SOUTH CAROLINA

WATER RESOURCES COMMISSION

Report No 3

Water Resources of Spartanburg County, South Carolina

By

W. M. Bloxham, George E. Siple, and T. Ray Cummings

Prepared by

U.S. Geological Survey, Water Resources Division

in cooperation with

Spartanburg County Planning And Development Commission

Spartanburg, South Carolina

1970

RESOURCES OF SPARTANBURG COUNTY · BLOXHAM , SIPLE & CUMMINGS

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ERRATA

WATER RESOURCES OF SPARTANBURG COUNTY should be amended by the following:

1. "Rainbow Lake" (pages 7, 9, and figure 2) should be subsequently identified as "R. B. Simms Filtration Plant."

2. "South Pacolet River Reservoir" (pages 7, 21, 23, and figures 5, 6, 9, 20, 23, 27, and plate 1) is known locally as "Reservoir No. 1."

3. The determination of oxygen sag in Fairforest Creek between miles 8 and 9 (page 51) was made prior to the treatment plant expansion and the resulting improvement in effluent quality.

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ABSTRACT

As a source of supply, the streams of Spartanburg County afford many times the quantity of water presently required. Total withdrawal of streamflow is about 50 cfs (cubic feet per second) or 33 mgd (millions gallons per day)--about 4 percent of the mean annual flow. Low-flow characteristics of the streams, emphasized in this report, are important factors in the utilization of streamflow during critical periods. The magnitude, duration, and frequency of low flows are analyzed to determine the available streamflow and to develop draft-storage relations.

Basin characteristics of the larger unregulated streams are shown to be similar by the shape and plotting position of the duration and frequency curves. The mean annual flow occurs at about the 30 percent duration point, and the minimum annual 7-day low flows anticipated at average intervals of 2 and 10 years occur at approximately the 90 and 99 percent duration points, respectively. Streams in the northern part of the county have the higher unit runoff, show less variability, and are better sustained at low flow than those in the southern part. The minimum annual 7-day, 10-year flow of North Pacolet River at Fingerville is 0.34 cfs per square mile compared with 0.16 cfs per square mile of Enoree River at Enoree. The smaller streams, demonstrated a marked variability of flow on an areal basis. The 7-day low-flow at 10-year recurrence intervals are displayed in a pattern of 3 gradations--0.07 to 0.11, 0.13 to 0.20 and 0.22 to 0.29 cfs per square mile. Flows at other recurrence intervals do not conform to this pattern. The degree of channel incisement is believed to account for the unexpected low yields of several streams that intersect or flow in formations containing wells with relatively high yields.

Streamflow was found sufficient to meet draft requirements of about 50 percent of the mean annual flow with seasonal storage. Over-year storage is required for greater draft-rates, although drafts over 60 to 70 percent of the mean annual flow are probably not economically feasible.

The surface waters have excellent quality for most uses. The content of dissolved solids is low and the water is soft. A discharge of waste, however, was evident in several streams--the North, Middle and South Tyger Rivers and Fairforest Creek.

Spartanburg County lies within the Inner Piedmont belt, and wells drilled in the granitic, biotitic, and hornblendic rocks, characteristic of this region, yield from 1 to 250 gpm (gallons per minute). The highest average yields (35 gpm) of the wells inventoried were obtained from those drilled in the biotite gneiss and migmatite. Wells drilled in quartz monzonite had the lowest average yields. The average yield of all wells for which data were available was 20 gpm. The average for those wells drilled to obtain their maximum development was 53 gpm. The average yield for the highest 3 percent was 139 gpm. The 7-day, 2-year low-flow yield of streams throughout the county ranges from 0.23 to 0.43 mgd per square mile (160-292 gpm per sq mi), which represents a minimum quantity available for ground-water development.

Ground waters in Spartanburg County are of good to excellent quality for most domestic, municipal, and industrial use. Most of the waters sampled were soft, slightly acidic, and low in dissolved solids.

INTRODUCTION

Purpose and Scope of the Investigation

This report presents the results of a 3-year study of the water resources of Spartanburg County, South Carolina. The purpose of the study was to collect and evaluate information on the surface-water resources and to summarize and evaluate ground-water data obtained in previous reconnaissances, supplemented by data collected during brief periods within the past 2 years. The information in the report is basic to an understanding of the occurrence and characteristics of the county's water resources and to their wise use and management.

The investigation was made in cooperation with the Spartanburg County Planning and Development Commission, Mr. Richard E. Tukey, 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 March 1966 to November 1967. Discharge measurements were made at 60 sites on several occasions to provide data on the amount of water available for use. At each site the chemical characteristics of the water were determined by field measurements, and samples were collected on three occasions at many of these sites for chemical analysis in the laboratory. Information concerning the physical characteristics of wells was obtained from owners and well drillers, and water samples from wells and springs were collected for chemical analyses at intervals throughout the study. These data were needed to supplement those obtained during previous statewide studies. Additional samples of water were collected from wells selected as representative of different geologic formations. Either a partial analysis was made in the field or a complete chemical analysis was made in the laboratory for each sample collected. The available geologic maps were considered adequate for evaluating the general hydrogeologic data.

Previous Investigations

Previous investigations of surface-water resources of Spartanburg County have been limited to the collection of streamflow and water-quality data at a few selected sites. No previous ground-water investigations have been made exclusively in Spartanburg County. Previous ground-water reports (Siple, 1946; Koch, 1968) include basic data and interpretation concerning the geohydrology of this county as part of reconnaissances of larger areas. Wyrick (1968) included Spartanburg County as part of Sub-Region D (North Carolina, South Carolina and Georgia) in an evaluation of the maximum development of ground-water resources in Appalachia.

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 63.

Table 1.--Summary of climatological data at Spartanburg, S.C., 1931-60

(Data from published records of U.S. Weather Bureau)

	Temperature (°F)			Precipitation (inches)		
	Mean	Highest	Lowest	Maximum[1/]	Minimum[1/]	Average
Jan......	43.6	80	5	7.85	1.40	4.27
Feb......	45.0	78	3	8.80	1.06	4.00
Mar......	51.0	87	13	10.33	2.02	4.60
Apr......	60.8	90	28	9.79	.98	3.98
May......	69.6	98	39	5.42	.15	3.22
June.....	77.4	105	51	5.09	1.14	2.95
July.....	79.1	103	55	9.84	1.60	4.36
Aug......	78.1	101	55	8.92	.89	4.32
Sept.....	72.6	101	41	9.43	.13	3.90
Oct......	62.4	95	29	9.55	.22	3.36
Nov......	51.1	83	11	9.17	.52	2.87
Dec......	43.5	78	9	7.26	.69	3.82
Annual	61.2	105	3	10.33	.13	45.65

1/ 1940-60

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. For example, SP-1 indicates the first well inventoried in Spartanburg County.

Plate 1 shows the locations of surface-water sites and 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. The cooperation and assistance of individual well owners is also acknowledged. In addition, well drillers and well-drilling companies, including Willis S. Gowan, Robbins Brothers, Inc., and Harold Lee provided information from their records concerning wells drilled within the area. This information was particularly useful in the description and evaluation of ground-water characteristics of Spartanburg County.

GEOGRAPHY

The water resources of a region are related to climate, topography, drainage pattern, and geology. The amount of precipitation in an area, which varies seasonally and yearly, directly affects the amount of streamflow and the amount of water stored in ground-water bodies. As water moves over the land surface, the rate of flow depends on such factors as surface slope, soil type, and vegetation. The areal distribution of streams is influenced by topography, and their drainage patterns give an indication of the nature of the underlying strata. Geologic characteristics affect the availability and quality of water that seeps into the ground and, to a large extent, determine the low flow of streams.

Location and Extent of the Area

Spartanburg County occupies an area of 830 square miles in northwestern South Carolina. It is bounded on the west by Greenville County, on the south by Laurens County and the Enoree River, and on the east by Cherokee and Union Counties. On the north, it is bounded by the North Carolina State line.

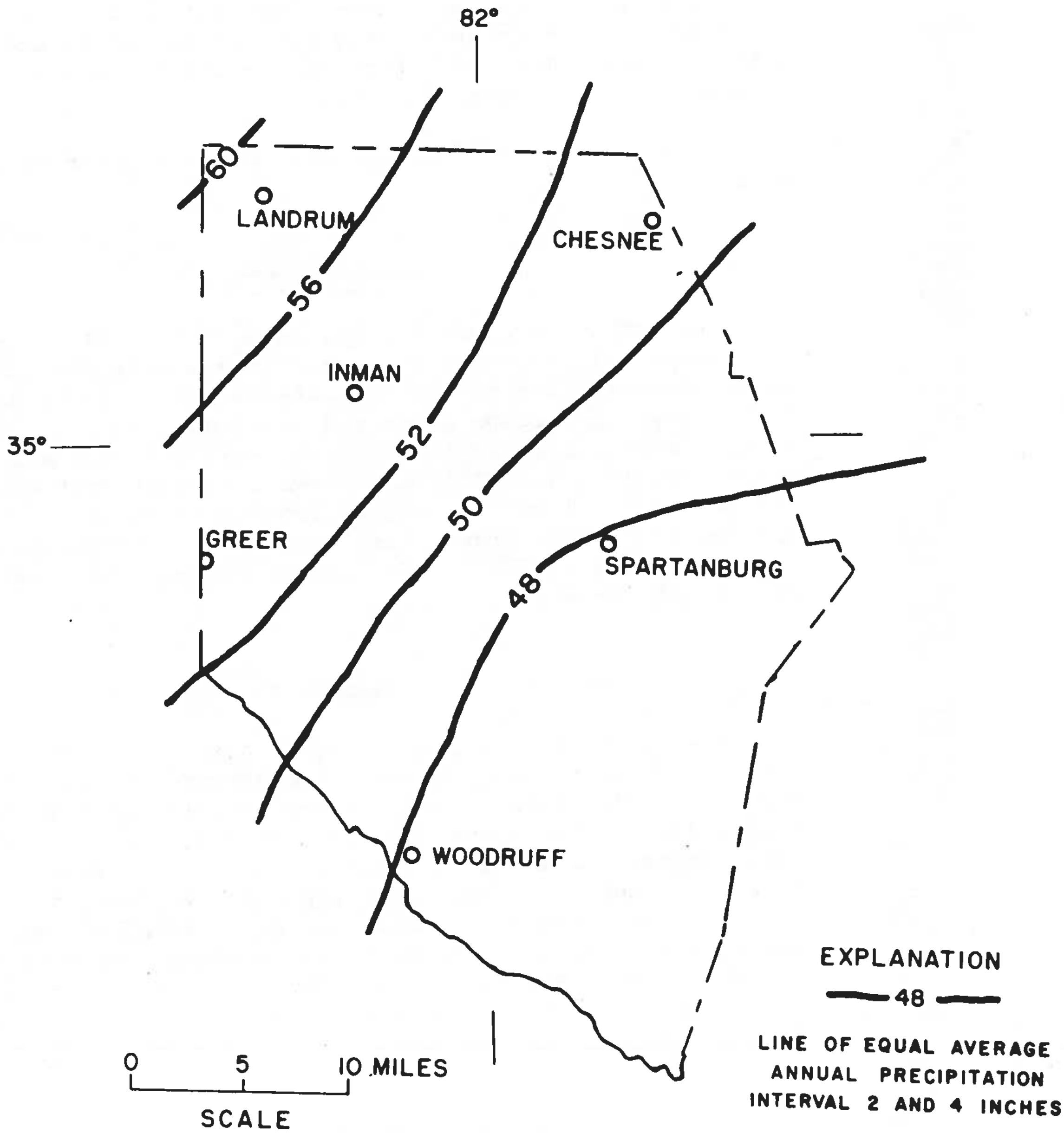


Figure 1.--Distribution of average annual precipitation in Spartanburg County (extracted from map prepared by State Climatologist based on period 1935-64)

Topography

Spartanburg County lies just southeast of the Blue Ridge Mountain in the Piedmont province, which is characterized by subdued topographic features and moderate relief. The land surface is inclined so that elevations exceed 1,000 feet in the northwest section of the county but decrease to less than 600 feet in the southeast. The hills have a well-rounded appearance with no conspicuously prominent ridges or peaks. Valley floors are generally about 100 feet deep with well-developed water courses. There are few swamplike areas.

Climate

A humid, temperate climate characterizes the area. Spartanburg County is located on the lee side of the mountains, which provide protection from the cold air masses that move southeastward during the winter. At Spartanburg, temperatures usually are between $32^{\circ}F$ and $90^{\circ}F$ for 8 months of the year; the average daily temperature for the county is about $60^{\circ}F$. Table 1 shows temperature and precipitation extremes at the U. S. Weather Bureau station at Spartanburg.

Figure 1 shows the rainfall-distribution pattern in Spartanburg County. Average annual rainfall is about 50 inches--an amount that exceeds the national average by 20 inches. Rainfall is usually well distributed throughout the year. Depending upon location, accumulations may vary from 30 inches in a dry year to over 80 inches in a wet year. Figure 2 illustrates variability of annual rainfall at Rainbow Lake adjacent to South Pacolet River Reservoir. For example, it is probable that an average yearly precipitation of 35 inches at Rainbow Lake will occur once in 20 years, and equally probable that an average precipitation of 67 inches will occur once in 20 years. Snowfall adds little to the annual precipitation. Average annual snow, most of which falls in two or three minor storms, is 3.7 inches per year at Spartanburg.

Evaporation and transpiration of plants reduce the amount of water available for man's use. In Spartanburg County more than half the average annual precipitation is returned to the atmosphere each year by evaporation and the transpiration of plants. The combined effect, evapotranspiration, is greatest during the warm growing season.

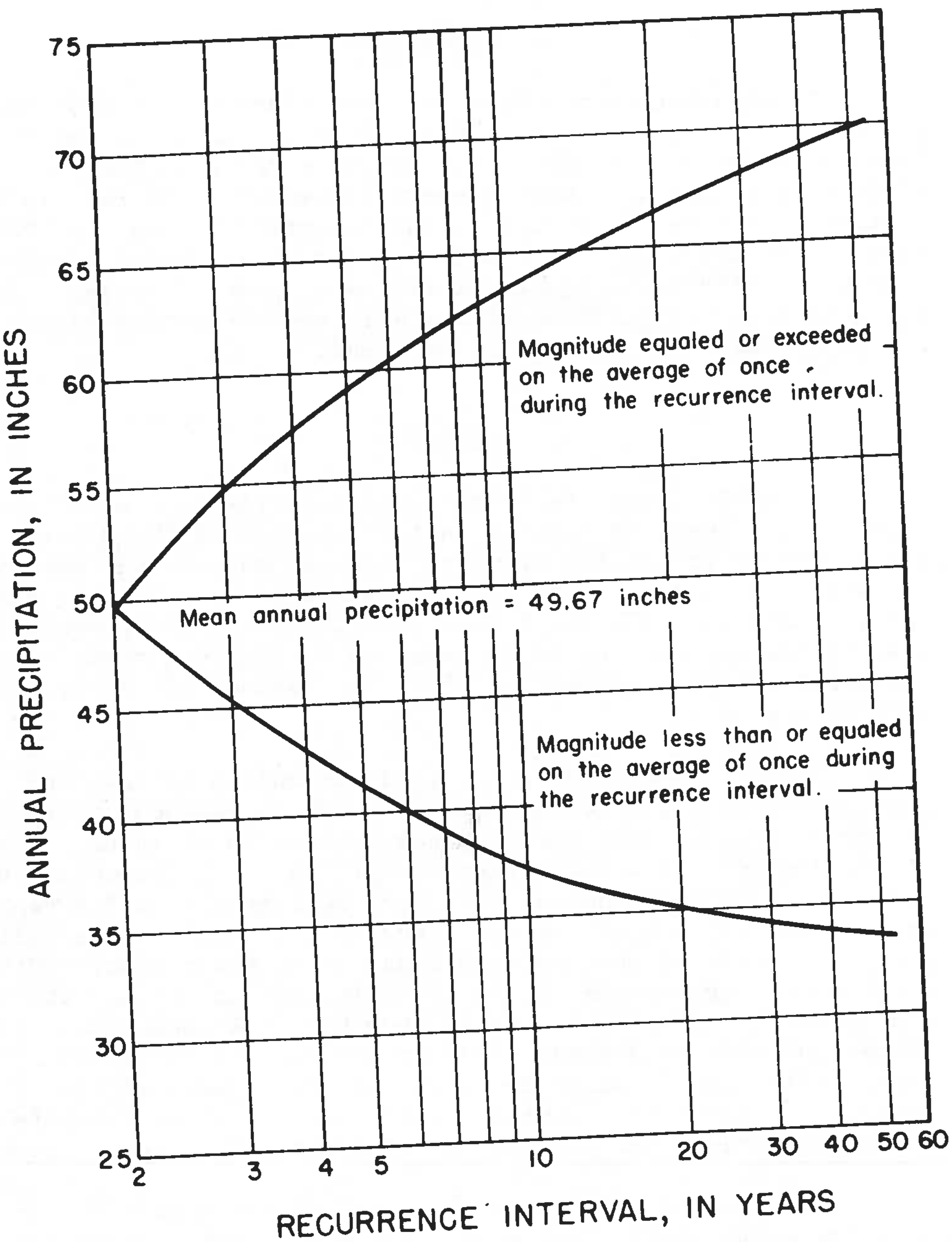


Figure 2.--Magnitude and frequency of mean annual precipitation at Rainbow Lake, based on period 1931-60

Water loss by evaporation from a body of water depends on many factors and it may exceed precipitation. Since 1965 the U. S. Weather Bureau has recorded the daily evaporation at Rainbow Lake. The average yearly evaporation rate is about 48 inches and monthly rates vary from less than 1 inch during the winter to more than 7 inches in the summer.

Currently about 1 inch of rainfall sustains all of man's municipal and industrial water requirements in Spartanburg County.

Drainage

Spartanburg County extends into three parallel drainage basins. (See fig. 3.) Consequent or trunk streams in this area resulted from the initial tilt of the land surface, and streamflow is toward the southeast at a general slope of about 15 feet per mile. Described as in a youthful stage, in geologic terms, the streams are capable of carrying all the sediment load from the tributaries and are in the process of deepening their channels. Rapids form where the rocks are particularly resistant to erosion, and narrow flood plains at some locations indicate that the streams are approaching an early stage of maturity. Figure 4 shows the relation of stream length to drainage area in Spartanburg County. About 3.5 square miles of the basin are drained for each mile in length along a mainstem.

One measure of natural drainage development is drainage density or the ratio of the total length of streams in a basin to the drainage area of the basin. In Spartanburg County, the ratio is estimated to be about 1.5 miles per square mile, indicating a fairly wide spacing of stream channels and a relatively long overland travel of surface water.

The tributary stream patterns are dendritic, or treelike, because there is little variation in the resistance of the rock structure to influence the direction of flow. Slopes of tributary streams are greater than those of mainstems, and their juncture with larger streams is usually at right angles. The total length of tributaries is about five times that of the mainstems.

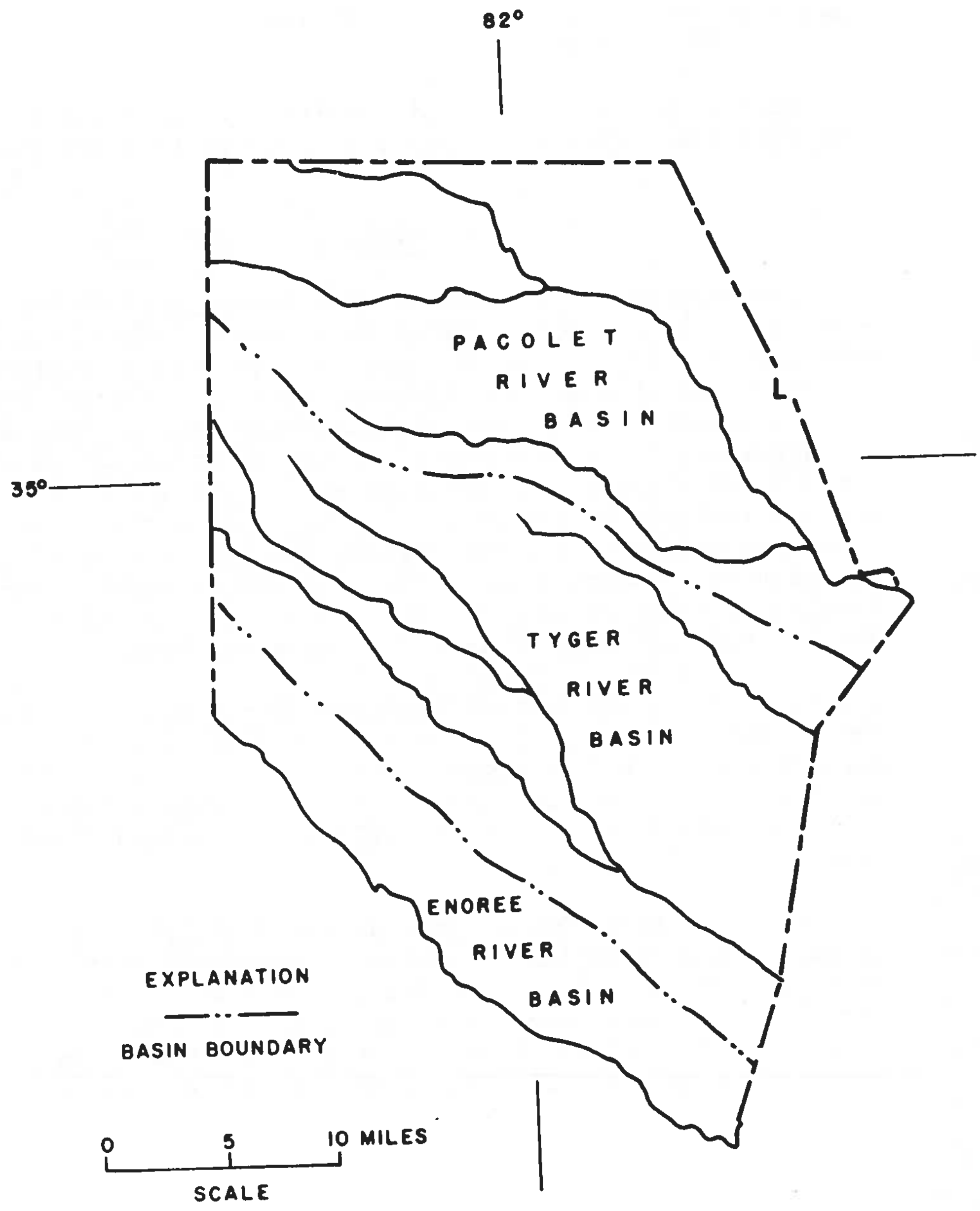


Figure 3.--Major drainage basins of Spartanburg County

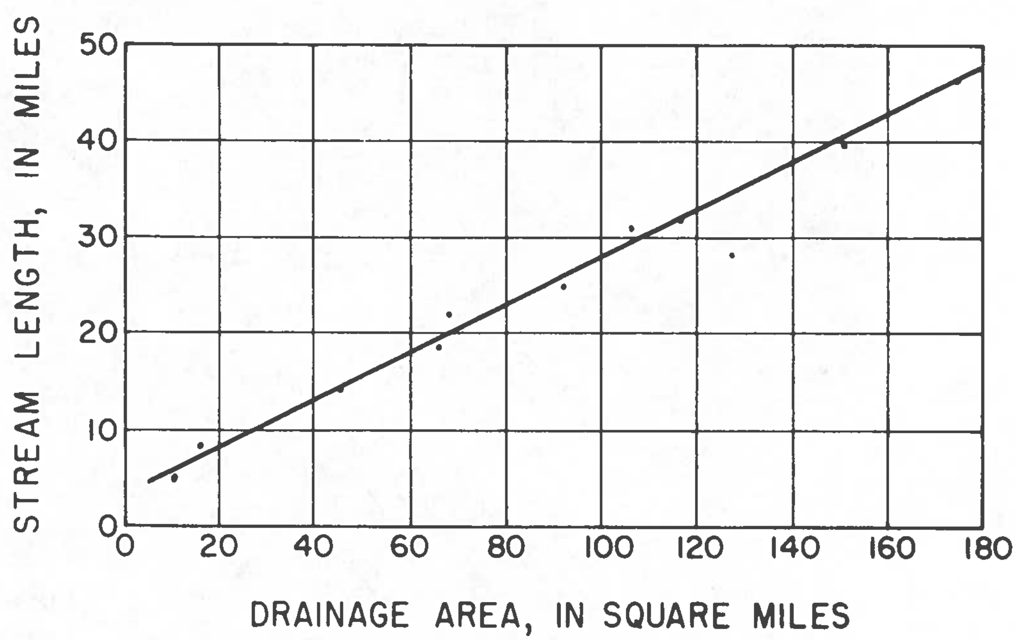


Figure 4.--Relation between drainage area and stream length in Spartanburg County

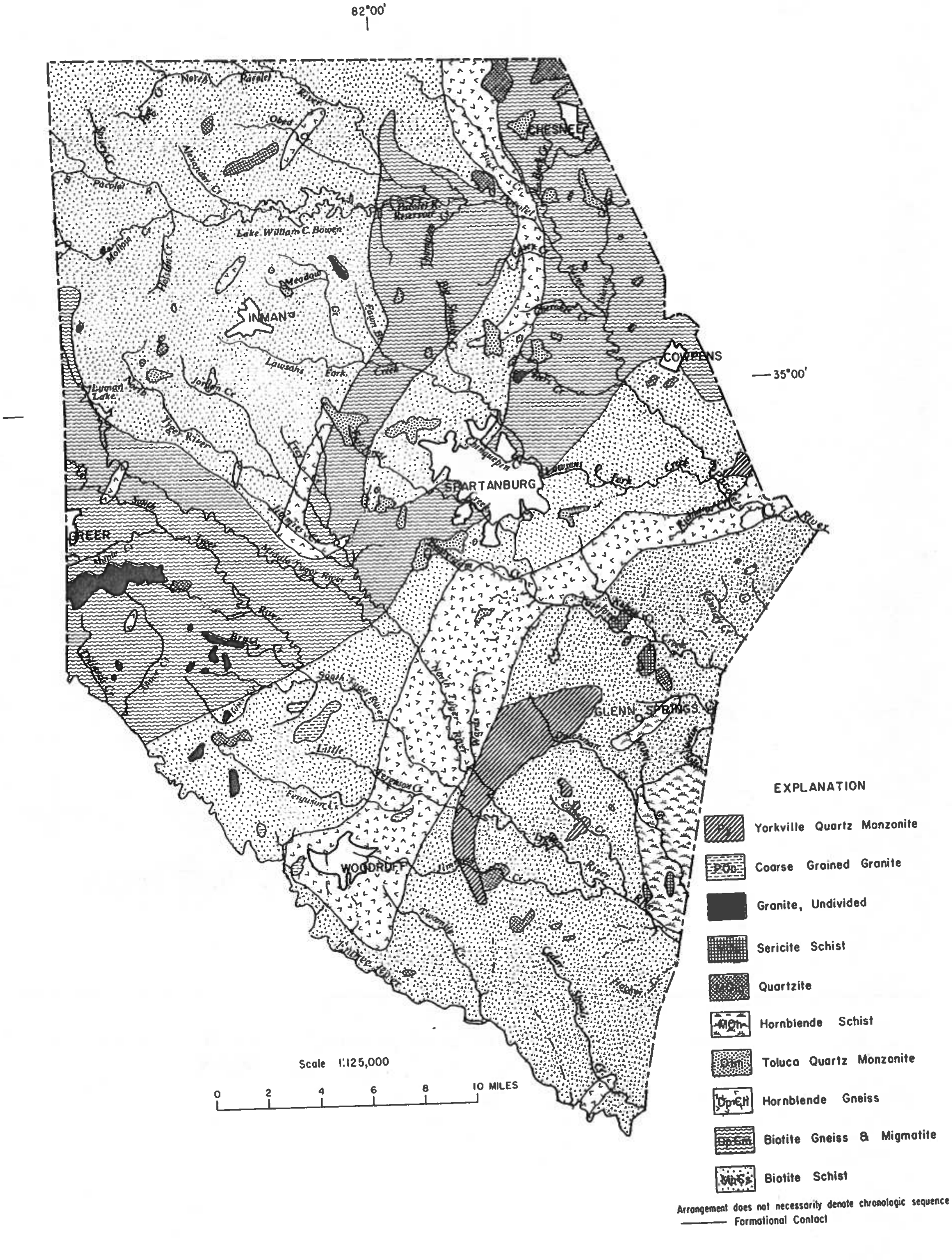


Figure 5.--Geologic map of Spartanburg County (adapted from Overstreet and Bell, 1965a)

Geology

Nearly all of Spartanburg County, except for some small areas in the southeastern part bordering Union County, lies within the Inner Piedmont belt, a major sub-division of crystalline rocks in the Piedmont province (King, 1955). The small area in the southeastern part of the county contains rocks typical of the Kings Mountain belt. The Inner Piedmont belt includes metamorphic rock types such as biotite gneiss, biotite schist, quartzite, hornblende gneiss, and other rocks of gabbroic nature. The Kings Mountain belt is characterized by the presence of sericite schist, hornblende schist, quartz monzonite, and minor amounts of quartzite and marble (King, 1955).

The geologic belts east of the Brevard belt (a narrow strike-slip fault zone separating the rocks of the Inner Piedmont belt from those of the Blue Ridge belt) are distinguished principally by modifications of the original sedimentary rocks by folding, regional metamorphism, and igneous intrusion (Overstreet and Bell, 1965b, p. 16). As such, they represent metamorphic zones superimposed on a regional stratigraphic sequence.

Intrusive rocks, in addition to the monzonite, include unnamed granites, mafic dikes, muscovite-pegmatite dikes, and fine-grained diabase dikes.

Over much of the county, the hard crystalline rock has weathered to a soft clayey or sandy material (saprolite), which maintains many of the original rock structures and extends from ground surface to depths of as much as 140 feet.

A geologic map of Spartanburg County, figure 5, has been adapted from Overstreet and Bell (1965a). Some recent modifications not shown include a fairly significant plutonic body southwest of Pacolet and a manganese-rich zone delineated along the east boundary of Croft State Park (Henry Bell, III, oral commun., 1969).

Population

About 75 percent of the county's total population of about 165,000 is concentrated in the central part, which includes the city of Spartanburg and other urban and manufacturing centers. In recent years, economic factors have caused a movement to urban localities, but much of the county remains rural. The northern section, with thriving peach farms, supports about 15 percent of the total population, whereas the southern section is generally thinly populated and of diminished agricultural activity.

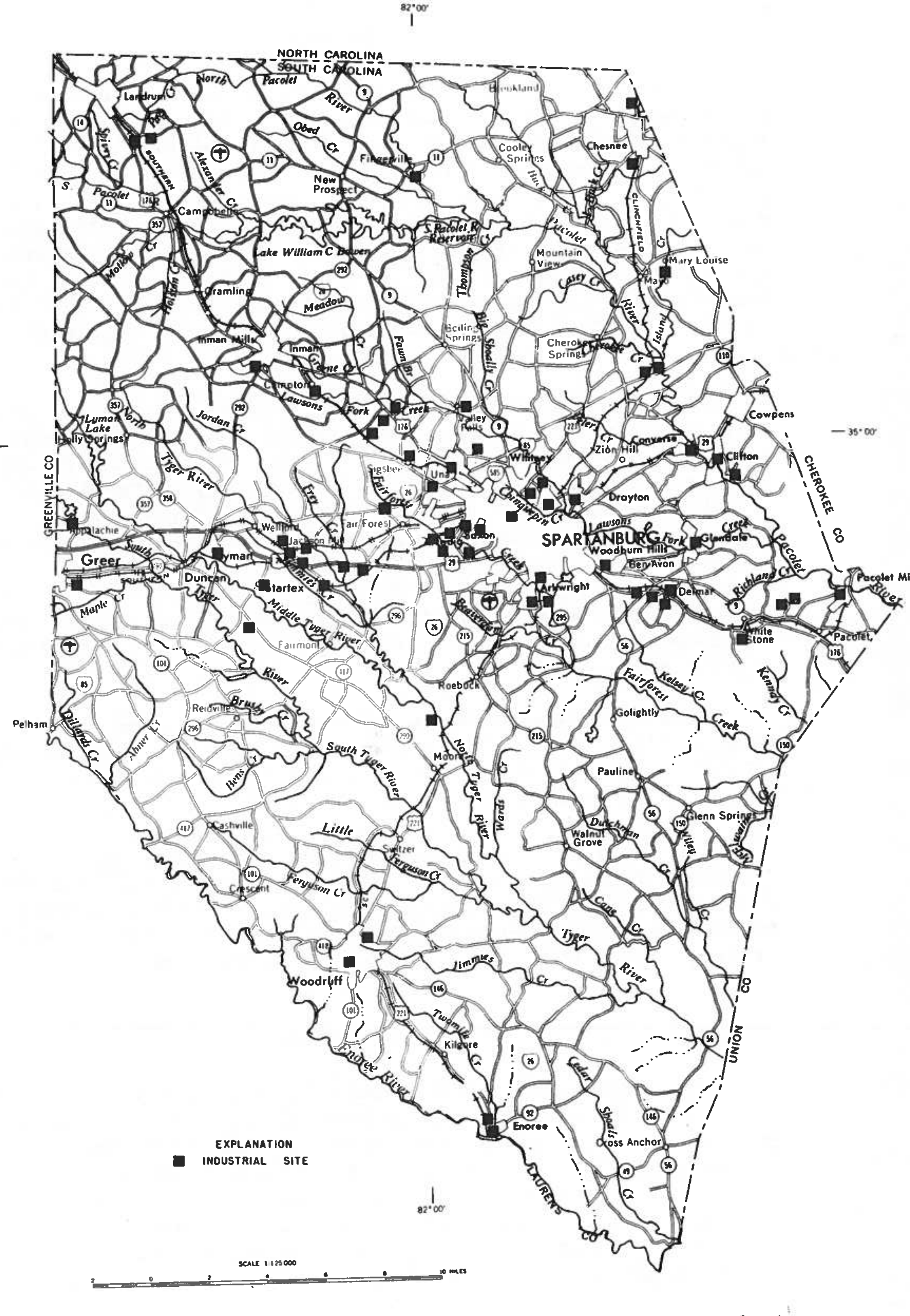


Figure 6.--Distribution of major industries in Spartanburg County.

Industrialization

Geographical distribution of major industrial developments is shown in figure 6. Industries in Spartanburg County are predominately textile, but machinery, paper product, chemical, and fabricated-metal industries are a diverse development. All the major streams yield water supplies to industries.

CURRENT UTILIZATION OF WATER

Sources of Supply

Streams and lakes supply about 95 percent of the water for industrial and domestic use. The current daily demand for surface water is about 33 mgd, a large part of which comes from reservoirs on the South Pacolet River. Treated water is distributed by the Spartanburg Water Works to the shaded areas shown in figure 7. Withdrawal of water from the South Pacolet River has nearly doubled since 1958. The average daily flow from the treatment plant is about 20 million gallons (fig. 8) which serves nearly two-thirds of the total population and about half of the industries.

The combined yield of the major streams offers a potential many times greater than is presently used. Yet, the withdrawal from any specific stream is comparatively small, with the exception of that from the South Pacolet River and about 8 mgd from Middle Tyger River. Future water-supply developments, particularly those involving industrial use, are certain to include an increased withdrawal from the larger streams and utilization of water from the tributaries.

Ground-water supply is largely a function of subsurface composition. Consolidated rocks and overlying weathered material are the most commonly used aquifers in the region. The supply of water from wells penetrating these formations is reliable but may be limited by the capacity of the aquifer to store and transmit large quantities.

About 5 percent of the total volume of water used comes from wells; however, almost one third of the population, scattered over a widespread area, is dependent on this source of supply. Industrial use of ground water is generally confined to the older textile communities, where usual water requirements are met by wells yielding less than 100 gpm.

