GEOLOGY AND GROUND-WATER
in the
DURHAM AREA, NORTH CAROLINA

By

GEORGE L. BAIN
Geologist, U. S. Geological Survey

Chemical Quality of Water Section

By

J. D. THOMAS, *Chemist*, U. S. Geological Survey

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NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES

GEORGE E. PICKETT, *Director*

Division of Ground Water

HARRY M. PEEK, *Chief*

Prepared Cooperatively By
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North Carolina
Board of Water Resources

Letter of Transmittal

Raleigh, North Carolina
May 6, 1966

The Honorable Dan K. Moore
Governor of North Carolina

Dear Governor Moore:

I am pleased to submit Ground-Water Bulletin Number 7, "Geology and Ground-Water in the Durham Area, North Carolina".

This report contains the results of an investigation made by the U. S. Geological Survey in cooperation with the North Carolina Department of Water Resources, as a part of the program of reconnaissance studies to evaluate the ground-water resources of the State. It presents the data collected and describes the general geologic and ground-water conditions in Chatham, Durham, Orange, Person, and Randolph Counties.

This report is a valuable contribution to the knowledge of the ground-water resources of the area. It will be available to all persons and agencies concerned with the development and conservation of these resources.

Respectfully submitted,

George E. Pickett

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Geology and Ground Water in the Durham Area, North Carolina

By

George L. Bain

ABSTRACT

The Durham area is in the north-central part of the Piedmont physiographic province and consists of Chatham, Durham, Orange, Person, and Randolph Counties—a total of 2,605 square miles. In 1960 the area had a population of 269,641.

The Durham area is geologically complex. Most of it lies within the so-called Carolina slate belt, which consists of slightly metamorphosed, volcanic, and sedimentary rocks. The volcanic and sedimentary rocks are tightly to openly folded and are faulted and intruded by igneous plutons. The volcanic rocks are felsic to mafic in composition. The plutonic igneous rocks range in composition from granite to gabbro. The area outside the Carolina slate belt is underlain by mica gneiss, mica schist, and hornblende gneiss, and by younger rocks of Triassic age.

Ground water in the area is obtained from drilled, bored, and dug wells and from springs. It is stored in secondary openings such as the planes of schistosity, joints, and cleavage of the unweathered rocks or in the voids of the overlying porous mantle of soil and weathered rock. The relative abundance of secondary openings for the storage and transmission of ground water is not necessarily related to any particular rock type or mapped unit in the area.

At least three factors—rock type, depth of weathering, and topography—govern the potential yield at any one place in the Durham area. A statistical treatment of the well data shows that the two highest average yields, 0.20 and 0.18 gallon per minute per foot of uncased hole, are in granodiorite and granite. Depth of weathering is shown to have a greater influence on yields from the metavolcanic, and argillite-graywacke units than it has on yields from the triassic, and granite and granodiorite units, which appear to reflect topographic control.

Comparison of yields from different topographic situations

indicates that the slopes are the most dependable positions for wells in the Durham area.

Ground water in the Durham area is principally the sodium, calcium, and magnesium bicarbonate type and is suitable for most domestic, municipal, and industrial uses. Calcium and sodium chloride are present in water from a few wells in the metavolcanic, argillite-graywacke, and triassic units. Bromide is associated with chloride in water from two wells in the metavolcanic unit. In general, however, the chemical character of the ground water of the area shows little relationship to the rock units.

INTRODUCTION

Location and Scope of Investigation

The area described in this report is in the north-central part of the Piedmont physiographic province, and consists of Chatham, Durham, Orange, Person, and Randolph Counties. The city of Durham in Durham County is the largest in the area. Figure 1 shows the location of reconnaissance ground-water investigations in North Carolina.

The purpose of this investigation was to evaluate the geology and ground-water resources of the area by determining the areal distribution, attitude, and water-yielding properties of the rocks and the chemical quality of their contained water. The field work consisted of two phases—the well inventory and the reconnaissance geologic mapping.

Basic well data were obtained for 626 wells and 2 springs by interviewing well owners, well drillers, and municipal and county officials. Well data were checked against drillers' records for accuracy whenever possible. As this was not always possible, part of the information, given from memory, may be inaccurate.

Reconnaissance geologic mapping consisted of field checking the existing geologic maps, mapping new units on the basis of natural stratigraphic boundaries, and refining those previously mapped units that fitted the stratigraphic breakdown used in this report.

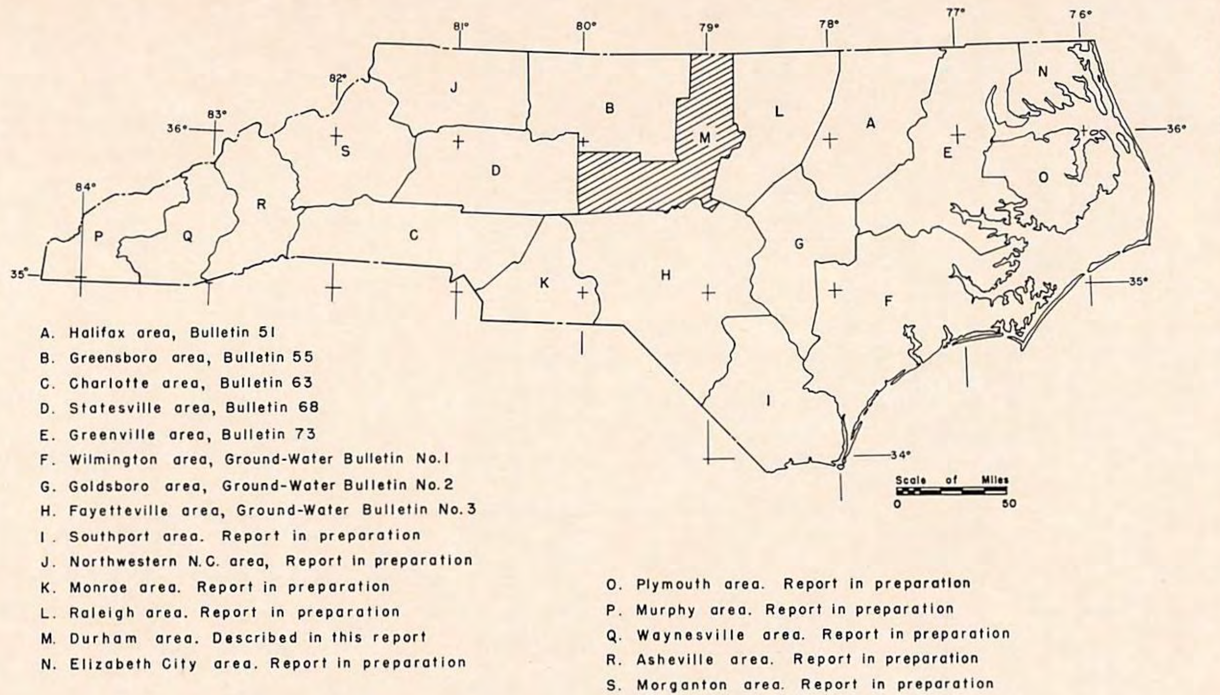


Figure 1. Index map of North Carolina showing areas covered by reconnaissance ground-water investigations.

Cooperation and Direction

The investigation was conducted under the general supervision of O. Milton Hackett, Chief, Ground Water Branch, U. S. Geological Survey. Immediate supervision was by P. M. Brown, District Geologist for the Ground Water Branch in North Carolina, and by J. O. Kimrey, Piedmont Area Supervisor, North Carolina. G. A. Billingsley, District Chemist, Quality of Water Branch, supervised the laboratory analytical work and the preparation of the section entitled, "Chemical Quality of Water."

Previous Investigations

No previous ground-water investigations have been made in the Durham area; however, parts of the report area have been mapped during previous geologic investigations.

Previous geologic investigations include those by Olmsted (1825), Emmons (1856), Kerr (1875), and Williams (1894). Part of Person County was included in the geologic maps by Laney, F. B., and Pogue (1908) and Laney (1917) on the Virgilina copper district. Stuckey (1928) mapped an area surrounding the Deep River pyrophyllite deposits that extend across the Moore-Chatham County line. Reinemund (1955) mapped the Triassic rocks in the extreme south-central and southeastern parts of Chatham County. Several geologists contributed to the reconnaissance mapping used to prepare the 1958 State geologic map (Stuckey and Conrad, 1958). Stromquist and Conley (1959) and Conley (1962) demonstrated that a definite mappable stratigraphic sequence is present in the Albemarle and Denton quadrangles and in Moore County. The stratigraphic divisions used in this report on the Durham area are in part based on the work of Conley and Stromquist.

Acknowledgments

The writer expresses his appreciation to the many well owners, well drillers, county and municipal officials whose generous and courteous assistance made this report possible, and to R. L. Laney, Chemist, U. S. Geological Survey, who assisted in preparation of the quality of water section.

GEOGRAPHY

Area and Population

The area covered by this report totals 2,605 square miles. According to the 1960 Bureau of the Census report, the Durham area has a population of 269,741, or about 103 per square mile. There are 15 cities and towns having a population of more than 1,000 each. Of these, Asheboro, Chapel Hill, and Durham have a population in excess of 10,000. The city of Durham is by far the largest with a population of 79,398. With the exception of the Durham-Chapel Hill, and Asheboro-Randleman areas, the report area is almost exclusively rural.

Economic Development

According to the 1960 Census, 62 percent of the Durham area is classed as farmland.

The agricultural products include tobacco, corn, hay, dairy products, livestock, and poultry. Tobacco is the chief cash crop and is the major source of income for many farm families. The broiler industry is an important source of farm income in Chatham County.

Manufacturing is important in the Durham area. Many people who operate small farms are employed on a full or part-time basis by industry. Industries include the manufacture of cigarettes, furniture, textiles, lumber, brick, and tile; the production of crushed stone; and poultry processing.

Mineral resources of economic importance include shale, clay, stone, pyrophyllite, and coal (Broadhurst, 1955). Copper, gold, lead, zinc, quartz, iron ore, and kyanite also are present in the Durham area. Triassic shale and clay used in the manufacture of brick and tile, and stone, which is crushed for road metal and general construction purposes, are the area's most valuable mineral resources. Argillite from the argillite-graywacke unit (pl. 2) meets the rigid requirements for primary highway construction. The argillite, where it is well sheared and jointed, has proved to be an economic source of crushed stone, owing to its ease of excavation and crushing. Where the argillite has a well-developed bedding plane cleavage and is not deformed, it is a potential source of building stone.

Pyrophyllite is mined only at Hillsboro in Orange County.

Coal is interbedded with the Triassic rocks in southern Chatham County in economic quantities (Reinemund, 1955), but it is not being mined at the present time. Copper deposits occur in Person County, and in Chatham County near Harpers Cross Roads, but they are not economically important under present market conditions.

Climate

Comparison of U. S. Weather Bureau records at five stations for the 30-year period 1931-60 reveals that the Durham area has a normal annual temperature of 60.1° F. Records of precipitation for the same period show that the normal annual precipitation at nine stations ranges from a maximum of 45.14 in. at Moncure in Chatham County to a minimum of 42.65 in. at Durham in Durham County. The normal monthly precipitation and temperature at the Chapel Hill station are plotted on figure 2.

Physiography and Drainage

The Durham area is within the Piedmont physiographic province. According to Fenneman (1938), the Piedmont is an uplifted peneplain in various stages of dissection, having a general slope from the mountains toward the Coastal Plain. In the southern part of Durham County and in the eastern part of Chatham County (pl. 2) the Piedmont upland is interrupted by a distinct lowland developed on weak Triassic rocks.

Topographic coverage is available for approximately one-tenth of the report area. Where coverage is not available, relief is estimated to rarely exceed 300 feet and to average about 50 feet per mile. An exception is in the vicinity of the Uwharrie Mountains in Randolph County, where relief commonly is in excess of 400 feet per mile. The Piedmont upland slopes from 850 feet in northwestern Randolph County to 180 feet in southeastern Chatham County, and from 700 feet in northeastern Orange County to 250 feet in eastern Durham County.

Surface water, derived from direct runoff and ground-water discharge, is drained by four major stream systems—the Pee Dee, the Cape Fear, the Neuse, and the Roanoke Rivers (fig. 3). Randolph County is drained by the Uwharrie River, which empties into the Pee Dee River, and by the Deep River, which empties into the Cape Fear River. The Deep River, which

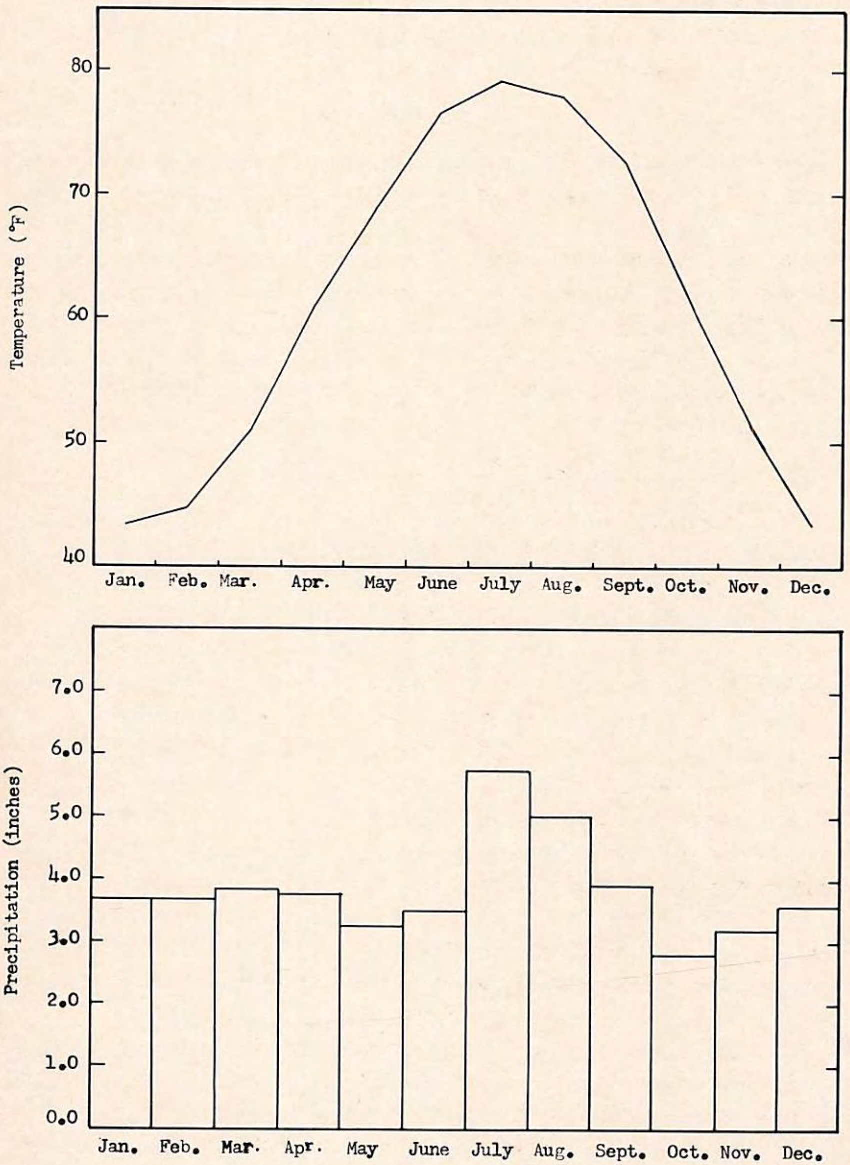


Figure 2. Normal monthly temperature and precipitation at Chapel Hill in Orange County for the period of record, 1931-60.

forms most of the southern border of Chatham County, joins with the Haw River near Moncure to become the Cape Fear River. The remainder of Chatham County is drained by the Rocky, Haw, and New Hope Rivers, which also are part of the Cape Fear system. Most of Durham and Orange Counties are drained eastward into the Neuse by the Eno and Little Rivers. The Flat River, also a tributary of the Neuse, flows through southern Person and northeastern Durham County. In northern and western Person County the Hyco River flows northeastward across the Virginia line into the Roanoke River.

The Deep, Rocky, Haw, Eno, and Little Rivers flow transverse to the northeastward-trending structural elements and are therefore antecedent or superposed. The Uwharrie, New Hope, and Hyco Rivers are flanked by more resistant rocks and reflect structural control. Most minor tributaries and short reaches of the major streams show local adjustment to structure. The en echelon reaches and rectangular offsets exhibited by the Deep River in south-central Chatham County and in the southeast corner of Randolph County are caused by faulting.

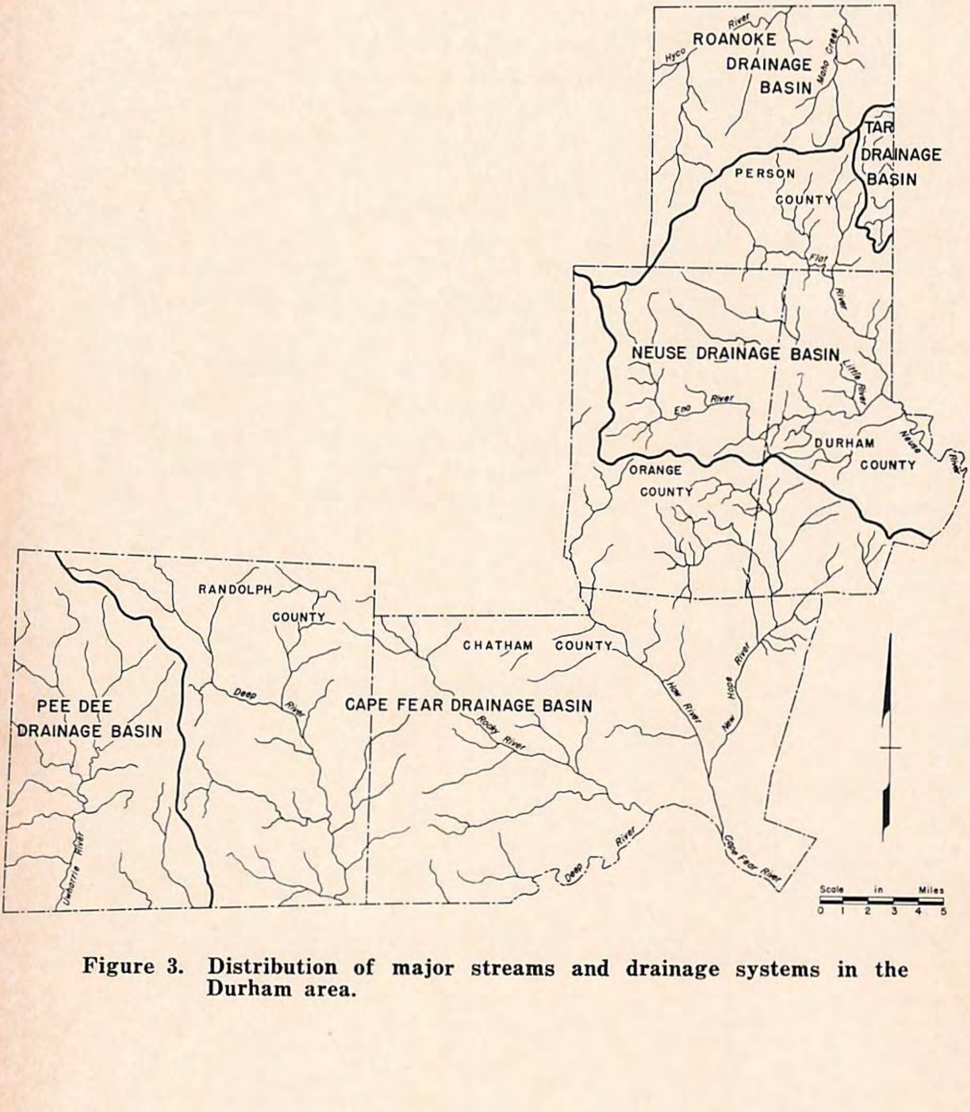


Figure 3. Distribution of major streams and drainage systems in the Durham area.

GEOLOGY

Stratigraphy

The area described in this report is geologically complex. Most of the area is included within the so-called Carolina slate belt, which actually consists of slightly metamorphosed volcanic and sedimentary rocks that are tightly to openly folded, faulted, and intruded by igneous plutons. The volcanic rocks are felsic to mafic in composition. The plutonic igneous rocks range from granite to gabbro. Mica gneiss and schist, and hornblende gneiss, which appear to be older than the slate belt rocks, crop out in northwestern Person County, eastern Durham County, and southeastern Chatham County. Rocks of Triassic age are exposed in a grabenlike structure in the eastern part of the Durham area.

Owing to the complex geology, short field season, and large size of the area, geologic mapping was done on a reconnaissance basis. The map units are broad and generalized and their contacts are located approximately.

The volcanic and sedimentary rocks in the Durham area have a recognizable stratigraphic order which has permitted division of these rocks into lithostratigraphic map units. Relationships between the map units used in this report and those used in Moore County and in the Denton and Albemarle quadrangles are shown in figure 4. The map units are described below in order of decreasing age.

Mica Gneiss and Schist Unit

This unit is exposed in northwest Person County and in the extreme southeast tip of Chatham County south of Corinth (pl. 2). The mica gneiss usually is a mica-quartz-feldspar gneiss, which when unweathered is a dark-colored rock having bands of biotite mica alternating with bands of quartz and feldspar. The schist is a light-colored foliated rock composed of sericite, biotite, muscovite mica, and lenses of quartz and feldspar.

The mica gneiss and schist unit is deeply weathered and is mantled by light- to dark-red saprolite. Only a few outcrops of unweathered rock were seen; thus, this unit may contain other rock types.

