Water Resources of the Yadkin-Pee Dee River Basin, North Carolina

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1415

Prepared in cooperation with Division of Water Resources, Inlets and Coastal Waterways, North Carolina Department of Conservation and Development

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By R. E. FISH, H. E. LEGRAND *and* G. A. BILLINGSLEY

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PREFACE

The report on the water resources of the Yadkin-Pee Dee River basin is one of a series of river basin reports describing the water resources of North Carolina. When the contemplated series is completed, information for the entire State will be available to assist in the orderly planning and development of the water facilities required for municipal and industrial expansion, and for the expansion of the uses of water in agriculture.

This report was prepared by the U. S. Geological Survey, with the financial assistance of the Division of Water Resources, Inlets, and Coastal Waterways of the North Carolina Department of Conservation and Development. E. B. Rice, district engineer, Surface Water Branch, H. E. LeGrand, district geologist, Ground Water Branch, and G. A. Billingsley, district chemist, Quality of Water Branch were in charge of the project and many individuals in the Water Resources Division contributed to the collection, compilation, and interpretation of data used in preparing this report.

Most of the data summarized in this report have been collected over a period of many years by the U. S. Geological Survey in cooperation with the North Carolina Department of Conservation and Development, the State Board of Health, and the Corps of Engineers, U. S. Army, Charleston, S. C. Other data and information presented in this report are based on data collected by, in cooperation with, or are from technical reports, or publications of the U. S. Weather Bureau, North Carolina State Stream Sanitation Committee, and the North Carolina State Highway and Public Works Commission.

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WATER RESOURCES OF THE YADKIN-PEE DEE RIVER BASIN

NORTH CAROLINA

By R. E. Fish, H. E. LeGrand, and G. A. Billingsley

ABSTRACT

Sufficient water is available in the basin of the Yadkin and Pee Dee Rivers to meet present requirements and those for many years to come if water use increases at about the present rate. Data presented in this report show that the average annual streamflow from approximately 82 percent of the basin area during the 25-year period, 1929–53, was about 6,200 mgd, representing essentially the total available water supply. Comparison of the available water supply to the estimated withdrawal use (excluding water power) of both surface and ground water of 600 mgd indicates the relative utilization of the water resources of the basin at present. If proper pollution controls are observed and practiced so that water in the various streams may be reused several times, the potential water available is even greater than indicated by the above comparison. Preliminary studies indicate that the quantity of water now being withdrawn from ground-water reservoirs in the basin is only a fraction of the total that may be obtained from this source.

Twenty-eight of the 64 municipalities having public water-supply systems use surface water; however, as the largest cities in the area use surface supplies, about 85 percent of the water used for public supplies is from surface sources.

Of the 20 complete-record stream-gaging stations now in operation in this area 7 have been in operation for 24 years or longer. Periodic measurements of the rate of flow have been made at 31 additional sites on streams scattered widely over the basin. All available streamflow data including those for 1953 are summarized in either graphic or tabular form, or both. Because of the critically low flows occurring during the drought of 1954, several illustrations include data for 1954 and the early months of 1955 for comparison with the minima of previous years.

Adequate water for domestic use is avnilable from wells throughout the basin. The consolidated rocks of the Piedmont furnish water for small industries and for municipalities whose population is less than about 1,500. The yields of wells in rock range from less than 1 gpm to as much as 200 gpm with local, rather than regional, geologic factors controlling the yield. The average municipal well in consolidated rocks yields about 30 gpm. In contrast, the sands of the Coastal Plain, in the eastern part of the basin, furnish as much as 500 gpm to individual wells, and ground-water conditions are generally similar throughout that region. A cumulative deficiency in rainfall from 1953 to 1955, has caused ground-water levels to fall below the seasonal averages, but the decline is thought not to indicate a long-term trend. The most serious problem involving future use of ground water is the lack of knowledge of the characteristics of the ground-water provinces in the basin.

Generally the chemical quality of the surface waters in the Yadkin-Pee Dee River basin is good. They are low in mineral matter and soft, although some of the surface water contains excessive quantities of iron. In some local areas the streams have been polluted by municipal and industrial wastes. During periods of high runoff many of the streams transport large quantities of suspended sediment. Tributary streams in the lower eastern part of the basin are highly colored because of drainage from swampy areas.

Ground water from the consolidated rocks in the Piedmont region is more variable in quality than water from other areas in the basin. The dissolved solids in water from the consolidated rocks ranged from 26 to 1,480 ppm with a median of 109 ppm. Wells in the Cretaceous clay province normally yield slightly acid waters. The pH ranges from 4.7 to 7.7 with a median of 5.3. Generally ground water in this province is extremely soft and low in dissolved solids. Wells in the Cretaceous sand province yield a sodium bicarbonate type of water ranging in hardness from 2 to 130 ppm.

INTRODUCTION

Among the many factors that influence the economic growth of the Yadkin-Pee Dee River basin, none plays a more important role than water. A basic need of any region is adequate water supplies for municipal, industrial, rural domestic, agricultural, and other uses. These supplies must furnish not only a sufficient quantity of water but also water of satisfactory chemical and physical quality. The natural increase in population, the expansion of industrial facilities, and the demands on agricultural production, have focused attention on the need for accurate and continuing appraisals of the water resources of the basin. Such appraisals are prerequisite to plans for the development of the resources to meet the accelerating demands for water.

PURPOSE

This report has been prepared to summarize and evaluate the data now available on the quantity and quality of both surface and ground waters in the part of the Yadkin-Pee Dee River basin that lies in North Carolina. It is hoped that the report will assist in the location, development, or expansion of municipal, industrial, agricultural, and other water supplies and, perhaps, be a guide for the future study of water resources in the area.

GEOGRAPHY

The basin of the Yadkin and Pee Dee Rivers trends southeastward through west-central North Carolina. The Yadkin River rises along the eastern edge of the Blue Ridge in Caldwell, Watauga, and Wilkes Counties in North Carolina and flows northeastward for about 100 miles before turning southeastward near Winston-Salem. The Pee Dee River is formed by the confluence of the Yadkin and Uwharrie Rivers in the vicinity of Albemarle. The Pee Dee River continues southeastward through South Carolina before emptying into Winyah Bay and thence into the Atlantic Ocean near Georgetown. The Waccamaw River, which also flows into Winyah Bay, drains a small area adjacent and to the east of the lower Pee Dee River basin. In this report the areas drained by the Yadkin, Pee Dee, and Waccamaw Rivers are treated as one basin and are called the Yadkin-Pee Dee River basin.

The length of the basin in North Carolina is about 235 miles and its width above the point where the Pee Dee River enters South Carolina averages about 65 miles. The Yadkin-Pee Dee River basin, as defined, drains a total area in North Carolina of 10,650 square miles. Of this total, 1,350 square miles are tributary to the Waccamaw River.

Slightly more than 1 million people live in the basin, or about 25 percent of the population of North Carolina. The only city with more than 100,000 people is Winston-Salem, although there are 64 municipalities large enough to have public water-supply systems. About 40 percent of the population is urban and about 60 percent rural.

TOPOGRAPHY

The Yadkin and Pee Dee Rivers flow over igneous and metamorphic rocks of the Piedmont region before entering South Carolina. The streams of the southeastern part of the area covered by this report, including the parts of the Lumber and Waccamaw River basins lying in North Carolina, flow over sands and clays of the Coastal Plain.

The surface features in the Piedmont are directly or indirectly the result of the streams lowering their channels into the rocks for long periods of geologic time. This degrading by streams, coupled with the humid climate, has resulted in a close network of perennial streams, separated chiefly by well-drained, rolling upland areas. The rocks have been altered through physical and chemical processes, so that a moderately deep layer of reddish soil underlain by soft, decayed rock is characteristic of the upland areas. The streams, in most places, are bordered by flat bottom land, or flood plains.

In the western part of the Coastal Plain the topography is similar to that of the Piedmont region. Closely spaced perennial streams and intervening rounded hills are characteristic. However, a conspicuous mantle of coarse sand on the interstream areas has resulted in this region being known as the "Sand Hills." Owing to the infertility of the surface sand, vegetation is sparse in the Sand Hills. Coastward from the Sand Hills, the upland surface is relatively flat and smooth. Stream channels are as much as 30 to 50 feet below the upland surface. Swampy terraces lie along most of the streams, and are bordered by a low but pronounced scarp leading to the upland plain.

CLIMATE

The Yadkin-Pee Dee River basin has a humid climate. Because of the length of the basin and its extension from the mountain region to the Atlantic Ocean, there are minor variations in climate through the area.

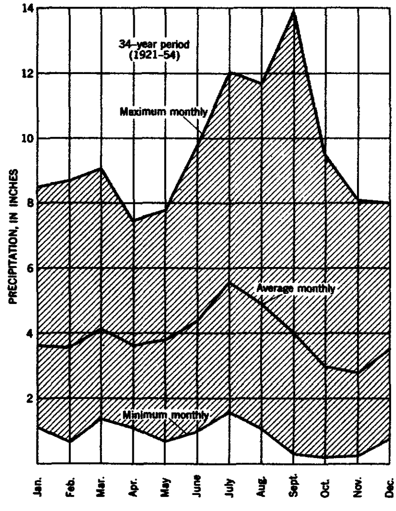
Precipitation occurs chiefly as rainfall and varies with the seasons and with elevation. The mean annual precipitation ranges from 44 inches in the area between Winston-Salem and Albemarle in the center of the basin to 56 inches in the mountains northwest of Wilkesboro. (See pl. 1.) Mean annual precipitation is about 51 inches near the coast. This rainfall is generally well distributed through the year but is greatest during the summer and early fall (fig. 1). The heaviest monthly rainfall recorded in the basin was at least 20.7 inches (Buffalo Cove, Caldwell County, August 1940, U. S. Forest Service) but the average is only a fifth of that amount.

Mean annual temperatures also vary from northwest to southeast, being about 57°F in the northern Piedmont section of the basin and about 62°F in the Coastal Plain. Temperatures vary seasonally and are highest, of course, during the summer months, generally reaching a peak in July (fig. 2). The highest temperature recorded in the basin was 109°F (Albemarle, July 1940). The lowest temperature recorded in the basin was -15°F (Rockingham, February 1899). The growing season ranges from about 175 days in the northwest part of the basin to about 235 days in the southeast part.

AGRICULTURAL AND INDUSTRIAL DEVELOPMENT

The Yadkin-Pee Dee River basin is in large measure an agricultural region, tobacco being the chief dollar crop in many counties. Other important crops include corn, small grains, cotton, and hay. Corn occupies a greater acreage than any other crop grown in the basin. Dairying, beef cattle, and poultry production are important in most counties. The use of forest products has grown steadily. The major portion of the forest harvest is cut for saw logs, fuelwood, pulpwood, veneer, and posts.

There is considerable industrial diversification in the basin. Major industries include the generation of electric power, the manufacture of textiles, tobacco products, aluminum, and furniture.



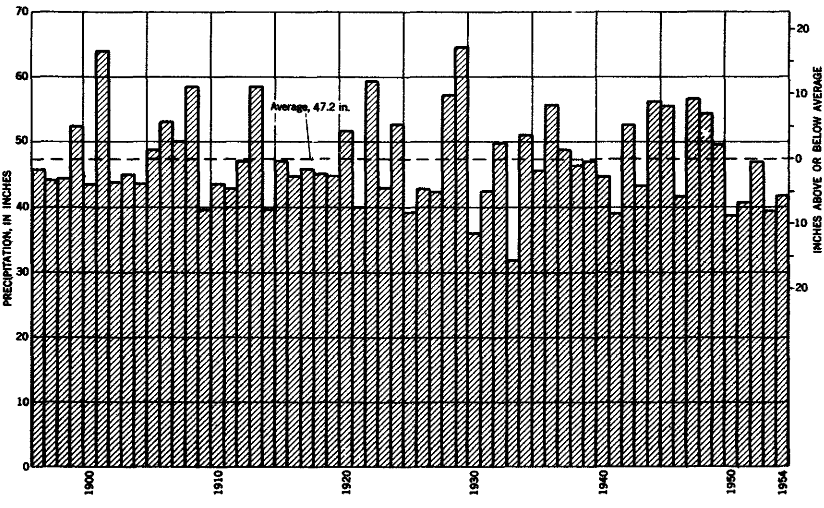


Figure 1.—Monthly and annual precipitation computed as the average of Lumberton, Mount Airy, Rockingham, and Salisbury.

The manufacture of cigarettes and other tobacco products is concentrated at Winston-Salem, and aluminum is produced at Badin. Other industries include the processing of food and other agricultural products.

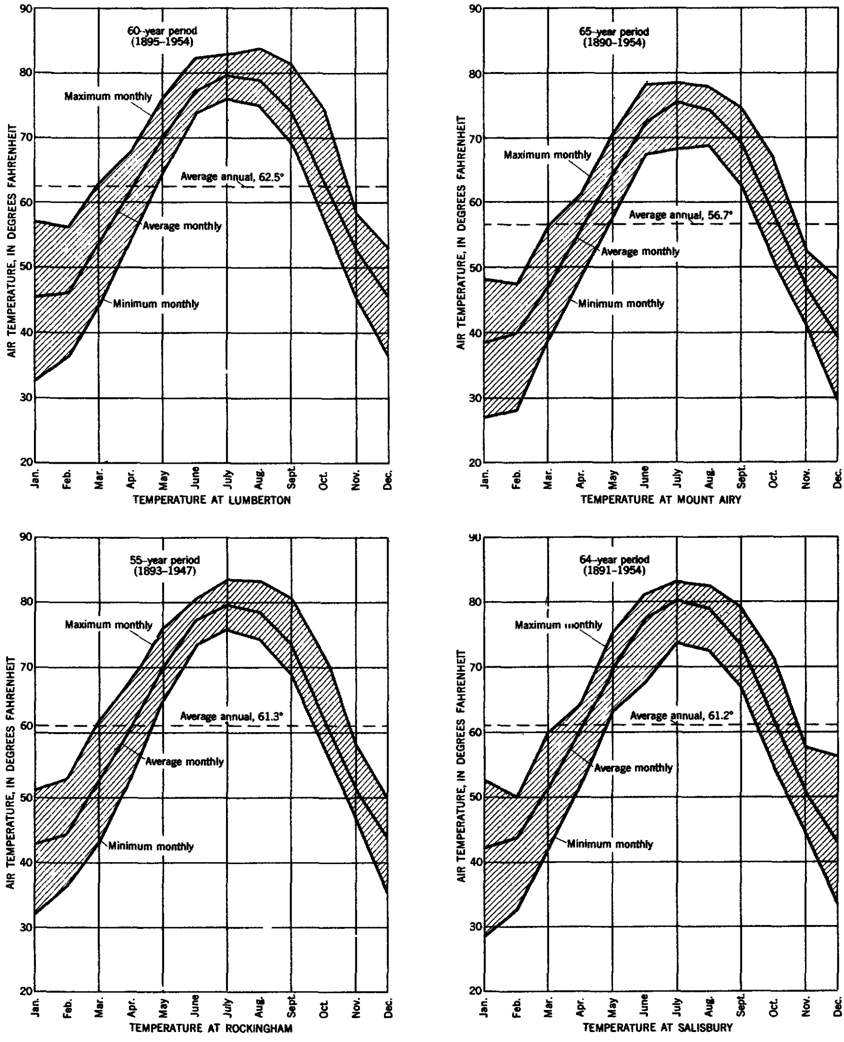


Figure 2.—Maximum, minimum, and average air temperature at Lumberton, Mount Airy, Rockingham, and Salisbury.

A great variety of minerals occurs in the basin, but only the production of sand and gravel and of dimension and crushed stone has been consistently important. Mining of granite is significant in the vicinity of Mount Airy and Salisbury. Production of sand and gravel is centered at Lilesville.

The many small towns and the several cities are important commercial centers. The usual commercial enterprises are well represented in the basin; one of the most important is that of buying and selling tobacco at the many warehouses and markets in the basin.

Several railroads serve the area but the extensive network of all-weather roads has made trucking an important means of transport. Airlines serve the area through ports at Hickory, Winston-Salem, Greensboro, Charlotte, Pinehurst, Fayetteville, and Wilmington.

DEFINITION OF TERMS

The records for quantities of water are expressed in various terms in the presentation of hydrologic data. Some of these terms have become associated with certain types of works and may be divided into two general groups: those that represent a rate of flow such as million gallons per day (mgd), gallons per minute (gpm), cubic feet per second (cfs), million gallons per day per square mile, and cubic feet per second per square mile, and those that represent volume of water, as million gallons, million gallons per square mile, and runoff depth in inches on the drainage basin.

The gallon is the volumetric unit commonly used in North Carolina in connection with pumping rates, storage for water supplies, and sprinkler-type irrigation systems, whereas the cubic foot is the volumetric unit generally used in connection with power generation and with flood flows.

The units in which hydrologic data are given in this report may be defined as follows:

A *cubic foot per second* is the rate of discharge equivalent to that of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second.

A million gallons per day per square mile is defined as 1 million gallons of water per day flowing from each square mile of area drained, on the assumption that runoff is distributed uniformly as regards time and area.

Cubic feet per second per square mile is the average number of cubic feet of water per second flowing from each square mile of area drained, on the assumption that the runoff is distributed uniformly as regards time and area.

The *water-year* begins October 1 and ends September 30 and is the year for which most streamflow data are reported. The water-year is used in analysis and presentation of data on low flow in this report except that magnitude and frequency analyses of low flows are based on a *climatic-year* beginning April 1 and ending March 31.

One *part per million* (ppm) is a unit weight of a constituent in a million unit weights of water. In the chemical analysis of water samples, it is necessary to determine the presence of various substances usually found in minute amounts; therefore, the results are usually expressed in parts per million rather than in percentages. One part per million equals one ten-thousandth of one percent (0.0001 percent).

The hydrogen-ion concentration in an aqueous solution or in water is represented on the pH scale by a number which is the negative logarithm of the hydrogen-ion concentration in moles per liter of solution. A solution having a pH value of 7.0 is neutral—that is, it is neither acid nor alkaline. Progressive pH values below 7.0 denote increasing acidity, and progressive pH values above 7.0 denote increasing alkalinity.

Specific conductance is a measure of the ability of a water to conduct an electrical current and is expressed in micromhos at a temperature of 25°C. It varies directly with the concentration and degree of ionization of the different minerals in solution and with the temperature. The conductance furnishes a rough measure of the mineral content of the water, it does not indicate the relative quantities of different salts in solution.

OCCURRENCE AND QUALITY OF WATER

THE HYDROLOGIC CYCLE

The water we use, whether it is from surface or ground water sources, has its origin in precipitation. In the natural sequence of events, the water that is evaporated from the ocean by the energy of the sun is carried inland as vapor, and falls on the land from clouds as rain, snow, sleet, or hail. Some of the precipitation is returned to the atmosphere by evaporation and transpiration but the remainder percolates into the soil or flows overland in surface streams. Much of the water that enters the soil is evaporated or transpired, and the remainder percolates downward to the water table and enters the zone of saturation where most of it moves laterally toward streams, maintaining their fair-weather flow. That water which moves beneath or upon the land surface eventually reaches the sea where it is again evaporated. This recurring succession of events is known as the hydrologic cycle.

It is evident that, although the quantity of water involved in the hydrologic cycle remains rather constant for the earth as a whole, the amount of water available from any specific source varies with precipitation from time to time or from place to place. Because of this natural circulation, water may be regarded as a renewable resource.

Rainfall that reaches the ground and does not evaporate or run off seeps downward, moving through the minute spaces between soil particles. Much of this water is held in the soil to be used by trees, crops, and other vegetation. Soil-moisture requirements have a priority on precipitation and a large percentage of precipitation, especially during the growing season, is used by vegetation.

When precipitation exceeds the rate at which it can be absorbed by the ground, water must flow on the surface, where it develops channels or gullies in the land in its search for drainageways. Runoff may be stored in ponds or other reservoirs to minimize flood damage and to provide water during periods of deficiency which may follow. If water levels are higher in streams than in the surrounding rock formations, some water may enter into and recharge the ground-water reservoir. However, in North Carolina such a situation generally exists only temporarily during floods, and the water that recharges the rocks (bank storage) soon drains back into the streams as their levels fall.

SOURCES OF WATER

Both surface and ground water sources are utilized in the Yadkin-Pee Dee River basin.

In the Piedmont section of the basin, wells rarely yield as much as 100 gpm and usually yield much less. Water supplies for large cities such as Winston-Salem and Salisbury must necessarily come from surface sources. Large mills or other industrial plants must also obtain most of their water from lakes or streams, either by constructing their own facilities or by purchasing treated water from a public supply. Ground water is used by several small towns in the Piedmont section but is not used by any large city in the area.

In the Coastal Plain, ground-water sources are more important than in the Piedmont. Wells yielding more than 300 gpm are common. Because of the low relief over much of the Coastal Plain, the construction of large dams for water supplies or other purposes is not generally feasible and only three public supplies, those for Lumberton, Laurinburg, and Hamlet, are obtained from surface water. Large supplies for public, industrial, and irrigation uses are available from ground-waters sources.

In general, large water supplies are obtained from surface sources in the Piedmont section and from wells in the Coastal Plain. Of the 64 cities and towns in the Yadkin-Pee Dee River basin that have public water supplies, 56 percent, serving 43,000 persons, use ground water, while 44 percent, serving 329,000 persons, have surface-water sources. (See pl. 4.) Ground water is used for domestic supplies by about 65 percent of the basin's population, including the rural population.

SIGNIFICANCE OF QUALITY OF WATER

An adequate water supply is a determining factor in the selection of an industrial site. Sharing importance with quantity is a knowledge of the chemical quality, degree of pollution, and seasonal amount of suspended sediment carried by the stream.

Chemical analyses of water for municipal or industrial uses are necessary to determine whether the water is suitable for specific purposes, and, if not, to determine the type and cost of the treatment needed to make it satisfactory. The analyses aid in determining the suitability of the water for drinking, steam production and heating, manufacturing, laundering, and other uses. Comprehensive analyses can also be used to determine the cost of softening water, its scale-forming properties, and its tendency to corrode plumbing.

The chemical requirements for water used by different industries are so variable that it is impossible to establish specifications to fit all uses. In general, however, most industries require clear water low in total mineral content and hardness. Water temperature is also an important factor in determining the value of water for industrial use.

Generally accepted chemical specifications have been established for waters used domestically. These chemical specifications are independent of any sanitary specifications established for protection of the public health. In 1946 the United States Public Health Service established chemical and physical specifications for drinking water used on interstate carriers as follows:

Iron and manganese together	ppm ≤	0.3
Magnesium	ppm ≤	125
Chloride	ppm ≤	250
Sulfate	ppm ≤	250
Fluoride	ppm ≤	1.5
Lead	ppm ≤	.1
Color	units ≤	20
Total solids	ppm ≤	[1]500

[1] 1,000 ppm permitted if no other water is available.

The above specifications have since been adopted by the American Water Works Association and most municipalities as a standard for public water supplies.

Water containing less than 500 ppm of dissolved solids generally is satisfactory for most domestic and industrial uses. However, an excessive iron content or hardness may cause difficulty in some uses. Waters containing more than 1,000 ppm of dissolved solids are likely to include certain constituents that make them unsuitable for domestic or industrial uses.

Information on hardness of water is of great importance. In domestic use hardness is recognized by the difficulty in obtaining a lather without an excessive consumption of soap, the insoluble sticky curd that results in washing processes using soap, and the scale formed in vessels in which the water is boiled. Industry gives much attention to hardness of water supplies because it affects manufacturing processes, and the finished product. Furthemore the scale deposited in hot-water pipes, hot-water heaters, and steam boilers, results in economic loss through loss of heat transfer, increased fuel consumption, and breakdown of equipment. Calcium and magnesium are the principal causes of hardness. Other constituents, such as iron, manganese, aluminum, barium, strontium, and free acid, also cause hardness but generally they are not present in sufficient quantities to have an appreciable effect on the hardness. Water having a hardness of less than 60 ppm is usually rated as soft and suitable for most purposes. Hardness ranging between 60 and 120 ppm may be considered moderate, but it does not seriously interfere with the use of the water except in high-pressure steam boilers and in some industrial processes. Water having a hardness ranging from 121 to 200 ppm is hard, and, in the upper ranges, laundries and industries may profitably soften the supply. Water having a hardness greater than 200 ppm is usually softened before being used.

Iron and manganese in excess of 0.3 ppm are objectionable because they form reddish-brown stains on white porcelain or enamel ware, on fixtures, and on clothing or other fabrics and interfere with dyeing, tanning, paper manufacturing, and the manufacture of photographic film and many other products.

Color, in water analysis, refers to the appearance of water that is free of suspended material. Generally waters are colored by organic matter leached from plants, tree roots, and organic components of soils. Highly colored waters may foam in boilers and can stain processed products. It is more difficult to remove iron and to soften the water with hot phosphate solutions in highly colored waters than in clear water. Also, color is objectionable in public water supplies for esthetic reasons.

SURFACE WATER

STREAM-GAGING SITES

Early use of the Yadkin-Pee Dee River and tributaries consisted of a few small water-powered gristmills. At present the streams still furnish power for operation of grist and sawmills and the additional jobs of supplying water for generation of electric power, municipal and industrial use, recreation, and other purposes.

The rivers and creeks are valuable assets to the area, but at times they can be liabilities. On occasion streamflow was inadequate to meet the established requirements of many users in the basin, notably during the drought in 1954. At times floods have menaced extensive areas, for example, the upper Yadkin River valley in 1940.

Streamflow information consists of continuous records of flow at gaging stations on the rivers and smaller streams and periodic and occasional measurements of flow at other sites. At present 20 gaging stations are operated within the basin, some having been maintained since 1920. (See fig. 3.) The gaging station on Yadkin River near Salisbury was established in 1895, and was one of the earliest records in the State. This station was discontinued when the High Rock reservoir was filled in 1927. However, a gaging station on Yadkin River at Yadkin College draining an area of about two-thirds that at the Salisbury gage was established in 1928, and a relation between the low flow at the two sites has been established using the overlapping record for the station at High Rock. By use of this relation and by use of relations with other stations during periods when neither the Yadkin College or Salisbury stations were operating, the low-flow characteristics of the Yadkin River at Yadkin College have been computed for the period 1896 to 1954.

On many small streams where continuous records of flow are not available, measurements of streamflow have been made during periods of low-flow to supply a more intense coverage of the area. Records of daily flow and results of miscellaneous measurements are published in annual Water-Supply Papers of the U. S. Geological Survey. Gaging sites at which continuous records of flow are

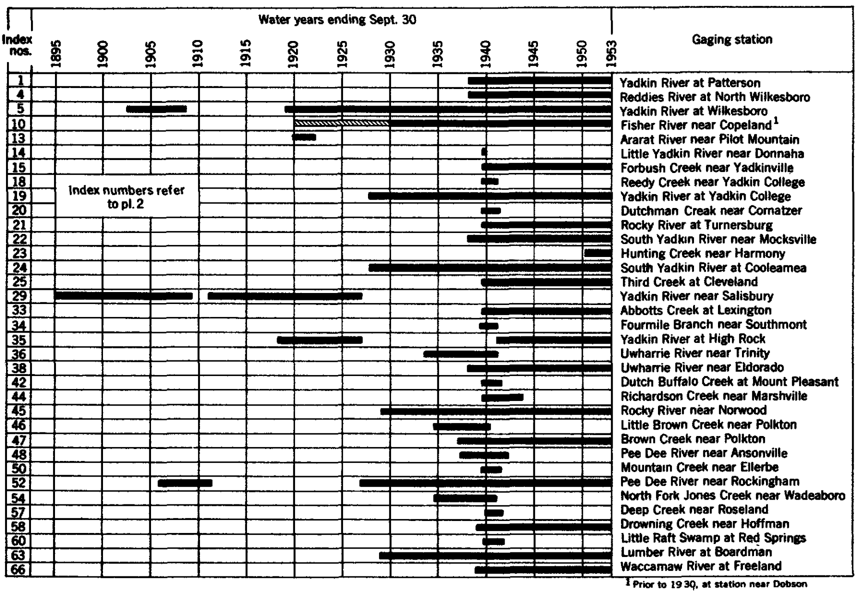


Figure 3. —Duration of records at gaging stations in the Yadkin-Pee Dee River basin.

not obtained are known as partial-record stations. Locations of complete-record gaging stations and partial-record stations are shown on plate 2 and pertinent descriptive data are given in table 1.

In evaluating and comparing the flow characteristic of streams, it is advantageous to have these characteristics computed for a common period of record, often called the base period.

In this report the period October 1, 1928 to September 30, 1953 (water years 1929–53) was selected as the base period. This base period was chosen because several records beginning in 1928 were available for use in a regional analysis, and because the records subsequent to September 30, 1953, had not been computed in final form at the time the report was being prepared. Some of the more noteworthy floods and droughts occurred during the base period, but on many streams the flow during the 1954 drought was lower than at any time during the base period. However, comparison with earlier records that are available at a few stations indicate that in general the average flow during the base period was less than during the period 1896 to 1954.

Table 1.—*Stream-gaging sites and quality-of-water sampling sites in the Yadkin-Pee Dee River basin*

No. (pl. 2)	Gaging station	Drainage area (sq. miles)	Type and length of record: Discharge		Type and length of record: Chemical quality		Location
			Type	Number of years	Type	Water year	
1	Yadkin River at Patterson	28.8	Daily	15	Monthly	1948	Caldwell County, lat 35°59'30" long. 81°33'30", above bridge on State Highway 268, ½ mile south of Patterson.
2	Elk Creek at Elkville	50	Partial	5			Wilkes County, lat 36°04'20", long. 81°24'15", at bridge on State Highway, at Elkville, 0.4 mile above mouth.
3	Middle Fork Reddies River near Wilbar	13.9	Partial	5			Wilkes County, lat 36° 15'50", long. 81°17'55", at highway bridge 1 mile east of Wilbar and 2¼ miles above mouth.
4	Reddies River at North Wilkesboro	93.9	Daily	14			Wilkes County, lat 36°10', long. 81°10' just above highway 1¼ miles northwest of North Wilkesboro, and 2 miles above mouth.
5	Yadkin River at Wilkesboro	493	Daily	33	Daily	1948	Wilkes County, lat 36°09', long. 81°09', just above bridge on U. S. Highway 421, just below Reddies River, and ½ mile northeast of Wilkesboro.
6	Mulberry Creek near North Wilkesboro	43.0	Partial	2			Wilkes County, lat 36°12', long. 81°07', at bridge on State Highway 268, 1.1 miles above mouth, and 1¼ miles east of North Wilkesboro.
7	Roaring River near Roaring River	122	Partial	5			Wilkes County, lat 36°15'20", long. 81°02'30", at highway bridge 3½ miles northwest of Roaring River, and 4 miles above mouth.
8	Mitchell River near Mountain Park	32.8	Partial	3			Surry County, lat 36°25'10", long. 80°52'00", at highway bridge, 3 miles north of Mountain Park.
9	Mitchell River near State Road	80.4	Partial	2			Surry County, lat 36°19'00", long. 80°48'40", at bridge 3¼ miles east of State Road.
10	Fisher River near Copeland	121	Daily	33	Monthly	1948	Surry County, lat 36°20', long. 80°40', 500 feet above bridge on State Highway 268, and 2 miles northwest of Copeland.
11	Ararat River at Mount Airy	66.6	Partial	2			Surry County, lat 36°30'00", long. 80°35'40", at bridge on State Highway 103, in Mount Airy.
12	Stewart Creek near Mount Airy	89.2	Partial	5			Surry County, lat 36°27'45", long. 80°37'30" at bridge on U. S. Highway 601, 2 miles above mouth, and 3 miles southwest of Mount Airy.

13	Ararat River near Pilot Mountain	287	Daily	2			Surry County, lat 36°21', long. 80°32', at highway bridge, and 5 miles west of Pilot Mountain.
14	Little Yadkin River near Donnaha	59.7	Daily	1			Forsyth County, lat 36°15'40", long. 80°26'35", at highway bridge 1¼ miles above mouth and 2 miles northwest of Donnaha.
15	Forbush Creek near Yadkinville	21.7	Daily	13			Yadkin County, lat 36°08', long. 80°33', 900 feet above at highway bridge, and 6 miles east of Yadkinville.
16	Deep Creek at Shacktown	65.9	Partial	2			Yadkin County, lat 36°06'20", long. 80°34'40", at highway bridge ¾ mile south of Shacktown.
17	Muddy Creek near Clemmons	111	Partial	6			Forsyth County, lat 36°01'28", long. 80°21'16", at bridge on U. S. Highway 158, 1½ miles east of Clemmons.
18	Reedy Creek near Yadkin College	13.3	Daily	2			Davidson County, lat 35°54'45", long. 80°20'05", at bridge on State Highway 703, and 4 miles northeast of Yadkin College.
19	Yadkin River at Yadkin College	2,280	Daily	25	[a]Daily	1944; 1951	Davidson County, lat 35°51'24", long. 80°23'09", at bridge on U. S. Highway 64, 1½ miles south of Yadkin College, and 6¼ miles below Reedy Creek.
20	Dutchmans Creek near Cornatzer	83.6	Daily	2			Davie County, lat 35°55'50", long. 80°30'10", at highway bridge, and 1½ miles west of Cornatzer.
21	Rocky River at Turnersburg	85.5	Daily	13			Iredell County, lat 35°54', long. 80°48', 1000 feet below bridge on U. S. Highway 21 at Turnersburg, and 1½ miles above mouth.
22	South Yadkin River near Mocksville	313	Daily	15			Davie County, lat 35°51', long. 80°40', at highway bridge and 6½ miles southwest of Mocksville.
23	Hunting Creek near Harmony	153	Daily	2	Monthly	1953	Iredell County, lat 36°00', long. 80°44', at highway bridge, and 3½ miles northeast of Harmony.
24	South Yadkin River at Cooleemee	569	Daily	25	Daily	1948	Davie County, lat. 35°48', long. 80°34', 550 feet above bridge on State Highway 801, in Cooleemee.
25	Third Creek at Cleveland	87.4	Daily	13	Daily	1950	Rowan County, lat 35°45', long. 80°41', just below highway bridge ¾ mile north of Cleveland and 7 miles above Fourth Creek.
26	Fourth Creek at Statesville	15.8	Partial	3			Iredell County, lat 35°48'30", long. 80°52'45", and 1 mile north of Statesville.
27	Second Creek near Barber	119	Partial	6			Rowan County, lat 35°43'00", long. 80°35'45", at bridge on U. S. Highway 70, and 2.7 miles east of Barber.
28	Grants Creek at Salisbury	38.8	Partial	6			Rowan County, lat. 35°40'00", long. 80°30'30" at bridge on State Highway 150, 2 miles west of Salisbury.
29	Yadkin River near Salisbury	3,400	Daily	31			Rowan County, lat 35°43'30", long. 80°27'40", at old highway bridge 1,000 feet above Southern Railway bridge, and 6 miles northeast of Salisbury.

[a]Samples for analysis of suspended sediment collected daily January 1951 to September 1953.

