the Santee River Valley and Lake Moultrie. Ground water within the confines of the Santee River Valley discharges towards the river and fluctuations in river stage affect both water levels and the rate of ground-water discharge. The fluctuations in lake surface elevations of Lake Moultrie cause corresponding changes in ground-water levels of the Tertiary Limestone-Black Mingo Aquifer Systems in the vicinity of the lake. South of Lake Moultrie and the Santee River, ground-water flows to the south-southeast.

The Shallow Aquifer System underlies the entire sub-basin. It is generally composed of interbedded marine sands and clays, and locally contains shell and limestone beds. The thickness of the aquifer system ranges from about 10 feet in northern Berkeley County to more than 50 feet in coastal Charleston County. The Shallow Aquifer System is relatively thin in most of Berkeley County and, therefore, is not extensively used. However, in coastal Charleston County, the system is thicker and is a preferred source of ground-water supply. The greatest number of shallow wells exist in the area south of McClellanville and east of U.S. Highway 17, where the population density is highest and where most underlying aquifers contain brackish water. Within that area, the municipalities of McClellanville, Mt. Pleasant, Isle of Palms, and Sullivan's Island rely heavily on the Shallow Aquifer System as a sole or supplementary source of water, as do numerous domestic users. Yields from shallow wells may be highly variable depending on intended use, thickness of the aquifer, and local lithology. Domestic wells are usually less than 40 feet deep and pump between 8 and 15 gpm. Municipal wells are generally more productive. Groups of wells on Sullivan's Island, ranging from 20 to 30 feet deep, collectively yield about 100 gpm.

Water Quality

Ground water in all major aquifers exhibit progressively increasing chloride and fluoride concentrations nearer the coast. Concentrations of most constituents also increase with increasing depth. In the Charleston vicinity, concentrations of chlorides range from less than 250 mg/L to more than 1,000 mg/L in ground water from the Tertiary Limestone Aquifer System. During the last twenty years, chlorides in the Tertiary Limestone and Black Mingo have increased as a result of large ground-water withdrawals. The fluoride content increases from less than 1 mg/L in Summerville to more than 5 mg/L along the coast.

Water quality of the Black Creek Aquifer System is representative of a sodium bicarbonate type and is generally soft, with a pH ranging from 8.4 to 8.6 and low iron concentrations (Fig. 118). The Black Mingo Aquifer System contains water of the sodium and calcium bicarbonate type and has high concentrations of dissolved silica. The Tertiary Limestone Aquifer System contains water classified as a calcium bicarbonate type which is moderately hard to hard with iron concentrations often exceeding acceptable drinking water limits.

WATER USE

Gross water use is 399 mgd of which 14.2 mgd is consumed (Table 108). This sub-basin's gross usage is sixth in the State. Thermoelectric power generation is the leading gross water user in the sub-basin withdrawing 372 mgd, self supplied industry is second withdrawing 10.3 mgd, and self-supplied domestic is the third withdrawing 8.8 mgd. The major water users by type and supply source are shown in Figure 119.

Surface water supplies 96 percent of the gross water use demand. Excluding the thermoelectric power water use, ground water supplies 60 percent of gross demand. Approximately 65 mgd of Edisto River water is transported into this sub-basin for public supply and industrial use. This use is accounted for in the Edisto River Sub-basin.

Public supply use represents one percent of the total gross use and almost three percent of consumptive use. Most of the public supply needs are met by surface water transported into the sub-basin. Of the approximately 65 mgd transferred into the sub-basin, 44 mgd are for public supply. Currently, 4 mgd of ground water is used for public supply.

Self-supplied domestic water use, which depends solely on ground-water sources, accounts for two percent of the gross water use. However, this use accounts for 53 percent of the consumed water use. This use is the leading ground-water withdrawal in the sub-basin, and the largest rural domestic ground-water withdrawal in the State.

Agricultural water use represents less than one percent of the sub-basin gross water withdrawal, with 0.53 mgd use, and four percent of the consumptive use. Irrigation demand accounts for 62 percent of agricultural gross usage with ground water supplying 58 percent of this demand. When

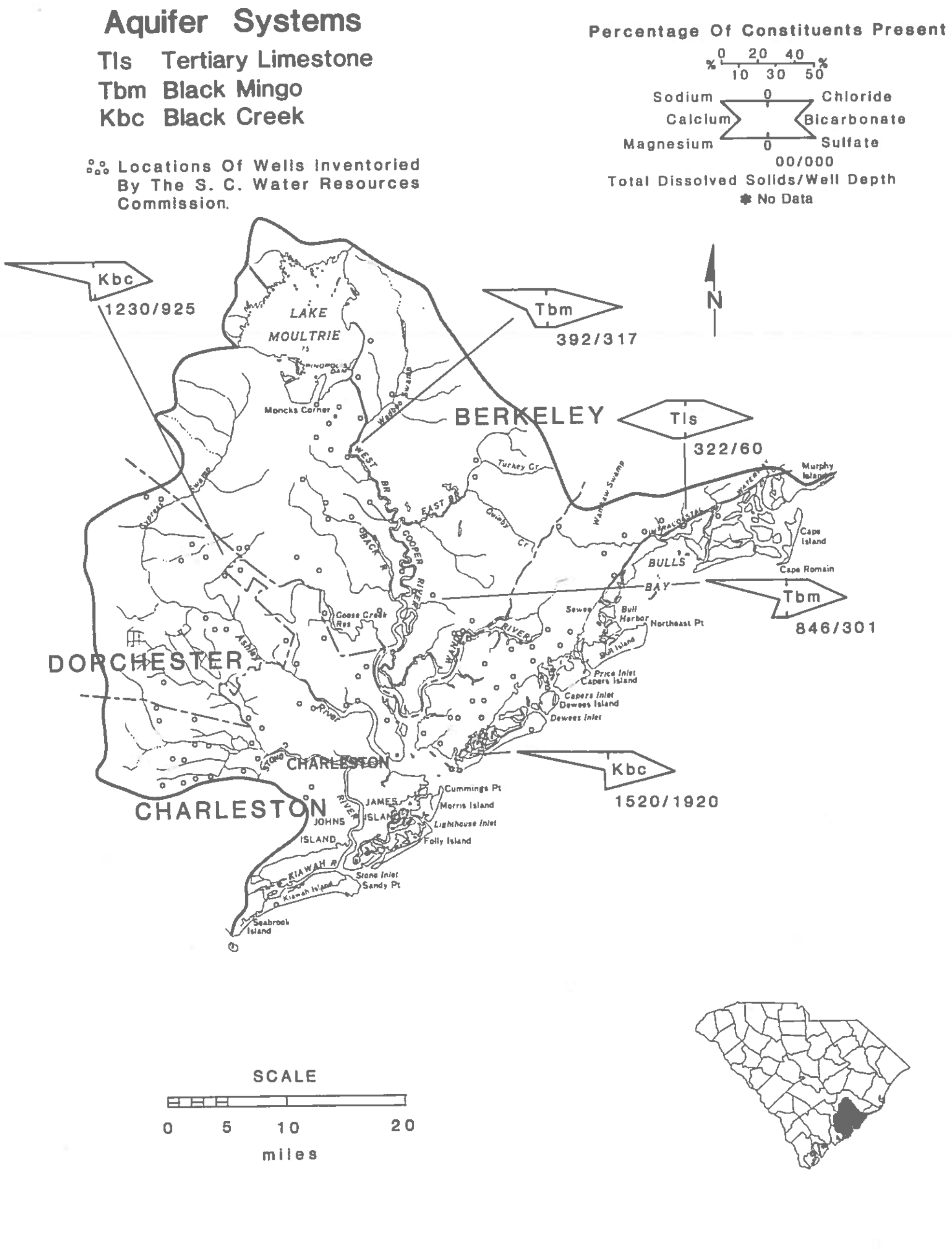


Figure 118.
Ground-water quality of selected aquifer systems and major inventoried wells in the Ashley-Cooper River Sub-basin, South Carolina.

Table 108.

Current and projected water use in the Ashley-Cooper River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	4.1	0.0	4.16	5.20	16.4	21.6	6.24	32.9	39.1	7.18	47.3	54.5	7.89	59.3	67.2
	Consumed	0.42	0.0	0.42	0.52	1.64	2.2	0.62	3.29	3.91	0.72	4.73	5.45	0.79	5.93	6.72
Self-supplied Domestic	Gross	8.8	---	8.8	11	---	11	13	---	13	15	---	15	17	---	17
	Consumed	7.5	---	7.5	9.4	---	9.4	11	---	11	13	---	13	14	---	14
Agriculture Irrigation	Gross	0.19	0.14	0.33	0.67	0.39	1.1	1.2	0.58	1.8	1.6	0.75	2.4	2.1	0.90	3.0
	Consumed	0.19	0.14	0.33	0.67	0.39	1.1	1.2	0.58	1.8	1.6	0.75	2.4	2.1	0.98	3.0
Agriculture Livestock	Gross	0.10	0.10	0.20	0.11	0.11	0.22	0.13	0.13	0.26	0.15	0.15	0.30	0.17	0.17	0.34
	Consumed	0.10	0.10	0.20	0.11	0.11	0.22	0.13	0.13	0.26	0.15	0.15	0.30	0.17	0.17	0.34
Self-supplied Industry	Gross	2.87	10.3	13.17	3.16	11.9	15.1	3.47	13.0	16.5	3.82	14.3	18.1	4.39	15.8	20.2
	Consumed	0.53	1.91	2.44	0.58	2.20	2.78	0.64	2.41	3.05	0.71	2.65	3.36	0.81	2.92	3.73
Thermoelectric Power	Gross	---	372	372	---	420	420	---	433	433	---	446	446	---	459	459
	Consumed	---	3.36	3.36	---	37.5	37.5	---	61.9	61.9	---	102	102	---	168	168
Total	Gross	16.1	383	399	20.1	449	469	24.0	480	504	27.8	509	536	31.6	535	567
	Consumed	8.74	5.51	14.3	11.3	41.8	53.1	13.6	68.3	81.9	16.2	110	126	17.9	178	196

averaged over the five-month growing season, irrigation use equals 0.80 mgd, comprising 0.2 percent of total sub-basin use. Livestock demand is met equally by ground and surface water.

Self-supplied industry accounts for three percent of the gross water use and 17 percent of the consumptive use. Surface water is used to meet 78 percent of this demand.

Thermoelectric power production is the leading water user, accounting for over 93 percent of the gross water use. This use accounts for 24 percent of consumptive use. Fresh surface water supplies nearly all the demand, however, 16 mgd of saline water use was reported. All three steam power plants were constructed near plentiful water sources.

Total gross water use is projected to grow 42 percent to 567 mgd by the year 2020. Thermoelectric power water use will remain the leading user and surface water the most heavily used source of supply. Public supply water use is projected to increase more than any use type in the sub-basin. This growth will be partially attributed to the increased demand on Back River Reservoir as a public supply source by the City of Charleston.

WATER USE VERSUS AVAILABILITY

Current surface-water withdrawals are made primarily from man-made impoundments and ungaged tributary streams. The largest surface-water use (372 mgd) is by three thermoelectric power plants, one on the Ashley River, one on the Pinopolis tail race canal, and one on Back River Reservoir (Fig. 119). These water bodies provide sufficient supplies to meet current demand. Most remaining surface-water withdrawals occur from Back River Reservoir. This reservoir is well supplied from the Cooper River and tributary streams and provides a reliable supply source.

Adequate water availability for projected 2020 demand is dependent on the type and location of the supply source. Thermoelectric power facilities will continue to be the largest surface-water users (459 mgd) and their current location on well supplied sources assures a reliable surface-water supply. Current impounded freshwaters could provide ample water for the remaining projected demand (76.2 mgd). However, withdrawals from tributary streams may experience periodic interruptions due to low-flow conditions.

Possible saltwater contamination of Back River Reservoir, following rediversion, would greatly impair current and projected use of this important source of fresh surface water and limit further surface-water dependent development in this sub-basin.

Current and projected ground-water demands within the Ashley-Cooper River Sub-basin can be met when certain regulatory measures, such as well construction standards, well spacing, and depth requirements, are maintained. In general, ground-water pumpage from the two principal aquifer systems, the Tertiary Limestone and the Black Mingo, has significantly decreased in the Charleston area. The most potentially productive water bearing aquifer system, that of the Black Creek, is not presently developed because of the greater depth (and the greater cost) required for its development.

Table 108 shows the 1980 recorded ground-water use (16.1 mgd) along with the projected use for the year 2020 (31.6 mgd). The quantity required for present ground-water use could be supplied by one well pumped at a rate of 600 gpm for six hours each day for each 23 square mile area of the sub-basin, or a total of about 75 such wells. The projected requirements for 2020 could be obtained by pumping a similar well in each 12 square mile area which would require about 146 wells pumped at the same time and rate.

Ground-water availability may be limited in certain areas of the sub-basin due to water quality. High chloride concentrations are already present in the Tertiary Limstone Aquifer in the Charleston vicinity and a potential danger of saltwater contamination of the Black Creek Aquifer System in the coastal area may limit its future development. Excessive

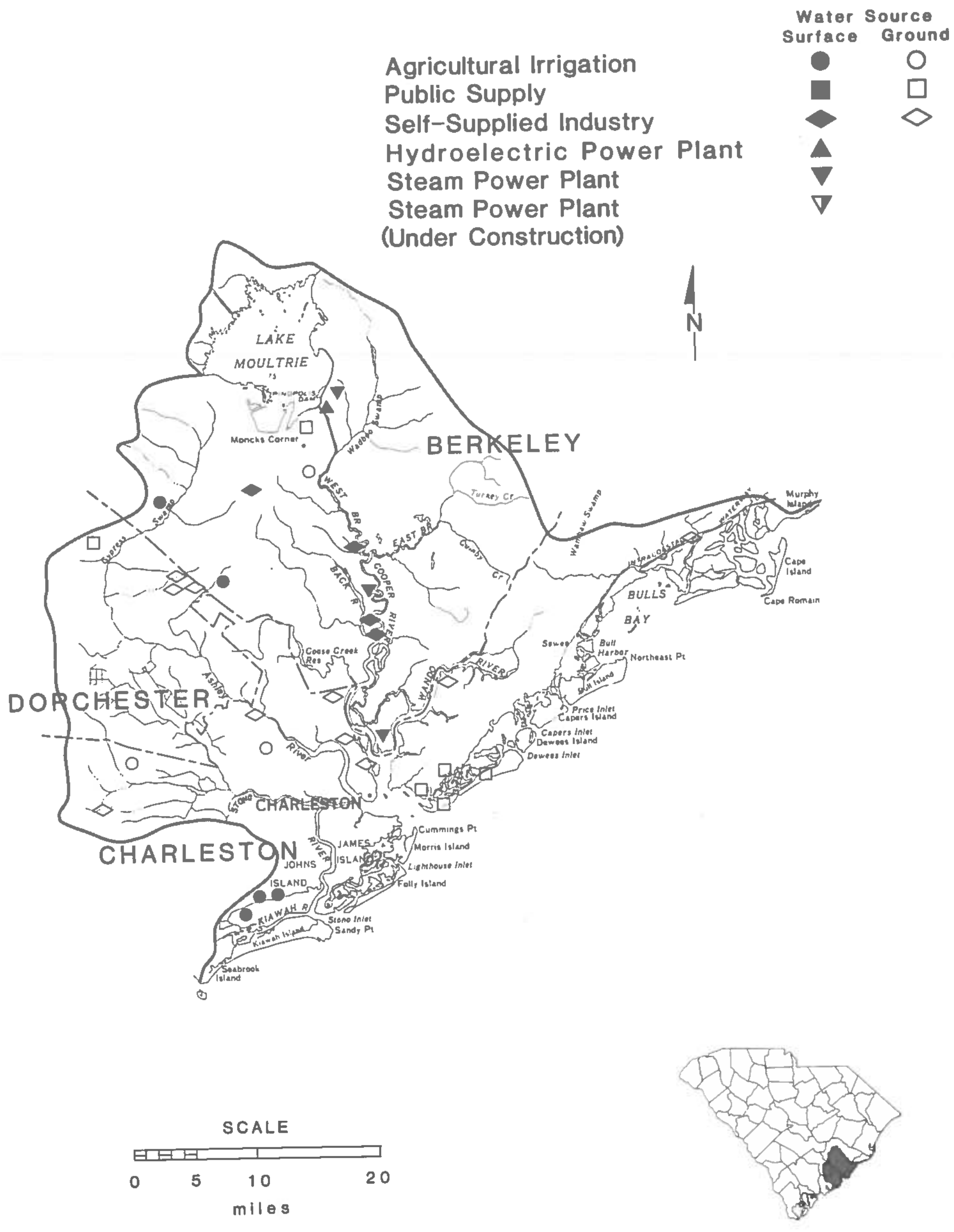


Figure 119.
Location, type, and supply source of water users in the Ashley-Cooper River Sub-basin, South Carolina.

fluoride, chloride, and total dissolved solids within the Black Creek Aquifer System in coastal areas might constitute treatment problems in the future utilization of this resource.

Major water resource problems and opportunities in the sub-basin are summarized in Table 109.

Table 109.

Major water resource findings in the Ashley-Cooper River Sub-basin, South Carolina.

Opportunities

1. Lake Moultrie is a source of large quantities of good quality water.
2. Decreased Cooper River streamflows after completion of the Cooper River Rediversion Project should reduce shoaling in Charleston Harbor, create a well mixed estuary, and possibly accelerate tidal flushing of wastes.
3. Potential deep-draft navigation exists for Charleston Harbor, Cooper River, Wando River, Shipyard River, and the Ashley River.
4. Six major aquifer systems underlie the sub-basin and provide large supplies of ground water able to meet projected (2020) ground water demand.
5. A segment of the Ashley River has been determined eligible for the State Scenic Rivers Program.

Problem

1. Unregulated streams in this Lower Coastal Plain sub-basin have variable, and unreliable flows of low volume.
2. A large portion of the current Cooper River streamflow will be lost after completion of the Cooper River Rediversion Project.
3. Water supply development should include surface-water storage capabilities.
4. Decreased streamflow in the Cooper River following its rediversion will reduce waste assimulative capacity of the river and may allow occasional saltwater intrusion into Back River Reservoir.
5. The Ashley River exhibits marginally degraded water quality conditions with high nutrient levels and occasional contraventions of State standards for dissolved oxygen and fecal coliform bacteria.
6. Abundant noxious aquatic plant populations restrict water use activities on portions of Goose Creek Reservoir, Back River Reservoir, and the Cooper River.
7. Current heavy sediment loading in Charleston Harbor causes dredge and dredge spoil disposal problems.
8. Suitable dredge material disposal sites are difficult to locate and maintain.
9. High flows in Goose Creek, Turkey Creek, and Eagle Creek occasionally cause flood damage to development on adjacent watershed lands.
10. Beach erosion adversely impacts Folly Island and other barrier islands.
11. The Tertiary Limestone Aquifer System in the Charleston area is experiencing saltwater contamination.
12. The potential exists for saltwater contamination of the Black Creek Aquifer System in the coastal areas.
13. Excessive fluoride, chloride, and total dissolved solids concentrations occur in the Black Creek Aquifer System along the coast.
14. Heavy pumpage by closely associated wells causes localized water level declines in the Tertiary Limestone and Black Mingo Aquifer Systems.
15. Heavy pumpage near outcrop areas has caused land surface collapse.

Edisto River Sub-basin

GENERAL OVERVIEW

The Edisto River Sub-basin is located in southcentral South Carolina. From its western extreme, in eastern Edgefield County, the sub-basin extends in a southeasterly direction to the coast following the course of the Edisto River. The sub-basin encompasses portions of 12 South Carolina counties, including most of Colleton and Orangeburg Counties and smaller portions of Aiken, Bamberg, Barnwell, Berkeley, Calhoun, Charleston, Dorchester, Edgefield, Lexington, and Saluda Counties (Fig. 120). The areal extent of the sub-basin is approximately 3,120 square miles, 10.0 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 189,500, six percent of South Carolina's total population (Table 110). By 2020 the sub-basin population is expected to reach 336,500, an increase of 77.6 percent. The highest rate of population growth for this time period is anticipated in Dorchester County, with a projected increase of 245.2 percent.

The sub-basin is primarily rural in character with the Cities of Aiken and Orangeburg being the only sizable urban areas. The major centers of 1980 population within the sub-basin are Aiken (14,777), Orangeburg (14,584), and Denmark (4,138), in addition to numerous smaller towns, including Batesburg (3,990), Bamberg (3,633), Johnston (2,618), St. George (2,071), Holly Hill (1,170), and Bowman (1,116). The basin boundary is close to the urban area of Charleston (69,291) to the south.

Economy

The 1979 per capita income for the sub-basin area ranged from $5,461 in Colleton County which ranked 37th among the 46 counties, to $6,782 in Calhoun County which ranked 16th. The mean per capita income for the region was $6,097, about $960 less than that for the State. The 1980 median household income for the sub-basin counties averaged $13,142, which was about $3,300 below that for the State as a whole, ranging from $11,147 in Calhoun County to $16,459 in Dorchester County.

During 1979, the annual average employment of non-agricultural wage and salary workers in the sub-basin averaged 65,100. The dominant employment types were: manufacturing, 39 percent; government, 22 percent; wholesale and retail trade, 18 percent; services and mining, 11 percent; construction, 5 percent; transportation and public utilities, 3 percent; and finance, insurance, and real estate, 3 percent. Compared to the State as a whole, this sub-basin

Figure 120.
Location of the Edisto River Sub-basin in South Carolina.

Table 110.
Current and projected population for the Edisto River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)*					*% Change 1980-2020*
		1980	*1990*	*2000*	*2010*	*2020*	
Aiken	14.4	15.3	17.9	19.7	21.2	22.0	43.8
Bamberg	26.2	4.8	5.4	5.9	6.2	6.4	33.3
Barnwell	26.9	5.4	6.2	6.8	7.4	7.6	40.7
Berkeley	1.9	1.8	2.6	3.6	4.6	5.2	188.9
Calhoun	33.8	4.1	4.7	5.0	5.3	5.5	34.1
Charleston	5.6	15.6	17.6	18.6	19.5	20.0	28.2
Colleton	67.3	21.4	24.7	26.9	28.6	29.6	38.3
Dorchester	36.9	21.7	33.0	47.8	64.0	74.9	245.2
Edgefield	25.1	4.4	5.0	5.2	5.5	5.6	27.3
Lexington	11.9	16.9	23.2	30.4	37.5	41.8	147.3
Orangeburg	93.5	77.2	91.6	102.5	111.8	116.8	51.3
Saluda	5.8	0.9	1.0	1.1	1.1	1.1	22.2
Total		189.5	232.9	273.5	312.7	336.5	77.6

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

has more than its share of manufacturing and government employees, and less than its share of the remaining categories.

In the sectors of manufacturing, mining, and public utilities, the sub-basin counties had an annual product value of approximately $1,281.9 million during fiscal year 1978-79, six percent of the State total.

Agriculture is important in most sections of the sub-basin, but economically it is most significant in Orangeburg County which ranked fourth in the State for 1979 cash crop receipts, with a total of nearly $39 million, and second in the State for livestock receipts which totaled $26 million.

SURFACE WATER

Hydrology

The Edisto River Sub-basin is drained by four major rivers, the South Fork Edisto River, North Fork Edisto River, Edisto River, and Four Hole Swamp. The North and South Fork Edisto Rivers originate and pass through the Upper Coastal Plain region before joining to form the Edisto River in the Middle Coastal Plain. The headwaters of Four Hole Swamp originate in the Upper Coastal Plain and discharge into the Edisto River in the Middle Coastal Plain. Much of the Edisto River and its tributary streams are associated with extensive swamplands. Near the coast the Edisto River divides to form the North and South Edisto Rivers. These tidally influenced saltwater streams also receive drainage from bordering salt marshes and tidal creeks.

Presently, streamflow is monitored at four gaging stations, two on the Edisto River, one on the North Fork Edisto River, and one on Cow Castle Creek (Fig. 121). Two streamflow stations on the South Fork Edisto River have been discontinued. Peak high flows are also recorded at three crest-stage stations (1725, 1732.5, 1730). Streamflow statistics for the six existing and discontinued streamflow stations are presented in Table 111.

Average annual streamflow on the Edisto River is 2,054 cfs near Branchville and 2,711 cfs near Givhans. Streamflow at these sites can be expected to equal or exceed 790 cfs and 740 cfs, respectively, 90 percent of the time. Large withdrawals by the City of Charleston, upstream of Givhans, may result in the lower 90 percent flow-duration value at this site. Streamflow on the Edisto River is substantial and fairly consistent as indicated by the moderately sloped flow duration curve (Fig. 122), uniform monthly flows, and narrow range between maximum and minimum monthly flows (Fig. 121). These well-sustained flows are due primarily to discharge from ground-water reserves in the Upper Coastal Plain region in which over one-half the sub-basin is located.

Average annual flow in the major gaged tributary streams is 242 cfs on the South Fork Edisto near Montmorenci, 797 cfs on the South Fork Edisto near Denmark, and 803 cfs on the North Fork Edisto at Orangeburg. Ninety percent of the time, streamflows at these sites should be at least 110 cfs, 360 cfs, and 365 cfs, respectively. As in the Edisto River, the flow-duration curves (Fig. 122) and monthly flows indicate steady streamflows in these tributaries with well-sustained low flows. These uniform flows are characteristic of Upper Coastal Plain streams.

By contrast, Cow Castle Creek exhibits more variable flows typical of most Middle and Lower Coastal Plain streams where flow is more dependent on rainfall and direct runoff. This is reflected in the more steeply sloped flow-duration curve (Fig. 122) and smaller unit 7Q10 discharge

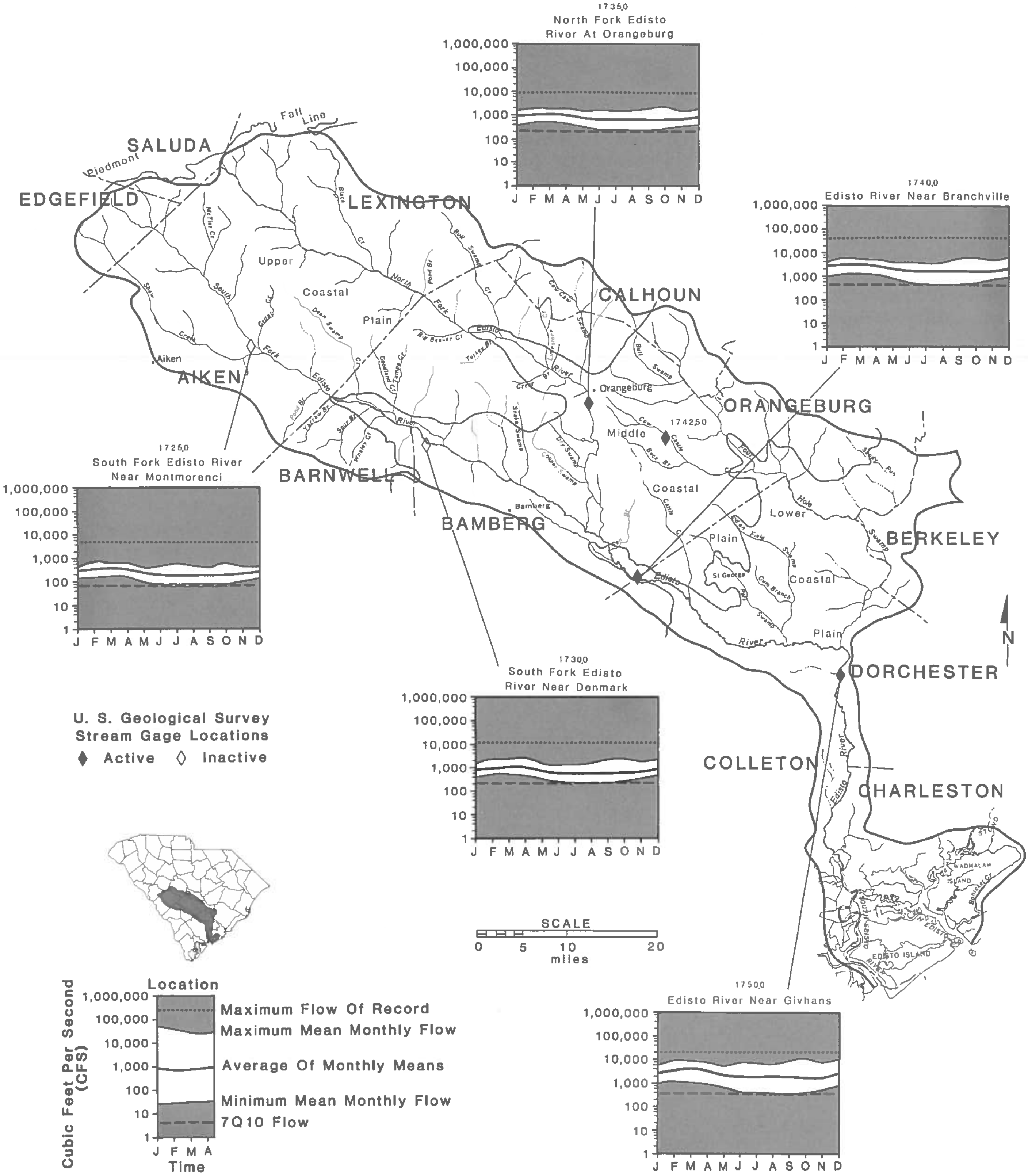


Figure 121.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Edisto River Sub-basin, South Carolina.

Table 111.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Edisto River Sub-basin, South Carolina.

Gaging Station		*Drainage Area*	*Period of Record*		*Average Flow*				
							90%[a]	*7Q10[b]*	
Number	*Name/Location*	*(mi²)*	*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*cfs*	*cfs*	*cfs/mi²*
1725	S. Fork Edisto River near Montmorence	198	Oct 1939-Sep 1966	27	242	1.22	110	65	0.33
1730	S. Fork Edisto River near Denmark	720	Aug 1931-Sep 1971	40	797	1.11	360	211	0.29
1735	N. Fork Edisto River at Orangeburg	683	Oct 1938-Present	42	803	1.18	365	225	0.33
1740	Edisto River near Branchville	1,720	Oct 1945-Present	35	2,054	1.19	790	455	0.26
1742.5	Cow Castle Creek near Bowman	23.4	Oct 1971-Present	10	23.4	1.00	2.3	0.74	0.03
1750	Edisto River near Givhans	2,730	Jan 1939-Present	41	2,711	0.99	740	442	0.16

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.

value (0.03 cfs/mi²) (Table 111). Average annual flow on this stream is 23.4 cfs and should be at least 2.3 cfs, 90 percent of the time.

Drought conditions in the mid-1950's resulted in record low flows in the Edisto River and its major tributaries. Lower record low flows on the Edisto River at Givhans (290 cfs) than upstream at Branchville (323 cfs) are probably attributable to large municipal supply withdraws by the City of Charleston.

An unnamed tropical storm in 1928, tropical storm Dora in 1964, and Hurricane David in 1979 caused localized flooding and accounted for most of the record flood flows in this sub-basin. The highest flow of record on the Edisto River is 25,700 cfs which occurred in September 1928.

The Edisto River and tributary streams in the Upper Coastal Plain exhibit well-sustained flows year round and provide a reliable water supply source. Tributary streams in the Middle and Lower Coastal Plain region, however, have more variable flows and provide limited surface-water availability during periods of low rainfall.

Development

Surface-water development in the Edisto River Sub-basin is limited primarily to a few navigation and flood control projects in the southern region (Fig. 123).

There are no large reservoirs in the sub-basin and the largest lake is unnamed and located in Sawhoo Swamp. It has a surface area of 400 acres and a volume of 800 acre-feet. Reynolds Pond in Giddy Swamp is smaller in area (200 acres) but larger in volume (2,000 acre-feet). Details of these two lakes are presented in Table 112. Lakes larger than ten acres have a total surface area of approximately 6,000 acres and a total volume of about 29,000 acre-feet.

One potential hydropower site has been identified by the U.S. Army Corps of Engineers within the sub-basin (Table 113). The project identified for this site is a pumped storage facility with the forebay reservoir located on Rocky Springs Creek and the afterbay reservoir located on the South Fork of the Edisto River. In addition, the S.C. Land Resources Conservation Commission has identified two potential small scale hydropower sites with a potential capacity of 0.2 MW (Long, 1980).

The U.S. Army Corps of Engineers has been involved in three navigation projects within the sub-basin. None of these projects are currently active. Detailed information about these projects is presented in Table 114.

The Soil Conservation Service, in conjunction with the Horse Range Watershed and Orangeburg Soil and Water Conservation District, completed a flood control project on Horse Range Swamp in 1975 which consisted of 19.8 miles of channel improvement. The U.S. Army Corps of Engineers completed a project on the North Fork Edisto River in 1969. This project consisted of removal of debris and control of alligatorweed from the City of Orangeburg to the confluence with the South Fork Edisto River. Both agencies have identified additional problem areas which are in various stages of activity. All flood control projects and studies are listed in Table 115.

Water Quality

The majority of main stem rivers in the Edisto Sub-basin are designated Class A waters, suitable for swimming and fishing (Fig. 124). Portions of the main stem rivers and some tributary streams have Class B water use designations. All coastal waters in this sub-basin are designated Class SA, saltwaters suitable for swimming, fishing, and harvesting clams, mussels, and oysters for human consumption. Water quality limited segments which require advanced treatment of wastewater effluents include all or portions of Caw Caw Swamp, Four Hole Swamp, Sandy Run, Polk Swamp, Gum Branch, Bohicket Creek, and several minor tributary streams (Fig. 125). Water quality is generally acceptable for designated water uses throughout the sub-basin. This sub-basin, like many others in the Coastal Plain, experiences widespread low dissolved oxygen concentrations, especially during the summer months.

Table 111. (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
37.0	Jul 4, Sep 26, 1954	5,010	Aug 31, 1964
146	Aug 12, 1956	17,100	Oct 1929
190	Sep 13,14, 1954	10,000	Sep 1928
323	Aug 14, 1956	25,700	Sep 1928
0.64	Oct 24, 1978	2,340	Sep 4 or 5, 1979
290	Aug 16, 1956	24,900	Feb 1925

This problem is attributed to natural swamp drainage, low streamflows, and elevated water temperatures during the summer. Localized water quality problem areas occur in streams associated with urban areas.

Water quality in the Edisto River is generally good (S.C. Department of Health and Environmental Control, 1980b). Chronic low dissolved oxygen levels are primarily due to natural conditions. Most water quality problems in this sub-basin are associated with tributary streams which occasionally impact the main stem river.

The South Fork Edisto River exhibits good water quality throughout the year with no apparent change in quality during recent years (S.C. Department of Health and Environmental Control, 1980b).

Water quality conditions in the North Fork Edisto River are also generally good (S.C. Department of Health and Environmental Control, 1980b). However, municipal and industrial wastewater discharges in the vicinity of Orangeburg greatly impact the quality of this river. The portion of the river below Orangeburg has experienced contraventions of State standards for fecal coliform bacteria and dissolved oxygen (S.C. Department of Health and Environmental Control, 1975b). Biological monitoring indicates decreasing water quality in this stretch of river since 1976 (S.C. Department of Health and Environmental Control, 1980b). Recently, a black substance was reported covering the bottom of the lower North Fork Edisto and upper Edisto Rivers. The S.C. Department of Health and Environmental Control identified the substance as a conglomeration of naturally occurring material in the river and municipal and industrial discharges from the City of Orangeburg. Action is presently being taken to control the problem. Portions of this river also experience periodic alligatorweed infestations which impair recreational use (S.C. Aquatic Plant Management Council, 1982).

Cooper Swamp, a tributary to the North Fork Edisto River, experiences water quality problems which impair recreational use. Elevated fecal coliform bacteria concentrations in this stream are attributed to agricultural non-point source pollution (S.C. Department of Health and Environmental Control, 1981c).

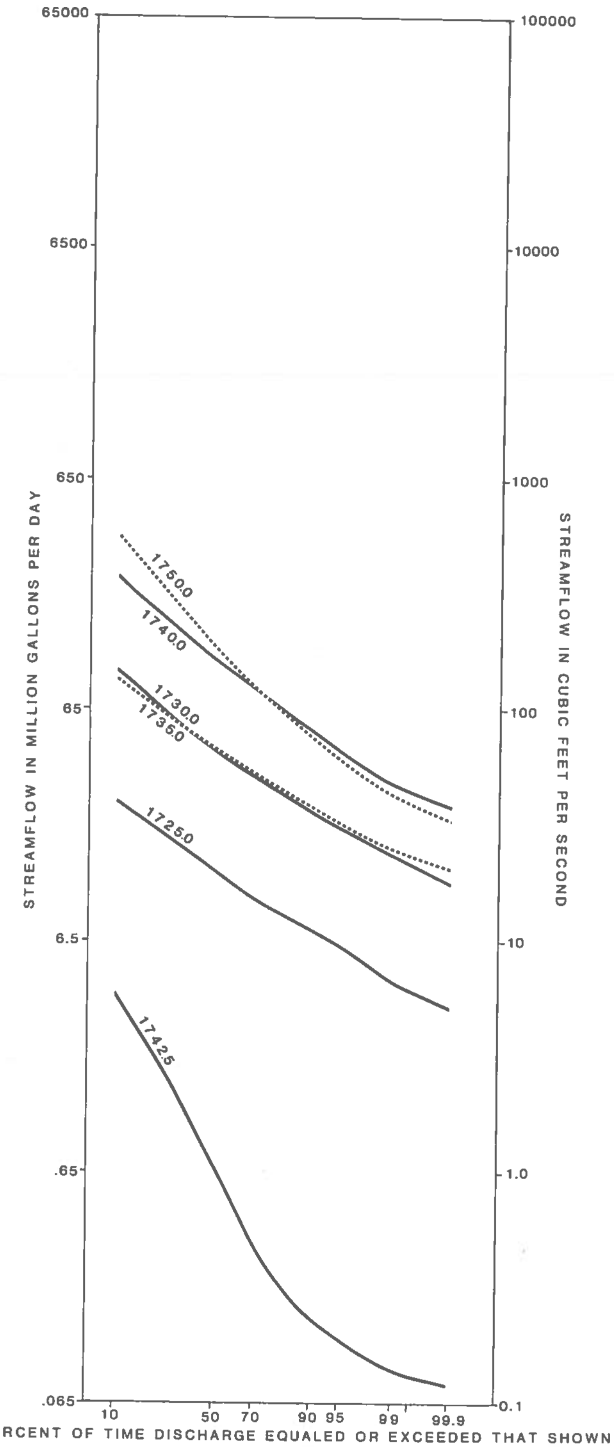


Figure 122.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Edisto River Sub-basin, South Carolina.

Table 112.
Existing lakes larger than 200 acres in the Edisto River Sub-basin, South Carolina.

Map No.	Name	Stream	Surface Area (acres)	Storage Capacity (acre-feet)	Purpose
1	Unnamed	Dawhoo Swamp	400	800	Recreation
2	Reynolds Pond	Giddy Swamp	200	2,000	Recreation

Source: S.C. Water Resources Commission, 1974.

Table 113.
Existing and potential hydroelectric power development in the Edisto River Sub-basin, South Carolina.

Map No.	Facility/Site Name	Facility/Site Location		Owner	No. of Units	Total Capacity (MW)	Surface Area (acres)	Status
		County	River					
3	Rocky Springs[a]	Aiken	Rocky Springs Cr. South Fork-Edisto	--[b]	--	500.0	8,100	Potential

[a] Pumped storage facility.
[b] -- indicates information not available.

Sources: U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

Table 114.
U.S. Army Corps of Engineers navigation projects in the Edisto River Sub-basin, South Carolina.

Map No.	Project Name	County	Responsible District	Length (miles)	Width (feet)	Status/Remarks
4	Edisto River	Charleston Colleton Dorchester Bamberg Orangeburg	Charleston	175.0	50	Project provided for the removal of snags and shoals and general improvement of channel to provide a channel suitable for light draft steamers from the sea to the junction of North and South Forks and suitable for rafts and flatboats 53 miles further up South Fork. Project completed 1896. No longer maintained.
5	Adams Creek	Charleston	Charleston	1.5	80	Project provides for a 10 foot deep channel from Bohicket Creek 1.5 miles up from Adams Creek. Completed 1973.
6	Russell Creek	Charleston	Charleston	4.2	60	Project provides for 5 foot deep channel from the mouth of Russell Creek 4.2 miles to Hwy. 174. Project deauthorized 1977.

Source: U.S. Army Corps of Engineers, 1982b.

Table 115.
Flood control projects in the Edisto River Sub-basin, South Carolina.

Map No.	Project/Watershed Name	County	Responsible Agency[a]	Status
7	Horse Range Swamp	Orangeburg	SCS	Completed 1975
8	Toogooloo Creek	Charleston	SCS	Terminated
9	North Fork Edisto River	Orangeburg	COE	Completed 1969
10	Good Bys Creek	Calhoun/Orangeburg	SCS	Identified problem area
11	Upper Cow Castle and Patrick Branch	Orangeburg	COE	Preliminary investigation
12	Polk Swamp	Dorchester/Orangeburg	SCS	Identified problem area
13	Indian Field Community	Dorchester/Orangeburg	SCS	Identified problem area
14	Duncan Chapel	Dorchester/Orangeburg	SCS	Identified problem area
15	Providence Swamp	Orangeburg	SCS	Identified problem area
16	Target Swamp	Orangeburg	SCS	Identified problem area
17	East Cottageville	Colleton	SCS	Identified problem area
18	Flea Bite Creek	Calhoun/Orangeburg	SCS	Identified problem area

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

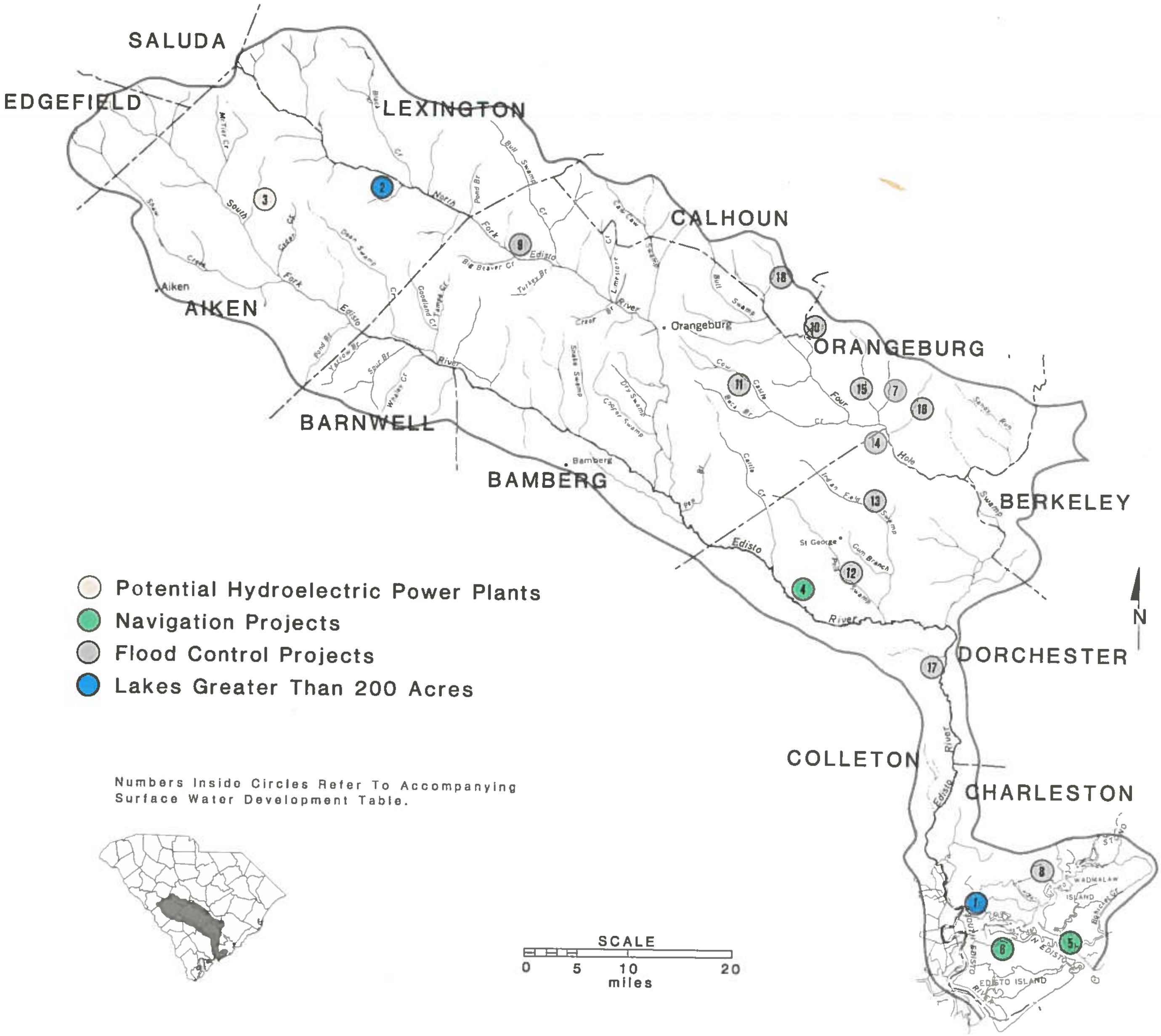


Figure 123.
Surface-water development in the Edisto River Sub-basin, South Carolina.

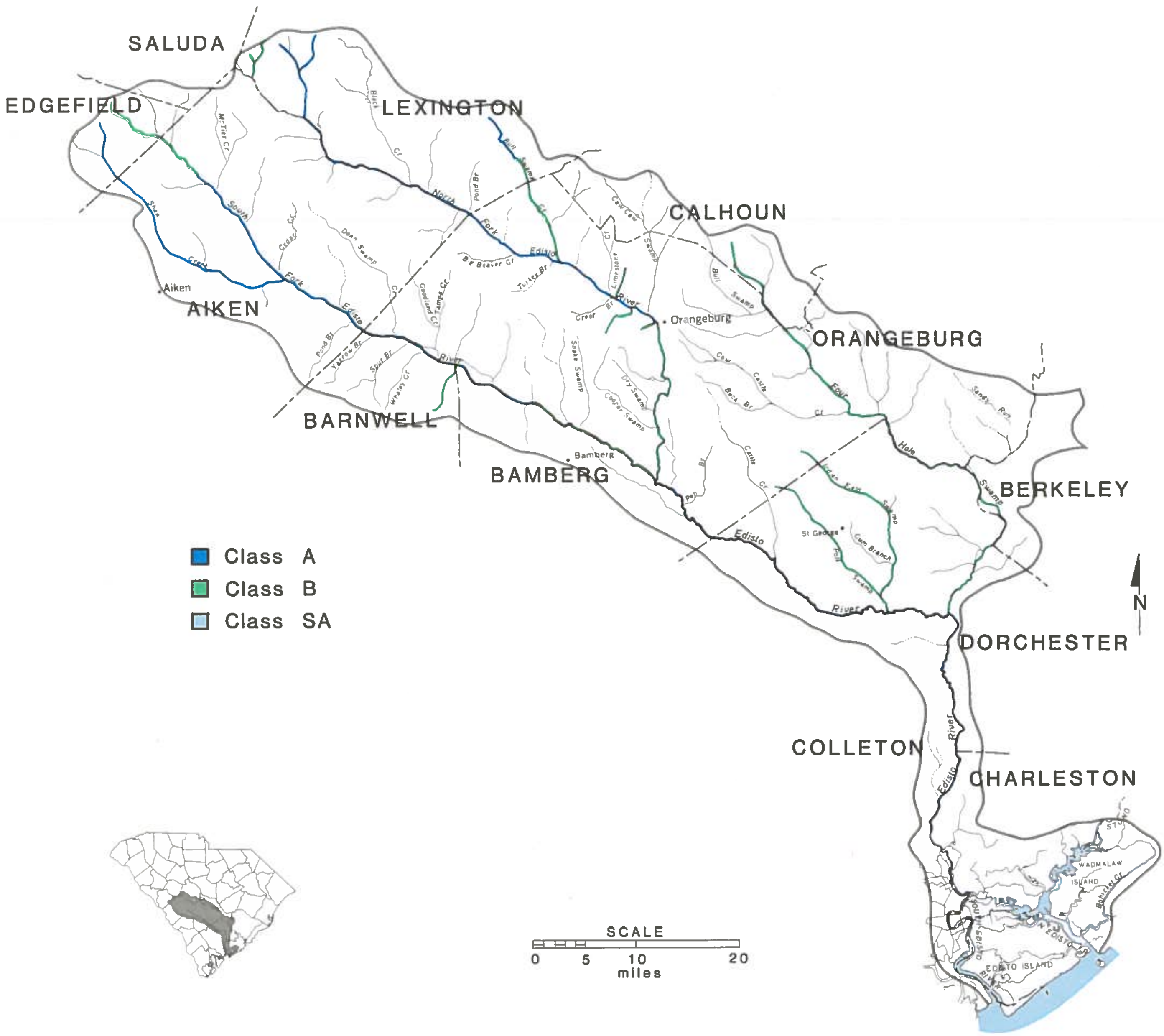


Figure 124.
Surface-water quality classifications in the Edisto River Subbasin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

Figure 125.
Water quality limited segments and prohibited shellfishing areas in the Edisto River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Four Hole Swamp exhibits satisfactory chemical and physical water quality conditions during most of the year. Biological studies indicate fair to good quality conditions with signs of nutrient enrichment (S.C. Department of Health and Environmental Control, 1980b). Water quality problems include depressed dissolved oxygen concentrations and elevated fecal coliform bacteria levels. These problems have been attributed to natural characteristics of this sub-basin and non-point sources. Severely depressed dissolved oxygen levels are most common during the summer months and were the apparent cause of a large fish kill totaling 5,000 sunfish in August 1979 (S.C. Department of Health and Environmental Control unpublished fish kill records). While overall quality appears to be improving, a trend of decreasing quality due to fecal coliform bacteria is apparent.

A majority of the sub-basin's coastal waters are suitable for the harvesting of shellfish; however, water quality conditions prohibit the taking of shellfish in a small portion of these tidally influenced waters near Edisto Island and Wadmalaw Island (Fig. 125).

GROUND WATER

Hydrology

The level of hydrogeologic knowledge throughout the sub-basin ranges from the reconnaissance level in the northwestern region to the evaluation level in the southeastern region (Fig. 18).

The Edisto River Sub-basin lies completely within the Coastal Plain Province. The basement (pre-Cretaceous) rocks occur at a depth of about 100 feet below land surface at the northwest border of the sub-basin which approximates the Fall Line. The rocks crop out in riverbeds in the extreme upper reaches of the sub-basin. In the southeastern part of the sub-basin near the coast, the sediments are about 3,500 feet thick. Selected ground-water data for the sub-basin are presented in Table 116.

