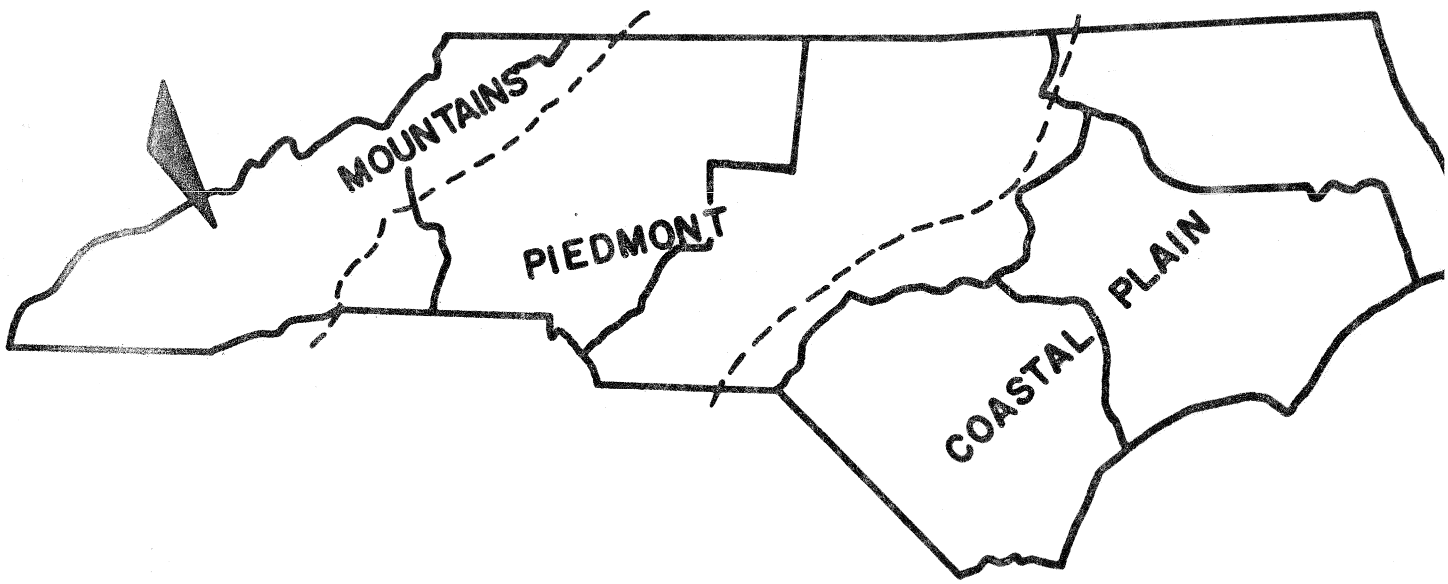
GROUND WATER CONDITIONS IN THE CLYDE AREA HAYWOOD COUNTY, NORTH CAROLINA

GROUND-WATER CIRCULAR NO. 6



DIVISION OF GROUND WATER

NORTH CAROLINA

DEPARTMENT OF WATER RESOURCES

1965

G R O U N D   W A T E R   C O N D I T I O N S   I N   T H E
C L Y D E   A R E A ,   N O R T H   C A R O L I N A

by

Donald A. Duncan

Ground-Water Circular No. 6

North Carolina
DEPARTMENT OF WATER RESOURCES
Walter E. Fuller, Director

DIVISION OF GROUND WATER
Harry M. Peek, Chief

Raleigh

1965

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GROUND WATER CONDITIONS IN THE CLYDE AREA, NORTH CAROLINA

By Donald A. Duncan

INTRODUCTION

The Town of Clyde, in making plans for the expansion and development of their 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 survey of the geology and hydrology of Clyde and the immediate area was made during the spring and summer of 1964 by District No. 1 of the Division of Ground Water under the direct supervision of Harry M. Peek, Chief, Division of Ground Water. This investigation included reconnaissance geologic mapping, and inventory of approximately 75 wells, and collection of 15 samples of water from representative wells to obtain general information on the quality of ground water in the area under investigation.

This report was designed to provide the Town of Clyde 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 generous cooperation and assistance of the officials of the Town of Clyde 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 is based on a statewide grid system of longitude and latitude.

The state is divided into quadrangles of five-minutes latitude, identified by upper-case letters, and five-minutes longitude, identified by numbers. Each five-minute quadrangle is divided into 25 one-minute quadrangles, identified by lower case letters. The wells in each one-minute quadrangle are numbered serially. Thus a well numbered "N91-k2" would be well No. 2 in the one-minute quadrangle "k" of the five-minute quadrangle N91 (Figure 1).

GEOGRAPHY

The Town of Clyde is located approximately four miles west of the City of Canton and five miles northeast of the City of Waynesville in Haywood County. The investigation was limited to an area in and around the Town of Clyde and is bounded by latitudes 82°52'30" and 82°57'30" and longitudes 35°30'00" and 35°35'00".

