SOUTH CAROLINA

WATER RESOURCES

PLANNING AND COORDINATING COMMITTEE

Report No. 1

A Reconnaissance of the Water Resources of Pickens County, South Carolina

By:

F. A. Johnson, George E. Siple, and T. Ray Cummings

Prepared by
U. S. Geological Survey, Water Resources Division
in cooperation with
Pickens County Planning and Development Commission
Columbia, South Carolina
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CONTENTS

ILLUSTRATIONS

TABLES

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ABSTRACT

The magnitude and frequency of low flows in Pickens County, S.C., have been estimated from gaging station records and from a reconnaissance investigation conducted during August, September and October 1967. Average flows and 7-day low flows having recurrence intervals of 2 and 10 years have been computed for 26 stream locations. The 2-year (median), 7-day low flows range from about 0.3 cubic foot per second per square mile in the southern part of the county to about 0.9 cubic foot per second per square mile in the mountainous north. Storage requirements based on low-flow recurrence intervals of 5 and 10 years have been computed also. At most locations surface water in Pickens County has a low dissolved-solids content and is generally suitable for most uses.

Generally, wells drilled to a depth of less than 250 feet in rocks of the Inner Piedmont and Brevard Belts of Pickens County yield from one-half to 500 gallons per minute. The highest average yields were obtained from wells drilled in biotite granite gneiss whereas the lowest average yields were from wells in hornblende gneiss. Wells drilled in biotite schist, and biotite gneiss and migmatite, had intermediate yields of about 14 gallons per minute. The average yield of all wells inventoried was 21 gallons per minute; the average for the highest 3 percent was 112 gallons per minute. Wells drilled through 15 to 90 feet of saprolite produce the highest average yields. Records obtained on the base flow of streams (2-year, 7-day low flow) throughout the county indicate that approximately 0.3 to 0.7 million gallons of water per square mile are discharged daily. This amount is the minimum potentially available for ground-water withdrawal.

The ground water of Pickens County is of good to excellent quality for most domestic, municipal and industrial uses. Most of the waters sampled were soft, slightly acidic, and low in dissolved solids.

INTRODUCTION

Use of water in the United States increased almost threefold between 1940 and 1965, and by 1980, it is predicted that use of water will have increased another one-third (U.S. Dept. of Commerce, 1967). Most of the increased use of water is accounted for by expanding industrial and municipal requirements. Industrial development and urban growth depend to a large extent on the quantity and quality of available water, and how readily the water may be utilized. The collection, evaluation, and dissemination of basic water facts is necessary to the efficient use of water and to the planning and management of water-resources projects.

Purpose and Scope of the Investigation

This report presents the results of a reconnaissance investigation of the water resources of Pickens County, South Carolina. The purpose of the investigation was to collect sufficient information on the occurrence and characteristics of surface and ground water to appraise these resources. The information obtained will be useful in the planning of future water-resources projects, and in pointing out specific areas in the county where more detailed evaluations may be needed.

This investigation was made in cooperation with the Pickens County Planning and Development Commission, Mr. Ernest Cooler, Executive Director. The investigation was supervised by John S. Stallings, District Chief, Water Resources Division, U.S. Geological Survey.

Method of Investigation

Surface-water data for this investigation were obtained during August, September and October 1967. Discharge measurements were made at selected sites during low-flow conditions to provide data on the minimum amount of surface water likely to be available for use. At each site the chemical characteristics of the water were determined by field measurements, and samples were obtained at selected sites for complete chemical analysis in the laboratory. Data on well depth, yield and location were collected over a period of several months to augment data obtained during previous statewide studies. Samples of ground water were obtained from selected wells for chemical analyses.

Previous Investigations

Previous investigations of surface-water resources of Pickens County have been confined to the collection of streamflow and water-quality data at a few selected sites. Previous ground-water reports

(Siple, 1946; Koch, 1968) contained information on Pickens County as part of reconnaissance surveys of larger areas. No interpretive reports have been published previously concerning Pickens County specifically.

Stream and Well-Numbering System

Stream-gaging stations have been assigned the downstream-order numbers that are used in the Geological Survey's annual series of Water-Supply Papers. For this report, miscellaneous sites where discharge measurements were made also have been assigned downstream-order numbers SW 1 to SW 32.

Water wells within the county are numbered serially, the number being derived from a two-letter abbreviation for the county name, followed by a number indicating the chronological order in which the well data were obtained. Thus, PK-12 indicates the twelfth well inventoried in Pickens County.

Plate 1 shows the locations of surface-water sites and of selected wells.

Acknowledgments

The authors acknowledge the cooperation and assistance of municipal and industrial officials throughout the county who contributed information concerning the nature and utilization of their water-supply facilities. Special acknowledgment is given to the Robbins Brothers Well Drilling Co., Greenville, S.C., for making available their records on Pickens County, and to the J. R. Chandler Well Drilling Co., Pelzer, S.C., who provided additional information on several wells drilled in the area.

GEOGRAPHY

Location and Extent of the Area

Pickens County occupies an area of 508 square miles in northwestern South Carolina. It is bounded on the west by the Keowee River and Hartwell Reservoir, on the south by Anderson County, on the east by the Saluda River, and on the north by the North Carolina State line and the South Saluda River.

Topography

Physiographically, Pickens County is within the Appalachian Highlands. The northern quarter of the county lies in the southern section of the Blue Ridge province. The area is dissected by youthful to mature streams and has an average relief of about 400 feet. Elevation above mean sea level exceeds 3,000 feet at several locations. Sassafras Mountain, the highest point in the State, is 3,548 feet. The central and southern part of the county lies within the Piedmont Upland of the Piedmont province. This area is characterized by rolling topography; relief is about 200 feet. The elevation on the southern boundary of Pickens County is about 900 feet above mean sea level.

Geology

Pickens County is underlain by rocks of the Inner Piedmont belt in the southern part, comprising about three-fourths of the total area, and rocks of the Brevard belt in the northern part, which is included in the Blue Ridge province. The Inner Piedmont belt includes such metamorphic rock types as mica, hornblende and granite gneiss, and other rocks of gabbroic nature. The Brevard belt includes such rocks as dark-gray and brown phyllite and schist, bluish marble, amphibolite, and hornblende gneiss, with some granite and augen gneiss (King, 1955, p. 337).

Pegmatite and diabase dikes cut across the various rock types. The dikes generally range in width from one-half foot to 25 feet. Owing to the high degree of disturbance which affected these rocks, their strike and dip are alined in many different directions. In general, however, their alinement is to the northeast-southwest across the county; their dip is generally to the southeast. The rocks range in age from Paleozoic to Precambrian(?).

In much of the county, the hard crystalline rock has weathered to a soft sandy or clayey material (called saprolite) that extends to an average depth of about 60 to 70 feet.

Figure 1 is a geologic map of Pickens County. A description of each rock type mapped is given in table 10.

Climate

Annual precipitation in Pickens County ranges from about 70 inches in the mountainous northwestern part to about 50 inches in the central and southern parts (U.S. Dept. of Commerce, 1966). At a climatological station near Pickens, precipitation was 51.58 inches in 1965 and 57.70 inches in 1966. Precipitation over the county is highest in March, July, August, and December; it is lowest in October and November. In general, precipitation is well distributed throughout the year. Droughts are uncommon.

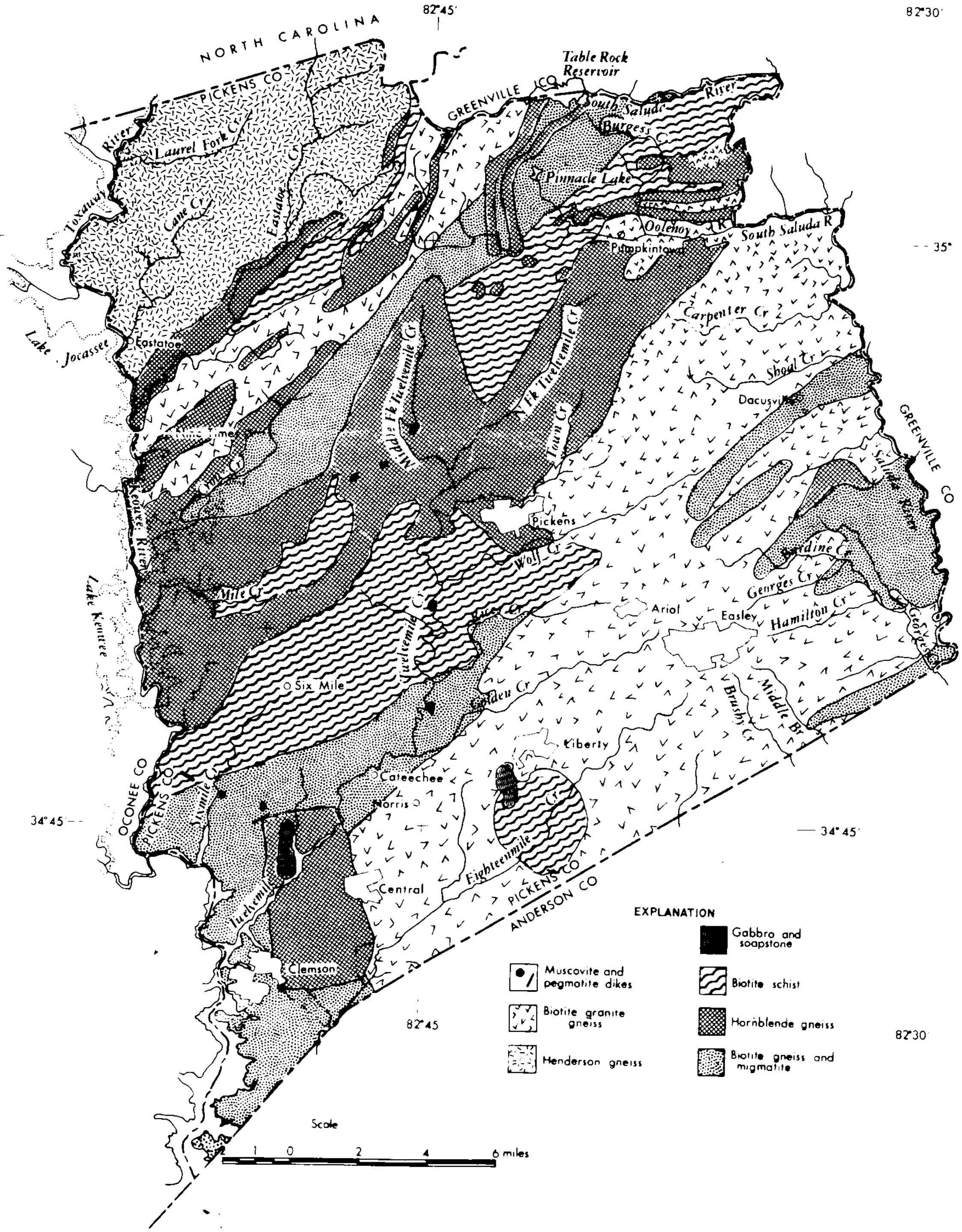


Figure 1. Geologic map of Pickens County (Adapted from Overstreet and Bell, 1965).

Average monthly air temperatures in the county, except at higher elevations in the mountains, range from 43.6°F in December to 79.0°F in July. The highest temperature recorded in 1966 at the climatological station near Pickens was 99°F on July 28; the lowest temperature was -1°F on January 30. In general, the climate of Pickens County is mild and well suited to most agricultural activities.

Population

The total population of Pickens County in 1960 was 46,030, an increase of 14.9 percent since 1950 (U.S. Dept. of Commerce, 1961) 1/. The urban population was 23.8 percent of the total and was concentrated near the southern border of the county, and in the town of Pickens in the center of the county. The major urban areas in order of population were: Easley, 8,282; Liberty, 2,657; Pickens, 2,198; Clemson, 1,577; and Central, 1,473.

Economic Development

Pickens County is predominantly rural; 39.5 percent of the area is used as farm land. The greater part of the mountainous north is woodland. In 1960, the total employed population was 18,313. Of this total, 53.4 percent were employed in manufacturing and 26.5 percent were employed in white-collar jobs (U.S. Dept. of Commerce, 1962). Industry has developed generally along the Southern Railway in Easley, Liberty, Norris, and Central, or in Pickens along the Pickens Railroad which connects Pickens and Easley. Textiles and allied products are the major industries. Recreation sites, including Table Rock State Park, are located in the mountainous north. The county has an extensive network of hard surfaced roads.

The Keowee-Toxaway project, now under construction by Duke Power Co., will supply additional power for economic development in a region comprising several states. The project will provide 750 thousand kilowatts of hydroelectric power and eventually 7 million kilowatts of steam-powered generation. The steam-electric station will be nuclear fueled. The extent of the area to be inundated by Lakes Keowee and Jocassee is outlined on plate 1.

1/ The population of Pickens County was increased about 4,000 in 1967 by the annexation of a part of Oconee County.

SURFACE WATER RESOURCES

Source and Occurrence

Streamflow in a region is dependent on many factors. Chief among these are precipitation, evaporation, transpiration, and the geologic characteristics of the land surface and underlying rocks. Also, streamflow may be regulated by the operation of reservoirs, or affected by agricultural practices that influence the rate of runoff. In the South Atlantic-Eastern Gulf region, average runoff is approximately 0.78 mgd per sq mi (million gallons per day per square mile) or about twice the average for the United States as a whole (Piper, 1965). Although average runoff varies from basin to basin within a region and varies locally from place to place, states in the southeastern United States have an abundance of surface water.

The principal streams draining Pickens County are the Keowee River, which forms the western boundary; the Saluda River, which forms the eastern border; and Twelvemile Creek, which drains the central part of the county. Other important streams are Estatoe Creek, a tributary of the Keowee River, and Oolenoy and South Saluda Rivers, tributaries of the Saluda River. Eighteenmile Creek flows southwest near the southern border of the county into Hartwell Reservoir in Anderson County. Gaging-station records and discharge measurements of these and other streams provide the basis for appraising the surface-water resources of Pickens County.

Available data

Long-term streamflow records have been obtained at three gaging stations in or bordering Pickens County. A gaging station on Keowee River near Jocassee has been in continuous operation since 1949. A gaging station on Twelvemile Creek near Liberty was operated from July 1954 to September 1964, and from May 1967 to the present. A gaging station on Saluda River near Greenville has been operated since 1941. A total of 192 discharge measurements of low flow have been made at 32 miscellaneous sites since 1945; 48 of the measurements were made at 26 sites during the field reconnaissance for this investigation. Table 1 gives the date of measurement, the discharge, and the drainage area appropriate to the site measured. Long-term streamflow records have been published in the annual basic-data reports of the U.S. Geological Survey and are not included in this report (see selected references). Records are published for each water year, which begins on October 1 and ends on September 30. Unless otherwise specified, citation of a year in this report refers to the water year.

Table 1. Low-flow discharge measurements at miscellaneous sites in Pickens County.

Site Number	Stream	Date	Discharge (cfs)
	SALUDA RIVER BASIN		
SW 1	Oolenoy River above Pumpkintown Drainage area: 14.4 sq mi	8/ 8/67	21.1
		10/16/67	20.6
SW 2	Oolenoy River near Pumpkintown Drainage area: 42.2 sq mi	10/ 8/67	49.4
		10/16/67	62.9
SW 3	South Saluda River at Freeman Bridge near Marietta	8/ 6/52	226
		9/ 9/52	130
		8/ 8/67	164
		10/16/67	217
SW 4	Carpenter Creek near Dacus-ville Drainage area: 7.55 sq mi	8/ 8/67	6.43
		10/16/67	9.06
SW 5	Saluda River at Hunts Bridge near Dacusville	8/ 8/67	261
		10/16/67	406
SW 6	Georges Creek near Easley Drainage area: 5.20 sq mi	8/ 5/52	4.64
		9/ 8/52	2.99
		8/ 8/67	1.75
		10/16/67	3.70
SW 7	Burdine Creek at State road 39-95 near Easley Drainage area: 4.60 sq mi	10/29/46	5.11
		8/ 8/67	.60
		10/16/65	.61
SW 8	Hamilton Creek near Easley Drainage area: 3.46 sq mi	5/20/59	10.2
		6/ 3/59	8.31
		6/11/59	5.62
SW 9	Georges Creek near Greenville Drainage area: 27.7 sq mi	5/20/59	59.7
		6/ 3/59	62.8
		6/11/59	37.6
		8/ 8/67	18.0
		10/17/67	20.2
	KEOWEE RIVER BASIN		
SW 10	Eastatoe Creek near Pickens Drainage area: 30.2 sq mi	1/27/67	113
		3/ 1/67	73.4
		3/ 1/67	73.7
		5/10/67	68.4
		6/21/67	77.7
		10/16/67	44.3
SW 11	Eastatoe Creek near Nine Times Drainage area: 46.3 sq mi	10/ 8/54	15.4
		9/16/59	84.1
		12/11/59	74.1
		9/ 2/60	94.4
		12/28/60	57.6
		9/19/61	99.2
		10/26/61	54.8
		4/25/62	167
		10/15/62	45.5
		4/22/63	72.1
		10/16/63	39.5
		5/18/65	116
		9/13/66	45.2
		8/ 8/67	69.4
		10/16/67	56.7
SW 12	Crow Creek near Pickens Drainage area: 2.77 sq mi	8/ 8/67	2.87
		10/16/67	2.59
SW 13	Sixmile Creek at Six Mile Drainage area: 4.26 sq mi	8/ 8/67	5.14
		10/17/67	4.42
	TWELVEMILE CREEK BASIN		
SW 14	Middle Fork Twelvemile Creek near Pickens Drainage area: 15.7 sq mi	8/ 8/67	16.7
		10/16/67	16.0
SW 15	North Fork Twelvemile Creek near Pickens Drainage area: 15.6 sq mi	8/ 8/67	11.2
		10/16/67	12.7
	TWELVEMILE CREEK BASIN--Continued		
SW 16	Twelvemile Creek at Pickens Drainage area: 34.8 sq mi	8/ 8/67	30.9
		8/ 8/67	31.8
		10/16/67	29.7
SW 17	Town Creek at Pickens Drainage area: 11.7 sq mi	10/29/46	12.4
		10/ 7/47	6.16
		10/26/48	7.04
		12/ 1/49	22.1
		12/ 1/50	10.0
		10/11/51	6.56
		8/31/54	4.16
		9/ 9/54	4.63
		11/ 3/55	5.74
		9/20/56	4.87
		8/ 8/67	9.72
		10/17/67	11.8
SW 18	Twelvemile Creek west of Pickens at State Highway 183 Drainage area: 52.7 sq mi	2/ 6/53	62.1
		2/18/53	108
SW 19	Wolf Creek at Pickens Drainage area: 9.28 sq mi	8/ 8/67	6.91
		10/17/67	6.89
SW 20	Wolf Creek near Pickens Drainage area: 15.4 sq mi	2/ 6/53	14.8
		2/18/53	29.7
		8/ 8/67	10.5
		10/17/67	9.31
SW 21	Twelvemile Creek near Pickens Drainage area: 78.6 sq mi	10/29/46	85.5
		10/26/48	57.4
		6/15/49	156
		12/ 1/49	142
		8/ 8/67	68.7
		10/17/67	66.3
SW 22	Rices Creek at Easley Drainage area: 4.79 sq mi	2/ 6/53	5.12
		2/18/53	8.70
		8/ 8/67	3.43
		10/17/67	3.11
SW 23	Rices Creek near Liberty Drainage area: 14.7 sq mi	8/ 5/54	7.42
		8/25/54	13.1
		9/ 9/54	3.88
		1/14/55	14.3
		4/ 8/55	25.4
		8/30/55	6.49
		12/27/55	8.08
		3/ 8/56	18.2
		6/26/56	9.61
		9/19/56	4.65
		12/12/56	10.8
		6/26/57	12.3
		8/ 8/57	5.59
		12/19/57	20.1
		3/20/58	30.0
		6/13/58	22.4
		9/16/58	13.7
		11/19/58	13.0
		2/19/59	20.4
		6/24/59	16.1
		11/ 3/59	19.0
		5/24/60	22.0
		12/18/60	15.7
		1/31/61	17.6
		6/ 7/61	17.4
		8/ 9/61	27.4
		11/22/61	13.6
		7/19/62	16.7
		12/12/62	15.2
		2/19/63	29.9
		9/10/63	12.0
		12/ 4/63	18.2
		2/ 3/64	22.8
		6/ 8/64	25.3
		8/ 8/67	12.6
		10/17/67	10.8

See note at end of table.

Table 1. Low-flow discharge measurements at miscellaneous sites in Pickens County -- continued.

Site Number	Stream	Date	Discharge (cfs)
	TWELVEMILE CREEK BASIN--Continued		
SW 24	Golden Creek at U.S. Hwy 178	11/21/45	6.14
	at Liberty	10/29/46	6.25
	Drainage area: 4.76 sq mi	10/26/48	3.91
SW 25	Golden Creek near Liberty	2/ 6/53	12.3
	Drainage area: 11.6 sq mi	3/ 4/53	51.0
		5/25/54	10.2
		8/ 5/54	3.94
		9/ 9/54	2.92
		1/14/55	9.84
		4/ 8/55	20.0
		8/29/55	2.47
		12/27/55	5.26
		3/ 8/56	11.2
		6/22/56	7.61
		9/19/56	2.38
		12/12/56	7.94
		6/26/56	9.70
		8/ 8/57	4.16
		12/17/57	14.1
		3/20/58	21.9
		6/13/58	15.4
		9/16/58	8.48
		11/19/58	9.52
		6/24/59	10.3
		11/ 3/59	12.0
		5/24/60	15.8
		12/18/60	10.7
		1/31/61	12.1
		6/ 7/61	14.5
		8/ 9/61	15.0
		11/22/61	9.86
		1/30/62	24.6
		4/27/62	25.1
		7/19/62	12.5
		12/19/62	11.7
		2/20/63	22.3
		6/18/63	14.2
		9/10/63	7.24
		12/ 4/63	12.4
		2/ 4/64	18.6
		6/ 8/64	17.2
		8/ 8/67	5.79
		10/17/67	6.51
	TWELVEMILE CREEK BASIN--Continued		
SW 26	Twelvemile Creek at State road	2/ 6/53	152
	39-15 near Central 1/	2/18/53	225
SW 27	Twelvemile Creek at State High-	11/ 8/55	81.7
	way 133 near Clemson 1/	11/18/55	39.2
		12/11/55	171
	SENECA RIVER BASIN		
SW 28	Seneca River at U.S. Highway	6/24/52	918
	123 at Clemson 1/	11/ 5/52	462
	Drainage area: 640 sq mi	6/ 3/53	756
		11/ 6/53	458
		9/ 1/54	284
		3/16/55	874
		11/ 2/55	338
	EIGHTEENMILE CREEK BASIN		
SW 29	Eighteenmile Creek at Liberty	11/21/45	7.58
	Drainage area: 9.73 sq mi	2/13/53	23.1
		3/ 3/53	24.7
		5/25/54	9.68
		9/17/54	4.71
		10/ 2/55	4.84
		9/19/56	2.54
SW 30	Eighteenmile Creek below	8/ 8/67	6.11
	Liberty	10/17/67	10.5
	Drainage area: 11.4 sq mi		
SW 31	Eighteenmile Creek near Liberty	11/18/55	4.25
	Drainage area: 12.8 sq mi	12/16/55	5.98
		10/ 6/59	10.9
		9/18/63	9.89
		10/15/63	7.92
		10/30/63	8.91
		3/11/64	24.3
SW 32	Eighteenmile Creek near Central	8/ 8/67	14.2
	Drainage area: 22.5 sq mi		

Note.-- 1/ Measured prior to filling of Hartwell Reservoir

Variation in streamflow

Average streamflow in Pickens County ranges from about 3.3 cfs per sq mi (cubic feet per second per square mile) in the mountainous region of the northwest to about 1.8 cfs per sq mi in the south-central section. Streamflow in the county also varies from year to year and season to season. Figure 2 illustrates the variations of monthly and yearly discharges for Keowee River near Jocassee. The maximum monthly mean discharge during 1966 was 1,075 cfs in February; the minimum monthly mean discharge was 205 cfs in July. The maximum yearly mean discharge during the 1951-66 period was 661 cfs in 1958; the minimum yearly mean discharge was 286 cfs in 1956.