Ground-water availability in Lexington County is variable. At sites located along the Fall Line, water must usually be obtained from the underlying crystalline rock aquifers where yields are generally low, often less than 15 gpm, and dry holes are frequent. The southern part of Lexington County is underlain by the Middendorf, the Tertiary Sand and possibly the Black Mingo Aquifer Systems. However, little is known about the Middendorf Aquifer System in this part of the State. The Tertiary Sand and perhaps the Black Mingo Aquifer System have been developed to some extent in this area.

Aiken County is underlain by about 200 feet of sediments comprising the Shallow and Tertiary Sand Aquifer Systems which yield sufficient quantities of water for small industries and domestic use. Some small towns also use this aquifer as a municipal supply. A more dependable source of a good quality water is available from the Middendorf Aquifer System (including the Ellenton Formation) which occurs between depths of 180 to 700 feet.

Throughout most of Orangeburg County, ground water of good quality in relatively large quantities is available from the Cretaceous and Tertiary sediments (Siple, 1975). Most wells in the Upper Coastal Plain of Orangeburg County are developed in the Orangeburg Group which comprises the Tertiary Sand Aquifer System, whereas wells in the Lower Coastal Plain are developed primarily in the Tertiary Limestone, Black Mingo, and Black Creek Aquifer Systems.

The Upper Coastal Plain, occupying the northwestern third of Orangeburg County, is underlain by the Middendorf, Tertiary Sands (Orangeburg Group), and Shallow Aquifer Systems. Here the top of the Middendorf Aquifer System ranges in depth from 300 to 700 feet below land surface. However, there are no data available for ground-water yields from this system in the northwest region of the county. Use of the Hawthorne Formation, which comprises

Table 116.
Selected ground-water data for the Edisto River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Pelion	Middendorf/Tertiary Sand	255-270	133	--[a]
Swansea	Middendorf/Tertiary Sand	202-237	350	--
Aiken	Middendorf	200-300	300-1000	--
Cameron	Black Mingo	250-280	250	--
Northwest Orangeburg County	Tertiary Sand	200-300	50-400	--
Orangeburg	Middendorf/Black Creek	760-970	200-1000	--
Bowman	Middendorf	--	Flowed: 500 Pumped: 1100	--
Norway	Peedee	400-480	750	17
North	Black Mingo/Peedee	238-476	760	--

[a]--indicates data not readily available.

the Shallow Aquifer System in this region, is limited to dug or shallow drilled wells.

The Middle and Lower Coastal Plain regions of Orangeburg County are underlain by the Middendorf, Black Creek, Peedee, Black Mingo, and Tertiary Limestone Aquifer Systems. The top of the Middendorf Aquifer System occurs at a depth of 650 feet at the City of Orangeburg and dips southeast to about 1,100 feet at the county border. Properly constructed and developed large diameter wells screened in this aquifer system yield from 1,200 to 2,000 gpm. Within Orangeburg County, the only wells known definitely to penetrate any significant depth into the Middendorf Aquifer System are those located near the City of Orangeburg and the Town of Bowman. The transmissivity of the aquifer at Orangeburg is estimated to be 20,000 ft^2/day. In 1963, the potentiometric surface for the Middendorf Aquifer System was measured in an Orangeburg County well at about 190 feet above mean sea level. Pumping from three large wells in the area during the period 1964-1971 caused the static water head to decline by approximately 10 feet at Orangeburg.

There are limited data or well records available concerning the Black Creek Aquifer System in the Orangeburg area, except from three wells at Greenwood Mills which penetrate the Black Creek from 600 to 690 feet and the Middendorf from 800 to 970 feet. Water quality analyses indicate that these wells derive a large percentage of their water from either the Black Creek or the Ellenton Formation.

The Peedee Aquifer System underlies most of Orangeburg County. Some information is available concerning wells screened in this unit in the western portion of Orangeburg County (Table 116).

No known wells tap just the Black Mingo Aquifer System in the Edisto Sub-basin; therefore, no hydrogeologic information is available for this aquifer system. However, several wells near the Towns of Eutawville and North are screened in the Black Mingo and Peedee Aquifer Systems and withdraw a mixture of water from both. The Tertiary Limestone Aquifer System is the second most productive aquifer in Orangeburg County. The reported specific capacities of wells constructed in the Tertiary Limestone Aquifer System have a wide range (0.2 to 14.6 gpm/ft.). Transmissivity values are estimated to range from 2,500 to 40,000 ft^2/day (Siple, 1975) and yields as high as 600 to 700 gpm have been reported. The largest user of the aquifer system is a limestone quarry where ground water is being removed at the rate of 6,000 gpm in order to permit a dry mining operation.

The Cooper, Duplin, and Pleistocene deposits overlie the Tertiary Limestone Aquifer System. The Barnwell, McBean, Warley Hill, and Congaree Formations are included in the Orangeburg Group and are recharged by direct precipitation in the outcrop areas in the northern part of Orangeburg County and adjacent Lexington County. Wells 200 to 300 feet deep are developed in these deposits and yield from 50 to 400 gpm. The Cooper has little significance as an aquifer, but functions primarily as a confining bed. Some of the surficial deposits in the northwestern part of the county include sand and clayey sand of the Hawthorne Formation. These deposits are principally used as a domestic water source. The sandy parts of the Duplin Formation yield moderate amounts of water to shallow wells. Alluvial deposits (30 to 60 feet thick) of Pleistocene and Holocene age underlying the extensive floodplains bordering all the major streams could conceivably yield several hundred gallons per minute to large diameter wells. However, there are no records presently available concerning wells within the sub-basin utilizing these deposits as an aquifer.

Two major aquifer systems are present in the lower part of the Edisto River Sub-basin, the Shallow and Tertiary Limestone Aquifer Systems. The Shallow Aquifer System is used primarily in the coastal islands areas because the underlying Tertiary Limestone and the Black Mingo Aquifer Systems contain brackish water. The Tertiary Limestone Aquifer System is 100 to 350 feet thick and dips southeasterly at about 12 feet per mile. The top of this aquifer ranges from 20 feet below land surface at Harleyville to 300 feet below mean sea level in the vicinity of Edisto Island. Water levels in this aquifer system range from 100 feet above mean sea level at St. George in northwest Dorchester County to mean sea level at Edisto Beach.

Water Quality

The water quality from the Middendorf Aquifer System is good in the Orangeburg vicinity. This water is soft, acidic, low in total dissolved solids, and may have low concentrations of iron. However, wells constructed in the Middendorf are also screened in the Ellenton Aquifer System where iron concentrations are high; therefore, the resulting chemical characteristics may represent a mixture from both aquifer systems. The Stiff Diagrams in Figure 126 indicate a calcium sulfate type of water. The concentration of chloride, fluoride, and total dissolved solids tends to increase toward the coast, with increasing depth of the aquifer, and with longer time of contact between the water and the mineral content of the aquifer.

Ground water from the Tertiary Sand Aquifer System in localized areas of Orangeburg County contains naturally high levels of radioactivity, some in excess of acceptable drinking water standards (5pCi/L). Water from wells near the Town of North contains radium-226 levels ranging from 4.6 to 7.1 pCi/L (Scott and Barker, 1962; Siple, 1975). The source of this radiation is radium, a disintigration product of the granitic rock element thorium. Its appearance is concentrated in a narrow zone of crystalline rocks and sediments adjoining the Fall Line.

The quality of water in the sands of the Orangeburg Group is fair to good. The water is low in dissolved solids, strongly acidic, and has variable dissolved iron content. In some wells the water may contain hydrogen sulfide gas. The Stiff Diagrams in Figure 126 show a sodium chloride type of water for this aquifer.

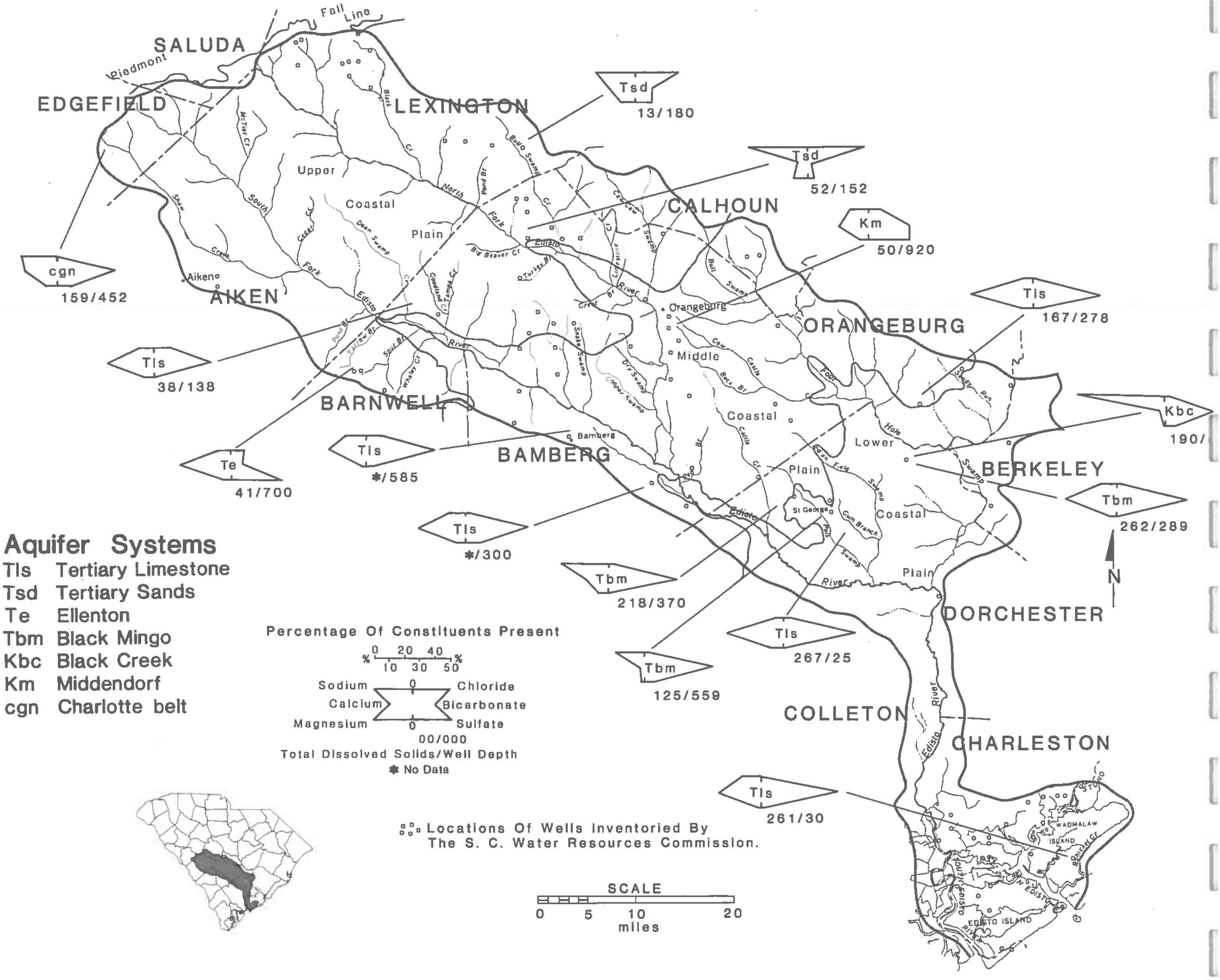


Figure 126.
Ground-water quality of selected aquifer systems and major inventoried wells in the Edisto River Sub-basin, South Carolina.

Water from the Tertiary Limestone Aquifer System has a total hardness of 60 to 120 mg/L and becomes brackish in coastal areas. The Stiff Diagram shows a calcium bicarbonate type of water for this aquifer system throughout the sub-basin.

The ground water in the Black Mingo Aquifer System is generally soft with locally high concentration of iron, total dissolved solids, and chloride. The pH ranges from 7.3 to 8.6. The Stiff Diagram shows a sodium bicarbonate type of water.

WATER USE

Total gross use averages 264 mgd presently with 36 percent of this (94.7 mgd) consumed (Table 117). Most of this water consumption is due to 65.7 mgd transported into the Ashley-Cooper Sub-basin for drinking water by the City of Charleston. The Edisto River Sub-basin total gross use ranks seventh in the State. The leading water users are thermoelectric power (157 mgd), public supply (78.3 mgd), and agricultural irrigation (14.8 mgd). The major water users by type and supply source are shown in Figure 127.

Surface water supplies 93 percent of the total demand and 83 percent of all demand excluding thermoelectric power water use. Water use is heaviest in the lower and upper portions of the sub-basin. Ground-water, surface-water, and total gross water withdrawals for agricultural irrigation are the greatest in the State. Over a quarter of the irrigated acreage in the State is located in this sub-basin.

Public supply accounts for 30 percent of total gross use and 71 percent of the consumptive use, which is the largest consumptive use in the sub-basin. Most of this consumptive use is due to the 65.7 mgd transported to the Ashley-Cooper Sub-basin by the City of Charleston. Surface water supplies 95 percent of the demand.

Self-supplied domestic use is one percent of the gross use and two percent of the consumptive use. Ground water is the only source tapped for this use.

Agricultural water use accounts for six percent of gross water use and 17 percent of consumptive use. Irrigation demand accounts for 93 percent of the gross use, with surface water supplying 73 percent of this demand. When averaged over the five-month growing season, irrigation use equals 36 mgd, comprising 13 percent of gross use and 31 percent of consumptive use in the sub-basin. Fifty-nine percent of the livestock use is withdrawn from ground-water sources.

Self supplied industry uses 10.0 mgd of water which is four percent of the total gross use. This use accounts for two percent of the consumptive total. Ground water supplies 70 percent of the demand.

A single thermoelectric power plant is the leading water user, accounting for 60 percent of the gross use. This use represents eight percent of the total consumptive use. Surface water is the only source utilized and represents the largest surface-water withdrawal in the sub-basin. This steam power plant withdraws water directly from the lower portion of the Edisto River.

Total gross water use is projected to increase 52 percent to 401 mgd by 2020. Consumptive use is projected to increase 160 percent to 334 mgd by the year 2020. Most of the increase in both total gross and consumptive use is due to projected growth in agricultural irrigation water use. Thermoelectric power should remain the leading gross

Table 117.
Current and projected water use in the Edisto River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water
Public Supply	Gross	4.28	74.0	78.3	5.35	76.1	81.5	6.15	77.7	83.9	7.08	79.40	8.65	7.78	80.8	88.5
	Consumed	0.43	66.5	66.9	0.54	66.7	67.2	0.62	66.9	67.5	0.71	67.10	67.8	0.79	67.2	68.0
Self-supplied Domestic	Gross	2.6	---	2.6	3.3	---	3.3	3.7	---	3.7	4.3	---	4.3	4.7	---	4.7
	Consumed	2.2	---	2.2	2.8	---	2.8	3.2	---	3.2	3.7	---	3.7	4.0	---	4.0
Agriculture Irrigation	Gross	3.8	11	15	13	30	43	23	45	68	33	59	92	42	71	110
	Consumed	3.8	11	15	13	30	43	23	45	68	33	59	92	42	71	110
Agriculture Livestock	Gross	0.71	0.46	1.2	0.81	0.52	1.3	0.92	0.60	1.5	1.1	0.68	1.8	1.2	0.78	2.0
	Consumed	0.71	0.46	1.2	0.81	0.52	1.3	0.92	0.60	1.5	1.1	0.68	1.8	1.2	0.78	2.0
Self-supplied Industry	Gross	6.99	3.00	9.99	8.04	3.45	11.5	8.84	3.80	12.6	9.73	4.17	13.9	10.7	4.59	15.3
	Consumed	1.29	0.56	1.85	1.49	0.64	2.13	1.64	0.70	2.34	1.80	0.77	2.57	1.98	0.85	2.83
Thermoelectric Power	Gross	---	157	157	---	162	162	---	167	167	---	172	172	---	177	177
	Consumed	---	7.75	7.75	---	12.8	12.8	---	21.1	21.1	---	34.8	34.8	---	57.4	57.4
Total	Gross	18.4	245	264	30.5	272	303	42.6	294	337	55.2	315	370	66.4	334	401
	Consumed	8.43	86.3	94.7	18.6	111	129	29.4	134	164	40.3	162	203	48.0	197	247

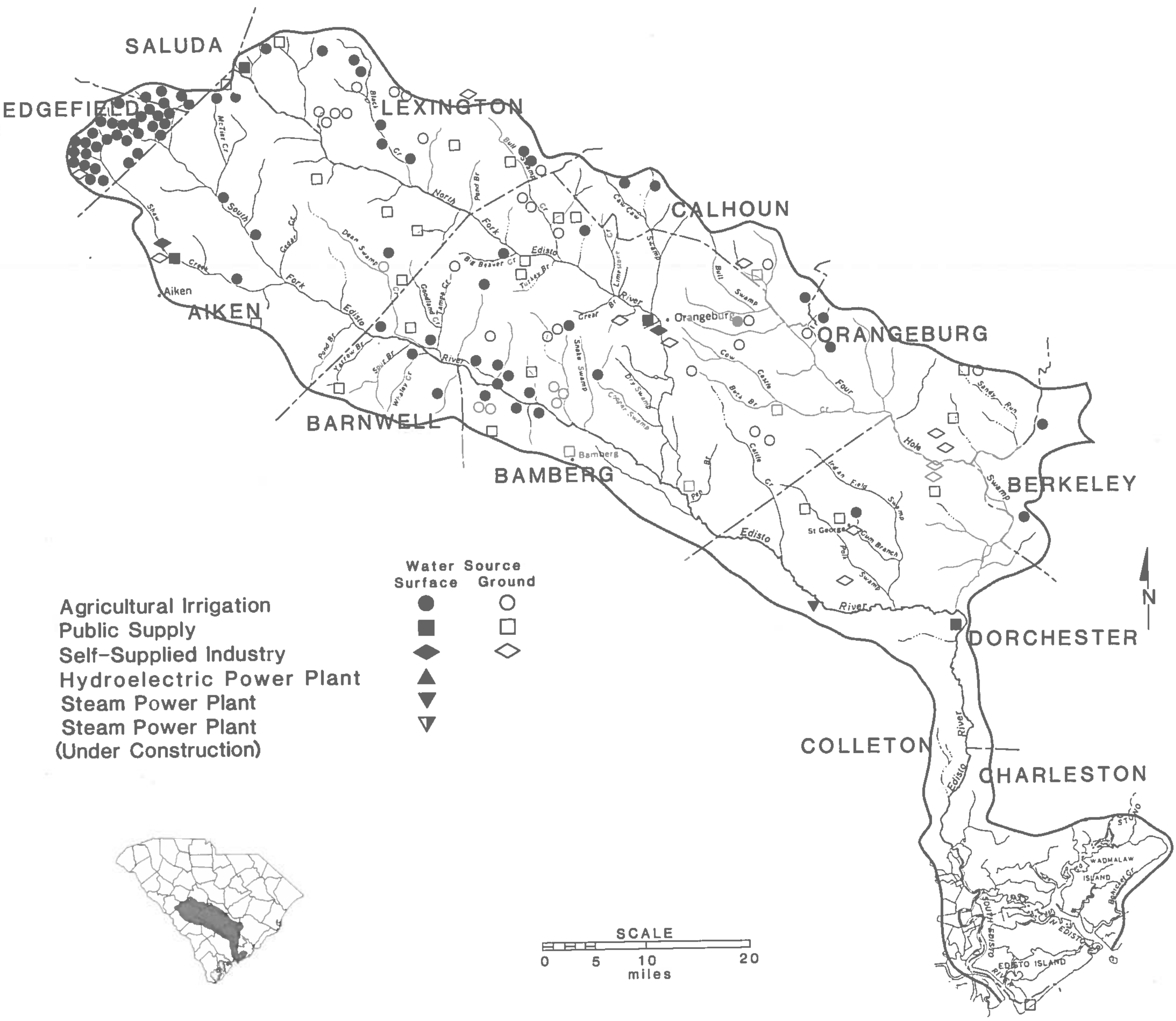


Figure 127.
Location, type, and supply source of water users in the Edisto River Sub-basin, South Carolina.

water user and irrigation the leading consumptive user. When projected agricultural irrigation is averaged over the growing season, it becomes the leading water user in 2020 with 275 mgd. Surface water should remain the most heavily used water source. Public supply growth rate will be less in this sub-basin than in other sub-basins due to the development of Back River Reservoir in the Ashley-Cooper River Sub-basin by the City of Charleston as an alternate public supply source.

WATER USE VERSUS AVAILABILITY

The current 245 mgd gross surface-water demand and 86.3 mgd consumptive surface-water demand are adequately supplied by streamflow 99.5 percent of the time (Fig. 128). Although 85 percent of total water use occurs in the lower sub-basin by two users, the largest number of users occurs in the upper portion of the sub-basin (Fig. 127). Majority of this use is for agricultural irrigation.

Projected 2020 gross surface-water demand of 334 mgd is expected to be supplied by streamflow 96 percent of the time. Projected 2020 consumptive surface-water demand of 197 mgd should be adequately supplied by streamflow.

Future demands for ground-water in the Edisto River Sub-basin (66.4 mgd) are more than three times greater than the present use (18.4 mgd). However, present and projected demands in the Edisto River Sub-basin can be met when proper management and applicable hydrogeologic principles are applied to well construction and spacing. The range of yields for those wells currently inventoried provide a reasonable base for projection of average yields for individual wells constructed at future times. This yield is from less than 250 gpm in the northwestern part of the sub-basin to more than 1,000 gpm in the remaining portion of the sub-basin. Thus, the present use could be supplied by approximately one well pumped at a rate of 600 gpm for six hours each day per 37 square mile area of the sub-basin. This would require about 85 such wells. Projected requirements for 2020 could be obtained by a similar well per 10 square mile area or about 307 such wells.

Ground-water availability may be limited in certain areas of the sub-basin due to water quality problems. The erratic distribution of high iron concentrations in some Cretaceous and Tertiary aquifers may restrict the use of this water for certain purposes. Increased concentrations of chloride, fluoride, and total dissolved solids in all aquifers in a direction toward the coast might also limit future use of this resource in coastal areas.

Major water resources problems and opportunities in the sub-basin are summarized in Table 118.

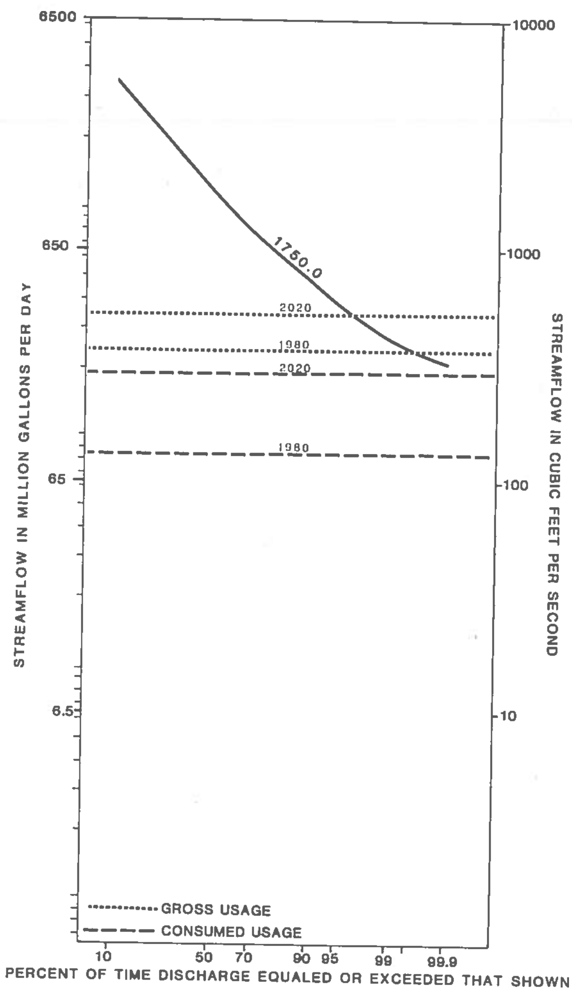


Figure 128.
Water use compared to availability in the Edisto River Sub-basin, South Carolina.

Table 118.

Major water resource findings in the Edisto River Sub-basin, South Carolina.

Opportunities

1. Surface-water supplies are adequate to meet current and projected (2020) surface-water demand most of the time.
2. Streams in the Upper Coastal Plain region have well-sustained flows year round and are a reliable source of surface water.
3. One potential hydroelectric power development site has been identified in the sub-basin.
4. The Edisto River and North and South Fork Edisto Rivers exhibit generally good quality water.
5. Shellfish harvesting is allowed in most of the coastal waters.
6. Projected ground-water demands can be met provided proper ground-water management techniques are employed.
7. Large quantities of ground water are available from the Middendorf, Black Creek, Ellenton, Peedee, Black Mingo, Tertiary Sand, and Tertiary Limestone Aquifer Systems.
8. The deeper aquifers (Middendorf, Black Creek) in the central portion of the sub-basin are underdeveloped and are able to provide large quantities of water.

Problems

1. Streams in the Middle and Lower Coastal Plain region have poorly sustained flows year round and are generally unreliable sources of surface water.
2. Flood problem areas include Good Bys Creek, Polk Swamp, Indian Field Community, Duncan Chapel, Providence Swamp, Target Swamp, East Cottageville, and Flea Bite Creek.
3. Projected increases in surface-water use for agricultural irrigation may result in use conflicts on Middle and Lower Coastal Plain tributary streams during periods of low flow.
4. The portion of the North Fork Edisto River below the City of Orangeburg experiences periodic water quality problems due to municipal and industrial discharges.
5. Portions of the North Fork Edisto River are infested with alligatorweed which impairs recreational use of this river.
6. Depressed dissolved oxygen levels occur in streams throughout the sub-basin during the summer months due to natural conditions.
7. Chloride, fluoride, and total dissolved solids progressively increase in all aquifer systems with distance toward the coast.
8. High iron concentrations occur in some Cretaceous and Tertiary aquifer systems.
9. Naturally high levels of radiation occur in ground water in the Tertiary Sand Aquifer System in localized areas in Orangeburg County.

Combahee-Coosawhatchie River Sub-basin

GENERAL OVERVIEW

The Combahee-Coosawhatchie River Sub-basin is located in the southern Coastal Plain region of the State. The sub-basin extends approximately 95 miles inland from the Atlantic Ocean and includes all of Beaufort County and portions of Aiken, Allendale, Bamberg, Barnwell, Colleton, Hampton, and Jasper Counties (Fig. 129). The areal extent of the basin is approximately 3,270 square miles, 10.5 percent of State land area.

Population

The 1980 population of the sub-basin was estimated at 139,400, 4.5 percent of the State's total population (Table 119). By the year 2020 the sub-basin population is expected to reach 233,400, an increase of 67.4 percent. The highest rate of population growth during this time period is anticipated for Beaufort County, with a projected increase of 97 percent.

In general, this is a rural area with the exception of Beaufort County which is more urbanized and contains the affluent retirement and resort community of Hilton Head Island.

The major centers of 1980 population in the sub-basin were Hilton Head Island (11,344), Beaufort (8,651), Walterboro (5,914), Barnwell (5,556), Laurel Bay (5,238), Allendale (4,362), Denmark (4,138), Bamberg (3,633), and Hampton (3,086).

Economy

The counties in the region had an average median family income of $12,484 in 1980, which was $4,000 lower than the State average. The per capita income of the region in 1979 ranged from $8,720 in Beaufort County which ranked first among the State's 46 counties, to $4,543 in Allendale County, which ranked 45th. None of the remaining sub-basin counties had a per capita income as high as the State average.

During 1979, the annual average employment of non-agricultural wage and salary workers in the sub-basin totaled 50,500. The percentage breakdown by type of employment was: manufacturing, 27 percent; government, 23 percent; wholesale and retail trade, 19 percent; services and mining, 16 percent; construction, 7 percent; finance, insurance, and real estate, 5 percent; and transportation and public utilities, 4 percent.

In the sectors of manufacturing, mining, and public utilities, the sub-basin counties had a relatively low annual product value of $632 million during fiscal year 1978-79, which was 2.9 percent of the State total.

Agricultural productivity is not as pronounced in this portion of the State. Only Hampton County ranked in the top one-third of South Carolina counties for cash crop receipts from farm marketing in 1979, with a total value of almost $16 million. Of the remaining sub-basin counties, all but Jasper ranked in the top 50 percent of cash crop receipts.

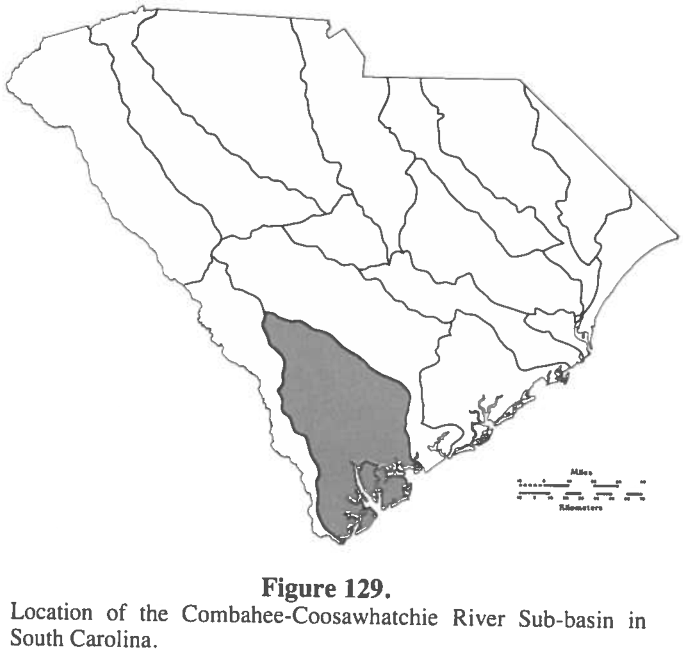


Figure 129.
Location of the Combahee-Coosawhatchie River Sub-basin in South Carolina.

Table 119.
Current and projected population for the Combahee-Coosawhatchie River Sub-basin, South Carolina, 1980-2020.

County	% Population in Sub-basin[a]	Population (in thousands)					% Change 1980-2020
		1980	1990	2000	2010	2020	
Aiken	0.1	0.1	0.1	0.1	0.1	0.2	100
Allendale	81.3	8.7	9.6	10.0	10.4	10.6	21.8
Bamberg	73.8	13.4	15.3	16.5	17.5	18.0	34.3
Barnwell	68.5	13.7	15.9	17.5	18.8	19.5	42.3
Beaufort	100.0	65.7	84.4	102.8	119.6	129.4	97.0
Colleton	32.7	10.4	12.0	13.0	13.9	14.4	38.5
Hampton	91.3	16.6	19.3	20.9	22.3	23.0	38.6
Jasper	74.1	10.8	13.2	15.4	17.2	18.3	69.4
Total		139.4	169.8	196.2	219.8	233.4	67.4

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

SURFACE WATER

Hydrology

The major freshwater streams draining this mostly Middle and Lower Coastal Plain sub-basin are the Salkehatchie River, the Coosawhatchie River, and the Ashepoo River. The Salkehatchie and Little Salkehatchie Rivers join to form the tidally influenced Combahee River. The Coosawhatchie River discharges into the Broad River, a tidal saltwater river which also receives drainage from surrounding marshlands. The coastal area of this sub-basin contains the most extensive estuarine waters in the State. These coastal waters are dominated by St. Helena Sound and Port Royal Sound and include numerous, often interconnecting, tidal creeks and rivers.

Streamflow has been monitored on the Salkehatchie and Coosawhatchie Rivers (Fig. 130) since 1951. A streamflow gage has also been in operation on Great Swamp since 1977. Peak flows are recorded at three crest-stage stations (1753, 1754.5, 1761) throughout the sub-basin. Streamflow statistics for the three gaging stations gages are presented in Table 120.

Average annual streamflow on the Salkehatchie River near Miley is 356 cfs and can be expected to be at least 95 cfs, 90 percent of the time. Streamflow at this site is relatively steady as evidenced by uniform mean monthly flow, a narrow range between maximum and minimum monthly flow (Fig. 130), and the moderately sloped flow-duration curve (Fig. 131). This well-sustained flow is probably due to discharges from ground-water storage with several headwater streams located in the Upper Coastal Plain region.

Streamflow in the Coosawhatchie River is more variable than in the Salkehatchie River, and average annual flow is 189 cfs and can be expected to equal or exceed only 3.7 cfs, 90 percent of the time. This stream is entirely contained in the Middle and Lower Coastal Plain, and is, therefore, dependent on rainfall and ensuing runoff from the area's low and highly permeable terrain to support streamflow. The highly variable flows of this river are graphically illustrated by the steep flow-duration curve (Fig. 131), small unit average and 7Q10 discharge values (Table 120), highly variable mean and minimum monthly flow pattern, and wide range between minimum and maximum monthly flow (Fig. 130). Periods of zero-flow have been recorded on the Coosawhatchie River numerous times since 1951. The flood flow of record (8,160 cfs) in the sub-basin was recorded in this river in 1969.

While the period of record for streamflow data on Great Swamp is short, data collected to date indicate characteristics typical of Lower Coastal Plain streams. Average annual flow is 42.8 cfs; however, due to the dependence of this stream on rainfall and runoff, several periods of zero-flow have been recorded.

The quantity of fresh surface water available within this sub-basin is limited. While available streamflow in the upper portion of the Salkehatchie River is reliable, flow downstream in the Middle and Lower Coastal Plain region may be subject to greater variability. Available streamflow in the Coosawhatchie River and Great Swamp is extremely limited and unreliable since flow is often non-existent during the summer and fall months.

Development

Surface-water development in the Combahee-Coosawhatchie River Sub-basin includes primarily navigation projects in the coastal waters, while some flood control projects occur throughout the area. All known surface-water developments are identified in Figure 132.

There are no large reservoirs within the sub-basin and the largest lake is an unnamed lake near the Ashepoo River with a surface area of 800 acres and a volume of 2,400 acre-feet. Lake Warren on Black Creek has a surface area

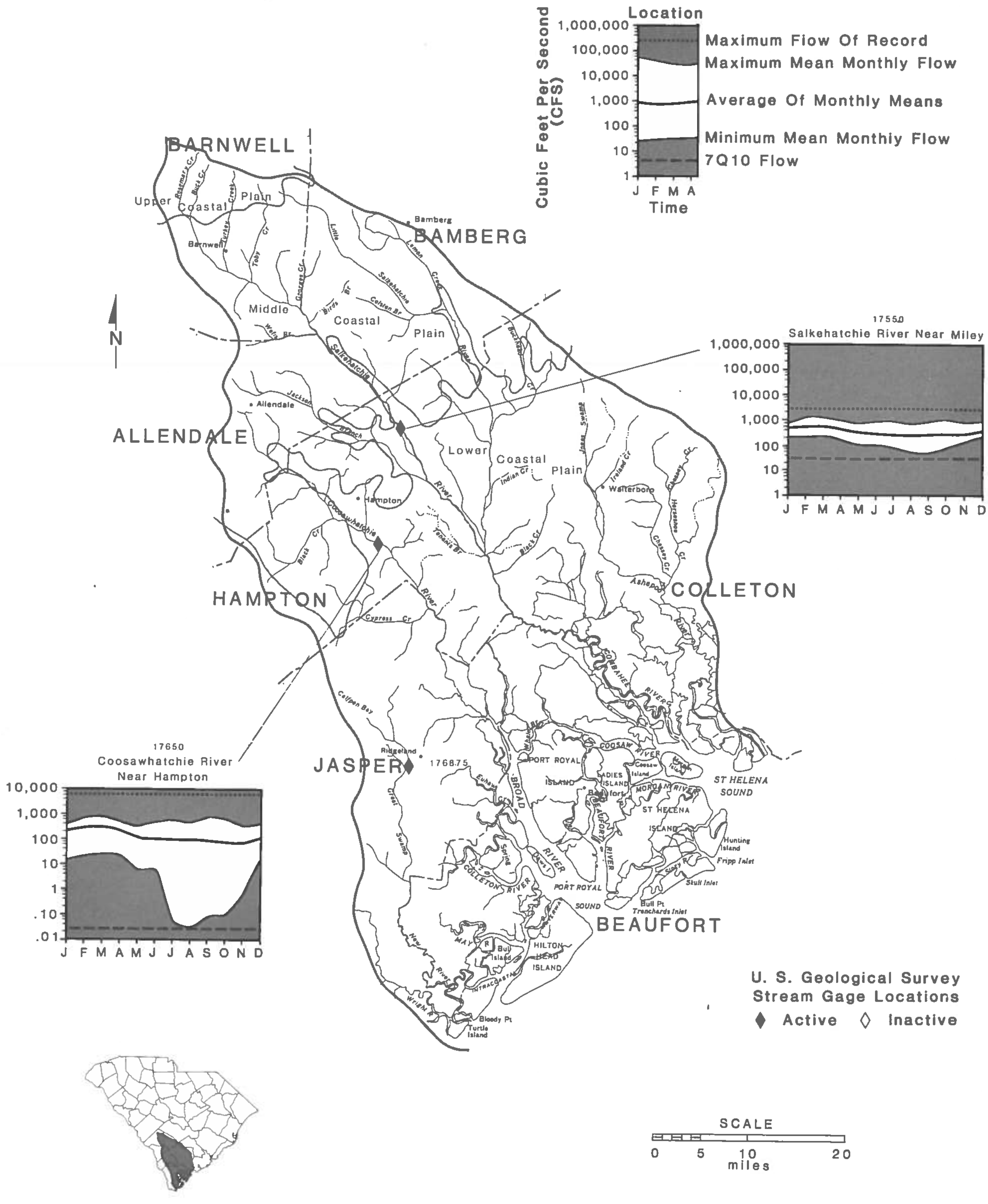


Figure 130.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Table 120.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Gaging Station		*Drainage Area*	*Period of Record*		*Average Flow*				
								7Q10[b]	
Number	*Name/Location*	*(mi^2)*	*Dates*	*Total Years*	*cfs*	*cfs/mi^2*	*90%*[a] *cfs*	*cfs*	*cfs/mi^2*
1755	Salkehatchie River near Miley	341	Feb 1951-Present	29	356	1.04	95	33	0.10
1765	Coosawhatchie River near Hampton	203	Feb 1951-Present	29	189	0.93	3.7	0.03	0.0001
1768.75	Great Swamp near Ridgeland	48.8	Oct 1977-Present	3	42.8	0.88	*[e]	*	*

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] * Indicates statistic not calculated.

of 600 acres and a volume of 3,600 acre-feet. These and all other lakes larger than 200 acres are presented in Table 121. The total surface area of all lakes larger than ten acres is about 7,000 acres and total volume is approximately 29,000 acre-feet.

Currently, no hydroelectric power sites exist in the sub-basin and no potential sites have been identified.

The U.S. Army Corps of Engineers has been involved in numerous navigation projects within the sub-basin (Table 122). These projects were concentrated primarily in coastal waters; however, none are currently active.

The Willow Swamp region of Colleton and Bamberg Counties is the site of the only completed Soil Conservation Service flood control project within the sub-basin. It includes 37.1 miles of channel improvement. The Upper New River of Beaufort and Jasper Counties is the site of construction which will include 28 miles of channel improvement. These projects and other problem areas are presented in Table 123 and Figure 132.

Water Quality

The major portion of freshwaters in this sub-basin have Class A water use designations, suitable for primary contact recreation (Fig. 133). All other freshwater bodies are designated Class B. Coastal waters are primarily designated Class SA, indicating saltwaters suitable for harvesting of clams, mussels, and oysters for human consumption. All other tidal waters in this sub-basin are designated Class SB. Water quality limited segments which require advanced treatment of wastewater discharges include all or part of the Coosawhatchie River, Black Creek, Lemon Creek, Buckhead Creek, Inland Creek, Great Swamp and several minor tributary streams (Fig. 134). Water quality in the Combahee-Coosawhatchie Sub-basin is generally adequate for most designated water use activities. However, due to natural conditions, such as drainage from extensive swamplands, high summer water temperatures, and slow moving waters, water bodies throughout this sub-basin experience chronic low dissolved oxygen concentrations.

The Coosawhatchie River exhibits generally satisfactory conditions with lower water quality during portions of the year (S.C. Department of Health and Environmental Control, 1980b). Water quality problems in this river include high mercury and fecal coliform bacteria concentrations and low dissolved oxygen levels. While the source of mercury contamination is unknown, dissolved oxygen and fecal coliform bacteria problems are attributed to natural conditions and/or non-point source pollution. Contraventions of State dissolved oxygen standards in this river often occur during the summer months (U.S. Geological Survey, 1979, 1980, 1981; S.C. Department of Health and Environmental Control, 1980b). A fish kill in July 1980 of about 1,200 eel, bream, and catfish was attributed to low dissolved oxygen concentrations in this river (S.C. Department of Health and Environmental Control, unpublished fish kill records).

The Salkehatchie River has in the past experienced depressed dissolved oxygen levels and elevated fecal coliform bacteria concentrations (S.C. Department of Health and Environmental Control, 1975c). These water quality problems were attributed primarily to non-point sources and some municipal point source discharges. Current assessments, however, indicate that this river has generally good water quality and has exhibited a slight improvement in dissolved oxygen levels during recent years (S.C. Department of Health and Environmental Control, 1980b).

Chemical and physical water quality parameters indicate that water quality in the tidally influenced coastal waters is satisfactory with decreased quality during portions of the year. Problem conditions include high concentrations of metals and fecal coliform bacteria and low dissolved oxygen values. These problem conditions have been attributed primarily to natural conditions and non-point source runoff. Biological data from these coastal waters indicate fair to good conditions with no noticeable trends (S.C. Department of Health and Environmental Control, 1980b). High concentrations of fecal coliform bacteria levels have resulted in the closing of shellfish grounds in waters near Beaufort, Hilton Head Island, and Turtle Island (Fig. 134).

Table 120 (Continued)

Extreme Flows			
Minimum[c]		Maximum[d]	
cfs	*Dates*	*cfs*	*Date*
17.0	Sep 13, 1954	3,300	Mar 13, 1980
0.0	Many days in 1951, 54, 56, 57, 68, 69, 80	8,160	Sep 2, 1969
0.0	Many days in 1977, 78, 79, 80	1,360	Mar 13, 1980

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout the sub-basin ranges from the field data level in the northwestern region to the development level in the southeastern region (Fig. 18). Detailed ground-water studies have been conducted for a large portion of the sub-basin (Siple, 1957, 1960, 1967; Hayes, 1979; Spigner and Ransom, 1979).

The Combahee-Coosawhatchie River Sub-basin lies within the Lower Coastal Plain Province. Ground water in the sub-basin occurs in six major aquifer systems, the Middendorf, Black Creek, Peedee, Black Mingo, Tertiary Limestone, and Shallow Aquifer Systems.

The Middendorf Aquifer System is not generally tapped as a source of ground-water supply in this area primarily because of its depth and poor water quality and the availability of water from shallower aquifer systems. The top of this aquifer system extends from approximately 300 feet below land surface at Williston to 2,670 feet on the coast. The entire thickness of the aquifer has not yet been penetrated, but is estimated to range from approximately 660 feet in northeastern Colleton County to more than 1,500 feet near the coast at the South Carolina-Georgia border.

The Black Creek Aquifer System has been completely penetrated by only a few wells, therefore, the hydrogeologic properties of this aquifer system are not well known. The top of this aquifer system is estimated to be at a depth of approximately 100 feet in northern portions of the sub-basin to about 2,000 feet near the coast. In Colleton County the Black Creek Aquifer System is about 350 feet thick. In Walterboro, two wells screened between the depths of 1,609 and 1,760 feet, flow at a rate of more than 1,000 gpm. In Beaufort County, the Black Creek Aquifer System consists of about 700 to 800 feet of sediments. In Allendale, Colleton, and Hampton Counties, several large diameter municipal and irrigation wells withdraw water from this aquifer with yields in excess of 1,000 gpm.

The Peedee Aquifer System is not a major source of ground water in the sub-basin. The top of the aquifer system

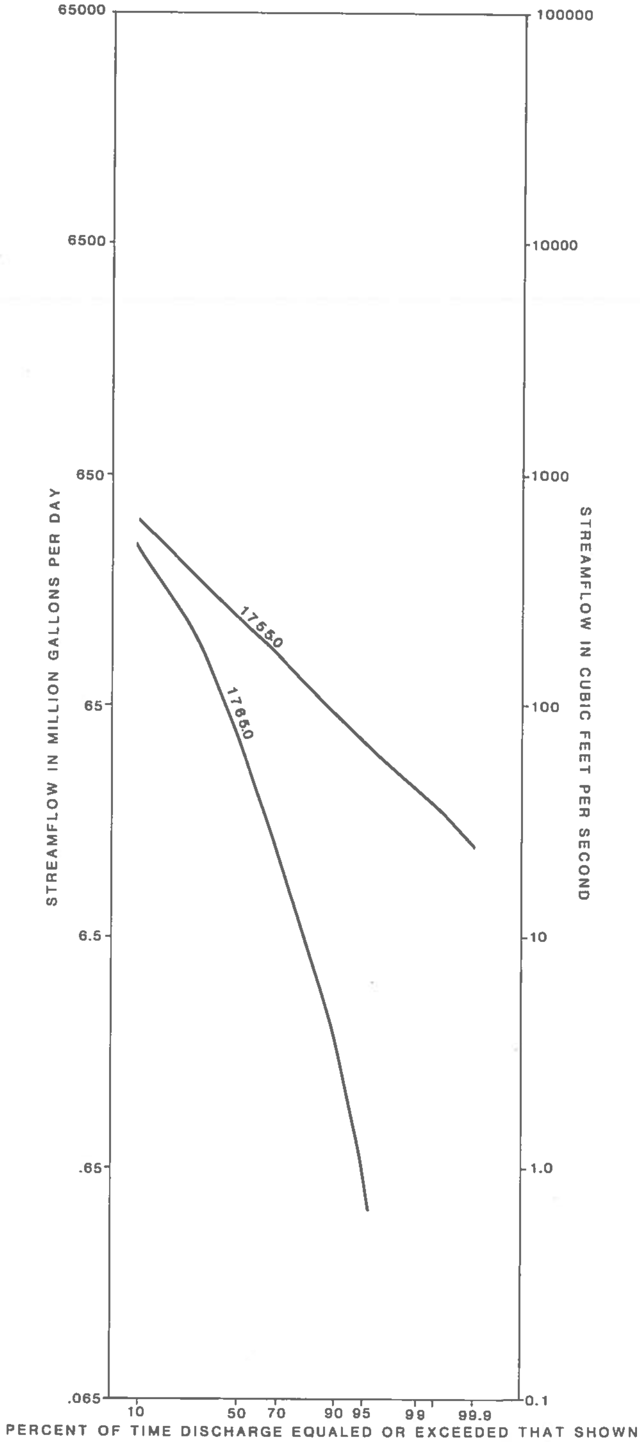


Figure 131.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Table 121.
Existing lakes larger than 200 acres in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Lake Warren	Black Creek	600	3,600	Recreation
2	Unnamed	Ashepoo River	800	2,400	Recreation
3	Unnamed	Combahee	300	360	Recreation
4	Buckfield Pond	Tulifinny River	240	576	Recreation
5	Nemours Plantation	Branford Creek	220	660	Recreation

Source: S.C. Water Resources Commission, 1974.

Table 122.
U.S. Army Corps of Engineers navigation projects in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
6	Salkehatchie/ Combahee River	Colleton Beaufort Hampton	Charleston	42.0	--[a]	Project provides clearing of obstructions from the river to provide a clear channel for rafts and flatboats from Hwy. 17 to Hwy. 601. Recommended for abandonment in 1926. Presently inactive.
7	Village Creek	Beaufort	Charleston	5.3	80	Project provides for 8 foot deep channel from Morgan River to Porpoise Fish Company pier. Completed 1965. Not maintained due to lack of suitable spoil disposal area.
8	Ward's Creek	Beaufort	Charleston	1.6	--	A reconnaissance evaluation in 1979 was made to determine Federal interest in establishing project here. Conclusion determined project would benefit single user, therefore does not qualify.
9	Fripp Inlet	Beaufort	Charleston	2.5	--	Reconnaissance report in 1978 found it uneconomical to provide channel across ocean bar.
10	Archers Creek	Beaufort	Charleston	2.0	75	Project provides 6 foot deep channel from its intersection with Beaufort River for a distance of two miles. Project completed in 1914. Recommended for abandonment in 1926. Presently inactive
11	Port Royal Harbor	Beaufort	Charleston	21.0	300-500	Project provides 27 foot deep channel across the ocean bar and into Port Royal Sound for 13.5 miles, thence a 24 foot deep channel in Beaufort River and Battery Creek for 7.5 miles including a 27 foot deep turning basin adjacent to S.C.S.P.A. Docks. Project completed in 1959.
12	Coosawhatchie and Broad River	Beaufort/ Jasper	Charleston	--	--	Studies started in 1967 to consider and Broad River Jasper deep draft channel from Port Royal Sound up the Broad River to Dawson Landing. Study halted in 1968 due to lack of industrial development in the area.

[a] --indicates information not available.

Source: U.S. Army Corps of Engineers, 1982b.

