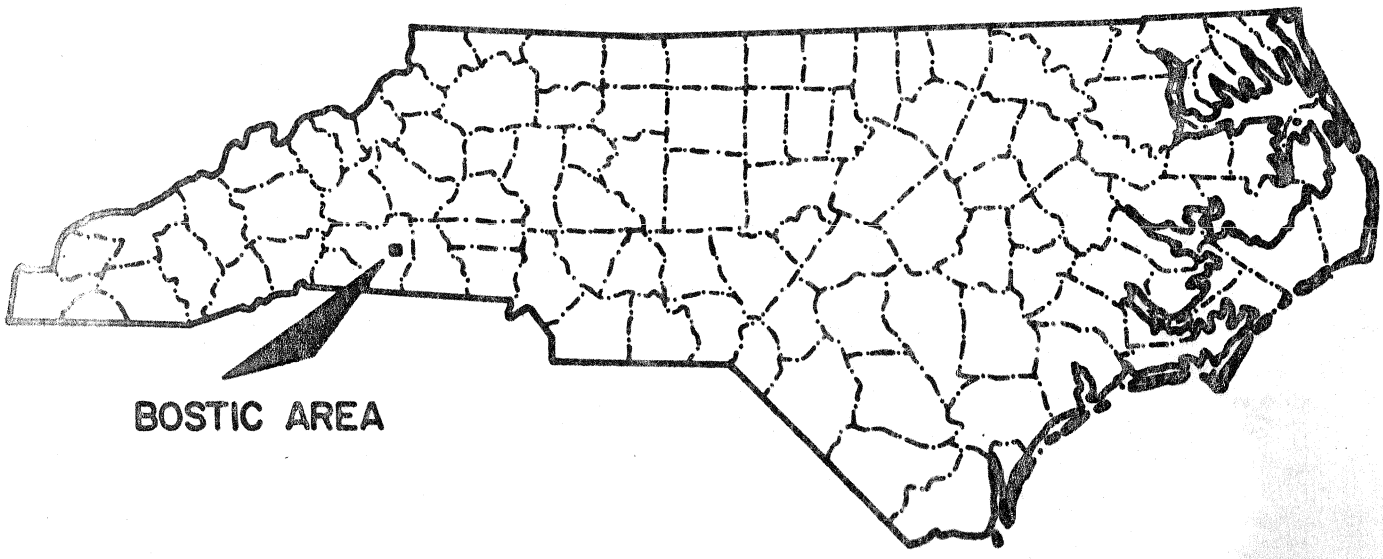
GEOLOGY AND GROUND-WATER RESOURCES IN THE BOSTIC AREA, NORTH CAROLINA

GROUND-WATER CIRCULAR NO. 11



DIVISION OF GROUND WATER
NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES
1965

NORTH CAROLINA

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GEOLOGY AND GROUND-WATER RESOURCES IN THE BOSTIC AREA, NORTH CAROLINA

A Reconnaissance

By Donald A. Duncan

INTRODUCTION

The Town of Bostic, in making plans for the development and construction of a municipal water-supply system utilizing deep wells as a water source, requested the Division of Ground Water to provide them with information on the availability and quality of ground water in the area. In complying with this request, a reconnaissance of the geology and hydrology of Bostic and the immediate area was made during the spring and summer of 1964 by the Division of Ground Water, District No. 1, under the general supervision of Mr. Harry M. Peek, Chief, Division of Ground Water. This investigation included reconnaissance geologic mapping, an inventory of 39 selected wells, and collection of 25 samples of water from representative wells to determine the general quality of ground water in the area.

This report was designed to provide the Town of Bostic information and recommendations regarding the availability, quality, quantity, and development of a dependable ground-water supply.

Acknowledgments

The writer wishes to express appreciation for the cooperation and assistance of the officials of the Town of Bostic and the well drillers

of the area who contributed valuable information about the area during the course of this investigation.

Well-Location and Numbering System

The location and numbering of wells in this report are based on a statewide grid system of longitude and latitude.

The state is divided into quadrangles of 5-minutes of latitude, identified by upper-case letter, and 5-minutes of longitude, identified by numbers. Each 5-minute quadrangle is divided into twenty-five 1-minute quadrangles, identified by lower-case letters. The wells in each 1-minute quadrangle are numbered serially. Thus, a well numbered P78t-2 would be well 2 in the 1-minute quadrangle "t" of the 5-minute quadrangle P-78 (fig. 1).

Geography

The Town of Bostic is located approximately 2 1/2 miles northeast of Forest City in Rutherford County. The investigation was limited to an area in and around the Town of Bostic which is bounded by long 81°49'40" and 81°50'46" and by lat 35°21'16" and 35°22'10" (fig. 1).

The area of investigation is located in the western part of the Piedmont plateau and is characterized by gentle to steep slopes, low rounded hills, and is thoroughly and fairly deeply dissected. The altitude ranges from about 900 feet above sea level to about 1,150 feet above sea level, with the maximum relief about 250 feet. The drainage of the Bostic area forms a dendritic pattern consisting of Puzzle Creek and Robinson Creek which flow generally southward and empty into Second Broad River.