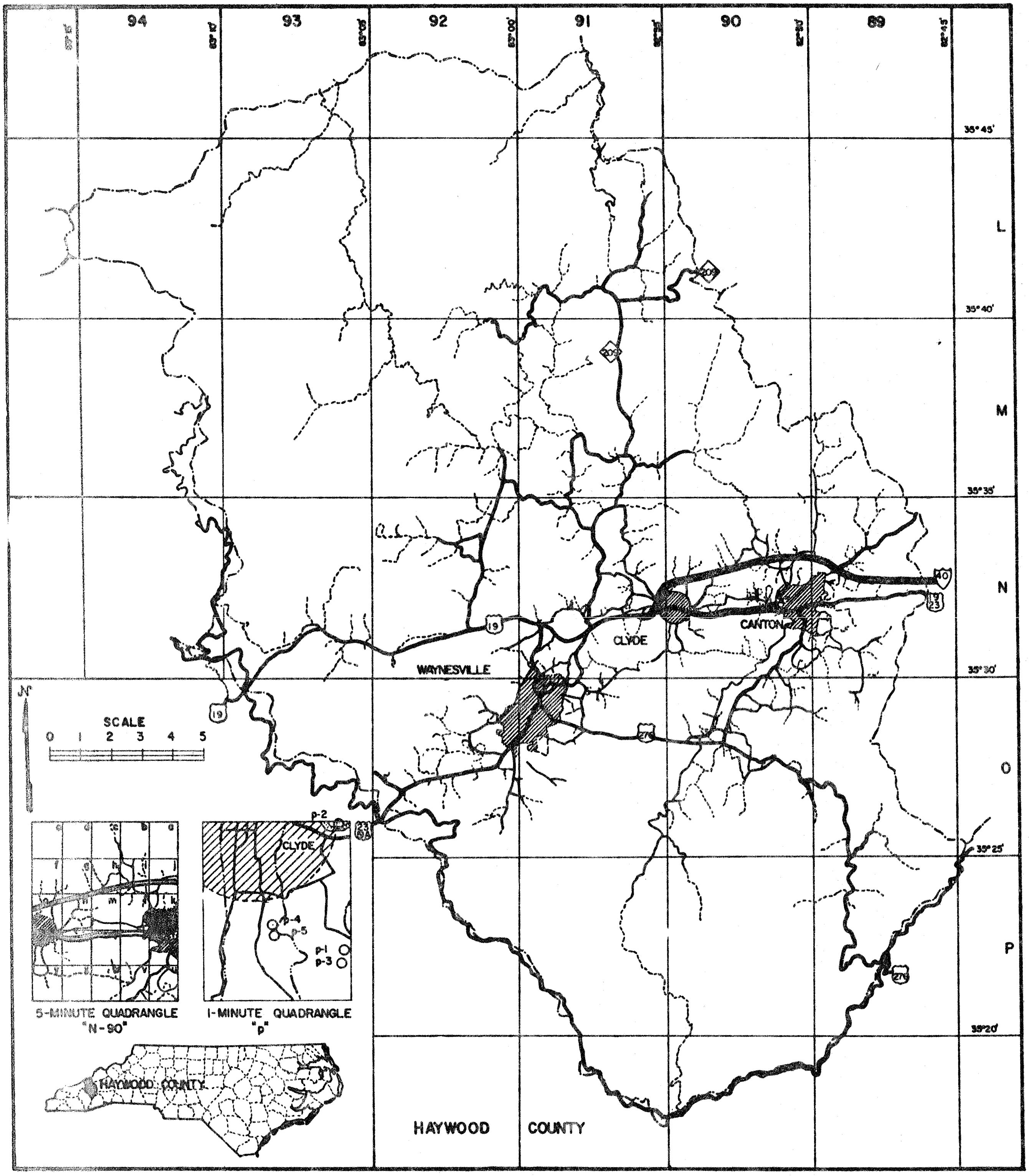

Figure I - Map of Haywood County showing location of the town of Clyde and well numbering system

The area of investigation is located in the Pigeon River Valley in the Blue Ridge physiographic province. The Town proper is situated on the broad, level flood plain of the Pigeon River and is flanked by high mountains to the north and south.

Chambers Mountain, with an elevation of over 4500 feet, is the highest in the area studied. The lowest point, at an elevation of 2500 feet, is on the Pigeon River, south of Hyder Mountain. Thus, the maximum relief over the entire area is about 2000 feet.

The Pigeon River drains the entire area and flows to the northwest into the Tennessee Valley. The principal tributaries of the Pigeon River in the area of investigation are Conner Mill Branch, Sally Haines Branch, Richland Creek, and Chambers Branch.

CLIMATE

The climate of the Clyde area is of the modified continental type and is temperate. The warmest month in the summer averages about 71°F, and the coldest month in the winter averages about 38°F.

Table I is compiled from the records of the U. S. Weather Bureau recording stations at Waynesville and Canton in Haywood County.

The average rainfall is about 41 inches annually, and the average snowfall is 10.7 inches. Precipitation is about 20 per cent less in fall than in other seasons. Moderately dry periods of two to five weeks often occur late in spring and early in summer and are common in fall.

TABLE I. Temperature at Waynesville (elevation 2638 feet), Haywood County, and precipitation at Canton (elevation 2662 feet), Haywood County

Month	Temperature*			Precipitation**			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1941)	Wettest year (1949)	Average snowfall
December	38.4	74	-4	3.10	2.77	1.63	2.0
January	38.0	78	-12	3.49	1.51	2.63	2.7
February	37.8	75	-10	3.36	.64	3.73	2.7
Winter	38.06	78	-12	9.95	4.92	7.99	7.4
March	46.7	89	2	4.20	3.09	3.16	2.9
April	53.5	89	15	3.03	1.62	4.00	.1
May	61.4	91	29	2.87	.61	3.99	T
Spring	53.86	91	2	10.10	5.32	11.15	3.0
June	67.8	94	34	3.46	2.72	7.13	T
July	70.7	97	43	5.03	8.73	8.34	.0
August	70.1	96	42	4.82	2.67	11.41	.0
Summer	69.53	97	34	13.31	14.12	26.88	T
September	65.6	91	29	2.65	.78	1.60	.0
October	54.5	86	14	2.68	1.47	4.90	T
November	45.5	80	4	2.42	1.18	2.03	.3
Fall	55.20	91	4	7.75	3.43	8.53	.3
Year	54.16	97	-12	41.11	27.79	54.55	10.7

*Temperatures shown in degrees Fahrenheit.