Duration of flow at gaging stations

Flow-duration curves are used frequently in studies of streamflow variation. They are valuable in studies of water supply and waste disposal and as a means of comparing the flow characteristics of different streams. If streamflow during a period is typical of the long-term behavior of the stream, a flow-duration curve for that period indicates the probable long-term distribution of future streamflow.

Flow-duration data can be arranged to show (1) the percentage of time that selected discharges were equaled or exceeded, or (2) the discharge that was equaled or exceeded for selected percentages of time. With either arrangement, flow-duration curves can be plotted readily from the tabulated data. The second arrangement, however, is simpler in form and better suited for comparing different streams. Flow-duration curves for Keowee River near Jocassee and Twelvemile Creek near Liberty are shown in figure 3. Data used to prepare the curves are shown on the figure. The curve for Keowee River is based on data obtained from 1949 to 1966; the curve for Twelvemile Creek is based on data obtained from 1955 to 1964.

Regulation of streamflow

The natural flow of a stream may be altered significantly by the construction and operation of a reservoir. Storm runoff is collected by a flood-control reservoir and released to a stream at a lower rate. If the reservoir is used for hydroelectric power, discharge from the reservoir may change several times a day according to power needs. Generally, the construction of a reservoir on a stream lowers high flows downstream, and increases minimum flows. The flow of a regulated stream varies greatly from the flow of an unregulated stream. Thus, the flow pattern for a regulated stream can not be used to determine the pattern of natural flow for an unregulated stream. Data on highly-regulated streams, therefore, are not presented in this report.

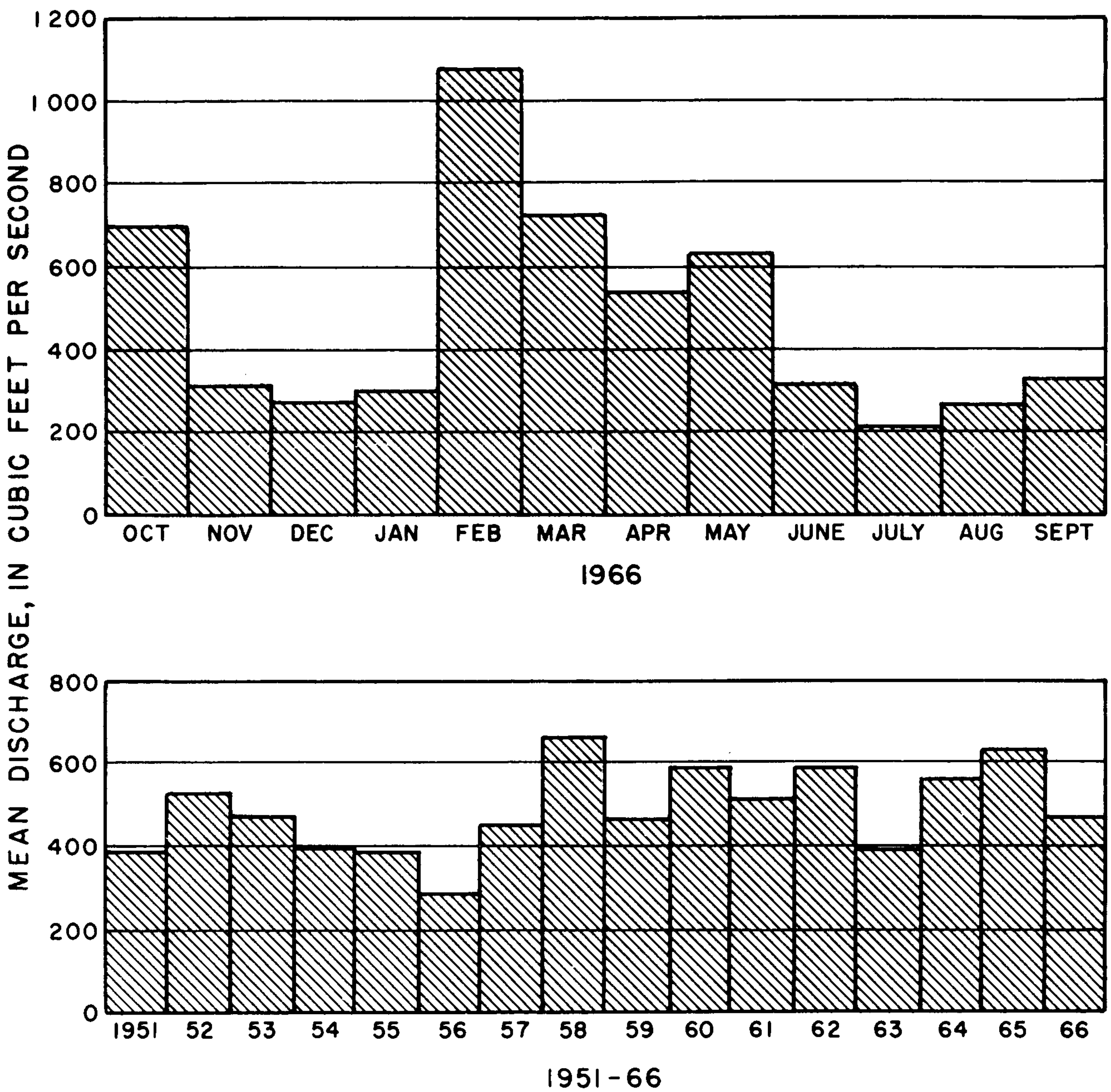
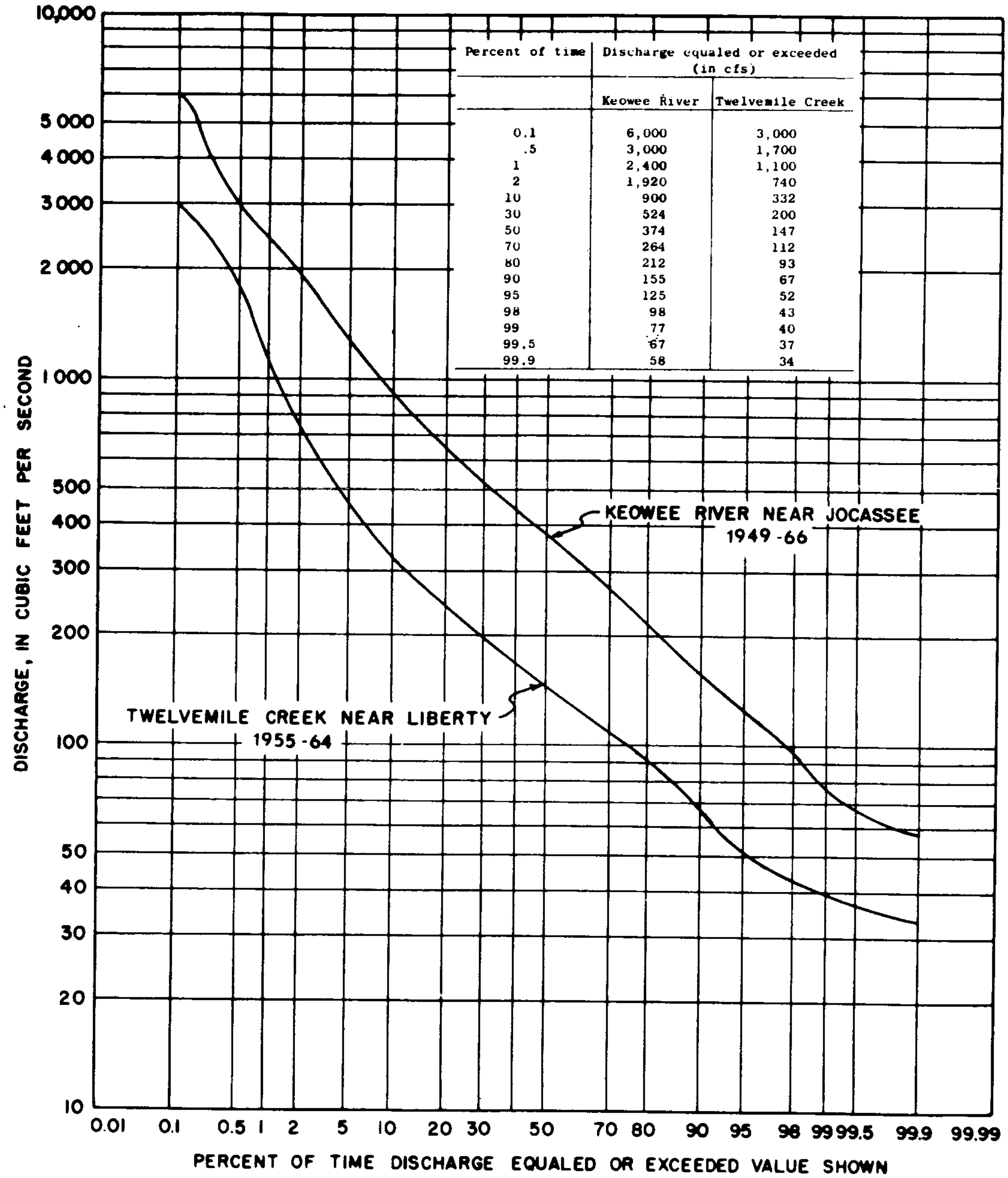


Figure 2. Monthly-mean discharges for 1966 and yearly mean discharges for 1951-66 at Keowee River near Jocassee.



Percent of time	Discharge equaled or exceeded (in cfs)	
	Keowee River	Twelvemile Creek
0.1	6,000	3,000
.5	3,000	1,700
1	2,400	1,100
2	1,920	740
10	900	332
30	524	200
50	374	147
70	264	112
80	212	93
90	155	67
95	125	52
98	98	43
99	77	40
99.5	67	37
99.9	58	34

Figure 3. Flowduration curves, Keowee River near Jocassee and Twelvemile Creek near Liberty.

Minimum flows of record

The minimum flows of record in Pickens County occurred during the drought of 1954. The drought was not limited to Pickens and surrounding counties, but was regional in extent -- affecting the adjacent states of Georgia and North Carolina as well as South Carolina. The frequency of drought conditions comparable to those of 1954 can not be determined from the data available; however, on a statewide basis, streamflow was lower than at any other time during the 1929-67 period (Stallings, 1968). The lowest flows of record at gaging stations on Keowee River near Jocassee and Twelvemile Creek near Liberty are given in table 2.

Frequency of annual-minimum flows at gaging stations

A knowledge of the magnitude and frequency of annual minimum flows is essential in planning the future use of a stream. Annual minimum flows are computed as the lowest average flow each year for selected durations ranging from 1 day to 274 consecutive days. Recurrence intervals of annual minimum flows can be computed by the following formula:

$$RI = \frac{n + 1}{m}$$

where RI is the recurrence interval, in years; n is the number of years of record; and m is an order number determined by the magnitude of the annual minimum flow. For each selected duration, annual minimum average flows for all years of record are arrayed and numbered in order of magnitude, beginning with the lowest as order number 1.

Figure 4 shows the recurrence intervals for the annual 7-day minimum flows at Twelvemile Creek near Liberty. It shows, for example, that every five years there probably will occur at least one period of seven consecutive days having an average discharge of no more than 38 cfs, or about one-fifth the long-term average discharge (table 2).

Table 2 gives the lowest 7-day flow of record, the 10-year, 7-day low flow, the 2-year, 7-day low flow, and the average flow for the period of record at the gaging stations. Projections of low flow may be extended to greater recurrence intervals if longer periods of record are used as a basis. Data given in table 2 are based on the 1949-67 period, which corresponds to the period of record at Keowee River near Jocassee. Data for Twelvemile Creek near Liberty have been estimated for the periods 1949-53 and 1965-66 in order that both streams could be compared over the same time span.

Table 2.--Low flow of Keowee River River near Jocassee and Twelvemile Creek near Liberty, 1949-67.

Station		2-1850. Keowee River near Jocassee
Location		Lat 34°57'21", long 82°54'41", on right bank 0.6 mile downstream from bridge on State Highway 11, 1.8 miles southeast of Jocassee, Oconee County, and 2.6 miles upstream from Eastatoe Creek.
Drainage Area (sq mi)		148
Period of Record		1949-67
Lowest 7-Day Flow of Record[1/]	cfs	58.4
	cfs per sq mi	0.39
7-Day 10-Year Low Flow	cfs	79
	cfs per sq mi	0.53
7-Day 2-Year Low Flow	cfs	141
	cfs per sq mi	0.95
Average Flow	cfs	485
	cfs per sq mi	3.28

Station		2-1860. Twelvemile Creek near Liberty
Location		Lat 34°48'05", long 82°44'55", on left bank 40 ft downstream from bridge on State road 39-137, 0.8 mile downstream from Rices Creek, and 3.4 miles west of Liberty, Pickens County.
Drainage Area (sq mi)		106
Period of Record		1954-64, 1967
Lowest 7-Day Flow of Record[1/]	cfs	33.9
	cfs per sq mi	0.32
7-Day 10-Year Low Flow	cfs	31
	cfs per sq mi	0.29
7-Day 2-Year Low Flow	cfs	62
	cfs per sq mi	0.58
Average Flow	cfs	197
	cfs per sq mi	1.86

1/ Occurred in 1954.

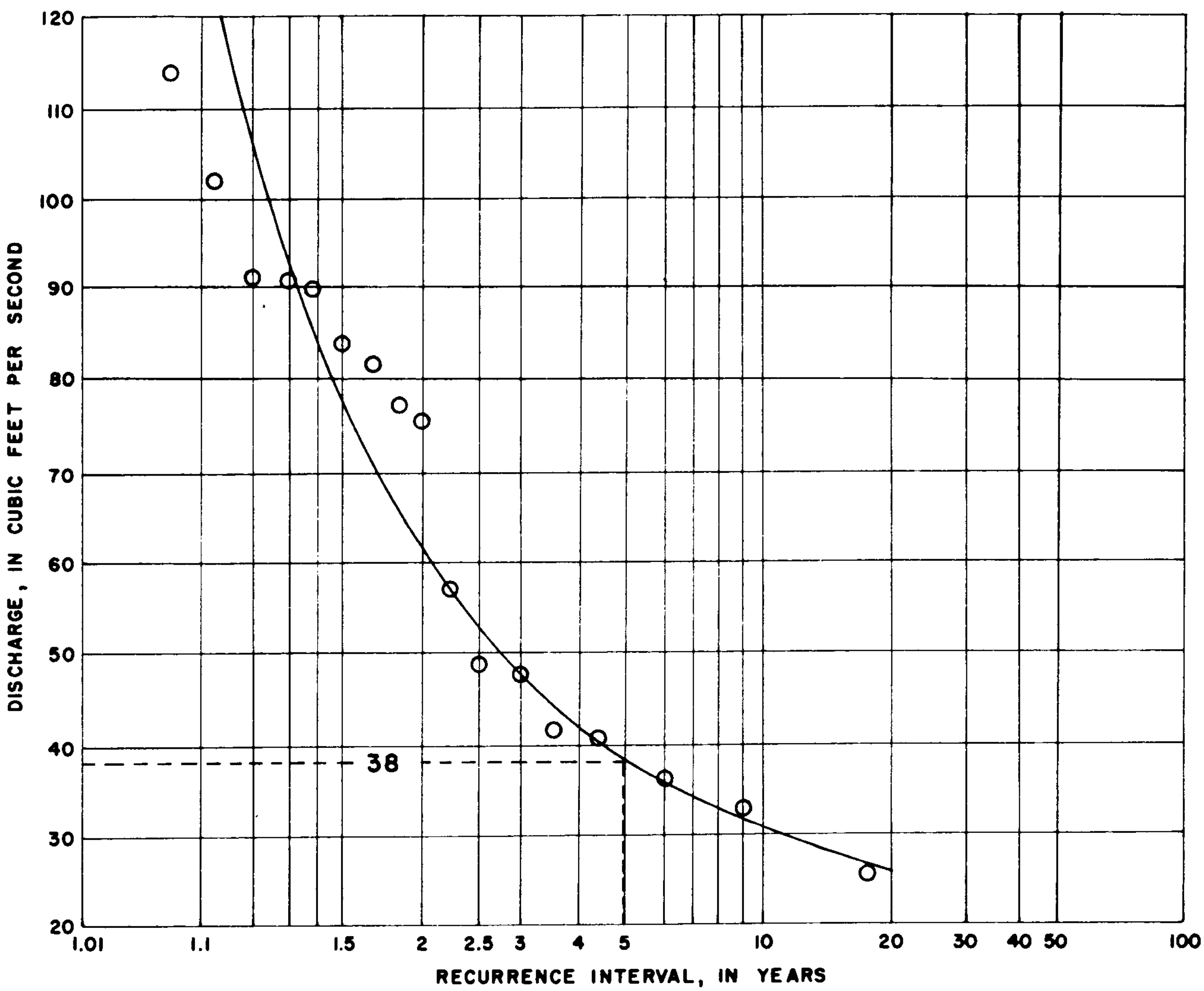


Figure 1. Frequency of annual 7-day minimum flows, Twelvemile Creek near Liberty

The 2-year, 7-day low flows are used in water-pollution studies and for delineating areal variation in base flow 1/ characteristics of streams. A flow with a recurrence interval of 2 years is a median flow unaffected by extreme values, and thus is a good index of normal conditions. Figure 5 shows the areal variation of median, 7-day low flow in Pickens County.

Estimation of flows at miscellaneous sites

When information on low-flow frequency for a miscellaneous site is needed, it must be estimated. The simplest method is to correlate measured flow at the miscellaneous site with that at a gaging station (index station) in the same or an adjacent drainage basin. The correlation is made by plotting the discharge measured on a given day at the miscellaneous site against the daily mean discharge for the same day at the index station. A graphic correlation of a gaged and a miscellaneous site is shown in figure 6. Using data found in table 1 and in table 3, which gives selected daily mean discharges at three index stations, Rices Creek near Liberty (miscellaneous site) has been correlated with Twelvemile Creek near Liberty. To estimate, for example, the annual 10-year, 7-day minimum flow for Rices Creek near Liberty, corresponding data for Twelvemile Creek near Liberty are selected from table 4, which gives the discharge for several periods of consecutive days for 2-, 5-, and 10-year recurrence intervals. The 10-year, 7-day minimum flow for Twelvemile Creek is 31 cfs. By using the curve of figure 6, a corresponding 10-year, 7-day minimum flow of 3.9 cfs can be estimated for Rices Creek near Liberty.

The correlation curve in figure 6 is a straight line with a slope of about 1:1. This is true of the correlation between Twelvemile Creek and Keowee River (figure 7), and also true of most of the correlations between index stations and miscellaneous sites in this section of the Piedmont province. Because this indicates homogeneous low-flow behavior of streams in Pickens County, a 1:1 flow relationship with an index station may be assumed when very little data on a miscellaneous site are available, as illustrated in figure 8.

Using the procedures outlined, estimates for 10-year, 7-day low flow, 2-year, 7-day low flow, and average flow have been made for miscellaneous sites. These values are given in table 5. Burdine Creek near Easley, because of withdrawals, is not listed in table 5.

1/ Base flow is streamflow that contains no direct runoff, or none that enters a stream promptly after rainfall.