Table 1.—*Stream-gaging sites and quality-of-water sampling sites in the Yadkin-Pee Dee River basin*—Continued

No. (pl. 2)	Gaging station	Drainage area (sq. miles)	Type and length of record				Location
			Discharge		Chemical quality		
			Type	Number of years	Type	Water year	
30	Swearing Creek at Linwood	34.9	Partial	6			Davidson County, lat 35°45'19'', long. 80°18'22'', at highway bridge 0.6 mile east of Linwood, and 2 miles above mouth.
31	Abbotts Creek near Thomasville	65.9	Partial	5			Davidson County, lat 35°54'05'', long. 80°11'20'', just aboye Thomasville water supply intake, 5½ miles west of Thomasville.
32	Rich Fork near Holly Grove	47.3	Partial	2			Davidson County, lat 35°51'15'', long. 80°10'57'', at highway bridge 1½ miles above Hamby Creek and 2¾ miles north of Holly Grove.
33	Abbotts Creek at Lexington	174	Daily	13	Daily	1948	Davidson County, lat 35°48'24'', long. 80°14'06'', 300 feet above highway bridge, 1½ miles southeast of Lexington, and 4.9 miles below Rich Fork.
34	Fourmile Branch near Southmont	19.4	Daily	2			Davidson County, lat 35°40'00'', long. 80°10'25'', at highway bridge, 5 miles east of Southmont.
35	Yadkin River at High Rock	3,980	Daily	20	Daily	1948	Davidson County, lat 35°35'46'', long. 80°13'59'', 0.3 mile below High Rock Dam and 0.6 mile west of High Rock.
36	Uwharrie River near Trinity	11.3	Daily	8			Randolph County, lat 35°52'00'', long. 79°59'20'', 500 feet below highway bridge, and 2 miles south of Trinity.
37	Uwharrie River near Asheboro	31.9	Partial	5			Randolph County, lat 35°47'30'', long. 80°00'00'', at highway bridge, and 12 miles northwest of Asheboro.
38	Uwharrie River near Eldorado	347	Daily	15	Monthly	1948	Montgomery County, lat 35°25'30'', long. 80°01'00'', 300 feet below bridge on State Highway 109, and 3 miles south of Eldorado.
39	Rocky River near Roberta Mill	87.9	Partial	2			Cabarrus County, 35°21'33'', long. 80°40'31'', at bridge on U. S. Highway 29, 2¼ miles west of Roberta Mill.
40	Coddle Creek near Concord	56.6	Partial	5			Cabarrus County, 35°24'29'', long. 80°40'29'', at bridge just below Afton Run, and 5 miles west of Concord.
41	Rocky River near Concord	402	Partial	6			Cabarrus County, lat 35°19', long. 80°29', three quarters of a mile above Dutch Buffalo Creek and 9 miles southeast of Concord.

42	Dutch Buffalo Creek at Mount Pleasant......	64.1	Daily	2			Cabarrus County, lat 35°23'45", long. 80°25'15", at bridge on State Highway 73, one mile east of Mount Pleasant.
43	Big Bear Creek near Albemarle...............	71.6	Partial	5	Monthly	1952	Stanly County, lat 35°16'45", long. 80°18'10", at bridge on State Highway 27, 8 miles southwest of Albemarle.
44	Richardson Creek near Marshville............	170	Daily	4			Union County, lat 35°05'55", long. 80°23'05", at bridge on State Highway 205, 7½ miles north of Marshville.
45	Rocky River near Norwood.....................	1,370	Daily	24	Daily	1947–48	Stanly County, lat 35°09'00", long. 80°10'30", 1,000 feet below Lanes Creek, 1½ miles above highway bridge, and 6 miles southwest of Norwood.
46	Little Brown Creek near Polkton..............	13.5	Daily	6			Anson County, lat 34°58'45", long. 80°11'20", 1½ miles above confluence with Brown Creek, and 2 miles southeast of Polkton.
47	Brown Creek near Polkton......................	110	Daily	16			Anson County, lat 35°02'10", long. 80°08'40", 400 feet below bridge on State Highway 742, 3½ miles below Little Brown Creek, and 4 miles northwest of Polkton.
48	Pee Dee River near Ansonville................	6,330	Daily	5			Anson County, lat 35°05'25", long. 79°59'55", at bridge on State Highway 109, 1 mile below Brown Creek, and 6 miles east of Ansonville.
49	Little River near Star..........................	97.6	Partial	4			Montgomery County, lat 35°23'10", long. 79°50'00", at highway bridge 3 miles west of Star.
50	Mountain Creek near Ellerbe..................	33.4	Daily	2			Richmond County, lat 35°06', long. 79°48', at bridge on State Highway 73, and 5 miles northeast of Ellerbe.
51	Cartledge Creek near Rockingham...........	31.4	Partial	4			Richmond County, lat 34°58'35", long. 79°51'30", at highway bridge, ½ mile above mouth, and 5½ miles northwest of Rockingham.
52	Pee Dee River near Rockingham.............	6,870	Daily	32		1946–47; 1947–48	Richmond County, lat 34°56'40", long. 79°52'10", at bridge on U. S. Highway 74, 3.3 miles below Blewett Falls Dam, and 6 miles west of Rockingham.
53	Falling Creek near Rockingham..............	6.0	Partial	4			Richmond County, lat 34°57'40", long. 79°42'15", at bridge 1 mile south of U. S. Highway 1, and 4 miles east of Rockingham.
54	North Fork Jones Creek near Wadesboro......	10.0	Daily	6			Anson County, lat 34°55'20", long. 80°04'05", just below highway bridge 3½ miles south of Wadesboro, and 5½ miles above confluence with Jones Creek.
55	Marks Creek near Osborne.....................	29.2	Partial	2			Richmond County, lat 34°49'40", long. 79°48'00", at highway bridge 2½ miles northwest of Osborne.
56	Drowning Creek near Jackson Springs........	30.5	Partial	5			Moore County, lat 35°11'35", long. 79°38'50", at bridge on State Highway 73, 2 miles southwest of Jackson Springs.

Table 1.—*Stream-gaging sites and quality-of-water sampling sites in the Yadkin-Pee Dee River basin*—Continued

No. (pl. 2)	Gaging station	Drainage area (sq. miles)	Type and length of record				Location
			Discharge		Chemical quality		
			Type	Number of years	Type	Water year	
57	Deep Creek near Roseland	18.9	Daily	2			Moore County, lat 35°07'20", long. 79°32'25", at highway bridge 2 miles southwest of Roseland.
58	Drowning Creek near Hoffman	178	Daily	14	Daily	1946–47	Richmond County, lat 35°03'38", long. 79°29'39", at bridge on U. S. Highway 1, ¾ mile below Deep Creek, and 4 miles northeast of Hoffman.
59	Lumber River near Pembroke	421	Partial	4			Robeson County, lat 34°42', long. 79°15', at bridge ¾ mile above U. S. Highway 74 bridge, and 3½ miles west of Pembroke.
60	Little Raft Swamp at Red Springs	23.1	Daily	2			Robeson County, lat 34°49'50", long. 79°10'55", at bridge on State Highway 71, at Red Springs.
61	Raft Swamp near Lumberton	107	Partial	5			Robeson County, lat 34°43', long. 79°05', at bridge on State Highway 211, 1¾ miles above Richland Swamp, and 6 miles northwest of Lumberton.
62	Big Swamp near Tarheel	225	Partial	5			Bladen County, lat 34°43', long. 78°50', at highway bridge 2½ miles above Goodman Swamp, and 2¾ miles west of Tarheel.
63	Lumber River at Boardman	1,220	Daily	24	Daily	1946–47	Columbus County, lat 34°26', long. 78°58', at bridge on U. S. Highway 74 at Boardman, and 1½ miles below Big Swamp.
64	Gum Swamp Creek near Laurinburg	42.4	Partial	5			Scotland County, lat 34°51'15", long. 79°31'30", at highway bridge 6½ miles northwest of Laurinburg.
65	Shoeheel Creek near Laurinburg	84.5	Partial	5			Scotland County, lat 34°45', long. 79°23', at bridge on U. S. Highway 74, 4½ miles southeast of Laurinburg.
66	Waccamaw River at Freeland	626	Daily	14	Daily	1950–51	Brunswick County, lat 34°05'43", long. 78°32'56", 150 feet below bridge on State Highway 130, 1 mile west of Freeland.

The Yadkin-Pee Dee River basin is one of the more highly industrialized areas of the State. The flow of many of the streams is considerably affected by the artificial controls of man in supplying municipal and industrial requirements. The flow of the Yadkin and Pee Dee Rivers is regulated by the operation of hydroelectric plants at Idols, High Rock, Narrows, Falls, Tillery, and Blewett Falls dams. Tributary streamflows are regulated by water-power plants on Reddies, Elkin, Ararat, South Yadkin, Uwharrie, and Little Rivers and some smaller streams. Streamflow is diverted locally for water supplies at many places.

FLOW CHARACTERISTICS

Streamflow varies greatly from day to day, season to season, and from year to year. (See fig. 23.) The long-term average streamflow varies considerably from place to place within the basin but is relatively constant for a particular area. A study of streamflow records indicates that runoff during individual years or during a succession of several years may deviate sharply from the long-term average, but the records show that this is the usual pattern of occurrence in long periods of time. In the Yadkin-Pee Dee River basin the average annual streamflow varies from approximately 0.5 mgd per square mile in some areas to as much as 1.0 mgd per square mile in other areas. This variation in average streamflow reflects differences in rainfall, topography, geology, vegetation, size of drainage area, and other factors.

Curves showing streamflow characteristics are sometimes prepared for the period of record for each station. However, through regional analysis, curves for short-term stations can be adjusted to longer periods and curves for long-term stations can be compared with each other and modified on the basis of the experience at surrounding gaging stations. These adjusted and modified curves, although not a completely accurate record of recorded flows, serve as a better basis for predicting the probable occurrence of future flows than the actual record. Regional analysis of the low-flow data was used in this report to adjust all records to the base period October 1, 1928 to September 30, 1953.

DURATION OF FLOW

The flow-duration curve shows the percentage of time during which a specific daily discharge was equaled or exceeded during the period of record. Flow-duration curves for six representative gaging stations in the basin are given in figure 4–6. Flow-duration data and average discharge for all gaged sites are given for the period 1929–53 in table 2. Although the flows of some streams

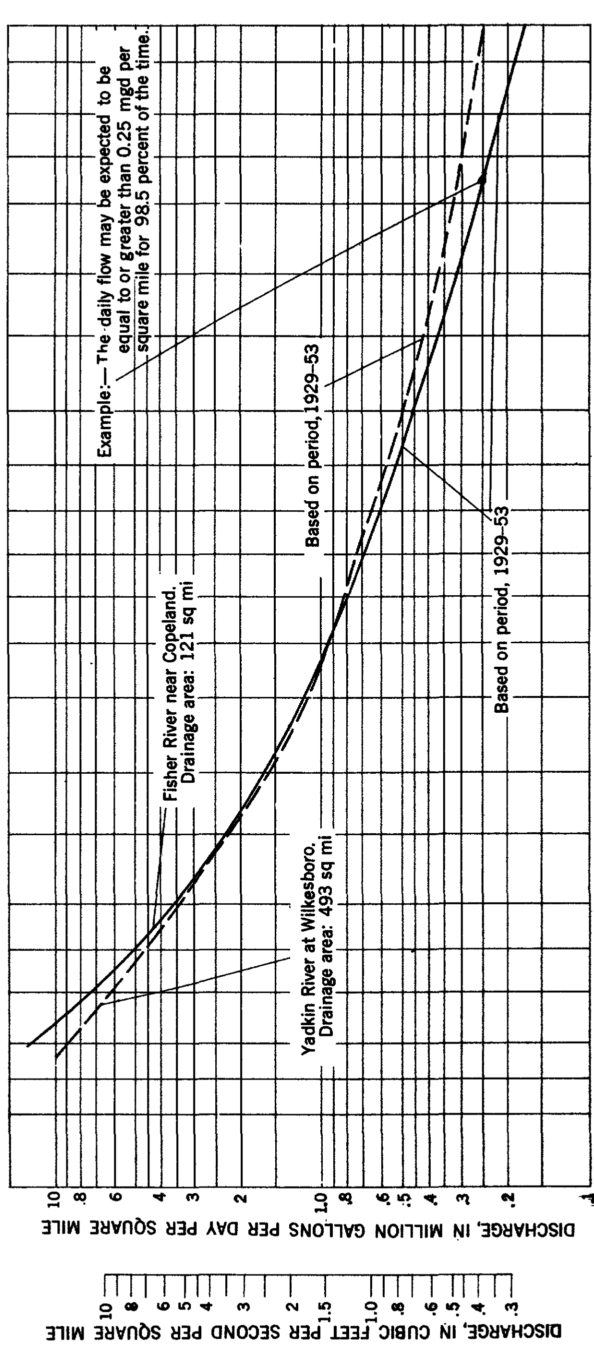


Figure 4. —Duration curve of daily flow, Yadkin River at Wilkesboro and Fisher River near Copeland.

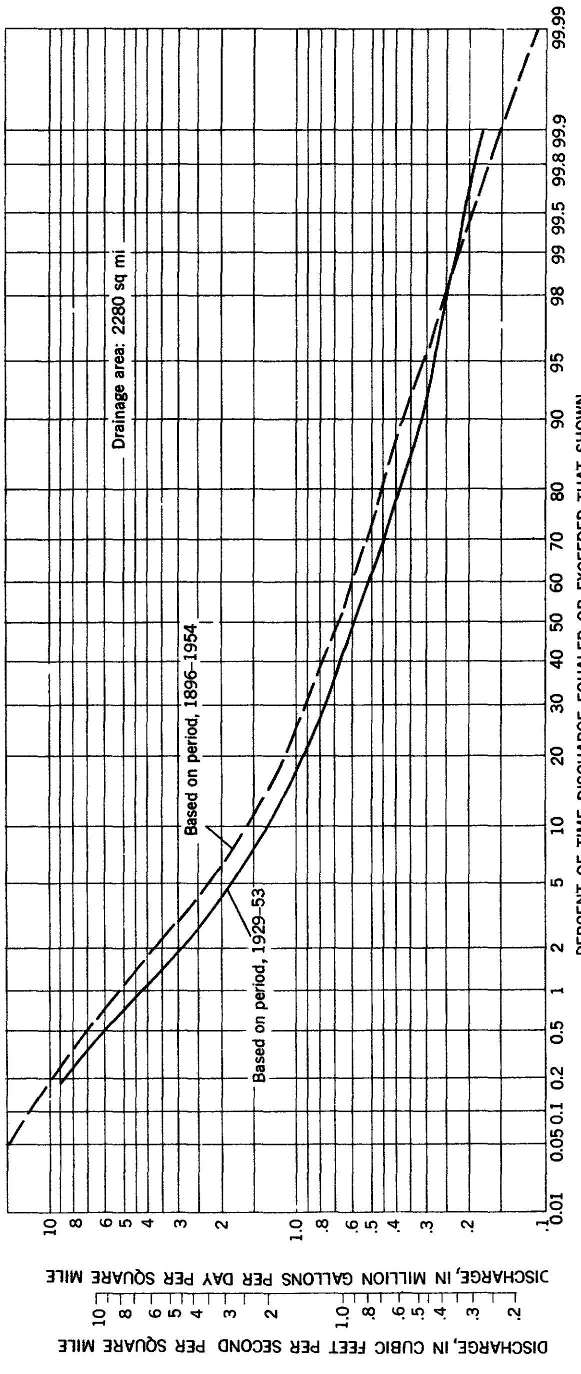


Figure 5. —Duration curve of daily flow, Yadkin River at Yadkin College.

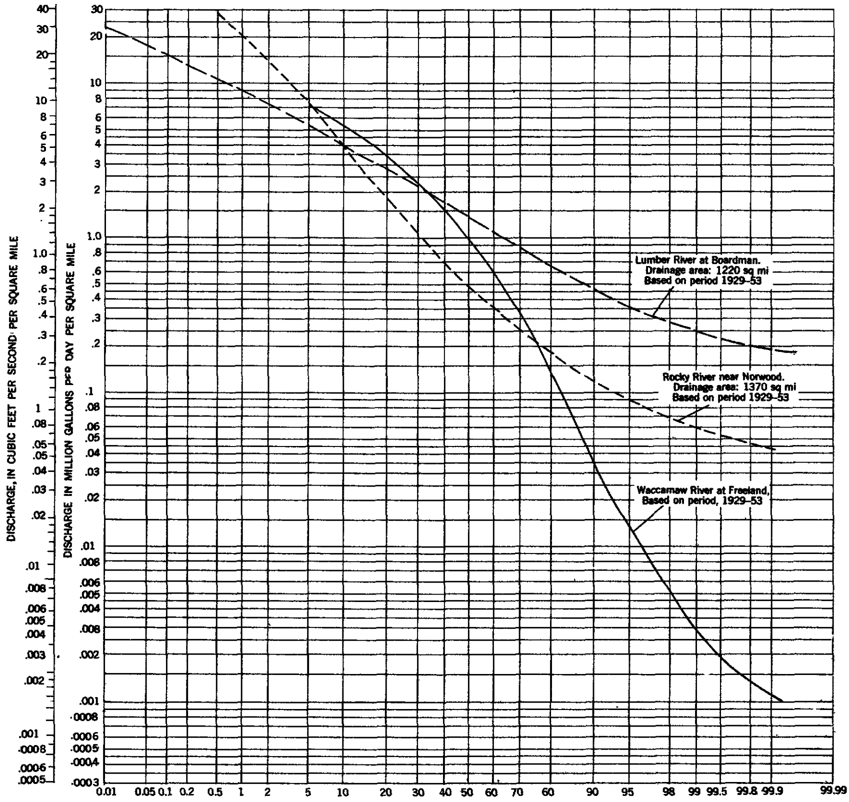


Figure 6. —Duration curve of daily flow, Rocky River near Norwood, Lumber River at Boardman, and Waccamaw River at Freeland.

listed in this table are affected by regulation or diversion, the effect is not appreciable except for those streams (marked by an asterisk) for which data is applicable only at the gaging station site and are given in million gallons per day.

A flow-duration curve shows the cumulative frequency of occurrence of different rates of daily flow at a given point. Assuming that future flow will follow the pattern of that measured in the past, the flow-duration curve may be used to estimate the probable occurrence of a specified discharge. In planning dams, reservoirs and other works to develop streamflow, however, this assumption must be made with the knowledge that possible errors may result. For example, figure 5 illustrates how the flow-duration data for the base period on Yadkin River at Yadkin College compares with that for the period October 1, 1895 to September 30, 1954. At this station the duration curve for the base period shows about a 20 percent lower discharge between 5 and 95 percent duration, and

Table 2.—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*

[Data for stations 24, 30, 32, 35, 41, 45, 48 and 52 (marked by asterisks, *) are applicable only at gaging station sites and are in million gallon per day]

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations					
	1. Yadkin River at Patterson	2. Elk Creek at Elkville	3. Middle Fork Reddies River near Wilbar	4. Reddies River at North Wilkesboro	5. Yadkin River at Wilkesboro	6. Mulberry Creek near North Wilkesboro
Drainage area sq miles..	28.8	50.0	13.9	93.9	493	43.0
Average.........	1.05	1.0	1.4	0.977	1.03	1.1
Percent of time:						
0.1..............	15.5	....	....	22.6	12.1	....
0.5..............	7.09	....	....	6.43	6.55	....
2................	3.47	....	....	3.13	3.44	....
5................	2.27	....	2.95	2.03	2.12	....
10..............	1.66	1.66	2.15	1.48	1.56	1.65
20..............	1.20	1.19	1.65	1.13	1.15	1.25
30..............	.999	.995	1.50	1.02	.969	1.14
50..............	.729	.700	1.09	.743	.747	.840
70..............	.559	.519	.860	.595	.587	.670
80..............	.460	.425	.740	.519	.517	.600
90..............	.393	.360	.609	.494	.431	.500
95..............	.330	.300	.515	.396	.373	.445
98..............	.280	.250	.455	.347	.322	.390
99..............	.260	.235	.409	.320	.299	.360
99.5............	.244	.212	.385	.306	.280	.345
99.8............	.227	.201	.365	.279	.262	.310
99.9............	.217	.195	.335	.272	.252	.305

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations					
	7. Roaring River near Roaring River	8. Mitchell River near Mountain Park	9. Mitchell River near State Road	10. Fisher River near Copeland	11. Ararat River at Mount Airy	12. Stewart Creek near Mount Airy
Drainage area sq miles..	122	32.8	80.4	121	66.6	89.2
Average.........	0.96	1.0	1.1	0.983	0.87	0.89
Percent of time:						
0.1..............	....	....	....	26.9	....	....
0.5..............	....	....	....	7.45	....	....
2................	....	....	....	3.47	....	....
5................	2.03	....	....	2.22	....	2.05
10..............	1.45	1.55	1.55	1.63	....	1.50
20..............	1.13	1.20	1.22	1.15	1.05	1.05
30..............	1.02	1.10	1.05	.935	.825	.845
50..............	.745	.810	.815	.694	.615	.630
70..............	.595	.650	.605	.534	.475	.495
80..............	.519	.590	.595	.460	.420	.430
90..............	.425	.495	.495	.375	.335	.355
95..............	.372	.445	.435	.318	.285	.305
98..............	.315	.385	.375	.264	.235	.255
99..............	.290	.360	.355	.232	.208	.235
99.5............	.275	.345	.345	.211	.190	.211
99.8............	.245	.315	.305	.188	.165	.190
99.9............	.239	.305	.302	.174	.155	.178

Table 2.—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*—Con.

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	13. Ararat River near Pilot Mountain	14. Little Yadkin River near Donnaha	15. Forbush Creek near Yadkinville	16. Deep Creek at Shacktown	17. Muddy Creek near Clemmons
Drainage area sq miles..	287	59.7	21.7	65.9	111
Average..........	0.82	0.56	0.649	0.69	0.62
Percent of time:					
0.1..........	....	....	14.3	....	....
0.5..........	....	....	6.85	....	....
2..........	....	....	3.13	....	....
5..........	1.85	1.60	1.77	....	....
10..........	1.30	1.05	1.19	1.29	....
20..........	.945	.675	.774	.825	.720
30..........	.770	.545	.631	.675	.615
50..........	.565	.375	.441	.441	.415
70..........	.405	.260	.313	.325	.285
80..........	.360	.210	.255	.265	.230
90..........	.270	.155	.189	.193	.165
95..........	.220	.139	.159	.160	.139
98..........	.175	.096	.120	.121	.105
99..........	....	.084	.108	.108	.092
99.5..........	....	.079	.099	.100	.085
99.8..........	....	.072	.085	.085	.071
99.9..........	....	.064	.079	.079	.065

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	18. Reedy Creek near Yadkin College	19. Yadkin River at Yadkin College	20. Dutchmans Creek near Cornatzer	21. Rocky River at Turnersburg	22. South Yadkin River near Mocksville
Drainage area sq miles..	13.3	2,280	83.6	85.5	313
Average..........	0.60	0.827	0.84	0.839	0.655
Percent of time:					
0.1..........	....	18.0	....	15.1	9.40
0.5..........	....	6.06	....	7.33	5.06
2..........	....	3.12	....	3.40	2.79
5..........	....	1.84	....	1.97	1.64
10..........	1.04	1.30	1.43	1.38	1.15
20..........	.595	.935	.980	.967	.805
30..........	.415	.776	.750	.771	.650
50..........	.270	.592	.465	.571	.465
70..........	.177	.453	.260	.435	.369
80..........	.134	.392	.199	.374	.301
90..........	.093	.323	.122	.306	.248
95..........	.067	.281	.095	.268	.215
98..........	.044	.241	.069	.228	.185
99..........	.032	.224	.059	.208	.168
99.5..........	.026	.207	.051	.198	.154
99.8..........	.018	.180	.042	.178	.137
99.9..........	....	.174	.039	.170	.125

Table 2.—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*—Con.

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	23. Hunting Creek near Harmony	*24. South Yadkin River at Cooleemee	25. Third Creek at Cleveland	26. Fourth Creek at Statesville[a]	27. Second Creek near Barber
Drainage area sq miles..	153	569	87.4	15.8	119
Average..............	76	(401)	0.659	0.68	0.60
Percent of time:					
0.1	....	(4,790)	....	....	....
0.5	....	(3,140)	7.00	....	....
2	3.10	(1,580)	2.92	....	....
5	1.80	(956)	1.55	1.60	1.55
10	1.28	(666)	1.06	1.56	1.04
20	.890	(472)	.740	.750	.680
30	.710	(375)	.605	.640	.542
50	.530	(275)	.442	.500	.370
70	.400	(205)	.335	.395	.262
80	.350	(175)	.290	.360	.223
90	.285	(142)	.239	.275	.176
95	.250	(123)	.204	.265	.146
98	.220	(104)	.174	.220	.120
99	.195	(90)	.160	.212	.109
99.5	.185	(87)	.150	.198	.100
99.8	.165	(79)	.141	.190	.094
99.9	.160	(76)	.135	.184	.090

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	28. Grants Creek at Salisbury	*30. Swearing Creek at Linwood	31. Abbotts Creek near Thomasville	*32. Rich Fork near Holly Grove	33. Abbotts Creek at Lexington
Drainage area sq miles..	38.8	34.9	65.9	47.3	174
Average..............	0.62	(21)	0.63	(27)	0.602
Percent of time:					
0.1	....	....	....	....	17.5
0.5	....	....	....	....	9.28
2	....	....	....	....	4.08
5	....	....	....	....	2.15
10	....	(37.0)	....	....	1.24
20	.720	(24.6)	.661	(30.5)	.661
30	.565	(18.8)	.490	(19.9)	.446
50	.382	(11.3)	.325	(9.93)	.249
70	.262	(7.3)	.219	(5.2)	.139
80	.213	(5.8)	.170	(3.6)	.102
90	.164	(4.3)	.125	(2.1)	.065
95	.133	(3.3)	.100	(1.4)	.045
98	.106	(2.6)	.076	(.85)	.029
99	.095	(2.2)	.065	(.62)	.022
99.5	.087	(2.1)	.053	....	.016
99.8	.080	(1.8)	.051	....	.011
99.9	.076	(1.7)	.038	....	.009

[a]Based on streamflow data collected prior to diversion above gaging site by city of Statesville for water supply beginning in May 1950.

Table 2.—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*—Con.

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	34. Fourmile Branch near Southmont	*35. Yadkin River at High Rock	36. Uwharrie River near Trinity	37. Uwharrie River near Asheboro	38. Uwharrie River near Eldorado
Drainage area sq miles..	19.4	3, 980	11.3	31.9	347
Average..............	0.42	(3, 100)	0.658	0.66	0.603
Percent of time:					
0.1..............	....	(30, 000)	28.3	....	15.8
0.5..............	....	(20, 000)	11.2	....	9.40
2..............	....	(10, 000)	4.26	....	4.75
5..............	1.80	(5, 730)	1.97	....	2.51
10..............	.960	(4, 380)	1.11	....	1.34
20..............	.460	(3, 590)	.640	.659	.652
30..............	.280	(3, 260)	.429	.420	.400
50..............	.129	(2, 780)	.226	.230	.201
70..............	.049	(2, 170)	.117	.132	.113
80..............	.027	(1, 680)	.077	.090	.079
90..............	.0063	(935)	.046	.052	.046
95..............	....	(64)	.027	.028	.029
98..............	....	(22)	.014	.0115	.016
99..............	....	(16)	.008	.0056	.010
99.5..............	....	(12)	.004	.0027	.007
99.8..............	....	(10)	.001	....	.004
99.9..............	....	(9)	....	....	.003

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	39. Rocky River near Roberta Mill	40. Coddle Creek near Concord	*41. Rocky River near Concord	42. Dutch Buffalo Creek at Mount Pleasant	43. Big Bear Creek near Albemarle
Drainage area sq miles..	87.9	56.6	402	64.1	71.6
Average..............	0.60	0.66	(261)	0.64	0.60
Percent of time:					
0.1..............	....	....	....	....	....
0.5..............	....	....	....	....	....
2..............	....	....	....	....	....
5..............	....	2.63	(1, 040)	2.69	....
10..............	1.35	1.32	(531)	1.40	1.32
20..............	.620	.675	(265)	.650	.604
30..............	.405	.465	(175)	.380	.340
50..............	.238	.290	(100)	.185	.145
70..............	.140	.185	(60)	.094	.054
80..............	.110	.145	(46)	.066	.030
90..............	.081	.112	(35)	.044	.014
95..............	.065	.0935	(29)	.034	.0081
98..............	.054	.079	(24)	.026	.0053
99..............	.049	.072	(21)	.023	.0036
99.5..............	.045	.068	(20)	.020	.0029
99.8..............	.039	....	(18)	.015	.0021
99.9..............	.037	....	(17)	.013	.0017

Table 2—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*—Con.

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	44. Richardson Creek near Marshville	*45. Rocky River near Norwood	46. Little Brown Creek near Polkton	47. Brown Creek near Polkton	*48. Pee Dee River near Ansonville
Drainage area sq miles..	170	1,370	13.5	110	(6,330)
Average..........	0.50	(815)	0.50	0.489	....
Percent of time:					
0.1.............	....	(23,600)	....	17.3	....
0.5.............	....	(13,200)	....	10.3	(30,700)
2...............	5.90	(6,780)	6.44	5.20	(15,500)
5...............	2.79	(3,550)	3.20	2.70	(8,290)
10	1.32	(1,810)	1.60	1.44	(5,680)
20	.505	(827)	.590	.573	(4,200)
30	.258	(490)	.206	.256	(3,500)
50	.090	(240)	.036	.068	(2,840)
70	.027	(119)	.0038	.015	(2,100)
80	.0125	(84)	.0012	.005	(1,610)
90	.0066	(56)	....	.001	(1,000)
95	.0035	(42)	....	....	(610)
98	.0014	(33)	....	....	(320)
99	....	(29)	....	....	(230)
99.5............	....	(26)	....	....	(150)
99.8............	....	(22)	....	....	(120)
99.9............	....	(21)	....	....	....

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	49. Little River near Star	50. Mountain Creek near Ellerbe	51. Cartledge Creek near Rockingham	*52. Pee Dee River near Rockingham	53. Falling Creek near Rockingham
Drainage area sq miles..	97.6	33.4	31.4	6,870	6.0
Average..........	....	0.64	0.55	(5,090)	0.95
Percent of time:					
0.1.............	....	....	....	(74,200)	....
0.5.............	....	....	....	(39,200)	....
2...............	....	....	....	(23,300)	
5...............	....	2.0	2.19	(12,900)	2.21
10	....	1.40	.159	(8,380)	1.71
20	....	1.03	.107	(5,690)	1.33
30	0.580	.79	.750	(4,590)	1.10
50	.330	.492	.352	(3,620)	.800
70	.207	.290	.140	(2,780)	.560
80	.153	.198	.074	(2,230)	.450
90	.098	.117	.031	(1,480)	.335
95	.066	.096	.023	(893)	.302
98	.038	.049	.0050	(360)	.210
99	.023	.040	....	(230)	.190
99.5............	.014	.033	....	(160)	.174
99.8............	.0054	.028	....	(110)	.158
99.9............	....	.026	....	(89)	.152

Table 2.—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*—Con.

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	54. North Fork Jones Creek near Wadesboro[b]	55. Marks Creek near Osborne	56. Drowning Creek near Jackson Springs	57. Deep Creek near Roseland	58. Drowning Creek near Hoffman
Drainage area sq miles..	10.0	29.2	30.5	18.9	178
Average..............	0.64	0.91	1.1	0.96	0.937
Percent of time:					
0.1	....	....	....	....	9.58
0.5	....	....	....	....	5.12
2	4.70	....	....	....	3.07
5	2.55	....	....	....	2.21
10	1.35	....	....	....	1.71
20	.660	1.31	....	1.34	1.32
30	.405	1.07	1.22	1.10	1.09
50	.210	.740	.890	.720	.780
70	.110	.460	.629	.630	.540
80	.076	.332	.500	.525	.425
90	.048	.208	.344	.420	.308
95	.032	.178	.297	.390	.276
98	.019	.098	.165	.290	.185
99	....	.083	.136	.253	.165
99.5	....	.072	.116	.245	.149
99.8	....	....	.101	.230	.136
99.9	....	....	.093	.222	.130

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations				
	59. Lumber River near Pembroke	60. Little Raft Swamp at Red Springs	61. Raft Swamp near Lumberton	62. Big Swamp near Tarheel	63. Lumber River at Boardman
Drainage area sq miles..	421	23.1	107	225	1,220
Average..............	0.94	0.53	0.37	....	0.650
Percent of time:					
0.1	....	....	....	....	5.46
0.5	....	....	....	....	3.76
2	....	....	....	....	2.49
5	....	....	....	....	1.80
10	....	....	....	....	1.34
20	1.22	.870	....	....	.938
30	1.00	.660	.410	....	.710
50	.742	.405	.245	.231	.461
70	.551	.235	.148	.135	.297
80	.465	.167	.107	.097	.230
90	.360	.103	.069	.058	.160
95	.304	.088	.049	.040	.123
98	.250	.046	.034	.025	.096
99	.228	.036	.026	.018	.084
99.5	.206	.029	.020	.012	.075
99.8	.193	....	.015	.0086	.069
99.9	.182	....	.012	.0060	.065

[b]Based on records collected prior to construction of reservoir and diversion above station by town of Wadesboro for water supply beginning in 1941.

Table 2.—*Duration table of daily flow in Yadkin-Pee Dee River basin, 1929–53*—Con.

	Flow, in million gallons per day per square mile, that was equaled or exceeded at indicated gaging stations.		
	64. Gum Swamp Creek near Laurinburg	65. Shoeheel Creek near Laurinburg	66. Waccamaw River at Freeland
Drainage area....sq miles..	42.4	84.5	626
Average....	0.99	0.70	0.659
Percent of time:			
0.1....	....	....	6.13
0.5....	....	....	4.60
2....	....	....	3.30
5....	....	1.90	2.52
10....	....	1.24	1.86
20....	1.29	.942	1.18
30....	1.06	.748	.768
50....	.800	.525	.330
70....	.638	.380	.101
80....	.565	.310	.044
90....	.488	.232	.013
95....	.435	.188	.0046
98....	.388	.156	.0016
99....	.370	.140	.00099
99.5....	.351	.124	.00065
99.8....	.340	.117	.00046
99.9....	.332	.115	.00038

a higher discharge than that of the 59-year curve beyond 95 percent duration (the extreme low end).

The slope of a duration curve is a good index of the natural storage within a basin, including ground-water storage; that is, the flatter the general slope of the curve the more uniform the flow. Streams are said to have a well-sustained flow if the flow per square mile during dry weather is greater than usually found over a large area. A comparison of flow-duration curves for several streams in the basin shows which ones have the better sustained flow. In figures 7 to 9 it may be observed that the lower part of the curve for the Yadkin River at Wilkesboro is the highest of the six and, therefore, indicates the best sustained flow. The curve for Fisher River near Copeland shows somewhat better sustained flow than those for the four other stations illustrated.

As an example of the further use of flow-duration curves, assume that it is desired to locate an industrial plant at a site on Fisher River in the vicinity of Copeland at which the drainage area is 100 square miles and that construction of a storage dam is not planned. Further assume that a flow of 25 mgd (0.25 mgd per square mile from 100 square miles) is required for plant operation. Inasmuch as the observed minimum flows are less than the required flow, it is necessary to know the probable average number of days per year that there will be a shortage of water. From the curve for the base period (water year 1929–1953, fig. 7), a flow of 0.25 mgd per square mile will be available 98.5 percent of the time. Thus over a long period of time there will be sufficient water 98.5 percent of the days and a shortage on 1.5 percent of the days. The advantages of the proposed site where a water shortage will occur 1.5 percent of the time could be weighed with alternate sites farther downstream (larger drainage areas) or sites on other streams where the required flow will be available a greater part of the time.