**Precipitation given in inches.

Winters are not excessively long nor harsh, and the summers are relatively mild. The growing season in this area is of sufficient length for most commercial crops, the average length of frost-free period being about 190 to 195 days.

Annually the Clyde area has about 150 days of clear weather, about 115 days are partly cloudy, and 100 days are cloudy.

GEOLOGY

The principal rock type of the Clyde area is a complex, highly metamorphosed mica gneiss of pre-Cambrian (?) age. Several varieties of mica gneiss are present and are interlayered in various proportions. They range in composition from schist that is rich in muscovite, with a little quartz, feldspar, and biotite, to the more abundant quartzose mica gneiss which occurs as banded granular layers of feldspar, quartz, and either muscovite or biotite or both with accessory minerals. Some of this gneiss has a rather uniform texture and banding while other parts of it exhibit a strong banding with variations in texture. These variations are attributed to differences in the original composition of the rocks prior to metamorphism. At some localities bands or zones of garnet gneiss, garnet schist, and kyanite gneiss were found associated with the mica schist.

Also, hornblende gneiss and schist occur as layers a few inches to tens of feet thick in the micaceous rocks. The hornblende schist consists mostly of hornblende with quartz, feldspar, and a little biotite. The hornblende gneiss is a banded rock composed of alternating

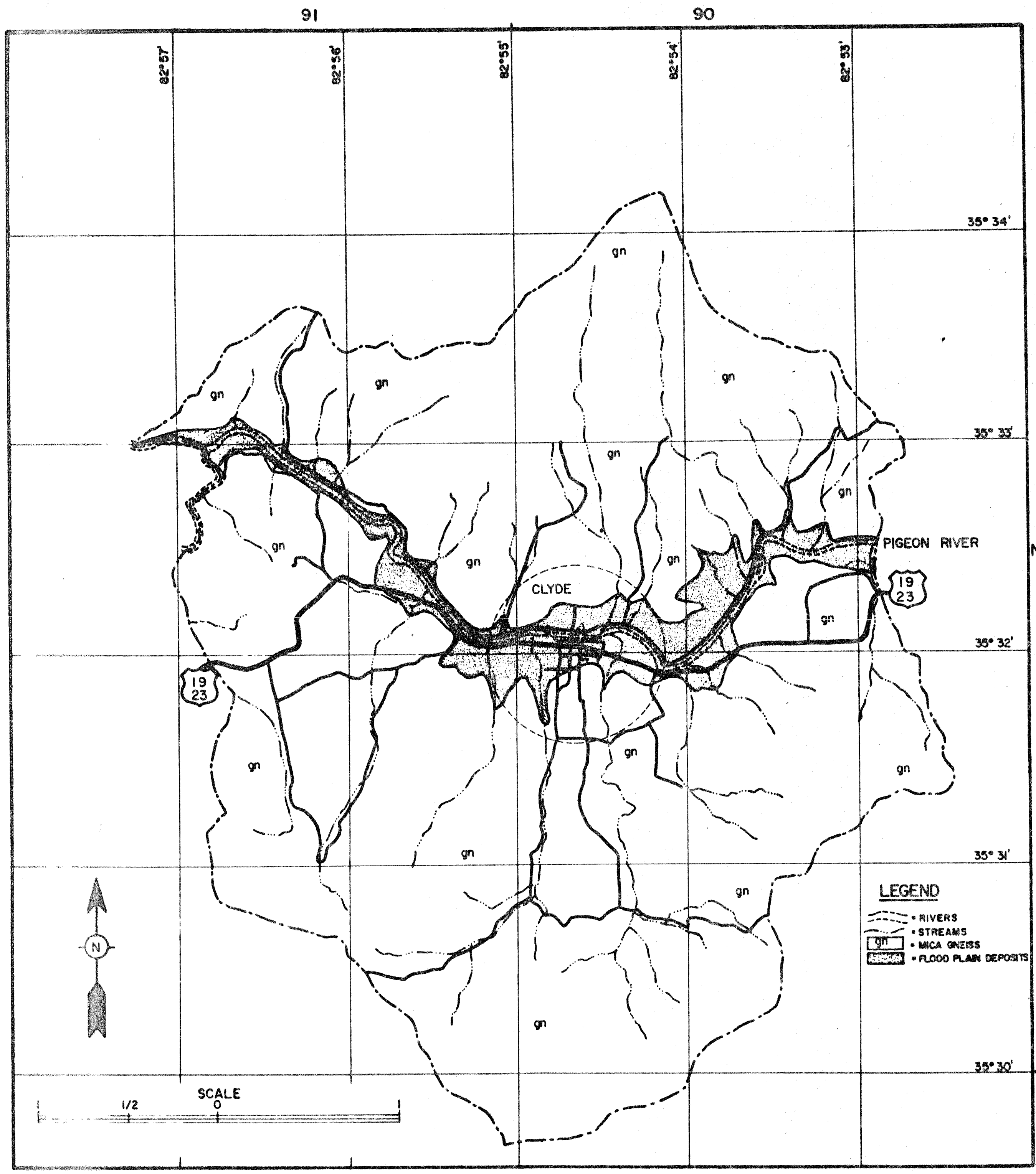

Figure 2 - Geologic map of the Clyde area, North Carolina

dark (hornblendic) and light (quartz-feldspar) layers. The color of these rocks ranges from light to dark grey to almost black and weather to dull gray, greenish-gray, or reddish-yellow.