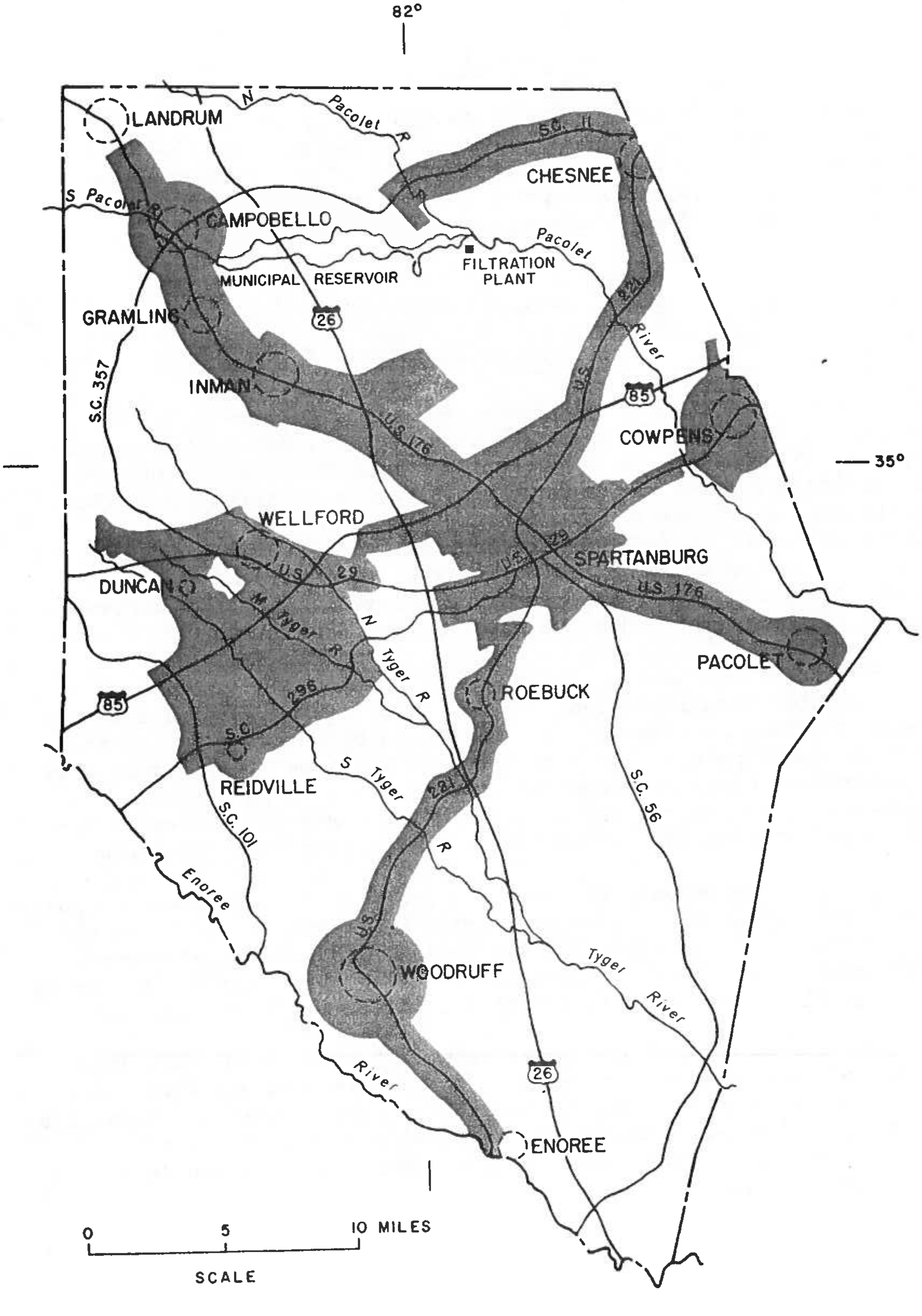


Figure 7.--Areas presently served by Spartanburg Water Works

Quantity Used

The volume used in Spartanburg County is hardly perceptible in terms of the amount of water available. The annual withdrawal of about 35 mgd from lakes, streams, and wells is less than 5 percent of the county's average streamflow. The principal water users are listed in appendix table 5.

Industry requires an average of nearly 20 mgd, about 60 percent of all water used. Among the individual industries, daily use ranges from 700 to more than 7 million gallons. Each of 12 industries withdraw in excess of 0.30 mgd. The textile industries, as a group, require the most water--about 13.5 mgd, or two-thirds the industrial demand. Power generation by one steam-electric plant is not a significant factor in water use.

The following data indicate that a larger volume of water is used by self-supplied industry than by those dependent on a public-supply system. As a general rule, the older industries have their own sources of supply, which are adequate to meet the usual requirements of less than 0.1 mgd. Several other self-supporting industries, such as Lyman Printing and Finishing Company, withdraw water from streams in far greater amounts.

Direct Source	Industrial (mgd)	Municipal (mgd)	Rural (mgd)
Public-Supply System	9.0	11.0	-1/
Streams	10.0	1.5	-2/
Wells	1.0	.5	2.0
Total	20.0	13.0	2.0

1/ Served by Water Districts supplied by Spartanburg Water Works and included in municipal use.

2/ Negligible.

New industries with very large water requirements will probably remain dependent, to some extent, on self-supply. On the other hand, development of more moderate individual water supplies has apparently been minimized by the extension of the public-supply system.

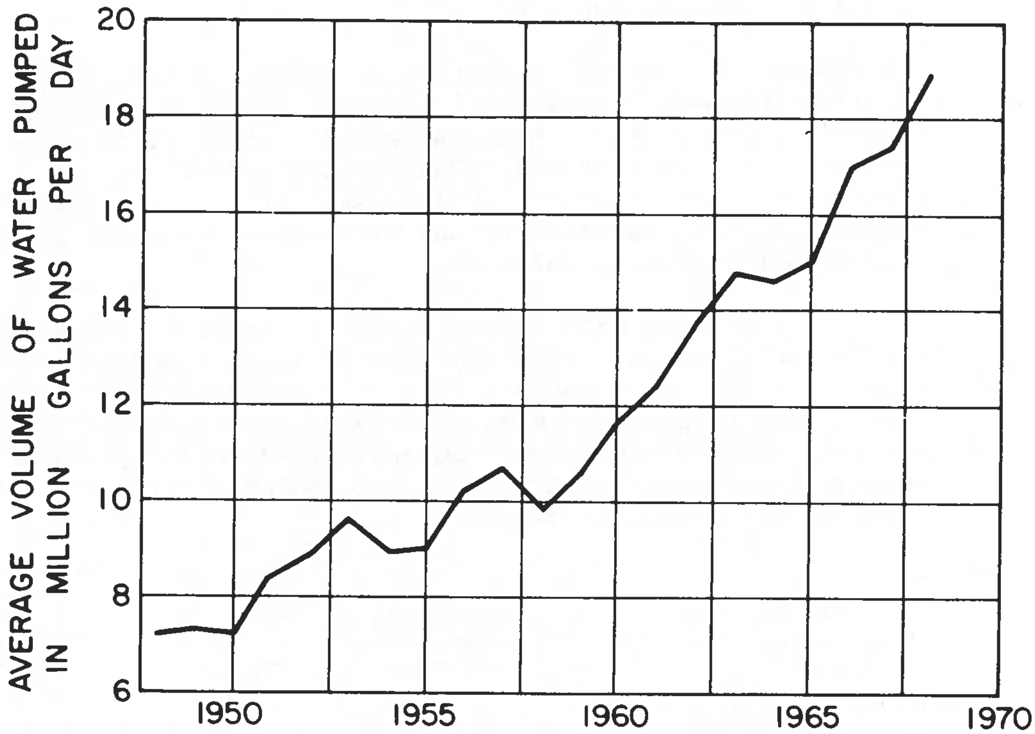


Figure 8.--Volume of treated water pumped by Spartanburg Water Works

Industries using water from public-supply systems[1/] are numerous and diverse. Average daily use is about 0.20 million gallons, with a range of from one-tenth to 10 times this amount among individual users.

The volume of water consumed (unavailable for further use) in industrial processes has not been determined, but it probably does not exceed 1 percent of the total amount withdrawn.

About 15 mgd of water is used for public supply. Based on county population (165,000), per capita use is about 90 gpd (gallons per day). About 50,000 self-supplied rural inhabitants, however, used about 40 gpd each. The remainder, 7 of every 10 persons in the county, utilizes a public supply. Because domestic use varies according to population density, the gradation in per capita requirements ranges from 50-60 gpd for rural areas to 60-70 gpd for small towns to about 120 gpd for municipalities.

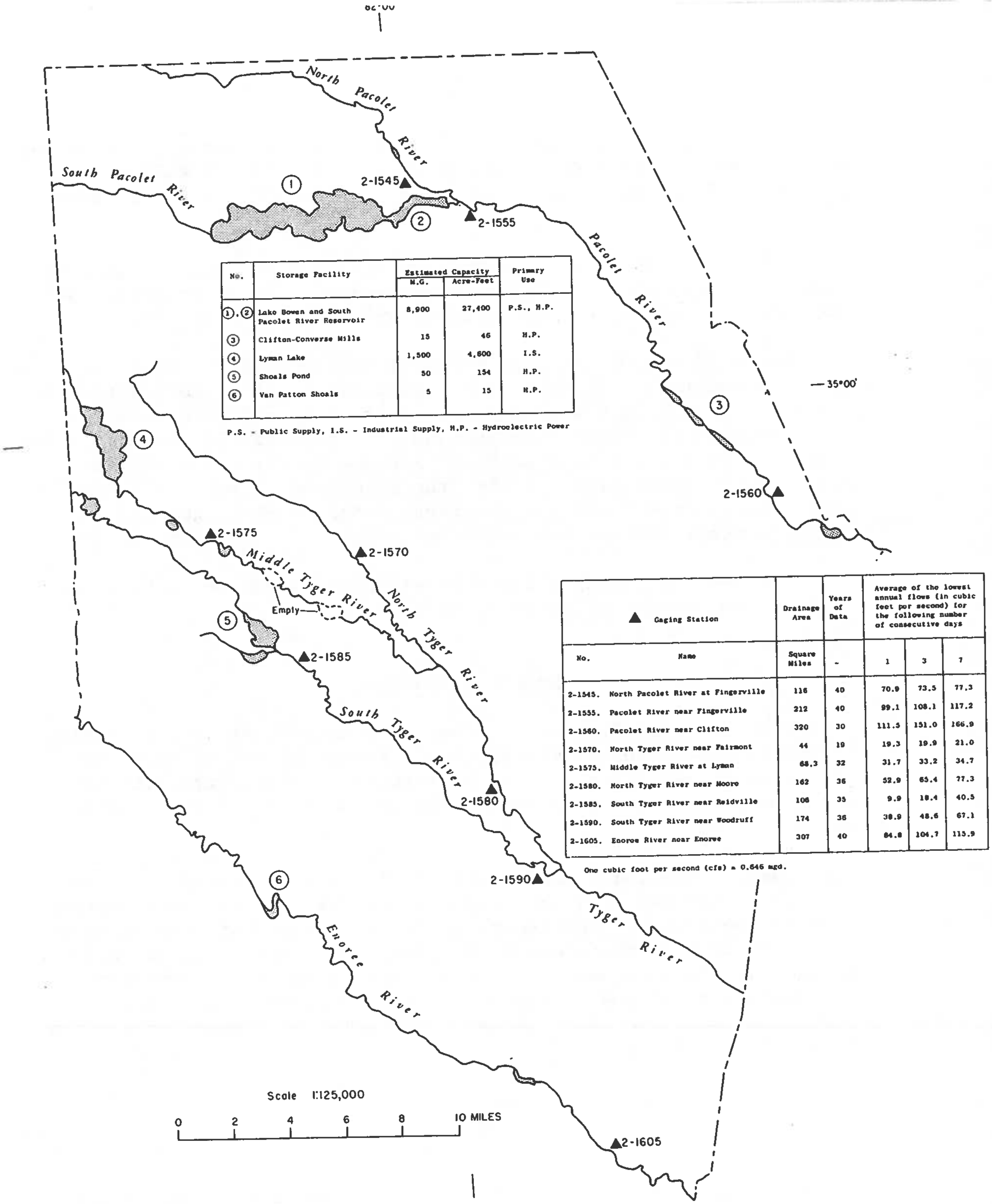
One average industry's use of water is enough to sustain the normal requirements of about 5,000 persons.

Stream Development

The use of surface water alters the natural streamflow regimen by diverting or storing water. Man's temporary use of water has only a small net effect in terms of total availability, although daily regulation is quite noticeable on the flow pattern of some streams.

Lakes, when full, contain about 11.0 billion gallons (33,800 acre-feet) or less than one-twentieth of the average annual streamflow of the county. Reservoirs on the South Pacolet River account for 75 percent of the storage, exerting the largest single influence on water control and use. Overall, total capacity is governed by the small size of most structures and the degree of siltation, particularly of the older lakes. The following summarizes surface-water storage by basin:

1/ Nearly 40 percent of the output of the Spartanburg Water Works is used by industries at present.



No.	Storage Facility	Estimated Capacity		Primary Use
		M.G.	Acre-Feet	
1, 2	Lake Bowen and South Pacolet River Reservoir	8,900	27,400	P.S., H.P.
3	Clifton-Converse Mills	15	46	H.P.
4	Lyman Lake	1,500	4,600	I.S.
5	Shoals Pond	50	154	H.P.
6	Van Patton Shoals	5	15	H.P.

P.S. - Public Supply, I.S. - Industrial Supply, H.P. - Hydroelectric Power

▲ Gaging Station		Drainage Area	Years of Data	Average of the lowest annual flows (in cubic feet per second) for the following number of consecutive days		
No.	Name	Square Miles	-	1	3	7
2-1545.	North Pacolet River at Fingerville	116	40	70.9	73.5	77.3
2-1555.	Pacolet River near Fingerville	212	40	99.1	108.1	117.2
2-1560.	Pacolet River near Clifton	320	30	111.5	151.0	166.9
2-1570.	North Tyger River near Fairmont	44	19	19.3	19.9	21.0
2-1575.	Middle Tyger River at Lyman	68.3	32	31.7	33.2	34.7
2-1580.	North Tyger River near Moore	162	36	52.9	65.4	77.3
2-1585.	South Tyger River near Reidville	106	35	9.9	18.4	40.5
2-1590.	South Tyger River near Woodruff	174	36	38.9	48.6	67.1
2-1605.	Enoree River near Enoree	307	40	84.8	104.7	115.9

One cubic foot per second (cfs) = 0.646 mgd.

Figure 9.--Major streams development and data showing effect on streamflow.

River basin	Estimated storage capacity		Storage capacity as a percentage of average annual basin streamflow
	Million gallons	Acre-Feet	
Pacolet	8,940	27,500	6.10
Tyger	1,600	4,910	.13
Enoree	10	30	.01

Effect on Streamflow

Artificial patterns of streamflow are the result of upstream lake or reservoir operation. Generally, the regulation is of two types in Spartanburg County--either maintaining a constant discharge, from storage, during periods when the natural flow may fall below a certain magnitude or releasing water during specified periods of the day for power generation.

Most of the larger streams support one or more storage facilities or exhibit the effects of regulation. Lakes that have some influence on the natural flow are shown in figure 9, with a partial listing of gaging-station data for comparison. The data represent the condition of no surface runoff, and the flow is either natural or is influenced by release from storage. The degree of stream regulation by controlling structures is shown, to some extent, in the relation between consecutive-day flows. A large difference between the average 1- or 3-day flow and the 7-day values indicates a reduction in streamflow, probably on weekends, to replenish reservoir storage. Conversely, little or no regulatory pattern occurs (at the gaging station) when a small difference in the three values is shown. All lakes except Bowen and Lyman and South Pacolet River Reservoir have insufficient capacity to affect monthly streamflow values.

A comparison between natural flow and that sustained from lake storage during periods of normally decreasing flow is made in figure 10. The two curves, based on gage records of Middle Tyger River at Lyman, relate the annual minimum flows for 7 consecutive days to recurrence intervals. To illustrate, prior to Lake Lyman's construction (Sept. 1955), an annual minimum 7-day flow of not more than 20 cfs or 12.9 mgd could be expected to occur at average intervals of 5 years. Augmenting the low flow from lake storage has, in effect, reduced the frequency1/ of the same flow occurring to average intervals of 9 years.

1/ The division of one period of record into two for comparative purposes should be qualified by the possibility that climatic differences during the periods can exert some influence on the relative position of the curves.

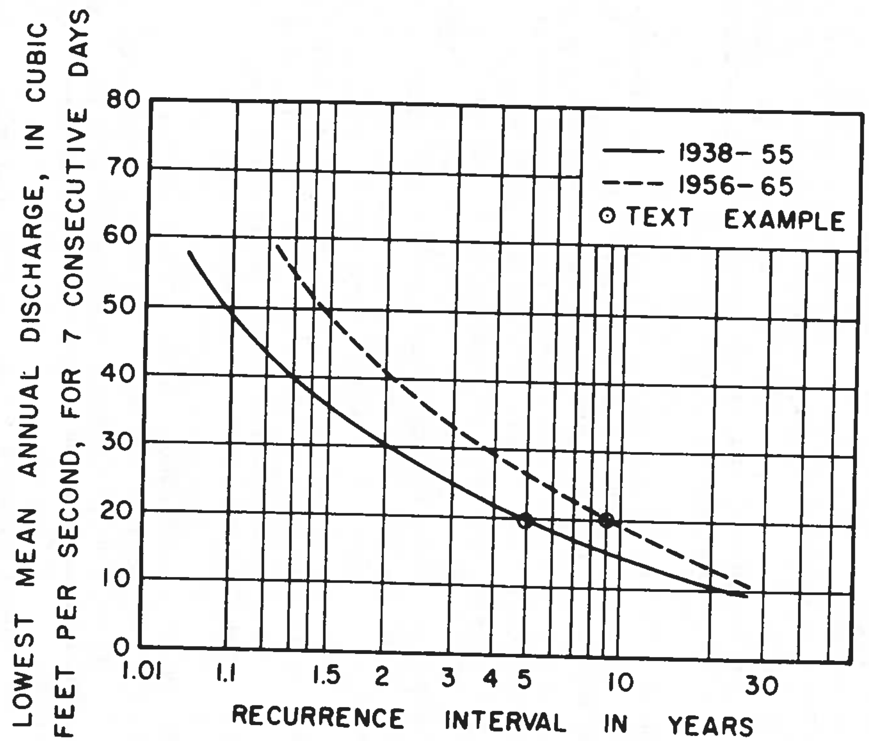


Figure 10.--Change in magnitude and frequency of annual minimum 7-day flow by regulation on Middle Tyger River

The prevalent type of stream regulation in the county, which results in rapid fluctuations of streamflow, is associated with a daily manipulation of the release of water from storage. For instance, in the generation of power at Shoals Pond, on the South Tyger River, capacity only about one-tenth of one percent of the average annual streamflow, the volume of outflow may vary by 10 times within a day. Streamflow regulation at other sites is less extreme but difficult to generalize because of the difference in the determining factors of storage capacity, volume of inflow, and gate operation (generation schedule).

The regulatory pattern becomes diminished as the flow proceeds downstream. The combined effects of channel storage, tributary inflow, and ground-water contribution are evident in comparing the relative values (in fig. 9) of the 1, 3, and 7-day minimum flows at South Tyger near Reidville with those at Woodruff, for example.

Diversion

When water is diverted from a stream, the natural flow characteristics undergo a change. As with regulation, diversion becomes more significant during dry periods, when the low flow is sensitive to external influence.

In Spartanburg County, the usable supply of water is not affected because the only substantial diversion is from storage of excess streamflow. About 31 cfs (20 mgd) is withdrawn from the South Pacolet River Reservoir by the Spartanburg Water Works. At least 75 percent is released in the vicinity of Spartanburg by treatment plants--east of the city into Lawsons Fork Creek and south of the city into Fairforest Creek. The remainder, excepting losses, is discharged by other population centers and industries where local streams are the recipients.

Diversion for agriculture is neglible because little irrigation is practiced.

Farm Ponds

Tributary streams support about 875 ponds with an average size of 2.5 acres. These small reservoirs are capable of retaining some surface runoff and, to that extent, may produce a change in streamflow characteristics. The location and capacity of storage on an individual tributary is important but, overall, the effect of farm ponds is probably negligible under low-flow conditions. Streams are normally sustained by ground water during these periods.

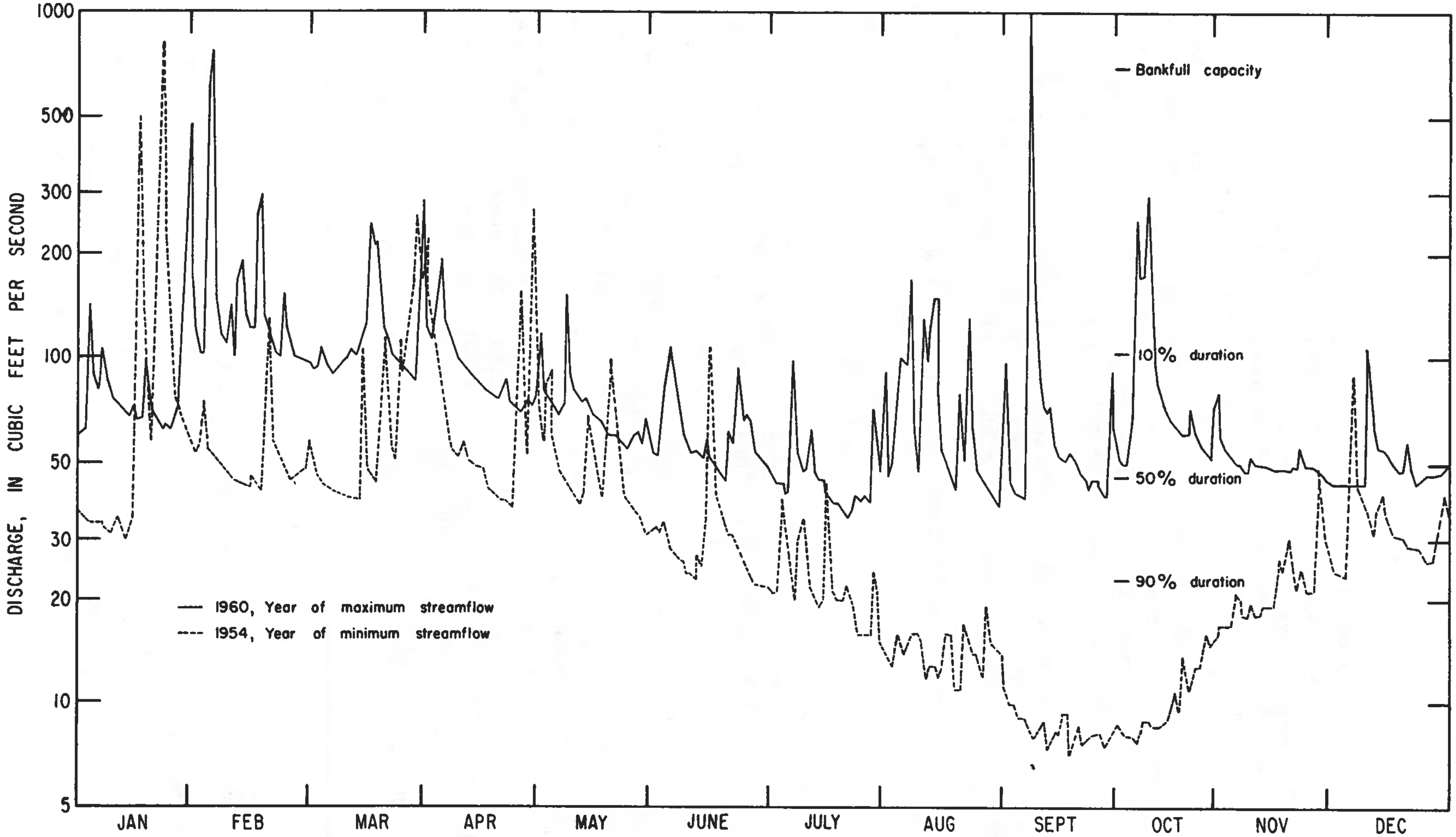


Figure 11.--Hydrograph of daily discharge for North Tyger River near Fairmont

SURFACE WATER CHARACTERISTICS

Total available surface-water resources of Spartanburg County greatly exceed present needs. The mean annual surface-water discharge in the county is about 1,250 cfs (800 mgd) or, about 1.5 cfs (approx. 1 mgd) per square mile. However, streams rarely flow at their average rate because the discharge varies in response to environmental influences. A description of stream behavior is therefore essential to an analysis of surface-water resources.

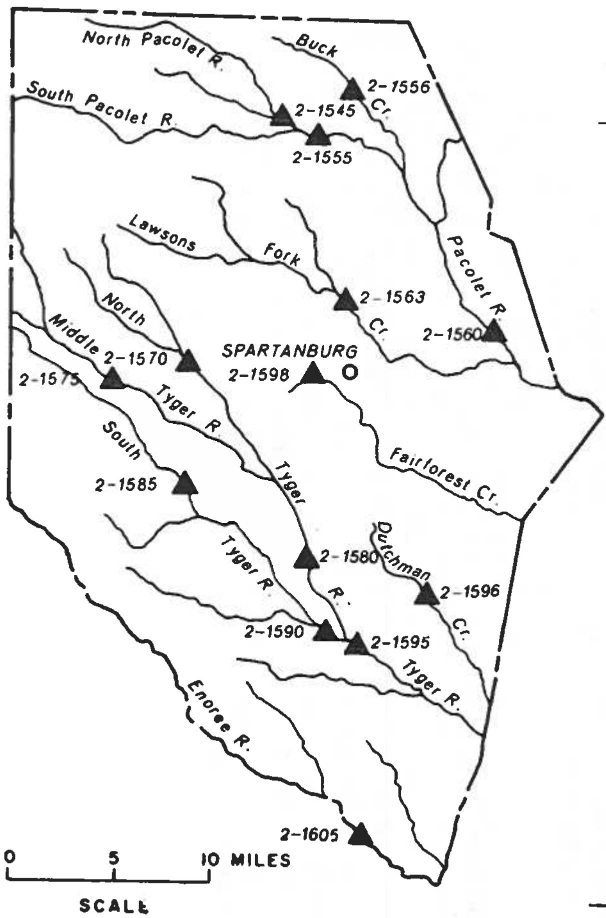
Variation in Streamflow

In Spartanburg County, about 40 percent of the average rainfall becomes streamflow. Mean annual runoff ranges from 26.0 inches at North Pacolet River at Fingerville to 18.5 inches at Enoree River near Enoree--runoff being a combination of intermittent direct surface runoff from rainfall and the inflow of ground water to the stream channel.

Seasonal streamflow behavior is generally characterized by high flow periods in the winter, a recession in late spring, and gradually diminishing low flow during the summer and early fall. The streamflow pattern resembles that of precipitation to some extent, except when modified by evaporation and losses to plant life during the warm growing season. Generally, about 12 percent of the annual discharge occurs in March in comparison with only 5 percent in September.

Yearly variations in streamflow are less predictable than seasonal variations; individual wet or dry years cannot be foreseen because there is little relation to a recurring sequence of events.

A comparison of a high streamflow year with a low streamflow year is shown by the graphical presentation of daily discharge in figure 11. Average runoff exceeded the 18-year mean by 33 percent in 1960, yet, in 1954, runoff was only 70 percent of the mean. The hydrograph for 1954 shows the effect of sparse, poorly distributed rainfall--nearly 20 inches less than in 1960--only 3.75 inches during June-September. In October, increased streamflow is due to a decrease in evapotranspiration rather than to rainfall, which was less than one-fourth inch.



Location	Drainage Area (sq mi)	Maximum Flow (cfs)	Minimum Daily Flow (cfs)	Average Flow (cfs)	Average Runoff (cfs per sq mi)
2-1560. Pacolet River	320	26,800	17	492	1.54
2-1595. Tyger River	351	28,000	29	465	1.32
2-1605. Enoree River	307	30,000	20	418	1.36
2-1555. Pacolet River	212	22,800	32	340	1.60
2-1590. South Tyger River	174	9,510	12	237	1.36
2-1580. North Tyger River	162	12,300	16	233	1.44
2-1545. North Pacolet River	116	12,500	28	207	1.78
2-1585. South Tyger River	106	6,420	5.5	160	1.51
2-1575. Middle Tyger River	68.3	4,800	5.0	103	1.51
2-1563. Lawsons Fork Creek	65.2	2,730	29†	101	1.55
2-1570. North Tyger River	44.0	3,610	7.0	64.0	1.45
2-1598. Fairforest Creek	17.8	2,590	9.1†	29.7	1.67
2-1556. Buck Creek	10.5	3,000	5.8†	19.5	1.86
2-1596. Dutchman Creek	8.97	983	3.5†	10.2	1.14

† Period of record does not include 1954 drought.

Figure 12.--Gage sites and basic streamflow data

The characteristics of a stream are most conveniently determined by continuously monitoring the flow over a period of time. Data collected at gaging stations provide a daily record of streamflow passing the site, and, from such records, estimates of the magnitude and distribution of future flows can be made.

About 75 percent of the county's drainage area is gaged by the network shown in figure 12. The tabulated data are arranged with average flow values in descending order for comparative purposes. Average flows are closely related to the size of the corresponding drainage areas, as shown graphically in figure 13. Mean annual precipitation and basin slope are additional factors that significantly affect average flow. Consequently, highest unit runoff generally occurs on the streams in the northern part of the county, whereas those in the south experience the least, although unit runoff also tends to decrease slightly with increasing drainage area. Direct storm runoff from city street is reflected in the value for Fairforest Creek.

Prediction of Supply

The description of average runoff is a convenient method of summarizing a streamflow record but gives no indication of the variability of the flow. By means of a flow-duration curve, discharge distribution for the period of record is shown. The percentage of time a specific discharge is equaled or exceeded can be predicted when the assumption is made that data were collected over a time period extensive enough to give a reasonable representation of the long-term flow pattern and that no appreciable changes were made in the drainage basin.

Three streams, one each from the northern, central, and southern sections of the county, were selected for their usefulness in portraying representative flow characteristics. The duration curves shown in figure 14 are plotted from data that have been reduced to a common factor, cubic feet per second per square mile, to permit direct comparison.

Common streamflow and basin characteristics are generally indicated by the similarity in the shape of the three curves. The divergence at the extreme lower end is attributed to minor regulation of the Enoree River at low flow rather than to significant geologic differences.

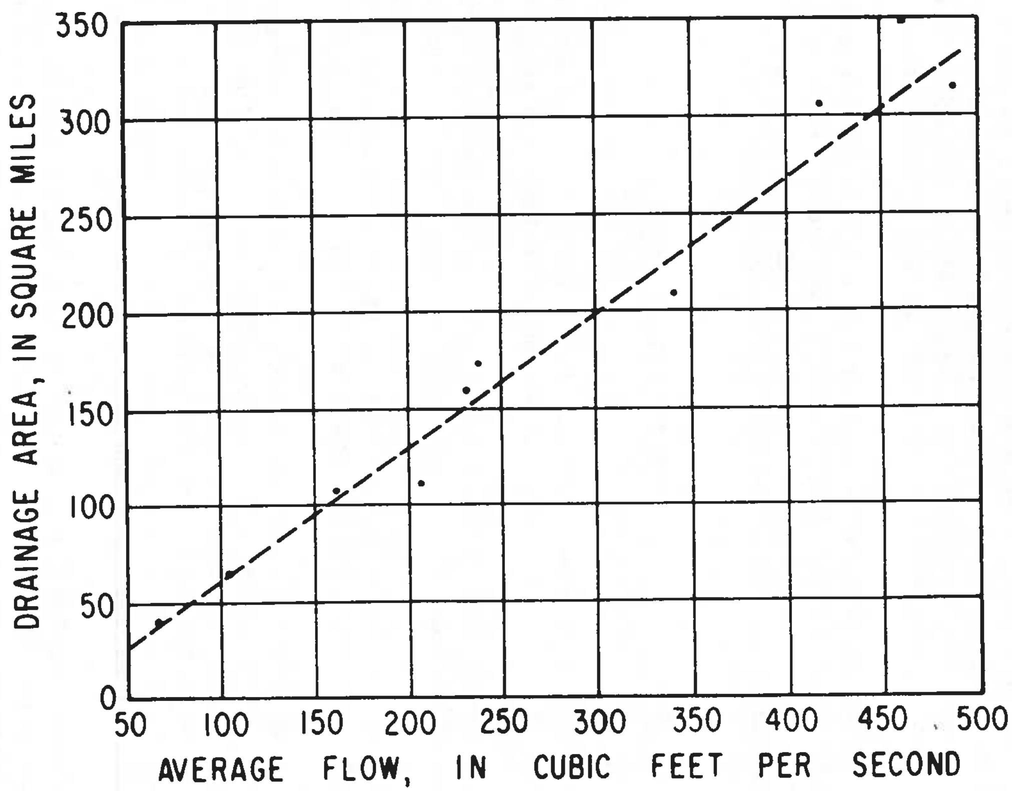


Figure 13.--Average flow-drainage area relationship for streams in Spartanburg County

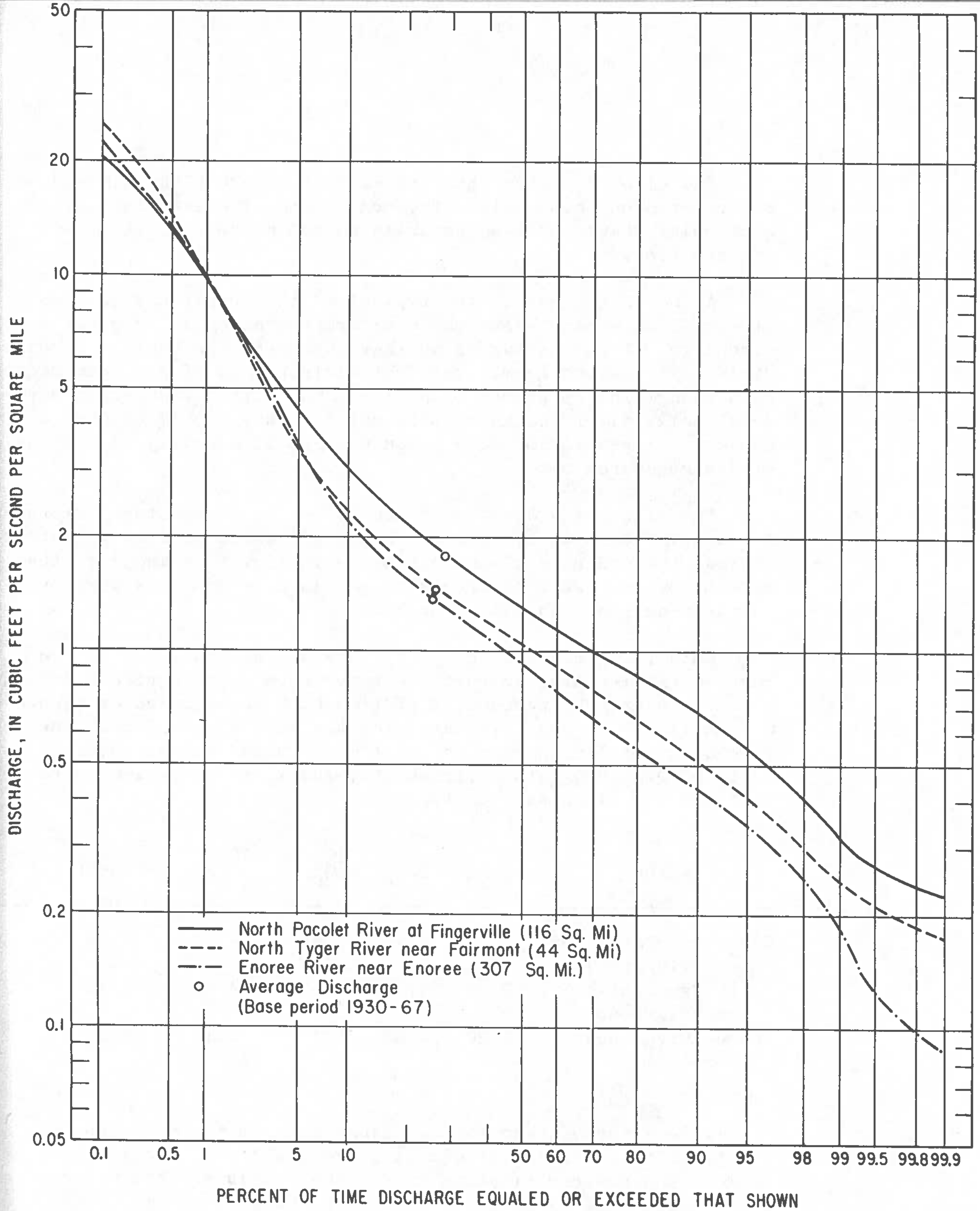


Figure 14.--Duration curves of daily flow for three Spartanburg County streams

The given duration data are valid for 1930-67 and should be interpreted on this basis. The occurrence of events for any particular year do not necessarily resemble the long-term distribution.

Although the curves are typical of the larger unregulated streams in the county and the data are expressed in terms of unit discharge, it is not suggested that each drainage basin has uniform yield. The discharge may vary between segments of a stream because of a change in topography or geology, and stream regulation may drastically alter the shape of a curve. Care should be used in applying flow-duration data to an ungaged site solely on the basis of drainage-area size.

The slope of a duration curve is an index of natural storage. A sharply declining curve denotes a high degree of flow variability, whereas the moderate slopes exhibited in figure 14 indicate that streamflow is sustained from storage, largely ground water, over a fairly wide range in discharge.

