POWER GENERATION AND RELATED WATER USE IN GEORGIA

By
Julia L. Fanning, Glenn A. Doonan,
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DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

INFORMATION CIRCULAR 87

Cover: Eagle and Phenix #1 and #2, hydroelectric power plant in Columbus, Georgia in September 1989

Photo courtesy: Darrell Dorminey, U. S. Geological Survey

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

The following factors may be used to convert inch-pound units to metric units (International System):

Multiply	*By*	*To obtain*
	Length	
inch (in.)	25.4	millimeter (mm)
	0.0254	meter (m)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	259.0	hectare (ha)
	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
	3.785	cubic decimeter (dm^3)
	0.003785	cubic meter (m^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
	0.003785	cubic hectometer (hm^3)
billion gallons (Bgal)	3.785	cubic hectometer (hm^3)
	Flow	
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
	28.32	cubic decimeter per second (dm^3/s)
	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	43.81	cubic decimeter per second (dm^3/s)
	0.04381	cubic meter per second (m^3/s)
billion gallons per day (Bgal/d)	43.81	cubic meter per second (m^3/s)

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ABSTRACT

In 1987, total freshwater use in Georgia averaged about 5.8 billion gallons per day. Surface-water withdrawals totaled about 4.6 billion gallons per day, of which about seventy-five percent was used for cooling purposes at thermoelectric power generating plants. Although the amount of water used for thermoelectric power production in Georgia is large, only about 0.12 billion gallons per day is consumed with the remainder being returned to the source water bodies. Additionally, about 45 billion gallons per day of surface-water was used in-stream for hydroelectric power generation.

The water used and power produced at 18 thermoelectric and 39 hydroelectric plants, located in or adjacent to Georgia, are presented for the period of 1980 through 1987 to show the relation that exists between water use and power generation. Droughts, such as those that occurred in 1981 and 1986, significantly affect power production, especially hydroelectric power. For example, in 1980, an average of about 55 billion gallons per day of water was used to produce 5,520 gigawatt-hours of power at 39 hydroelectric plants. Then in 1981, a drought year, only about 32 billion gallons per day was used to produce 2,960 gigawatt-hours of power at these same plants.

[1]U.S. Geological Survey
[2]Georgia Geologic Survey

INTRODUCTION

Georgia's population and electrical power demands are growing rapidly. The 1980 population of approximately 5.4 million people is expected to grow to about 7.0 million by the year 2000 (University of Georgia, 1986). With this growth will come an increasing demand for electrical power. Georgia Power Company, the State's largest private utility, supplied four times as much power to its customers in 1987 as it did in 1963 (George Guill, Georgia Power Company., oral comm., 1988).

The primary sources of electrical power for Georgia are steam-electric and hydroelectric generating plants. The terms "steam-electric" and "thermoelectric" are used synonymously throughout this report because the vast majority of Georgia's thermoelectric plants are steam driven. The thermoelectric plants are designed to operate continuously, supplying normal electrical demands, whereas the hydroelectric plants furnish the additional power required during peak-demand periods. The locations of 57 of Georgia's largest thermoelectric and hydroelectric plants are shown in figure 1.

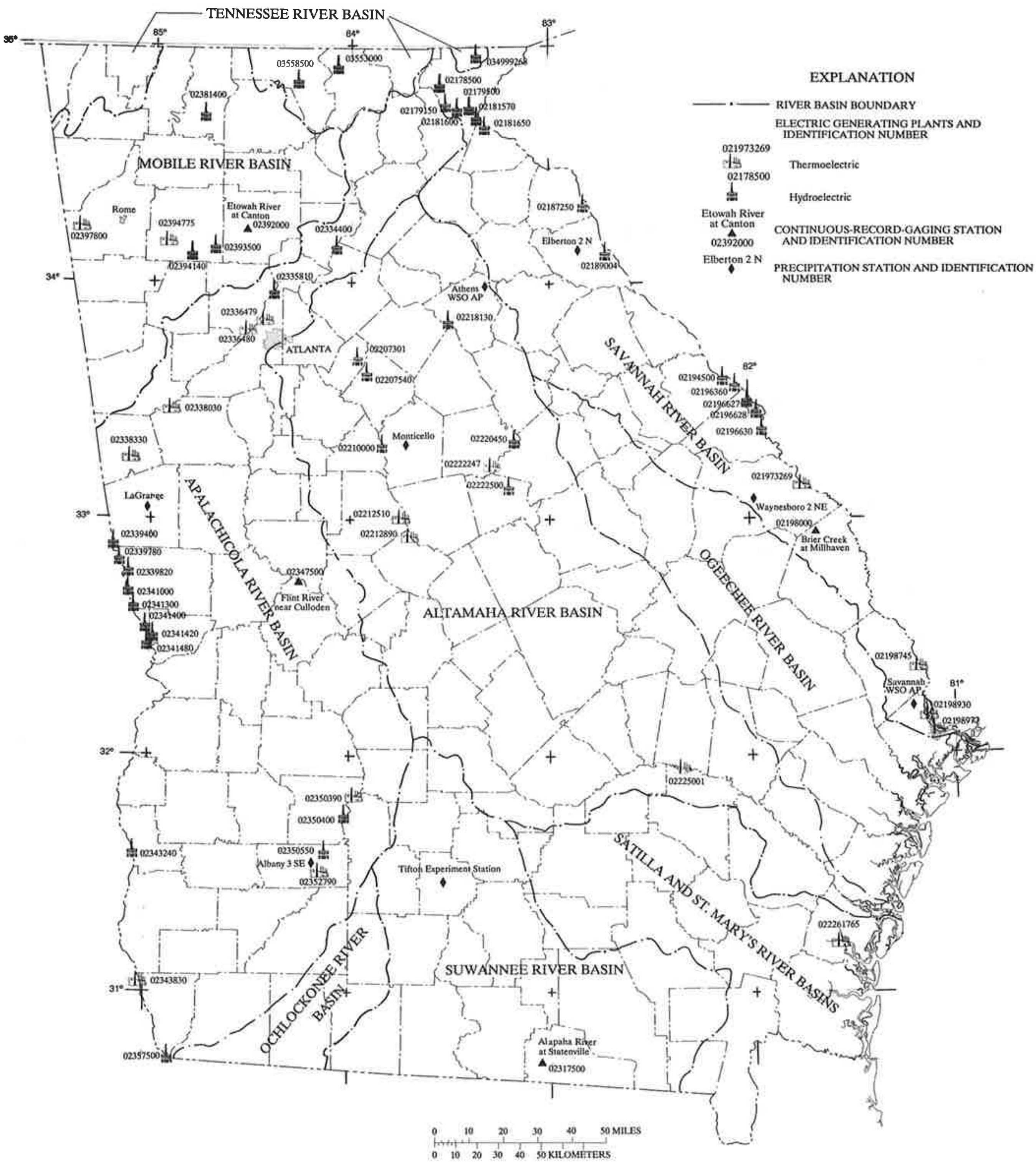


Figure 1.--Power-generating facilities in Georgia by major river basin, 1980-87.

Both thermoelectric and hydroelectric plants require large volumes of water to generate electricity. Most of the water withdrawn for power production in Georgia is from surface-water sources with very little ground water used for this purpose. In 1987, an average of about 3.4 billion gallons per day were withdrawn from Georgia waters to operate 18 utility company thermoelectric power plants. An additional estimated 45 billion gallons per day were used in-stream for power generation at 39 of the State's hydroelectric power plants.

Georgia receives an abundant supply of rainfall, averaging about 50 inches per year (fig. 2). Consequently, many of the State's rivers have flows sufficient for power production. However, critically low streamflow conditions, such as those experienced in 1981 and 1986, can force utility companies to alter their normal operating practices. Hydroelectric power plant operations are especially affected by drought. For instance, the U.S. Army Corps of Engineer's Hartwell plant, a large hydroelectric facility, produced only half as much power in 1981 as in 1980. For these same two years, the power generated at Georgia Power Company's Plant Bowen, the largest thermoelectric plant in the State in 1981, remained about the same.

Purpose and Scope

This study was conducted by the U.S. Geological Survey, in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, as part of a water-use program. The purpose of this report is to present and summarize data on electric power production in Georgia, and the amount of water used to generate this power. The report is based on power-production and water-use data for 39 hydroelectric and 18 thermoelectric power plants operated from 1980 through 1987. These 57 plants are located either in or adjacent to Georgia (fig. 1) and all use water from streams or aquifers in Georgia.

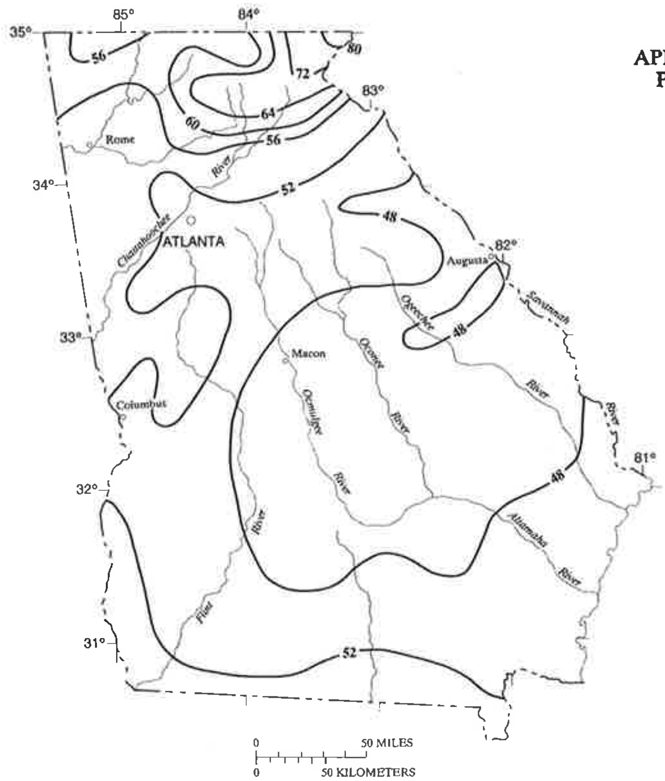
The 39 hydroelectric plants range in size from large, Federally-owned plants to small, privately-owned plants. All but six of the Georgia hydroelectric plants listed in the Federal Energy Regulatory Commission report, "Hydroelectric Power Resources of the United States - Developed and Undeveloped - January 1, 1988," were included in this study. The six plants that were excluded from this study are all very small operations, each having generating capacities of less than 2,000 kilowatts.

The 18 thermoelectric plants included in this study represent all the utility company plants of this type that were operating in or adjacent to Georgia during 1980 through 1987. Of these, 15 plants use conventional fossil fuel (coal, oil, gas) as an energy source and three use nuclear fuel (uranium). All 18 thermoelectric plants use steam to drive their turbines. Georgia's privately-owned non-utility thermoelectric plants were not included in the study because power-production data for these plants are not readily available.