The micaceous gneiss and schist are generally considered to represent sediments of pre-Cambrian (?) age which have been altered greatly by regional metamorphism. Some of the hornblendic rocks may represent sills, but their interlayering with diverse rock types and other structural relationships suggests that they probably are largely of volcanic or sedimentary origin.

The major structural trend of the rocks is northeastward, and they dip southeastward, although extreme variations occur locally.

The Pigeon River flood plain deposits consist of rounded boulders, cobbles, and gravels with fine- to coarse grained quartz sand, silt, and clay.

GROUND WATER

Hydrologic Cycle

The ultimate source of the ground water is precipitation. 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 shallow depth as soil moisture, which is subject to evaporation and the demands of plant growth. During the summer, evapotranspiration may return moisture to the atmosphere at rates

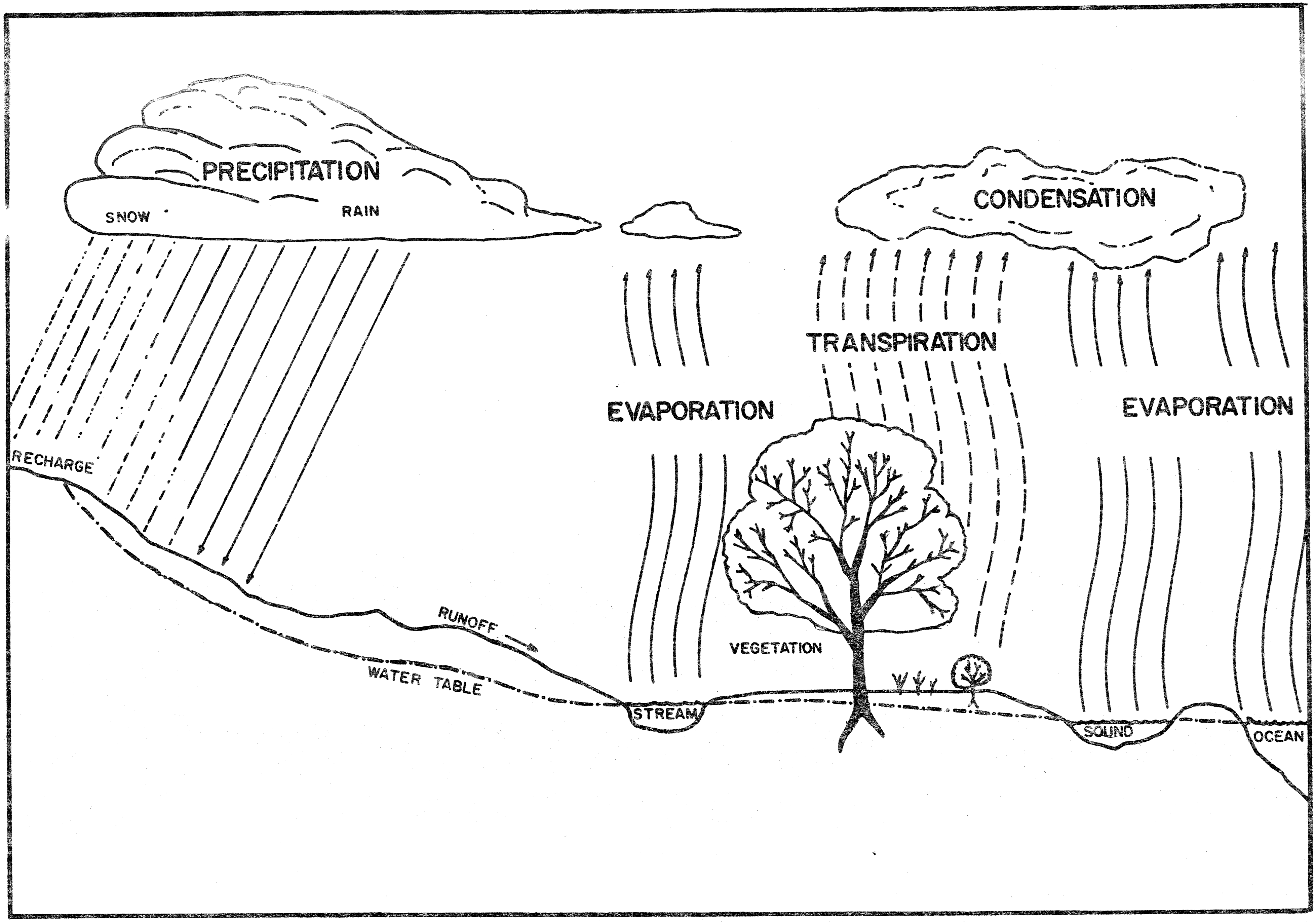

Figure 3 - The Hydrologic Cycle

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 Clyde 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 Clyde ground water is recovered from dug wells, springs, and drilled wells. The dug wells are of large diameter (up to four feet) and as a rule, are fairly 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. As 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.

Most of the drilled wells are about 6 inches in diameter and penetrate bedrock. The depth of these wells range from about 50 to more than 300 feet. These wells recover water from the structural openings such as faults, joints, and similar fractures in the crystalline bedrock. The layer of clayey and sandy soil and weathered

TABLE II. Inventory of selected wells in the Clyde area, N. C.

Well No.: Numbers correspond to those in Figure 5 and Table 3. Asterisk indicates chemical analyses (Table 3).
All wells are drilled, 6- or 8-inch diameter.
Water-bearing unit for all wells is mica gneiss.
All yields are reported.