The flow-duration curve does not show whether the days of insufficient flow will be consecutive or how frequently shortages will occur. It may be possible to operate the plant for short periods on less than 25 mgd or if not, possibly the plant can be shut down occasionally if the shortage does not recur too frequently. Therefore, it is necessary to know more about the low-flow characteristics of the stream. How frequently will the flow be insufficient? How long will deficiencies last? How much storage will be required to provide the necessary flow? These questions may be answered by use of the low-flow frequency curve, the maximum period of deficient-discharge curve, and the storage-requirement curve.

LOW-FLOW FREQUENCY

The low-flow frequency curve gives the average interval at which a specified discharge may be expected to recur as the lowest flow in the climatic year (April 1 to March 31). Low-flow frequency curves for the average flow during periods of 1, 7, 30, 60, and 90 consecutive days are shown in figures 7 to 10. The

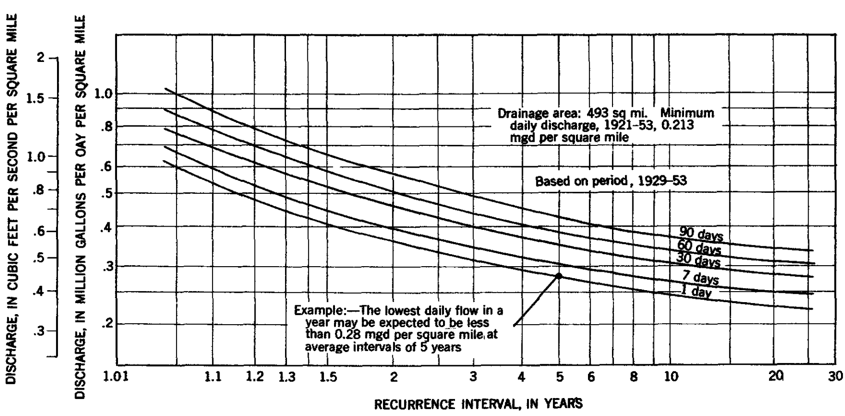


Figure 7.—Magnitude and frequency of annual low flows, Yadkin River at Wilkesboro.

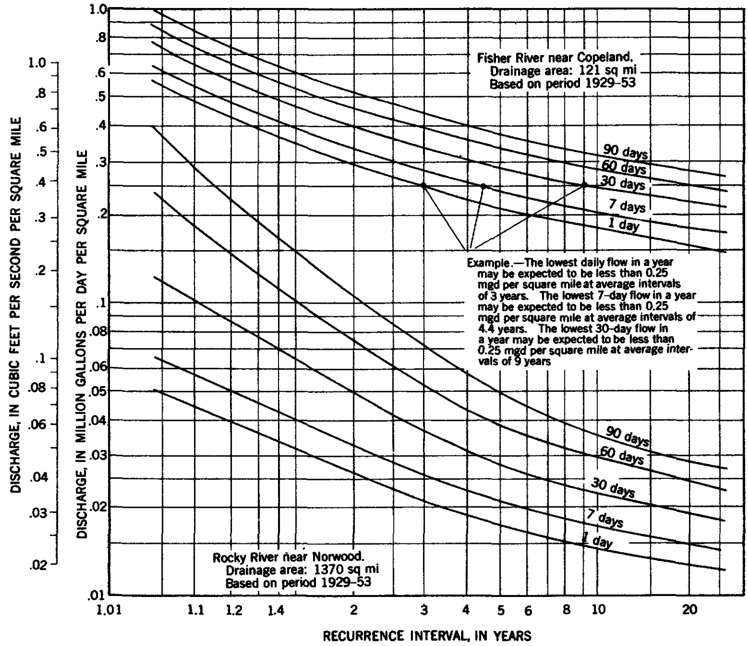


Figure 8.—Magnitude and frequency of annual low flows, Fisher River near Copeland and Rocky River near Norwood.

amount and frequency of annual low flows for the same number of consecutive days are given in table 3. The data in the figures and tables are based on the period 1929–53 and although the flows of some streams in the table are affected by regulation or diversion, the effect is not appreciable except for those streams for which data are applicable only at the gaging station site and are given in million gallons per day.

If records from 1896 to 1928 and for 1954 had been included the net effect on the shape and position of the curves would be similar to that shown in figure 8. The dashed line shows the average recurrence interval for annual 7-day minimum flow at Yadkin College during the 59-year period, April 1, 1896, to March 31, 1955. At short recurrence intervals the flow shown by the dashed line is slightly higher than that shown by the curve based on a regional analysis of records for the period 1929–53 (solid line) and at longer intervals the position of the two curves is reversed. Therefore, if data for the period 1896–1955 had been used to prepare this table the flow would be increased at the 2-, 3-, 5-, and 10-year recurrence intervals and would be decreased at the 25-year interval. For stations such as Yadkin River at Yadkin College that have a high flow per square mile during droughts the maximum change would be about 20 percent, but for stations such as Waccamaw River at Freeland that have low discharge per square mile during

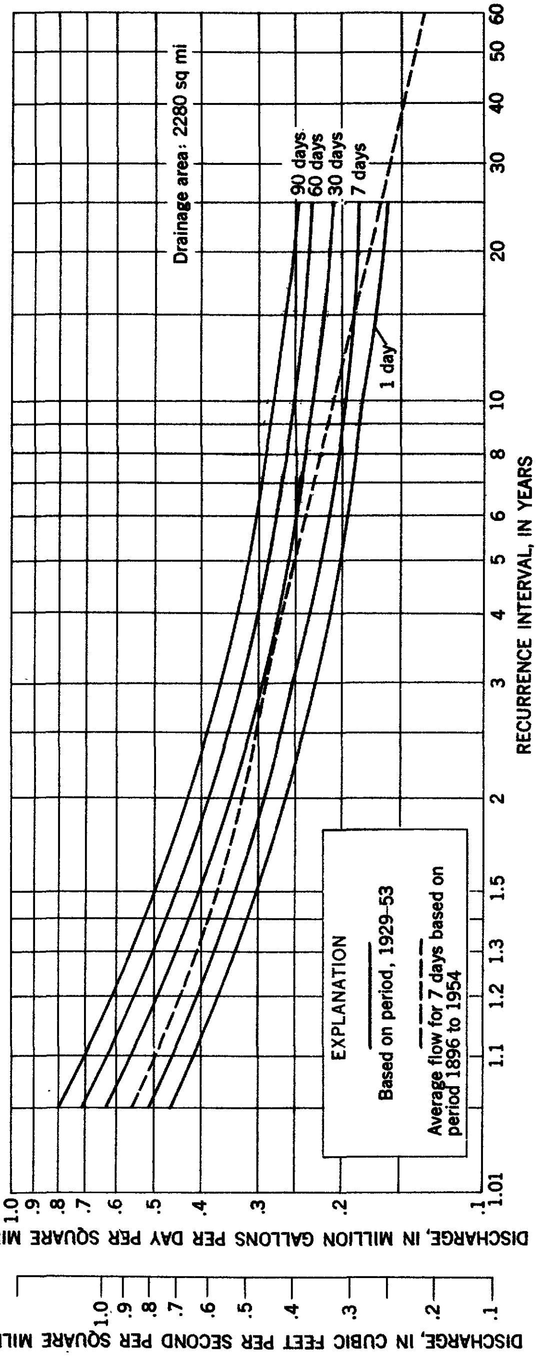


Figure 9.—Magnitude and frequency of annual low flows, Yadkin River at Yadkin College.

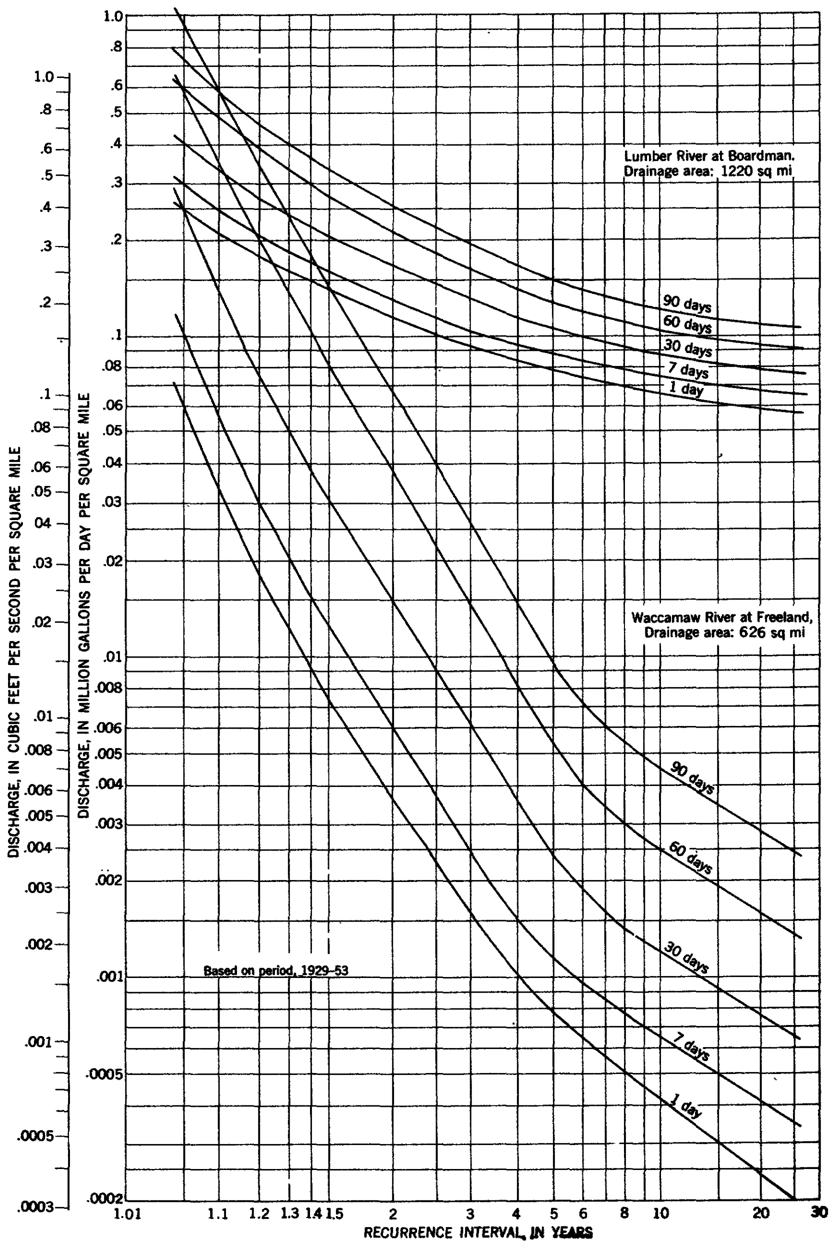


Figure 10. —Magnitude and frequency of annual low flows, Lumber River at Boardman and Waccamaw River at Freeland.

Table 3.—*Magnitude and frequency of annual low flow in the Yadkin-Pee Dee River basin for periods of 1, 7, 30, 60, and 90 days, based on records April 1, 1929 to March 31, 1953*

[Data for stations 30, 32, 39, 41, and 45 (marked with asterisks) are applicable only at gaging station site and are in million gallons per day]

No. (pl. 2)	Gaging sites	Drainage area (square miles)	Minimum daily discharge of record[a] (mgd)	Periods (consecutive days)	Lowest flow, in million gallons per day per square mile, and recurrence intervals, in years					
					2	3	5	10	15	25
1	Yadkin River at Patterson	28.8	3.4	1	0.301	0.265	0.233	0.207	0.193	0.186
				7	.341	.294	.256	.224	.215	.206
				30	.408	.343	.296	.260	.242	.236
				60	.473	.397	.334	.289	.276	.265
				90	.534	.449	.377	.314	.301	.287
2	Elk Creek at Elkville	50.0	....	1	.273	.240	.210	.184	.173	....
				7	.312	.268	.232	.201	.193	.184
				30	.380	.315	.269	.237	.219	.212
				60	.445	.368	.306	.263	.252	.241
				90	.501	.420	.348	.288	.274	.263
3	Middle Fork Reddies River near Wilbar	13.9	....	1	.502	.443	.383	.337	.310	....
				7	.570	.497	.422	.367	.352	.330
				30	.680	.583	.500	.423	.410	.390
				60	.767	.648	.557	.478	.459	.436
				90	.853	.725	.618	.528	.500	.472
4	Reddies River at North Wilkesboro	93.9	15	1	.378	.341	.304	.272	.255	.244
				7	.420	.372	.329	.292	.282	.268
				30	.482	.423	.374	.329	.320	.307
				60	.533	.464	.409	.361	.350	.336
				90	.585	.509	.447	.391	.374	.359
5	Yadkin River at Wilkesboro	493	73	1	.356	.316	.278	.246	.233	.220
				7	.394	.343	.304	.269	.257	.245
				30	.460	.398	.346	.308	.293	.283
				60	.515	.445	.386	.339	.324	.310
				90	.570	.493	.424	.368	.351	.337
6	Mulberry Creek near North Wilkesboro	43.0	....	1	.425	.383	.342	.305	.286	....
				7	.470	.417	.368	.328	.316	.301
				30	.545	.473	.420	.367	.359	.345
				60	.595	.520	.457	.406	.392	.376
				90	.653	.568	.500	.437	.419	.404
7	Roaring River near Roaring River	122	....	1	.352	.310	.273	.240	.223	....
				7	.393	.342	.299	.262	.252	.237
				30	.464	.399	.345	.299	.289	.276
				60	.519	.442	.383	.332	.321	.306
				90	.575	.493	.422	.364	.345	.330

8	Mitchell River near Mountain Park	32.8	...	1	.421	.382	.342	.305	.289	...
				7	.467	.416	.369	.330	.318	.302
				30	.533	.472	.418	.369	.359	.345
				60	.586	.517	.457	.404	.393	.377
				90	.643	.564	.497	.438	.418	.403
9	Mitchell River near State Road	80.4	...	1	.418	.377	.338	.302	.284	...
				7	.462	.411	.364	.325	.314	.299
				30	.530	.467	.413	.364	.355	.341
				60	.584	.508	.452	.399	.387	.370
				90	.634	.552	.491	.431	.414	.398
10	Fisher River near Copeland	121	11	1	.297	.254	.214	.177	.163	.150
				7	.340	.288	.238	.200	.188	.176
				30	.409	.344	.289	.244	.231	.216
				60	.470	.398	.331	.278	.262	.248
				90	.521	.445	.370	.312	.292	.278
11	Ararat River at Mount Airy	66.6	...	1	.263	.227	.191	.158	.147	...
				7	.303	.257	.212	.179	.168	.157
				30	.363	.305	.258	.218	.206	.193
				60	.417	.357	.295	.249	.233	.222
				90	.462	.397	.328	.268	.259	.248
12	Stewart Creek near Mount Airy	89.2	...	1	.285	.249	.213	.181	.169	...
				7	.322	.278	.234	.200	.191	.181
				30	.384	.327	.279	.239	.228	.215
				60	.435	.373	.316	.270	.255	.243
				90	.481	.415	.348	.299	.282	.270
13	Ararat River near Pilot Mountain	287	...	1	...	...	...	...	...	...
				7	.239	.195	...	...	...	...
				30	.299	.241	.197	...	...	...
				60	.349	.286	.232	.188	...	...
				90	.399	.328	.267	.217	.199	.188
14	Little Yadkin River near Donnaha	59.7	...	1	.115	.094	.079	.063	.057	...
				7	.138	.112	.089	.073	.067	.063
				30	.176	.139	.112	.091	.085	.078
				60	.214	.168	.132	.106	.098	.093
				90	.244	.197	.154	.122	.112	.104
15	Forbush Creek near Yadkinville	21.7	.9	1	.143	.118	.098	.079	.072	.066
				7	.169	.138	.111	.091	.084	.078
				30	.214	.171	.138	.113	.106	.097
				60	.258	.204	.162	.131	.122	.116
				90	.295	.238	.188	.150	.138	.130
16	Deep Creek at Shacktown	65.9	...	1	.145	.119	.099	.079	.072	...
				7	.173	.140	.112	.091	.084	.078
				30	.221	.174	.140	.114	.107	.098
				60	.267	.211	.166	.132	.123	.117
				90	.306	.247	.193	.152	.140	.132

Table 3.—*Magnitude and frequency of annual low flow in the Yadkin-Pee Dee River basin for periods of 1, 7, 30, 60, and 90 days, based on records April 1, 1929 to March 31, 1953*—Continued

No. (pl. 2)	Gaging sites	Drainage area (square miles)	Minimum daily discharge of record[a] (mgd)	Periods (consecutive days)	Lowest flow, in million gallons per day per square mile, and recurrence intervals, in years					
					2	3	5	10	15	25
17	Muddy Creek near Clemmons	111	....	1	0.123	0.102	0.083	0.066	0.060	....
				7	.148	.119	.094	.077	.070	0.065
				30	.190	.150	.119	.097	.090	.082
				60	.232	.182	.142	.113	.104	.098
				90	.268	.213	.167	.130	.119	.112
18	Reedy Creek near Yadkin College	13.3	....	1	.077	.057	.041	.029	....	....
				7	.099	.073	.050	.036	.032	.029
				30	.141	.103	.073	.053	.048	.042
				60	.182	.134	.095	.068	.061	.054
				90	.223	.166	.117	.085	.075	.068
19	Yadkin River at Yadkin College	2, 280	223	1	.268	.235	.207	.180	.170	.159
				7	.298	.256	.227	.198	.190	.179
				30	.349	.300	.259	.229	.220	.208
				60	.397	.340	.292	.254	.242	.231
				90	.439	.377	.323	.275	.260	.253
20	Dutchmans Creek near Cornatzer	83.6	....	1	.087	.066	.050	....	....	....
				7	.111	.080	.059	.045	....	....
				30	.156	.111	.082	.061	.056	.050
				60	.204	.145	.105	.077	.069	.062
				90	.258	.182	.131	.094	.084	.077
21	Rocky River at Turnersburg	85.5	8.4	1	.255	.222	.194	.167	.157	.147
				7	.287	.244	.212	.185	.176	.167
				30	.339	.287	.248	.215	.206	.195
				60	.387	.327	.280	.241	.228	.216
				90	.431	.364	.311	.265	.251	.240
22	South Yadkin River near Mocksville	313	25	1	.200	.174	.152	.130	.122	.114
				7	.225	.193	.167	.145	.135	.129
				30	.271	.227	.193	.169	.160	.152
				60	.260	.310	.219	.188	.179	.170
				90	.351	.295	.246	.209	.197	.186
23	Hunting Creek near Harmony	153	18	1	.237	.208	.180	.156	.147	....
				7	.267	.227	.198	.173	.164	.156
				30	.313	.267	.229	.201	.193	.182
				60	.357	.301	.260	.225	.213	.202
				90	.399	.337	.290	.246	.234	.223

24	South Yadkin River at Cooleemee	569	15	1	......	......	......	......	......	......
				7	.228	.197	.170	.145	.140	.131
				30	.274	.231	.198	.170	.164	.154
				60	.312	.264	.222	.190	.182	.175
				90	.349	.296	.251	.209	.199	.190
25	Third Creek at Cleveland	87.4	7.1	1	.194	.171	.151	.132	.124	.118
				7	.218	.188	.164	.144	.137	.131
				30	.256	.218	.189	.166	.159	.152
				60	.292	.248	.211	.184	.174	.168
				90	.324	.273	.236	.201	.189	.182
26	Fourth Creek at Statesville[b]	15.8		1	......	......	......	......	......	......
				7	.274	......	......	......	......	......
				30	.312	.274	......	......	......	......
				60	.346	.302	.265	......	......	......
				90	.377	.328	.291	.257	......	......
27	Second Creek near Barber	119	......	1	.137	.118	.101	.087	.082	......
				7	.158	.132	.113	.097	.091	.086
				30	.191	.158	.133	.114	.108	.102
				60	.223	.183	.152	.128	.121	.116
				90	.252	.207	.173	.143	.133	.127
28	Grants Creek at Salisbury	38.8	......	1	.123	.103	.087	.073	.067	......
				7	.145	.118	.099	.083	.077	.072
				30	.179	.145	.118	.100	.094	.088
				60	.215	.172	.138	.115	.107	.102
				90	.250	.197	.162	.130	.118	.113
*30	Swearing Lake at Linwood	34.9	......	1	3.0	2.4	2.0	1.6	1.5	......
				7	3.6	2.9	2.3	1.9	1.7	1.6
				30	4.7	3.6	2.9	2.3	2.2	2.1
				60	5.8	4.5	3.5	2.8	2.6	2.4
				90	6.8	5.3	4.1	3.2	2.9	2.7
31	Abbotts Creek near Thomasville	65.9	......	1	.084	.065	.049	.038	.032	.027
				7	.103	.084	.065	.049	.042	.036
				30	.143	.117	.091	.069	.060	.052
				60	.193	.151	.116	.094	.084	.071
				90	.241	.190	.147	.114	.101	.086
*32	Rich Fork near Holly Grove	47.3	......	1	.95	......	......	......	......	......
				7	1.5	1.0	......	......	......	......
				30	2.6	1.8	1.1	.66	......	......
				60	4.4	2.9	1.8	1.2	.95	.71
				90	6.4	4.3	2.7	1.8	1.4	1.0
33	Abbotts Creek at Lexington	174	1.3	1	.033	.022	.014	.0087	.0066	.0049
				7	.048	.034	.022	.014	.010	.0079
				30	.080	.057	.039	.024	.019	.015
				60	.123	.085	.056	.040	.033	.026
				90	.169	.119	.082	.056	.046	.035

Table 3.—*Magnitude and frequency of annual low flow in the Yadkin-Pee Dee River basin for periods of 1, 7, 30, 60, and 90 days, based on records April 1, 1929, to March 31, 1953*—Continued

No. (pl. 2)	Gaging sites	Drainage area (square miles)	Minimum daily discharge of record[a] (mgd)	Periods (consecutive days)	Lowest flow, in million gallons per day per square mile, and recurrence intervals, in years					
					2	3	5	10	15	25
34	Fourmile Branch near Southmont	19.4	......	1	......	......	......	......	......	......
				7	......	......	......	......	......	......
				30	0.014	0.0030	......	......	......	......
				60	.039	.018	0.0028	......	......	......
				90	.068	.036	.015	0.0025	......	......
36	Uwharrie River near Trinity	11.3	0	1	.017	.0083	.0019	......	......	......
				7	.029	.017	.0086	.0025	......	......
				30	.059	.037	.021	.010	0.0061	0.0022
				60	.096	.072	.040	.023	.016	.011
				90	.143	.093	.060	.037	.028	.019
37	Uwharrie River near Asheboro	31.9	......	1	......	......	......	......	......	......
				7	.030	.016	.0062	......	......	......
				30	.064	.039	.020	.0078	.0042	......
				60	.112	.069	.043	.022	.016	.0090
				90	.156	.109	.067	.038	.027	.017
38	Uwharrie River near Eldorado	347	.32	1	0.19	.011	.0057	.0018	.0013	.00063
				7	.031	.018	.0074	.0033	.0021	.0011
				30	.055	.035	.019	.0088	.0058	.0037
				60	.087	.059	.039	.020	.015	.010
				90	.119	.077	.051	.032	.026	.018
*39	Rocky River near Roberta Mill	87.9	......	1	5.0	4.3	3.7	3.3	3.0	2.8
				7	5.9	5.0	4.3	3.7	3.4	3.2
				30	8.1	6.5	5.3	4.4	4.0	3.8
				60	11	8.4	6.7	5.4	5.1	4.6
				90	14	11	8.2	6.4	5.8	5.1
40	Coddle Creek near Concord	56.6	......	1	.084	.073	.064	......	......	......
				7	.094	.083	.073	.064	......	......
				30	.126	.104	.088	.075	.070	.065
				60	.166	.132	.107	.090	.082	.076
				90	.209	.163	.128	.103	.094	.085
*41	Rocky River near Concord	402	......	1	25	21	18	16	......	......
				7	29	25	21	18	17	16
				30	39	32	27	22	21	19
				60	53	41	33	27	25	23
				90	70	52	40	32	29	26

42	Dutch Buffalo Creek at Mt. Pleasant	64.1	...	1	.028	.023	.018	.012	.0085	.0048
				7	.035	.028	.023	.017	.016	.011
				30	.051	.040	.031	.024	.021	.017
				60	.080	.056	.041	.032	.028	.025
				90	.114	.076	.054	.038	.034	.029
43	Big Bear Creek near Albemarle	71.6	...	1	.0057	.0037	.0025	.0016	.0013	.0010
				7	.0090	.0057	.0037	.0024	.0019	.0015
				30	.020	.012	.0068	.0040	.0032	.0026
				60	.042	.022	.012	.0073	.0058	.0042
				90	.073	.039	.021	.011	.0085	.0061
44	Richardson Creek near Marshville	170	...	1	.0020	...	...	...	...	...
				7	.0038	.0020	...	...	...	...
				30	.0093	.0051	.0028	.00056	...	...
				60	.021	.010	.0056	.0030	.0020	.0010
				90	.039	.020	.0099	.0050	.0036	.0024
*45	Rocky River near Norwood	1,370	12	1	36	29	25	19	18	16
				7	44	36	29	23	22	19
				30	67	51	38	30	27	25
				60	101	71	52	40	36	32
				90	145	99	68	49	42	37
46	Little Brown Creek near Polkton	13.5	0	1	...	...	...	...	...	...
				7	...	...	...	...	...	...
				30	...	...	...	...	...	...
				60	.0025	.00051	...	...	...	...
				90	.0094	.0022	...	...	...	...
47	Brown Creek near Polkton	110	0	1	.00008	...	...	...	...	...
				7	.00036	.00007	...	...	...	...
				30	.0023	.00070	.00016	...	...	...
				60	.0093	.00028	.00068	.00019	.00007	...
				90	.025	.0085	.0025	.00068	.00031	.00009
49	Little River near Star	97.6	...	1	.045	.026	.010	...	...	...
				7	.070	.043	.015	...	...	...
				30	.114	.077	.045	.019	.011	...
				60	.165	.120	.085	.048	.036	.023
				90	.217	.150	.106	.072	.060	.043
50	Mountain Creek near Ellerbe	33.4	...	1	.070	.044	.035	.027	.024	.021
				7	.086	.061	.041	.033	.030	.026
				30	.130	.088	.059	.044	.038	.034
				60	.194	.127	.082	.059	.053	.045
				90	.245	.163	.103	.077	.068	.059
51	Cartledge Creek near Rockingham	31.4	...	1	.013	.0049	...	...	...	...
				7	.019	.0098	.0016	...	...	...
				30	.038	.020	.0090	.0028	...	...
				60	.073	.036	.018	.0090	.0066	.0034
				90	.107	.054	.026	.016	.013	.0090

Table 3.—*Magnitude and frequency of annual flow in the Yadkin-Pee Dee River basin for periods of 1, 7, 30, 60, and 90 days, based on records April 1, 1929, to March 31, 1953*—Continued

No. (pl. 2)	Gaging sites	Drainage area (square miles)	Minimum daily discharge of record[a] (mgd)	Periods (consecutive days)	Lowest flow, in million gallons per day per square mile, and recurrence intervals, in years					
					2	3	5	10	15	25
53	Falling Creek near Rockingham	6.0	....	1	0.257	0.211	0.178	0.156	....	....
				7	.285	.239	.194	.173	.163	.153
				30	.356	.289	.233	.200	.188	.177
				60	.447	.350	.278	.233	.222	.203
				90	.510	.403	.314	.267	.252	.233
54	North Fork Jones Creek near Wadesboro[c]	10.0	0.13	1	.023	....	....	....	....	....
				7	.033	.023	....	....	....	....
				30	.060	.041	.026	....	....	....
				60	.093	.064	.043	.028	.023	.018
				90	.131	.091	.061	.040	.032	.025
55	Marks Creek near Osborne	29.2	....	1	.132	.099	.075	....	....	....
				7	.159	.120	.086	.072	....	....
				30	.230	.163	.116	.090	.080	.073
				60	.328	.224	.153	.116	.105	.093
				90	.400	.280	.188	.145	.131	.116
56	Drowning Creek near Jackson Springs	30.5	....	1	.227	.165	.123	.096	.085	.077
				7	.270	.200	.140	.117	.104	.092
				30	.373	.274	.194	.148	.132	.119
				60	.492	.366	.260	.194	.176	.153
				90	.570	.438	.312	.245	.222	.194
57	Deep Creek near Roseland	18.9	....	1	.340	.290	.253	.225	.214	.202
				7	.372	.321	.270	.249	.239	.225
				30	.442	.374	.315	.280	.262	.248
				60	.535	.440	.362	.315	.301	.281
				90	.595	.490	.400	.353	.335	.315
58	Drowning Creek near Hoffman	178	19	1	.229	.185	.154	.132	.123	.114
				7	.258	.211	.169	.149	.140	.129
				30	.330	.261	.207	.174	.162	.131
				60	.421	.323	.250	.207	.194	.178
				90	.486	.378	.287	.240	.225	.207
59	Lumber River near Pembroke	421	....	1	.292	.249	.213	.186	.175	.158
				7	.318	.272	.232	.206	.193	.180
				30	.374	.320	.270	.236	.223	.207

				60	.450	.370	.310	.272	.260	.243
				90	.505	.413	.341	.303	.288	.272
60	Little Raft Swamp at Red Springs	23.1	....	1	.066	.046	.031	....	....	....
				7	.079	.058	.038	.029	....	....
				30	.113	.081	.055	.040	.035	.030
				60	.165	.112	.076	.055	.049	.042
				90	.202	.140	.093	.071	.064	.055
61	Raft Swamp near Lumberton	107	....	1	.046	.032	.022	.014	.0094	.0034
				7	.054	.038	.027	.020	.016	.011
				30	.074	.055	.038	.029	.025	.021
				60	.102	.073	.052	.040	.036	.030
				90	.124	.087	.062	.049	.044	.040
62	Big Swamp near Tarheel	225	....	1	.036	.024	.014	.0072	.0050	....
				7	.044	.030	.019	.012	.0091	.0060
				30	.064	.045	.030	.021	.017	.013
				60	.093	.063	.042	.030	.027	.022
				90	.114	.078	.052	.039	.035	.030
63	Lumber River at Boardman	1, 220	60	1	.117	.094	.078	.067	.063	.057
				7	.132	.106	.086	.075	.070	.065
				30	.169	.133	.105	.088	.082	.076
				60	.221	.167	.128	.106	.099	.091
				90	.262	.195	.147	.123	.115	.106
64	Gum Swamp Creek near Laurinburg	42.4	....	1	.423	.385	.357	.337	.327	.314
				7	.448	.405	.372	.351	.341	.331
				30	.495	.450	.405	.375	.365	.353
				60	.555	.495	.440	.405	.395	.380
				90	.600	.527	.465	.434	.420	.405
65	Shoeheel Creek near Laurinburg	84.5	....	1	.180	.153	.131	.117	.112	.103
				7	.200	.167	.142	.127	.121	.114
				30	.241	.202	.167	.145	.137	.129
				60	.300	.239	.195	.167	.160	.149
				90	.340	.270	.217	.189	.178	.167
66	Waccamaw River at Freeland	626	0.06	1	.0036	.0015	.00076	.00043	.00031	.00022
				7	.0060	.0026	.0010	.00064	.00059	.00035
				30	.015	.0061	.0024	.0012	.00091	.00066
				60	.039	.014	.0052	.0025	.0019	.0013
				90	.069	.026	.0089	.0044	.0034	.0025

[a] For periods of record see figure 3. Data include low flows to September 30, 1954.
[b] Based on streamflow data collected prior to diversion above gaging site by city of Statesville for water supply beginning in May 1950.
[c] Based on records collected prior to construction of reservoir and diversion above station by town of Wadesboro for water supply beginning in 1941.

Table 4.—*Lowest average flow for 7 consecutive days in every year at gaging stations in the Yadkin-Pee Dee River basin*

[Million gallons per day]

Year beginning April 1	Gaging station and no. (pl. 2)																		Year beginning April 1	
	1. Yadkin River at Patterson	4. Reddies River at North Wilkesboro	5. Yadkin River at Wilkesboro	10. Fisher River near Copeland[a]	15. Forbush Creek near Yadkinville	19. Yadkin River at Yadkin College	21. Rocky River at Turnerburg	22. South Yadkin River near Mocksville	24. South Yadkin River at Cooleemee	25. Third Creek at Cleveland	33. Abbotts Creek at Lexington[b]	36. Uwharrie River near Trinity	38. Uwharrie River near Eldorado	45. Rocky River near Norwood[c]	47. Brown Creek near Polkton	58. Drowning Creek near Hoffman	63. Lumber River at Boardman	66. Waccamaw River at Freeland		29. Yadkin River near Salisbury
1921	...	...	235	44	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1895	905
1922	...	...	285	58	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1896	704
1923	...	...	202	33	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1897	711
1924	...	...	250	54	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1898	931
1925	...	...	117	14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1899	995
1926	...	...	109	22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1900	1,110
1927	...	...	162	28	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1901	2,120
1928	...	...	369	49	...	1,100	...	...	118	...	...	...	...	...	...	...	...	...	1902	1,140
1929	...	...	300	63	...	1,180	...	...	...	...	...	...	...	...	...	...	...	...	1903	1,210
1930	...	...	154	16	...	489	...	...	83	...	...	...	...	25	...	...	92	...	1904	769
1931	...	...	132	26	...	462	...	...	80	...	...	...	...	27	...	...	129	...	1905	1,140
1932	...	...	131	18	...	448	...	...	82	...	...	...	...	29	...	...	115	...	1906	1,670
1933	...	...	171	24	...	525	...	...	129	...	...	...	...	27	...	...	95	...	1907	1,170
1934	...	...	207	35	...	814	...	...	151	...	...	0.35	...	64	...	...	186	...	1908	1,610
1935	...	...	251	47	...	860	...	...	154	...	...	.33	...	53	...	...	100	...	1909	1,360
1936	...	...	207	41	...	698	...	...	148	...	...	.27	...	40	...	...	220	...	1910	...
1937	...	...	239	54	...	963	...	...	195	...	...	.42	...	55	...	...	178	...	1911	...
1938	...	...	217	43	...	756	...	73	119	...	...	.30	...	35	0	...	196	...	1912	989
1939	...	...	172	39	...	586	...	74	114	...	...	.51	16	38	0	...	198	23	1913	1,230
1940	9.7	38	193	41	3.9	872	21	60	114	17	8.6	.44	4.6	28	0	20	87	.39	1914	872
1941	9.6	33	154	21	2.1	453	17	48	77	13	1.8	.002	.46	18	0	34	107	.45	1915	1,110
1942	17	48	244	47	3.4	879	24	61	127	17	6.0	...	20	49	.37	38	185	3.6	1916	1,530
1943	9.6	39	202	50	4.0	730	27	72	121	21	5.9	...	9.5	43	0	50	167	16	1917	1,110
1944	7.6	36	152	39	5.0	737	22	68	115	19	4.3	...	10	45	0	81	295	8.5	1918	950
1945	7.8	40	182	44	3.4	750	20	60	96	19	4.3	...	16	44	.03	62	199	14	1919	1,320
1946	6.7	39	163	42	3.8	637	24	72	116	18	13	...	23	64	.06	85	289	81	1920	1,300
1947	10	34	185	51	3.4	743	27	68	118	17	3.8	...	9.3	51	.05	58	189	25	1921	969
1948	12	44	273	42	3.6	808	29	78	132	18	7.5	...	14	46	0	52	193	15	1922	1,110

Table 4.—*Lowest average flow for 7 consecutive days in every year at gaging stations in the Yadkin-Pee Dee River basin*—Continued

Year beginning April 1	Gaging station and no. (pl. 2)																		Year beginning April 1	
	1. Yadkin River at Patterson	4. Reddies River at North Wilkesboro	5. Yadkin River at Wilkesboro	10. Fisher River near Copeland[a]	15. Forbush Creek near Yadkinville	19. Yadkin River at Yadkin College	21. Rocky River at Turnerburg	22. South Yadkin River near Mocksville	24. South Yadkin River at Cooleemee	25. Third Creek at Cleveland	33. Abbotts Creek at Lexington[b]	36. Uwharrie River near Trinity	38. Uwharrie River near Eldorado	45. Rocky River near Norwood[c]	47. Brown Creek near Polkton	58. Drowning Creek near Hoffman	63. Lumber River at Boardman	66. Waccamaw River at Freeland		29. Yadkin River near Salisbury
1949.............	22	75	415	88	6.6	1,380	45	118	233	26	14	....	21	75	.15	81	354	46	1923	956
1950.............	16	58	285	70	5.4	1,010	40	116	207	27	17	....	20	41	0	48	186	18	1924	1,070
1951.............	7.3	34	172	38	1.9	543	19	54	83	14	3.5	....	2.4	26	0	27	83	7.8	1925	514
1952.............	6.4	26	159	45	3.7	672	26	76	118	18	6.6	....	25	60	.21	41	135	1.9	1926	615
																			1927	659

[a] Records for station near Dobson (drainage area 109 square miles) prior to 1932.
[b] Unadjusted for diversions.
[c] Unadjusted for regulation by water-supply reservoirs.

droughts (fig. 10) the percentage change would be much greater; the flow at the 2-, 3-, 5-, and 10-year interval might be increased as much as 100 percent and the flow at the 25-year interval might be decreased as much as 50 percent. These curves do not imply a regularity of occurrence but rather the probable average interval between specified low flows. Assuming that the flow during the period April 1929 to March 1953 was normal and that future flow will follow the pattern of that measured in the past, these curves may be used to predict future streamflow.