Data from the duration curves are summarized below, where Q represents discharge in cubic feet per second per square mile; the subscripts are the percentage of time each was equaled or exceeded; Q mean is the average discharge for the period; and P mean the percentage of time during which it was equaled or exceeded. The ratio of Q_{10} to Q_{90} is a variability index for conveniently relating high and low flows as a unit.

Station	Q_{10}	Q_{50}	Q_{90}	Q_{10}/Q_{90}	Q Mean	P Mean
North Pacolet River near Fingerville	3.02	1.29	0.68	4.44	1.78	29
North Tyger River near Fairmont	2.31	1.04	.52	4.45	1.45	27
Enoree River near Enoree	2.20	.92	.43	5.11	1.36	26

Values for Q_{10} and for Q_{90} decrease from the northern part of the county to the southern, indicating, generally, the parallel relation to mean annual precipitation and to the subsurface contribution of streamflow. The variability index increases in the same direction, offering some evidence that natural streamflow in the southern part of the county exhibits more variability.

Flow-duration curves do not show frequency of occurrence. In figure 14, the fact that discharge at the North Pacolet River station has dropped to 0.68 cfs per square mile or less 10 percent of the time means that, on an average, this has occurred 36 days per year but does not suggest the days were consecutive nor even that a flow of 0.68 cfs per square mile necessarily occurred in some years.

Frequency of Low Flow

Usually, demand for water is greatest when the natural supply is least. Flow-flow characteristics become significant when streamflow, which is derived almost entirely from ground-water storage during prolonged rainless periods, diminishes from natural losses and withdrawals. Predictions of the frequency and magnitude of specific low flows are made by relating lowest average flow for various periods of time with probability of occurrence (actually, the reciprocal of probability--the recurrence interval).

A family of low-flow frequency curves for North Tyger River is shown in figure 15. Each curve represents a continuous period of length, the recurrences are average intervals of time, and the discharge represents annual minimum flow. For example, about every 20 years, on the average, the annual minimum flow for 30 consecutive days can be expected to average no more than 10 cfs.

Low-flow-frequency relations have been computed for other gaging stations in an open-file report of the Geological Survey (Stallings, 1967). The data for Spartanburg County is shown for convenience in appendix table 6. Most of these streams are subject to regulation, and application of the frequency relations should be based on the assumption of little change in the previous regulatory pattern.

The lowest average discharge for 7 consecutive days is often utilized as an annual minimum because the effect of diurnal fluctuations and the disproportionate influence of unusual short-term events are minimized. Low-flow frequency curves for the three representative streams are plotted in figure 16, with the discharge reduced on a unit drainage-area basis for direct comparison of the streamflow characteristics. A summary, given below, shows selected annual minimum 7-day flows in cubic feet per second per square mile for indicated recurrence intervals.

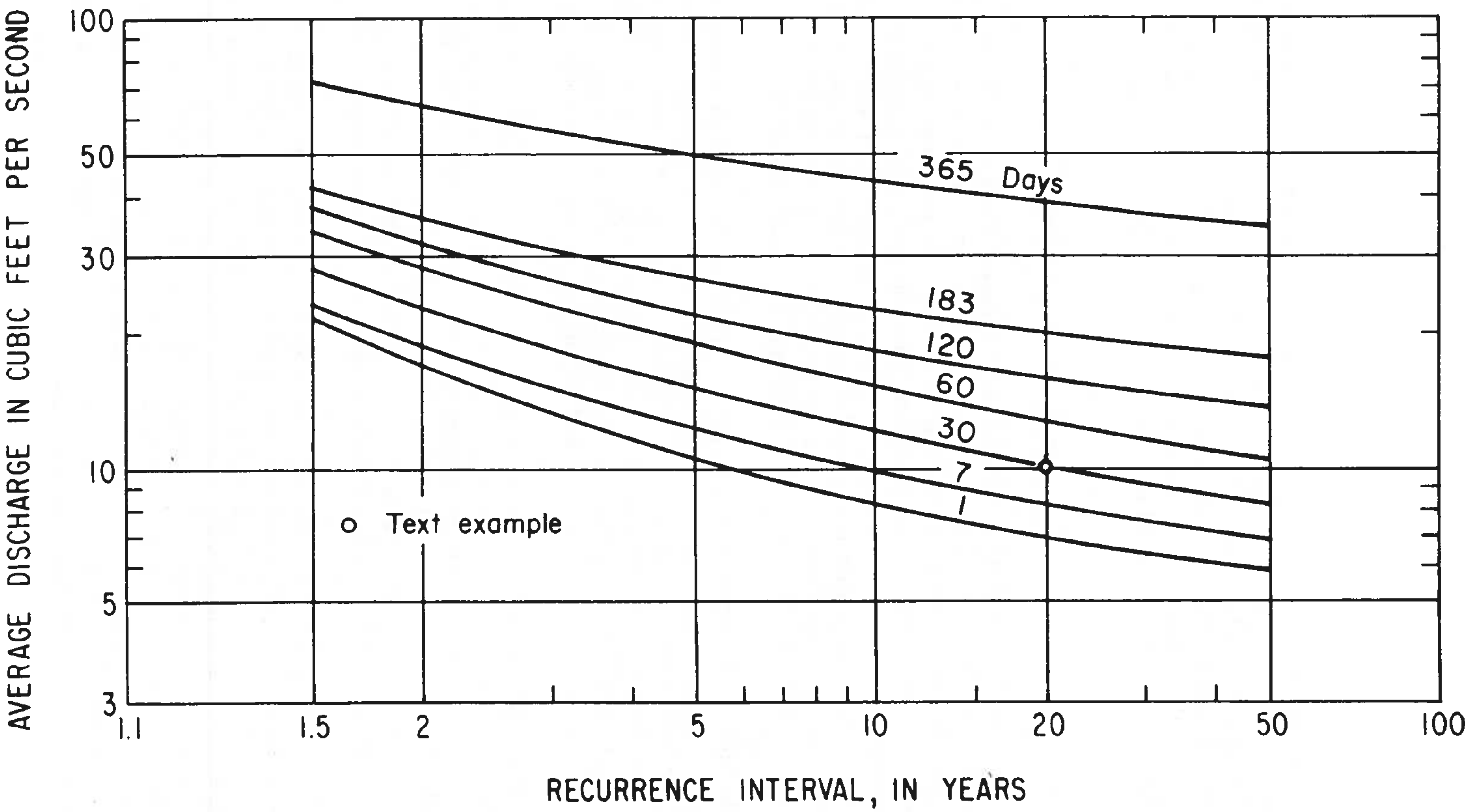


Figure 15.--Magnitude and frequency of annual minimum flows at North Tyger River near Fairmont

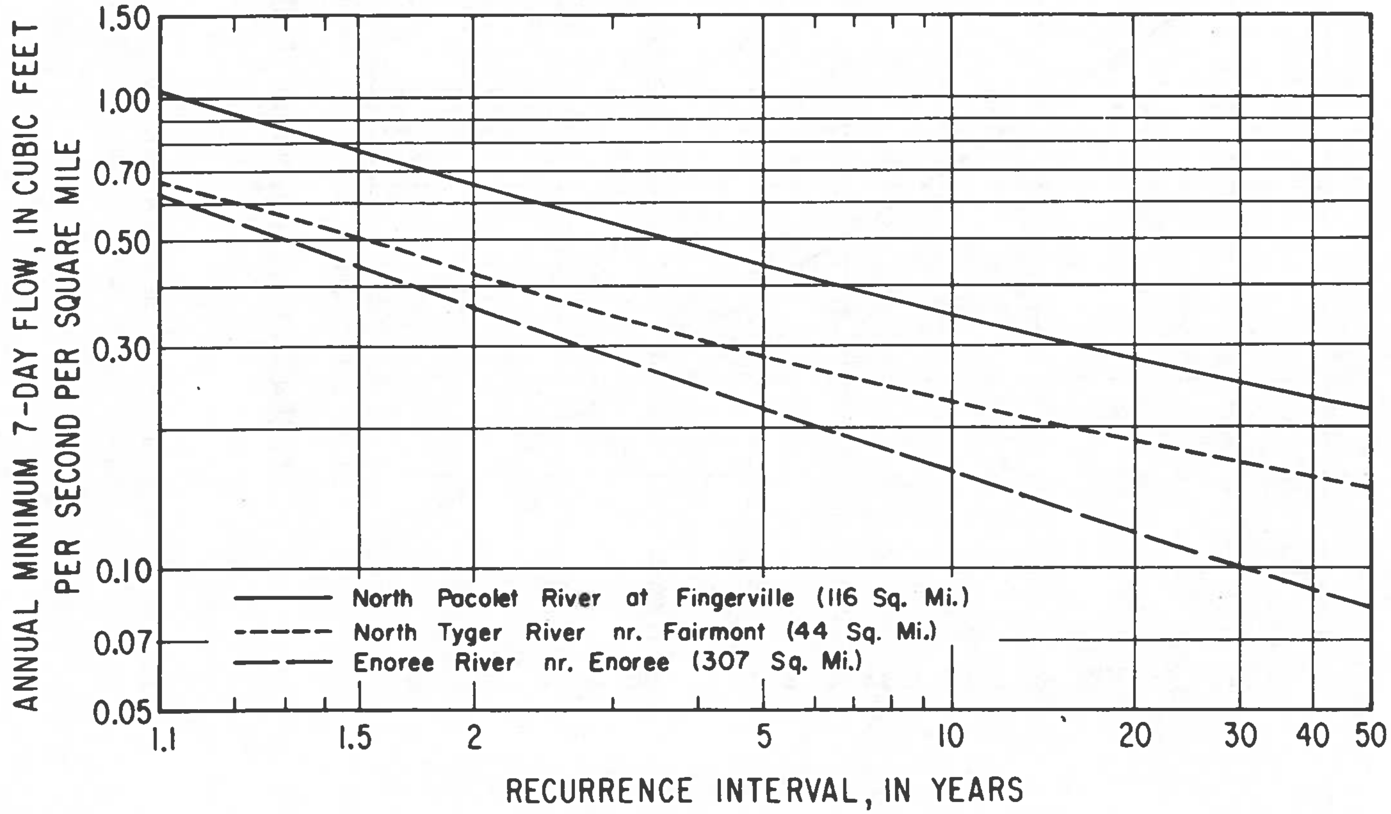


Figure 16.--Magnitude and frequency of annual minimum 7-day flow for three Spartanburg County streams

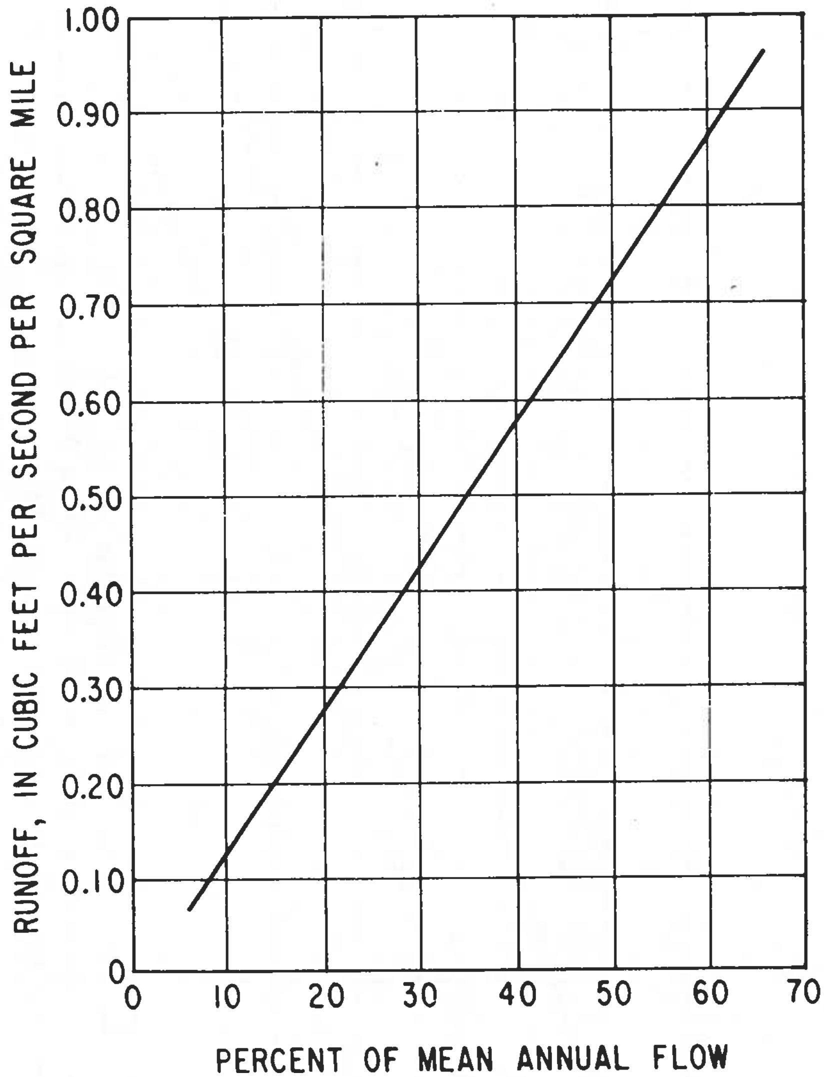


Figure 17.--Relation of mean annual flow to runoff of Spartanburg County streams

Stream	Drainage area (sq mi)	Recurrence Interval in Years				
		2	5	10	20	50
North Pacolet River at Fingerville	116	0.66	0.45	0.34	0.28	0.22
North Tyger River near Fairmont	44	.43	.28	.23	.19	.15
Enoree River near Enoree	307	.36	.22	.16	.12	.08

A descending order of base-flow yield from the northern part of the county to the southern can be anticipated from the relative position of the curves. The steeper slope of the Enoree River curve and the relation of extreme values in the table are an indication that streamflow in the southern part of the county is probably less well sustained under low-flow conditions in comparison with other locations.

During 1930-67, the annual 7-day minimum flow at the North Pacolet River gage was less than 0.34 cfs per square mile (the 10-year event) in 1931, 1941, 1954, and 1956, or four times in 37 years, which agrees closely with the probable frequency. The intervals between occurrences, however, were 10, 13, and 2 years, emphasizing the irregularity of recurrence.

The Storage of Streamflow

The discharge of natural streams, being variable, is less than the average or mean annual flow about 70 percent of the time. If the demand for water is constant, the specific use of natural streams may be limited by the minimum flows, and it then becomes necessary to consider the retention of water for use during periods of insufficient streamflow.

Storage can be replenished each year if the uniform draft rate is less than the minimum annual mean flow. Within-year variations of inflow are then controlled by the required seasonal storage. The minimum annual flows listed below for Spartanburg County streams occur at approximately the 70-percent duration points, and the ratio values suggest that, generally, the streams will support demands of about half the mean annual flows without over-year storage. The relation in figure 17 indicates that a draft of about 0.75 cfs (0.48 mgd) per square mile is then possible. For greater draft rates, the volume of water used cannot be replaced within the year, and carryover or over-year storage is required.

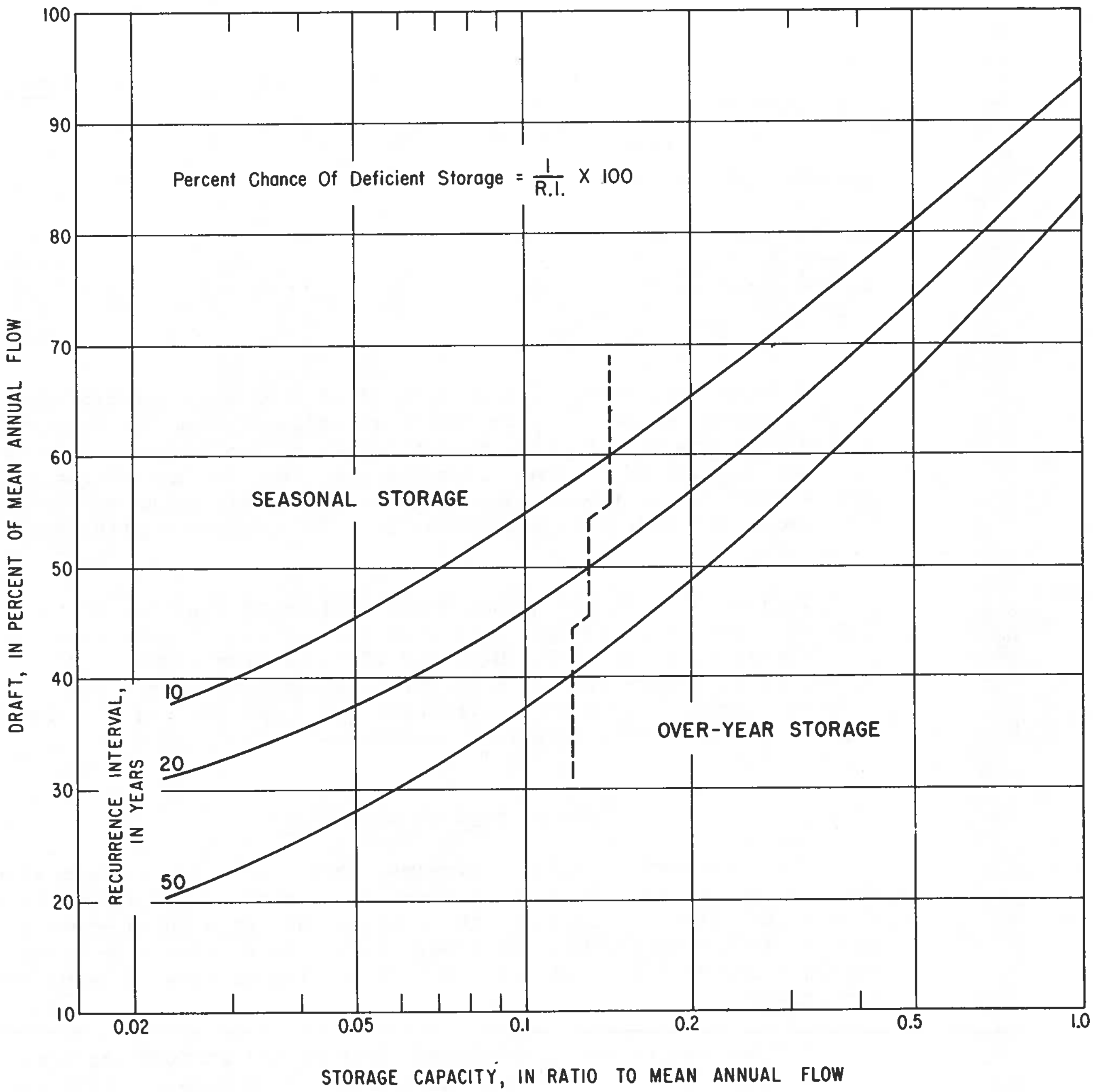


Figure 18.--Draft-storage-frequency relations for Spartanburg County streams

No.	Gaging station	Minimum Annual Mean Flow, in cfs	Ratio to Mean Annual Flow
2-1545.	North Pacolet River at Fingerville	113	0.51
2-1555.	Pacolet River near Fingerville	190	.56
2-1560.	Pacolet River near Clifton	269	.55
2-1570.	North Tyger River near Fairmont	40.6	.53
2-1575.	Middle Tyger River at Lyman	55.8	.54
2-1580.	North Tyger River near Moore	126	.54
2-1585.	South Tyger River near Reidville	83.8	.52
2-1590.	South Tyger River near Woodruff	126	.53
2-1605.	Enoree River near Enoree	215	.51

On the basis of past records of essentially unregulated streamflow, volumes of storage required to maintain specific draft rates can be determined and a value of probability of insufficient storage assigned. For the representative streams of North Pacolet, North Tyger, and Enoree Rivers, data such as shown in figure 15 were used to prepare frequency-mass curves, from which seasonal storage requirements for various draft rates were obtained.

Over-year storage was computed statistically--based on the identification of the distribution of mean annual flows as one of three standard probability distributions and the use of diagrams relating a statistical coefficient, draft rates, and storage at various recurrence intervals. The resulting curves[1/], which combine seasonal with over-year storage to give draft-storage-frequency relations for total storage, are shown in figure 18. These curves are derived from the similar plotting positions of like curves for each of the three index streams and are believed to be representative of unregulated streams.

At any given volume of storage, it is evident that an increase in allowable draft is possible by risking a more frequent chance of deficiency, although this does not imply an equal probability for each year.

When draft rates exceed about 60 percent of the mean annual flow, the required storage capacity increases much faster than the allowable draft. For example, in accepting a 5-percent chance of deficiency (the 20-year recurrence interval), an increase in draft from 70 to 80 percent of the mean annual flow necessitates a 50-percent increase in storage.

1/ The dimensionless values may be converted to more familiar terms as follows:
draft x mean annual flow = cfs
storage x mean annual flow = cfs-days
cfs-days x 1.983 = acre-feet

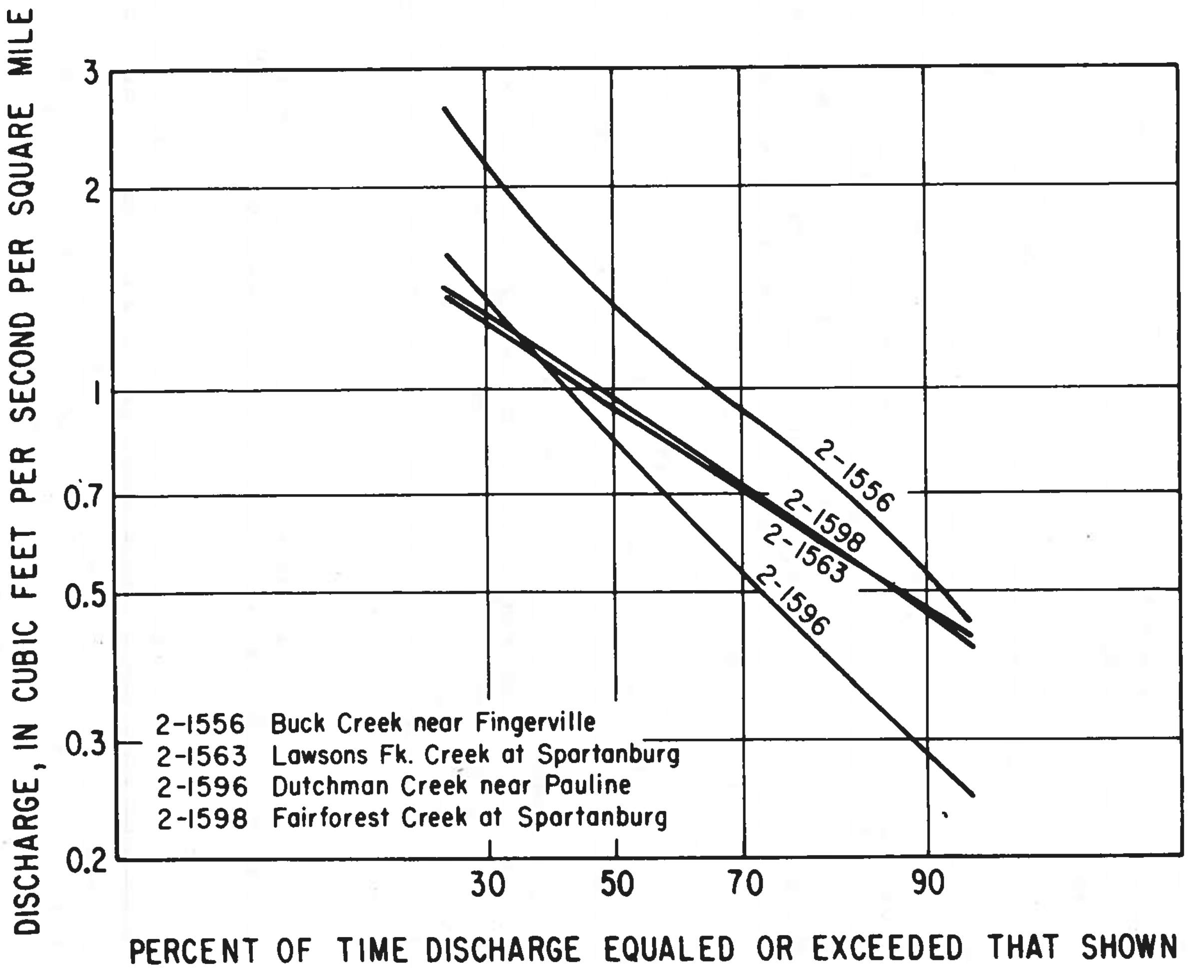


Figure 19.--Duration curves of daily flow for four short-term gaging stations

Losses from storage by evaporation or silt accumulation are not included in figure 18, and individual adjustments are required of the storage volumes under these conditions.

Characteristics Based on Short-Term Records

A description of low-flow characteristics, where only a short record of streamflow is available, has a low order of accuracy because of the limited sampling of events in time and in magnitude. The reliability of the characteristic definition can be improved by relating the short experience to a long-term record.

Streamflow characteristics of four streams, ungaged before 1966, are summarized below. An individual comparison of the annual 7-day minimum flow at the 2-year recurrence interval (median flow) and discharge at the 90-percent-duration point shows the two values to be nearly equal, which is typical of most unregulated streams in the county.

Gaging Station	Drainage area (sq mi)	Probable flow, in cubic feet per second, equaled or exceeded for indicated percent of time				Annual minimum low flow, in cfs, for indicated number of consecutive days at probable recurrence interval			
						7-day		30-day	
		30	50	70	90	2-yr	10-yr	2-yr	10-yr
Buck Creek near Fingerville	10.5	23	13.5	10	5.5	5.4	2.1	6.5	2.8
Lawsons Fork Creek at Spartanburg	74.7	94	70	53	35	35	18	40	22
Dutchman Creek near Pauline	8.97	12.5	7.5	4.8	2.5	2.1	1.0	2.8	1.1
Fairforest Creek at Spartanburg	17.8	23	17	13	8.2	7.2	4.3	8.9	4.7

If the tabular data are reduced to a common base, cubic feet per second per square mile, it is evident that Lawsons Fork and Fairforest Creeks have similar characteristics in contrast to the more variable low flow exhibited by Buck and Dutchman Creeks. The segments of flow-duration curves shown in figure 19 demonstrate indirectly that discharge may or may not be proportional to drainage-basin size. Gaging stations on Buck and Dutchman Creeks record the runoff from basins of nearly equal size, yet the flow is about 50-percent greater at the former site. About four times more drainage area is represented at the Lawsons Fork Creek gage than at the Fairforest Creek gage, whereas the shape and position of the flow-duration curves for these stations are nearly identical.

Table 2.--Low-flow yield of tributary streams in Spartanburg County

Site No.	Stream	Drainage Area (sq mi)	Estimated annual minimum 7-day flow for indicated recurrence interval: 2-Year cfs	2-Year mgd	10-Year cfs	10-Year mgd	Variability Index $7Q_2/7Q_{10}$
	Pacolet River Basin						
1	Page Creek near Landrum	4.36	2.1	1.4	1.1	0.7	1.92
4	Obed Creek at Fingerville	9.30	4.5	2.9	2.0	1.3	2.25
5	Spivey Creek near Campobello	5.14	2.6	1.7	1.4	.9	1.86
6	Motlow Creek near Campobello	7.95	4.7	3.0	2.0	1.3	2.35
8	Holston Creek near Campobello	5.56	2.6	1.7	1.2	.8	2.16
12	Little Buck Creek near Chesnee	9.68	3.0	1.9	1.5	1.0	2.00
14	Casey Creek near Mayo	6.51	2.4	1.6	1.3	.8	1.85
15	Cherokee Creek near Cherokee Springs	4.82	1.8	1.2	.9	.6	2.00
16	Island Creek near Mayo	13.8	3.6	2.3	1.4	.9	2.57
19	Lawsons Fork Creek near Inman	8.37	3.7	2.4	2.1	1.4	1.76
20	Greene Creek near Inman	4.56	1.8	1.1	1.0	.6	1.80
21	Meadow Creek near Inman	9.64	3.7	2.4	1.6	1.0	2.31
22	Fawn Branch near Boiling Springs	4.58	1.7	1.1	.8	.5	2.12
23	Big Shoally Creek near Valley Falls	6.17	2.4	1.5	1.0	.6	2.40
25	Chinquepin Creek at Spartanburg	4.75	2.8	1.8	1.4	.9	2.00
	Tyger River Basin						
28	Jordan Creek near Inman	4.50	1.8	1.1	1.0	.6	1.80
29	Jordan Creek near Wellford	12.8	5.6	3.5	3.0	1.9	1.86
30	Frey Creek near Wellford	9.18	4.0	2.5	2.1	1.4	1.90
31	Jimmies Creek near Fairmont	4.48	1.8	1.1	1.0	.6	1.80
38	Maple Creek near Duncan	10.2	5.8	3.7	2.8	1.8	2.07
40	Brushy Creek near Reidville	4.26	1.2	.8	.4	.3	3.00
41	Bens Creek near Reidville	10.0	2.8	1.8	1.4	.9	2.00
42	Fergerson Creek near Woodruff	10.7	3.1	2.0	1.4	.9	2.22
43	Little Fergerson Creek near Woodruff	5.28	2.1	1.4	.8	.5	2.62
44	Fergerson Creek near Woodruff	24.6	7.7	5.0	4.0	2.6	1.92
46	Jimmies Creek near Enoree	17.1	4.3	2.8	1.8	1.2	2.38
47	Cane Creek near Glen Springs	5.82	1.1	.7	.4	.3	2.75
53	Beaverdam Creek near Spartanburg	9.33	4.0	2.6	2.6	1.7	1.54
54	Kelsey Creek at Camp Croft	4.23	1.3	.8	.6	.4	2.16
55	McElwain Creek near Glen Springs	8.34	2.2	1.4	1.2	.8	1.83
56	Kennedy Creek near Pacolet	6.85	2.7	1.7	1.5	1.0	1.80
	Enoree River Basin						
57	Dillards Creek near Pelham	4.28	1.3	.8	.7	.5	1.86
59	Abners Creek near Pelham	11.2	4.2	2.7	2.0	1.3	2.10
62	Two Mile Creek near Enoree	8.85	2.8	1.8	1.2	.8	2.33
63	Cedar Shoals Creek near Cross Anchor	11.1	3.7	2.4	1.9	1.2	1.94

Tributary Streamflow

A long stream may intercept many different geologic units, and inconsistencies in aquifer yield are generally concealed by the accumulated inflow. However, small streams are sensitive to local geologic or topographic features, and the influence on low-flow characteristics may be difficult to predict without individual study.

Base-flow characteristics of ungaged streams can only be inferred unless discharge measurements are obtained and correlated with the record of a gaged stream. The analyses of small stream low-flow behavior in this report are based on the measurements in appendix table 7 and the long-term records of North Pacolet River at Fingerville, North Tyger River near Fairmont, and Enoree River near Enoree.

Frequency characteristics of 35 tributary streams, with an index for comparing the variability of flow, are given in table 2. The index is actually the average slope of the frequency curve between the 2- and 10-year recurrence intervals. Therefore, a low index value indicates a moderately sloping curve or a better sustained flow, whereas a high value denotes the more variable stream.

In comparing the variability indices, dissimilarities in the low-flow characteristics of streams in the same river basin are evident. This fact is more apparent from the areal variations of the 7-day minimum flows outlined in figure 20 for the 10-year recurrence interval and emphasizes the importance of discharge measurements in detecting the anomalous low-flow behavior in small-stream basins.

The pattern pertains only to the given recurrence interval and to the tributaries actually measured. It is not applicable to the major streams because they represent a composite of hydrologic conditions of more than one specific locality.

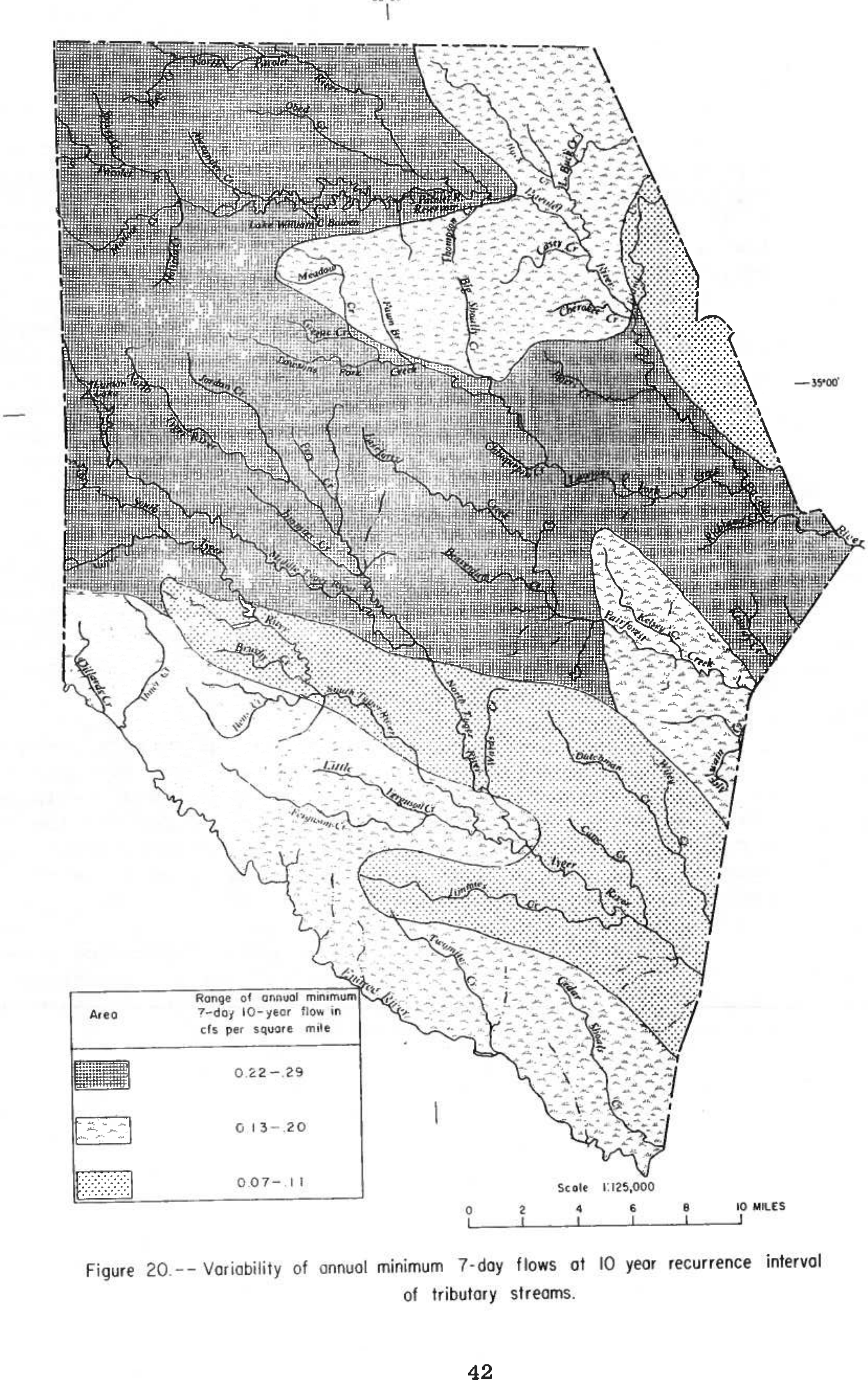


Figure 20.-- Variability of annual minimum 7-day flows at 10 year recurrence interval of tributary streams.

Quality of Water

The chemical and physical characteristics of waters are determined by both natural and man-made conditions. Soluble minerals in soils and in exposed geologic strata provide the principal natural source of minerals taken into solution by surface water. The amount taken into solution, however, depends largely on how well leached the rocks and soils are and on how resistant they are to the solvent action of water. The topography of an area affects the rate of surface runoff and thus the length of time water is in contace with soluble minerals of the earth's surface. The longer the contact, particularly in areas where soluble minerals are abundant, the more highly mineralized water becomes. Precipitation largely controls the amount of runoff available for solution. Other effects on water quality are related to vegetation. Heavy vegetation promotes percolation of rainfall into soils; decaying vegetation yields both organic and inorganic substances to water. Evaporation of water leaves a higher concentration of minerals in streams and lakes. The effect of transpiration, the process by which water vapor escapes from plants to the atmosphere, is similar, although minerals are also taken up in solution. In addition, carbon dioxide, which is present in the atmosphere and in the soil, enhances the ability of water to dissolve minerals and stabilizes the form of some dissolved substances.

In Spartanburg County, all these factors are important. Of principal importance, however, is the fact that soils tend to be well leached, and exposed rocks are more resistant to the solvent action of water than in many parts of the country.