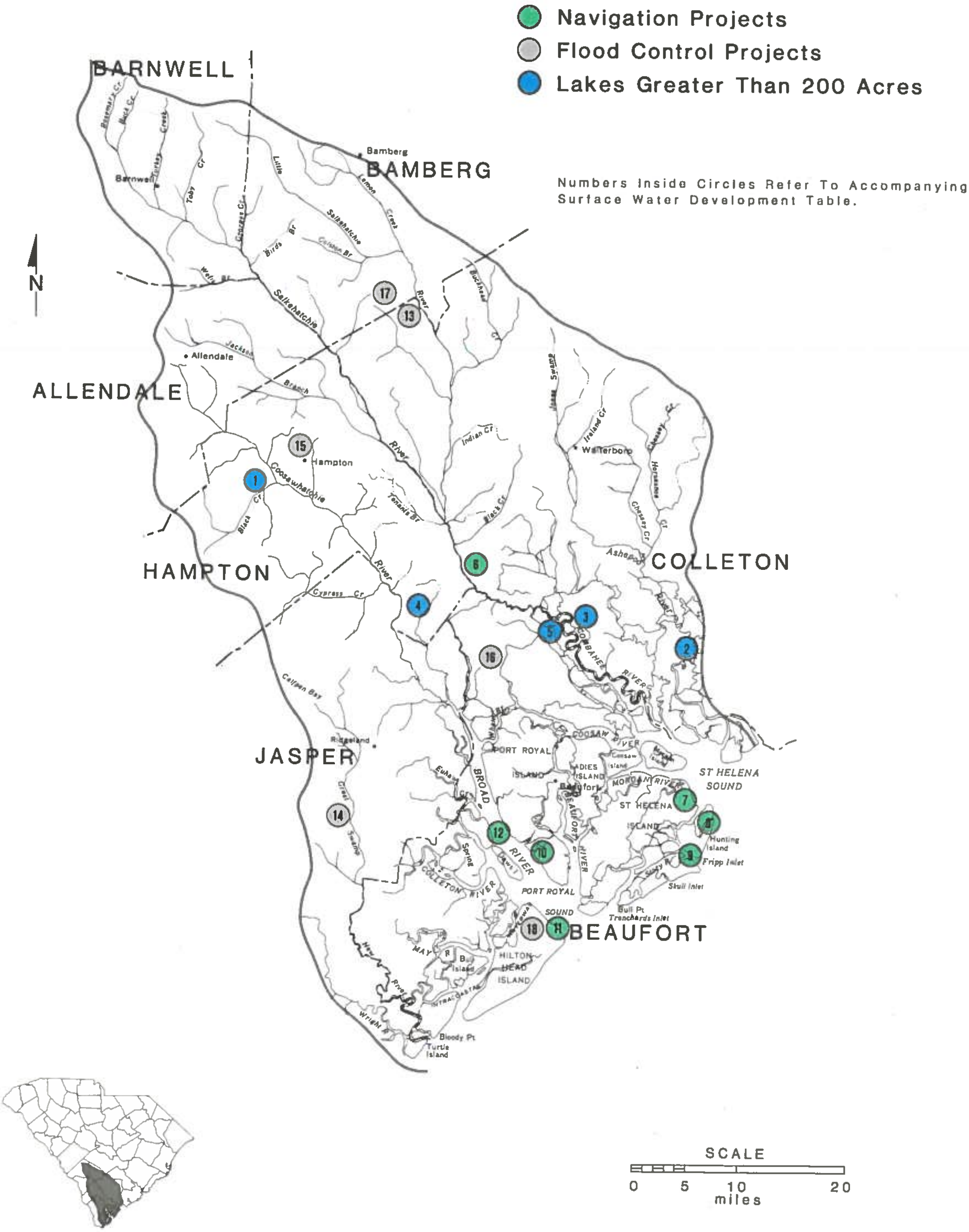


Figure 132.
Surface-water development in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Table 123.
Flood control projects in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
13	Willow Swamp	Colleton/Bamberg	SCS	Completed 1974
14	Upper New River	Beaufort/Jasper	SCS	Under construction
15	Sanders Branch/ Crooked Creek	Hampton	SCS	Terminated
16	Sheldon Watershed	Beaufort	SCS	Terminated
17	Ehrhardt	Bamberg	SCS	Identified problem area
18	North Hilton Head	Beaufort	SCS	Identified problem area

[a] SCS indicates Soil Conservation Service.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

occurs at a depth of 830 feet in Colleton County and about 1,500 feet near Beaufort. The aquifer is about 300 and 500 feet thick, respectively. Fine grained sediments, such as clay or clayey limestone within the Peedee, function more as confining beds than as aquifers and probably contain mineralized water in coastal Beaufort and southern Colleton and Jasper Counties. The occurrence of freshwater in the Peedee Aquifer System was reported in a well in northern Beaufort County (Siple, 1960). This well has been subsequently filled in and duplicate analyses of freshwater from the Peedee Aquifer have not been obtained.

The top of the Black Mingo Aquifer System in Hampton and Colleton Counties occurs at a depth of approximately 600 feet, and in Beaufort County at depths of 860 to 1,100 feet. The thickness of sediments is about 400 feet. Wells thought to be screened in the Black Creek or Ellenton Aquifer Systems have natural flows of 50 to 250 gpm of good quality water in Hampton and Colleton Counties. In Beaufort and Jasper Counties, the water-bearing properties of the Black Mingo System are not known.

The Tertiary Limestone Aquifer System is the main source of ground water in the sub-basin. More than 4,000 wells approximately 50 to 250 feet deep tap this aquifer system and provide over 80 percent of the ground water used in this area. The thickness of the Tertiary Limestone Aquifer System ranges from 400 feet in Hampton and Colleton Counties to more than 900 feet in Beaufort County, and probably more than 1,000 feet in southern Jasper County.

The Tertiary Limestone Aquifer System in the southern coastal counties was differentiated by Hayes (1979) into two permeable zones, the Upper Unit and the Lower Unit, separated by a zone of low permeability. The Lower Unit is about 30 feet thick in Beaufort and Colleton Counties. In Jasper County, the thickness and water bearing characteristics of the Lower Unit are unknown. The transmissivity of the Lower Unit in northern Colleton and Hampton Counties is estimated to range from 500 to 5,000 ft^2/day. Wells drilled into the Lower Unit are usually open to the Upper Unit. The Upper Unit of the Tertiary Limestone Aquifer System is the major source of ground water in the sub-basin. Wells which tap this unit range from 50 feet deep in the vicinity of Beaufort to more than 200 feet deep in Jasper County. The hydraulic properties of this unit vary considerably. The permeability of the aquifer system as a whole decreases from southwest (Jasper County) to the northeast (southern Colleton County) where the Upper Unit is absent.

The large volume of water pumped from the Tertiary Limestone Aquifer System by the City of Savannah has lowered water levels in the aquifer from the original potentiometric surface of 10 to 35 feet above mean sea level in 1880, to approximately 150 feet below mean sea level in 1980. The decline of water levels has changed or reversed the original direction of ground-water movement from a direction toward Port Royal Sound to one toward the center of pumpage at Savannah. Continued dewatering of the Tertiary Limestone Aquifer System will affect the area near the cone of depression, centered at Savannah, by causing compaction of overlying confining beds and possibly land-surface collapse.

The Shallow Aquifer System (Hawthorne, Duplin, and Pleistocene sediments) occurs discontinuously throughout the sub-basin. Wells less than 25 feet to about 100 feet deep tap these sediments. The hydrologic characteristics of the Shallow Aquifer System are unknown; however, this system is an important source for domestic water supplies in coastal areas.

Water Quality

In general, water quality from all aquifer systems in the northern extremes of the sub-basin is good and suitable for most uses. However, as these systems down dip toward the coast, water quality generally deteriorates. High water temperatures, chlorides, and dissolved solids in the deep-lying Middendorf and Black Creek Aquifer Systems make these systems undesirable sources of ground water in the southern portion of the sub-basin. Brackish water in the Peedee Aquifer System also discourages use of this ground-water source. The Black Mingo Aquifer System exhibits occasional high iron concentrations which affect the taste and use of this water in some areas of the sub-basin.

The most utilized aquifer system in the sub-basin is the Tertiary Limestone Aquifer System. The concentration of major chemical constituents varies among wells. Hardness is usually below 140 mg/L, total dissolved solids below 200 mg/L, and pH ranges from 7.5 to 8. Chloride concen-

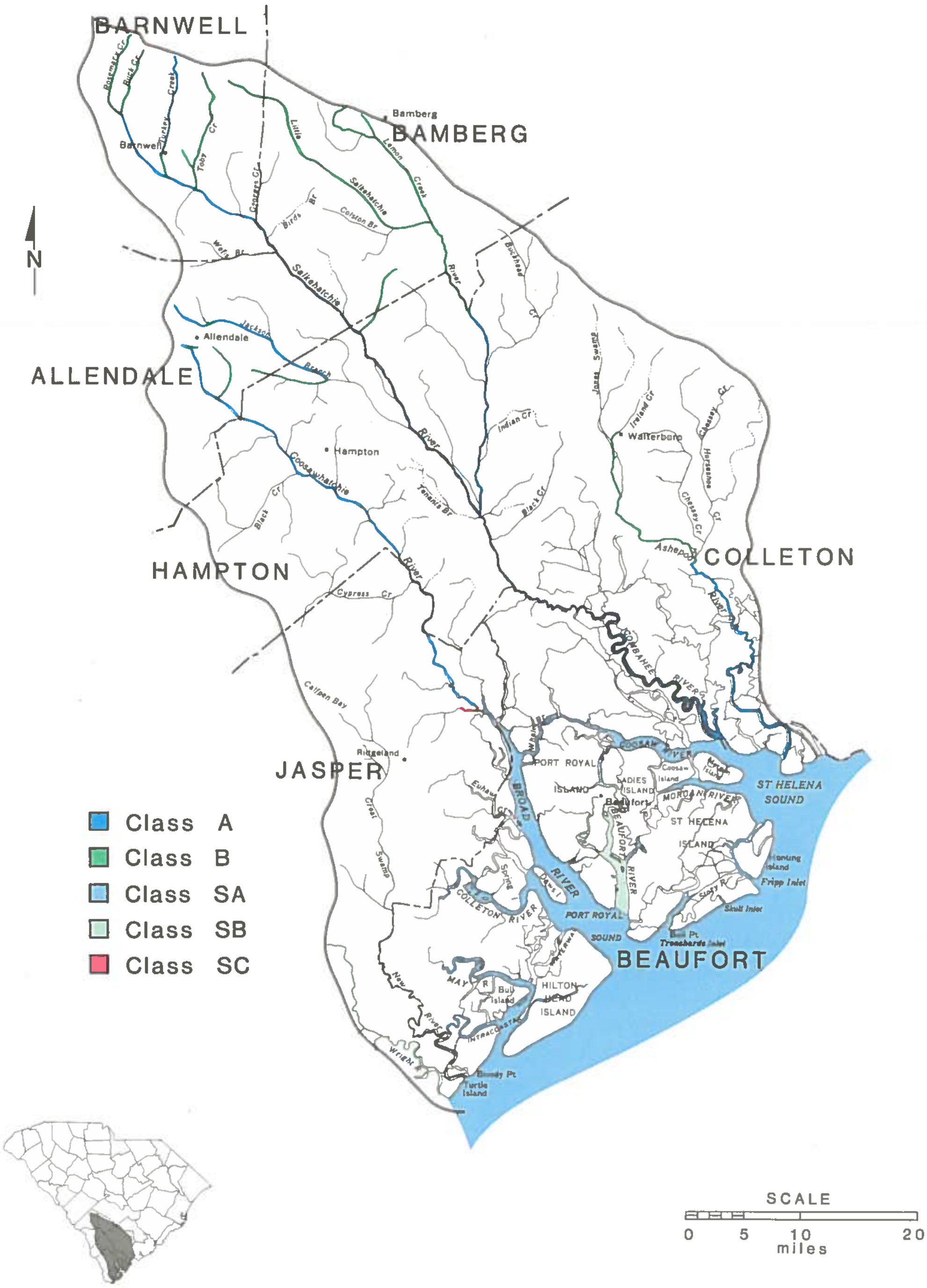


Figure 133.
Surface-water quality classifications in the Combahee-Coosawhatchie River Sub-basin, South Carolina (S. C. Department of Health and Environmental Control, 1980a).

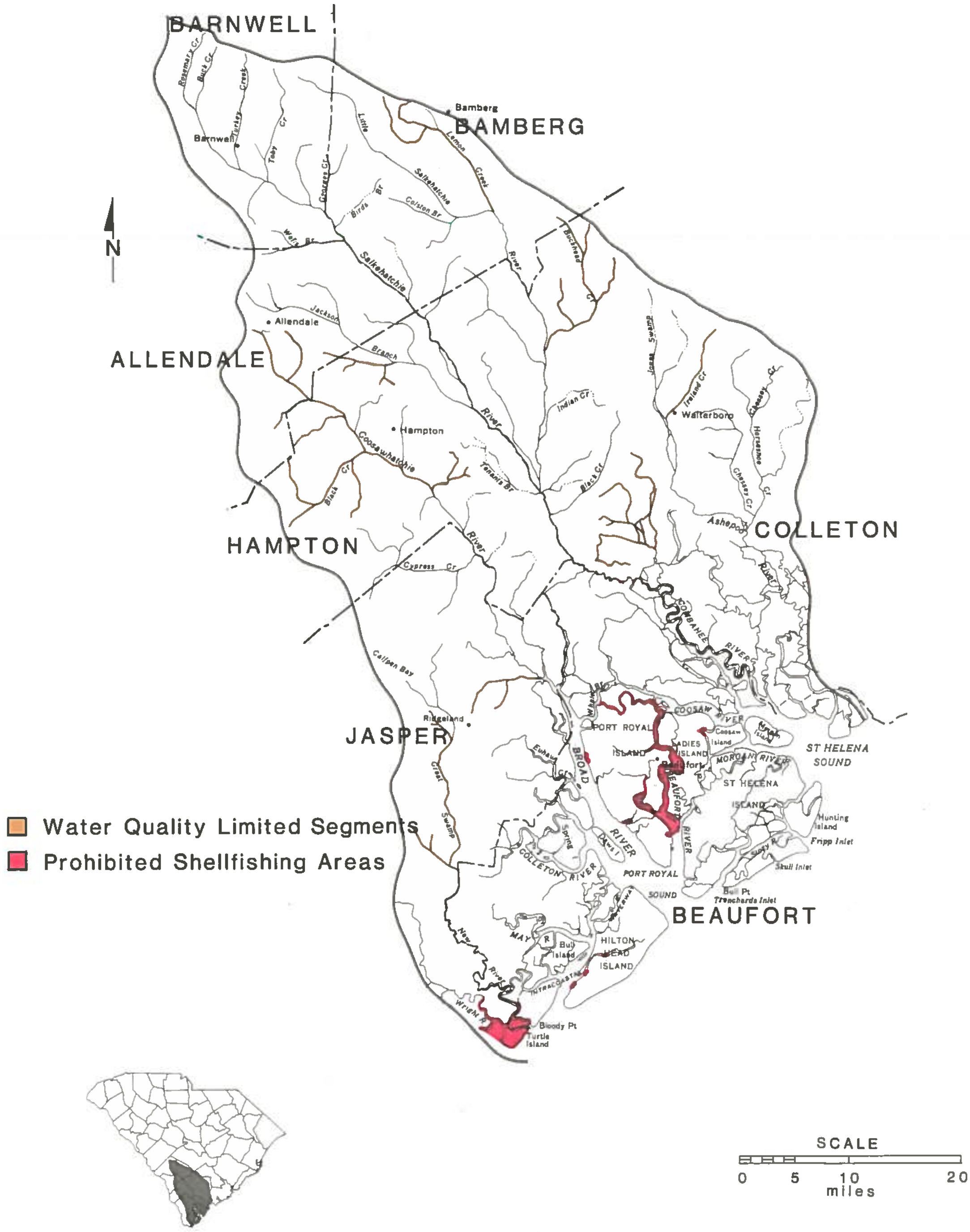


Figure 134.
Water quality limited segments and prohibited shellfishing areas in the Combahee-Coosawhatchie River Sub-basin South Carolina (S.C. Department of Health and Environmental Control, 1980a).

Table 124.
Current and projected water use in the Combahee-Coosawhatchie River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water	Ground Water	Surface Water	Total Water
Public Supply	Gross	11.2	---	11.2	13.4	---	13.4	15.5	---	15.5	17.0	---	17.0	17.9	---	17.9
	Consumed	1.12	---	1.12	1.34	---	1.34	1.55	---	1.55	1.70	---	1.70	1.79	---	1.79
Self-supplied Domestic	Gross	6.4	---	6.4	7.7	---	7.7	8.8	---	8.8	9.7	---	9.7	10	---	10
	Consumed	5.4	---	5.4	6.6	---	6.6	7.5	---	7.5	8.3	---	8.3	8.5	---	8.5
Agriculture Irrigation	Gross	3.5	3.0	6.5	12	8.3	20	21	12	33	30	16	46	39	19	58
	Consumed	3.5	3.0	6.5	12	8.3	20	21	12	33	30	16	46	39	19	58
Agriculture Livestock	Gross	0.42	0.41	0.83	0.48	0.47	0.95	0.55	0.53	1.1	0.62	0.61	1.2	0.71	0.69	1.4
	Consumed	0.42	0.41	0.83	0.48	0.47	0.95	0.55	0.53	1.1	0.62	0.61	1.2	0.71	0.69	1.4
Self-supplied Industry	Gross	2.50	1.89	4.39	2.88	2.17	5.05	3.16	2.39	5.55	3.48	2.63	6.11	3.83	2.89	6.72
	Consumed	0.46	0.35	0.81	0.53	0.40	0.93	0.58	0.44	1.02	0.64	0.49	1.13	0.71	0.53	1.24
Thermoelectric Power	Gross	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Consumed	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	Gross	24.0	5.3	29.3	36.5	10.9	47.4	49.0	14.9	63.9	60.8	19.2	80.0	71.4	22.6	94.0
	Consumed	10.9	3.76	14.7	21.0	9.17	30.1	31.2	13.0	44.2	41.3	17.1	58.4	50.7	20.2	70.9

trations range from 5 to 75 mg/L except in more contaminated areas where chloride concentrations range from 500 mg/L to more than 10,000 mg/L. The Stiff Diagram in Figure 135 shows a calcium bicarbonate type of water.

The Shallow Aquifer System exhibits variable water quality dependent on local geology and surface-water influence. In coastal areas where the Tertiary Limestone Aquifer System contains brackish water, the Shallow Aquifer System is an important source of domestic ground-water supplies.

WATER USE

Total gross water use is currently estimated at 29.3 mgd with 50 percent of this withdrawal (14.7 mgd) consumed (Table 124). This gross use is 12th in the State. The leading water uses are public supply (11.2 mgd), agricultural irrigation (6.5 mgd), and self-supplied domestic (6.40 mgd). The major water users by supply and source are shown in Figure 136. Ground water supplies 82 percent of the gross use.

Public supply withdrawal represents 38 percent of gross use and eight percent of consumptive use with ground water being the only source utilized. Approximately 6.2 mgd of surface water is transported into this sub-basin from the Lower Savannah River Sub-basin for public supply use. This water is accounted for in the Lower Savannah River Sub-basin.

Self-supplied domestic use accounts for 22 percent of the gross use and 37 percent of the consumptive use. Ground water is the only source of supply used.

Agricultural water use represents 25 percent of gross use and 50 percent of consumptive use. Irrigation demand makes up 89 percent of this use with ground water accounting for 54 percent of the demand. This surface-water withdrawal is the largest in the sub-basin with most of the irrigated acreage located in the upper half of the sub-basin (Fig. 136). When averaged over the five-month growing season, irrigation water use is even more significant equaling 16 mgd and comprising 41 percent of gross use and 66 percent of consumptive use in the sub-basin. Livestock water withdrawals are equally divided between ground- and surface-water sources.

Self-supplied industrial use represents 15 percent of the gross use and six percent of the consumptive use. Ground water supplies 57 percent of the demand.

No thermoelectric power plants are located in this sub-basin.

Total gross use is projected to increase 220 percent to 94.0 mgd by 2020. Consumptive use is projected to grow almost 380 percent to 70.9 mgd by 2020. Most of the growth in both gross and consumptive use is due to the projected increase in agricultural irrigation. This should remain the leading water user. Ground water will remain the most heavily used source of supply.

WATER USE VERSUS AVAILABILITY

The current gross (5.30 mgd) and consumptive (3.76 mgd) surface-water demand are adequately supplied by streamflow (Fig. 137). Most of this demand is concentrated in the upper reaches of the sub-basin (Fig. 136) where streamflow may be less substantial.

Projected 2020 gross surface-water use is 22.6 mgd, while projected consumptive surface-water demand is 20.2 mgd. This projected gross and consumptive demand should be met 99.7 and 99.8 percent of the time, respectively, provided the use occurs above the gaging stations. It is only possible to estimate the amount of water available in the lower reaches. Water use conflicts occur on tributary streams in Hampton County during periods of low flow.

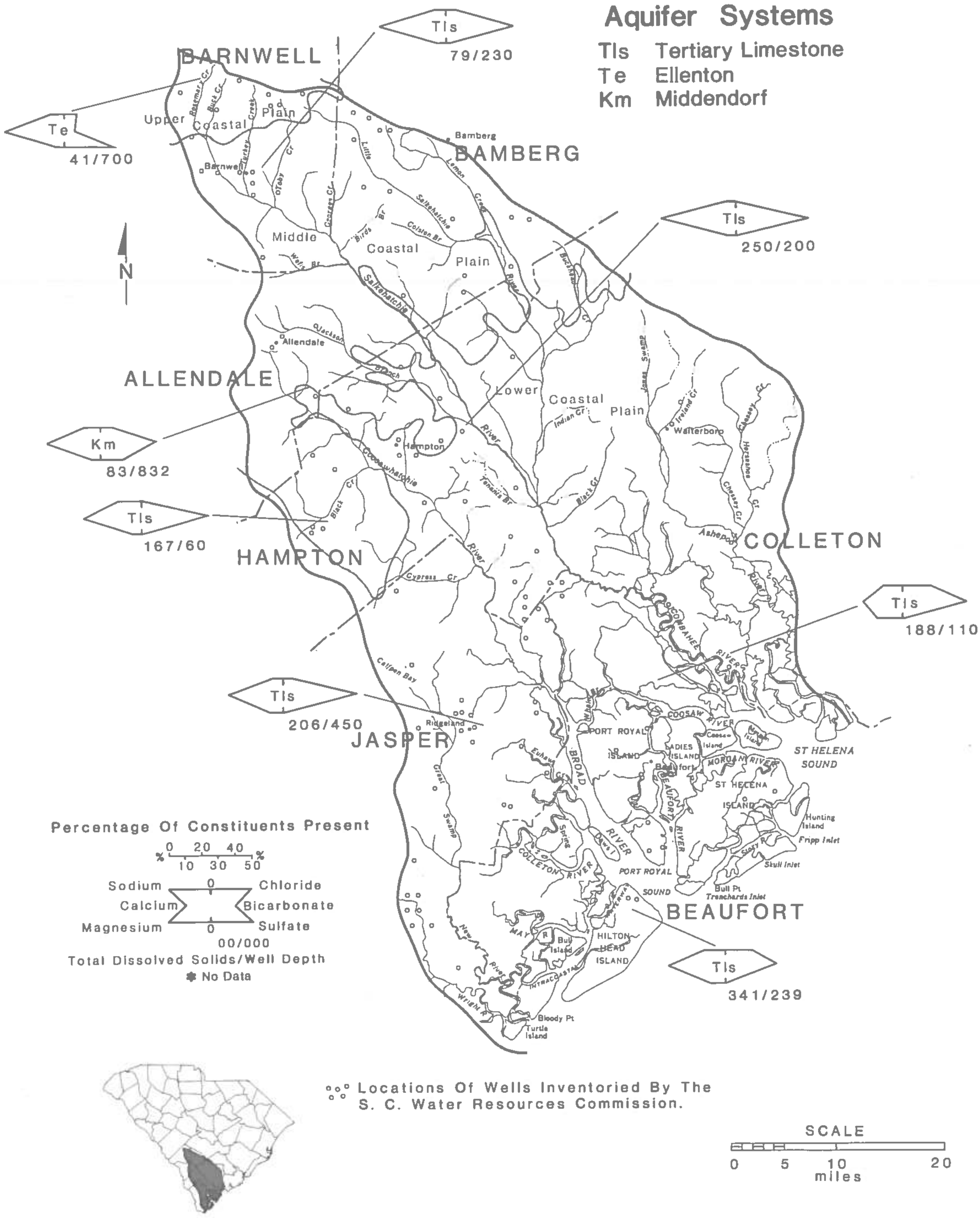


Figure 135.
Ground-water quality of selected aquifer systems and major inventoried wells in the Combahee-Coosawhatchie River Subbasin, South Carolina.

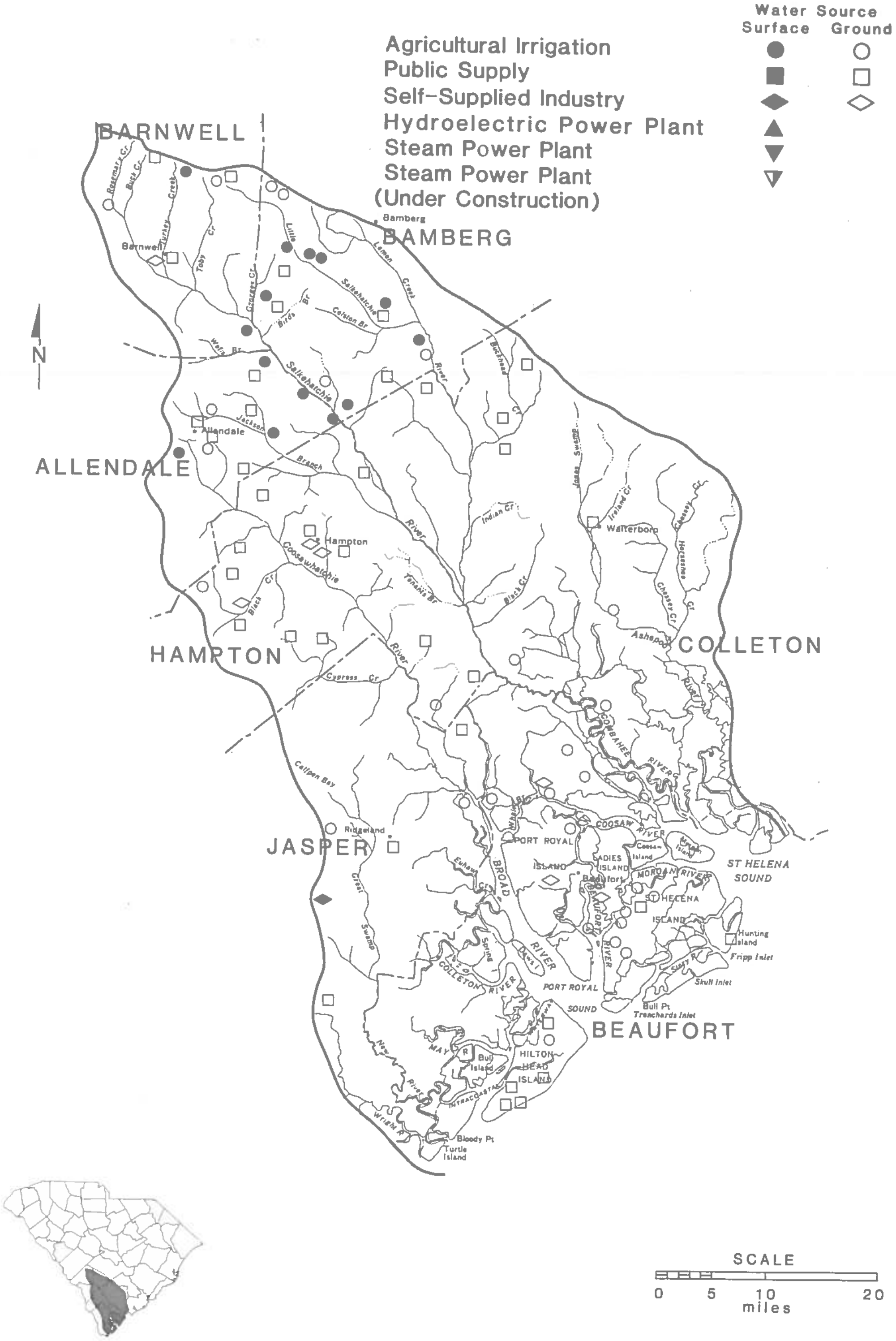


Figure 136.
Location, type, and supply source of water users in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Use of small tributary streams for water supply sources should include site specific hydrologic analysis to determine the quantity of streamflow available, particularly at rainfall times.

Ground water provides 82 percent of the total water supply in the Combahee-Coosawhatchie River Sub-basin. Projections for ground-water demand in the year 2020 show that these requirements will increase almost three times, from 24.0 mgd to 71.4 mgd and will equal 76 percent of the total demand. The range in yields for wells currently inventoried provides an estimate of average yields. Thus, the present ground-water use could be obtained from 111 wells pumping an average of 600 gpm for six hours each day. This constitutes a well density of one well per 29 square miles of drainage basin. The projected requirements for 2020 could be obtained by pumping one such well per 10 square mile area or a total of 330 wells.

Ground-water availability will be limited in certain areas of the sub-basin due to the heavy pumpage from the Tertiary Limestone Aquifer System in the Savannah area. This has reduced significantly the potentiomentric head of this aquifer system in the western part of the sub-basin.

Ground-water quality problems may limit the availability of the resource at some future time. High chloride concentrations in both the Tertiary and Cretaceous aquifer systems accompanied by an increase in total dissolved solids with depth in coastal zones, might cause treatment problems for the future users of the resource.

Major water resource problems and opportunities in the sub-basin are summarized in Table 125.

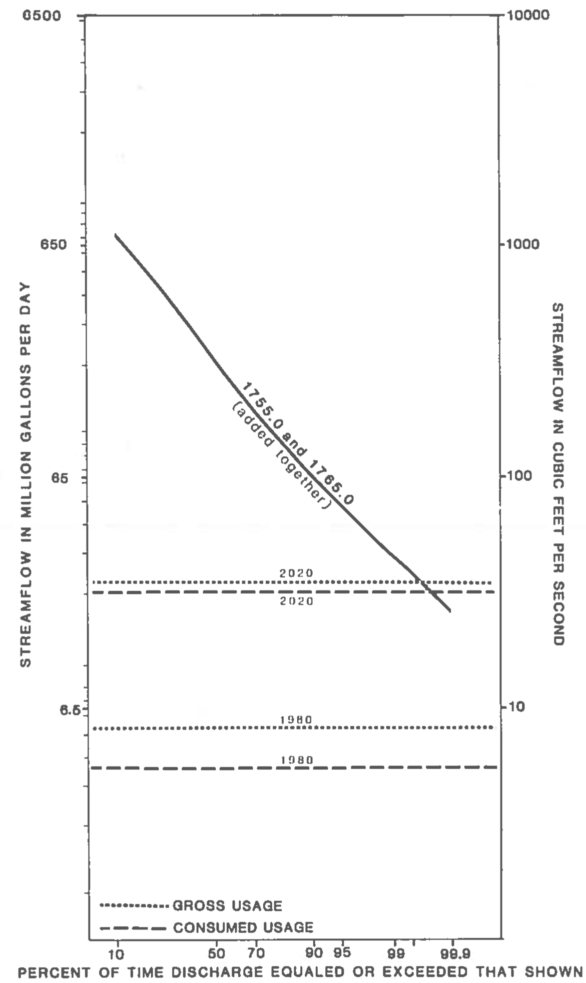


Figure 137.
Water use compared to availability in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Table 125.
Major water resource findings in the Combahee-Coosawhatchie River Sub-basin, South Carolina.

Opportunities
1. Surface-water supplies are adequate to meet current and projected water use most of the time.
2. Streams in the Upper Coastal Plain region have well-sustained flows year round and are reliable sources of surface water.
3. Commercial navigation exists in several coastal waters and the potential for deep-draft navigation exists in Port Royal Harbor, Coosawhatchie River, and Broad River.
4. Shellfishing is allowed in most coastal waters except near highly developed areas.
5. Surface-water supplies adequately meet current surface-water demand most of the time.
6. Generally, water quality in all aquifer systems in the sub-basin is good to acceptable.

Problems
1. Water use conflicts currently occur on tributary streams in Hampton County during periods of low flow; such conflicts are projected to increase throughout the sub-basin.
2. Beach erosion adversely impacts Hunting Island and other barrier islands.
3. Natural conditions and non-point source runoff degrade water quality in streams throughout the sub-basin, especially during the summer months.
4. Heavy pumpage by the City of Savannah, Georgia and South Carolina has caused water level declines and saltwater contamination in the Tertiary Limestone Aquifer System in the lower portion of the sub-basin.
5. High iron concentrations and hard water may occur in the Tertiary Aquifer System and high sodium and fluoride concentrations are found in the Cretaceous Aquifer System.
6. The deep lying Middendorf and Black Creek Aquifer Systems are undesirable ground-water sources near the coast due to high water temperatures, chlorides (at some depths), and dissolved solids.

Sub-basin Analyses: Savannah River Basin

Upper Savannah River Sub-basin

GENERAL OVERVIEW

The Upper Savannah River Sub-basin is located in the northwest section of South Carolina and extends from a common northern border with North Carolina and Georgia southeast for approximately 140 miles to the Edgefield-Aiken County border. The sub-basin shares a western border with Georgia, along portions of three rivers, the Chattooga, the Tugaloo, and the Savannah, and contains within its boundary the two South Carolina counties of McCormick and Oconee as well as portions of Abbeville, Anderson, Edgefield, Greenwood, Pickens and Saluda Counties (Fig. 138). The areal extent is approximately 3,200 square miles, 10.3 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 269,100, 8.6 percent of the State's total population (Table 126). By the year 2020, the sub-basin population is expected to reach 478,300, an increase of 77.7 percent. Pickens County is expected to exhibit the greatest population change during this time period, with an increase of 123 percent, while McCormick County will experience a net loss of population, decreasing by 2.6 percent. This loss of population is related to the lack of economic opportunities in the county and out-migration of the population.

The region is predominately rural with several major population centers dispersed throughout. The major cities and centers of 1980 population in the sub-basin were Anderson (27,819), Greenwood (21,568), Easley (14,345), Clemson (7,994), Seneca (7,422) and Abbeville (5,857). In addition, there are six towns with populations between 2,500 and 5,000.

Economy

The 1979 per capita income for the sub-basin counties averaged $6,263, almost $800 below the State average, and ranged from $5,080 in McCormick County, which ranked 40th to $7,342 in Anderson County which ranked 11th, out of the 46 South Carolina counties. All of the counties in the upper two-thirds of the sub-basin had a 1980 median household income near or exceeding the State average of $16,509. Edgefield and McCormick Counties had low median household incomes and McCormick County was almost $5,000 below the State average.

During 1979, the annual average employment of non-agricultural wage and salary workers in the sub-basin totaled approximately 111,800. Compared with the State as a whole, the sub-basin contains more than its share of manufacturing employees and less than its share of the remaining categories. The percentage breakdown by type of employment was: manufacturing, 51 percent; government, 17.12 percent; wholesale and retail trade, 14.4 percent; services and mining, 8.2 percent; construction, 4 percent; transportation and public utilities, 3 percent; finance, insurance, and real estate, 2.3 percent.

In the sector of manufacturing, mining and public utili-

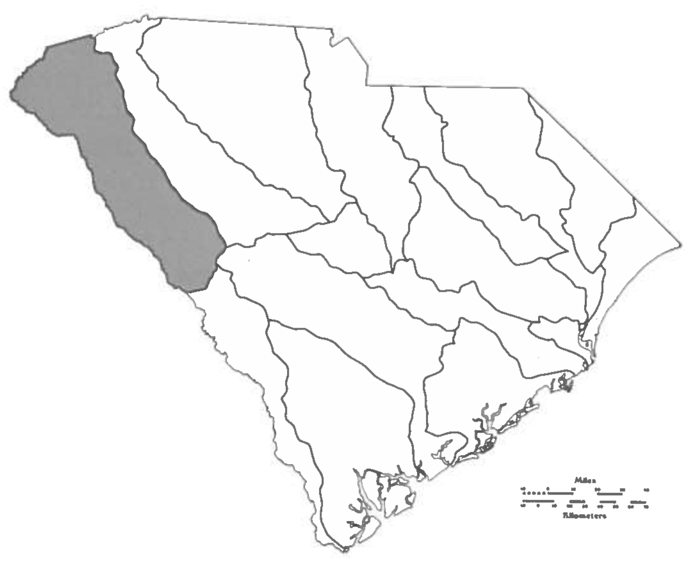


Figure 138.
Location of the Upper Savannah River Sub-basin in South Carolina.

Table 126.
Current and projected population for the Upper Savannah River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)*					*% Change 1980-2020*
		1980	*1990*	*2000*	*2010*	*2020*	
Abbeville	91.0	20.6	22.3	23.1	23.7	24.1	17
Anderson	81.4	109.0	138.5	166.6	191.9	206.5	89.4
Edgefield	72.6	12.8	14.4	15.2	15.9	16.3	27.3
Greenwood	19.6	11.4	13.3	14.8	15.9	16.6	45.6
McCormick	100.0	7.8	7.7	7.6	7.6	7.6	-2.6
Oconee	100.0	48.8	58.6	66.5	73.2	76.9	57.6
Pickens	72.8	58.1	77.5	98.2	117.8	129.6	123.1
Saluda	3.7	0.6	0.7	0.7	0.7	0.7	16.7
Total	269.1	333.0	392.7	446.7	478.3	77.7	

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

ties, the annual product value of the sub-basin counties totaled $3,147.2 million during fiscal year 1978-79, which was 14.6 percent of the State's total.

Agricultural activity is limited in the sub-basin. One county, Edgefield, ranked in the top one-third for 1979 cash crop receipts with a total of $18 million, primarily from peach crops. Only Anderson County ranked in the top ten of livestock receipts with a total of nearly $16 million.

SURFACE WATER

Hydrology

The upper portion of the Savannah River is the main watercourse of this drainage system. With headwaters in the Blue Ridge Province of North Carolina and Georgia, the Tugaloo and Seneca Rivers converge to form the Savannah River. Several other tributaries drain South Carolina and Georgia watersheds and contribute to streamflow in the Savannah River. Those streams in South Carolina include the Chattooga River, Twelvemile Creek, Rocky River, Little River, and Stevens Creek. Since 1950, four large reservoirs have been built on the upper Savannah River and its major headwater tributaries in South Carolina and a fifth reservoir is nearing completion. Upon completion of the most recent reservoir, Richard B. Russell Lake, virtually all of the upper portion of the Savannah River will be inundated. Controlled discharges from hydroelectric power facilities associated with each reservoir greatly affect streamflow in the main stem.

Streamflow is currently monitored at four gaging stations, two on the Savannah River and two on tributary streams (Fig. 139). Flow data are also available from ten discontinued gaging stations throughout the sub-basin. Streamflow statistics for these existing and discontinued gaging stations are presented in Table 127. Peak-flow data are collected at six crest-stage stations (1841, 1854, 1879, 1880, 1924.5, 1925) and lake level recorders are located on Hartwell and Clarks Hill Lakes.

Extensive development on the Savannah River has eliminated most of the free flowing stream. Currently, gaged segments occur near Iva (Station 1875) and Calhoun Falls (Station 1890). Both gaging stations will be discontinued after completion of Richard B. Russell Lake. Average annual streamflow on the Savannah River is 4,557 cfs near Iva and 5,320 cfs near Calhoun Falls. Flow at these sites is at least 410 cfs and 1,400 cfs, respectively, 90 percent of the time. While daily flows are somewhat variable due to fluctuating discharges from upstream hydroelectric power plants, minimum flows are well-sustained due to minimum release requirements.

Unregulated streams in the sub-basin are heavily dependent on direct precipitation and surface runoff and ground-water discharges to support flows. Streams located in the Blue Ridge region, where average annual rainfall is high and ground-water storage is substantial, exhibit generally uniform flows year round with well-sustained base flows. These well-sustained and regular flows are evidenced by the moderately sloped flow-duration curves (Fig. 140), fairly even minimum monthly flows year round, narrow range between maximum and minimum monthly flows (Fig. 139), and relatively high unit average and 7Q10 discharge values for the Chattooga River (Station 1770), Whitewater River (Station 1845), Keowee River (Station 1850), Little River (Station 1852), and Seneca River (Station 1855) (Table 127). Average annual streamflow in the Chattooga River is 668 cfs and should exceed 235 cfs, 90 percent of the time.

With increasing distance from the mountains, rainfall diminishes, ground-water contributions to flow decrease, and streamflow becomes progressively more variable. Streamflow characterisitics for the Little River and Stevens Creek show more variable average monthly streamflow, wider range between maximum and minimum monthly flows (Fig. 139), steeper sloped flow-duration curves (Fig. 140), and lower low-flow and unit discharge values (Table

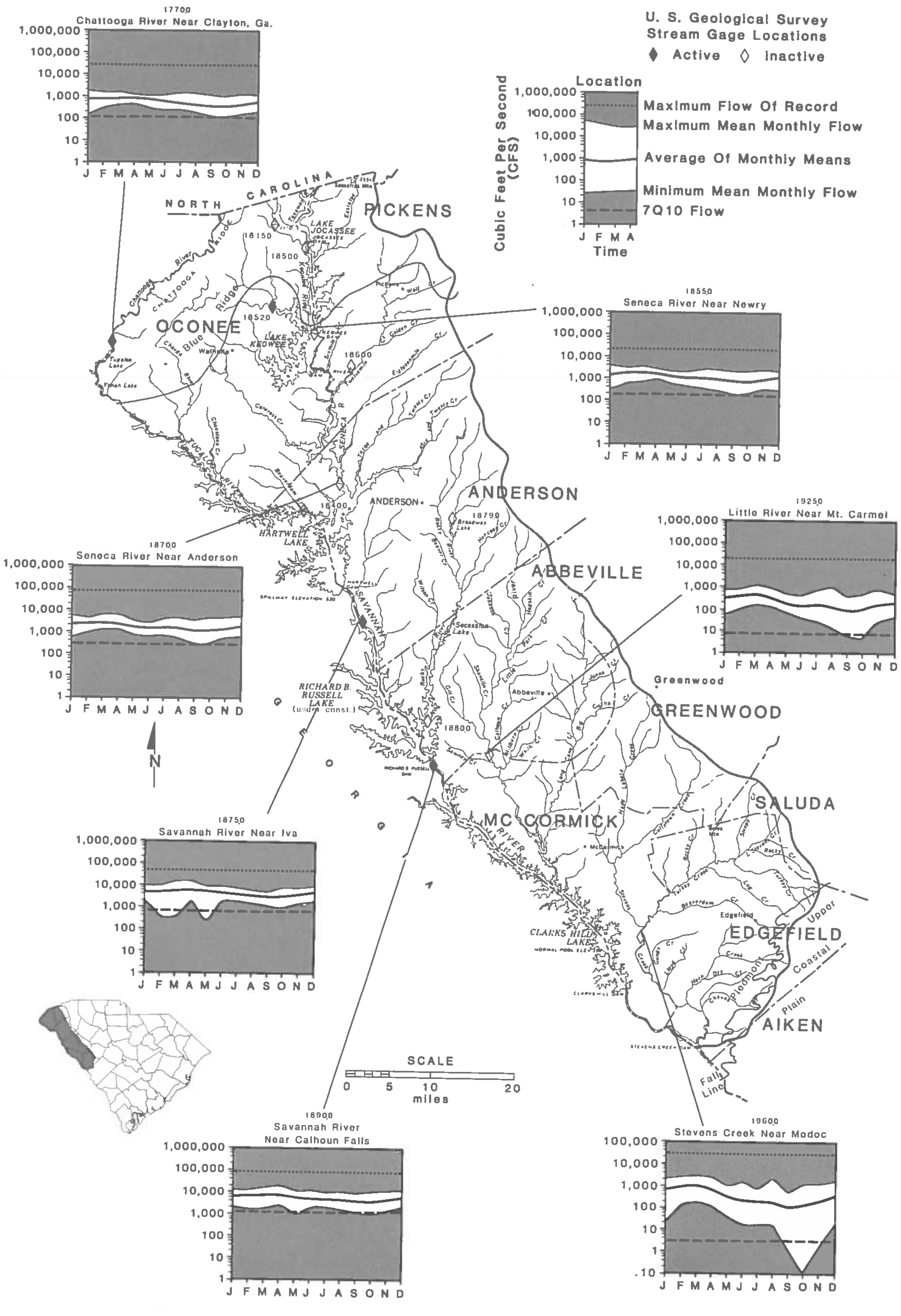


Figure 139.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Upper Savannah River Sub-basin, South Carolina.

Table 127.

Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Upper Savannah River Sub-basin, South Carolina.

Gaging Station			*Period of Record*		*Average Flow*				
		Drainage Area					*90%[a]*	*7Q10[b]*	
Number	*Name/Location*	*(mi^2)*	*Dates*	*Total Years*	*cfs*	*cfs/mi^2*	*cfs*	*cfs*	*cfs/mi^2*
1770	Chattooga River near Clayton, Ga.	207	Oct 1939-Present	41	668	3.23	235	124	0.60
1840	Tugaloo River at Hartwell, Ga.	909	Apr 1925-Sep 1927; Feb 1940-Dec 1960	22	1,947	2.15	*[e]	*	*
1845	Whitewater River at Jocassee	47.3	Jan 1951-Apr 1968	16	177	3.74	57	31	0.66
1850	Keowee River near Jocassee	148	Dec 1949-Apr 1968	17	488	3.30	155	79	0.53
1852	Little River near Walhalla	72.0	Mar 1967-Present	13	198	2.75	81	24	0.33
1855	Seneca River near Newry	455	Oct 1939-Jun 1961	21	1,140	2.51	380	187	0.41
1860	Twelve Mile Creek near Liberty	106	Jul 1954-Sep 1964	10	197	1.86	62	33	0.31
1870	Seneca River near Anderson	1,026	Jun 1928-Jan 1960	31	1,997	1.95	720	359	0.35
1875	Savannah River near Iva	2,231	Oct 1949-Present	31	4,557	2.04	410	650	0.29
1879	Broadway Creek near Anderson	26.4	Feb 1967-Aug 1968 Jul 1969-Sep 1970	2	25.6	0.97	*	*	*
1880	Rocky River near Calhoun Falls	267	Feb 1950-Sep 1966	16	307	1.15	105	38	0.14
1890	Savannah River near Calhoun Falls	2,876	Mar 1930-Jun 1932 Apr 1938-Present	44	5,320	1.85	1,400	1,350	0.47
1925	Little River near Mount Carmel	217	Dec 1939-Sep 1970	30	214	0.99	42	7.2	0.03
1960	Stevens Creek near Modoc	545	Nov 1929-Sep 1931 Feb 1940-1978	39	418	0.77	16	1.6	0.0039

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] * Indicates statistic not calculated.

127) than stations in the upper portion of the sub-basin. Stevens Creek, the most distant gaged stream from the Blue Ridge region, exhibits the most variable flows and most poorly sustained base flows of the two rivers. Average flow in Stevens Creek is 418 cfs and is expected to equal or exceed only 16 cfs, 90 percent of the time. Zero-flow conditions were recorded in this stream on numerous occasions during the drought of 1954.

The Savannah River main stem provides large quantities of surface water throughout the year. While flows may be somewhat variable, minimum flows are uniform and substantial. Tributary streams in the upper portion of the sub-basin support well-sustained flows and are reliable water supply sources provided quantity is adequate for use. Tributary streams in the middle and lower portion of the sub-basin are progressively less reliable sources of surface water since flows in these streams drastically decrease during the summer and fall months.

Development

The Upper Savannah River Sub-basin is one of the most intensely developed sub-basins in the State with numerous flood control projects and hydroelectric power facilities throughout the area. Figure 141 illustrates surface-water development in the sub-basin.

Four of the largest reservoirs in South Carolina dominate this sub-basin, these are Lake Jocassee, Lake Keowee, Hartwell Lake, and Clarks Hill Lake (Table 128). A fifth major reservoir, Richard B. Russell Lake, is nearing completion. Lake Jocassee is in the upper reaches of the sub-basin on the Keowee River and extends up the Toxaway and Whitewater Rivers. Completed in 1974, Lake Jocassee holds over 1,185,000 acre-feet of water with a surface area of 7,565 acres. This lake is the sixth largest by volume in the State. The Jocassee Hydroelectric Station is a pumped storage generating facility. Reversible turbines at this station allow water from downstream Lake Keowee to be pumped back into Lake Jocassee during periods of low electrical demand. The lake and generating facilities are owned and operated by Duke Power Company. The only other use of the lake is for recreation.

Immediately downstream of Lake Jocassee are the waters of Lake Keowee. Created by the damming of adjacent rivers, the Keowee and the Little, the pooled waters of the two rivers merge to form Lake Keowee. Constructed in 1971 by Duke power Company, this lake acts as a lower reservoir for the pumped storage facility at Jocassee Dam. In addition, hydropower is produced at the dam located on the Keowee River. The lake contains nearly 1,000,000 acre-feet of water with a surface area of 18,372 acres. Lake Keowee ranks seventh in area and eighth in volume among lakes in South Carolina. In addition to hydropower production, the lake's waters are used for recreation and for cooling water at the adjacent Oconee Nuclear Station, the largest thermopower plant in the State. The lake is currently being developed as a main supply source for the City of Greenville.

Hartwell Lake is located west of the City of Anderson on the Savannah River. The waters of the lake extend up the Savannah, as well as the Tugaloo and Seneca Rivers. The lake has a surface area of over 56,000 acres and a volume of 2,549,000 acre-feet. It ranks fourth in surface area and first in volume among lakes in the South Carolina. Construction in 1962 by the U.S. Army Corps of Engineers, it

Table 127 (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
88.0	Oct 18, 12, 13, 1954	29,000	Aug 30, 1940
188.0	Oct 18, 1954	28,600	Aug 31, 1940
22	Dec 17, 1955	6,900	Oct 4, 1964
57	Oct 7, 1954	21,000	Oct 4, 1964
15.0	Jul 11-20, Oct 3-8, 1970	14,400	Jun 4, 1967
152	Oct 8, 14, 1954	25,200	Aug 13, 1940
30.0	Jul 23, 1955	5,360	Dec 12, 1961
170	Sep 20, 1931	81,100	Aug 17, 18, 1928
78.0	Oct 23, 24, 1961	54,400	Mar 12, 1952
7.0	Jun 17, 22, 23, 1970	904	Dec 12, 1967
9.0	Sep 21, 22, 1954	10,900	Mar 26, 1964
300.0	Nov 5, 1961	96,500	Aug 13, 1940
0.7	Oct 9, 1954	20,800	Aug 14, 1940
0.0	Sep 14, 15, 24-Nov 16, 22, 1954	35,100	Aug 14, 1940

is used for hydropower production, flood control, water supply, and recreation.

Richard B. Russell Dam and Lake is under contruction five miles south of Calhoun Falls on the Savannah River. When completed in 1985, the lake will have a surface area of 26,650 acres and a volume of over 1,026,000 acre-feet, ranking it sixth in area and seventh in volume among lakes in the State. The lake is being built primarily for the production of hydropower and flood control, but will also be used for recreation. The entire project is managed by the U.S. Army Corps of Engineers.

Clarks Hill Dam and Lake is located on the Savannah River two miles southeast of the Town of Clarks Hill. The lake has a surface area of 70,000 acres and a volume of approximately 2,510,000 acre-feet. This lake is the second largest in surface area and volume of all lakes in the State. Used primarily for the production of hydropower, the reservoir also provides flood control and recreation.

The total surface area of all lakes larger than ten acres within the sub-basin is about 196,000 acres and the total volume is approximately 9,000,000 acre-feet. All lakes larger than 200 acres are listed in Table 128.