For example, the curves in figure 9 show that daily flow will be insufficient to satisfy the needs of the hypothetical industrial plant that requires 25 mgd (0.25 mgd per square mile from 100 square miles) at average intervals of 3 years. The average flow for 7 consecutive days will be insufficient at average intervals of 4.4 years and the average flow for 30 consecutive days will be insufficient at average intervals of 9 years.

The pattern of low flow in many streams becomes irregular in the lower reaches of the stream owing to regulation of the discharge at some upstream point. The regulation frequently causes a period of very low flow of short duration within a longer period of relatively uniform flow. The minimum daily flow of these streams is often considered too limited a measure of the flow characteristics for many uses of the water. Where the regulation is minor and when it occurs in uniform weekly patterns, the average 7-day flow is a better indication of the flow characteristics of the stream. The lowest average 7-day flow for each year of record at gaging stations in the Yadkin-Pee Dee River basin is shown in table 4.

MAXIMUM PERIOD OF DEFICIENT DISCHARGE

Useful analyses of low-flow characteristics may also include curves that indicate the maximum number of consecutive days during which the flow was less than a specified discharge. The maximum period of deficient discharge that may be expected for gaging stations in the Yadkin-Pee Dee River basin for a 25-year period in which the flow pattern was similar to that for 1929–53 is shown in figures 11, 12, and 13 and listed in table 5. Although the flows of some streams listed in this table are affected by regulation or diversion, the effect is not appreciable. Again using the hypothetical industrial plant site, assume it is necessary to know the maximum number of consecutive days, even in unusual years, when the flow will be less than 25 mgd. On figure 12 the curve for the period 1929–53 shows that the flow at the plant site may be expected to be less than 0.25 mgd per square mile, or 25 mgd where the drainage area is 100 square miles for not more than 24 consecutive days.

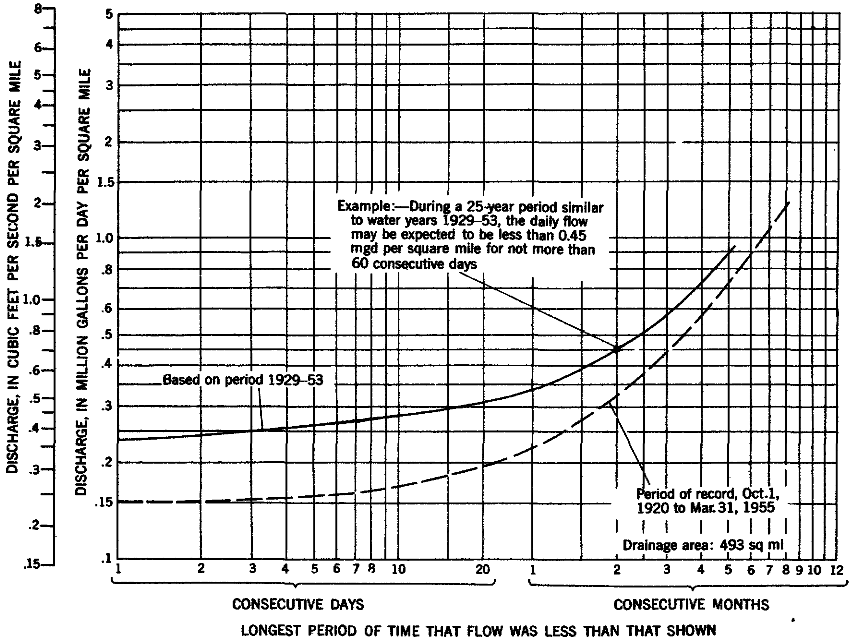


Figure 11. —Maximum period of deficient discharge, Yadkin River at Wilkesboro.

STORAGE REQUIREMENTS

Frequently during dry periods streamflow is inadequate to meet the minimum requirements for many uses, without the use of a storage reservoir. Storage of streamflow is provided for municipal and industrial water supplies, power generation, supplements to low flows for waste dilution and navigation, flood control, and other uses in many places.

The draft-storage curve is another means of studying the flow characteristics of streams. This curve shows the additional net storage required, disregarding evaporation, leakage, and dead storage, to maintain specific outflow rates. Storage curves for six representative gaging stations in the Yadkin-Pee Dee River basin are given in figures 14 to 16. Net storage for selected outflow rates and the average flow for all sites in the basin are listed in table 6. In general, the storage curves were computed to 70 percent of average flow.

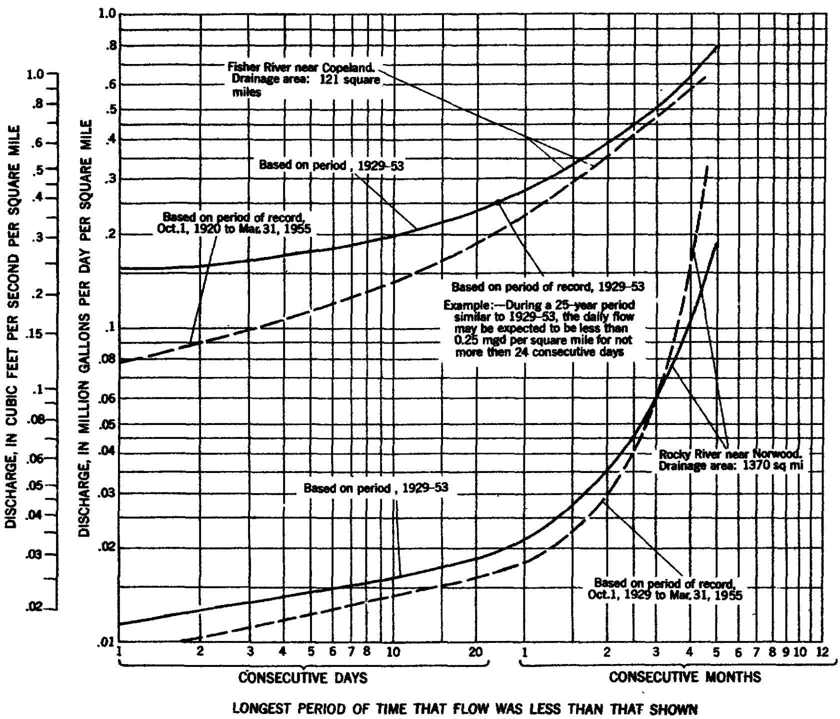


Figure 12. —Maximum period of deficient discharge. Fisher River near Copeland and Rocky River near Norwood.

As an example of the use of the storage curve, assume that the hypothetical industrial plant at a site on Fisher River (with a drainage area of 100 square miles) is to be expanded and that the total water requirement is to be 40 mgd. With this new water supply criterion, the stream will be able to meet the demand only 86 percent of time (fig. 4) and production stoppages or cutbacks will be more frequent and of greater proportions than before the expansion. If such a restricted schedule of operation is uneconomical, it will be necessary to build a storage reservoir to maintain the flow required for continuous plant operation. The curve for the period 1929–53, figure 15, shows that a storage capacity of 12.5 million gallons per square mile of drainage area or a total of 1,250 million gallons, will be required to meet the sustained demand of 40 mgd (or 0.40 mgd per square mile). To this volume must be added the amount of dead storage below the reservoir outlet and an allowance for evaporation and leakage from the reservoir.

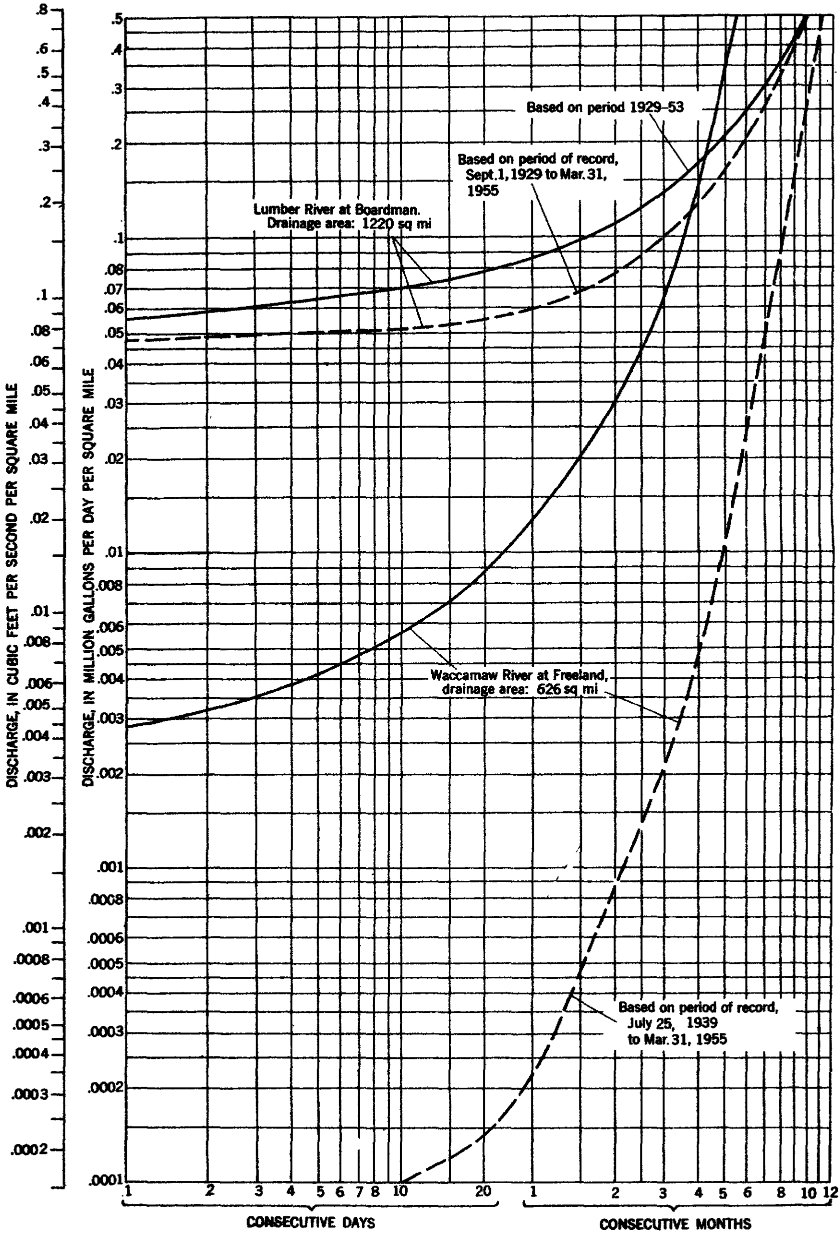


Figure 13. —Maximum period of deficient discharge, Lumber River at Boardman and Waccamaw River at Freeland.

Table 5.—*Maximum number of consecutive days when discharge in the Yadkin-Pee Dee River basin was less than that indicated, 1929–53*

No. (pl. 2)	Gaging Station	Drainage area (sq miles)	Maximum number of consecutive days during which discharge, in million gallons per day per square mile, was less than that indicated.																	
			0.0005	0.002	0.012	0.02	0.034	0.06	0.08	0.10	0.12	0.17	0.20	0.25	0.30	0.50	0.60	0.70	0.80	1.0
1	Yadkin River at Patterson	28.8	...	...	...	...	...	...	...	...	...	...	2	15	32	86	105	123	140	168
2	Elk Creek at Elkville	50	...	...	...	...	...	...	...	...	...	1	6	23	43	92	115	128	143	170
3	Middle Fork Reddies River near Wilbar.	13.9	...	...	...	...	...	...	...	...	...	...	...	...	1	35	54	71	84	115
4	Reddies River at North Wilkesboro.	93.9	...	...	...	...	...	...	...	...	...	...	...	1	10	72	96	118	136	...
5	Yadkin River at Wilkesboro	493	...	...	...	...	...	...	...	...	...	...	...	3	17	74	97	116	135	174
6	Mulberry Creek near North Wilkesboro.	43.0	...	...	...	...	...	...	...	...	...	...	...	...	3	54	80	100	118	...
7	Roaring River near Roaring River.	122	...	...	...	...	...	...	...	...	...	...	...	6	20	78	98	120	139	...
8	Mitchell River near Mountain Park.	32.8	...	...	...	...	...	...	...	...	...	...	4	15	26	76	96	118	136	165
9	Mitchell River near State Road	80.4	...	...	...	...	...	...	...	...	...	...	...	...	4	61	82	108	...	...
10	Fisher River near Copeland	121	...	...	...	...	...	...	...	...	...	3	10	22	36	88	110	130	146	174
11	Ararat River at Mount Airy	66.6	...	...	...	...	...	...	...	...	...	8	16	30	46	101	126	145	160	...
12	Stewart Creek near Mount Airy.	89.2	...	...	...	...	...	...	...	...	...	2	10	24	40	100	121	141	160	185
13	Ararat River near Pilot Mountain.	287	...	...	...	...	...	...	...	...	...	...	34	52	65	112	131	151	172	...
14	Little Yadkin River near Donnaha.	59.7	...	...	...	...	...	1	12	26	39	64	76	94	110	...	...	...	...	...
15	Forbush Creek near Yadkinville	21.7	...	...	...	...	...	...	3	12	23	48	61	80	95	140	...	...	...	...
16	Deep Creek at Shacktown	65.9	...	...	...	...	...	...	3	12	23	48	60	76	91	138	...	...	...	...
17	Muddy Creek near Clemmons	111	...	...	...	...	...	1	9	22	34	58	69	89	103	...	...	...	...	...
18	Reedy Creek near Yadkin College.	13.3					8	25	37	47	58	76	85	100	111	146	158	165	180	...
19	Yadkin River at Yadkin College	2,280	...	...	...	...	...	...	...	...	...	1	8	30	48	105	126	145	163	...
20	Dutchmans Creek near Cornatzer.	83.6	...	...	...	...	...	21	36	45	55	72	82	92	98	128	142	...	...	...
21	Rocky River at Turnersburg	85.5	...	...	...	...	...	...	...	...	...	3	15	37	55	109	129	150	...	...
22	South Yadkin River near Mocksville.	313	...	...	...	...	...	...	...	...	...	20	35	55	72	130	155	...	...	...
23	Hunting Creek near Harmony	153	...	...	...	...	...	...	...	...	...	6	22	45	62	116	140	...	...	...
24	South Yadkin River at Cooleemee.	569	...	...	...	...	...	...	...	...	...	...	35	56	75	130	...	...	...	...

25	Third Creek at Cleveland	87.4	....	....	....	....	....	....	....	....	....	25	41	63	81	145	170	....	....	....
26	Fourth Creek at Statesville[a]	15.8	....	....	....	....	....	....	....	....	....	....	....	39	63	130	163	....	....	....
27	Second Creek near Barber	119	....	....	....	....	....	....	1	12	28	55	69	90	108	163	....	....	....	....
28	Grants Creek at Salisbury	38.8	....	....	....	....	....	....	7	23	36	62	73	91	105	158	175	....	....	....
30	Swearing Creek at Linwood	34.9	....	....	....	....	....	15	34	46	58	80	90	108	120	165	....	....	....	....
31	Abbotts Creek near Thomasville	65.9	....	....	....	....	3	27	41	55	66	96	105	126	141	....	....	....	....	....
33	Abbotts Creek at Lexington	174	....	....	11	27	44	67	80	93	104	123	133	147	158	....	....	....	....	....
34	Fourmile Branch near Southmont.	19.4	59	63	78	87	102	118	129	138	145	158	167	....	....	....	....	....	....	....
36	Uwharrie River near Trinity	11.3	5	13	39	51	65	83	94	104	110	128	135	149	161	....	....	....	....	....
37	Uwharrie River near Asheboro	31.9	....	....	35	47	60	87	94	105	114	131	139	150	158	....	....	....	....	....
38	Uwharrie River near Eldorado	347	....	8	40	56	75	100	112	125	134	155	....	....	....	....	....	....	....	....
40	Coddle Creek near Concord	56.6	....	....	....	....	....	....	39	60	76	108	121	140	151	....	....	....	....	....
42	Dutch Buffalo Creek at Mount Pleasant.	64.1	....	....	6	21	34	89	105	118	128	146	154	....	....	....	....	....	....	....
43	Big Bear Creek near Albemarle	71.6	....	10	64	80	98	118	130	135	142	155	....	....	....	....	....	....	....	....
44	Richardson Creek near Marshville.	170	34	43	88	104	120	139	148	154	159	....	....	....	....	....	....	....	....	....
46	Little Brown Creek near Polkton	13.5	....	98	125	135	145	155	162	169	171	180	183	190	201	209	....	....	....	....
47	Brown Creek near Polkton	110	60	77	106	116	129	142	150	155	161	171	178	183	190	209	....	....	....	....
49	Little River near Star	97.6	....	....	25	33	45	65	77	88	98	119	130	144	158	....	....	....	....	....
50	Mountain Creek near Ellerbe	33.4	....	....	....	....	15	39	80	100	118	145	160	....	....	....	....	....	....	....
51	Cartledge Creek near Rockingham.	31.4	....	26	64	88	119	149	161	175	185	....	....	....	....	....	....	....	....	....
53	Falling Creek near Rockingham	6.0	....	....	....	....	....	....	....	....	....	13	30	64	96	175	....	....	....	....
54	North Fork Jones Creek near Wadesboro[b].	10.0	....	....	....	39	56	82	96	110	120	140	149	160	....	....	....	....	....	....
55	Marks Creek near Osborne	29.2	....	....	....	....	....	....	20	39	54	94	110	131	150	....	....	....	....	....
56	Drowning Creek near Jackson Springs.	30.5	....	....	....	....	....	....	....	8	16	40	54	80	96	160	190	....	....	....
57	Deep Creek near Roseland	18.9	....	....	....	....	....	....	....	....	....	....	....	15	42	149	....	....	....	....
58	Drowning Creek near Hoffman	178	....	....	....	....	....	....	....	....	1	26	47	82	110	183	....	....	....	....
59	Lumber River near Pembroke	421	....	....	....	....	....	....	....	....	....	4	12	40	69	186	235	280	....	....
60	Little Raft Swamp at Red Springs	23.1	....	....	....	....	20	60	89	110	130	160	178	....	....	....	....	....	....	....
61	Raft Swamp near Lumberton	107	....	1	4	16	41	91	130	161	204	240	265	300	....	....	....	....	....	....
62	Big Swamp near Tarheel	225	....	....	15	28	59	113	148	174	196	258	271	....	....	....	....	....	....	....
63	Lumber River at Boardman	1, 220	....	....	....	....	....	3	21	42	70	120	146	182	215	....	....	....	....	....
64	Gum Swamp Creek near Laurinburg.	42.4	....	....	....	....	....	....	....	....	....	....	....	....	....	120	191	250	300	....
65	Shoeheel Creek near Laurinburg	84.5	....	....	....	....	....	....	....	....	9	52	92	120	150	....	....	....	....	....
66	Waccamaw River at Freeland	626	9	47	110	128	151	177	193	....	....	....	....	....	....	....	....	....	....	....

[a]Based on streamflow data collected prior to diversion above gaging site by city of Statesville for water supply beginning in May 1950.
[b]Based on records collected prior to construction of reservoir and diversion above station by town of Wadesboro for water supply beginning in 1941.

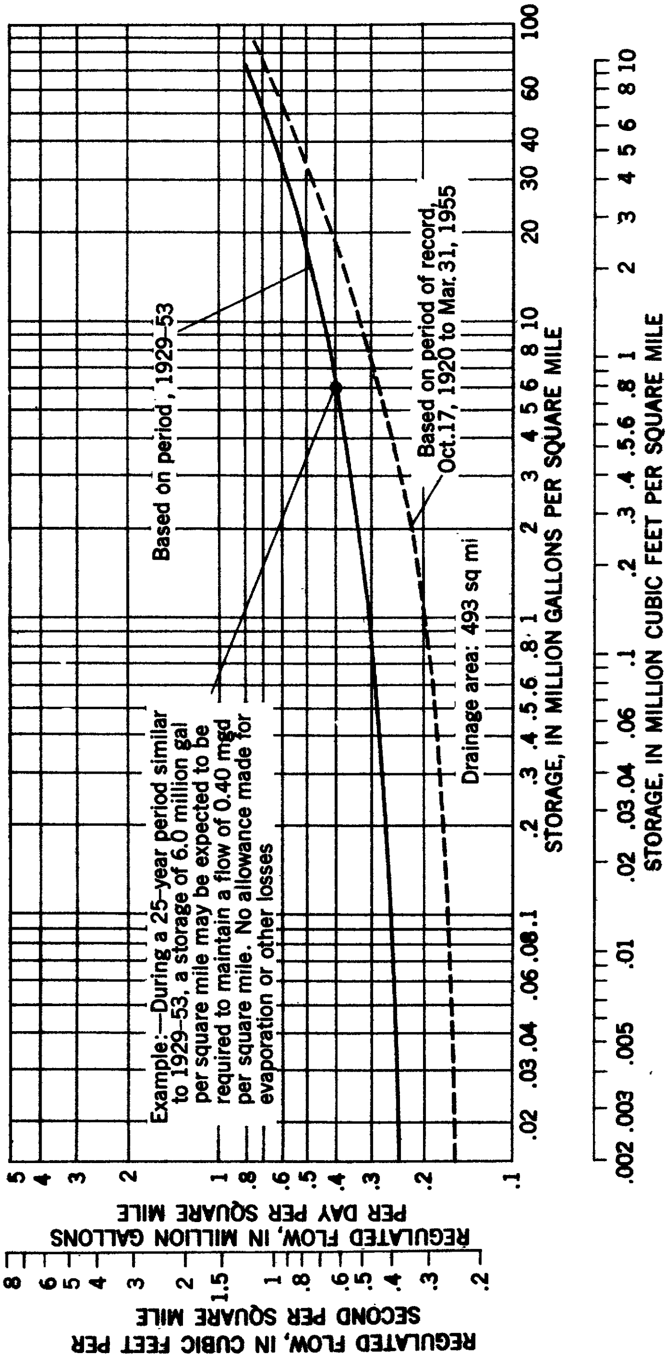


Figure 14. —Storage requirements, Yadkin River at Wilkesboro

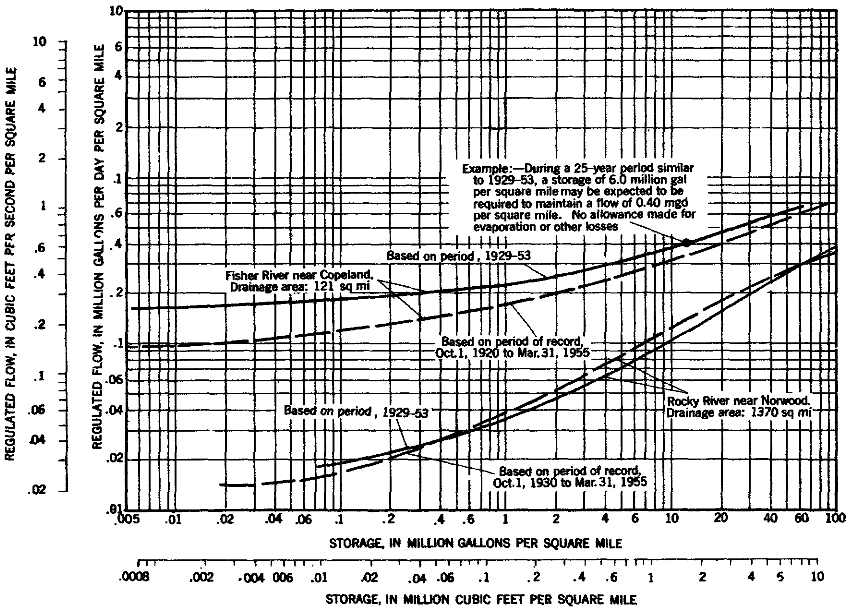


Figure 15.—Storage requirements, Fisher River near Copeland and Rocky River near Norwood.

FLOOD FREQUENCIES

A State-wide study of flood frequency has recently been completed by the Geological Survey (Riggs 1955). Results of this study allow reliable flood-frequency relations to be established for Yadkin-Pee Dee River tributaries and for Yadkin River main stem upstream from High Rock reservoir. These relations are shown for five gaging stations in the basin in figures 17 to 20. Regulation of Yadkin-Pee Dee River downstream from High Rock reservoir precludes determination of flood frequency by the usual methods.

Each frequency curve shows the average interval, in years, between floods that equal or exceed a given elevation. This does not mean that floods occur with any regularity; the recurrence intervals are average values only. It would be possible to have two floods of 50-year interval in successive years or in the same year.

Although frequency curves give average recurrence intervals only, they have much practical utility. For example, the frequency curve might be used to determine the elevation of a building in the flood plain of a river so that flood waters would reach it, on the average, only once in 50 years. Similarly, the average frequency of flooding of a road fill could be determined from the curve.

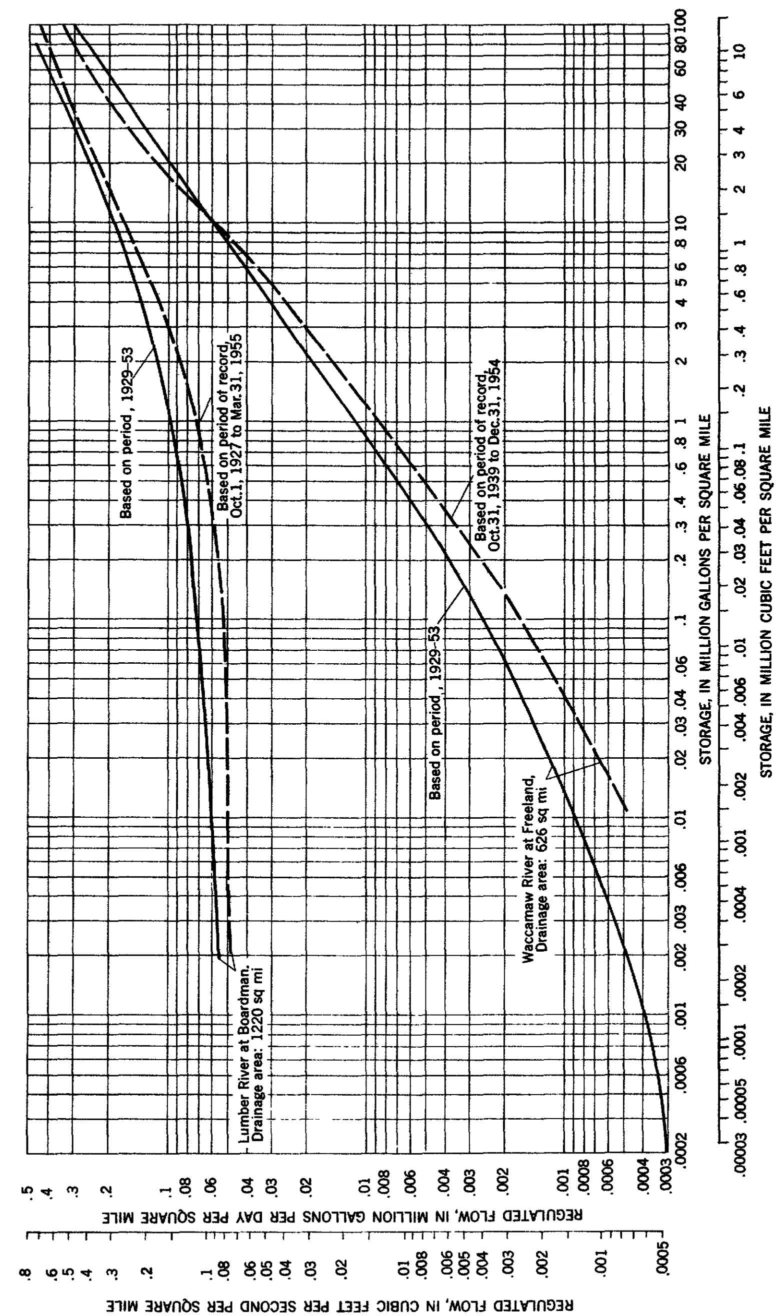


Figure 16. —Storage requirements, Lumber River at Boardman and Waccamaw River at Freeland.

Table 6.—*Storage requirements in the Yadkin-Pee Dee River basin, 1929–53*

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow					
	1. Yadkin River at Patterson	2. Elk Creek at Elkville	3. Middle Fork Reddies River near Wilbar	4. Reddies River at North Wilkesboro	5. Yadkin River at Wilkesboro	6. Mulberry Creek near North Wilkesboro
Drainage area sq miles..	28.8	50.0	13.9	93.9	493	43.0
Average...........	1.05	1.0	1.4	0.977	1.03	1.1
Regulated:						
0.002...........	......	......	......	......	......	......
.006...........	......	......	......	......	......	......
.012...........	......	......	......	......	......	......
.03	......	......	......	......	......	......
.04	......	......	......	......	......	......
.05	......	......	......	......	......	......
.07	......	......	......	......	......	......
.08	......	......	......	......	......	......
.1.............	......	......	......	......	......	......
.13	......	......	......	......	......	......
.14	......	......	......	......	......	......
.18	......	.006	......	......	......	......
.22	.097	.450	......	......	......	......
.26	1.2	1.85	......	......	.09	......
.45	16.5	19.5	2.15	8.7	10.4	3.50
.6.............	40	42.5	13.0	29.5	31.5	19.5
.8.............	97	......	35.5	71	71	57.0

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow					
	7. Roaring River near Roaring River	8. Mitchell River near Mountain Park	9. Mitchell River near State Road	10. Fisher River near Copeland	11. Ararat River at Mount Airy	12. Stewart Creek near Mount Airy
Drainage area sq miles..	122	32.8	80.4	121	66.6	89.2
Average...........	0.96	1.0	1.1	0.983	0.87	0.89
Regulated:						
0.002...........	......	......	......	......	......	......
.006...........	......	......	......	......	......	......
.012...........	......	......	......	......	......	......
.03	......	......	......	......	......	......
.04	......	......	......	......	......	......
.05	......	......	......	......	......	......
.07	......	......	......	......	......	......
.08	......	......	......	......	......	......
.1.............	......	......	......	......	......	......
.13............	......	......	......	......	......	......
.14	......	......	......	......	......	......
.18	......	......	......	.045	.265	.028
.22	......	......	......	.61	1.31	.630
.26	.205	......	......	2.18	3.25	2.05
.45	11.0	5.05	5.55	18.2	22.5	19.5
.6.............	32.5	20.5	22.5	42.5	51.0	50.0
.8.............	......	62.0	62.0	......	......	......

Table 6.—*Storage requirements in the Yadkin-Pee Dee River basin, 1929–53*— Continued

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	13. Ararat River near Pilot Mountain	14. Little Yadkin River near Donnaha	15. Forbush Creek near Yadkinville	16. Deep Creek at Shacktown	17. Muddy Creek near Clemmons
Drainage area sq miles..	287	59.7	21.7	65.9	111
Average............	0.82	0.56	0.649	0.69	0.62
Regulated:					
0.002..........	....	....	....	....	....
.006..........	....	....	....	....	....
.012..........	....	....	....	....	....
.03..........	....	....	....	....	....
.04..........	....	....	....	....	....
.05..........	....	....	....	....	....
.07..........	....	.056	....	....	.035
.08..........	....	.230	.015	.010	.180
.1..........	....	1.0	.29	.250	.70
.13..........	....	2.7	1.35	1.25	2.15
.14..........	....	3.5	1.9	1.80	2.85
.18..........	1.40	7.25	4.85	4.70	6.50
.22..........	2.55	12.5	9.0	8.60	11.0
.26..........	7.1	18.9	13.5	13.4	16.6
.45..........	33.5	....	55.0	50.0	....
.6..........	80.0	....	....	....	....
.8..........	....	....	....	....	....

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	18. Reedy Creek near Yadkin College	19. Yadkin River at Yadkin College	20. Dutchmans Creek near Cornatzer	21. Rocky River at Turnersburg	22. South Yadkin River near Mocksville
Drainage area sq miles..	13.3	2, 280	83.6	85.5	313
Average............	0.60	0.827	0.84	0.839	0.655
Regulated:					
0.002..........	....	....	....	....	....
.006..........	....	....	....	....	....
.012..........	....	....	....	....	....
.03..........	.265	....	....	....	....
.04..........	.585	....	.006	....	....
.05..........	1.04	....	.100	....	....
.07..........	2.45	....	.680	....	....
.08..........	3.35	....	1.16	....	....
.1..........	5.50	....	2.40	....	....
.13..........	9.25	....	4.90	....	.0074
.14..........	10.7	....	5.6	....	.068
.18..........	17.0	.021	10.0	.100	1.1
.22..........	23.6	.60	15.5	.93	3.6
.26..........	30.5	2.2	22.0	3.2	6.8
.45..........	66.0	22.5	64.0	25.5	37.5
.6..........	....	57	....	59	....
.8..........	....	....	....	....	....