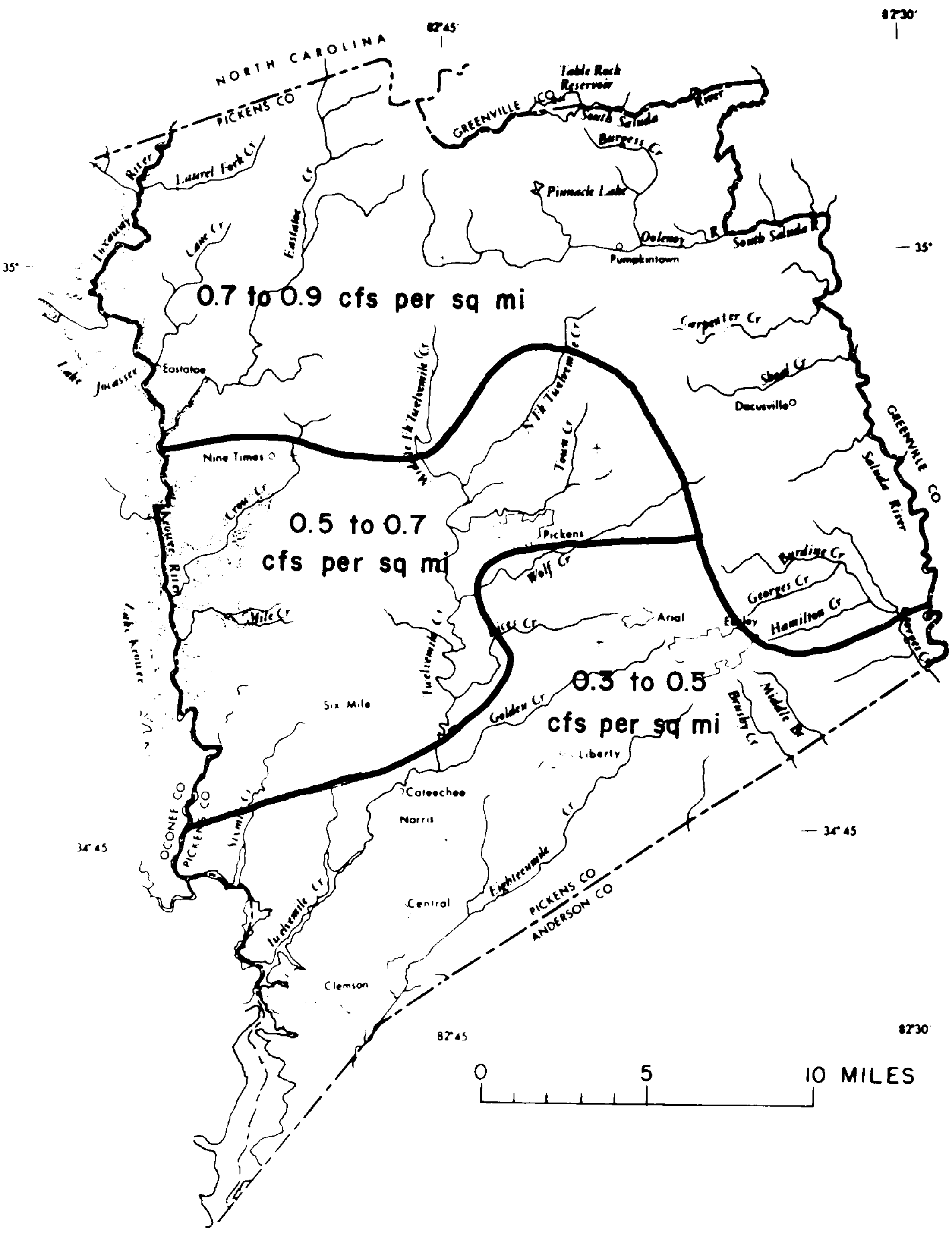


Figure 5. Areal variation in median, 7-day low flow.

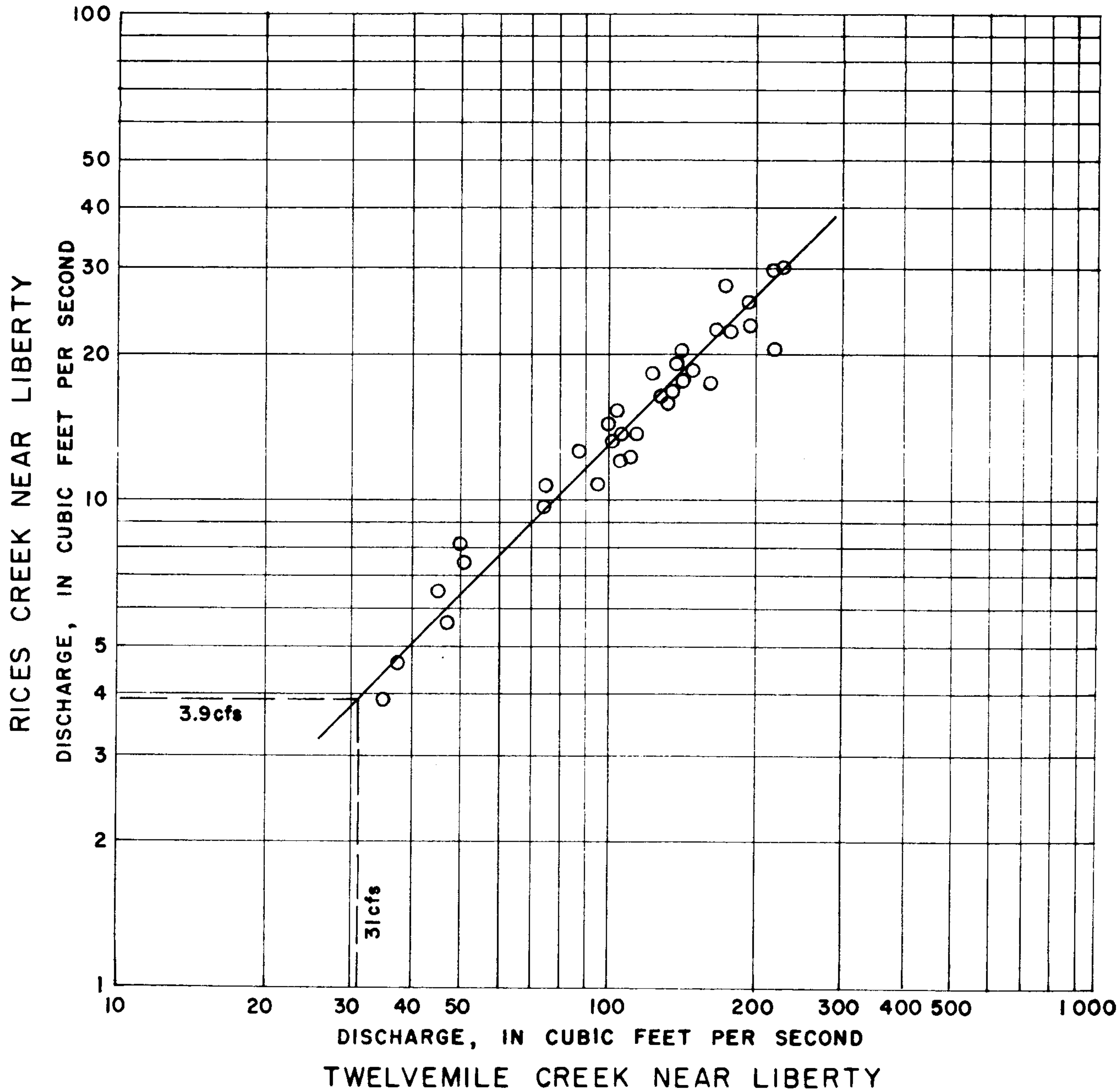


Figure 6. Discharge correlation, Rices Creek near Liberty and Twelvemile Creek near Liberty.

Table 3.--Selected mean-daily discharges at index stations in Pickens County, S. C.

2-1850. Keowee River near Jocassee

Date	Discharge (cfs)
10/ 8/54	58
9/16/59	333
12/11/59	339
9/ 2/60	350
12/28/60	211
9/19/61	473
10/26/61	215
4/25/62	680
10/15/62	238
4/22/63	297
10/16/63	145
5/18/65	387
1/27/67	580
3/ 1/67	362
5/10/67	381
6/21/67	395
8/ 8/67	278
10/16/67	255

2-1860. Twelvemile Creek near Liberty[1]

Date	Discharge (cfs)
6/24/52	100
8/ 5/52	168
9/ 8/52	73
11/ 5/52	47
2/ 6/53	163
2/13/53	270
2/18/53	225
3/ 3/53	320
6/ 3/53	94
11/ 6/53	51
5/25/54	115
8/ 5/54	51
8/31/54	45
9/ 1/54	42
9/ 9/54	35
9/17/54	39
1/14/55	100
3/16/55	114
4/ 8/55	193
8/29/55	44
8/30/55	45
10/ 2/55	72
11/ 2/55	57
11/ 3/55	47
11/18/55	52
12/16/55	55
12/27/55	50
3/ 8/56	124
6/22/56	74
9/19/56	37
9/20/56	37

2-1860. Twelvemile Creek near Liberty--Continued

Date	Discharge (cfs)
12/12/56	74
6/26/57	111
8/ 8/57	47
12/17/57	143
12/19/57	141
3/20/58	228
6/13/58	166
9/16/58	107
11/19/58	102
2/19/59	218
5/20/59	183
6/ 3/59	406
6/11/59	168
6/24/59	128
10/ 6/59	83
11/ 3/59	139
5/24/60	178
12/18/60	132
1/31/61	143
6/ 7/61	161
8/ 9/61	173
11/22/61	114
1/30/62	260
4/27/62	266
7/19/62	134
12/12/62	103
12/19/62	99
2/19/63	218
2/20/63	228
6/18/63	149
9/10/63	106
9/18/63	108
10/15/63	100
10/30/63	83
12/ 4/63	149
2/ 3/64	194
2/ 4/64	186
3/11/64	222
6/ 8/64	192
8/ 8/67	87
10/16/67	94
10/17/67	95

2-1870. Seneca River near Anderson (Prior to filling of Hartwell Reservoir)

Date	Discharge (cfs)
6/24/52	1,170
11/ 5/52	623
6/ 3/53	1,060
11/ 6/53	708
9/ 1/54	445
3/16/55	1,330
11/ 2/55	492

1/ Discharges for Twelvemile Creek near Liberty from June 1952 to May 1954 are estimates.

Table 4.--Selected annual minimum flows for Keowee River near Jocassee and Twelvemile Creek near Liberty, S. C.

2-1850. Keowee River near Jocassee

Consecutive Days Duration	Discharge, in cfs, for Indicated Recurrence Interval, in years		
	2	5	10
7	141	97	79
30	170	112	89
60	194	127	101
120	239	158	127
274	378	280	280

2-1860. Twelvemile Creek near Liberty

Consecutive Days Duration	Discharge, in cfs, for Indicated Recurrence Interval, in years		
	2	5	10
7	62	38	31
30	71	43	34
60	80	48	36
120	96	60	47
274	143	101	84

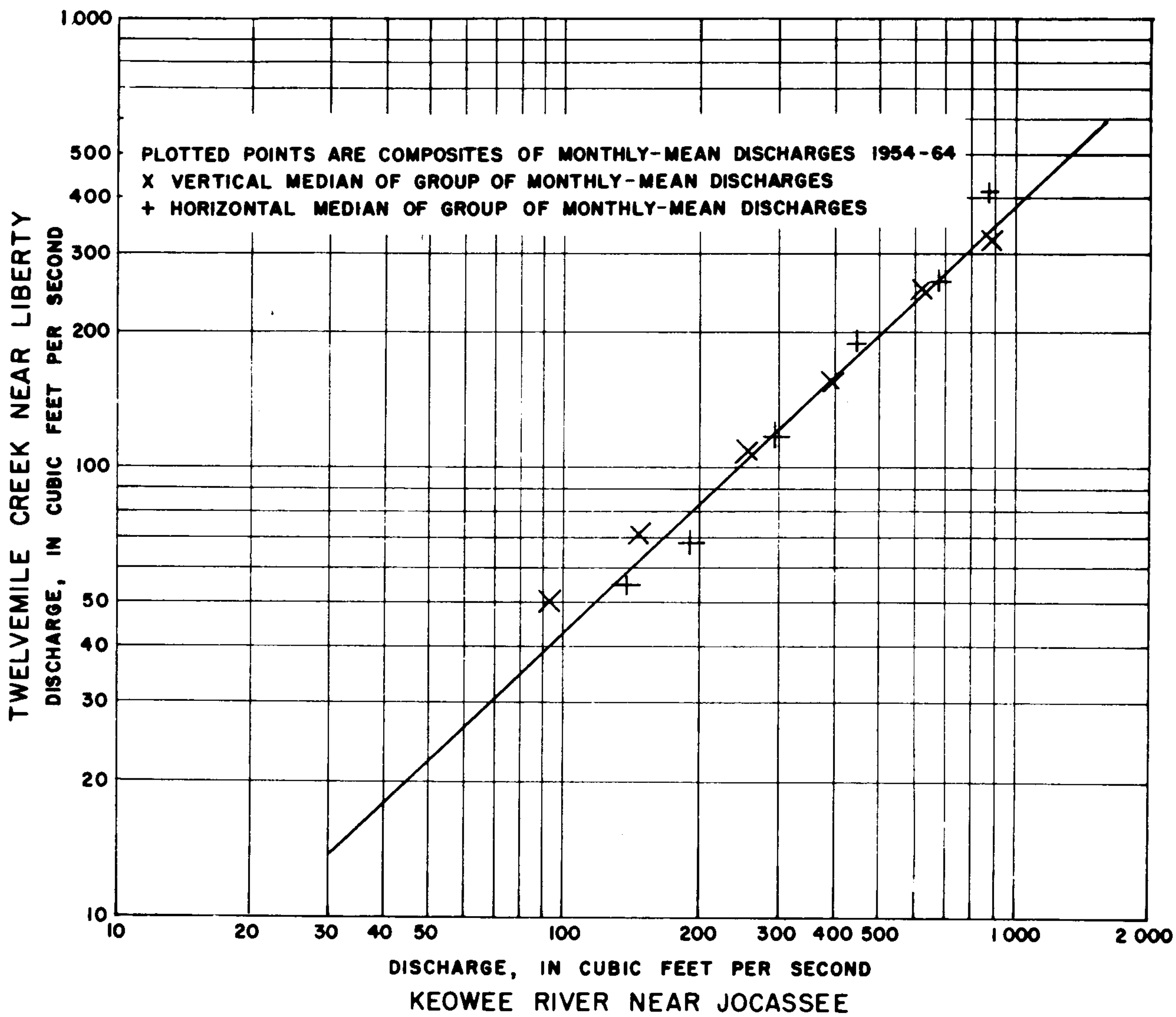


Figure 7. Correlation of monthly mean discharges, Twelvemile Creek near Liberty and Keowee River near Jocassee.

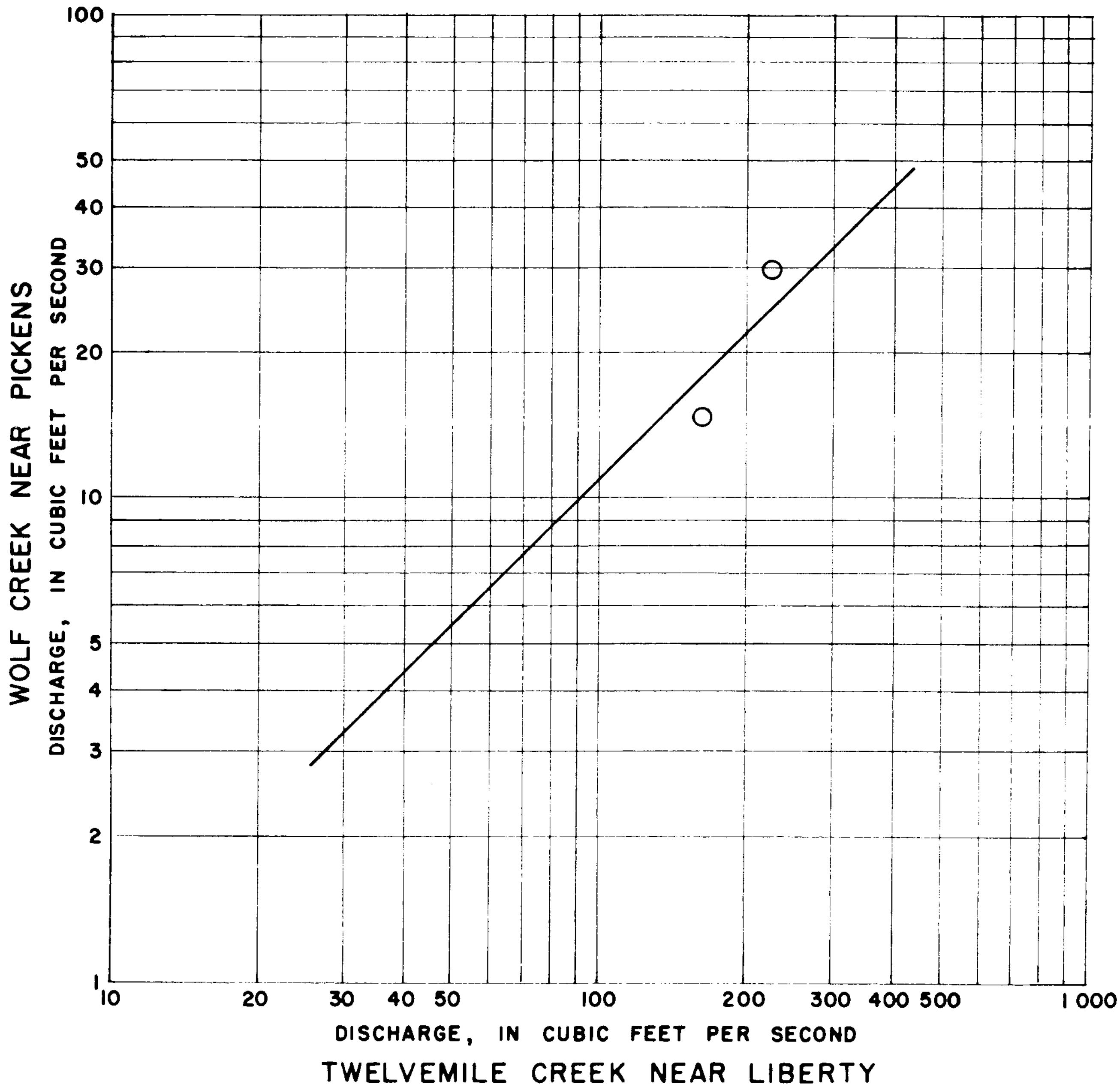


Figure 8. Assumed discharge correlation, Wolf Creek near Pickens and Twelvemile Creek near Liberty.

Table 5. Low flows at miscellaneous sites in Pickens County -- continued.

Site Number	Stream	Estimated 7-Day 10-Year Low Flow		Estimated 7-Day 2-Year Low Flow 1949-1967		Estimated Average Flow 1949-1967	
		cfs	cfs/sq mi	cfs	cfs/sq mi	cfs	cfs/sq mi
	TWELVEMILE CREEK BASIN--Continued						
SW 20	Wolf Creek near Pickens Lat 34°51'40", long 82°43'30", at bridge on State road 39-138, 1.8 miles southwest of Pickens.	3.4	0.22	6.7	0.44	22	1.43
SW 21	Twelvemile Creek near Pickens Lat 34°50'35", long 82°44'45", at bridge on State road 39-267, 0.8 mile below Wolf Creek.	23	.29	46	.59	150	1.91
SW 22	Rices Creek at Easley Lat 34°50'50", long 82°39'15", at bridge on State Highway 8 at Easley.	1.1	.22	2.2	.44	7.1	1.43
SW 23	Rices Creek near Liberty Lat 34°49'05", long 82°43'45", at bridge on State road 39-222, 1.1 miles above mouth and 3 miles northwest of Liberty.	3.9	.27	7.8	.53	25	1.70
SW 25	Golden Creek near Liberty Lat 34°48'00", long 82°43'30", at bridge on State road 39-158, 2 miles northwest of Liberty.	2.4	.21	5.2	.45	18	1.55
	EIGHTEENMILE CREEK BASIN						
SW 29	Eighteenmile Creek at Liberty Lat 34°46'30", long 82°40'10", at bridge on U.S. Highway 178, at Liberty.	2.2	.23	4.4	.45	15	1.54
SW 30	Eighteenmile Creek below Liberty Lat 34°46'00", long 82°40'25", at bridge on State road 39-64, 1.9 miles southeast of Liberty.	2.7	.24	5.5	.48	17	1.49
SW 31	Eighteenmile Creek near Liberty Lat 34°45'20", long 82°41'00", at bridge on State road 39-43, 2.2 miles south of Liberty.	2.8	.22	6.0	.47	23	1.80
SW 32	Eighteenmile Creek near Central Lat 34°43'00", long 82°44'10", at bridge on State road 39-44, 2.6 miles east of Central.	5.0	.22	10	.44	32	1.42

Table 5. Low flows at miscellaneous sites in Pickens County.

Site Number	Stream	Estimated 7-Day 10-Year Low Flow		Estimated 7-Day 2-Year Low Flow 1949-1967		Estimated Average Flow 1949-1967	
		cfs	cfs/sq mi	cfs	cfs/sq mi	cfs	cfs/sq mi
	SALUDA RIVER BASIN						
SW 1	Oolenoy River above Pumpkintown Lat 34°59'45", long 82°42'45", at bridge on State road 39-48, 3.4 miles west of Pumpkintown.	7.1	0.49	14	0.97	45	3.12
SW 2	Oolenoy River near Pumpkintown Lat 35°00'10", long 82°37'20", at bridge on State road 39-47, 1.8 miles east of Pumpkintown.	19	.45	39	.92	120	2.84
SW 4	Carpenter Creek near Dacusville Lat 34°57'50", long 82°34'25", at bridge on State road 39-71, 2.3 miles north of Dacusville.	2.7	.36	5.3	.70	17	2.25
SW 6	Georges Creek near Easley Lat 34°51'10", long 82°33'50", at bridge on State road 39-192, 1.4 miles northeast of Easley and 2 miles above Burdine Creek.	.9	.17	1.8	.35	5.5	1.06
SW 8	Hamilton Creek near Easley Lat 34°50'50", long 82°31'40", at bridge on State road, 0.6 mile above mouth and 4.6 miles east of Easley.	1.3	.38	2.7	[illegible]	[illegible]	2.42
SW 9	Georges Creek near Greenville Lat 34°50'00", long 82°29'50", at bridge on U.S. Highway 123A, 0.5 mile below Little Georges Creek and 5.6 miles west of Greenville.	5.4	.19	12	.43	46	1.66
	KEOWEE RIVER BASIN						
SW 10	Eastatoe Creek near Pickens Lat 34°57'28", long 82°51'11", at bridge on State road 39-143, 1.1 miles above Little Eastatoe Creek, and 10.5 miles northwest of Pickens.	12	.40	23	.76	91	3.01
SW 11	Eastatoe Creek near Nine Times Lat 34°56'55", long 82°53'00", at bridge on State road 39-196, 1.8 miles below Little Eastatoe Creek, and 3 miles northwest of Nine Times.	20	.43	36	.78	120	2.59
SW 12	Crow Creek near Pickens Lat 34°55'10", long 82°49'50", at bridge on State road 39-49, at Nine Times.	.8	.29	1.4	.51	4.8	1.73
SW 13	Sixmile Creek at Six Mile Lat 34°48'05", long 82°50'40", at bridge on State road 39-291, at Six Mile.	1.4	.33	2.6	.61	8.7	2.04
	TWELVEMILE CREEK BASIN						
SW 14	Middle Fork Twelvemile Creek near Pickens Lat 34°54'45", long 82°45'40", at bridge on State road 39-33, 3.5 miles northwest of Pickens.	5.6	.28	11	.70	36	2.29
SW 15	North Fork Twelvemile Creek near Pickens Lat 34°54'15", long 82°44'10", at bridge on State road 39-272, 2.3 miles northwest of Pickens.	4.1	.26	8.2	.53	26	1.67
SW 16	Twelvemile Creek at Pickens Lat 34°54'00", long 82°44'20", at bridge on State road 39-174, at Pickens.	11	.32	22	.63	69	1.98
SW 17	Town Creek at Pickens Lat 34°53'30", long 82°41'50", at bridge on State Highway 8, at Pickens.	4.1	.35	7.4	.63	19	1.62
SW 19	Wolf Creek at Pickens Lat 34°52'35", long 82°40'50", at bridge on State road 39-90, at Pickens.	2.4	.26	4.7	.51	15	1.62

Storage requirements for reservoirs

The feasibility of constructing a water-supply reservoir on a stream depends ultimately on the low-flow characteristics of a stream -- frequency, duration and magnitude. Based on data given in table 4, within year storage requirements for various draft rates have been computed and are listed in table 6. These storage-draft rates correspond to minimum flows having recurrence intervals of 5 and 10 years. Because of insufficient data at miscellaneous sites, data in table 6 should be considered only as estimates showing the broad capabilities of Pickens County streams.