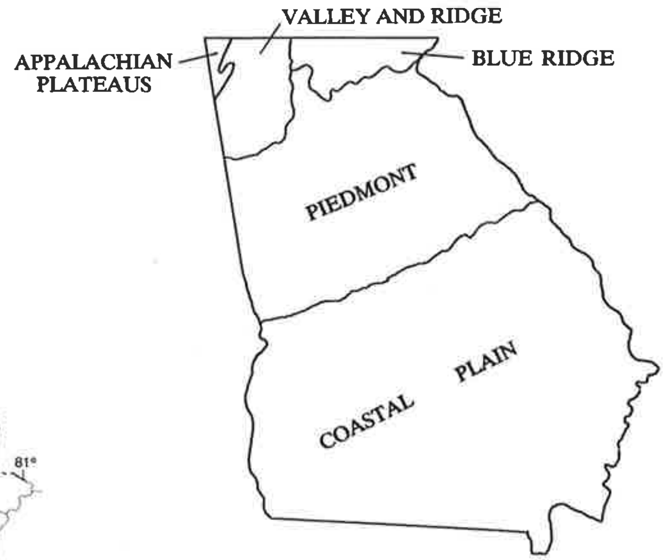
Data Collection

Data on the amount of water used for the production of electrical power were compiled for 57 power plants. These data were gathered from a variety of sources. The Environmental Protection Division (EPD) of the Georgia Department of Natural Resources was a major source of information. Water users who withdraw more than 100,000 gallons per day are required to obtain a permit to operate, and to report monthly water-use figures every quarter to the Water Resources Management Branch of EPD. As part of the Georgia Water-Use Program conducted by the U.S. Geological Survey in cooperation with EPD, power plant owners/operators are contacted on an annual basis to obtain general information on facility practices and operations. Hydroelectric plant owners also provide power-generation figures for each month and a conversion coefficient (gallons of water per megawatt hour of electricity) for the plant. Water use for hydroelectric plants was estimated using a conversion routine in the Georgia Water-Use Data System (GWUDS) and cross-checked with information reported to EPD.

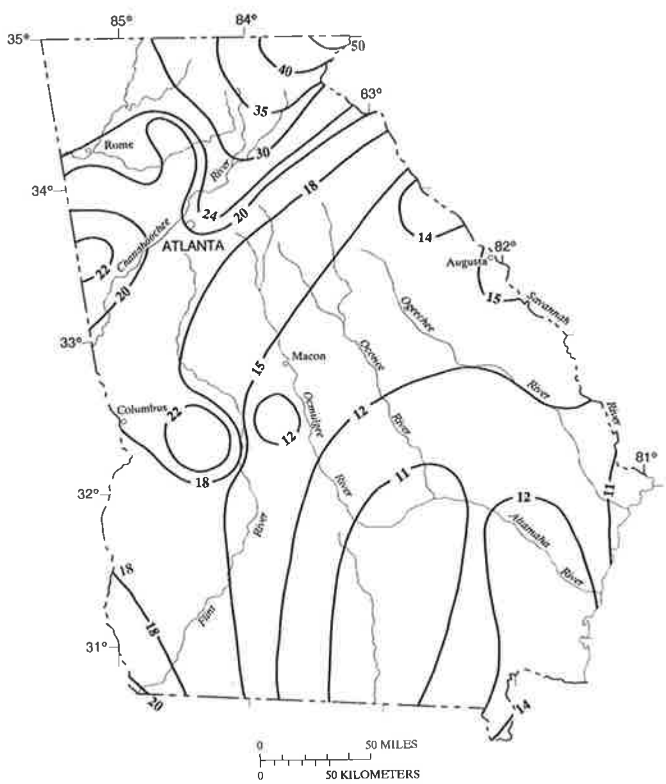
Thermoelectric (including nuclear) power generation figures were provided by the Department of Energy EIA-759 monthly power plant reports (U.S. Department of Energy, 1980, 1981, 1982, 1983, 1984a, 1985, 1986, 1987). This information was cross-checked with data obtained from the Westinghouse Hanford Company report, "Estimated Water Use of Power Plants - Georgia", 1984 (U.S. Department of Energy, 1984b).



PRECIPITATION



PHYSIOGRAPHIC DIVISIONS



RUNOFF

EXPLANATION

— 60 — LINE OF EQUAL AVERAGE PRECIPITATION-
Interval variable, in inches

— 15 — LINE OF EQUAL AVERAGE ANNUAL RUNOFF-
Interval variable, in inches

Figure 2.--Average annual precipitation and runoff for 1951-80 and physiographic provinces in Georgia.

Basic information about power plant location, fuel source, generating capacity, year service began, drainage area and average flow of the water source were obtained from records of the U.S. Geological Survey (USGS), power plant operators, and the following reports: "National Hydroelectric Power Resources Study" (U.S. Army Corps of Engineers, 1981), "Hydroelectric Power Resources of the United States" (Federal Energy Regulatory Commission, 1988), and "Inventory of Power Plants in the United States" (U.S. Department of Energy, 1987). Hydrologic unit codes of the stream basins were determined from USGS hydrologic unit maps. Also, each facility was assigned a unique identification number that corresponds to the USGS downstream order number of the supplying stream at the point of the facility intake. This identification number was used throughout the tables in this report.

Acknowledgments

The authors acknowledge the assistance provided by George Guill, Georgia Power Company; and James Fox and Roberto Del Valle, U.S. Army Corps of Engineers, Atlanta, whose cooperation helped make this report possible. The authors also are indebted to the power plant owners and operators who provided data and other information about the plants. Special thanks are also extended to Robert F. Carter, U.S. Geological Survey [retired], for his enthusiastic support of this study and his many valuable contributions and suggestions during the preparation of this report.

TERMINOLOGY IN WATER-POWER DEVELOPMENT

It will be helpful for the reader to understand the intended meaning of a number of commonly-used power-development terms in this report. They are as follows:

Boiler - a vessel into which water is fed through a piping system. Heat is used to convert the water to pressurized steam.

Condenser - a container where the steam used to drive the turbine is converted back into water. Cool water circulates inside a separate system of pipes inside the condenser unit and causes the spent steam to be cooled and to condense on the outside of the cooling pipes.

Dam - a structure across a watercourse to control the flow, provide storage, and increase the elevation of the water to produce a higher head. The water contained by the dam is, in effect, stored energy. Gates in the dam regulate the flow of water.

Generator - a device that produces electricity. It consist of two parts: A stationary coil of copper wire and a magnet that rotates inside the coil of wire. The magnet is attached to and is driven by a turbine rotor. As the magnetic field issuing from the magnet moves across the coil of wire, an electric current is created.

Head - the difference between the reservoir level at the dam to the water level at the river below. The difference in height between the headwater and the river below provides a direct measure of the potential energy available for conversion to electricity.

Hotwell/condensate pump - the hotwell is a basin at the bottom of the condenser that provides an area for the condensate to collect. The condensate pump forces the water back to the boiler.

Hydroelectric power - electrical power that is generated from water power.

Penstock - a large pipe that directs water from the reservoir to the turbine(s) in the hydroelectric power station.

Reservoir - a place where water is collected and stored for use. The main function of a reservoir is to stabilize the flow of water usually by regulating the amount of supply as it is needed.

Thermoelectric power - electrical power that is generated by using fossil fuel, nuclear energy, or geothermal sources. In Georgia, most of this type power is generated at steam-driven power plants using oil, gas, or coal combustion or the fission of uranium to generate steam.

Turbine - a machine having a rotor with many small blades or vanes that can be driven by the pressure of water or steam directed at or passing through the blades. Turbines are used to convert potential energy in the form of pressure or head to mechanical energy to drive generators.

COMMON TYPES OF POWER-GENERATING PLANTS

Thermoelectric Plants

Thermoelectric power plants use steam, or in some instances another gas, to drive a turbine, which drives a generator to produce electricity. Figure 3 shows the basic design of a steam-driven thermoelectric plant. Water is heated in a boiler with a fuel source such as gas, coal, oil, or nuclear fission to produce high pressure/high temperature steam. The steam is then directed onto the turbine blades. The steam drives the turbine which then drives the generator. Electricity is produced in the generator as a magnet rotates inside a large coil of copper wire setting up an electric current.

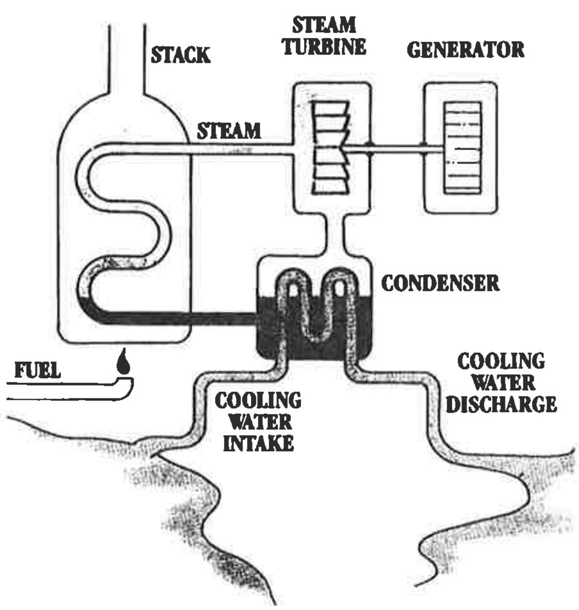


Figure 3.--Schematic diagram of steam-electric generating facility with once-through cooling. [Modified from Epsey, Huston, & Associates, 1985.]

Once the steam passes through the turbine, it enters the condenser where it is cooled and converted to water. The condensate then is collected in the hotwell and pumped back into the boiler to begin the process again. The same water is recycled constantly with only small amounts lost through leakage. The cooling system of the condenser, however, may require large volumes of water. The once-through cooling system is the most commonly used system in Georgia. Once-through cooling draws the cooling water from its source and discharges the heated water directly to the same or adjacent water course so that cooling water passes through the plant only once.

Hydroelectric Plants

Hydroelectric power is generated by releasing water from a reservoir or dam through a turbine, which drives the generator. When the magnet in the generator moves across the coil of wire inside the generator, an electrical current is produced. Thus, the kinetic energy (energy in motion) of the falling water is converted to the mechanical energy of the rotating turbine, which in turn, is converted to the electrical energy produced by the generator (fig. 4). Once the water passes through the turbine, it usually is released downstream.

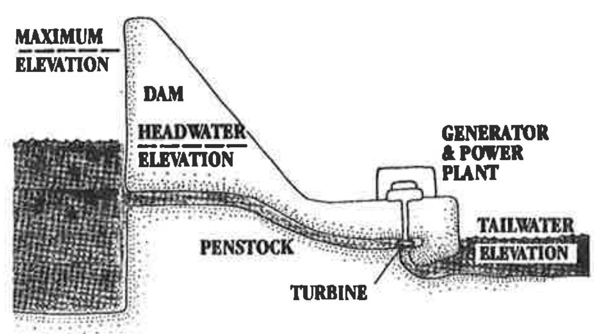


Figure 4.--Schematic diagram of a hydroelectric dam. [Modified from Epsey, Huston, & Associates, 1985.]