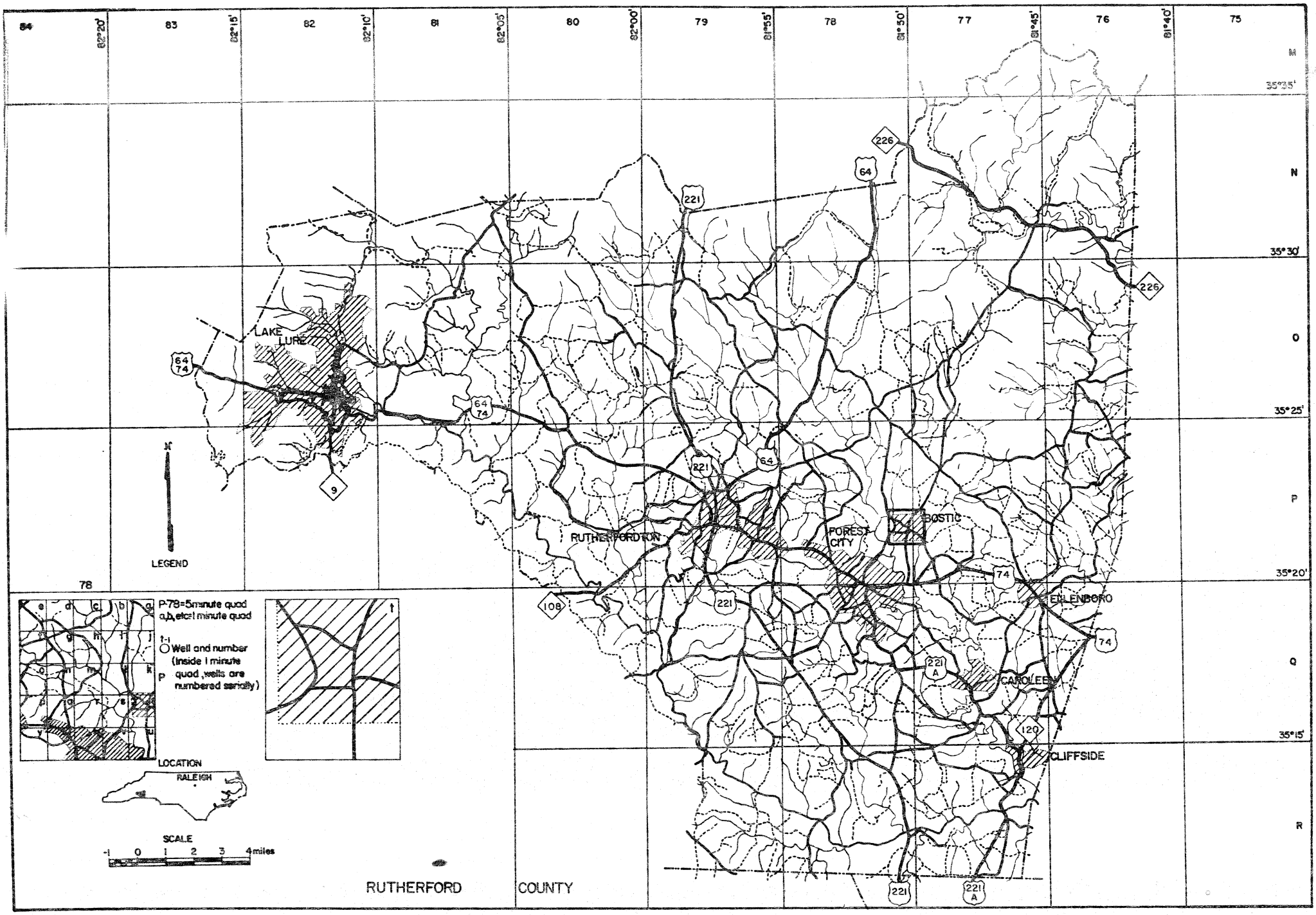

Figure 1 - Map of Rutherford County showing location of the Town of Bostic and well numbering system

Climate

The climate is of the modified-continental type and is warm and temperate. The warmest month in summer (July) averages 79° F, and the coldest month in winter (January) averages 43° F.

Table 1 is compiled from the records of the U. S. Weather Bureau recording station at Shelby, N. C., being based on 22 years of record, 1931-52.

The average annual rainfall is 47.5 inches, and the average annual snowfall is 7.1 inches. Precipitation is about 25 percent less in the fall than in other seasons. Moderately dry periods of 2 to 5 weeks often occur late in spring and early in summer and are common in fall.

Winters are fairly short and relatively mild. Periods when the temperature is below the freezing point seldom exceed 4 or 5 days, and there are only a few days of freezing temperature each winter.

Annually, the Bostic area has about 145 days of clear weather, the remaining 220 days being cloudy to partly cloudy.

GEOLOGY

The rocks of the Bostic area, like those of the surrounding Piedmont, consist primarily of a complex series of metamorphic and igneous rocks. Natural exposures of bedrock in the Bostic area are rare. This lack of natural outcrop constituted an obstacle to detailed geologic mapping; however, artificial exposures were available in road cuts, although the rocks observed there were generally highly weathered. Observations were also made by examining float material, which is available in considerable quantities throughout the area.

Table 1.--Temperature and precipitation at Shelby, Cleveland County, N. C.
(Elevation 997 feet)

Month or season	Temperature			Precipitation			
	Average (°F)	Absolute maximum (°F)	Absolute minimum (°F)	Average (inches)	Driest year (1933) (inches)	Wettest year (1929) (inches)	Average snowfall (inches)
December	42.7	79	5	4.49	2.41	2.20	2.0
January	43.4	81	-3	4.10	2.76	3.15	1.8
February	45.1	81	9	3.83	3.74	9.01	.6
Winter	43.7	81	-3	12.42	8.91	14.36	4.4
March	52.3	91	12	4.68	1.79	7.71	2.7
April	60.7	93	26	3.40	2.67	3.31	0
May	69.5	100	38	3.40	2.40	5.61	0
Spring	60.8	100	12	11.48	6.86	16.63	0
June	78.0	105	46	3.81	1.53	3.70	0
July	79.0	107	54	5.45	3.92	10.54	0
August	78.3	104	52	4.95	5.50	1.12	0
Summer	78.4	107	46	14.21	10.95	15.36	0
September	72.6	104	39	3.01	2.30	7.10	0
October	62.3	97	22	3.37	1.11	10.80	0
November	50.4	84	11	2.98	1.71	5.62	0
Fall	61.8	104	11	9.36	5.12	23.52	0
Year	61.2	107	-3	47.47	31.84	69.87	7.1

(Compiled from the records of the U. S. Dept. of Commerce Weather Bureau.)