Three potential hydropower sites have been identified by the U.S. Army Corps of Engineers within the sub-basin. Two of these sites have produced hydropower in the past, but were discontinued for various reasons; however, the current cost of producing energy makes these sites attractive for possible redevelopment. All existing and potential hydropower sites are presented in Table 129 and Figure 141. In addition, the S.C. Land Resources Conservation Commission has identified 11 potential small scale hydropower

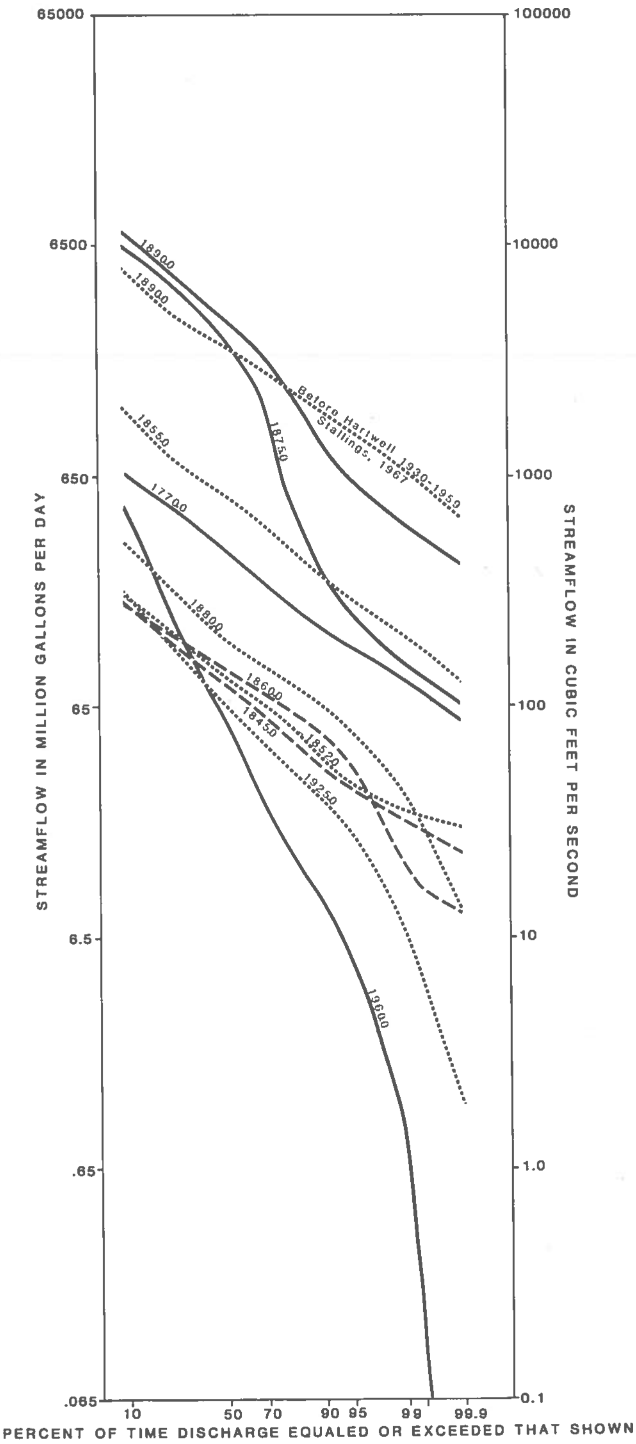


Figure 140.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Upper Savannah River Sub-basin, South Carolina.

Table 128.
Existing lakes larger than 200 acres in the Upper Savannah River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Clarks Hill Lake	Savannah	70,000	2,510,000	Flood Control Power Recreation
2	Hartwell Lake	Savannah	56,000	2,549,000	Flood Control Power Recreation
3	Richard B. Russell Lake	Savannah	26,650	1,026,000	Flood Control Power Recreation
4	Lake Keowee	Keowee River	18,372	1,000,000	Power Recreation Water Supply
5	Lake Jocassee	Keowee River	7,565	1,185,000	Power Recreation
6	Lake Secession	Rocky River	880	19,360	Power Recreation Water Supply
7	Lake Tugaloo	Tugaloo River	300	18,000	Power Recreation
8	Broadway Lake	Rocky River	300	1,800	Recreation
9	Stevens Creek Lake	Savannah	--a	17,700	Power Recreation
10	Cherokee Lake	Cranes Creek of Little River	250	3,000	Recreation
11	Lake Yonah	Tugaloo River	200	6,400	Power Recreation

[a] -- indicates information not available.

Sources: S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1981b.

Table 129.
Existing and potential hydroelectric power development in the Upper Savannah River Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*[a]	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
12	Tugaloo	Oconee	Tugaloo	Georgia Power Co.	--[b]	45.0	300	Const. 1923
13	Yonah	Oconee	Tugaloo	Georgia Power Co.	--	22.5	200	Const. 1925
14	Rocky River	Abbeville	Rocky River	City of Abbeville	2	2.8	880	Const. 1940
15	Stevens Cr.	Edgefield	Savannah	SCE&G	8	18.9	--	Const. 1952
16	Clarks Hill	McCormick	Savannah	COE	7	280.0	70,000	Const. 1954
17	Lake Hartwell	Anderson	Savannah	COE	4	264.0	56,000	Const. 1962
18	Lake Jocasseec	Oconee	Keowee	Duke Power Co.	4	610.0	7,565	Const. 1974
19	Lake Keowee	Oconee	Keowee	Duke Power Co.	1	140.0	18,372	Const. 1971
20	Dan River #1	Pickens	Twelvemile Creek	--	--	5.5	--	Potential
21	Dan River #2	Pickens	Twelvemile Creek	--	--	6.9	--	Potential
22	Lower Whitewater	Oconee	Whitewater R.	--	--	16.7	162	Potential
23	Richard B. Russell[c]	Abbeville	Savannah	COE	4	600.0	26,650	Under Const.
24	Bad Creek[c]	Oconee	Bad Creek	Duke Power Co.	4	1000.0	318	Under Const.

[a] SCE&G indicates S.C. Electric and Gas Company.
COE indicates U.S. Army Corps of Engineers.
[b] -- indicates information not available.
[c] Pumped storage facility.

Sources: Federal Power Commission, 1970.
S.C. Water Resources Commission, 1974.
U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1981b.
U.S. Army Corps of Engineers, 1982a.

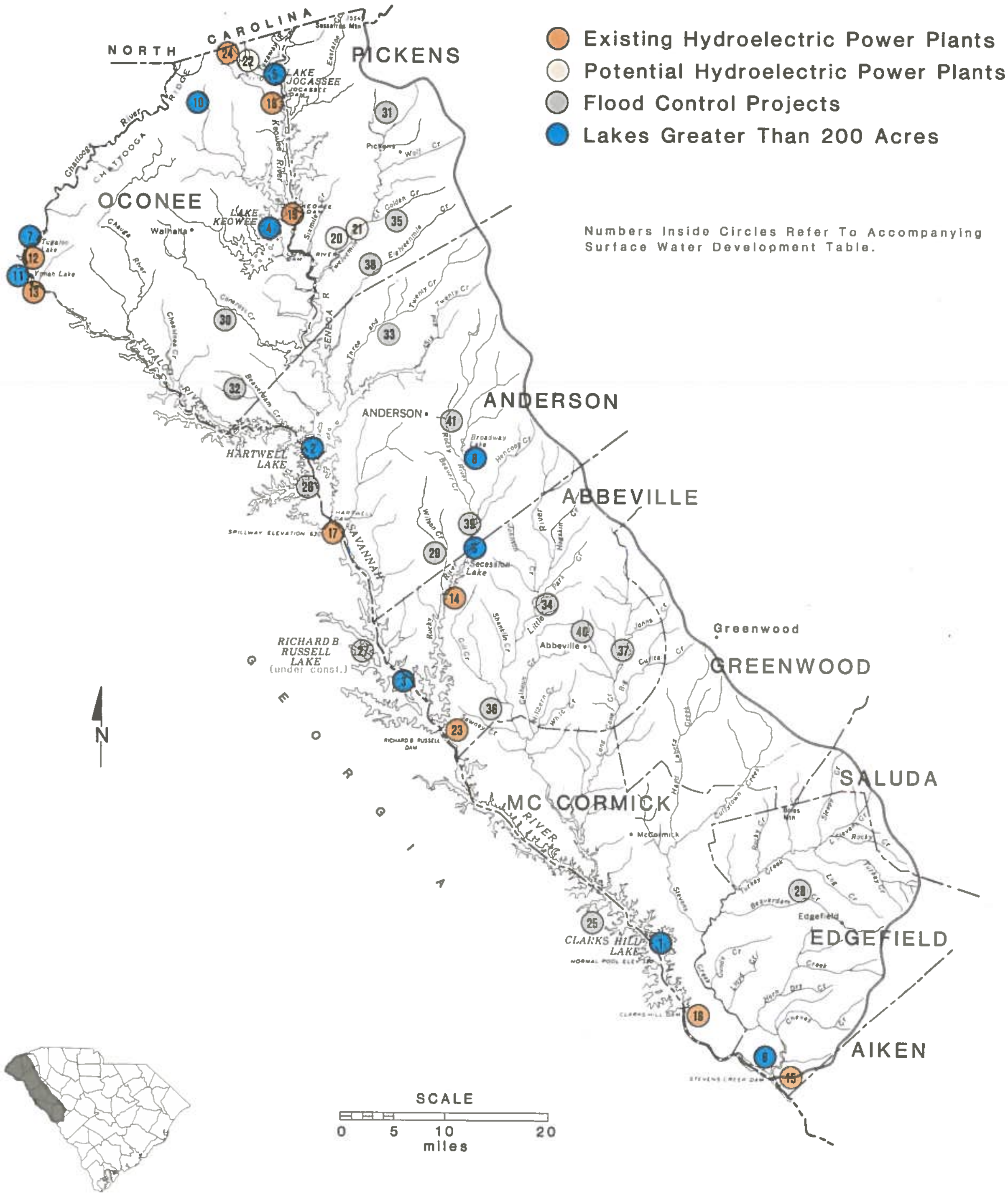


Figure 141.
Surface-water development in the Upper Savannah River Subbasin, South Carolina.

Table 130.
Flood control projects in the Upper Savannah River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency*[a]	*Status*
25	Clarks Hill Lake	McCormick	COE	Completed 1954
26	Hartwell Lake	Anderson/Oconee/Pickens	COE	Completed 1962
27	Richard B. Russell Lake	Anderson/Abbeville	COE	Under construction
28	Beaverdam Creek	Edgefield	SCS	Completed 1968
29	Wilson Creek	Anderson/Abbeville	SCS	Completed 1979
30	Coneross Creek	Oconee	SCS	Completed 1967
31	Twelvemile Creek	Pickens	SCS	Completed 1954
32	Beaverdam Creek	Anderson/Oconee	SCS	Under construction
33	Three and Twenty Creek	Anderson/Pickens	SCS	Under construction
34	Upper Savannah	Abbeville/McCormick	SCS	Terminated
35	Golden Creek	Pickens	SCS	Terminated
36	McKenley-Sawney Creeks	Abbeville	SCS	Terminated
37	Long Cane-Turkey Creeks	Anderson/Abbeville/Greenwood	SCS	Unserviced application
38	Eighteen Mile Creek	Pickens/Anderson	SCS	Terminated
39	Rocky River	Anderson	SCS	Terminated
40	Norris Creek	Abbeville	COE	Study completed
41	Rocky River	Anderson	COE	Reconnaissance completed

[a] SCS indicates Soil Conservation Service.
COE indicates U.S. Army Corps of Engineers.

Sources: U.S. Department of Agriculture, 1980, 1983.
U.S. Army Corps of Engineers, 1982c.

sites with a total potential generating capacity of 17.2 MW (Long, 1980).

There are no navigation projects within the sub-basin.

The Soil Conservation Service has been active with flood control projects in the upper reaches of the sub-basin, particularly in Oconee, Pickens, and Anderson Counties. One of the most important factors making the projects possible is the high level of citizen involvement. Farmers and landowners of Anderson, Pickens, and Oconee Counties organized the Upper Savannah Soil Conservation District in 1937, the second such district in the United States. Today this one district has been divided up into separate soil and water conservation districts.

In 1954, the Twelvemile Creek pilot project, which included the State's first floodwater retarding structure, was completed by the Soil Conservation Service. The project was considered a great success and prompted many additional projects. Since that time three other projects have been completed, which included 20 floodwater retarding structures and 52.8 miles of channel improvement. Many other projects are under construction or are in various stages of planning.

The large reservoirs built by the U.S. Army Corps of Engineers have been important in reducing flooding on the Savannah River by providing floodwater storage, thus greatly reducing peak flows. All flood control projects and studies are presented in Table 130.

Water Quality

All major impoundments and main stem rivers in the Upper Savannah River Sub-basin have Class A water use designations (Fig. 142). Streams tributary to these waters are primarily Class B waters. A few Class AA waters, those constituting outstanding recreational or ecological resources, occur in the upper portion of the sub-basin. Water quality limited segments which require advanced treatment of wastewater effluents include all or portions of Lake Keowee, Lake Hartwell, Clarks Hill Lake, Chattooga River, Three and Twenty Creek, Six and Twenty Creek, Sawney Creek, and several minor tributary streams (Fig. 143). Water quality in the major impoundments and main stem rivers usually meets standards for designated water use needs. However, tributary streams draining urbanized areas of the sub-basin may experience water quality problems sufficient to limit some water use activities.

The Chattooga River is the only designated National Wild and Scenic River in South Carolina. This river is widely recognized for its outstanding recreational and ecological importance and exhibits good to excellent water quality conditions (Georgia Department of Natural Resources, 1974, undated; S.C. Department of Health and Environmental Control, 1980b).

Water quality and quantity in the Savannah River below Lake Hartwell are greatly affected by discharges for hydropower generation. While water quality in this reach of the river is generally good, highly fluctuating flows and oxygen deficient discharges adversely affect some forms of aquatic life (Georgia Department of Natural Resources, 1974). Completion of the proposed Richard B. Russell Dam and Lake Project in 1985 will alter present water quality conditions and water use activities. The 26,650 acre impoundment will change the current cold water stream fishery to a cold and warm water lake fishery. Anticipated dissolved oxygen problems in the proposed lake may be corrected by oxygen enrichment of discharge waters from Hartwell Dam (U.S. Army Corps of Engineers, 1974).

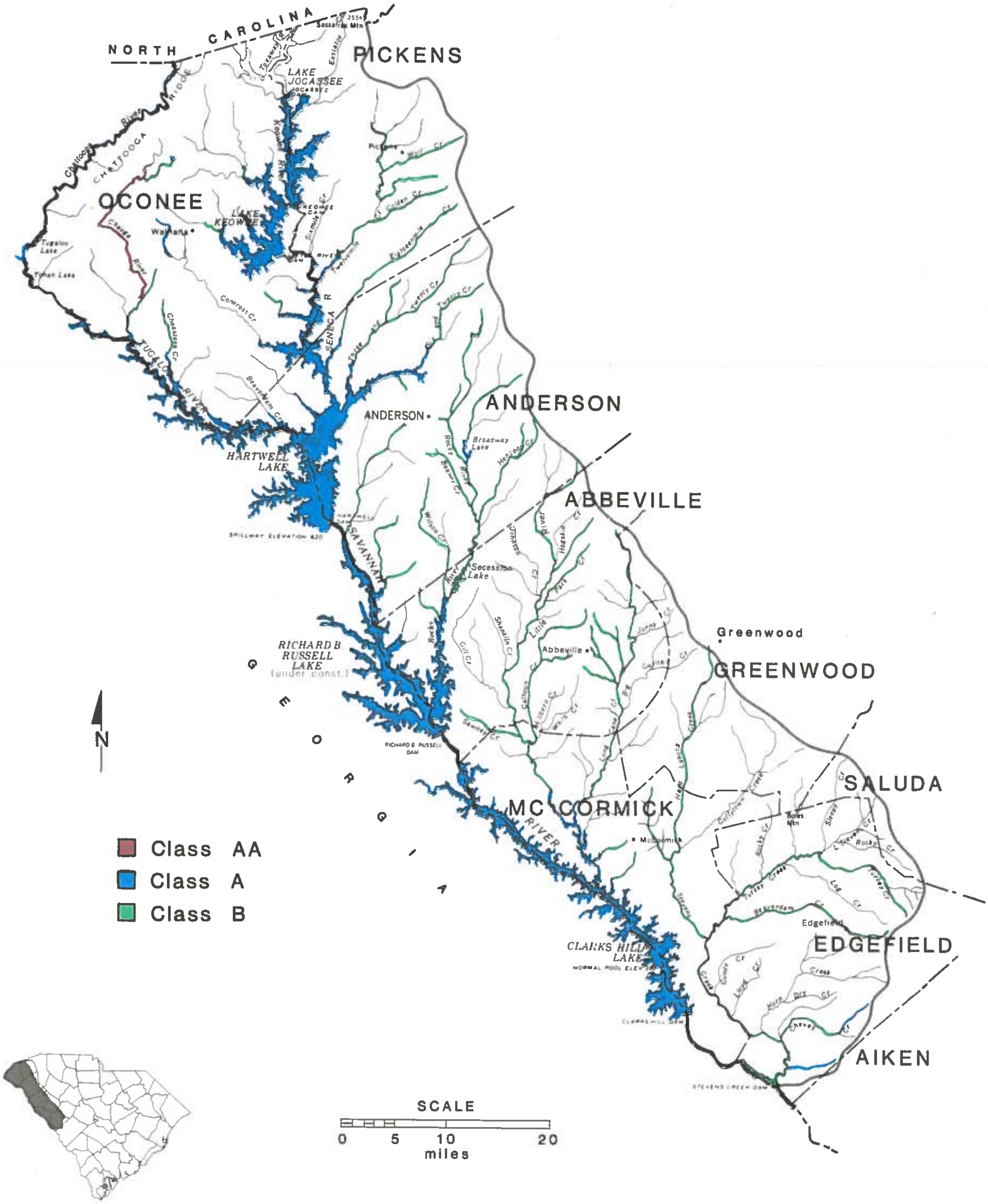


Figure 142.
Surface-water quality classifications in the Upper Savannah River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1980a).

Figure 143.
Water quality limited segments in the Upper Savannah River Subbasin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

A major tributary to this portion of the Savannah River is Rocky River. This river receives industrial and municipal wastewater from the Anderson metropolitan area and experiences elevated levels of biochemical oxygen demand, total phosphorus, fecal coliform bacteria, and metals (S.C. Appalachian Council of Governments, 1979). Secession Lake, an impoundment on Rocky River, has been characterized as eutrophic and ranked eleventh out of 13 South Carolina lakes surveyed for trophic quality (U.S. Environmental Protection Agency, 1976f). Approximately 75 percent of the phosphorus load entering this lake is attributed to point source discharges.

Lake Jocassee is an oligotrophic lake receiving little nutrient enrichment. Water quality data indicate good conditions with borderline good quality during portions of the year (S.C. Department of Health and Environmental Control, 1980b). Shortly after impoundment, excessive mercury concentrations were found in fish from this lake and an advisory was issued in 1975 restricting fish consumption. This water quality problem was attributed to slightly higher mercury levels in the soils underlaying the lake and the oligotrophic character of the lake. Recent monitoring indicates that fish mercury levels have declined to safe levels and all restrictions on fish consumption have been lifted (S.C. Department of Health and Environmental Control, 1980b).

Lake Keowee has been classified as mesotrophic indicating moderate nutrient loading. Prior to impoundment of Lake Jocassee, the U.S. Environmental Protection Agency (1975f) ranked Lake Keowee as the least eutrophic lake in the State and attributed all phosphorus loading to non-point sources. Water quality in this lake is considered good with no apparent trends (S.C. Department of Health and Environmental Control, 1980b).

Lake Hartwell is a mesotrophic lake and ranks second in trophic quality below Lake Keowee (U.S. Environmental Protection Agency, 1975g). Phosphorus loading to the lake is divided equally between point and non-point sources. Overall water quality in Lake Hartwell is good with a trend toward improving water quality in terms of temperature and nutrients (S.C. Department of Health and Environmental Control, 1980b). A major water quality problem that impacts recreational use of Lake Hartwell is the occurrence of high concentrations of polychlorinated biphenyls (PCB's) in fish from certain areas of the lake. A statewide study of toxic substances in fish tissue found that, with one exception, all fish with PCB concentrations in excess of U.S. Food and Drug Administration recommended consumption levels came from Lake Hartwell and Twelvemile Creek, a tributary stream (Aldridge, 1978). Due to these high PCB levels the S.C. Department of Health and Environmental Control and the U.S. Environmental Protection Agency issued a joint advisory in 1976 restricting the consumption of fish from Lake Hartwell and Twelvemile Creek. The source of this toxic pollutant was identified and the industrial discharger involved has since eliminated the use of PCB's. While recent monitoring indicates decreasing levels of PCB's in fish, restrictions on fish consumption continue in effect for areas of the lake above S.C. Highway 24 (S.C. Department of Health and Environmental Control, 1980b).

Clarks Hill Lake exhibits fair to good water quality. Regular blue green algal blooms, however, indicate some nutrient enrichment (S.C. Department of Health and Environmental Control, 1980b).

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout the sub-basin ranges from the field data level in the southeastern region to the reconnaissance level in the northwestern region (Fig. 18). Adequate hydrogeologic information is not available to evaluate the potential of ground water as a supply source throughout the sub-basin. Additional specific and more intense studies are needed to evaluate the full ground-water potential.

The Upper Savannah River Sub-basin lies within the Blue Ridge and Piedmont Province. The rocks of the Blue Ridge belt, Brevard fault zone, Inner Piedmont belt, Kings Mountain belt, Charlotte belt, Carolina slate belt, and Kiokee belt are represented. The sub-basin extends from the western most part of the State to the Fall Line.

Reports describing the hydrologic and geologic conditions of Oconee, Pickens, and Anderson Counties have been published (Johnson and others, 1960; Snipes, 1981). The area is underlain by crystalline rocks which are highly folded, creating some large faults (Secor and others, 1968). The faults in the region range in length from less than one mile to as much as ten miles; widths range from 15 feet to about 12,000 feet. The fault zones are highly fractured and have been partially filled with quartz since their occurrence. However, the remaining openings in the faults provide storage and transmission routes for water. Wells within these fracture zones yield 10 to 500 gpm, while nearby wells outside the zone often yield one gpm or less (Boyter, 1979). Additional work is needed to better identify and map these fault zones.

There have been few hydrologic investigations in Oconee County. Basic hydrologic and geologic data from 103 wells in the county indicate that wells ranging in depth from 60 to 570 feet yield 5 to 500 gpm from the crystalline rock aquifers. Only a few of these wells yield 20 gpm or more. Eight of these wells range in depth from 100 to 355 feet and yield 20 to 500 gpm.

Abbeville, Greenwood, and Saluda Counties are also underlain by the crystalline rock of the Piedmont Province, but data are inadequate to properly assess the ground-water resource in the area. Generally, yields are poor to moderate, depending on the amount of cleavage or foliation in the rock and the number of fractures intercepted by the well. Existing wells in the area range from less than 20 feet deep to as much as 350 feet deep; yields vary from as little as one gpm to 150 gpm in parts of Saluda County. Average yields can be expected to be about 10 to 20 gpm.

McCormick County is underlain by rocks of the Charlotte, Carolina slate, and Kiokee belts. These types of rock generally do not yield large quantities of water to wells. Available data on 14 wells indicate yields of 30 to 65 gpm and a range in depth from 175 to 320 feet. One well, 37 feet deep and developed in the floodplain of the Savannah River, yields 90 gpm. Data from two additional wells in McCormick County indicate one well, which is 130 feet deep, yields 47 gpm from fractures in granitic rock reported at depths of 55, 90, and 125 feet. The other well is 300 feet deep and yields 15 gpm from fractures at depths of 75 and 145 feet.

Edgefield County is underlain by rock of the Charlotte and Carolina slate, and Kiokee belts. Due to the heterogeneous nature of the occurrence of ground water in crystalline rocks, it is not unusual to have wells with fairly high yields in close proximity to "dry holes". Available records for Edgefield County include information on 74 wells with depths ranging from 42 to 720 feet and yields from 2 to 50 gpm.

Water Quality

The chemical composition of ground water is affected by the rock units with which it comes in contact and can be highly variable. Water samples from selected wells were found to contain from 17 to 127 mg/L of total dissolved solids; range in hardness from 4 to 82 mg/L; have iron contents of 0.1 to 0.86 mg/L; and have pH values of 5.5 to 7.4 (Johnson and others, 1968). The Stiff Diagrams in Figure 144 show that water from rock aquifers ranges from a calcium bicarbonate to a sodium bicarbonate to a calcium sulfate type.

WATER USE

Presently, gross water use in the Upper Savannah River Sub-basin is 2,080 mgd (Table 131), ranking this sub-basin first in the State for total gross demand. Thermoelectric power is the leading water use category (2,040 mgd) followed by public supply (25.1 mgd) and self-supplied industry (7.54 mgd). Consumptive use is currently 28.6 mgd. Water users in this sub-basin depend heavily (99.7 percent) upon surface-water sources to supply their needs. Even after excluding the large use for thermoelectric power production, surface-water supplies 88 percent of total sub-basin demand. The major users by type and supply source are shown in Figure 145.

Total water use, total surface-water withdrawals, and total withdrawals for thermoelectric power production, are greater in this sub-basin than in other sub-basins of the State.

Public supply water use represents one percent of gross use and nine percent of consumptive use. Almost all of public supply water is withdrawn from surface-water sources. The majority of public supply systems are located in the upper portion of the sub-basin.

Self-supplied domestic water use accounts for less than one percent of gross use and 13 percent of consumptive use. All supply needs for this group are furnished from ground-water sources. Consequently, this user group is the largest ground-water user in the sub-basin, withdrawing 4.20 mgd from this single source.

Less than one percent of total gross demand is for agricultural water use needs. Irrigation accounts for 0.3 percent of gross use and almost 18 percent of consumptive use. When averaged over the five-month growing season,

Table 131.
Current and projected water use in the Upper Savannah River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			*1990*			*2000*			*2010*			*2020*		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	0.02	25.1	25.1	0.03	40.1	40.1	0.03	54.3	54.3	0.03	65.9	65.9	0.04	71.50	71.50
	Consumed	<0.01	2.51	2.51	<0.01	11.9	11.9	<0.01	20.4	20.4	<0.01	26.9	26.9	<0.01	30.6	30.6
Self-supplied Domestic	Gross	4.2	---	4.2	5.3	---	5.3	6.3	---	6.3	7.3	---	7.3	7.6	---	7.6
	Consumed	3.6	---	3.6	4.5	---	4.5	5.4	---	5.4	6.2	---	6.2	6.5	---	6.5
Agriculture Irrigation	Gross	0.01	2.3	2.3	0.04	6.3	6.3	0.06	9.5	9.6	0.09	12	12	0.11	15	15
	Consumed	0.01	2.3	2.3	0.04	6.3	6.3	0.06	9.5	9.6	0.09	12	12	0.11	15	15
Agriculture Livestock	Gross	0.55	0.63	1.2	0.63	0.72	1.4	0.71	0.82	1.5	0.81	0.93	1.7	0.93	1.1	2.0
	Consumed	0.55	0.63	1.2	0.63	0.72	1.4	0.71	0.82	1.5	0.81	0.93	1.7	0.93	1.1	2.0
Self-supplied Industry	Gross	0.96	6.58	7.54	1.10	7.57	8.67	1.21	8.32	9.53	1.34	9.16	10.5	1.47	10.1	11.6
	Consumed	0.18	1.22	1.40	0.20	1.40	1.60	0.22	1.54	1.76	0.25	1.69	1.94	0.27	1.87	2.14
Thermoelectric Power	Gross	---	2,040	2,040	---	2,101	2,101	---	2,164	2,164	---	2,229	2,229	---	2,296	2,296
	Consumed	---	17.6	17.6	---	29.0	29.0	---	47.9	47.9	---	79.1	79.1	---	130	130
Total	Gross	5.74	2,070	2,080	7.10	2,160	2,160	8.31	2,240	2,250	9.57	2,320	2,330	10.2	2,390	2,400
	Consumed	4.34	24.3	28.6	5.37	49.3	54.7	6.39	80.2	86.6	7.35	121	128	7.81	179	186

Figure 144.
Ground-water quality of selected aquifer systems and major inventoried wells in the Upper Savannah River Sub-basin, South Carolina.

Figure 145.
Location, type, and supply source of water users in the Upper Savannah River Sub-basin, South Carolina.

irrigation use equals 5.6 mgd, comprising 0.3 percent of total sub-basin use. Virtually all (99 percent) irrigation water comes from surface-water sources. Livestock needs represent less than 0.1 percent of gross use and almost four percent of consumptive use. Surface water supplies about 52 percent of livestock needs.

Water use for self-supplied industry accounts for 0.4 percent of gross use and five percent of consumptive use. This user group relies heavily (87 percent) on surface-water sources to supply their need. Industrial withdrawals occur primarily in the upper portion of the sub-basin.

Thermoelectric power water withdrawals represent the largest gross use (98 percent), the largest consumptive use (62 percent), and the largest surface water use (2,040 mgd) in the Upper Savannah Sub-basin. The single facility that represents this user group withdraws and discharges cooling water from Lake Keowee and does not significantly affect water availability downstream.

Gross water use in the Upper Savannah Sub-basin is projected to increase by 16 percent from current levels to 2,400 mgd in 2020. Consumptive use is expected to increase by 550 percent to 186 mgd. While thermoelectric power should show the largest increase in quantity (256 mgd), agricultural irrigation is anticipated to have the largest percentage increase (552 percent). Thermoelectric power will remain the major water user group (2,296 mgd) and surface water the major supply source in the sub-basin through 2020. The City of Greenville will tap Lake Keowee in 1985 for an initial 5 mgd with rights to as much as 90 mgd in 2020. The Saluda River public supply reservoirs are currently near their safe yield and the upper Savannah water supply is the most economical to use. The water transferred from Lake Keowee will be totally removed from this sub-basin.

WATER USE VERSUS AVAILABILITY

Minimum streamflow in the upper portion of the Savannah River is ample to supply all current and projected surface-water demand through 2020 (Fig. 146). Most surface-water users are located on tributary streams in the upper and extreme lower portion of the sub-basin (Fig. 145). Tributary streamflow in the upper sub-basin area should be adequate for demand year round; however, highly variable tributary flow in the lower portion of the sub-basin may limit surface-water withdrawals during the summer and fall months. Thermoelectric power is the largest gross and consumptive water use group, and location of these facilities on major reservoirs provides more than adequate cooling water supply now and in the foreseeable future.

In general, ground-water yields in this sub-basin are relatively low (less than 300 gpm) and are insufficient to meet large municipal, industrial, and irrigation demands. However, rural and suburban domestic needs are adequately met by supplies from shallow and intermediate aquifers. While present records indicate comparatively low yields per individual well, full potentials have not yet been determined since many wells are not constructed to obtain maximum yields.

Future availability of ground water in the sub-basin cannot currently be accurately estimated since the range in well yields is too large (1-300 gpm). However, the base flow of the Savannah River provides one method of calculating the future potential for ground-water availability. The flow of the Savannah River at Augusta, Georgia is about 3,000 mgd 99 percent of the time. This represents the minimum base flow of the stream where total flow is assumed to be ground-water discharge of about 0.41 mgd per square mile of basin area. This calculated ground-water discharge, adjusted to the South Carolina area of the drainage basin, (1,310 mgd) exceeds projected ground-water use in the year 2020 by about 130 times.

The greatest problem in developing ground water in the Upper Savannah River Sub-basin is limited individual well yields and high iron and fluoride concentrations at several locations.

Major water resource problems and opportunities in the sub-basin are summarized in Table 132.

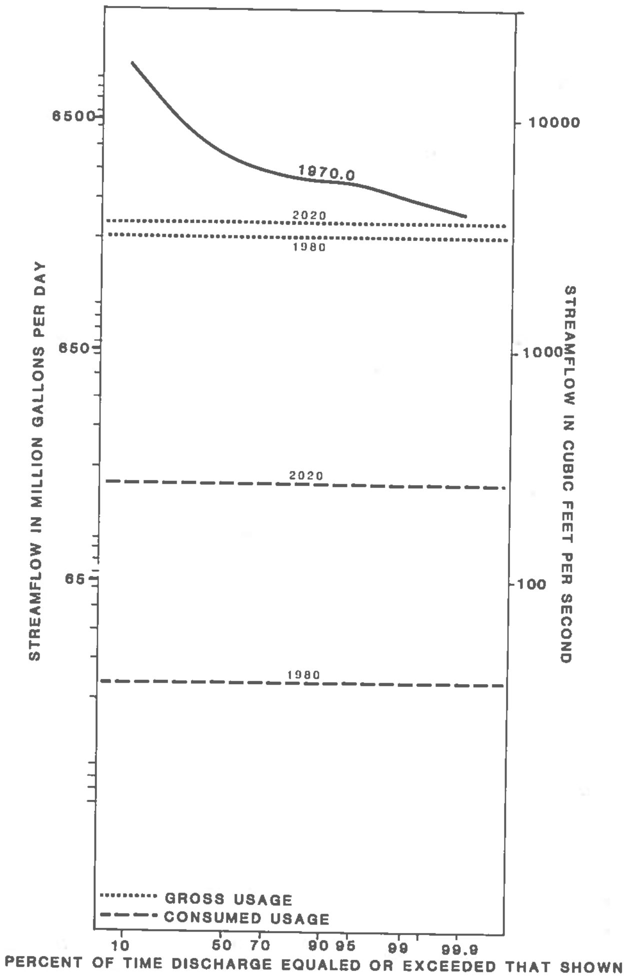


Figure 146.
Water use compared to availability in the Upper Savannah River Sub-basin, South Carolina.

Table 132.

Major water resource findings in the Upper Savannah River Sub-basin, South Carolina.

Opportunities

1. Surface-water supplies are more than adequate to meet current and projected surface-water demand.
2. Streamflow in the upper portion of the sub-basin is generally well-sustained year round and provides a reliable surface-water source.
3. The Chattooga River exhibits very good water quality and provides excellent recreational opportunities and is ecologically important.
4. Three hydroelectric power development sites have been identified in the sub-basin.
5. Ground water of generally good quality is available in limited quanity throughout the sub-basin.

Problems

1. Streamflow variability increases in the lower portion of the sub-basin where streams are less reliable surface-water sources.
2. Point and non-point sources of pollution from highly developed areas adversely impact streams and lakes in the upper portion of the sub-basin.
3. High concentrations of PCB's in fish have resulted in restricted consumption of fish from Lake Hartwell and Twelvemile Creek.
4. Projected increases in surface-water use for agricultural irrigation may result in water use conflicts in lower Piedmont streams.
5. Ground-water data are insufficient to adequately assess the resource.
6. Limited well yields occur from crystalline rock aquifers throughout the sub-basin and are insufficient to satisfy large municipal and industrial use.
7. High iron and manganese concentrations occur in several rock aquifers in the sub-basin.

Lower Savannah River Sub-basin

GENERAL OVERVIEW

The Lower Savannah River Sub-basin parallels the Savannah River along the western edge of the State. The sub-basin extends from the Edgefield-Aiken County border for approximately 125 miles to the coast. Portions of five South Carolina counties are included in the sub-basin: Aiken, Allendale, Barnwell, Hampton, and Jasper (Fig. 147). The areal extent of the sub-basin is approximately 1,295 square miles, 4.2 percent of the State's land area.

Population

The 1980 population of the sub-basin was estimated at 98,900, 3.2 percent of the State's total population (Table 133). By the year 2020 the sub-basin population is expected to reach 142,500, an increase of 44.1 percent. The largest population increase during this time period is expected to occur in Jasper County, with a 68.4 percent increase.

The sub-basin region is predominantly rural, with the exception of Aiken County, in which 60 percent of the population is classified as urban. Industrial complexes, such as the textile industry in Aiken County and the Savannah River Plant (Dupont) in Barnwell and Aiken Counties, have resulted in greater employment opportunities in the northern portion of the sub-basin than in the southern portion. The major cities in the sub-basin are Aiken (14,777) and North Augusta (13,451), both located in Aiken County.

Economy

Aiken County ranked fifth in the State in 1979 for per capita income, with $8,031, while Jasper County ranked 44th with a per capita income of $4,663. The 1980 median household income in Aiken County was $18,888, over $2,000 greater than the State average. Conversely, median household income in Jasper County was $10,833, much lower than the State average.

During 1979, the average annual employment of non-agricultural wage and salary workers in Aiken and Jasper Counties totaled 40,000. Compared to the State as a whole, the sub-basin has more than its share of manufacturing employees and less than its share of the remaining categories. The percentage breakdown by type of employment was: manufacturing, 49 percent; wholesale and retail trade, 14 percent; government, 14 percent; services and mining, 11 percent; construction 5 percent; transportation and public utilities, 4 percent; and finance, insurance, and real estate, 3 percent. An active textile industry in Aiken County comprises most of the manufacturing employment in the sub-basin.

In the sector of manufacturing, mining, and public utilities, the annual product value for Aiken County was $684.4 million during fiscal year 1978-79. Jasper County's annual product value was $4.3 million, the lowest in the State. Combined, these counties total 3.2 percent of the State's total annual product.

Agriculture is not economically dominant in this sub-basin, although Aiken County ranked ninth in the State for 1979 livestock receipts from farm marketings, with a total

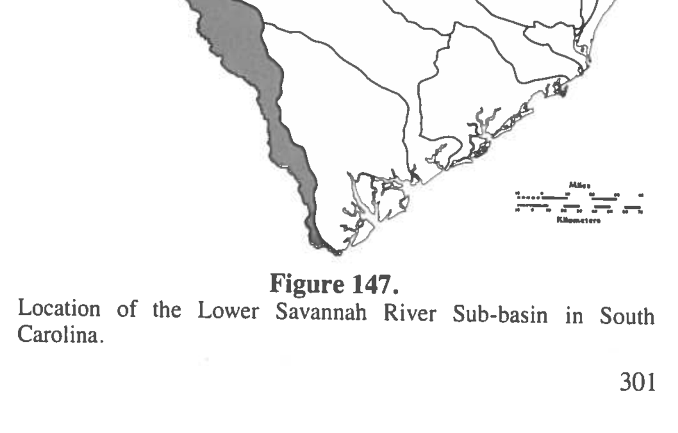


Figure 147.
Location of the Lower Savannah River Sub-basin in South Carolina.

Table 133.
Current and projected population for the Lower Savannah River Sub-basin, South Carolina, 1980-2020.

County	*% Population in Sub-basin*[a]	*Population (in thousands)* 1980	1990	2000	2010	2020	*% Change 1980-2020*
Aiken	85.5	90.6	105.8	116.6	125.5	130.2	43.7
Allendale	18.7	2.0	2.2	2.3	2.4	2.4	20.0
Barnwell	4.6	0.9	1.0	1.2	1.2	1.3	44.4
Hampton	8.7	1.6	1.8	2.0	2.1	2.2	37.5
Jasper	25.9	3.8	4.7	5.4	6.1	6.4	68.4
Total		98.9	115.5	127.5	137.3	142.5	44.1

[a] Estimated percent of total county population living within the hydrologic boundary of the sub-basin (S.C. Water Resources Commission, 1975).

Sources: S.C. Division of Research and Statistics, 1981.
S.C. Water Resources Commission, 1981.

of $13,431 million. Cash receipts from farm marketings in Aiken and Jasper Counties totaled almost $32 million, three percent of the State total.

SURFACE WATER
Hydrology

The lower portion of the Savannah River from the Fall Line to the Atlantic Ocean forms the main stem of this drainage system. Several small to moderate size tributary streams drain the Lower Savannah River Sub-basin. The largest of these occur in the Upper Coastal Plain region and include Horse Creek, Upper Three Runs Creek, and Lower Three Runs Creek. Tributary streams in the Middle and Lower Coastal Plain region are generally small, associated with swamplands, and follow ill-defined, meandering channels. Two large urban areas, Augusta-North Augusta and Savannah, Georgia, make extensive use of these flowing waters.

Streamflow in the sub-basin is presently monitored at 18 gaging stations (Fig. 148). Three of these stations are located on the Savannah River (1970, 1973.2, 1985) while all others are located on tributaries in and around the Savannah River Plant. Streamflow in the Savannah River has been regulated since 1951 by controlled releases from Clarks Hill Lake. Three gaging stations (1970, 1975, 1985) were in place before hydroelectric development upstream and reflect the combination of flow conditions before and after regulation. Controlled flows occur at all tributary gaging stations except for Upper Three Runs Creek near Ellenton (1973). Streamflow data for all stations, except those on regulated streams on the Savannah River Plant, are presented in Table 134. Peak high flows are recorded at one crest-stage station (1974.1) in the upper portion of the sub-basin.

Average annual streamflow in the Savannah River is 10,300 cfs at Augusta and increases to 12,200 cfs downsteam near Clyo, Georgia. Ninety percent of the time, streamflow at these sites should be at least 5,600 cfs and 6,800 cfs, respectively. Flow characteristics at all main stem gaging stations reflect controlled discharges from upstream hydroelectric power facilities. This streamflow regulation has resulted in higher and more well-sustained low flows as shown by the flow-duration curves for two gaged sites (1970, 1985) before and after regulation (Fig. 149). Streamflow in the upper portion of the main stem is generally more variable due to controlled releases but becomes more uniform downstream as inflow from tributary streams in the upper Coastal Plain region and the modifying effect of surrounding wetlands stabilize flow. These more even flows in the lower portion of the river are evidenced by the narrow range between minimum and maximum monthly flow (Fig. 148) and a more gently sloped flow-duration curve (Fig. 149) than at upstream stations. Low flow and flood flow of record on the Savannah River occurred prior to regulated flow. The record low flow (1,040 cfs) and flood flow (360,000 cfs) occurred at Augusta in 1927 and 1796, respectively.

The only gaged tributary stream, Upper Three Runs Creek, is located in the Upper Coastal Plain region and exhibits the characteristically well-sustained flows for streams in this physiographic province. Streamflow averages 112 cfs and should be at least 86 cfs, 90 percent of the time. Uniform flow and well-supported base flow from groundwater resources is evidenced by the almost flat flow-duration curve (Fig. 149), regular monthly flow pattern (Fig. 148), the high unit 7Q10 discharge value (0.67 cfs/mi^2), and a record low flow of only 66 cfs (Table 134). No data exist for tributary streams in the Middle and Lower Coastal Plain region of the sub-basin. However, streamflow characteristics for these streams are probably similar to those of other Middle and Lower Coastal Plain streams which exhibit highly variable flow and poorly sustained base flow during periods of low rainfall.

The Savannah River, along its entire length, provides large quantities of surface water year round and is a reliable source of supply. Tributary streams in the Upper Coastal Plain region are also a reliable source of surface water provided flow is of sufficient volume. Middle and Lower Coastal Plain streams are generally small and probably exhibit highly variable flows of limited volume. Year round use of these streams may require storage facilities to ensure adequate supplies especially during the summer months.

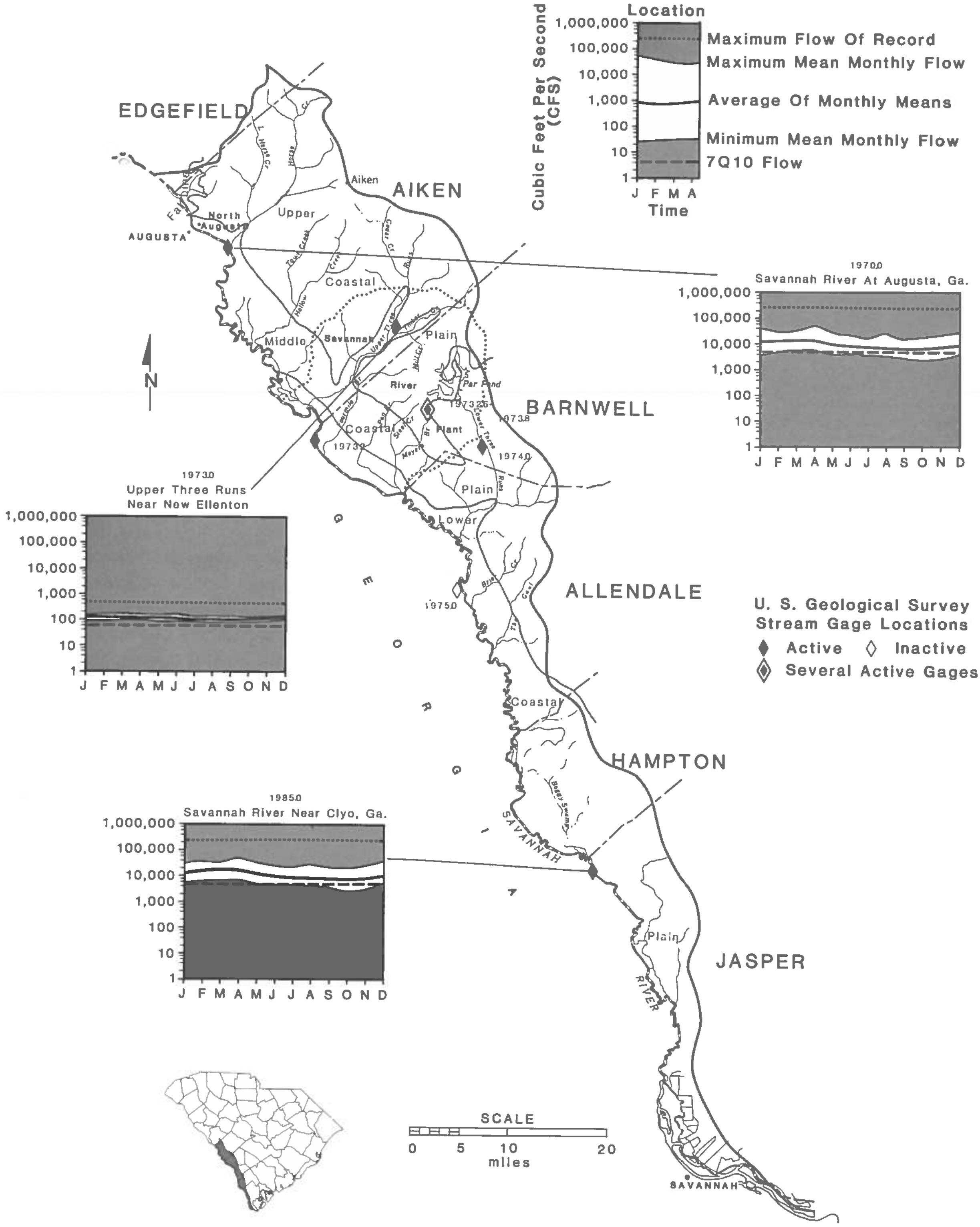


Figure 148.
U.S. Geological Survey streamflow gaging stations with hydrologic information for selected sites in the Lower Savannah River Sub-basin, South Carolina.

Table 134.
Selected streamflow characteristics at U.S. Geological Survey gaging stations in the Lower Savannah River Sub-basin, South Carolina.

Gaging Station		*Drainage Area*	*Period of Record*		*Average Flow*				
								7Q10[b]	
Number	*Name/Location*	*(mi²)*	*Dates*	*Total Years*	*cfs*	*cfs/mi²*	*90%*[a] *cfs*	*cfs*	*cfs/mi²*
1970	Savannah River at Augusta, Ga.	7,508	Oct 1883-Dec 1891; Jan 1896-Dec 1906; Jan 1925-Present	73	10,300	1.37	5,600	4,700	0.63
1973	Upper Three Runs near New Elleton	87.0	Jun 1966-Present	14	112	1.29	86	58	0.67
1973.2	Savannah River near Jackson	*[c]	Oct 1971-Present	9	*	*	*	*	*
1974	Lower Three Runs near Snelling	59.3	Mar 1974-Present	6	102	1.72	*	*	*
1975	Savannah River at Burtons Ferry Bridge, near Millhavan, Ga.	8,650	Oct 1939-Sep 1970	31	10,520	1.22	6,000	4,950	0.57
1985	Savannah River near Clyo, Ga.	9,850	Oct 1929-Sep 1933; Oct 1937-Present	47	12,200	1.24	6,800	5,800	0.59

[a] Flow equaled or exceeded 90 percent of the time.
[b] Seven day low flow with a 10 year recurrence interval.
[c] Minimum daily flow for period of record.
[d] Instantaneous maximum flow for period of record.
[e] * indicates data not available.
[f] Streamflow above 20,000 cfs.

Development

Surface-water development is somewhat limited in the Lower Savannah River Sub-basin (Fig. 150). Most development consists of navigation projects in the Savannah River from Savannah Harbor to Augusta, Georgia.

There is only one large lake within the sub-basin. Par Pond, located on Lower Three Runs Creek on the Savannah River Plant, has a surface area of 2,700 acres and a total volume of 54,000 acre-feet. All lakes larger than 200 acres are listed in Table 135.

The U.S. Army Corps of Engineer has identified seven potential hydropower sites along the lower stretch of the Savannah River. These sites would include low-head hydropower facilities and locks to allow navigation to Augusta while taking advantage of the run-of-river power potential. These potential sites are listed in Table 136 along with existing facilities. In addition, the S.C. Land Resources Conservation Commission has identified one potential small scale hydropower site with a generating capacity of 0.2 MW (Long, 1980).

The entire lower portion of the Savannah River is included in two U.S. Army Corps of Engineers navigation projects. One project involves Savannah Harbor while the other provides for a nine foot deep channel from Savannah Harbor to Augusta, Georgia. This provides the only inland commercial navigation in the State. Details of these projects are presented in Table 137.

There are no completed flood control projects in the sub-basin, although the U.S. Army Corps of Engineers has completed reconnaissance studies of two problem areas in Aiken County, Sand River and Horse Creek. Table 138 presents details of these studies.

Water Quality

The majority of streams draining the Lower Savannah River Sub-basin in South Carolina, including the entire stretch of the Savannah River, are designated Class B waters (Fig. 151). Only portions of tributary streams are designated Class A. Water quality limited segments in this sub-basin which require advanced treatment of wastewater discharges include portions of all of Horse Creek, Par Pond, Lower Three Runs, Savannah River, and several minor tributary streams (Fig. 152). Water quality conditions are generally adequate for most water use designations. Water quality problems in the Augusta-North Augusta area, however, continue to restrict some water use activities.