Hydroelectric plants are usually classified as storage plants or run-of-river plants. At storage plants, a reservoir is created which has sufficient capacity to allow the operator to store water during wet periods for use during dryer periods. A run-of-river plant has only a small reservoir which can store very little water. Thus, the run-of-river plant can only use available streamflow.

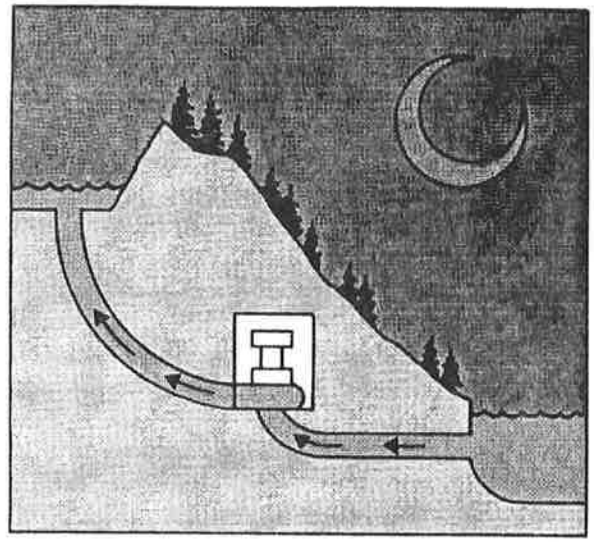
In recent years, the addition of pumped-storage capability to hydroelectric plants has become common. At these plants, water discharged from the turbines is collected in a downstream reservoir and later pumped back to the upstream reservoir during periods of off-peak power demand. This water is used again for power generation during the next peak-power demand period (fig. 5).

About two thirds of the power generating plants in Georgia are hydroelectric plants. The natural continuous flow of water in streams makes hydroelectric power generation a relatively inexpensive and clean method of producing electricity.

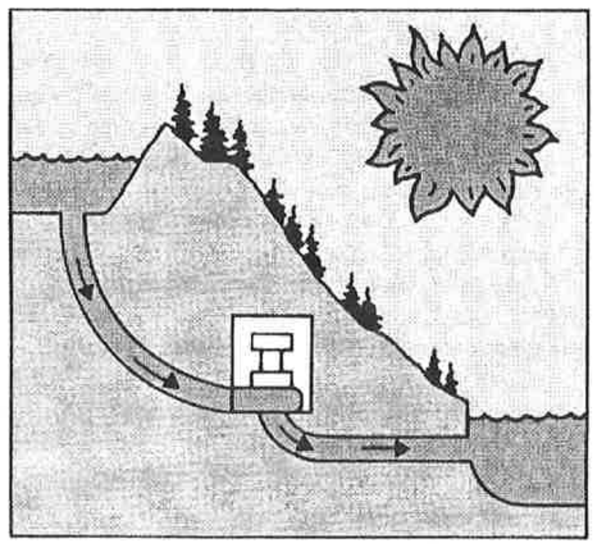
DATA REQUIREMENTS FOR POTENTIAL POWER DEVELOPMENT

The potential for development of hydroelectric and thermoelectric power is contingent upon the availability of a dependable supply of water. The power-facility planner needs to have a clear understanding of the location and the availability of water to make educated decisions concerning plant design and the amounts and the uses of the water that is withdrawn.

Streamflow data are very useful for evaluating the proper site selection and design of thermoelectric and hydroelectric power plants. Records of streamflow and stream-stage over a long, continuous period of time provide the most useful information for these studies. However, records of minimum and/or maximum flows can be very helpful in lieu of continuous data. The USGS maintains records of streamflow for hundreds of stream sites in Georgia. In 1987, there were 115 continuous streamflow-record-gaging stations and 105 peak-flow-only stations in Georgia.



At night when customer demand for energy is low, water is pumped to a storage pool above the dam.



When demand is high and a heavy load is placed on the system, water is allowed to flow back through the turbine-generators.

Figure 5.--Schematic diagram of a pumped-storage facility. [From DOI, Bureau of Reclamation, 1983.]

Flow-duration analysis of continuous streamflow records is helpful in determining a prospective power plant's generating capacity. This type of analysis provides information on the percentage of time selected design flows are expected to be equalled or exceeded.

Draft-storage analysis also is readily performed using continuous-record flow data. The objective of this analysis is to determine the amount of reservoir storage needed to provide the water to produce the desired amount of electricity. Using historic streamflow data, proposed water-withdrawal rates can be tested to evaluate the amount of stored water needed during times when streamflow is inadequate for water-use requirements. Records for years of critically low streamflows often are used for draft-storage analysis because they represent worst-case water-supply conditions.

Flood-flow data also is necessary when a reservoir is planned. This information is useful for the estimation of design floods. The design flood is then used to help determine such things as the physical dimensions of the dam and spillway structures.

GENERAL SETTING

Hydroelectric and thermoelectric power production requires large amounts of water. Fortunately, water is one of Georgia's most abundant resources. There are 10 principal river basins in the State; the Savannah, Altamaha, Satilla, St Marys, Suwanee, Ochlockonee, Apalachicola, Mobile, Tennessee, and Ogeechee (fig. 1). Statewide, the average annual precipitation is 50 inches and the average annual runoff is 15 inches (Carter and Fanning, 1982). However, as figure 2 shows, average annual rainfall and runoff vary greatly across the State, with both generally decreasing from north to south.

Georgia encompasses parts of five physiographic provinces (fig. 2); the Appalachian Plateau, the Valley and Ridge, the Blue Ridge, the Piedmont, and the Coastal Plain (Fenneman, 1938). Physical and hydrologic characteristics vary widely among these provinces, however, each has sufficient water resources for power production.

Northwest Georgia lies within the Appalachian Plateau and the Valley and Ridge provinces. In this area, average annual rainfall ranges from about 48 to 56 inches and runoff from about 16 to 24 inches. Numerous springs discharge into streams causing base-flow runoff to vary among the streams in this area. The larger streams in this region, such as the Etowah and Oostanaula, are characterized by low stream-gradients and wide flood plains.

The Blue Ridge province in northeastern Georgia is the most mountainous of the five provinces. Most streams have steep gradients. The mean annual rainfall and runoff in this area are the highest in the State, ranging from about 54 to 76 inches and 24 to 48 inches, respectively.

The Piedmont province, in the north-central part of the State, has an average annual rainfall of about 44 to 64 inches and average annual runoff of about 10 to 32 inches. The streams generally have moderate slopes with occasional rapids and even a few waterfalls.

The Coastal Plain province is in the southern half of the State. Streams in this province generally have very mild slopes with wide, wooded flood plains. Average annual rainfall in this area ranges from about 44 to 56 inches and average annual runoff ranges from less than 10 to 24 inches.

Power plants are located in each of the five physiographic provinces except the Appalachian Plateau. The number of hydroelectric and thermoelectric plants located in each province are in table 1.

Table 1.–*Power generating plants in Georgia by physiographic province, 1980-87*

Physiographic province	Hydroelectric plants	Thermoelectric plants	Total power plants
Appalachian Plateau	0	0	0
Valley & Ridge	3	2	5
Blue Ridge	7	0	7
Piedmont	25	7	32
Coastal Plain	4	9	13
Total	**39**	**18**	**57**

HISTORICAL WATER-POWER DEVELOPMENTS IN GEORGIA

As Georgia was settled, the use of falling water to produce power for flour and grist mills, saw mills, cotton gins, furniture factories, tanneries, and a variety of other small industries was common. Power was harnessed directly by using water to turn paddle wheels which drove the desired machinery. Because of its relatively steep stream gradients and numerous shoals, north Georgia was particularly suited to this falling-water power production. The city of Augusta made exceptional use of this type water power. In 1845, work began on the Augusta Power Canal to bring water from the Savannah River into the city for powering manufacturing machinery. This project was so successful that Augusta was called the "Lowell of the South" after the prominent manufacturing community of Lowell, Massachusetts.

Unfortunately, many Georgia cities were not as suitably located as Augusta, and their growth was hampered by limited available water power until the use of electrical power to operate machinery became feasible. With the development of electricity came the development and use of water power. Falling water could be used to operate turbine-driven generators and the electrical power could then be delivered to the cities and towns by transmission lines. In 1889, a study of the water-powers of Georgia was initiated by the then-named Geological Survey of Georgia (Hall, 1896). Hall reported "Very few of the large water-powers of Georgia are utilized. This is a fact, not from lack of energy and enterprise in the people of the State; but because their energy has, heretofore, been directed mainly to agriculture and commerce, and not to manufacturing. But a rapid change is taking place in this respect; and it is all the better for our future, that this, the dawn of the age of electricity, has found us with undeveloped powers...". Hall (1896) documented a number of "great powers, in the State, that are running to waste" and presented a survey of power utilization at that time.

By 1921, when the third report on the water powers of Georgia was written (Hall and Hall, 1921), a substantial amount of hydropower development had occurred in Georgia. According to Hall and Hall (1921), about 24 hydroelectric power plants were then being operated with a combined total capacity of about 182,000 kilowatts. The largest of these plants was the "Diversion Dam" at Tallulah Falls with a total capacity of about 72,000 kilowatts. The use of falling-water power to produce electricity was well underway with many projects under construction and even more being planned.

While hydroelectric power production was developing, steam-electric (thermoelectric) power also was coming into increasing use. Although less obvious than with hydroelectric power, water also is very important in steam-electrical power generation for both the steam to drive the turbines and for cooling purposes. In 1955, there were 24 steam-electric plants (11 utilities and 13 industries) listed as Georgia water users in the Georgia Geologic Survey Bulletin 65 (Thomson and others, 1956).

PRESENT-DAY WATER-POWER DEVELOPMENTS IN GEORGIA

In 1987, there were 45 hydroelectric plants operating in or adjacent to Georgia, according to the Federal Energy Regulatory Commission report "Hydroelectric Power Resources of the United States - Developed and Undeveloped - January 1, 1988." There were also 18 utility-company thermoelectric plants producing power in 1987. Table 2 summarizes pertinent information about all of these plants except six small hydroelectric plants for which data were not readily available. The combined total capacity of the 57 plants listed in table 2 was approximately 21,000,000 kilowatts with thermoelectric and hydroelectric plants accounting for capacities of about 19,000,000 kilowatts and 3,000,000 kilowatts, respectively.

Most of the power produced in Georgia comes from thermoelectric plants. These plants are capable of producing large amounts of power and running continuously. They require large volumes of water for cooling purposes. Table 3 lists the amounts of water used and the power produced from 1980 through 1987 by 18 thermoelectric plants in or adjacent to Georgia. Water withdrawn for these plants surpassed all other water uses in the State in 1987, totaling 57 percent of all ground-water and surface-water offstream withdrawals (Trent and others, 1990). However, it should be noted that only about 4 percent of the water withdrawn was consumed and not returned to the source.