Depth of wells and water level: R, reported; M, measured.
Method of lift: S, submersible; J, jet (deep well); T, turbine
Use of water: D, domestic; PS, public supply.
Use of well: A, abandoned.

Quadrangle and Well No.	Date Drilled	Depth of Well	Depth of Casing	Altitude of land surface (feet)	Yield	Method of Lift	Use of Water	Measuring Point		Water Level		Remarks
								Description	Height Above or below Land Surface (feet)	Below Land Sur-face	Date measured	
N90-p4	1953	300	---	2590	9	T	PS	Land Sur.	0.0	2.0	4-10-61	Town well
N90-p5	1952	235	---	2585	20	T	PS	Land Sur.	0.0	37.0	4-10-61	Town well
N90-o6		310	---	2595	12	S	PS	Land Sur.	0.0	+.2	4-10-61	Town well
N90-q2	10-60	220	60	2533	45	S	D	Land Sur.	0.0	12.0	3-62	
N91-k6	1-64	70	52	2550	20	J	D	Top of csg.	0.5	20.0	1-16-64	
N91-u1	7-60	82	68	2680	12	J	D	Top of csg.	1.0	30.0	7-8-60	
N91-12	4-60	164	---	2620	---	S	D	Land Sur.	0.0	100.0	4-7-60	
N91-k1*	8-60	120	40	2610	---	---	D	Top of csg.	1.0	60.0	8-30-60	
N90-o1	10-60	84	52	2720	6	J	D	Top of csg.	1.5	25.0	10-24-60	
N90-o2	11-60	89	79	2740	10	---	D	Top of csg.	0.7	40.0	11-3-60	
N90-o3	11-60	91	82	2760	9	---	D	Top of csg.	1.0	40.0	11-8-60	
N90-p1	8-62	101	45	2730	4.5	J	D	Top of csg.	1.0	21.0	8-20-62	
N91-i2	7-62	83	80	2590	4	J	D	Top of csg.	0.6	15.0	7-16-62	
N91-k3	3-61	104	52	2555	6	J	D	Land Sur.	0.0	20.5	3-18-61	
N91-t2	9-61	63	53	2590	14	---	D	Land Sur.	0.0	35.0	9-5-61	
N91-t1	3-61	51	45	2640	10	J	D	Land Sur.	0.0	15.0	3-13-61	
N91-k2	12-60	97	79	2595	6	---	D	Land Sur.	0.0	41.0	12-1-60	
N90-p2*	8-61	145	50	2525	15	---	D	Land Sur.	0.0	50.5	8-1-61	
N91-k4	7-61	108	90	2602	15	---	D	Land Sur.	0.0	32.0	7-21-61	
N90-o4*	10-61	150	51	2775	10	S	D	Land Sur.	0.0	70.0	10-2-61	
N90-p3	3-62	282	110	2742	2	J	D	Land Sur.	0.0	19.5	3-21-62	
N90-n1*	9-62	120	95	2680	5	S	D	Land Sur.	0.0	60.0	9-5-62	
N91-i1*	10-62	196	82	2845	3	S	PS	Land Sur.	0.0	75.0	10-16-62	
N91-t3	7-63	176	97	2605	5	S	D	Land Sur.	0.0	48.0	7-30-63	
N90-x1	8-63	280	85	2935	0	---	A	---	---	---	---	Dry hole
N90-x2	9-63	88	76	2935	10	J	D	Land Sur.	0.0	15.0	9-6-63	
N90-o5	10-63	278	62	2750	1	S	D	Land Sur.	0.0	70.0	10-11-63	
N90-q1	10-63	112	85	2600	8	J	D	Land Sur.	0.0	38.5	10-29-63	
N91-k5*	3-64	286	80	2535	5	S	D	Land Sur.	0.0	85	3-20-64	
N90-n2	10-58	138	100	2720	3	---	D	Land Sur.	0.0	68.0	10-23-58	
N90-y1	1-60	105	69	2650	4	S	D	Land Sur.	0.0	65.0	1-21-60	
N91-11*	2-60	186	91	2680	8	S	PS	Land Sur.	0.0	140.0	2-22-60	
N90-m1*	2-60	123	51	2630	5	---	D	Land Sur.	0.0	70.0	2-1-60	
N90-y2	5-59	97	89	2715	15	S	D	Land Sur.	0.0	75.0	5-7-59	
N91-k7	3-59	88	15	2595	10	---	D	Land Sur.	0.0	50.5	3-27-59	
N90-h1*	5-63	146	97	2720	5	---	PS	Land Sur.	0.0	75.0	5-21-63	
N90-h2	12-61	150	84	2755	15	J	D	Land Sur.	0.0	22.0	12-5-61	

bedrock that overlies much of the area is generally very porous and acts as a recharge reservoir to feed water into the structural openings and fractures in the bedrock. Therefore, the yield of wells penetrating bedrock should be fairly uniform throughout the year and almost unaffected by moderate periods of drought.

Quality of Ground Water

The ground water of the Clyde area is, with few exceptions, of good chemical quality. The minerals in ground water in the Clyde 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 the longer the circulating ground water is in contact with the soil and rocks, the greater is the opportunity to dissolve mineral matter. As a result, ground water of the Clyde area generally contains relatively small amounts of dissolved mineral matter. However, locally, the ground water recovered from wells penetrating the mica schist may contain iron in objectionable amounts.

Preliminary chemical analyses of nine samples from selected wells are shown in Table III.