The two major rock types underlying the area consist of a biotite schist and a quartz-biotite gneiss (fig. 2). These rocks strike from N. 35° E. to N. 55° E. and dip about 20-25° SE.; although locally, the dip may be as great as 45-50°. Structural relationships indicate that these two rock types are interlayered with one another in varying degrees.

Mineralogically the schist is composed of biotite and quartz, with sillimanite, muscovite, and sericite in varying amounts. Accessory minerals include garnet, chlorite, kyanite, pyrite, and ilmenite.

Numerous narrow quartz veins and small pegmatites occur throughout the schist, both parallel to and cutting across the bedding. The pegmatites are composed chiefly of quartz, feldspar, muscovite, and biotite with small amounts of tourmaline.

The gneiss is composed chiefly of quartz, biotite, feldspar, and muscovite with accessory minerals. Locally the gneiss may contain appreciable amounts of hornblende and garnet.

These rocks are deeply weathered throughout most of the area and are covered by a layer of clayey, sandy residual material and weathered rock, a few feet to several tens of feet thick.

GROUND WATER

Hydrologic Cycle

The primary source of the ground water is precipitation (fig. 3). Of the total precipitation, part returns directly to the atmosphere, part infiltrates the ground, and part runs off overland into the streams. Much of the water moving downward into the soil and subsoil is retained at a shallow depth as soil moisture which is subject to evaporation and the

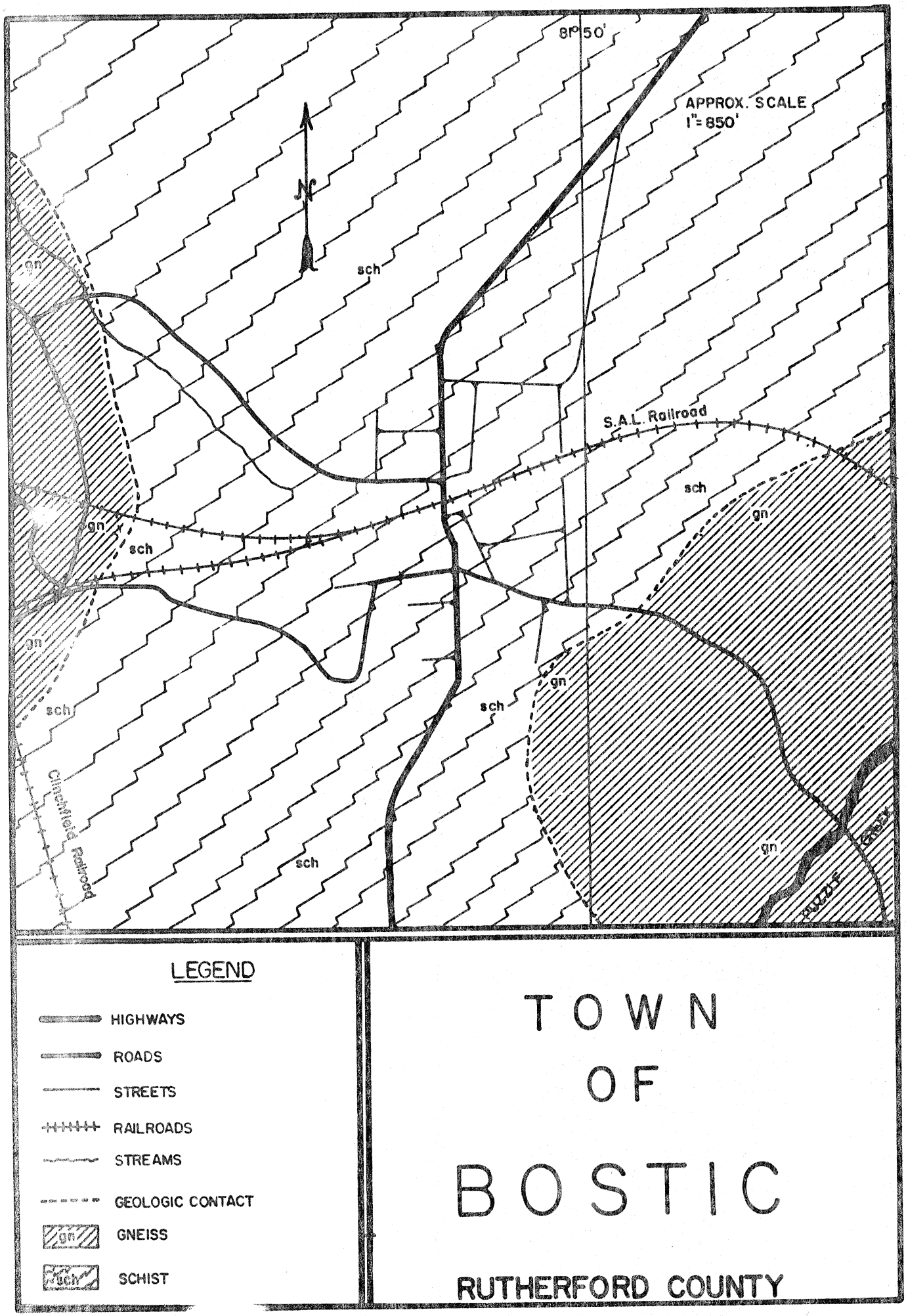

Figure 2. - Geologic : Bostic area, N.C.