A listing of the water used and power produced at the 39 hydroelectric plants for the 1980-87 period is presented in Table 4. The plants range in generating capacity from 500,000 kilowatts at the Federally-owned Carters Plant on the Coosawattee River to 240 kilowatts at Georgia Power Company's Estatoah Plant on Mud Creek. In 1987, the 39 hydroelectric plants produced about 4,700 gigawatt-hours (4,700,000 megawatt-hours) of electricity using an estimated average of 45 billion gallons of water per day. Of the 39 plants listed, 25 are storage-reservoir plants and the other 14 are run-of-river plants. Three of the hydroelectric plants (Russell, Wallace, and Carters) have pumped-storage capability.

A listing of power produced by the 57 plants from 1980 through 1987 (table 5), indicates that the thermoelectric plants provided about 95 percent of the total power generated. Conversely, table 6, a listing of water used by these plants for that same period, indicates that hydroelectric plants by far use the largest amount of water.

Table 5.--*Total power production in Georgia, 1980-87*

[Figures may not add exactly to totals because of independent rounding]

	Power production in gigawatt-hours							
Type of plant	1980	1981	1982	1983	1984	1985	1986	1987
Thermoelectric	63,700	65,500	67,400	74,400	82,200	90,100	85,200	94,700
Hydroelectric	5,520	2,960	4,430	5,480	5,460	3,690	3,610	4700
Total	69,200	68,500	71,800	79,900	87,700	93,800	88,800	99,400

Table 6.--*Total surface water used for power production in Georgia, 1980-87*

[Figures may not add exactly because of independent rounding]

	Total surface water used in million gallons per day							
Type of plant	1980	1981	1982	1983	1984	1985	1986	1987
Thermoelectric	3,140	3,000	2,480	2,620	3,250	3,430	3,440	3,410
Hydroelectric	55,300	32,100	47,600	56,700	56,200	41,900	34,100	45,200
Total	58,400	35,100	50,100	59,300	59,400	45,300	37,500	48,600

EFFECTS OF DROUGHT ON POWER PRODUCTION

Because power production is very water-dependent, natural variations in weather patterns can affect the amount of power produced. Deficient precipitation results in reduced streamflows and less water available for hydroelectric power production. Abnormally low precipitation also may be accompanied by increased demands for electricity to power pumps, air conditioners, and other equipment.

The 1980-87 period shows the close relation between rainfall and power production in Georgia. These eight years have been characterized by several periods of deficient precipitation and streamflow. Precipitation and streamflow observed at several locations in the State during the 1980-87 period, and their relation to long-term averages are shown in figures 6 and 7. In 1981, many streams experienced their lowest rates of flow since the notable drought of 1954 (Carter, 1983). Also, pool levels at Hartwell Lake and Lake Sidney Lanier were at their lowest levels since they were first filled (Carter, 1983). During the 1986 water year (October 1985 through September 1986), annual runoff was the lowest on record for such long-term stations as Oconee River at Dublin (89 years), Chattahoochee River at Columbus (57 years), Etowah River at Canton (59 years), and Coosa River near Rome (55 years) (Stokes and others, 1987). Although there is a general upward trend in annual power production from 1980 through 1987, 1981 production was less than the production in 1980 and 1982 (fig. 8, table 5). Similarly, 1986 power production was less than that in 1985 and 1987 (fig. 8, table 5).

Hydropower production is affected more by drought than is thermoelectric-power production. Small run-of-river plants have little storage or reserve capacity and are sometimes forced to cease operation during drought. Even large storage-reservoir hydropower plants are affected, as can be seen from a review of hydropower plant production listed in table 4.

During 1986, monthly power production at the Allatoona hydroelectric plant was much lower than the long-term average (fig. 9). Monthly mean flows for January through September at the Etowah River at Canton gaging station which accounts for almost half the drainage basin of Allatoona Reservoir, were also very low compared to long-term averages. Although streamflow for the inflow station was near normal for October through December 1986, the power produced was still well below average. This was because the reservoir pool was still low from prior streamflow deficits.

WATER USED FOR POWER PRODUCTION

The amount of water used to generate both thermoelectric and hydroelectric power in Georgia has increased with the growth in population and the increased demand for electric power (fig. 10 and 11). Power production at the thermoelectric and hydroelectric power generating plants withdrawing water from streams and aquifers in Georgia has increased from about 69,000 gigawatt-hours in 1980 to about 99,000 gigawatt-hours in 1987 (fig. 8, table 5).

In 1987, the water used by 18 thermoelectric power plants totaled about 3,410 million gallons per day (Mgal/d) (table 6) and accounted for about 75 percent of the total off-stream use of surface water in the State. The largest use of water by a single thermoelectric power generation facility (986 Mgal/d) was at the Harlee Branch Plant in Putnam County in the Altamaha River basin (table 3).

The in-stream use of water by 39 hydroelectric power generating facilities was about 45,000 Mgal/d in 1987 (table 6). This was the largest use of water in the State. The largest use of water by a single hydroelectric facility was at the Walter F. George facility, which used about 4,800 Mgal/d (table 4). Four other hydroelectric facilities used in excess of 3,000 Mgal/d (table 4).

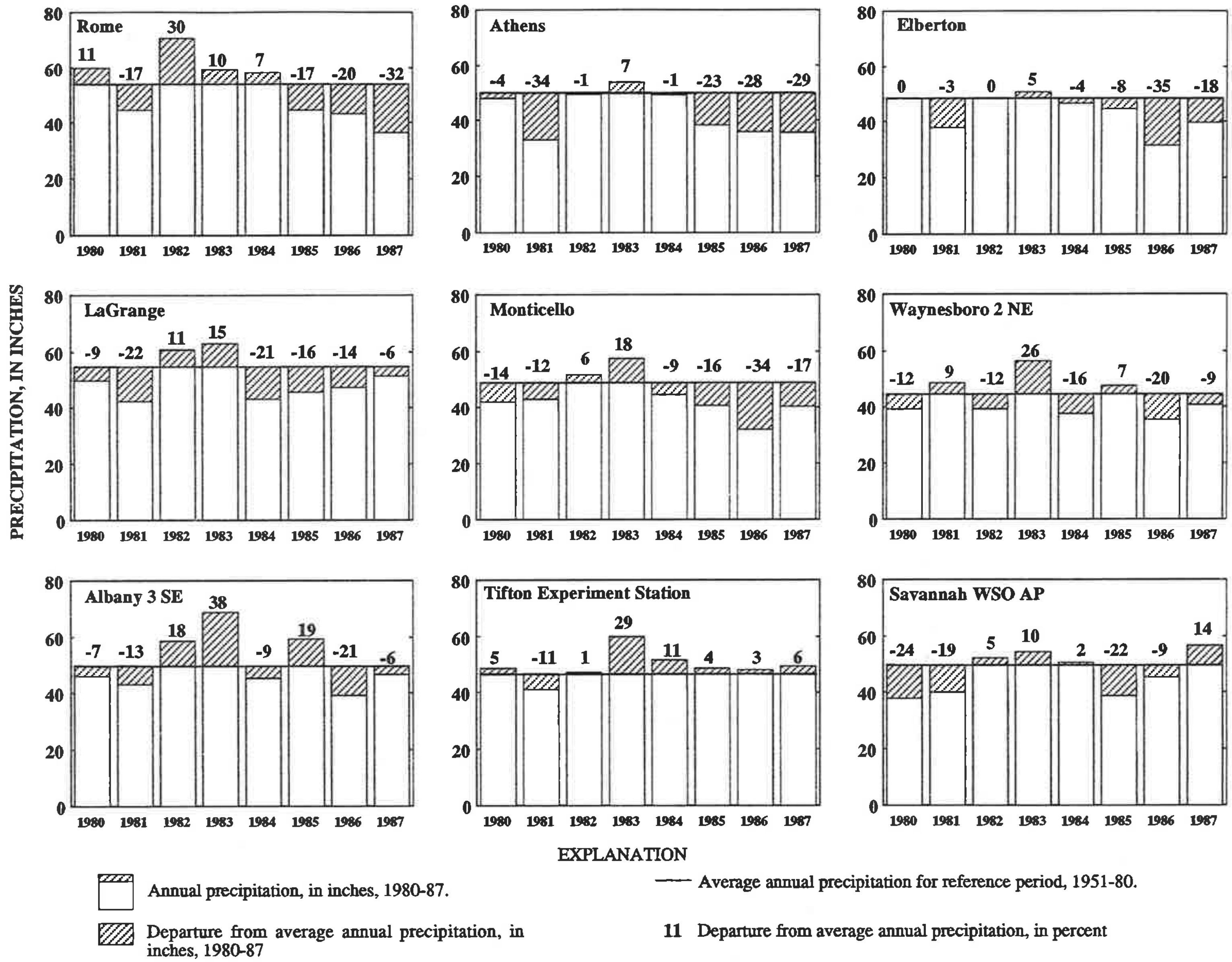


Figure 6.--Annual precipitation and departure from average annual precipitation at selected stations, 1980-87.