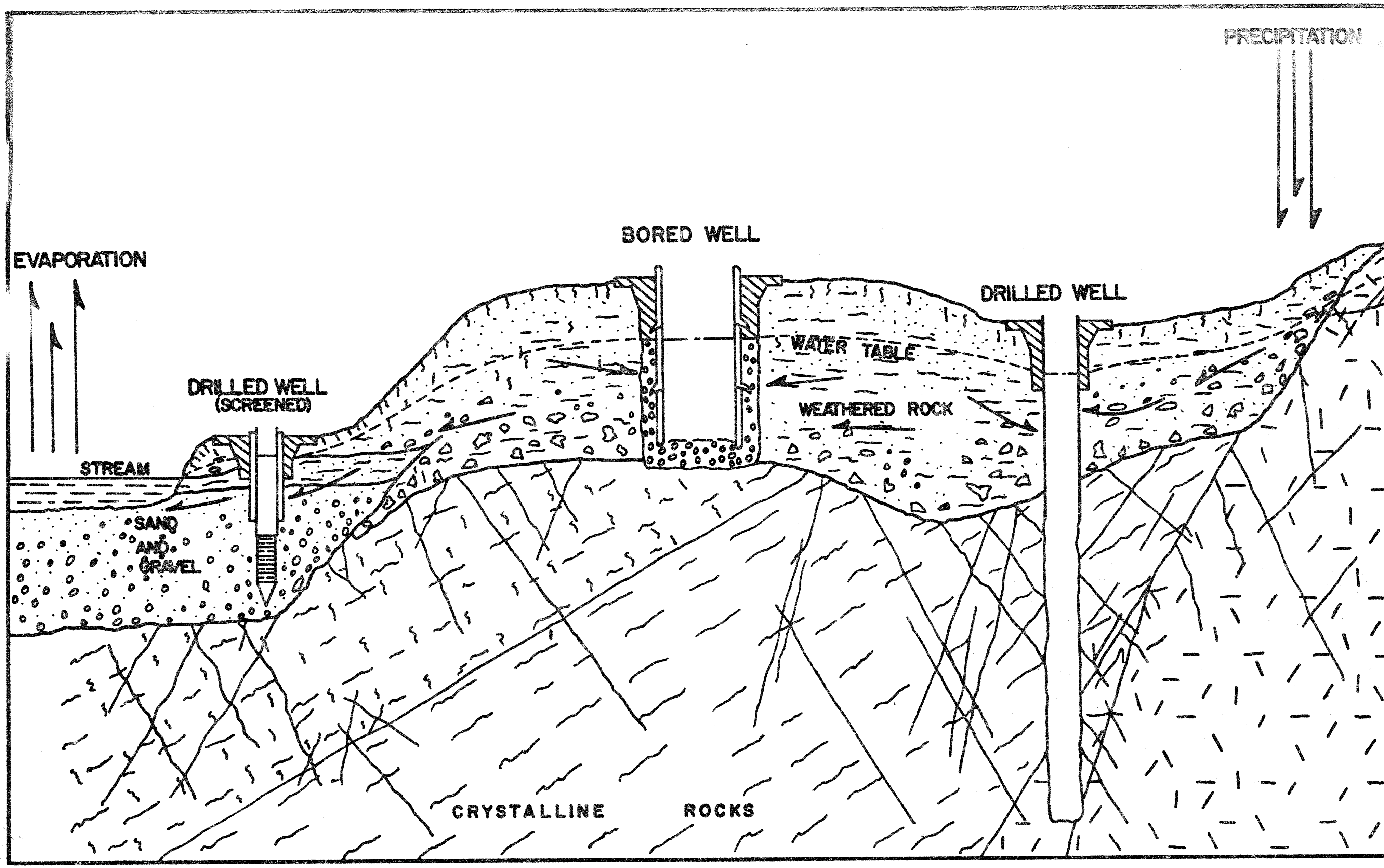

Figure 4 — Diagram showing common types of well construction

TABLE III. Chemical analyses of water from selected wells in the Clyde area, N. C.*
(Analyses by N. C. Division of Ground Water)

Well Number	N90-m1	N90-n1	N90-o4	N90-p2	N90-h1	N91-k1	N91-k5	N91-i1	N91-l1
Iron (Fe)	.03	.00	.01	.04	.00	.01	.02	.02	.01
Bicarbonate (HCO_3)	37	61	44	35	20	66	53	30	36
Carbonates (CO_3)	0	0	0	0	0	0	0	0	0
Chloride (Cl)	0.0	2.2	2.1	3.0	0.0	2.3	1.8	1.9	2.2
Sulfate (SO_4)	6.0	7.0	11.0	6.0	15.0	9.0	4.0	6.0	11.0
Fluoride (F)	.1	.00	.00	.2	.00	.00	.1	.00	.00
Hydrogen Sulfide (H_2S)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrate (NO_3)	.3	.4	.1	.00	.3	.1	.00	.3	.2
Ammonium Nitrogen (as N)	.01	.01	.10	.14	.05	.04	.11	.11	.01
Dissolved Solids	64	72	43	51	59	81	46	55	72
Hardness as $CaCO_3$	17	17	34	17	51	34	17	51	17
Hardness Total	34	51	68	34	85	68	51	68	34
Alkalinity as $CaCO_3$	30	44	64	35	85	49	68	60	28
Specific Conductance (micromhos at 25° C)	99	110	66	78	91	125	70	85	111
pH	6.0	6.2	6.4	6.3	6.5	6.2	6.2	6.4	6.2
Color (apparent)	0	0	0	0	0	0	0	0	0
Turbidity, Jackson units	0	0	0	0	0	0	0	0	0
Temperature (°F)	58.5	59	59	61.5	60	59	58.5	57.5	57.5
Date and appearance when collected	9-11-64 Clear	9-11-64 Clear	9-11-64 Clear	9-11-64 Clear	9-11-64 Clear	1-20-65 Clear	1-20-65 Clear	1-20-65 Clear	1-20-65 Clear
Date and appearance when analyzed	9-14-64 Clear	9-14-64 Clear	9-14-64 Clear	9-14-64 Clear	9-14-64 Clear	1-21-65 Clear	1-21-65 Clear	1-21-65 Clear	1-21-65 Clear

*Results given in parts per million.