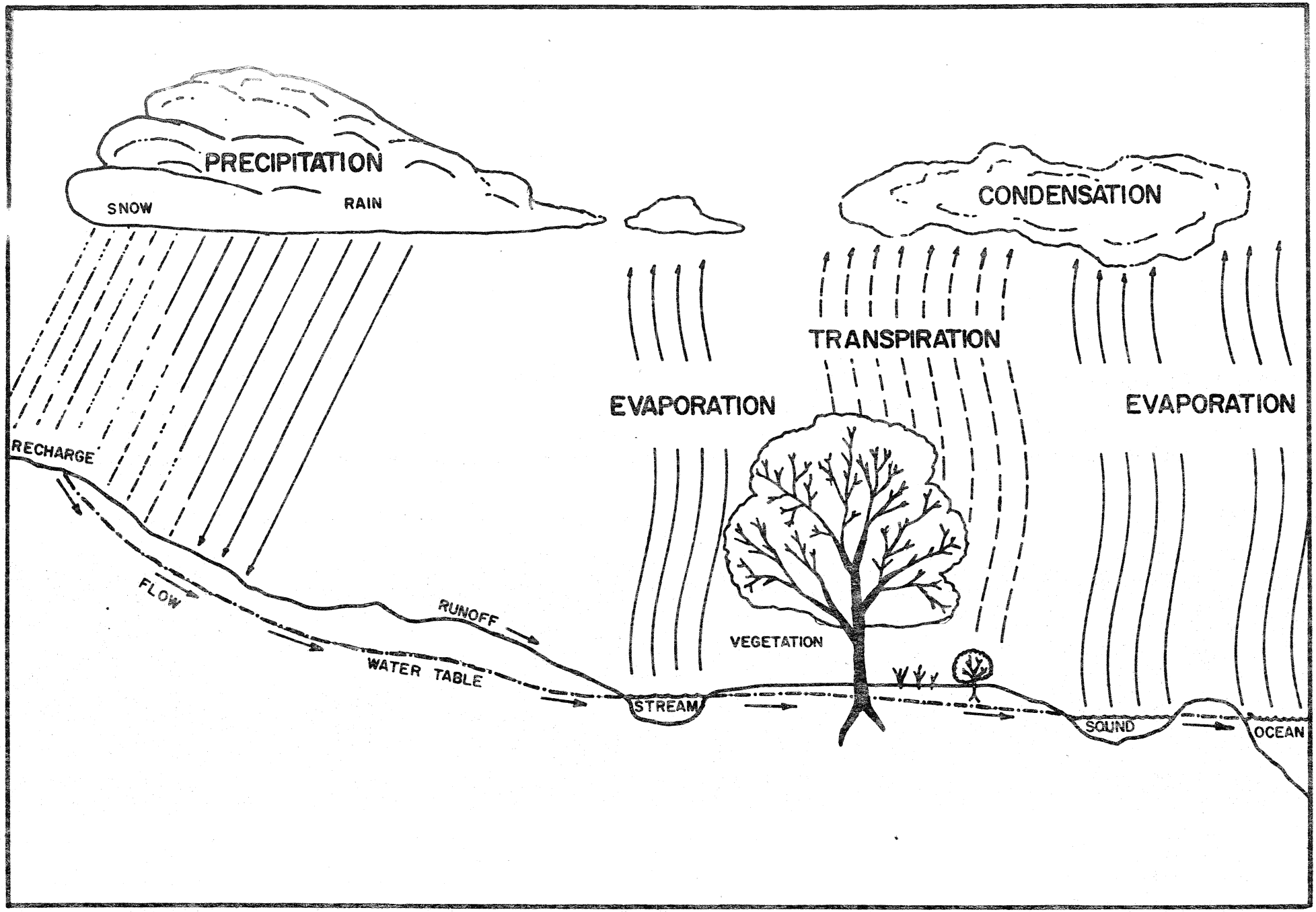

Figure 3 - The hydrologic cycle.

demands of plant growth. During the summer, evapotranspiration may return moisture to the atmosphere at rates similar to or exceeding those of precipitation. During the remainder of the year, water available after the soil-moisture requirements have been met moves down through the soil and rocks to the water table and becomes ground water.

Occurrence and Movement

Below a certain depth, the rocks of the Bostic area are generally saturated with water and are said to be in the zone of saturation. The upper surface of the zone of saturation is called the water table. In general, the water table is a subdued replica of the configuration of the land surface. In and around Bostic ground water is recovered from dug, bored, and drilled wells (table 2 and fig. 4). The dug and bored wells are large-diameter (up to 4 feet) wells that generally are shallow and do not penetrate bedrock. These wells recover ground water from the surficial material consisting of clayey and sandy soil and weathered rock. Water occurs in this material only between the individual rock fragments and mineral grains. Because the water table does not remain in a stationary position but fluctuates seasonally with variations in the gain or loss of water, these wells are often affected by extended periods of drought.

The drilled wells are small-diameter (usually 6 inches) wells that are relatively deep and penetrate bedrock. These wells recover water from the structural openings such as faults, joints, and similar fractures in the crystalline bedrock. The thick layer of clayey and sandy soil and weathered bedrock that overlies most of the area, which as a rule is highly porous and permeable, acts as a recharge reservoir from which water flows into the structural openings and fractures in the bedrock. Therefore, the

Table 2.--Inventory of selected wells in the Bostic area, North Carolina

Well numbers correspond to those in figure 5 and table 3. Asterisk indicates chemical analyses (table 3)
Use of water: C, commercial; D, domestic; PS, public supply