In the northwest corner of Person County, the gneiss and

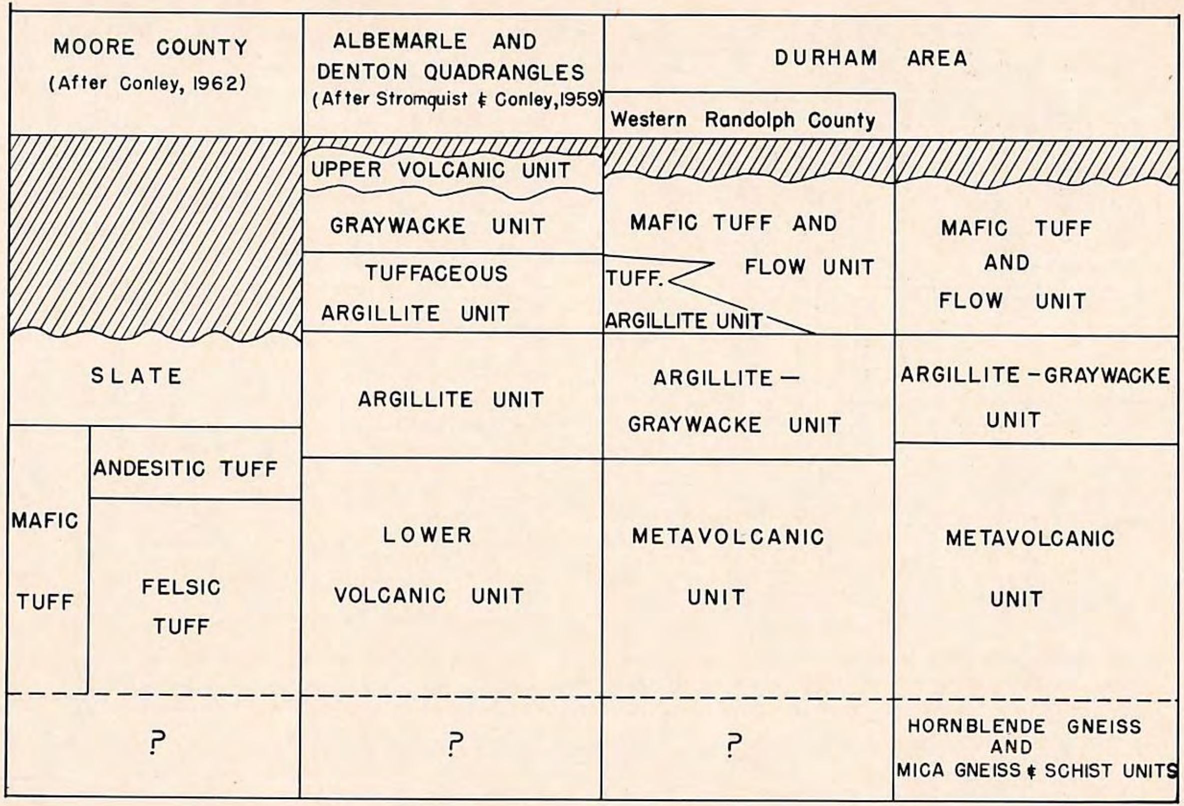


Figure 4. Generalized correlation chart of the slate belt rocks of North Carolina.

schist crops out in a belt trending about N. 45° E. toward the North Carolina-Virginia line. A distinctive outcrop of mica gneiss is exposed in a creekbed on the Person-Caswell County line, just south of the Virginia line.

Another outcrop area, which probably is similar to the mica gneiss and schist described above, was mapped in western Person County. No well-preserved outcrops were found, but it weathers much more like the mica gneiss and schist unit than the hornblende gneiss that surrounds it. Mica gneiss and schist also was mapped in the southeastern tip of Chatham County southeast of the Jonesboro fault. Here, too, the unit is deeply weathered. One unweathered exposure of biotite-quartz-feldspar gneiss occurs south of Corinth near the Cape Fear hydroelectric plant.

The attitude of the mica gneiss and schist unit could not be determined, but these rocks crop out northwest of the southeastward-dipping hornblende gneiss. If these two units are conformable, then the mica gneiss and schist unit lies stratigraphically below the hornblende gneiss and is the older of the two. On this basis the mica gneiss and schist unit has been placed below the hornblende gneiss on figure 4 and plate 2.

Hornblende Gneiss Unit

This unit is confined to northwestern Person County, between the mica gneiss and schist unit in the northwest and the granite and volcanic rocks in the southeast. The hornblende gneiss generally is a black hornblende-plagioclase gneiss interbedded with pink to light-gray quartz-feldspar gneiss and white feldspathic quartzite. On weathering it forms a relatively thin dark-brown sticky soil. Injected pegmatites are generally present. In west-central Person County, pegmatite and amphibolite dikes compose most of hornblende gneiss unit.

The combination of distinctive bedding and interbedded quartzite indicates a sedimentary origin for the hornblende-gneiss unit. Intrusion of diorite and gabbro into older rock (either conformably or otherwise), as postulated by some geologists to explain the source of hornblende, is considered unlikely, at least in Person County. No crosscutting relationships were observed, and the likelihood of silled intrusives remaining sill-like is questionable. Furthermore, quartzite and extrusive lava are geologically possible but unlikely associates. Hornblende is a possible metamorphic product of impure dolomite or calcareous sediments, as has been suggested by Kesler (1944) and by Parker (1952) for similar rocks in North Carolina. Certainly the carbonate-quartzite assemblage is more tenable, and their association is well established geologically.

Bedding-plane strikes and dips indicate that the hornblende gneiss forms the southeast flank of an anticline trending about N. 55° E. Dips in the hornblende gneiss unit increase from 10° to 30° at its contact with the mica gneiss and schist unit on the northwest to a maximum of 65° to 80° at its contact with the granitic and volcanic rocks to the southeast. One reversal of dip was noted in west-central Person County near the Person-Caswell County line. Several high-angle faults and associated drag folds are present. The outcrop pattern of the hornblende gneiss unit is shown in figure 5.

The age of the hornblende gneiss unit is not known. It is similar to Keith's Roan Gneiss, of former usage, (Mundorff, 1948, p. 7), which has been labeled Precambrian in age.

Metavolcanic Unit

The metavolcanic unit, predominantly pyroclastics deposited in a subaerial environment, is interbedded with flows, argillaceous tuff, and graywacke. As mapped, this unit is the stratigraphic interval between the overlying argillite graywacke unit and the underlying gneiss and schist of Person, Chatham, and Durham Counties.

The textural varieties of tuff present in the metavolcanic unit are highly diverse. Some representative lithologies are crystal lithic tuff, vitric lithic tuff, welded flow tuff, lapilli tuff, and coarse breccia or agglomerate. Nearly all possible textural gradations between any two typical tuffs are present in the Durham area. In addition, there is a series of rocks which are difficult to classify as tuffs in the absence of lithic fragments, or as flows in the absence of flow banding. Many rocks formally classed as rhyolite flows are suspected to be welded flow tuffs.

Flows are interbedded with and are subordinate in amount to the tuffs of the volcanic-sedimentary unit. They are widely distributed both stratigraphically and areally. Three general varieties of flows are present. One rhyolitic variety has porphy-

Figure 5. Outcrop of hornblende gneiss unit near McGehees Mill, Person County. Attitude of bedding is about N. 50° E. 40° SE.

roblasts of euhedral feldspar and some beta quartz set in a dark to light-gray aphanitic groundmass. This rhyolitic type is quite dense and "glassy." It has a white weathering "rind" and usually shows swirl banding on the weathered surface. A second rhyolitic variety shows distinct laminar flow banding. It is dense and "glassy," shows an occasional feldspar lath, and many samples contain bombs and lapilli around which the flow lines are bent. The third is a heavy basaltic variety that is dark-green to nearly black when unweathered. Many samples contain amygdules filled with either quartz or calcite and epidote.

Argillaceous tuffs and graywackes are interbedded with the flows and tuffs. They weather much deeper than the more resistant tuffs and flows with which they are interbedded; consequently, they easily go unnoticed. Although exposures were found in only a few deep road cuts, it is estimated that graywacke and argillaceous tuff may compose as much as 30 percent of the metavolcanic unit. One possible mudflow occurs east of Silk Hope in Chatham County. It contains one boulder which is about 2½ feet in diameter (fig. 6).

Rocks similar to the felsic lower volcanic unit of Conley (1962b) and its equivalent in Moore County are exposed in isolated areas in the Durham area. Strike and dip information and distribution of the overlying argillite-graywacke unit suggest that these areas are anticlinal. The largest of these areas is in central and south-central Randolph County. The felsic volcanic rocks are in contact with argillite from southwestern Randolph County to the vicinity of Asheboro (pl. 2). From Asheboro the contact swings northward to form a narrow neck between Cedar Falls and Randleman. From Cedar Falls the contact extends southeastward to a point about 2 miles northwest of Erect, then eastward approximately 3 miles, and then southwestward to the Randolph-Moore County line.

The felsic tuffs and flows are recognizable not only by their quartz and feldspar content and white weathering rinds, but also by their pink and cream-colored soils that are similar in color to those developed on granite and quartz monzonite.

The area outlined above is not composed entirely of felsic tuffs and flows. Minor amounts of mafic tuff, recognized by the dark-red or dun-colored soils and the presence of graywacke and argillaceous beds, are interbedded with the felsic rocks. This area of felsic volcanics is also intruded by gabbro sills and, probably, is unconformably overlain by patches of rocks equivalent to the upper volcanic unit mapped by Conley (1962b) in the Albemarle quadrangle.

The corner of a roughly triangular area of sheared felsic tuff is exposed at Bennett in southwestern Chatham County where it is in fault contact with mafic tuff. From Bennett the area extends northward about 2 miles, then eastward approximately 4 miles.

Felsic crystal tuffs and flows are found in a northeast-trending elliptical area east and southeast of Hillsboro in Orange County. Unweathered exposures can be seen on the U. S. Route 70 bypass from the junction of U. S. Routes 70 and 70A northwestward to the Eno River. Excellent outcrops of unweathered rock are exposed to N. C. Route 86 about 4 miles south of Hills-

Figure 6. Large float block of volcanic breccia or mudflow of the metavolcanic unit near Silk Hope, Chatham County. Boulder in upper right corner is 2½ to 3 feet in diameter.

boro. A very narrow belt of felsic tuffs and flows crops out along county road 1942, southwest of University Lake (southwest of Chapel Hill) toward the WUNC transmitter site. Other isolated patches of felsic rock are located in the extreme southwestern tip of Orange County. The area included between Orange Grove, Dodsons Crossroads and Teer is believed to be underlain by rocks which could be classed as felsic volcanics.

A large area of felsic tuffs and flows is exposed in Durham County in a northeast-trending belt adjacent to the Triassic basin. The outcrop belt is about 3 miles wide and 8 miles long. Its northwest contact roughly conforms to a line drawn from the point where U. S. Route 70 crosses the Durham-Orange County line northeastward to Bahama. The area north of Mangum Store and east of the granodiorite body in northwest Durham County is most likely an extension of this belt.

Felsic crystal and crystal lithic tuff and flows are confined to the southeast corner of Person County. They are in contact with granodiorite on the southeast and extend westward to within a mile of Mt. Tirzah and northward to within 2 or 3 miles of Peeds Store.

The remainder of the outcrop area of the metavolcanic unit, not known to be underlain by felsic rocks, consists largely of more mafic rocks which are andesitic to basaltic in composition. Conley (1962a) divided the mafic sequence in Moore County into two units: an andesitic tuff and a mafic tuff. He states that the mafic tuffs ". . . in general are andesitic in composition, but contain some material that might be classified as basalt." They are grayish green to greenish black when unweathered, and they weather to dark, dun-colored soils similar in color to soils usually developed on gabbro. The andesitic tuffs are massive to finely laminated, some shade of purple or lavender (owing to interstitial hematite) when unweathered, sometimes sheared and phyllitic, and mantled with wine- or maroon-colored soils that are typical of diorite. The andesitic tuffs in the Durham area, as in Moore County, become less massive and more argillaceous toward the top of the section.

In some places, andesitic tuff grades upward into laminated argillite, indicating that at least the uppermost section of the andesitic tuff is a facies of the argillite-graywacke unit. This probably explains the conspicuous absence of andesitic tuff in western Randolph County.

The largest exposure of andesitic tuff occupies about 60 square miles of central Chatham County. Weathered andesitic tuff is well exposed on U. S. Route 64 between Pittsboro and Siler City. Additional exposures in Chatham County are along N. C. Route 87 north of Pittsboro and at Bynum. Andesitic tuff crops out in isolated to fairly continuous exposures along a line that begins at a point south of Hillsboro and then trends northeastward to Quail Roost. From Quail Roost the line of exposures trends nearly due north to Mt. Tirzah, and thence northeastward to an isolated exposure southeast of Denny Store. Andesitic tuff is exposed also in the vicinity of Caldwell in Orange County and northward across the Person-Orange County line.

Mafic tuff that weathers to a dun-colored soil is widely distributed throughout the Durham area. It seems to be interbedded with the more typical andesitic variety as well as the felsic tuff and the overlying argillite. Most of the area, south of Pittsboro toward Moncure and southwest of Pittsboro toward Goldston in Chatham County is underlain by rock that could be classed as mafic tuff. The southwestern corner of Chatham County south of Bennett and Harpers Crossroads is underlain with mafic tuff that in places is bedded and argillaceous. Mafic tuff is exposed in a narrow belt about 15 miles long that begins at a point north of the Siler City water-treatment plant and extends northeastward to the Alamance County line. Additional outcrops are present in the vicinity of Buckhorn in Orange County and in the vicinity of Peeds Store in Person County.

There are several localities in the Durham area in which the rocks of the metavolcanic unit are so deeply weathered, or are in areas with such low relief, or both, that outcrops are either scarce or nonexistent. Most of these localities are on the northwest side of the metavolcanic unit, where granite and granodiorite intrusions are most prominent. Where outcrops occur, the rocks are either badly sheared, schistose, or phyllitic. These rocks probably are similar to the greenstone schist unit mapped by Mundorff (1948) in the Greensboro area.

Rocks of the metavolcanic unit have been folded into northeast-southwest folds that are more tightly compressed in the southeastern part of the area than in the northwest. Axial plane cleavage dips steeply northwestward, except in Person County and northern Orange County, where the dip is vertical or steeply southeastward. Rocks of this unit show little shearing effect in hand specimens, but under higher magnifications an incipient lineation usually can be detected. Quartz dikes are almost universal in extent and range in width from a few millimeters to 3 or 4 feet. These quartz-filled fractures probably are the primary storage spaces for most ground water in the metavolcanic unit. Insufficient data were gathered to learn to what extent faulting has determined the present distribution and attitude of the different rocks of the metavolcanic unit. The occasional inability to trace individual rock types along the strike from one road to another, the presence of quartz and diabase dikes, and the rectangular and en echelon offsets of drainage indicate that faulting is extensive.

The age of the metavolcanic unit is not known. Emmons (1856) classed these rocks as Precambrian. The Hyco Quartz Porphyry and Goshen Schist of Laney (1917) are included within the metavolcanic unit in Person County. Laney gave these two formations an age of Ordovician(?), principally on the basis of their similarity to known Ordovician volcanics in the Arvonia and Quantico synclines. The metavolcanic unit of this report is given a tentative age of Ordovician(?).

Figure 7. Outcrop of graywacke conglomerate of the argillite-graywacke unit near Timberlake, Person County. Largest cobbles are about 2 inches in diameter.

Argillite-Graywacke Unit

The metavolcanic unit is overlain in the Durham area by a sequence, predominantly sedimentary, consisting of argillite, graywacke, conglomerate, and tuff in order of predominance. This sequence is present in the argillite-graywacke unit throughout the Durham area, except in western Randolph County where graywacke and conglomerate may be present but were not found. The thick argillite section in western Randolph is the "varved" argillite (fig. 4) of Stromquist and Conley (1959). The argillite-graywacke unit of this report includes this argillite and is at least partially equivalent to the slate unit mapped by Conley (1962a) in Moore County.

Graywacke conglomerate (fig. 7) usually is present at the base of the argillite-graywacke unit in the rest of the Durham area. It crops out in a belt that ranges in width from 10 to 20 miles and extends from southwestern Chatham County to northeasternmost Person County—a distance of 85 miles. Although conglomerate was not found in western Randolph County, Conley (1962b) reports conglomerate at the base of the argillite unit south and along the strike in the Albemarle quadrangle. Conglomerates are interbedded with the graywacke sandstones and usually possess a graywacke matrix, although some conglomerates having a tuffaceous matrix have been seen. Pebbles of acid volcanics, feldspathic quartzites, quartz-hornblende gneisses, and jasper (?) are among the lithologies found in the graywacke conglomerate. Individual pebbles are well to subrounded and range from pea-size to cobbles larger than softballs. Sphericity and sorting are poor.

Graywacke conglomerate grades upward into graywacke sandstone by successively thicker interbeds of sandstone. Graywacke sandstone attains its best development in the Person County outcrop area, where it is massive and shows pronounced graded bedding. Crossbedding occurs in a few thin beds associated with argillite. Individual beds range in thickness from a quarter of an inch to several feet. Where fresh the graywacke sandstone is a massive, dark-gray to greenish-gray rock that breaks with a conchoidal fracture. Pyrite cubes are present in most exposures. The more massive graywacke weathers into structureless bright maroon and vermilion saprolite containing spheroidal residual boulders. The graywacke sandstone is interbedded with and grades upward into argillite or slate.

The slate and argillite are easily distinguished from other rocks by their finely laminated character. The laminae or beds range in thickness from 0.1 mm to 5.0 mm and are graded. Graded bedding can be seen in the thicker beds. According to Conley (1962b), graded bedding is easily observed in thin section consisting "of a bottom silt layer which grades upward to a clay layer." He found that the silt layer was composed of "angular quartz grains with some feldspar fragments, and relic outlines of ferromagnesian minerals now completely changed to chlorite" and that the "clay layers are altered to sericite." The argillite and slate originated as shales which were probably composed of land waste derived from metamorphic and volcanic terranes, and airborne volcanic dust.

Slate having well-defined axial-plane cleavage is confined to the southern part of Chatham County, the southeastern part of Orange County, and the axial region of the Person County outcrop area—that is, where dynamic metamorphism was greatest. Argillite generally has excellent bedding-plane cleavage and an incipient axial-plane cleavage. Porphyroblasts of biotite-sericite-chlorite, which according to Stromquist (Stromquist and Conley, 1959) have retrogressed from chloritoid, are developed across bedding planes in the argillite of western Randolph County. Thin limestone beds are interbedded with the argillite in this area and can be observed in the Superior Stone quarry at Asheboro.

Argillite and slate saprolites are various shades of ocherous red and yellow. Weathering depths are quite variable. Argillite in parts of western Randolph County is weathered deep enough to permit construction of large-diameter bored wells to depths greater than 100 feet, whereas in most of the Durham area casing depths average much less.

The argillite-graywacke unit crops out in northeastward-trending synclines and synclinoriums which are overturned to the southeast in southern Chatham County. The axial-plane regions of the folds generally are sheared. Well-exposed outcrops reveal that argillite in most of the Durham area is offset by many high-angle faults of short throw and that contorted folds having wave lengths of only a few feet are superimposed upon the larger folds.

Laney (1917) named the argillite in Person County the Aaron Slate, which he classed as Ordovician in age on the basis of its similarity to known Ordovician rocks in the Arvonia and Quantico synclines. This unit is given a tentative age of Ordovician (?) in this report.

Tuffaceous Argillite Unit

Argillite in southwestern Randolph County grades upward into massive tuffaceous argillite by an increase of thicker beds of tuffaceous argillite and a decrease of laminated argillite. As mapped the contact is an arbitrary line drawn where the more massive beds of tuffaceous argillite exceed those of laminated argillite. It is equivalent to the felsic tuffaceous argillite unit of Conley (1962b).

The tuffaceous argillite is a dark-gray massive, well-jointed rock which upon weathering passes through successively lighter shades of gray to bright shades of red and yellow when completely decomposed. The unweathered rock breaks into sharp splinters with conchoidal fracture. Pyrite generally is present as cubes disseminated throughout the rock.

The tuffaceous argillite unit is assigned an age of Ordovician (?) because of its conformable relation to the underlying laminated argillite.

Mafic Tuff and Flow Unit

A sequence of mafic tuffs and flows overlies the argillite-graywacke unit. The mafic tuff and flow unit is exposed in Person County, in the western part of Randolph County, and along the Randolph-Chatham County line. The strike and dip relationships of the two units indicate that their contact is conformable in Person County and along the Chatham-Randolph County line. The outcrop in western Randolph County indicates that their contact is disconformable (pl. 2). However, the presence of interbeds of tuffaceous argillite in western Randolph County indicates that the mafic tuffs and flows may be a facies of the tuffaceous argillite unit.

The lithology and weathering characteristics of the mafic tuff and flow unit are strikingly similar to the upper volcanic unit of Conley (1962b), especially in Randolph County. It is possible that part or all of this unit is equivalent to the upper volcanic unit of Conley (fig. 4).

Mafic tuffs and flows exposed in Person County and those distributed along the Randolph-Chatham County line are similar in lithology and weathering characteristics. The tuffs range from gray-green fine-grained, water-laid tuffs to dark-gray coarse, massive breccias and agglomerates. Flows are massive, dark green, and amygdaloidal. Epidote-quartz veins are very distinctive of this unit.

The mafic tuff and flow unit in western Randolph County differs from that in the rest of the Durham area, in that tuffaceous argillite, welded tuff, and lithic-crystal tuff are interbedded with the more basic tuffs.

Rocks of the mafic tuff and flow unit weather to dark, dun-colored soils. Concretionlike pebbles, which cover the soil in some places, probably are quartz-epidote amygdales that have weathered out.