Figure 9 shows storage requirements for streams in the three areas of Pickens County outlined in figure 5. Storage requirements for any site not listed in table 6 may be estimated by determining the drainage area, and converting the desired draft rate in cfs to cfs per sq mi.

Quality of Surface Water

The chemical characteristics of surface water are affected by geology, soils, topography, precipitation, vegetation, evaporation, transpiration, and many other factors. Soils and geologic strata exposed at the earth's surface provide the principal source of minerals subjected to the solvent action of water. Topography affects the rate of surface runoff and thus the length of time water is in contact with the earth's surface. A long period of contact usually results in the solution of more mineral matter. Precipitation largely determines the amount of runoff, and therefore the amount of water available for solution processes. Vegetation promotes percolation of rainfall into soils where chemical reaction may occur. Decaying vegetation is a source of some of the organic and inorganic substances in water. Evaporation from water surfaces tends to concentrate the water solution. Transpiration, the process by which water vapor escapes from plants to the atmosphere, may significantly reduce the total amount of water, and thus have effects similar to those of evaporation. In addition to these factors, carbon dioxide dissolved from the atmosphere and soils is important. Carbon dioxide reacts with water to form a weak acid which enhances the ability of water to dissolve minerals and effectively stabilizes the form of some of the dissolved components.

The effect of man's activity on the chemical characteristics of natural water has become increasingly important. Natural water quality is altered frequently by waste discharges and physical changes within a basin. Physical changes in a basin may either improve or adversely affect water quality; but waste discharges, unless treated, usually cause unwanted changes.

Table 6. Estimated draft-storage relations at stream sites in Pickens County.

Number	Name	Drainage Area (square miles)	Recurrence Interval (years)	Allowable draft, in cubic feet per second, for indicated storage in acre-feet per square mile				
				acre-feet per square mile				
				10	25	50	75	100
				cubic feet per second				
2-1860.	Twelvemile Creek near Liberty	106	5	56	67	81	92	102
			10	45	57	71	80	86
SW 1	Oolenoy River above Pumpkintown	14.4	5	13	15	19	21	23
			10	10	13	16	18	20
SW 2	Oolenoy River near Pumpkintown	42.2	5	35	41	50	57	63
			10	27	35	44	49	53
SW 4	Carpenter Creek near Dacusville	7.55	5	5.0	5.9	7.1	8.2	9.0
			10	3.9	5.1	6.3	7.0	7.6
SW 6	Georges Creek near Easley	5.20	5	1.6	1.9	2.3	2.7	3.0
			10	1.3	1.7	2.1	2.3	2.5
SW 8	Hamilton Creek near Easley	3.46	5	2.4	2.9	3.5	3.9	4.4
			10	1.9	2.5	3.0	3.4	3.7
SW 9	Georges Creek near Greenville	27.7	5	9.7	12	14	16	17
			10	7.8	9.4	12	14	15
SW 10	Eastatoe Creek near Pickens	30.2	5	19	22	26	29	31
			10	17	20	22	24	25
SW 11	Eastatoe Creek near Nine Times	46.3	5	31	37	43	48	51
			10	28	32	37	40	41
SW 12	Crow Creek near Pickens	2.77	5	1.3	1.5	1.7	1.9	2.1
			10	1.1	1.3	1.5	1.6	1.7
SW 13	Sixmile Creek at Six Mile	4.26	5	2.2	2.6	3.0	3.4	3.6
			10	2.0	2.3	2.6	2.8	2.9
SW 14	Middle Fork Twelvemile Creek near Pickens	15.7	5	8.0	9.6	12	13	15
			10	6.4	8.2	10	11	12
SW 15	North Fork Twelvemile Creek near Pickens	15.6	5	7.5	8.9	11	12	13
			10	5.9	7.6	9.4	11	11
SW 16	Twelvemile Creek at Pickens	34.8	5	20	24	29	33	37
			10	16	21	26	29	31
SW 17	Town Creek at Pickens	11.7	5	7.5	8.9	11	12	14
			10	6.0	6.9	9.5	11	11
SW 19	Wolf Creek at Pickens	9.28	5	4.5	5.3	6.3	7.2	8.0
			10	3.5	4.5	5.6	6.3	6.8
SW 20	Wolf Creek near Pickens	15.4	5	6.2	7.4	8.9	10	11
			10	4.9	6.3	7.9	8.8	9.5
SW 21	Twelvemile Creek near Pickens	78.6	5	42	50	60	68	75
			10	33	42	53	59	64
SW 22	Rices Creek at Easley	4.79	5	1.9	2.3	2.8	3.2	3.5
			10	1.5	2.0	2.4	2.7	3.0
SW 23	Rices Creek near Liberty	14.7	5	7.2	8.7	10	12	13
			10	5.7	7.4	9.1	10	11
SW 25	Golden Creek near Liberty	11.6	5	4.4	5.2	6.4	7.3	8.0
			10	3.5	4.5	5.6	6.3	6.7
SW 29	Eighteenmile Creek at Liberty	9.73	5	4.1	4.9	5.8	6.7	7.4
			10	3.2	4.2	5.2	5.7	6.2
SW 30	Eighteenmile Creek below Liberty	11.4	5	5.0	5.9	7.2	8.2	9.1
			10	4.0	5.1	6.4	7.1	7.6
SW 31	Eighteenmile Creek near Liberty	12.8	5	5.1	6.1	7.4	8.4	9.3
			10	4.1	5.2	6.5	7.3	7.9
SW 32	Eighteenmile Creek near Central	22.5	5	9.0	11	13	15	16
			10	7.2	9.2	11	13	14

Note.--1 cfs = 0.646 mgd.

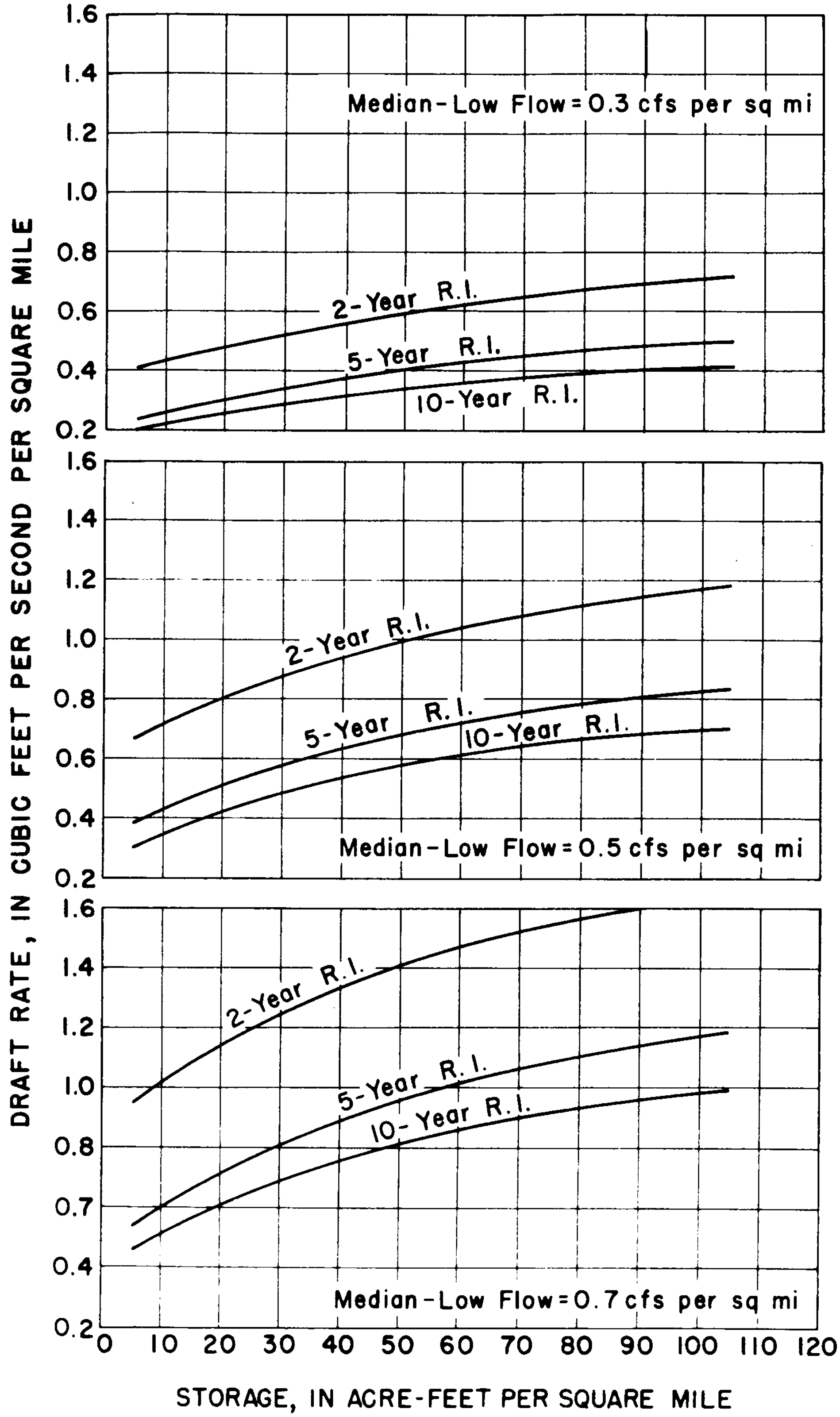


Figure 9. Areal draft-storage curves for 2-, 5-, and 10-year recurrence intervals for streams in Pickens County.

Water-quality criteria

The suitability of water for use depends largely on the chemical characteristics of water. Generally the higher the dissolved-mineral content, the less suitable water will be for most uses. The water-quality requirements of municipal, domestic, industrial, and agricultural users vary widely, and water suitable for one user may not be suitable for another.

Water for municipal or domestic use is commonly evaluated using criteria of the U.S. Public Health Service (1962), which established limits for dissolved substances in water used for drinking and culinary purposes on interstate commerce carriers. Some of the maximum concentration limits are: dissolved-solids content, 500 mg/l (milligrams per liter 1/); sulfate, 250 mg/l; chloride, 250 mg/l; nitrate, 45 mg/l; and iron, 0.3 mg/l. Although standards for hardness (a measure of the ability of water to consume soap) have not been set, the following arbitrary classification is frequently used: 60 mg/l or less, soft; 61-120 mg/l, moderately hard; 121-180 mg/l, hard; and 181 mg/l or more, very hard.

Because industrial water-quality requirements are closely related to the specific use, evaluation of the suitability of water for industrial use can be made only if the intended use is known. Reports by Moore (1940) and by the California State Water Quality Control Board (1963) contain information on industrial water-quality requirements and may be consulted for criteria applicable to a specific use. Water that has a low dissolved-solids content and a low hardness, and does not vary greatly in quality or temperature, meets the requirements of many industries.

Collection of data

Data on the chemical characteristics of water were obtained at 27 sites in Pickens County during August and October 1967. Field measurements of specific conductance, pH, dissolved oxygen and temperature were made at the time flow measurements were made. Samples were collected in October at 12 sites for complete analysis in the laboratory. These data, used in conjunction with data collected in prior years, provide the basis for appraisal of the chemical characteristics of water in Pickens County.

1/ One milligram per liter is equivalent to one pound in 120,000 gallons. In waters having a total dissolved-solids content of less than about 7,000 milligrams per liter, one milligram per liter is equivalent to one part per million.

Measurements of specific conductance

Specific conductance is a measure of the ability of water to conduct an electrical current and is related to the dissolved-solids content of water and to the type of ions in solution. It is expressed in micromhos per centimeter at 25°C (for brevity in this report expressed as "micromhos"). For most natural waters, the ratio of dissolved-solids content (in mg/l) to specific conductance (in micromhos) is in the range 0.5 to 0.8. Specific conductance is thus a good indicator of dissolved-solids content and for some waters, it can be correlated with the concentration of individual ions in solution. Measurements of specific conductance were made on water at each site using field instruments, and on water samples in the laboratory prior to their analysis.

Figure 10 shows the relation between dissolved-solids content and specific conductance for surface water in Pickens County. The figure was prepared using data obtained during this investigation. The equation of the line is: Dissolved-solids content (in mg/l) = 8.8 + /0.56 x specific conductance (in micromhos)/. The relation is applicable to all stream sites in Pickens County except Eighteenmile Creek below Liberty and thus may be used to estimate dissolved-solids content from most measurements of specific conductance made during this reconnaissance. Table 7 lists field measurements of specific conductance, pH, dissolved oxygen, and temperature at 27 sites.

Specific conductance ranged from 16 micromhos for Keowee River near Jocassee to 210 micromhos for Eighteenmile Creek below Liberty. Five of the 42 measurements of specific conductance given in table 7 exceeded 50 micromhos. Water having a specific conductance greater than 50 micromhos occurred in Georges Creek, Golden Creek, and Eighteenmile Creek, each of which receives either municipal or industrial waste discharges. Other field measurements given in table 7 show that the pH of the water ranged from 5.9 to 8.0; dissolved oxygen ranged from 7 to 10 mg/l. The lowest dissolved oxygen concentration occurred in Eighteenmile Creek below Liberty.

Laboratory analyses

Table 8 gives the results of complete chemical analyses made in the laboratory on water obtained at 12 sites. These analyses have been used to illustrate the chemical characteristics of the water by means of diagrams shown in figure 11. For convenience in preparing the diagrams, data in table 8 were converted from mg/l to me/l (milliequivalents per liter). Milliequivalents per liter express the chemical equivalence of dissolved ions, and are calculated by multiplying

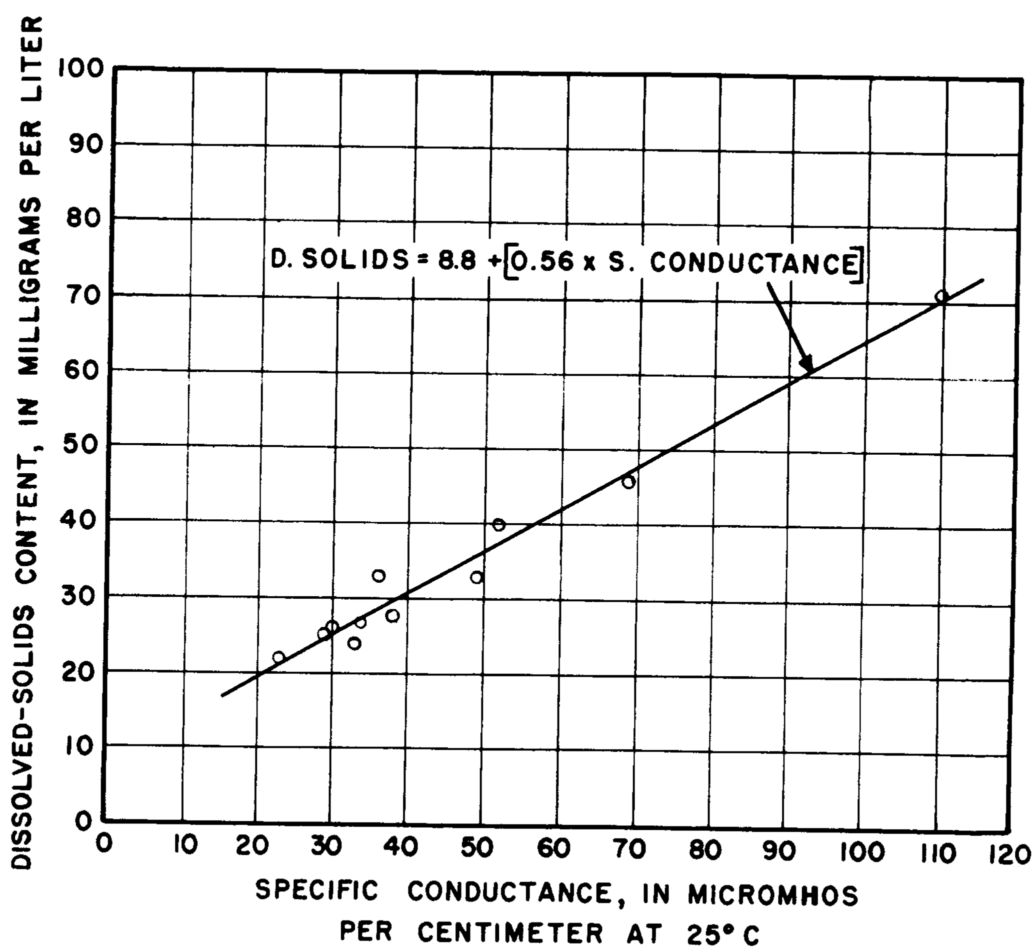


Figure 10. Relation of dissolved-solids content to specific conductance for surface water in Pickens County.

Table 7. Field measurements of temperature, specific conductance, pH, and dissolved oxygen of streams in Pickens County.

Site Number	Stream and location	Date	Temperature °F	Specific Conductance (in micromhos)	pH	Dissolved Oxygen (O_2)
1	Oolenoy River above Pumpkintown	Aug. 8, 1967	69	30	6.7	10
	-do-	Oct. 16, 1967	61	33	7.2	10
2	Oolenoy River near Pumpkintown	Aug. 8, 1967	69	32	7.1	9
3	South Saluda River at Freeman Bridge near Marietta	Aug. 8, 1967	74	27	7.2	9
	-do-	Oct. 16, 1967	61	29	7.2	9
4	Carpenter Creek near Dacusville	Aug. 8, 1967	70	29	6.0	10
	-do-	Oct. 16, 1967	58	28	7.6	10
5	Saluda River at Hunts Bridge near Dacusville	Aug. 8, 1967	69	38	6.6	10
2-1625.[1]	Saluda River near Greenville	Aug. 9, 1967	75	32	6.8	8
	-do-	Oct. 16, 1967	61	31	8.0	9
6	Georges Creek near Easley	Aug. 8, 1967	66	72	7.2	9
7	Burdine Creek at State road 39.95 near Easley	Aug. 8, 1967	67	34	6.4	9
9	Georges Creek near Greenville	Aug. 8, 1967	67	54	7.2	9
2-1850.[1]	Keowee River near Jocassee	Aug. 8, 1967	74	16	6.5	10
	-do-	Oct. 17, 1967	64	18	7.5	10
10	Eastatoe Creek near Pickens	Aug. 8, 1967	71	24	7.6	10
11	Eastatoe Creek near Nine Times	Aug. 8, 1967	72	27	7.5	10
	-do-	Oct. 16, 1967	61	29	7.5	10
12	Crow Creek near Pickens	Aug. 8, 1967	70	38	7.2	9
	-do-	Oct. 16, 1967	61	39	7.3	9
13	Sixmile Creek at Six Mile	Aug. 8, 1967	71	30	7.5	10
14	Middle Fork Twelvemile Creek near Pickens	Aug. 8, 1967	65	36	6.3	9
	-do-	Oct. 16, 1967	63	36	7.2	9
15	North Fork Twelvemile Creek near Pickens	Aug. 8, 1967	71	32	6.1	9
	-do-	Oct. 16, 1967	61	42	7.5	9
16	Twelvemile Creek at Pickens	Aug. 8, 1967	72	37	6.3	10
17	Town Creek at Pickens	Aug. 8, 1967	71	36	7.4	10
	-do-	Oct. 17, 1967	60	38	7.2	10
19	Wolf Creek at Pickens	Aug. 8, 1967	73	34	5.9	9
	-do-	Oct. 17, 1967	60	35	7.8	9
20	Wolf Creek near Pickens	Aug. 8, 1967	74	38	7.3	9
	-do-	Oct. 17, 1967	66	38	7.7	10
21	Twelvemile Creek near Pickens	Aug. 8, 1967	73	41	7.2	8
	-do-	Oct. 17, 1967	62	40	7.2	9
22	Rices Creek at Easley	Aug. 8, 1967	76	48	7.1	9
	-do-	Oct. 17, 1967	62	46	7.8	9
23	Rices Creek near Liberty	Aug. 8, 1967	76	40	7.4	9
2-1860.[1]	Twelvemile Creek near Liberty	Aug. 8, 1967	71	49	7.2	9
	-do-	Oct. 17, 1967	62	38	7.2	9
25	Golden Creek near Liberty	Aug. 8, 1967	71	52	7.2	9
30	Eighteenmile Creek below Liberty	Aug. 8, 1967	69	210	7.6	7
32	Eighteenmile Creek near Central	Aug. 8, 1967	69	115	7.5	9

1 U.S.G.S. gaging station number.

Table 8. Chemical analyses of surface water in Pickens County

[Results in milligrams per liter except as indicated. Analyses by U. S. Geological Survey]

Date of collection	Discharge (cfs)	Temperature (°F)	Silica (SiO_2)	Iron (Fe) 1/	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Calculated	Dissolved solids: Residue on evaporation at 180°C	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units 2/)	Dissolved oxygen (O_2)	Remarks
Site 2. Oolenoy River near Pumpkintown																									
Oct. 16, 1967	62.9	61	15	0.04	--	2.7	0.6	2.7	0.8	15	0	1.2	1.9	0.0	0.2	0.00	32	26	10	0	30	6.2	10	9	3/
Site 5. Saluda River at Hunts Bridge near Dacusville																									
Oct. 16, 1967	406	61	14	0.05	--	2.4	0.3	2.6	0.6	13	0	1.6	2.3	0.0	0.3	0.00	30	25	8	0	29	6.2	8	10	3/
Site 6. Georges Creek near Easley																									
Oct. 17, 1967	3.70	60	13	0.02	--	4.2	0.9	7.7	2.0	24	0	3.2	4.5	0.0	1.5	0.00	49	46	14	0	69	5.9	5	9	3/
Site 7. Burdine Creek at State road 39-95 near Easley																									
Oct. 17, 1967	0.61	80	14	0.13	--	2.2	1.3	3.3	1.2	13	0	1.0	3.3	0.1	1.5	0.00	34	27	11	1	34	6.4	20	9	3/
Site 9. Georges Creek near Greenville																									
Oct. 16, 1967	20.2	58	15	0.07	--	3.4	1.2	5.4	1.6	21	0	2.2	7.2	0.1	0.6	0.49	47	40	14	0	52	6.2	10	9	3/
Site 10. Eastatoe Creek near Pickens																									
Oct. 16, 1967	44.3	82	14	0.04	--	1.7	0.4	2.7	0.7	11	0	0.8	2.0	0.0	0.3	0.00	28	22	6	0	23	6.2	10	10	3/
Site 13. Sixmile Creek at Six Mile																									
Oct. 17, 1967	4.42	61	12	0.05	--	2.3	1.5	2.3	1.2	13	0	1.4	3.0	0.0	1.3	0.00	31	24	12	2	33	6.2	15	10	3/

Table 8. Chemical analyses of surface water in Pickens County -- continued.