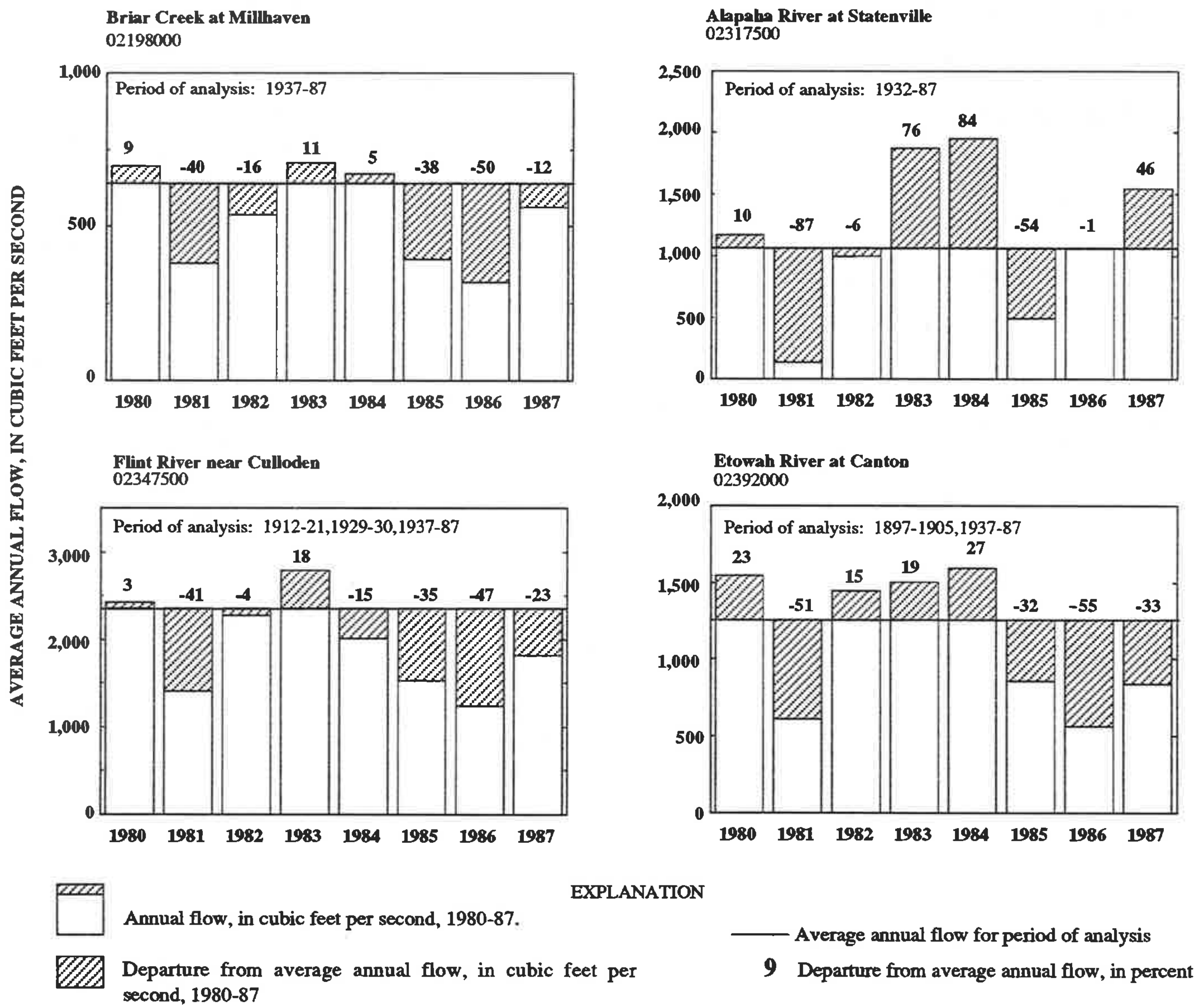


Figure 7.–Annual flow and departure from average annual flow at selected stations, 1980-87.

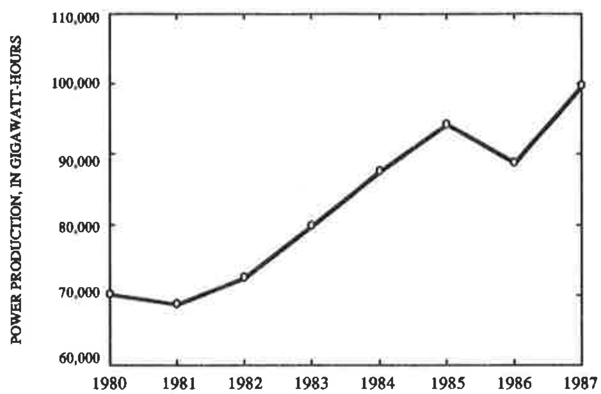


Figure 8.--Total power production in Georgia, 1980-87.

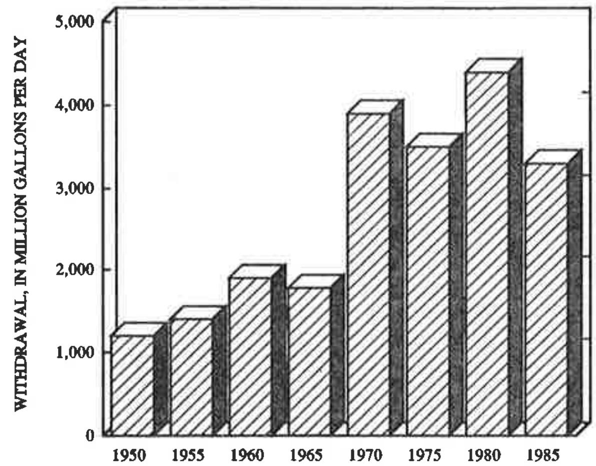


Figure 10.--Surface-water withdrawal for thermoelectric power generation in Georgia, 1950-85.

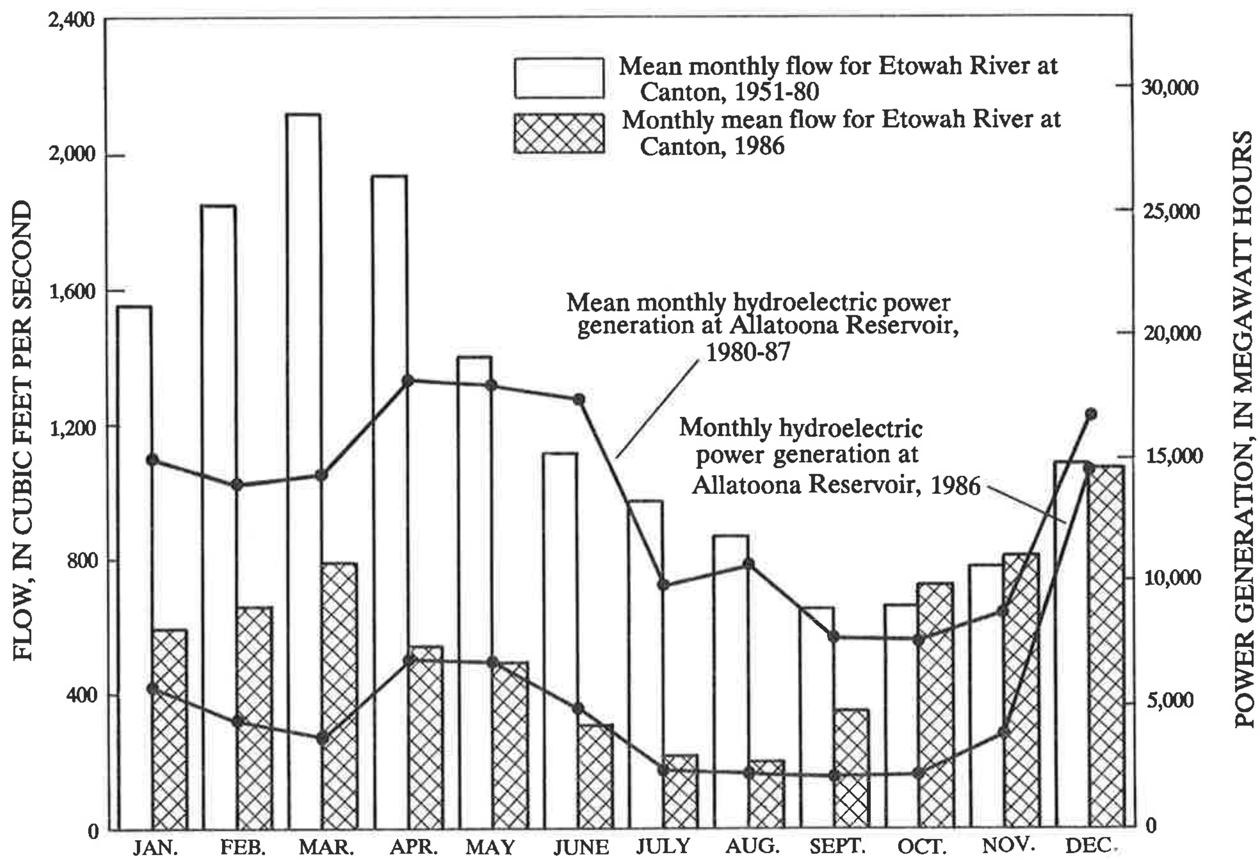


Figure 9.--Comparison of 1986 monthly flows for the Etowah River at Canton and monthly power generation at Allatoona Reservoir with long-term means.

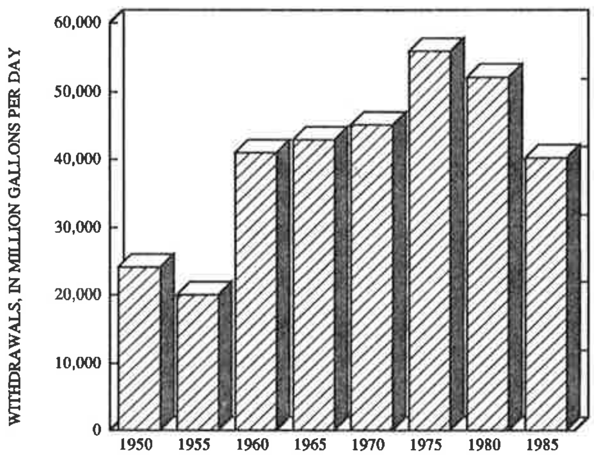


Figure 11.--Surface-water withdrawal for hydroelectric power generation in Georgia, 1950-85.

SUMMARY

Water has been used to produce power in Georgia since the early grist and saw mills and other small industries made direct use of falling water. Production of electricity using water power in Georgia began in the late 1800's and expanded rapidly in the early 1900's. In 1987, there were about 18 utility company thermoelectric plants and 45 hydroelectric plants operating in or adjacent to Georgia. During that year, the thermoelectric plants and 39 of the hydroelectric power plants in Georgia produced about 95,000 and 4,700 gigawatt-hours of power, respectively. There were 3.4 billion gallons per day (Bgal/d) of water withdrawn for cooling purposes for the 18 thermoelectric power plants and about 45 Bgal/d used in-stream to produce power at the 39 hydroelectric plants.

Extreme hydrologic conditions, such as recent droughts, affect power production, as seen during the period from 1980-87, a period of significant climatic variability. Thermoelectric- and hydroelectric-power generation statistics for individual plants and statewide totals during the 1980-87 period show that hydropower production is affected by the reduced availability of water during periods of drought.