In Person County andesitic tuffs and flows crop out in two linear belts along the axial region of the Virgilina synclinorium. Laney mapped these two outcrop belts and the sheared argillite or slate between them as one unit, which he called the Virgilina Greenstone.

The age of the mafic tuff and flow unit is not known. It is given a tentative age of Ordovician(?) on the basis of its apparent conformity in places to the underlying argillite-graywacke unit.

Granite and Granodiorite Unit

Volcanic and sedimentary rocks in the Durham area have been intruded and locally altered by plutonic igneous rocks that range in composition from granite to gabbro. Because compositions vary considerably from place to place and within the same pluton, it is difficult to separate the different varieties into mappable units. For convenience, rocks ranging in composition from granite to granodiorite were mapped as one unit.

Granite crops out in the northwestern part of Randolph County (pl. 2), in the north-central part of Chatham County, in the southeastern and northwestern parts of Orange County, and in the southwestern and central parts of Person County. The granite plutons listed above include xenoliths of volcanic rocks and other igneous varieties too small to map. The granite is pink to gray, medium-grained to porphyritic, well jointed, and locally sheared. Orthoclase and plagioclase feldspar, biotite mica, and quartz give the granite an equigranular texture. The granite weathers to pink, light-red or cream-colored soils.

The rest of the granite and granodiorite unit contains rocks that are mostly granodiorite in composition. As in the case of the granite, the granodiorite includes rocks of other compositions. Volcanic rocks and dikelike bodies of pegmatite, granite, diorite, and amphibolite are present. The contacts between the granodiorite and the country rock are less well defined and the alteration halo wider than that of granite. In some places, such as the area west of Carrboro, the granodiorite appears to have emplaced itself by assimilation of volcanic rock. Most rock classed as granodiorite is well jointed and is mantled by light-gray to dark-red saprolite.

Both granite and granodiorite weather deep enough in some localities to permit construction of large-diameter bored and dug wells below the lowest level of the water table. Large residual boulders and unweathered rock are close to the surface in areas where relief is great enough that the weathered material has been removed by erosion.

Diorite Unit

Diorite occurs in plutons and dikes massive enough to map only in Person County. The largest outcrop of diorite is in the vicinity of Hurdle Mills. Another outcrop is approximately 2 miles south of Hesters Store in southwestern Person County and another is in the northeastern section of the county north of Dixons Store. The diorite generally is fine to medium grained, massive, well jointed, and not deeply weathered. Weathering colors range from dark brown on nearly fresh rock to dark red on thoroughly decomposed rock.

Gabbro Unit

Gabbro sills and dikes are relatively plentiful in the Durham area. This is especially true of western Randolph County, where a swarm of gabbro sills and dikes have intruded the argillite and the metavolcanic unit in a few places. Gabbro sills and dikes in this area show good conformity to regional structure. Most of the high peaks and ridges in western Randolph County are underlain by gabbro. Gabbro also occurs north of Calvander in Orange County, and in Person County southeast of Moriah and north of Denny Store. The gabbro is medium grained to pegmatitic, massive, and well jointed. It weathers from dark, dun-colored to dark-red shallow soils.

The age of the various intrusions is not known. However, they are younger than the mafic tuff and flow unit which they intrude and older than the Triassic which they do not intrude. They are classed as Mississippian(?) in this report.

Triassic Unit

In the Durham area rocks of Late Triassic age are exposed in a northeastward-trending structural and topographic lowland known as the Deep River Triassic basin. This basin is structurally similar to several isolated basins located at intervals within the Piedmont Province from Nova Scotia to South Carolina.

The Deep River basin extends northeastward from western Moore County to east-central Granville County. Along its nearly 100-mile length, it includes parts of southern and southeastern Chatham County, southeastern Orange County, and most of Durham County. Its maximum and minimum widths are about 20 and 5 miles, respectively.

The rocks of Triassic age are principally continental and consist of maroon to reddish-gray sandstones, shales, siltstones, conglomerates, and fanglomerates (fig. 8). However, coal beds are interbedded with gray to black shales and siltstones, indicating that during at least part of Triassic time restricted lakes or marshland favorable to the accumulation of vegetable matter existed and that the rate of sedimentation probably was slow.

Although gross lithologies are similar from outcrop to outcrop, individual beds change rapidly in thickness laterally, and in lithology both laterally and vertically. These factors have an important effect on the location of suitable ground-water supplies. Wells which penetrate the coarser, better sorted sandstones tend to yield more water than those in the relatively tighter shales and siltstones.

The Triassic rocks are separated from the metamorphic and igneous rocks to the east by the Jonesboro fault, which generally is well defined by a northwestward-facing fault scarp. The Triassic rocks are bordered on the west by volcanic and igneous rocks of the slate belt. The western contact in the Durham area is straight locally, but more often is a sinuous line caused by the original uneven surface upon which the basal Triassic rocks were deposited and by the notching effect of tranverse streams that have eroded through the thin updip edge of the Triassic. Where straight, the contact possibly is controlled by a western border fault such as that found by Conley (1962a) in Moore County. The western contact is offset locally by cross faults such as those mapped by Reinemund in the southern part of Chatham County.

In the Deep River basin the Triassic rocks dip 10° to 20° to the southeast, in contrast to those of the Dan River basin of North Carolina and Virginia (Mundorff, 1948) which dip to the northwest. Possibly, the monoclinal dip results in part from an initial dip and in part from contemporaneous and postdepositional movements along the Jonesboro fault. A few flowing wells

Figure 8. Outcrop of light-gray sandstone in the Triassic unit near Seaforth, Chatham County.

are present in the Triassic rocks of Durham and Chatham Counties. Water percolating downdip through the more permeable sandstones develops sufficient artesian pressure, or head, to produce flowing wells in some localities.

Maximum thickness of the Triassic wedge has been estimated to range from 7,000 to 8,000 feet in the southern part of the basin to 4,000 to 5,000 feet in southeastern Chatham County. Prouty (1931) has estimated that in the northern part of the basin (Durham County area) the Triassic rocks may be as thick as 10,000 feet.

In Late Triassic time the sedimentary rocks were intruded by dikes and sills of diabase, which have formed narrow baked zones along their contacts. These diabase dikes are frequently found in the slate belt of North Carolina. The writer was able to trace one such dike in Randolph County for a distance of 7 miles.

Time did not permit separation of the Triassic into lithologic units. Reinemund divided the Triassic rocks in the vicinty of the Deep River coal field into the following formations, which are listed in the order of increasing age: Sanford Formation, Cumnock Formation, and Pekin Formation.

Near Bonsal, on the Wake-Chatham County line, the Triassic is thinly veneered with patches of unconsolidated sand and clay that are probably of Tuscaloosa age. Throughout the Deep River basin there is evidence of reworked Triassic, indicating encroachment of shallow seas during post-Triassic time.

Structure

Little is known concerning the regional structure of the volcanic and sedimentary rocks of the Durham area, nor the relationship of the volcanic and sedimentary rocks to the schist and gneiss which border them on the northwest and southeast. However, available information indicates that the regional structure is a synclinorium.

In the Greensboro area, which lies northwest of and adjacent to the Durham area, Mundorff (1948) points out that ". . . the dip southeast of the quartzite and schist unit is uniformly to the southeast (toward the Durham area) with relatively few exceptions." This was found to be true also of the hornblende gneiss unit in northwest Person County (pl. 2). Furthermore, similar rocks exposed to the east and southeast in Vance County dip to the northwest (V. J. May, personal communication). Slaty cleavage observed by the writer and reported by Stuckey and Conrad (1958) dips to the northwest in the southeastern part of the Durham area and is vertical or dips steeply to the southeast in the northwestern part of the area. If fracture cleavage developed contemporaneously with regional folding, rather than during some later regional deformation, such cleavage further suggests a synclinoriumlike structure with its axis trending southwestward from somewhere in the vicinty of southwest Person County through Efland in Orange County. If the structure of the volcanic and sedimentary rocks is a synclinorium, then the metavolcanic unit overlies the gneiss and schist which bound it and is the younger as the difference in degree of metamorphism suggests.

A recent gravity study by Mann (1962) is not conclusive as to the regional structural relationships in the area of this report. Mann points out that the slate belt area appears as a positive mass separating two large negative areas and that density mesurements and remapping of the various rock types will be helpful in interpreting the various anomalies.

Whatever the regional structure, it is obvious from the geologic map (pl. 2) that the volcanic and sedimentary rocks have been folded into a series of northwestward-trending synclines and anticlines. The rocks of western Randolph County have been relatively open folded, whereas to the east and northeast the rocks assume a more slaty character and have been more tightly folded. Axial planes in southern Chatham County, for example, have been overturned to the southeast as in Moore County. Regional trend varies from N. 10° E. to N. 30° E. in Randolph and west-central Chatham Counties, to N. 70°-85° E. in central Chatham County, to about N. 30°-45° E. in Orange County, to N. 10°-30° E. in Person County.

Major folds are the Troy anticlinorium, which can be traced from southern Montgomery County to a few miles northeast of Asheboro in Randolph County, and the Virgilina synclinorium, which can be traced from a point 2 miles southwest of Rougemont in Durham County northeastward across the Virginia-North Carolina line.

Faulting has modified the areal distribution of lithologic units in the Durham area, especially near the Triassic basin where both longitudinal and transverse types are numerous. Faults have been noted on the geologic map (pl. 2) only where individual map units were obviously offset or ended abruptly. However, offset drainage patterns exhibited by some streams, the presence of many quartz and diabase dikes, and the inability to trace individual tuff beds along the strike for any distance indicate that faulting, at least on a minor scale, is quite extensive throughout the Durham area. The metavolcanic unit is thick enough and sufficiently weathered that faults with large lateral and vertical displacements could be virtually unnoticed.

The volcanic and sedimentary rocks in the southeastern part of the Durham area are interrupted by a basin or grabenlike structure in which Triassic strata are terminated against what is known as the Jonesboro fault. Reinemund (1955) has estimated that the maximum vertical displacement of this fault may be as much as 6,000 to 8,000 feet. Conley (1962a) believes that this "basin" is a rift valley, at least in Moore County, which has been tilted by postdepositional faulting along the Jonesboro fault.

GROUND-WATER HYDROLOGY

Hydrologic Cycle

All ground water yielded to wells in the Durham area was once precipitation which fell in the form of rain or snow. The earth contains a vast but fixed supply of water. Through energy supplied by the sun, water evaporates from the oceans, lakes, streams, and surface of the earth to become water vapor in the atmosphere. There, water vapor condenses and falls as precipitation. Part of the water falling upon the land surface is discharged directly to streams as surface runoff, part is returned to the atmosphere by evaporation, and the remainder is retained in the soil and rocks as ground water. Ground water is eventually discharged to streams through springs, seeps, and wells or is returned to the atmosphere by evaporation and transpiration. The unending circulation of water between the earth and the atmosphere is called the hydrologic cycle.

Occurrence and Movement of Ground Water

Source

Gravity and capillary action cause water derived from precipitation to percolate downward through the soil cover until it reaches a zone of saturation within which all open spaces are completely filled with water. Water in the zone of saturation is called ground water. The upper surface of the zone of saturation is referred to as the water table. The zone between the water table and the land surface is called the zone of aeration (fig. 9).

The percentage of precipitation that becomes ground water depends on several interrelated factors, such as the slope of the land surface, the relative ability of the soil cover to transmit water, the intensity and duration of rainfall, the type and amount of vegetation, and the temperature. Topographic relief in the Durham area averages about 50 feet per mile, but there are some broad interstream areas developed on granite and volcanic terranes where lateral movement of surface water would be expected to be slower than in the Uwharrie Mountains where local relief exceeds 300 feet per mile. Rainfall is greatest during July and August and is least in October (fig. 2). The average temperature also is highest during July and August, so that losses from evaporation and transpiration probably are at their maxi-

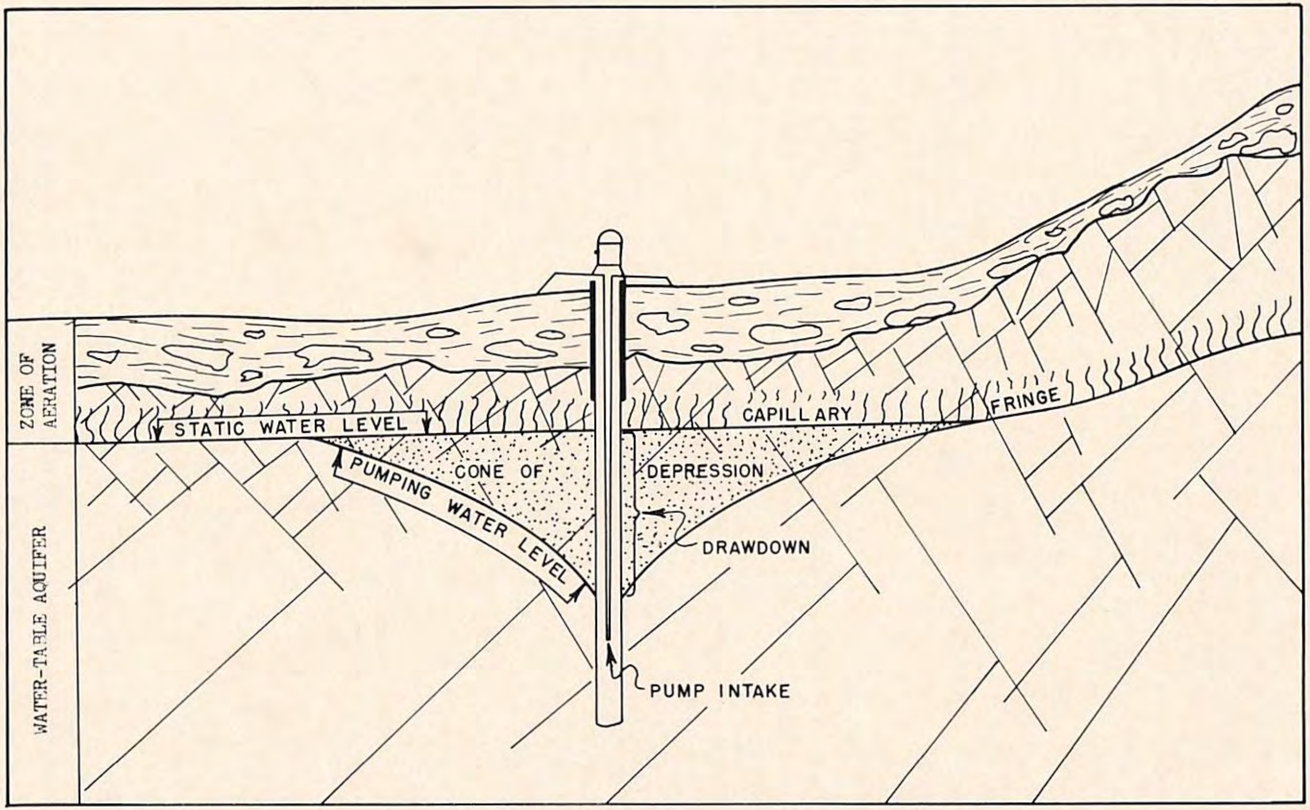


Figure 9. Diagram showing relation of a well to hydrologic conditions in a water-table aquifer.

mum during this period. The permeability, or relative ability of the soil cover to transmit water, differs considerably from place to place. The granites, granodiorites, and acid volcanic rocks weather to silt loams, because of their high quartz content. Water percolates downward faster through the silt loams than through the dense, sticky clays developed on the gabbro, diorites, and more mafic volcanic rocks.

Water-Bearing Properties of Rocks

In the zone of saturation all openings or interstices are filled with water. The size and type of interstices depend in part on the type of rock and in part on the rock's postdepositional history.

Rock interstices may be classed as original or secondary according to their mode of origin. According to Meinzer (1923), "The original interstices were created when the rock came into existence as a result of the processes by which it was formed; the secondary interstices were developed by processes that affected the rock after it was formed." The open spaces between grains in unconsolidated and sedimentary rocks and the cavities and vesicles in volcanic rocks produced by escaping gases and by movement are all original interstices. The solution openings and joints resulting from weathering processes and the fractures, cleavage planes, and planes of schistosity resulting from dynamic metamorphism are all secondary interstices.

Athough original openings may be locally important in the Triassic rocks, the secondary openings are the most important with respect to the occurrence of ground water in the Durham area. Rock interstices range in size from the submicroscopic pores in clays and shales to the large solution openings in limestone. Some typical interstices are shown in figure 10.

The quantity of water that a rock can hold depends on its porosity. The porosity of a rock can be expressed as the percentage of the total volume of the rock that is occupied by interstices. In sedimentary rocks porosity is governed by the size, degree of sorting, shape, arrangement, and degree of cementation of the individual grains. In crystalline rocks porosity is governed by the size and number of fractures, solution openings, and joints per unit volume. Clean, well-sorted sand may have an initial porosity as high as 40 percent, but by compac-

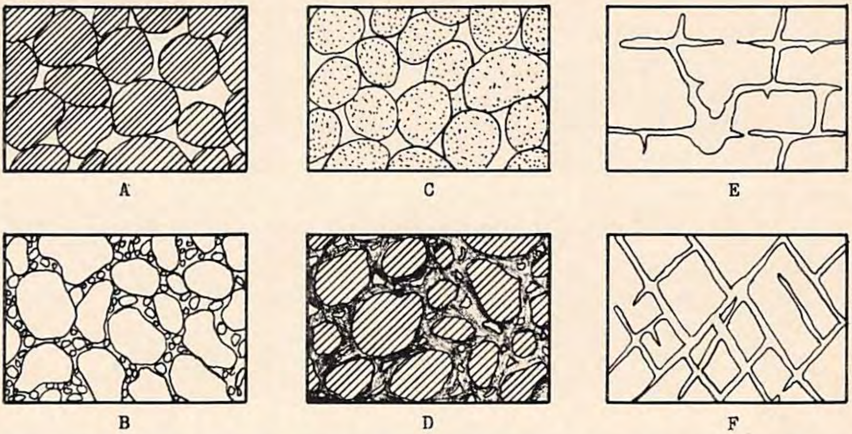


Figure 10. Diagram showing several types of rock interstices and relation of rock texture to porosity. A, Well-sorted sedimentary deposit having high porosity; B, poorly sorted sedimentary deposit having low porosity; C, well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity; D, well-sorted sedimentary deposit whose porosity has been diminised by the deposition of mineral matter in the interstices; E, rock rendered porous by solution; F, rock rendered porous by fracturing (after O. E. Meinzer, 1923a).

tion and cementation the porosity of the resultant sandstone may be reduced to 15 or 20 percent. Clay may have a very high porosity, but because of the smallness of its interstices, the contained water is retained by molecular attraction. Consequently, clays and clayey sediments yield relatively little water.

The permeability of a rock, that is, its relative ability to transmit water in response to gravity and changes in hydrostatic pressure, is very important. The permeability of a rock is governed by the size and shape of its pore spaces and the degree to which they are interconnected. A rock that is nonporous is obviously impermeable. As noted above, clays have high porosities but their water is retained by molecular attraction. Lava flows frequently are very vesicular and, thus, have a high porosity; however, the vesicles usually are isolated or poorly connected and the lava yields little water (Meinzer, 1923). On the other hand, water may be yielded freely from rocks in which the porosity is low but the pores are interconnected and are large enough to minimize the molecular attraction.

Specific yield is related to both porosity and permeability. It is the ratio of the volume of water that a saturated rock will yield by gravity to the total volume of the rock. Specific yield is expressed as a percentage.

An aquifer is a formation, group of formations, or part of a formation that is water-bearing (Meinzer, 1923). In the Durham area most water is contained in the upper or weathered part of the rock unit. The boundaries of the water-bearing rock or aquifer do not necessarily coincide with formational boundaries in this area, but with that part of the formation where secondary pore space is best developed.

The Water Table

The water table is defined above as the upper surface of the zone of saturation. It is not everywhere a flat surface, but one that conforms in general to the land surface and is a modified replica of that surface. Figure 11 shows the relation of the water table to the topography.

The water table is not a stationary surface but is continually fluctuating in response to natural and artificial forces applied to the zone of saturation. Natural forces which cause the water table to fluctuate include precipitation, temperature, evaporation, transpiration, and atmospheric pressure. Artificial forces causing fluctuation of the water table include discharge of water from or recharge of water to the zone of saturation—generally through wells.

In the Durham area ground-water levels are highest in late winter and early spring. They begin to decline in April and May, because of increasing transpiration of vegetation and increasing evaporative capacity of the air. Although the greatest monthly rainfall occurs in July and August, water levels continue to decline through summer and early autumn (fig. 12). The water table begins to rise slowly in late autumn, owing to the lower evaporative capacity of the air and the dormant condition of the vegetation.