TABLE IV. Analyses of Town's water supply
(After Chemical and Physical Character of Municipal Water Supplies in North Carolina, 1961.)

	Well 1	Well 2	Conners Mill Branch Raw Water	Conners Mill Branch Finished Water
Silica (SiO_2)	19	26	20	19
Iron (Fe)	.25	.02	.00	.00
Manganese (Mn)	.00	.00	.01	.05
Calcium (Ca)	7.2	13	5.2	7.6
Magnesium (Mg)	1.4	2.3	2.7	1.8
Sodium (Na)	5.2	6.6	3.1	3.8
Potassium (K)	1.5	1.8	2.2	1.6
Bicarbonate (HCO_3)	36	54	30	34
Carbonate (CO_3)	0	0	0	0
Sulfate (SO_4)	6.1	11	2.7	6.5
Chloride (Cl)	2.4	2.3	2.0	2.3
Fluoride (F)	.0	.1	.0	.0
Nitrate (NO_3)	.4	.0	1.3	.5
Dissolved solids	62	91	54	61
Hardness as $CaCO_3$:				
Total	24	42	24	26
Noncarbonate	0	0	0	0
Alkalinity as $CaCO_3$	30	44	25	28
Specific conductance (micromhos at 25° C)	71.1	112	60.8	70.9
pH	6.6	7.4	7.0	6.4
Color	5	5	10	3
Temperature	61	61		
Date of collection	8/8/58	8/8/58	8/8/58	8/8/58
Depth (feet)	269	300		
Diameter (inches)	6	6		
Date drilled	1952	1953		

Yield of Wells

Available data indicate that a moderate amount of water can be obtained almost anywhere in the Clyde area. Yields of wells in the area vary from 0 gpm upward to about 50-60 gpm, with the average well producing about 8-12 gpm.

The yield and depth of wells in metamorphic or crystalline rock vary areally, both widely 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 yield of the two main types of rocks, gneiss and schist, suggests that the average drilled wells in the 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 gneiss 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, generally 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 found in crystalline rock above the 250-foot depth, it is common practice to move to a different location. However, it is possible that productive water-bearing zones occur at much greater depths at many places.

WELL SITE LOCATIONS

Topography is probably the most important single factor to consider in selecting well sites in the mountains of North Carolina, as it is usually a surface expression of the underlying geologic structures and rock types. Careful examination and interpretation of the topographic features can be a most valuable guide in locating satisfactory water well sites.

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

As previously stated, the water in the unweathered crystalline rocks occurs in the fractures, and appreciable quantities of water are generally available to wells only where there is a sufficient number of interconnected joints and fractures. As the location of these interconnected joints and fractures is not often known in detail, the success or failure of a well in crystalline rocks cannot be predicted with certainty.

As a part of this ground-water study, several potential drilling sites were selected and are shown in Figure 5. The most favorable (primary) sites are those selected where a major draw intersects with the Pigeon River Valley. The secondary sites are those selected where a minor draw intersects with a major draw. The existing municipal wells were drilled in what is considered by the author less favorable locations. It is the opinion of the author that wells drilled in the primary locations would probably yield larger quantities of water than now being recovered from existing wells.

PRESENT WATER SYSTEM

At the present time the Town of Clyde obtains water from three wells and an impoundment on Conner Mill Branch. The combined yield of the 3 wells is approximately 41 gallons per minute, which will provide 59,000 gallons per day. The wells are currently being pumped at a rate of 45,000 gallons per day, which supplies about 43 per cent of the Town's water. The remaining 57 per cent is taken from Conner Mill Branch. The Town does not own a watershed on Conner Mill Branch; therefore, the surface water used requires complete treatment by coagulation with alum, chlorination, sedimentation, rapid sand filtration, and adjustment of pH with soda ash. The water from the wells requires no treatment. Raw-water storage facilities consist of a 100,000-gallon reservoir, and finished-water storage consists of one