Quadrangle and well No.	Owner	Type of well	Depth of well (feet)	Depth of casing (feet)	Yield (gpm)	Rock type	Use of water	Static water level (feet)	Remarks
P77p-1*	Bostic School	Drilled	90	------	20	Schist	PS	40	----------
P78t-1	Victor Logan	Bored	72	72	-----	Weathered schist	D	6	Daily use reported as 200 gallons
P78t-2	Robert Carson	Dug	70	15	-----	-------do.------	--do.-	10	Daily use reported as 200 gallons
P78t-3*	John Gettys	Drilled	75	20	-----	Schist	--do.-	20	Serves 3 houses
P78t-4	B. G. Cole	Bored	68	68	-----	Weathered schist	--do.-	6	Daily use reported as 200 gallons
P78t-5	L. R. Robbins	--do.--	58	58	-----	-------do.------	--do.-	-----	Serves 3 houses
P78t-6	W. D. Funderburke	--do.--	75	75	-----	-------do.------	--do.-	8	Serves 3 houses
P78t-7	D. U. Smart	Dug	22	22	-----	Soil zone	--do.-	5	Daily use reported as 100 gallons
P78t-8	Sue Dobbins	Bored	45	45	-----	Weathered schist	--do.-	15	----------
P78t-9	D. Martin	Dug	60	12	-----	-------do.------	--do.-	8	Daily use reported as 200 gallons
P78t-10	Vantz B. Bailey	Bored	65	65	-----	-------do.------	--do.-	10	----------
P78t-11	Lee Smith	Dug	38	38	-----	-------do.------	--do.-	10	Daily use reported as 200 gallons

Table 2.--Inventory of selected wells in the Bostic area, North Carolina--Continued

Quadrangle and well No.	Owner	Type of well	Depth of well (feet)	Depth of casing (feet)	Yield (gpm)	Rock type	Use of water	Static water level (feet)	Remarks
P78t-12	Mrs. Padgett	Dug	45	45	-----	Weathered schist	D	8	Daily use reported as 50 gallons
P78t-13	Mrs. Sam Harrill	Bored	79	79	-----	-------do.------	-do.-	30	Daily use reported as 400 gallons
P78t-14	Charles Worley	Bored	70	70	3	-------do.------	-do.-	20	Daily use reported as 200 gallons
P78t-15	Lee Pace	--do.--	70	70	-----	-------do.------	-do.-	25	Daily use reported as 200 gallons
P78t-16	A. W. Hollifield	--do.--	46	46	-----	-------do.------	-do.-	18	Daily use reported as 200 gallons
P78t-17	John McArthur	Drilled	143	------	-----	Schist	-do.-	50	----------
P78t-18	Arthur McKinney	Dug	35	35	-----	Weathered schist	-do.-	10	Daily use reported as 200 gallons
P78t-19*	Howard Smart	Drilled	100	80	20	Schist & gneiss	-do.-	60	----------
P78t-20*	Bostic Service Sta.	Bored	56	56	-----	Weathered schist	C	40	----------
P78t-21	Lillie Harrill	--do.--	60	60	-----	-------do.------	D	-----	Daily use reported as 300 gallons
P78t-22	Ralph Harrill	Dug	80	80	-----	-------do.------	-do.-	70	Daily use reported as 250 gallons
P78t-23	R. W. Soens	Bored	80	60	-----	-------do.------	-do.-	25	----------
P78t-24	Hubert Bailey	Dug	28	28	-----	Soil zone	-do.-	6	----------

Table 2.--Inventory of selected wells in the Bostic area, North Carolina--Continued

Quadrangle and well No.	Owner	Type of well	Depth of well (feet)	Depth of casing (feet)	Yield (gpm)	Rock type	Use of water	Static water level (feet)	Remarks
P78t-25	C. T. Harrill	Bored	67	67	-----	Weathered schist	D	20	----------
P78t-26*	Sprat Gin	Dug	50	none	-----	-------do.------	C	6	Serves a bank, store & gin
P78t-27	Old Meth. Parsonage	--do.--	70	20	-----	-------do.------	D	8	----------
P78t-28	Max Gunters	Bored	60	60	-----	-------do.------	-do.-	27	Daily use reported as 200 gallons
P78t-29	W. M. Harrison	Dug	71	71	-----	-------do.------	-do.-	29	----------
P78t-30*	Harrison's Mill	Bored	50	50	-----	-------do.------	C	22	Daily use reported as 400 gallons
P78t-31*	J. G. Michael	Dug	40	15	-----	-------do.------	D	6	Daily use reported as 150 gallons
P78t-32	Ruby Lattimore	--do.--	56	10	-----	-------do.------	-do.-	10	----------
P78t-33*	A. O. Harrill	--do.--	72	72	-----	-------do.------	-do.-	17	Daily use reported as 200 gallons
P78t-34	Buena Feree	--do.--	70	70	-----	-------do.------	-do.-	20	Daily use reported as 100 gallons
P78t-35	Wade Fortune	--do.--	85	30	-----	-------do.------	-do.-	30	Daily use reported as 200 gallons
P78t-36	Ed Henson	--do.--	70	25	-----	-------do.------	-do.-	20	Daily use reported as 100 gallons
P78t-37*	Baptist Parsonage	Drilled	120	60	5+	Schist	-do.-	13	----------
P78t-38	Crawford Nanney	--do.--	98	58	5	Schist	-do.-	75	----------