Recovery of Ground Water

Most well sites in the Durham area, especially the domestic ones, are located as close as possible to where the water is to be used. The principal factors that govern ground-water recovery or yield in the Durham area are discussed below. Use of these

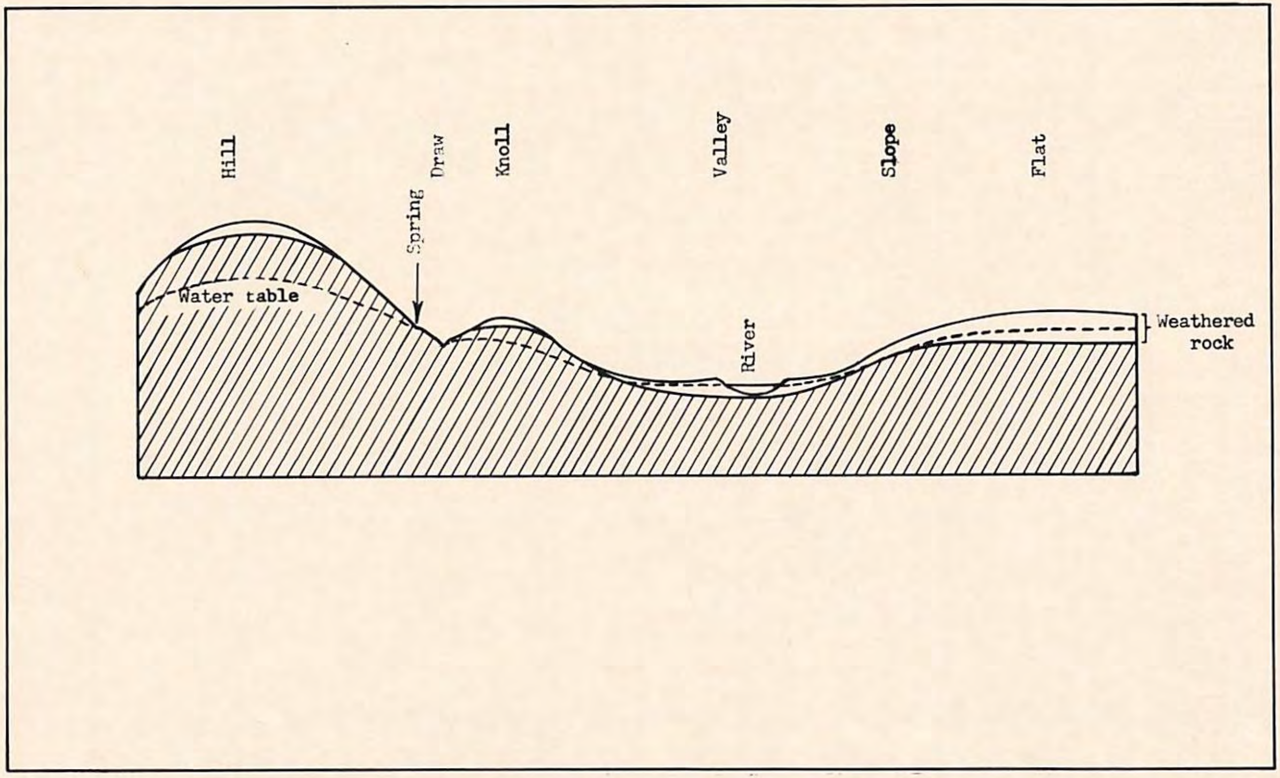


Figure 11. Section showing relation of the water table and weathered rock to the topography.

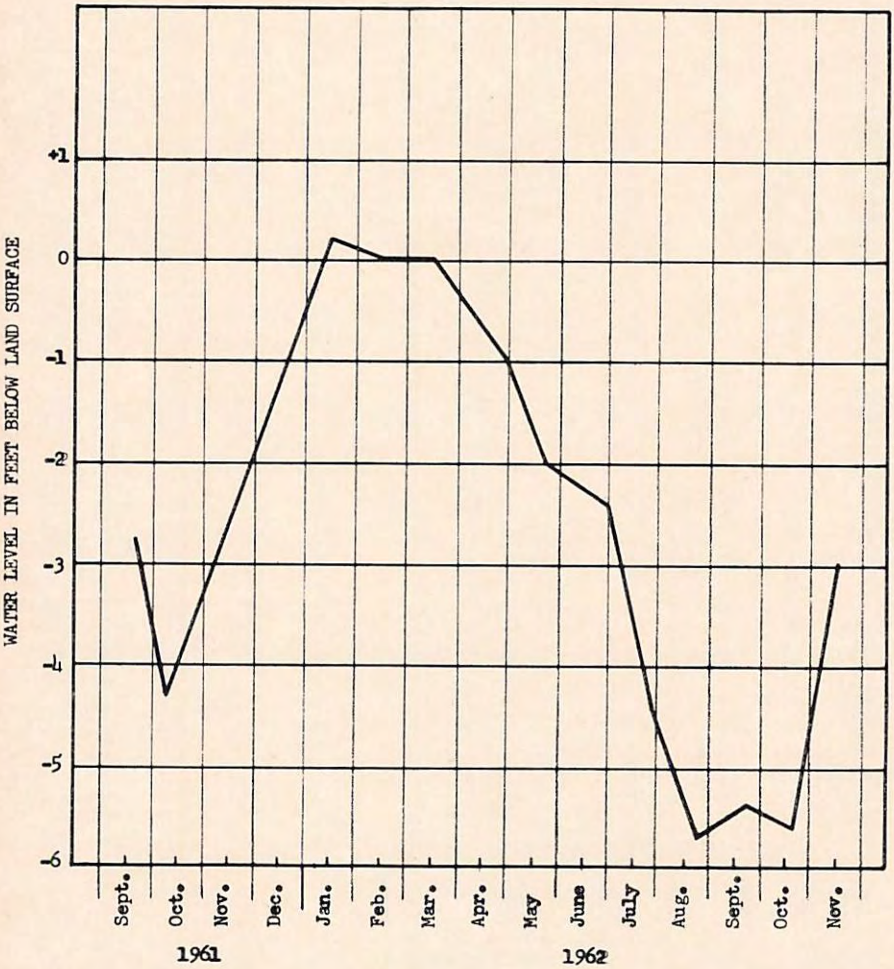


Figure 12. Hydrograph of observation well 77 in Chatham County showing seasonal fluctuation of the water table.

factors as criteria for the selection of a well site deserves careful consideration if maximum yields are to be obtained.

Wells and Springs

Ground water in the Durham area is recovered through dug, bored, and drilled wells or springs.

Dug wells are large-diameter holes which are excavated by hand to a point below the water table. They usually are curbed with stone, brick, concrete, or terra cotta tile to prevent slumping of unstable material into the well. The chief advantages of dug wells are their economy of construction and their large storage capacities. Their chief disadvantages are their susceptibility to contamination from surface sources and their shallow depths. Because of the difficulty of constructing dug wells in hard rock, very few extend many feet below the water table. Consequently, the water table may drop below the bottom of the dug well during periods of drought.

Bored wells are similar to dug wells except that the weathered rock and soil is removed by means of an auger. They generally are cased with terra cotta or concrete tile. The depth of bored wells is governed by the depth of the water table and the type of the material penetrated. Bored wells are quickly constructed and are relatively inexpensive. Because they are generally tightly cased and covered, the chance of contamination is less than that of dug wells. Bored wells are usually deeper than dug wells and are not so likely to go dry. In parts of the Durham area where weathering is fairly deep, bored wells are the most common.

Drilled wells in the Durham area are constructed by the cable-tool, rotary, and coring methods. Cable-tool drilling consists of alternately raising and lowering a bit and a string of tools in a hole. The rock fragments loosened by the abrasive action of the bit are periodically removed by bailing. Wells so constructed range in diameter from 4 to 10 inches in the Durham area. In recent years, the rotary-pneumatic method has been used by some well drillers in this area. The drill bit is rotated and vibrated up and down simultaneously. Air or water is forced down through the hollow drill stem to raise cuttings to the surface. A well drilled by this method often can be completed in a day. Some wells in the Durham area have been constructed by coring with chilled shot or a diamond-tipped bit. Wells drilled by this method range in size from 2 to 4 inches in diameter. Cuttings are brought to the surface by water forced down through the hollow drill stem.

In areas of hard rock, drilled wells have the distinct advantage over bored and dug wells of being easily constructed far below the water table. Where properly cased, drilled wells are safe from surface-water contamination.

For a more thorough discussion of well construction and drilling methods the interested reader is referred to Mundorff (1948).

Hydrologic Principles Affecting Recovery

The normal water level in an unpumped, nonartesian well is in hydrologic equilibrium with the water level in the surrounding zone of saturation and is called the static water level. When water is withdrawn from a well a difference in head is created between the well and the surrounding aquifer, causing water to flow toward the well (fig. 9). The flow of water toward the well lowers the water table in the surrounding aquifer in the shape of an inverted cone known as the cone of depression. The apex of the cone is located in the well at the pumping water level. The distance between the static water level and the pumping water level is called the drawdown. The area affected by the pumping well is termed the area of influence. The extent and shape of the cone of depression is governed by the pumping rate and by the permeability of the surrounding water-bearing material.

Physical Factors Affecting Recovery

Topography has an important bearing on the quantity of water that a well will yield. In homogeneous rocks the lowest yield generally can be expected on the hill. The slopes, flats, and valleys should yield greater amounts of water in the order listed.

There are definite reasons for lower yields on hills. The depth to the water table is greater beneath the hill than beneath the valley and slope (fig. 11). A greater percentage of precipitation becomes surface runoff on the hill than on the flat and valley. Further, rocks underlying valleys and flats receive influent recharge from the surrounding uplands. Some hills exist because they are underlain by massive, poorly jointed rock that is very resistant to erosion. Such rock has few secondary pore spaces for the storage of water. The lateral growth of the cone of depression of a pumped well on a hill is limited by the boundary of that hill, whereas in the valley and large flat areas its expansion is not so limited.

The topography was noted at five different situations in the Durham area where wells were inventoried. Figure 11 illustrates the various topographic terms used. A statistical treatment of the effect of topography on water yield in the mapped lithologic units is given in tables 2-5. Average yield per foot of well is graphed according to topographic location of the various rock units in figure 13.

Inspection of tables 2-5 and figure 13 indicates that the progressive increase of yield from hill to valley does not necessarily hold true in the Durham area, especially in the flat areas on Triassic rocks and argillite, and in the valleys and draws on argillite. It was noted during the field work that the flats, valleys, and draws underlain by argillite and volcanic rock were mantled with only a thin veneer of weathered material in some places. Wells drilled in these topographic-geologic situations quickly encounter unweathered rock, where secondary openings are less favorable for the storage and transmission of ground water. The reason for low yields from flat areas in Triassic rocks is not well understood. Although slopes are thinly veneered with weathered material, they are indicated to be the most dependable topographic position for well location in the Durham area regardless of the geology. This is most likely due to influent seepage along fracture systems from the adjacent hills and upland areas. The lower yields obtained on the low hills or knolls probably can be attributed to a combination of shallow weathering and deep water table.

The relation of depth to yield in the different rock units is presented in tables 2-5. The effect of increasing depth on yield of uncased hole is shown graphically in figure 14. It is obvious, from inspection of figure 14, that the yield per foot of well decreases with depth. The data presented in tables 2-5 indicate that the decrease in yield (per foot of uncased hole) is greater between 100 and 150 feet than it is at greater depths. Near the surface secondary openings have been formed by weathering processes. Planes of schistosity and other fractures present at

Figure 13. Average yield per foot of well of the lithologic units according to topographic location.

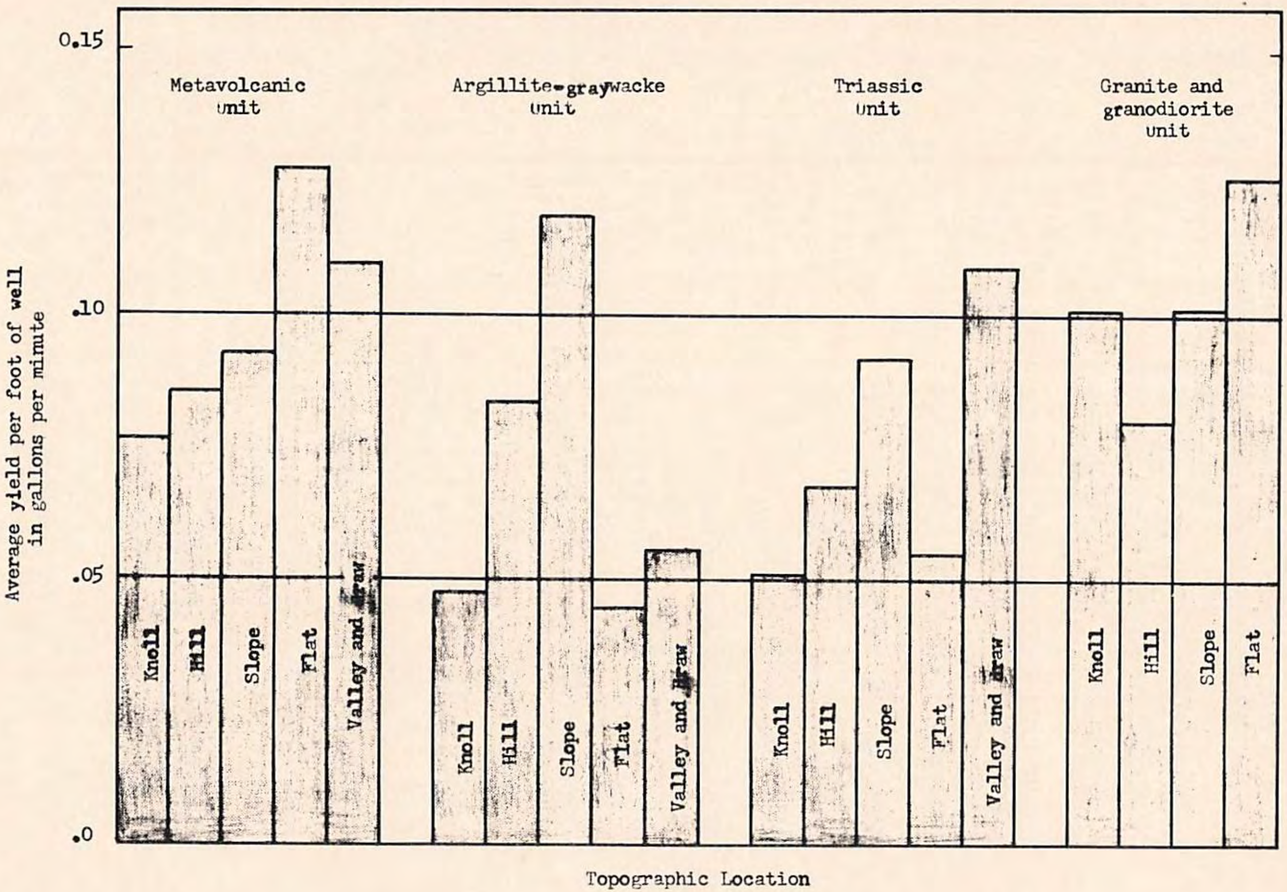


Table 2. Average yield of wells in the metavolcanic unit

According to Range in Depth

Range in depth (feet)	Number of wells	Average depth (feet)	Average uncased depth 1/ (feet)	Yield (gallons per minute)		
				Average	Per foot of well	Per foot of uncased hole
0-100	203	67.2	37.2	8.4	0.12	0.30
0-150	266	80.8	50.8	8.1	.10	.16
0-200	291	88.5	58.5	8.4	.01	.14
0-600	307	97.7	67.7	9.5	.10	.14

1/Average casing depth for metavolcanic unit is 30.0 feet.

According to Topographic Location

Topographic location	Number of wells	Average depth (feet)	Average casing depth (feet)	Average uncased depth (feet)	Yield (gallons per minute)		
					Average	Per foot of well	Per foot of uncased hole
Hill	110	103.0	37.0	66.0	8.8	0.09	0.13
Knoll	35	94.6	33.1	61.5	7.3	.08	.12
Slope	76	96.5	25.5	71.0	9.0	.10	.13
Flat	68	104.8	34.6	70.2	13.4	.13	.19
Valley and draw	12	101.9	30.4	71.5	11.2	.11	.16

Table 3. Average yield of wells in the argillite-graywacke unit

According to Range in Depth

Range in depth (feet)	Number of wells	Average depth (feet)	Average uncased depth 1/ (feet)	Yield (gallons per minute)		
				Average	Per foot of well	Per foot of uncased hole
0-100	49	73.7	37.9	7.4	0.10	0.20
0-150	64	87.1	51.3	7.2	.08	.14
0-200	72	96.6	60.8	7.5	.08	.12
0-283	74	100.6	64.8	7.4	.07	.11

1/Average casing depth for argillite-graywacke unit is 35.8 feet.

According to Topographic Location

Topographic location	Number of wells	Average depth (feet)	Average casing depth (feet)	Average uncased depth (feet)	Yield (gallons per minute)		
					Average	Per foot of well	Per foot of uncased hole
Hill	16	112.0	42.6	69.4	9.4	0.08	0.14
Knoll	11	100.5	40.1	60.4	4.8	.05	.08
Slope	18	92.4	32.2	60.2	4.1	.04	.07
Flat	15	86.6	36.2	50.4	10.3	.12	.20
Valley and draw	4	101.2	10.5	90.7	5.7	.06	.06

Table 4. Average yield of wells in the Triassic unit

According to Range in Depth

Range in depth (feet)	Number of wells	Average depth (feet)	Average uncased depth 1/ (feet)	Yield (gallons per minute)		
				Average	Per foot of well	Per foot of uncased hole
0-100	50	78.1	51.6	7.4	0.10	0.14
0-150	94	99.0	72.5	7.1	.07	.10
0-200	99	102.4	75.9	7.1	.07	.09
0-300	106	112.0	85.5	7.2	.06	.08

1/Average casing depth for the Triassic unit is 26.5.

According to Topographic Location

Topographic location	Number of wells	Average depth (feet)	Average casing depth (feet)	Average uncased depth (feet)	Yield (gallons per minute)		
					Average	Per foot of well	Per foot of uncased hole
Hill	22	125.2	25.4	99.8	8.3	0.07	0.08
Knoll	25	121.6	34.1	87.5	6.2	.05	.07
Slope	25	101.4	20.6	80.8	9.3	.09	.12
Flat	23	127.5	27.8	99.7	7.0	.06	.07
Valley and draw	10	102.1	27.4	74.7	11.1	.11	.15

Table 5. Average yield of wells in the granite and granodiorite unit

According to Range in Depth

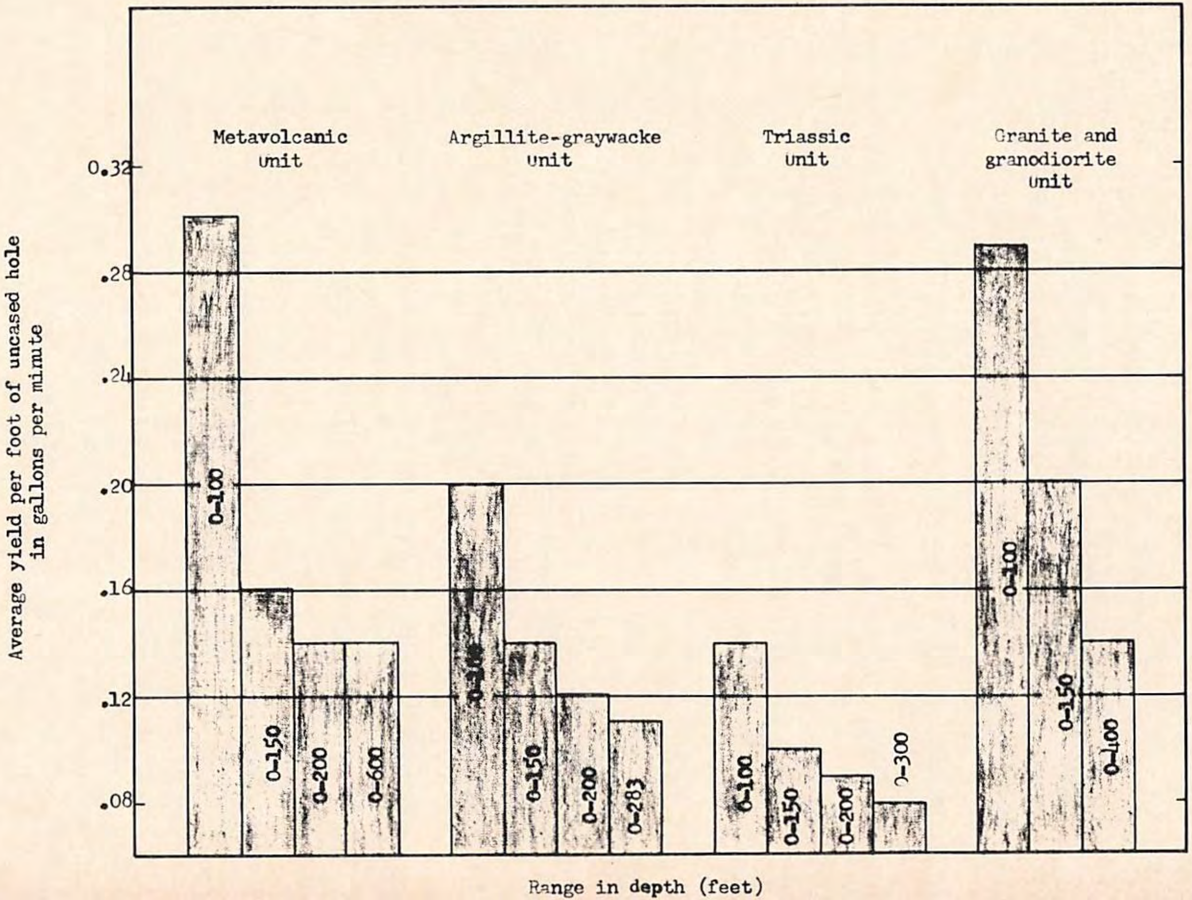
Range in depth (feet)	Number of wells	Average depth (feet)	Average uncased depth 1/ (feet)	Yield (gallons per minute)		
				Average	Per foot of well	Per foot of uncased hole
0-100	59	63.1	27.1	7.9	0.12	0.29
0-150	75	75.8	39.8	8.0	.10	.20
0-400	81	86.8	50.8	8.2	.09	.16

1/Average casing depth for the granite and granodiorite unit is 36.0 feet.