The Savannah River and tributary streams near the Augusta-North Augusta area have historically experienced severe water quality problems (U.S. Environmental Protection Agency, 1972; Georgia Department of Natural Resources, 1974). Water quality conditions in Horse Creek, which receives large amounts of industrial and municipal wastewater discharge, have regularly contravened State standards and posed a health hazard to area residents (U.S. Environmental Protection Agency, 1972). Water quality conditions which have impacted Horse Creek include elevated levels of fecal coliform bacteria and metals, problem pH levels, and severely depressed dissolved oxygen concentrations (U.S. Environmental Protection Agency, 1972; S.C. Department of Health and Environmental Control, 1975c). The North Augusta area was one of the first in the State to receive Federal Municipal Construction Grants funding and construct improved wastewater treatment facilities. As a result, water quality has improved significantly in recent years, although some problems still exist. More recent evaluations indicate that water quality in the Savannah River is generally good and progressively improves downstream from the Augusta-North Augusta area (Georgia Department of Natural Resources, undated; S.C. Department of Health and Environmental Control, 1980b).

The U.S Department of Energy's Savannah River Plant, which produces nuclear materials for the U.S. Department of Defense, discharges reactor cooling water and other wastewater effluent into Par Pond, Beaver Dam Creek, Four Mile Creek, and Pen Branch. Water temperatures of

Table 134 (Continued)

Extreme Flows			
Minimum[c]		*Maximum*[d]	
cfs	*Dates*	*cfs*	*Date*
1,040	Oct 2, 1927	360,000	1796
66.0	Sep 14, 1969	420	Aug 17, 1971
5,770	Jan 2, 1979	--[f]	Apr 1, 1980
24	Jul 16, 17, 1980	735	Mar 13, 1980
2,120	Sep 9, 1951	141,000	Aug 18, 1940
1,950	Sep 27, 1931	270,000	Oct 6, 1929

streams on the Savannah River Plant property which receive thermal effluent from reactors are often in excess of State water quality standards for temperature. Water temperatures in Beaver Dam Creek and Four Mile Creek are high and detrimental to aquatic life. Beaver Dam Creek, which receives the smallest thermal effluent, has a mean temperature of 74.3°F (23.5°C) with a maximum temperature in 1981 of 92.3°F (33.5°C) (U.S. Geological Survey, 1981). Temperatures in Four Mile Creek average 79.7°F (26.5°C) with a maximum temperature of 104°F (40.0°C) (U. S. Geological Survey, 1981). Discharges from these tributaries appear to have little adverse impact on the quality of the Savannah River (E.I. Dupont Co., 1981). The greatest impacts occur during the summer when streamflows are naturally low and water temperatures high. Current Savannah River Plant operations cause a 1- in -10 year maximum increase in Savannah River water temperature of 2.9°F (1.6°C) (U.S. Department of Energy, 1982).

Reactor operations have also resulted in the discharge and accumulation of radioactive materials in receiving streams on the Savannah River Plant property. Tritium is the major radioactive material being discharged to tributary streams (E.I. Dupont Co., 1981). Average annual tritium concentrations in the Savannah River (4.1 pCi/ml) are within the U.S. Environmental Protection Agency guidelines for drinking water (20 pCi/ml). Trace amounts of strontium and cesium have also been detected in Savannah River water but are generally below detectable levels (E.I. Dupont Co., 1981). Radiocesium (Ce-137) is strongly associated with sediments in Steel Creek due to previous discharges from fuel element storage basins. Concentrations of 1200 ± 716 pCi/g have been detected in suspended solids (U.S. Department of Energy, 1982). Acculations of radiocesium may also be present in sediments of other effluent receiving streams.

The Savannah River near the City of Savannah exhibits generally good water quality (Georgia Department of Natural Resources, undated; S.C. Department of Health and

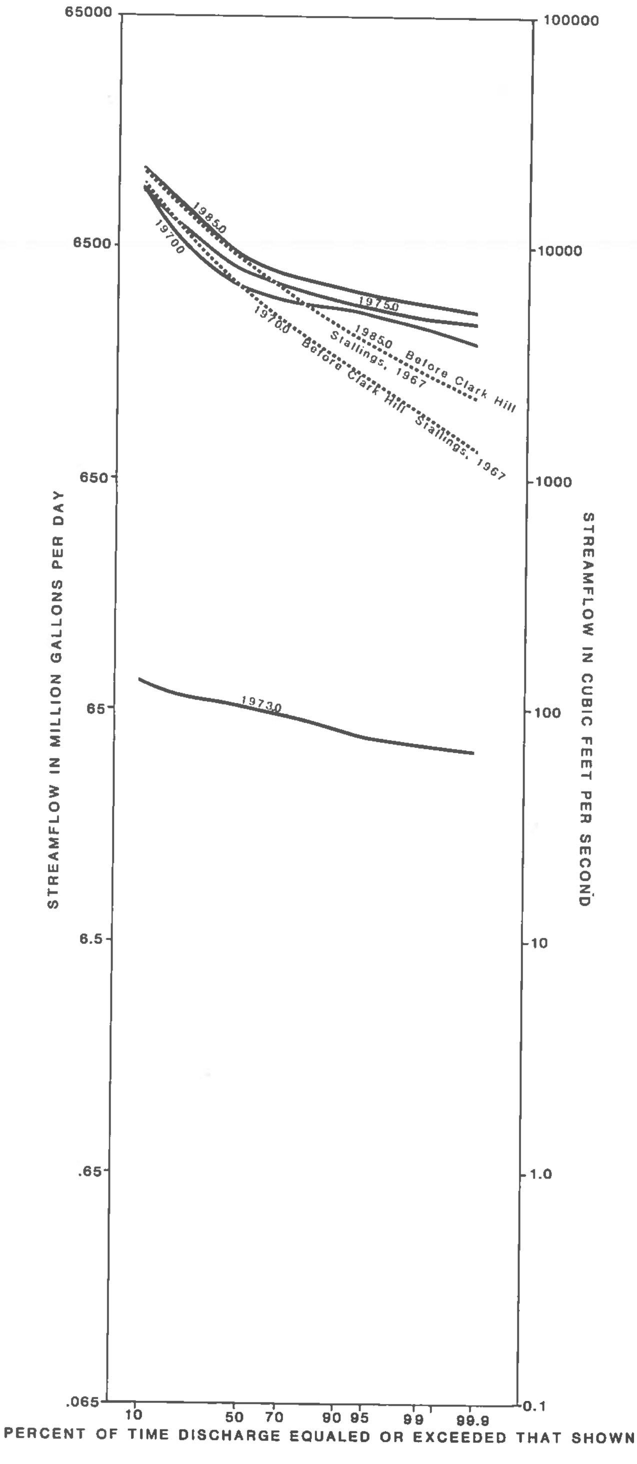


Figure 149.
Flow-duration curves for selected U.S. Geological Survey streamflow gaging stations in the Lower Savannah River Sub-basin, South Carolina.

Table 135.
Existing lakes larger than 200 acres in the Lower Savannah River Sub-basin, South Carolina.

Map No.	*Name*	*Stream*	*Surface Area (acres)*	*Storage Capacity (acre-feet)*	*Purpose*
1	Par Pond	Lower Three Runs Creek	2,700	54,000	Industry
2	Horse Creek Pond (Langley Pond)	Horse Creek	250	1,250	Industry

Source: S.C. Water Resources Commission, 1974.

Table 136.
Existing and potential hydroelectric power development in the Lower Savannah River Sub-basin, South Carolina.

Map No.	*Facility/Site Name*	*Facility/Site Location*		*Owner*	*No. of Units*	*Total Capacity (MW)*	*Surface Area (acres)*	*Status*
		County	*River*					
3	Graniteville	Aiken	Horse Creek	Graniteville Mills	1	0.45	--[a]	Const. 1938
4	Vaucluse	Aiken	Horse Creek	Graniteville Mills	1	0.24	--	Const. 1918
5	New Savannah Bluff	Aiken	Savannah	--	--	23.7	--	Potential
6	Eagle Point	Aiken	Savannah	--	--	21.5	3,871	Potential
7	Steel Creek	Barnwell	Savannah	--	--	22.2	11,672	Potential
8	Low Johnson's Landing	Allendale	Savannah	-- --	--	23.3	869	Potential
9	Lookout Point	Allendale	Savannah	--	--	24.9	2,990	Potential
10	Bull Pen Point	Hampton	Savannah	--	--	12.8	51	Potential
11	Low Stokes Bluff	Hampton	Savannah	--	--	13.3	3,376	Potential

[a] -- indicates information not available.

Sources: Federal Power Commission, 1970.
U.S. Army Corps of Engineers, 1981a.
U.S. Army Corps of Engineers, 1982a.

Table 137.
U.S. Army Corps of Engineers navigation projects in the Lower Savannah River Sub-basin, South Carolina.

Map No.	*Project Name*	*County*	*Responsible District*	*Length (miles)*	*Width (feet)*	*Status/Remarks*
12	Savannah Harbor	Jasper	Savannah	21.3	200-600	Project provides 40 foot deep channel through the jetties, and then 38 foot deep channel to Kings Island turning basin, and then 36 foot deep channel to the Argyle turning basin. From this point it is 30 feet deep to mile 21.3. The project is complete and a study is underway to consider further channel dredging.
13	Savannah River	Aiken Barnwell Allendale Hampton Jasper	Savannah	181.3	---[a]	Project provides for a 9 foot deep channel from the upper Savannah Harbor to August, Ga. Project is complete.

[a] -- indicates information not available.

Source: U.S. Army Corps of Engineers, 1982b.

Table 138.
Flood control projects in the Lower Savannah River Sub-basin, South Carolina.

Map No.	*Project/Watershed Name*	*County*	*Responsible Agency[a]*	*Status*
14	Sand River	Aiken	COE	Reconnaissance Complete
15	Horse Creek	Aiken	COE	Reconnaissance Complete

[a] COE indicates U.S. Army Corps of Engineers.

Source: U.S. Army Corps of Engineers, 1982c.

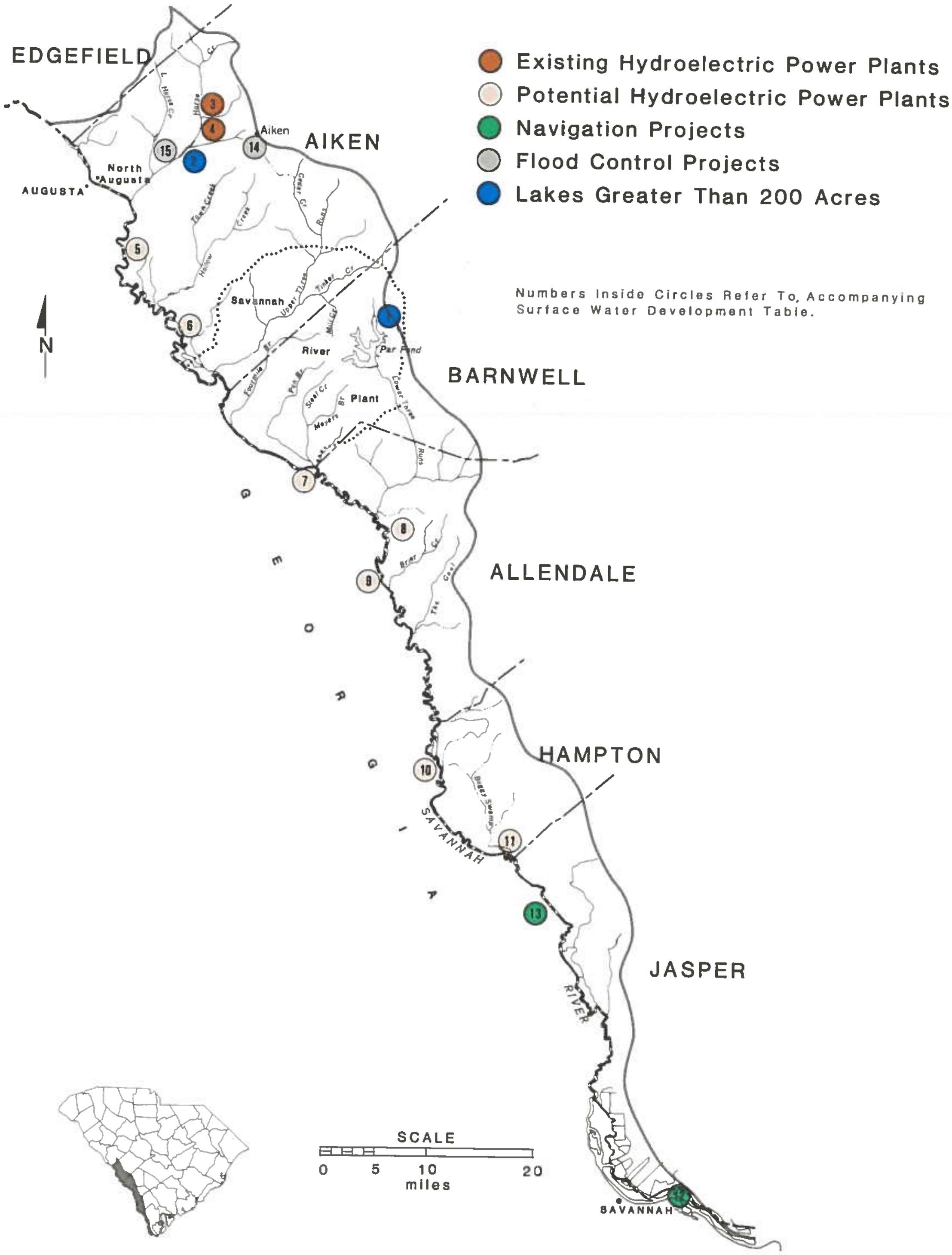


Figure 150.
Surface-water development in the Lower Savannah River Subbasin, South Carolina.

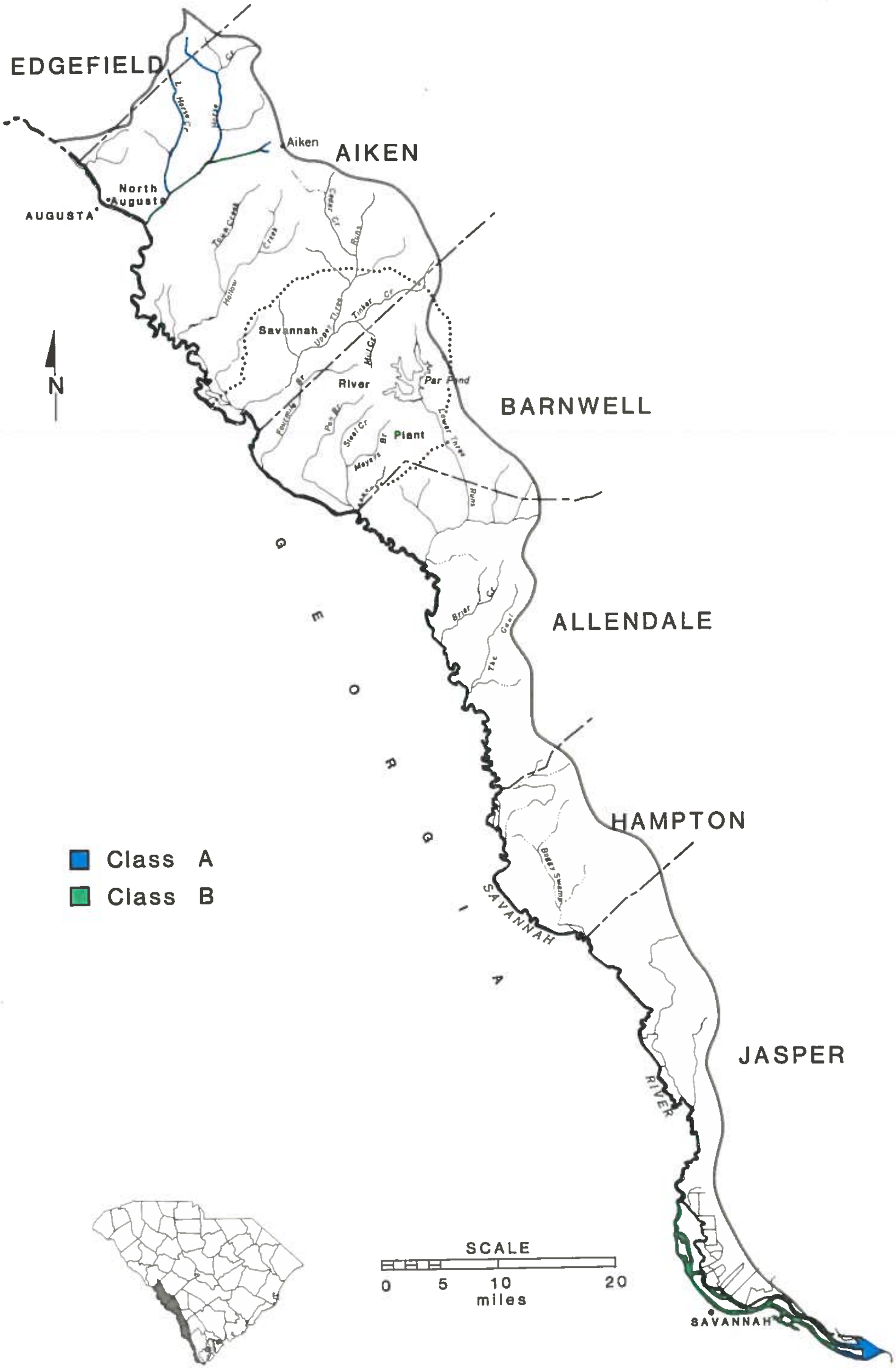


Figure 151.
Surface-water classifications in the Lower Savannah River Subbasin, South Carolina (S.C. Department of Health and Environmental Control 1980a).

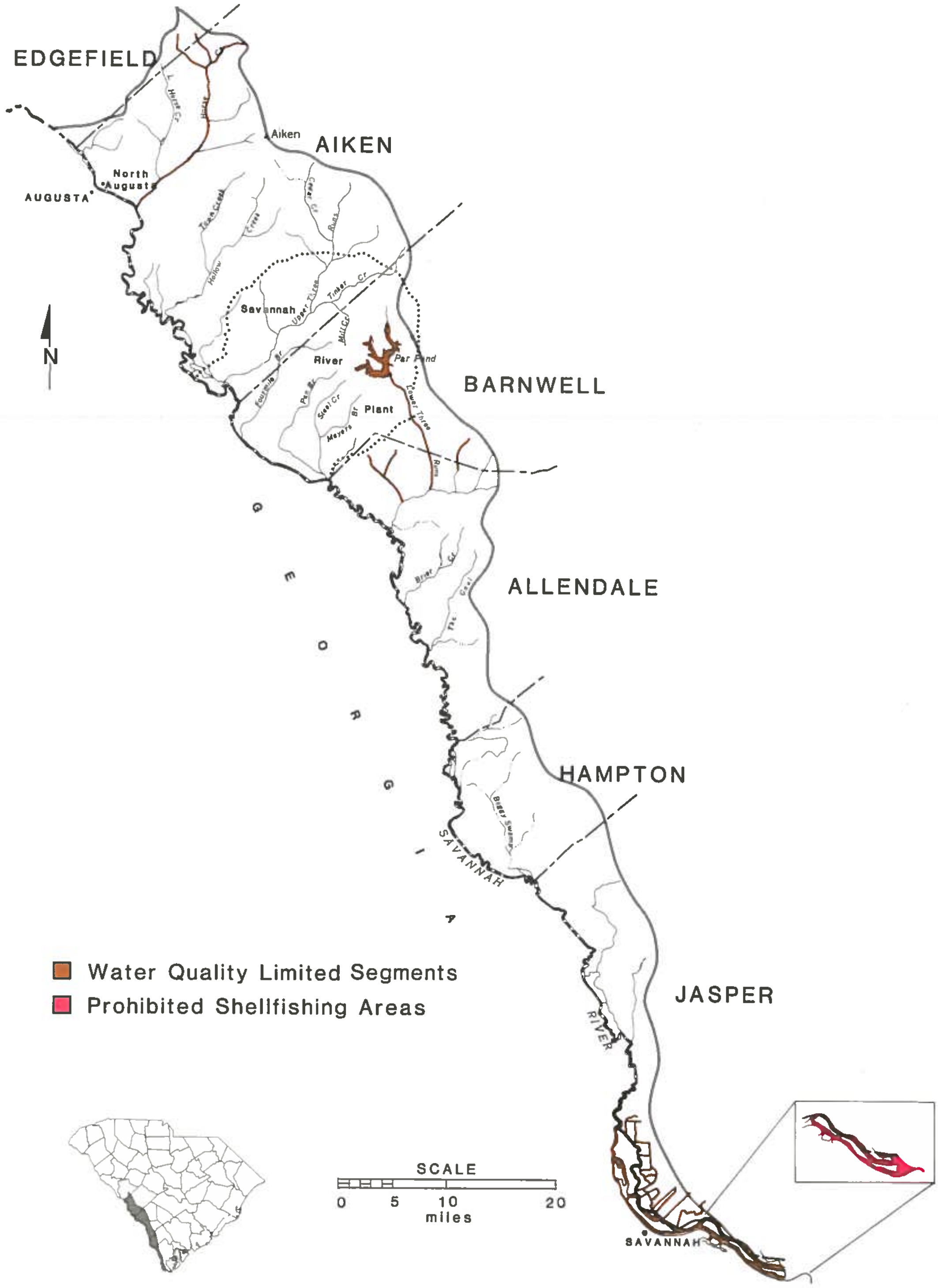


Figure 152.
Water quality limited segments and prohibited shellfishing areas in the Lower Savannah River Sub-basin, South Carolina (S.C. Department of Health and Environmental Control, 1979).

Environmental Control, 1980b). Occasional water quality problems that occur in this area include depressed pH and dissolved oxygen levels. These problems have been attributed to effects from local swamp drainage and point source discharges from Georgia (S.C. Department of Health and Environmental Control, 1980b). Increased penetration of saltwater up the Savannah River since 1939 due to river channel modification and flow regulation by upstream impoundments has caused contraventions of drinking water standards in the upper Savannah River estuary. Consequently, future drinking water withdrawals from this portion of the river may have to be curtailed (Georgia Department of Natural Resources, 1981). Shellfish grounds in the lower portion of the Savannah River (Fig. 152) have been closed due to elevated fecal coliform bacteria levels.

GROUND WATER

Hydrogeology

The level of hydrogeologic knowledge throughout the sub-basin ranges from the field data level in Allendale County to the development level in the Savannah River Plant vicinity and coastal parts of Jasper and Beaufort Counties (Fig. 18). Because a large part of this sub-basin occurs along the floodplain of the Savannah River and is uninhabited, hydrogeologic data for this area are not readily available.

The Lower Savannah River Sub-basin lies almost entirely in the Coastal Plain Province and is generally underlain by the same aquifer systems that occur throughout the Coastal Plain of South Carolina. The systems originate southeast of the Fall Line and dip toward the coast. The bottom-most aquifer system is the Middendorf, which first occurs at a depth of 50 to 100 feet below the ground-surface in the upper extent of the sub-basin and deepens to approximately 2,500 feet in southern Jasper County. The Middendorf Aquifer System ranges in thickness from 0 to 1,500 feet from the upper to the lower extent of the sub-basin. Overlying the Middendorf Aquifer System in the northern portion of the sub-basin is a system of undetermined extent called the Ellenton. Further southeast, the Ellenton is separated from the Middendorf Aquifer System by the Black Creek and Peedee Aquifer Systems and is overlain by the Black Mingo, Congaree, McBean, Barnwell, Tertiary Limestone, and Shallow Aquifer Systems. The geographical extent of these systems vary somewhat in each county of the sub-basin. Selected ground-water data for the sub-basin are presented in Table 139.

Hampton and Jasper Counties are underlain by the Middendorf, Black Creek, Peedee, Black Mingo, Tertiary Limestone, and Shallow Aquifer Systems. Few wells tap the Middendorf, Black Creek, and Peedee Aquifer Systems in this two-county area of the sub-basin because of the greater depth and in some cases the poorer water quality of these aquifer systems, especially near the coast. A few large wells in Hampton County, however, withdraw water in excess of 1,000 gpm from the Black Creek Aquifer System. The Black Mingo Aquifer System in Hampton County occurs at a depth of approximately 600 to 800 feet and wells thought to be screened in this system naturally flow at 50 to 250 gpm. Hydrogeologic information is not available for this aquifer system in Jasper County. The Tertiary Limestone Aquifer System is the primary source of ground water in these two counties. Wells taping this system range from 50 to 250 feet deep and yield 50 to 2,500 gpm. However, most wells in Hampton and Jasper Counties do not penetrate the full thickness of the aquifer systems, so consequently the wells produce less than the maximum possible yields. Maximum potential yields from the Tertiary Limestone Aquifer System are in excess of 1,000 gpm throughout most of the Jasper County and Hampton County portion of the sub-basin (Hayes, 1979). Heavy pumping by the City of Savannah, Georgia has adversely impacted well yields in this southern portion of the sub-basin. Since 1880, ground-water levels in the Tertiary Limestone Aquifer System have declined 10 feet in Hampton County and over 100 feet in Jasper County near Savannah (Hayes, 1979). The water-bearing characteristics of the Shallow Aquifer System in this sub-basin are not known although this is an important source of domestic ground water.

The major aquifer systems underlying Aiken and Barnwell Counties are the Middendorf, Ellenton, and the Tertiary Sand. The Middendorf Aquifer System underlies the two county area and is the principal aquifer. At sites close to the Fall Line where overlying sand deposits become very

Table 139.
Selected ground-water data for the Lower Savannah River Sub-basin, South Carolina.

Vicinity	*Aquifer System*	*Screened Depths (feet)*	*Yield (gpm)*	*Specific Capacity (gpm/ft)*
Aiken County	Middendorf	30-500	20-800	--[a]
Savannah River Plant	Middendorf	200-800	370-1870	--
Williston	Tertiary Sand	100-150	200	--

[a]--indicates data not readily avialable.

thin, the Middendorf Aquifer System produces less water than in other areas farther south and east. A well for the City of Aiken reached basement granite at a depth of 517 feet below land surface. The transmissivity determined from aquifer tests in wells in Aiken County ranges from 13,400 to 53,500 ft²/day and the storage coefficient ranges from 0.0002 to 0.0008. A test hole located near the center of the Savannah River Plant reached basement at 696 feet below mean sea level. Triassic rocks (basement) were reached at 1,044 feet below mean sea level in a well in the southern portion of the Savannah River Plant. The Middendorf and the overlying Ellenton Aquifer System are geologically distinguishable but ground water in some areas moves freely between the two formations. One test well located within the Savannah River Plant is screened partly in the Ellenton and partly in the Middendorf Aquifer System and yields 540 gpm with an estimated transmissivity of 8,500 ft²/day. A nearby well pumped at a rate of 560 gpm indicated an estimated transmissivity of 12,000 ft²/day. Another test well screened in the Middendorf Aquifer System yields 1,500 gpm and has an estimated transmissivity of 12,000 ft²/day (Siple, 1967).

The water level in the Middendorf Aquifer System has been observed since 1954 and no significant changes have occurred except in very localized areas of heavy pumpage. At the Savannah River Plant, heavy withdrawals (4,500 gpm) have resulted in water-level declines of over then feet since 1972. Pumping tests indicate that wells spaced 2,000 feet apart will be capable of developing yields of 3,000 gpm each.

The Ellenton Aquifer System is penetrated by a well located four miles northeast of Ellenton. At that location, the formation is 60 feet thick and occurs between the depths of 310 and 370 feet below land surface. This aquifer is tapped by wells as far south as central Allendale County and as far north as Salley in northern Aiken County. There is evidence that its occurrence is considerably more widespread than this but it has not been mapped in detail to date (David Prowell, U.S. Geological Survey, verbal communication, 1983).

The Tertiary Sand Aquifer System, composed of the Congaree, McBean, and Barnwell Formations overlies the Ellenton Aquifer System. Its thickness ranges from about 125 feet in the northwestern part of the Savannah River Plant to about 400 feet in the southeastern part near the Allendale County line. Yields of wells tapping aquifers in the McBean and Congaree Formations range from 60 to 660 gpm in the Savannah River Plant area. The Barnwell Formation in Aiken and Barnwell Counties thickens from a feather edge in the northern part of Aiken County to approximately 90 feet at the southeastern boundary of Barnwell County. Because aquifer boundaries do not always coincide with formational boundaries water in the Barnwell aquifer may be in hydraulic continuity with that of the McBean aquifer.

Water Quality

The ground water from the Middendorf Aquifer System is soft and low in total dissolved solids and iron content. Low pH values make water from the Middendorf Aquifer System corrosive to most metal surfaces. Waste disposal at the Savannah River Plant has had an impact on ground-water quality in the Middendorf Aquifer System. Two production wells, penetrating the Middendorf have been abandoned because of high levels of organic contaminants (Triclene, Perclene, TCE) (Pat Shirley, S.C. Department of Health and Environmental Control, personal communication). The presence of metals, nitrates, and radioactive materials in the soil profile and shallow ground water also presents a potential for the contamination of underlying aquifers and the migration of the contaminants outside of the Savannah River Plant (U.S. Energy Research and Development Administration, 1977; U.S Department of Energy, 1982). The Stiff Diagram in Figure 153 shows a sodium bicarbonate water quality for this aquifer although a sodium chloride type water is also common.

Water from the Ellenton Aquifer System is characterized by moderate total dissolved solids content, low hardness, and a high iron and sulfate content. The Stiff Diagram indicates a typical calcium sulfate type of water in this aquifer system.

Water from the Tertiary Sand Aquifer System is generally acidic and low in total dissolved solids, but in many wells the water is high in iron. The Stiff Diagram shows a calcium bicarbonate type of water.

Water from the Tertiary Limestone Aquifer System is moderately hard to hard, and may be high in iron and dissolved solids. The Stiff Diagram shows a typical calcium bicarbonate type of water for this aquifer system.

WATER USE

Gross water use in the Lower Savannah River Sub-basin is presently 710 mgd (Table 140), placing this sub-basin third statewide in total gross water demand. The leading water users in the sub-basin are self-supplied industry (514 mgd), thermoelectric power (166 mgd), and public supply (11.5 mgd). Major water users by type and source are shown in Figure 154. Consumptive use amounts to 82.5 mgd. Surface water is by far the major source of water supply, satisfying 97 percent of current water use needs. Even excluding water use for thermoelectric power production, surface water supplies about 96 percent of the sub-basin needs. Some surface-water withdrawals from the lower portion of the sub-basin are lost due to interbasin transfer to the Combahee-Coosawhatchie Sub-basin. However, these withdrawals do not presently affect other water use needs on the Savannah River. This sub-basin has the largest surface- and ground-water withdrawals in the State by self-supplied industry with 514 mgd and 13.3 mgd, respectively.

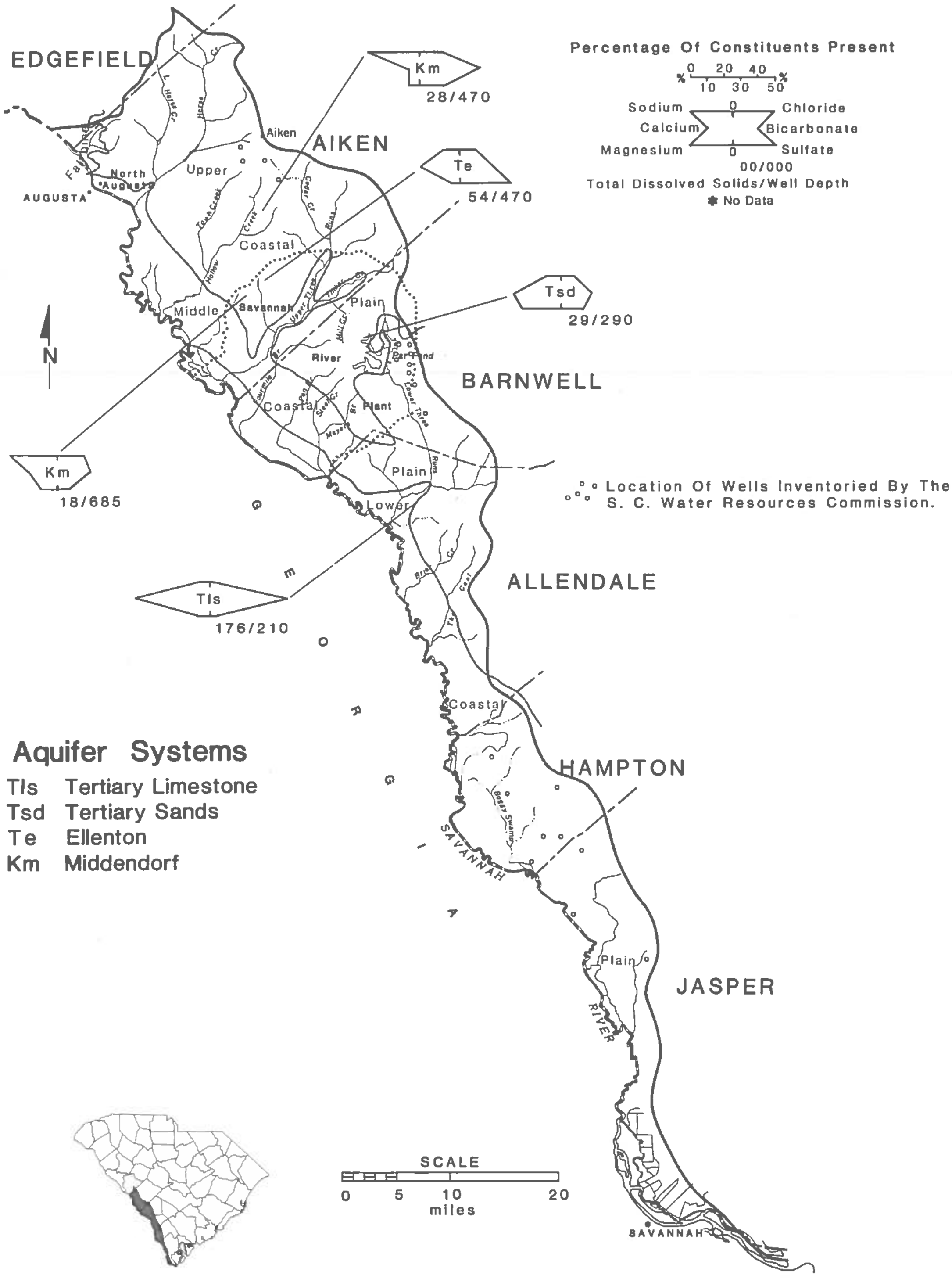


Figure 153.
Ground-water quality of selected aquifer systems and major inventoried wells in the Lower Savannah River Sub-basin, South Carolina.

Table 140.

Current and projected water use in the Lower Savannah River Sub-basin, South Carolina, 1980 - 2020.

		Water Use (mgd)														
		1980			1990			2000			2010			2020		
Type Use		*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*	*Ground Water*	*Surface Water*	*Total Water*
Public Supply	Gross	3.13	8.40	11.5	3.60	9.96	13.6	3.96	11.3	15.3	4.36	12.5	16.9	4.57	13.1	17.7
	Consumed	0.31	6.39	6.7	0.36	7.66	8.02	0.40	8.79	9.19	0.44	9.68	10.1	0.46	10.2	10.7
Self-supplied Domestic	Gross	1.7	---	1.7	2.0	---	2.0	2.2	---	2.2	2.4	---	2.4	2.5	---	2.5
	Consumed	1.4	---	1.4	1.7	---	1.7	1.9	---	1.9	2.0	---	2.0	2.1	---	2.1
Agriculture Irrigation	Gross	1.8	1.3	3.1	6.3	3.6	9.9	11	5.4	16	15	7.0	22	20	8.4	28
	Consumed	1.8	1.3	3.1	6.3	3.6	9.9	11	5.4	16	15	7.0	22	20	8.4	28
Agriculture Livestock	Gross	0.40	0.14	0.54	0.46	0.16	0.62	0.52	0.18	0.70	0.59	0.21	0.80	0.68	0.24	0.92
	Consumed	0.40	0.14	0.54	0.46	0.16	0.62	0.52	0.18	0.70	0.59	0.21	0.80	0.68	0.24	0.92
Self-supplied Industry	Gross	13.3	514	527	15.3	591	606	16.8	650	667	18.5	715	734	20.4	787	807
	Consumed	2.46	66.7	69.2	2.83	109	112	3.11	120	123	3.42	132	135	3.77	146	150
Thermoelectric Power	Gross	---	166	166	---	171	171	---	176	176	---	181	181	---	187	187
	Consumed	---	1.62	1.62	---	2.67	2.67	---	4.41	4.41	---	7.28	7.28	---	12.0	12.0
Total	Gross	20.3	690	710	27.7	776	803	34.5	843	877	40.9	916	957	48.2	996	1,040
	Consumed	6.37	76.2	82.5	11.7	123	135	16.9	139	156	21.5	156	178	27.0	177	204

Water use for public supply purposes accounts for two percent of gross use and eight percent of consumptive use. Currently, surface water supplies 73 percent of all public supply needs. Most public supply withdrawals occur in the extreme upper and lower portions of the sub-basin. Withdrawals from the lower reaches of the Savannah River by the Beaufort-Jasper Water Authority are transferred and used in the Combahee-Coosawhatchie Sub-basin. This interbasin transfer accounts for a loss of about 6 mgd and is reflected in the relatively high consumptive use value for this user group. Other water use groups on the lower Savannah River are unaffected by these relatively small withdrawals.

Self-supplied domestic water use represents less than one percent of gross use and two percent of consumptive use. All water for this group is drawn from ground-water sources.

Agricultural activities comprise less than one percent of gross demand. Irrigation of about 4,065 acres in the sub-basin, accounts for 85 percent of this demand. Agricultural irrigation accounts for less than one percent of total consumptive use. When averaged over the five-month growning season, irrigation use is 7.6 mgd, comprising one percent of total sub-basin use. Ground water currently serves as the major source (58 percent) for irrigation water needs. Livestock water use represents less than one percent of gross use and one percent of consumptive use. Seventy-four percent of livestock water use needs are supplied from ground-water sources.

Self-supplied industrial use (527 mgd) accounts for 74 percent of gross sub-basin use and 84 percent (69.2 mgd) of consumptive use. Ninty-seven percent of gross use and 96 percent of consumptive use occur at the Savannah River Plant in the upper portion of the sub-basin. The Lower Savannah River Sub-basin has the largest consumptive use of ground water, surface water, and total water by self-supplied industry in the State.

Thermoelectric power is the second largest water user, accounting for 24 percent of total gross use. Consumptive use by this group is two percent of the sub-basin total.

Gross use by the year 2020 is projected to increase by 47 percent to 1,040 mgd, while consumptive use is expected to increase by 147 percent to 204 mgd. The largest increase in water use by percent is expected to be by agricultural irrigation (800 percent), while the largest increase by volume should be by self-supplied industry (280 mgd). Self-supplied industry should continue to be the major gross water use in 2020 and surface water the major supply source.

WATER USE VERSUS AVAILABILITY

Current streamflow in the lower portion of the Savannah River is more than sufficient to meet current and projected surface-water use in the sub-basin (Fig. 155). However, surface-water quality problems in tributary streams near the cities of Augusta, North Augusta, and Savannah may limit water use activities requiring high quality water such as public supply, some industrial processes, and shellfish harvesting.

Present and projected ground-water demands within the Lower Savannah River Sub-basin can be met when well construction standards, well spacing, and depth requirements are managed properly. The general well yields range from less than 250 gpm in the northwestern portion of sub-basin to more than 1,000 gpm in southeastern part.

Table 140 reports the 1980 recorded ground-water use (20.3 mgd) along with the projected use for the year 2020 (48.2 mgd). Present use could be obtained by approximately one well pumped at a rate of 600 gpm for six hours each

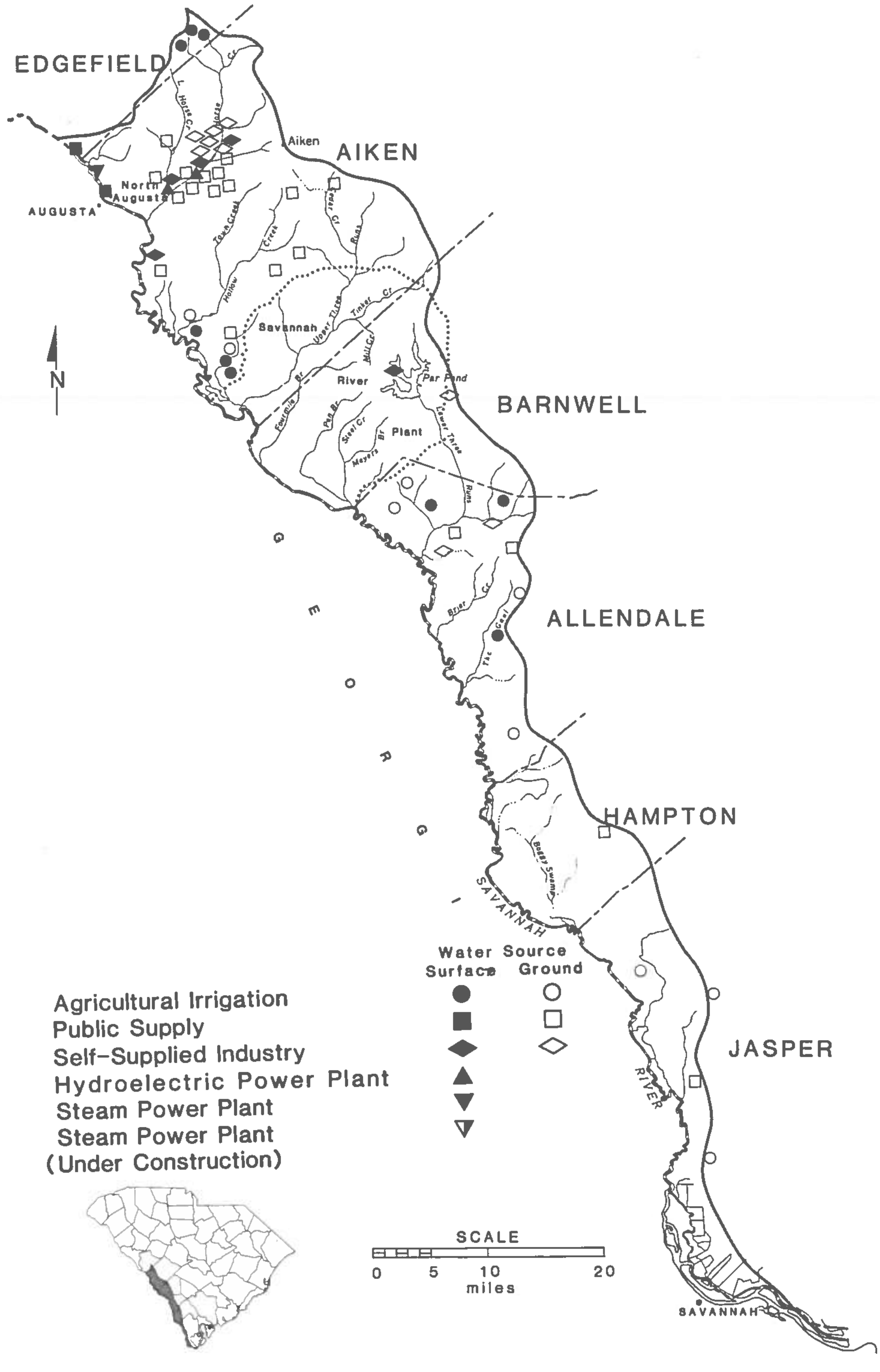


Figure 154.
Location, type, and supply source of water users in the Lower Savannah River Sub-basin, South Carolina.

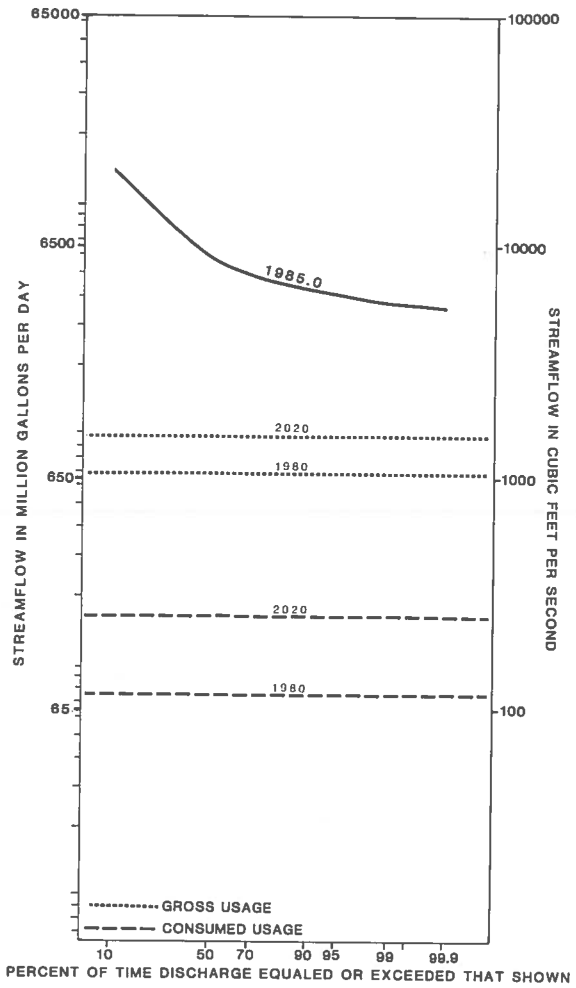


Figure 155.
Water use compared to availability in the Lower Savannah River Sub-basin, South Carolina.

day per 14 square mile area of the sub-basin. This would require about 94 such wells. The projected requirements for 2020 could be obtained by pumping one such well per five square mile area of the sub-basin, equal to about 223 total wells.

Heavy pumpage by the City of Savannah has greatly reduced water levels in the Tertiary Limestone Aquifer System and affected well yields in the Hampton and Jasper County area of the sub-basin. Future development of the aquifer system in this two county area will depend primarily on the success of currently implemented management efforts.

Ground-water availability may also be limited in certain areas of the sub-basin due to quality. Irrigation practices of completely screening and gravel packing wells from top to bottom, coupled with heavy ground-water withdrawals causes aquifer contamination by surface pollutants and interaquifer mixing of ground water. In addition, heavy irrigation pumpage in areas near animal feedlots, where thin, permeable deposits separate the Tertiary Limestone Aquifer System from the land surface, can cause vertical leakage of waste (nitrates and bacteria) into this and deeper aquifer systems. Slightly acidic water from the Middendorf Aquifer System makes the water corrosive to some metals. The disposal of radioactive wastes has not yet seriously affected the quality of the ground water outside the Savannah River Plant area, but alternative methods of disposal are being studied to enhance the protection of the aquifers involved.

The present extent of ground-water knowledge within the Lower Savannah River Sub-basin is considered limited, except for the Savannah River Plant and its vicinity. The potential for future development in the remainder of the sub-basin will depend on the results of additional studies.

Major water resource problems and opportunities in the sub-basin are summarized in Table 141.

Table 141.

Major water resource findings in the Lower Savannah River Sub-basin, South Carolina.

Opportunities

1. Surface-water supplies are more than adequate to meet current and projected surface-water demands.
2. Streams in the Upper Coastal Plains have well-sustained flows and provide reliable sources of surface water.
3. Seven potential hydroelectric power development sites have been identified in the sub-basin.
4. The Savannah River has generally good water quality that improves with distance downstream from Augusta-North Augusta.
5. Large quantities of water can be obtained from the largely undeveloped Middendorf, Black Creek, Ellenton, Tertiary Sand, and Tertiary Limestone Aquifer Systems in many parts of the sub-basin.

Problems

1. Streams in the Middle and Lower Coastal Plain region of the sub-basin have poorly sustained flows year round and are not reliable sources of surface water.
2. Shellfish harvesting is prohibited in coastal waters.
3. Oceanic saltwater incursion up the Savannah River is progressively increasing and may restrict the use of the lower portion of this river as a drinking water supply source.
4. Point and non-point sources of pollution from the cities of Augusta, North Augusta, and Savannah adversely impact the quality of the Savannah River and tributary streams.
5. A portion of the Savannah River between Clarks Hill Lake and Stevens Creek is infested with Brazilian elodea, which impairs recreation, hydroelectric power production, and municipal water supply in South Carolina and Georgia.
6. Heavy pumpage by the City of Savannah has greatly reduced water levels in the Tertiary Limestone Aquifer System affecting well yields in the Hampton and Jasper County area of the sub-basin.
7. High iron concentrations occur in the Tertiary Sand Aquifer System.
8. Water from the Middendorf Aquifer System is slightly acid, which makes water corrosive to metal surfaces.
9. Irrigation practices of complete screening and gravel packing of wells from top to bottom coupled with heavy ground-water pumpage causes aquifer contamination by surface pollutants and interaquifer mixing of ground water.
10. Heavy irrigation pumpage in areas near animal feed lots where thin permeable deposits separate the Tertiary Limestone Aquifer System from the land surface, can cause vertical leakage of feedlot wastes into this and deeper aquifer systems.
11. Heated water effluent and radioactive materials discharged from Savannah River Plant facilities adversely impact some tributary streams.
12. Organics (Triclene, Perclene, TCE), metals (mercury, lead), and nitrates have been detected in the shallow ground water (Barnwell Formation) within the Savannah River Plant. These contaminats may be migrating to underlying aquifers.
13. Tritium and strontium are present in ground water beneath the Savannah River Plant, originating from seepage basins. An accidental spill in 1968 and a transfer accident in 1962 introduced plutonium and beta-gamma isotopes to the ground water table.
14. Heavy withdrawals (4,500 gpm) at the Savannah River Plant for the past 22 years have caused a decline in water levels in the Middendorf Aquifer System. Additional proposed withdrawals at the L-Area will add to these declines.

Special Topics

Water resource activities and concerns are numerous and varied. Some have already been presented in the statewide overview and the sub-basin analyses; however, many water resource topics require more in-depth coverage and/or do not lend themselves to the statewide/sub-basin presentation format. While several topics could be presented in this section, the most important and timely were selected to give the reader a balanced overview of water resource concerns.

The special topics in order of presentation are:

1. Hydroelectric Power
2. Navigation
3. Instream Flow Needs
4. Sedimentation in Surface Waters
5. Nuisance Aquatic Plants
6. Coastal Concerns
7. Water Recreation
8. Scenic Rivers
9. Unique Wetland Areas
10. Water Conservation
11. Flooding

HYDROELECTRIC POWER

Not until the mid-1800's were turbines developed that could efficiently produce electricity from flowing water. Beginning in the 1880's, the nation as well as the State saw a dramatic increase in the development of hydroelectric power. The Piedmont of South Carolina with its abundance of free-flowing waters and relatively high relief was ideally suited for this type of development. Industry quickly took advantage of these conditions and built factories with hydropower facilities at many of the available sites, thus providing each factory with its own source of electricity. The Columbia Water Power Company, in 1895, became the first company to commercially produce electricity in South Carolina (Kohn, 1910; Federal Power Commission, 1970). Power from the company's Columbia Canal facility was first sold to local mills, then later used to power streetcars and streetlights in the City of Columbia. South Carolina Electric and Gas Company operates this facility.