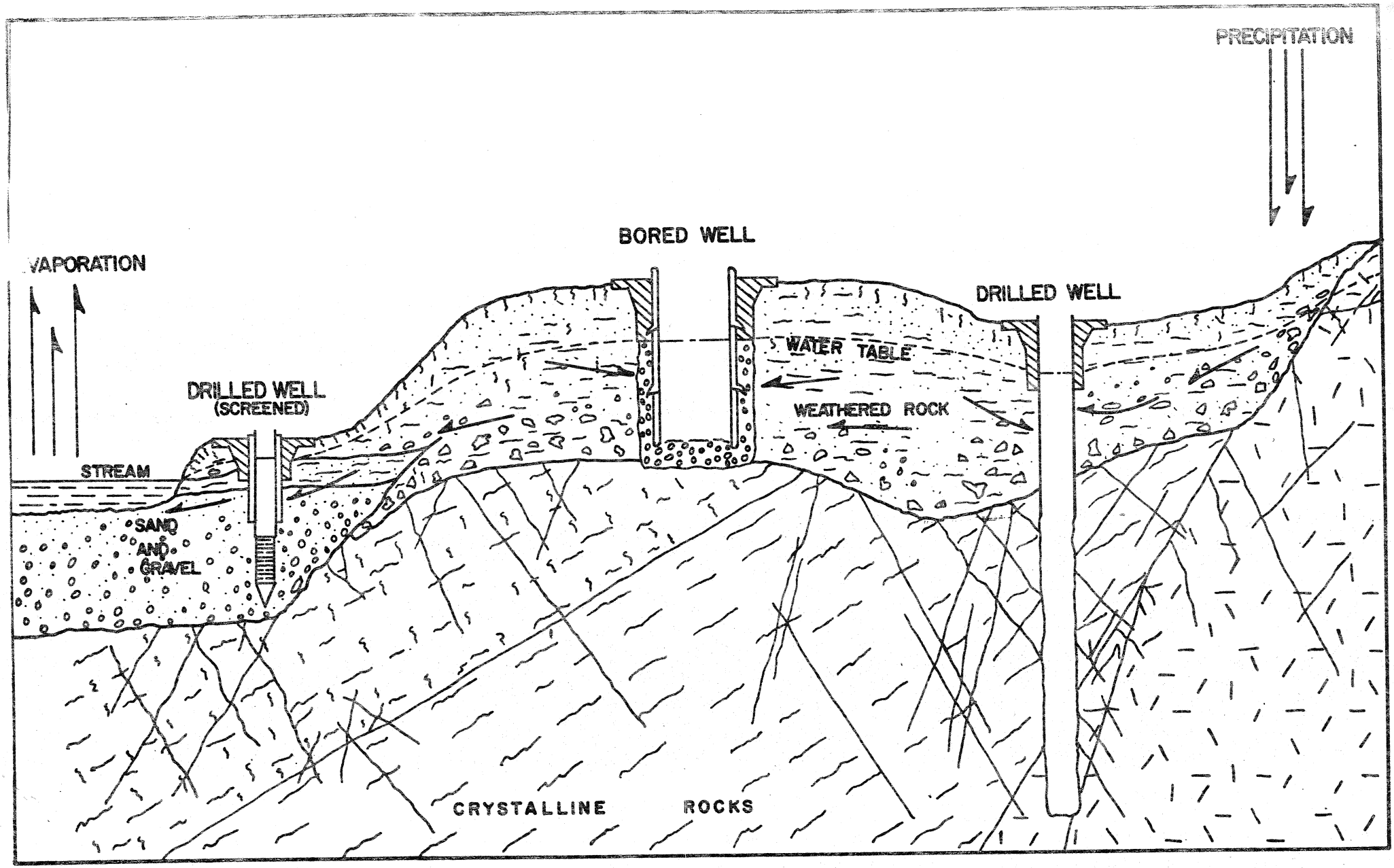

Figure 4 – Diagram showing common types of well construction.

yield of wells penetrating bedrock should be uniform throughout the year and affected little by short periods of drought.

Quality of Ground Water

The ground water of the Bostic area is of good chemical quality. The minerals in ground water in the Bostic area are dissolved primarily from the soils and rocks through which the water percolates. The chemical character of the water is, therefore, not uniform throughout the area, but varies with the chemical composition of the soils and rocks and with the rate and pattern of the circulation of the ground water. Water from precipitation immediately begins to dissolve mineral matter upon entering the soil and rocks; and the longer the circulating ground water is in contact with the soil and rocks, the greater is the opportunity to dissolve mineral matter. The ground water of the Bostic area contains relatively small amounts of dissolved mineral matter. However, locally, the ground water recovered from wells penetrating the biotite schist may contain iron in objectionable amounts.

Partial chemical analyses of nine samples from selected wells are shown in table 3.

Suggested Quality of Water Standards

In 1962, the U. S. Public Health Service established revised standards for drinking water. Although these standards are set up for water used on common carriers engaged in interstate commerce, they have been accepted by most state departments of health as a basis for quality control and have been adopted by the American Water Works Association as standards for all public water supplies. Table 4 lists some common

Table 3.--Partial chemical analyses of water from selected wells in the Bostic area, North Carolina

(Analyses by North Carolina Division of Ground Water. Results in parts per million except as indicated.)

Well number	P77p-1	P78t-3	P78t-19	P78t-20	P78t-26	P78t-30	P78t-31	P78t-33	P78t-37
Iron (Fe)	0.02	0.02	2.2	0.20	0.10	0.05	0.10	0.10	0.10
Bicarbonate (HCO_3)	60	11	14	42	55	12	90	3	22
Carbonates (CO_3)	0	0	0	0	0	0	0	0	0
Chloride (Cl)	8	2.4	5	8	11	4	10	7	6
Sulfate (SO_4)	8.5	2.3	7	12	1.7	23	5.5	4.4	16
Fluoride (F)	0.20	0.10	.01	0	0	0	0.02	0	0.01
Hydrogen sulfide (H_2S)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrogen (NO_2 and/or NO_3)	1.3	3.5	1.1	1.8	0	0	0.6	2.1	4
Ammonium nitrogen (as N)	.11	0	0.43	0.35	0	0.17	0.01	0	0.10
Dissolved solids	62	31	78	81	79.3	65	32.5	111	39
Hardness as $CaCO_3$	17.1	17.1	51.3	---	17.1	34.2	17.1	68.4	17.1
Hardness total	68.4	17.1	68.4	34.2	34.2	51.3	17.1	85.5	34.2
Specific conductance (micromhos at 25° C)	95	47	120	125	122	100	50	170	60
pH	6.4	5.5	6.5	---	6.8	6.6	5.4	7.7	6.7
Color (apparent)	0	0	70	0	0	0	0	0	0
Turbidity, Jackson units	0	0	20	0	0	0	0	0	0
Temperature (°F)	61	62	61	61	62	61	59	62	60
Date and appearance when collected	10-6-64 clear	7-31-64 clear	7-31-64 turbid	10-6-64 clear	7-31-64 clear	10-6-64 clear	7-31-64 clear	7-31-64 clear	7-31-64 clear
Date and appearance when analyzed	10-7-64 clear	7-31-64 clear	7-31-64 turbid	10-7-64 clear	7-31-64 clear	10-7-64 clear	7-31-64 clear	7-31-64 clear	7-31-64 clear