According to Topographic Location

Topographic location	Number of wells	Average depth (feet)	Average casing depth (feet)	Average uncased depth (feet)	Yield (gallons per minute)		
					Average	Per foot of well	Per foot of uncased hole
Hill	37	94.4	34.5	59.9	7.5	0.08	0.12
Knoll	14	103.3	42.3	61.0	10.4	.10	.17
Slope	18	68.4	31.6	36.8	6.9	.10	.19
Flat	12	69.7	34.3	35.4	8.8	.13	.25

Figure 14. Average yield per foot of uncased hole of the lithologic units according to range in depth.



depth are more tightly pressed together with increasing depth owing to the weight of overburden.

The average depth of all wells inventoried in the Durham area is 99.2 feet. Wells drilled to depths below 200 feet are not usually successful in obtaining large additional quantities of water. There are notable exceptions, but if enough water is not obtained at 200 feet of depth, the prospective well owner is advised to drill three or more wells rather than one well 600 feet deep.

The thickness of weathered material above solid rock apparently has a very significant effect on yield in the Durham area. In some places it may be more important than either topography or rock type. The relation of weathered material to yield in different topographic situations is shown graphically in figures 15-18.

Yields from wells in the argillite-graywacke and metavolcanic units appear to be directly proportional to depth of weathering except on the slopes, where the somewhat anomalous yields are probably due to influent seepage from upslope. A thick section of weathered material serves both as a reservoir for increased infiltration and as an aquifer. Depth of weathering appears to have little relation to yield in the Triassic and granite and granodiorite units. However, at least 50 percent of the wells in granite and granodiorite obtain their water from the weathered upper surface. The effect of depth of weathering on yield in these units is probably masked by the topographic effect.

The effect of rock type on yield has already been shown (tables 2-5). The relative ability of the different rock units to yield water can be directly related to the type, size, and amount of original openings and to the ease with which secondary openings are produced by weathering processes and dynamic metamorphism.

Secondary pore spaces such as joints, planes of schistosity, and cleavage planes are important for storage and transmittal of water in the Durham area. Figure 21 illustrates how water percolates downward through fracture systems to a drilled well. Figures 11, 19, and 20 illustrate several types of secondary pore spaces.

Quartz veins are important sources of ground water in the Durham area. Because quartz (commonly called white flint) is

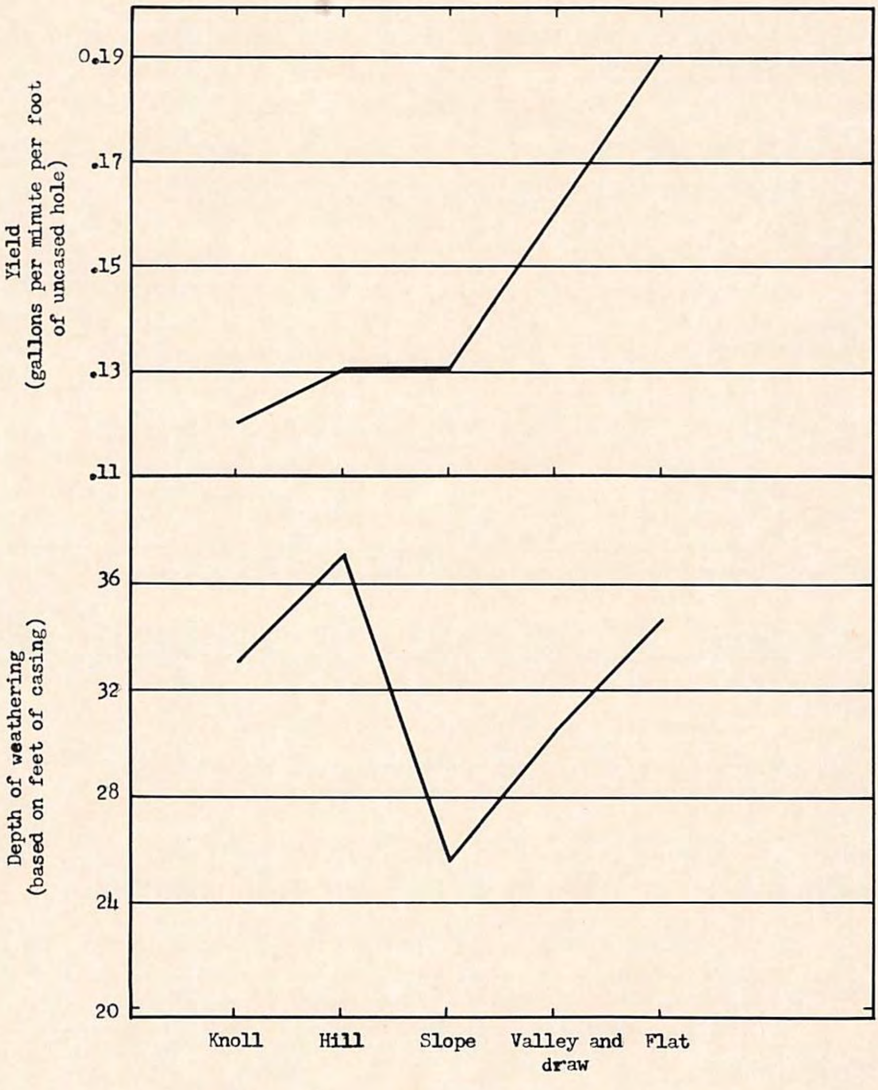


Figure 15. Relation of depth of weathering to average yield of the meta-volcanic unit in different topographic situations.

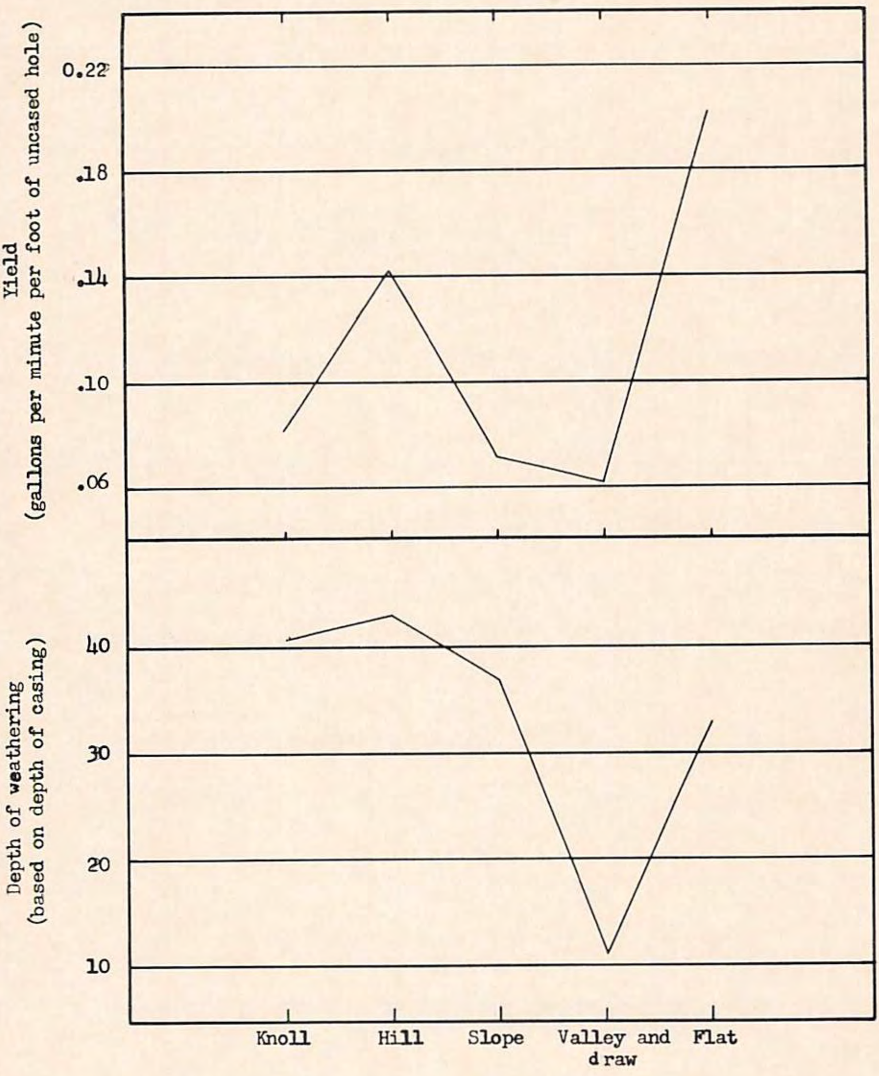


Figure 16. Relation of depth of weathering to average yield of the argillite-graywacke unit in different topographic situations.

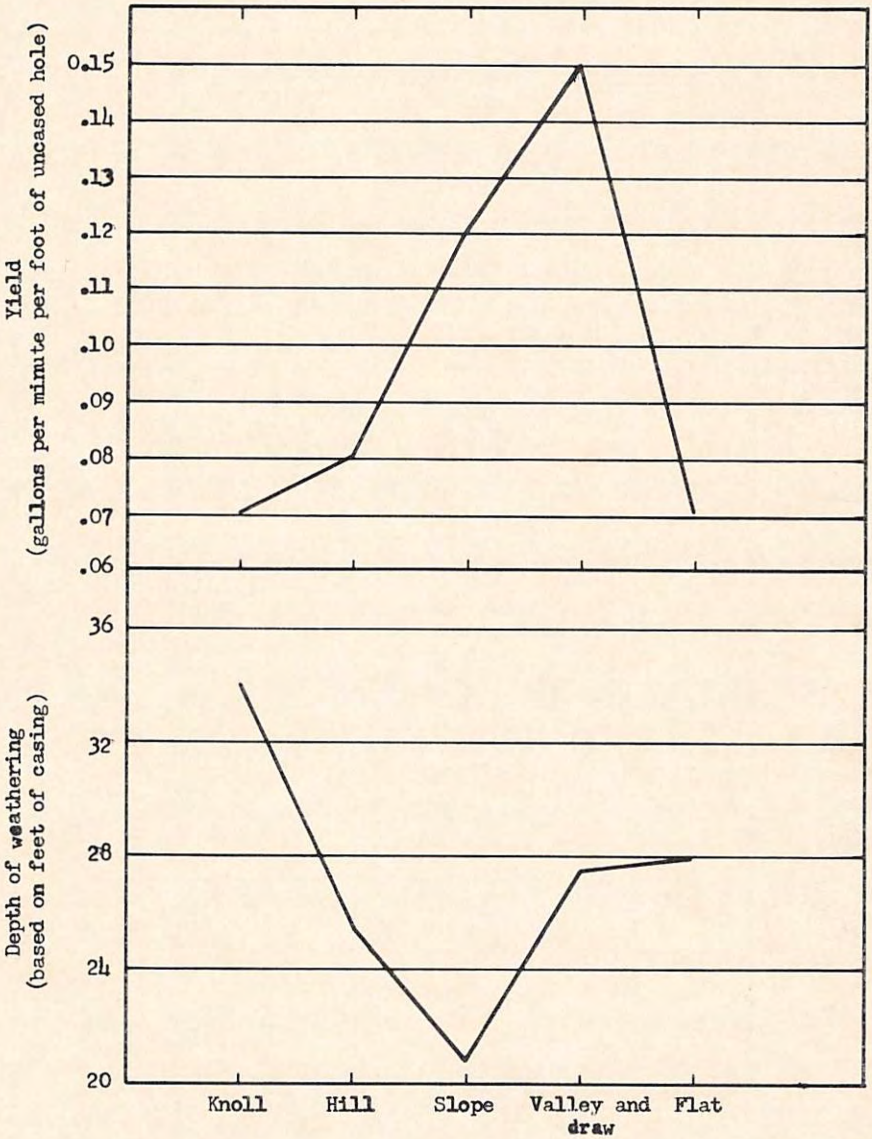


Figure 17. Relation of depth of weathering to average yield of the Triassic unit in different topographic situations.

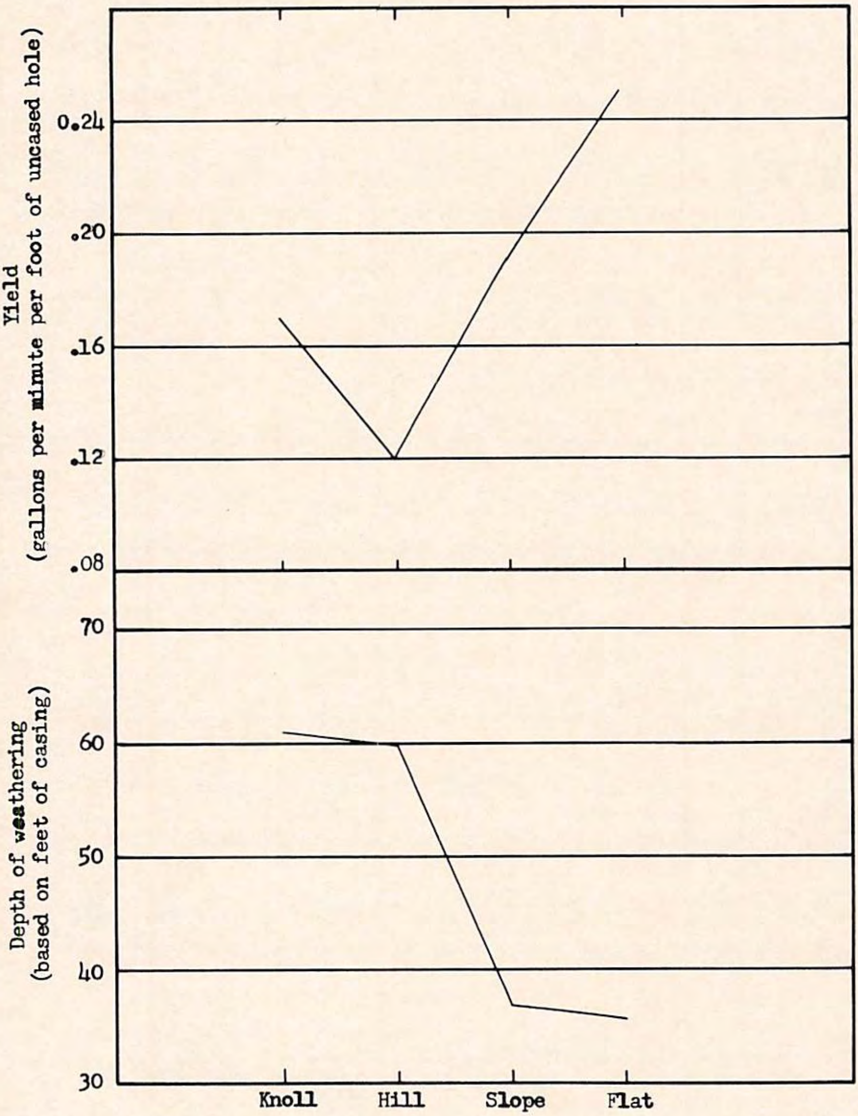


Figure 18. Relation of depth of weathering to average yield of the granite and granodiorite unit in different topographic situations.

brittle, quartz veins are well fractured. Consequently, they store and yield their water freely compared to the surrounding rock. Many of the wells having high yields in the Durham area are in quartz veins. Most large quartz veins were observed to dip steeply to the northwest. Care should be exercised in locating a well on or near a quartz dike so that the well will intersect the dike below the water table. Figure 21 illustrates a drilled well that intersects both fracture systems and quartz dikes. A well drilled at position *B* will penetrate a quartz dike, but the dike will be devoid of water at this point because of its position above the water table.

Where practicable, wells should be spaced far enough apart to avoid mutual interference through pumping. How far apart they should be spaced depends on the pumping rate and permeability of the surrounding rock.

The Triassic rocks in the Durham area are intruded by numerous diabase dikes that are dense and impermeable. Where cut by transverse streams or located downgradient from the direction of groundwater movement, dikes tend to impound ground water behind them. One such dike which is very large is just northwest of the junction of the Eno and Little Rivers in Durham County. Yields in the Triassic rocks north of this point are greater than average.

Relative Water-Yielding Properties of the Map Units

General Conditions

The rocks of the Durham area include igneous, metamorphic, and highly indurated sedimentary rocks in which secondary interstices are the principal storage spaces for ground water.

The factors which have determined the distribution and relative abundance of secondary interstices in the Durham area are complex and interrelated. They include the composition of the rock, the degree of dynamic metamorphism, the relative ability of the rocks to weather, the degree to which the rocks have been intruded by quartz dikes, and the relative position of the rock with respect to drainage systems. Thus, the occurrence of suitable secondary openings for the storage and transmission of ground water in the Durham area is not necessarily related to any particular rock type or lithologic unit. For example, an acid tuff may be a good aquifer in one locality because it is deeply weathered and well jointed, but the same tuff

Figure 19. Outcrop of acid lithic tuff near Coleridge in Randolph County. Joints through which water is seeping are typical of the massive tuffs.

may be practically devoid of water in another locality because it is not weathered and well jointed.

Analysis of Well Data

The following statistical treatment of the well data reveals that, although yields differ greatly from place to place in the same rock type, there is a difference of a few gallons per minute in average yield between some of the rock types.

Table 6 shows the average yields of the mapped units described in this report. It is evident from column 5 that granodiorite has the highest average yield and that the metavolcanic and granite units are second and third in yield, respectively (the mica gneiss and schist unit contains too few wells for its average yield to be significant). In column 6 the yields are tabulated in gallons per foot with reference to the total depth of the hole. Hornblende gneiss, which has a lower average yield than the Triassic unit, is potentially a better aquifer than the Triassic. The yield in gallons per foot of the uncased part of the well is presented in column 7. Rock above the bottom of the

Figure 20. Outcrop of granodiorite near Parks Crossroads in Randolph County. This outcrop shows joints and fractures through which water is seeping.

casing yields no water directly to the well; that is, water in the rock opposite the casing must move downward to the rock in the uncased part of the well. Thus, the figures tabulated in column 7 represent a closer approximation of the actual water-transmitting properties of the different lithologic units.

The higher yields of granite and granodiorite undoubtedly are due to deep weathering and to the high quartz content of their saprolites. Both factors tend to facilitate recharge, storage, and recovery of ground water. Granite and granodiorite are poor aquifers where unweathered. Higher yields can be expected in the metavolcanic unit where it is deeply weathered, or where it is well jointed and sheared or intruded by quartz dikes. Wells in deeply weathered argillite in Randolph County yield an average 0.140 gpm per foot of uncased hole compared to 0.123 for the area as a whole. Low yields in the Triassic rocks probably can be attributed to inherent low porosity and permeability.

Areal Distribution of Yields

Ground water is more plentiful in some sections of the Durham area than in others. This may be seen on plate 1, a map

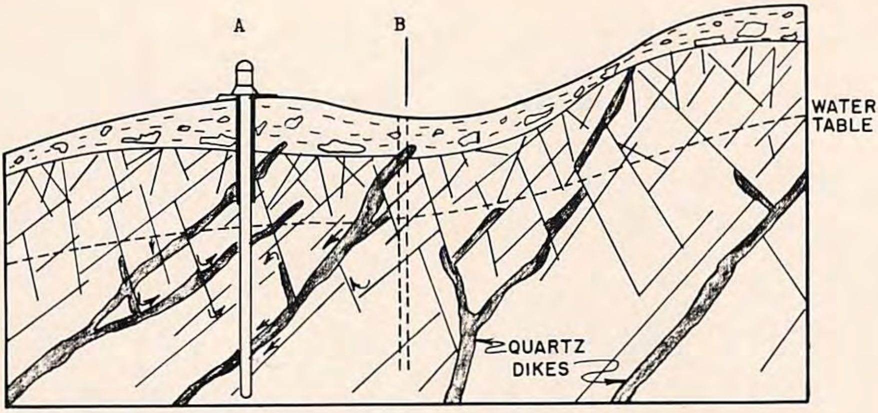


Figure 21. Diagrammatic section illustrating fracture and quartz-dike development in rocks of the Durham area. When well at A is pumped, water moves toward the well as indicated by arrows.

of the Durham area illustrating the distribution of relative yields. Relative yield is defined as the yield of a well in gallons per minute (gpm) for each foot of uncased hole. The unshaded areas represent places where yields can be expected to exceed one-tenth gallon for every foot below casing. Thus, an 80-foot well that is cased 30 feet below the surface should yield 5 gpm —an adequate amount for most domestic purposes. The horizontal-lined areas represent places in the Durham area where yields of less than one-tenth gpm per foot are common.

The data used to prepare the relative-yield map were calculated from information obtained from well owners and from drillers' records. Therefore, some of the data may be inaccurate. Nevertheless, the fact that the yields can be contoured at all attests to their significance.

The distribution of relative yield conforms to the geology as mapped (pl. 2) only in a general way. It is probable that the areal distribution of high yield and low yield is dependent upon several interrelated factors such as depth of weathering; rock type; and relative amounts of shearing, jointing, and quartz-dike intrusion. Thus, a rock type that has a low average yield but is deply weathered and well jointed or contains numerous quartz dikes is quite likely to yield more water than a more favorable rock type that is not. As stated above, there is a definite difference in average yield between the different rock types, but there is also a great variation in yield from place to place of the same rock type.

Table 6. Summary of the water-bearing properties of the mapped lithologic units

Map unit	Number of wells	Average depth (feet)	Average casing depth (feet)	Yield (gallons per minute)		
				Average	Per foot of well	Per foot of uncased hole
Metavolcanic unit	317	94.8	30.0	9.6	0.10	0.15
Argillite-graywacke unit	77	102.4		7.3	.07	.12
Triassic unit	110	115.3	26.5	7.2	.06	.08
Granite and — granite	61	82.5	36.0	8.2	.10	.18
Granodiorite unit — granodiorite	22	86.7	36.0	10.0	.12	.20
Diorite unit	11	96.2		5.7	.06	
Hornblende gneiss unit	11	60.7	22.5 1/	4.0	.07	
Mica gneiss and schist unit	4	134.0		8.8	.07	

1/Based on two wells

CHEMICAL QUALITY OF WATER

By

J. D. THOMAS

General Quality of Water

This section of the report evaluates the chemical quality of the ground water in the Durham area. Information concerning the chemical quality of water is important to the future development of the area, especially in locating industries that require a particular kind of water.