Man's influence on the quality characteristics of streams has become increasingly important as the demand for greater amounts of water has grown. Waste discharges, which often contain a wide variety of chemical substances, may exert only a minor influence on natural water quality or may alter it to the extent that downstream use of water is impaired. Physical changes in a basin, such as the construction of a reservoir or canal, or a major change in land use, also may alter water quality. In Spartanburg County, municipal and industrial wastes degrade water quality at several locations.

Water-Quality Criteria

Water-quality criteria provide a basis for judging suitability of water for a given use and serve as a guide in making water-management decisions. Criteria have been established for the various types of water use, and limits on many of the chemical and physical characteristics of water have been recommended.

The U. S. Public Health Service (1962) established limits for dissolved substances in drinking and culinary water used on interstate common carriers. These limits are commonly used to evaluate the suitability of municipal and domestic water supplies. Some of the chemical limits are as follows:

Constituent	Maximum recommended Concentration (mg/l)[1/]
Iron (Fe)	0.3
Manganese (Mn)	.05
Sulfate (SO_4)	250
Fluoride (F)	.8 - 1.7[2/]
Nitrate (NO_3)	45
Dissolved Solids	500

Other limits recommended by the U. S. Public Health Service are: turbidity, 5 units, and color, 15 units.

Hardness, an important property of water to domestic and industrial users, is caused principally by calcium and magnesium. High hardness causes excessive soap consumption and promotes the formation of scales in boilers and pipes. The following arbitrary classification is used by the Geological Survey: 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.

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

2/ Recommended limits for fluoride are based on the annual average of maximum daily air temperatures. For example, when the average is 10.0°C to 12.0°C, the recommended upper limit is 1.7 mg/l; when the average is between 26.3°C to 32.5°C, the upper limit is 0.8 mg/l.

Water quality standards of the South Carolina Pollution Control Authority (1967) specify that waters used for domestic purposes, food processing, and swimming shall have a pH ranging from 6.0 to 8.0, with the exception of swamp waters which may range from 5.0 to 8.0. For the propagation of fish, industrial use, and agricultural use, lower limits are the same, but an upper limit of 8.5 is specified.

The amount of dissolved oxygen in water is an important indicator of the general health of a stream. Low dissolved oxygen usually indicates the presence of organic matter added to the stream as a waste discharge. Because oxygen is vital to life processes, streams having low dissolved oxygen are unsuitable for most fish and aquatic life. In South Carolina, water-quality standards for dissolved oxygen are based on a stream-classification system established by the South Carolina Pollution Control Authority (1967). Dissolved-oxygen limits range from a minimum of 5.0 mg/l for class AA streams to 3.0 mg/l for class Ca streams. Streams classed as "swamp," however, may have a minimum limit of 2.5 mg/l dissolved oxygen.

The temperature of water affects its suitability for use. To the municipal and industrial user, water temperature is important because it affects purification, filtration, corrosion rates, and the suitability of water for cooling. The reproduction and growth rate of fish and aquatic life are influenced greatly by water temperature and by abrupt changes in temperature.

Industrial water-quality requirements are closely related to the intended use of water. Evaluation of the suitability of water can be made only if the intended use is known. Generally, water that has low dissolved solids, silica, and hardness, and does not vary greatly in quality or temperature, is suitable for use by many industries. Reports by the National Technical Advisory Committee (1968) and the California State Water Quality Control Board (1963) contain information on industrial water-quality criteria and may be consulted for criteria applicable to a specific use.

Collection of Data

Data on the chemical and physical characteristics of water in Spartanburg County were collected during May and September 1966 and during October and November 1967. Field measurements of specific conductance, dissolved oxygen, hardness, pH, and temperature were made at 71 sites. At 31 of these sites, samples were obtained for complete chemical analysis in the laboratory. These data, along with data obtained in prior years, provide the basis for evaluating water quality in Spartanburg County.

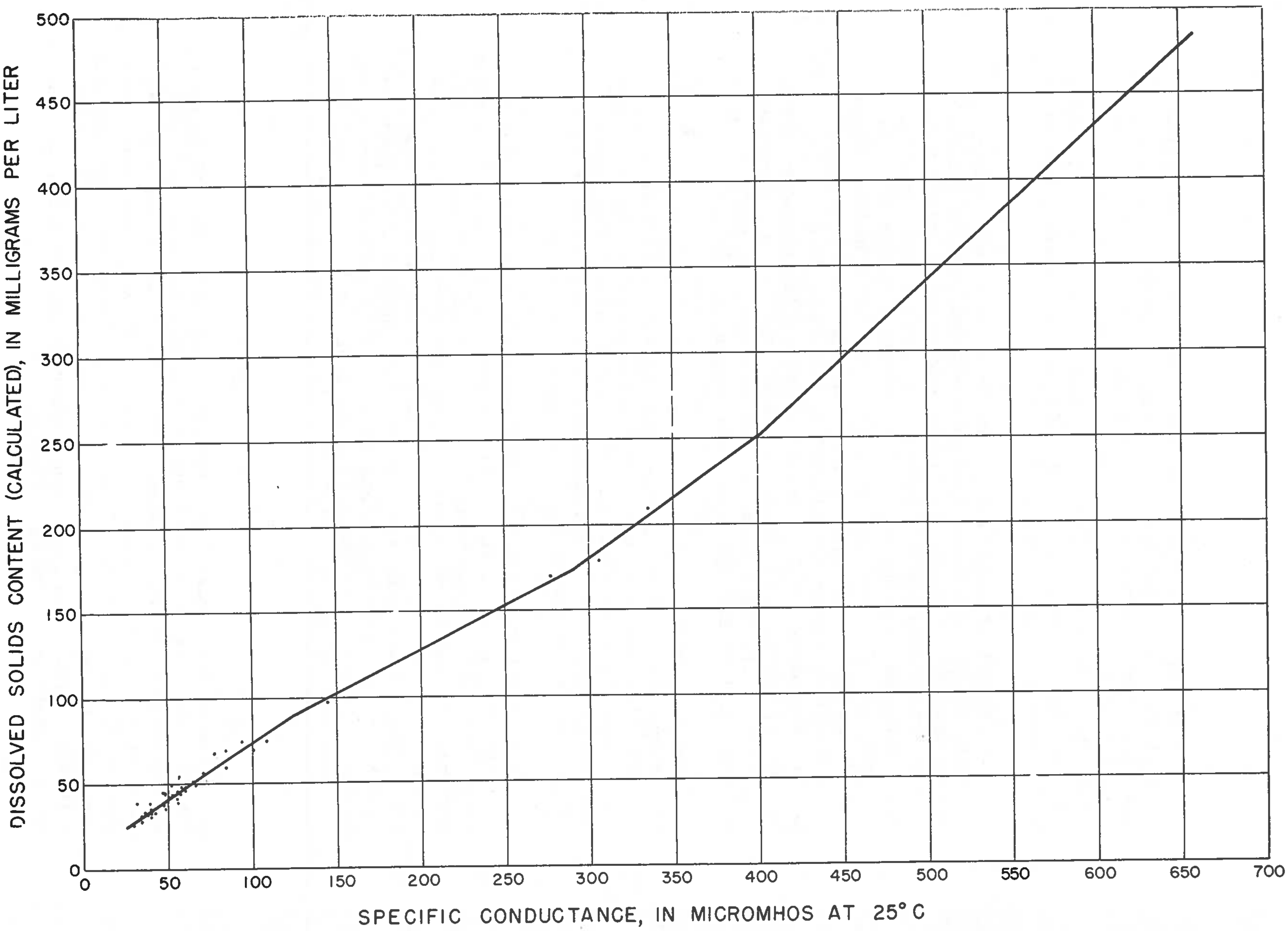


Figure 21.--Relation of dissolved-solids content (calculated) to specific conductance

Figure 21.--Relation of dissolved-solids content (calculated) to specific conductance

Field Measurements of Water-Quality Parameters

Appendix table 8 gives the results of field measurements of specific conductance, dissolved oxygen, hardness, pH, and temperature. Specific conductance and pH were measured with battery operated field instruments that are accurate and reliable. Dissolved oxygen and hardness were measured with water-test kits that are rapid and reliable but are less accurate than laboratory analyses. Data obtained, however, is suitable for making a general appraisal of the water.

Specific Conductance

Specific conductance is a measure of the ability of water to conduct an electric current and is related to the dissolved-solids content of water and to the type of dissolved substances 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 milligrams per liter) to specific conductance (in micromhos) is in the range 0.5 to 0.8. Specific conductance is thus a good indicator of the dissolved-solids content, and, for some waters, it may be correlated with the individual ions in solution.

During this investigation, the specific conductance of streams in Spartanburg County ranged from 27 to 651 micromhos. At 43 of the 71 stream sites given in appendix table 8, specific conductance was 60 micromhos or less; at 60 of the sites specific conductance was 100 micromhos or less. Generally, the northeast part of the county contains waters having the lowest specific conductance. The highest specific conductance occurs in a band running east to west through the central part of the county--a reflection of waste discharges to streams from urban areas.

An estimate of dissolved-solids contents corresponding to the specific-conductance values given in appendix table 8 can be made by utilizing data in appendix table 9, which contains complete chemical analyses, including both dissolved-solids content and specific conductance. Figure 21 shows the relation between these specific-conductance values and the calculated dissolved-solids contents. No single line may be drawn satisfactorily through the entire range of observed values. By considering segments of the relation separately, however, a line of best fit has been drawn and its equation calculated. Thus, the following equations may be used to estimate dissolved-solids content from specific conductance of streams in Spartanburg County.

Specific Conductance (micromhos at 25°C)	Equation
less than 130	D. Solids = 8 + (0.67 x S. Cond.)
130 to 290	D. Solids = 26 + (0.50 x S. Cond.)
290 to 400	D. Solids = -46 + (0.73 x S. Cond.)
400 to 650	D. Solids = -18 + (0.66 x S. Cond.)

Of the 129 measurements of specific conductance given in table 6, only 16 (about 12 percent) exceeded 100 micromhos. Based on the above equations, 100 micromhos is equivalent to a dissolved-solids content of 75 mg/l.

Hardness

The hardness of surface waters in Spartanburg County ranged from 7 to 60 mg/l. (See appendix tables 8 and 9.) At 50 of the 71 sites given in appendix table 8, hardness is equal to or less than 20 mg/l; at 64 of the sites hardness did not exceed 40 mg/l. Hardness tends to be higher when streamflow is low. No areal variation of hardness is evident from the data obtained. Streams that receive waste may or may not have the highest hardness values, depending on the type of waste discharge. All surface waters in Spartanburg County, however, may be classed as soft.

pH

The pH[1/] of water indicates the degree of acidity or alkalinity. A pH of 7.0 indicates that the water is neither acidic nor alkaline; pH values progressively lower than 7.0 denote increasing acidity. In Spartanburg County pH values range from 5.9 at Maple Creek at County Road 644 to 8.9 at North Tyger River at State Highway 296. The higher pH at the latter site undoubtedly is due to waste discharges. At 37 of the 71 sites given in appendix table 8, the pH of the water was 7.0 or less each time it was measured. At 30 other sites, pH was 7.0 or less on one occasion. The lowest pH values at each site usually occurred in May, when flow was higher than in September. The average of September values is about 0.5 units higher than the average of May values. With exception of the two extreme values cited above, the pH values of streams in Spartanburg County are well within limits acceptable to most users of water and meet criteria of the South Carolina Pollution Control Authority (1967).

1/ A pH unit is the negative logarithm of the hydrogen ion concentration.

Dissolved Oxygen

Dissolved-oxygen values given in appendix table 8 range from 2 mg/l at North Tyger River at State Highway 296 to 12 mg/l at several locations in the county. All measurements made at 62 of the 71 sites given in the table were 8 mg/l or greater; at four sites dissolved oxygen was less than 5 mg/l on at least one occasion. The lowest dissolved-oxygen values occurred on Lawsons Fork Creek, Maple Creek, and on the North, Middle, and South Tyger Rivers. Each of these streams receive wastes, which deplete dissolved oxygen.

During October and November 1967, a dissolved-oxygen survey was made of four streams known to receive wastes--North, Middle, and South Tyger Rivers, and Fairforest Creek. Measurement of dissolved oxygen was made using a galvanic-cell oxygen analyzer that provides results more accurate than those obtained with water-test kits. Dissolved oxygen was measured at as many points as possible on each stream during a time period when flow and waste-discharge conditions were likely to be relatively constant. The results of these measurements are given in appendix table 10. The initial starting point of the measurements (mile 0.0 in the table) was selected so as to be above municipal or industrial waste outfalls.

The effect of wastes on these streams is illustrated in figure 22. Dissolved oxygen, as a percentage of saturation (the amount that should be present at prevailing water temperature, dissolved-solids content, and barometric pressure), is plotted against distance downstream from initial point (mile 0.0). The effect of wastes on North Tyger River is dramatic. Below industrial-waste outfalls, dissolved oxygen drops to less than 10 percent of saturation and remains so for several miles. A series of rapids, which aerate the stream in the lower reaches, promotes rapid recovery.

Dissolved oxygen of Middle Tyger River seems to show the effect of two separate waste discharges several miles apart. The authors, however, were unable to locate a second source of waste that would result in the dissolved-oxygen sag illustrated. It is likely that the discharge of waste near mile 5 on the Middle Tyger River was not constant, and, because measurements of dissolved oxygen below mile 9 were made the day after those made upstream from mile 6, second-day measurements were probably made on a part of the same water measured the first day.

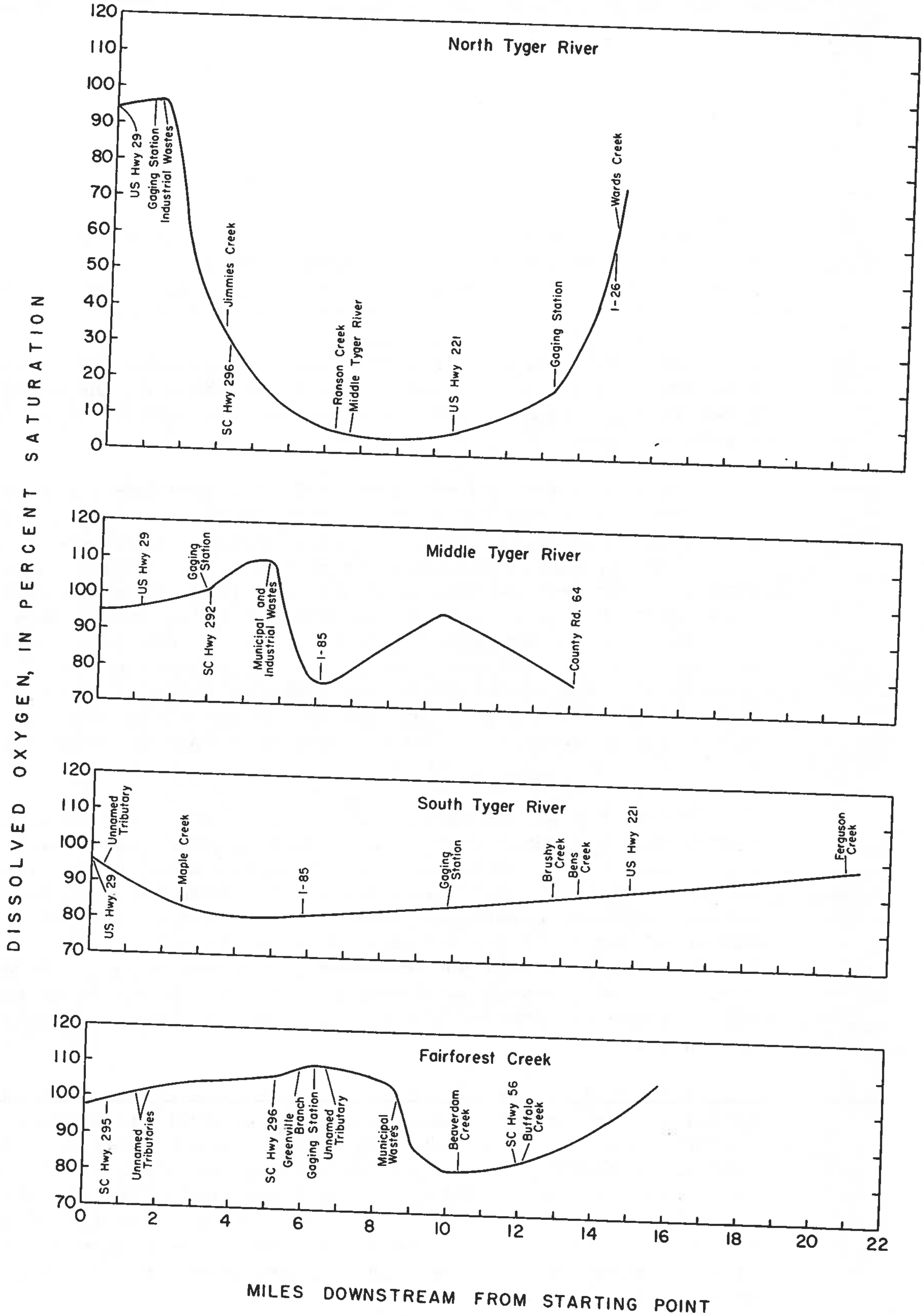


Figure 22.--Effect of waste discharge on Fairforest Creek and North, Middle, and South Tyger Rivers, October and November 1967

The dissolved-oxygen sag of South Tyger is somewhat different from that of the other streams. The dissolved-oxygen decrease is less rapid, and the recovery is slower. Waste entering the South Tyger River may be of a different type from that entering the other streams.

Fairforest Creek shows an oxygen sag resulting from municipal wastes entering the stream between miles 8 and 9. Dissolved oxygen did not drop below 80 percent of saturation, and the recovery occurs after the water has moved downstream about 5 miles.

The results obtained during October and November 1967 are probably typical of the effect of wastes on these streams. Many other patterns of dissolved-oxygen depletion are likely to occur on each stream, however, depending on the quantity and type of waste, the period of time wastes are released, and the volume of streamflow. In general, a higher natural assimilative capacity for organic wastes is associated with the shallow, fairly swift streams typical of Spartanburg County. These same properties are associated with restricted stream size, which, at some locations, limits the quantity of water available for dilution of wastes, particularly during low flow.

Laboratory Analyses

Appendix table 9 gives the results of complete chemical analyses made in the laboratory on water obtained at 31 sites. The results of the chemical analyses show that the concentration of most dissolved substances is low and that the water is of excellent quality at most locations for a wide variety of uses. The analyses have been used to illustrate the chemical characteristics of water by means of diagrams shown in figure 23. For convenience in preparing the diagrams, data in appendix table 9 were converted from milligrams per liter to milliequivalents per liter. Milliequivalents per liter express the chemical equivalence of dissolved ions and are calculated by multiplying the reciprocal of the combining weight[1/] of an ion by the concentration of the ion, in milligrams per liter.

At locations where the effect of waste is most evident, the concentrations of sodium and bicarbonate increase greatly; sulfate and chloride also increase, but by lesser amounts.

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

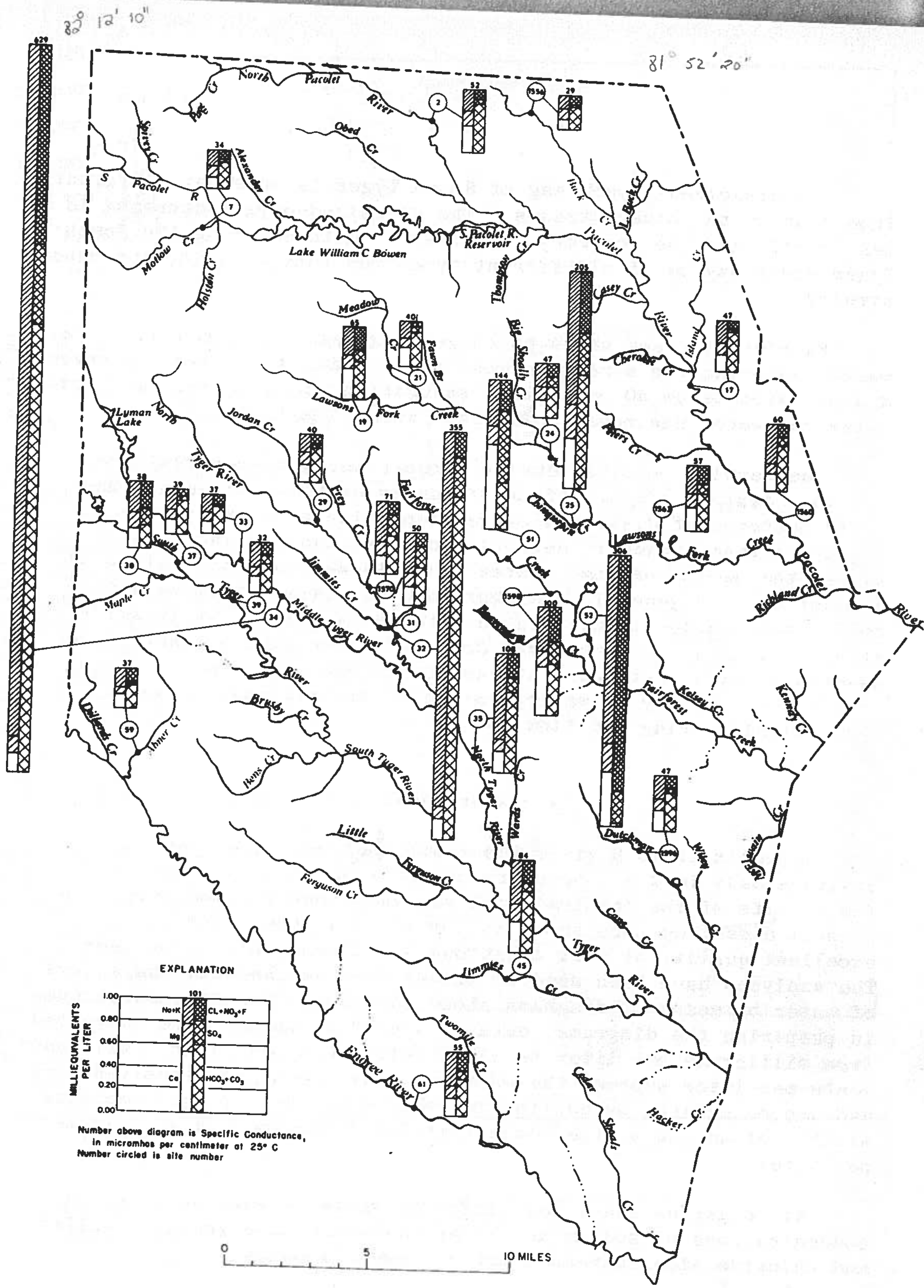


Figure 23.--Chemical characteristics of surface water in Spartanburg County

Relation of Water-Quality to Discharge

Since 1946, the Geological Survey has obtained chemical-quality data at eight sampling stations where seven or more chemical analyses have been made. The data have been published by Harris (1962) and in the Geological Survey's annual series of basic-data reports. Cummings (1969) wrote a summary and interpretation of these data.

At three of these sampling stations, sufficient information is available to relate water quality to discharge. Figure 24 shows the relation of dissolved-solids content to discharge for Pacolet River near Fingerville, North Tyger River near Moore, and Enoree River near Enoree.

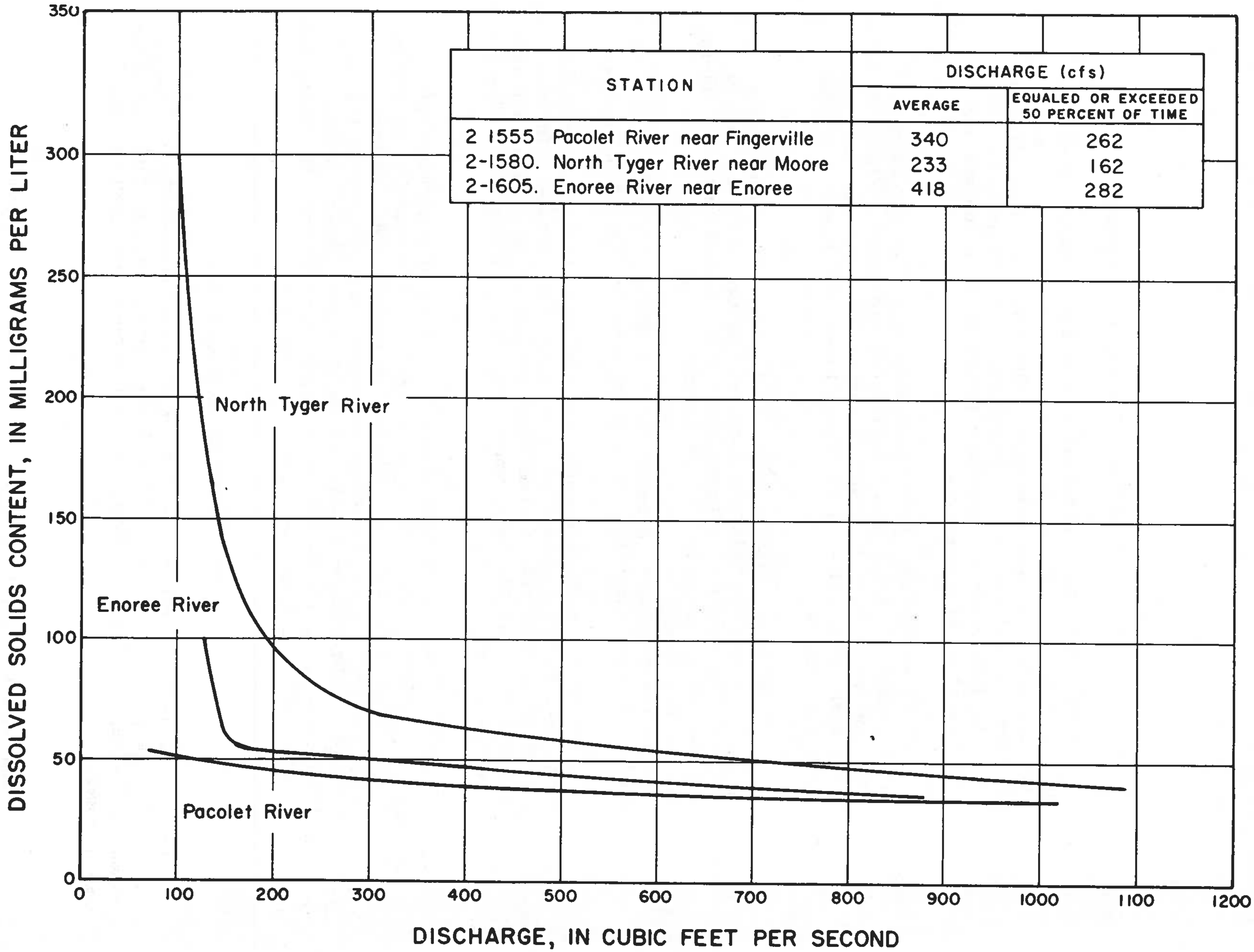
Pacolet River near Fingerville illustrates a dissolved-solids content - discharge relation for a stream that does not receive wastes. The relation is based on 69 chemical analyses made during 1950-65; it is probably typical of that of other streams in Spartanburg County that do not receive wastes. Figure 24 shows that in the discharge range of 100 to 1,000 cfs, dissolved-solids content is not likely to exceed 60 mg/l or be less than 30 mg/l.

The dissolved-solids content - discharge relation for Enoree River near Enoree is based on 32 analyses made during 1946-65. Enoree River does not receive large quantities of wastes, but data indicate that, at low flow, wastes may have a significant effect on water quality.

North Tyger River near Moore is typical of a stream that receives substantial quantities of wastes. The relation of figure 24 is based on 42 analyses made during 1946-65. At discharges less than about 250 cfs, wastes increase the dissolved-solids content of the stream rapidly. At higher discharges, however, the dissolved-solids content is comparable to streams in Spartanburg County that do not receive waste discharges.

Temperature of Surface Water

The temperature of surface water varies seasonally, following a pattern of change related to changes in air temperature. Smaller streams respond more rapidly to changes in air temperature than large streams.



STATION	DISCHARGE (cfs)	
	AVERAGE	EQUALED OR EXCEEDED 50 PERCENT OF TIME
2 1555 Pacolet River near Fingerville	340	262
2-1580. North Tyger River near Moore	233	162
2-1605. Enoree River near Enoree	418	282

Figure 24.--Relation of dissolved-solids content to discharge of three Spartanburg County streams

During October 1966 to September 1968, continuous temperature recorders were operated on North Tyger River near Fairmont and Enoree River near Enoree. Appendix table 11 shows the maximum and minimum monthly temperatures[1/] recorded at these stations. The highest temperature recorded at either station was 28°C in August 1968 on the Enoree River; the lowest temperature recorded was 2°C in February 1968, also at Enoree River.

Figure 25 is a frequency curve of daily mean water temperatures of Enoree River near Enoree. Ten percent of the time the mean temperature equaled or exceeded 24°C; 50 percent of the time, 16°C; and 90 percent of the time, 6°C.

Appendix table 12 lists average monthly water temperatures at gaging stations in Spartanburg County during 1949-67, when the gaging stations were visited to make discharge measurements. Average monthly temperatures do not differ appreciably from station to station. The temperature of Middle Tyger River at Lyman, however, seems to be higher than the other streams. This may be the result of heated waste waters raising the temperature of the stream.

GROUND WATER CHARACTERISTICS

Ground water is one of the most important natural resources of Spartanburg County. It is the principal source of water for rural homes and farms, small to medium-sized industries, and some supplemental irrigation. The quantity of water available from wells drilled in consolidated rock is usually less than that which may be obtained from surface-water sources. However, the importance of ground water lies in the fact that in moderate amounts, it is available in a large part of the area and thus can satisfy the requirements for most domestic, stock, and small industrial use. The consistency of ground-water quality and temperature are additional factors that enhance its utility and economic value.

1/ In October 1967 the Geological Survey began reporting temperature data in degrees Celsius ($^{\circ}$C). Degrees Celsius are equivalent to the more familiar degrees centigrade.

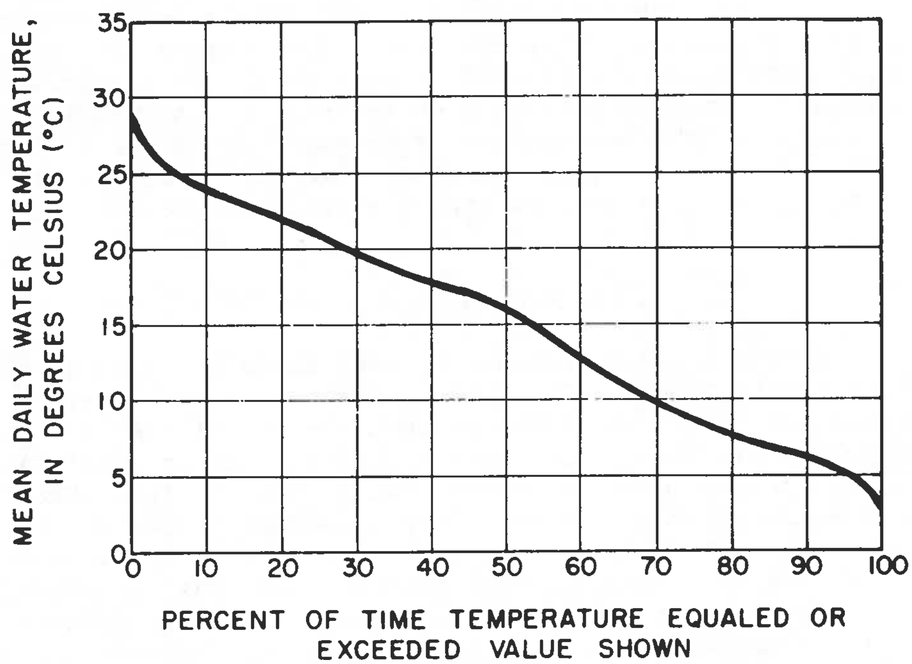


Figure 25.--Frequency curves for daily mean temperature at Enoree River near Enoree, October 1966 to September 1968

Description of Water-Bearing Rocks

The distribution of specific rock types throughout Spartanburg County is shown on figure 5, which was adapted from Overstreet and Bell (1965a). Although 10 rock units are shown as cropping out within the county, all but a small percentage of the rocks exposed are contained within five major units. These are the biotite schist, biotite gneiss and migmatite, quartz monzonite, hornblende gneiss, and hornblende schist. Descriptions of these units are given in appendix table 13 and are adapted principally from those of Overstreet and Bell (1965b).

Occurrence of Ground Water

General Hydrologic Conditions

In areas underlain by crystalline rocks, such as those found in Spartanburg County, ground water occurs in both the mantle of weathered rock, or saprolite, overlying the hard rock and in the secondary fractures, such as joints, faults, bedding planes, or foliation planes within the hard rock. Where the rock is composed of water-soluble minerals, the fractures may become enlarged by solution from circulating ground water. Owing to the increasing load of overburden with increasing depth, both the number and size of the fracture openings decrease with depth. Because of this, most of the higher yields from wells in the Piedmont occurs in those wells drilled to depths less than 250 feet. At depths greater than about 300 feet the number and size of fractures tend to diminish to a degree where only small quantities of water circulate through them. Some fractures formed at depths greater than 1,000 feet by deep-seated orogenic or seismic activity may contain significant amounts of water, but generally the water is highly mineralized. Only minor amounts of water may collect and move through the intergranular spaces in the rock itself, because of the extremely low porosity and permeability of unfractured crystalline rock.

Water movement in the saprolite is controlled to a large extent by the permeability of the unit. Where the saprolite is comparatively less permeable than the underlying fractured rock, it can act as a confining bed. The saprolite layer usually functions as a reservoir to receive and store percolating rain water and subsequently supply ground water over protracted periods of below-normal rainfall.

Early development of ground water in Spartanburg County consisted predominantly of dug wells or springs. In fact, several springs were utilized in the development of spas or health resorts. Some spring waters are still bottled and marketed today, for example, the water of Glenn Springs (pl. 1). The dug wells were generally 2 to 3 feet in diameter and lined with wood, stone, or brick curbing. They were dug by hand and usually obtained water from the saprolite or from the top few feet of the underlying hard rock. The bottom of such a well was usually only a few feet below the normal water table. Thus, in sustained drought, the water table would recede below this depth and the well became dry.

Both water-table and artesian conditions are characteristic of the area, although the former is more typical. Under water-table conditions, the surface of the zone of saturation (or water table) is under atmospheric pressure and is free to move upward or downward, without being confined by impermeable, or nearly impermeable, material. Under artesian conditions the potentiometric surface (an imaginary surface that coincides everywhere with the head of water in the aquifer) usually occurs above the saprolite-hard rock contact. The water table may fluctuate across this contact. Where percolating waters enter an inclined fracture zone, the water level in a well intercepting these fractures at depth will rise above the top of the fracture zone, and might rise above the top of the casing and flow if the well is at a lower elevation than the area of recharge.

Recharge and Discharge

The source of all ground water in Spartanburg County is the precipitation (mostly in the form of rainfall) within the county plus the underflow across county boundaries. Approximately one-quarter to one-third of the precipitation filters down into the zone of saturation, whereas the remainder is lost to surface runoff or evapotranspiration. The proportion of rainfall that finally reaches the water table is affected by several factors. The intensive summer storms of short duration contribute a much smaller amount of recharge than the steady light rains characteristic of the fall and winter seasons. A high rate of evapotranspiration during the growing season likewise diminishes the amount of rainfall that might otherwise reach the water table.

Rocks or soils of high permeability, such as sand or highly fractured rocks, can readily absorb and transmit water and are therefore more receptive to higher rates of recharge via the high-rate, short-duration type of rainfall. However, the less permeable soils or rocks containing relatively few or small-sized fractures require the slow-rate, long-duration type of rainfall for significant recharge.

Subsequent to the recharge process, whereby rainfall percolates down through the soil to the saturated zone or water table and forms a reservoir of ground water, the water moves by gravity toward points of lower elevation to discharge in springs, swamps, streams, or lakes, where the water table intersects the ground surface. Where the water table lies close to the ground surface, additional discharge takes place by evapotranspiration from the ground or leaves of plants and trees. Artificial discharge takes place through the pumping of wells.

Well Yield

Wells drilled in either the comparatively soft weathered rock or the hard fractured crystalline rocks of the Piedmont, generally have low to moderate yields. The data available on Spartanburg County (appendix table 14) indicate a range in well yield of 1 to 250 gpm. The average yield of all wells was about 20 gpm, and the median yield about 7 gpm. Most domestic wells are not drilled to develop maximum yield, and, thus, statistical parameters applied to the total number of wells do not reflect accurate values of average yield. The average yield of those wells drilled to obtain maximum yield was 53 gpm.