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Table 2.--*Power generating plants in Georgia by river basin, 1980-87*

Plant name Downstream order no. - Owner	Type/ Fuel source	County	Hydrologic unit	Water source/ Reservoir	Year in service	Capacity (kilowatts)
			SAVANNAH RIVER BASIN			
BURTON 02178500 - Georgia Power Company	Hydro storage	Rabun	03060102	Tallulah River/ Lake Burton	1927	6,120
NACOOCHEE 02179150 - Georgia Power Company	Hydro storage	Rabun	03060102	Tallulah River/ Seed Lake	1926	4,800
TERRORA 02179500 - Georgia Power Company	Hydro storage	Rabun	03060102	Tallulah River/ Mathis Reservoir	1925	16,000
TALLULAH 02181570 - Georgia Power Company	Hydro storage	Rabun	03060102	Tallulah River/ Tallulah Falls Lake	1913	72,000
TUGALO 02181600 - Georgia Power Company	Hydro storage	Habersham	03060102	Tugaloo River/ Tugalo Lake	1923	45,000
YONAH 02181650 - Georgia Power Company	Hydro storage	Stephens	03060102	Tugaloo River/ Yonah Lake	1925	22,500
HARTWELL 02187250 - U.S. Army Corps of Engineers	Hydro storage	Hart	03060103	Savannah River/ Hartwell Lake	1962	344,000
RUSSELL 02189004 - U.S. Army Corps of Engineers	Hydro storage	Elbert	03060103	Savannah River/ Richard B. Russell Reservoir	1984	300,000
THURMOND 02194500 - U.S. Army Corps of Engineers	Hydro storage	Columbia	03060103	Savannah River/ Thurmond Lake (formerly Clarks Hill Lake)	1953	280,000
STEVENS CREEK 02196360 - South Carolina Electric and Gas Company	Hydro run-of-river	Columbia	03060106	Savannah River/ power pool	1914	18,900
SIBLEY 02196627 - Graniteville Company	Hydro run-of-river	Richmond	03060106	Savannah River by Augusta Canal/none	1920	2,100
KING MILLS 02196628 - Division of Spartan Mills	Hydro run-of river	Richmond	03060106	Savannah River by Augusta Canal/none	1943	2,250
ENTERPRISE 02196630 - Graniteville Company	Hydro run-of-river	Richmond	03060106	Savannah River by Augusta Canal/none	1920	1,200
VOGTLE 021973269 - Georgia Power Company	Thermo nuclear	Burke	03060106	Savannah River/ none	1987	2,320,000
MCINTOSH 02198745 - Savannah Electric and Power Company	Thermo fossil fuel	Effingham	03060109	Savannah River/ none	1979	178,000
PORT WENTWORTH 02198930 - Savannah Electric and Power Company	Thermo fossil fuel	Chatham	03060109	Savannah River/ none	1958	334,000
RIVERSIDE 02198977 - Savannah Electric and Power Company	Thermo fossil fuel	Chatham	03060109	Savannah River/ none	1949	80,000

Table 2.--*Power generating plants in Georgia by river basin, 1980-87*--Continued

Plant name Downstream order no. - Owner	Type/ Fuel source	County	Hydrologic unit	Water source/ Reservoir	Year in service	Capacity (kilowatts)
			ALTAMAHA RIVER BASIN			
MILSTEAD 02207301 - McRay Energy Inc.	Hydro run-of-river	Rockdale	03070103	Yellow River/ power pool	1924	800
PORTERDALE 02207540 - Porterdale Associates	Hydro run-of-river	Newton	03070103	Yellow River/ power pool	1927	1,600
LLOYD SHOALS 02210000 - Georgia Power Company	Hydro storage	Butts	03070103	Ocmulgee River/ Lloyd Shoals Reservoir	1911	14,400
SCHERER 02212510 - Georgia Power Company	Thermo fossil fuel	Monroe	03070103	Ocmulgee River and Rum Creek Lake Juliette	1982	3,270,000
ARKWRIGHT 02212890 - Georgia Power Company	Thermo fossil fuel	Bibb	03070103	Ocmulgee River/ none	1941	160,000
BARNETT SHOALS 02218130 - Georgia Power Company	Hydro run-of-river	Oconee	03070101	Oconee River/ power pool	1910	2,800
WALLACE 02220450 - Georgia Power Company	Hydro storage	Putnam	03070101	Oconee River/ Lake Oconee	1980	321,000
HARLEE BRANCH 02222247 - Georgia Power Company	Thermo fossil fuel	Putnam	03070101	Oconee River/ Sinclair Reservoir	1965	1,540,000
SINCLAIR 02222500 - Georgia Power Company	Hydro storage	Baldwin	03070101	Oconee River/ Sinclair Reservoir	1953	45,000
EDWIN I. HATCH 02225001 - Georgia Power Company	Thermo nuclear	Appling	03070106	Altamaha River/ none	1975	1,163,000
			SATILLA AND ST MARYS RIVER BASINS			
MCMANUS 022261765 - Georgia Power Company	Thermo fossil fuel	Glynn	03070203	Turtle Creek/ none	1952	115,000
			APALACHICOLA RIVER BASIN			
BUFORD 02334400 - U.S. Army Corps of Engineers	Hydro storage	Forsyth	03130001	Chattahoochee River/ Lake Sidney Lanier	1957	86,000
MORGAN FALLS 02335810 - Georgia Power Company	Hydro storage	Fulton	03130001	Chattahoochee River/ Blue Sluice Lake	1904	16,800
ATKINSON 02336479 - Georgia Power Company	Thermo fossil fuel	Cobb	03130002	Chattahoochee River/ none	1930	240,000
MCDONOUGH 02336480 - Georgia Power Company	Thermo fossil fuel	Cobb	03130002	Chattahoochee River/ none	1963	490,000
YATES 02338030 - Georgia Power Company	Thermo fossil fuel	Coweta	03130002	Chattahoochee River/ none	1950	1,250,000
WANSLEY 02338330 - Georgia Power Company	Thermo fossil fuel	Heard	03130002	Chattahoochee River& Yellow Dirt Creek/ none	1976	1,730,000
WEST POINT 02339400 - U.S. Army Corps of Engineers	Hydro storage	Troup	03130002	Chattahoochee River/ West Point Lake	1975	73,400

Table 2.--*Power generating plants in Georgia by river basin, 1980-87*--Continued

Plant name Downstream order no. - Owner	Type/ Fuel source	County	Hydrologic unit	Water source/ Reservoir	Year in service	Capacity (kilowatts)
			APALACHICOLA RIVER BASIN--Continued			
LANGDALE 02339780 - Georgia Power Company	Hydro run-of-river	Harris	03130002	Chattahoochee River/ power pool	1924	1,040
RIVERVIEW 02339820 - Georgia Power Company	Hydro run-of-river	Harris	03130002	Chattahoochee River/ power pool	1918	480
BARTLETTS FERRY 02341000 - Georgia Power Company	Hydro storage	Harris	03130002	Chattahoochee River/ Lake Harding	1926	173,000
GOAT ROCK 02341300 - Georgia Power Company	Hydro run-of-river	Harris	03130002	Chattahoochee River/ power pool	1912	26,000
OLIVER 02341400 - Georgia Power Company	Hydro storage	Muscogee	03130003	Chattahoochee River/ Lake Oliver	1959	60,000
NORTH HIGHLANDS 02341420 - Georgia Power Company	Hydro run-of-river	Muscogee	03130003	Chattahoochee River/ power pool	1963	29,600
EAGLE & PHENIX #1 & #2 02341480 - Fieldcrest Cannon Inc.	Hydro run-of-river	Muscogee	03130003	Chattahoochee River/ power pool	1915	31,800
WALTER F. GEORGE 02343240 - U.S. Army Corps of Engineers	Hydro storage	Clay	03130003	Chattahoochee River/ Walter F. George Lake	1963	130,000
JOSEPH M. FARLEY 02343830 - Alabama Power Company	Thermo nuclear	Houston (Alabama)	03130004	Chattahoochee River/ none	1977	1,720,000
CRISP 02350390 - Crisp County Power Comm.	Thermo fossil fuel	Worth	03130006	Flint River/ Lake Blackshear	1958	12,500
WARWICK 02350400 - Crisp County Power Comm.	Hydro storage	Worth	03130006	Flint River/ Lake Blackshear	1930	16,400
FLINT RIVER 02350550 - Georgia Power Company	Hydro storage	Dougherty	03130008	Flint River/ Lake Worth	1921	5,400
MITCHELL 02352790 - Georgia Power Company	Thermo fossil fuel	Dougherty	03130008	Flint River/ none	1948	170,000
JIM WOODRUFF 02357500 - U.S. Army Corps of Engineers	Hydro storage	Gadsden (Florida)	03130004	Appalachicola River/ Lake Seminole	1957	49,800
			MOBILE RIVER BASIN			
CARTERS 02381400 - U.S. Army Corps of Engineers	Hydro storage	Murray	03150102	Coosawattee River/ Carters Lake	1976	500,000
ALLATOONA 02393500 - U.S. Army Corps of Engineers	Hydro storage	Bartow	03150104	Etowah River/ Allatoona Reservoir	1950	74,000
CARTERSVILLE 02394140 - ECC America International	Hydro run-of-river	Bartow	03150104	Etowah River/ power pool	1927	625
BOWEN 02394775 - Georgia Power Company	Thermo fossil fuel	Bartow	03150104	Etowah River/ none	1971	3,160,000
HAMMOND 02397800 - Georgia Power Company	Thermo fossil fuel	Floyd	03150105	Coosa River/ none	1954	800,000

Table 2.--*Power generating plants in Georgia by river basin, 1980-87*--Continued

Plant name Downstream order no. - Owner	Type/ Fuel source	County	Hydrologic unit	Water source/ Reservoir	Year in service	Capacity (kilowatts)
			TENNESSEE RIVER BASIN			
ESTATOAH 034999268 - Georgia Power Company	Hydro run-of-river	Rabun	03060102	Mud Creek/ power pool	1928	240
NOTTELY 03553000 - Tennessee Valley Authority	Hydro storage	Union	06020002	Nottely River/ Nottely Lake	1956	15,000
BLUE RIDGE 03558500 - Tennessee Valley Authority	Hydro storage	Fannin	06020003	Toccoa River/ Blue Ridge Lake	1931	20,000

Table 3.--*Thermoelectric plants in Georgia, 1980-87*

[Mgal/d, million gallons per day; GW, ground water; SW, surface water; GWh, gigawatt-hour; N/A, data not available. Figures may not add exactly to totals because of independent rounding]

Plant name - County Downstream order no.	Average flow (Mgal/d)	Year	Withdrawal (Mgal/d) GW	SW	TOTAL	Percent consumed	Consumptive use (Mgal/d)	Power generated (GWh)
			SAVANNAH RIVER BASIN					
VOGTLE - Burke 021973269	6,580					100		
		1980	0.21	0	0.21		0	N/A
Note: Average flow is estimated.		1981	.29	0	.29		0	N/A
		1982	.28	0	.28		0	N/A
		1983	.40	0	.40		0	N/A
		1984	.36	.34	.70		.34	N/A
		1985	.86	7.1	8.0		7.1	N/A
		1986	1.9	.44	2.3		.44	N/A
		1987	2.5	50.0	52.2		50.0	4,430
MCINTOSH - Effingham 02198745	N/A					0		
		1980	0.11	107	107		0	182
		1981	.12	107	107		0	212
		1982	.15	107	107		0	584
		1983	.31	107	107		0	916
		1984	.33	107	107		0	1,020
		1985	.27	107	107		0	920
		1986	.20	107	107		0	1,080
		1987	.20	107	107		0	1,110
PT. WENTWORTH - Chatham 02198930	N/A					0		
		1980	1.3	267	268		0	1,580
		1981	1.2	254	255		0	1,540
		1982	1.1	254	255		0	1,320
		1983	0.80	254	255		0	1,130
		1984	1.0	254	255		0	1,120
		1985	1.4	254	255		0	1,220
		1986	.97	254	255		0	1,160
		1987	.90	254	255		0	974
RIVERSIDE - Chatham 02198977	N/A					0		
		1980	1.9	96.0	98.0		0	14.0
		1981	1.7	96.0	98.0		0	37.0
		1982	1.9	96.0	98.0		0	0.89
		1983	1.0	96.0	97.0		0	5.4
		1984	1.4	96.0	97.4		0	.37
		1985	1.9	96.0	98.0		0	1.5
		1986	2.2	96.0	98.2		0	2.8
		1987	1.4	96.0	97.4		0	.28