Most of the waters analyzed were calcium, sodium, and magnesium bicarbonate types which are suitable for most domestic, municipal, and industrial uses. Objectionable amounts of iron, chloride, and hardness make a few waters unfit for some uses.

The chemical quality of ground water depends upon the kinds and amounts of dissolved mineral constituents in the water. These at any one place and time depend on such factors as the temperature of the water, the hydrostatic and atmospheric pressures present in the hydrologic system, the mineral composition of the host rocks and soil, the duration of contact, or residence time, of the water and the minerals of the rocks and soil, and the kind and quantity of absorbed gases. Rainwater contains dissolved gases, principally carbon dioxide and oxygen, which are dissolved from the atmosphere, the soil, and organic substances. Dissolved carbon dioxide forms a weak acid capable of reacting with and dissolving most minerals found in the rocks and soil.

Dissolved Mineral Constituents

The salts of the common metals, which include potassium, sodium, calcium, iron, and magnesium, make up most of the dissolved mineral constituents in ground water. These are in solution as cations or anions. Cations are positively charged particles and anions are negatively charged particles. Chemical analyses of ground water determine the amount of cations and anions in solution.

The chemical analyses of ground water in this report are expressed in parts per million (ppm). A part per million is a unit weight of a constituent in a million unit weights of water.

Analyses of water from 72 selected wells and springs were used to determine the chemical quality of ground water from the individual rock types of the Durham area. Sixty-four analyses were made as a part of this investigation. The remainder are from the files of the Quality of Water Branch, U. S. Geological Survey at Raleigh.

The following is a discussion of the dissolved mineral constituents as they are usually reported in water analyses. The range and median of concentrations of chemical constituents in ground water in the Durham area are presented in table 1.

Silica (SiO_2)

Silica in ground water is derived from the weathering of silicate minerals which include the feldspars, mica, amphiboles, and pryoxenes. Except in boiler feed and steam turbine water, the concentrations of silica in ground water in the Durham area are not objectionable for most industrial processes.

Aluminum (Al)

Aluminum is a very common element in the earth's crust. However, high concentrations of aluminum are not common in ground water, because this metal is generally left behind in the clay minerals during the weathering process.

Iron (Fe)

Iron is abundant in many rocks, especially those containing high percentages of ferromagnesian minerals, such as hornblende gneiss and mafic volcanic rock. Iron is soluble in ground water, particularly in acidic ground water. Ferrous iron dissolved in ground water is oxidized to insoluble ferric hydroxide on exposure to air and is responsible for the red or brown stains on porcelain sinks and laundry. Additional iron may be added to water by the corrosive action of acidic ground water in contact with iron pipes and tanks of water systems.

Water containing less than 0.3 ppm iron is suitable for most domestic purposes. Sixty-two percent of the ground-water samples analyzed for iron contained less than 0.3 ppm.

Manganese (Mn)

The chemical behavior of manganese in water resembles that of iron. However, manganese is much less abundant in rocks,

Table 1. Minimum, Maximum, and Median Concentrations of Chemical Constituents in Ground Water in the Durham Area

Constituent	Parts per million		
	Minimum	Maximum	Median
Silica (SiO_2)	6.6	47	25
Iron (Fe)	.00	5.4	.19
Calcium (Ca)	1.1	388	23
Magnesium (Mg)	.4	89	7.9
Sodium (Na)	.2	188	13
Potassium (K)	.1	6.3	.3
Bicarbonate (HCO_3)	14	412	111
Sulfate (SO_4)	.4	67	4.4
Chloride (Cl)	.2	750	12
Fluoride (F)	.0	1.5	.1
Nitrate (NO_3)	.0	75	3.2
Hardness	5	1340	86
Dissolved solids	16	806	162
Hydrogen-ion concentration (pH)	5.8	8.0	6.8
Specific conductance in micromhos	22	3100	255

and manganese concentrations in ground water are generally lower than iron concentrations. The U. S. Public Health Service recommends that manganese not exceed 0.05 ppm in drinking and culinary water. Ninety-one percent of the water analyzed for manganese contained less than 0.05 ppm.

Calcium and Magnesium (Ca and Mg)

Calcium and magnesium are common constituents of rocks in the Durham area. Minerals which contain calcium include calcite, plagioclase feldspar, pyroxene, and the amphiboles. Magnesium is usually present in pyroxene, biotite, olivine, and the amphiboles.

Calcium and magnesium account for most of the hardness of ground water. They combine with bicarbonate to form scale in boilers and other containers in which water is heated or evaporated.

The U. S. Public Health Service recommends that drinking water contain less than 50 ppm magnesium. The highest concentration of magnesium in ground water from the Durham area was 89 ppm.

Sodium and Potassium (Na and K)

The presence of sodium and potassium in ground waters usually can be attributed to the chemical breakdown of the plagioclase and orthoclase feldspars. Potassium is slightly less abundant in rocks than sodium. However, potassium is generally much less concentrated in ground water than sodium, owing to the tendency of potassium to remain behind as a constituent of the clay minerals during the weathering process. Their relative concentrations in ground water from the Durham area are shown in table 1.

Lithium (Li)

Lithium-bearing minerals are comparatively rare. The scarcity of lithium in rocks of the Durham area accounts for low concentrations in the ground water.

Bicarbonate (HCO_3) and Carbonate (CO_3)

Bicarbonate (HCO_3) is the principal anion in ground water in the Durham area. The principal cations are calcium, sodium, and magnesium.

Unless calcium and magnesium are present in high concentrations, bicarbonate has little effect on the domestic utilization of water. Bicarbonate in the Durham area ranged from 14 to 412 ppm.

No carbonate (CO_3) was reported in any ground water analyzed from the Durham area.

Sulfate (SO_4)

Sulfate may be derived from the decomposition of organic matter and the oxidation of iron-sulfide minerals, such as marcasite and pyrite (FeS_2).

The low concentrations of sulfate in ground water in the Durham area are not objectionable for most uses. The U. S. Public Health Service recommends that sulfate not exceed 250 ppm in drinking and culinary water.

Chloride (Cl)

Only small amounts of chloride are dissolved during the weathering of crystalline and sedimentary rocks.

The U. S. Public Health Service recommends that chloride concentrations in drinking and culinary water should not exceed 250 ppm. Eight percent of the samples of ground water analyzed from the Durham area contained chloride in excess of 250 ppm.

Abnormally high chloride concentrations in ground water in the Durham area may result from retention of fossil sea water, or from domestic or industrial pollution. The association of bromide with chloride in some waters and the low nitrate concentrations seem to rule out pollution and to favor residual sea water as the source.

Bromide (Br)

Except for certain sedimentary deposits, rocks contain only small amounts of bromide. Bromide in ground water is considered a minor or trace element.

The chemical behavior of bromide in water resembles that of chloride, and both are concentrated in sea water and brines. The presence of bromide in conjunction with high chloride concentrations may indicate a water that is in part "fossil" or residual sea water.

Concentrations of bromide in water from wells in the Durham area are given in tables 9 and 21.

Fluoride (F)

Fluoride in ground water is dissolved from fluoride-bearing minerals such as mica, apatite, and hornblende. According to medical evidence 1.0 to 1.5 ppm of fluoride will aid in the prevention of tooth decay. Excess amounts of fluoride are undesirable, however, because it may cause mottling of teeth. Fluoride concentrations in ground water from the Durham area did not exceed 1.5 ppm.

Nitrate (NO_3)

Nitrate in ground water is considered to be the final oxidation product of nitrogeneous organic materials. Water intended for human use should not exceed 45 ppm nitrate according to the U. S. Public Health Service. The median concentration of nitrate in ground water analyzed from the Durham area was 3.2 ppm. Concentrations greater than 3.2 ppm may indicate pollution by sewage, fertilizers, or human wastes. Dug wells and improperly cased drilled wells are especially subject to contamination by surface water.

Phosphate (PO_4)

Phosphate in ground water may result from the solution of apatite or phosphate fertilizers. Phosphate concentrations in ground water sampled in the Durham area were below 0.4 ppm.

Hardness

Hardness of water is caused chiefly by the amount of calcium and magnesium in a particular water, and is expressed as equivalent ppm of calcium carbonate ($CaCO_3$). Hardness of water is usually recognized by the increased amount of soap necessary to form and maintain a lather. The U. S. Geological Survey uses a classification of water hardness with respect to calcium carbonate as follows:

Hardness as $CaCO_3$ (ppm)	*Classification*
0-60	Soft
61-120	Moderately hard
121-180	Hard
181+	Very hard

Sixty-three percent of the ground-water samples analyzed in the Durham area are classed as moderately hard to very hard.

Total And Computed Dissolved Solids

Total dissolved solids are the residue after a given volume of water has been evaporated and dried at a definite temperature (180°C by the U. S. Geological Survey). Computed dissolved solids are equal to approximately one-half the bicarbonate plus the sum of the other chemical constituents in ppm. Computed dissolved solids are used in this report, unless stated otherwise.

The U. S. Public Health Service recommends that public water supplies should not contain more than 500 ppm dissolved solids. In the Durham area four samples of ground water were analyzed which contained more than 500 ppm dissolved solids.

Hydrogen-ion Concentration (pH)

The hydrogen-ion concentration, expressed in pH units, is a measure of the degree of acidity or basicity of the water. The pH of a solution is the negative logarithm of the concentration of the hydrogen ion in moles per liter. Water having a pH of 7.0 is neutral, lower than 7.0 is acidic, and higher than 7.0 is basic. The pH values are important indicators of the corrosive potential of ground water. Acid waters generally are more corrosive than alkaline waters. The pH of ground water from the Durham area range from 5.8 to 8.0.

Specific Conductance

Specific conductance is a measure of the capacity of a water to conduct an electric current. The conductance is primarily dependent upon the amount of dissolved constituents and their degree of ionization. Therefore, specific conductance values are used to estimate the total amount of solids in solution and are expressed in reciprocal ohms times 10^6 (micromhos) at a standard temperature of 25°C.

Relation of Chemical Quality of Water to Geology

The chemical composition of a particular ground water should in some degree reflect the mineral composition of the rock with which it has been in contact. Weathering of igneous, metamorphic, and most sedimentary rocks releases principally silica, calcium, magnesium, sodium, potassium, and bicarbonate to ground water. Granite, for example, is composed largely of sodium and potassium feldspars and quartz. Water from granite should be a sodium bicarbonate type. Gabbro, on the other hand, is composed largely of calcium feldspars and ferromagnesian minerals. Water from gabbro should be a calcium or magneisum bicarbonate type. However, this simple relationship is complicated if there is mixing of waters from adjacent rock types of different compositions or if the host rock is intermediate in composition.

Water quality shows no clear-cut relationship with geology in the Durham area. There are several possible reasons for this discrepancy. The mineral composition of the rock types varies considerably within the mapped units, especially the metavolcanic unit, and the granite and granodiorite unit. Most ground water in the area is confined to the weathered portion of the rocks so that lateral movement and mixing of ground waters between rock types undoubtedly takes place. The effect of such factors as selective absorption of ions and base exchange in the rocks of the area is not known.

More detailed mapping and water sampling is necessary to understand fully what relationships do exist between water quality and geology in the Durham area. The following discussion points out some possible relationships.

Hornblende Gneiss and Mica Gneiss and Schist Units

Analyses of water from selected wells in these two units are found in table 18. Water from only one well in the mica gneiss and schist unit, and from only two wells in the hornblende gneiss unit were analyzed. Both waters from the hornblende gneiss unit were magnesium bicarbonate types.

Metavolcanic Unit

The metavolcanic unit is composed of interbedded, slightly metamorphosed volcanic tuffs and flows which range in composition from felsic to mafic. Rocks containing calcium, sodium, and magnesium are widespread.

The waters from this unit are principally calcium (40%), sodium (24%), and magnesium (28%) bicarbonate types. One sodium chloride and two calcium chloride waters were analyzed. Iron ranged from 0.0 ppm to 5.4 ppm; the median was 0.22

ppm. Total hardness ranged from 11 ppm to 492 ppm and the median was 102 ppm. Chloride ranged from 0.2 ppm to 311 ppm and the median was 12 ppm.

Analyses of water from selected wells in this unit are listed in tables 9, 12, 15, 18, and 21.

Argillite-Graywacke Unit

The argillite-graywacke unit includes interbedded argillite, graywacke sandstone, graywacke conglomerate, and felsic tuff. Analyses of water from selected wells in this unit are listed in tables 9, 15, 18, and 21.

The waters from this unit are principally calcium and magnesium bicarbonate and calcium chloride types. One sodium chloride type water and one sodium bicarbonate water were analyzed. The inherent low sodium content of shales and argillites probably accounts for the low sodium concentrations in the ground water from this unit.

Iron ranged from 0.04 ppm to 1.4 ppm. The median for iron was 0.15 ppm. Total hardness ranged from 33 ppm to 1340 ppm and the median was 63 ppm. Chloride ranged from 3 ppm to 750 ppm and the median was 16 ppm.

Granite and Granodiorite Unit

The granite and granodiorite unit includes plutonic igneous rocks which range in composition from the typical granite through granodiorite. This unit also includes small bodies of diorite and xenoliths of volcanic rock too small to map. Analyses of ground water from selected wells in this unit are listed in tables 9, 12, 15, 18, and 21.

The water from granite and granodiorite is predominantly a calcium bicarbonate type (46%). Sodium and magnesium bicarbonate types constitute 23 and 30 percent, respectively, of the waters analyzed from this unit. The relative proportions of sodium, calcium, and magnesium in this unit are quite similar to those of the metavolcanic unit, indicating that their bulk compositions are approximately the same.

Triassic Unit

The rocks of Triassic age are principally continental and consist of maroon to reddish-gray sandstones, shales, siltstones, conglomerates, and fanglomerates. Waters from this unit differ from those of the other map units in that there are an equal number of calcium and sodium bicarbonate types and no magnesium bicarbonate types. One each of the sodium and calcium chloride types was present.

Analyses of water from selected wells in the Triassic unit are listed in tables 9 and 12.

Iron ranged from 0.01 ppm to 0.90 ppm, and the median was 0.15 ppm. Total hardness ranged from 46 ppm to 524 ppm, and the median was 158 ppm. Chloride ranged from 12 to 384 ppm, and the median was 75 ppm.

Summary and Conclusions

The chemical character of the ground water in the Durham area shows little relation to the rock units. Water from the Triassic unit usually contained more dissolved solids than water from the other units. Water from the metavolcanic unit is similar to that of the granite and granodiorite unit. Calcium and sodium chloride water was found in a few wells in the metavolcanic, argillite-graywacke, and Triassic units. Bromide occurred in association with excessive chloride in two wells in the metavolcanic unit. Objectionable amounts of iron were reported in some samples from the metavolcanic unit. Ground water in the area is of the sodium, calcium, and magnesium bicarbonate type, and is suitable for most domestic, municipal, and industrial uses.

COUNTY DESCRIPTIONS

Chatham County

(Area 707 square miles; population 26,785)

Chatham County is the southeasternmost county in the Durham area. It is bounded on the north by Alamance, Orange, and Durham Counties, to the west by Randolph County, to the south by Moore and Lee Counties, and to the east by Harnett and Wake Counties. Pittsboro, the county seat, is the second largest town in Chatham County. Siler City, near the Randolph-Chatham County line, is the largest town, with a population of 4,455 according to the 1960 Bureau of the Census report. Other towns in the county are Bennett, Goldston, and Moncure.

The county is drained by the Deep, Rocky, Haw, and New Hope Rivers. The Haw and Deep Rivers become the Cape Fear River at their confluence south of Moncure.

The topography of Chatham County is similar to that of other counties in the Piedmont province. The upland surface generally slopes toward the southeast and is submaturely dissected by southeastward-flowing antecedent streams. A topographic lowland has developed on the Triassic rocks in the eastern and southeastern parts of the county. Highest elevations occur along a northeastward-trending ridge between Siler City and Pittsboro and on the large granite pluton between Bynum and Chapel Hill. The lowest altitude is along the Cape Fear River on the Chatham-Harnett County line.

The economy of the county depends largely on its agriculture. The production of broilers is quite important and one of the largest poultry-processing plants in the State is at Pittsboro. Other agricultural products include tobacco, corn, small grains, and livestock. Textile plants are at Bynum, Pittsboro, and Siler City.

Geology

Most of Chatham County is underlain by rocks of the metavolcanic unit (pl. 2), which include felsic to mafic pyroclastics, flows, and interbedded sedimentary rocks. The volcanic rocks are deeply weathered and poorly exposed. Where unweathered they are dense, flinty rocks that break with a conchoidal fracture and are green to gray in color. Tuffs ranging in texture from glassy varieties to coarse agglomerates are present. Most interbedded sedimentary rocks in the metavolcanic unit appear to be silicified argillite. They are aphanitic and glassy and are easily confused with rhyolite flows.

Rocks of the metavolcanic unit grade upward into a predominantly sedimentary unit, which is mapped as the argillite-graywacke unit. The argillite-graywacke unit includes argillite, slate, graywacke, sandstone, graywacke conglomerate, and minor amounts of tuff. The argillite-graywacke unit is exposed in tightly folded, northeastward-trending synclines in the western half of the county. The sedimentary rocks of the argillite-graywacke unit are apparently overlain by andesitic tuffs and flows included in the mafic tuff and flow unit.

The sedimentary and volcanic rocks have been intruded and locally metamorphosed by igneous plutons of granite to granodiorite composition. The largest of these plutons is north of Pittsboro. Smaller plutons are exposed northwest of Terrells, east of Bynum, and south and east of Corinth. One outcrop of biotite schist is exposed in the southeastern tip of the county.

The eastern and south-central parts of Chatham County are underlain by rocks of Triassic age. These rocks include maroon to gray arkosic sandstones, siltstones, shales, and fanglomerates. The Triassic rocks dip to the southeast where they abut against the Jonesboro fault. The Triassic rocks as well as the surrounding volcanic-sedimentary terrane have been intruded by diabase dikes of Triassic age.

Ground Water

All water used for domestic and industrial purposes in Chatham County is obtained from wells or springs except in the towns of Pittsboro and Siler City, which utilize surface water. Most dug wells obtain their water from the saprolite overlying unweathered rock and they frequently go dry during periods of drought. Drilled wells in Chatham County obtain their water from fractures, planes of schistosity, and other secondary openings below the water table, and are more dependable sources of water than the dug wells. (See figs. 22 and 23.)

Data from 228 wells in Chatham County are summarized in table 7. Comparison of yields in table 7 indicates that wells in granite and granodiorite have three times the yield per foot of well that wells in the argillite-graywacke unit have, and nearly

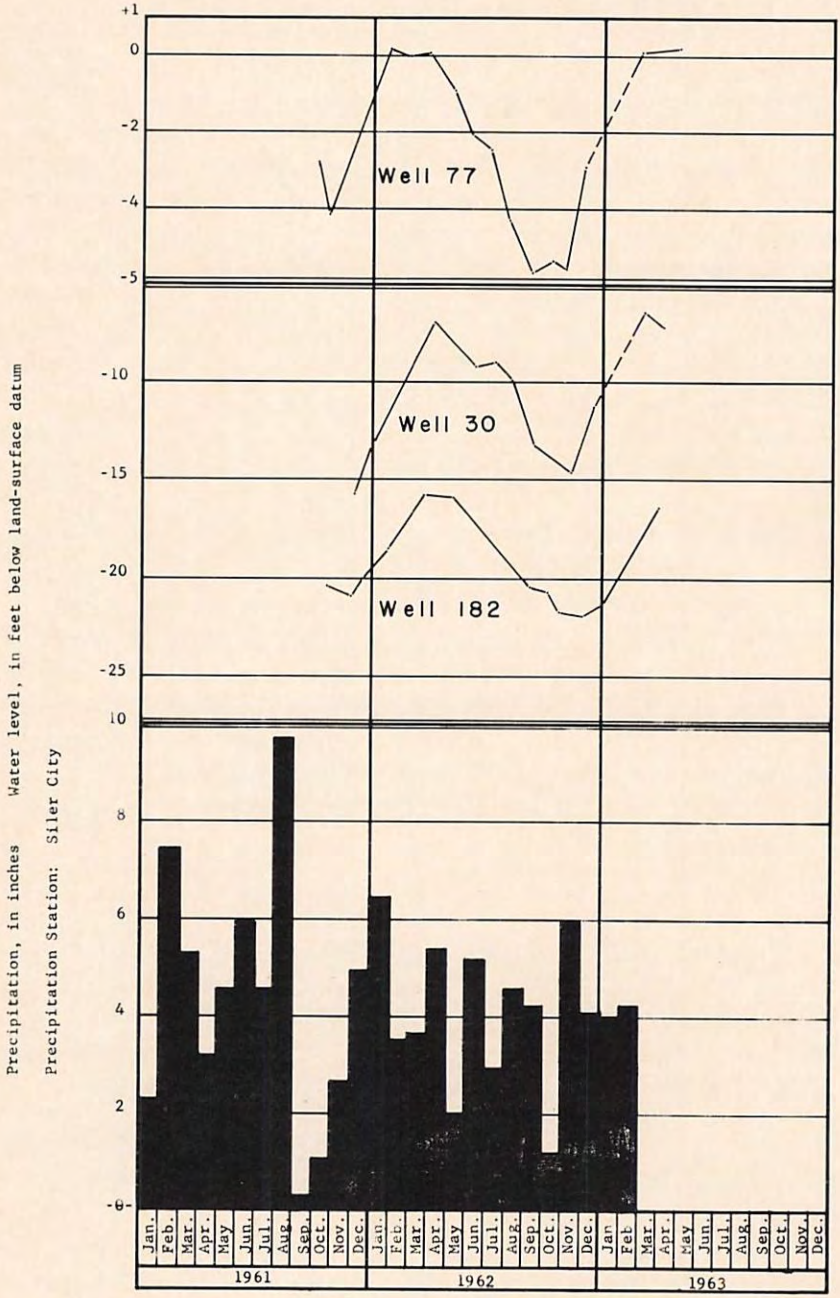


Figure 22. Selected hydrographs showing seasonal fluctuation of the water table in Chatham County.