A study of well yields in the Appalachian area (Wyrick, 1966, p. 35), which includes Spartanburg County, estimates the maximum potential yield of wells in these types of rocks as equivalent to the average yield of the highest 3 percent of the most productive wells inventoried. For Spartanburg County this average yield was reported as ranging from 100 to 300 gpm. In the present study, this average maximum yield was calculated to be 139 gpm.

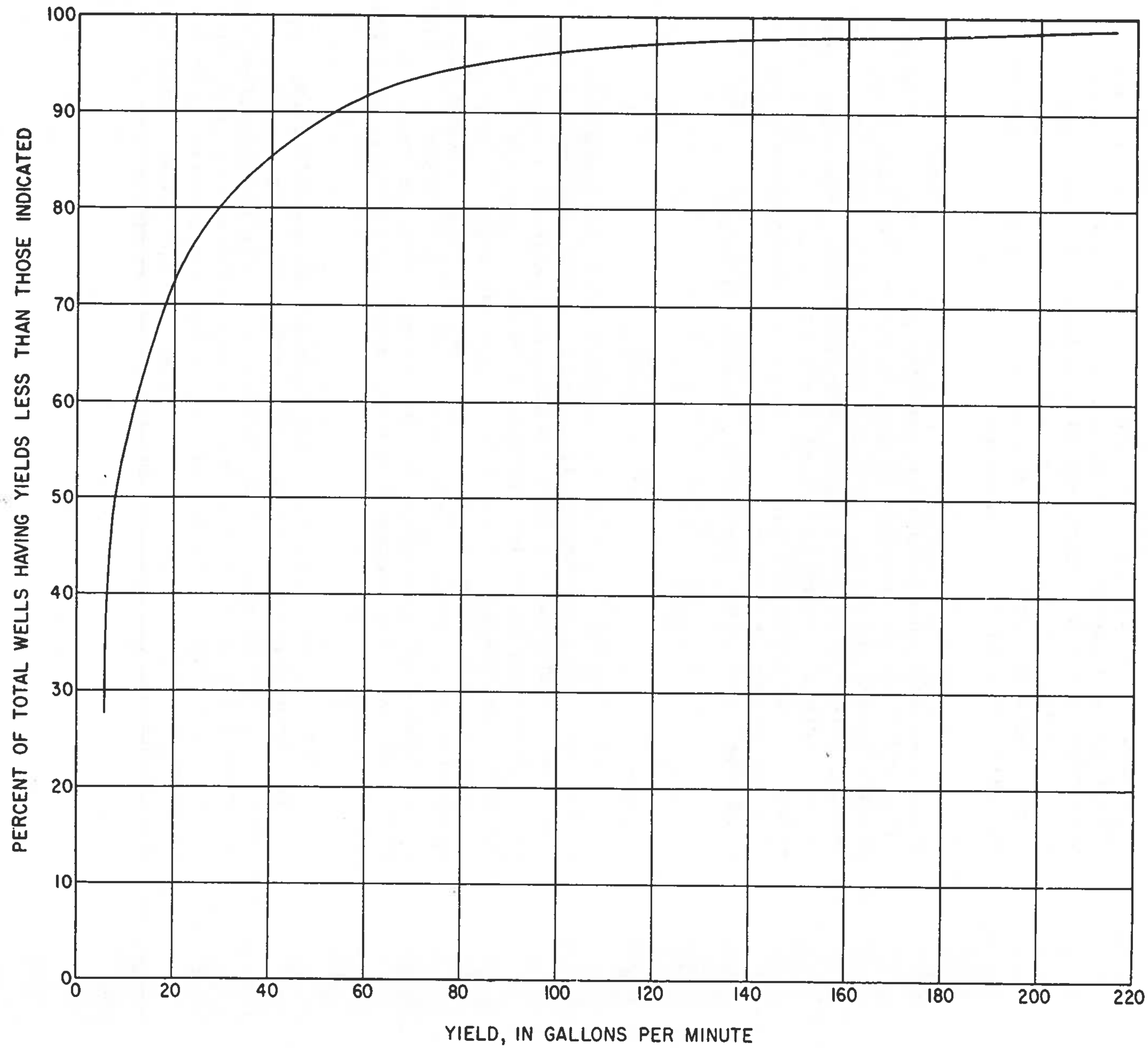


Figure 26.--Distribution of well yields

YIELD, IN GALLONS PER MINUTE

Figure 26.--Distribution of well yields

The base flow of a stream is derived almost entirely from ground-water discharge and is commonly used to evaluate potential well yields in the area. The data on page 35 give the 7-day low flow for various recurrence intervals of several representative streams. The flow for the 2-year recurrence interval ranges from 0.66 cfs per square mile in the northern part of the county to 0.36 cfs per square mile in the southern part. Well yields are usually expressed to gallons per unit of time, so converting the cubic feet per second per square mile data to these units, the low-flow data indicate that an average of 0.23 to 0.42 mgd is discharged as ground water from each square mile of drainage area. These amounts are roughly comparable to the streamflow at the 90 percent duration point (figure 14), which is likewise derived almost exclusively from ground water. The discharge at this percentile ranges from 0.43 cfs per square mile at station 2-1605 to 0.67 cfs per square mile at station 2-1545--a range of 0.28 to 0.43 mgd per square mile, or an average of about 0.4 gpm per acre.

Figure 26 shows the distribution of well yields in Spartanburg County. Of those wells for which data are available, 72 percent had yields of 20 gpm or less, and about 8 percent had yields of more than 60 gpm. Whereas an analysis of a greater number of wells might shift the distribution slightly, this appears to be reasonably representative of the yields that might be expected from wells located throughout the county.

Factors Affecting Well Yield

Both intensive studies and reconnaissances of ground water have been carried out in areas adjacent to or not far from Spartanburg County that are underlain by similar crystalline rock (Mundorff, 1948; Marsh, 1966; LeGrand, 1967; Koch, 1968; Siple, 1946, 1968). The results of these studies show that generally two of the more important factors affecting well yield in the Piedmont province are topographic location and rock type. The effects of the latter might be masked or offset by significant changes in other factors such as well depth (and diameter) and thickness of overlying saprolite. In essence, the primary variable governing the yield of a well in crystalline rock is the permeability of the rock, which, in this case, is dependent upon the number and size of water-yielding fractures penetrated by the well. The concentration of these fractures in any particular area is affected to a considerable extent by the factors discussed below.

Topography

The mass of statistical data evaluated in the various studies referred to above indicates that in areas underlain by crystalline rocks, the highest percentage of wells with high yields are located in topographically low areas such as draws, lowlands, or on gentle slopes. This is due in part to the fact that valleys are formed in areas of concentrated fracture zones. Conversely, the highest percentage of wells with low yields are those on hilltops, dissected uplands, or steep slopes. Several factors may account for the difference in yield. A valley presents a larger area for well recharge and usually represents a locality of rock weakness with a greater number of fractures. The movement of water in hills is generally in a vertical direction downward whereas the general lateral movement in the valley provides a greater flow to the well.

The surface of the water table is a subdued replica of the ground surface. The water table lies at a greater depth below the surface on the hills than in the valleys. Where it intersects the valley wall, springs occur, and where these are numerous enough or have sufficient flow, they form streams. Thus, in general, wells on hilltops must be drilled deeper than those drilled in valleys.

Rock Type

Although rock type is a significant factor affecting well yield, it is difficult to separate from the other interrelated factors of topography, weathering, and structure. Highly fractured or highly foliated rock types have a greater capacity for storing and transmitting water than the more dense rocks. Thus the more highly foliated gneissic rocks and schists usually afford greater yields to wells than do the more massive or dense gneissic or gabbroic rocks. The porosity of fresh crystalline rock is generally less than 1 percent and the permeability, almost negligible. The porosities of weathered rocks commonly range from 30 to 50 percent (Stewart, 1962).

Coarse-grained rocks containing a significant proportion of stable minerals (principally quartz) and subjected to the weathering process, may have comparatively high permeabilities. Circulating waters may increase the porosity by the dissolution of unstable minerals.

Table 3.--Well yields in relation to geologic unit.

Aquifer Units	Number of Wells	Yield (gpm)			
		Maximum	Minimum	Average	Median
Biotite schist (MpЄs)	108	125	1	22.5	14.2
Biotite gneiss and migmatite (DpЄm)	32	250	1	34.8	25
Quartz monzonite (Py)	5	22	3	11	6
Hornblende gneiss (DpЄh)	95	140	1	12.7	6.7
Hornblende schist (MOh)	2	20	2.5	11.2	11.2

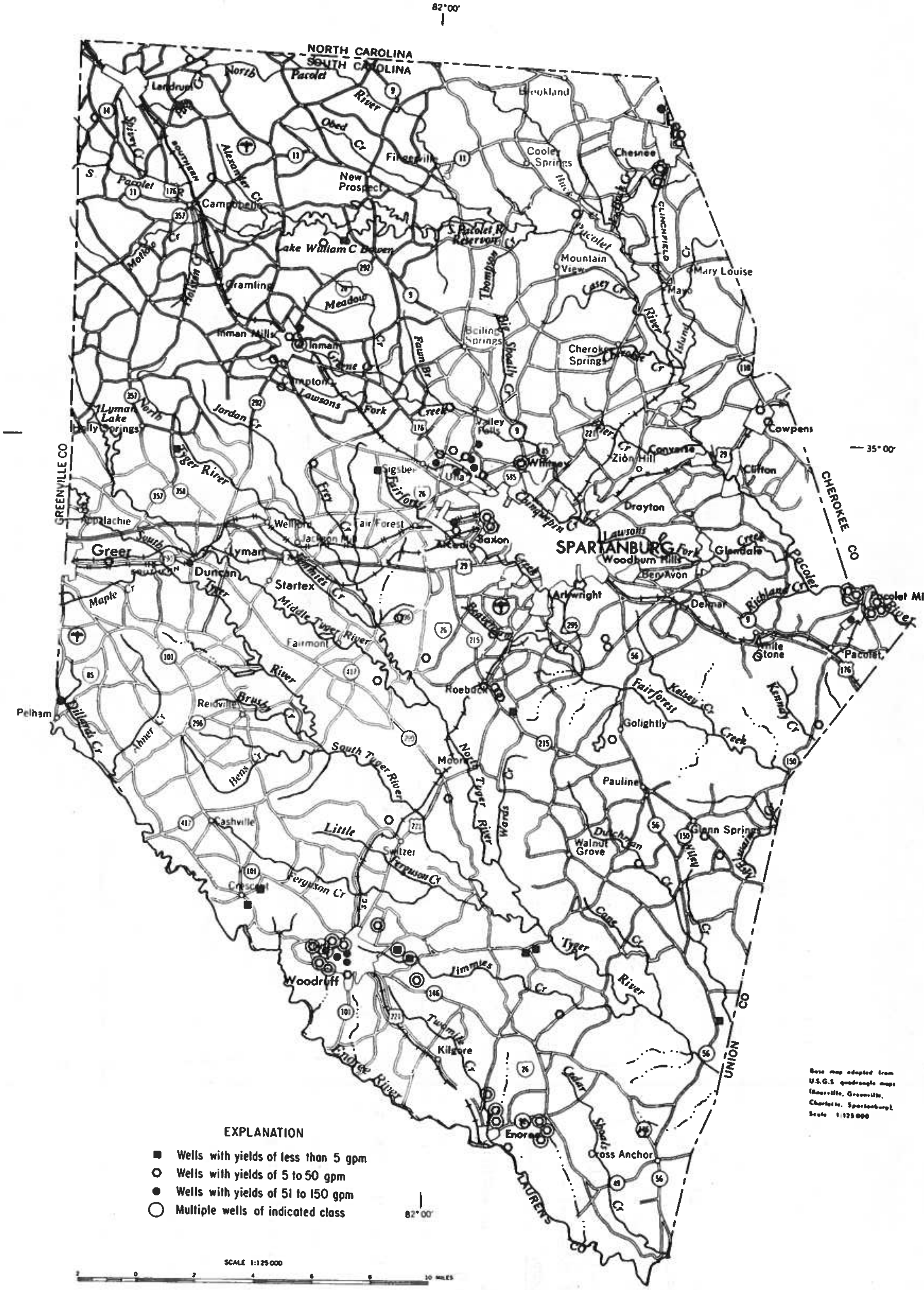


Figure 27.--Location of wells with respect to low, medium, and high yields.

The data available concerning wells in Spartanburg County (table 3) indicate that the highest average yields (35 gpm) are obtained from wells drilled in biotite gneiss and migmatite. The maximum yield (250 gpm) was reported from a well drilled in the same unit. The highest median yield (25 gpm) was also obtained from wells in the biotite gneiss and migmatite, and the next highest (14 gpm) from wells in the biotite schist.

Table 3 includes wells developed in 5 of the 10 rock units recognized within the county. However, almost all the well data pertain to the 5 units listed, inasmuch as a large percentage of the total area of the county is underlain by these types of rocks.

Generally, the higher yielding wells shown in figure 27 are associated with outcrop areas of the biotite schist and the biotite gneiss and migmatite. The possibility that the hornblende gneiss developed secondary permeability through solution or the incidence of intrusive stocks of coarse-grained granite in the area west of Woodruff might account for the cluster of high-yielding wells.

The well yields is this same illustration also correlate in general with the gradational zonation of low-flow stream discharge as shown in figure 20. Thus wells with the higher yields occur generally in those areas defined as having the highest and second-highest stream discharge.

Structure

As mentioned in the description of general hydrologic conditions, rock structure is a very important factor in the development of maximum yields of drilled wells. This applies in particular to those wells drilled into the hard rock, where the permeability of the water-bearing unit is dependent upon such structural features as faults, joints, and bedding or foliation planes.

Although structure has a definite effect on well yield, its significance is related in large measure to the direct influence of topography and rock type.

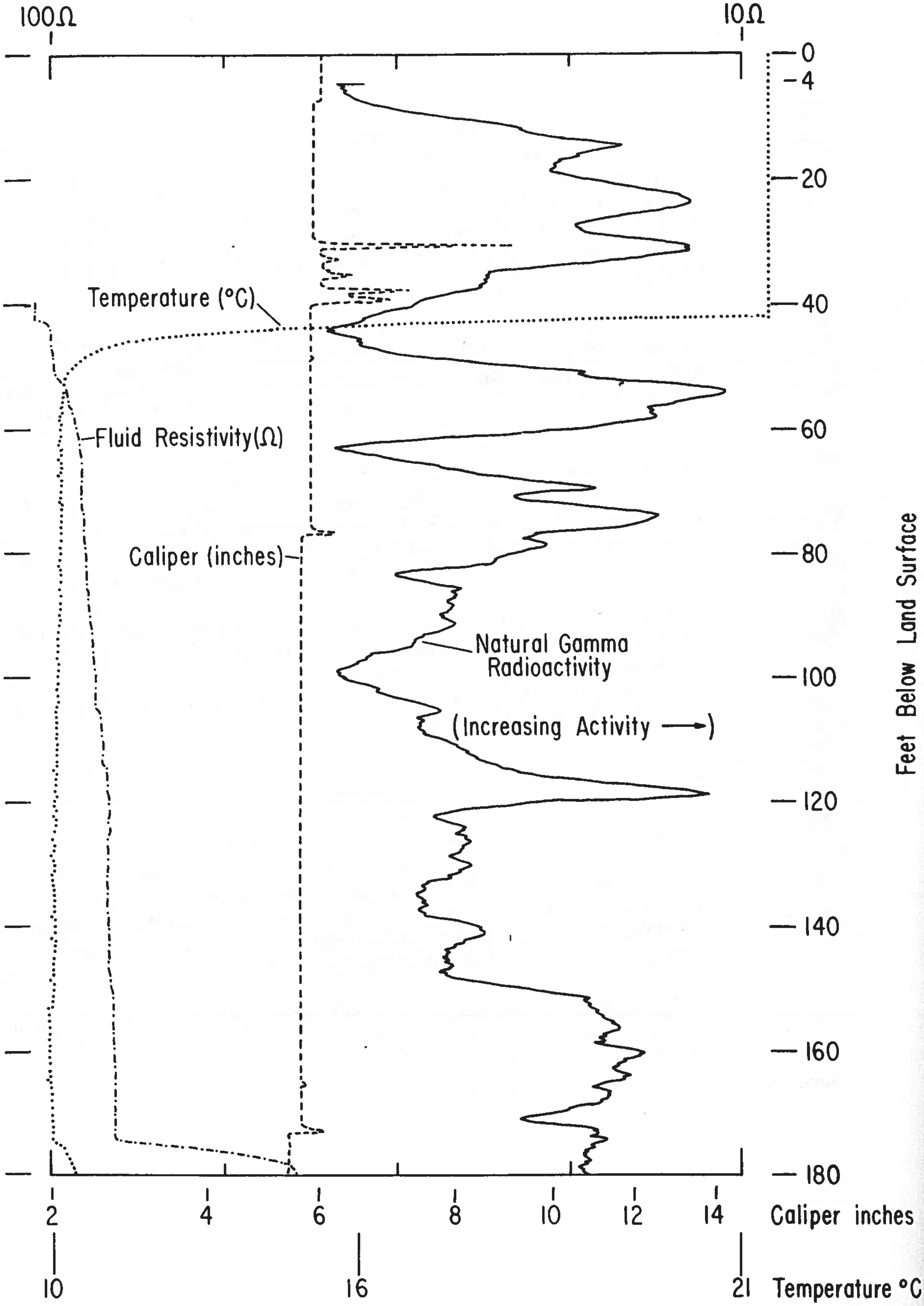


Figure 28.--Caliper, Temperature, Gamma-Ray and Fluid Resistivity logs of well SP-291

The angle of incidence between the rock fracture and the ground surface or the interface between the saprolite and the hard rock, affects well yield because those wells that intersect the greater number of water-bearing fractures will ordinarily have higher yields. Wells intersecting low-angle fractures will likely penetrate more fractures per foot of depth than if they intersected high-angle fractures. This feature is also affected by topography because if the fractures intersect the ground surface where it has a steep slope they will not receive as much recharge as if they intersected the ground where it has a gentle slope. Thus higher yields result when fractures intersect the ground surface or the saprolite at low angles and where the dip of the fractures is in the same direction as the slope of the ground surface.

Identification of fractures or water-bearing zones in the subsurface may be enhanced by use of a caliper tool, which measures variations in the diameter of the well along its entire length. Recording equipment registers a line graph or temperature log which is plotted with variations of the borehole diameter (including fractures) as a function of depth.

The caliper device consists of a probe to which three legs or "feelers" are attached, separated by 120°. The probe is lowered to the bottom of the hole with the legs collapsed against the side of the probe. Then, by electronic control from the surface, the legs are extended and the probe raised to ground level. As it traverses the borehole, the legs spread against the wall of the well and record the variations in hole diameter caused by fractures or caved zones.

Figure 28 shows a caliper log of well SP-291 in addition to gamma-ray, temperature and fluid-resistivity logs of the same well. The principal fractures are indicated prominently on the caliper log as occurring between 28 to 30 feet and 38 to 40 feet. These depths are a few feet higher than the static water level (42.7 feet), as measured at the time the well was logged, and at that time water was cascading from these fractures down the hole to the water surface. This suggests that nonequilibrium conditions existed in the vicinity of the well, as might be expected in view of the short time (less than 36 hours) that had elapsed since completion of the well.

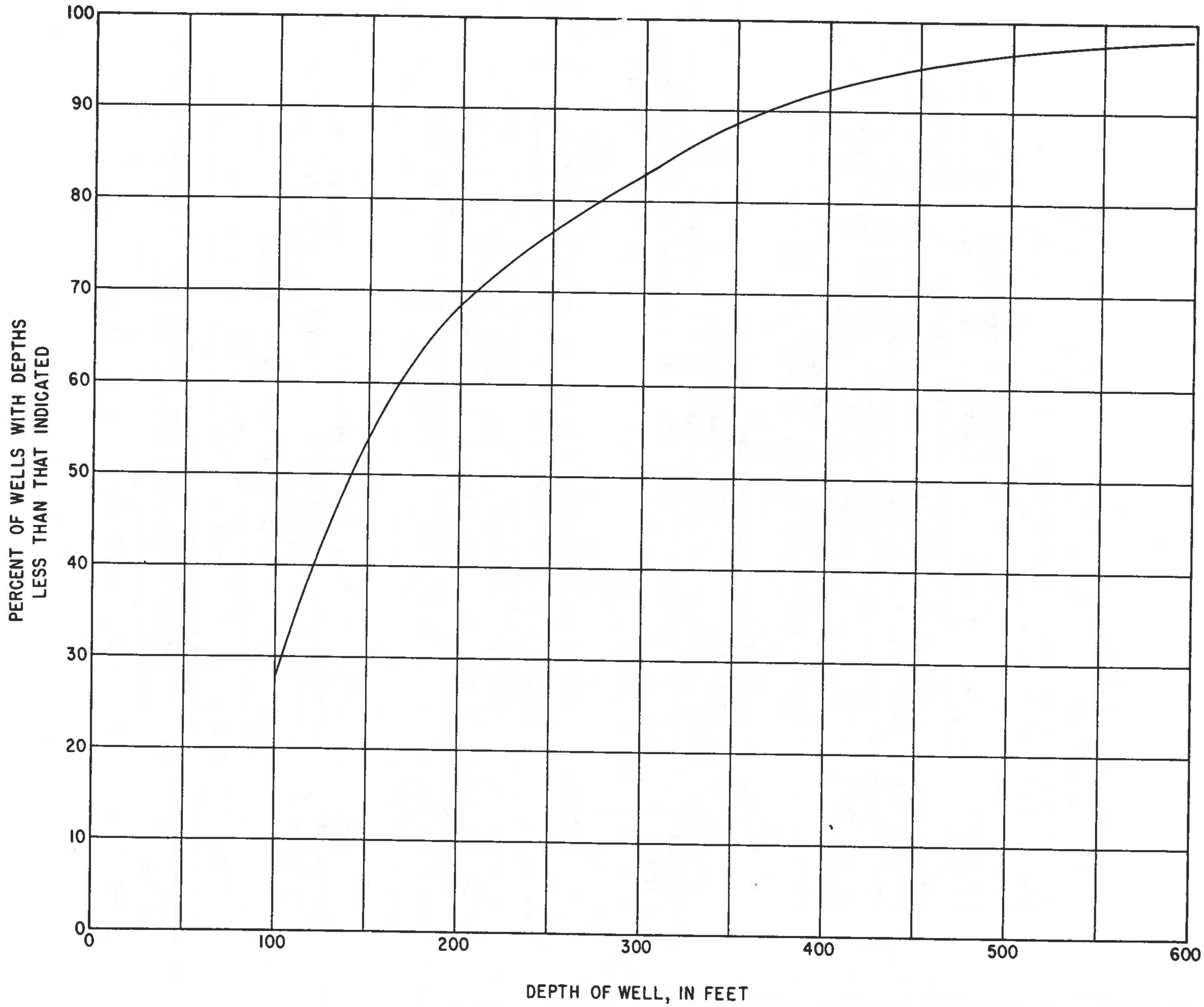


Figure 29.--Distribution of wells according to depth

DEPTH OF WELL, IN FEET

Figure 29.--Distribution of wells according to depth

The gamma-ray log for well SP-291 shows a very low gamma radiation opposite the zone immediately below the fractures. Another smaller fracture appears to occur at a depth of about 78 feet, where the coincidence of a low gamma radiation is not as apparent, although a lower zone does occur at a depth of about 82 feet. The fractures are possibly associated with the occurrence of quartz dikes or pegmatites in this area. Were it possible to obtain several caliper logs over an extensive area, such fracture systems might be correlated and used to locate additional wells by extrapolation of the fracture zones.

Well Depth

Well yields are dependent to a certain extent on the depth of the well because, other factors being equal, the greater the depth, the greater the number of water-bearing fractures the well will intersect. However, this is conditioned or limited by the fact that some massive rocks have a comparatively small number of fractures and that the number and size of fractures (and thus the rock permeability) decrease with depth rather than being uniformly distributed. Low-grade metamorphic rocks (phyllite, slate and gabbro) tend to have less resistance to fracture closure at increasing depths. Thus the well yield is not directly proportional to its depth.

As shown on figure 29, about 75 percent of the wells inventoried in Spartanburg County are less than 250 feet--and most are less than 150 feet deep. Significantly, the smallest percentage of wells yielding less than 5 gpm are those drilled to only 100 feet (table 4). Although this table shows the highest average yield as having been recorded from wells 400 to 600 feet deep, this statistical value is affected appreciably by the small number of wells in that depth range as compared with the number having depths up to 200 feet. In addition, inadequate records are kept of deep wells that yield little or no water. Considering the incompleteness and known inaccuracies of the data used, the weight of the evidence suggests that optimum depths would most probably range from 100 to 250 feet. The yield per foot of well is highest in wells of these depths.

Thickness of Saprolite

The thickness of weathered rock or saprolite as it affects well yields in the Piedmont province has been discussed in several reports on areas not very distant from Spartanburg County (Siple, 1946; LeGrand and Mundorff, 1952; LeGrand, 1967). The presence of the saprolite suggests that accelerated weathering, probably associated with an underlying zone of rock fractures, has occurred in this area.

Table 4.--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	128	49.3	2.5-250	13.9	7.1	0.28	7
101-200	63	154.8	1 -125	18.8	15	.12	17
201-400	49	271	1 -165	27.9	20	.10	16
401-600	10	483	4 -100	54.1	47.5	.11	10
All Wells	250	136.7	1 -250	19.5	6.7	.14	12

This weathered mantle also acts as a storage reservoir to receive and absorb rainfall, which is subsequently released as recharge to fractures in the underlying hard rock. This reservoir provides a more stable yield to wells and tends to lessen the incidence of extreme high and low water storage caused by alternate periods of drought and abundant rainfall. Where the weathered zone is absent and bare rock is exposed, potential recharge by rainfall tends to be lost by overland runoff.

Whether or not a direct proportionality exists between thickness of saprolite and well yield is difficult to determine in this area. Figure 30 shows the relation between thickness of saprolite (as indicated by the length of casing) and well yield for those wells 101 to 200 feet deep. As shown by the figure, the thickness of this zone of weathered rock ranges from 5 to 145 feet. Using a computer, the relation between this thickness and yield (as affected by variables such as well depth and rock type) were analyzed by a least-squares technique.

The results were not definitive, probably due in large measure to the fact that in this short study it was not possible to eliminate all the other variables, such as topographic location, rock type, and well depth, in order to restrict the data to one variable--that of saprolite thickness. In addition, whereas the depth of casing is in general an approximate index of the thickness of saprolite, it is not an exact measure of this thickness. Thus some wells are cased deeper than others through a saprolite having approximately the same thickness.

The highest degree of correlation was obtained in the set of values for those wells 101-200 feet deep. The slope of the locus line A-B was computed by the least-squares technique, and, although it represents an accurate determination in the statistical analysis of the data points, it probably is unrealistic in a physical sense. Certainly there is a limiting boundary on its extrapolation towards the higher yields. An increase of approximately 20 feet of saprolite could not possibly increase well yield by 900 gpm because maximum yields are in the range of 250-300 gpm. The interpolation slope of the line C-D is probably more representative of the physical conditions involved, although its application is likewise limited to yields of 300 gpm or less.

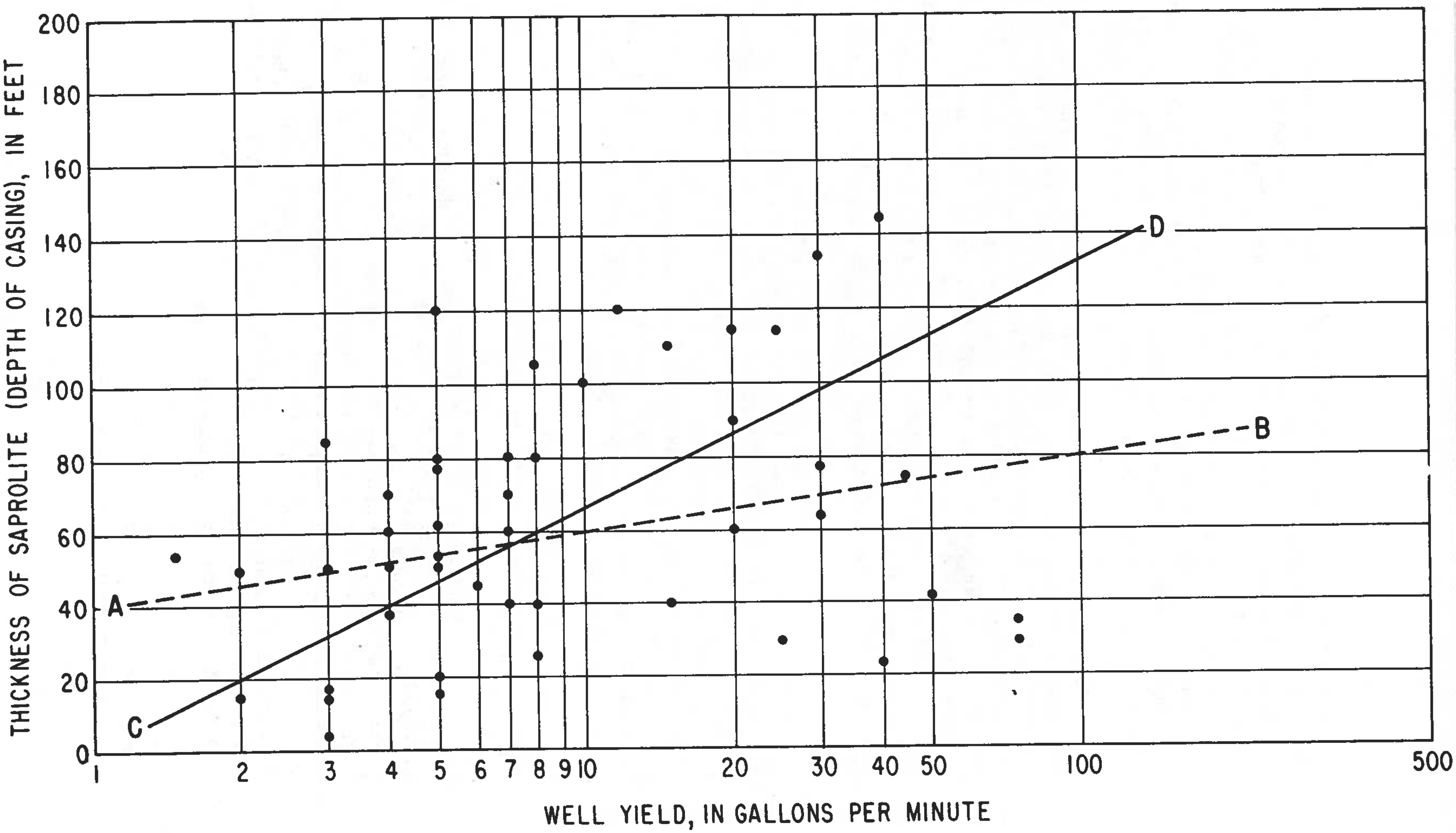


Figure 30.--Relation of well yield to thickness of saprolite in wells 100-200 feet deep

Water Levels

The water table represents the surface of the zone of saturation and in crystalline rock may occur in the weathered zone or, in some places, in the buried fractures of the hard rock. An inclined fracture zone or a clay bed may act as a confining layer to prevent or retard the upward movement of water. The water level attained in wells penetrating the confining layer as well as the unconfined level of the water table are referred to as potentiometric surfaces, which are reflections of dynamic conditions within the aquifer. Cycles of rising or falling water levels occur over relatively short and long-term periods. If the water table is shallow with respect to depth from land surface, the rise or fall coincide closely with periods of climatic change, which reflects direct recharge to or discharge from the water-table aquifer. During periods of rainfall there will be a short-term recharge to the aquifer and the water table will rise. During drought conditions the aquifer continues to discharge, lowering the water table.

During the winter and early spring, the water table is usually high as a result of recharge from the steady penetrating rainfall characteristic of this season. During the summer and early fall the rainfall is normally a high intensity-low duration type, which results in a high surface runoff, and thus considerably less water seeps into the ground to recharge the aquifer. During this same period, evaporation and transpiration are taking place at maximum rates, and, thereby, a large percentage of the rainfall is returned to the atmosphere that might otherwise have recharged the aquifer. The net effect is to cause a decline in water levels regardless of the higher amounts of rainfall during this period. During autumn the rates of evaporation and transpiration decrease and the water table recovers to a higher level. This annual cycle is repeated year after year and changes in response to any deviation from the normal climatic cycle.

The artesian potentiometric surface responds similarly to that of the water table except that, being a pressure surface, it is affected by such loading effects as earth tides, barometric pressure, surface-water bodies, and passing trains. It might also change due to the loading effect of increased volumes of water stored in water-table aquifers (Siple, 1957) and as a result, the level fluctuations simulate those of the water table. However, the largest fluctuations in either potentiometric surface (water table or artesian) are likely to occur as a result of pumping in nearby wells.

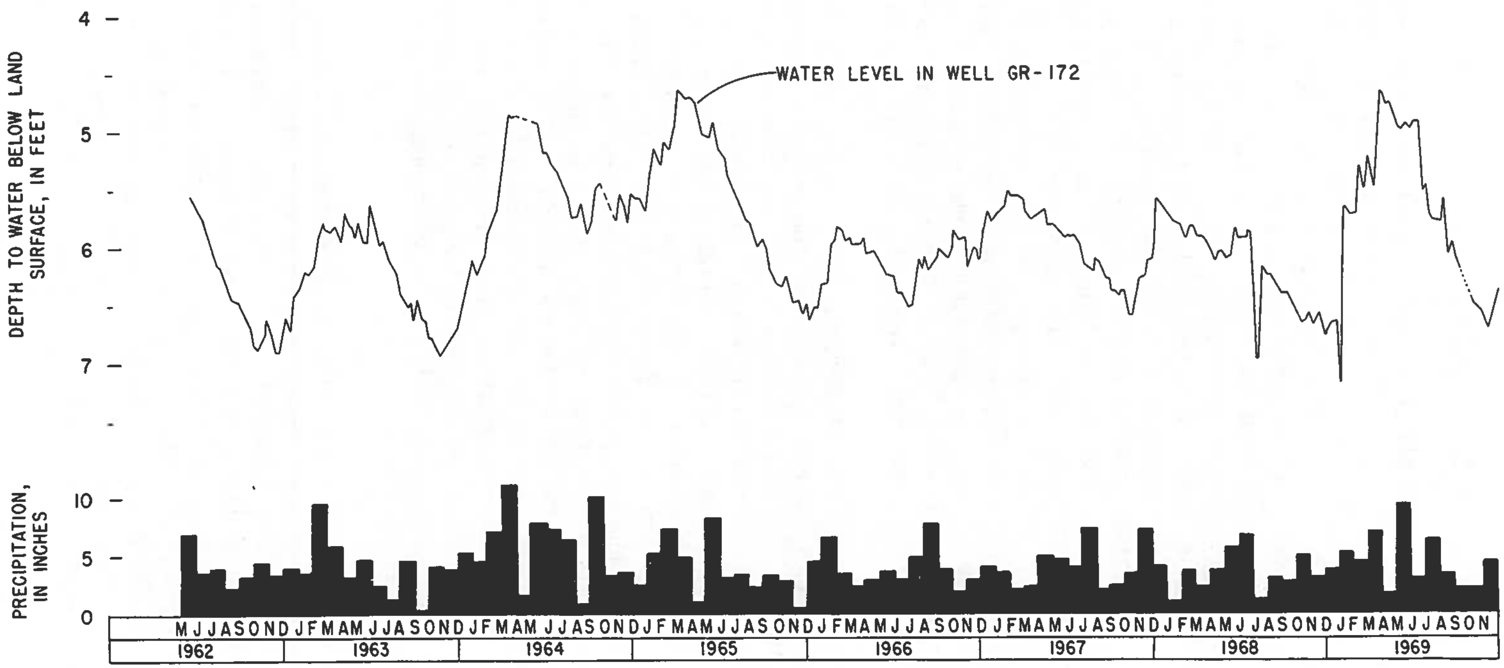


Figure 31.--Weekly low-water levels in well GR-172 and rainfall at Greenville-Spartanburg airport

During this investigation, no continuous records of water-level change were obtained in wells within the county. However, the records of such changes in a well in adjacent Greenville County will suffice to reflect similar conditions in Spartanburg County. These records were obtained from an observation well at Fountain Inn during a period of several years. Figure 31 shows water-level changes recorded in this well and rainfall reported during the same period. The cyclic pattern of water-level change is illustrated here, and it might be noted that at the end of 8 years' observation the water level remains substantially in the same relative position.

Quality of Ground Water

The chemical quality of ground water is evaluated on the basis of the amount and nature of dissolved mineral constituents in the water. Rainfall, which contains gasses dissolved from the atmosphere and from organic matter, percolates downward through soil and rocks. The principal dissolved gas, carbon dioxide, forms a weak acid, which acts as a solvent on almost all minerals in the rocks.