Table 3.–*Thermoelectric plants in Georgia, 1980-87*--Continued

[Mgal/d, million gallons per day; GW, ground water; SW, surface water; GWh, gigawatt-hour; N/A, data not available. Figures may not add exactly to totals because of independent rounding]

Plant name - County Downstream order no.	Average flow (Mgal/d)	Year	Withdrawal (Mgal/d) GW	SW	TOTAL	Percent consumed	Consumptive use (Mgal/d)	Power generated (GWh)
			ALTAMAHA RIVER BASIN					
SCHERER - Monroe	1,640					100		
02212510		1980	0.07	0	0.07		0	N/A
		1981	.09	58.2	58.3		58.2	N/A
		1982	.07	7.0	7.0		6.9	1,440
		1983	.07	.51	.58		.51	3,040
		1984	.08	.18	.26		.18	5,200
		1985	.05	9.2	9.3		9.2	6,230
		1986	.06	4.6	4.7		4.6	4,650
		1987	.04	.74	.78		.74	5,530
ARKWRIGHT - Bibb	1,710					0		
02212890		1980	0	238	238		0	607
		1981	0	181	181		0	742
		1982	0	103	103		0	397
		1983	0	96.4	96.4		0	403
		1984	0	197	197		0	710
		1985	0	189	189		0	880
		1986	0	190	190		0	882
		1987	0	135	135		0	643
HARLEE BRANCH - Putnam	2,100					0.01		
02222247		1980	0	140	140		0.15	5,560
		1981	0	673	673		.09	7,130
		1982	0	455	455		.06	6,140
		1983	0	726	726		.09	7,130
		1984	0	943	943		.12	9,390
		1985	0	1,060	1,060		.14	10,500
		1986	0	957	957		.12	9,820
		1987	0	986	986		.13	9,850
EDWIN I. HATCH - Appling	7,420					50		
02225001		1980	0.21	65.0	65.2		32.5	8,440
		1981	.28	49.0	49.0		24.3	7,230
		1982	.25	52.0	52.2		26.0	6,600
		1983	.22	56.0	56.0		28.0	7,770
		1984	.21	49.0	49.0		24.4	5,470
		1985	.22	55.2	55.4		28.0	10,100
		1986	.19	55.0	55.0		27.3	7,240
		1987	.23	58.3	59.0		29.2	10,800

Table 3.--*Thermoelectric plants in Georgia, 1980-87*--Continued

[Mgal/d, million gallons per day; GW, ground water; SW, surface water; GWh, gigawatt-hour; N/A, data not available. Figures may not add exactly to totals because of independent rounding]

Plant name - County Downstream order no.	Average flow (Mgal/d)	Year	Withdrawal (Mgal/d) GW	SW	TOTAL	Percent consumed	Consumptive use (Mgal/d)	Power generated (GWh)
			SATILLA AND ST MARYS RIVER BASINS					
MCMANUS - Glynn 022261765	N/A					0.01		
		1980	0.04	155	155		1.5	72.0
		1981	.04	29.1	30.0		0.29	60.5
		1982	.03	23.0	23.0		.23	12.0
		1983	.02	48.0	48.0		.48	8.4
		1984	.01	54.1	54.1		.54	6.1
		1985	.01	46.0	46.0		.46	15.0
		1986	.02	46.1	46.1		.46	77.0
		1987	.02	33.3	33.3		.33	33.5
			APALACHICOLA RIVER BASIN					
ATKINSON - Cobb 02336479	1,600					0		
		1980	0	72.0	72.0		0	132
		1981	0	0	0		0	0
		1982	0	0	0		0	0
		1983	0	22.0	22.0		0	32.0
		1984	0	1.0	1.0		0	1.3
		1985	0	36.0	36.0		0	17.0
		1986	0	45.0	45.0		0	21.0
		1987	0	16.2	16.2		0	4.7
MCDONOUGH - Cobb 02336480	1,600					0		
		1980	0	394	394		0	1,970
		1981	0	356	356		0	3,220
		1982	0	349	349		0	2,740
		1983	0	349	349		0	3,200
		1984	0	347	347		0	3,620
		1985	0	345	345		0	3,270
		1986	0	359	359		0	3,180
		1987	0	362	362		0	3,480
YATES - Coweta 02338030	2,570					1.6		
		1980	0	666	666		11.0	6,400
		1981	0	419	419		6.8	6,720
		1982	0	317	317		5.1	5,680
		1983	0	264	264		4.3	5,370
		1984	0	392	392		6.3	6,380
		1985	0	430	430		7.0	6,430
		1986	0	536	536		8.7	6,360
		1987	0	555	555		9.0	6,940

Table 3.--*Thermoelectric plants in Georgia, 1980-87*--Continued

[Mgal/d, million gallons per day; GW, ground water; SW, surface water; GWh, gigawatt-hour; N/A, data not available. Figures may not add exactly to totals because of independent rounding]

Plant name - County Downstream order no.	Average flow (Mgal/d)	Year	Withdrawal (Mgal/d) GW	SW	TOTAL	Percent consumed	Consumptive use (Mgal/d)	Power generated (GWh)
APALACHICOLA RIVER BASIN--Continued								
WANSLEY - Heard 02338330	2,640					75		
		1980	0	25.0	25.0		18.5	11,700
		1981	0	26.0	26.0		19.4	11,300
		1982	0	14.0	14.0		10.4	10,500
		1983	0	3.8	3.8		2.8	11,100
		1984	0	14.3	14.3		11.0	12,100
		1985	0	23.0	23.0		17.0	11,400
		1986	0	21.2	21.2		16.0	11,100
		1987	0	11.1	11.1		8.3	11,200
JOSEPH FARLEY - Houston (Alabama) 02343830	6,710					0		
		1980	0	72.0	72.0		0	4,890
		1981	0	107	107		0	5,890
		1982	0	94.4	94.4		0	11,100
		1983	0	100	100		0	11,900
		1984	0	101	101		0	12,700
		1985	0	101	101		0	12,000
		1986	0	100	100		0	12,400
		1987	0	97.2	97.2		0	12,000
CRISP - Worth 02350390	2,870					0		
		1980	0	2.2	2.2		0	15.0
		1981	0	2.8	2.8		0	17.0
		1982	0	0.63	0.63		0	3.2
		1983	0	.81	.81		0	5.0
		1984	0	2.2	2.2		0	8.2
		1985	0	2.2	2.2		0	4.8
		1986	0	1.5	1.5		0	4.0
		1987	0	1.1	1.1		0	1.4
MITCHELL - Dougherty 02352790	4,060					0.03		
		1980	0	232	232		0.06	1,120
		1981	0	135	135		.04	998
		1982	0	148	148		.04	970
		1983	0	145	145		.04	954
		1984	0	184	184		.05	1,220
		1985	0	178	178		.05	1,260
		1986	0	151	151		.04	1,070
		1987	0	146	146		.04	1,200

Table 3.--*Thermoelectric plants in Georgia, 1980-87*--Continued

[Mgal/d, million gallons per day; GW, ground water; SW, surface water; GWh, gigawatt-hour; N/A, data not available. Figures may not add exactly to totals because of independent rounding]

Plant name - County Downstream order no.	Average flow (Mgal/d)	Year	Withdrawal (Mgal/d) GW	SW	TOTAL	Percent consumed	Consumptive use (Mgal/d)	Power generated (GWh)
			MOBILE RIVER BASIN					
BOWEN - Bartow 02394775	1,550					48		
		1980	0	60.0	60.0		29.0	17,700
		1981	0	59.0	59.0		28.0	17,100
		1982	0	49.0	49.0		23.4	17,100
		1983	0	41.0	41.0		20.0	18,500
		1984	0	53.0	53.0		25.2	19,000
		1985	0	58.5	58.5		28.0	20,900
		1986	0	57.0	57.0		27.0	21,200
		1987	0	55.0	55.0		26.2	21,500
HAMMOND - Floyd 02397800	4,360					0		
		1980	0	548	548		0	3,350
		1981	0	448	448		0	3,300
		1982	0	415	415		0	2,800
		1983	0	314	314		0	2,980
		1984	0	454	454		0	4,240
		1985	0	435	435		0	4,960
		1986	0	457	457		0	4,990
		1987	0	449	449		0	4,960

Table 4. --*Hydroelectric plants in Georgia, 1980-87*

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			SAVANNAH RIVER BASIN				
BURTON - Rabun	115		112		219		3.40×10^9
02178500		1980		230		24.5	
		1981		102		11.0	
		1982		201		21.5	
		1983		252		27.0	
		1984		233		25.0	
		1985		123		13.1	
		1986		104		11.1	
		1987		157		17.0	
NACOOCHEE-Rabun	136		62		245		5.80×10^9
02179150		1980		260		16.5	
		1981		132		8.4	
		1982		223		14.1	
		1983		275		17.4	
		1984		258		16.3	
		1985		144		9.1	
		1986		117		7.4	
		1987		176		11.1	
TERRORA-Rabun	151		187		265		2.00×10^9
02179500		1980		283		52.0	
		1981		135		25.0	
		1982		255		47.0	
		1983		317		58.0	
		1984		298		54.4	
		1985		169		31.0	
		1986		136		25.0	
		1987		209		38.2	
TALLULAH-Rabun	186		598		310		0.69×10^9
02181570		1980		357		188	
		1981		157		83.0	
		1982		312		164	
		1983		390		205	
		1984		358		188	
		1985		208		109	
		1986		165		87.0	
		1987		237		125	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			SAVANNAH RIVER BASIN--Continued				
TUGALO-Habersham	464		142		742		2.57×10^9
02181600		1980		837		119	
		1981		368		52.2	
		1982		794		113	
		1983		959		136	
		1984		878		125	
		1985		553		109	
		1986		429		61.0	
		1987		657		93.0	
YONAH-Stephens	470		69		103		5.60×10^9
02181650		1980		926		60.4	
		1981		426		28.0	
		1982		878		57.3	
		1983		1,060		69.0	
		1984		937		61.0	
		1985		613		40.0	
		1986		429		28.0	
		1987		669		44.0	
HARTWELL-Hart	2,090		172		2,710		1.96×10^9
02187250		1980		*3,240		604	
		1981		*1,620		302	
		1982		*1,520		284	
		1983		*2,880		538	
		1984		3,030		539	
		1985		2,040		218	
		1986		1,550		296	
		1987		1,980		369	
RUSSELL-Elbert	2,900		161		3,290		2.50×10^9
02189004		1980		0		0	
		1981		0		0	
Note: has pumped-		1982		0		0	
storage capability		1983		0		0	
		1984		*1.0		.15	
		1985		2,440		211	
		1986		2,000		295	
		1987		2,600		380	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
SAVANNAH RIVER BASIN--Continued							
THURMOND-Columbia 02194500	6,140		109		8,860		*0.7 x 10^9
		1980		*1,710		893	
		1981		*819		427	
		1982		*1,020		533	
		1983		*1,550		808	
		1984		*1,640		857	
		1985		*890		464	
		1986		*825		430	
		1987		*1,150		601	
STEVENS CREEK-Columbia 02196360	7,170		28		6,390		15.80 x 10^9
		1980		3,710		86.0	
		1981		3,010		70.0	
		1982		3,340		77.2	
		1983		4,170		96.3	
		1984		4,200		97.0	
		1985		3,160		73.0	
		1986		2,930		68.0	
		1987		3,670		85.0	
SIBLEY-Richmond 02196627	7,500		33		6,580		13.00 x 10^9
		1980		439		12.3	
		1981		429		12.0	
		1982		434		12.2	
		1983		435		12.2	
		1984		410		11.5	
		1985		441		12.4	
		1986		502		14.0	
		1987		506		14.2	
KING MILLS-Richmond 02196628	7,500		32		6,580		15.40 x 10^9
		1980		0		0	
		1981		0		0	
		1982		0		0	
		1983		0		0	
		1984		542		13.0	
		1985		512		12.2	
		1986		542		13.0	
		1987		542		13.0	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			SAVANNAH RIVER BASIN--Continued				
ENTERPRISE-Richmond 02196630	7,500		30		6,580		10.30 x 10^9
		1980		103		3.7	
		1981		73.2		2.6	
		1982		136		4.8	
		1983		21.0		0.74	
		1984		0		0	
		1985		0		0	
		1986		3.3		.12	
		1987		19.0		.67	
			ALTAMAHA RIVER BASIN				
MILSTEAD-Rockdale 02207301	210		44		161		5.30 x 10^9
		1980		0		0	
		1981		0		0	
		1982		0		0	
		1983		0		0	
		1984		0		0	
		1985		0		0	
		1986		17.5		1.2	
		1987		30.0		2.1	
PORTERDALE-Newton 02207540	413		47		321		5.30 x 10^9
		1980		0		0	
		1981		0		0	
		1982		0		0	
		1983		*24.0		1.6	
		1984		153		10.5	
		1985		112		7.7	
		1986		66.3		4.6	
		1987		78.4		5.4	