[Results in milligrams per liter except as indicated. Analyses by U. S. Geological Survey]

Date of collection	Discharge (cfs)	Temperature (°F)	Silica (SiO_2)	Iron (Fe) 1/	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Calculated	Dissolved solids: Residue on evaporation at 180°C	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units 2/)	Dissolved oxygen (O_2)	Remarks
Site 21. Twelvemile Creek near Pickens																									
June 15, 1949	156	68	12	0.06	--	2.5	1.0	3.7 4/	--	16	0	1.6	2.0	0.0	0.9	--	--	33	10	0	33	6.2	2	--	3/
Oct. 16, 1967	29.7	63	16	.06	--	3.3	1.4	2.7	1.0	19	0	1.0	2.5	0.0	0.2	0.00	37	33	14	0	36	6.3	15	10	3/
Site 23. Rices Creek near Liberty																									
Oct. 17, 1967	10.8	61	11	.04	--	3.2	1.0	3.4	1.2	16	0	1.0	3.3	0.0	0.9	0.00	33	28	12	0	38	6.1	10	9	3/
Site 25. Golden Creek near Liberty																									
Oct. 17, 1967	6.51	60	15	.02	--	3.7	1.4	4.7	1.5	20	0	2.8	4.5	0.0	0.6	0.00	44	33	15	0	49	6.0	5	9	3/
Site 30. Eighteenmile Creek below Liberty																									
Oct. 17, 1967	10.5	59	15	.39	--	7.7	1.6	32	3.4	63	0	39	6.8	0.0	0.6	1.7	142	141	26	0	205	6.4	15	8	3/
Site 32. Eighteenmile Creek near Central																									
Oct. 17, 1967	--	59	15	.14	--	6.7	1.7	13	2.5	39	0	15	5.5	0.0	0.6	0.15	79	71	24	0	110	6.3	10	10	3/

1/ In solution when analysed. 2/ Based on platinum-cobalt scale (Hazen, 1692). 3/ Laboratory analysis. O_2 determined in field. 4/Includes Potassium (K).

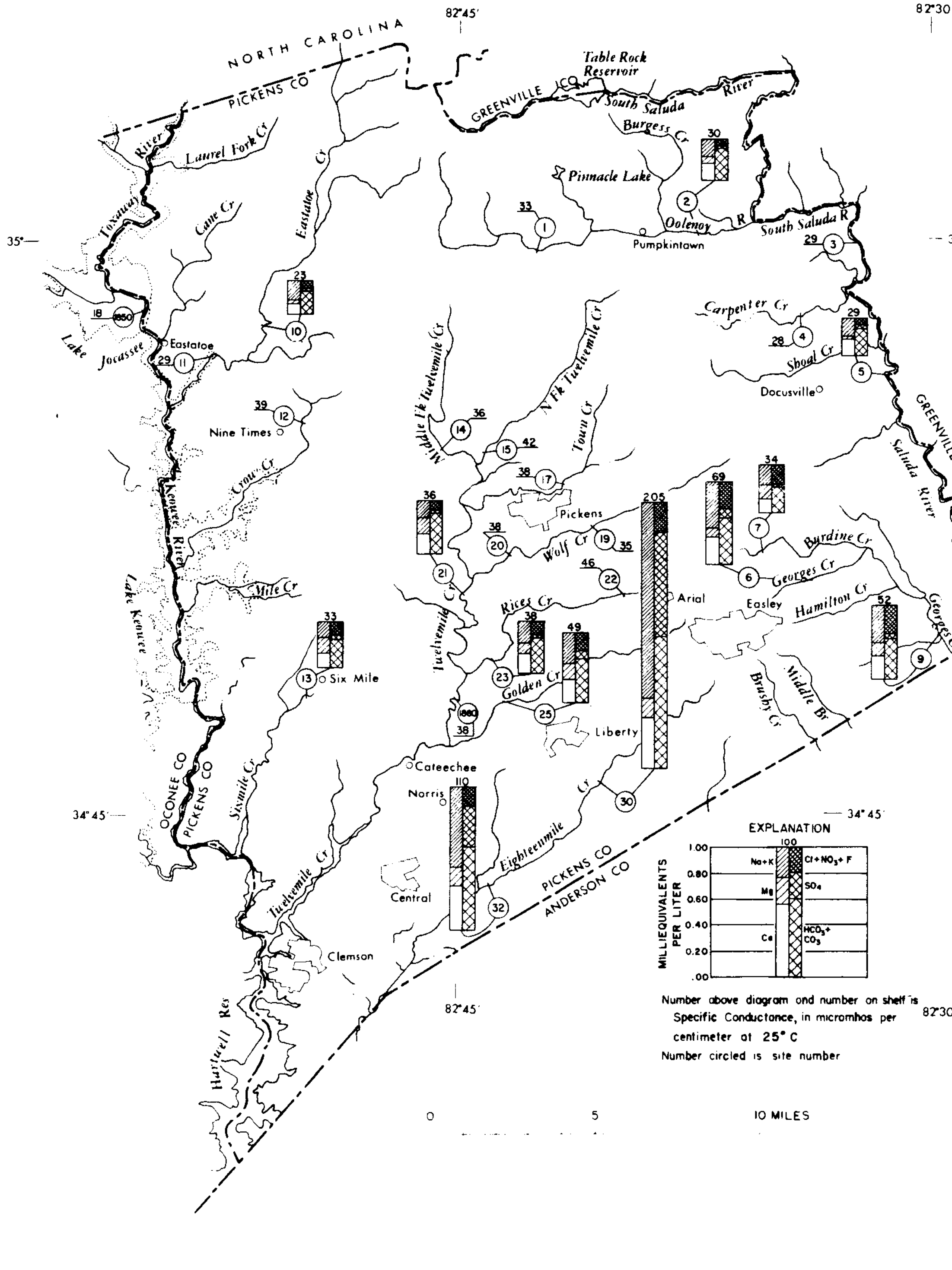


Figure 11. Chemical characteristics of surface water, October 16-17, 1967.

the reciprocal of the combined weight 1/ of an ion by the concentration of the ion in milligrams per liter.

Specific conductance measurements at 27 sites are shown also in figure 11 to aid in comparing the water quality of different streams. If an analysis is illustrated, the laboratory measurement of specific conductance for the site is given above the diagram. If no analysis was made, the field measurement of specific conductance at the site is given on a shelf. Site numbers, which have been circled, correspond to those used in tables 7 and 8.

Table 9 gives the maximum and minimum values of dissolved substances and physical properties of water at sampling stations on the Saluda, Keowee, and Seneca Rivers. The analyses have been published in the U.S. Geological Survey's annual series of Water-Supply Papers (see selected references). Samples from Seneca River at Clemson and near Newry were obtained at locations now inundated by Hartwell Reservoir. Although the analyses were made prior to the present study, reconnaissance data indicate that no significant changes in water quality have occurred. The analyses of water of the Keowee and Seneca Rivers are indicative of the type of water that Lakes Keowee and Jocassee will contain.

Temperature of surface water

The temperature of surface water varies with air temperature, and follows seasonal patterns similar to those of air. Generally, the smaller a stream, the more rapidly it will respond to a rapid change in air temperature. The temperature of water is important to municipal and industrial users of water. Temperature affects purification, filtration, corrosion rates, and the suitability of water for cooling. Water temperature is a principal factor governing the type of fish and other aquatic life that exist in a stream.

The U.S. Geological Survey operates a temperature recorder on Keowee River near Jocassee. Figure 12 shows frequency curves for daily maximum and daily minimum water temperature for Keowee River near Jocassee for the period October 1961 to September 1966. The frequency curves show that the daily maximum water temperature equalled or exceeded 50 percent of the time was about 58°F, and that the daily minimum water temperature equalled or exceeded 50 percent of the time was about 56°F. The maximum water temperature during the period of record

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1/ A combined weight is calculated by dividing the atomic or molecular weight of an ion by the ionic charge of the ion.

Table 9. Maximum and minimum values of dissolved substances and physical properties of water of streams bordering Pickens County.

[Results in milligrams per liter except as indicated. Analyses by U. S. Geological Survey]

	Saluda River near Greenville, Aug. 1946 to April 1965 (23 analyses)		Keowee River near Jocassee, Mar. 1955 to Jan. 1966 (9 analyses)		Seneca River near Newry, 1/ Aug. 1940 to Mar. 1955 (15 analyses)		Seneca River at Clemson, 1/ June 1952 to Sept. 1956 (7 analyses)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Silica (SiO_2)	8.9	15	7.0	9.6	5.7	15	11	14
Iron (Fe) 2	.00	.16	.01	.10	.00	.08	.00	.14
Calcium (Ca)	1.3	2.5	.8	2.4	1.1	2.4	1.6	2.4
Magnesium (Mg)	.1	.9	.1	.4	.4	1.1	.4	1.2
Sodium (Na)	1.3	3.9	1.1	2.7	1.4	2.8	2.1	4.9 3/
Potassium (K)	.5	1.2	.3	.7	.6	1.1	.6	1.2
Bicarbonate (HCO_3)	8	18	6	10	5	15	12	20
Sulfate (SO_4)	.9	3.3	.2	2.3	.7	2.5	.5	2.0
Chloride (Cl)	.5	2.0	.5	2.2	.8	1.5	1.0	2.0
Fluoride (F)	.0	.2	.0	.1	.0	.1	.0	.2
Nitrate (NO_3)	.1	.8	.0	1.0	.0	.7	.2	1.1
Phosphate (PO_4)	--	--	.00	.10	--	--	--	--
Dissolved solids (Residue at 180°C)	22	36	14	23	19	31	26	36
Hardness (as $CaCO_3$)	5	10	3	7	5	9	6	11
Noncarbonate hardness (as $CaCO_3$)	0	0	0	0	0	1	0	0
Specific conductance (micromhos at 25°C)	22	32	14	25	19	49	26	48
pH (in pH units)	6.0	6.9	6.1	6.6	5.6	6.8	6.3	6.7
Color (in color units) 4	0	28	5	10	3	21	2	22

1. Site now inundated by Hartwell Reservoir.
2. In solution when analyzed.
3. Includes small but undetermined amount of potassium (K).
4. Based on platinum-cobalt scale (Hazen, 1892).

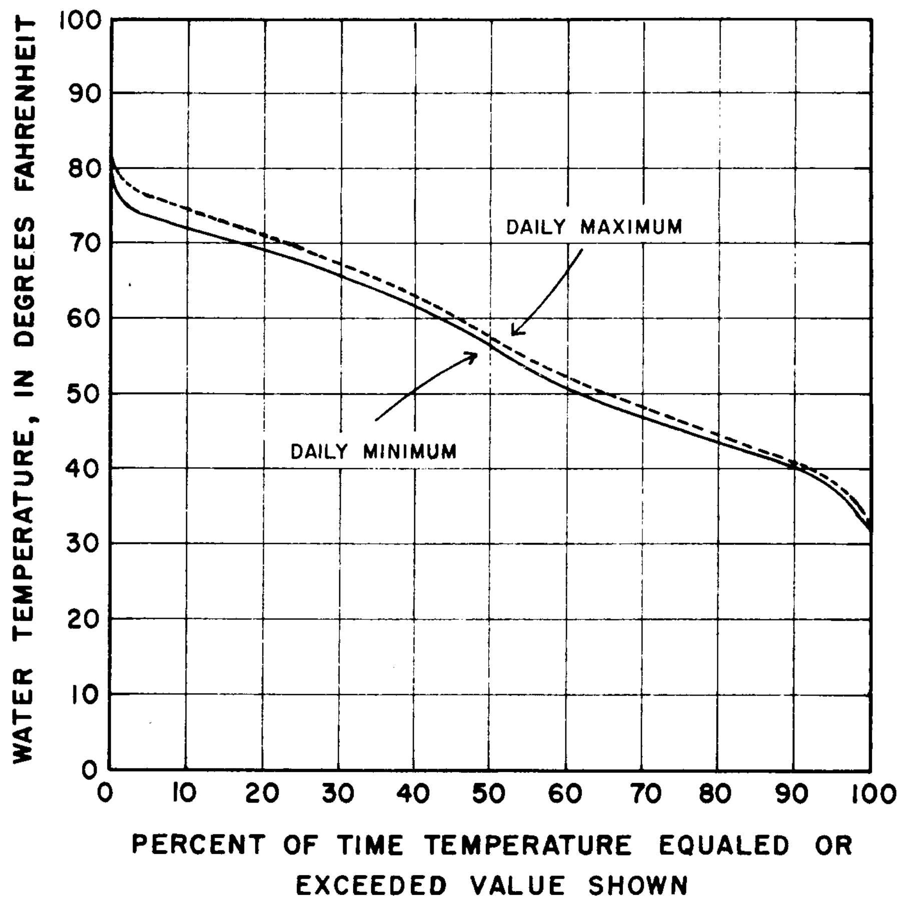

Figure 12. Frequency curves for daily maximum and daily minimum water temperatures, Keowee River near Jocassee, October 1961 to September 1966.

was 82°F; the minimum water temperature was 32°F on several days during winter months. Although these data cannot be used to predict the water temperature of other streams in Pickens County, it is likely that similar temperature ranges and seasonal patterns occur throughout the county. The temperature of surface water at the time reconnaissance data were obtained is given in table 7.

Suitability of water for use

Available data indicate that most streams in Pickens County contain water of excellent quality, and that Lakes Keowee and Jocassee, once completed, will also contain water of excellent quality. It is likely that a longer period of more intense monitoring would show that streams occassionally have slightly higher dissolved-solids contents. However, the fact that quality of water data were obtained during a period of low flow, when the mineralization of streams is normally greater, suggests that no great differences should be expected. Thus, with the exceptions of streams receiving wastes, surface water of Pickens County should be suitable for most uses at all times with only minor treatment. Streams receiving wastes occassionally may be of poorer quality than indicated by the reconnaissance, depending on the amount and type of waste being discharged to the stream at a given time.

GROUND WATER RESOURCES

Ground water is one of the primary natural resources of Pickens County. The quality of water available from wells drilled in crystalline rocks at a specific locality is ordinarily less than that available from streams or from wells drilled in unconsolidated rocks of other areas. However, the importance of ground water in an area underlain by crystalline rock lies not in its availability in large yields per individual well, but in the fact that moderate amounts of water, sufficient for most domestic, stock, and small industrial requirements, are available throughout the area. Of additional advantage are the factors of relatively constant temperature and chemical composition which may enable even small quantities of water to be of significant economic value.

Description of Water-Bearing Rocks

Figure 1, which shows the distribution of specific rock types as they occur throughout Pickens County, is adapted from Overstreet and Bell (1965a). Six major rock units are indicated and these include the Henderson Gneiss, biotite granite gneiss, gabbro and soapstone, biotite schist, hornblende gneiss, and biotite gneiss and migmatite. The descriptions given in table 10 are adapted from those given by Overstreet and Bell (1965b).

Table 10. Description of rock units in Pickens County

(Adapted from Overstreet and Bell, 1965a).

System	Description
Upper Triassic(?)	Diabase dikes: Black, fine-grained. These and muscovite dikes cut across older rock units and range from less than a foot to several feet in width and up to several miles in length.
Mississippian to Permian(?)	Muscovite pegmatite dikes: White, coarse-grained, zoned muscovite-plagioclase-quartz-perthite pegmatite dikes.
Ordovician to Devonian	Biotite-granite-gneiss: Medium-grained white to gray, strongly gneissic rock composed of orthoclase, oligoclase, quartz, biotite and muscovite, with accessory amounts of apatite, epidote, garnet, ilmenite, monzonite and sphene. In northern Pickens County, the unit is correlative with that formerly designated as the Whiteside Granite by Keith (1907, p. 45). Henderson Gneiss: Light-gray to light-bluish-gray, generally fine-grained, but in places coarse-grained, porphyritic and slightly gneissic rock, sometimes referred to as an augen gneiss. It is composed of orthoclase, plagioclase, quartz, and minor amounts of muscovite and biotite. Less common phases in Pickens County include laminated and contorted biotite gneiss and schistose muscovite gneiss. These phases are granitic in composition and fairly abundant in microcline.
Ordovician	Gabbro and soapstone: Forms small circular to irregular-shaped bodies in the Inner Piedmont belt; composed of hornblende gabbro, olivene gabbro, pyroxene, peridotite and soapstone. Many thin disrupted dikes of gabbro, in addition to those indicated on the map, probably occur also throughout the county.
Upper Cambrian to Devonian	Henderson Gneiss: An assemblage of metamorphosed and igneous rocks consisting of dark green to black fine- to coarse-grained gneissic, schistose, and massive hornblende rocks. Varieties of rock units include garnet-bearing hornblende gneiss and schist, diopside-hornblende gneiss and schist, combinations of diopside, hornblende, labradorite, scapolite and oligoclase gneiss and schist, actinolite schist, and chlorite schist. The hornblende gneiss is also interlayered with rock types common to the biotite schist. Because data for adequate separation are not available, small masses of hornblende, gabbro, olivene, pyroxenite, peridote, and soapstone are also included as part of the hornblende gneiss unit. Biotite gneiss and migmatite: Light- to dark-gray, fine- to medium-grained gneiss of more massive and granitic appearance than those rocks in the biotite schist unit. It includes biotite-oligoclase gneiss, biotite-oligoclase quartz gneiss, garnet-biotite-oligoclase-quartz gneiss, biotite-sillimanite-oligoclase gneiss and garnet bearing gneisses of quartz monzonite to grandiorite composition. Thin layers of hornblende, biotite and sillimanite schist are common. Flat, lenticular layers of gneiss rich in sphene, calcite, and graphite occur in discontinuous masses.
Upper Pre-Cambrian to Mississippian	Biotite schist: Includes an assortment of thin-layered, fine- to coarse-grained, strongly foliated biotitic rocks which are folded and contorted and enclose numerous pegmatite veins or dikes. Predominant varieties include the biotite-oligoclase schist, kyanite-biotite-oligoclase schist, and sillimanite biotite-oligoclase schist. There are also fairly common occurrences of biotite gneiss, graphite schist, quartzite, marble, calcareous quartz-biotite gneiss, hornblende schist, and hornblende gneiss.

Occurrence of Ground Water

General hydrologic conditions

Ground water occurs in the saprolite derived from cyrstalline rocks where the composition of this material is permeable, and in the secondary fractures which interlace the underlying hard rock. The fractures occur principally along foliation planes, joints, faults, and bedding planes. Some fractures are enlarged by solution. Owing to the increasing load of overburden with increasing depth, both the number and size of the fracture openings decrease with depth -- at least for those associated with rock weathering. Because of this, most of the higher yielding wells in the Piedmont are at depths of about 250 feet or less. At depths greater than 300 feet the number and size of the fractures tend to diminish to the point where only small quantities of water circulate through them. In some areas underlain by crystalline rocks, fractures formed at depths greater than 1,000 feet by deep seated orogenic or seismic activity contain significant amounts of water -- but the water is usually too highly mineralized for general use. To a lesser extent water may collect and move through the intergranular spaces in the rock itself.

Ground water occurs under both water-table and artesian conditions. The former condition is probably more representative of this area. Under water-table conditions the water in the saturated zone is free to move upward or downward without being confined by impermeable or nearly impermeable material. The surface of this zone, or water table, is under atmospheric pressure. Under artesian conditions vertical movement is restricted by the presence of a confining bed above the aquifer, and the static water level rises above the base of the confining bed where the aquifer is penetrated by a well. Where artesian conditions exist, the piezometric surface 1/ is usually above the saprolite-hard rock contact whereas under water-table conditions the water-table surface is usually below this contact. At places where water enters a zone of inclined fractures at high elevations, the water level in a well intercepting these fractures at depth will rise above the top of the fracture zone although this occurrence might not qualify as strictly within the definition of artesian conditions.

The saprolite, where relatively less permeable than the underlying fractured rock, acts as a confining bed. Whatever its degree of permeability, it usually acts as a reservoir to feed ground water into

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1/ The piezometric surface is defined as an imaginary surface that everywhere coincides with the head of water in the aquifer.

the underlying fractures thereby sustaining the ground-water supply during protracted periods of less than normal rainfall or drought.

In past years, ground water in Pickens County was developed predominantly from springs and dug wells. These wells were generally 2 to 3 feet in diameter and were lined with brick, stone or wood curbing. Water was obtained from the saprolite or from the top few feet of the underlying hard rock. The wells generally penetrated only a few feet below the water table. In periods of sustained drought, the water table would fall below the bottom of the well, which then became dry.

In recent years, most ground-water supplies are developed by means of the drilled well which is lined with steel casing generally 4 to 8 inches in diameter, that extends from ground surface down through the saprolite and is seated in the hard rock. Most drilled wells obtain water directly from fractures in the rock.

Characteristics of recharge and discharge

Recharge is effected principally by direct precipitation in the area although some is derived by underflow from adjacent counties. Rainfall percolating downward to the water table moves by gravitation toward points of lower elevation to discharge in springs, streams, or lakes where the water table intersects the ground surface. Where the water table is near the ground surface, additional water will be discharged through plants and trees by evapotranspiration. Water percolating downward to the saturated zone may also be intercepted by plants and trees and discharged by evapotranspiration. Induced discharge takes place through the pumping of wells.

Well Yield

Water yields from wells drilled in crystalline rocks range generally from less than one gpm (gallons per minute) to several hundred gpm. As indicated by the data available for Pickens County (table 11), the yields range from $\frac{1}{2}$-gpm to 500 gpm; the average yield is 21 gpm. The yields of those wells drilled to obtain maximum yield range from 9 to 500 gpm. The average yield of these wells (exclusive of well PK-130, whose reported yield was 500 gpm) is 48 gpm. If this well is included, the average yield is 61 gpm.