Whereas several factors affect the concentration of dissolved constituents in ground water, two of the most important are the mineral composition of the rock and the residence time or duration of contact between the water and mineral particles in the rock.

Where rocks undergo chemical weathering, most of the chemical constituents are dissolved as positively charged particles (cations) and negatively charged particles (anions). Iron may be present in the form of colloidal suspension or as a cation. In most natural waters, silica is in a nonionic form.

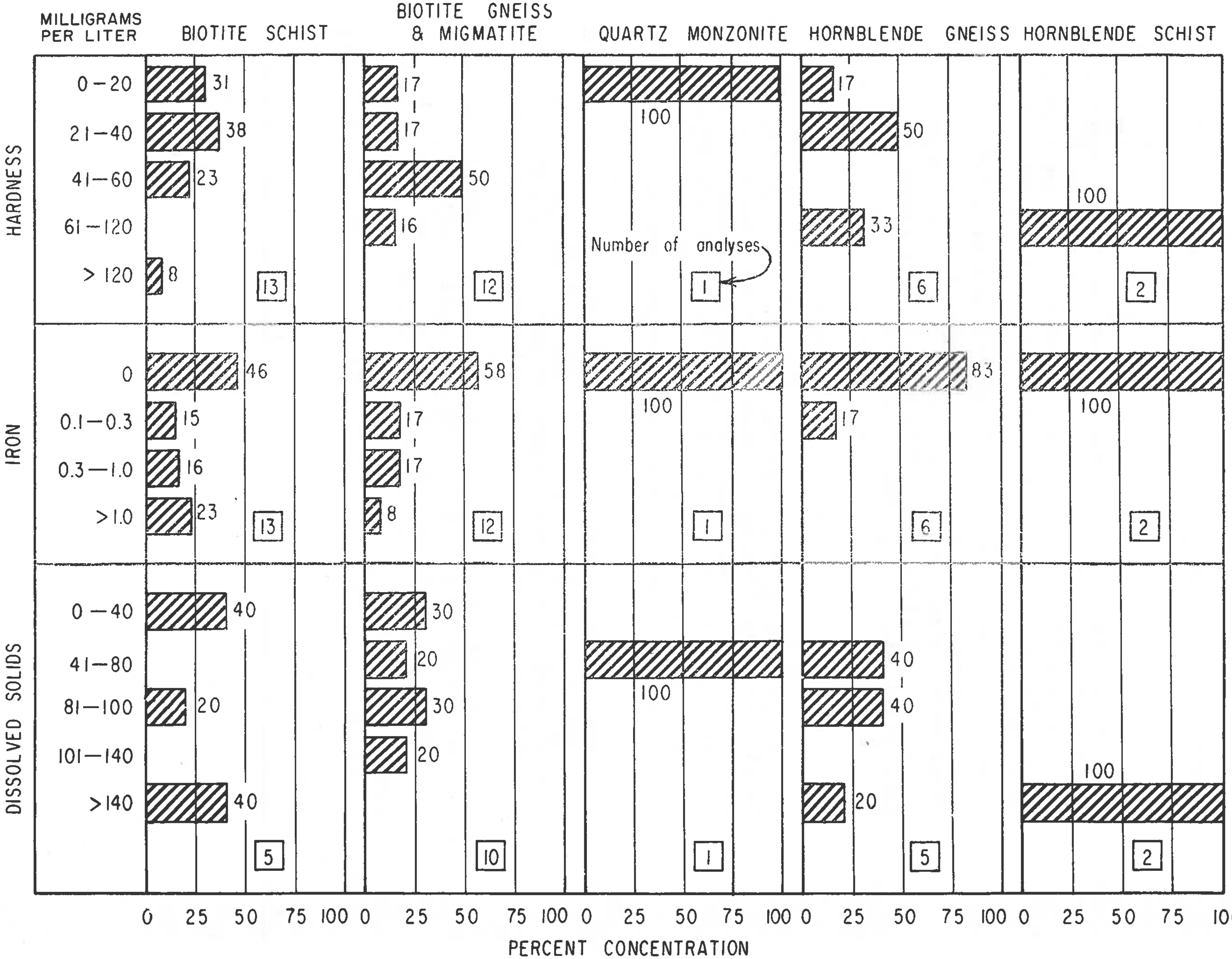


Figure 22.--Distribution of selected [illegible]

Water Quality as Affected by Lithologic Units

The Geological Survey now reports chemical analysis of water samples in milligrams per liter. Appendix table 15 lists the complete chemical analyses for selected well and spring water in Spartanburg County, and appendix table 16 summarizes the range in concentration, arithmetic mean and median values for the principal constituents reported in these analyses. Figure 32 shows the distribution of hardness, dissolved iron, and dissolved solids by rock type. The percentage of analyses for hardness within the class interval indicated for waters in the quartz monzonite and hornblende schist should not be considered representative because of the small number of analyses (1 and 2, respectively). The same applies to the distribution of iron and dissolved solids in waters from these two units. However, the larger number of analyses of waters circulating through the biotite schist, biotite gneiss and migmatite, and the hornblende gneiss are probably representative of the distribution of the chemical characteristics of waters from these units. These data show the characteristic soft water, low in iron for the biotite schist and biotite gneiss, and the comparatively higher hardness of waters circulating through the hornblende gneiss.

For purposes of correlating formational or lithologic units with the chemical composition of circulating ground waters, a method of comparing the relative amounts of chemical constituents of one water with those of another is required, and expression of the analyses in milliequivalents per liter is more useful than in milligrams per liter. In the concept of chemical equivalence, the sum of the cations, in milliequivalents is equal to the sum of the anions, in milliequivalents. This equivalency is commonly demonstrated by means of a columnar diagram such as those shown in figure 33. Because there were not sufficient analyses available for well waters considered as representative of all predominant geologic units, the analyses of several streams that drained these formations are included as substitutes. However, some of these probably have more dilute concentrations of chemical constituents than well waters from the same geologic unit. An example of this probably accounts in part for the difference in dissolved solids shown in the analyses for well 74 with those shown for the stream water at site 42.

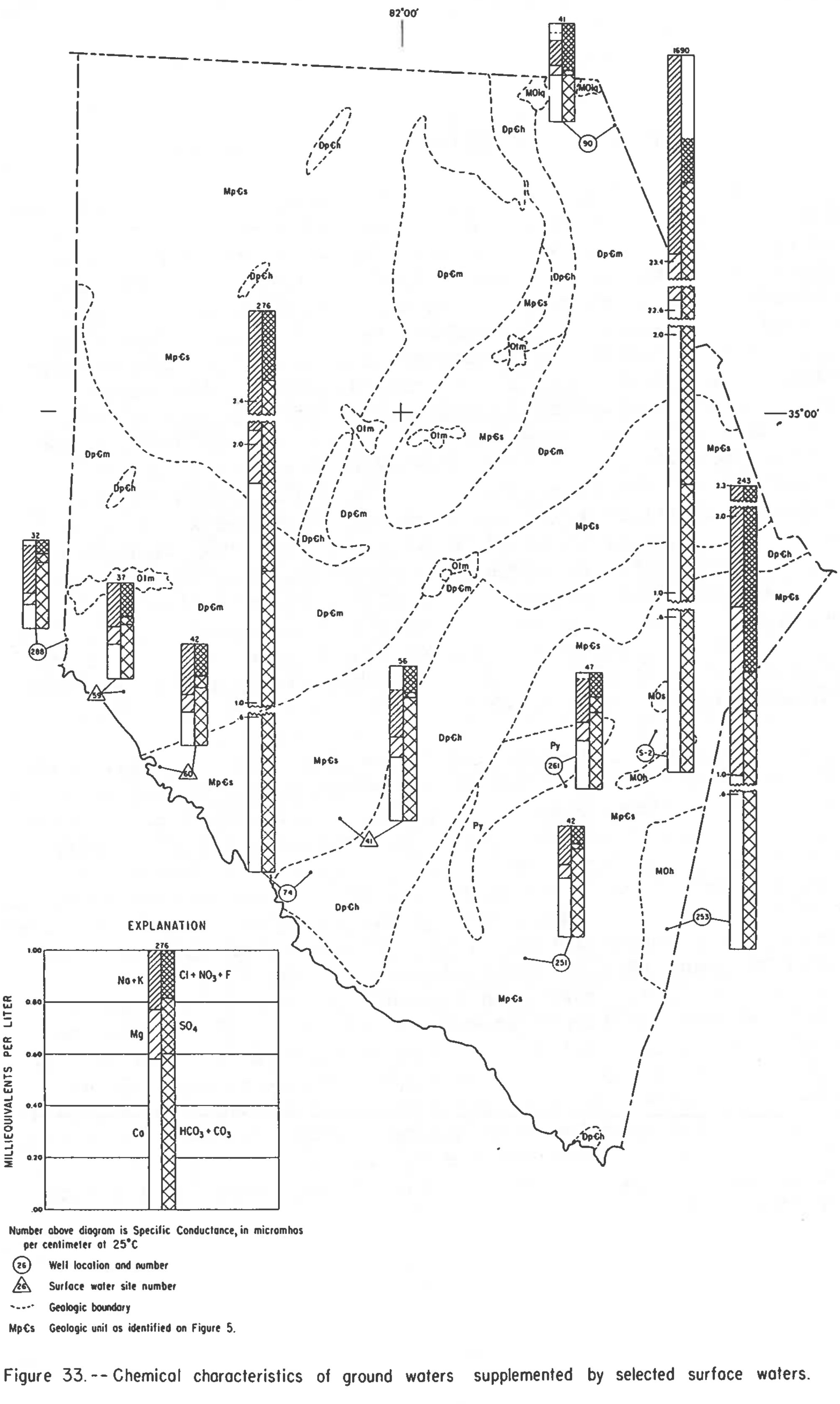


Figure 33.--Chemical characteristics of ground waters supplemented by selected surface waters.

The chemical composition of ground waters in Spartanburg County, like those of many other areas underlain by crystalline rocks, can be grouped into at least two general types. One is represented by those waters circulating through quartzose, micaceous, and mostly silicate light-colored rocks. These waters are usually soft and low in dissolved solids. The other type is represented by waters circulating through rocks composed largely of gabbro, hornblende, diorite, amphibolite, and other dark-colored calcium magnesium-rich minerals. These waters are moderately hard to hard, have a higher dissolved-solids content and may have a higher iron content than the former type.

Waters from the biotite schist (well SP-251), quartz-monzonite (SP-261) and the biotite gneiss and migmatite (SP-90) generally consist of a calcium sodium bicarbonate type of soft water, with a low dissolved-solids content. The chemical analyses of streams draining areas underlain by this rock type indicate a similar composition (as for example, the analysis shown at site 59-C).

Water from wells drilled in hornblende gneiss (SP-74) or hornblende schist (SP-253) are represented in figure 33 as having higher concentrations of calcium, magnesium, chloride, sulfate, and dissolved solids. The scale of milliequivalents had to be broken in this illustration in order to accomodate the analyses having very high values.

The geographic location of Glenn Springs is shown on figures 5 and 33 as underlain by biotite schist. However, the chemical analysis of water from this spring indicates that more probably the water circulates through nearby rocks of hornblendic composition, or possibly mineral suites associated with pegmatitic or diabase dikes.

Suitability of Water for Use

The chemical analyses available for well waters in Spartanburg County show that these waters are of good to excellent quality for most domestic, municipal, industrial and agricultural uses.

Standards for the quality of drinking water, established by the U. S. Public Health Service (1962) and applied to waters supplied by common carrier are commonly used as uniform standards for municipal or public water supplies. These standards are indicated above (on p. 44).

Appendix tables 15 and 16 show that the maximum concentrations of dissolved constituents in well waters do not exceed the recommended standards except for a few analyses. Six analyses show iron concentrations greater than 0.3 mg/l. Only one well (SP-254) contained water with a nitrate content higher than the recommended limit. This high concentration could be indicative of contamination around the well. The topographic location of the well, on a hilltop, and its shallow depth indicates that probably contamination enters the well from a nearby source rather than through fractures connected with the surface. One analysis, that of water from well SP-74 shows a fluoride content (2.5 mg/l) higher than the recommended standard. The presence of fluoride-bearing minerals such as mica, apatite, and hornblende in fairly substantial amounts in this area probably accounts for the higher concentration of fluoride in these ground waters. In all other respects the dissolved constituents in these waters were well below recommended maximum concentrations for drinking waters.

With respect to spring waters, the analysis for Glenn Springs shows that several constituents in this water exceed the recommended maximum limits; specifically with respect to calcium (454 mg/l), sulfate (1,070 mg/l), and dissolved solids (1,780 mg/l). It would also be considered a very hard water, inasmuch as the total hardness is 1,170 mg/l.

Most of the well waters analyzed from Spartanburg County were soft, and only five were moderately hard (61-103 mg/l). This is somewhat uncommon in areas underlain by crystalline rocks, but probably indicative of the proportionately larger amounts of quartzose and micaceous rocks, as compared with calcium magnesium-rich rocks.

The specific conductance of well waters in Spartanburg County ranges from 42 micromhos in a well drilled in biotite schist at Chesnee, to 306 micromhos in a well drilled in hornblende schist at Enoree. The specific conductance of the water from Glenn Springs was 1,690 micromhos, exceeding that of any other well water in the county.

However, additional springs occur throughout the county, particularly in the eastern and northeastern parts, but these springs were not sampled and analyzed. The probabilities are that they would discharge water having higher concentrations of chemical constituents than those characteristic of well waters. Spring water generally circulates through the more weathered parts of the rock and contacts more soluble minerals than the deeper waters circulating through hard rock.

Waters circulating through rocks composed largely of silicate minerals commonly contain as much as 60 mg/l silica. Table 16 shows that as much as 52 mg/l has been analyzed for some of the ground water in Spartanburg County. The rocks underlying the area contain several kinds of silicate minerals of igneous and metamorphic origin. In temperate climates quartz is highly resistant to solution by water with a pH less than 9.0. The higher concentrations found here, thus, probably originated in the chemical breakdown of silicates by metamorphism and weathering.

The amount of silica indicated by the analyses of ground waters within the county is not harmful to human beings or livestock, but some concentrations may exceed desirable limits for specific industrial purposes. Thus, those waters in which the silica content exceeds 30 mg/l may form scale in boilers if the boiler pressure exceeds 150 psi. A maximum concentration of 50 mg/l is also recommended for water used in the manufacture of pulp or paper (National Technical Advisory Comm. 1968).

Temperature of Ground Waters

Temperatures within the earth increase from the surface toward the center of the earth. Because of this thermal gradient, ground water temperatures at equilibrium with the rocks also increase with increased depth. This thermal gradient is about half a degree Celsius for each 60 to 120 feet of depth.

The temperature of shallow (less than 100 feet) ground waters normally approximates that of the mean annual air temperature, which ranges from 60°F (16°C) written commun., John C. Purvis, ESSA, Col. S.C.) on the north edge of the county to about 62°F (17°C) on the southern boundary.

The temperature of ground waters from 15 wells, measured at ground surface, ranged from 14°C to 17°C and averaged about 16°C. However a temperature log (fig. 28) of well SP-291 indicated an anomalously low temperature of 10.5°C or less for the greater length of the hole. Because the temperature-recording device was calibrated before its use, this lower temperature is attributed to a combination of factors, some of which are not immediately identifiable. The well had been completed less than 36 hours, and all the water used in drilling had not been removed from the well. Also, the drilling water was obtained from another well at a higher elevation and, thus, possible containing cooler water. In addition, the well had been pumped by the injection of air into the water column, and this possibly contributed to a decrease in temperature. Regardless of the cause of the anomalous temperature, it is rather obvious that the natural thermal equilibrium in the vicinity of the well had been disturbed and had not yet returned to normal at logging time.

The fluid-resistivity log appears to validate the accuracy of the temperature log in that it shows an increase in conductivity (decrease in resistivity) at the same depth (176 ft) as an increase in temperature is shown. The caliper log likewise shows a small increase in hole diameter at this point, which probably represents a small fracture through which additional water was entering the well.

CONCLUSIONS

About 40 percent of the average rainfall in Spartanburg County becomes streamflow. The mean annual discharge of the drainage system is about 1,250 cfs or 1.5 cfs per square mile. However, streamflow is less than this amount more than 70 percent of the time, being sustained by ground-water inflow, as indicated by the moderate slope of the flow-duration curves. Streams in the upper part of the county generally exhibit less variability of flow and have a higher rate of runoff than those in the lower part.

In comparing the low-flow characteristics on the basis of unit runoff per square mile, the larger natural streams were found better sustained in the northern section of the county than in the southern. For example, the minimum annual 7-day flow likely to occur once in 10 years at North Pacolet River at Fingerville is 0.34 cfs per square mile, as compared with 0.16 cfs per square mile at Enoree River at Enoree. Low-flow events of the same magnitude do not occur with the same frequency in all parts of the county.

Streamflow is less than minimum mean annual flow 30 percent of the time but will support a maximum draft rate of about half the mean annual flow (about 0.75 cfs per square mile) with seasonal storage. A capacity for the storage of about 13 percent of the mean annual flow would be required at this draft. Over-year storage is necessary for greater draft rates, although the required storage capacity, which increases rapidly, may limit the practicality of drafts above 60 to 70 percent of the mean annual flow.

Small streams are subject to the influence of local geologic features, and low-flow characteristics may be difficult to predict without discharge measurements. The range in estimated annual 7-day minimum flows for the 10-year recurrence interval varied more than 4 times--from 0.07 to 0.29 cfs per square mile. The small streams in the southern and eastern sections of the county were generally least well sustained.

Storage facilities, such as lakes and ponds, established in a river basin modify the natural flow pattern. Lakes have an estimated capacity for about 5 percent of the county's mean annual streamflow. The effect of regulation varies but, generally, is most noticeable on the Pacolet and Tyger Rivers.

The total quantity of water used in the county is about 35 mgd or about 4 percent of the average streamflow--surface water being the source of 95 percent of the supply. Predominant consumption is by the textile industry, which requires about 13.5 mgd for processing. The ratio of industrial to municipal use is about 1.7 to 1.

Most streams in Spartanburg County contain water having excellent quality for domestic, industrial, and agricultural uses. The dissolved-solids content, which can be predicted from measurements of specific conductance, is less than 100 mg/l at most locations. The water is soft and has low concentrations of individual dissolved substances. Some streams in the central part of the county, however, receive waste discharges that increase dissolved-solids content and deplete dissolved oxygen. The effect of these wastes is pronounced on the North, Middle, and South Tyger Rivers and on Fairforest Creek, particularly at low flow. Temperatures of surface water throughout the county are fairly uniform; changes in temperature at most locations are in response to seasonal weather conditions. The lowest average monthly temperature was 6°C in January on the Pacolet and North Pacolet Rivers. The highest average monthly temperature, 27°C, was found on the Middle Tyger River in August. Temperatures measured on the Middle Tyger River may be slightly higher than natural because of waste discharges.

Ground water occurs in the fractured hard rock and mantle of weathered rock throughout Spartanburg County. The area lies wholly within the Inner Piedmont belt, which includes primarily a series of igneous and metamorphic rocks, predominantly mica schist and gneiss granite and hornblende gneiss, and other rocks of gabbroic composition.

Well yields range from 1 to 250 gpm and average 20 gpm. The average yield of those wells drilled to obtain maximum yield was 53 gpm. The average yield of the highest of 3 percent of the most productive wells inventoried was 139 gpm. On the basis of statistical analyses in adjoining areas, wells in topographically low areas, such as draws and gentle slopes, generally have the highest yields. Wells located on topographically high areas or on steep slopes generally have the lowest yields.

The highest average yields of wells in Spartanburg County are obtained from wells drilled in the biotite gneiss and migmatite and the lowest average yields from wells in the quartz monzonite.

Although some wells are as deep as 600 feet, 75 percent of all wells recorded were less than 250 feet, and most are less than 150 feet deep. Optimum depths for maximum yields probably range from 100 to 250 feet.

Rock structure has a very important bearing on well yield in that rock permeability is dependent primarily upon fractures, faults, joints, and bedding or foliation planes. Wells intersecting the greatest number of water-bearing fractures produce the highest yields. The structural control is related to the influence of topography and rock type.

The thickness of saprolite appears to affect well yield of those wells drilled through greater thickness of saprolite providing the higher yields. However this does not apply exclusively, and the relation of saprolite thickness to well yield is not strictly linear.

Fluctuations of the potentiometric surface (either water-table or artesian), reflect a dynamic condition of cyclic rise and fall, which are dependent to a large extent on variations in climatic conditions. The water table generally rises in the winter and early spring and declines during the summer or early autumn. The greatest change in water level in wells is likely to result from pumping of nearby wells. In December 1969, after a period of 8 years of continuous measurement, the water table, as reflected by the hydrograph for well GR-172, was within 1 foot of that measured in May 1962. Thus, there is no evidence to indicate any continuous downward trend in water levels.

The ground waters of Spartanburg County, as indicated by the data collected in this project, are generally of good to excellent quality and suitable for most domestic, municipal, and agricultural uses. Most waters were soft, slightly acidic, and low in dissolved solids. Most waters were of the calcium bicarbonate type, except for the waters from hornblende schist, which were predominantly of a sodium and magnesium chloride or sulfate type. Some analyses of waters circulating through the biotite schist showed a predominance of sodium over calcium in the cations and bicarbonates as the predominant anion.

The chemical components of most waters analyzed were within drinking-water standards recommended by the U. S. Public Health Service, although a few contained concentrations of iron, hardness, and fluoride that exceed these standards. The analyses for the Glenn Springs showed this water to contain the highest concentration of dissolved solids and the hardest water in the county. It is predominantly a calcium sulfate water.

If additional and more intensive ground-water investigations are made in this area, it would appear that more complete coverage of the county is needed for representative well and spring data, including more definitive water-quality and water quantity data. Additional review and field checking of lithologic or geologic units is desirable in order to obtain more precise data on the relation of rock type to well yield and water quality. The determination of aquifer characteristics through a series of pumping tests would be of considerable value, along with some laboratory determinations of porosity for the unconsolidated material. Comparative cost analyses of ground-water development would be beneficial to present and future utilization of this resource.

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APPENDIX

Tables 5 through 16

Table 5.--Inventory of principal water use in Spartanburg County

City, Town, or Service Area	Industry	Estimated Use (mgd)	Source of Water	Estimated Population Served
Clifton-Converse Community	--	.10	Wells	2,000
	Clifton Mfg. Co. Mills 1,2,3	.40	"	--
Cowpens Water District	--	.22	S.W.W.[2]	4,200
Cowpens	--	.14	"	2,200
Enoree	--	.02	Wells	500
Glendale	--	.04	Wells	600
	Venmar Mills	.01	"	--
Greer (metropolitan)	--	.37[1]	G.W.W.[3]	5,200
Greer (city)	--	.18[1]	"	2,500
	Stevens Co. (Appalachia Plant)	.07	"	--
	" " (Victor Plant)	.16	"	--
Inman-Campobello Water District	--	.43[1]	S.W.W.	7,000
Inman	--	.12[1]	"	1,700
	Inman Mills (Inman Plant)	.05	Wells	--
	Inman Mills (Saybrook Plant)	.05	"	--
	Sylvan Chemical Co.	.13	S.W.W.	--
Landrum Community	--	.22[1]	L.W.W.[4]	3,500
Landrum	--	.14[1]	"	1,950
	Bigelow-Sanford Carpet Co.	.04	"	--
	Bommer Spring Hinge Co.	.04	"	--
Liberty-Chesnee-Fingerville Water District	--	.29[1]	S.W.W.	4,900
Chesnee	--	0.07[1]	"	1,050
	Reeves Bros. (Chesnee Mill)	.03	S.W.W., Wells	--
	Spartan Mills (Chesnee Div.)	.07	S.W.W.	--
Fingerville	Indian Head Mills (Franklin Process Co.)	.17	"	--
Lyman	--	.09	Middle Tyger River	1,200
	Lowenstein & Sons (Wamsutta) Lyman Printing & Finishing Co.	7.30	" " "	--
	Spartan Mills (Startex Div.)	.40	" " "	--
Mayo	Massachusetts Mohair Co. (Mayo Mills)	.01	Wells	--
Pacolet - Pacolet Mills	--	.20	Wells[5]	3,300
	Campbell Limestone Co.	.50	Pacolet River	--
	Pacolet Ind. (Pacolet Mill)	.10	Spring	--
	Spartan Minerals Co.	.50	Pacolet River	--
Spartanburg (metropolitan)	--	7.50[1]	S.W.W.	65,000
Spartanburg (city)	--	6.00[1]	"	49,000
	Alamo Polymer Co.	.20	"	--
	Arkwright Mills	.15	"	--
	Blackman-Uhler Chemical Co.	.16	"	--
	Burlington Ind. (Martel Mill)	.05	"	--
	Crown Cork & Seal Co.	.04	"	--
	Deering-Milliken Research	.37	"	--
	Draper Corp.	.16	"	--
	Fairforest Finishing Co.	2.07	"	--
	Firestone Steel Products Co.	.80	"	--
	Hercules-Farbwerke	.70	"	--
	International Minerals & Chemical Corp.	.12	"	--
	Jonathan Logan (Interstate Hwy. 85)	.15	"	--
	" " (U.S. Hwy. 29)	.05	"	--
	Kohler Co.	.13	"	--
	Mayfair Mills	.14	"	--
	Moreland Chemical Co.	.03	"	--
	Pacolet Ind. (Drayton Mill)	.10	"	--
	Powell Knitting Mill	.07	"	--
	" " "	.03	Wells	--
	Southern Crown Chemical Corp.	.03	S.W.W.	--
	Southern Railway	.13	"	--
	Spartan Mills (Beaumont Div.)	.37	"	--
	" " (Spartan Div.)	.40	"	--
	Taylor-Piedmont Co.	.12	Creek	--
	Union Bag-Camp Paper Corp.	.02	S.W.W.	--
	Whitney Yarn Mill	.05	"	--
Startex-Jackson-Wellford-Duncan Water District	--	.70[1]	S.W.W.	9,000
Duncan	--	.10	"	1,350
Wellford	--	.09	"	1,150
	Jackson Mills	.18	Wells,Creek	--
Una Water District	--	.30[1]	S.W.W.	4,000
Woodruff-Roebuck-Enoree Water District	--	.52[1]	S.W.W.	9,000
Woodruff	--	.26[1]	"	3,950
	Abney Mills	.06	"	--
	Reeves Bros. (Woodruff Mill)	.06	"	--

1/ Excludes use by industries listed.
2/ Spartanburg Water Works - Source, Reservoirs on South Pacolet River.
3/ Greer Water Works - Source, South Tyger River.
4/ Landrum Water Works - Source, Vaughn Creek.
5/ Pending service by Spartanburg Water Works.

Table 6.--Magnitude and frequency of annual low flows at gaging stations in Spartanburg County

No.	Gaging Station	Drainage area (sq mi)	No. of consecutive days	Annual low flow, in cubic feet per second, for indicated recurrence interval, in years				
				2	5	10	20	40
2-1545.	North Pacolet River at Fingerville	116	7	76	52	40	32	26
			30	89	62	49	39	31
			60	101	69	54	43	35
			120	121	85	68	55	45
			274	170	125	103	86	72
2-1555.	Pacolet River near Fingerville	212	7	115	76	59	46	36
			30	137	88	66	51	39
			60	158	106	82	64	51
			120	194	130	101	79	62
			274	277	200	160	131	109
2-1560.	Pacolet River near Clifton	320	7	162	103	78	59	45
			30	197	123	92	69	52
			60	231	150	113	87	67
			120	281	181	138	105	81
			274	401	283	228	185	151
2-1575.	Middle Tyger River at Lyman	68.3	7	34	22	17	13	10
			30	39	26	20	15	12
			60	45	30	23	18	14
			120	54	37	29	23	18
			274	79	57	47	40	34
2-1580.	North Tyger River near Moore	162	7	74	48	36	27	20
			30	90	59	45	35	28
			60	105	70	55	44	35
			120	126	84	67	54	44
			274	176	130	111	98	88
2-1585.	South Tyger River near Reidville	106	7	38	21	15	10	7.2
			30	59	35	25	18	13
			60	70	46	35	27	21
			120	87	58	44	35	27
			274	122	92	78	67	58
2-1590.	South Tyger River near Woodruff	174	7	63	36	25	18	13
			30	85	52	38	28	21
			60	105	63	45	33	24
			120	127	84	65	51	40
			274	178	129	108	90	76
2-1595.	Tyger River near Woodruff	351	7	139	87	65	49	38
			30	161	104	80	62	49
			60	200	136	108	86	70
			120	240	161	129	104	86
			274	360	262	221	190	167
2-1605.	Enoree River near Enoree	307	7	112	67	48	36	27
			30	140	88	66	50	39
			60	166	106	80	61	47
			120	200	139	109	87	70
			274	312	228	186	153	129

Table 7.--Discharge measurements made at project sites in Spartanburg County

Site Number	Stream	Drainage Area (sq mi)	Date	Discharge (cfs)
	PACOLET RIVER BASIN			
1	Page Creek near Landrum	4.36	5/17/66 9/ 7/66 9/19/67	5.62 3.08 3.51
2	North Pacolet River near Fingerville	98.8	5/17/66 9/ 7/66	145 68.7
3	Obed Creek near New Prospect	5.80	5/17/66 9/ 8/66	6.57 2.76
4	Obed Creek at Fingerville	9.30	5/17/66 9/ 7/66 9/19/67	13.1 3.71 7.24
5	Spivey Creek near Campobello	5.14	5/17/66 9/ 7/66	6.32 3.31
6	Motlow Creek near Campobello	7.95	9/ 7/66 9/20/67	3.91 8.38
7	Motlow Creek at Campobello	12.0	5/17/66 9/10/66 11/ 7/67	16.4 10.7 10.6
8	Holston Creek near Campobello	5.56	5/17/66 9/ 7/66 9/20/67	4.80 3.57 5.69
9	Alexander Creek near Campobello	4.10	5/17/66	5.50
10	Thompson Creek near Fingerville	3.48	5/17/66	4.02
11	Buck Creek near Chesnee	18.5	5/17/66 9/ 6/66 9/18/67	16.9 7.58 17.2
12	Little Buck Creek near Chesnee	9.68	5/17/66 9/ 6/66 9/18/67	7.86 4.37 7.46
13	Buck Creek near Mayo	36.0	5/17/66 9/ 6/66 9/18/67	32.6 17.8 33.9
14	Casey Creek near Mayo	6.51	5/17/66 9/ 6/66 9/18/67	5.52 3.33 3.98
15	Cherokee Creek near Cherokee Springs	4.82	5/17/66 9/ 6/66 9/18/67	3.78 3.08 3.11
16	Island Creek near Mayo	13.8	5/17/66 9/ 6/66 9/18/67	9.93 5.71 9.52
17	Pacolet River near Cowpens	295	9/ 6/66 11/ 7/67	165 246
18	Peters Creek near Converse	6.42	5/18/66	2.17
19	Lawsons Fork Creek near Inman	8.37	5/17/66 7/26/66 9/ 8/66 9/19/67 11/ 7/67	8.46 4.76 3.92 7.68 7.87
20	Greene Creek near Inman	4.56	5/17/66 9/ 8/66 9/19/67	4.67 2.26 3.27
21	Meadow Creek near Inman	9.64	5/17/66 9/ 8/66 9/19/67 11/ 7/67	10.9 2.99 6.17 7.48
	PACOLET RIVER BASIN--Continued			
22	Fawn Branch near Boiling Springs	4.58	5/17/66 9/ 8/66 9/19/67	5.18 2.19 3.72
23	Big Shoally Creek near Valley Falls	6.17	5/17/66 9/ 7/66 9/19/67	7.83 2.54 3.36
24	Lawsons Fork Creek near Whitney	55.5	9/ 8/66 9/19/67 11/ 7/67	25.7 34.1 42.8
25	Chinquepin Creek at Spartanburg	4.75	5/18/66 9/ 7/66 9/20/67 11/ 9/67	5.88 3.63 5.38 5.75
26	Lawsons Fork Creek at Glendale	80.6	9/10/66	34.6
27	Richland Creek near Pacolet	5.37	5/18/66 9/ 8/66 9/21/67	3.02 6.88 3.02
	TYGER RIVER BASIN			
28	Jordan Creek near Inman	4.50	5/17/66 9/ 7/66 9/20/67	4.54 2.57 4.25
29	Jordan Creek near Wellford	12.8	5/18/66 9/ 8/66 9/20/67 11/ 7/67	12.8 6.56 9.24 11.0
30	Frey Creek near Wellford	9.18	5/18/66 9/ 7/66 9/20/67	9.15 3.62 5.66
31	Jimmies Creek near Fairmont	4.48	9/20/67 11/ 8/67	2.95 3.49
32	North Tyger River near Fairmont	54.7	5/18/66 9/ 8/66 11/ 8/67	57.8 30.2 47.3
33	Middle Tyger River at Lyman	69.0	5/18/66 9/10/66 11/ 8/67	55.8 81.4 37.9
34	Middle Tyger River near Startex	73.0	5/18/66 9/ 7/66 11/ 8/67	74.6 77.4 51.4
35	North Tyger River near Moore	155	11/ 9/67	118
36	Wards Creek near Moore	7.85	5/19/66 9/ 6/66 9/20/67	5.36 1.96 3.21
37	South Tyger River above Duncan	80.0	5/20/66 9/ 8/66 11/ 8/67	24.3 45.4 60.7
38	Maple Creek near Duncan	10.2	5/19/66 9/ 8/66 9/19/67 11/ 8/67	10.4 6.95 11.0 10.6
39	South Tyger River below Duncan	94.8	5/19/66 9/10/66 11/ 8/67	282 48.1 70.3
40	Brushy Creek near Reidville	4.26	5/19/66 9/ 6/66 9/20/67	4.70 2.05 3.61

Table 7.--Discharge measurements made at project sites in Spartanburg County--continued.

Site Number	Stream	Drainage Area (sq mi)	Date	Discharge (cfs)
	TYGER RIVER BASIN--Continued			
41	Bens Creek near near Reidville	10.0	5/19/66 9/ 6/66 9/20/67	9.77 4.05 5.43
42	Fergerson Creek near Woodruff	10.7	5/19/66 9/ 7/66 9/20/67	10.4 4.28 6.50
43	Little Fergerson Creek near Woodruff	5.28	5/19/66 9/ 6/66 9/20/66	5.71 3.70 2.83
44	Fergerson Creek near Woodruff	24.6	5/19/66 9/ 9/66 9/20/67	17.8 10.1 13.9
45	Jimmies Creek near Woodruff	8.18	9/20/67 11/ 8/67	4.84 5.27
46	Jimmies Creek near Enoree	17.1	5/19/66 9/ 7/66 9/19/67	14.6 6.06 9.92
47	Cane Creek near Glen Springs	5.82	5/19/66 9/ 7/66 9/19/67	5.09 1.73 3.46
48	Dutchman Creek near Glen Springs	16.2	5/19/66 9/ 7/66 9/19/67	14.7 5.79 10.6
49	Wiley Creek near Glen Springs	4.61	5/19/66	2.88
50	Dutchman Creek near Glen Springs	26.9	5/19/66 9/ 7/66 9/19/67	18.3 6.25 13.6
51	Fairforest Creek above Spartanburg	10.6	9/ 7/66 9/26/67 11/ 9/67	5.71 8.34 9.46
52	Fairforest Creek below Spartanburg	23.6	5/18/66 9/10/66 11/ 9/67	31.2 18.9 24.5
53	Beaverdam Creek near Spartanburg	9.33	5/18/66 9/ 8/66	7.55 4.63
54	Kelsey Creek at Camp Croft	4.23	5/18/66 9/ 8/66 9/20/67	1.47 2.04 2.38
55	McElwain Creek near Glen Springs	8.34	5/18/66 9/ 7/66 9/19/67	4.55 1.93 3.36
56	Kennedy Creek near Pacolet	6.85	5/18/66 9/ 8/66 9/21/67	6.08 3.22 4.60
	ENOREE RIVER BASIN			
57	Dillards Creek near Pelham	4.28	5/19/66 9/ 8/66 9/19/67	3.11 1.66 2.39
58	Abners Creek near Reidville	4.07	9/ 8/66	2.16
	ENOREE RIVER BASIN--Continued			
59	Abners Creek near Pelham	11.2	5/19/66 9/ 8/66 9/19/67 11/ 9/67	13.7 5.50 7.72 7.61
60	Enoree River near Cashville	127	5/19/66 9/ 8/66 9/19/67	128 61.0 73.8
61	Enoree River near Enoree	257	5/19/66 9/10/66 11/ 9/67	245 118 178
62	Two Mile Creek near Enoree	8.85	5/19/66 9/ 6/66 9/20/67	7.18 3.40 4.10
63	Cedar Shoals Creek near Cross Anchor	11.1	5/19/66 9/ 7/66 9/19/67	9.40 5.52 6.90

ed.