Table 4.--Common chemical and physical properties of ground water and relation to use

Constituents and properties	Effects of excessive quantities	Recommended limits for domestic use
Iron (Fe)	Metallic taste, stains fabrics and porcelain, promotes growth of iron bacteria.	0.3 ppm
Manganese (Mn)	Metallic taste, stains fabrics and porcelain.	0.05 ppm
Sulfate (SO_4)	Laxative effects, salty taste.	250 ppm
Chloride (Cl)	Salty taste, corrosive	250 ppm
Fluoride (F)	Causes mottling of teeth; however, in optimum quantities (.8 to 1.2 ppm) is effective in preventing dental cavities.	1.5 ppm
Nitrate (NO_3)	Possible infantile nitrate poisoning; indicates pollution.	45 ppm
Hardness (as $CaCO_3$)	High soap consumption, forms scale on heated vessels and pipes	0-60 ppm - soft 60-120 ppm - moderately hard 120+ ppm - hard
Dissolved solids	Represents total mineral and organic material dissolved in water.	500 ppm
Hydrogen-ion concentration (pH)	Low pH increases the corrosive action of water on metal and concrete. Water with a pH of less than 4.0 usually has a sour taste.	pH 0-7 - acidic pH 7-14 - basic pH 7 - neutral pH 6-8 - normal pH 10.6 - maximum

chemical and physical properties of water and the standards of the U. S. Public Health Service that pertain to the characteristics of water supplies.

Yield of Wells

Available data indicate that a moderate amount of water can be obtained almost anywhere in the Bostic area. Yields of individual wells in the area range from 0 gpm (gallons per minute) to about 40-45 gpm, with the average well yielding about 4-8 gpm.

The yield and depth of wells in metamorphic or crystalline rock vary areally, both regionally and locally from well to well, depending on the number and size of openings and on the topography; therefore, data for a single well or a group of wells may be applied only in a general way to indicate the probability of obtaining a required yield in any given locality. A review of the available data on the two main rock types, biotite schist and quartz-biotite gneiss, suggests that the average drilled wells in gneiss have slightly higher yields than wells in the schist. This is reasonable because the fracturing of the coarser grained and more brittle rocks, such as gneisses, has produced wider and more continuous joint openings than the fracturing in the finer grained rocks, such as schist.

The rock openings, such as joints and other fractures, become more widely spaced and narrower with depth. The depth below which joints are too tightly closed to contain recoverable water is not precisely known, and it probably varies from place to place. Experience of drillers indicates that if a sufficient supply of water is not obtained after drilling through 250 feet of rock, the chances of getting the needed water by

drilling deeper are poor. Where no water is encountered in crystalline rock above the 250-foot depth, it is common practice to move to a different location.

Selection of Well Sites

Topography is perhaps the most important consideration in locating water wells in the Piedmont of North Carolina. Since the topography is usually a surface expression of the geologic structures and rock types underlying an area, a careful examination and interpretation of the topographic features can be helpful in locating satisfactory water-well sites.

Hills, as a rule, are the least favorable locations for a well. They represent areas that are highly resistant to erosion and are usually underlain by rocks that are hard and contain few joints and fractures for ground water to flow through. Draws and valleys represent zones of weakness in the rocks where fracturing and jointing are more highly developed; therefore, a well located in a valley or draw generally has a greater chance for yielding large amounts of water. Another factor to take into consideration is that the direction of movement of ground water is towards the draws and valleys and away from the hills.

Because appreciable water is yielded to a well only where there is a sufficient number of interconnected joints and fractures and because the location of these interconnected joints and fractures is not known in detail, the success or failure of a well in crystalline rock cannot be predicted with certainty.

One of the principal objectives of this investigation was the selection of well locations for the present and future development of the Town's water system. Well locations selected during the course of this

investigation, as shown in figure 5, include 4 primary and 5 secondary sites. The primary locations are the most favorable sites based on all available criteria, and should be given priority over all others in the development and future expansion of the water supply for the Town. Construction of wells at the selected sites should provide an adequate source of water for the foreseeable future.

Water Requirements

The officials of the Town of Bostic, realizing the need and value of a municipal water-supply system to provide the citizens with an adequate water supply, and further realizing that it is a basic necessity for attracting industry and maintaining the general growth of the community, initiated plans for a municipal water-supply system. This system is presently under construction.

The present needs require a sufficient amount of water to provide for a population of about three hundred. In order to meet these requirements and to meet the recommended standards of the State Board of Health of 100 gpd (gallons per day) per person for basic sewage flow and water consumption, wells producing about 30,000 gpd are needed. Therefore, a single well producing a minimum flow of 25 gpm would be sufficient for present needs. However, in order to provide for the future growth of the Town and to meet any emergency, wells producing at least 40-50 gpm should be developed.