In a recent evaluation of well yields for areas in the Appalachian region, in which Pickens County was included, Wyrick (1967) assessed the potential yield of wells in crystalline rock by using the average yield of the highest 3 percent of all wells inventoried. Of the wells in Pickens County, this average yield amounts to 112 gpm.

Table 11. Data on wells and springs in Pickens County.

Well No.	Location	Driller	Depth (ft.) Total	Depth (ft.) Casing	Diameter (in.)	Principal Aquifer or Formation	Water Level: Depth below land surface (ft.)	Water Level: Date of measurement	Yield (gpm)	Drawdown (ft.)	Temperature (°F)	Use	Remarks
1-6	Easley Cotton Mill #1, Easley		70	40	4	bggn	12	1/46	300		63	I	Six wells.
7	Do		260	240	6	bggn	12	1/46	200			I	Drilled 1900.
8	Jones Cannery, Rt. 1, Easley	Robbins Bros.	130	65	6	bggn	30	1/46	15		61	I	P.A.
9-10	Do		20	10	2	bggn	15	1/46	8			D-I	
11-12	Do		20	10	2	bggn	15	1/46	8			I	
13-15	Do		20		2	bggn	15	1/46	10			D-I	
16	Mr. Cox, Rt. 1, Easley		130		6	bggn						D	Drilled 1946.
17	Alice Mfg. Co., Arial		240	90	6	bggn			30-40			I	
18	Do		240		6	bggn			30			I	
19	Do		240		6	bggn			30			I	
20	Do		240		6	bggn			40			I	
21	Do		240		6	bggn			40			I	
22	Do		240		6	bggn			30		60	I	P.A.
23	Do		240		6	bggn			15-18			I	
24	Stewart Lumber Co., Six Mile		30		36	bs & w/gn						D	Used for drinking purposes.
25	Do		25			bs & w/gn						I	
26	Norris Cotton Mills, Cateechee	Robbins Bros.	260-280		6	bgm			10		60	I	
27	Do	do	140	140	6	bgm			8			I	
28	Do	do	180-200		6	bgm			22			I	
29	E.D. Allgood, south of Pickens	do	121	40	6	hbgn			7			D	
30	Miss T. Alexander, south of Norris	do	85	40	6	bggn			10			D	
31	Arial Mill, Arial	do	113	68	6	bggn			75			I	
32	Do	do	152½	90	6	bggn			40			I	
33	Mr. Bevins, 3 miles above Pickens	do	139	84	6	hbgn			12			D	
34	Mr. Billingsley, 6 miles east of Easley	do	75	53	6	bgm						D	
35	Cleve Barbery, 10 miles northeast	do	141	42	6	hbgn	56	5/22/57	4			D	
36	A.C. Babb	do	79	52	6	bgm	11	10/22/57	40-50			D	
37	Elliott Batson, at Saluda Lake	do	254	20	6	bgm	95	7/5/51	19			D	
38	John Batson, at Saluda Lake	do	155	30	6	bgm			15-20			D	
39	Mrs. Sarah Cooper, 5 miles northwest of Dacusville	do	80	53	6	bggn			3-4			D	
40	Kenneth Fryfogle, at Saluda Lake	do	98		6	bgm			2			D	
41	Luther Black, near Saluda Dam Road	do	160	30	6	bgm			15			D	
42	Mr. Bridges, off US-123	do	120	105	6	bggn	15	9/27/55	20			D	
43	Aida Burgess, Pumpkin Town	do	117		6	bggn			8			D	
44	Clyde Burgess	do	250	70	6	bggn			5			D	
45	Mr. Burgess, Pumpkin Town	do	112	88	6	bggn	10	9-1-58	6			D	

Table 11. Data on wells and springs in Pickens County -- continued.

Well No.	Location	Driller	Depth (ft.) Total	Depth (ft.) Casing	Diameter (in.)	Principal Aquifer or Formation	Water Level: Depth below land surface (ft.)	Water Level: Date of measurement	Yield (gpm)	Drawdown (ft.)	Temperature (°F)	Use	Remarks
46	Clyde Burgess, Pumpkin Town	Robbins Bros.	156	145	6	bggn			15			D	
47	T.C. Castles, above Daucusville	do	102	42	6	bggn			30-40			D	
48	D.C. Clark, Old Easley highway at county line	do	120	62	6	bggn	50	4/11/56	4			D	
49	Albert Chapman, on Alt-US-123 between Georges Creek and Saluda River	do	115	40	6	bgm			1½			D	
50	W.E. Cockran, 3 miles above Peters Creek	do	110	38	6	bggn			6-7			D	
53	C.E. Davidson, Brushy Creek Road	do	111	58	6	bggn	48	7/26/51	5			D	
54	Thelma Davis, off Farrs Bridge Road, 4 miles from river	do	61	57	6	bgm	20	2/14/59	20			D	
55	Mr. Duncan, Peters Creek	do	125	91	6	bggn	80	1/57	4			D	
56	Carl Ellenburg, near Arial Mill	do	220	45	6	bggn			1½			D	
57	Dr. Finley, off Farrs Bridge Road	do	178	78	6	bggn			10-12			D	
58	Mr. Franklin, south of Pickens	do	140	32	6	bs			6			D	
59	Pickens, S.C.	do	345	62	6	bs			60			PS	Yield possibly as high as 110 gpm.
60	County house, near Pickens	do	180	180	6	bs			8-10			D	
62	Mt. Carmel Baptist Church	do	81½	30	6	hbgn			4-5			D	
63	Six Mile Grammar School, Six Mile	do	154	72	6	hbgn	35	1945	5			PS	
64	Norris Mill, Norris	do	152	35	6	bgm			20			I	
65	Do	do	200	78	6	bgm	3	9/15/54	20			I	
66	Do	do	435	89	6	bgm	3	10/25/54	8-9			I	
67	Do	do	235	27	6	bgm	25	7/30/53	45			I	
68	Do	do	357	37	4	bgm	40	10/27/50	25			I	
69	Six Mile Hospital, Six Mile	do	143	56	6	hbgn			3			PS	
70	West Dairy, Easley	do	114	90	6	bggn	40	10/5/51	20			S	
71	John McConnell, east of Peters Creek	do	120	115	6	bggn			15-20			D	
72	Charlie McConnell	do	103	73	6	bggn			4			D	
73	Mrs. Jackson, Peters Creek	do	127	105	6	bggn			10			D	
74	Gene McConnell, above Peters Creek	do	85	53	6	bggn			10			D	
75	Mr. Bivins, above Pickens	do	156	45	6	hbgn	47		5			D	
76	Joe Steward, above Pickens	do	98	67	6	hbgn			10-12			D	
77	Joseph Liptack, above Pickens	do	138	70	6	hbgn						D	
78	Guy Keaster, above Pickens	do	100	71	6	hbgn			20			D	
79	Maison Harris, above Pickens	do	196	92		hbgn			5			D	
80	George Cox, Dacusville road near Easley	do	134	110	6	bggn	25	1/17/46	10	100		D	D/L.
81	Ralph Lamar, near Easley	do	219½	60	6	bggn	60	5/25/53	25-30			D	
82	Mr. Nelson, Easley	do	150	63	6	bggn			20			D	
83	John McCravey, Easley	do	105		6	bggn			20-25			D	
84	Mr. Whittaker, near Easley	do	80	56	6	bggn			15			D	
85	Do	do	58	38	6	bggn			12			D	

Table 11. Data on wells and springs in Pickens County -- continued.

Well No.	Location	Driller	Depth (ft.)		Diameter (in.)	Principal Aquifer or Formation	Water Level		Yield (gpm)	Drawdown (ft.)	Temperature (°F)	Use	Remarks
			Total	Casing			Depth below land surface (ft.)	Date of measurement					
86	Wayne Williams, Dacusville	Robbins Bros.	100		6	bggn			7			D	
87	Norman Williams, Dacusville	do	140	79	6	bggn			15			D	
88	James Wilson and R.C. McGuire, Cateechee	do	103		6	bgm			5			D	
89	Mr. Smith, Cateechee	do	103	56	6	bgm			5			D	
90	J.F. McColl, near Cateechee	do	110	30	6	bgm			15			D	
91	Mr. Flint, near Cateechee	do	112	46	6	bgm			5-6			D	
92	Fred Rollins, near Arial	do	49	40	6	bggn			15			D	
93	Mrs. Onogene Gillespie, near Arial Mill	do	167	35	6	bggn			4			D	
94	Mr. Whitlock, near Pickens Country Club	do	116	56	6	bggn			12			D	
95	Mr. Sloane, near Pickens Country Club	do	200		6	bs			3			D	
96	Leon Pilgrim, Pickens	do	125	112	6	bs			7-8			D	
97	Dr. Moore, Pickens	do	161	104	6	bs			4			D	
98	C.E. Morris, Pickens	do	200	52	6	bs			6			D	
99	Mr. Harris, Pickensville, out from Easley	do	101	50	6	bggn			2			D	
100	Mrs. Margert Harris	do	135	34	6	bggn	32	1/23/47	½			D	
101	Mr. Hendricks	do	49	28	6	bggn	22	2/22/46	10			D	D/L.
102	Dr. Cannon, Rosemond Road, Pickens	do	105	3	6	hbgn	10	4/45	3			D	
103	J.C. Williams	do	115	89		bggn	32	1/27/47	8			D	D/L.
104	Louis Hazelwood, on Saluda River near dam	do	128	65	6	bgm	35	1/45	10			D	
105	Roy Finley, near Maynard School	do	275	183	6	bggn	27	2/20/46	10	200		D	D/L.
106	Mr. Hood, near Crossroad	do	52		6	bggn			15			D	
108	Edwin Lewis, 5 miles from Pickens on Rosman Road	do	112	90	6	bs			7-8			D	
109	A.J. McHaffey, near Croswell School, Easley	do	89		6	bggn			5			D	
110	Holder and Floyd, near Pickens Country Club	do	98	49	6	bs			25				
111	Georges Creek Church parsonage	do	100	26	6	bggn			1			D	Drilled 1951. Driller reported hard rock.
113	Mrs. Loggins, on right of old Saluda Dam Road, past Georges Creek	do	57	30	6	bgm	35		20				Drilled 1956.
114	Ralph Kay, near Brushy Creek Church	do	90	80	6	bggn			12-20				Drilled 1955.
115	Mr. Thomas, old Easley Brodge Road,	do	68	58	6	bggn			5				do.
116	Mr. Waldrop, Easley highway, just across river on US-123	do	80	31	6	bggn	3						Drilled 1952.
117	Mr. Stone, new Easley highway, US-123 at bridge	do	111	77	6	bggn			3				Drilled 1953.
118	Miller Poster Advertising, new Easley highway, junction US-123 & Alt. US-123	do	105	25	6	bggn			1				

Table 11. Data on wells and springs in Pickens County -- continued.

Well No.	Location	Driller	Depth (ft.) Total	Depth (ft.) Casing	Diameter (in.)	Principal Aquifer or Formation	Water Level: Depth below land surface (ft.)	Water Level: Date of measurement	Yield (gpm)	Drawdown (ft.)	Temperature (°F)	Use	Remarks
119	Jack Wilson Pump Co., US-123 1 mile past river	Robbins Bros.	113	60	6	bggn			7-8				Drilled 1955.
120	Bill Ballentine, near dam on Saluda River, at lake	do	127	55	6	bgm	45		8				Drilled 1945.
121	Dr. Robinson, Saluda Lake, north of Saluda Dam Road	do	127	70	6	bgm			10-15				Drilled 1956.
122	R.A. Welch, across river on old Saluda Dam Road	do	52	20	6	bgm			20				Drilled 1953.
123	Mr. Southerlin, near river just off Farrs Bridge Road	do	49	22	6	bgm			15-20				Drilled 1953.
124	The Southerner Cafe, on Easley hwy.	do	102	38	6	bggn			7-12				Drilled 1950.
125	Mr. Smith, on Easley highway, near Southerner Cafe-Motel	do	75	42	6	bggn			20-25				Drilled 1950.
126	Southerner Motel, Easley highway	do	300	24	6	bggn			3-5				Drilled 1961.
127	Saco-Lowell, Easley (100 yards north-east of water tank)	Chandler	300	83	5	bggn	50		20			I	Drilled 1962 Well No. 1.
128	Do (about 1,000 yards east of PK-127)	do	223	64	5	bggn	45		35-40			I	Drilled 1962. Well No. 2.
129	Do (by ball park, at side of road)	do	140	20+	5	bggn			20±				Drilled 1962. Well No. 3.
130	Deal Mfg. Co., Pickens (at water tank on southwest end of plant)		273			hbgn			500		61	I	Drilled 1959. Process water.
131	Mark Jefferson, off US-123 (Easley highway)	Robbins Bros.	92	82	6	bggn			2			D	Drilled 1955.
132	Mr. Gillespie, on Easley highway	do	123	80	6	bggn			15-20			D	Drilled 1951.
133	Mr. Letton, 1.1 mile west of jct., highways US-123 and US-123A	do	100		6	bggn			3			D	Drilled 1946.
134	R.G. Gillespie, old Easley Road (US-123)	do	60	55	6	bggn			4				Drilled 1956.
137	Mamie Williams, Farrs Bridge Road	do	191	163	6	bgm			5				Drilled 1955.
138	Mr. Southerlen, off Farrs Bridge Road	do	49	30	6	bgm			25				Drilled 1953. Hit rock @ 2 ft.
139	Norris Miles	do	152	35	6	bgm			20				Drilled 1948.
140	Claude Wellborne, near Dr. Rossmond's	do	98	75	6½	bggn			10-12				Drilled 1960.
141	Curtis Watson, near Setton Hill farm	do	75	40	6	bggn			3				Drilled 1955.
142	Joe Worthington	do	149	125	6				150				Drilled 1962.
143	I.A. McIntyre, 0.6 mile west of Saluda River (US-123A), Easley hwy.	do	126	80	6½	bggn	50		7			D	Drilled 1959.
144	Mrs. Nola Smith, near Garrison's Service Station, US-123A	do	138	60	6½	bggn			2				Drilled 1959.
145	Mr. Sanders, off US-123A	do	63	35	6	bggn			4				Drilled 1951.
146	Mr. Thomas, old Easley Bridge Road	do	96	95½	6	bggn			3				Drilled 1952.
148	Preacher Looper, near Hendrick's Store	do	99		6	bggn			20				Drilled 1956. Filled up 8 ft.
149	Jerry Looper, near Hendrick's Store	do	212	147	6	bggn			2				Drilled 1959.
150	Mack Bolt, Georges Creek Drive	do	238		6	bggn?			5				Drilled 1960.
151	Dr. Moore, Pickens (well no. 2)	do	105	75	6	bs			25				Drilled 1953.
152	Mr. Medlin, near Jay's Dairy	do	91	80	6	bggn			4				Drilled 1954.

Table 11. Data on wells and springs in Pickens County -- continued.

Well No.	Location	Driller	Depth (ft.) Total	Depth (ft.) Casing	Diameter (in.)	Principal Aquifer or Formation	Water Level: Depth below land surface (ft.)	Water Level: Date of measurement	Yield (gpm)	Drawdown (ft.)	Temperature (°F)	Use	Remarks
153	O.R. O'Shields, near Jay's old dairy	Robbins Bros.	175	110	6	bggn			3				Drilled 1960.
154	Patterson (Bailey Brazell, near Easley)	do	140		6	bggn?			5				Drilled 1960.
156	Crossroad Parsonage	do	109	96	6	bggn			10-12				Drilled 1951.
158	Mrs. Vaughn, Sunset	do	61	40		hbgn			25				Drilled 1960.
159	William Rhodes, off Farrs Branch Road	do	130	104		bgm			4-5				Drilled 1960.
160	L.T. Poston, off Saluda Dam Road	do	181	40	6	bgm	60		5			D	Drilled 1957.
161	L.V. Starkey, Clemson	do	122	40	6	bgm			4				Drilled 1956. Water @ 115 ft.
162	L & B Ranch, near Clemson (Mr. Edwards)	do	170	169	6	hbgn			8-9				Drilled 1951.
165	Mr. Hendricks, near Bowie's Store	do	105	55	6	bggn			5				Drilled 1954.
166	Smith, Farrs Bridge Road	do	87	16	6	bggn			4-5				Drilled 1953.
167	Milton Whitlock, 0.1 mile south of cemetery on 274 (south of Pickens)	ABC Drill Co.	140		6	bs	18.56	8/16/67	18			D	Drilled 1964.
168	Vocational Center, near county road 274	Robbins Bros.			6	bggn	35.79	8/16/67					Drilled 1966. Not used.
169	I.A. McEntire, US-123A, west of Saluda River		105		6	bggn	30	8/17/67	7			D	Drilled 1946?
170	Genett Lumber Co., 0.8 mile north of SC-183 on US-178	Chandler	180			hbgn						I	Drilled 1966.
171	E.C. Gillespie, Saluda Dam Road, 0.3 mile east of S-135 and 2.6 miles north of SC-8					bggn						D	
172	Mayson, 0.5 mile south of SC-93 on county road 271		18		5	hbgn						D	
173	Roach (tenant), on county road 62 near US-123				24	hbgn						D	Dug well.
174	Joe Terry, 3.0 mile north of Central on Maw Bridge Road		119	52	6½	bgm			7			D	
175	Rayson Floral Co., US-123, east of Easley					bggn							
176	E.W. Gilstrap, Norris (SC-93 at railroad crossing)	Harris	135		6	bggn	50	9/12/67	60				Drilled 1948.
177	F. Langston, jct. SC-137 and S-39-52, Norris	Robbins Bros.				bgm			8			D	Drilled 1960.
178	Mr. Fraizier, Norris		56		24	bgm						D	Dug 1938.
179	Leland Kelley, 0.6 mile north jct. S-39-277 and Maw Bridge Road				6								
180	Jenkins, above Pickens		150			hbgn			3			D	
181	Clint McCall, Liberty (0.3 mile west of Rug Mill, S-39-277)		109	17	6	gs			10			D	Drilled 1958
182	Paul McCall, 3.4 miles north of Liberty on US-178		115			bgm	30	9/12/67				D	Drilled 1940.
183	Whitworth, south of Pickens (¼-mile west of jct. S-39-267 and S-39-122)	Robbins Bros.				bs							
184	Luke Winchester, Nine Times (0.15 mile southeast of jct. S-39-50 and S-39-32)	Monty Smith	175	30	6	hbgn? & bgm						D	Drilled 1952.

Table 11. Data on wells and springs in Pickens County -- continued.

Well No.	Location	Driller	Depth (ft.) Total	Casing	Diameter (in.)	Principal Aquifer or Formation	Water Level: Depth below land surface (ft.)	Date of measurement	Yield (gpm)	Drawdown (ft.)	Temperature (°F)	Use	Remarks
185	Dewey Winchester, Nine Times (0.1 mile northeast of jct. S-39-50 and S-39-32)	Monty Smith	250		6	hbgn & bggn						D	Drilled 1952.
186	F.W. Fowler, 0.7 mile southwest of Liberty on S-39-27	E. Barnette	402	26	8	gs	65					D	Drilled 1947. Not used; insufficient yield.
187	Paul Porter, 2 miles south of jct. of highways SC-133 and 15		25		18	gs							Dug well.
188	W.L. Waldrop, Morgan Dairy Road, 2 miles west of Central	Bobo	180		6	gs						D	Drilled 1955-1957.
189	A.B. Abercrombie, 0.5 mile north of Daniel High School, Central	do	176	100	6	bgm						D	Drilled 1955.
190	Mrs. J. Mark, 2.4 miles west of river on SC-183	Robbins Bros.	165-170		6	bgm							Drilled 1945. High in Fe.
191	Cecil Steward, Sunset, 0.8 mile south of jct. of S-39-143 and SC-11		15			Hgn						D	Dug 1947.
192	R.J. Stewart, Sunset, at jct. of S-39-143 and SC-11	Robbins Bros.	90	80	6	Hgn						D	

Spring No.	Location	Owner	Topography	Formation	Structure	Character	Improvements	Use	Remarks
PK-S1	1.8 mile west of Pumpkintown, on SC-11	Sumter National Forest	Road cut	Henderson Gneiss	Gravity spring	Seepage spring	Block structure with extending pipe	D	C.A. 10/31/67.

Geologic Symbols:

Pg	Muscovite and pegmatite dikes
bggn	Biotite granite gneiss
Hgn	Henderson gneiss
gs	Gabbro and soapstone
bs	Biotite schist
hbgn	Hornblende gneiss
bgm	Biotite gneiss and migmatite
*/gn	Weathered gneiss

Other Symbols and Abbreviations:

D	Domestic use
I	Industrial use
PS	Public Supply
S	Stock use
A	Abandoned
P.A.	Partial Chemical Analysis
C.A.	Complete Chemical Analysis
D/L	Drillers Log available

Another evaluation of potential ground-water development might be determined by use of stream discharge data. Thus the base flow of a stream constitutes essentially a drain discharge from ground-water storage and is potentially available for withdrawal through wells. Table 5 indicates 7-day low flows for 2- and 10-year recurrence intervals; these are base flows. The 2-year, 7-day low flow ranges from about 0.5 to 1.0 cfs per sq mi of drainage area. Expressed in gallons, this means that every square mile would yield from 0.3 to 0.7 mgd (million gallons per day). As a basis for comparison, the duration curve (fig. 3) for Twelvemile Creek near Liberty (drainage area, 106 sq mi) shows that 90 percent of the time the discharge equals or exceeds 67 cfs; the duration curve for Keowee River near Jocassee (drainage area, 148 sq mi) shows that 90 percent of the time the drainage equals or exceeds 155 cfs. At this percentile, almost all the streamflow is derived from ground water. For Twelvemile Creek the flow amounts to about 0.4 mgd per sq mi, and for Keowee River about 0.7 mgd per sq mi. In terms of well yield about 1 gpm per acre is now being discharged by streams that could be developed as additional ground water supply. As a consequence of such development, the quantity of water being discharged as streamflow would be decreased by an amount equal to the increase in well yield.

Factors Affecting Well Yield

A number of both intensive and broad general studies (Siple, 1946; Mundorff, 1948; Marsh, 1966; LeGrand, 1967; Koch, 1968) have been carried out in nearby areas underlain by crystalline rock. From these studies it seems apparent that two of the more important, if not the most important, factors affecting well yield are topographic location and rock type. Others include well depth (and diameter) and the thickness of overlying saprolite.

Topography

Statistical analyses of well yields in several parts of the Piedmont province indicate that the highest percentage of wells having large yields are located in topographically low areas such as draws or valleys with gentle slopes. The highest percentage of wells having low yields are situated on hilltops or steep-sided slopes. Inasmuch as the water table lies at a greater depth below land surface on hills than in valleys, wells drilled on hills generally must be drilled deeper than those drilled in valleys.