Table 8.--Miscellaneous field measurements of the chemical and physical properties of streams in Spartanburg County

Site Number	Stream and Location	Date	Specific Conductance (micromhos at 25°C)	Hardness[1]/ (Ca, Mg) as mg/l $CaCO_3$	pH	Dissolved Oxygen[1]/ (mg/l)	Temperature (°C)
1	Page Creek 2.4 mi east of Landrum	May 17, 1966 Sept. 7, 1966	50 57	20 30	6.7 7.6	8 9	17 20
2	North Pacolet River 2 mi north northwest of Fingerville	May 17, 1966 Sept. 7, 1966 Nov. 6, 1967	84 81 --	7 19 --	6.7 7.0 --	10 8 11	18 22 --
3	Obed Creek at State Hwy 9	May 17, 1966 Sept. 8, 1966	44 41	20 15	7.0 6.9	8 9	17 21
4	Obed Creek at County Road 42	May 17, 1966 Sept. 7, 1966	38 38	20 30	6.5 7.2	10 10	18 18
2-1545.	North Pacolet River near Fingerville	May 17, 1966 Sept. 12, 1966	60 72	10 30	6.4 7.8	9 10	18 22
5	Spivey Creek at County Road 209	May 17, 1966 Sept. 7, 1966	42 42	20 15	7.0 7.1	9 10	16 20
6	Motlow Creek 2¼ mi southwest of Campobello	Sept. 7, 1966	34	15	7.2	10	21
7	Motlow Creek 0.6 mi south of Campobello	May 17, 1966 Sept. 6, 1966 Nov. 6, 1967	34 34 --	9 9 --	6.5 6.8 --	9 10 11	17 21 --
8	Holston Creek at US Hwy 176	May 17, 1966 Sept. 7, 1966	46 44	20 15	6.9 7.7	9 9	17 22
9	Alexander Creek 2 mi east northeast of Campobello	May 17, 1966	42	20	7.0	9	17
10	Thompson Creek at County Road 55	May 17, 1966	28	10	6.8	9	18
2-1556.	Buck Creek near Fingerville	May 17, 1966 Sept. 6, 1966 Nov. 6, 1967	29 27 --	8 8 --	6.2 6.5 --	9 9 11	18 21 --
11	Buck Creek at County Road 43	May 17, 1966 Sept. 6, 1966	32 30	20 15	6.9 6.8	9 8	18 20
12	Little Buck Creek 2.2 mi southwest of Chesnee	May 17, 1966 Sept. 6, 1966	40 46	10 15	6.6 6.8	10 8	19 21
13	Buck Creek 1.4 mi west northwest of Mayo	May 17, 1966 Sept. 6, 1966	32 36	10 15	6.7 6.8	9 9	19 21
14	Casey Creek at County Road 190	May 17, 1966 Sept. 6, 1966	34 36	10 15	6.7 7.5	9 8	20 22
15	Cherokee Creek 0.8 mi east of Cherokee Springs	May 17, 1966 Sept. 6, 1966	36 38	10 15	6.8 7.9	9 10	19 21
16	Island Creek at County Road 105	May 17, 1966 Sept. 6, 1966	30 30	10 15	6.7 7.6	9 10	19 21
17	Pacolet River at Interstate Hwy 85	Sept. 8, 1966 Nov. 6, 1967	70 --	20 --	6.7 --	10 10	24 --
18	Peters Creek at County Road 659	May 18, 1966	34	10	6.5	10	18
2-1560.	Pacolet River near Clifton	May 18, 1966 Sept. 8, 1966 Nov. 6, 1967	48 60 --	12 15 --	6.6 6.8 --	9 9 10	20 24 --

Table 8.--Miscellaneous field measurements of the chemical and physical properties of streams in Spartanburg County--continued.

Site Number	Stream and Location	Date	Specific Conductance (micromhos at 25°C)	Hardness[1] (Ca, Mg) as mg/l $CaCO_3$	pH	Dissolved Oxygen[1] (mg/l)	Temperature (°C)
19	Lawsons Fork Creek 3 mi southeast of Inman	May 17, 1966 Sept. 6, 1966 Nov. 6, 1967	66 96 --	18 20 --	6.3 6.6 --	6 5 10	17 21 --
20	Greene Creek at Interstate Hwy 26	May 17, 1966 Sept. 8, 1966	50 54	20 15	7.0 7.3	8 8	16 21
21	Meadow Creek at County Road 581	May 17, 1966 Sept. 6, 1966 Nov. 6, 1967	40 41 --	12 13 --	6.6 6.9 --	9 9 12	17 22 --
22	Fawn Branch 0.8 mi below County Road 56	May 17, 1966 Sept. 8, 1966	30 30	10 15	6.7 7.4	9 8	16 21
23	Big Shoally Creek at County Road 43	May 17, 1966 Sept. 7, 1966	35 32	10 15	6.9 7.9	9 9	18 21
24	Lawsons Fork Creek at Interstate Hwy 85	Sept. 7, 1966 Nov. 6, 1967	51 --	14 --	6.5 --	8 11	21 --
25	Chinquepin Creek at North Fairview Ave., Spartanburg	May 18, 1966 Sept. 7, 1966 Nov. 7, 1967	150 160 --	30 45 --	6.9 7.7 --	8 6 7	20 22 --
2-1563.	Lawsons Fork Creek near Spartanburg	May 18, 1966 Sept. 7, 1966 Nov. 7, 1967	55 62 --	16 17 --	6.5 6.7 --	8 9 11	19 22 --
26	Lawsons Fork Creek at County Road 30	May 18, 1966 Sept. 7, 1966	55 62	16 18	6.6 7.0	8 8	18 21
27	Richland Creek at County Road 108	May 18, 1966 Sept. 8, 1966	110 70	30 30	6.5 7.2	10 8	17 23
28	Jordan Creek at State Hwy. 292	May 17, 1966 Sept. 7, 1966	46 44	20 15	6.9 6.8	8 9	17 17
29	Jordan Creek at State Hwy 129	May 17, 1966 Sept. 7, 1966 Nov. 7, 1967	42 45 --	14 13 --	6.7 7.0 --	10 10 12	18 17 --
30	Frey Creek at US Hwy 29	May 18, 1966 Sept. 7, 1966	42 46	10 15	6.9 7.0	8 10	19 17
2-1570.	North Tyger River near Fairmont	May 18, 1966 Sept. 7, 1966 Nov. 7, 1967	52 55 --	13 14 --	6.6 6.6 --	8 8 11	19 19 --
31	Jimmies Creek 1¼ mi northeast of Fairmont	Nov. 7, 1967	--	--	--	12	--
32	North Tyger River at State Hwy 296	May 18, 1966 Sept. 7, 1966 Nov. 7, 1967	406 651 --	14 15 --	7.7 8.9 --	4 2 6	19 21 --
33	Middle Tyger River at County Road 242	May 18, 1966 Sept. 7, 1966 Nov. 7, 1967	35 37 --	10 10 --	6.8 6.7 --	8 8 11	20 22 --
34	Middle Tyger River at Interstate Hwy 85	May 18, 1966 Sept. 7, 1966 Nov. 7, 1967	373 238 --	12 10 --	7.0 7.0 --	3 6 10	22 22 --
35	North Tyger River at US Hwy 221	Nov. 6, 1967	--	--	--	8	--

of

Table 8.--Miscellaneous field measurements of the chemical and physical properties of streams in Spartanburg County--continued.

Site Number	Stream and Location	Date	Specific Conductance (micromhos at 25°C)	Hardness1/ (Ca, Mg) as mg/l $CaCO_3$	pH	Dissolved Oxygen1/ (mg/l)	Temperature (°C)
36	Wards Creek 100 yards above mouth	May 19, 1966	54	20	6.5	8	20
		Sept. 6, 1966	57	15	7.9	10	17
37	South Tyger River at State Hwy 290	May 18, 1966	36	10	6.2	8	20
		Sept. 7, 1966	42	11	6.4	6	22
		Nov. 7, 1967	--	--	--	10	--
38	Maple Creek at County Road 644	May 18, 1966	98	14	6.2	4	18
		Sept. 7, 1966	86	16	5.9	6	18
		Nov. 7, 1967	--	--	--	10	--
39	South Tyger River at County Road 242	May 18, 1966	39	9	6.1	4	20
		Sept. 7, 1966	50	12	6.5	6	21
		Nov. 7, 1967	--	--	--	9	--
40	Brushy Creek at County Road 242	May 19, 1966	45	15	6.5	8	18
		Sept. 6, 1966	45	15	7.0	10	18
41	Bens Creek at State Hwy 417	May 19, 1966	47	20	6.5	9	17
		Sept. 6, 1966	48	15	7.9	10	18
42	Fergerson Creek at County Road 197	May 19, 1966	56	17	6.8	8	18
		Sept. 7, 1966	62	15	7.8	10	17
43	Little Fergerson Creek at US Hwy 221	May 19, 1966	48	20	6.8	9	18
		Sept. 6, 1966	48	15	7.8	9	17
44	Fergerson Creek at County Road 200	May 19, 1966	58	20	6.7	9	18
		Sept. 9, 1966	58	15	7.9	9	19
45	Jimmies Creek at County Road 86	May 19, 1966	77	18	6.6	10	21
		Sept. 8, 1966	95	24	7.0	9	20
		Nov. 6, 1967	--	--	--	9	--
46	Jimmies Creek at County Road 113	May 19, 1966	73	20	6.5	8	22
		Sept. 7, 1966	82	30	7.6	10	22
47	Cane Creek at County Road 235	May 19, 1966	56	20	6.2	7	22
		Sept. 7, 1966	58	30	7.7	9	21
2-1596.	Dutchman Creek near Pauline	May 19, 1966	48	12	6.6	8	21
		Sept. 8, 1966	50	13	6.9	10	18
		Nov. 6, 1967	--	--	--	10	--
48	Dutchman Creek at State Hwy 56	May 19, 1966	53	20	6.5	8	21
		Sept. 7, 1966	52	30	7.8	9	21
49	Wiley Creek 1 mi above mouth	May 19, 1966	90	25	6.7	8	21
50	Dutchman Creek at County Road 91	May 19, 1966	65	20	6.4	10	21
		Sept. 7, 1966	58	30	7.9	9	21
51	Fairforest Creek at County Road 1550	Sept. 7, 1966	89	23	6.6	10	19
		Nov. 7, 1967	--	--	--	11	--
2-1598.	Fairforest Creek at Spartanburg	May 18, 1966	134	41	6.4	8	18
		Sept. 7, 1966	107	28	6.7	10	21
		Nov. 7, 1967	--	--	--	11	--
52	Fairforest Creek at County Road 651	May 18, 1966	277	44	6.4	7	18
		Sept. 9, 1966	335	38	6.2	6	20
		Nov. 7, 1967	--	--	--	8	--

Table 8.--Miscellaneous field measurements of the chemical and physical properties of streams in Spartanburg County--continued.

Site Number	Stream and Location	Date	Specific Conductance (micromhos at 25°C)	Hardness 1/ (Ca, Mg) as mg/l $CaCO_3$	pH	Dissolved Oxygen 1/ (mg/l)	Temperature (°C)
53	Beaverdam Creek at County Road 88	May 18, 1966 Sept. 8, 1966	56 64	20 30	6.8 7.8	8 9	17 18
54	Kelsey Creek at Dairy Ridge Road	May 18, 1966 Sept. 8, 1966	175 230	40 60	6.7 7.9	8 10	17 17
55	McElwain Creek at 50 yds below mouth of Glen Creek	May 18, 1966 Sept. 7, 1966	110 115	40 60	6.6 7.8	10 9	17 20
56	Kennedy Creek at State Hwy 150	May 18, 1966 Sept. 8, 1966	46 50	10 15	6.7 7.0	10 9	18 20
57	Dillards Creek 1 mi east of Pelham	May 19, 1966 Sept. 8, 1966	36 36	10 15	6.9 7.7	10 10	17 17
58	Abners Creek at County Road 63	Sept. 8, 1966	34	15	7.0	10	17
59	Abners Creek 2 mi southeast of Pelham	May 19, 1966 Sept. 8, 1966 Nov. 7, 1967	35 35 --	8 8 --	6.5 6.8 --	8 10 12	17 17 --
60	Enoree River at Anderson Bridge	May 19, 1966 Sept. 8, 1966	42 160	10 15	6.5 7.8	9 9	18 18
61	Enoree River at Kilgore Bridge	May 19, 1966 Sept. 8, 1966 Nov. 6, 1967	45 80 --	10 13 --	6.4 6.7 --	9 8 10	20 21 --
62	Two Mile Creek 1 mi north of Enoree	May 18, 1966 Sept. 6, 1966	72 70	20 30	6.5 7.7	9 10	21 21
2-1605.	Enoree River near Enoree	May 19, 1966 Sept. 8, 1966	52 65	20 15	6.7 7.1	10 9	21 22
63	Cedar Shoals Creek at State Hwy 49	May 19, 1966 Sept. 7, 1966	54 60	20 30	6.5 7.9	8 9	21 21

1/ Analysis made with portable water test kit

Table 9.--Chemical analyses of surface water in Spartanburg County

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

Date of collection	Discharge (cfs)	Temperature (°C)	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°	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units 2/)	Turbidity 3/	Dissolved oxygen (O_2) 4/
Site 2. North Pacolet River near Fingerville																									
May 17, 1966	145	18	13	0.04	---	1.6	0.6	15	1.0	39	0	3.8	4.0	0.1	0.5	0.04	59	54	7	0	84	6.7	20	---	10
Sept. 7, 1966	68.7	22	14	.04	0.00	---	---	---	---	34	-	---	---	---	---	--	--	60	19	-	81	7.0	10	4	8
Nov. 6, 1967	118	8	14	.01	.00	4.8	1.6	4.0	1.2	26	0	2.0	2.7	.0	.3	.00	44	46	18	0	52	6.6	5	---	11
Site 7. Motlow Creek near Campobello																									
May 17, 1966	16.4	17	12	0.13	--	2.6	0.6	2.3	0.6	15	0	0.8	2.9	0.0	0.9	0.04	30	35	9	0	34	6.5	30	---	9
Sept. 6, 1966	10.7	21	13	.09	0.01	---	---	---	---	16	-	---	---	---	---	--	--	31	9	-	34	6.8	10	3	10
Nov. 6, 1967	10.6	8	13	.19	.00	2.1	1.2	2.9	.8	14	0	.8	2.9	.0	.8	.00	31	26	10	0	34	6.3	10	---	11
2-1556. Buck Creek near Fingerville																									
May 17, 1966	10.4	18	9.7	0.06	--	2.7	0.4	1.6	1.0	12	0	0.8	2.5	0.0	1.0	0.07	26	24	8	0	29	6.2	10	---	9
Sept. 6, 1966	5.20	21	9.2	.03	0.01	---	---	---	---	12	-	---	---	---	---	--	27	--	8	-	27	6.5	7	0.1	9
Nov. 6, 1967	12.6	8	10	.05	.00	1.9	1.1	1.9	1.0	12	0	.8	2.6	.0	.4	.00	26	18	10	0	29	6.2	5	---	11
Site 17. Pacolet River near Cowpens																									
Sept. 8, 1966	165	24	9.4	0.01	0.00	---	---	---	---	28	-	---	---	---	---	--	--	50	20	-	70	6.7	5	2	10
Nov. 6, 1967	246	9	12	.00	--	3.2	1.2	3.4	1.3	22	0	1.2	3.3	0.2	0.3	0.00	37	35	16	0	47	6.4	2	---	10
Site 18. Peters Creek near Spartanburg																									
May 18, 1966	2.2	18	10	0.12	--	2.6	0.7	2.1	1.3	11	0	1.8	3.2	0.1	1.5	0.01	28	27	10	1	34	6.5	20	---	10
2-1560. Pacolet River near Clifton																									
May 18, 1966	370	20	11	0.07	--	3.2	1.1	3.5	1.1	20	0	2.8	3.0	0.0	1.2	0.02	37	34	12	0	48	6.6	20	---	9
Sept. 8, 1966	167	24	9.4	.01	0.00	---	---	---	---	28	-	---	---	---	---	--	--	45	15	-	60	6.8	5	4	9
Nov. 6, 1967	252	10	11	.06	.00	3.3	1.1	6.9	1.4	25	0	3.6	4.0	.2	1.4	.01	45	46	12	0	60	6.9	10	---	10
Site 19. Lawsons Fork Creek near Inman																									
May 17, 1966	8.46	17	13	0.09	--	5.3	1.4	4.4	1.4	22	0	5.0	4.2	0.1	2.5	0.35	49	50	18	1	66	6.3	15	---	6
Sept. 6, 1966	3.92	21	14	.04	0.01	---	---	---	---	23	-	---	---	---	---	--	--	67	20	-	96	6.6	3	4	5
Nov. 6, 1967	7.87	8	14	.05	.00	5.6	1.5	5.0	1.7	21	0	4.8	5.0	.1	3.3	.15	51	45	20	3	65	6.6	5	---	10
Site 21. Meadow Creek near Inman																									
May 17, 1966	10.9	17	10	0.10	--	2.9	1.3	2.1	1.1	17	0	1.6	3.1	0.1	0.9	0.03	31	--	12	0	40	6.6	25	---	9
Sept. 6, 1966	2.99	20	11	.18	0.02	---	---	---	---	19	-	---	---	---	---	--	--	33	13	-	41	6.9	18	6	9
Nov. 6, 1967	7.48	7	11	.05	.00	3.4	1.0	2.6	1.0	18	0	2.4	1.2	.1	.7	.00	32	43	12	0	40	6.6	10	---	12

Table 9.--Chemical analyses of surface water in Spartanburg County--continued.

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

Date of collection	Discharge (cfs)	Temperature (°C)	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°	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units 2/)	Turbidity 3/	Dissolved oxygen (O_2) 4/
Site 24. Lawsons Fork Creek above Spartanburg																									
Sept. 7, 1966	25.7	21	10	0.01	0.02	---	---	---	---	19	-	---	---	---	---	--	--	40	14	--	51	6.5	4	2	8
Nov. 6, 1967	42.8	8	11	.05	.00	3.3	1.4	3.6	1.6	17	0	4.2	4.0	0.0	1.4	0.00	39	32	14	0	47	6.2	5	-	11
Site 25. Chinquepin Creek at Spartanburg																									
Nov. 7, 1967	5.75	13	13	0.04	--	9.1	3.6	24	4.8	62	0	18	20	0.4	0.2	5.1	128	122	36	0	205	6.2	7	-	7
2-1563. Lawsons Fork Creek at Spartanburg																									
May 18, 1966	77.0	19	10	0.01	--	5.0	0.7	3.5	1.4	19	0	2.8	4.9	0.1	1.6	0.03	39	36	16	0	55	6.5	15	-	8
Sept. 7, 1966	42.0	22	10	.01	0.01	---	---	---	---	21	-	---	---	---	---	--	--	46	17	-	62	6.7	7	5	9
Nov. 7, 1967	56.0	8	11	.01	.00	4.3	1.5	4.5	1.8	20	0	4.4	5.3	.1	1.1	.00	44	34	17	1	57	6.1	5	-	11
Site 26. Lawsons Fork Creek at Glendale																									
May 18, 1966	73.0	18	11	0.03	--	5.0	0.9	3.4	1.4	21	0	3.2	4.7	0.1	1.4	0.02	41	38	16	0	55	6.6	15	-	8
Sept. 7, 1966	34.6	21	11	.02	0.01	---	---	---	---	22	-	---	---	---	---	--	--	45	18	-	62	7.0	5	4	8
Site 29. Jordan Creek near Wellford																									
May 17, 1966	12.8	18	12	0.04	--	3.8	1.2	2.5	0.8	18	0	1.0	3.3	0.0	1.4	0.02	35	33	14	0	42	6.7	30	-	10
Sept. 7, 1966	6.56	17	12	.11	0.01	---	---	---	---	20	-	---	---	---	---	--	--	41	13	-	45	7.0	23	0.1	10
Nov. 7, 1967	11.0	8	12	.07	.00	3.3	1.3	3.2	.5	19	0	1.6	2.8	.0	1.0	.00	35	37	14	0	40	6.6	3	-	12
2-1570. North Tyger River near Fairmont																									
May 18, 1966	41.5	19	13	0.09	--	3.8	0.8	4.6	0.9	20	0	5.0	3.5	0.1	0.8	0.31	43	42	13	0	52	6.6	15	-	8
Sept. 7, 1966	24.0	19	13	.02	0.01	---	---	---	---	20	-	---	---	---	---	--	--	45	14	-	55	6.6	6	10	8
Nov. 7, 1967	35.0	7	14	.09	--	3.5	1.5	8.4	1.2	21	0	9.0	2.6	.3	.8	4.5	56	62	15	0	71	6.1	0	-	11
Site 31. Jimmies Creek near Fairmont																									
Nov. 7, 1967	3.49	4	14	0.01	0.00	3.8	1.5	3.7	1.3	21	0	2.6	3.7	0.1	0.9	0.00	42	39	16	0	50	6.4	5	-	12
Site 32. North Tyger River near Fairmont Mills																									
May 18, 1966	57.8	19	13	0.26	--	4.0	0.9	91	2.4	234	0	17	5.5	0.2	0.3	1.7	251	270	14	0	406	7.7	50	-	4
Sept. 7, 1966	30.2	21	13	.45	0.02	---	---	--	---	330	27	--	---	---	---	---	--	420	15	-	651	8.9	32	3	2
Nov. 7, 1967	47.3	6	14	.16	.01	3.9	1.3	76	3.3	187	0	17	3.5	.1	4.2	2.6	218	238	16	0	355	7.1	15	-	6
Site 33. Middle Tyger River near Lyman																									
May 18, 1966	55.8	20	12	0.03	--	3.0	0.6	2.7	0.8	16	0	1.6	2.2	0.0	0.8	0.04	32	30	10	0	35	6.8	15	-	8
Sept. 7, 1966	81.4	22	10	.07	0.00	---	---	---	---	17	-	---	---	---	---	--	--	33	10	-	37	6.7	15	2	8
Nov. 7, 1967	37.9	8	11	.02	.00	2.2	1.0	3.4	1.4	15	0	1.2	2.5	.0	.2	.00	30	28	10	0	37	6.2	10	-	11

Table 9.--Chemical analyses of surface water in Spartanburg County--continued.

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

Date of collection	Discharge (cfs)	Temperature (°C)	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°	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units 2/)	Turbidity 3/	Dissolved oxygen (O_2) 4/
Site 34. Middle Tyger River near Startex																									
May 18, 1966	74.6	22	14	0.87	--	3.7	0.9	77	4.0	156	0	17	28	0.4	0.5	0.46	224	236	12	0	373	7.0	50	-	3
Sept. 7, 1966	77.4	22	11	.05	0.01	---	---	--	---	108	-	--	---	---	---	--	---	151	10	-	238	7.0	13	3	6
Nov. 7, 1967	51.4	10	15	.05	.00	3.4	1.8	137	6.6	243	0	34	60	.6	2.9	.55	457	399	16	0	629	7.0	50	-	10
Site 35. North Tyger River at U. S. Hwy. 221																									
Nov. 6, 1967	118	8	13	0.09	0.00	3.9	1.3	16	1.9	44	0	6.4	7.5	0.1	1.3	0.08	74	68	15	0	108	6.4	10	-	8
Site 37. South Tyger River above Duncan																									
May 18, 1966	270	20	13	0.00	--	3.0	0.4	2.7	1.0	16	0	1.2	2.0	0.1	1.1	0.10	33	28	10	0	36	6.2	15	-	8
Sept. 7, 1966	45.4	22	11	.00	0.01	---	---	---	---	18	-	---	---	---	---	--	--	39	11	-	42	6.4	5	2	6
Nov. 7, 1967	60.7	8	15	.02	--	2.6	1.1	2.9	1.4	18	0	2.2	2.0	.2	.5	.04	38	38	10	2	39	6.4	0	-	10
Site 38. Maple Creek near Duncan																									
May 18, 1966	10.4	18	12	0.11	--	4.2	0.7	10	2.5	34	0	5.6	6.0	0.1	2.0	2.2	--	58	14	0	98	6.2	25	-	4
Sept. 7, 1966	6.95	18	11	.11	0.07	---	---	--	---	8	-	---	---	---	---	---	--	65	16	-	86	5.9	13	4	6
Nov. 7, 1967	10.6	5	12	.01	.00	3.7	1.7	6.1	2.0	13	0	6.6	4.7	.2	4.9	.35	48	50	16	6	58	5.9	1	-	10
Site 39. South Tyger River below Duncan																									
May 18, 1966	282	--	12	0.00	--	2.6	0.7	2.8	1.1	15	0	2.0	2.3	0.1	1.5	0.13	32	30	9	0	39	6.1	10	-	4
Sept. 7, 1966	48.1	21	11	.02	0.00	---	---	---	---	18	-	---	---	---	---	--	--	42	12	-	50	6.5	6	0.1	6
Nov. 7, 1967	70.3	8	13	.02	.00	3.0	1.0	4.2	1.6	16	0	3.8	3.0	.0	1.2	.24	39	36	12	0	32	6.1	5	-	9
Site 42. Ferguson Creek near Woodruff																									
May 19, 1966	10.4	18	23	0.15	--	5.1	1.0	4.1	1.4	29	0	0.8	3.2	0.2	0.6	0.03	54	51	17	0	56	6.8	15	-	8
Site 45. Jimmies Creek near Woodruff																									
May 19, 1966	--	21	25	0.15	--	5.8	1.0	6.9	2.0	31	0	3.4	4.6	0.2	2.3	0.84	67	66	18	0	77	6.6	15	-	10
Sept. 8, 1966	--	20	26	.01	0.01	---	---	---	---	41	-	---	---	---	---	--	--	83	24	-	95	7.0	5	3	10
Nov. 6, 1967	5.27	9	24	.01	.00	5.6	1.9	8.0	2.7	33	0	3.8	5.6	.2	1.2	.39	69	66	22	0	84	6.2	10	-	9
2-1596. Dutchman Creek near Pauline																									
May 19,1966	8.00	21	18	0.08	--	3.2	1.1	3.7	1.5	21	0	2.0	2.8	0.1	1.2	0.04	44	42	12	0	48	6.6	20	-	8
Sept. 8, 1966	3.91	18	18	.12	0.01	---	---	---	---	21	-	---	---	---	---	--	--	45	13	-	50	6.9	7	2	10
Nov. 6, 1967	7.66	7	18	.12	.00	3.8	1.2	4.2	1.5	21	0	2.0	3.4	.1	.5	.00	45	50	14	0	47	6.6	5	-	10

Table 9.--Chemical analyses of surface water in Spartanburg County--continued.

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

Date of collection	Discharge (cfs)	Temperature (°C)	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		Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color (units 2/)	Turbidity 3/	Dissolved oxygen (O_2) 4/
																	Calculated	Residue on evaporation at 180°	Calcium, Magnesium	Noncarbonate					
Site 51. Fairforest Creek above Spartanburg																									
Sept. 7, 1966	5.71	19	11	0.01	0.01	---	---	---	---	23	-	---	---	---	---	--	--	64	23	--	89	6.6	5	10	10
Nov. 7, 1967	9.46	8	12	.02	.00	15	2.1	8.9	2.2	25	0	31	8.0	0.2	2.0	3.6	97	97	47	26	144	6.3	7	--	11
2-1598. Fairforest Creek at Spartanburg																									
May 18, 1966	19.0	18	15	0.01	--	9.6	4.1	6.5	1.9	21	0	20	7.8	0.7	3.7	16	95	92	41	24	134	6.4	15	--	8
Sept. 7, 1966	9.51	21	11	.05	0.00	---	---	---	---	31	-	---	---	---	---	--	--	74	28	--	107	6.7	6	2	16
Nov. 7, 1967	13.9	7	12	.02	.00	8.9	1.7	7.8	2.4	28	0	9.4	8.4	.2	3.1	.80	69	65	29	6	100	6.3	10	--	11
Site 52. Fairforest Creek below Spartanburg																									
May 18, 1966	31.2	18	15	0.10	--	13	2.9	32	4.0	35	0	32	34	1.6	12	3.1	167	169	44	16	277	6.4	25	--	7
Sept. 9, 1966	18.9	20	13	.09	0.11	--	---	---	---	--	-	---	---	---	---	--	--	209	38	--	335	6.2	38	4	6
Nov. 7, 1967	24.5	11	26	.52	.20	9.8	2.9	32	7.0	--	0	14	30	---	17	--	178	212	50	49	306	4.8	60	--	8
Site 59. Abners Creek near Pelham																									
May 19, 1966	13.7	17	11	0.07	--	2.2	0.7	2.5	1.3	14	0	1.8	3.0	0.0	1.6	0.03	31	27	8	0	35	6.5	15	--	8
Sept. 8, 1966	5.50	17	9.7	.07	0.00	---	---	---	---	13	-	---	---	---	---	--	--	33	8	-	35	6.8	8	4	10
Nov. 7, 1967	7.61	4	12	.06	.00	2.6	.8	3.0	1.7	13	0	1.6	3.5	.0	1.2	.00	32	31	10	0	37	6.3	5	--	12
Site 60. Enoree River near Reidville																									
May 19, 1966	128	--	11	0.07	--	2.6	0.8	3.9	1.4	14	0	1.8	3.0	0.1	1.4	.04	33	31	10	0	42	6.5	15	--	9
Site 61. Enoree River at Kilgore Bridge near Enoree																									
May 19, 1966	245	20	13	0.01	--	3.8	0.6	3.7	1.3	19	0	1.8	3.2	0.1	1.3	0.01	38	34	10	0	45	6.4	10	--	9
Sept. 8, 1966	118	21	13	.00	0.00	---	---	---	---	19	--	---	---	---	---	--	--	58	13	--	80	6.7	6	0.1	8
Nov. 6, 1967	178	9	14	.02	.00	3.2	1.3	5.7	1.8	20	0	3.2	5.3	.1	.4	.00	45	38	14	0	55	6.2	5	--	10

1/ In solution when analyzed.

2/ Based on platinum-cobalt scale (Hazen, 1892).

3/ Reported as mg/l SiO_2.

4/ O_2 determined in field with portable test kit.

Table 10.--Dissolved oxygen at Fairforest Creek and North, Middle, and South Tyger Rivers, October and November, 1967.

Date	Location	Mile	Dissolved Oxygen (mg/l)	Dissolved Oxygen (Percent Saturation)
	North Tyger River			
Oct. 5	At US Hwy. 29	0.0	9.1	94
Oct. 5	At gage 2.2 mi north of Fairmont	1.1	8.8	95
Oct. 5	At State Hwy. 296	3.3	2.7	30
Oct. 6	At County Rd. 64	5.5	.8	8.5
Oct. 6	At US Hwy. 221	9.5	.6	6.4
Oct. 6	At gage 2.6 mi southeast of Moore	12.3	1.7	19
Oct. 6	At County Rd. 231	14.1	6.8	75
	Middle Tyger River			
Oct. 5	At County Rd. above US Hwy. 29	0.0	8.6	95
Oct. 5	At State Hwy. 292	3.0	9.0	101
Oct. 5	At County Rd. 242	4.1	9.7	109
Oct. 5	At Interstate Hwy. 85	6.1	6.1	76
Oct. 6	At County Rd. at Fairmont Mills	9.4	8.6	96
Oct. 6	At County Rd. 64	13.1	7.0	77
	South Tyger River			
Oct. 5	At US Hwy. 29	0.0	8.6	96
Oct. 5	At State Hwy. 290	1.7	7.9	87
Oct. 5	At County Rd. 62	3.0	7.4	82
Oct. 5	At County Rd. 63	5.7	7.2	81
Oct. 6	At State Hwy. 296	10.0	7.6	85
Oct. 6	At County Rd. 197	15.8	8.4	92
Oct. 6	At County Rd. 230	21.2	9.0	98
	Maple Creek			
Oct. 5	At County Rd. 644	0.7 1/	6.9	74

Table 10.--Dissolved oxygen at Fairforest Creek and North, Middle, and South Tyger Rivers, October and November, 1967--continued.

Date	Location	Mile	Dissolved Oxygen (mg/l)	Dissolved Oxygen (Percent Saturation)
	Tyger River			
Oct. 6	At County Rd. 50	0.5 2/	9.3	105
Oct. 6	At County Rd. 113	3.2 2/	9.6	110
	Fairforest Creek			
Nov. 15	At County Rd. 525	0.0	10.4	97
Nov. 15	At State Hwy. 295	.6	10.7	99
Nov. 15	At Powell Mill Rd.	1.9	11.1	102
Nov. 15	At State Hwy. 296	5.2	11.9	107
Nov. 15	At US Hwy. 221	6.3	12.0	110
Nov. 15	At State Hwy. 295	8.4	11.3	105
Nov. 15	At County Rd. 651	9.1	9.0	87
Nov. 15	At County Rd. 88	10.2	8.5	82
Nov. 15	At State Hwy. 56	12.0	9.0	85
Nov. 15	At end of County Rd. 394	15.5	11.3	105
	Greenville Branch			
Nov. 15	At dirt road 0.1 mi north of juncture of Crescent and Irwin Avenues, Spartanburg	0.1 3/	7.9	77
	Unnamed Creek			
Nov. 15	At bridge on Collins Ave., Sptbg.	0.3 3/	10.3	98
	Beaverdam Creek			
Nov. 15	At County Rd. 88	0.2 3/	12.5	116

1/ Miles upstream from confluence with South Tyger River
2/ Miles downstream from confluence with South Tyger River
3/ Miles upstream from confluence with Fairforest Creek

Table 11.--Monthly maximum and minimum temperatures at North Tyger River near Fairmont and Enoree River near Enoree, October 1966 to September 1968

[Temperature values reported in degrees Celsius (°C)]

Year	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Mi
2-1570. North Tyger River near Fairmont																								
1967	18	11	15	7	12	4	10	5	11	3	15	5	18	12	19	14	22	16	22	22	23	18	19	1
1968	16	9	12	6	10	4	--	--	--	--	17	7	19	13	19	14	23	17	--	--	24	17	21	1
2-1605. Enoree River near Enoree																								
1967	20	11	17	6	12	3	12	4	12	3	19	6	22	13	23	13	27	16	26	21	27	20	23	1
1968	19	9	14	5	13	5	9	2	9	2	17	3	20	11	23	13	26	17	26	20	28	18	23	1

Table 12.--Average monthly temperatures at gaging stations in Spartanburg County, 1949-1967

[Temperature values reported in degrees Celsius (°C)]

Station Number	Stream and Location	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
2-1545.	North Pacolet River at Fingerville	17	11	7	6	9	12	14	19	23	24	24	21
2-1555.	Pacolet River near Fingerville	18	12	7	6	8	11	16	20	23	24	24	22
2-1560.	Pacolet River near Clifton	18	13	7	6	9	11	15	21	25	25	26	21
2-1570.	North Tyger River at Fairmont	16	10	7	7	7	11	13	18	21	23	23	21
2-1575.	Middle Tyger River at Lyman	19	13	9	8	8	11	16	21	25	23	27	23
2-1580.	North Tyger River near Moore	18	11	8	7	8	11	14	20	23	24	25	23
2-1585.	South Tyger River near Reid-ville	18	11	7	7	7	11	13	20	23	24	25	22
2-1590.	South Tyger River near Woodruff	18	11	7	7	8	11	14	21	24	24	25	23
2-1605.	Enoree River near Enoree	17	11	8	7	8	11	14	19	23	25	26	23

Table 13.--Description of rock units in Spartanburg County

System	Description: Rock Unit
Upper Triassic(?)	Diabase dikes (₨d): 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 (PMp): White, coarse-grained, zoned muscovite-plagioclase-quartz-perthite pegmatite dikes.
Permian	Yorkville Quartz-Monzonite (Py): Medium to dark gray, fine- to coarse-grained, porphyritic, massive to gneissic biotite-quartz monzonite. Revised from the formerly named Yorkville Granite, it intrudes the sericite schist unit and the hornblende schist.
Ordovician to Permian	Coarse-grained granite (POc): Light gray, coarse-grained, massive to weakly foliated biotite granite.
Ordovician to Mississippian	Granite, undivided (POu): Dark gray, medium-grained, massive to gneissic biotite granite and biotite-quartz monzonite. Sericite schist (MOs): White, gray and brown, fine-grained laminated argillite; tuffaceous argillite and graywacke; includes felsic and mafic agglomerates, breccias, tuffs, and volcanic flows. Quartzite (MOiq): Gray to dark gray or white, fine grained quartzite, biotite and muscovite quartzite; may include large quartz veins. Hornblende Schist (MOh): Hornblende schist, hornblende gneiss, actinolite schist, chlorite schist and marble, formed by metamorphism of mafic effusive and intrusive rocks, graywacke, and calcareous sediments. The unit includes the formations formerly (Keith and Sterrett, 1931 maps) called Roan Gneiss and Roan Gneiss closely injected by Bessemer Granite.
Ordovician	Toluca Quartz Monzonite (Otm): Typically a gray, gneissic, medium-grained rarely porphyritic, biotite-quartz monzonite. Although varied in composition, it consists principally of oligoclase, microcline, orthoclase, quartz, biotite, and accessory amounts of garnet, zircon and monzonite. Whereas along contacts it is strongly gneissic, a few hundred feet from the contact the structure changes to a nearly massive character. The monzonite generally conforms to the structure of the enclosed biotite schist, biotite gneiss, and migmatite and is sheet-like in habit. Thus, outcrops of this type of rock tend to be long and narrow.
Upper Pre-Cambrian to Devonian	Hornblende gneiss (Dp€h): Dark gray to green or black, fine- to coarse-grained gneissic, schistose, or massive metamorphosed igneous and sedimentary rocks including hornblende gneiss, hornblende schist, amphibolite, and biotite-hornblende-oligoclase gneiss, metamorphosed diorite, gabbro and pyroxenite; thin discontinuous layers of marble and calc-silicate rock. Biotite gneiss and migmatite (Dp€m): 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 (Mp€s): Includes an assortment of thin-layered, fine- to coarse-grained, strongly foliated biotite 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.