Another milestone in South Carolina's hydropower development was the transmission of power from Portman Shoals to Anderson in 1897, the longest distance of electric power transmission in the United States at the time (Confederation of South Carolina Historical Socities, 1978). Such long distance power transmission allowed for development of remote hydropower sites.

Types of Facilities

Hydropower has experienced tremendous growth and change since its beginnings. Hydroelectric power facilities range in size from small developments with little storage to large dams with several turbines. These smaller facilities often depend entirely on streamflow and are referred to as run-of-river plants; these were the type most frequently constructed in the early days of hydroelectric development.

Today, a single hydropower facility may impound thousands of acre-feet of water and produce thousands of megawatt hours of energy. Besides the numerous technological improvements which have allowed for more efficient production of electricity, many new concepts in hydropower production have been developed. One of the most important of these is the development of pumped storage facilities. At a conventional hydropower facility, once water is released from the reservoir to produce electricity, it is lost downstream. At a pumped storage site, some water is retained in a tailwater pool and can later be returned to a headwater pool to be used to generate more electricity, thus the water can be recycled. This is made possible by reversible pump-turbines. When flow is in one direction these turbines serve as generators, while moving in the other direction they act as pumps. During periods of high electrical demand, water is released from the headwater pool through the pump-turbines generating electricity and is stored in the tailwater pool. Later during periods of low electrical demand, when electricity is less expensive, usually late at night or on weekends, excess electricity from within the network provides power to reverse the turbines and pump water back into the headwater pool where it is reused during another peak demand time. More energy is required to pump the water back to the headwater pool than is generated when the water is released, but because the electricity used to pump back the water is much less expensive than the electricity that is generated, this process is economically feasible. Another factor which contributes to the economic feasibility of this process is the use of electricity from thermoelectric plants within the network during periods of low electrical demand. Normally thermoelectric plants would have to reduce their output during these low demand times, which is a costly and slow process. By supplying electricity to pumped storage facilities, the load factor of these plants is increased, making their operation more economical. Although pumped storage facilities allow water to be used more than once to generate electricity, not all water within the tailwater reservoir is retained. Discharges are allowed to maintain flow requirements downstream and to compensate for inflow.

A modern, sophisticated steam plant may require up to 72 hours to build up enough steam to start producing electricity, making it very expensive to either start or stop operations. Thus, these plants are better suited for meeting base load demands. Base load is defined as the mean of the Monday to Friday minimum loads, plus 10 percent. Base load operation of hydropower plants is normally confined to those facilities which lack storage (run-of-river) or those which must be run continually to meet downstream flow requirements. Hydropower plants are well suited for meeting peak loads (defined as the greatest difference between the Monday to Friday daily peak and the daily load equaled or exceeded 12 hours per day) because they have the ability to produce electricity on short notice and then to stop quickly once demands are met or are reduced. Newer hydropower plants reflect this use as peaking units; they are designed to operate less than 20 percent of the time. The recent and continuing construction of large pumped storage units also emphasizes the importance placed on hydropower for peaking energy.

The distribution of power generated at hydropower plants in South Carolina depends mainly on plant ownership and location. Hydropower generated by municipalities or cooperatives is usually used in the immediate vicinity of the plant site. Power produced at Federal projects such as Clarks Hill and marketed by the Southeastern Power Administration is often carried through major transmission lines or "wheeled" to distant users.

Current Facilities

There are currently 35 hydroelectric plants using the waters in or adjacent to South Carolina (Fig. 156). These facilities range in capacity from less than 1 MW to 610 MW (Table 142). The largest conventional hydropower plant is the 280 MW U.S. Army Corps of Engineers facility at Clarks Hill Dam. The total generating capacity of all the hydroelectric plants in or adjacent to South Carolina is 2,630 MW. This is about 25 percent of the total capacity of all types of electric generating facilities in the State, including gas, oil, coal, and nuclear. Of the total hydropower generating capacity, 1,121 MW are provided by pumped storage facilities. Since hydroelectric power plants are generally designed to operate less than 20 percent of the time, yearly outputs are much lower than these numbers indicate. In 1980, hydropower provided seven percent of the total electricity used in the State.

The owner of the most hydroelectric facilities in or adjacent to South Carolina is Duke Power Company which owns 13 facilities. They are followed by the South Carolina Electric and Gas Company which owns six facilities. The South Carolina Public Service Authority, the U.S. Army Corps of Engineers, and the Georgia Power Company each own two facilities. The remaining 10 facilities are owned by either municipalities, cooperatives, or private firms. Three hydroelectric facilities are currently under construction, Bad Creek, Richard B. Russell, and St. Stephens. Upon completion, the first will be owned and operated by Duke Power Company, while the latter two will be owned by the U.S. Army Corps of Engineers. The majority of hydroelectric facilities are located in the Piedmont region of the State on the Savannah, Broad, Saluda, and Catawba-Wateree Rivers. The only large facilities outside the Piedmont are those associated with the Santee-Cooper Lakes.

Potential Hydropower Sites

In 1976 Congress authorized the National Hydroelectric Power Resources Study (NHS). One of the objectives of this study was to identify potential sites for the development of future hydroelectric power facilities. Results of the study indicated that South Carolina has considerable potential for additional hydropower development. Ten existing dams and 27 undeveloped sites were revealed as being potentially feasible for hydropower development in South Carolina (Table 143). If fully developed, these facilities and facilities currently under construction could provide a total potential generating capacity of about 4,000 MW and produce an additional 4.8 million MWH of electricity annually (U.S.Army Corps of Engineers, 1982a).

Potential for hydropower development in the Pee Dee Basin is limited due to the basin's low topographic relief. The dam at Lake Robinson, in the Black River Sub-basin, is the only existing site having potential for hydropower development. This lake is presently used to furnish cooling water for the H. B. Robinson steam electric plant owned by the Carolina Power and Light Company. With a power head of 32.6 feet, this site has the potential to support a 1.7 MW capacity and generate 4,860 MWH of energy annually (U.S. Army Corps of Engineers, 1982a). If installed, this project would have to be operated in conjunction with the steam electric plant.

Most of the State's potential hydroelectric power development is in the Broad River Sub-basin. Twelve major sites and six alternate sites have been identified on the Broad, Pacolet, and Tyger Rivers (Table 143). The maximum potential generating capacity of these sites totals 1,450 MW which could provide an additional 1.7 million MWH of electricity per year.

Four sites in the Saluda River Sub-basin have been identified in the National Hydropower Study as being feasible for development. Three sites occur on the Saluda River and one, a retired hydropower plant, is on the Reedy River. These sites have a total potential capacity of 40.5 MW and could provide almost 77,000 MWH of energy annually.

Most of the Catawba River, in the Catawba-Wateree Sub-basin has been developed for hydropower production. However, a head of 88.5 feet remains undeveloped between the existing Fishing Creek and Lake Wylie hydropower plants of Duke Power Company. Two potential hydroelectric sites have been identified to utilize this remaining head. These sites, Sugar Creek and Courtney Island, could support a total capacity of 77 MW and generate on the average

Figure 156.
Existing hydroelectric power plants in and adjacent to South Carolina (See Table 142 for site information).

Table 142.

Existing hydroelectric power plants in and adjacent to South Carolina.

Sub-basin / *Name of Plant*	*Owner*[a]	*Source of Water*	*Height of Dam (ft.)*	*Maximum Storage (1000 ac-ft.)*	*Capacity (MW)*	*Energy Generated 1980 (1000 MWH)*	*Average Annual Inflow (mgd)*	*Water Used 1980 (mgd)*
Broad								
1 Gaston Shoals	Duke	Broad River	64	2.0	9.1	33.8	1,310	720
2 99 Islands	Duke	Broad River	86	2.3	19.7	69.6	1,550	1,110
3 R.B. Simms (Rainbow Lake)	Spartanburg Waterworks	S. Pacolet River	58	4.5	1.0	3.6	100	77
4 Pacolet	Lockhart Power Co.	Pacolet River	24	.1	.8	3.8	400	175
5 Lockhart	Lockhart Power Co.	Broad River	16	1.5	12.3	85.2	2,350	1,680
6 Neal Shoals	SCE&G	Broad River	33	6.0	5.2	30.5	2,570	1,360
7 Fairfield[b] (Monticello Res.)	SCE&G	Broad River, Frees Creek	180	431	511	600	3,620	4,160
8 Parr Shoals	SCE&G	Broad River	50	51.2	14.9	91.1	3,930	2,880
9 Columbia	SCE&G	Broad River	14	1.1	10.6	50.9	4,320	1,660
Saluda								
10 Saluda	Duke	Saluda River	51	7.5	2.4	7.2	440	190
11 Piedmont	J.P. Stevens Co.	Saluda River	26	.6	1.0	2.5	480	175
12 Upper Pelzer	Kendall Co.	Saluda River	27	1.0	2.0	7.0	510	290
13 Lower Pelzer	Kendall Co.	Saluda River	44	.3	3.3	11.8	515	345
14 Hollidays Bridge	Duke	Saluda River	48	7.4	3.5	13.9	570	430
15 Ware Shoals	Riegel Textile	Saluda River	23	.1	5.0	17.0	650	340
16 Boyds Mill	Duke	Reedy River	50	3.0	1.0	2.3	200	52
17 Buzzards Roost (Lake Greenwood)	Greenwood Country[c]	Saluda River	82	270	13.2	52.9	1,060	1,070
18 Saluda (Lake Murray)	SCE&G	Saluda River	204	2,100	198	254	1,740	1,430
Catawba-Wateree								
19 Wylie	Duke	Catawba River	90	282	55.0	165	2,650	2,630
20 Fishing Creek	Duke	Catawba River	73	60.0	42.2	179	3,140	3,370
21 Great Falls-Dearborn	Duke	Catawba River	82	2.0	60.4	5,206	3,330	3,160
22 Rocky Creek-Cedar Creek	Duke	Catawba River	81	9.6	66.5	183	3,500	3,450
23 Wateree	Duke	Wateree River	106	304	71.5	267	3,760	3,780
Lower Santee								
24 Spillway (Lake Marion)	SCPSA	Santee River	61	1,500	2.0	10.0	11,600	370
Ashley-Cooper								
25 Jeffries (Lake Moultrie)	SCPSA	Lake Moultrie	81	1,110	130	669	10,100	10,000
Upper Savannah								
26 Tugaloo	Ga. Power Co.	Tugaloo River	155	43.0	45	119	745	850
27 Yonah	Ga. Power Co.	Tugaloo River	90	11.7	22.5	60.4	750	925
28 Jocassee[b]	Duke	Keowee River	365	1,160	610	748	195	2,660
29 Keowee	Duke	Keowee River	160	960	140	95.8	420	840
30 Hartwell	Corps of Engineers	Savannah River	204	2,840	264	606	3,170	3,350
31 Rocky River (Secession Lake)	City of Abbeville	Rocky River	60	31.2	2.8	9.5	290	125
32 Clarks Hill	Corps of Engineers	Savannah River	200	2,900	280	914	6,270	6,360
33 Stevens Creek	SCE&G	Savannah River	30	17.7	18.9	87.1	6,400	3,190
Lower Savannah								
34 Vaucluse	Graniteville Co.	Horse Creek	33	1.0	.24	.4	30	8
35 Graniteville	Graniteville Co.	Horse Creek	18	1.0	.45	.4	45	10
State Totals				14,123	2,630	5,650		63,200

[a] Duke- Duke Power Company.
SCE&G- South Carolina Electric and Gas Company.
SCPSA- South Carolina Public Service Authority.
[b] Pumped storage.
[c] Operated by Duke Power Company.

Sources: Public Service Commission of South Carolina, 1981.
U.S. Army Corps of Engineers, 1981a.
Personal correspondence.

Table 143.

Potential hydroelectric power sites in South Carolina.

Sub-basin Site Name	*Source of Water*	*Average Streamflow (cfs)*	*Surface-Area (acres)*	*Net Power Head (feet)*	*Capacity (MW)*	*Average Annual Energy (MWH)*
Pee Dee						
Lake Robinson	Black Creek	242	1,800	32.6	1.7	4,860
Broad						
Frost Shoals	Broad River	6,565	8,900	67.2	177.3	268,159
Blairs	Broad River	5,520	36,900	70.5	109.0	235,166
Lyles Ford [a]	Broad River	5,310	3,270	35.0	25.0	90,900
Blairs A-	Broad River	5,520	9,224	50.0	63.1	161,743
Greater Lockheart	Broad River	3,640	51,150	118.0	149.6	232,911
Greater Lockheart [b]	Broad River	3,640	58,600	170.0	284.0	319,000
Greater Lockheart PS [b,c]	Broad River	3,640	58,600	170.0	1,000.0	876,000
Greater Cherokee Falls	Broad River	2,342	470	33.0	15.0	47,811
Greater Gaston Shoals	Broad River	2,357	16,300	111.8	115.8	177,861
Trough	Pacolet River	701	1,340	45.0	6.9	18,362
Clifton No. 3	Pacolet River	485	29	27.0	2.6	7,455
Pacolet River	Pacolet River	453	1,050	60.0	6.6	15,963
W.C. Bowen Reservoir	Pacolet River	145	1,516	50.0	1.5	4,030
Whitmire [a]	Tyger River	1,200	17,310	86.0	20.4	80,519
Tyger River [a]	Tyger River	1,235	13,190	92.0	21.2	61,024
Burnt Factory	Tyger River	588	1,460	85.0	9.5	26,835
Print Crash	Tyger River	108	32	54.0	1.1	3,178
Berry Shoals	Tyger River	140	70	74.0	2.1	6,365
Saluda						
Fork Shoals	Reedy River	210	51	44.8	2.0	5,278
The Forks	Saluda River	655	7,652	95.0	18.3	37,010
Upper Ware Shoals	Saluda River	976	1,720	60.0	20.2	34,370
Lower Saluda	Saluda River	2,900	1,424	31.2	18.0	48,000
Catawba-Wateree						
Sugar Creek	Catawba River	4,863	2,500	36.5	26.4	88,722
Courtney Island	Catawba River	5,148	5,400	52.0	50.6	164,301
Congaree						
Lock & Dam #1	Congaree River	10,140	1,632	16.0	21.5	90,100
Lock & Dam #2	Congaree River	10,070	1,440	14.0	9.3	62,700
Lock & Dam #3	Congaree River	9,840	1,648	15.0	19.5	82,000
Reregulator [d]	Congaree River	9,329	727	35.0	56.5	179,000
Ashley-Cooper St, Stephen[e]	Rediversion Canal (Lake Moultrie)	12,600	60,400	49	84	418,000
Edisto						
Rocky Springs[c]	S.F. Edisto River	242	8,100	190.0	500.0	438,000
Upper Savannah						
Dan River No. 2	Twelvemile Creek	150	-[f]	37.0	5.5	10,856
Dan River No. 1	Twelvemile Creek	230	-	49.0	6.9	14,852
Lower Whitewater	Whitewater River	70	162	890	16.7	30,778
Richard B. Russell[c,e]	Savannah River	5,078	26,650	162	600	788,400
Bad Creek[c,e]	Bad Creek, Lake Jocassee	5	318	1,230	1,000	32,000
Lower Savannah						
New Savannah Bluff	Savannah River	10,200	-	12.2	23.7	71,465
Eagle Point	Savannah River	10,800	3,871	14.0	21.5	84,418
Steel Creek	Savannah River	11,000	11,672	14.0	22.2	87,349
Low Johnsons Landing	Savannah River	11,300	869	14.0	23.3	91,511
Dicks Lookout Point	Savannah River	11,800	2,990	14.0	24.9	97,899
Bull Pen Point	Savannah River	12,000	51	14.0	12.8	80,762
Low Stokes Bluff	Savannah River	12,100	3,376	14.0	13.3	82,844

[a] Alternatives to Blairs development.
[b] Alternatives to Greater Lockhart development - evaluated by FPC in 1970.
[c] Pumped storage.
[d] Would inundate Lower Saluda Site.
[e] Under construction.
[f] - indicates information not available.

Source: U.S. Army Corps of Engineers, 1982a.

253,000 MWH of energy annually. Development of these sites would inundate the Catawba River's only remaining free-flowing water and create a chain of hydroelectric reservoirs from the North Carolina boundary to Lake Wateree. Development of Courtney Island may also have significant impacts on the Landsford Canal State Park.

Four potential hydroelectric power sites have been identified in the Congaree River Sub-basin. In 1965 the Charleston District of the U.S. Army Corps of Engineers completed an interim report on navigation for the Santee River System from Charleston to Columbia. Part of this report proposed development of three low-level locks and dams on the Congaree River. These low-level dams were included in the National Hydropower Study with all three being economically favorable. Part of a navigation plan recommended prior to the above plan proposed development of a dam site just above the Gervais Street bridge in Columbia, known as Reregulator. Development of this site would renovate the existing Columbia hydropower plant owned by the South Carolina Electric and Gas Company and would inundate the Lower Saluda site. The potential generating capacity of these four sites is almost 107 MW with an average annual energy output of 414,000 MWH.

Several reservoir sites in the Ashley-Combahee-Edisto River Basin were evaluated in the National Hydropower Study with only one site being potentially feasible. This site, located in the upper portion of the Edisto River Sub-basin, is a pumped storage development. The headwater reservoir would be located on Rocky Springs Creek with the tailwater located on the South Fork Edisto River. This development would permit a gross power head of 190 feet with a capacity of 500 MW and average annual energy output of 438,000 MWH. The St. Stephens Hydroelectric Plant is currently under construction on the Rediversion Canal in the Ashely Cooper River Sub-basin. This facility, which will be owned by the U.S. Army Corps of Engineers and operated by the S.C. Public Service Authority, will have a capacity of 84 MW and an average annual energy output of 418,000 MWH.

The Savannah River Basin has undergone extensive hydropower development in its upper reaches. Richard B. Russell Dam will take advantage of the last available power head above Augusta, Georgia. Three potential hydropower sites, however, have been identified in the Upper Savannah River Sub-basin. These sites are two retired low-head hydroelectric power plants located on Twelvemile Creek and one one the lower portion of Whitewater River. If developed, these facilities, excluding those currently under construction, would have a total capacity potential of 29 MW and could provide an average of 56,500 MWH of energy annually.

There is greater potential for hydropower development in the Lower Savannah River Sub-basin than in the Upper. An ongoing feasibility study to create a 12-foot navigation channel on the Savannah River between the cities of Savannah and Augusta includes the development of seven lock and dam sites. These sites as identified in Table 143 could also produce electricity under run-of-river conditions. The potential generating capacity of these sites is about 142 MW,providing an average annual energy contribution of over 596,000 MWH.

Water Use and Impacts

In 1980, 35 hydroelectric power facilities used about 63,200 mgd of water to generate 5.6 million MWH of power. This water use, when totaled with all withdrawal uses (thermoelectric power, industrial, public supply, and rural use), represents about 92 percent of total water use in South Carolina. However, unlike the other uses, water for hydroelectric power generation is generally not removed from the stream nor consumed, although off stream channel diversion and interbasin transfer may occur. This nonwithdrawal or instream water use by hydroelectric power facilities increased about eight percent during the past decade. Two new pumped storage facilities alone increased total use by 6,820 mgd, an amount greater than all withdrawal water uses combined.

Although water for hydropower facilities is never removed from a stream, the operation of many of these facilities greatly impacts water availability and quality in downstream waters. Since hydroelectric power plants are used for peak power generation, releases from these facilities are greatly increased during periods of high energy demand. This usually occurs during brief periods during the day. Weekends are periods of generally low energy demand. Discharges from peaking power facilities are, thus, periodic and result in highly variable flows downstream. When these plants are not in operation, which is most of the time, downstream flows are very low. Low and fluctuating flows downstream of hydropower facilities adversely impact future water-dependent development, waste assimilative capacity of streams, and biological communities. Hydropower reservoirs trap sediment and nutrients from upstream waters. Depending on a facility design and operation, discharge waters may be significantly colder than ambient water temperatures and have extremely low dissolved oxygen content.

Hydroelectric power generation is important to current and future development in South Carolina. As the need for energy increases in the State, potential sites are available for additional hydroelectric power development. With careful planning of plant design and operation, future hydropower facilities in South Carolina can provide inexpensive and reliable energy while maintaining the physical, chemical, and biological integrity of the States waters. The development of any hydropower site, however, usually raise questions concerning environmental, economic, and social impacts. Such impacts should be carefully weighed against potential benefits gained from development of the site.

Table 144.

Hydroelectric power — problems and opportunities.

Opportunities

1. Numerous potential hydroelectric power sites (42) have been identified in South Carolina, providing a total potential generating capacity of 4,000 MW, producing an additional 4.8 million MWH of electricity per year.
2. Pumped storage facilities reuse water and can provide relatively large amounts of electricity.
3. Hydroelectric power currently provides about 25 percent of the total generating capacity in South Carolina, but only about seven percent of the energy.
4. The Broad River Sub-basin has the greatest number of potential hydroelectric power sites (18).

Problems

1. Highly fluctuating discharges from some hydropower facilities adversely affect downstream water quantity and quality, adversely impacting numerous uses.
2. Impoundment of some potential hydropower sites will have permanent adverse economic, social, cultural, and environmental consequences.

NAVIGATION

The importance of navigation in South Carolina dates back to the Colonial period. For early settlers, the waterways were an indispensable means of communication and transportation. As early as 1714, legislation was passed by the Colonial government for the improvement of inland navigation. Slowly settlers moved inland and established settlements at the heads of navigation on the larger rivers in the State. By the 1780's, State legislation was passed requiring improvements on nearly all of the rivers in South Carolina.

One important event in the improvement of inland navigation was the formation in 1786 of "The Company for the Inland Navigation from Santee to Cooper River". The purpose of the company was to construct a canal from the Santee River to the Cooper River providing navigation directly from the coastal port of Charleston to inland towns. Completed in 1800, the Santee Canal was 22 miles in length, four feet deep, and 20 feet wide at the bottom. Two double and eight single locks could raise a vessel 34 feet from the Santee River to the summit of the canal and then lower it 69 feet to the Cooper River (Epting, 1936). Although built over a poorly chosen course, the canal was prosperous for over 30 years and did much to improve trade within the State.

In 1818, the Legislature of South Carolina appropriated $1 million for public works of which the greatest part was for canal construction. By 1820 plans were formed for eight canals, two on the Saluda, one on the Broad, one on the Congaree, and four on the Catawba-Wateree. Navigation was planned to extend all the way up the Catawba to Morganton, North Carolina. All four of South Carolina's canals on the Catawba were completed by 1830. One has been restored for its historical significance at Landsford Canal State Park. The other three were flooded by hydroelectric reservoirs.

Another significant project was the Columbia Canal which used tolls to meet its construction and operating expenses. Completed in 1823, it enabled river traffic to pass around the shoals in the upper portion of the Congaree River at the confluence of the Broad and Saluda Rivers near Columbia. The canal was three miles long with three locks which overcame a fall of 34 feet (Epting, 1936). The canal was instrumental in the growth of Columbia.

At the height of development of inland navigation within the State, every region of the State except Greenville was accessible by water (Fig. 157). More than 2,000 miles of inland water were navigable (Epting, 1936). The Savannah River was navigable from its mouth to Augusta, Georgia. In addition, smaller vessels were able to descend down the Savannah River from as far up as the Tugaloo and Seneca Rivers. The Santee River was navigable along its entire length and the Wateree River to five miles past Camden. Boat traffic on the Santee River could also go up the Congaree River and then up either the Broad or Saluda Rivers. Two of the major tributaries of the Broad River, the Pacolet and Tyger Rivers, were also navigable. The Saluda River was navigable to 120 miles above Columbia. The entire length of the Pee Dee River in South Carolina was navigable as was the Little Pee Dee River. Other rivers in the State maintained for navigation included the Combahee, Salkahatchie, Waccamaw, Edisto, Black, Lynches, Ashley, Cooper, and Ashepoo.

When inland navigation was at its height of development and use in the mid-1800's, the rapidly developing railroads quickly replaced inland waterways as the best method of moving people and goods. Soon many of the inland waterways fell into disrepair and quickly became unusable. The introduction of the railroad was the beginning of the end for inland navigation in South Carolina.

Navigation projects up to this time were the responsibility of State or private entities. The first Federal involvement began in 1880 with projects on the Pee Dee, Waccamaw, and Salkahatchie Rivers. The Federal government's role quickly expanded and soon projects were underway on all

Figure 157.
Greatest extent of commercial navigation in South Carolina (mid-1800's).

of the State's major rivers within the Coastal Plain. The projects continued until boat traffic on the rivers declined to a point not to warrant further maintenance.

Today, the U.S. Army Corps of Engineers is still actively involved in maintaining navigable waters along the South Carolina coast. Present activities include the Little River Inlet Project, the Murrells Inlet Project, the Cooper River Rediversion Project, and the maintenance of Charleston Harbor, Savannah Harbor, the Intracoastal Waterway, and the Savannah River below Augusta. In addition, emergency maintenance is performed in other areas as the need arises (U.S. Army Corps of Engineers, 1982b).

Current navigation projects of the Federal government satisfy many water use objectives. These objectives may be to assist in the development, conduct, safety, and efficiency of interstate and foreign waterborne commerce; promote the production and harvest of seafood; encourage expansion of existing and development of new industrial and agricultural production; meet the needs of recreational boating; enhance fish and wildlife resources; enhance environmental quality; and enhance social effects. Federal navigation improvements must be in the interest of the general public and must be accessible and available to all on equal terms (U.S. Army Corps of Engineers, 1982b).

Federal practice pertaining to navigation improvement, which has developed over the years on the basis of Congressional actions, extends only to providing waterway channels, anchorages, turning basins, locks and dams, harbor areas, and protective jetties and breakwaters of dimension adequate for the movement of vessels efficiently and safely between harbors and other areas of use. The provision of docks, terminals, local access channels, and other similar structures are the responsibility of local interests (U.S. Army Corps of Engineers, 1982b).

The maintenance of coastal navigation aids such as lighthouses, buoys, range markers and charts is the responsibility of the U.S. Coast Guard. These include two systems, the Intracoastal Waterway System and the Lateral System for navigation from port through the channel outward to the sea buoy at the mouth of each channel.

Upstream from the coastal habors no aids to navigation system exist on the rivers; however, the South Carolina Department of Wildlife and Marine Resources, the U.S. Corps of Engineers, and private power companies maintain some buoys and markers in the major reservoirs.

While commercial navigation is currently limited primarily to coastal waters and the Savannah River below Augusta, Georgia, navigation for recreational purposes is suitable in lakes and streams throughout the State. Recreational navigation is generally easier in Coastal Plain streams than in Piedmont streams because of reduced stream gradients and shoal obstructions.

A primary problem impacting current and future navigation in South Carolina is the insufficient availability of dredge material disposal sites in coastal areas. Laws preventing the filling of wetlands coupled with the rapidly increasing value of high ground restrict the availability (and affordability) of suitable disposal sites near areas of dredge activity. Other navigation problems include hazardous navigation due to continually shifting ocean bars in front of Little River Inlet, Fripp Inlet, and Five Fathom Creek (Town Creek); limited vessel access into the Intracoastal Waterway, Charleston Harbor, Winyah Bay (Georgetown Harbor), Port Royal Harbor, Ashley River, Shipyard River, Village Creek, and Wards Creek because of high shoaling rates and insufficient depths; and inadequate berthing facilities in the Ashley River and, in the future, Charleston Harbor (U.S. Army Corps of Engineers, 1982b). Increasing channel depths in Port Royal Harbor and Winyah Bay would be difficult. Deepening Port Royal Harbor could puncture underlying freshwater aquifers causing saltwater contamination of an important drinking water supply. The presence of rock in the upper channel reaches and high shoaling rates restrict channel deepening in Winyah Bay. Some of these navigation problems, however, may soon be eliminated. Completion of the Cooper River Rediversion Project should reduce much of the shoaling problem in Charleston Harbor and safe navigation to and from Little River Inlet should be possible upon completion of the Little River Inlet Project in 1984.

Table 145.
Navigation — problems and opportunities.

Opportunities

1. The Intracoastal Waterway provides a safe commercial navigation route along the entire coast of South Carolina.
2. Current heavy shoaling in Charleston Harbor should be reduced upon completion of the Cooper River Rediversion Project.
3. Completion of the Little River Inlet Project should provide safe navigation to and from Little River Inlet.

Problems

1. Suitable dredge material disposal sites are few and decreasing in number.
2. Hazardous navigation due to shifting sands occurs in front of Little River Inlet, Fripp Inlet, and Five Fathom Creek (Town Creek).
3. Some vessel access is limited due to insufficient depths in the Intracoastal Waterway, Charleston Harbor, Winyah Bay (Georgetown Harbor), Port Royal Harbor, Ashley River, Shipyard River, Village Creek, and Wards Creek.
4. Adequate berthing facilities are unavailable in the Ashley River and, in the future, Charleston Harbor.

INSTREAM FLOW NEEDS

Many important instream water uses in South Carolina are dependent upon the presence of a certain amount of water flowing within natural stream channels. These instream uses differ from typical agricultural, industrial, and domestic water uses in that water is not withdrawn from the stream course but is utilized within the stream itself. Principal instream uses and values include the survival and propagation of aquatic biota, including important fish and wildlife species; assimilation of discharged wastewater; water quality protection; hydroelectric power generation; navigation; recreational activities; aesthetic appeal of water bodies; preservation of floodplain wetlands and riparian vegetation; and maintenance of freshwater inflow to coastal estuaries. Many of these instream uses involve interests of the general public and the protection of public waters, as well as interests of riparian owners in streams flowing through private property.

Instream flow needs (or requirements) refer to the amount of water that is needed within a stream channel to sustain all relevant instream uses at an acceptable level. Maintenance of desirable aquatic biological populations requires the presence of sufficient volume and depth of water to facilitate all life cycle functions including feeding and reproduction. The U.S. Fish and Wildlife Service has developed methodologies for assessing instream flow needs for fish and wildlife populations in individual water bodies (Bayha, 1978). Protection of water quality requires instream flow of a sufficient level to assimilate waste materials discharged by municipalities and industries. Water quality management procedures are generally based on streamflow equal to or greater than the minimum seven day average flow rate that occurs with an average frequency of once in ten years (7Q10). Instream flow of less than the 7Q10 rate may not be sufficient to adequately assimilate wasteloads and can result in water quality standards violations and impairment of both instream and offstream water uses. Flow requirements for navigation depend upon the type of navigation which individual streams are capable of supporting. Large streams which sustain commercial navigation have greater instream flow needs than smaller streams which may support only recreational or other types of navigation by small watercraft. In general, instream flow requirements are dependent upon characteristics of individual streams and on instream uses under consideration, and must be determined on an individual, case-by-case basis.

Instream flow is affected by several natural and man-induced factors. The amount of precipitation falling on watershed lands, topography, rate of evaporation and transpiration, and ground-water discharge are natural factors which affect streamflow. In South Carolina these natural factors generally result in high flow rates during winter and spring months and low flow rates during summer and fall months. Human activities having a major effect on instream flow are diversions of water from the stream channel for withdrawal water uses and controlled releases of water from storage reservoirs. Withdrawal uses may be consumptive, non-consumptive, or interbasin transfer of water. Consumptive uses, such as agricultural irrigation, and interbasin transfers result in a permanent reduction of the instream flow rate for a particular stream. Irrigation withdrawals are especially detrimental to instream flow since this use is totally consumptive and most intense during dry periods when streamflow may already be at low levels. Most withdrawal uses, however, are non-consumptive and involve the removal of water from the stream channel, offstream use, and discharge of a similar amount of water to the same stream. This type of use results in, at most, a temporary and localized reduction of streamflow.

Controlled releases from storage reservoirs are most pronounced at hydroelectric generating facilities used for peaking power generation. These facilities typically release water from a reservoir to downstream channels only during times of highest demands for electrical power. Discharge may occur during only a brief period each day, resulting in highly variable and frequently low streamflow conditions downstream. Adverse impacts of fluctuating hydroelectric releases on downstream biological communities have been documented by numerous studies and are summarized by Walburg and others (1981). Other types of controlled releases are intermittent discharges from large wastewater holding reservoirs at industrial and municipal waste treatment facilities. Wastewater from such facilities is usually released when streamflow, and waste assimilative capacity of the receiving stream is high and stored when streamflow is low. In situations where the same stream is used for both water supply and waste assimilation, water may be diverted from the stream but not returned during periods when instream flow is already low due to other factors, thus causing further reductions of instream flow. Although no municipal facilities currently use controlled releases, several are considering the possibility.

Significant conflicts between instream water uses and withdrawal uses first developed in western states where water supplies are limited and water is allocated among users under the appropriation doctrine of water law. In the past, available water was allocated for those withdrawal uses which resulted in greatest economic benefit, with little consideration of instream uses. More recently, many western states have recognized the need to protect instream uses and have developed provisions for reserving a portion of available streamflow for these uses. In states east of the Mississippi River, where water is more plentiful, interest in instream flow needs has only recently developed, and conflicts have been highly localized and usually occur only during low-flow periods. Water law in most eastern states, including South Carolina, is based on the riparian doctrine which provides all owners of property adjacent to a stream course an equal right to reasonable use of water in the stream. The riparian doctrine does not, however, provide a good mechanism for protecting the general public interest in instream uses and values because the doctrine focuses only on reparian owners.

In South Carolina, instream flow problems have occurred primarily during low-flow summer months and have been caused or aggravated by hydroelectric power production and irrigation water usage. The Catawba-Wateree and Saluda Rivers are heavily utilized for peaking power production and some segments are subject to instream flow problems (Johnson and de Kozlowski, 1981). Minimal hydroelectric plant releases on these rivers do not always provide adequate streamflow to sustain all instream uses. Similar size streams which are not used for peaking hydroelectric generation do not exhibit instream flow problems except during extremely low-flow conditions caused by drought. Heavy irrigation water withdrawals also pose threats to instream uses in small- and medium-size streams. Instream flow problems due to irrigation water usage have been reported in the Edisto River and tributaries of the Salkehatchie River. Cumulative irrigation water withdrawal capabilities on some streams are equal to or in excess of available streamflow. Under such conditions, instream uses may be completely eliminated during the irrigation season. Other withdrawal uses can have a similar, although usually less severe, impact on instream flow.

As water use demands increase with population and economic growth, competition among users for available streamflow will intensify. Total water withdrawals in South Carolina increased by nearly 100 percent between 1970 and 1980 and are expected to further increase by over 40 percent by the year 2020. Consumptive use, which is most detrimental to instream flow and uses, is estimated to increase by approximately 435 percent between 1980 and 2020. This increase in consumption will be due, to a large extent, to the expanded use of agricultural irrigation. Greatest increases in irrigation water withdrawals are expected in the Combahee-Coosawhatchie, Edisto, and Pee Dee River Sub-basins; consequently, these areas are probable sites for instream flow problems in future years. However, increases in total withdrawal use in all river basins will probably contribute to instream flow concerns throughout the State.

Two important problems regarding instream flow needs have been a general lack of recognition of the significance of these needs and the absence of an adequate legal and institutional basis for management of instream flow. Recent recognition of instream flow needs in South Carolina appeared in a water resources management plan for the Yadkin-Pee Dee River Basin which recommended that the States of North Carolina and South Carolina "...develop criteria for protecting all instream uses of water" (U.S. Water Resources Council and others, 1981). The Water Law Review Committee appointed by Governor Richard W. Riley in 1982 also recognized the importance of instream needs, stating that: "A minimum amount of water should be maintained to support in-stream needs in rivers, streams and lakes. The State should, giving due consideration to existing uses, determine instream flow needs and consider those needs in reviewing present and future development" (Governor's State Water Law Review Committee, 1982).

The Committee submitted the following specific recommendations regarding instream flow needs.

"1. That the State adopt a policy recognizing the need to maintain minimum stream flows;
2. That an agency, or agencies, be directed to determine the appropriate procedures for the establishment of in-stream flow requirements;
3. That the State agencies be directed to consider the maintenance of minimum stream flows under their existing authority until comprehensive in-stream flow legislation can be developed and implemented;
4. That legislation to provide for the establishment and maintenance of in-stream flows be developed and implemented in a timely manner;
5. That all future construction affecting the flow of a stream or river be designed to accommodate minimum in-stream flow needs."

Implementation of these recommendations would provide the State with an official mechanism for recognizing and protecting instream flow needs. Such a mechanism does not currently exist in South Carolina.

Table 146.
Instream flow needs — problems and opportunities.

Opportunities

1. Maintenance of sufficient instream flow will enhance water quality, navigation, hydroelectric power generation, recreational activities, riverine environments, and fish and wildlife populations.

Problems

1. Low flows due to minimal releases from hydroelectric power plants occur on the Saluda and Catawba-Wateree Rivers and restrict some water uses.
2. Low flows due to heavy withdrawals for irrigation occur on the Edisto River and tributaries of the Salkehatchie River and restrict some water uses.
3. Projected increases in irrigation withdrawal use in the Combahee-Coosawhatchie, Edisto, and Pee Dee River Sub-basins make these areas probable sites for instream flow problems in the future.
4. There is a general lack of recognition of the significance of instream flow needs.
5. Adequate legal and institutional bases do not exist for the management of instream flow.

SEDIMENTATION IN SURFACE WATERS

Sediment is any particulate material that is transported and deposited by water, wind, or ice. Waterborne sediments may be composed of organic material (plant and animal matter), inorganic material, or, as is usually the case, a mixture of both. The size of sediment particles usually include a wide range from very fine clays and sands to large rocks and boulders. However, sediment material can be placed into two general categories based on modes of transport: suspended sediments and bed load sediments (Farnworth and others, 1979). Suspended sediments include small sized particles (silts and clays) that are maintained in the water column by turbulence and carried with water flow. Bed load sediments usually include large sized particles (sand, gravel, rocks) that rest on the streambed and are moved along the bottom by streamflow. Some sediment particle sizes may be included in either category depending on water body characteristics and environmental conditions.

Impact on Water Resources

Both water quality and quantity are impacted by heavy sediment loads. Bedload sediment movement impacts primarily stream environments through the scouring and abrading of streambeds, altering habitat structure, and burying bottom-dwelling organisms (Farnworth and others, 1979). Suspended sediments, however, may impact all types of waters but especially slow moving waters such as lakes and reservoirs. This form of sedimentation is one of the most insidious forms of water pollution because it is widespread, often goes unnoticed, and damage is often permanent (Smith, 1966).

Table 147.
Estimated sediment deposition in the major reservoirs in the Santee River Basin, South Carolina.

Name of Reservoir	*River*	*Data Storage Began*	*Total Drainage Acre (sq. mi.)*	*Planned Capacity* *Minimum (ac. ft.)*	*Planned Capacity* *Maximum (ac. ft.)*	*Average Annual Sediment Deposition (ac. ft.)*	*Capacity Lost By Sediment As of 1970 (ac.ft.)*
Lake Wylie (Lake Catawba)	Catawba	1925	3,020	131,700	281,900	520	24,000
Fishing Creek Reservoir	Wateree	1916	3,810	22,500	60,000	220	12,000
Great Falls, Dearborn	Wateree	1907	4,100	14,431	16,000	110	7,000
Lake Greenwood	Saluda	1940	1,150	96,000	270,000	180	6,000
Lake Marion	Santee	1941	14,700	350,000	1,450,000	1,500	45,000
Lake Moultrie	Cooper	1941	15,000	450,000	1,110,000	230	7,000
Lake Murray	Saluda	1930	2,420	1,040,000	2,096,000	380	30,000
Lake William C. Bowen	Pacolet	1958	90	---[a]	24,550	20	200
S. Pacolet River Res.	Pacolet	1925	90	1,074	3,015	Negligible	920
Parr Shoals	Broad	1914	4,750	8,775	10,775	200	10,000
Rocky Creek, Cedar Creek	Catawba	1916	4,360	21,462	23,000	90	5,000
Wateree Pond (Lake Wateree)	Wateree	1919	4,750	128,800	303,900	140	21,000
Total				2,264,742	5,649,140	3,590	168,120

[a] Water supply reservoir, no minimum planned.

Source: U.S. Department of Agriculture, 1973.

High levels of suspended sediments are not only aesthetically undesirable but are also detrimental to several water use activities. The efficiency and effectiveness of municipal and industrial water treatment processes are reduced when suspended solids are greater than normal levels (U.S. Environmental Protection Agency, 1976a). Agricultural use may be adversely affected. Use of irrigation water with high levels of suspended solids may result in crust formation on soils which inhibits water infiltration, soil aeration, and plant emergence; cause film formation on crops which blocks sunlight and impairs photosynthesis; and damage pumps and water delivery systems (U.S. Environmental Protection Agency, 1976a). The safe use of a water body for recreational activities, such as swimming and diving, is impaired by highly turbid waters.

When water turbulence subsides, the heavier particles settle to the bottom causing additional problems. The accumulation of sediments in lakes can greatly reduce storage capacity. Almost 3,600 acre-feet of storage are lost annually from the major reservoirs in the Santee River Basin in South Carolina (Table 147). Lake Marion alone loses about 1,500 acre-feet per year. Silted navigation channels hinder boat traffic and increase dredging time and cost. The U.S. Army Corps of Engineers dredges an average of about 15,000 tons of sediment per year from the Intracoastal Waterway between Charleston and Beaufort. The multi-million dollar U.S Army Corps of Engineers Cooper River Rediversion Project was initiated because of heavy sedimentation and shoaling in Charleston Harbor.

In addition to adverse impacts on man's use of water, excess sedimentation is also harmful to all levels of aquatic life. High levels of suspended solids block sunlight and inhibit growth of microscopic plants; clog the filtering structures of mollusks, and gill structures of fish; reduce fish growth rates and desease resistance; and modify natural fish movements (Farnworth and others, 1979). Heavy deposition of sediments on the bottom of water bodies may alter existing habitats; smother and kill bottom-dwelling organisms; kill fish eggs; and alter the existing biological community. Organic matter, nutrients, heavy metals, and pesticides are also often associated with sediments and may alter water quality and impact aquatic organisms.

Source of Sediment

Surface-water sediments come from eroded soil washed off watershed lands during periods of heavy rainfall. An estimated 1.8 billion tons of valuable soil enters the nation's waterways each year (Beck, 1980). In South Carolina, over 18 million tons of soil are eroded each year, contributing to surface-water sedimentation problems (U.S. Department of Agriculture, 1980b). The rate at which eroded soils enter water bodies is dependent on precipitation, water flow, land use, slope, soil type, and vegetative cover of the watershed (Farnworth and others, 1979). Land use activities which contribute to soil erosion and subsequent sedimentation include agriculture, silviculture, construction, mining, and hydrologic modification. Agricultural activities are a major cause of soil erosion in South Carolina (4.65 tons/acre/year) (U.S. Department of Agriculture, 1980b). The U.S. Department of Agriculture (1980b), Soil Conservation Service, determined that agricultural croplands, which comprise about 18 percent of nonfederal acreage in the State, contribute about 85 percent of total soil erosion (15.5 million tons/year). Soil erosion due to silviculture activities is much less significant (0.18 tons/acre/year). Forest lands which comprise over 59 percent of nonfederal acres in South Carolina contribute only about 11 percent (1.9 million tons/year) of total soil erosion (U.S. Department of Agriculture, 1980b). While construction activities generally cause the greatest rate of erosion (20 - 100 tons/acre/year), the extent of land disturbed by construction is small and can vary significantly from year to year (S.C. Land Resources Conservation Commission, 1978a).

Geological and morphological characteristics of a watershed greatly affect the rate of erosion and sedimentation. Variations in these characteristics are exemplified by the major land resource areas in South Carolina which include the Blue Ridge Mountain, Southern Piedmont, Carolina and Georgia Sand Hills, Southern Coastal Plain, Atlantic Coast Flatwoods and Tide Water Areas (Figure 5). In general, erosion is greatest in the Piedmont where slopes are steep and soils contain relatively high percentages of silt and clay and erosion is least in the Atlantic Coast Flatwoods region where sandy flat terrain allows little runoff. About 56 percent of total State soil loss occurs in the Piedmont, 23 percent occurs in the Southern Coastal Plain, 15 percent occurs in the Sand Hills region, and 6 percent occurs in the Atlantic Coast Flatwoods (S.C. Land Resources Conservation Commission, 1978b). It is further estimated that 25 percent of the gross soil movement from agricultural croplands in the Piedmont is delivered to watershed outlets. This estimation is 17.5 percent in the Sand Hills, 13 percent in the Southern Coastal Plain, and 10.6 percent in the Atlantic Coast Flatwood land resource areas (S.C. Land ResourcesConservation Commission, 1978b).

Management of the Sedimentation Problem

Pollution from the erosion and sedimentation process enters streams and lakes from broad areas and is, therefore, classified as non-point source pollution. As such, control and abatement of sediment loss due to most land use activities is strictly voluntary. Recommended best management practices (BMP's) have been developed by the S.C. Department of Health and Environmental Control (1978) in conjunction with several other State and Federal agencies to help control non-point source pollution. Specifically, best management practices are techniques or methodologies that have been determined to be the most effective and practicable means of preventing or reducing pollution due to non-point sources at levels compatible with water quality goals. These practices include sediment control techniques and have been developed for several different land use activities including agriculture, silviculture, construction, and hydrologic modification.

Mandatory control of sediment loss due to soil disturbance is very limited in South Carolina. In 1971, the General Assembly passed the County Sediment Control Act. Under the Act, individual counties may establish sediment control programs requiring grading permits and erosion control plans for construction activities. To assist counties in developing compatible programs, the S.C. Land Resources Conservation Commission prepared a guide for developing county sediment control programs. To date, only five counties (Aiken, Fairfield, Lexington, Newberry, and Richland) have enacted sediment control legislation. The S.C. Land Resources Conservation Commission is currently drafting legislation for statewide control of sedimentation due to construction activities.

Table 148.
Sedimentation — problems and opportunities.

Opportunity

1. Best Management Practices (BMPs) have been developed for several land use activities which can minimize erosion and sedimentation.

Problems

1. Large quantities of sediment enter South Carolina's surface waters each year filling navigation channels and lakes; impairing municipal, industrial, and recreational water use; and adversely impacting aquatic organisms.
2. Most sedimentation control is voluntary and inadequate legislation has been developed to properly control soil loss and sedimentation in South Carolina.

NUISANCE AQUATIC PLANTS

Importance of Aquatic Plants

Aquatic plants are an important part of the surface-water environment. These plants provide food, shelter, and reproductive habitat for numerous fish, wildlife, and other animal species. When present in limited populations, aquatic plants can improve water quality and enhance the aesthetic appeal of surface water. Natural controls, such as foraging by animals, disease, and competition with other plants, maintain most native aquatic plant populations at levels that are compatible with man's use of the water resource.

Non-native plant species are frequently not vulnerable to the same natural population controls as are native species. As a result, when an exotic plant is introduced to a new area, this plant is often able to out compete native species, and become very abundant. These abundant populations of non-native plants are the cause of most major aquatic plant problems in South Carolina. These plants become so numerous that they interfere with virtually every withdrawal and instream use of surface waters. They obstruct navigable waterways, restrict water flow, clog water intakes, degrade water quality, provide breeding habitat for mosquitoes and other pests, interfere with recreation, and may upset the balance of desirable fish populations. Left unchecked, these nuisance plants can render a water body virtually worthless for any uses beneficial to man.

History of Aquatic Plant Problem and Management

During the past century, many non-native aquatic plants have been introduced to the United States from Asia, Africa, South America, and Europe. These plants have thrived and developed to nuisance levels in some areas of this country. Due to a favorable climate and the presence of numerous shallow, nutrient-rich water bodies, several southeastern states, including South Carolina, have been

Table 149.
Description of identified aquatic plant problem areas in South Carolina.

1) Water body - Lake Marion
   Location - Sumter, Clarendon, Calhoun, and Orangeburg Counties
   Aquatic weeds - Alligatorweed *(Alternanthera philoxeroides)*, Brazilian elodea *(Egeria densa)*, water primrose *(Ludwigia uruguayensis)*, slender naiad *(Najas minor)*, pondweed *(Potamogeton sp.)*, hydrilla *(Hydrilla verticillata)*
   Coverage - approximately 30,000 acres
   Impaired water uses - Recreation (boating, fishing, hunting, swimming, etc.)
2) Water body - Lake Moultrie
   Location - Berkeley County
   Aquatic weeds - Alligatorweek *(Alternanthera philoxeroides)*, water primrose *(Ludwigia urugayensis)*, slender naiad *(Najas minor)*, pondweed *(Potamogeton sp.)*
   Impaired water uses - Recreation
3) Water body - Lake Murray
   Location - Lexington, Richland, and Newberry Counties
   Aquatic weeds - Alligatorweed *(Alternanthera philoxeroides)*, water primrose *(Ludwigia uruguayensis)*, spikerush *(Eleocharis sp.)*
   Coverage - Confined to shallow coves (less than 500 acres total)
   Impaired water uses - Recreation
4) Water body - Waccamaw, Black, and Pee Dee Rivers
   Location - Georgetown and Horry Counties
   Aquatic weeds - Brazilian elodea *(Egeria densa)*
   Coverage - 500 acres of navigable creeks
   Impaired water uses - Recreation
5) Water body - Cooper River
   Location - Berkeley County
   Aquatic weeds - Brazilian elodea *(Egeria densa)*, alligatorweed *(Alternanthera philoxeroides)*, water primrose *(Ludwigia uruguayensis)*
   Coverage - 4,600 acres
   Impaired water uses - Recreation
6) Water body - Back River Reservoir
   Location - Berkeley County
   Aquatic weeds - Brazilian elodea *(Egeria densa)*, alligatorweed *(Alternanthera philoxeroides)*, water primrose *(Ludwigia uruguayensis)*, water pennywort *(Hydrocotyl ranunculoides)*
   Coverage - 400 acres
   Impaired water uses - Recreation, industrial water supply, municipal water supply, thermoelectric power generation
7) Water body - Goose Creek Reservoir
   Location - Berkeley County
   Aquatic weeds - Smartweed *(Polygonum densiflorum)*, water hyacinth *(Eichhornia crassipes)*, coontail *(Ceratophyllum demersum)*, duckweed *(Lemna minor)*
   Coverage - 600 acres
   Impaired water uses - Recreational, municipal water supply, also contributes to flooding of residential property
8) Water body - Several waterfowl management ponds, tidal marsh areas, and dredge disposal sites
   Location - Coastal Counties, primarily Georgetown County
   Aquatic weeds - Reedcane *(Phragmites communis)*
   Coverage - Approximately 4,000 acres
   Impaired water uses - Waterfowl management, hunting, dredged material disposal
9) Water body - Prestwood Lake
   Location - Darlington County
   Aquatic weeds - Watermilfoil *(Myriophyllum)*, bladderwort *(Utricularia)*
   Coverage - 200 acres
   Impaired water uses - Recreation, industrial water supply
10) Water body - Black Creek
   Location - Darlington County
   Aquatic weeds - Alligatorweed *(Alternanthera philoxeroides)*
   Coverage - 800 acres
   Impaired water use - Recreation
11) Water body - North Fork Edisto River
   Location - Orangeburg County
   Aquatic weeds - Alligatorweed *(Alternanthera philoxeroides)*
   Coverage - Unknown
   Impaired water uses - Recreation
12) Water body - Lake William C. Bowen
   Location - Spartanburg County
   Aquatic weeds - Slender naiad *(Najas minor)*
   Coverage - 75% of shoreline
   Impaired water uses - Recreation, municipal water supply
13) Water body - Savannah River
   Location - Edgefield County
   Aquatic weeds - Brazilian elodea *(Egeria densa)*
   Coverage - Unknown
   Impaired water uses - Recreation, hydroelectric power generation

especially affected by the proliferation of non-native aquatic plants.