Rock type

The effect of rock type on well yield in Pickens County is less definite than that of topography and is secondary in importance.

Highly fractured or highly foliated rock units have a greater capacity for transmitting water. The coarser grained rocks also tend to store and transmit water more readily, especially after partial disintegration. Thus gneissic rocks and some schists usually provide higher water yields to wells. Granite, where intersected by an appreciable number of joints and fractures, will have favorable yields. In the more massive granites, where joint fractures are fewer, wells will have smaller yields.

Available data (table 12) indicate that the highest average yields in the county are obtained from wells drilled in biotite granite gneiss (average yield, 20 gpm). The lowest yields are obtained from wells drilled in hornblende gneiss (average yield, 8 gpm). The maximum yields are reported also from wells in the biotite granite gneiss exclusive of the reported yield (500 gpm) for well PK-130. Because yields of this magnitude are so unusual in this or in any other area in the South Carolina Piedmont and because some doubt exists as to the accuracy of the reported yield, it is not included in the computation of maximum, minimum, average, or median yields. The chemical composition of water from well PK-130 (fig. 13) indicates that it obtains as much if not more water from hornblende gneiss as it does from the biotite granite gneiss. Thus it may be finished near the contact zone or near a fault between the two units. Other wells similarly situated may obtain similar yields.

Yields for wells drilled in the Henderson Gneiss and the gabbro and soapstone units are not included in table 12 because of the scarcity of data available on wells in these units.

Rock structure

Rock structure also affects well yield although this factor may be considered as part of the effects exhibited by topography and rock type. The angle of dip or inclination of rock fracture with respect to the ground surface (or overlying saprolite) affects well yield in that those wells situated so as to intersect the greatest number of water-bearing fractures will ordinarily have higher yields. Where fractures intersect the surface or saprolite at locations of potentially greater recharge and lesser runoff, i.e., in valleys and on gentle slopes, higher yields are also likely to be obtained. Specifically the higher yields result when the fractures intersect the surface or saprolite at low angles and where the angle of fracture dip is in the same direction as the slope of the ground surface.

Well depth

Depth affects well yield because, other factors being equal, the greater the depth of a well the greater the number of water-bearing

Table 12. Well yields in relation to geologic unit.

Aquifer Units	Number of Wells	Yield (gpm)			
		Maximum	Minimum	Average	Median
Biotite granite gneiss	86	200	0.5	19.81	10
Biotite gneiss & migmatite	33	45	1.5	14.24	10
Biotite schist	11	60	3	13.72	7.5
Hornblende gneiss	14	25	3	8.28	5

Table 13. Well yield in relation to depth of well.

Depth (feet)	Number of Wells	Average Depth (feet)	Yield (gpm)				Percent of Wells Yielding Less Than 5 gpm
			Range	Average	Median	Per Foot of Well	
0-100	45	67	2 - 75	20.47	11	.30	22
100-150	64	120	.5-150	13.25	7.50	.11	26
151-200	21	172	3 - 40	11.57	8.50	.07	19
201-250	13	235	1.5- 45	24.42	30	.10	15
Over 250	11	316	1.5-500	78.00	19	.24	18
Over 250 1/	10	320	1.5-200	35.80	14.50	.11	20
All Wells	154	136	.5-500	20.70	9.75	.15	22

1/ Excluding PK-130, which is 273 feet in depth and is reported to yield 500 gpm.

fractures it will intersect. However, because the number and size of fractures, and thus the rock permeability, are not uniformly distributed in depth, the well yield and depth are not directly proportional.

As indicated in table 13, more than 90 percent of the inventoried wells in Pickens County are 250 feet or less in depth; most are less than 150 feet deep. The smallest percentage of wells yielding less than 5 gpm are those drilled to depths of from 200 to 250 feet. The highest average yields were obtained from wells 251 to 300 feet deep. However, considering the known inaccuracies and vagaries of the statistical analyses, optimum depths would appear most probably to range from 100 to 250 feet. As stated previously, wells drilled beyond 300 feet have only a small probability of obtaining much additional water.

Thickness of weathered rock

The thickness of weathered rock (saprolite) has been evaluated previously as an additional parameter which affects well yield (Siple, 1946; LeGrand and Mundorff, 1952; LeGrand, 1967). The greater the thickness of saprolite, the greater the well yield tends to be. A greater thickness of saprolite is usually indicative of rocks which are more easily disintegrated by weathering and probably more highly fractured. Higher yields can usually be obtained by intersecting these fractures.

Exact correlation of well yield with the thickness of saprolite has not been possible with the data obtained in this area. This is evident in figures 14a and 14b. Both illustrations were prepared to show the relationship of well yield to thickness of saprolite. The thickness was considered roughly equivalent to the depth of casing, although in some cases this may not be strictly true. Figures 14a and 14b indicate a scatter pattern correlation between these two variables. However a median line drawn through the plotted points indicates an approximate increase in yield of 3 gpm for each additional foot of saprolite. A further refinement of this method to assess the effect of saprolite on well yield was made by considering only those wells in a single depth class (100-150 feet). The greatest number of wells were drilled to depths in this class. The relation is shown both for those wells drilled to obtain maximum yield (fig. 14b) and for all wells on which data were available (fig. 14a). Figure 15 shows those thicknesses of saprolite associated with highest average well yields when the data from all wells were used. Thicknesses of 15 to 45 feet and 60 to 90 feet appear to coincide with the higher average yields. Thicknesses of 60 to 75 feet are coincident with maximum average yield. However, intermediate and even greater thicknesses of saprolite, by class interval, apparently coincide with lower yields.

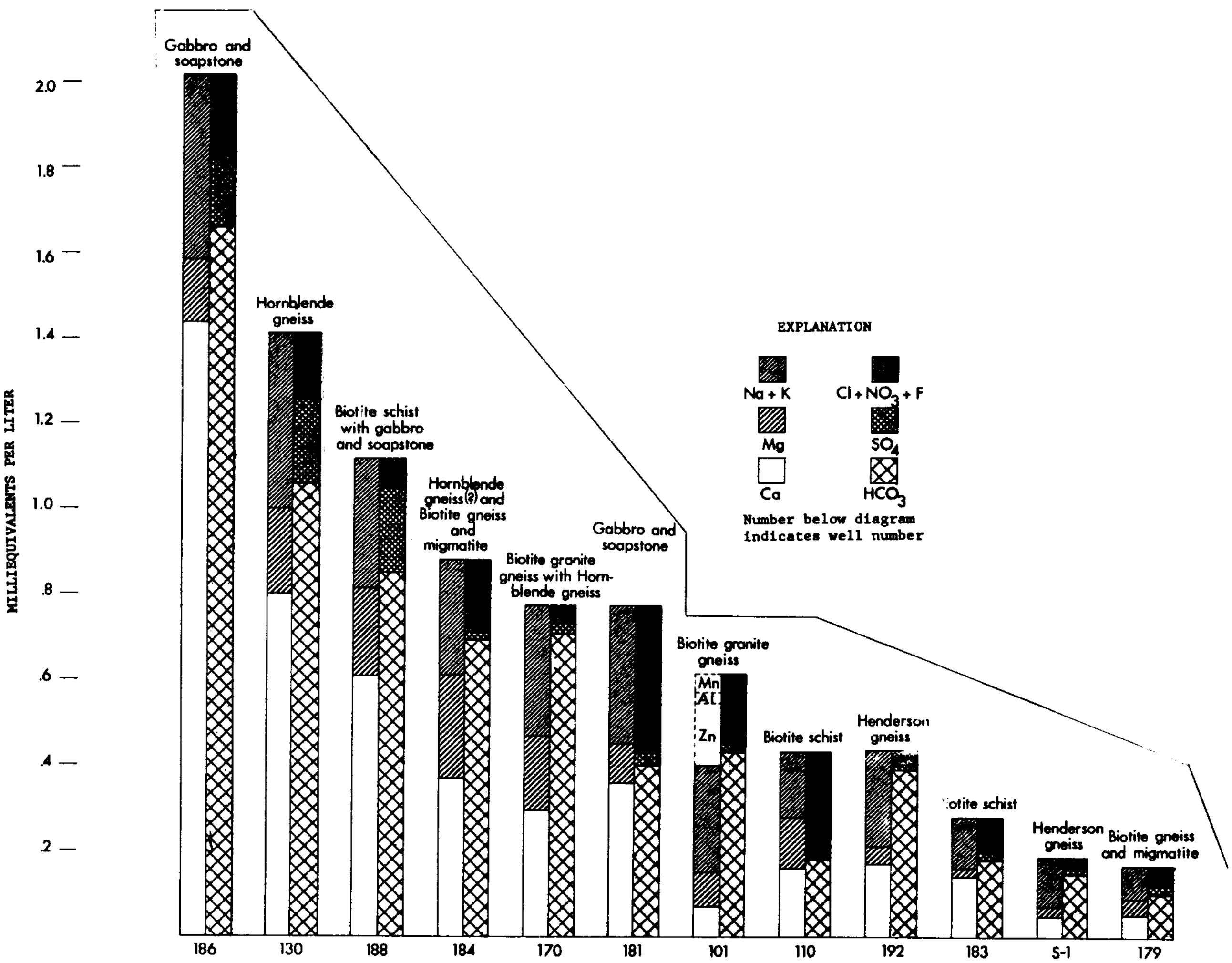

Figure 13. Chemical characteristics of representative ground waters.

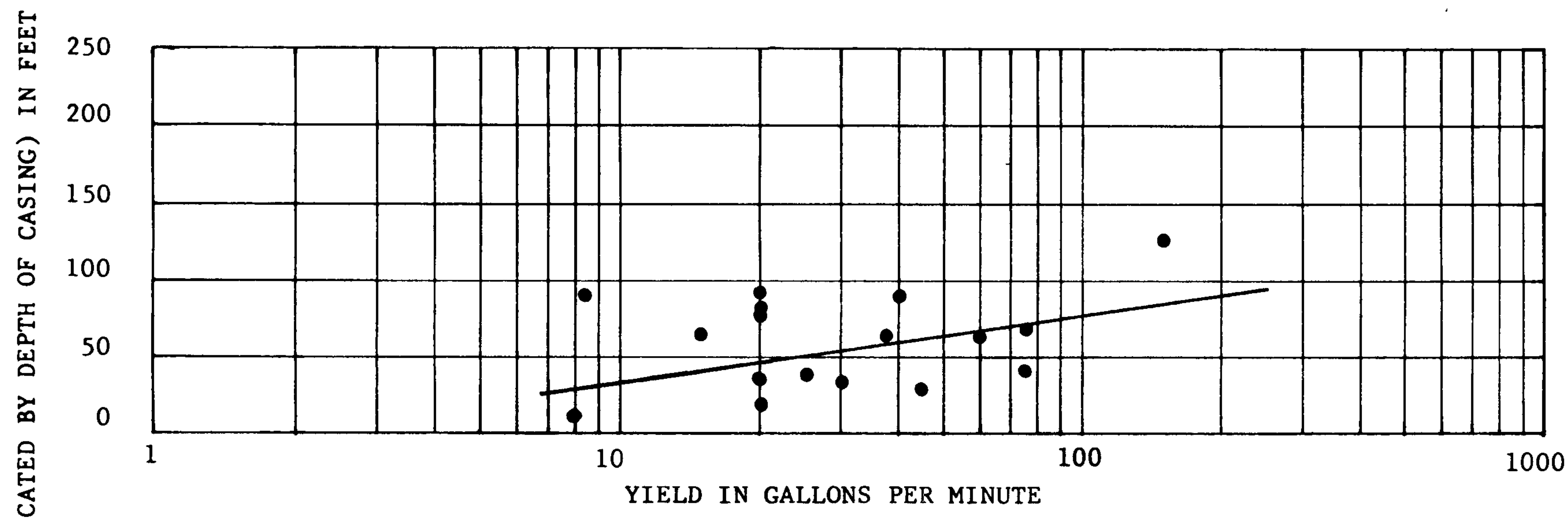

Figure 14a. Relation of well yield to thickness of saprolite in wells 100 to 150 feet deep, drilled to obtain maximum yield.

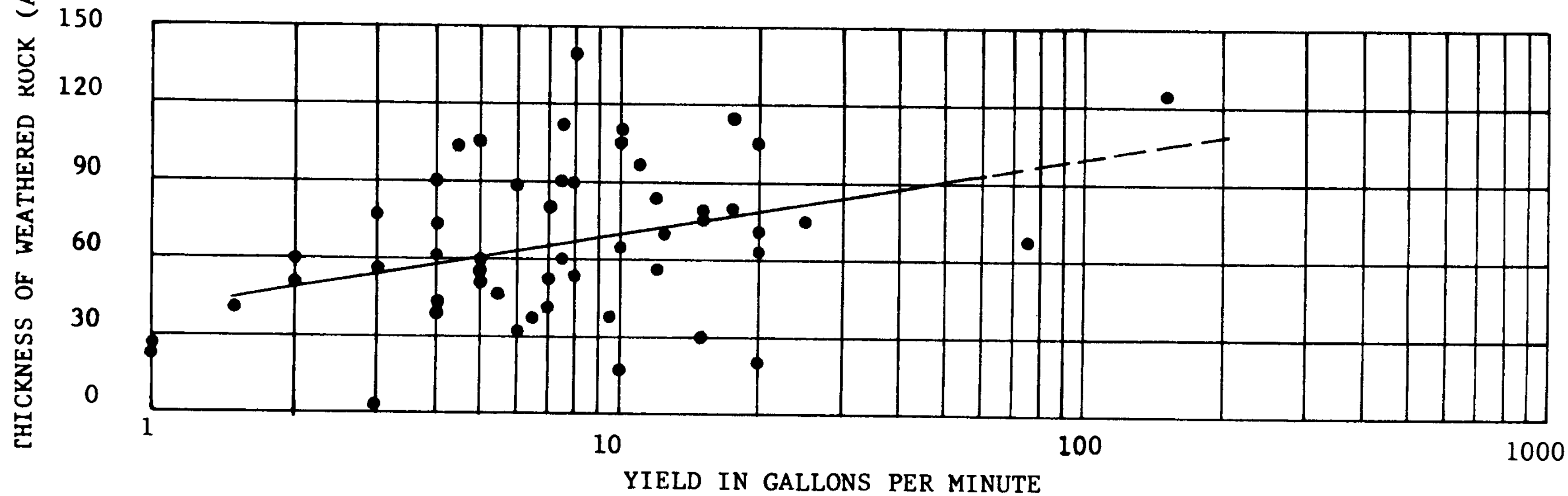

Figure 14b. Relation of well yield to thickness of saprolite in all recorded wells 100 to 150 feet deep.

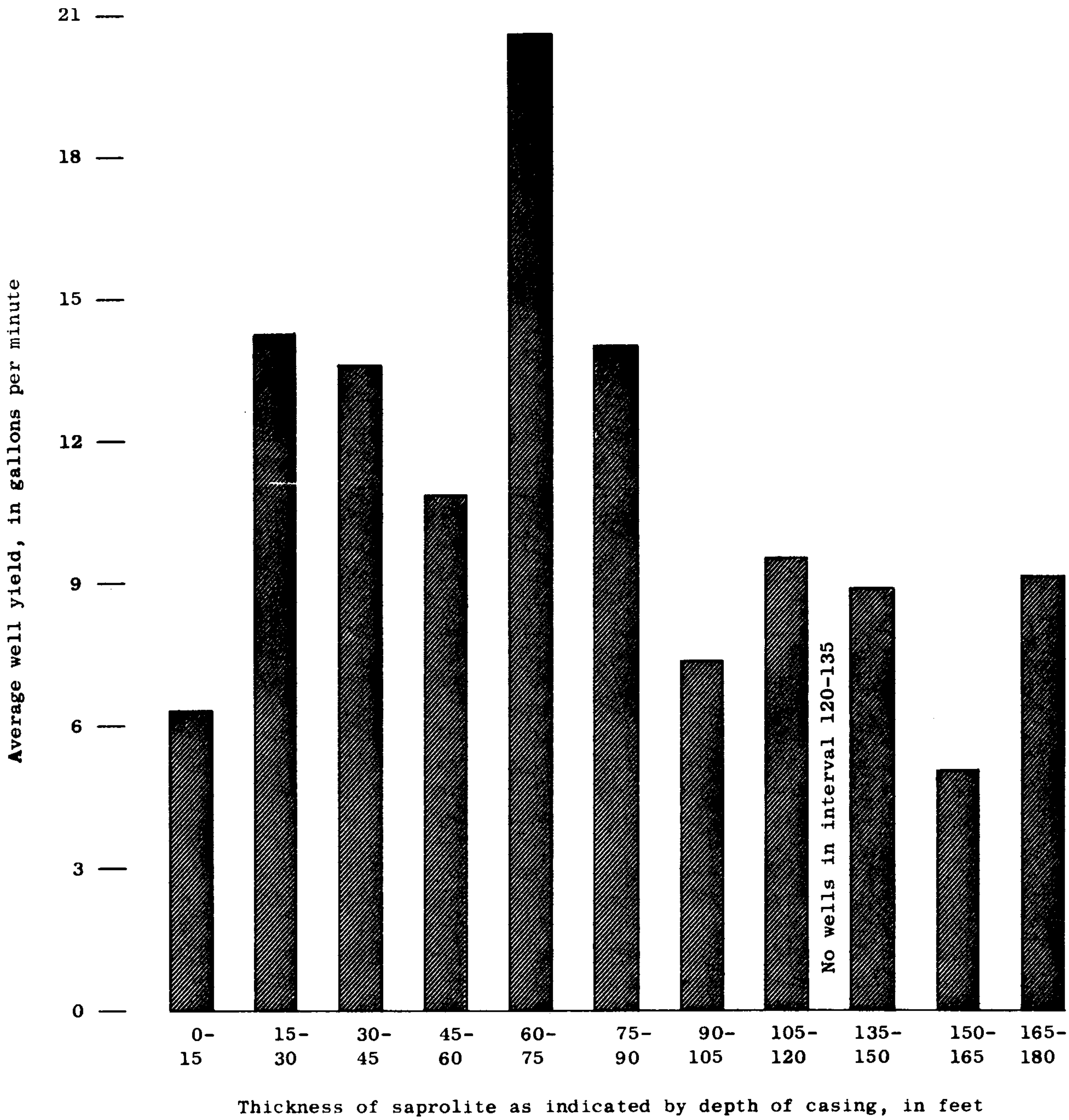

Figure 15. Relation of average well yield to increasing thickness of saprolite for all wells.

Water-Level Fluctuations

The water table or piezometric surface reflects a dynamic condition in the aquifer, with cycles of rising or falling stages occurring over both relatively short- and long-term periods. When the water table is comparatively shallow with respect to land surface, periods of rise or fall coincide closely with periods of climatic change, which affects direct recharge to or discharge from the water-table body. Thus, during periods of rainfall there will be a short-term recharge to the aquifer and the water-level will rise. During periods of drought the aquifer continues to discharge, thus lowering the water table. During the first part of the year, including the winter and early spring months, the water-table usually rises as a result of recharge from the slow penetrating rains characteristic of this time of year. During the summer months the rainfall is of the high intensity-low duration type which produces high runoff, and thus proportionately lesser amounts of water seep into the ground to recharge the water table. In addition, during this season evaporation and transpiration are taking place at maximum rates and thereby return much rainfall to the atmosphere that might otherwise have recharged the aquifer. As a result, the water-table declines in spite of the fact that maximum rainfall occurs during this season. Evaporation and transpiration decrease during the autumn and the water table begins to rise again.

The piezometric surface acts in a manner similar to that of the water table except that it is also influenced by loading effects due to earth tides and barometric pressure. In addition loading effects caused by rainfall recharge to water-table aquifers have been described for aquifers in South Carolina (Siple, 1957). The greatest fluctuations in either the water table or piezometric surface are likely to occur as a result of pumping in nearby wells.

Although this investigation was too short to obtain adequate records of water-level changes in Pickens County, a fairly close relation probably exists between conditions in this county and those in adjacent Greenville County. Water-level changes have been monitored with an automatic stage recorder for the past several years at Fountain Inn in Greenville County. Figure 16 compares these weekly low water levels with rainfall recorded by the U.S. Dept. of Commerce (1963-67) at the Greenville-Spartanburg airport.

Quality of Ground Water

Water quality in relation to rock type

Because rock types differ in mineral composition and because the mineral constituents in these rocks are dissolved at different rates,

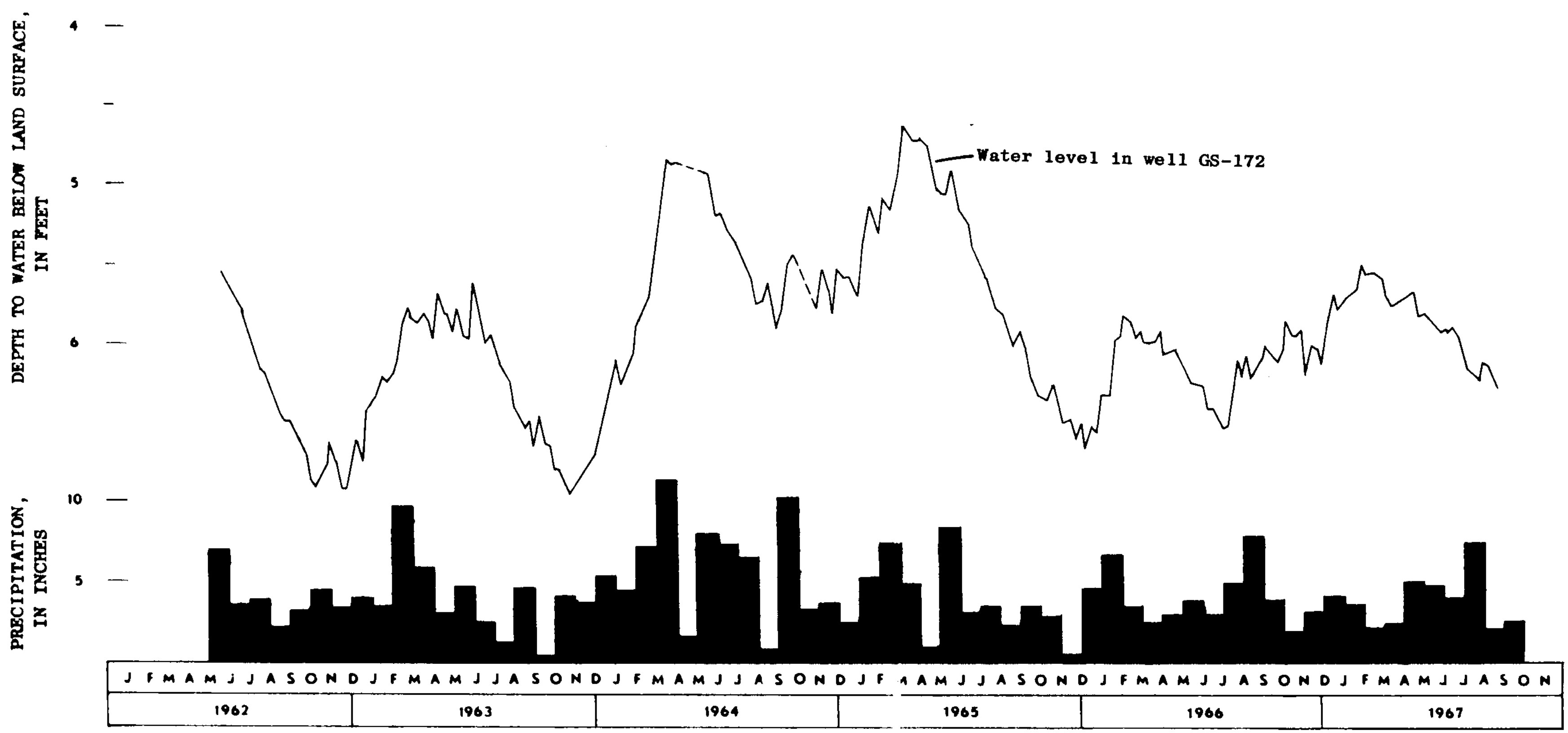

Figure 16. Weekly low water in well GR-172 and rainfall at Greenville-Spartanburg airport.

the chemical composition of ground waters is correlative generally with the particular rock unit through which it has had longer contact.