Table 4. *–Hydroelectric plants in Georgia, 1980-87*–Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
				ALTAMAHA RIVER BASIN--Continued			
LLOYD SHOALS-Butts 02210000	1,400		100		1,100		4.06 x 10^9
		1980		760		68.3	
		1981		358		32.2	
		1982		794		71.4	
		1983		447		40.2	
		1984		759		68.2	
		1985		668		60.0	
		1986		397		36.0	
		1987		575		52.0	
BARNETT SHOALS-Oconee 02218130	835		49		774		8.36 x 10^9
		1980		168		7.4	
		1981		109		4.8	
		1982		62.2		2.7	
		1983		144		6.3	
		1984		161		7.0	
		1985		166		7.3	
		1986		156		6.8	
		1987		192		8.4	
WALLACE-Putnam 02220450 Note: Pumped storage facility	1,830		94		1,560		3.88 x 10^9
		1980		3,700		348	
		1981		3,500		329	
		1982		3,620		340	
		1983		4,390		413	
		1984		3,550		334	
		1985		4,010		377	
		1986		3,220		303	
		1987		2,730		257	
SINCLAIR-Baldwin 02222500	2,900		96		2,130		3.93 x 10^9
		1980		1,420		132	
		1981		569		53.0	
		1982		1,260		117	
		1983		1,480		138	
		1984		1,320		123	
		1985		874		81.3	
		1986		668		62.0	
		1987		983		91.0	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			APALACHICOLA RIVER BASIN				
BUFORD-Forsyth	1,040		149		1,300		*2.35×10^9
02334400		1980		*1,690		263	
		1981		859		127	
		1982		733		110	
		1983		1,410		222	
		1984		1,550		247	
		1985		833		128	
		1986		661		103	
		1987		840		130	
MORGAN FALLS-	1,370		39		1,750		7.63×10^9
Fulton		1980		1,470		70.4	
02335810		1981		851		41.0	
		1982		879		42.0	
		1983		1,390		66.3	
		1984		1,520		73.0	
		1985		894		43.0	
		1986		716		34.0	
		1987		903		43.2	
WEST POINT-	3,380		68		3,500		*5.61×10^9
Troup		1980		*3,910		254	
02339400		1981		*1,790		116	
		1982		*3,060		199	
		1983		*4,060		264	
		1984		3,890		262	
		1985		2,410		148	
		1986		1,520		99.0	
		1987		2,520		164	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
		APALACHICOLA RIVER BASIN--Continued					
LANGDALE-Harris	3,630		13		3,670		30.30×10^9
02339780		1980		426		5.2	
		1981		370		4.5	
		1982		382		4.6	
		1983		434		5.2	
		1984		459		5.5	
		1985		404		4.9	
		1986		381		4.6	
		1987		413		5.0	
RIVERVIEW-Harris	3,660		9.0		3,700		28.20×10^9
02339820		1980		279		3.6	
		1981		715		9.3	
		1982		262		3.3	
		1983		256		3.3	
		1984		234		3.0	
		1985		189		2.5	
		1986		185		2.4	
		1987		188		2.4	
BARTLETTS	4,240		108		4,030		3.13×10^9
FERRY-		1980		3,620		422	
Harris		1981		2,140		250	
02341000		1982		3,130		365	
		1983		3,720		434	
		1984		3,810		445	
		1985		2,100		245	
		1986		1,980		232	
		1987		3,200		371	
GOAT ROCK-Harris	4,520		66		4,300		5.98×10^9
02341300		1980		2,740		174	
		1981		1,810		111	
		1982		2,660		163	
		1983		2,940		179	
		1984		2,850		174	
		1985		2,090		128	
		1986		1,590		97.0	
		1987		2,360		144	

Table 4. *–Hydroelectric plants in Georgia, 1980-87*–Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			APALACHICOLA RIVER BASIN–Continued				
OLIVER-Muscogee	4,630		66		4,400		5.59×10^9
02341400		1980		3,990		261	
		1981		2,250		147	
		1982		3,570		234	
		1983		4,360		285	
		1984		4,350		285	
		1985		2,730		178	
		1986		2,040		133	
		1987		3,050		199	
NORTH	4,630		39		4,160		9.44×10^9
HIGHLANDS-		1980		4,050		157	
Muscogee		1981		2,240		87.0	
02341420		1982		3,610		140	
		1983		4,420		171	
		1984		4,000		155	
		1985		2,690		104	
		1986		2,030		79.0	
		1987		3,080		119	
EAGLE & PHENIX	4,640		26		4,480		17.70×10^9
#1 and #2-		1980		419		9.0	
Muscogee		1981		356		7.6	
02340480		1982		244		5.2	
		1983		296		6.3	
Note: Drainage		1984		308		6.6	
area and average flow		1985		350		7.5	
based upon combined		1986		277		5.9	
capacities of two		1987		374		8.0	
generators #1 and #2.							
WALTER F.-	7,460		85		6,450		*4.45×10^9
GEORGE-		1980		*6,160		506	
Clay		1981		*3,160		260	
02343240		1982		*5,710		470	
		1983		*7,060		579	
		1984		6,440		513	
		1985		3,830		300	
		1986		3,200		262	
		1987		4,830		396	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			APALACHICOLA RIVER BASIN--Continued				
WARWICK-Worth	3,600		28		2,800		14.60×10^9
02350400		1980		1,710		43.0	
		1981		1,190		30.0	
		1982		2,220		56.0	
		1983		2,160		54.0	
		1984		2,230		56.0	
		1985		1,720		43.0	
		1986		1,510		38.0	
		1987		1,910		48.0	
FLINT RIVER-	4,180		27		3,270		14.80×10^9
Dougherty		1980		1,270		31.0	
02350550		1981		921		23.0	
		1982		1,360		34.0	
		1983		1,180		29.0	
		1984		1,360		34.0	
		1985		1,300		32.0	
		1986		1,120		28.0	
		1987		1,240		30.5	
JIM WOODRUFF-	17,150		27		21,800		*1.41×10^9
Gadsden (Florida)		1980		837		216	
02357500		1981		702		181	
		1982		1,010		263	
		1983		858		222	
		1984		830		214	
		1985		933		241	
		1986		734		190	
		1987		725		187	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			MOBILE RIVER BASIN				
CARTERS-Murray	376		363		271		*0.91 x 10^9
02381400		1980		*2,510		191	
		1981		0		0	
Note: Has pumped-		1982		*1,830		171	
storage capability		1983		*1,140		106	
		1984		1,410		144	
		1985		1,160		100	
		1986		1,160		464	
		1987		1,210		486	
ALLATOONA-	1,110		140		1,070		*2.58 x 10^9
Bartow		1980		*1,400		199	
02393500		1981		*569		81.0	
		1982		*1,460		206	
		1983		*1,400		198	
		1984		1,490		216	
		1985		735		101	
		1986		399		56.4	
		1987		745		105	
CARTERSVILLE-	930		14		897		1.75 x 10^9
Bartow		1980		0		0	
02394140		1981		0		0	
		1982		0		0	
		1983		0		0	
		1984		0		0	
		1985		6.8		1.4	
		1986		6.3		1.3	
		1987		4.6		.96	

Table 4. --*Hydroelectric plants in Georgia, 1980-87*--Continued

[mi^2, square miles; Mgal/d, million gallons per day; GWh, gigawatt-hour; Gal/GWh, gallons per gigawatt-hour; *, figures are estimated. Figures may not add exactly to totals because of independent rounding]

Name - County Downstream order no.	Drainage area (mi^2)	Year	Average head (feet)	Surface-water use (Mgal/d)	Average flow (Mgal/d)	Power generated (GWh)	Conversion coefficient (Gal/GWh)
			TENNESSEE RIVER BASIN				
ESTATOAH-	not		610		65		0.66 x 10^9
Rabun	measured	1980		2.9		1.7	
034999268		1981		1.7		0.94	
		1982		46.0		26.0	
		1983		1.3		.74	
		1984		1.3		.74	
		1985		.90		.48	
		1986		.51		.31	
		1987		2.1		1.2	
NOTTELY-Union	214		127		367		*2.63 x 10^9
03553000		1980		272		50.0	
		1981		147		20.0	
		1982		245		34.4	
		1983		335		42.3	
		1984		298		44.0	
		1985		163		23.0	
		1986		*112		*16.0	
		1987		*153		*21.3	
BLUE RIDGE-	232		130		404		*3.43 x 10^9
Fannin		1980		408		49.0	
03558500		1981		254		20.0	
		1982		349		41.0	
		1983		440		51.0	
		1984		450		53.0	
		1985		244		26.0	
		1986		*180		*19.0	

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Editor: Patricia A. Allgood

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