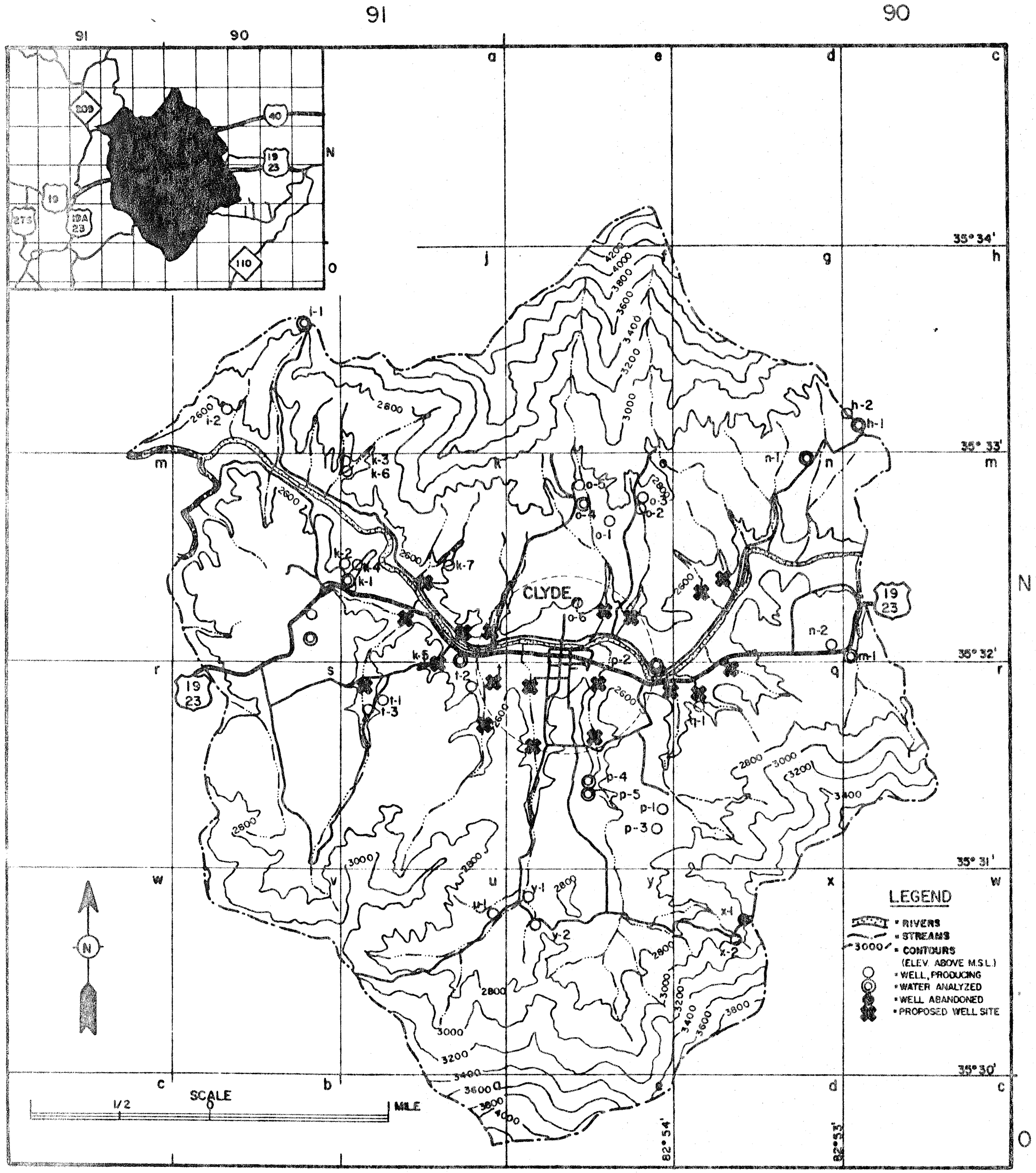

Figure 5 -- Map of the Clyde area showing location of inventoried wells and proposed well sites

clear well with a capacity of 12,000 gallons and an elevated tank with a capacity of 50,000 gallons. This system serves an estimated population of 1,400 persons, with an average daily use of 105,000 gallons. Realizing the need and value of an adequate water system to provide for the needs of their citizens and further realizing that it is a basic necessity for attracting industry and maintaining the general growth of the community, the Town officials are initiating plans for the future development and expansion of the Town's water supply system.

SUMMARY

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

1. The principal rock type is a complex, highly metamorphosed mica gneiss. Several varieties of mica gneiss are present and are interlayered in various proportions. The Pigeon River flood plain deposits consist of rounded boulders, cobbles, and gravels with fine- to coarse-grained quartz sand, silt, and clay.

2. Available data indicate that a moderate amount of water can be obtained almost anywhere in the Clyde area. Yields of wells in the area vary from 0 gpm upward to about 50-60 gpm, with the average well producing about 8-12 gpm.

3. The ground water is, as a rule, of good chemical quality, generally containing relatively small amounts of dissolved mineral matter.

4. The Town of Clyde obtains water from three wells and an impoundment on Conner Mill Branch. The wells supply 43 per cent of the Town's water. The water recovered from the wells requires no treatment. In the opinion of the author, these wells were drilled in sites where only moderate yields should have been expected. The impoundment on Conner Mill Branch supplies 57 per cent of the Town's water which requires complete treatment.

5. One of the principal objectives of this investigation was the selection of well locations for the future development and expansion of the Town's water supply. Well locations selected during the course of this investigation are shown in Figure 5. The most favorable (primary) sites are those selected where a major draw intersects with the Pigeon River Valley. The secondary sites are those selected where a minor draw intersects with a major draw.

RECOMMENDATIONS

This investigation has illustrated that ground water of sufficient quantity and satisfactory quality to meet the requirements of the Town can be obtained in the Clyde area. As ground water would require no expensive treatment and no extensive watershed area development (with costly structures; i.e., dams, treatment plant, etc.), and the maintenance cost of wells would be minimal, the following recommendations are made as the most economical means of expanding and developing the present water system:

1. A step-drawdown pumping test of at least 24 hours' duration should be made on each of the existing wells to determine the specific capacity and most efficient pumping rate, so that they may be utilized at their maximum capacity. It should be kept in mind that the most economical and efficient operation of both pumps and wells is obtained when pumping is as continuous as practical.

2. It is recommended that the Town drill a sufficient number of wells to provide for the expected future demand on the Town's water system.

3. Additional storage facilities with a capacity of at least 200,000 gallons should be constructed.

REFERENCES

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