The Town has drilled 4 wells (see fig. 5), 2 of which are satisfactory for incorporation into the new system. Town well No. 1 was drilled in October of 1964 by Hickory Well Supply, Inc. This well is 285 feet deep and yields 20 gpm. Town well No. 4 was drilled in February of 1965 by

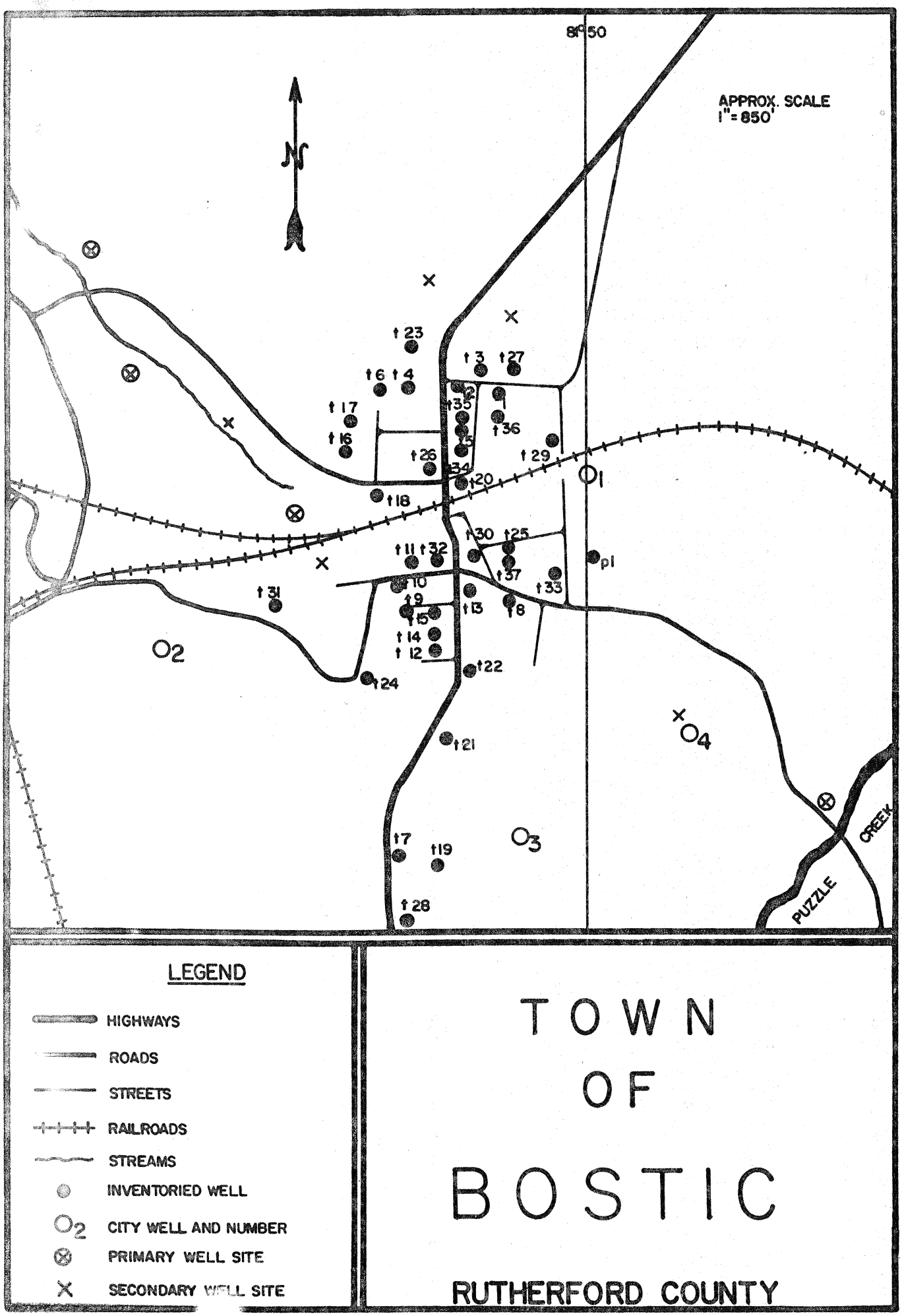

Figure 5.- Map of the area showing location of inventoried wells and proposed well sites.

Suburban Well Drillers, Inc. Well 4 is 300 feet deep and yields 15 gpm. In the opinion of the author, these wells (with the exception of Town well No. 4) were drilled at sites where only moderate yields should have been expected.

SUMMARY

The results of the investigation of the geology and ground-water resources of the Bostic area are as follows:

1. Two major rock types underly the area: biotite schist and quartz-biotite gneiss. Structural relationships indicate that these rocks are interlayered with one another in varying degrees. These rocks are deeply weathered and are usually covered by residual soil and weathered rock, a few feet to several tens of feet thick.

2. Available data indicate that a moderate amount of water can be obtained almost anywhere in the Bostic area. Yields of wells in the area range from 0 gpm to about 40-45 gpm, with the average well yielding about 4-8 gpm.

3. Ground water of the Bostic area is of good chemical quality, containing relatively small amounts of dissolved mineral matter. Locally, ground water may contain iron in objectionable amounts.

4. Bostic needs a water supply sufficient to provide for the basic water requirements for a population of about three hundred. Wells producing about 30,000 gpd would fulfill this requirement.

RECOMMENDATIONS

This investigation has illustrated that ground water of sufficient quantity and satisfactory quality to meet the Town's requirements can be

obtained in the Bostic area. Therefore, the following recommendations are made:

1. Pumping tests of at least 24 hours' duration should be made on existing and future wells to determine the maximum yield and most efficient pumping rate so that they may be utilized at maximum capacity.

2. The Town should give priority to the primary well locations selected during this investigation as additional wells are needed.

3. To provide for future growth of the Town, and to meet any emergency, wells producing at least 40-50 gpm should be obtained.

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