Table 6.—*Storage requirements in the Yadkin-Pee Dee River basin, 1929–53*—Continued

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	23. Hunting Creek near Harmony	25. Third Creek at Cleveland	26. Fourth Creek at Statesville[b]	27. Second Creek near Barber	28. Grants Creek at Salisbury
Drainage area sq miles..	153	87.4	15.8	119	38.8
Average..........	0.76	0.659	0.68	0.60	0.62
Regulated:					
0.002..........	....	....	....	....	....
.006..........	....	....	....	....	....
.012..........	....	....	....	....	....
.03	....	....	....	....	....
.04	....	....	....	....	....
.05	....	....	....	....	....
.07	....	....	....	....	....
.08	....	....	....	....	.06
.1..........	....	....	....	.090	.50
.13	....	....	....	.980	1.95
.14	....	.075	....	1.52	2.65
.18	.205	1.15	.013	4.65	6.25
.22	1.30	3.85	.730	9.20	10.9
.26	3.65	7.9	3.0	15.0	16.5
.45	28.5	45.5	31.5	....	....
.6..........	....	....	....	....	....
.8..........	....	....	....	....	....

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	31. Abbotts Creek near Thomasville	33. Abbotts Creek at Lexington	34. Fourmile Branch near Southmont	36. Uwharrie River near Trinity	37. Uwharrie River near Asheboro
Drainage area sq miles..	65.9	174	19.4	11.3	31.9
Average..........	0.63	0.602	0.42	0.658	0.66
Regulated:					
0.002..........	....	....	....	....	....
.006..........	....	....	....	....	....
.012..........	....	.050	1.32	.340	.465
.03	.0064	.615	3.55	1.36	1.75
.04	.062	1.12	5.0	2.09	2.65
.05	.215	1.72	6.45	2.95	3.69
.07	.760	3.26	9.65	4.85	6.10
.08	1.14	4.40	11.4	5.95	7.40
.1..........	2.18	6.25	15.0	8.20	10.4
.13	4.30	10.0	20.6	12.1	15.0
.14	5.05	11.7	22.9	13.6	16.7
.18	9.20	18.1	32.5	20.5	23.5
.22	14.5	25.0	43.5	28.0	30.5
.26	21.5	32.8	56.0	37.5	38.0
.45	60.2	78.0	....	....	75.0
.6..........	....	....	....	....	....
.8..........	....	....	....	....	....

[b]Based on streamflow data collected prior to diversion above gaging site by city of Statesville for water supply beginning in May, 1950.

Table 6.—*Storage requirements in the Yadkin-Pee Dee River basin, 1929–53*—Continued

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	38. Uwharrie River near Eldorado	40. Coddle Creek near Concord	42. Dutch Buffalo Creek at Mount Pleasant	43. Big Bear Creek near Albemarle	44. Richardson Creek near Marshville
Drainage area sq miles..	347	56.6	64.1	71.6	170
Average.........	0.603	0.66	0.64	0.60	0.50
Regulated:					
0.002..........	.008	....	....	.006	....
.006..........	.10	....	....	.145	.380
.012..........	.345	....	.0175	.570	1.08
.03..........	1.49	....	.450	2.45	3.65
.04..........	2.35	....	1.09	3.75	5.10
.05..........	3.30	....	2.0	5.20	7.10
.07..........	5.35	.250	4.1	8.30	11.0
.08..........	6.75	.590	5.5	10.1	14
.1..........	9.60	1.70	8.60	14.0	17.1
.13..........	14.5	4.40	14.0	20.1	24.5
.14..........	16.1	5.35	15.6	22.5	27.5
.18..........	24.2	10.0	24.0	32.5	39.5
.22..........	33.5	15.8	33.0	42.5	....
.26..........	44.0	22.8	42.5	54.0	....
.45..........	130	....	....	....	....
.6..........	....	....	....	....	....
.8..........	....	....	....	....	....

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	46. Little Brown Creek near Polkton	47. Brown Creek near Polkton	49. Little River near Star	50. Mountain Creek near Ellerbe	51. Cartledge Creek near Rockingham
Drainage area sq miles..	13.5	110	97.6	33.4	31.4
Average.........	0.50	0.489	....	0.64	0.55
Regulated:					
0.002..........	....	.191	....	....	....
.006..........	960	.70	....	....	....
.012..........	2.1	1.69	....	....	.520
.03..........	.30	5.10	0.985	.060	2.05
.04..........	8.80	7.0	1.60	.295	3.15
.05..........	11.5	9.10	2.25	.710	4.50
.07..........	16.8	13.5	3.55	1.91	7.40
.08..........	19.8	16.0	4.35	2.65	9.05
.1..........	25.5	21.1	6.0	4.50	13.0
.13..........	36.0	29.9	9.05	8.0	19.1
.14..........	40.0	32.5	10.4	9.20	21.9
.18..........	60.0	45.5	15.4	15.1	32.9
.22..........	92.5	62.5	21.5	22.0	45.0
.26..........	....	86.0	29.0	30.5	60.0
.45..........	....	....	76.5	....	155
.6..........	....	....	....	....	....
.8..........	....	....	....	....	....

Table 6.—*Storage requirements in the Yadkin-Pee Dee River basin, 1929–53*—Continued

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	53. Falling Creek near Rockingham	54. North Fork Jones Creek near Wadesboro[c]	55. Marks Creek near Osborne	56. Drowning Creek near Jackson Springs	57. Deep Creek near Roseland
Drainage area sq miles..	6.0	10.0	29.2	30.5	18.9
Average..........	0.95	0.64	0.91	1.1	0.96
Regulated:					
0.002..........	....	....	....	....	....
.006..........	....	....	....	....	....
.012..........	....	....	....	....	....
.03	....	....	....	....	....
.04	....	1.56	....	....	....
.05	....	2.45	....	....	....
.07	....	4.25	.010	....	....
.08	....	5.15	.062	....	....
.1............	....	7.65	.355	.115	....
.13	....	12.1	1.35	.680	....
.14	.0104	13.9	1.75	1.00	....
.18	.540	21.1	4.15	2.65	....
.22	2.15	29.5	7.15	5.00	.070
.26	4.65	38.5	11.0	8.10	.70
.45	27.0	....	37.0	31.5	14.5
.6............	82.0	....	66.5	58.0	37.5
.8............	120	....	115	100	88.5

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow				
	58. Drowning Creek near Hoffman	59. Lumber River near Pembroke	60. Little Raft Swamp at Red Springs	61. Raft Swamp near Lumberton	62. Big Swamp near Tarheel
Drainage area sq miles..	178	421	23.1	107	225
Average..........	0.937	0.94	0.53	0.37	....
Regulated:					
0.002..........	....	....	....	....	....
.006..........	....	....	....	....	.0165
.012..........	....	....	....	.030	.094
.03	....	....	....	.405	.785
.04	....	....	.375	.90	1.45
.05	....	....	.900	1.60	2.30
.07	....	....	2.20	3.50	4.70
.08	....	....	3.05	4.75	6.10
.1............	....	....	5.00	7.70	9.70
.13	.05	....	8.70	13.3	16.0
.14	.150	....	10.1	15.5	19.0
.18	1.3	.040	16.8	25.0	30.5
.22	3.35	.500	24	36.5	46.0
.26	6.25	1.65	33.6	50	64.0
.45	31.5	20.5	115	....	....
.6............	64.0	48.5	....	....	....
.8............	....	110	....	....	....

[c]Based on records collected prior to construction of reservoir and diversion above station by town of Wadesboro for water supply beginning in 1941.

Table 6.—*Storage requirements in the Yadkin-Pee Dee River basin, 1929–53*—Continued

Flow (mgd per square mile)	Storage required, in million gallons per square mile, to maintain a regulated flow			
	63. Lumber River at Boardman	64. Gum Swamp Creek near Laurinburg	65. Shoeheel Creek near Laurinburg	66. Waccamaw River at Freeland
Drainage area.......sq miles..	1,220	42.4	84.5	626
Average..........................	0.650	0.99	0.70	0.659
Regulated:				
0.002...........................	....	....	....	.060
.006...........................	....	....	....	.405
.012...........................	....	....	....	1.23
.03...........................	....	....	....	3.85
.04...........................	....	....	....	5.80
.05...........................	....	....	....	7.90
.07...........................	.069	....	....	12.5
.08...........................	.245	....	....	15.0
.1...........................	1.10	....	.003	20.5
.13...........................	3.35	....	.30	29.0
.14...........................	4.0	....	.60	32.5
.18...........................	8.6	....	2.60	45.0
.22...........................	15.0	....	5.80	60.5
.26...........................	22.5	....	10.0	79.0
.45...........................	74.0	5.25	46.0	191
.6...........................	....	26.5	100	....
.8...........................	....	85.0	....	....

However, there are problems in which data on flood frequencies at certain times of the year are needed. To meet this need, summer and winter flood frequency curves are presented. The summer period extends from May 1 to October 31, and the winter period is the remaining 6 months of the year. These curves may be used to determine the probability of occurrence of a given flood in the selected season.

For example suppose that a construction project is proposed for a location in the vicinity of Rocky River near Norwood at an elevation of 237 feet above sea level. By use of figure 19 recurrence interval of winter floods reaching that height may be determined as 5.3 years. This means that there is about a 1 to 5 chance that the work will be interrupted by flooding if it is done in a winter season. Similarly, from the curve for summer floods the chances are about 1 to 4 that the work would be interrupted if it is done in a summer season. In the example cited the probability of flooding is greater in summer than in winter. Conversely, if the elevation at the proposed project site is lower than 234 feet above mean sea level the curves in figure 19 indicate that the probability of flooding in summer is less than in winter but, of course, much greater than at higher elevations. The curve for summer floods could also be used to evaluate the risk of farming on a flood plain or of putting the flood plain to other seasonal use.

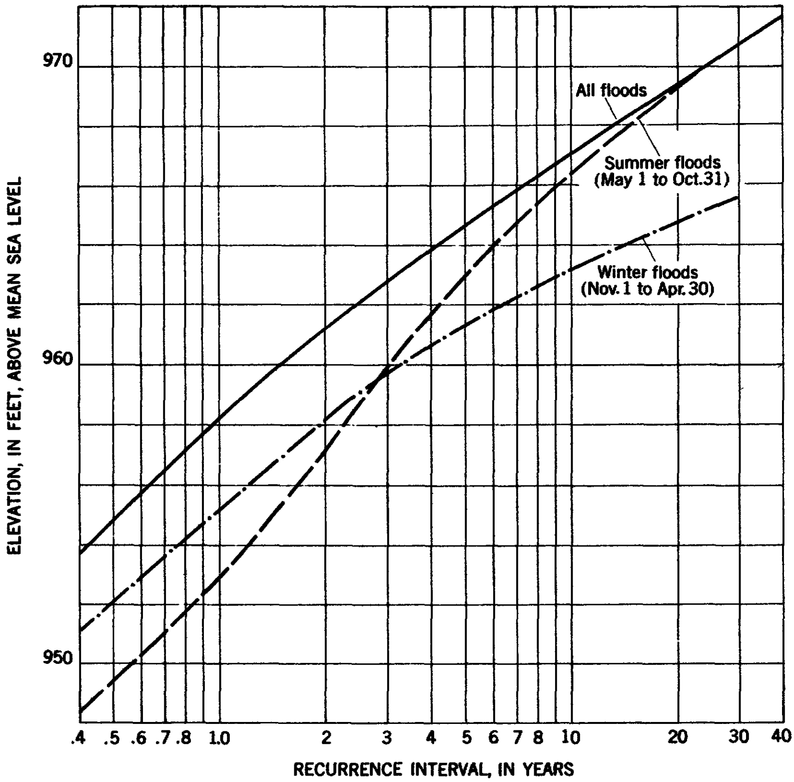


Figure 17. —Flood-stage frequencies, Yadkin River at Wilkesboro.

In general, the curve for frequency of all floods should be used in design of structures that are made to last for several years and the seasonal curves to evaluate the risk of flooding in a single season. The design of dam spillways or other structures, whose failure will result in considerable damage or loss of life downstream, is usually based on analyses involving maximum known floods rather than a flood of a specified frequency.

QUALITY OF SURFACE WATERS

Chemical quality of water in the Yadkin-Pee Dee River basin was first studied in 1906. Daily samples were collected from the Pee Dee River near Pee Dee for a period of 1 year and samples were collected intermittently and analyzed during the year 1925–26. A continuing cooperative program to determine the chemical quality of surface waters in North Carolina was established in 1943, between the U. S. Geological Survey and the North Carolina

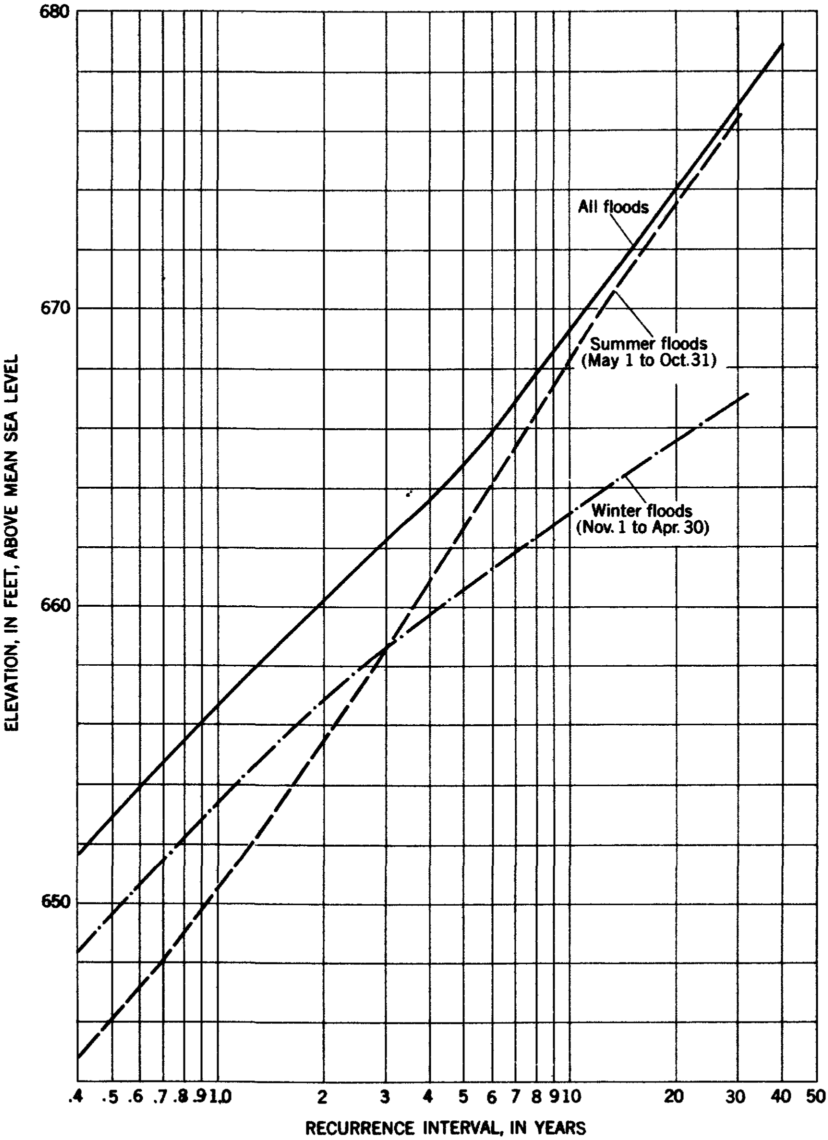


Figure 18. —Flood-stage frequencies, Yadkin River at Yadkin College.

Department of Conservation and Development. Eleven daily and 5 monthly sampling stations for chemical quality studies have been in operation on streams in the Yadkin-Pee Dee River basin for at least 1 year since 1943. Data for these stations are summarized in table 7. In addition to the daily and monthly sampling stations, samples for chemical analyses have been collected intermittently at all complete and partial-record gaging stations

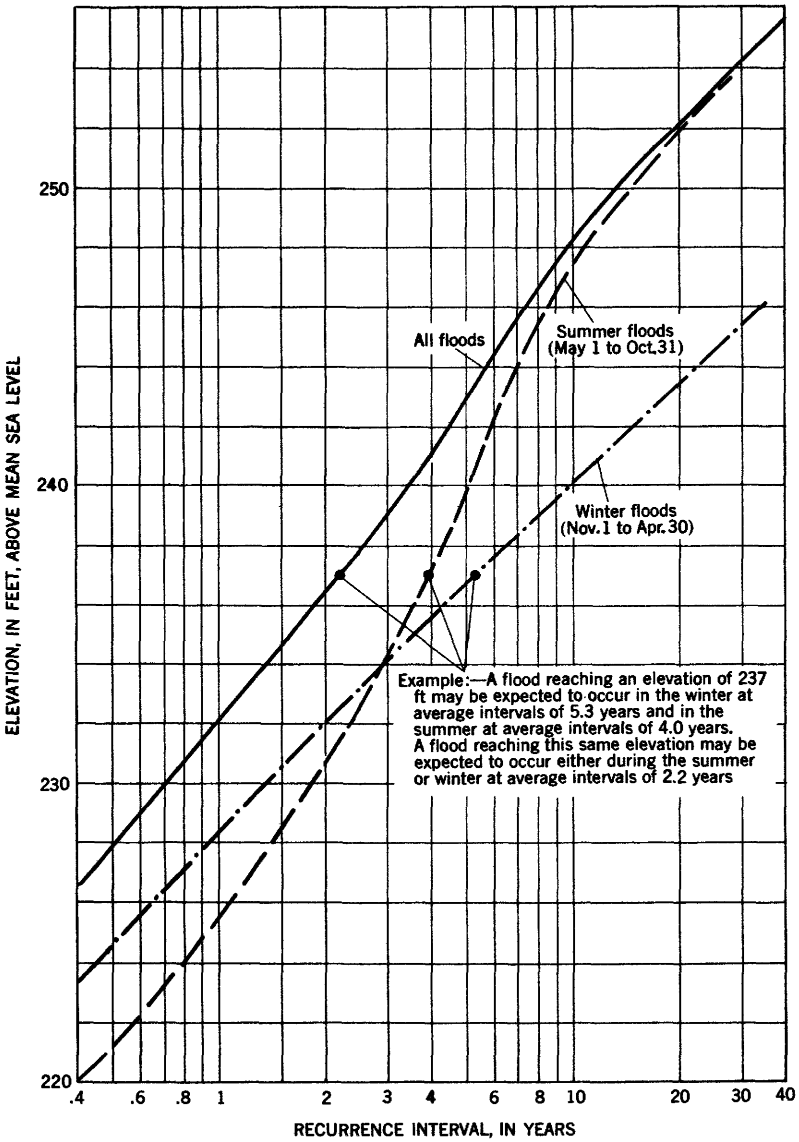


Figure 19.—Flood-stage frequencies, Rocky River near Norwood.

within the basin. These data are published annually in North Carolina Department of Conservation and Development, Bulletin 52. Figure 21 shows the average chemical composition of the dissolved solids of the surface water at each of the daily sampling stations in the basin during the period 1943–53. The relation of hardness to dissolved solids in surface waters in the Yadkin-Pee River basin is shown in figure 22.

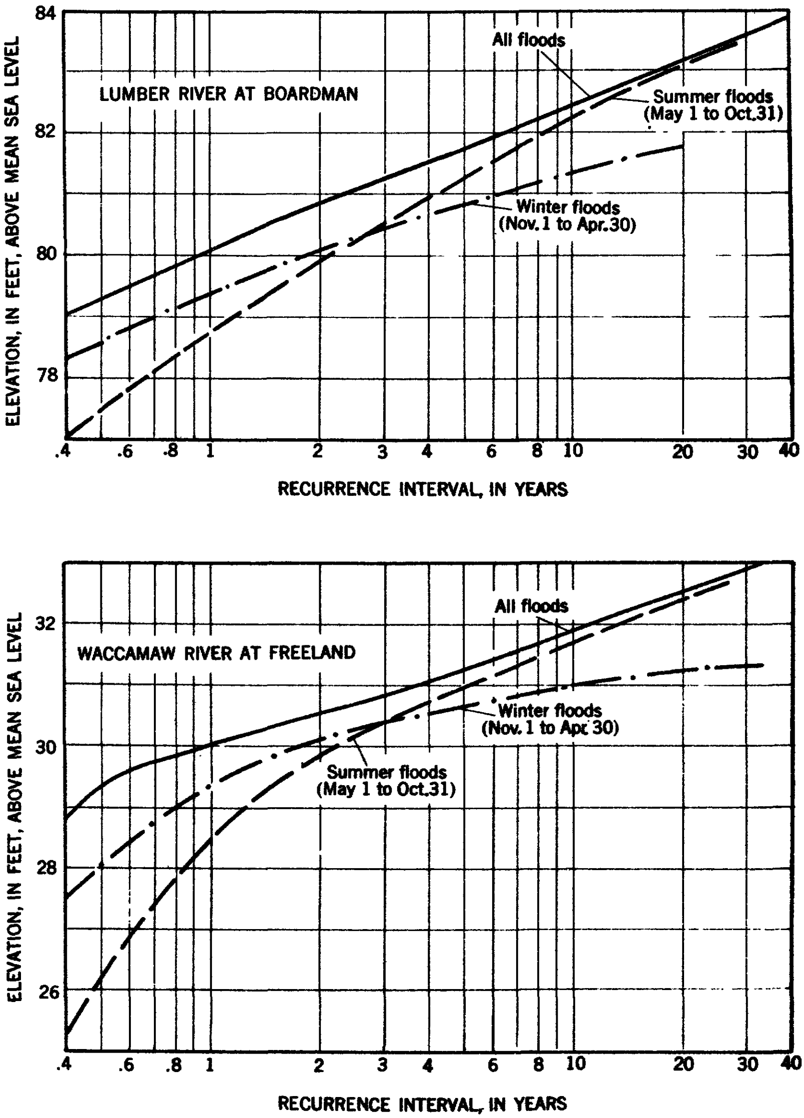


Figure 20. —Flood-stage frequencies, Lumber River at Boardman and Waccamaw River at Freeland.

The relation between streamflow and the chemical and physical characteristics of Rocky River near Norwood during the 1948 water year is shown in figure 23. The hardness, chloride, and dissolved solids fluctuated inversely as the rate of streamflow, being highest during October, May, and September when streamflow was at its lowest.

Table 7.—*Summary of chemical analyses of water from streams in the Yadkin-Pee Dee River basin*

[Chemical constituents in parts per million. See figure 5 for location of gaging stations]

	1, Yadkin River at Patterson Oct. 1947 to Sept. 1948			5, Yadkin River at Wilkesboro Oct. 1947 to Sept. 1948			10, Fisher River near Copeland Oct. 1947 to Sept. 1948		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Discharge ... cfs	402	17	56.3	5,440	277	946	1,520	61	194
Silica (SiO_2)	12	8.9	11	14	9.7	12	11	5.8	8.5
Iron (Fe)	.06	.02	.03	.13	.01	.04	.09	.01	.04
Calcium (Ca)	3.2	1.4	2.2	3.3	1.8	2.3	2.8	1.6	2.1
Magnesium (Mg)	1.3	.8	1.0	1.4	.7	1.0	1.2	.8	1.0
Sodium (Na) Potassium (K)	5.0	2.4	3.3	5.3	1.8	3.3	3.4	.6	2.2
Bicarbonate (HCO_3)	19	11	15	20	12	15	15	9	11
Sulfate (SO_4)	2.6	1.5	2.0	3.0	1.4	2.1	3.8	1.2	2.4
Chloride (Cl)	1.8	1.0	1.3	2.2	1.0	1.4	2.0	.9	1.2
Fluoride (F)	.3	.0	.1	.2	.0	.1	.1	.0	.1
Nitrate (NO_3)	.6	.0	.3	.5	.0	.3	.5	.1	.2
Dissolved solids (residue on evaporation at 180°C)	32	24	29	37	27	32	30	22	25
Hardness as $CaCO_3$	13	7	10	14	6	10	11	7	9
Color ... units	24	3	8	14	2	7	16	2	5
pH	7.4	6.6	6.9	7.6	6.6	7.0	7.2	6.5	6.8
Specific conductance ... micromhos at 25°C	....	....	....	....	....	....	....	....	....

Table 7.—*Summary of chemical analyses of water from streams in the Yadkin-Pee Dee River basin*—Continued

	19, Yadkin River at Yadkin College						23, Hunting Creek near Harmony			24, South Yadkin River at Cooleemee		
	Oct. 1943 to Sept. 1944			Oct. 1950 to Sept. 1951			Oct. 1952 to Sept. 1953			Oct. 1947 to Sept. 1948		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Discharge.....cfs..	19,400	898	2,653	17,500	895	2,555	2,490	44	155	5,180	87	788
Silica (SiO_2).....	14	9.4	11	18	6.2	13	13	7.3	11	14	8.9	12
Iron (Fe).....	.30	.01	.04	.10	.01	.05	.17	.03	.07	.05	.01	.03
Calcium (Ca).....	4.2	2.6	3.3	4.4	2.5	3.8	3.5	2.0	2.4	4.5	2.4	3.2
Magnesium (Mg).....	1.6	.9	1.2	1.5	.8	1.2	1.1	.3	.8	1.8	1.1	1.4
Sodium (Na)..... Potassium (K).....	7.1	3.2	4.7	15	3.6	5.9	5.3	2.9	3.8	5.4	1.4	3.4
Bicarbonate (HCO_3).....	26	13	19	44	15	21	17	10	14	24	14	19
Sulfate (SO_4).....	4.2	2.5	3.1	6.7	2.8	3.9	3.3	1.2	2.0	3.5	1.6	2.3
Chloride (Cl).....	3.0	1.5	2.4	8.1	2.1	3.4	2.5	1.5	2.1	2.2	1.2	1.8
Fluoride (F).....	.1	.0	.1	.2	.0	.1	.1	.0	.1	.2	.0	.1
Nitrate (NO_3).....	2.1	.0	1.1	1.5	.5	.9	1.6	.0	.6	.8	.2	.4
Dissolved solids (residue on evaporation at 180°C).....	47	32	41	85	34	45	36	26	31	42	30	36
Hardness as $CaCO_3$.....	17	10	13	17	11	14	12	7	9	17	10	14
Color.....units..	19	3	8	20	3	6	40	3	12	22	2	6
pH.....	....	....	....	8.4	6.2	6.7	7.8	6.0	6.7	7.4	6.5	6.9
Specific conductance micromhos at 25°C..	....	....	....	88.1	43.4	55.2	40.8	26.7	31.4	....	....	....

Table 7.—*Summary of chemical analyses of water from streams in the Yadkin-Pee Dee River basin*—Continued

	25, Third Creek at Cleveland Oct. 1949 to Sept. 1950			31, Abbotts Creek at Lexington Oct. 1947 to Sept. 1948			35, Yadkin River at High Rock Oct. 1947 to Sept. 1948			38, Uwharrie River near Eldorado Oct. 1947 to Sept. 1948		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Discharge..........cfs..	853	46	92.4	2,290	10	185	37,700	34	5,795	5,840	11	403
Silica (SiO_2)..........	26	15	20	23	11	18	14	7.2	11	18	6.6	13
Iron (Fe)..........	.23	.02	.06	.07	.01	.03	.27	.01	.03	.16	.02	.05
Calcium (Ca)..........	8.8	4.8	6.1	12	5.4	8.7	5.5	3.2	3.9	7.5	3.1	5.8
Magnesium (Mg)..........	2.9	2.0	2.4	4.0	2.1	3.3	1.9	1.3	1.6	3.4	1.4	2.7
Sodium (Na).......... Potassium (K)..........	7.5	3.4	5.0	31	6.8	12	9.9	3.3	5.1	7.6	2.9	5.2
Bicarbonate (HCO_3)..........	39	26	34	70	24	46	29	15	21	44	13	32
Sulfate (SO_4)..........	8.4	2.5	3.5	11	6.2	8.3	5.7	2.1	4.1	6.8	2.8	4.2
Chloride (Cl)..........	5.0	1.2	2.9	23	4.5	9.6	3.8	2.2	3.0	3.8	2.0	3.2
Fluoride (F)..........	.4	.0	.1	.3	.1	.2	.3	.0	.1	.3	.0	.1
Nitrate (NO_3)..........	1.0	.3	.6	2.4	.3	1.1	1.6	.3	.8	.8	.1	.5
Dissolved solids (residue on evaporation at 180°C	70	50	59	136	58	89	53	36	44	67	34	55
Hardness as $CaCO_3$..........	34	21	25	46	22	35	21	13	16	33	14	26
Color..........units..	12	2	5	36	3	13	24	2	11	44	4	18
pH..........	7.1	6.5	6.8	7.3	6.7	7.0	7.2	6.5	6.9	7.3	6.6	7.1
Specific conductance micromhos at 25°C..	85.9	57.0	72.4	....	....	....	....	....	....	....	....	....

Table 7.—*Summary of chemical analyses of water from streams in the Yadkin-Pee Dee River basin*—Continued

	43, Bear Creek near Albemarle Oct. 1951 to Sept. 1952			45, Rocky River near Norwood			52, Pee Dee River near Rockingham Oct. 1946 to Sept. 1947			52, Pee Dee River near Rockingham Oct. 1947 to Sept. 1948		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Discharge........cfs..	....	....	....	30,600	69	1,783	43,900	314	6,091	78,300	458	9,735
Silica (SiO_2)........	13	4.8	9.9	16	3.8	11	13	4.7	9.9	12	7.7	10
Iron (Fe)........	.21	.03	.08	.23	.01	.03	.09	.02	.03	.24	.01	.04
Calcium (Ca)........	7.4	3.3	5.1	11	3.4	6.4	5.2	3.8	4.3	5.5	3.2	4.1
Magnesium (Mg)........	3.0	1.7	2.3	4.8	1.8	2.9	2.1	1.6	1.8	2.6	1.3	1.7
Sodium (Na)........ Potassium (K)........	8.3	3.7	5.9	45	5.5	14	9.8	4.9	6.6	9.4	4.1	5.5
Bicarbonate (HCO_3)........	34	8	23	109	16	41	30	18	24	32	15	22
Sulfate (SO_4)........	8.1	3.3	5.6	14	5.9	8.4	6.5	3.8	4.8	5.7	3.4	4.6
Chloride (Cl)........	8.6	4.0	5.7	30	4.0	10	8.8	3.1	4.6	6.9	2.5	3.9
Fluoride (F)........	.2	.0	.1	.3	.1	.2	.2	.0	.1	.9	.0	.2
Nitrate (NO_3)........	22	.2	2.6	2.4	.1	.8	1.7	.4	.9	2.7	.5	.9
Dissolved solids (residue on evaporation at 180°C)........	82	40	53	172	43	79	57	44	50	54	38	46
Hardness as $CaCO_3$........	30	15	22	47	16	28	21	16	18	24	13	17
Color........units..	25	4	13	34	6	15	52	3	20	36	3	13
pH........	7.4	5.7	6.7	7.7	6.5	7.1	7.25	6.4	6.9	7.5	6.5	6.9
Specific conductance micromhos at 25°C..	94.8	54.2	75.3	....	....	....	....	....	....	....	....	....

Table 7.—*Summary of chemical analyses of water from streams in the Yadkin-Pee Dee River basin*—Continued

	56, Drowning Creek near Hoffman Oct. 1946 to Sept. 1947			63, Lumber River at Boardman Oct. 1946 to Sept. 1947			66, Waccamaw River at Freeland Oct. 1950 to Sept. 1951		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Discharge...cfs..	1,040	73	241	3,750	280	1,112	1,250	15	377
Silica (SiO_2)	6.8	1.3	3.9	9.1	0.8	5.5	9.4	2.2	6.0
Iron (Fe)	.06	.02	.03	.36	.02	.07	.42	.05	.20
Calcium (Ca)	2.4	.7	1.1	2.6	1.2	1.8	8.2	3.2	4.8
Magnesium (Mg)	.7	.3	.5	1.2	.6	.8	1.6	.8	1.1
Sodium (Na) Potassium (K)	4.0	1.8	2.9	5.4	2.1	3.7	20	1.6	4.8
Bicarbonate (HCO_3)	8.0	5.0	6.0	10	4.0	6.2	41	6	10
Sulfate (SO_4)	2.7	1.3	1.9	6.7	2.5	3.6	15	2.2	4.9
Chloride (Cl)	4.0	2.5	2.9	6.5	3.4	4.8	16	7.4	9.0
Fluoride (F)	.1	.0	.0	.2	.0	.0	.2	.0	.0
Nitrate (NO_3)	.6	.1	.2	1.0	.1	.3	1.2	.1	.3
Dissolved solids (residue on evaporation at 180°C)	37	19	26	59	28	45	116	56	72
Hardness as $CaCO_3$	9	3	5	11	6	8	27	12	16
Color...units..	88	28	49	170	52	103	220	75	120
pH	6.3	5.25	6.0	6.05	5.05	5.6	6.9	5.3	5.8
Specific conductance...micromhos at 25°C..	...	...	...	...	...	...	155	46.2	59.2

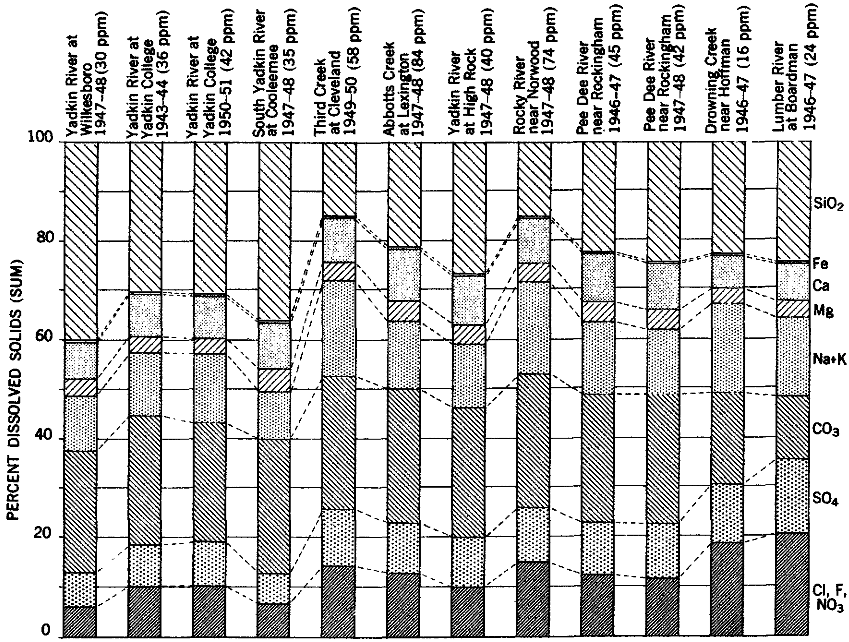


Figure 21. —Average composition of dissolved solids in surface waters in the Yadkin-Pee Dee River basin.