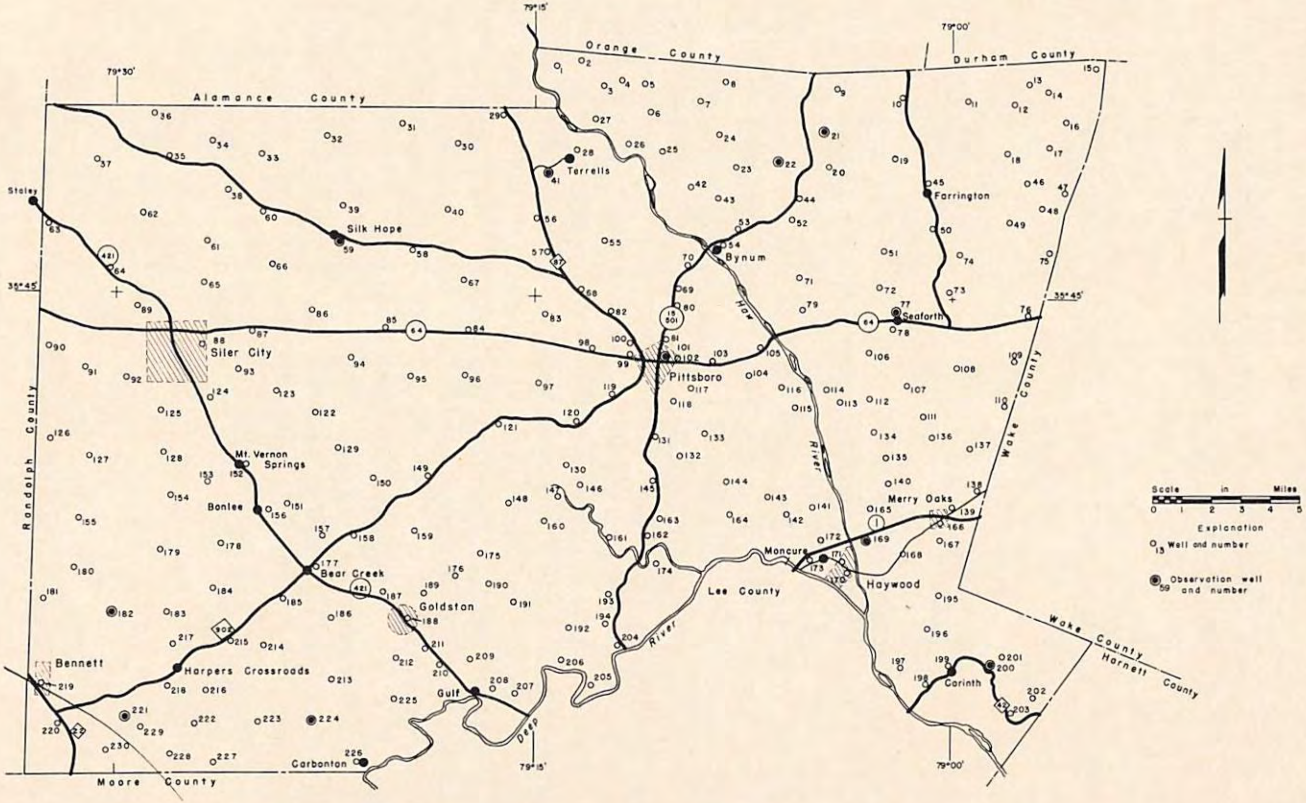


Figure 23. Map of Chatham County showing the location of wells.

Table 7. Summary of Well Data in Chatham County according to Rock Type

Map unit	Number of wells	Yield (gallons per minute)		Average depth (feet)
		Average	Per foot of well	
Granite and granodiorite	21	8.0	0.12	68.1
Triassic	64	6.7	.07	97.7
Argillite-graywacke	17	5.0	.04	123.4
Metavolcanic	120	7.3	.07	99.2

Average water level in Chatham County is 24.2 feet below land surface.

twice the yield of wells in the Triassic and volcanic rocks. The higher yield in granite and granodiorite is attributed to deep weathering and to the higher permeability of the weathered material. The poorer yields in the argillite-graywacke unit (table 7) can no doubt be attributed to the thinner veneer of weathered material on this unit in Chatham County.

There is a great difference in yield from place to place in the same rock unit. Figures 15 and 16 show that depth of weathered material has a greater influence on yield in the metavolcanic and argillite-graywacke units than does topography. Plate 1 shows the areal distribution of relative yields for the Durham area. It can be seen from this map that a large area extending northeastward across Chatham County has yields that exceed 0.1 gpm per foot of uncased hole. In this area an 80-foot well cased to a depth of 30 feet should yield 5 gpm or more. The areas having a horizontal-line pattern should yield less than 5 gpm for the same well and casing depths. Areas in which yields would be expected to be less than 1 gpm under the same conditions are shown in a cross-hatched pattern. Records of wells in Chatham County are shown in table 8.

Table 8. Records of Wells in Chatham County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1	3.1 mi. N of Terrells----	F. J. Ferguson	Hill---	-Dr--	100	6	Mafic tuff---	30	20	6	0.09	M	
2	3.2 mi. N of Terrells----	Walter Atwater	Slope--	-do--	63	6	-----do------	-------	20	6	--------	S	
3	3.1 mi. NE of Terrells----	Ben Mann-------	Hill---	-do--	84	6	Granite------	-------	20	0.5	--------	H	
4	4.4 mi. NE of Terrells----	Mrs. K. H. Hackney------	--do---	--D--	52	36	-----do------	0	46	4	--------	S	
5	3.1 mi. NE of Terrells----	E. F. Moses----	--do---	--B--	33	20	-----do------	33	21	3	--------	S	
6	5.6 mi. NE of Terrells----	Mrs. John Kenfield-----	--do---	-Dr--	90	6	-----do------	-------	25	15	--------	S	
7	5.9 mi. NE of Terrells----	J. B. Faircloth	Slope--	--D--	26	24	-----do------	0	21	1	--------	S	
8	4.6 mi. NW of Farrington--	Mrs. Pendergraph	--do---	-do--	21	30	-----do------	0	15	2	--------	M	Iron taste reported.
9	3.2 mi. N of Farrington--	Dennis Boggs---	Draw---	-Dr--	107	6	Triassic-----	35	19	6	0.08	M	
10	3.3 mi. NE of Farrington--	N. C. State College------	Flat---	--D--	30	48	-----do------	0	14	5	--------	S	
11	4.1 mi. NE of Farrington--	A. C. Horton---	Hill---	-Dr--	104	6	-----do------	36	19	5	0.07	H	
12	5.0 mi. NE of Farrington--	J. E. Burke----	--do---	-do--	133	6	-----do------	20	20	5	.04	M	Limy taste reported.
13	5.3 mi. NE of Farrington--	M. A. Sims-----	Knoll--	-do--	92	6	Triassic diabase----	-------	50	3	--------	M	Do.
14	7.0 mi NE of Farrington--	W. W. High-----	--do---	-do--	85	6	Triassic-----	-------	35	4	--------	M	
15	5.3 mi. NE of Farrington--	J. B. Slade----	Slope--	-Dr--	96	6	Triassic-----	20	60	1.5	0.20	M	Limy taste reported.
16	4.5 mi. NE of Farrington--	J. C. Riggsbee	Hill---	--D--	49	48	-----do------	0	44	0.5	--------	M	Do.
17	3.0 mi. NE of Farrington--	Hallie Council	Upland flat--	-Dr--	105	6	-----do------	-------	21	3	--------	M	

Nos. on map do not agree with locations

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
18	1.5 mi. NW of Farrington--	Paul Atwater--	Flat---	-do--	103	6	-----do------	20	30	3	0.04	H	
19	3.5 mi. W of Farrington--	Lester Laney--	Slope--	-do--	69	6	Granite------	-------	22	3	--------	S	
20	4.0 mi. NW of Farrington--	Lystra Baptist Church------	Hill---	--D--	41	36	-----do------	0	37	0.5	--------	---------	Observation well analysis in table
21	3.9 mi. NE of Bynum-------	A. T. Burgess-	Flat---	--B--	23	24	-----do------	23	13	3	--------	S	Do.
22	3.0 mi. NE of Bynum-------	Mrs. Eula Mann	Slope--	-Dr--	88	6	-----do------	35	23	10+	0.19	M	
23	5.8 mi. E of Terrells----	Kenneth Ryan--	Hill---	-do--	83	6	-----do------	21	32	1	.02	M	
24	3.2 mi. E of Terrells----	Dr. Loyd Riggsbee----	Slope--	-do--	80	6	-----do------	-------	-----	5	--------	S	
25	2.0 mi. E. of Terrells----	C. R. White---	Knoll--	--B--	28	30	-----do------	28	15	3	--------	S	
26	1.5 mi. NE of Terrells----	R. S. Dodson, Jr.---------	Slope--	-Dr--	98	6	-----do------	40	20	20	0.34	M	
27	0.4 mi. NE of Terrells----	D. A. Stone---	Hill---	--D--	28	24	Felsic tuff--	28	13	3	--------	S	
28	2.5 mi. NW of Terrells----	George Metcalf	--do---	-Dr--	145	6	Granite gneiss	38	20	2.5	0.02	S	
29	5.1 mi. NE of Silk Hope---	L. E. Thomas--	--do---	-do--	172	4	-----do------	32	9	8	.06	H	
30	2.2 mi. NE of Silk Hope---	Gerold Thomas-	Slope--	-do--	80	6	Tuff---------	30	15	3	.06	S	
31	3.4 mi. N of Silk Hope---	Darryle Lindley-----	Slope--	-Dr--	103	6	Felsic tuff--	30	20	5	0.07	S	
32	3.7 mi. NW of Silk Hope	W. A. Hinshaw-	--do---	-do--	85	6	Mafic tuff---	10	10	1	.01	S	
33	6.4 mi. NE of Staley------	W. H. Brodebank	Hill---	-do--	50	6	Felsic tuff--	-------	18	40	--------	M	
34	6.4 mi. NW of Silk Hope---	Alma Duncan---	--do---	-do--	112	6	-----do------	18	15	10	0.11	S	Analysis in table.

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
35	5.1 mi. NE of Staley------	Floyd White---	Flat---	-do--	33	6	-----do------	27	12	16	3.4	S	
36	2.5 mi. NE of Staley------	T. C. Albright	Slope--	-do--	60	6	Mafic tuff---	27	-----	0	.00	---------	
37	3.9 mi. NW of Silk Hope---	H. H. Buckner	--do---	-do--	210	6	-----do------	25	35	1	.01	S	
38	1.0 mi. N of Silk Hope---	H. J. Johnson	Hill---	-do--	220	6	-----do------	35	50	13	.07	S	Analysis in table.
39	3.8 mi. NE of Silk Hope---	J. E. Fogleman	Slope--	-do--	61	5 3/8	-----do------	10	25	4.5	.09	S	
40	0.8 mi. SW of Terrells----	W. K. Mann----	Flat---	--D--	26	36	Felsic tuff--	0	14	5	--------	M	Sulfur taste reported; analysis in table.
41	2.3 mi. N of Bynum-------	Walker Perry--	Hill---	-Dr--	95	15	Granite------	15	22	20	0.25	S	
42	1.8 mi. N of Bynum-------	Oscar Kirby---	Slope--	-do--	128	6	-----do------	-------	-----	6	--------	M	
43	3.5 mi. NE of Bynum-------	J. O. Farrington---------	Knoll--	-do--	96	6	-----do------	15	12	8	0.10	H	Some iron reported
44	Farrington----	T. V. Scott---	Slope--	-do--	96	6	Triassic-----	30	20	4.5	.07	M	Limy taste reported.
45	3.5 mi. E. of Farrington--	C. H. Pendergraft-------	Flat---	-do--	125	6	-----do------	20	20	5	.05	S	
46	4.8 mi. E. of Farrington--	Brodie Smith--	Hill---	--D--	30	36	Triassic-----	0	16	3	--------	S	
47	4.0 mi. E. of Farrington--	Mrs. A. J. Riggsbee----	Flat---	-Dr--	101	6	-----do------	-------	15	4	--------	S	
48	3.1 mi. SE of Farrington--	H. O. Kelly, Jr.---------	Upland flat-	-do--	110	6	-----do------	30	20	15	0.19	S	
49	1.3 mi. S of Farrington--	T. W. Horton--	Slope--	-do--	65	6	-----do------	25	18	20	.50	M	Slight taste reported.
50	2.5 mi. SW of Farrington--	Mrs. Herman Scott-------	Flat---	-do--	100	6	-----do------	-------	20	5	--------	S	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
51	3.0 mi. NW of Bynum-------	R. E. Ward----	Knoll--	-Dr--	91	6	Granite------	28	20	4	0.06	S	
52	1.3 mi. E of Bynum-------	Earl Cotner---	Flat---	-do--	50	6	-----do------	32	10	25	1.39	M	Some iron reported.
53	Bynum---------	Lewis Cooper--	Hill---	-do--	105	6	-----do------	30	30	4	.06	S	
54	3.5 mi. W of Bynum-------	Jasper Jones--	Knoll--	--D--	33	48	Mafic tuff---	33	29	4	--------	H	Limy taste reported.
55	2.2 mi. SW of Terrells----	T. C. Justice	--do---	-Dr--	168	6	Argillite----	60	20	3	0.03	M	
56	3.1 mi. SW of Terrells----	Roscoe Lee----	Flat---	-do--	75	6	Felsic tuff--	-------	2	3	--------	H	Slight taste reported.
57	2.5 mi. E of Silk Hope---	Z. V. Perry---	--do---	-do--	102	6	-----do------	-------	5	5	--------	S	
58	Silk Hope-----	Silk Hope School------	--do---	-do--	99	6	Mafic tuff---	-------	12	3	--------	S	Observation well, analysis in table.
59	2.6 mi. NW of Silk Hope---	Harry Fox-----	Hill---	-do--	75	5 5/8	-----do------	21	16	8	0.15	S	
60	3.7 mi. N of Siler City--	W. H. Ingle---	Slope--	-do--	90	6	-----do------	20	20	10	.14	S	
61	4.7 mi. N of Siler City--	Billy York----	--do---	-Dr--	148	4	Felsic tuff--	20	-----	1.5	0.01	S	
62	0.5 mi. SE of Staley------	J. G. Smith, Jr.---------	--do---	-do--	142	6	-----do------	20	20	2	.02	S	
63	4.0 mi. NW of Siler City--	W. M. Scotton	Flat---	-do--	100	6	Mafic tuff---	18	18	15	.18	M	Some iron reported.
64	2.3 mi. N of Siler City--	Van C. Andrew	Hill---	-do--	202	6	Argillite and graywacke--	7	30	2	.01	M	
65	2.3 mi. SW of Silk Hope---	Mrs. J. C. Fox	Slope--	-do--	97	6	Felsic tuff--	30	24	2.5	.04	S	
66	4.5 mi. SE of Silk Hope---	Leroy Self----	--do---	-do--	97	6	Andesitic tuff-------	35	35	12	.20	S	Reported to be corrosive.