While aquatic weeds occur throughout South Carolina, nuisance populations and associated water use problems have been most prevalent in the Coastal Plain. Large areas of the Santee-Cooper lakes, Cooper River, Back River Reservoir, Edisto River, and other lowcountry streams and lakes are infested with aquatic weeds. Some of the most troublesome species have been alligatorweed *(Alternanthera philoxeroides)*, water primrose *(Ludwigia uruguayensis)*, Brazilian elodea *(Egeria densa)*, and reedcane *(Phragmites communis)*. In addition, the especially problematic plant hydrilla *(Hydrilla verticillata)* was discovered in upper Lake Marion in July 1982. Hydrilla has been described as the "perfect aquatic weed" and is the most potentially damaging aquatic plant currently occurring in South Carolina.

Large-scale aquatic plant management in South Carolina began in the 1940's with the S.C. Public Service Authority's efforts to control alligatorweed in Lake Marion. The Rivers and Harbors Act of 1958 gave the U.S. Army Corps of Engineers authority to administer a 30 percent state/70 percent Federal cost sharing program to assist states with the control of nuisance aquatic plants in public waters. Under this program, the Corps of Engineers and S.C. Public Service Authority participated in a cooperative program for Lake Marion from 1960 to 1967. Subsequently, the Public Service Authority has continued in its efforts to control alligatorweed and later Brazilian elodea, water primrose, and hydrilla in the Santee-Cooper lakes.

In 1967 the emphasis of the state/Federal cooperative program in South Carolina was shifted from Santee-Cooper lakes to other alligatorweed infested waters of the State. At that time, the S.C. Department of Agriculture entered a cooperative agreement with the Corps of Engineers for the control of alligatorweed in portions of Black River, Black Mingo Creek, Congaree River, Little Pee Dee River, and the North Fork Edisto River. This agreement continued until 1975 when new regulations were developed which prevented the use of herbicides effective in controlling alligatorweed in flowing waters. More recently, these regulations have been modified to permit uses of certain herbicides in flowing waters.

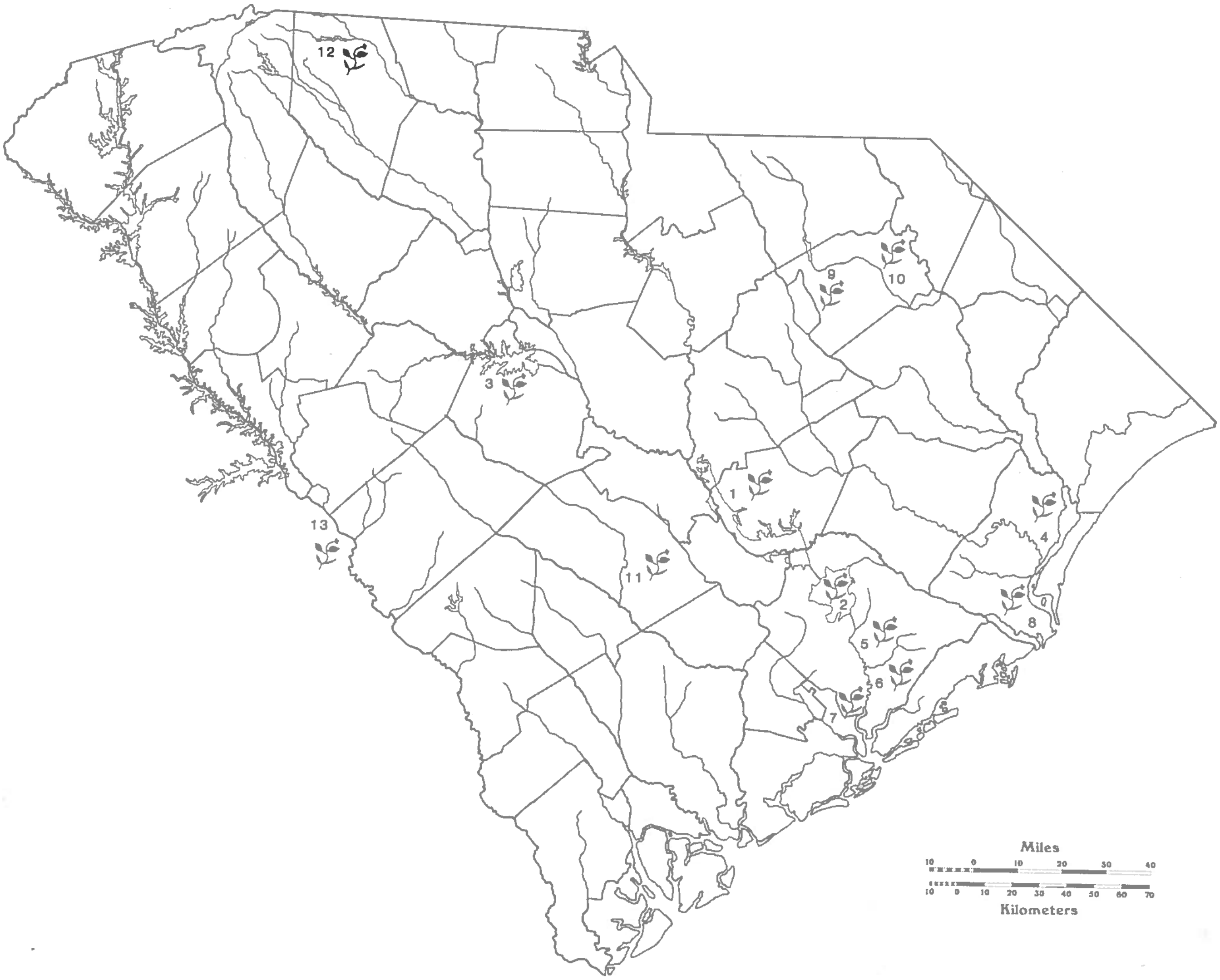


Figure 158.
Major aquatic plant problem areas in South Carolina (See Table 149 for site information).

Management of aquatic plants in private waters has been the responsibility of the owner. Assistance, in the form of professional advice regarding plant control agents and methods, is available to owners of private waters through the S.C. Wildlife and Marine Resources Department, the Clemson University Agricultural Extension Service, and the Soil Conservation Service of the U.S. Department of Agriculture. Owners may choose to implement control methods themselves or arrange for a commercial lake management firm to do so. Public funds have not been available to assist owners in implementing aquatic plant control.

The S.C. Aquatic Plant Management Society, a non-profit organization, was formed in 1978 to promote the management of noxious aquatic plants. The Society's membership includes individuals from the private, public, and academic sectors with interests in all aspects of aquatic plant management. The Society has fostered recent interest in the development of a statewide program for aquatic plant management.

Aquatic Plant Management Council

During 1980, Governor Richard W. Riley was informed of the severity and importance of South Carolina's aquatic plant problem by a number of State agencies and the S.C. Aquatic Plant Management Society. In response to this information, Governor Riley issued Executive Order 80-38 on October 10, 1980 which created the S.C. Aquatic Plant Management Council. The Council is composed of one representative each from the S.C. Water Resources Commission; S.C. Department of Health and Environmental Control; S.C. Wildlife and Marine Resources Department; S.C. Department of Agriculture; S.C. Coastal Council; S.C. Public Service Authority; S.C. Land Resources Conservation Commission; S.C. Department of Parks, Recreation, and Tourism; Clemson University Plant Pest Regulatory Service; and the Governor's Office. The representative from the S.C. Water Resources Commission serves as Chairman of the Council.

The primary responsibility of the Council is to develop and implement a program for control and management of aquatic plants in South Carolina. Toward that end, the Council is required to prepare an Aquatic Plant Management Plan which identifies problem areas, prescribes management practices, and sets management priorities. The Plan may be updated and amended as needed. Priorities for funding of management activities are to be established annually.

The S.C. Water Resources Commission provides primary staff support to the Council and has final approval authority over sections of the management plan and its amendments and priorities which do not receive two-thirds approval of the Council. The Commission is also designated to receive Federal and other funds that may be available for aquatic plant management and to distribute these funds according to policies and priorities of the Aquatic Plant Management Plan.

Management plans have been prepared and implemented to the extent that funding permitted in 1981 and 1982. Aquatic plant problem areas identified in the more recent 1982 Plan are described in Table 149 and located in Figure 158. Management strategies were developed for each of these problem areas and available public funding was allocated according to a priority rank assigned to each area. The Council has estimated that full implementation of the Management Plan would require funding of approximately $1.5 million to $2 million annually. To date, available funding has been for much less than that amount.

During 1981, the Council received $60,000 in Federal matching funds through the U.S. Army Corps of Engineers. The Council allocated $57,000 of these funds to the S.C. Public Service Authority for plant management at Lake Marion. The Authority used these funds to chemically treat approximately 500 acres of the area uplake of the Rimini railroad trestle. The herbicide Diquat was used to treat for Brazilian elodea and other submersed weed species. The remainder of the Federal funds were used to assist in development of the Council's management program.

Table 150.

Nuisance aquatic plants -- problems and opportunities.

Opportunities

1. The S.C. Aquatic Plant Management Council was established in 1980 by Governor Richard Riley to develop plans and coordinate aquatic plant management activities in public waters throughout South Carolina.
2. Assistance for the management of aquatic plants in private waters is provided by the S.C. Wildlife and Marine Resources Department, Soil Conservation Service, and Clemson University Agricultural Extension Service.
3. Some funding for aquatic plant control activities is available through U.S. Army Corps of Engineers' cost sharing program (30 percent state/70 percent Federal).

Problems

1. Abundant populations of aquatic weeds can interfere with almost all withdrawal and instream uses making a water body virtually useless.
2. Large populations of noxious aquatic plants impair water use activities in Lake Marion, Cooper River, Back River Reservoir, Goose Creek Reservoir, and other rivers and lakes throughout the State.
3. The most troublesome plant species are not native to South Carolina and include alligatorweed, Brazilian elodea, water primrose, reedcane, and hydrilla.
4. The recently discovered submersed aquatic plant, hydrilla, is extremely prolific and difficult to control and poses a serious potential threat to all waters of the State.
5. Sufficient funds are not available to adequately control the aquatic weed problem in South Carolina.

In 1982, the Council allocated $13,000 of Federal matching funds to Berkeley County for control of water hyacinth at Goose Creek Reservoir. The herbicides Diquat and 2,4-D were used in this control effort. The Council also allocated $30,000 in Federal funds to the S.C. Public Service Authority for application of Diquat and Aquathol-K to control hydrilla and other submersed plants in Lake Marion.

COASTAL CONCERNS

The coastal area of South Carolina is the most rapidly developing area of the State. Population increases stimulated by increased levels of industrial, residential, and resort development in each of the eight coastal zone counties (Beaufort, Jasper, Colleton, Charleston, Dorchester, Berkeley, Georgetown, and Horry) have resulted in increasing demands for very limited resources within a fragile environment. As a result of this competition for space, real estate prices within the coastal area have escalated and prime locations (especially waterfront sites) are becoming increasingly expensive and hard to find.

In an effort to balance out the needs of various activities for space along the coastal zone and in an effort to protect the sensitive nature of the environment, the South Carolina Coastal Zone Management Act was enacted in 1977. This Act recognizes the importance of the coastal zone, with its many competing uses, demands for resources and building spaces, and the rich, but sensitive limited environment in which this development takes place.

Managed by the South Carolina Coastal Council, the South Carolina Coastal Zone Management Program attempts to accommodate the population increase and accompanying demands for utilization of coastal resources in a manner in which adjacent or adjoining resources will not be affected adversely by the new development. By carefully reviewing development proposals and ensuring that all necessary environmental and economic factors are weighed, most activities should be able to operate side by side. When such is not the case, the natural resources and public interest will dictate the decision.

Among the many different types of uses and activities the Council must consider are:

1. Population growth and the demand for residential space,
2. Space needs for different types of industrial or economic activities,
3. Recreational uses and needs for beachfront or water access,
4. Mineral resources,
5. Agricultural activities,
6. New energy sources,
7. Transportation,
8. Shellfish harvesting,
9. Water quality concerns,
10. Tourism, and
11. Public safety.

In addition to the Coastal Council, various other State and Federal agencies are involved in coastal management decisions, including the S.C. Department of Health and Environmental Control, S.C. Water Resources Commission, S.C. Wildlife and Marine Resources Department, U.S. Army Corps of Engineers, U.S. Fish and Wildlife, and others.

Coastal concerns are broadly classified into five categories: economic development, environmental impacts, competition for land and water space, erosion protection, and recreational opportunities. These categories represent different perspectives or viewpoints of an issue. Each category and the issues which are included within are discussed individually.

Economic Development

Need for Waterfront Industrial Property

Coastal areas are generally attractive to five types of industrial manufacturing or shipping facilities. These are:

1. Industries that benefit from or depend upon a waterfront location for shipment of goods,
2. Industries that derive power or are dependent upon a waterfront location for cooling or various manufacturing processes,
3. Industries that derive their workforce from coastal population centers but do not directly depend upon a waterfront location for use in manufacturing or access,
4. Marine transportation industries, and
5. Industries that depend directly on the marine environment for raw materials.

Industrial activities by their nature can often produce conflicts between the existing environment or land uses sharing a common body of water. For example, commercial shrimping or fishing often will depend upon the same body of water that some other manufacturing industry is dependent upon for cooling water, transportation, or similar uses.

Most importantly, the coastal zone is unique because the operation of many industrial activities is completely dependent upon a waterfront location with specific site requirements. Examples of these activities can include shipyards, commercial fishing docks, and port facilities. Space to accommodate these activities is limited.

Development of a Mariculture Industry

Another economic development issue which could be important to South Carolina's future growth is the potential for establishment of a mariculture industry. Mariculture is the cultivation and production of marine plants and animals for human use. With careful planning and management, a mariculture industry could be developed without significantly affecting the coastal environment and the natural life cycle processes of marine organisms. The potential for the estuaries and oceans to provide a significant portion of the world's food supply has been largely undeveloped. Commercial fishing catches have been highly variable in recent years, resulting in economic instability within the industry. The pollution of estuarine environments has resulted in the destruction or restriction of many once productive marine nursery areas. A mariculture industry could offset some of the unpredictability of nature and effects of pollution and potentially produce significant quantities of food protein.

A mariculture industry would compete with other water users for the limited available resource. Many mariculture activities would require good water quality which could be affected by other water users. The development of other water and land activities adjacent to mariculture operations may have impacts on mariculture operations unless properly controlled.

At the present state of technology, the cost of production of marine organisms for food is in most cases too high for commercial production. Continued research is needed to facilitate cost effective mariculture operations. The recent development of a new mariculture research center in Beaufort County demonstrates South Carolina's commitment to the establishment of this important industry.

Location and Siting of Energy Facilities

The siting of energy producing and refining facilities is a growing coastal concern. This issue will involve the review of applications for potential offshore oil exploration, oil refinery locations, sites for electric generating facilities, and others. The Coastal Zone Management Act requires that a great deal of attention be given to this subject, and in support of those directives the South Carolina Coastal Zone Management Program contains a number of policies for dealing with the issue.

The increasing concentration of people along the coast will require energy to provide for personal needs as well as the demands of commercial and industrial interests. At the same time, these population concentrations will compete for choice locations required to site energy facilities. The amount of land which is needed and the specific site demands (such as waterfront locations) of most energy producing facilities can result in a number of environmental problems. Acceptable sites may be hard to find.

Increased Cost for Road and Railroad Construction

Another important issue affecting coastal economic development concerns the building of roads and railroads. Often the building of a roadbed will require the crossing of wetlands or waterways. Consequently, costs for construction will be higher, as bridges or causeways must be built to support the road or rail bed. The environmental costs of altering the areas must also be considered when making transportation decisions. An improperly designed road can create many problems, such as loss of wildlife habitat, pollution of water bodies from stormwater runoff, and increased flooding by altering drainage patterns.

Costs for Maintaining Navigation Channels

Another economic issue of growing importance is the ability to maintain navigation channels to certain ports and docking facilities without Federal assistance. New Federal budgetary constraints indicate that a larger share of the costs for these types of activities must now be borne by local governments or by the industries which benefit from the action. Without Federal assistance, some navigation channels may not be maintained, resulting in a loss of waterfront activities.

Impact of Development on the Commercial Oyster Industry

Increasing urbanization of the coast will continue to have negative economic impacts on the commercial oyster industry unless better management practices are developed. Most of these impacts will occur gradually and will be more difficult to notice. However, the effects of pollution on the successful operation of the commercial oyster industry are highly visible. Commercially leased oyster beds will be closed if polluted from stormwater runoff or industrial waste. This may result in lost revenue and jobs in the commercial oyster industry. Currently, approximately one-third of the coastal waters are closed to oyster harvesting. Additional areas will be closed unless properly protected from the impacts of urbanization.

Redevelopment of Waterfront Property

The limited amount of waterfront property and increasing population growth will inevitably result in competition for available building space. Generally, the higher the value of property, the denser the development pattern. Presently, single family beach homes in the upper Grand Strand area are being removed and replaced by condominium projects; more units per acre increase real estate values. This pattern is likely to continue in future years.

Impact of Tourism on the Local Infrastructure

Although tourism brings new income to coastal areas, it also has negative impacts on local infrastructures. Most people vacationing in South Carolina come to the coastal area for recreational purposes. Consequently, the population of many coastal communities usually increases geometrically between the winter and summer seasons. In order to handle these variations, water, sewer, and utility systems must be oversized to handle the maximum population, roads must be larger, and police and fire departments must have adequate manpower to handle the population change. All of these contribute to increased costs of providing services.

These larger and more variable populations can also have environmental consequences. Motels, condominiums, and shopping and recreational facilities will be constructed to meet the demands of the population. The increased development creates spinoff effects, such as pollution of water bodies, loss of wildlife habitat, and destruction of sand dunes. The impact of these spinoff effects must be considered in making coastal management decisions.

Environmental Impacts

Runoff from urban and agricultural areas and occasional violations of wastewater discharge permits contribute to adverse environmental consequences in sensitive coastal water environments. While management efforts by State and local agencies help minimize the negative impacts of coastal development, some environmental concerns still exist. Projected growth will compound current problems and demand more effective management of activities affecting water quality.

Non-point Source Pollution of Coastal Waters

Non-point source pollution of surface water is one of the most serious development related impacts on the environment presently found within the coastal zone. Urban and agricultural runoff are classified as non-point sources of pollution. Drainage from developed areas usually contains nutrients, oils and greases, metals, chemicals, and other substances which are often directly deposited into coastal waters. Drainage of fertilizer and pesticides from farm fields has been documented as being a cause of fish kills in surface waters of the coastal zone.

Technology is presently available to remove most polluting elements from stormwater runoff. Unfortunately, it is very difficult to remedy existing situations; measures to limit non-point source pollution must often be put in place at the design and initial construction phases of projects. A common method of treatment is the retention of stormwater to allow pollutants to settle out or to bond to vegetation. Cleaner water is then discharged through natural filtering areas, such as salt marshes or freshwater wetlands, prior to entry into surface waters. Through permitting and certification procedures, the Coastal Council currently reviews major development projects to make sure strategies for control of non-point sources of pollution have been considered in designing the project. However, additional local government development regulations are needed to make sure that non-point source pollution is minimized.

Pollution from Sewage Treatment Plants

Although discharges from wastewater treatment plants and the siting of septic tanks are strictly regulated by the S.C. Department of Health and Environmental Control, and local authorities, violations do occasionally occur. Improperly treated effluent from these types of facilities is discharged or leached into tidal waters. Although violations are addressed by the appropriate enforcement authority and corrective action taken, each violation contributes to the problem of managing a sensitive coastal environment. The proliferation of these facilities resulting from expanded development of the coastal zone will make the problem much greater in future years. Increased monitoring and strict enforcement of penalties for violations of water quality standards must be imposed if South Carolina is going to maintain a high quality coastal environment.

Water Quality Degradation from Mining Activities

Mining activities taking place adjacent to coastal wetlands can cause environmental problems unless properly regulated. Flooding, water quality degradation, and loss of wetlands and wildlife habitat can occur in and adjacent to improperly sited or operated facilities.

Landfill Locations

In coastal areas where land prices are at a preminum, environmentally acceptable sites to locate landfills will be increasingly hard to find. Economic forces and scarcity of acceptable highland areas could encourage the use of unsuitable sites for landfills. Freshwater wetland areas have in past years been used as landfill sites; generally these are not acceptable locations. Marginal lands used for landfill sites could have an impact on surface and ground-water quality and the surrounding environment. Solid waste disposal problems will continue to be an important issue in coastal areas during future years.

Preservation of Pristine Water Quality and Undeveloped Lands

The amount of urbanized development that is expected to take place in coming years will make the pristine undeveloped sections of the coast even more valuable. All of South Carolina's islands, rivers, creeks, beaches, and bays can not be preserved in their natural state; however, many can be protected. A number of protective actions are available. These can include: the outright donation or purchase of land by the Federal or State government, reclassifying rivers or creeks SAA which would prohibit discharges and restrict certain types of development, classifying certain bays or estuaries as marine or estuarine sanctuaries to limit development actions, as well as several other alternatives.

Competition for Land and Water Space

Competition for Water Use Rights

The legal rights and privileges to the use of the water bottom lands of South Carolina remains in question. Property owners with buildings constructed over water and wetland areas currently are not paying any fee for the use of the property upon which they are built, and in many cases have no title to the property. This issue needs to be resolved and it may be a very complicated resolution.

Competition for waterfront space can often occur in more subtle forms. For example, some lowcountry creeks have become virtually unusable for shrimping, seining or other recreational activities because of a proliferation of private docks along the banks. It is likely that in future years undeveloped creeks will be extremely rare.

Marinas Versus Shellfish Leases

The most visible example of competition for space has begun to occur between marina developers and commercial shellfish lease holders. Marinas require a buffer area of 1,000 feet in which shellfishing is prohibited because of potential contamination. This removes a sizeable portion of productive area once available for commercial shellfish leasing. The rights to the use of the bottoms and privileges associated with the development of waterfront property adjacent to oyster lease areas will have to be addressed in the near future. Three or more parties (the leaseholders, marina developer, and State) should be involved in each decision.

Marina Traffic Problems

Marina developments can also impact land traffic flow. Increasing boat traffic, especially by sailboats, can increase the number of bridge openings, depending upon the size of the boat, height of the bridge opening, and location of the marina. A poorly sited marina could result in so many bridge openings that the traffic flow patterns of the adjacent land area are changed. Restrictions on bridge openings can be instituted, but the successful operation of the marina and road network depend upon good location and planning during the initial stages of development.

Erosion Protection

Shoreline erosion is a natural and continuous process which greatly affects development activities along the coast. In some areas, such as Folly Beach and Myrtle Beach, excessive beach erosion is seriously threatening residential and commercial structures. Some basic information about shoreline dynamics is known; however, insufficient data are available to accurately predict the location, timing, and extent of beach erosion. Secondary and tertiary dune systems and maritime forests are important shoreline stabilizing features. Often these dunes and forests are completely removed during construction activities. Once removed, the natural protective system can not function and man-made structures are directly exposed to the forces of the ocean.

Environmental management agencies, such as the South Carolina Coastal Council, protect immediately threatened property that has already been developed while carefully permitting construction in undeveloped areas. Before structural corrective measures are made to alleviate erosion problems, all mitigation options are explored so the public's use and enjoyment of the beach is not impaired. Hopefully, as a better understanding of the erosion process develops, corrective actions will have increasingly positive results. In the meantime, construction will continue as close to the ocean as the law allows. Greater support on local and State

Table 151.
Coastal concerns -- problems and opportunities.

Opportunities

1. South Carolina's coast represents a unique resource for a wide variety of activities and uses and is the State's greatest tourist attraction and favorite recreational destination.
2. The S.C. Coastal Council has developed and implemented a Federally approved Coastal Zone Management Program to protect and manage coastal resources.
3. South Carolina has the potential to develop a cost effective and environmentally compatible mariculture industry.
4. The S.C. Coastal Council and the National Hurricane Center are funding a project to mathmatically model anticipated flood levels along the coast due to storm activities.

Problems

1. Waterfront space to accommodate water dependant industries is limited.
2. Industrial, commercial, and residential development may cause adverse environmental impacts if not properly sited and regulated.
3. Federal budgetary cutbacks threaten navigation channel maintenance in some areas.
4. Highly variable community populations often strain municipal services during the peak tourist season.
5. Non-point source pollution is one of the most serious environmental impacts along the coast.
6. Occasional contamination due to improper septic tank sitings and wastewater discharge permit violations has contributed to coastal water quality problems.
7. As coastal development progresses, competition for land and water space increases.
8. Shoreline dynamics are not fully understood and excessive erosion threatens some currently developed beachfront areas, such as Myrtle Beach and Folly Beach.
9. Increased congestion and pollution due to coastal development will have an adverse effect on the recreational use and enjoyment of coastal waters.
10. High density developments are still being constructed in beachfront areas subject to erosion and land instability.
11. Public access to beaches and shellfish gathering areas is inadequate to meet the demand for these recreational activities. Public areas may exist but access and parking are severely restricted.

levels needs to be generated to expand current legislated construction setbacks and enact better land use management principles. Until that occurs, only wise decisions by development interests can ensure the protection of structures from erosion and ultimately ensure minimal damage to one of our primary coastal resources -- the beach.

Recreation

The increased development of the coastal zone will place a greater dependence upon existing recreational facilities. The impacts from development in the form of congestion and pollution will have an effect on the use and enjoyment of the waters as recreational facilities. It is, therefore, very important that decisions to protect existing facilities, improve access points, and construct new waterfront access opportunities be made in coming years. These improvements in access are likely to involve such things as permitting ocean fishing piers, dune walkovers, parking lots adjacent to the beach, and ferry services to barrier lands.

Most of the following recreational concerns have been discussed in preceding sections and will not be reiterated:

1. Protection of water quality for recreational activities
2. Need for more recreational access points
3. Water quality conflicts between marina locations and public oyster grounds
4. Need for more waterfront recreational facilities
5. Expansion of recreational shellfish areas
6. Providing improved access to State and Federally owned barrier islands

WATER RECREATION

Water is the focal point for a large number of recreational activities including fishing, boating, and swimming. Many outdoor activities such as camping, hiking, and picnicking are enhanced when performed near water. Fortunately, South Carolina is well supplied with fresh and saltwater resources which allow a wide variety of water oriented recreation for the State's residents and visitors. The attraction of South Carolina's water resources supports a healthy and growing recreation and tourism industry. Travelers spent more than $2.4 billion in South Carolina during 1981, up 13 percent from 1980. In addition, it is estimated that these tourist dollars directly generated about 5.7 percent of the State's total employment (U.S. Travel Data Center, 1982).

The major recreational water bodies in the State are lakes, rivers, and coastal waters. Each of these and their associated recreational activities are discussed below.

Lake Recreation

Few natural lakes exist in South Carolina; however, the construction of reservoirs for hydropower, water supply, and flood control provide the State with over 1,400 lakes greater than 10 acres in size. Collectively, these lakes cover over 525,000 acres and impound nearly 15,700,000 acre-feet of water. The largest lakes provide a wide variety of recreational opportunities (Table 152). Most of the major lakes are located in the Blue Ridge Mountain and Piedmont regions of the State with the exception of Lakes Marion, Moultrie, and Robinson which are in the Coastal Plain region.

While most of these major lakes were impounded for the production of electric power, many serve secondary purposes, including recreation. These major lakes are second only to the Grand Strand area in offering the public its greatest existing and potential recreational resource. A wide range of water-based recreational opportunities is available at lakes, with the most popular being fishing, water skiing, and boating. Public recreation areas are widely available, while the availability of commercial or private facilities is more dependant upon the amount of lake use. Lakes near large population centers, such as Lake Murray and Lake Wylie, experience high public use and thus a wide variety of recreational opportunities are available. Marinas and restaurants are located around the perimeter of these lakes. In addition to the state parks listed in Table 152, lake recreation is also available to the public at lakes contained completely within the following parks: Aiken, Andrew Jackson, Barnwell, Cheraw, Croft, Kings Mountain, Lee, Little Pee Dee, N. R. Goodale, Oconee, Paris Mountain, Pleasant Ridge, Poinsett, Sesquincentennial, Table Rock and Lake Warren.

Lakes located away from large population centers are not heavily used and few commercial and private recreation areas are available. However, adequate numbers of public facilities are available to meet recreational needs.

River Recreation

South Carolina is interlaced with numerous rivers and streams totaling over 2,200 miles. While many river stretches have been impounded, most of the State's rivers still flow free and offer a variety of recreational opportunities in all parts of South Carolina. The diversity of the State's waterways provides a variety of riverine environments from the turbulent whitewater streams of the Blue Ridge and Piedmont to the tranquil blackwater streams of the Coastal Plain.

Many different types of recreational activities occur on the State's rivers including fishing, boating, hunting, swimming, and camping. However, the particular activity engaged in is dependent on the characteristics of the stream.

Table 152.
Recreational overview of the major lakes in South Carolina.

Lake	Storage Capacity (acre-feet)	Surface Area (acres)	Recreational Overview
1. Hartwell Lake	2,549,000	56,000	Similar to Clarks Hill Reservoir; however, has more private development with much less publically owned shoreline. One State Park (Sadlers Creek) is located on the reservoir and a second park is under construction. Georgia has two parks on the reservoir.
2. Clarks Hill Lake	2,510,000	70,000	Extensive public recreation sites; limited commercial or private sites due to publicly owned shoreline. All forms of recreation available, including camping, hiking, boating, and fishing. Intensive management of adjacent forests and wildlife by the Corps of Engineers. Three S.C. State Parks are located on the reservoir (Hickory Knob, Baker Creek, and Hamilton Branch). Georgia has three parks on the reservoir.
3. Lake Murray	2,114,000	51,000	Extensive private and commercial development. Dreher Is. State Park located on northern shore. SCE&G maintains 8 public parks and landings. All forms of recreation available.
4. Lake Marion	1,400,000	110,600	Along with Lake Moultrie, one of the most popular tourist areas in the State. Santee State Park located on the western shore. Over one-half of the lake is a National Wildlife Refuge. All forms of recreation available, the most popular being fishing. Future development committed to extensive planning to make best possible use of areas involved. Seventy percent of land around lake to remain in natural condition.
5. Lake Moultrie	1,211,000	60,400	Similar to Lake Marion in most aspects. Game management area located on southern shore. All forms of recreation available.
6. Lake Jocassee	1,185,000	7,565	Limited recreational development by Duke Power Company because of large fluctuation in water levels. There are two boat ramps and one campsite. The Foothills Trail provides hiking access to the upper end of the lake.
7. Richard B. Russell	1,026,000	26,650	To be completed in 1985. Most recreational facilities will be provided by the Corps of Engineers. Two state parks are planned for the South Carolina side. All forms of recreation should be available.
8. Lake Keowee	1,000,000	18,372	Most development by Duke Power Company. All forms of recreation available but in limited quantities. Duke Power Company has plans for several high quality, major development complexes. Keowee Toxaway State Park is located on the northern end of the lake.
9. Lake Monticello	431,000	6,800	Recently completed by SCE&G. Limited recreation available in the form of boating and fishing.
10. Wateree Lake	310,000	13,710	In addition to several access areas maintained by Duke Power Company, there are a limited number of commercial recreational areas. Little commercial or private development has occurred but all forms of recreation are available in limited quantities. A new state park is under construction at Desport Island.
11. Lake Wylie	281,900	12,455	Commercial and private recreation sites available as well as several access areas maintained by Duke Power Company. Extensive home construction has occurred on the N.C. side of the Lake. All forms of recreation available.
12. Lake Greenwood	270,000	11,400	Current recreation facilities are extremely limited with the exception of Greenwood State Park.
13. Fishing Creek Reservoir	80,000	3,370	Current recreation facilities are extremely limited. Duke Power Company maintains two access areas.
14. North Saluda Reservoir	76,108	1,080	Used only as a municipal water source, no recreation available.
15. Par Pond	54,000	2,700	Used as a cooling pond for several nuclear reactors, no recreation available.
16. Parr Reservoir	32,533	4,400	Access to the reservoir is limited. Most recreation consists of boating and fishing.
17. Lake H. B. Robinson	31,000	2,250	Only access to lake is via three commercial boat landings. Public recreation sites extremely limited. Main recreational activities include boating and skiing.
18. Lake W. C. Bowen	24,550	1,600	Lake serves mainly as a municipal water source, but limited recreation in the form of boating, fishing and swimming is available.

Fishing is the most popular form of riverine recreation (S.C. Department of Parks, Recreation, and Tourism, 1979). Trout fishing is popular in the cold waters of the Blue Ridge and Piedmont, while striped bass, catfish, and red breast are more popular in the Coastal Plain streams.

Boating, including canoeing, kayaking, and rafting, occurs throughout the State. However, motorboating is more popular on Coastal Plain streams since these waters are more navigable than those of the Piedmont. The S.C. Department of Parks, Recreation, and Tourism, in cooperation with the S.C. Wildlife and Marine Resources Department (1978), has identified segments of South Carolina's rivers which are especially suitable for use by canoeists and boaters. A summary of these river trails and their location is presented in Table 153 and Figure 159, respectively.

Rivers or portions of rivers with unique natural or cultural characteristics can be maintained in their current state through the National Wild and Scenic Rivers Program or the South Carolina Scenic Rivers Program and provide unique recreational experiences. In addition, the following State Parks provide river oriented recreation: Aiken, Colleton and Givhans Ferry are on the Edisto River; Rivers Bridge on the Salkehatchie, Old Dorchester on the Ashley; Landsford Canal on the Catawba; and Hampton Plantation on the Santee. Lee and Lynches River State Parks are both on Lynches River and Little Pee Dee State Park is on the river of the same name. Two undeveloped state park sites are on rivers, Musgrove Mill on the Enoree and Long Bluff on the Pee Dee. Caesars Head State Park includes the Middle Saluda and scenic Raven Cliff Falls.

Coastal Water Recreation

South Carolina's coastline stretches approximately 190 miles between Little River Inlet and Savannah Harbor. In addition to the open ocean, numerous inlets, bays, sounds, and tidal rivers contribute to the diversity of South Carolina's coastal waters. Nearly 3,000 miles of tidal shoreline and over 450,000 acres of tidelands make this area one of the State's most important and productive natural resources.

The natural beauty, diversity, and productivity of South Carolina's coastal waters attract numerous resident and out-of-state visitors each year. The most popular recreation areas in the State are along the coast and offer a variety of recreational opportunities including swimming, fishing, sailing, motorboating, shellfishing, water skiing, camping, and beachcombing. The coast can be divided into three major tourist and recreation areas: the Grand Strand, Charleston, and the lower coastal area near Beaufort.

With nearly 60 miles of unbroken beaches, the Grand Strand area is the most popular recreation site in the State for both out-of-state visitors and residents. While the most popular form of recreation is ocean swimming and sunbathing, activities such as camping and fishing are also very popular. In the Grand Strand area alone there are about 12,000 camp sites. Fishing piers dot the coast and charter boats are available for ocean gamefishing. Two state parks are located in the Grand Strand area, providing natural recreation areas which sharply contrast with the numerous commercial activities present in the area (S.C. Department of Parks, Recreation, and Tourism, undated).

Beaches in the Charleston area are heavily used by the local population and have not experienced the degree of commercial development which has occurred in the Grand Strand area. Ocean swimming is the most popular water-based recreational activity. Also popular are boating, fishing, and water skiing.

Between Charleston and Beaufort the numerous islands are in private hands and several are developed as resorts. Edisto Beach State Park provides the major public access to this section of coast.

The lowcountry area of Beaufort has become more popular in recent years with resort development on barrier islands such as Hilton Head Island. The semitropical climate of the area makes water-related recreation possible for most of the year. Hunting Island State Park is a popular recreation site, and the maze of tidal waters further inland also receive heavy use. Activities such as fishing, boating, water skiing, and sailing are popular all year round.

Although the areas surrounding Beaufort, Charleston, and the Grand Strand are major recreation sites, the entire coastline offers many different outdoor recreational opportunities.

Restrictions

Most waters of the State are suitable for several types of recreation. However, some activities may be periodically restricted due to insufficient water quality and/or quantity, excessive aquatic vegetation, or other adverse impacts.

Fecal coliform bacteria contamination indicating potential public health problems relating to swimming, diving, and water skiing activities, is found in some waters of the State (see surface-water quality section of individual subbasin assessments). About one third of South Carolina's estuarine waters are closed to shellfish harvesting because of high fecal coliform bacteria levels. High concentrations of PCB's in fish in Lake Hartwell and its tributary Twelvemile Creek have resulted in restricted consumption of fish caught in these areas. Low flows on some streams, especially during late summer and early fall, may severely impair access and navigation. Aquatic weed infestations in several lakes and rivers in the State impair boating, fishing, and swimming activities primarily during the summer months (see Nuisance Aquatic Plants section of Special Topics). Management activities by several State and Federal agencies are trying to control these and other water resource problems so that all waters of the State can eventually meet the Federal goal of fishable and swimmable.

Accessibility

A problem common to all three focuses of water recreation -- lakes, rivers, and coastal beaches -- is the lack of adequate accessibility for the general public. The demand for water-related recreation is expected to grow rapidly during the next few decades (S.C. Department of Parks, Recreation, and Tourism, 1980). Although the demand is expected to increase, the basic supply is relatively fixed. The number of miles of streams, estuaries, and coastal beaches can not be increased. However, more and improved accessibility to these water front areas, with adequate controls, can increase the utilization for recreational purposes.

The issue of public access to recreational waters and adjacent shores has two fundamental aspects (U.S. Water Resources Council and others, 1980). First, a legal public right to use recreational waters and adjacent shores must be established. This public right is often dependent upon establishing public ownership of use of the waters or adjacent shores. Second, in cases where public lands or waters are surrounded by private property or developments, the right of public access may be restricted. The public recreational user must then find some way of gaining access without trespassing. Historically, the provisions of legal public access through private lands has been undertaken by local, State, or Federal governments using the legal mechanisms of land acquisition or land use regulation. However, funding for acquisition, whether by purchase or access easement, is usually insufficient to meet the widespread needs for public recreational access, and does not include the significant ongoing cost of operation and maintenance of acquired access points. Provision of access by land use regulation is limited because of constitutional restrictions, and the widespread unpopularity of governmental regulation in general.

Table 153.

River trails in South Carolina (S.C. Department of Parks, Recreation, and Tourism and S.C. Wildlife and Marine Resources Department, 1978)

1. Ashepoo River

The navigable length of this coastal estuarine river is 37 miles. Access at S.C. Highway 303 allows canoe navigation to S.C. Highway 17 where camping and supplies are available. From this point the river is suitable for travel by johnboat for 18 miles to S.C. Highway 26. Here longer craft can be launched for travel to St. Helena Sound.

2. Black River

The navigable length of this typical black water river is 89 miles. The first 54 miles are suitable for canoeing, the next 17 for johnboat, and the final 18 for larger craft. Access points are available at most road crossings with several within five miles of each other. The greatest distance between access points is 13 miles. Camping and picnicking sites are available at seven of the ten access points.

3. Chattooga River

One of the longest and largest free-flowing rivers in the Southeast, this sparkling mountain stream is navigable on its lower 27 miles. This river is extremely dangerous and should only be navigated under the supervision of experienced individuals. Access is available at three highway crossings and at Lake Tugaloo. Wilderness camping is permitted along the river.

4. & 5. Congaree River, Lake Marion, Lake Moultrie, and the Cooper River

This 170-mile trail is the longest stretch of navigable inland water in the State and is recommended for motorboats only. Although there are numerous access points along the trail, fuel is only available approximately every 60 miles. Camping is available at Santee State Park and on Persanti Island.

6. Enoree River

Flowing through the Piedmont, this narrow river is ideal for canoeing and camping. This 31-mile trail is not well suited for large craft due to numerous log jams and sandbars. Most access points are small and difficult to find. The entire river trail is within Sumter National Forest and camping is available by obtaining permission from the District Ranger.

7. Little Pee Dee River

The 91-mile blackwater river trail passes through deep swamp and sand ridges of the Coastal Plain. The first 34 miles are suitable for canoes only, the next 43 for johnboat, and the final 14 for larger craft. There are numerous access points along the trail but many are small and difficult to find from land because the river is surrounded by deep swampland. The distance between the first two access points on the trail is 16 miles. Below these, access points can be found every three to five miles. With the exception of Little Pee Dee State Park, all camping facilities are located on the lower nine miles of the river trail.

8. North Fork Edisto River

The Edisto Rivers are blackwater rivers bordered by hardwoods and cypress. The lower 44 miles of the North Fork Edisto are passable by canoe only because of numerous log jams. The first access point is at S.C. Highway 321. All access points are from seven to eleven miles apart. Picnic sites are available at Edisto Gardens in Orangeburg.

9. South Fork Edisto River

The South Fork Edisto is also recommended for canoes only on the lower 27 miles. The first recommended access point is at S.C. Highway 321. Distance between access points varies from two to fourteen miles.

10. Main Stem Edisto River

The entire Main Stem Edisto is passable by johnboat. From the first access point at County Road 434, the distance is 86 miles to the Intracoastal Waterway. Larger craft are suitable for travel on the lower 24 miles of river. Distance between access points varies, ranging from one to seventeen miles. Camping is available at Colleton State Park, Givhans Ferry State Park, and West Bank landing. A picnic area can be found at S.C. Highway 17-A.

11. Saluda River at Columbia

The Saluda River below Lake Murray Dam is an 11 mile white water run within easy access of Columbia. There are two access points below Lake Murray Dam and one take-out point in Columbia. Numerous rocks make the river suitable for canoes and rafts only. Cold waters combined with rapidly fluctuating water levels make this a dangerous river for inexperienced paddlers.

12. Santee River

The Santee River is navigable from Wilson Dam to the Atlantic Ocean, a distance of approximately 70 miles. The stretch of river downstream of the dam for a distance of 17 miles is navigable by canoe only. Johnboats are suitable for travel from this point on and larger craft can be launched at U.S. Highway 17. Distances, between access points varies greatly. Camping is allowed on Cedar and Murphy Islands of the Santee Coastal Reserve and on lands of the Francis Marion National Forest.

13. Tyger River

This 24 mile river trail is located within the Sumter National Forest. Numerous log jams and sandbars make this river suitable for canoe travel only.

Table 154.
Water recreation -- problems and opportunities.

Opportunities

1. Numerous lakes, rivers, and coastal waters provide a wide variety of water-based recreational opportunities.
2. The Grand Strand area is the most popular recreational site in the State.

Problems

1. Fecal coliform bacteria contamination indicating potential public health problems relating to water recreation activities, such as swimming, water skiing, and diving and shellfish harvesting, is found in some waters of the State.
2. High levels of PCB's in fish from Lake Hartwell and Twelvemile Creek have resulted in restricted consumption of fish caught in those areas.
3. Low flows on some streams due to natural and man-induced causes may impair boater access and navigation.
4. Noxious aquatic plant infestations in several lakes and rivers impair boating, fishing, swimming, and other recreational activities, especially during the summer months.
5. Accessibility to public waters for recreational purposes is inadequate in some locations.

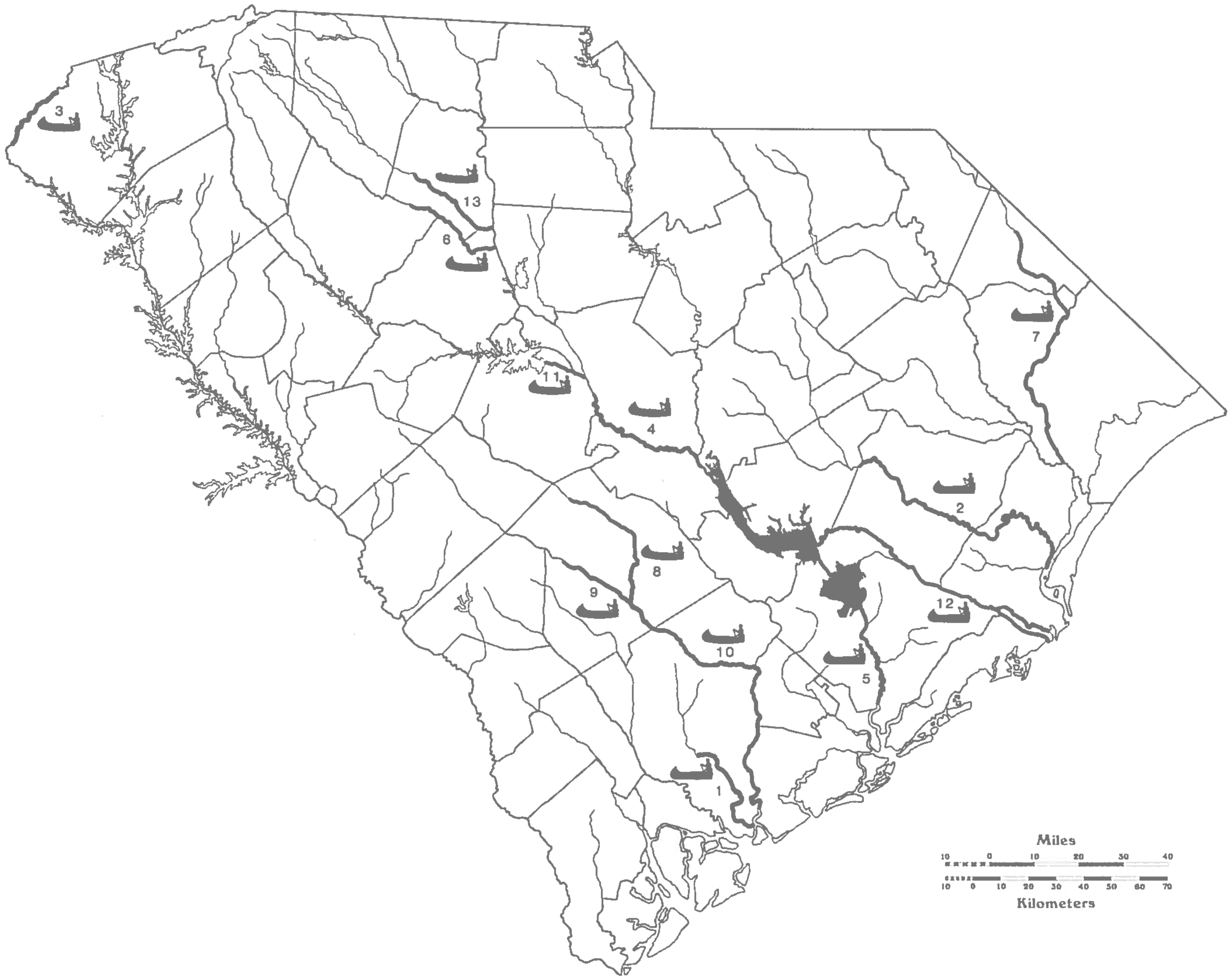


Figure 159.
River trails in South Carolina (See Table 153 for site information).

SCENIC RIVERS

Many of South Carolina's rivers and streams are virtually undeveloped and as such offer ample opportunity for riverine recreation and scenic enjoyment. With this opportunity to protect some of South Carolina's most scenic waterways that may otherwise be lost through future development, South Carolina implemented a State Scenic Rivers Program. In July 1974, Governor John West signed into law the South Carolina Scenic Rivers Act. The Act authorizes the establishment of scenic rivers and specifies procedures for designating and obtaining certain river segments which possess unique and outstanding scenic, recreational, geologic, fish and wildlife, historic, or cultural values. The Act also specifies the methods by which scenic rivers are to be used and protected for the benefit of present and future generations. The South Carolina Scenic Rivers System is administered by the South Carolina Water Resources Commission in its planning and acquisition stages, and by the South Carolina Wildlife and Marine Resources Department in its regulatory stage. The system relies on voluntary donations of land and easements by citizens, as well as purchase by the State from willing sellers.

The State Scenic Rivers Program identifies three levels of eligibility and management criteria to be applied to potential scenic rivers: Class I, Natural River Area; Class II, Pastoral River Area; and Class III, Partially Developed River Area. These criteria are used both in assessing the potential eligibility of a river and in managing the river after gaining scenic river status.