The Yadkin River at Patterson, the uppermost stream gaging station in the basin where chemical quality of water is determined, is of excellent chemical quality that is uniformly low in mineral content. For the period October 1947 to September 1948 the dissolved solids ranged from 24 to 32 ppm and the hardness ranged from 7 to 13 ppm. The mineral content of the water from the Yadkin River at Wilkesboro is comparable to that from the river at Patterson. A daily sampling station for chemical quality of water studies was in operation on the Yadkin River at Yadkin College during the period October 1943 to September 1944 and again from October 1950 to September 1951. The range in quality of the water was small during the two periods; however, a greater range in chemical quality was noted for the 1951 water year than for the 1943 water year. During the 1943 water year the dissolved solids ranged from 32 to 47 ppm whereas during the 1951 water year the dissolved solids ranged from 34 to 85 ppm.

The water from South Yadkin River, a major tributary to the Yadkin River, would generally be suitable for an industrial or public water supply on the basis of mineral content. The uniformity of the low dissolved solids and low hardness makes it very desirable for most uses. During periods of high runoff the stream appears to carry large quantities of suspended sediment.

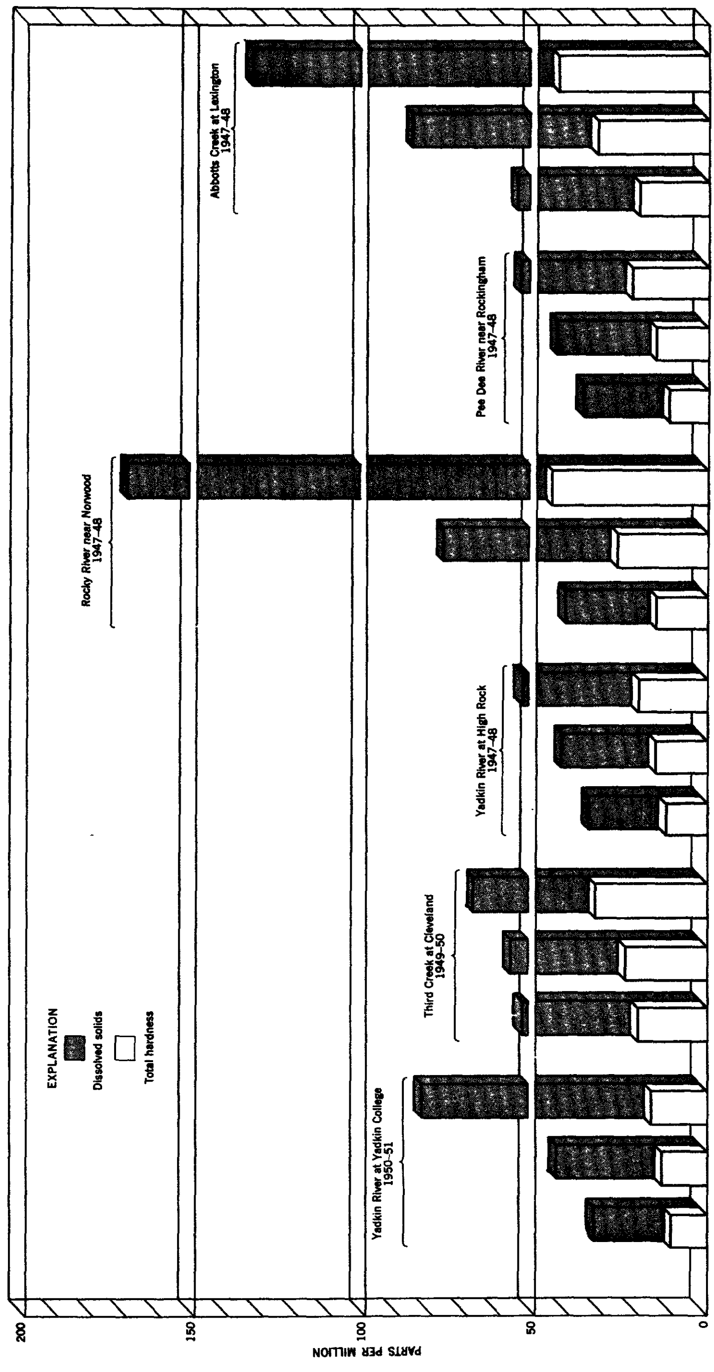


Figure 22. —Relation of hardness to dissolved solids of surface waters in the Yadkin-Pee Dee River basin.

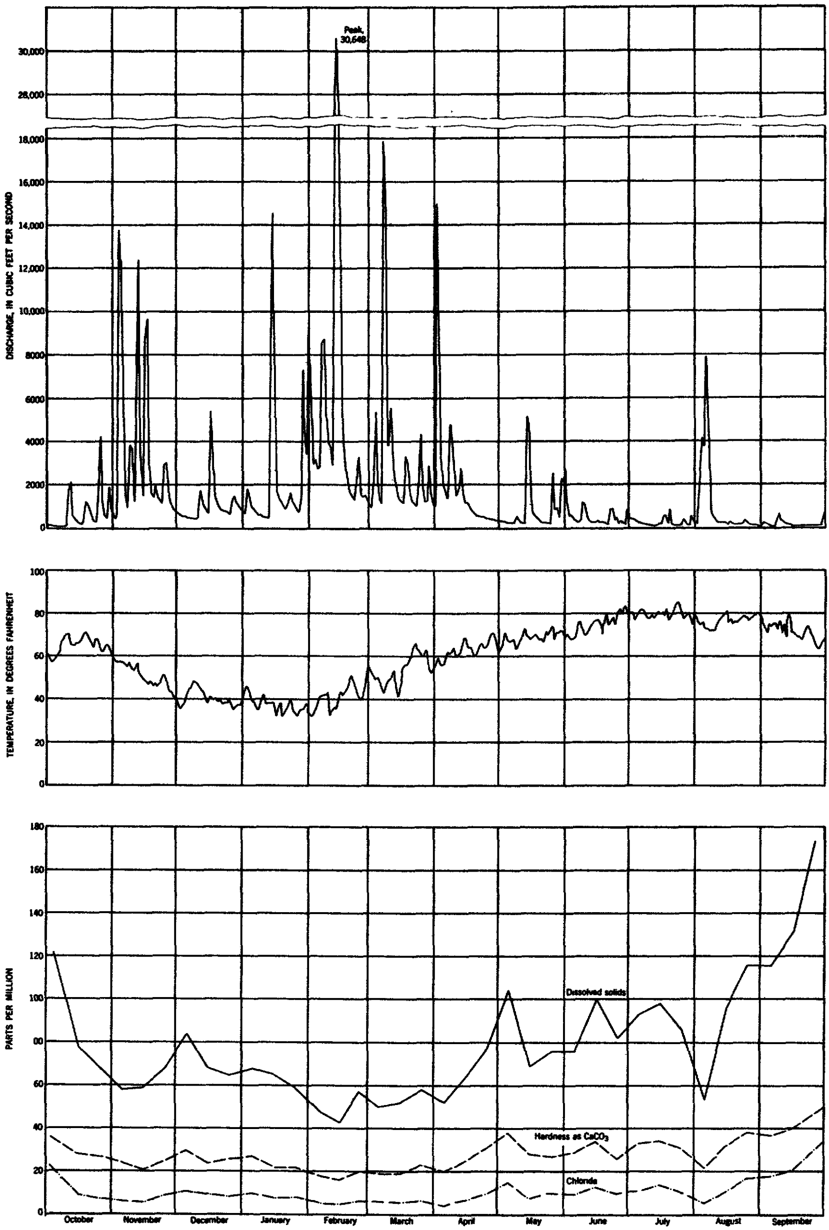


Figure 23. —Relation between streamflow and selected chemical and physical characterisitcs of Rocky River near Norwood, 1947-48.

Abbotts Creek, source of water supply for Lexington, is more variable in chemical quality than many of the tributaries of the Yadkin River. The dissolved solids ranged from 58 to 136 ppm and the hardness ranged from 22 to 46 ppm during the 1948 water year. Objectionable amounts of color (as much as 36 units) occurred during the period of record.

According to the data obtained, the chemical character of the water from Rocky River near Norwood varied more than from any of the other streams in the Yadkin-Pee Dee River basin. The dissolved solids ranged from 43 to 172 ppm, and hardness ranged from 16 to 47 ppm. The chloride ranged from 4.0 to 30 ppm, which is considerably greater than for other streams in the area, indicating either ground-water inflow or pollution.

Although the chemical quality of the water from the Pee Dee River near Rockingham is good, the mineral content increased slightly from Wilkesboro to Rockingham.

Except for excessive iron and color, the chemical quality of the water from Waccamaw River at Freeland and Lumber River at Boardman is good. Swamp drainage flowing into the two streams contributes colored waters.

In 1951 a sedimentation program to determine the amount of suspended sediment being transported by the Yadkin River was begun. One daily-sampling station was established on the Yadkin River at Yadkin College. The relation between streamflow and the amount of suspended sediment being transported on the Yadkin River at Yadkin College for the 1953 water year is shown in figure 24.

GROUND WATER

OCCURRENCE OF GROUND WATER

Ground water occurs throughout the Yadkin-Pee Dee River basin in the open spaces within the rock materials below the water table. There is a great range in number, size, and shape in the open spaces containing the water. In the sedimentary rocks, such as sand and clay, a large number of relatively small interstices occur, whereas in igneous and metamorphic rocks, such as granite and slate, the pore spaces are restricted to fractures. The nature of the open spaces determines the porosity, which is generally expressed as the percentage of total volume not occupied by solid material. Rocks of low porosity are not capable of absorbing, holding, or yielding much water. Rocks of high porosity may yield considerable water, although this is not necessarily true. Some

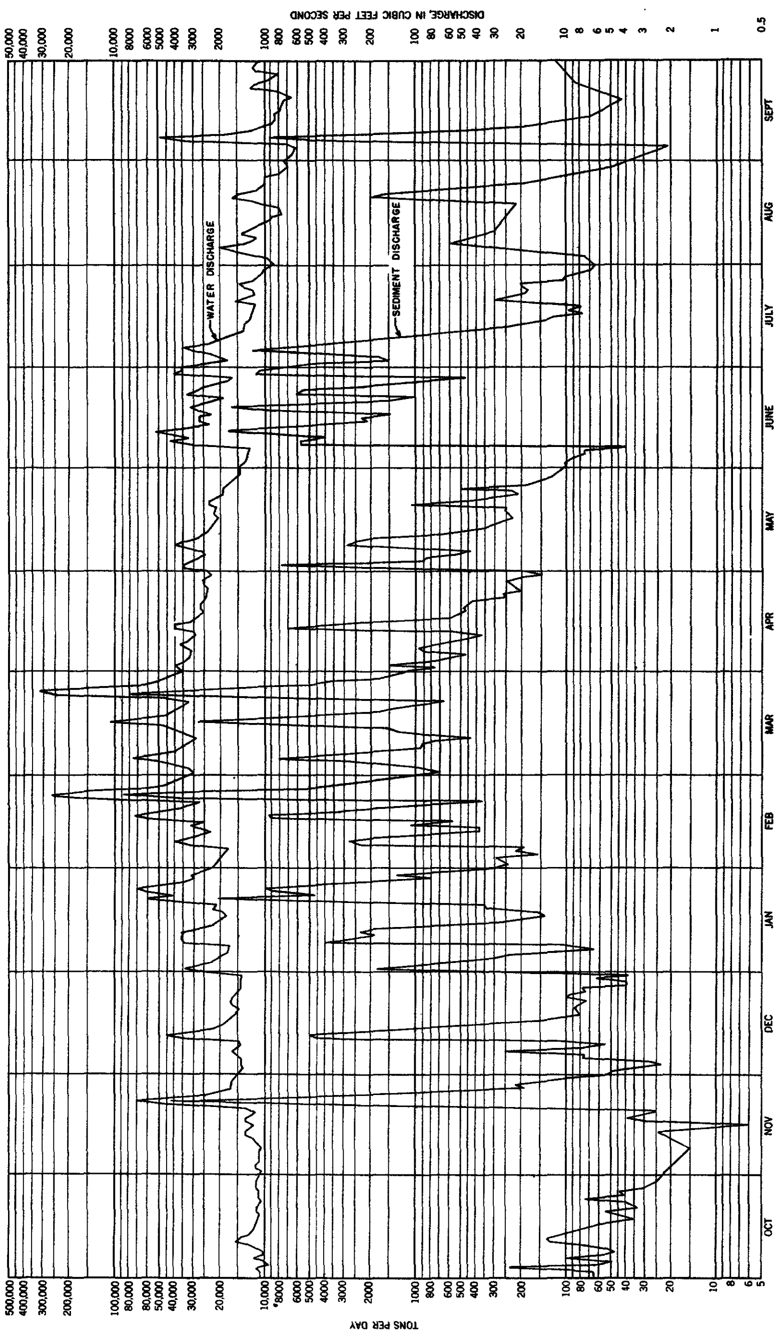


Figure 24. —Relation between streamflow and suspended sediment in Yadkin River at Yadkin College, 1952-53.

sands and some clays have approximately the same porosity, although the sands will yield water to wells or springs more readily than will the clays. The difference lies in the ability of the clays to hold much water by molecular attraction (high specific retention) and in the ability of the sands to allow the water to move by gravity through the pore space (high permeability). The capacity of rock formations to absorb water during periods of surplus and to store it where it can be withdrawn from wells on a perennial basis is an important asset to any area, the larger the storage capacity and the more productive the wells the greater the asset.

Although the storage facilities of the rock formations, or underground reservoirs, are good, the sustained yield of water to wells and springs is not necessarily assured. The openings must be interconnected sufficiently to allow water to be transmitted in the rocks as in a network of pipes. Water can thus be transmitted from distant parts of the underground reservoir to a pumped well. As pumping of a well continues, more water is drawn from storage and water levels decline. Unless the reservoir has facilities for taking in new water to replenish that withdrawn, there can be no sustained yield. The limit of perennial yield is controlled by the replenishment, or recharge, to the reservoir. Fortunately, in the Yadkin-Pee Dee River basin, precipitation is great enough and is distributed throughout the year evenly enough to keep the underground reservoirs full to overflowing most of the time.

Water leaks out of the underground reservoirs through springs or seeps. This discharge demonstrates the existance of natural movement of water, but movement is extremely slow, generally not exceeding a few feet per day. Ground water moves by gravity from recharge areas through the reservoir to areas of natural discharge, and through the years the average recharge to the reservoir is equal to the average discharge from it. Discharge facilities, and the consequent movement of water from the recharge area, are necessary to purge the underground reservoir of highly mineralized water. Some of the artesian formations in the southeast part of the basin still contain salty water that has not been flushed out since the beds were filled with it.

When wells are put down, unsaturated sand, clay, and other rock materials are found to extend from the surface to a depth ranging from a few inches to as much as 60 feet in this basin. Beneath the unsaturated zone is a zone where all the pore spaces are filled with water under hydrostatic pressure. This is known as the zone of saturation and the top of it is the water table. In a general sense the water table is a subdued image of the surface topography. It rises higher under the hills than in valleys, although it lies deeper under the hills. Water-table conditions exist in the near-surface rocks throughout the basin area.

In the Coastal Plain there are many alternating layers of permeable sand and impermeable clay sloping southeastward. The slope of the beds is slightly greater than the slope of the land surface, and water, entering the sand beds at high elevations, moves southeastward to exert pressure on the water already confined in the sand beds between clay beds. Water thus confined under pressure is known as artesian water. The artesian water level of each sand bed is generally within a few feet of the land surface, even though the bed itself may lie hundreds of feet below, and in much of the low areas to the southeast artesian wells will overflow.

GEOLOGY

The geology of the basin influences both the ground-water and surface-water resources. In general, steep slopes and impermeable rocks favor rapid runoff and low infiltration capacity. Conversely gentle slopes and permeable materials at the surface favor recharge to the underground reservoirs,so that the streams have a relatively good flow in long periods of fair weather. The movement and storage of ground water depend on several geologic factors, including the type of rock, the compactness and arrangement of the mineral grains, and the way the rocks are fractured.

The western or Piedmont half of the basin is underlain by dense, ancient rocks of complex character and structure. In general, they include granite and related crystalline rocks, slate, and some compact shale and sandstone. Their porosity and permeability are generally low. In the eastern half of the basin (the Coastal Plains) the ancient rocks are overlain by beds of younger, relatively unconsolidated sand and clay. These beds slope eastward a little more steeply than does the land surface, and, consequently, any given bed is buried progressively deeper toward the coast. These beds increase in total thickness to the east and reach a maximum thickness of more than 1,000 feet in the easternmost part of the basin. With the exception of a thin mantle of sand and clay at the surface, the sediments of the Coastal Plain are composed of three Upper Cretaceous formations, which are, from oldest to youngest, the Tuscaloosa, Black Creek, and Peedee formations.

ROCKS OF THE PIEDMONT

Granite and schist.—Northwest of a line extending northeastward through central Cabarrus, Rowan, and Davidson Counties is a sequence of crystalline rocks, composed principally of granite and schist. The schist is laminated and contains mica and quartz and varying amounts of feldspar and accessory minerals, representing sedimentary rocks that have been metamorphosed by great heat and pressure, deformed, and tipped on edge. They have been invaded by molten magma which rose from below and solidified as it cooled. The cooled intrusive rocks are chiefly light-colored granite and dark-colored diorite, but for convenience in this report all intrusive rocks are called granite. The granite occurs as large, massive bodies, such as those in the vicinity of Mount Airy in Surry County and Granite Quarry in Rowan County, and as thin lenticular bands enclosed in the schist. The schist and thin bodies of enclosed granite commonly trend northeastward, although no brief statement can adequately describe the complex arrangement of the rocks in the granite and schist sequence.

Volcanic rocks and slates.—Southeast of the granite-schist belt is a northeastward-trending belt of slate or slatelike rocks. These rocks represent a series of old volcanic rocks and include interbedded tuff, lava flows, and slate. Most of the rocks of this series are dense and fine grained, being composed largely of minerals rich in silica. However, there is no basalt, a common type of volcanic rock in many other parts of the earth. The rocks have been folded and tilted so that the total thickness is obscured in the repetition of beds that occurs in the belt, which is more than 25 miles wide. Joints and other fractures are common in the exposed rocks.

Newark group.—In a belt roughly 10 miles wide, which lies along the eastern part of the Piedmont is a group of rocks of Triassic age, known as the Newark group from rocks of similar age and type at Newark, N. J. These rocks consist chiefly of red to brown shale, claystone, and sandstone beds. They were deposited as interbedded lenses in a subsiding inland basin or trough, which trends northeastward. They have been hardened by compaction and cementation so that the original pore spaces have been filled with cemented material. The strata commonly have a slight dip to the southeast.

ROCKS OF THE COASTAL PLAIN

Tuscaloosa formation.—The basal formation of the Coastal Plain is the Tuscaloosa formation of Late Cretaceous age, which lies on the buried surface of the dense rocks exposed in the Piedmont region. It is the formation underlying the "Sand Hill country" of Moore, Richmond, Scotland, and Hoke Counties. It is composed of gray, red, and tan sand and clay. The strata are not well defined and generally do not contain well-sorted material. The formation increases in thickness from a featheredge at the western edge of the Coastal Plain to approximately 300 feet in Robeson County. It probably thickens even more to the southeast, although no wells have been drilled through it to the basement rocks in that area.

The Tuscaloosa dips southeastward at a rate greater than that of the land surface, probably greater than 15 feet per mile.

Black Creek formation.—The Black Creek formation, also of Late Cretaceous age, crops out in a belt southeast of the belt of outcrop of the Tuscaloosa formation. However, actual exposures of the Black Creek formation are rare because of an overlying thin cover of surficial sand and clay. The Black Creek is the near-surface formation throughout Robeson County. It dips gently to the southeast and increases wedgelike in thickness to several hundred feet in the eastern part of the basin. It consists of dark-gray to black laminated clay beds alternating with strata of fine- to medium-grained sand. The clay commonly contains black woody material, and some of the beds of sand in the upper part of the formation contain the green mineral glauconite. A few beds contain fossils.

Peedee formation.—The Peedee formation, also of Late Cretaceous age, overlies the Black Creek formation and constitutes the near-surface formation in the Columbus and Brunswick County part of the basin. It dips and thickens to the southeast, but its thickness and character beneath the surface have not been determined. Like the Black Creek formation that underlies it, the Peedee consists of interbedded strata of sand and dark clay. The sand commonly contains glauconite. Thin beds of limestone occur at various levels in the formation, becoming more prevalent toward the coast.

Undifferentiated surficial deposits.—Overlying the Black Creek and Peedee formations are thin deposits of sand and clay that cannot everywhere be assigned to a geologic formation. Some of the deposits may have originated by weathering and by soil-forming processes from the underlying formations. In other places they are a thin veneer of sand and clay deposited when the sea invaded the area during the Pleistocene epoch, or Ice Age. In the easternmost part of the basin, scattered deposits of limestone, or shell rock, of Eocene or Miocene age, lie on the Peedee formation. The extent of the limestone has not been determined, but its maximum thickness probably does not greatly exceed 30 feet.

GROUND-WATER PROVINCES

The ground-water conditions are far from uniform throughout the Yadkin-Pee Dee River basin. Not only do they vary from one rock type, or formation, to another, they also vary to some extent from place to place within each formation. Several water-bearing units, or aquifers, are distinguished in the Yadkin-Pee Dee River basin on the basis of differences in the lithology and structure of the rocks and in the yield of wells and quality of the water. These ground-water units may consist of one formation, or several formations, having similar hydrologic properties. The quantity and quality of water that can be obtained from each water-bearing unit varies with the type of well and its location and depth. The areal extent of these units is shown in plate 3. These units have been grouped in a simplified manner in order to depict the ground-water resources conveniently. The indicated boundaries between the provinces are approximate.

The chemical quality of the ground water in the Yadkin-Pee Dee River basin is summarized in table 8. Selected analyses of water from each ground-water province are presented graphically in figure 25.

CRYSTALLINE-ROCK PROVINCE

The crystalline-rock province is underlain by dense, massive granitelike rocks and schists or foliated rocks in the mountains and northwestern part of the Piedmont. The crystalline rocks are too dense to contain a continuous network of pore spaces. As a result, usable water in the hard rock occurs only in joints and along planes separating some of the beds. (All such openings hereinafter are called joints.) Above the hard rock is loose rock material that includes the soil zone near the surface and soft, decayed rock material below. All this soft material is commonly called mantle rock and is the medium through which water passes from its infiltration at the surface to its entrance into the joints in the rocks beneath.

The mantle rock contains materials of different permeability but clay is present in sufficient amounts to give the mantle rock a low average permeability. The mantle rock ranges from a few feet to several tens of feet deep. In most places the water table lies in the mantle rock. As a result, shallow wells developed in the mantle rock generally yield a few gallons of water per minute, enough for normal rural domestic use. During some dry periods the water table declines below the bottom of some of the shallow wells, causing them to go dry.

For supplies greater than a few gallons per minute, deep wells may be drilled into the hard, dense rock. These wells draw water from the joints in the rocks. The joints are not evenly distributed, some being a few inches and others many feet apart. Some are only a fraction of an inch wide, although there is a great variation in size of openings. The size and number of joints decrease with depth. To a depth of about 150 feet many of the joints are interconnected sufficiently to allow water to circulate through them.

Table 8.— *Summary of analyses of ground waters in the Yadkin-Pee Dee River basin*

[Chemical constituents in parts per milion]

	Crystalline rock province				Cretaceous clay province				Cretaceous sand province			
	Number of samples analyzed	Median	Minimum	Maximum	Number of samples analyzed	Median	Minimum	Maximum	Number of samples analyzed	Median	Minimum	Maximum
Silica (SiO_2)	112	27	1.4	51	11	9.2	3.2	19	18	20	7.9	44
Iron (Fe)	113	.23	.00	23	10	.27	.00	5.5	35	.49	.06	6.8
Manganese (Mn)	105	.03	.00	.34	9	.01	.00	.06	19	.02	.00	.25
Calcium (Ca)	112	14	.7	94	11	2.0	.3	13	19	19	.3	47
Magnesium (Mg)	112	4.3	.6	42	11	.7	.3	7.7	19	2.0	.2	12
Sodium (Na) Potassium (K)	112	8.8	1.3	472	11	3.3	1.6	33	19	16	1.9	114
Bicarbonate (HCO_3)	127	63	1	320	12	3	1	152	36	112	2	301
Sulfate (SO_4)	126	5.1	.7	420	12	2.9	.2	17	29	2.3	.7	4.7
Chloride (Cl)	126	4.5	1.0	560	12	4.0	1.9	12	30	4.0	2.0	54
Fluoride (F)	116	.1	.0	1.5	10	.0	.0	.2	21	.1	.0	.6
Nitrate (NO_3)	113	.6	.0	47	10	2.0	.0	31	20	.1	.0	.8
Dissolved solids (residue on evaporation at 180°C)	117	109	26	1,480	11	33	16	157	18	144	23	307
Hardness as $CaCO_3$	131	55	5	378	12	9	2	64	36	34	2	130
Color ... units	110	2	0	17	10	3	1	7	18	3	0	6
pH	116	6.8	4.7	8.2	11	5.3	4.7	7.7	19	7.2	5.1	9.2

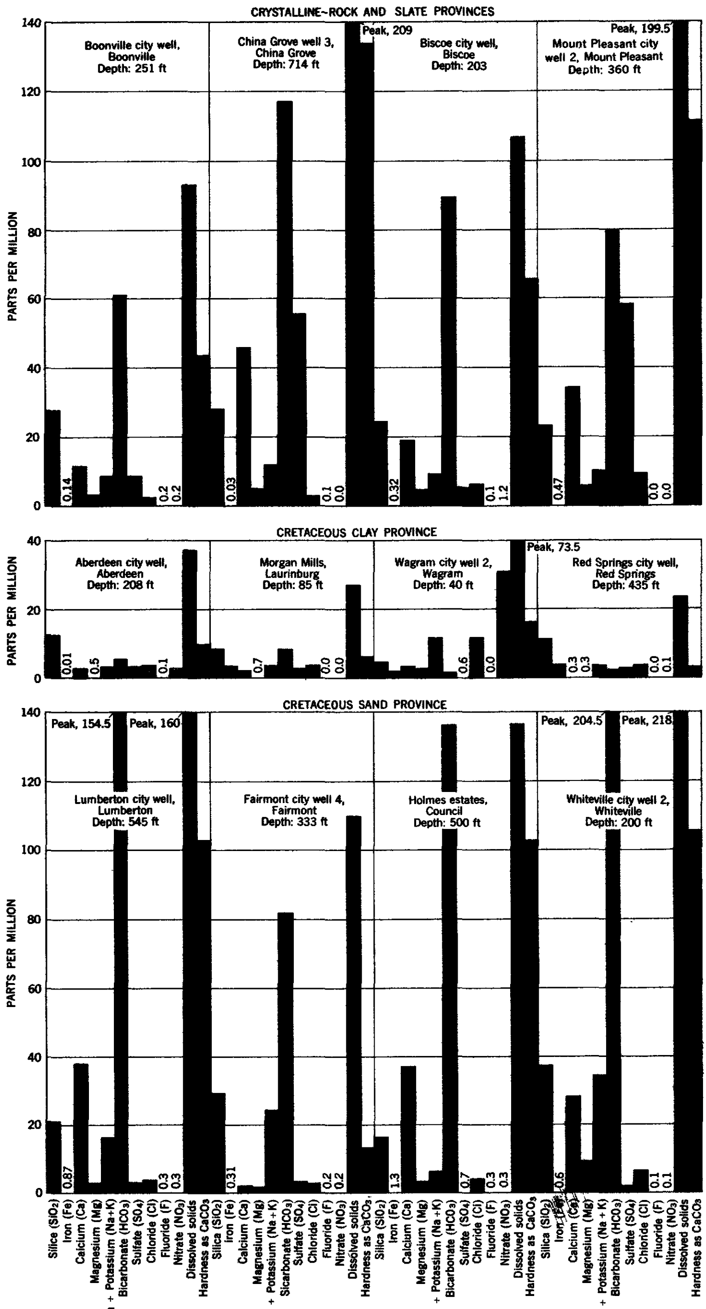


Figure 25. —Chemical character of selected ground waters in the Yadkin-Pee Dee River basin.

Depth of wells.—Shallow wells, drawing water from the mantle rock, are generally no deeper than 50 feet and yield only a few gallons per minute. Deep wells, on the other hand, have a wide range in both depth and yield.

In attempting to develop an adequate water supply, the well owner generally is concerned only that his well be deep enough to give the required amount of water of suitable quality. Unfortunately, the relation between the depth and yield of wells is not a simple one, and there is no assurance that the yield of a well will increase if its depth is made deeper; many wells fail to increase in yield with increasing depth, owing to the decrease in size and number of joints with depth. It is generally true that deeper wells in the crystalline rocks yield more than shallower wells. This apparent relationship is misleading because the greater yield of deep wells is due, not so much to greater depth, but to the fact that deep wells are generally for municipal and industrial use and consequently are pumped at greater rates and have a greater drawdown of the water level than shallow wells, most of which are drilled for domestic use.

If a satisfactory supply of water is not available at a certain depth, it is, of course difficult to decide how much deeper to drill. As a matter of hindsight it appears that some wells abandoned at depths greater than 400 feet because of lack of water should have been abandoned at much shallower depths; on the other hand, many wells abandoned at depths of about 150 feet might have yielded good supplies if they had been drilled deeper. The depth at which an inadequate well should be abandoned is largely an economic problem of the well owner. (LeGrand, 1954, p. 19).

Drilling to great depths in crystalline rocks is rarely justified. Unless a well shows an appreciable increase in yield between the depths of 200 to 300 feet, it generally is not worth while to drill deeper than 300 feet.

Yield of wells.—Although considerable water is stored in the crystalline rocks, the rocks release the water slowly to wells, and consequently wells capable of yielding less than 25 gpm are common. Even where geologic conditions appear to be similar, individual drilled wells show a wide range in yield; one well may yield too little water to pump, whereas another a few hundred feet away may yield as much as 100 gpm. At least one well in the basin yields more than 600 gpm, whereas many yield as little as 1 gpm, and the average well yields 25 to 40 gpm. This great variation in yield and the impossibility of predicting the yield of a prospective well gives the impression that getting a good well is a matter of luck or chance.

In a report on the Statesville area (LeGrand, 1954, p. 20), a graph shows the probability of obtaining a well whose yield is equal to or more than a specified amount. Although the Statesville report includes data from two counties not in the present report and does not include the part of the crystalline-rock unit in the upper part of the basin, the graph (fig. 26) is thought to apply to this unit in the basin. The data used in making the graph are not altogether accurate because the yields and the drawdowns have been reported by well owners and well drillers, many of the reports coming from memory. The reported yields are too great for some wells and too low for others. Nevertheless, it is likely that there is nearly complete compensation of the inaccuracies in the data, and consequently the curve is thought to be representative of actual conditions.

The lower curve is the cumulative frequency curve of yield of industrial, municipal, and domestic drilled wells that yield at least 59 gpm. The average static (nonpumping) water level is 29 feet below the land surface and the average pumping level is 104 feet below the surface. The middle curve is of yields of industrial and municipal wells, the average pumping level being 135 feet below the land surface and the average static level, 30 feet. The upper curve is a hypothetical curve showing the expected yield if wells were pumped sufficiently to lower the level to an average of 150 feet below the land surface, assuming an average static level of 30 feet.

The probability of obtaining successful wells, shown in figure 26, was based on records of wells whose locations were selected by the owners largely for convenience. Most wells are on hills where conditions for large supplies are unfavorable. The geologic factors that govern the yield of wells are complex and will not be discussed in this report. However, a study of the data indicate a greater likelihood of developing a large-yielding well in a draw, or other low ground, where the soil zone is thick and the rock commonly is relatively highly fractured, than on a sharp hill where bare rock is exposed.

Quality of water.—Generally the crystalline rocks yield water of good chemical quality; the observed range in dissolved solids and hardness was 26 to 482 and 8 to 378 ppm, respectively. Calcium bicarbonate waters predominate. Except for one well near Winston-Salem, Forsyth County, waters from the crystalline rocks in Surry, Wilkes, Forsyth, and Yadkin Counties, in the upper part of the basin, are soft and low in dissolved solids. Only three wells yield water that contains more than 0.60 ppm of iron. The chemical character of the water from the crystalline rocks is more variable in Iredell, Davie, Davidson, Rowan, Cabarrus, and

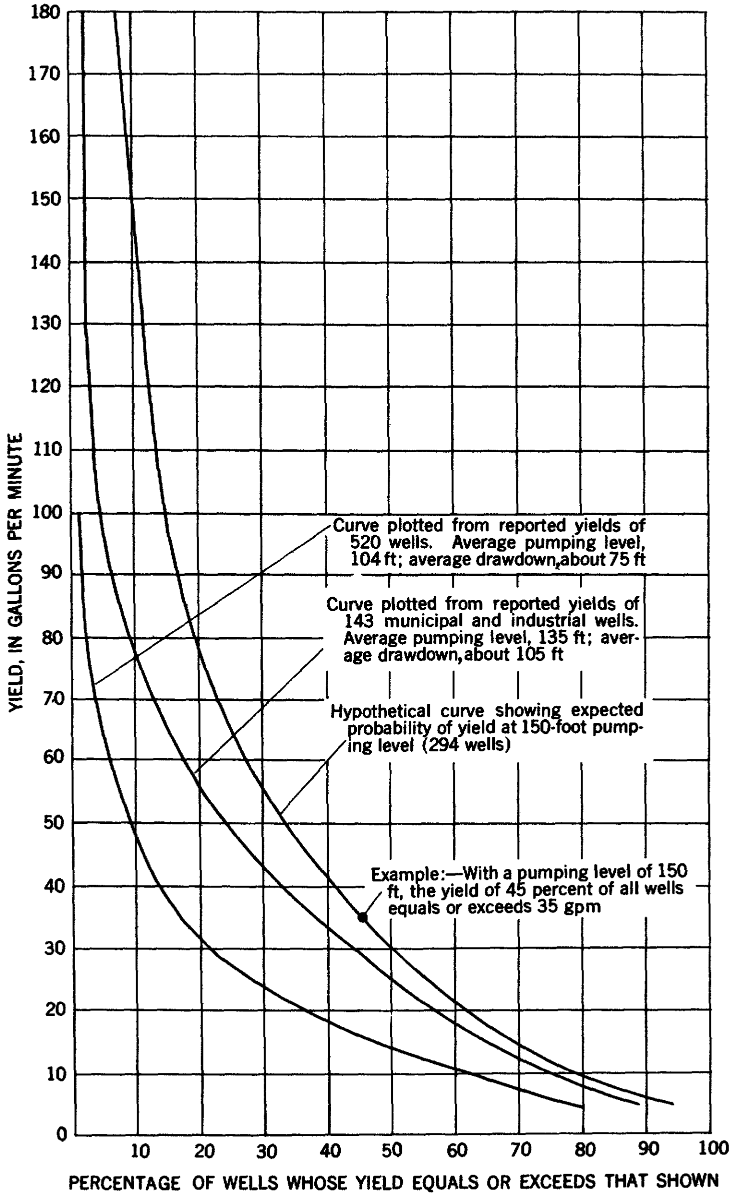


Figure 26. —Cumulative frequency curves of yield of wells in the crystalline-rock province.

Mecklenburg Counties than in the counties in the upper part of the basin. Objectionable amounts of iron are present in water from some wells near Statesville, Troutmans, East Monbo, and Gold Hill. One sample from a well near Mooresville, Iredell County, contained 420 ppm of sulfate and had a hardness of 378 ppm.