In Pickens County, as in most other areas underlain by crystalline rocks, the chemical composition of ground waters can be grouped into two general types. The first includes water from the quartzose, micaceous and light-colored mostly silicate rocks, which is usually soft and has a low dissolved solids content. The second includes water from gabbro, hornblende and dark-colored calcic-magnesium rocks, which is moderately hard to hard, has a higher dissolved solids content and may have a higher iron content.

Figure 13 illustrates the range of chemical characteristics of water from the major rock units in Pickens County. Water from the biotite schist (wells PK-110 and PK-183), biotite granite gneiss (well PK-179), and Henderson Gneiss (well PK-192) contains small amounts of dissolved solids and is soft. Water from the gabbro and soapstone (well PK-186) and the hornblende gneiss (well PK-130) or combinations of rock containing these units (wells PK-170 and PK-188) has a higher dissolved-solids content and is somewhat harder. Water from the biotite granite gneiss and the biotite schist is of the sodium bicarbonate type, rather than of a calcium bicarbonate type which is characteristic of most other ground waters in Pickens County. Water obtained from spring S-1, located in an area underlain by Henderson Gneiss, has a low dissolved-solids content which compared with the composition of water from well PK-192, also drilled in Henderson Gneiss, shows the increase in dissolved-solids content in the well water resulting from a longer time of contact or longer path of contact for ground water circulating through a particular rock type. Thus the flow path of water discharging as a seepage spring is usually of shorter length (and in contact with the rock for a shorter period of time) than that of water circulating down to the rock aquifer and pumped from a well. Analyses shown in figure 13 support this conclusion.

Figure 17 shows the hydrochemical characteristics of selected wells in Pickens County. The more critical hydrochemical parameters of ground water in each of the wells are indicated as a fractional notation. The depth and yield of the well are given in the numerator and the specific conductance and hardness of the water are shown in the denominator.

The specific conductance of ground waters in Pickens County ranged from 17 micromhos (well PK-179 and spring S-1) to 178 micromhos (well PK-186). Water from the biotite gneiss and migmatite, and from Henderson Gneiss at the spring had the lowest specific conductance and the lowest dissolved-solids content. Water circulating through the gabbro and soapstone (well PK-186) had the highest specific conductance.

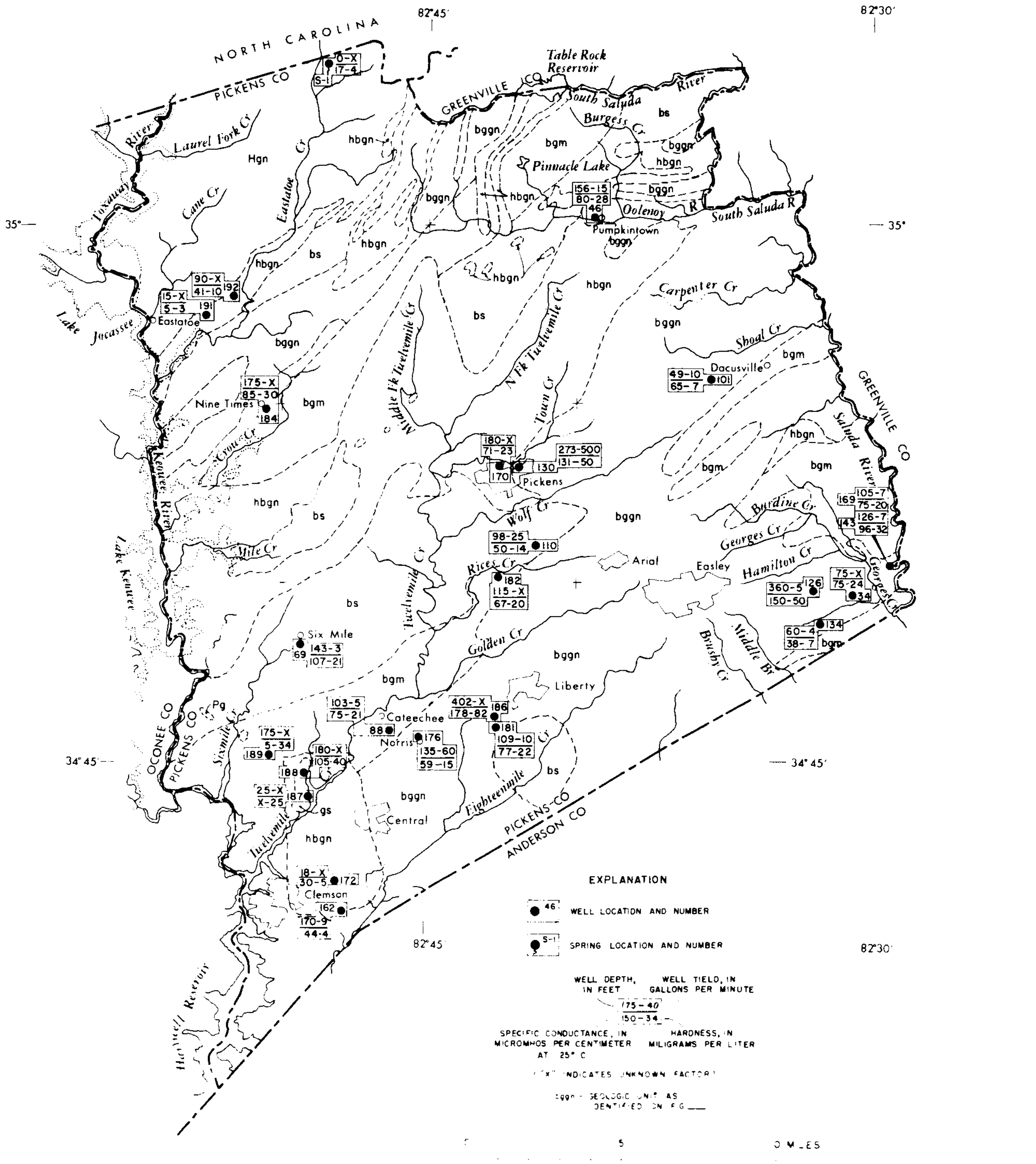

Figure 17. Hydro-chemical characteristics of selected wells and springs.

The ratio of dissolved solids to specific conductance ranged from 0.7 to 1.3. Normally this ratio lies between 0.6 and 0.8. Probably the higher ratio for these waters can be attributed to the presence of fairly high concentrations of silica.

Silica in most natural waters ranges from 1 to 30 mg/l although concentrations as high as 100 mg/l are not uncommon. The silica content in ground waters from Pickens County ranges from 4.8 mg/l to 39 mg/l. Water having more than 20 mg/l of silica may form scale on boilers when the pressure exceeds 150 psi. A maximum of 20 mg/l is also recommended for water used in the manufacture of paper (soda process and sulfate or Kraft process) (Miller, 1940). Silica in the crystalline form as quartz comprises one of the major constituents in the igneous and metamorphic rock units in Pickens County. However, because of its resistance to solution by water in temperate climates, quartz more than likely is not the source of the higher silica content of these waters. More probably the silica originates in the chemical breakdown of silicates in the process of metamorphism or weathering. The ferromagnesian minerals and the feldspars, as silicate structures forming substantial parts of the rocks in this area, are unstable under weathering conditions and are probably responsible for the higher silica content.

Tables 14 and 15 list the laboratory and field analyses of selected ground waters in Pickens County.

Suitability of water for use

These analyses show that ground water at most locations is of good to excellent quality for most domestic, municipal, industrial, and agricultural uses. The standards recommended for drinking water by the U.S. Public Health Service (1962) are met for most of the constituents listed in the analyses. However, the iron content of water from wells PK-22, PK-26, PK-183, and PK-186 exceeded the recommended limit 1/ suggested by the U.S. Public Health Service. The source of the high iron concentration is probably the amphiboles, pyroxenes, and dark ferromagnesian micas found in the biotite granite gneiss, biotite schist and the gabbro and soapstone. The manganese content of water from wells PK-101 and PK-183 and the fluoride content of water from

1/ U.S. Public Health Service limit for iron is 0.30 mg/l.

Table 14. Chemical analyses of selected well and spring waters in Pickens County.

[Results in milligrams per liter except as indicated. Analyses by U. S. Geological Survey]

Well Number	Aquifer	Date of collection	Silica (SiO_2)	Iron (Fe) 1/	Manganese (Mn) 1/	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Residue on evaporation at 180°C	Dissolved solids: Calculated	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units 2/)
PK-1	bggn	Jan. 8, 1946	--	0.11	--	--	--	--	--	19	4.0	5.0	--	6.6	--	--	--	22	--	--	--	--
PK-8	bggn	Jan. 11, 1946	--	.12	--	--	--	--	--	14	1.0	3.0	--	7.4	--	--	--	20	--	--	--	--
PK-22	bggn	Jan. 11, 1946	--	.49	--	--	--	--	--	41	1.0	2.0	--	1.8	--	--	--	41	--	--	--	--
PK-26	bgm	Jan. 11, 1946	--	.40	--	--	--	--	--	37	10	4.0	--	.1	--	--	--	37	--	--	--	--
PK-101	bggn	Sept. 13, 1967	9.9	.01	0.11	1.5	1.0	4.9	1.6	27	.8	5.5	0.1	.8	0.00	40	44	16	0	61	5.9	2
PK-110	bs	Aug. 18, 1967	13	.19	.05	3.1	1.4	3.9	.4	11	.2	3.2	.1	8.7	.00	42	39	14	6	50	5.6	2
PK-130	bggn	July 27, 1967	27	.02	.01	16	2.3	7.8	2.8	64	10	5.0	.3	.1	.01	105	102	50	0	131	6.9	2
PK 170	hbgn	Aug. 18, 1967	39	.03	.01	5.6	2.0	7.4	.9	43	.8	1.3	.2	.3	.27	81	79	23	0	71	6.2	8
PK-179	hbgn	Sept. 11, 1967	7.2	.02	.02	1.0	.5	1.2	.7	6	.8	1.8	.1	.2	--	17	17	4	0	17	5.5	8
PK-181	gs	Sept. 11, 1967	30	.03	.02	7.0	1.1	6.4	1.5	25	1.6	7.2	.1	9.2	--	80	76	22	2	77	6.0	5
PK-183	bs	Sept. 12, 1967	4.8	.86	.11	2.3	.2	2.1	1.1	12	.8	2.8	.1	.2	--	18	21	8	0	26	6.4	3
PK-184	bgm	Sept. 13, 1967	29	.04	.01	7.4	2.8	5.3	1.8	42	.8	5.0	.1	1.6	--	75	75	30	0	85	6.2	4
PK-186	gs	Oct. 30, 1967	22	.52	.02	29	1.8	9.3	1.1	100	8.4	1.5	2.8	.1	--	127	126	82	0	178	7.4	5
PK-188	gs	Oct. 30, 1967	31	.15	.04	12	2.5	5.3	2.4	52	9.6	2.0	.1	.1	--	90	91	40	0	105	6.8	5
PK-192	Hgn	Oct. 31, 1967	27	.07	.01	3.4	.5	4.6	.9	24	.6	1.5	.2	.0	--	52	51	10	0	41	6.2	3
PK-S 1	Hgn	Oct. 31, 1967	14	.02	.01	1.0	.2	2.2	.4	9	.6	1.0	.0	.0	--	22	24	4	0	17	6.0	2

1/ In solution when collected. 2/ Based on platinum-cobalt scale (Hazen, 1892).

Table 15. Field analyses of selected well waters in Pickens County, S.C.

Well Number	Hardness (mg/l)	Fe (mg/l)	pH	Specific Conductance (micromhos)
PK-34	24	--	6.5	75
PK-46	28	0.09	7.6	80
PK-69	21	--	6.0	107
PK-77	39	.15	6.3	122
PK-88	21	--	6.7	75
PK-126	50	--	7.6	150
PK-143	32	.3	6.9	96
PK-162	4	.9	6.5	44
PK-169	20	--	6.5	75
PK-171	16	--	6.3	75
PK-172	5	--	5.9	30
PK-173	12	--	5.7	45
PK-176	15	--	6.3	59
PK-180	9	.15	6.8	43
PK-182	20	--	6.6	67
PK-187	25	--	6.3	--
PK-189	34	--	7.1	99
PK-191	3	--	6.3	25

well PK-186 also exceeded recommended limits 1/. The zinc content (5.0 mg/l) of water from well PK-101 equaled the recommended limit. This amount of dissolved zinc in ground water is rather unusual. From the data available it is not known whether this concentration results from an artificial condition, such as the solution of zinc coating on water pipes, or if it represents a natural condition and thus possibly indicates a zone of zinc mineralization in the vicinity of the well.

The pH of water indicates the balance between its acids and alkalies. It may range from 0 to 14 but a common range lies between 6 and 8. A pH of 7.0 indicates neutral water. The analyses in tables 14 and 15 show a range in pH from 5.6 to 7.6. Most of the ground waters sampled from Pickens County are slightly acidic.

Temperature of ground water

Because of the earth's thermal gradient, by which ground temperatures increase from the surface towards the center of the earth, ground waters also increase in temperature and this gradient amounts to about one degree Fahrenheit for each 60 to 120 feet of increased depth.

The temperature of ground waters in shallow wells (less than 100 feet) normally approximates the mean annual air temperature, which ranges from 56°F (written commun., John C. Purvis, Meteorologist, U.S. Dept. of Commerce, Columbia, S.C.) on the northern boundary of Pickens County to about 61°F on the southern boundary.

CONCLUSIONS AND RECOMMENDATIONS

Pickens County may be divided into three zones to identify the low flow of streams. Based on 2-year, (median) 7-day low flows, the southern zone has a range of 0.3 to 0.5 cfs per sq mi; the central zone has a range of 0.5 to 0.7 cfs per sq mi; and, the northern and eastern zone has a range of 0.7 to 0.9 cfs per sq mi. Streams having comparable rates of sustained-low flow are capable of supporting high draft rates in relation to the drainage area and to the required storage. In general, the low-flow characteristics of streams in Pickens County indicate that the surface water resources have excellent

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1/ U.S. Public Health Service limit for manganese is 0.05 mg/l; recommended limits for fluoride are based on the annual maximum daily air temperature. The annual average maximum daily air temperature at the Pickens, S.C. Weather Bureau is 72.2°F. A maximum concentration of 1.0 mg/l is recommended when the maximum daily air temperature ranges from 70.7°F to 79.2°F.

potential for development and are well distributed throughout the county. The quality of water is excellent at most locations. Impairment of water quality does occur, however, and the effect is most noticeable on Eighteenmile Creek.

Ground water of good quality can be obtained in usable quantities almost everywhere in Pickens County. Well yields range from one-half to 500 gpm and average 21 gpm. However, an average yield of 48 gpm was obtained in those wells drilled to obtain maximum yield. The average yield of the highest 3 percent of wells inventoried was 112 gpm. Statistical analyses show that the highest percentage of wells having high yields are located in topographically low areas such as draws or valleys with gentle slopes. The highest percentage of wells having low yields are located in topographically high areas, hilltops, and on steep slopes.

The highest well yields in Pickens County were obtained from wells drilled in the biotite granite gneiss whereas the lowest yields were obtained from wells drilled in the hornblende gneiss.

Data indicate that where there is a greater thickness of saprolite the well yields tend to be higher. Analysis of the well data for this county appears to indicate that wells drilled through thicknesses of 15 to 45 feet and 60 to 90 feet produce the highest average yields, and that each additional foot of saprolite seems to increase the well yield by about 3 gpm. However, these values should be used with a degree of caution -- recognizing that the data might not be representative, that most wells are not drilled to obtain maximum yield, and that much of the data is reported rather than measured.

The water table or piezometric surface reflects a dynamic condition in the aquifer, subject to constantly changing cycles of rising or falling. The period of water-level rise generally occurs during the winter and early spring and the period of water-level decline generally occurs during the summer or early autumn. Pumping of nearby wells is likely to have the greatest effect on water-level change.

Ground water in Pickens County is generally of good to excellent quality for most domestic, municipal, and agricultural uses. Most waters sampled were soft, slightly acidic, and low in dissolved solids. Most were of the calcium bicarbonate type, except for those from the biotite granite gneiss, Henderson Gneiss, and the biotite schist, which were a sodium bicarbonate type. At some locations concentrations of iron, manganese, and fluoride do not meet the recommended standards of the U.S. Public Health Service.

No analyses were made for trace elements and therefore these concentrations can not be compared with the recommended standards.

If future ground-water studies are made within the county some desirable objectives would include the following: (1) obtain more complete or representative well data and chemical analyses, including additional information for springs; (2) make necessary adjustments of the geologic map to reflect a more exact representation of the units as observed in the field and synthesize these into recognizable hydrogeologic units; (3) conduct a series of pumping tests to define the hydraulic characteristics of the rock system and the effect of fracture orientation on well yield; (4) define the range in permeability and porosity of the saprolite in order to facilitate the evaluation of a water budget for selected areas considered representative of larger areas; and (5) obtain additional information on ground-water temperatures, including data concerning the effective depth at which little or no annual variation in temperature occurs.

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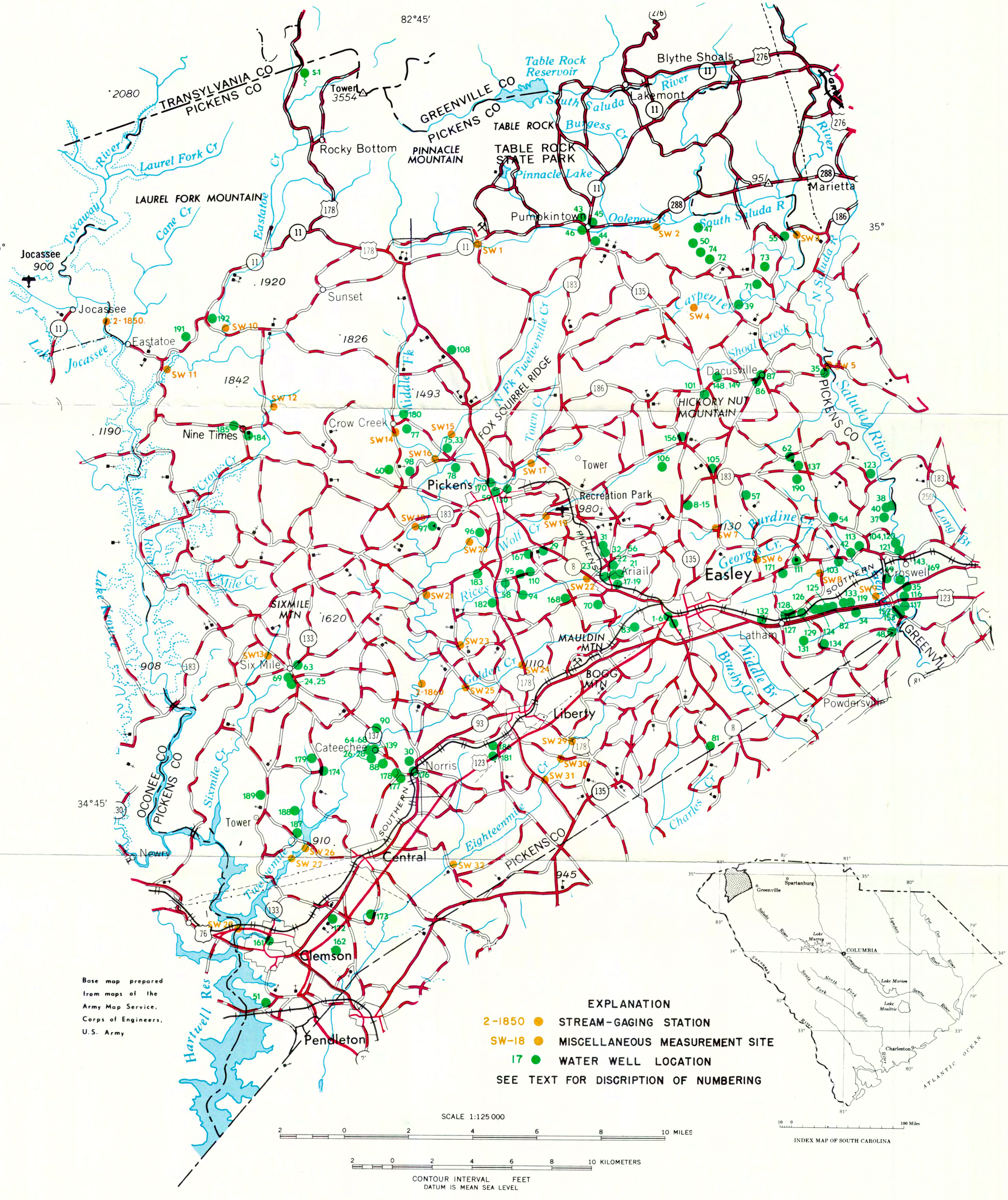

PLATE I. MAP SHOWING STREAM GAGES AND WELL LOCATIONS, PICKENS COUNTY, SOUTH CAROLINA