The Class I, Natural River Area includes those free-flowing rivers or sections of rivers with shorelines and

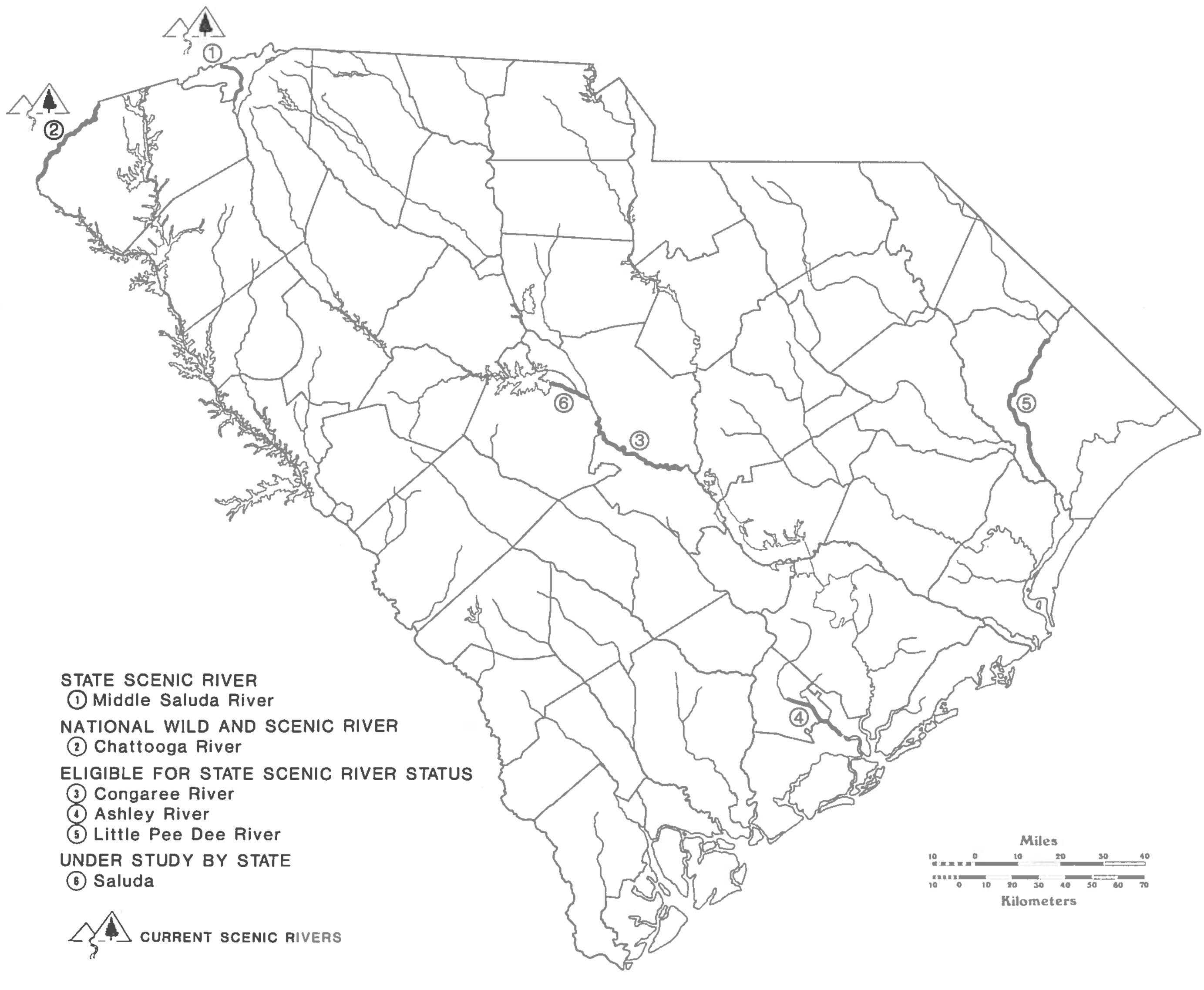


Figure 160.
Current and potential scenic rivers in South Carolina.

scenic vistas unchanged, or essentially unchanged, by man, with no extensive paralleling roads closer than one mile (except in river gorges where there must be no extensive paralleling roads within the gorge or within one-quarter mile from the gorge's rim). Only a limited number of crossing roads or spur roads can exist. Minimum lengths for river segments are one mile in the upper Piedmont and Blue Ridge provinces and three miles in the remainder of the State.

The Class II, Pastoral River Area includes those rivers or sections of rivers with adjacent land being partially or predominantly used for agriculture, silviculture, and other dispersed human activities which do not substantially interfere with public use and enjoyment of the rivers and their shores. The view from the river or its banks may be diverse, though still predominately wild, containing some pastoral countryside. The segment may be accessible intermittently by roads. Minimum lengths are the same as Class I.

The Class III, Partially Developed River Area includes those rivers or sections of rivers in areas affected by the works of man, but which still possess actual or potential scenic, recreational, or historic values. Included in this class would be rivers with developed or partially developed shorelines for residential purposes, rivers with parallel roads or railroads, rivers with some impoundments, and rivers with water quality which could be upgraded. Rivers in this class may possess free-flowing waters with relatively short stretches of impounded water. Some development may be visible on the shoreline, but must not detrimentally affect historical, recreational, or aesthetic values. Minimum lengths are the same as in Class I.

Initiation of the scenic river designation process begins upon the motion of the Water Resources Commission, or by request to the Commission, to examine a river or portion of a river to determine if such river is eligible as a State scenic river. Requests for an examination and designation of rivers may be made to the Commission by State agencies, local governments, or other governmental or citizen's groups. Written proposals are preferred, although not required.

Following such a request, an eligibility study is undertaken by the Commission to determine if the river meets the requirements of the program. In addition to examining the aesthetics of the river, a survey is made of the land owners to determine their willingness to participate in the program. The program is voluntary and the riparian landowners must be willing to sell, donate, or grant an easement to a strip of land adjacent to the river. If the proposed river meets minimum eligibility requirements and sufficient landowners are willing to participate, then the river is classified as "eligible for scenic river status", management regulations are developed, and arrangements are made to accept easements, donations, or purchases.

Presently, South Carolina has one designated scenic river under the South Carolina Scenic Rivers Act, a five mile stretch of the Middle Saluda River in Greenville County (Fig. 160). The area designated begins at U.S. Highway 278 and extends downstream to a point approximately one mile west of the old fish hatchery. Other streams which have been studied by the South Carolina Water Resources Commission and have been declared eligible for inclusion in the South Carolina Scenic Rivers Program include (1) the Congaree River in Richland and Calhoun Counties, from Congaree Creek to the U.S. Highway 601 bridge; (2) the Ashley River in Charleston and Dorchester Counties, from State Route 165 to the Seaboard Coastline Railroad Trestle; and (3) the Little Pee Dee River in Marion and Horry Counties, from the confluence with the Lumber River to the confluence with the Pee Dee River. In addition, a ten mile segment of the Saluda River, from Lake Murray to the confluence with the Broad River, is being studied for possible eligibility in the State Scenic Rivers Program.

On May 10, 1974, Congress designated the Chattooga River as a National Wild and Scenic River. The designated segment of the Chattooga River serves as the border between Georgia and South Carolina and extends upstream from Lake Tugaloo for approximately forty miles until it reaches the North Carolina border. The river has been identified as the best white water canoeing river in the eastern United States.

Table 155.
Scenic rivers -- problems and opportunities.

Opportunities

1. Rivers or portions of rivers with outstanding scenic, recreational, geologic, fish and wildlife, historic or cultural values can be protected under the South Carolina Scenic Rivers Program or the National Wild and Scenic Rivers Program.
2. In 1974, the Congress designated the Chattooga River in Oconee County as a National Wild and Scenic River.
3. A five-mile stretch of the Middle Saluda River in Greenville County is South Carolina's only State Scenic River.
4. Portions of the Congaree, Little Pee Dee, and Ashley Rivers have been declared eligible for inclusion in the State Scenic Rivers Program, and a portion of the Lower Saluda River is under study.

Problem

1. Currently, only a portion of one river has been included in the State Scenic Rivers Program because the acquisition of easements is primarily dependent on voluntary donations of land by citizens.

UNIQUE WETLAND AREAS

South Carolina's abundant wetland areas, including salt-water and freshwater tidelands, riverine swamps and flood plains, and isolated wetland sites, particularly Carolina Bays, are diverse ecosystems that serve a variety of functions beneficial to nature and mankind. The majority of wetlands in South Carolina occur in the Coastal Plain. The role of wetlands in maintaining water quality is well known. Serving as a buffer between upland areas and receiving streams, wetlands filter runoff from high ground areas prior to releasing these waters into adjacent streams, thus playing an important role in reducing sedimentation and other water pollution from non-point sources. Wetlands also serve as floodwater reservoirs by gathering and holding excess runoff and gradually releasing these waters into streams. They also recharge ground-water systems.

The diversity of South Carolina's wetland resources and the relative inaccessability of these areas serves to increase the value of wetlands as natural areas by harboring and providing habitat for a variety of animal and plant species. While all of the State's wetlands are valuable for these reasons, the tideland areas of the coastal zone, comprising approximately 500,000 acres of tidally influenced wetlands, are perhaps the most sensitive and productive of all. These tidal areas support a great variety of marine life during all or parts of their life cycles. They are especially important as nursery areas for several commercially harvested marine organisms such as shrimp, oysters, crabs, clams, and several fish species.

All of South Carolina's wetlands, therefore, may be considered as sensitive areas, functioning in a variety of ways to improve the quality of life, not only for man but for many other species. However, every year greater development pressures are placed on the wetlands, particularly in the coastal region of the State where competition for prime development sites is increasing. Riverine flood plains and associated wetlands are prime candidates for conversion to

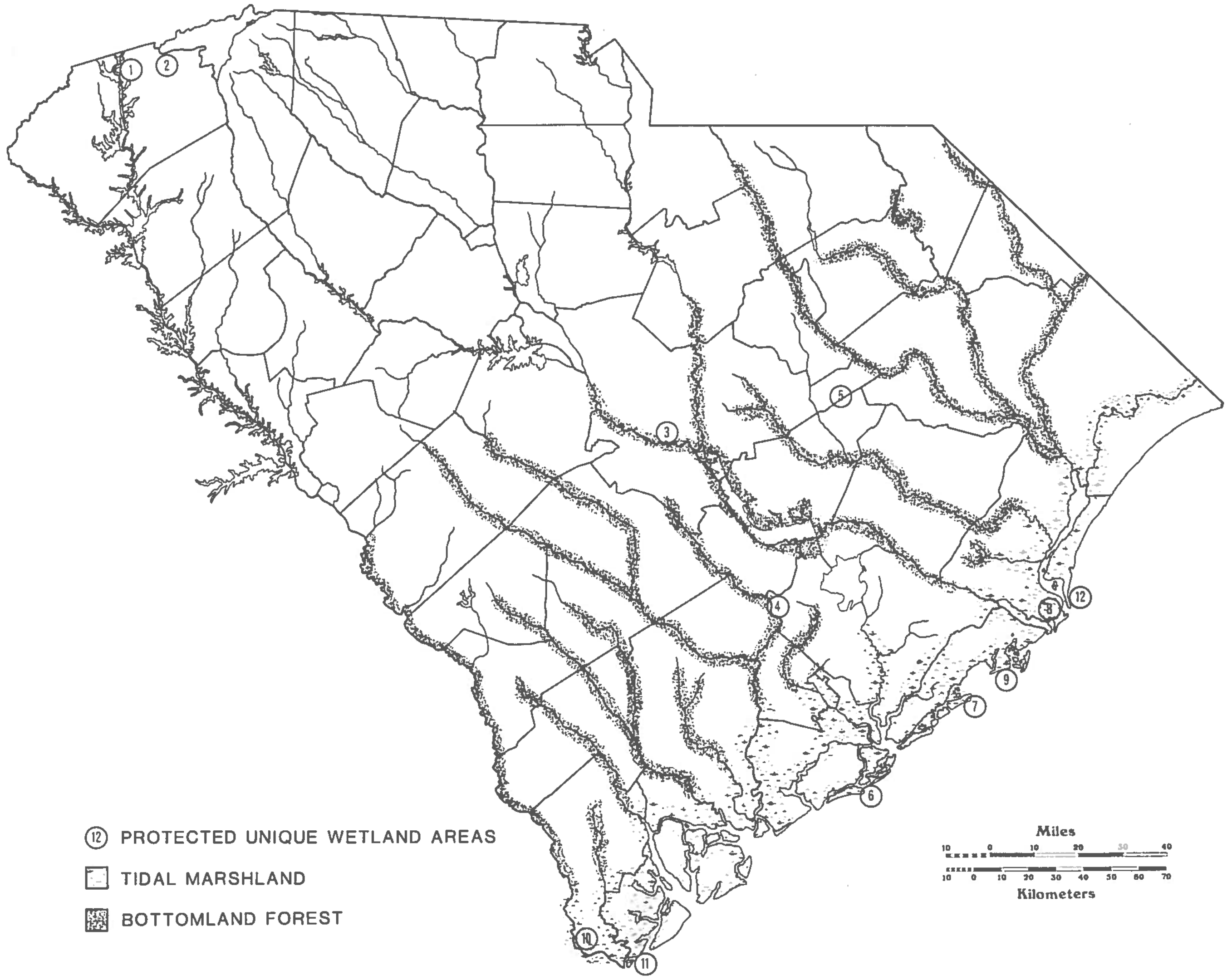


Figure 161.
Primary vegetated wetlands and protected unique wetland areas in South Carolina (See text for site information).

agricultural uses. Several basic questions concerning wetland loss remain unanswered. The extent and the rate at which wetland losses are occuring are unknown. More importantly, the economic and environmental impacts of the loss of these sensitive resource areas have yet to be assessed. Wise resource managment and increased knowledge are imperative to maintain the important functions of the State's wetlands.

Located throughout the State are specific wetland sites that have special characteristics that may lead to their classification as unique or sensitive natural areas. The South Carolina Wildlife and Marine Resources Department, through its Heritage Trust Program, is constantly striving to locate these special areas and incorporate them into this program to ensure the protection and preservation of their unique qualities. Some of the wetland-associated natural areas currently protected under the South Carolina Heritage Trust Program are identified in Figure 161 and briefly discussed below.

Mountains

1. Eastatoe Creek Natural Area - S.C. Wildlife and Marine Resources Department
2. Mountain Bridge Natural Area - S.C. Wildlife and Marine Resources Department and S.C. Department of Parks, Recreation, and Tourism

Both of these areas have mountain streams which support trout populations (native and non-native). The streams at Eastatoe occur in rocky gorges which support three rare fern species. A montane bog along a stream in the Mountain Bridge area supports a rare orchid species.

Coastal Plain

3. Congaree Swamp National Monument - National Park Service (Department of Interior) Floodplain forest and associated aquatic habitat along the Congaree River. This area supports virgin cypress and other bottomland tree species. Many Federal and State record sized trees are found here.
4. Francis Beidler Forest (Four Hole Swamp) - National Audubon Society and S.C. Nature Conservancy. This unique blackwater stream/swamp system supports virgin cypress and a large tract of undisturbed bottomland forest.
5. Woods Bay State Park - S.C. Department of Parks, Recreation, and Tourism
   Woods Bay is the only Carolina Bay in State ownership. Carolina bays, though of unsure origin, are unique features of the Atlantic Coastal Plain. Woods Bay supports several plant community types and numerous animal species. All undisturbed Carolina Bays in South Carolina would qualify as sensitive areas due to the high attrition rate of these unique areas.
6. Bird Key Stono - S.C. Wildlife and Marine Resources Department
7. Capers Island - S.C. Wildlife and Marine Resources Department
8. Tom Yawkey Wildlife Center - S.C. Wildlife and Marine Resources Department

These three properties are all examples of the varied estuarine environment of South Carolina. Bird Key is the largest rookery island in South Carolina for the endangered brown pelican. Capers Island is an undeveloped barrier island, and Tom Yawkey Wildlife Center is a 17,000 acre complex of barrier islands, impoundments, marsh, and uplands. All three of these properties and their flora and fauna are sensitive to changes in the estuarine environment.

Other wetland sites that have unique or special characteristics include the Cape Romain National Wildlife Refuge (9) in Charleston County, the Savannah and Tybee National Wildlife Refuges (10,11) in Jasper County, and the Belle W. Baruch Marine Research Institute (12) in Georgetown County.

Port Royal Sound in Beaufort County has been placed on a list of eligible candidates for inclusion in the Marine Sanctuary Program under the Office of Coastal Resource Management, National Oceanic and Atmospheric Administration. The purpose of the Marine Sanctuary Program is to set aside unique areas in the marine environment which need to be studied and utilized as a natural laboratory. The program provides focus and limited funding for research. An Environmental Inpact Statement would be required before designation as a sanctuary could occur.

Table 156.
Unique wetland areas -- problems and opportunities.

Opportunities

1. Some unique wetland areas are currently protected under the Heritage Trust Program administered by the S.C. Wildlife and Marine Resources Commission.
2. Wetlands are important natural areas which help maintain water quality and serve as floodwater reservoirs, ground-water recharge areas, nursery areas for numerous aquatic organisms, and feeding and nesting areas for birds and wildlife.
3. Numerous wetland areas occur throughout the State but mostly in the Coastal Plain.
4. Port Royal Sound is under initial consideration for inclusion in the Marine Sanctuary Program.

Problem

1. An unknown quantity of wetland habitat is lost each year; therefore, unique wetland areas need to be identified and the impacts of these losses assessed.

WATER CONSERVATION

Water conservation is more than just a practice to put into place during times of water shortage. Water should be conserved or used wisely at all times. The past three decades have witnessed almost a six-fold increase in water use in South Carolina, placing greater demands on a renewable yet limited resource. As competition for water increases, the cost of the water also increases. Water conservation becomes not only a wise ethic to follow, it becomes a matter of economic concern.

The benefits of implementing water conservation practices are many and should be carefully considered by all water users. A reduction in water use saves energy, and the energy savings can benefit the customer in reduced heating and electric bills. Large demands on our water resources diminish those resources, requiring increased funding to explore and develop additional sources of water. Increased water use generally means increased wastewater, which in turn increases treatment costs. Continued growth in water use shortens the life of existing water treatment facilities, often requiring expensive expansion to keep up with treatment needs.

In addition to impacts caused by increasing water demands, drought may cause surface water supplies to diminish and, if severe enough, cause levels of ground water to fall below pumping levels. A severe drought may have far reaching consequences. Lack of water may cause crops to fail and livestock to lose weight. In some instances, industries using water for cooling or in production may have to lay off workers and close temporarily. Air conditioning use increases during hot summer droughts so more electricity is needed, requiring more water for power generation. More water is also used during a drought for watering lawns and gardens.

With these demands being placed on our water supplies, conservation must play an increasingly larger role in water resources management decisions in South Carolina. As competition for water increases and costs involved in water resources development continue to escalate, economics will help dictate our choices. The following pages provide a brief overview of water conservation practices by water use category.

Public Supply Conservation

Recent case studies in the New England region (New England River Basins Commission, 1980) have indicated that municipal water usage can realistically be reduced 25 percent or more to meet short-term situations. However, in the long-term, a reduction of five to ten percent can be achieved only if a continuing water conservation program is pursued vigorously. Managers of public water supply districts or municipalities can utilize several techniques, either independently or collectively, to reduce the quantity of water needed to meet demands or to reduce the demand itself. Among these methods are leakage management, meter management, price structuring, user education, and, in times of emergency, regulation of water use.

Undetected leaks in a water distribution system can waste large amounts of water. Nationwide estimates (Howe, 1971) have indicated that the average loss for water through leaks in distribution systems is about 12 percent. These leaks occur because of broken or cracked waterlines, unseated pipe joints, and faulty connections to hydrants, trunk lines, and customers. In 1979, the City of Boston conducted a leak survey, found and repaired 112 leaks, and recovered about 2.9 million gallons of water per day. Between 1975 and 1978 the City of Arlington, Massachusetts saved over $173,000 in water costs by investing less than $16,000 in leak detection and repair (New England River Basin Commission, 1980). However, it is not economical to attempt to find and fix all leaks and a compromise between repair costs and water losses must be made.

Accurate metering is essential to monitoring water use and establishing equitable rate charges. In addition, water use tends to be lower in metered service areas than in unmetered service areas. The meter also allows the user to monitor his own use and may encourage conservation efforts. Meter slippage can be a serious problem that results in underregistration of water flows and subsequent losses of revenues. A routine service and maintenance program is needed to ensure accurate metering.

Price structuring of water rates can be a means to reduce water demand. Five basic rate structures are commonly used for water pricing and these, along with definitions and effects on conservation are listed below. Some of the rate structures encourage conservation while others encourage water use.

Flat rate - a fixed price charged per time period, regardless of water quantity. This method does not encourage conservation of water, instead it encourages water use.

Average uniform rate - a constant price per unit of water charged, regardless of quantity used. This method encourages conservation only slightly.

Declining block rate - price per unit of water decreases as the quantity of use increases. This method of pricing subsidizes the larger user at the expense of the smaller user. This method has an adverse effect on water conservation as it encourages water use. This rate structure is the type most commonly used in South Carolina.

Increasing block rate - price per unit of water increases as the quantity of use increases. This method is effective in encouraging water conservation. As larger quantities are used, the consumer pays a higher rate for the larger portions used.

Basic facility charge and commodity charge - the price per unit of water increases as the quantity of use increases. This method is effective in encouraging water conservation. This method is based on the premise that commodity expenses are shared by all customers.

The Water and Wastewater Department of the South Carolina Public Service Commission oversees rate setting for water suppliers. Public water supply managers should seek their advice in establishing rates to encourage water conservation.

The recent droughts throughout the country have focused attention on the need to instill a conservation ethic in water users. Water users must be kept informed of current and potential water problems and provided with the information needed to react to these problems. Continuous public education is a necessity for an effective water conservation program. Much has been written during the past few years concerning water conservation and public education and many innovative approaches have been devised. Public water suppliers should contact appropriate state agencies and water organizations to seek effective techniques to educate their users.

During times of drought or other water emergencies, water use may have to be regulated. Water suppliers would be prudent to have a water shortage contingency plan ready to put into action should such emergencies arise. Water use regulations can address a broad spectrum of uses and activities, from the large water using industry or irrigator to the single family resident. Many innovative approaches to regulation have been developed over the past few years. However, for the success of any water regulatory program, two ingredients are needed: user education and enforcement. The user must know that a problem exists and how that problem can affect him. Sufficient enforcement must be exercised to make users aware of the seriousness of the water problem.

Residential Water Conservation

During recent droughts, much emphasis has been placed on the need for domestic conservation. Although the amount of water saved through one family's conservation efforts is small compared to the enormous amounts of water required for power generation, industry, or agriculture, small savings multiplied by the efforts of thousands of South Carolinians can save a substantial amount of water.

The Water and Wastewater Department of South Carolina's Public Service Commission reports that the average family, based on national figures, consumes 7,000 gallons of water monthly. This is 230 gallons per day for an average family of two adults, one teenager and one preteen. Water is used as shown in Table 157.

Toilets use more water than any other fixture in the home; however, there are many conservation measures that can save a significant amount of this wasted water. By reducing the volume of water used to flush a toilet from the conventional seven gallons, to 3.5 gallons, up to 30,000 gallons can be saved annually. Even by reducing the volume of water needed to flush by only one gallon, 8,760 gallons of water can be saved in a year.

Newly designed toilets may reduce water use by one half over older models. A brick placed in the toilet tank is a means of reducing water volume; however, it may crumble causing plumbing problems, move with water flow damaging tank parts, or if dropped, break the tank. It is more efficient to install a Ballcock valve. It can be adjusted to admit the desired amount of water; although more expensive initially, it reduces the volume of water used to flush even more than the no-cost method of a jug or a bag filled with water being placed in the toilet tank.

Bathing accounts for the second largest amount of water used in the home. There are various types of shower heads or adapters which conserve water by reducing the flow rate or by producing a shower spray with an adjustable low-flow shower head. Showers usually take about 10 gallons per minute but by limiting shower time to five minutes, a substantial amount of water can be saved. Water used for showering can also be reduced up to 70 percent by installing a flow control device which reduces the rate of flow to three gallons per minute.

Whether the dishwasher is a new model or an old one makes a difference in the amount of water used. Old models use about 13 to 16 gallons per load compared to 7.5 gallons required by the new models. If the water runs continuously while washing dishes by hand, approximately 25 gallons is wasted. Rinsing dishes in standing water will reduce this use. Another conservation measure is to install an aerator or a flow control device on faucets.

Leaks are a major source of wasted water. This can be prevented by monitoring and repairing all leaks immediately. A one-drop-per second leak from a water faucet wastes a gallon of water each day; and a slow dribble, 170 gallons of water daily. In one month, such leaks could waste as much as 5,130 gallons of water. A test for determining leaks in the home is to turn off all water-using devices, then check the meter to ensure no flow is registering. To test for leaks in your toilet, place a few drops of laundry blueing or food coloring in the toilet tank and let stand for 15 minutes. If the color has filtered into the toilet bowl, there is a leak.

Other methods of conserving water and requiring only a little advance planning are: keep drinking water in the refrigerator instead of running the tap; water plants with left over water; wait until all food items are peeled before rinsing, scrape dirty dishes clean before washing and soak in a small amount of water, and always use full loads when washing dishes or clothes.

Table 157.
Average daily water use for a family of four.

Water Use	*Gallons*	*Percent of Total*
Toilets	102	42
Bathing and showering	81.5	31
Laundry	35.5	14
Food preparation, clean-up, including dish washing	27.5	11
All other purposes	5.5	2

The greatest amount of water used out-of-doors is for watering lawns and gardens. Conserve water by watering only when necessary and during the early morning, to avoid excessive evaporation, and water slowly to allow seepage into the root zone and prevent runoff. Heavier, and less frequent watering encourages development of deep rooted grass. The use of automatic timers and replacement of damaged or leaking sprinklers is another way of preventing wasteful use of water. Using a broom rather than a hose to clean driveways, patios, and walks can save a significant amount of water. Research has indicated that a substantial reduction in domestic use (as much as 33 percent) can result from installing water saving devices. Some new and renovated homes have these devices. However, to make an impact in the amount of water conserved statewide, the legislature would have to modify existing legislation for plumbing and/or housing codes. An opportunity also exists for the development of conservation-minded ordinances by progressive local governments.

Agricultural Water Conservation

Agriculture uses over 148 million gallons of water daily, or 2.5 percent of the State total use, for irrigating crops and maintenance of livestock. Irrigation, the dominant agricultural water use, accounts for over 138 million gallons daily during the growing season, representing 93 percent of the agricultural demand.

Irrigation operates on the premise that crop growth can be maximized by maintaining the optimum moisture levels by artificial means, when and where rainfall is deficient. In the dry west, irrigation is about the only way to maintain crops to maturity. However, in the humid Southeast, where water is generally plentiful, farming continues without the aid of irrigation. Droughts, sporadic rainfall, and higher water demanding crops, such as corn, have made irrigation a competitive practice in the Southeast. However, high interest rates and capital outlay at least temporarily have lessened the economic feasibility of irrigation.

In some locations in South Carolina, water supply developments for irrigation are beginning to compete with other uses for the same water sources. The seriousness of ground-water problems in coastal locations has resulted in several counties of the State being declared capacity use areas. A permit is now required to withdraw, obtain, or utilize ground water in Beaufort, Colleton, Jasper, Georgetown, Horry Counties and a portion of Marion County. Although it has been necessary to protect ground-water supplies by implementing ground-water management controls in some coastal areas, South Carolina farmers have been fortunate in escaping widespread incidents of ground-water depletion as has occurred in Georgia and other states.

For all practical purposes, agricultural irrigation is considered to be a totally consumptive water use, with little if any, water returning directly to its source. For this reason, water conservation will help relieve present and future water use problems and conflicts. Water conserving practices in irrigation depend on the crop, soil types, and lay of the land. Drip or trickle irrigation is the most water conserving irrigation method. Because this method is equipment intensive and is a permanent system, it requires that the irrigated crops be of a permanent nature, such as peach, apple or pecan orchards. Drip irrigation systems use pipes and tubes with small outlets near each plant which apply only the amount of water needed to sustain the plant. This eliminates runoff, evaporation, and watering of non-crop vegetation.

Subsurface irrigation is a soil moisture managing method which uses porous pipes or tiles placed in the field. In South Carolina, this system is used primarily in wet fields where excess water is drained off making unproductive land useful. During dry periods the system can be reversed to irrigate the fields. Subsurface irrigation systems are expensive to install but recent developments have helped reduce cost. Row crops can be grown using this system. The elimination of runoff and evaporation makes this a useful water conserving method.

Some controversy surrounds the claim that sprinkler irrigation is more water efficient than furrow or flood irrigation. The latter method is definitely much more labor intensive than sprinkler irrigation. However, on hot windy days, nearly one-half of the water sprayed by sprinkler irrigation systems evaporates before the water reaches the crop. Because the intent of irrigation is to maintain soil moisture for optimum plant growth, the application of water directly to the soil is most simply met by flood irrigation. This oldest of irrigation methods was improved upon by the use of furrows to direct water to plants. However, surface application methods require more water than is needed by the crop and expose the excess water to evaporative forces.

Sprinkler irrigation systems, including moveable and solid set pipe systems, center pivots, and traveling guns, are much less labor intensive. This irrigation method applies water in a manner similar to natural rainfall. However, a large portion of the water is lost to evaporation.

Pipelines require less land area than canals and provide more efficient control in water management. Recovery systems and drip and wastewater reclamation programs are also effective methods for conserving water. The reuse of irrigation water captured in tail-water pits conserves water and keeps poor quality runoff water from degrading receiving streams.

No-till planting and the application of mulch keep plant residues on the soil surface, helping to reduce evaporative loss. The use of narrow row spacing, selection of plants which require less water, application of growing practices that utilize available rainfall, and careful selection of planting dates will all assist in reducing water use.

The ability to apply the correct amount of water at the right time can greatly stabilize crop production. Irrigation helps sustain farmers through dry periods and helps to maximize agricultural production.

Industrial Water Conservation

Industrial water use, including that for the production of thermoelectric power, is the single largest withdrawal use in the State. Withdrawals total about 5,280 mgd, representing over 91 percent of total gross use. Thermoelectric power generation accounts for nearly 83 percent (4,370 mgd) of this use.

Nationally, during the past two decades industries have increased the use of water conservation methods. This is evidenced by a significant decrease in the amount of intake water use per unit of production (Oklahoma Water Resources Board, 1980). Much of this water conservation trend may be attributed to wastewater treatment requirements imposed by the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). The Act mandated the treatment of industrial wastewater to maintain water quality standards in the nation's water bodies. Because treatment costs can be high and are based on the volume and character of the wastewaters, industries were encouraged to reduce production costs by reducing the amount of water used and subsequent wastewater generated. Industries that are not self-supplied, but which purchase water for their operations, would have additional incentive to save water if the price of water increased. Other water conserving incentives include reductions in energy cost and profit from recoverable materials in recycling operations.

Some water conserving measures employed by industry include: (1) reuse and recycling of wastewater, (2) efficient use of water in industrial processes, (3) development and use of no-water and low-water industrial process technology, (4) repair and replacement of leaking pipes and equipment, (5) installation of automatic water cut-off valves where practical, and (6) installation of water saving devices for employee sanitation.

The greatest industrial use of water is for cooling purposes. This is especially true for thermoelectric power plants which individually require several hundred million gallons per day (mgd) to dissipate waste heat. Significant reductions in industrial water use are possible through the use of alternative cooling methods, such as air cooling devices or dry cooling towers.

Water conservation can reduce overall production costs by decreasing total water intake, pumping costs, and wastewater treatment costs. As process technology improves and the cost of treatment continues to escalate, the trend of increased water conservation by industry should continue.

Table 158.
Water conservation -- problems and opportunities.

Opportunities

1. Water conservation measures can save water; reduce water, energy, and treatment costs; and reduce water use competition and conflicts.
2. Numerous water saving devices and methods are available for residential, municipal, agricultural, and industrial water uses.
3. Water conservation methods for municipal supply systems include leakage management, meter management, price structuring, user education, and regulation of use.
4. Residential water conservation methods include leak repairs, toilet water use reduction, flow restrictor installation in shower heads and faucets, and reduction of lawn and garden watering.
5. Water conservation methods for agricultural activities include careful selection of planting dates to fully utilize available rainfall, selection of low-water demanding crop varieties, narrow row spacing, application of mulch and no-till planting, and use of low-water irrigation systems such as drip/trickle only when necessary.
6. Water conserving measures by industry include reuse and recycling of wastewater, efficient use of industrial process water, development and use of low-water or no-water process technology, leak repairs, and installation of water cut-off valves.

Problems

1. Some water conserving measures and devices may be initially expensive.
2. Without implementation of water conservation measures, water use competition and conflicts will increase, current water supplies will be stressed, new supply sources will need to be explored and developed, and impacts during droughts will be more severe.
3. Water use in South Carolina is projected to increase by 48 percent by 2020, while still utilizing current supply sources.

FLOODING

Flooding is a natural characteristic of all rivers and low lying coastal areas. Flooding occurs when the amount of surface water from any source exceeds drainage capabilities and inundates normally dry lands.

Flooding in South Carolina can be classified into four major categories: 1) flash flooding, 2) riverine flooding, 3) coastal storm flooding, and 4) urban stormwater flooding.

Sudden increases in the amount of surface water due to heavy rains or dam breaks can quickly exceed the drainage capacity of streams causing flash floods. These types of floods occur primarily in the Blue Ridge and upper Piedmont portion of the State where the steep topography and relatively impermeable soils allow rapid runoff. Flash floods can occur at any time of the year but the highest incidence is during the summer months.

Riverine flooding is the natural flood flow condition due to heavy runoff from extended rainfall or tropical storms. While this type of flooding occurs throughout the State, it is most prevalent in the lower Piedmont and Coastal Plain. In these areas of low relief, heavy sediment deposition and meandering channels reduce river channel capacities and increase flood frequency.

Coastal storm floods occur all along the shoreline of South Carolina and are caused by extremely high tides and storm surges resulting from tropical storms or Atlantic winter storms.

Development in low lying areas and poor drainage planning result in urban stormwater flood problems. The widespread use of impervious surfaces, such as asphalt, cement, and tile in urban areas, only increases the amount of runoff and compounds the drainage and flooding problem.

Flooding along South Carolina's streams and coastal shores has always occurred. However, it is only considered a problem when it conflicts with man's interests. Flooding is a persistent and serious problem throughout many regions of the State. Floods are responsible for excessive erosion, destruction to property, and occasionally loss of life. While flood damage data are not routinely maintained in South Carolina, it is generally accepted that the flood loss potential is increasing in all areas of the State due to continued development in flood-prone areas.

Current efforts to alleviate flood losses include the adoption by local governments of flood-plain building requirements; availability of technical information to educate local governments and the general public concerning flood hazards and to provide flood-plain management tools; the expanding availability of flood insurance; and the construction of flood control projects to alleviate flood losses. The extent and location of flood control projects and studies is presented in the Surface-water Development section of each sub-basin analysis.

In early 1983, there were 213 communities in South Carolina with identified flood prone areas. Of these, 166 communities were participating in the National Flood Insurance Program (NFIP). The remaining 47 communities have not adopted flood-plain building requirements consistent with federal minimum standards, a prerequisite for participation in the NFIP. This means that new development may be constructed in flood prone areas in these communities without the assurance that the structure is built at a safe level or is adequately flood proofed. In addition, non-participation means that property owners do not have the option to purchase federally subsidized flood insurance.

The South Carolina Water Resources Commission is the State Coordinator of the National Flood Insurance Program in South Carolina. The Commission, upon request, provides local governments general and technical assistance to participate in the Program. The Commission has also assisted in the development of a formal flood management program for State development activities. Under this program, the State has adopted flood-plain management standards for State-owned buildings. Under the program, the State Engineer is responsible for requiring flood protection measures to be incorporated in new State structures in flood prone areas. This includes structures constructed by all State agencies, with the exception of the Department of Highways and Public Transportation which will require similar standards of their own structures. These measures are outlined as state policy in Executive Order 82-19, signed by Governor Riley, April 28, 1982. The Executive Order will also improve coordination among State agencies and local government. The State Insurance Manager of the Division of General Services will keep flood insurance coverage on all State structures. The Water Resources Commission will provide flood data to assist all State agencies in complying with State standards. State officials are required to notify local government officials if a proposed State structure will encroach in a community's floodway.

Federal Sources of Assistance and Information

Various types of assistance in flood-plain management are available from Federal agencies in South Carolina. Each agency is responsible for a different facet of floodplain management and varies in the assistance it can provide. Those seeking assistance should, therefore, initially contact all of the relevant agencies to determine which offers the type of help needed.

U.S. Army Corps of Engineers

The Charleston and Savannah Corps Districts and the South Atlantic Division offices provide information and assistance in flood-related matters. They maintain a file of flood-plain information, surveys, and other reports containing flood-plain delineations, flood profiles, data on discharges and hydrographs, and information on operational and planned flood control projects. Each office provides interpretations as to flood depths, velocities, and durations from existing data; develops new data through field and hydrologic studies for interpretations; and provides guidance on adjustments to minimize the adverse effects of floods and flood-plain development.

The Corps constructs flood control projects pursuant to congressional authorization. Major projects such as large dams and reservoirs are usually also operated by the agency.

The Corps also administers a continuing authorities program to assist local communities with their water resource problems. These programs include flood control, channel clearing, navigation, beach erosion, and streambank stabilization. Projects authorized through these programs are usually cost shared with a local sponsoring governmental agency.

During flood emergencies, the Corps can assist the State and communities by providing materials, equipment, and personnel for flood fighting and construction of temporary levees or other temporary protective structures. Assistance is also available for rehabilitation of damaged public facilities and protective works.

Further information on assistance available from the Corps can be obtained from the following sources:

U.S. Army Corps of Engineers
South Atlantic Division
510 Title Bldg.
30 Pryor St., SW
Atlanta, GA 30303
(404) 221-6702

U.S. Army Corps of Engineers
Savannah District
P.O. Box 889
Savannah, GA 31402
(912) 944-5271
(Savannah River Basin Only)

U.S. Army Corps of Engineers
Charleston District
P.O. Box 919
Charleston, S.C. 29402
(803) 724-4308

Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP) as well as programs for disaster planning and recovery. Specifically, the NFIP is administered by the Federal Insurance Administration (FIA). The FIA works closely with states and communities in an effort to effect wise flood-plain management that includes flood loss prevention.

Another FEMA responsibility is to see that the NFIP's Standard Flood Insurance Policy is properly promoted and written. The Electronic Data Systems Corporation is under contract with the NFIP to assist with these marketing-related responsibilities. Some of FEMA's services include: 1) provision of flood hazard maps and data; 2) assistance in developing flood-plain regulations that meet federal criteria; and 3) provisions of disaster relief and recovery assistance.

The regional office of FEMA with jurisdictional authority for South Carolina is located at:

Federal Emergency Management Agency
1375 Peachtree St., N.E.
Atlanta, GA 30309
(404) 881-2391

National Weather Service

The National Weather Service issues weather forecasts and flood warnings. It also provides assistance to communities in establishing flood warning systems and conducting flood hazard analyses. The agency utilizes a network of about 7,900 precipitation and streamflow stations to support its flood forecast and warning services at about 2,500 communities. Types of information and assistance available include precipitation records and other climatological data; preparation of forecasting materials; assistance in organization and training of observers and those responsible for applying self-help warning systems; equipment installation and calibration; and stream depth data.

An annual publication entitled *River Forecasts Provided by the National Weather Service,* lists locations at which data are compiled and includes the flood stage as well as the maximum stage of record at each location.

For further information on available data and assistance, contact:

National Weather Service
Southern Region
819 Taylor Street
Room 10E09
Fort Worth, TX 76102
(817) 334-2674

Storm surge frequency information is also available. Studies have been completed for the Gulf of Mexico coast from the Alabama-Florida border to southern Florida; and along the Atlantic coast from southern Florida to Cape Henlopen, Delaware. The National Weather Service also provides warning to storm surges associated with tropical and extratropical storms. For storm surge frequency information and interpretative assistance contact:

Chief, Water Management
Information
NWS Office of Hydrology (W21)
8060 13th Street
Silver Spring, MD 20910
(301) 427-7543

Soil Conservation Service

The Soil Conservation Service carries out cooperative flood-plain management studies, at the request of local governments, which include flood hazard photomaps, flood profiles, and flood-plain management recommendations. The agency also provides technical and financial assistance to plan, design, and install watershed projects of less than 250,000 acres; and install emergency work such as stream-bank stabilization, debris removal from channels and bridges, and revegetation of denuded and eroded areas to protect life and property after storms and floods.

Types of information available from the Soil Conservation Service include; land treatment needs; project planning data; photomosaic maps delineating areas subject to inundation by floods of selected frequency and associated flood profiles; location, flood-plain management options (structural and nonstructural), design and construction information on flood prevention works; detailed soil survey data and maps; and snow survey data. In addition, the Soil Conservation Service provides continuing technical assistance to local governments after completion of studies it performs to assist in implementation of local flood-plain management programs.

Information on assistance and the availability of information can be obtained from the following locations:

State Conservationist
Soil Conservation Service
1385 Assembly Street
Columbia, S.C. 29201

U.S. Geological Survey

The U.S. Geological Survey maintains a network of about 7,700 continuous record streamflow gaging stations throughout the United States and Pureto Rico. Several thousand additional high-flow stations supplement this network. Many gaging stations are serviced periodically by observers who generally reside near the gage site. Arrangements for direct telephone notification of flood conditions can usually be made with observers.

The U.S. Geological Survey publishes an annual report entitled *Water Resources Data of South Carolina* which includes records of gage height, discharge, runoff, time of travel, and sediment discharge from a network of gaging stations. The agency also has information available on historic flood peaks and inundated areas and the magnitude, frequency and duration of flood flows. Areas subject to inundation by floods of selected frequencies, usually 100-year floods, have been delineated on topographic maps for:

1. Urban areas where the upstream drainage basin exceeds 25 square miles; and smaller drainage basins depending on topography and potential use of the flood plain;
2. Rural areas in humid regions where the upstream drainage basin exceeds 100 square miles; and
3. Rural areas in semiarid regions where the upstream drainage basin exceeds 250 square miles.

Assistance is also available in interpreting flood-frequency relations and computed water surface profiles and in identifying areas of potential flood hazard.

Information concerning the availability of information for a specific community can be obtained from:

U.S. Geological Survey
Strom Thurmond Federal Bldg.
Suite 658
1835 Assembly Street
Columbia, S.C. 29201

Problems and Needs

Presently, South Carolina does not have a formal statewide flood-plain management program. At a minimum, such a program would establish a time table for all communities in the State with flood prone areas to adopt floodplain building standards. A statewide program would allow the State to monitor local government compliance with standards at the state level. In addition, the State would enforce flood-plain building requirements in communities where local governments have failed to adopt standards or have failed to enforce the standards. Finally, a State program may include a system of data collection in addition to current Federal efforts. This may include data on flood prone areas as well as flood damages. At present, there is no monitoring or mapping program in South Carolina at the state level.

Table 159.
Flooding--problems and opportunities.

Opportunities

1. Out of 213 communities in South Carolina with identified flood prone areas, 166 are participating in the National Flood Insurance Program.
2. The Federal Emergency Management Agency (FEMA) monitors construction activities in flood plains to ensure that local governments comply with Flood Damage Reduction Ordinances.
3. The U.S. Geological Survey, U.S. Army Corps of Engineers, and the Federal Emergency Management Agency provide flood insurance studies to South Carolina communities.

Problems

1. There is no comprehensive flood-plain management program in South Carolina at the State level.
2. The State cannot require a community to participate in the National Flood Insurance Program and 47 eligible communities in the State do not.
3. The State cannot require a community to adopt or enforce local Flood Damage Reduction Ordinances and there are no minimum State flood-plain building standards.
4. The State does not collect flood data and the need for the collection of data beyond the Federal effort has to be determined.

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Appendix

Appendix A

Quality standards established for surface waters by the S.C. Department of Health and Environmental Control (1981a).

Water Classifications	*Water Quality Constituents and Parameters*	*Standards/ Specifications*
Class AA	1. Garbage, cinders ashes, oils, sludge, or other refuse.	None allowed.
	2. Treated wastes, thermal discharges, toxic wastes, deleterious substances, colored or other wastes.	None allowed.
	3. Dissolved oxygen.	Not to vary from levels existing under natural conditions.
	4. Fecal coliform.	Not to vary from levels existing under natural conditions.
	5. pH.	Not to vary from levels existing under natural conditions.
	6. Temperature.	Not to vary from levels existing under natural conditions.
	7. Turbidity.	Not to vary from levels existing under natural conditions.
Class A-Trout	1. Garbage, cinders, ashes, oils, sludge, or other refuse.	Not allowed.
	2. Treated wastes, toxic wastes deleterious substances, colored or other wastes except in 1. above.	None alone, or in combination with other substances or wastes, in sufficient amounts as to be injurious to reproducing trout populations or in any manner adversely affect the taste, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
	3. Dissolved oxygen.	Not less than 6 mg/l.
	4. Fecal coliform.	Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.
	5. pH.	Range between 6.0 and 8.0.
	6. Temperature	Not to vary from levels existing under natural conditions.
	7. Turbidity.	Not to exceed 10 NTU's or comparable units.
Class A	1. Garbage, cinders, ashes, sludge, or other refuse.	None allowed.
	2. Treated wastes, toxic wastes, deleterious sub-stances, colored or other wastes except in (1) above.	None, alone or in combination with other substances or wastes, in sufficient amounts: to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to these classes.
	3. Dissolved oxygen.	Daily average not less than 5 mg/l, with a low of 4 mg/l, except that specified waters may have an average of 4 mg/l due to natural conditions.
	4. Fecal coliform.	Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.
	5. pH.	Range between 6.0 and 8.0, except that specified waters may range from 5.0 to 8.0, due to natural conditions.
	6. Temperature.	See footnote.
Class B	1. Garbage, cinders.ashes, sludge, or other refuse.	None allowed.
	2. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except in 1. above.	None, alone or in combination with other substances or wastes, in sufficient amounts: to be harmful to the survival of freshwater fauna and flora or the culture or propagation thereof; to adversely affect the taste, color, odor or sanitary condition of fish for human consumption; to make the waters unsafe or unsuitable for a source of drinking water supply after conventional treatment; to make the waters unsafe or unsuitable for secondary contact recreation; or to impair the waters for any other best usage as determined for the specific waters which are assigned to these classes.
	3. Dissolved oxygen.	Daily average not less than 5 mg/l, with a low of 4 mg/l, except that specified waters may have an average of 4 mg/l due to natural conditions.

	4. Fecal coliform.	Not to exceed a geometric mean of 1000/100 ml based on five consecutive samples during any 30 day period; not to exceed 2000/100 ml in more than 20% of the samples examined during such period.
	5. pH.	Range between 6.0 and 8.5, except that specified waters may range from 5.0 to 8.5, due to natural conditions.
	6. Temperature	See footnote.
Class SAA	1. Garbage, cinders. ashes, oils, sludge, or other refuse.	None allowed.
	2. Treated wastes, thermal discharges, toxic wastes, deleterious substances, colored or other wastes.	None allowed.
	3. Dissolved oxygen.	Not less than 5 mg/l.
	4. Organisms of coliform group.	Not to exceed a MPN total coliform median of 70/100 ml, nor shall more than 10% of the samples exceed an MPN of 230/100 ml, where all tests are made using the five tube dilution method.
	5. pH.	Not to vary from levels existing under natural conditions.
	6. Temperature.	Not to vary from levels existing under natural conditions.
	7. Turbidity.	Not to vary from levels existing under natural conditions.
Class SA	1. Garbage, cinders ashes, oils, sludge, or other refuse.	None allowed.
	2. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except in 1. above.	None, alone or in combination with other substances or wastes, in sufficient amounts: to adversely affect the taste, color, odor or sanitary conditions of clams, mussels, or oysters for human consumption; or to impair the waters for any other best usage as determined for the specific waters which are assigned to these classes.
	3. Dissolved oxygen.	Daily average not less than 5 mg/l, with a low of 4 mg/l, except that specified waters may have an average of 4 mg/l due to natural conditions.
	4. Organisms of coliform group.	Not to exceed an MPN total coliform median of 70/100 ml, nor shall more than 10% of the samples exceed an MPN of 230/100 ml, where all tests are made using the five tube dilution method.
	5. pH.	Shall not vary more than 3/10 of a pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature, but not lower than 6.5 or above 8.5.
	6. Temperature	See footnote.
Class SB	1. Garbage, cinders, ashes, oils, sludge, or other refuse.	None allowed.
	2. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except in 1. above.	None alone or in combination with other substances or wastes in sufficient amounts: to make the waters unsafe or unsuitable for primary contact recreation; or to impair the waters for any other best usage as determined for the specific waters which are assigned to these classes.
	3. Dissolved oxygen.	Daily average not less than 5 mg/l, with a low of 4 mg/l, except that specified waters may have an average of 4 mg/l due to natural conditions.
	4. Fecal coliform.	Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the samples in any 30 day period exceed 400/100 ml.
	5. pH.	Shall not vary more than one-half of a pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature, but not lower than 6.5 or above 8.5
	6. Temperature.	See footnote.
Class SC	1. Garbage, cinders. ashes, sludge or other refuse.	None allowed.
	2. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except in 1. above.	None alone or in combination with other substances or wastes in sufficient amounts: to be harmful to the survival of marine or flora or the culture or propagation thereof; to adversely affect the taste, color, odor, or sanitary condition of fish for human consumption; to make the waters unsafe or unsuitable for secondary contact recreation; to impair the waters for any other best usage as determined for the specific waters which are assigned to these classes.
	3. Dissolved oxygen.	Not less than 4 mg/l.
	4. Fecal coliform.	Not to exceed a geometric mean of 1000/100 ml based on five consecutive samples during any 30 day period; nor exceed 2000/100 ml in more than 20% of the samples examined during such period.

5. pH.	Shall not vary more than one pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature but not lower than 6.5 or above 8.5.
6. Temperature	See footnote.

Temperature

a. All freshwaters of the State, other than those classified *AA* and *A-TROUT* or referred to in Section C., shall not exceed a maximum temperature of 90°F (32.2°C) at any time nor shall a maximum temperature rise above temperatures existing under natural conditions exceed 5°F (2.8°C) as a result of the discharge of heated liquids unless an appropriate temperature criteria or mixing zone, as provided below, has been established. The water temperature at the inside boundary of the mixing zone shall not be more than 18°F (10°C) greater than that of water unaffected by the heated discharge. The appropriate temperature criteria or the size of the mixing zone shall be determined on an individual project basis and shall be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which the heated discharge is made and shall allow passage of aquatic organisms.

b. The temperature of tidal saltwaters, other than those waters classified *SAA* and those waters inside approved mixing zones shall not exceed a weekly average temperature of 4°F (2.2°C) above temperatures existing under natural conditions during the fall, winter or spring, nor a weekly average of 1.5°F (0.8°C) above temperatures existing under natural conditions during the summer. The size of the mixing zone shall be determined on an individual project basis and shall be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which a heated discharge is made. Further, the mixing zone shall be kept at a minimum and shall allow the passage of aquatic organisms.

c. All waters of lakes and reservoirs of the State, except those classified *AA* or *A-TROUT,* shall not exceed a weekly average temperature of 90°F (32.2°C) after adequate mixing as a result of heated liquids, nor shall a weekly average temperature rise of more than 5°F (2.8°C) above temperatures existing under natural conditions be allowed as a result of the discharge of heated liquids unless an appropriate temperature criteria or mixing zone, as provided below, has been established. The water temperature at the inside boundary of the mixing zone shall not be more than 18°F (10°C) greater than that of water unaffected by the heated discharge. The appropriate temperature criteria or the size of the mixing zone shall be determined on an individual project basis and shall be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which the heated discharge is made and shall allow passage of aquatic organisms.

d. All temperature limits shall be subject to modifications as specified under the South Carolina Pollution Control Act, the Clean Water Act (P.L. 92-500, 95-217), and related regulations.

e. Upon a case-by-case determination by the S.C. Department of Health and Environmental Control and in accordance with the South Carolina Pollution Control Act, the Clean Water Act (P.L. 92-500, 95-217), and related regulations, the above temperature criteria may not apply to cooling water bodies with a primary purpose of providing a source and/or being a receptor of industrial cooling water.