SLATE PROVINCE

The slate province is underlain by volcanic rocks and slates. Most of the rocks of this sequence have a slaty cleavage and a cover of mantle rock, which makes them similar to the schists of the crystalline-rock province. The occurrence of ground water in the slate province is similar to that in the crystalline-rock province. Industrial and municipal wells generally yield more than 15 gpm, many yielding more than 35 gpm.

Quality of water..—The ground water in the slate province has a range in chemical character similar to that in the crystalline rocks. The light-colored rocks normally yield a soft water that ranges in hardness from 5 to 68 ppm and is low in dissolved solids, ranging from 28 to 130 ppm. The dark-colored rocks commonly yield a moderately hard to hard water ranging in hardness from 90 to 262 ppm. Water from some wells at Southmont, Trinity, Biscoe, Candor, and Star contains objectionable amounts of iron.

TRIASSIC PROVINCE

The Triassic province includes the rocks of the Newark group, consisting of sandstone, shale, mudstone, and conglomerate. Mundorff (1945, p. 17), reports that the materials are poorly sorted, resulting in a low porosity and permeability, which has been further reduced by compaction and cementation. Consequently, the movement of water is largely along bedding planes and joints. Joints are common in the dark-colored dikes that have intruded the sediments. The dikes commonly are only a few feet thick, but they are dispersed throughout the province.

A reconnaissance study of the ground-water resources in the Triassic province has been made by R. G. Schipf of the Geological Survey, who says (written communication):

> Although adequate domestic supplies may be had from the Triassic rocks, the same cannot be said for industrial or public supplies. Several wells yield as much as 50 gallons a minute but only one well listed in the well tables yields as much as 124 gallons a minute. It seems apparent that such large yields cannot be sustained over long periods of time without excessive drawdown ....

Water from the Triassic rocks is alkaline and moderately hard to very hard. Significant amounts of chloride (up to 250 parts per million) are known in some well water, but the water is generally satisfactory for most purposes. Temperatures range from 58°F to 66°F.

CRETACEOUS CLAY PROVINCE

The Cretaceous clay province coincides with the outcrop area of the Tuscaloosa formation and includes a northeastward-trending belt including southeastern Richmond and Moore Counties and northwestern Scotland and Hoke Counties. Loose permeable sand, ranging in thickness from a few inches to 20 feet or more, is underlain by dense blue-gray clay. The thickness of the formation as a whole increases from a featheredge at the western border to more than 275 feet at the eastern border.

The loose sand at the surface absorbs the precipitation readily so that direct surface runoff is not great. Water percolates downward through the surface sand faster than the underlying clay can absorb it. As a result, much water passing through the sand on upland slopes reappears as hillside seeps to be discharged into the streams. A few sand beds are penetrated locally within the clay, but they cannot be traced far laterally and are probably lenticular. The clay does not yield water readily, and consequently few drilled wells in the clay province yield more than 15 gpm. In an effort to obtain as much as 25 gpm many wells are drilled through the strata into the underlying slates. Wells in the eastern part of the province have penetrated more sand beds than those to the west, and the yields in the eastern part are greater.

Quality of water.—Ground water from the Cretaceous clay province is low in mineral matter, the dissolved solids generally ranging from 16 to 95 ppm (one sample contained 157 ppm of dissolved solids) and the hardness ranging from 3 to 64 ppm. (See table 8.) As the water from this province generally is slightly acid (pH as low as 4.7) and the mineral content is low, the water tends to be corrosive to metal surfaces. Objectionable quantities of iron are present in water from a well at Wagram.

CRETACEOUS SAND PROVINCE

The Cretaceous sand province is east of the Cretaceous clay province. It is formed by the outcrop areas of the Black Creek and Peedee formations, and it includes the underlying Tuscaloosa formation insofar as that formation can be reached by wells. Water moves through the nearly flat lying beds of sand, which are interlayered with beds of clay. The beds are inclined slightly to the southeast, having a slope slightly greater than that of the land surface. By entering the ground where the beds crop out, the water moves coastward in the beds of sand and becomes confined under artesian pressure beneath beds of clay.

All three principal formations of the province contain one or more beds of sand from which wells can draw water. Most of the municipal and industrial wells are drilled deep enough to tap several of the sand beds. Screens or slotted pipe are installed opposite the sands, so that water from all sands penetrated can enter the well. These wells range in depth from 100 to more than 600 feet, the aggregate yield generally increasing with depth. Properly developed industrial and municipal wells in this province are capable of yielding more than 300 gpm almost everywhere, and yields in excess of 500 gpm have been obtained.

Most of the rural domestic supplies in this province are obtained from driven wells, which rarely are more than 20 feet deep. The wells draw water from surfical sands that mantle the Cretaceous formations. Some rural domestic supplies are obtained from wells of small diameter commonly $1\frac{3}{4}$- or 2-inch, which tap a bed of sand shallower than 200 feet. Such a well is developed by setting the casing on a hard, firm bed and by removing, with compressed air, as much of the running sand in the underlying sand bed as possible. The well is open into the sand bed. Although the wells generally are capable of yielding more than 5 gpm, an excessive rate of pumping may bring in an objectionable amount of sand.

The water level of each sand bed in the province is separate and distinct from those of other sand beds. Too few measurements of water levels in individual beds have been made to determine the water levels in each bed. However, it is thought that, in most places, the deeper beds have higher water levels than do the shallow beds. Beneath the broad interstream areas the artesian water levels and the water table in the surfical sands generally lie at approximately the same depth - commonly 10 to 30 feet.

Quality of water .—The Cretaceous sand province yields mostly soft water, having an observed range in hardness from 2 to 130 ppm and in dissolved solids from 23 to 307 ppm. Although objectionable amounts of iron occur at certain localities, such water would be suitable, with slight treatment, for domestic and most industrial purposes.

WATER LEVELS

Changes of water levels in wells reflect the changes of water in storage in underground reservoirs. During droughts, drying up of many shallow wells is evidence of a falling water table. There is a continual discharge of ground water by seepage into streams and by evaporation and transpiration, generally along the streams. The discharge causes a gradual lowering of the water table except during and immediately after periods of significant precipitation, when replenishment to the underground reservoir exceeds the discharge from it; as a result of these periods of precipitation the water table rises. Figure 27 shows the water-level fluctuations in two wells in the basin. The water levels in these wells are controlled only by natural conditions, and their fluctuations are typical of those in water-table wells throughout the basin. The water table generally rises quickly during periods of recharge and then declines slowly over a longer period as the water drains out; therefore, the water table is declining most of the time. In a year of normal precipitation the recharge to the underground reservoir is approximately equal to the discharge from it, so that the water table at the end of the year is at about the same level as at the beginning of the year.

The relationship between the amount of precipitation and the position of the water table is not a simple one. In the basin there is a noticeable change in the water table with the seasons. The water table generally begins to decline in April and May because of increasing evaporation and of the use of water by plants, which, by disposing of water from rainfall, prevent it from reaching the water table. Generally the decline continues, interrupted for short periods by minor rises due to heavy rainfall, through the summer and early fall. In spite of relatively heavy rainfall during the summer, the average recharge does not keep pace with the discharge by seepage, evaporation, and transpiration. In late fall, generally in December when most of the vegetation is dormant and the evaporation capacity of the air is not great, any soil-moisture deficiency that has accumulated during the hot weather is made up and then the water level begins to rise. The winter rains are relatively gentle and steady and are more favorable for the infiltration of water. The seasonal high in the water table commonly occurs in the early spring.

Measurements of artesian water levels of the Coastal Plain section have not been adequate to determine the extent of their fluctuations. Because the artesian beds are full of water and are capable of taking in only a part of the water available for recharge, the artesian pressures in downdip areas fluctuate only slightly in response to recharge.

The withdrawal of water by pumping of wells in the basin is not great, and the lowering of the water table around individual wells does not affect the regional water table. There appears to be no evidence to support the commonly held belief that the water table has been declining during recent years. Measurements of the water table during the past 20 years (see fig. 27) refute this

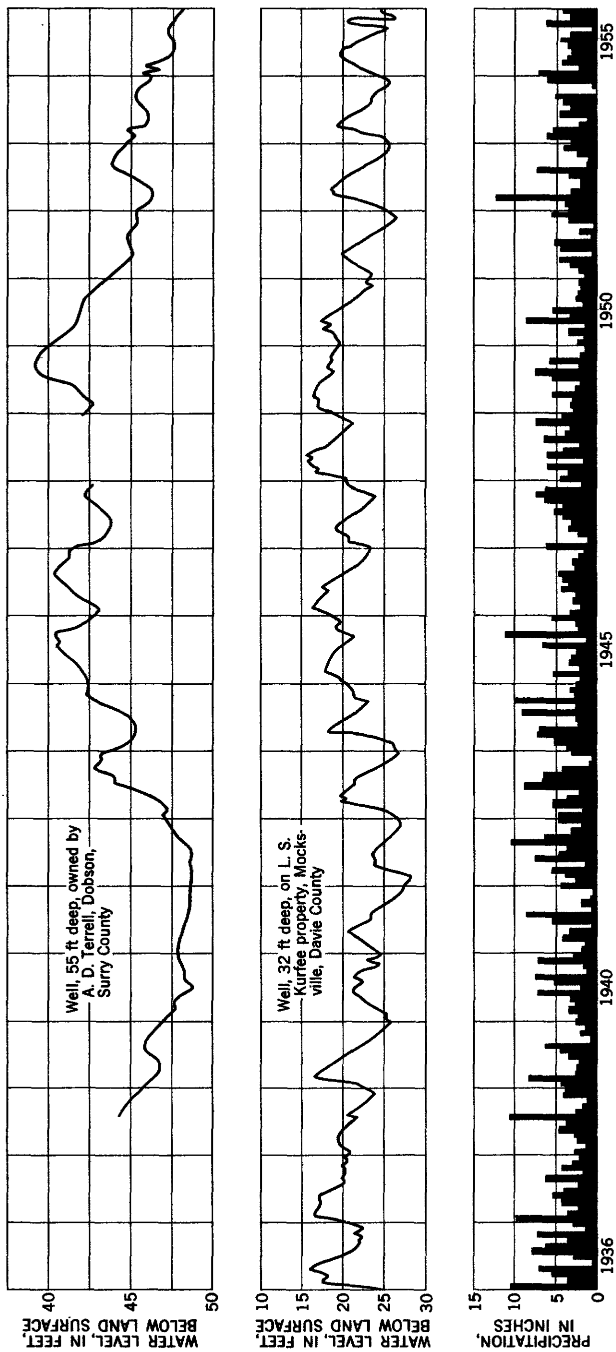


Figure 27. — Graph showing water levels in two wells in the Yadkin-Pee Dee River basin and precipitation at Salisbury.

belief, and show, instead, that the water table in unpumped or lightly pumped areas has no trend except that associated with seasonal changes in climate. A cumulative deficiency in precipitation from 1953 to the present time (May 1955) has caused ground-water levels to fall below the seasonal averages.

The water level is depressed around wells that are pumped, the water level forming a cone of depression. The lowest point in the water surface is at the well, and a hydraulic gradient is established which causes water to flow toward the well. As pumping continues to lower the water level in the well, the cone of depression extends farther away, inducing water to enter the well that ordinarily would have discharged elsewhere. If this intercepted water approximates in quantity that pumped out, the water level will eventually stablize.

PUBLIC WATER-SUPPLY SYSTEMS

The Yadkin-Pee Dee River basin is served by 64 public water systems, 28 using surface water and 36 using ground water. Location of the systems giving the source of supply, the dissolved solids content, and hardness of the waters is shown in plate 4. A summary of chemical analyses of raw and treated waters for the water-supply systems in the basin is given in table 9. Additional pertinent data relating to each of the systems in the basin are given below.

The data on yields of wells are not particularly significant in showing either the potential yield of the wells or that of the aquifer. Some of the reported yields apply to those derived in a short pumping test after the drilling of the well. The reported yield in this case is likely to be a near-maximum yield of the well in which the drawdown of the water table is considerable. Some of the yields, on the other hand, represent the pumping rate controlled by the user, in which case the drawdown may or may not be great, depending on the user's needs.

ABERDEEN, MOORE COUNTY

Ownership: Municipal. Population served: 2, 254. Source: Springs impounded in 75,000-gallon reservoir and 1 well, 208 feet deep. Treatment: Spring water chlorinated at pumping station. No treatment of well water. Elevated storage: 200, 000-gallon elevated tank.

ALBEMARLE, STANLY COUNTY

Ownership: Municipal. Population served: 13,100. Source: Yadkin River. Auxiliary supply: Long Creek impounded in 200-million-gallon reservoir. Treatment: Prechlorination, coagulation with alum and soda ash, sedimentation, rapid sand filtration, addition of Calgon for corrosion control, fluoridation, final pH adjustment with soda ash. Rated capacity of treatment plant: 4 mgd. Raw-water storage: 32-million-gallon reservoir. Finished-water storage: 1 clear well, 1.5 million gallons; 1 standpipe, 500,000 gallons, and 1 elevated tank, 100,000 gallons. Filtration plant is located about 3 miles northeast of Albemarle.

ASHEBORO, RANDOLPH COUNTY

Ownership: Municipal. Population served: 12,000. Source: 3 lakes west of Asheboro. Treatment: Coagulation with alum and lime, prechlorination, sedimentation, rapid sand filtration, addition of Calgon for corrosion control, adjustment of pH with lime. Rated capacity of filtration plant: 1.5 mgd. Ground storage: 1 clear well, 1 million gallons. Elevated storage: 500,000-gallon elevated tank. Location of filtration plant: 1.3 miles west of Asheboro.

BADIN, STANLY COUNTY

Ownership: Carolina Aluminum Co. Population served: 3,000. Source: Yadkin River. Treatment: Coagulation with alum and lime, prechlorination, ammoniation, rapid sand filtration, post-chlorination, adjustment of pH with soda ash. Rated capacity of filtration plant: 1.5 mgd. Ground storage: None. Elevated storage: 2 elevated tanks, 250,000 and 1 million gallons. Location of filtration plant: 2 miles east of Badin.

BISCOE, MONTOGOMERY COUNTY

Ownership: Municipal. Population served: 1,100. Source: 9 wells (Nos. 1–9), 179, 203, 400, 709, 425, 338, 200, 165, and 165 feet deep. The total yield of wells in use is reported to be 67 gpm. Treatment: None. Ground storage: None. Elevated storage: 75,000-gallon elevated tank. Will change source of water to Little River about December 1955. A filter plant with capacity of 500,000 gpd is under construction.

Table 9.—*Chemical analyses of water from public*

[Chemical constituents in parts per

Location	Date of collection 1955	Source	Depth of well (feet)	Type	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
Aberdeen....	Apr. 27	Well..................	208	R	0.0	0.34	0.00	0.6	0.5	3.2
Do........	...do......	Springs and well....	....	F	.0	.04	.00	1.2	.5	2.3
Albemarle...	Apr. 15	Yadkin River.......	....	R	10	.08	.00	4.6	1.4	5.7
Do........	...do......	....do................	....	F	9.5	.03	.00	4.3	1.4	21
Asheboro....	Dec. 3[1]	Black Creek.........	....	R	11	.13	.00	4.8	2.6	[2]5.8
Do........	...do......	....do................	....	F	9.7	.03	.00	12	2.4	[2]11
Badin........	Apr. 20	Yadkin River.......	....	R	4.7	.02	.00	4.1	1.2	4.5
Do........	...do......	....do................	....	F	2.2	.04	.00	7.9	1.5	11
Biscoe.......	Apr. 25	Well..................	179	R	17	.26	.00	27	6.3	8.4
Do........	...do......	....do................	203	R	24	.47	.14	36	5.8	11
Do........	...do......	....do................	209	R	31	.12	.00	12	7.6	9.6
Do........	...do......	....do................	200	R	22	.45	.18	70	21	7.9
Bladenboro..	Mar. 29	....do................	190	R	28	1.1	.00	19	2.4	9.5
Boonville....	Mar. 15[3]	....do................	251	R	28	.14	.00	12	3.3	[2]8.7
Brunswick...	Mar. 29	....do................	360	R	32	.06	.00	31	13	17
Candor......	Apr. 22	....do................	165	R	11	2.4	.11	9.2	2.8	6.4
Do........	...do......	....do................	70	R	1.4	.05	.00	.7	.7	3.0
Chadbourn..	Mar. 29	Well 1..............	107	R	38	.38	.00	51	4.5	8.9
Do........	...do......	Well 2..............	107	R	28	.39	.00	40	4.3	6.4
China Grove	Mar. 31	Well..................	683	R	22	.04	.00	72	4.1	10
Do........	...do......	....do................	714	R	28	.03	.00	46	5.0	9.3
Do........	...do......	....do................	750	R	32	.02	.00	55	8.2	11
Clarkton....	Mar. 29[4]	....do................	252	R	35	.05	.02	4.8	1.5	[2]36
Cleveland...	Apr. 14	....do................	446	R	24	.05	.00	51	13	11
Concord.....	Apr. 18	Coldwater Creek...	....	R	8.2	.06	.00	5.3	2.0	3.9
Do........	...do......	....do................	....	F	7.9	.05	.00	6.4	2.1	13
Cooleemee.	Mar. 31	South Yadkin River.	....	R	14	.00	.00	3.6	1.4	2.9
Do........	...do......	....do................	....	F	8.8	.02	.00	3.5	1.4	11
Denton......	Apr. 14	Lake..................	....	R	5.4	.04	.00	3.6	1.3	3.2
Do........	...do......	....do................	....	F	7.3	.04	.00	28	2.4	4.0
Elkin........	Mar. 16	Elkin River..........	....	R	7.9	.12	.00	2.6	.7	1.8
Do........	...do......	....do................	....	F	7.6	.00	.00	6.8	.5	2.2
Ellerbe......	Apr. 25	Well..................	120	R	2.5	3.5	.00	2.6	1.1	17
Do........	...do......	....do................	200	R	2.4	.10	.00	3.5	2.0	7.7
Fair Bluff....	Apr. 7	....do................	165	R	43	.94	.00	1.6	.5	44
Do........	...do......	....do................	145	R	40	.46	.00	11	5.2	17
Fairmont....	May 4	Well 2..............	300	R	35	.37	.00	.4	.6	34
Do........	...do......	Well 4..............	333	R	32	.52	.00	2.0	1.7	26
Gibson.......	May 5	Well..................	175	R	8.2	.19	.00	6.1	1.2	8.0
Hamlet......	Apr. 25	Marks Creek........	....	R	1.6	.07	.00	.6	.4	1.7
Do........	...do......	....do................	....	F	.9	.07	.00	.7	.2	6.9
Huntersville	Apr. 28	Well	64	R	18	.70	.00	10	4.0	5.8
Do........	...do......	....do................	190	R	20	1.7	.00	30	4.8	7.4
Do........	...do......	....do................	300	R	20	.07	.00	16	5.9	5.6
Kannapolis..	Apr. 15	Buffalo Creek.......	....	R	9.5	.04	.00	3.9	1.1	3.3
Do........	...do......	....do................	....	F	10	.05	.00	4.3	1.1	16
Kernersville	Mar. 16	Belew Creek........	....	R	9.5	.02	.00	4.3	2.0	3.0
Do........	...do......	....do................	....	F	11	.02	.00	15	1.9	3.0
Landis.......	Mar. 30	Grants Creek........	....	R	6.3	.01	.00	3.2	1.2	3.0
Do........	...do......	....do................	....	F	6.3	.03	.00	6.1	.9	13
Laurinburg..	May 5	Jordan Creek........	....	R	1.9	.07	.00	1.2	.4	3.0
Do........	...do......	....do................	....	F	1.6	.01	.00	9.2	.6	14
Lexington...	Apr. 14	Abbotts Creek.......	....	R	7.1	.05	.00	4.4	1.7	2.8
Do........	...do......	....do................	....	F	16	.06	.00	13	3.7	6.8
Lilesville...	Nov. 14[3]	Well..................	300	R	36	.14	.00	14	2.5	[2]15
Do........	...do......	....do................	472	R	19	2.2	.00	10	2.7	8.2
Lumberton..	May 4	Lumber River.......	....	R	0	.09	.00	2.0	.4	3.0
Do........	...do......	....do................	....	F	.0	.05	.00	17	.8	4.2
Maxton......	May 5	Well 1..............	400	R	7.9	.19	.00	2.4	1.5	13
Do........	...do......	Well 2	70	R	4.7	.11	.00	1.2	.5	3.1
Mocksville..	Feb. 22[5]	Bear Creek..........	....	R	13	.04	....	5.6	2.5	[2]3.6
Do........	...do......	....do................	....	F	11	.01	....	6.2	2.2	[2]6.6

water supplies in the Yadkin-Pee Dee River basin

million, R = Raw water; F = Finished water]

Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color (units)
0.4	4	0.9	3.0	0.0	5.0	25	4	0	33.5	5.7	3
.5	6	1.0	3.8	.0	.4	21	5	0	24.5	6.7	7
1.4	26	5.2	3.5	.1	.3	73	17	0	65.3	7.2	17
1.4	36	23	6.5	.9	.4	88	16	0	135	7.1	2
......	34	3.0	2.8	.1	.2	47	23	0	89.5	6.9	8
......	40	17	8.2	.1	.2	84	40	0	144	7.5	6
1.5	20	5.8	3.5	.0	.8	49	15	0	59.5	7.5	16
1.5	30	21	4.5	.1	1.3	75	26	1	111	7.3	5
.7	120	8.6	4.8	.0	.3	143	94	0	218	7.2	2
.4	80	59	9.5	.0	.0	200	113	47	281	6.6	0
.1	81	3.5	7.2	.0	1.1	113	60	0	160	7.0	1
.2	98	186	3.0	.7	.0	405	262	182	539	7.3	1
3.0	93	2.1	4.0	.1	.0	119	58	0	164	6.9	2
......	61	8.6	2.1	.2	.0	93	44	......	......	7.2	4
7.4	196	4.3	5.5	.0	.0	207	130	0	326	7.7	5
1.6	51	8.6	2.5	.1	.0	86	35	0	105	7.0	1
.6	1	1.2	3.2	.0	7.9	28	5	4	33.7	5.1	3
2.0	174	2.9	14	.0	.0	211	145	3	323	7.5	3
3.1	152	2.8	4.5	.0	.0	170	118	0	260	7.4	5
2.8	114	115	6.5	.1	.0	310	196	102	438	7.7	4
3.2	118	56	2.5	.1	.0	214	137	40	320	7.6	2
3.0	116	92	3.2	.1	.0	273	170	75	387	7.6	4
......	107	2.6	3.8	.1	.1	142	18	......	178	8.3	3
3.0	103	113	1.2	.1	.0	282	180	96	399	7.7	2
1.6	23	7.2	3.8	.2	.8	51	22	3	68.4	7.4	7
1.6	28	24	5.0	1.0	1.2	79	25	2	122	6.9	3
1.0	21	3.0	2.0	.0	.3	39	15	0	47.2	6.8	4
1.6	30	8.8	3.0	.0	.0	56	15	0	80.5	6.5	5
1.4	15	4.5	1.8	.2	1.3	50	14	2	43.1	6.6	2
1.1	37	49	7.0	.2	.0	126	81	50	194	8.8	3
.8	13	2.5	1.2	.0	.0	25	9	0	31.0	6.5	12
.8	15	11	2.0	.0	.0	39	19	7	60.0	6.6	3
1.3	4	12	20	.0	10	78	11	8	123	5.7	1
.9	14	3.3	6.2	.0	12	60	17	6	78.7	6.0	0
4.0	96	2.9	11	.6	.0	177	6	0	196	7.1	7
7.6	100	1.8	5.5	.1	.3	150	50	0	181	6.7	4
3.8	97	1.9	2.8	.3	.0	122	4	0	165	7.0	6
4.2	83	2.5	2.8	.2	.0	115	12	0	144	6.8	5
.7	19	4.1	9.0	.0	6.7	60	20	4	87.9	6.2	4
.4	3	3.0	2.2	.0	.0	11	3	1	19.0	6.2	30
.4	5	7.9	4.2	.2	.0	38	3	0	40.7	6.3	24
.7	47	4.0	7.0	.1	1.5	88	42	4	116	6.7	7
2.4	84	39	4.5	.0	.0	149	94	26	229	7.7	2
2.1	67	3.9	4.8	.1	8.5	105	63	8	155	6.9	2
2.1	20	5.2	2.8	.2	.7	45	14	0	54.3	7.1	4
2.3	38	12	6.2	.3	.0	75	15	0	108	7.4	4
1.4	24	4.6	1.0	.1	.8	47	19	0	57.5	6.8	6
1.5	36	12	8.0	.0	.5	80	45	15	118	9.1	3
2.2	17	5.7	3.0	.1	.0	36	13	0	48.8	6.7	4
2.0	29	15	6.8	.3	.0	67	19	0	111	7.3	4
.8	4	1.6	4.0	.0	.7	16	5	2	28.5	5.9	110
.2	27	22	8.2	.1	.2	84	26	4	124	7.4	2
1.8	21	5.4	2.8	.1	.7	53	18	1	55.7	6.9	35
1.4	41	15	7.0	1.0	.0	88	47	14	125	7.7	4
......	81	5.6	2.9	.4	.1	116	45	......	......	7.6	3
1.6	41	1.5	7.2	.1	10	90	36	2	121	7.0	2
.6	5	2.3	4.2	.0	1.3	16	7	3	31.2	5.9	130
.4	13	34	6.8	1.1	.0	84	46	36	128	7.0	15
1.8	2	4.4	18	.0	9.3	65	12	10	105	4.8	3
.4	1	4.0	4.0	.0	2.8	28	5	4	40.8	4.7	2
......	24	7.7	2.8	.1	.3	55	24	5	139	6.8	26
......	2	25	7.5	.1	.5	64	24	23	97.8	4.8	3

See footnotes at end of table.

Table 9.—*Chemical analyses of water from public water*

Location	Date of collection 1955	Source	Depth of well (feet)	Type	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
Monroe	Apr. 20	Richardson Creek	....	R	4.4	0.13	0.00	4.4	1.7	4.8
Do	..do...	.....do	....	F	4.6	.00	.00	20	1.7	4.8
Morven	Apr. 27	Well	186	R	38	1.8	.00	6.9	5.2	3.2
Do	..do...	.....do	210	R	36	2.0	.00	6.2	4.8	3.1
Mount Airy	Mar.16	Lovells Creek	....	R	7.0	.00	.00	3.8	.7	1.9
Do	..do...	.....do	....	F	3.6	.00	.00	8.3	.8	1.7
Mount Gilead	Apr. 22	Pee Dee River	....	R	11	.01	.00	4.3	1.4	5.4
Do	..do...	....do	....	F	10	.00	.00	4.5	1.2	49
Mount Pleasant	Apr. 15	Well 1	250	R	33	.06	.00	14	2.9	8.6
Do	..do...	Well 2	200	R	27	.40	.00	26	6.8	12
Do	..do...	Well 5	600	R	27	.07	.00	23	5.9	13
North Wilkesboro	Mar.17	Reddies River	....	R	7.9	.01	.00	2.0	.7	2.0
Do	..do...	.....do	....	F	9.8	.00	.00	5.6	.7	2.0
Norwood	Apr. 22	Pee Dee River	....	R	9.8	.00	.00	3.0	1.4	5.2
Do	..do...	.....do	....	F	4.7	.00	.00.	25	1.6	5.3
Oakboro	Apr. 15	Well	120	R	29	.99	.48	61	8.2	18
Do	..do...	.....do	115	R	24	1.2	.82	65	11	20
Pembroke	May 4	.....do	180	R	12	.54	.00	1.2	.5	2.8
Pilot Mountain	June 24[3]	.....do	250	R	33	3.7	.00	19	3.7	[2]12
Do	..do...	.....do	406	R	32	.12	.10	17	2.9	[2]10
Pinebluff	Apr. 27	Springs	....	F	.0	.07	.00	1.1	.2	1.6
Red Springs	May 5	Well 1	435	R	7.9	4.2	.00	.4	.5	2.0
Do	..do...	Well 4	420	R	7.9	5.3	.00	1.2	1.2	4.8
Roberdell	Apr. 25	Well	200	R	11	.00	.00	9.2	5.2	4.1
Rockingham	..do...	Falling Creek	....	R	.0	.22	.00	1.6	.2	2.6
Do	..do...	.....do	....	F	.0	.06	.00	15	.3	4.4
Rockwell	Apr. 28	Well	144	R	14	.04	.00	8.4	1.9	4.8
Do	..do...	.....do	500	R	22	.04	.00	15	4.6	6.0
Rowland	May 4	Well 1	400	R	11	.03	.00	10	.9	5.0
Do	..do...	.....do	450	R	7.9	5.7	.00	6.8	1.2	4.8
Rural Hall	Mar.16	Well	374	R	22	.19	.00	19	6.8	8.0
Saint Pauls	May 4	... .do	320	R	8.7	.66	.00	.8	1.0	6.5
Salisbury	Mar.30	Yadkin River	....	R	12	.00	.00	4.0	1.4	3.6
Do	..do...	.....do	....	F	9.5	.01	.00	8.7	1.3	4.9
Spencer	Mar.30	Well	250	R	42	.02	.00	37	17	14
Do	..do...	.....do	314	R	33	.09	.00	4.6	.6	11
Do	..do...	.....do	400	R	32	.01	.00	38	15	12
Star	Apr. 22	.....do	165	R	15	.18	.00	4.0	1.7	7.5
Do	..do...	.....do	365	R	28	2.3	.11	11	1.8	5.0
Statesville	Mar.31	Fourth Creek	....	R	20	.06	.00	5.5	2.2	4.0
Do	..do...	.....do	....	F	17	.02	.00	15	2.2	4.6
Tabor City	Apr. 7	Well	200	R	22	.06	.00	6.8	4.1	100
Do	..do...	.....do	400	R	17	.22	.00	5.6	.7	100
Thomasville	Apr. 14	Abbotts Creek	....	R	8.5	.09	.00	4.3	.4	4.0
Do	..do...	.....do	....	F	9.5	.04	.00	20	2.4	4.0
Troutmans	Mar.31	Well	275	R	16	8.3	.00	3.5	1.2	4.2
Do	..do...	.....do	555	R	19	.07	.00	16	3.2	6.6
Do	..do...	.....do	550	R	12	.22	.00	22	3.6	5.8
Troy	Apr. 22	Denson Creek	....	R	17	.08	.00	3.2	.7	4.2
Do	..do...	.....do	....	F	12	.00	.00	9.6	.7	4.8
Wadesboro	Apr. 27	Jones Creek	....	R	1.6	.14	.22	4.2	2.3	5.2
Do	..do...	.....do	....	F	1.3	.02	.42	13	2.1	5.2
Wagram	May 5	Well	55	R	2.4	.13	.00	3.0	1.8	9.0
Whiteville	May 4	Well 2	200	R	34	.04	.00	27	13	24
Do	..do...	Well 3	290	R	28	.18	.00	25	12	36
Wilkesboro	Mar.17	Little Cub Creek	....	F	7.6	.09	.00	2.1	.7	1.5
Do	Aug.11[5]	Well	400	R	28	.25	.00	16	5.4	9.1
Do	Mar.17	.....do	700	R	26	2.6	.00	10	1.6	5.5
Winston-Salem	Mar.16	Salem and Walker Creeks	....	R	8.5	.00	.00	4.0	1.5	2.6
Do	..do...	....do	....	F	7.4	.00	.00	8.0	1.4	3.7
Yadkinville	June 26[3]	Well	267	R	20	.11	.00	4.3	.7	[2]35
Do	Mar.17	.....do	278	R	28	2.9	.00	6.4	5.4	5.5

supplies in the Yadkin-Pee Dee River basin—**Continued**

Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color (units)
							Calcium, magnesium	Noncarbonate			
1.5	21	6.8	5.8	0.0	0.4	59	18	1	67.2	6.9	50
1.5	30	31	10	.1	.2	102	56	31	151	7.5	6
7.7	54	7.3	2.0	.2	.0	104	38	0	114	7.1	7
7.4	52	8.1	1.8	.2	.6	102	35	0	107	7.1	16
.7	15	3.7	1.5	.0	.2	31	12	0	36.5	6.7	17
.8	20	9.7	2.5	.0	.2	42	24	8	63.3	7.9	3
1.3	22	6.7	3.2	.1	.4	50	16	0	60.0	7.3	0
1.4	92	40	5.0	.0	.4	158	16	0	246	9.1	5
.4	65	3.4	4.5	.1	4.1	110	48	0	136	6.8	0
.3	77	12	22	.0	11	180	92	29	247	6.5	5
.5	86	9.1	9.5	.1	15	159	82	12	225	6.7	5
.8	12	2.3	1.0	.0	.8	30	8	0	28.9	6.9	7
.9	10	11	3.0	.0	.0	40	17	9	53.3	6.5	2
1.1	18	6.7	3.5	.1	.7	47	13	0	54.3	7.0	16
1.3	29	54	4.5	.1	.7	120	69	45	179	8.6	8
.4	145	64	25	.1	.0	290	186	67	431	7.2	2
.4	157	41	54	.1	.0	328	208	79	496	7.3	2
1.9	9	3.6	2.8	.0	.0	30	5	0	30.7	5.6	2
......	93	6.3	2.5	.5	.0	123	63	....	....	7.1	8
......	80	7.0	1.8	.4	.0	113	54	....	....	7.1	4
.0	9	.7	.1	.0	.0	13	4	0	21.8	6.4	6
.3	2	3.5	3.5	.0	.0	26	3	1	25.9	5.6	2
.7	4	7.1	7.2	.0	.3	39	8	5	53.4	5.7	7
.6	29	2.2	8.5	.0	20	95	44	21	120	6.9	0
.4	3	3.0	3.8	.0	.8	14	5	2	24.9	6.4	90
.3	13	30	5.0	1.1	.0	69	38	27	108	6.6	5
.3	43	1.9	3.5	.0	.5	70	29	0	84.2	6.6	3
.4	73	2.1	3.2	.0	2.0	101	56	0	138	6.9	2
.7	28	7.2	6.0	.0	1.2	62	29	6	90.7	6.6	5
1.6	31	4.5	2.8	.1	.0	49	22	0	71.3	6.4	3
3.7	109	6.5	2.5	.2	.0	124	76	0	192	7.3	2
1.6	0	9.6	8.5	.0	2.5	43	6	6	76.7	4.5	5
1.2	21	3.9	3.0	.1	.8	42	16	0	52.6	6.9	4
1.4	25	10	4.5	1.0	.5	58	27	6	86.1	7.4	4
2.3	126	28	26	.1	17	267	161	57	388	6.7	2
2.0	26	1.1	4.5	.1	9.5	90	14	0	84.3	6.1	2
1.8	158	20	14	.2	6.4	227	156	27	353	7.0	1
.0	20	1.2	7.8	.0	4.0	56	17	1	73.1	6.0	0
.0	36	13	2.8	.0	.0	86	35	5	96.1	6.7	0
1.3	33	3.9	2.0	.0	.0	56	23	0	68.6	6.9	7
1.2	30	26	4.2	.0	.0	88	46	21	128	6.8	4
14	301	1.8	4.5	.6	.8	302	34	0	470	7.9	2
6.0	271	2.2	6.5	.8	.3	276	17	0	439	8.4	5
1.8	18	5.5	2.0	.1	1.1	60	13	0	57.3	7.3	37
1.5	38	33	6.2	.2	.0	103	60	29	155	8.2	3
1.6	25	2.3	1.5	.1	.0	54	14	0	51.1	6.2	2
1.8	58	4.0	8.5	.1	3.1	105	54	6	149	6.6	7
2.2	83	11	2.0	.1	.0	115	69	1	165	7.6	5
1.0	18	2.9	3.0	.0	1.3	48	11	0	43.1	7.1	22
.8	23	10	7.2	.0	.2	69	27	8	82.1	7.4	6
2.2	23	5.5	6.8	.1	.3	57	20	1	74.7	6.9	40
1.9	20	26	10	.2	.0	80	42	25	131	6.6	6
2.4	2	.5	10	.0	24	70	15	13	102	4.7	1
7.3	203	1.9	6.5	.0	.6	213	118	0	334	7.8	2
11	234	.6	7.2	.0	.8	239	115	0	384	7.8	1
.6	10	2.9	1.5	.0	.0	29	8	0	26.6	6.6	7
2.6	51	3.8	12	.0	23	142	62	20	142	6.4	2
1.0	45	3.0	2.5	.1	1.4	78	32	0	91.9	6.9	2
1.7	18	5.2	2.8	.1	.5	41	16	1	52.1	6.8	10
1.7	18	12	5.0	1.2	.8	54	26	11	83.7	6.6	7
......	93	8.4	2.0	.5	.1	117	14	....	....	7.7	3
3.4	44	17	1.0	.0	.0	93	38	2	109	6.6	3

[1] 1953
[2] Na + K, calculated.
[3] 1947
[4] 1949
[5] 1954

BLADENBORO, BLADEN COUNTY

Ownership: Municipal. Population served: 908. Source: 2 wells, 190 and 327 feet deep. The yield is reported to be 200 and 30(gpm. Treatment: None. Elevated storage: 100,000-gallon elevated tank.