Note.--Arrangement does not necessarily denote chronologic sequence.

Table 14.--Data on wells and springs, Spartanburg 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(°C)	Use	Remarks
1-3	Riverside Mill, Enoree	--	70	--	6	Mp€s			22		--	I	Drilled 1915.
4	Do	Harrison	250	--	6	Mp€s			20		--	I	Drilled 1941.
5-9	Do	--	20	--	2	Mp€s			32		--	I	
10-16	Do	Hubble	35-40	--	2	Mp€s			35		17	I	C/A.
17-21	Do	--	35	--	2	Mp€s			85		--	I	
22-27	Do	Hubble	27-35	--	2	Mp€s			85		--	I	
28	Do	Harris	202	--	8	Mp€s			50		--	I	Abandoned.
29	Do	do	318	--	8	Mp€s			7		--	I	do.
30-35	Woodruff, S.C.	--	40-70	--	2	Dp€h			37		--	PS	
36-42	Do	--	50-65	--	2	Dp€h			37		--	PS	
43-50	Do	--	45-75	--	2	Dp€h			37		14	PS	C/A.
51-52	Do	--	90	--	2	Dp€h			30		16	PS	C/A.
53-55	Do	--	60	--	2	Dp€h			30		--	PS	
56-59	Do	--	70-75	--	-	Dp€h			30		--	PS	
60-64	Do	--	40-60	--	2	Dp€h			32		--	PS	
65-73	Do	--	40-60	--	2	Dp€h			75		--	PS	
74	Do	--	402	--	8	Dp€h			85		17	PS	C/A.
75	Cowpens, S.C.	--	369½	100	6	Dp€m			45-50		--	PS	C/A.
76	Do	--	275	80	6	Dp€m			45-50		--	PS	
77-83	Saxon Mills, Chesnee	--	--	--	-	Dp€m			300		--	I	
84-89	Do	--	--	--	2	Dp€m			150		--	I	
90	Chesnee, S.C.	--	206	--	8	Dp€m			20		--	PS	
91	Do	--	231	--	8	Dp€m			20		--	PS	
92	Do	--	151	--	8	Dp€m			40		--	PS	C/A.
93	Do	--	219	--	8	Dp€m			8		--	PS	
94-98	Pacolet Manufacturing Co., Pacolet	--	60-125	--	2	Dp€h			50		--	I	70,000 gpd.
99-106	Do	--	60-125	--	2	Dp€h			50		--	I	
107-113	Do	--	60-100	--	2	Dp€h			35		--	I	
114-118	Do	--	60-100	--	2	Dp€h			35		--	I	
119-122	Do	--	50-60	--	2	Dp€h			22		15	I	C/A.
123-128	Do	--	60	--	-	Dp€h			--		--	I	
129	Camp Croft, near Spartanburg	--	170½	--	6	Mp€s			40		15	M	Drld. 1940; C/A.
130	Do	--	600	400	6	Dp€m			22		--	M	Camp deactivated before well was used.
131	Do	--	440	--	6	Dp€m			--		--	M	Dry hole.
132	Southern Railroad, Inman	--	167	--	6	Mp€s			25		--	RR	Drilled 1946.
133	Spartanburg, S.C.	Lee	480	120	8	Mp€s			100		16	PS	Well B; C/A.
134	Do	do	512	120	6	Mp€s			50		--	PS	Well B.
135	Bochelder Smelting Co., US-29, Spartanburg	Robbins Bros.	125	30	6	Mp€s			75		--	I	Drilled 1966; pump setting 50 ft.

Table 14.--Data on wells and springs, Spartanburg 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 (°C)	Use	Remarks
136	Mayfair Cotton Mill No. 1, Arcadia	Lee	301	10	8	Mp€s	--		165	--	16	I	C/A; artesian 35 gpm.
137	Mayfair Cotton Mill No. 2, Arcadia	--	438	18	8	Mp€s	--		45	--	--	I	
138-143	Saxon Mills, Arcadia	--	40	--	2	Mp€s	--		50±	--	16	I	C/A.
144-150	Do	--	40	--	2	Mp€s	--		50±	--	--	I	
151	Jackson Mill, Wellford	--	218	--	4	Mp€s	--		--	--	--	I	C/A; flows 30 gpm.
152	Do	--	508	--	8	Mp€s	--		--	--	--	I	Flows 40 gpm.
153	Inman, S.C.	--	80	--	2	Mp€s	--		125	--	--	PS	Drilled 1921; C/A.
154-155	Do	--	70	--	2	Mp€s	--		78	--	--	PS	Drilled 1924, 1936 & 1938.
156	Do	--	85-100	--	2	Mp€s	--		--	--	--	PS	
157	Inman Mill, Inman	--	150	--	5	Mp€s	--		---	--	--	I	
158	Do	--	250	--	6	Mp€s	--		--	--	--	I	
159	Do	--	150	--	6	Mp€s	--		35	--	--	I	
160	Duncan, S.C.	--	296?	--	6	Dp€m	--		--	--	--	PS	Drilled 1951.
161	Fish Constructors, Spartanburg	Va. Mach. Co.	253?	--	6	Mp€s	--		55	--	--	I	do.
162	Duncan, S.C.	--	501?	--	6	Dp€m	--		60	--	--	PS	do.
163	Do	--	294	11	6	Dp€m	--		20	--	--	PS	do.
164	Do	--	505	--	6	Dp€m	--		60	--	--	PS	do.
165	Woodruff, S.C.	--	55±	--	-	Dp€h	--		105	--	--	PS	Drilled 1946; 9 wells; C/A.
166	Do	--	60±	--	-	Dp€h	--		105	--	16	PS	Drilled 1946; 10 wells; C/A.
167	Do	--	70	--	-	Dp€h	--		140	--	--	PS	Drilled 1953; 12 wells.
168	Do	--	60	--	-	Dp€h	--		35	--	--	PS	Drilled 1946; 7 wells.
169	Jules Blanchard, between Greer and Duncan (near Dobson peach orchard)	Robbins Bros.	80	41	-	Dp€m	--		25	--	--	D	Drilled 1950.
170	Jules Bradford, US-29, Tucapau	do	167	15	-	Mp€s	--		2	--	--	D	do.
171	J.H. Cooper, SC-292, between Inman and Wellford	do	90	--	-	Mp€s	--		--	--	--	D	Drilled 1962.
172	Union Camp Bag Paper Co., at I-85 and US-29, near Wellford	do	200	110	6½	Mp€s	--		6	--	--	I	Drilled 1959.
173	Deering-Milliken Research, near Spartanburg	do	200	23	-	Mp€s	--		50	--	--	I	Drilled 1961. Well No. 1.
174	Do	do	302	50	-	Mp€s	--		25	--	--	I	do; Well 2.
175	Mr. Stokes, Landrum hwy. above Berry's Mill	do	100	75	6	Mp€s	--		8-10	--	--	D	Drilled 1953.
176	Spartanburg, S.C. (Sub District B)	Lee	242	--	8	Mp€s	60		55	20	--	PS	Drilled 1930.
177	Do	do	267	--	8	Mp€s	18		30	--	--	PS	Drilled 1948.
178	Do	J.A. Gross	270	50	8	Mp€s	--		35	--	--	PS	Drilled 1954.
179	Do	do	367	110	6½	Mp€s	50		35	--	--	PS	Drilled 1958.
180	Do	do	325	--	6¾	Mp€s	60		100	65	--	PS	Drilled 1957.
181	Do	do	380	18	8	Mp€s	--		60	--	--	PS	Drilled 1961.
182	Sam Millwood, Rt. 1, Pacolet	Faulkner	105	20	6¾	Mp€s	--		5	--	--	D	Drilled 1968.
183	Mrs. JoAnn Barton, Mill Village, Clifton	do	125	64	6¾	Mp€s	--		30	--	--	D	do.
184	Piedmont Girl Scout Council, 373 Union St., Spartanburg	do	245	33	6	Mp€s	--		25	--	--	PS	do.
185	J.J. McAndrews, jct. hwys. 142 & 50, Roebuck	Lee	124	100	6	Dp€h	52		--	--	--	D	Driven 1954.
186	M.B. Gazaway, Lyman	Faulkner	325	74	6¾	Dp€m	--		2	--	--	D	Drilled 1968.

Table 14.--Data on wells and springs, Spartanburg County--continued.

Well No.	Location	Driller	Depth (ft.)		Diameter (in.)	Principal Aquifer or Formation	Water Level		Yield (gpm)	Drawdown (ft.)	Temperature(°C)	Use	Remarks
			Total	Casing			Depth below land surface (ft.)	Date of measurement					
187	Warren Spawn, Lyman	Faulkner	105	23	6½	Dp¢m	--		40			D	Drilled 1968.
188	John Murphy, 265 N. Church Street, Spartanburg	do	125	62	6½	Mp¢s	--		50			D	Drilled 1967.
189	Wayne Corn, Rt. 2, Inman	do	325	45	6½	Mp¢s	--		1			D	Drilled 1968.
190	Hubie Collins, Roebuck	Gowan	245	62	6	Dp¢h	--		6			D	do.
191	Benny Jones, Rt. 1, Chesnee	Faulkner	145	55	6½	Dp¢m	--		1½			D	do.
192	James P. Foster, Roebuck	Gowan	65	20	6	Dp¢h	--		.75			D	do.
193	Johnny Bogan, West Springs	do	165	120	6	MOh	--		12			D	do.
194	Raymond Petrie, Glendale	do	305	50	6	Mp¢s	--		7			D	do.
195	David Duey, Spartanburg(?)	do	365	80	6	Mp¢s	--		10			D	do.
196	Pat Thackston, Rt. 2, Woodruff	do	165	53	6	Dp¢h	--		5			D	do.
197	James Brockman, Walnut Grove	do	365	44	6	Py	--		22			DS	do.
198	Boyce Hall, Valley Falls	do	300	88	6	Dp¢m	--		25			D	do.
199	Dan Riddle, 707 Ridgedale Drive, Spartanburg	do	165	25	6	Mp¢s	--		8			D	do.
200	Ladson Morgan, Carolina Drive, Spartanburg	do	305	30	6	Mp¢s	--		15			D	do.
201	Norman Haskell, Inman	do	105	60	6	Mp¢s	--		7			D	do.
202	Robert Blanton, Glendale	do	145	80	6	Mp¢s	--		5			D	do.
203	Tom Moore Creig, Jr.	do	125	70	6		--		7			D	do
204	Jack Blackwell, Lake Bowen	do	105	78	6	Mp¢s	--		5			D	do.
205	Otis Jones, Calhoun Lake	do	305	122	6		--		12			D	do.
206	W.O. Hatchette, Glendale	do	145	62	6	Mp¢s	--		5			D	do.
207	Jack Chapman, Cannon Camp Ground Road, Spartanburg	do	203	45	6	Mp¢s	--		7			D	do.
208	Tommy Putman, El Paso Street and Cannon Camp Ground Rd., Spartanburg	do	225	70	6	Mp¢s	--		10			D	do.
209	Arthur Pittman, Rt. 2, Woodruff	do	225	45	6	Dp¢h	--		9			D	do.
210	Ernest Eaddy, Lake Zimmerman	do	165	40	6	Mp¢s	--		7			D	do.
211	N.A. Mahon, Calhoun Lakes	do	125	50	6		--		5			D	do.
212	Hugh Akins	do	45	20	6		--		100			DS	do.
213	Charlie Roper, Jct. hwys. 142 & 50, Roebuck	Lee	215	115	6	Mp¢s	35		11			D	Drilled 1957; C/A; 2 homes.
214	C.P. Capell, Fair Forest	Gowan	145	4	4	Dp¢m	--		3			D	Drilled 1968.
215	Ohio Construction Company, Blackstock Road, Spartanburg	do	145	40	6	Mp¢s	--		15			I	do.
216	Roland & Lynch Construction Contractors, SC-56, Spartanburg	do	225	78	6	Mp¢s	--		30			I	do.
217	Hugh Akins	do	185	70	6		--		4			D	do.
218	James Cristy, near I-26, Inman	do	175	138	6	Mp¢s	--		5			D	do.
219	Anderson Fertilizer Company, Howard Street, Spartanburg	do	105	50	6	Mp¢s	--		5			I	do.
220	G.W. Brooks, Rt. 1, Moore (Popular Springs)	do	145	15	6	Dp¢h	--		5			D	do.
221	Harry Patterson	do	185	100	6		--		10			D	do.
222	Buck Seay(?), off Parris Bridge Road	do	145	45	6		--		6			D	do.
223	Mrs. Elbert Eubanks, Roebuck	do	133	51	6	Dp¢h	--		4			D	do.
224	Toy Waddell, 101 Tyler Court, Spartanburg	do	165	80	6	Mp¢s	--		7			D	do.
225	T. Moffit	do	125	50	6		--		2			D	do.

Table 14.--Data on wells and springs, Spartanburg 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 (°C)	Use	Remarks
226	Mrs. Irma Hatchette, Glendale	Gowan	125	85	6	MpꞒs	--	--	30			D	Drilled 1968.
227	Snake Smith(?), West Springs	do	305	85	6	MpꞒs	--	--	20			D	do
228	Carolina Processing Co., Switzer	do	225	41	6	MpꞒs	--	--	20			I	do.
229	Grady Pace, RFD-3, Spartanburg	do	205	20	6	MpꞒs	--	--	5			D	do.
230	W.M. Lancaster, 165 Stribling Circle, Spartanburg	do	205	20	6	MpꞒs	--	--	25			D	do.
231	Bruce Durham, Rt. 2, Greer	Hughes	345	36	5	DpꞒm	40	6/21/67	1			D	Drilled 1967(?
232	W.L. Adams, Front St., Spartanburg	Dixie	46½	46½	24	MpꞒs	37	--	5			D	Bored 1968.
233	J.R. Cantrell, Boiling Springs	do	54	53	24	DpꞒm	23	2/28/68	--			D	do.
234	New mill above Chesnee	Lee-Gowan	100	80	6¼	DpꞒm	--	--	250			I	Drilled 1966.
235	Fairview Farms, SC-14 (Landrum exit, I-26)	Lee	250	85	6¼	MpꞒs	--	--	25			D S	Drilled 1967; 2 wells (1 dry well).
236	Kersey Green, Landrum	do	300	60	6¼	MpꞒs	--	--	3			D	Drilled 1967.
237	Al Ravan, Landrum	do	126	45	6¼	MpꞒs	--	--	6			D	do.
238	Mayfair Mill, Spartanburg	do	300	14	8	MpꞒs	--	--	125P 40F			I ?	Drilled 1962; Swimming pool.
239	Roebuck Lumber Company, Roebuck	do	200	110-115	5	DpꞒh	--	--	20			I	Drilled 1966.
240	High School, Roebuck	do	150	90	5	DpꞒh	--	--	20			PD	Drilled 1964.
241	Jesse Bobo, Roebuck	do	175	110	5	DpꞒh	--	--	15			D	Drilled 1966.
242	Presbyterian Church, Roebuck	do	135	115	5	DpꞒh	--	--	25			PD	Drilled 1965.
243	Baptist Church, Roebuck	do	200	60	5	DpꞒh	--	--	20			PD	do.
244	Roy McHugh, Roebuck	do	155	135	5	DpꞒh	--	--	30			D	Drilled 1967.
245	Jim Gentry, Inman	Lee-Gowan	540	60	6¼	MpꞒs	--	--	35			D	Drilled 1958.
246	Martin & Camp Feed, Chesnee	Lee	200	40	6	DpꞒh	--	--	8			C	Drilled 1967.
247	Mr. Bradley, Converse	do	175	40	6	MpꞒs	--	--	15			D	Drilled 1966.
248	Mr. Outz, Dogwood Road, Glendale	do	240	215	5	MpꞒs	--	--	12			D	Drilled 1967.
249	Kenneth Watson, Sinclair Station, SC-49, Cross Anchor	--	60	--	6	MpꞒs	--	--	--			C D	Station & two houses; C/A.
250	C.M. Irby, ½-mi. N. SC-49 & SC-146 jct., Cross Anchor	--	140	--	6	MpꞒs	--	--	20			D	Driven well.
251	Mrs. Edna Thrift, 0.1 mi. S.E. of SC-146 and hwy. 141 jct., Enoree	--	100 (?)	--	-	MpꞒs	--	--	--			D	Drilled well; C/A.
252	W.L. Lancaster, SC-146 and hwy. 141 jct., Enoree	--	55	--	-	MpꞒs	--	--	--			D	Dug well.
253	Floyd Messer, SC-56, 1.3 mi. N. of Tyger River	--	131	40-50	6	MOh	80	--	2½			D	Driven 1953; C/A.
254	Harry Taylor, 0.2 mi. N. SC-92 and hwy. 236 jct., Enoree	--	40	--	12	MOh	--	--	--			D	Driven well; C/A.
255	Spenser Atchly, 0.05 mi. S. of SC-215 and hwy. 110 jct., Pauline	--	152	80	6	Py	--	--	20			D	Driven 1940.
256	G.M. Atchley, SC-215 0.55 mi. S. of SC-150, Pauline	--	160	80	6	MOh	--	--	20			D	Driven well.
257	L.H. Dillard, SC-150 1 mi. N. of hwy. 681, Pacolet	Easler	180	120	6	MpꞒs	--	--	5			D	Driven well; two houses.
258	Milliken Company, hwy. 34 0.1 mi. E. of hwy. 681, White Stone	--	218	--	6	MpꞒs	60	--	30			I	Driven between 1945-47.
259	Spartanburg, S.C., Sub-treating Plant, hwy. 295 1.5 mi. W. of hwy. 681	--	550	--	8	MpꞒs	--	--	--			PS	Driven 1931; may be SP-130.
260	Mrs. Elizabeth Morrow, SC-215 and SC-56 jct., Pauline	--	100	--	6	Py	--	--	--			D	Driven 1860's; 4 houses.
261	Wayne Lawson, hwy. 90 0.5 mi. N. of hwy. 111, Pauline	--	155	55	6	Py	40	--	--			D	Driven 1962; C/A.
262	Harry Newcomer, SC-86 0.6 mi. S. of US-221, Moore	Gowan	185	105	6	DpꞒh	50±	--	8			D	
263	Do	Lee	150	35	6	DpꞒh	25(?)	--	--			S	Driven well.

Table 14.--Data on wells and springs, Spartanburg 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(°C)	Use	Remarks
264	W.R. Williams, SC-296 0.6 mi. N. of Tyger River	Cogsdale	360	20	6	DpꞒm	30(?)		35	--	--	D	
265	Anderson Mill, Moore	Gowan	125	--	6	DpꞒh	80		8	--	--	I	Driven 1958.
266	J.C. Blanton, Paris Bridge Road, Spartanburg	do	105	29	6	MpꞒs	--		25	--	--	D	
267	Holly Springs Peach Orchard, Chesney (B.B. Jolly)	do	205	105	6	DpꞒm	--		40	--	--	-	
268	Walnut Grove Plantation (E.C. Tenent)	do	185	43	6	Py	--		6	--	--	-	Drilled 1968.
269	Caroll Pritcher, Holly Springs Road, Spartanburg	do	165	23	6	MpꞒs	--		40	--	--	D	do.
270	Ohio Construction Co., Blackstock Rd., Spartanburg (Roman & Lynch)	--	165	--	6	MpꞒs	--		25	--	--	I	
271	B.V. Miller, Anders Mill Road	Gowan	--	--	6		--		25	--	--	D	Drilled 1968.
272	D.L. McCullough, 220 Langford Road, Spartanburg	--	125	35	6	MpꞒs	--		75	--	--	D	do.
273	Calhoun Lakes Housing Development, Spartanburg (Roger McDuffy)	Gowan	185	--	6	MpꞒs	--		25	--	--	D	
274	McKimsh Store, Glendale	do	185	37	6	MpꞒs	--		4	--	--	C	Drilled 1968.
275	Radio Station WORD, Spartanburg	do	225	60	6	MpꞒs	--		125	--	--	C	
276	Carol D. Compton, Clifton	do	145	63	6	MpꞒs	--		--	--	--	D	
277	Friendship Baptist Church, S-42-112 E. of S-42-111, Pauline	do	425	50	6	Py	--		4	--	--	PD	
278	Harold Wright, Cowpens	do	300	38	6	DpꞒm	--		1	--	--	D	Drilled 1968.
279	H.M. Rogers, Campobello	do	265	70	6	MpꞒs	--		50	--	--	D	do.
280	L.L. Sallars	do	125	60	6		--		4	--	--	D	do.
281	Jim Quinn, Pauline	do	165	15	6	Py	--		3	--	--	D	do.
282	Frank Patton, Lake Bowen	do	125	50	6	MpꞒs	--		3	--	--	D	do.
283	L.P. Pitts, Moore	do	165	40	6	DpꞒh	--		15	--	--	D	do.
284	J.M. Byers, SC-252 2.3 mi. E. of US-221, Enoree	--	72	--	24	MpꞒs	52		--	--	--	D	Dug well.
285	W.J. Phillips, S-42-85 0.15 mi. E. of S-42-51, Woodruff	Gowan & Lee	143	17	6	DpꞒh	--		3	--	--	D	
286	Walter Matosky, S-42-51 0.4 mi. S. of S-42-85, Woodruff	do	186	6	6	DpꞒh	40		1	--	--	D	
287	Dobson Brothers, SC-290 1.5 mi. E. of SC-101, Greer	Lewis	225	--	6	DpꞒm	40		15	--	--	D	
288	Stuckey's, Inc., US-85 and SC-14 jct. Greer (just E. of County Line)	do	127	--	6	DpꞒm	40		--	--	--	C	Across from Air Port; C/A.
289	B. Smith, US-85 and SC-14 jct., Greer	do	427	--	6	DpꞒm	14		100	50	--	-	do.
290	E.E. Lewis, S-42-60 and S-42-134, Greer (NNE of Welford)	Gowan	240	--	6	MpꞒs	30		35	--	--	D	
291	Carl Pruett, about 0.8 mi. S. of jct. of S-42-52 and S-42-38, about 2.7 mi. S.W. of Inman	Faulkner	180	--	6	MpꞒs	43	6/16/70	40	--	12	D	Geophysical logs.

Spring No.	Location	Owner	Topography	Formation	Structure	Character	Improvements	Use	Remarks
SP-S-1	W.R. Snow, 0.2 mi. S. of Bens Creek on unnumbered county road SSW of Reidville	W.R. Snow	Slope	DpꞒm	Gravity spring		Shallow pump	D	
SP-S-2	Glenn Springs, S.C.	J.W. Bell	Slope	MpꞒs		Seepage	Ceramic tile basin		

Geologic Symbols:

MpꞒs = Biotite schist
DpꞒm = Biotite gneiss and Migmatite
DpꞒh = Hornblende gneiss
MOh = Hornblende schist
Py = Quartz Monzonite

Other Symbols and Abbreviations:

PS = Public Supply
PD = Public-Domestic use
D = Domestic use
RR = Railroad use
C/A = Chemical Analysis
S = Stock use
M = Military use
C = Commercial use
I = Industrial use
D/L = Drillers Log

Table 15.--Chemical analyses of selected well and spring waters

Well Number	Aquifer	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe) 1/	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids		Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color (units) 2/
																		Calculated	Residue on evaporation at 180°C	Calcium, Magnesium	Noncarbonate			
SP-10-16	MpꞒs	Dec. 7, 1945	17	--	0.58	--	--	--	--	--	--	33	3.0	3.0	--	0.5	--	--	--	24	--	--	--	--
SP-43-50	DpꞒh	Feb. 14, 1955	14	28	.00	0.00	5.1	2.0	4.5	2.0	0	33	1.6	2.0	0.2	1.2	--	63	69	21	0	69	6.4	5
SP-51-52	DpꞒh	Feb. 14, 1955	16	34	.04	.00	5.4	.9	6.3	2.0	0	28	1.7	2.5	.1	4.2	--	71	76	17	0	75	6.4	4
SP-74	DpꞒh	Dec. 7, 1945	17	--	.11	--	--	--	--	--	--	90	50	4.0	--	.4	--	--	--	98	--	--	--	--
SP-74	DpꞒh	Feb. 14, 1955	17	13	.00	.00	37	2.5	15	2.0	0	92	47	4.8	2.5	.3	--	169	181	103	27	276	7.2	3
SP-75	DpꞒm	Dec. 26, 1945	--	--	.61	--	--	--	--	--	--	71	10	3.0	--	.1	--	--	--	58	--	--	--	--
SP-92	DpꞒm	Dec. 26, 1945	--	--	.34	--	--	--	--	--	--	54	8.0	2.0	--	.4	--	--	--	50	--	--	--	--
SP-119-122	DpꞒh	Dec. 24, 1945	15	--	.56	--	--	--	--	--	--	7	3.0	4.0	--	4.5	--	--	--	14	--	--	--	--
SP-129	DpꞒm	Jan. 15, 1946	15	--	5.4	--	--	--	--	--	--	48	2.0	7.0	--	.3	--	--	--	36	--	--	--	--
SP-133	MpꞒs	Jan. 16, 1946	16	--	.07	--	--	--	--	--	--	72	8.0	2.0	--	.0	--	--	--	52	--	--	--	--
SP-136	MpꞒs	Jan. 16, 1946	16	--	1.3	--	--	--	--	--	--	74	18	3.0	--	.2	--	--	--	58	--	--	--	--
SP-138-143	MpꞒs	Jan. 16, 1946	16	--	.23	--	--	--	--	--	--	8	1.0	6.0	--	6.4	--	--	--	16	--	--	--	--
SP-151	MpꞒs	Jan. 14, 1946	--	--	.19	--	--	--	--	--	--	56	4.0	2.0	--	1.7	--	--	--	44	--	--	--	--
SP-153	MpꞒs	Jan. 16, 1946	--	--	.07	--	--	--	--	--	--	26	2.0	4.0	--	1.4	--	--	--	21	--	--	--	--
SP-166	DpꞒh	Feb. 14, 1955	16	22	.00	.00	9.7	2.5	6.0	1.4	0	46	6.5	2.0	.4	.8	--	74	83	34	0	100	6.6	2
SP-213	MpꞒs	Aug. 15, 1968	--	22	.01	.00	5.8	1.9	9.0	1.7	--	47	1.0	4.4	.1	.2	0.26	69	90	22	0	81	6.4	5
SP-249	MpꞒs	Aug. 15, 1968	--	8.4	.01	.24	7.0	3.2	29	2.8	0	21	1.6	45	.0	22	.00	129	141	30	14	226	6.0	5
SP-251	MpꞒs	Aug. 15, 1968	--	16	.02	.00	4.7	.6	2.1	1.2	0	21	1.2	2.4	.0	.2	.01	38	40	14	0	42	5.7	5
SP-253	MOh	Aug. 15, 1968	--	52	.01	.00	20	8.6	13	1.9	0	76	7.0	31	.1	4.1	.00	175	198	86	23	243	6.5	5
SP-254	MOh	Aug. 15, 1968	--	7.6	.04	.01	5.8	12	31	2.7	0	17	5.0	49	.2	56	.00	178	202	66	52	306	6.6	5
SP-261	Py	Aug. 15, 1968	--	16	.03	.00	3.8	.8	3.4	.9	0	18	2.8	2.6	.0	2.6	.00	42	44	13	0	47	6.1	3
SP-288	DpꞒm	Jan. 31, 1969	--	17	.06	.02	2.2	.5	3.8	1.1	0	16	1.8	.2	.2	2.8	.00	38	38	8	0	32	6.5	0
SP-289	DpꞒm	Feb. 1, 1969	--	36	8.1	.02	20	1.2	13	1.7	0	88	6.0	1.8	.8	.3	.09	123	132	55	0	135	7.9	0
SP-S-2	MpꞒs	Aug. 2, 1969	--	30	1.5	.20	454	9.7	15	4.1	0	87	1070	3.7	1.4	.0	.00	1630	1690	1170	1100	1690	7.3	5
Cowpens3/	MpꞒs	Sept. 18, 1956	--	27	.00	.02	10	1.7	4.6	1.8	0	44	6.0	2.5	.1	1.2	.10	77	74	34	0	94	6.4	0
Cowpens3/	DpꞒm	Sept. 18, 1956	--	30	.08	.00	14	3.2	6.0	1.9	0	51	17	2.5	.1	.7	.00	100	99	49	7	127	6.6	2
Cowpens3/	DpꞒm	Sept. 18, 1956	--	32	.02	.01	18	4.4	7.0	1.9	0	78	11	2.5	.1	.6	.20	116	120	63	0	156	6.9	0
Cowpens3/	DpꞒm	Sept. 18, 1956	--	35	.28	.01	11	3.6	7.0	2.2	0	53	12	2.0	.2	.5	.20	100	100	41	0	117	6.8	3
Cowpens3/	DpꞒm(?)	Sept. 18, 1956	--	34	.19	.00	8.4	2.7	6.2	2.2	0	45	8.0	1.5	.1	.8	.20	86	84	32	0	96	6.7	2
Cowpens3/	MpꞒs	Sept. 18, 1956	--	17	.01	.00	3.2	1.7	2.5	.9	0	21	1.9	2.0	.1	.8	.10	40	38	15	0	42	6.0	0
Chesnee3/	DpꞒm	Sept. 18, 1956	17	11	.00	.00	3.6	.5	1.8	.7	0	11	1.0	3.0	.1	5.9	.00	33	34	12	3	42	5.7	1
Chesnee3/	DpꞒm	Sept. 18, 1956	17	19	.02	.01	18	2.8	3.3	1.5	0	55	15	2.0	.1	.5	.00	89	86	56	11	127	6.6	1
Chesnee3/	DpꞒm	Sept. 18, 1956	17	11	.01	.03	7.2	.9	3.6	1.6	0	22	2.1	5.0	.1	5.9	.00	48	64	22	4	87	5.9	1
Woodruff3/	DpꞒh	Feb. 14, 1955	14	30	.01	.00	10	1.9	6.4	1.4	0	46	6.6	3.0	.5	1.3	--	84	85	34	0	101	6.8	4

1/ In solution when collected. 2/ Based on platinum-cobalt scale (Hazen, 1892). 3/ No well number assigned as sample not collected by S.C. District.

Table 16.--Summary of statistical values for chemical analyses of well waters, Spartanburg County. (Concentrations in milligrams per liter except as indicated. Analyses by the U.S. Geological Survey)

Constituents	Low	High	Mean	Median
Silica (SiO_2)	7.6	52	23.2	22
Iron (Fe)	.01	5.4	.33	.04
Manganese (Mn)	.01	.24	.02	.00
Calcium (Ca)	3.2	37	10.4	8.5
Magnesium (Mg)	.5	12	2.9	2.2
Sodium (Na)	1.8	31	.8	6.1
Potassium (K)	.7	2.8	.2	1.8
Carbonate (CO_3)	--	--	--	--
Bicarbonate (HCO3)	7.0	92	44	46
Sulfate (SO_4)	1.0	50	8.5	5.0
Chloride (Cl)	1.5	49	10.0	3.0
Fluoride (F)	.0	2.5	.3	.1
Nitrate (NO_3)	0.0	56	4.1	.8
Hardness as $CaCO_3$	12	102	39.8	34
Dissolved solids (Residue upon evaporation @ 180°C)	34	202	95.4	84.5
pH	5.7	(7.5 1/) 7.2	6.4	6.5
Specific Conductance (micromhos at 25 C.)	42 (32 2/)	306	122.7	98

1/ Field measurement of water from well SP-264.
2/ Field measurement of water from well SP-214.

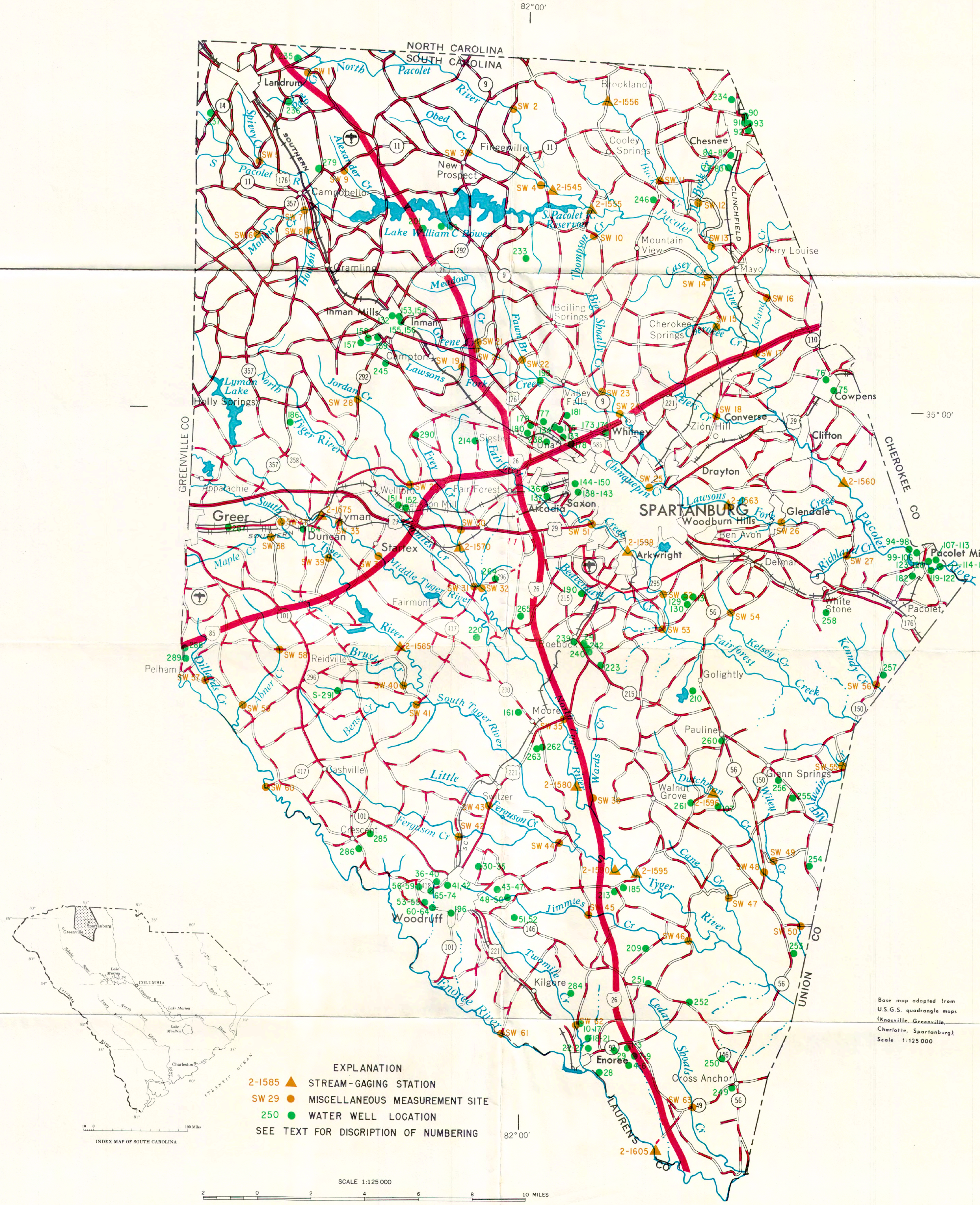

PLATE I. MAP SHOWING STREAM GAGES AND WELL LOCATIONS, SPARTANBURG COUNTY, SOUTH CAROLINA