BOONVILLE, YADKIN COUNTY

Ownership: Municipal. Population served: 572. Source: 1 well, 251 feet deep. The yield is reported to be 75 gpm. Treatment: None. Elevated storage: 75,000-gallon elevated tank.

BRUNSWICK, COLUMBUS COUNTY

Ownership: Redden Gaskin. Population served: 350. Source: 1 well, 360 feet deep. Treatment: None. Storage: 1,000-gallon pressure tank.

CANDOR, MONTGOMERY COUNTY

Ownership: Municipal. Population served: 617. Source: 3 wells (Nos. 1–3), 175, 70, and 65 feet deep. The yields are reported to be 23, 15, and 10 gpm respectively. Treatment: Caustic soda is used for well 1 to remove iron. Candor will change to a surface source (impoundment of an unnamed stream). A filter plant is under construction.

CHADBOURN, COLUMBUS COUNTY

Ownership: Municipal. Population served: 2,100. Source: 2 wells each 107 feet deep. The yield is reported to be 250 gpm from each well. Treatment: None. Elevated storage: 60,000-gallon elevated tank.

CHINA GROVE, ROWAN COUNTY

Ownership: Municipal. Population served: 1,812. Source: 3 wells (Nos. 1, 3, 4) 683, 714, and 750 feet deep. The yields are reported to be 105, 90, and 42 gpm respectively. Treatment: None. Elevated storage: 75,000-gallon elevated tank.

CLARKTON, BLADEN COUNTY

Ownership: Municipal. Population served: 165. Source: 1 well, 252 feet deep. Treatment: None. Elevated storage: 90, 000-gallon elevated tank.

CLEVELAND, ROWAN COUNTY

Ownership: Municipal. Population served: 580. Source: 3 wells (Nos. 1–3), 186, 275, and 446 feet deep. The yields are reported to be 24, 12, and 75 gpm respectively. Treatment: None. Elevated storage: 75, 000-gallon elevated tank.

CONCORD, CABARRUS COUNTY

Ownership: Municipal. Population served: 20, 000. Source: Coldwater Creek impounded in reservoir (Lake Fisher). Auxiliary supply: Lake Concord supplied by several springs. Treatment: Coagulation with alum, ammoniation, chlorination, addition of activated carbon for control of taste and odor, sedimentation, rapid sand filtration, addition of Calgon and lime for corrosion control, postchlorination, and final adjustment of pH with lime. Rated capacity of treatment plant: 6 mgd. Raw-water storage: Lake Fisher and Lake Concord 1, 100 million gallons and 450 million gallons respectively. Finished-water storage: Clear well, 2 million gallons; 2 elevated tanks, 500,000 and 1 million gallons; at old plant, 1. 5 million gallons. The raw-water intake is about 5 miles north of the treatment plant, which is north of the city in Wil-Mar Park section.

COOLEEMEE, DAVIE COUNTY

Ownership: Erwin Cotton Mills Co. Population served: 1, 925. Source: South Yadkin River. Treatment: Prechlorination, coagulation with alum and soda ash, rapid sand filtration, addition of Calgon for corrosion control, postchlorination, and final adjustment of pH with soda ash. Rated capacity of treatment plant, 2 mgd. Ground storage: 100,000-gallon clear well. Elevated storage: 2 standpipes, 200, 000 and 210, 000 gallons respectively.

DENTON, DAVIDSON COUNTY

Ownership: Municipal. Population served: 1, 050. Source: Lick Creek impounded. Treatment: Coagulation with alum and lime, and chlorination. Rated capacity of treatment plant: 250, 000 gpd.

Ground storage: 1 clear well, 15,000 gallons. Elevated storage: 100,000-gallon elevated tank.

ELKIN, SURRY COUNTY

Ownership; Municipal. Population served: 6,000. Source: Elkin River. Treatment: Coagulation with alum and lime, sedimentation, rapid sand filtration, addition of Calgon for corrosion control, final adjustment of pH with lime, and chlorination. Rated capacity of treatment plant: 1.5 mgd. Ground storage: 500,000-gallon clear well. Elevated storage: 4 elevated tanks, 1 million, 100,000, 25,000 and 75,000 gallons respectively. Filtration plant located in southwest section of Elkin. Jonesville is supplied by the Elkin municipal supply.

ELLERBE, RICHMOND COUNTY

Ownership: Municipal. Population served: 1,000. Source: 3 wells (Nos. 1–2, 4), 115, 120, and 200 feet deep. Treatment: None: Elevated storage: 100,000-gallon elevated tank.

FAIR BLUFF, COLUMBUS COUNTY

Ownership: Municipal. Population served: 200. Source: 2 wells, 165 and 145 feet deep. Treatment: Chlorination of well 2. Elevated storage: 75,000-gallon elevated tank.

FAIRMONT, ROBESON COUNTY

Ownership: Municipal. Population served: 2,800. Source: 3 wells (Nos. 2, 4, 5), 300, 333, and 490 feet deep. Well 5 used for emergency only. The yields are reported to be 100, 500, and 250 gpm, respectively. Treatment: Addition of Calgon for corrosion control. Ground storage: 100,000-gallon reservoir. Elevated storage: 2 elevated tanks, 60,000 and 100,000 gallons.

GIBSON, SCOTLAND COUNTY

Ownership: Municipal. Population served: 609. Source: 1 well, 175 feet deep. The yield is reported to be 150 gpm. Treatment: Chlorination, addition of Calgon and soda ash for softening and corrosion control. Ground storage: None. Elevated storage: 100,000-gallon elevated tank.

HAMLET, RICHMOND COUNTY

Ownership: Hamlet Water Co. Population served: 5,100. Source: Marks Creek impounded. Treatment. Prechlorination, coagulation with alum, sedimentation, rapid sand filtration, addition of Calgon for corrosion control, final adjustment of pH with lime, postchlorination. Rated capacity of treatment plant: 1.5 mgd. Ground storage: 1 clear well, 200,000 gallons. Elevated storage: 2 elevated tanks, 100,000 and 150,000 gallons respectively. Filtration plant located in southeastern part of Hamlet.

HUNTERSVILLE, MECKLENBURG COUNTY

Ownership: Municipal. Population served: 900. Source: 6 wells (Nos. 1–6), 60, 180, 96, 197, 300, and 148 feet deep. The total yield is estimated to be 70 gpm. Treatment: None. Elevated storage: 80,000-gallon elevated tank.

KANNAPOLIS, CABARRUS COUNTY

Ownership: Cannon Mill Co. Population served: 24,200. Source: Buffalo Creek impounded for the regular supply. Coddle Creek serves as an auxiliary supply. The intake at the dam is about 1½ miles west of Kannapolis. Treatment: Domestic: Prechlorination, coagulation with alum, sedimentation, addition of carbon for concontrol of taste and odor, rapid sand filtration, ammoniation, postchlorination, and softening with soda ash. Industrial: Prechlorination, coagulation with alum, sedimentation, addition of carbon for control of taste and odor, rapid sand filtration, and softening with soda ash. Rated capacity of treatment plant: 7.5 mgd. Raw-water storage: Impounding reservoir, 1,250 million gallons. Finished-water storage: Drinking water system: 2 elevated tanks, 250,000 gallons each; 2 clear wells, 100,000 and 75,000 gallons. Industrial and sprinkler system: 1 open reservoir, 98 million gallons; 2 standpipes, 250,000 gallons each; 4 elevated tanks, 250,000, 100,000, 100,000, and 75,000 gallons.

KERNERSVILLE, FORSYTH COUNTY

Ownership: Municipal. Population served: 2,550. Source: Belew Creek impounded. Reservoir on Harmonds Creek will be used as auxiliary supply. Treatment: Coagulation with alum and lime, addition of carbon for control of taste and odor, rapid sand filtration, final adjustment of pH with lime, and chlorination. Rated capacity of treatment plants, 1 mgd. Ground storage: 1

clear well, 300,000 gallons. Elevated storage: 100,000-gallon elevated tank. Filtration plant is located on Highway 421 toward Winston-Salem.

LANDIS, ROWAN COUNTY

Ownership: Municipal. Population served: 3,000. Source: 2 lakes on Grants Creek (12 and 65 million gallons). Auxiliary supply: 6 wells ranging in depth from 406 to 1,009 feet. Treatment of surface water supply: Coagulation with alum and lime, prechlorination, sedimentation, addition of carbon for control of taste and odor, rapid sand filtration, softening with soda ash, and addition of Calgon for control of corrosion. Rated capacity of treatment plant: 1 million gallons. Ground storage: 1 clear well, 250,000 gallons. Elevated storage: 100,000-gallon elevated tank. Filtration plant is located about 1 mile north of Landis.

LAURINBURG, SCOTLAND COUNTY

Ownership: Municipal. Population served: 8,000. Source: Jordan Creek. Auxiliary supply: 1 well, 390 feet deep, with a reported yield of 525 gpm. Treatment: Coagulation with alum and lime, rapid sand filtration, chlorination, addition of Calgon for corrosion control, final adjustment of pH with lime. Rated capacity of treatment plant: 1 mgd. Raw-water storage: 500,000 gallons. Elevated storage: 2 elevated tanks, 100,000 and 200,000 gallons.

LEXINGTON, DAVIDSON COUNTY

Ownership: Municipal. Population served: About 16,000. Source: Abbotts Creek. The intake is about 4 miles northeast of Lexington. Leonard Creek impounded in Leonard Lake is used as an auxiliary or emergency supply. Treatment: Prechlorination, coagulation with alum, air-mix flocculation, sedimentation, rapid sand filtration, postchlorination (if required), final adjustment of pH with lime, fluoridation. Rated capacity of treatment plant: 3.5 mgd. Raw-water storage: Leonard Lake, 365 million gallons. Finished-water storage: At plant, 1 million gallons; 1 elevated tank, 1 million gallons; 1 standpipe, 350,000 gallons. The treatment plant is located 4.1 miles northeast of Lexington on the Greensboro Road.

LILESVILLE, ANSON COUNTY

Ownership: Municipal. Population served: 1,000. Source: 2 wells, 300 and 472 feet deep. The yield is reported to be 40 gpm each. Treatment: None. Elevated storage: 75,000-gallon elevated tank.

LUMBERTON, ROBESON COUNTY

Ownership: Municipal. Population served: 6,000. Source: Lumber River; the intake is 2 miles west of the city. Auxiliary or emergency supply, 1 well, 545 feet deep, reported to yield 600 gpm. Treatment: Prechlorination, coagulation with alum and lime, sedimentation, rapid sand filtration, chlorination, final adjustment of pH with lime, addition of Calgon for control of corrosion, and fluoridation. Rated capacity of treatment plant: 2.25 mgd. Raw-water storage: None. Finished-water storage: 1 clear well, 750,000 gallons; 1 elevated tank, 300,000 gallons. Filtration plant is located on corner of 6th and Water Street in Lumberton.

MAXTON, ROBESON COUNTY

Ownership: Municipal. Population served: 2,075. Source: 2 wells, 400 and 70 feet deep. The reported yields are 500 and 125 gpm, respectively. Treatment: Water is pumped from wells to 200,000-gallon ground reservoir. Water is pumped from reservoir to elevated tank and sodium hydroxide is added on the pressure side of the pump. Ground storage: 200,000-gallon reservoir. Elevated storage: 100,000-gallon elevated tank.

MOCKSVILLE, DAVIE COUNTY

Ownership: Municipal. Population served: 2,200. Source: Bear Creek. The intake is located on Bear Creek, $\frac{3}{4}$ mile west of filter plant. Treatment: Coagulation with alum, prechlorination, sedimentation, rapid sand filtration, softening with lime, addition of Calgon for control of corrosion. Rated capacity of treatment plant: 250,000 gpd. Ground storage: 100,000-gallon clear well. Elevated storage: 100,000-gallon elevated tank. Filtration plant is located on Sanford Avenue at city limits.

MONROE, UNION COUNTY

Ownership: Municipal; also supplies Wingate and Marshville. Population served: 12,700. Source: Richardson Creek impounded in Lake Lee. The intake at Lake Lee is 2 miles east of treatment plant. Treatment: Prechlorination, coagulation with alum and lime, addition of carbon for control of taste and odor, sedimentation, rapid sand filtration, postchlorination, and addition of Calgon for corrosion control. Rated capacity of treatment plant: 2 mgd. Raw-water storage: 450 million gallons. Finished-water storage: 2 clear wells, 420,000 and 540,000 gallons; 4 elevated tanks, 165,000, 500,000, 135,000 and 50,000 gallons. Filtration plant is located $\frac{1}{4}$ mile east of main part of Monroe.

MORVEN, ANSON COUNTY

Ownership: Municipal. Population served: 601. Source: 2 wells, 210 and 186 feet deep. The yields are reported to be 35 and 55 gpm, respectively. Treatment: Chlorination. Elevated storage: 100,000-gallon elevated tank.

MOUNT AIRY, SURRY COUNTY

Ownership: Municipal. Population served: 7,500. Source: Lovells Creek. The intake on Lovells Creek is about 5 miles northeast of the treatment plant, which is on Orchard Street in the city. Treatment: Coagulation with lime and alum, sedimentation, rapid sand filtration, and chlorination. Rated capacity of treatment plant: 3 mgd. Raw-water storage: None. Finished-water storage: 2 clear wells, 500,000 and 160,000 gallons; 2 elevated tanks, 150,000 and 500,000 gallons; 1 standpipe, 200,000 gallons.

MOUNT GILEAD, MONTGOMERY COUNTY

Ownership: Municipal. Population served: 1,500. Source: Pee Dee River impounded in Lake Tillery. Treatment: Coagulation with alum and soda ash, sedimentation, rapid sand filtration, and final adjustment of pH with soda ash. Rated capacity of treatment plant: 250,000 gpd. Raw-water storage: None. Ground storage: 250,000-gallon clear well. Elevated storage: 100,000-gallon elevated tank. Filtration plant is located 0.9 mile west of Mount Gilead on Lake Tillery.

MOUNT PLEASANT, CABARRUS COUNTY

Ownership: Municipal. Population served: 2,400. Source: 5 wells (Nos. 1–5), 250, 360, 200, 263, and 600 feet deep. Treatment: Chlorination. Ground storage: 10,000-gallon reservoir. Elevated storage: 100,000-gallon elevated tank.

NORTH WILKESBORO, WILKES COUNTY

Ownership: Municipal. Population served: 5,000. Source: Reddies River impounded. Treatment: Coagulation with alum, rapid sand filtration, chlorination, final adjustment of pH with lime. Rated capacity of treatment plant: 3 mgd. Ground storage: 2 clear wells, 150,000 and 1 million gallons. Elevated storage: 2 elevated tanks, 100,000 and 200,000 gallons, and 1 standpipe, 140,000 gallons. Filtration plant is located on I Street in North Wilkesboro.

NORWOOD, STANLY COUNTY

Ownership: Municipal. Population served: 2,150. Source: Pee Dee River. Treatment: Coagulation with alum and lime, sedimentation, rapid sand filtration, final adjustment of pH with lime, and chlorination. Rated capacity of treatment plant: 500,000 gpd. Ground storage: 1 clear well, 28,000 gallons, and 1 storage reservoir, 200,000 gallons. Elevated storage: 6,000-gallon elevated tank. Filtration plant is located about one block northeast of main part of Norwood.

OAKBORO, STANLY COUNTY

Ownership: Municipal. Population served: 700. Source: 2 wells, 115 and 120 feet deep. Treatment: Addition of Calgon for corrosion control, and chlorination. Ground storage: None. Elevated storage: 75,000-gallon elevated tank.

PEMBROKE, ROBESON COUNTY

Ownership: Municipal. Population served: 1,200. Source: 1 well, 180 feet deep. The reported yield is 150 gpm. Treatment: Aeration, chlorination, and addition of lime. Ground storage: 30,000-gallon reservoir. Elevated storage: 2 standpipes, 10,000 gallons each and 2 elevated tanks, 50,000 and 75,000 gallons.

PILOT MOUNTAIN, SURRY COUNTY

Ownership: Municipal. Population served: 1,600. Source: 2 wells, 384 and 406 feet deep. Treatment: None. Elevated storage: 100,000-gallon elevated tank.

PINEBLUFF, MOORE COUNTY

Ownership: Municipal. Population served: 700. Source: 5 cased springs supplying approximately 50,000 gpd. Auxiliary supply: 500,000-gallon lake. Treatment: Chlorination. Elevated storage: 50,000-gallon elevated tank.

RED SPRINGS, ROBESON COUNTY

Ownership: Municipal. Population served: 2,535. Source: 3 wells (Nos. 1, 2, 4), 435, 350, and 420 feet deep. The yield is reported to be 500, 180, and 600 gpm. Well 3 is used for an emergency supply. Treatment: Aeration, coagulation with lime, filtration, and chlorination. Ground storage: 85,000-gallon reservoir. Elevated storage: 75,000-gallon elevated tank.

ROBERDELL, RICHMOND COUNTY

Ownership: Municipal. Population served: 400. Source: 1 well, 200 feet deep. Treatment: None. Elevated storage: 56,000-gallon standpipe.

ROCKINGHAM, RICHMOND COUNTY

Ownership: Municipal. Population served: 3,900. Source: Falling Creek impounded in 20 million-gallon reservoir. Auxiliary supply: Hitchcock Creek, which is about 5 miles northwest of treatment plant, impounded. Treatment: coagulation with alum and lime, addition of carbon for control of taste and odor, rapid sand filtration, postchlorination, final adjustment of pH with lime, fluoridation, addition of Calgon for corrosion control. Rated capacity of treatment plant: 1.5 mgd. Ground storage: 300,000-gallon clear well. Elevated storage: 2 elevated tanks, 75,000 and 300,000 gallons. Filter plant located on U. S. Highway 74 south, at city limits.

ROCKWELL, ROWAN COUNTY

Ownership: Municipal. Population served: 1,050. Source: 2 wells, 144 and 503 feet deep. The reported yields are 100 and 85 gpm, respectively. Treatment: None. Elevated storage: 100,000-gallon elevated tank.

ROWLAND, ROBESON COUNTY

Ownership: Municipal. Population served: 1,293. Source: 2 wells, 360 and 450 feet deep. The reported yields are 500 and 300 gpm, respectively. Treatment: None. Ground storage: 125,000-gallon reservoir. Elevated storage: 75,000-gallon elevated tank.

RURAL HALL, FORSYTH COUNTY

Ownership: Rural Hall Sanitary District. Population served: 1,000. Source: 2 wells, 350 and 376 feet deep. Treatment: None. Elevated storage: 75,000-gallon elevated tank.

SAINT PAULS, ROBESON COUNTY

Ownership: Municipal. Population served: 2,500. Source: 2 wells, 300 and 135 feet deep. The reported yields are 400 and 120 gpm respectively. Well 2 is used for emergency. Treatment: Addition of Nalco-18 for corrosion control. Ground storage: 100,000-gallon reservoir. Elevated storage: 100,000-gallon elevated tank.

SALISBURY, ROWAN COUNTY

Ownership: Municipal; also supplies Spencer and East Spencer in case of emergency. Population served: 26,600. Source: Yadkin River. Grants Creek is used in extreme emergency. The intake is at the junction of Yadkin and South Yadkin Rivers about 8 miles from the treatment plant, which is on Kerr Street in the city. Treatment: Prechlorination at raw-water reservoir and at plant (breakpoint), coagulation with alum, sedimentation, rapid sand filtration, fluoridation, and adjustment of pH with lime. Rated capacity of treatment plant: 4 mgd. Raw-water storage. Reservoir (near river), 8 million gallons. Finished-water storage: 2 clear wells, 750,000 and 1 million gallons; 2 elevated tanks, 1 million and 250,000 gallons.

SPENCER, ROWAN COUNTY

Ownership: Municipal. Population served: 4,000. Source: 3 wells (Nos. 1-3), 250, 314, and 400 feet deep. Treatment: None. Elevated storage: 2 elevated tanks 75,000 and 100,000 gallons.

STAR, MONTGOMERY COUNTY

Ownership: Municipal. Population served: 850. Source: 3 wells (Nos. 1–3), 180, 200, and 300 feet deep. The yields are reported to be 55, 35, and 168 gpm respectively. Treatment: No treatment for wells 1 and 2. Soda ash is used for well 3. Elevated storage: 75,000-gallon elevated tank.

STATESVILLE, IREDELL COUNTY

Ownership: Municipal. Population served: 18,600. Source: Fourth Creek. Morrison Creek emergency supply. The intake is about 1,600 feet north of the treatment plant, which is approximately 2 miles north of Statesville. Treatment: Prechlorination, coagulation with alum and lime, addition of activated carbon (if needed), sedimentation, rapid sand filtration, postchlorination (if needed), addition of Calgon for control of corrosion, and adjustment of pH with lime. Rated capacity of treatment plants, 3 mgd. Raw-water storage: None. Finished-water storage: 2 elevated tanks, 1 million gallons each; 1.1-million-gallon clear well.

TABOR CITY, COLUMBUS COUNTY

Ownership: Municipal. Population served: 2,200. Source: 3 wells (Nos. 1–3), 600, 200, and 350 feet deep. Treatment: None. Elevated storage: 75,000-gallon elevated tank.

THOMASVILLE, DAVIDSON COUNTY

Ownership: Municipal. Population served: 16,000. Source: Abbotts Creek. The intake is about 4 miles northwest of the treatment plant, which is 1½ miles west of the center of Thomasville on U. S. Highway 70. Treatment: Prechlorination, coagulation with alum and lime, sedimentation, rapid sand filtration, postchlorination at times, and adjustment of pH with lime. Rated capacity of treatment plants: 1.5 mgd; plant capacity is being increased to 3 mgd. Raw-water storage: None. Finished-water storage: 1 clear well, 480,000 gallons; 1 elevated tank, 1 million gallons.

TROUTMANS, IREDELL COUNTY

Ownership: Municipal. Population served: 1,050. Source: 4 wells (Nos. 1–4), 275, 555, 550, and 475 feet deep. The yields are reported to be 20, 30, 35, and 150 gpm respectively. Treatment: None. Elevated storage: 50,000-gallon elevated tank.

TROY, MONTGOMERY COUNTY

Ownership: Municipal. Population served: 3,000. Source: Denson Creek impounded. Auxiliary supply: 50-million gallon reservoir. Treatment: Coagulation with alum, prechlorination, sedimentation, rapid sand filtration, postchlorination, and final adjustment of pH with lime. Ground storage: 350,000-gallon clear well. Elevated storage: 75,000-gallon elevated tank. Filtration plant is located half a mile north of the center of Troy.

WADESBORO, ANSON COUNTY

Ownership: Municipal. Population served: 5,000. Source: Jones Creek impounded. Treatment: Coagulation with alum and lime, sedimentation, rapid sand filtration, adjustment of pH with lime, addition of Calgon for corrosion control, and chlorination. Ground storage: 500,000-gallon clear well. Elevated storage: 2 elevated tanks, 75,000 and 300,000 gallons.

WAGRAM, SCOTLAND COUNTY

Ownership: Municipal. Population served: 400. Source: 1 well, 55 feet deep. Treatment: None. Ground storage: None. Elevated storage: 100,000-gallon elevated tank.

WHITEVILLE, COLUMBUS COUNTY

Ownership: Municipal. Population served: 5,200. Source: 2 wells (Nos. 2, 3), 200 and 290 feet deep. The reported yields are 500 and 350 gpm respectively. Treatment: None. Elevated storage: 60,000-gallon elevated tank.

WILKESBORO, WILKES COUNTY

Ownership: Municipal. Population served: 1,875. Source: Cub Creek impounded and 2 wells, 400 and 700 feet deep. Treatment: Surface-water supply, chlorinated. Ground-water supply, no treatment. Wells are pumped directly into distribution system to supplement surface-water supply. Elevated storage: 200,000-gallon standpipe.

WINSTON-SALEM, FORSYTH COUNTY

Ownership: Municipal. Population served: 100,000. Source: Salem and Walker Creeks impounded in Salem Lake. The Yadkin River serves as an auxiliary or emergency supply, furnishing an additional 25 mgd. The intake on Salem Lake is 2 miles east of the treatment plant, which is about 2½ miles northeast of the center of the city. Treatment: Prechlorination, coagulation with alum, sedimentation, rapid sand filtration, postchlorination, fluoridation, addition of Calgon for corrosion control, and adjustment of pH with lime. Rated capacity of treatment plant: 20 mgd. Raw-water storage: Salem Lake, 1,250 million gallons, and 750,000-gallon standpipe on Yadkin River. Finished-water storage: 3 clear wells, 2 million gallons each; 3 elevated tanks, 1 million, 200,000, and 50,000 gallons.

YADKINVILLE, YADKIN COUNTY

Ownership: Municipal. Population served: 820. Source: 3 wells (School, South, No. 3), 286, 267, and 278 feet deep. Treatment: None. Elevated storage: 100,000-gallon elevated tank.

PRESENT WATER USE

Water uses are classified in many ways; in this report they are considered to be of either the withdrawal or the nonwithdrawal type. Withdrawal uses are those which remove, or divert, water from its natural medium and transport it elsewhere. Surface water that is withdrawn for many uses is returned in essentially undiminished quantity, commonly to the stream from which it was withdrawn. Thus the same water may be used many times if the quality has not been too greatly impaired. On the other hand, water withdrawn for irrigation, and distributed by sprinkler irrigation systems, as in North Carolina, is almost if not completely consumed. Irrigation, water-power, domestic, municipal, and industrial uses are of the withdrawal type. The uses of ground water are all of the withdrawal type.

Nonwithdrawal uses do not require diversion. Navigation, waste disposal, and most uses for recreation and for conservation of wildlife are examples of nonwithdrawal uses.

The total withdrawal of surface water for all uses, except water power, probably is in the order of 500 mgd. Total withdrawals of ground water aggregate about 100 mgd.

PRIVATE INDUSTRIAL SUPPLIES

Most industries in the basin of the Yadkin and Pee Dee Rivers use some water from public water-supply systems, but estimates of the quantities of water used are not available. Streamflow is used at various points in the basin for water power to operate grist mills, textile mills, and electric-power plants, for cooling water in steam-electric plants and other plants using steam power, and for processing textile products. Of the water withdrawn from streams for these uses, the greater part is returned to the stream from which it is withdrawn. The total volume of streamflow withdrawn for industrial use including water power, is estimated to be about 20,000 mgd.

Textile plants use the most ground water in the Yadkin-Pee Dee River basin. Most of these plants use ground water for drinking and some other purposes, but many use ground water for all or most of their operations. Many food-processing plants and several smaller industries use wells as a source of water supply. Industrial use of ground water in the basin is estimated to be about 35 mgd.

PUBLIC SUPPLIES

The 36 public water-supply systems using ground water in the basin of the Yadkin and Pee Dee River use an estimated 12 mgd. The 28 public water-supply systems taking water from streams use approximately 75 mgd.

RURAL DOMESTIC SUPPLIES

All farm homes, and all urban homes not using water from public water systems, are assumed to use ground water exclusively. Domestic water use in rural areas probably is about 40 mgd.

AGRICULTURAL USE

Many farm ponds in the Yadkin-Pee Dee River basin have been created by damming small streams or by devising hillside catchment basins to trap rainfall and runoff. Some ponds in the flat areas of the Coastal Plain have been excavated to a depth of several feet below the water table, and, consequently, may be considered large dug wells as surface inflow is negligible. The ponds are used for fishing, stock watering, and irrigating farm crops. Prior to 1954 little surface water was used for irrigation. During the drought period in the summer and fall of 1954. however, the practice of irrigation greatly increased. No estimate of the total volume of water used for agriculture is available but the amount is probably insignificant so far, in relation to the total supply in the basin. Irrigation during dry seasons may be expected to increase greatly in coming years.

There has been a significant increase in the use of water from wells for irrigation in recent years, although no reasonable estimate can yet be made of the volume used. The expected increase in use of ground water for irrigation should not cause a large-scale lowering of ground-water levels if the wells are spaced widely enough.

OTHER USES

One of the most important nonwithdrawal uses of streamflow in this area is for waste disposal by industries and municipalities. Recreational activities in certain areas constitute a significant use of the surface waters of the basin.

In addition to the uses of ground water discussed in the preceding sections, wells furnish water for a variety of uses, including motels, laundries, and air conditioning. These miscellaneous uses of ground water account for an estimated 5 mgd.

POTENTIAL SUPPLY

SURFACE WATER

At the present time the demand for surface waters of suitable quantity and quality is increasing rapidly. The industrial expansion in the State, gains in population, greater use of automatic home appliances, and widespread installation of irrigation equipment have caused an upsurge in the use of water. The withdrawal of surface waters for these uses may be expected to increase in the future.

The present sources of surface water generally appear to be adequate to provide the quantities required in the near future for the continued development of the area. Although it is probable that in most places the present withdrawal can be increased several times without danger of a shortage of supply, the demand for water in many localities will grossly exceed minimum streamflow, and additional storage facilities will be necessary. The adequacy of the surface-water supplies in several localities will depend in large measure upon pollution abatement.

Rainfall deficiencies during recent growing seasons have led to an increase in the volume of water used for irrigation, and similar rainfall deficiencies in the future will necessitate additional irrigation. Because of the humid climate in North Carolina irrigation will not be practiced on as large a scale as in the Western States; however, supplementary irrigation undoubtedly will be continued on an increasing scale.

GROUND WATER

In spite of the large percentage of the population using ground water in the Yadkin-Pee Dee River basin, the quantity now withdrawn from wells is only a small fraction of the total supply available. A great expansion in use of ground water is possible throughout the basin so long as the withdrawal is not excessively concentrated.

An accurate determination of the potential ground-water supply could be determined only by interpreting hydrologic data collected over a period of years. No ground-water studies have been made in about half the basin, and in the remainder only reconnaissance studies have been undertaken. Although detailed knowledge of the properties of the underground reservoirs have not been obtained, sufficient information is available to suggest areas of possible expansion and to point out some of the limitations on future development.

Domestic ground-water supplies (yields of a few gallons per minute) can be obtained throughout the basin and their development rarely presents a serious problem. Supplies for small municipalities and for small industrial use, but not for large-scale uses, are available in most parts of the Piedmont and in the western part of the Coastal Plain. In the Cretaceous sand in the eastern part of the Coastal Plain, large supplies for future municipal and industrial use are available.

If future increases in ground-water withdrawals could be distributed throughout the basin in accordance with the productivity of the several aquifers, there would be no reason for concern about a depletion of ground-water storage. However, the withdrawal of water is likely to be concentrated around industrial centers. The lowering of the water level around pumped wells is measurable for some distance outward from the wells, the shape and extent of the cone being dependent on the rate of pumping, the permeability of the water-bearing materials, and the recharge conditions. If the areas of influence of two or more wells overlap, there will be some mutual interference, and the aggregate yield will be less than the combined yield of each well pumped separately. A wide spacing of wells is important if large supplies of ground water are required. Consequently, it may not be possible for an industry to have several heavily pumped wells on its property, whereas a municipality, being able to space its wells over several square miles, may be in a position to furnish a large additional quantity of water for public use, including industrial use.

A limiting factor in future expansion of ground-water supplies in the easternmost part of the basin is the occurrence of salty water in some of the deeper beds. In Brunswick County and the adjoining part of Columbus County water having a chloride content greater than 250 ppm occurs at depths shallower than 300 feet. The withdrawal of water in this area at present is not great, and consequently there is no evidence of movement of salty water into the overlying fresh-water beds.

WATER LAWS

In North Carolina water rights, with only a few important exceptions, are based on the principal of riparian rights established under the English common law, as interpreted from time to time by various courts; however, by action of the 1955 General Assembly a State Board of Water Commissioners was created which, upon the declaration of an emergency by the Govenor, is vested with the authority to make allocations of water for human consumption, sanitation, and public safety.

In matters affecting public health, the statutes of North Carolina provide that the State Board of Health shall have control over domestic waste discharges where such discharges are into waters used as sources of public water supplies.

The North Carolina State Stream Sanitation Committee, by action of the General Assembly of 1951, was vested with the authority to establish standards applicable to the streams and watercourses of the State and with the responsibility of classifying such waters. Within the limits of the enabling act, control as to the manner and extent of disposal of sewage and waste and the maintenance of established stream standards rest with this Committee. Industries contemplating locating in North Carolina should clear with the State Stream Sanitation Committee plans and proposals for the disposal of waste into the streams of the State.

The General Statutes of 1943, as amended, provide that any person, firm, or corporation utilizing waters for irrigation that are taken from any stream, river, creek, or lake in North Carolina, in an amount sufficient to reduce substantially the volume of flow, shall obtain a permit for such use from the Director of the Department of Conservation and Development.

Navigable streams are under the jurisdiction of Congress through its constitutional powers to "---regulate commerce---among the several States." This power extends to the nonnavigable tributaries of navigable streams if the navigable capacity of the waterway or interstate commerce is affected. Flood control is also recognized as a Federal responsibility.

Control of navigable waters has been generally exercised by the Corps of Engineers, U. S. Army. Concurrent jurisdiction, however, is vested in the Federal Power Commission in the matter of permits and licenses where the construction and operation of hydroelectric installations are involved on navigable streams or tributaries thereto. The district office of the Corps of Engineers having jurisdiction over the navigable stream affected should be consulted where encroachment on a navigable stream is contemplated, or regarding any proposed impoundment of or diversion from such navigable stream or tributary thereto related to hydroelectric installations. The entire Yadkin-Pee Dee River basin lies within the jurisdiction of the Charleston, S. C., district of the Corps of Engineers.

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