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
67	3.6 mi. NW of Pittsboro---	Jack Johnson--	Flat---	-Dr--	99	6	Mafic tuff---	24	-----	14	.18	H	Slight taste reported.
68	1.6 mi. SW of Bynum-------	J. Roby Creed	Slope--	-do--	71	6	-----do------	30	19	12	.30	M	
69	0.7 mi. SW of Bynum-------	W. H. Morris	Hill---	-do--	134	6	-----do------	128	20	2.5	.42	H	
70	3.5 mi. NW of Seaforth----	Mt. Gilead Baptist Church	Slope--	-do--	50	6	Granite------	32	25	30	1.67	S	
71	1.2 mi. N of Seaforth----	W. B. Horton Estate	Hill---	-do--	119	6	Triassic-----	-------	20	6	--------	S	
72	2.1 mi. NE of Seaforth----	Mrs. J. V. Horton-------	Slope--	-do--	95	6	-----do------	10	20	15	0.18	S	
73	3.2 mi. NE of Seaforth----	Walter Boone--	Hill---	-do--	85	6	-----do------	17	42	4.5	.07	M	Limy taste reported.
74	5.6 mi. NE of Seaforth----	George Castlebury---------	Flat---	-do--	250	6	-----do------	75	25	5	.03	M	
75	4.5 mi. E of Seaforth----	Edna Hedgefeth	--do---	-do--	134	6	-----do------	50	25	12	.14	M	
76	Seaforth------	Murphy Holder	Valley-	-do--	65	6	-----do------	-------	2	20	--------	--------	Analysis in table Observation well.
77	Seaforth------	Murphy Holder	Valley-	-do--	55	6	-----do------	30	1	20	0.83	S	Observation well.
78	3.2 mi. W of Seaforth----	J. C. Hatley--	Draw---	-do--	92	6	Mafic tuff---	22	18	6	0.09	S	
79	1.8 mi. N of Pittsboro---	Lloyd E. Cooper	Hill---	-do--	50	6	Quartz dike in mafic tuff-------	40	20	20	2.00	H	Reported corrosive to copper.
80	0.8 mi. N of Pittsboro---	Joe T. Farar--	Draw---	-do--	48	6	Mafic tuff---	30	16	1.5	0.08	H	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
81	2.2 mi. NW of Pittsboro---	Leon Brooks---	Slope--	-Dr--	148	6	Mafic tuff---	28	-----	4	0.03	M	Slight taste reported.
82	4.1 mi. NW of Pittsboro---	J. Horace Mangum------	Flat---	-do--	60	6	Andesitic tuff-------	45	20	8	0.32	S	
83	6.5 mi. W of Pittsboro---	C. p. Clark---	Knoll--	-do--	105	6	-----do------	50	50	20	0.36	S	Analysis in table.
84	3.7 mi. SE of Silk Hope---	Floyd Bowers--	Flat---	-do--	43	8	-----do------	15	13	6	0.21	S	
85	2.5 mi. S of Silk Hope---	H. C. Owens---	Hill---	-do--	60	6	Argillite and tuff-------	------	20	5	--------	S	
86	2.4 mi. E of Siler City--	J. E. Lemon---	Knoll--	-do--	115	4	Argillite----	60	-----	5	0.09	S	Do.
87	Siler City----	N. C. State Highway-----	Flat---	-do--	190	-----	-----do------	175	-----	8	0.53	M	Do.
88	2.0 mi. NW of Siler City--	L. W. Craig---	Valley-	-do--	120	6	-----do------	7	-----	1	0.01	H	Bad taste reported.
89	4.5 mi. W of Siler City--	C. A. Burke---	Draw---	-do--	33	6	-----do------	15	15	4.5	0.25	S	
90	3.3 mi. W of Siler City--	C. K. Fox-----	Hill---	-do--	138	4	Mafic tuff---	30	40	3	0.03	S	Reported to be corrosive.
91	2.0 mi. SW of Siler City--	Fletcher Brooks	Flat	-do--	72	6	Argillite and felsic tuff	20	20	1.5	.03	--------	
92	2.0 mi. SE of Siler City--	Chatham Poultry	Slope--	-do--	100	6	Andesitic tuff-------	35	3	1	.02	S	
93	5.7 mi. E of Siler City--	Joe Johnson---	Hill---	-do--	60	6	-----do------	------	44	5	.23	S	
94	7.8 mi. E of Siler City--	Walter Powers	--do---	-do--	102	6	-----do------	80	30	20	--------	S	
95	6.0 mi. W of Pittsboro---	Jim Clark-----	--do---	-do--	150	6	-----do------	20	40	1	0.01	--------	
96	4.0 mi. SW of Pittsboro---	Ed Johnson----	Flat---	-do--	42	36	-----do------	2	32	5	--------	S	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
97	2.2 mi. W of Pittsboro---	Mrs. J. A. Webster-----	Hill---	-Dr--	60	6	Andesitic tuff-------	34	-----	3	0.12	M	
98	0.8 mi. W of Pittsboro---	F. C. Justice	--do---	-do--	140	6	Mafic tuff---	56	40	5	.06	S	
99	1.0 mi. NW of Pittsboro---	J. B. Reeves--	Knoll--	-do--	135	6	Andesitic tuff-------	125	30	10	1.00	--------	Analysis in table.
100	Pittsboro-----	Town of Pittsboro---	Slope--	-do--	117	6	Mafic tuff---	-------	16	10+	--------	--------	Observation well.
101	Pittsboro-----	A. J. Boone---	--do---	-do--	36	6	-----do------	20	5	4	0.25	--------	
102	1.8 mi. E of Pittsboro---	W. L. Mann----	--do---	-do--	70	6	-----do------	24	20	3	.67	S	
103	3.1 mi. E of Pittsboro---	H. D. Amos----	Flat---	-do--	96	6	-----do------	28	30	4.5	.06	S	
104	3.5 mi. E of Pittsboro---	David L. Richards----	Hill---	-do--	47	6	-----do------	21	-----	10	0.28	H	Bad taste reported.
105	1.5 mi. SW of Seaforth----	C. M. and W. W. Ward--------	Knoll--	-do--	107	6	Triassic-----	77	30	9	0.30	S	
106	2.2 mi. S of Seaforth----	Roy B. Farrar-	--do---	-do--	135	6	-----do------	50	50	2.5	.03	M	
107	2.6 mi. SE of Seaforth----	Dewey Poe-----	--do---	-do--	110	6	-----do------	11	22	15	.16	S	
108	4.3 mi. SE of Seaforth----	Earl G. Goodwin---------	Draw---	-do--	80	6	-----do------	40	8	30	.77	S	
109	4.6 mi. SE of Seaforth----	A. L. Barker--	Knoll--	-do--	215	6	-----do------	20	22	3	.02	M	
110	3.2 mi. S of Seaforth----	Mrs. J. L. Mathews-----	Slope--	-do--	109	6	-----do------	18	24	5	.06	M	
111	2.7 mi. SW of Seaforth----	Sam Jones-----	Knoll--	-do--	92	6	-----do------	39	15	5	.09	M	Limy taste reported.
112	3.3 mi. SW of Seaforth----	Harold Lasater	--do---	-do--	107	6	-----do------	40	40	6	.09	--------	Use water softener.
113	3.3 mi. SW of Seaforth----	Mrs. Eva Thomas	Hill---	-do--	100	6	Andesitic tuff-------	50	45	2.5	.05	S	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
114	4.9 mi. SE of Pittsboro---	C. P. Hackney	Hill---	-Dr---	142	6	Mafic tuff---	9	72	4.5	.03	M	
115	4.2 mi. E of Pittsboro---	Willie Keck---	--do---	-do---	160	6	-----do------	22	18	3	.02	M	Slight taste reported.
116	1.4 mi. SE of Pittsboro---	Sunshine Gardens-----	Valley	-do---	100	5	Andesitic tuff-------	47	10	12	.23	S	High bacteria count.
117	1.4 mi. SE of Pittsboro---	Webster Poultry Co.	Draw---	-do---	140	6	Mafic tuff---	------	40	27	--------	M	
118	1.8 mi. SW of Pittsboro---	Thomas D. Reavis------	Knoll--	-do---	75	6	-----do------	65	20	8	0.77	S	
119	3.4 mi. SW of Pittsboro---	Lillie Alston	Flat---	--D---	25	36	Mafic lithic crystal tuff-------	0	18	2	--------	S	
120	5.7 mi. SW of Pittsboro---	Robert L. Moore	Hill---	-Dr---	190	6	Mafic phyllithic tuff	17	18	20	0.12	S	
121	5.0 mi. SE of Siler City--	Rolfe Phillips	--do---	-do---	50	6	Andesitic tuff	22	15	6	.21	S	
122	3.4 mi. SE of Siler City--	W. Carl Groce, Jr.---------	--do---	-do---	65	6	Mafic tuff---	------	20	5	--------	--------	
123	1.8 mi. S of Siler City--	E. L. Lowe----	--do---	-do---	75	6	Andesitic tuff	15	-----	15+	0.25	S	
124	1.8 mi. S of Siler City--	Austin Isley--	Slope--	-do---	71	6	-----do------	27	8	5	.11	S	Some iron reported.
125	5.3 mi. SW of Siler City--	S. O. Johnson-	Knoll--	-do---	99	4	Felsic tuff--	------	20	7	1.0	S	
126	4.6 mi. SW of Siler City--	Edward Brewer-	Valley-	-do---	42	6	-----do------	35	10	10	1.43	S	
127	3.3 mi. S of Siler City--	Oakly Baptist Church------	Hill---	-do---	214	6	Andesitic tuff	29	-----	1	.01	M	Slight taste reported.
128	3.3 mi. E of Mt. Vernon Springs-----	N. H. Holt----	Knoll--	-do---	60	6	Mafic tuff---	25	12	13	.37	S	
129	4.7 mi. SW of Pittsboto---	Oran Rives----	--do---	--D---	36	36	-----do------	0	26	3	--------	M	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
130	2.5 mi. S of Pittsboro---	Pearl B. Foushee	Hill---	-Dr --	100	6	Rhyolite-----	35	50	1	0.02	M	Graphite taste reported.
131	3.2 mi. S of Pittsboro---	Benny Lowe----	--do---	-do---	95	6	Mafic tuff---	7	60	3	.03	S	
132	2.7 mi. SE of Pittsboro---	J. L. Petty---	Slope--	-do---	100	6	-----do------	15	7	4.5	.05	S	
133	3.8 mi. S of Seaforth----	C. D. Webster-	Flat---	--D---	20	54	Triassic-----	0	16	5	--------	M	
134	4.3 mi. NE of Moncure-----	James Gunter--	Hill---	-Dr---	150	6	Triassic and mafic tuff-	15	50	3	0.02	M	Slight taste reported.
135	4.1 mi. SE of Seaforth----	S. M. Sikes---	Knoll--	-do---	114	6	Triassic-----	30	42	6	.07	S	
136	2.8 mi. NE of Merry Oaks--	Mrs. L. N. Womble------	--do---	-do---	73	5	-----do------	20	-----	2.5	0.05	S	
137	1.8 mi. NE of Merry Oaks--	T. E. Gunter--	Slope--	-do---	90	6	-----do------	16	35	5	.07	M	
138	0.6 mi. NE of Merry Oaks--	Franklin Cherry------	Flat---	-do---	95	6	-----do------	20	-----	1	.01	M	
139	2.0 mi. NW of Merry Oaks--	Roy Holt------	Slope--	-do---	71	6	-----do------	30	32	4	.10	S	
140	1.9 mi. N of Moncure-----	C. C. Poe-----	Knoll--	-do---	95	6	Mafic tuff---	20	22	2	.03	M	Limy taste reported.
141	2.0 mi. N of Moncure-----	N. F. Baker---	Hill---	-do---	90	6	Triassic-----	30	30	10	.17	S	
142	2.7 mi. NW of Moncure-----	E. R. Holt----	Flat---	-do---	90	6	Mafic tuff---	-----	10	3	--------	M	
143	4.1 mi. NW of Moncure-----	Mrs. Carl Butler------	Slope--	--D---	24	30	-----do------	22	18	1	--------	S	
144	4.0 mi. S of Pittsboro---	Oscar Griffin	Hill---	-Dr---	73	6	Mafic lithic tuff-------	5	25	3	0.04	S	Analysis in table.
145	4.9 mi. SW of Pittsboro---	F. J. LeClair	Flat---	-do---	126	6	Mafic tuff---	90	25	8	.22	M	
146	5.5 mi. SW of Pittsboro---	H. L. Fields--	Slope--	--B---	80	30	-----do------	40	35	5.5	.14	S	
147	5.3 mi. NE of Goldston----	J. M. Moses---	Hill---	-Dr---	90	3	Mafic lithic tuff-------	-----	40	4	--------	S	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
148	5.1 mi. NE of Bear Creek--	Gerald Rives--	Flat--	-Dr--	150	6	Mafic tuff---	20	17	1.5	0.01	M	
149	3.9 mi. NE of Bear Creek--	A. J. McLaurin	Hill--	-do--	57	6	-----do------	21	25	8	.22	M	
150	1.0 mi. E of Bonlee------	McKinlew Marsh	Flat--	-do--	48	$6\frac{1}{4}$	-----do------	-----	10	6	--------	--------	
151	Mt. Vernon Springs-----	J. E. Rice----	Slope-	-do--	40	4	Andesitic tuff-------	24	35	35	2.00	S	
152	1.2 mi. SW of Mt. Vernon Springs-----	Hugh Tillman--	Hill--	-do--	60	4	-----do------	-----	20	5	--------	S	
153	2.5 mi. SW of Mt. Vernon Springs-----	B. E. Webster	--do--	-do--	80	6	-----do------	-----	30	9.5	--------	S	
154	6.1 mi. W of Bonlee------	L. T. Bray----	Flat--	-do--	67	6	Tuff and graywacke--	-----	19	5	--------	S	
155	Bonlee--------	Jullian Williams	Hill--	-do--	125	6	Quartz dike in mafic tuff-------	-----	25	100	--------	S	
156	1.3 mi. NE of Bonlee------	L. T. Jones---	--do--	-do--	114	6	Felsic tuff--	-----	14	4	--------	S	Analysis in table.
157	2.0 mi. NE of Bear Creek--	J. J. Ivey----	--do--	-do--	92	6	Tuffaceous argillite--	70	33	16	0.72	S	
158	3.0 mi. N of Goldston----	Tommy Fields--	Slope-	-do--	72	6	Tuff breccia	28	24	5.5	.13	S	
159	5.9 mi. NE of Goldston----	Beatrice Watson	Flat--	-do--	32	6	Mafic tuff---	-----	11	2	--------	S	
160	6.1 mi. S of Pittsboro---	W. L. Cheek---	Hill--	-do--	225	6	Felsic tuff--	25	35	2.5	0.01	H	
161	5.8 mi. S of Pittsboro---	H. L. Hardwood	Knoll-	-do--	96	6	Mafic tuff---	-----	20	5	--------	S	
162	5.2 mi. S of Pittsboro---	Silas Williams, Jr.---------	Flat--	-do--	56	6	Felsic tuff--	11	15	2.5	0.06	S	
163	3.4 mi. NW of Moncure-----	Mrs. D. L. Burns-------	Hill--	-do--	65	6	Mafic tuff---	41	55	8	.33	H	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
164	2.5 mi. NE of Moncure----	G. F. Carr----	Hill---	-Dr--	82	6	Triassic-----	-----	15	5	--------	S	
165	Merry Oaks---	L. S. Howard--	Knoll--	-do--	115	6	-----do------	12	10	1.5	0.02	H	
166	0.6 mi. S of Merry Oaks-	T. F. Williams	Slope--	-do--	53	6	Triassic shale and diabase----	20	18	12	.36	S	
167	1.5 mi. SW of Merry Oaks-	Sam Jones-----	Flat---	-do--	95	6	Triassic-----	20	29	10	0.13	M	
168	1.8 mi. E of Moncure----	J. T. Moore---	Knoll--	-do--	140	6	-----do------	-------	13	0.5	--------	--------	Observation well; analysis in table.
169	Haywood------	O. M. Covert--	Slope--	-do--	100	6	-----do------	25	------	20	0.27	S	
170	Haywood------	C. M. Burke---	--do---	-do--	74	6	-----do------	21	11	2	.04	M	Limy taste reported.
171	0.5 mi. N of Moncure----	Chatham County Schools-----	Flat---	-do--	120	4	-----do------	-----	22	8	--------	--------	Analysis in table.
172	Moncure------	O. M. Covert--	Slope--	-do--	100	6	-----do------	-----	------	18	--------	S	Bad taste reported.
173	5.4 mi. W of Moncure----	Sam Williams--	--do---	-do--	63	6	Quartz dike in mafic tuff-------	-----	------	8	--------	M	
174	3.4 mi. NE of Goldston---	Virgil Rives--	Hill---	-do--	95	6	Mafic tuff---	33	40	2	0.03	S	
175	2.3 mi. NE of Goldston---	Mrs. W. C. Mc-Millian-----	Knoll--	-do--	155	2½	Felsic tuff--	40	1	4	.04	H	Reported bad taste & corrosive.
176	Bear Creek---	John A. Gilmore	Draw---	-do--	180	6	Argillite----	10	------	2	.01	S	
177	1.6 mi. SW of Bonlee-----	Mrs. E. M. Leonard-----	Hill---	-do--	101	6	Mafic tuff---	30	27	8	.11	S	
178	3.6 mi. SW of Bonlee-----	A. B. Chilton-	--do---	-do--	167	6	-----do------	30	36	1	.01	H	Limy taste reported.
179	4.1 mi. N of Bennett----	C. L. Welch---	--do---	-do--	92	6	Quartz dike in felsic tuff or argillite--	80	32	10	.83	S	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
180	2.9 mi. N of Bennett-----	Mrs. B. F. Brown-------	Knoll--	-Dr--	50	6	Felsic tuff--	28	-----	10	0.46	S	
181	3.3 mi. NE of Bennett-----	E. R. Teague--	Hill---	-do--	170	4	Quartz dike in felsic tuff	24	16	5	.03	S	Observation well; analysis in table.
182	2.0 mi. N of Harper's Crossroads--	B. P. Phillips	Flat---	-do--	133	6	Felsic tuff--	30	56	6	.06	H	Analysis in table.
183	3.2 mi. W of Bear Creek--	Paul Fesmire--	--do---	-do--	187	4	Mafic tuff---	18	30	0.5	.00	M	Slight lime taste reported.
184	1.2 mi. SW of Bear Creek--	Charles Tillman	Hill---	-do--	220	6	Felsic tuff--	23	25	2	.01	M	
185	1.7 mi. S of Bear Creek--	Talmadge Elkins	Flat---	-do--	130	1½	Tuffaceous argillite--	18	30	4.5	.04	S	
186	1.3 mi. NW of Goldston----	W. F. Moses---	--do---	-do--	81	6	Mafic tuff---	40	15	2	.05	M	Some iron reported.
187	Goldston------	H. H. Elder Oil Company-----	--do---	-do--	115	6	-----do------	------	10	17	--------	M	
188	1.1 mi. NW of Goldston----	Marion Williams	--do---	-do--	93	6	-----do------	18	16	2	0.03	M	
189	3.2 mi. NE of Goldston----	J. W. Poe-----	Slope--	-do--	55	6	-----do------	16	12	0.5	.13	M	
190	3.8 mi. E of Goldston----	J. B. Oldham--	Hill---	-do--	200	6¼	Felsic tuff--	28	25	2.5	.02	--------	
191	4.0 mi. NE of Gulf--------	L. W. Burns---	Knoll--	-do--	65	6	Triassic-----	20	27	12	.27	S	
192	7.0 mi. E of Goldston----	Johnson's Grocery-----	Flat---	-do--	180	6	Argillite and graywacke--	------	22	5	--------	H	
193	5.0 mi. NE of Gulf--------	Margaret Gunter------	--do---	-do--	90	6	Argillite----	20	15	1	0.01	M	
194	2.3 mi. S of Merry Oaks--	R. M. Cotten--	--do---	-do--	95	6	Triassic-----	------	20	3	--------	H	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
195	1.6 mi. NW of Corinth-----	W. E. Peele----	Flat---	-Dr--	72	5	Triassic-----	32	40	5	0.13	S	
196	1.8 mi. W of Corinth-----	C. H. Marks----	Knoll--	-do--	63	4	-----do------	------	8	0.5	-------	S	
197	0.8 mi. W of Corinth-----	Fred L. Cross--	--do---	-do--	81	6	-----do------	19	52	4.5	0.07	S	
198	Corinth-------	A. A. Marks----	--do---	-do--	67	6	-----do------	30	23	1.5	.04	S	Some iron reported.
199	1.4 mi. E of Corinth-----	W. O. Jeffries	Hill---	-do--	118	6	-----do------	28	2	0	.00	H	Observation well; analysis in table.
200	1.8 mi. E of Corinth-----	James Cross----	--do---	-do--	75	------	-----do------	------	------	3	-------	H	
201	2.8 mi. SE of Corinth-----	C. R. Cotten---	--do---	-do--	101	6	Schist-------	------	41	5	-------	S	
202	2.5 mi. SE of Corinth-----	J. L. Ragland--	--do---	-do--	140	6	-----do------	100	70	13	0.33	S	
203	5.2 mi. E of Gulf--------	Clyde Williams	Slope--	-do--	150	6	Mafic tuff---	20	40	.1	.00	S	
204	4.0 mi. E of Gulf--------	C. V. Dowdy----	Valley-	-do--	45	6	Triassic-----	20	30	6	.24	S	Some iron reported.
205	3.2 mi. E of Gulf--------	E. O. Dowdy----	Flat---	-do--	100	6	-----do------	------	20	.5	-------	H	
206	1.0 mi. E. of Gulf--------	Chatham Brick and Tile-----	Valley-	-do--	90	4	-----do------	------	20	8	-------	--------	
207	Gulf----------	Gulf Creosot Company------	Flat---	-do--	220	6	-----do------	------	25	15	-------	H	Analysis in table.
208	1.1 mi. N of Gulf--------	Charles E. Frazier------	Knoll--	-do--	143	6	-----do------	11	35	2	0.02	M	
209	1.5 mi. NW of Gulf--------	Murchison Store	--do---	-do--	90	6	-----do------	------	20	3	-------	M	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
210	1.2 mi. SE of Goldston----	Gaines Lumber Company-----	Knoll--	-Dr--	110	6	Felsic tuff--	-----	20	3	-------	H	
211	1.3 mi. S of Goldston----	Thomas Martin-	Slope--	-do--	136	6	-----do------	-----	-----	3	-------	S	
212	3.1 mi. SW of Goldston----	G. J. Wilkie--	Hill---	-do--	100	6	Argillite----	27	45	2	0.03	S	
213	3.0 mi. SW of Bear Creek--	Aubrey Fields-	Flat---	-do--	140	6	Argillaceous tuff-------	10	27	3.5	.03	S	
214	2.0 mi. NE of Harper's Crossroads--	James Phillips	--do---	-do--	100	6	Felsic tuff--	20	50	1	.01	H	Limy taste reported.
215	1.2 mi. SE of Harper's Crossroads--	Willie Scott--	Knoll--	-do--	57	6	Mafic tuff and phyllite---	-----	20	4	-------	S	
216	0.9 mi. N of Harper's Crossroads--	Mossie Johnson	--do---	-do--	50	6	Mafic and Felsic tuff	10	20	1	0.02	S	
217	0.6 mi. SW of Harper's Crossroads--	Jack Dark-----	Hill---	-do--	105	6	Bedded mafic tuff-------	30	25	3	.04	M	
218	Bennett-------	Wade Brawer---	Flat---	-do--	149	6	Felsic tuff--	-----	20	6	-------	H	Use water softener; some iron reported.
219	1.5 mi. SE of Bennett-----	M. Z. Manoss--	Knoll--	-do--	155	6	Mafic tuff---	20	19	3	0.02	H	
220	3.0 mi. SE of Bennett-----	Archie Councilman---------	--do---	-do--	120	6	Felsic tuff--	22	16	0.8	.08	--------	Observation well.
221	1.8 mi. S of Harper's Crossroads--	Eugene Gaines-	--do---	-do--	77	6	Mafic tuff---	6	15	2	.03	H	

Table 8. Records of Wells in Chatham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
222	3.5 mi. NW of Carbonton---	Daniel Wilson	Knoll--	-Dr--	56	6	Argillite----	------	15	11	-------	S	
223	4.5 mi. SW of Goldston----	Ronald Gilliland---	--do---	-do--	163	6	-----do------	------	38	11	-------	S	Observation well; analysis in table.
224	2.6 mi. S of Goldston----	Robert Palmer	Hill---	-do--	218	6	Triassic-----	30	50	2.5	0.01	-------	
225	Carbonton-----	Walter Heron--	Valley-	-do--	90	6	-----do------	------	15	5	-------	S	
226	3.3 mi. SE of Harper's Crossroads--	W. D. Wilson--	Hill--	-do--	60	6	Mafic tuff---	------	-----	40	-------	S	
227	2.9 mi. S of Harper's Crossroads--	Paul H. Phillips	--do--	-do--	150	6	Felsic tuff--	20	37	2.5	0.02	S	Some iron reported.
228	3.5 mi. SE of Bennett-----	Archie Councilman---------	Flat--	-do--	135	6	Mafic tuff---	10	40	.8	.00	M	
229	3.0 mi. SE of Bennett-----	Mrs. Bert Brewer	Draw--	-do--	232	6	-----do------	18	-----	2	.01	M	

Table 8A. Records of Springs in Chatham County.

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1A	2.7 mi. NE of Terrells---	Grady Snipes---	Draw---	Spring	----	-----	Granite------	-----	-----	1.5	--------	S	

Quality of Water

Ground water in Chatham County is principally of the calcium and sodium bicarbonate types and is suitable for most domestic, industrial, and municipal purposes. Calcium and sodium chloride waters are present at some localities in the county.

Iron ranges from 0.00 to 5.0 ppm. Fifty percent of the wells analyzed for iron had iron concentrations below the 0.3 ppm maximum recommended by the U. S. Public Health Service. Chloride ranged from 0.2 ppm to 384 ppm. Eighty percent of the wells sampled had chloride concentrations below the 250 ppm limit recommended by Public Health Service. Hardness ranged from 5 ppm to 492 ppm. Analyses from 20 selected wells in Chatham County are listed in table 9.

Table. 9. Chemical Analyses of Ground Water for Chatham County (Numbers heading the columns correspond to well numbers in table 8)

(Parts per million)

	21	22	35[1]	39	41	59	77	84	87
Date of collection	12/1/61	12/1/61	12/17/62	7/10/58	12/1/61	12/1/61	12/1/61	12/18/62	7/10/58
Silica (SiO_2)	35	31	35	30	26	23	25	38	28
Aluminum (Al)	.0	.1	.2	.0	.1	.2	.0	.0	.0
Iron (Fe)	.18	.06	1.7	--	.02	1.2	--	.01	--
Manganese (Mn)	.00	.00	.05	.00	.00	.04	.00	.00	--
Calcium (Ca)	1.1	23	142	37	108	16	29	7.4	18
Magnesium (Mg)	.4	3.1	33	8.1	27	18	4.3	2.3	10
Sodium (Na)	7.6	11	42	15	56	18	25	9.3	9.3
Potassium (K)	.7	4.1	.1	.8	2.4	.1	.1	.1	.6
Lithium (Li)	.0	.2	.4	.1	.8	.2	.2	.0	.0
Bicarbonate (HCO_3)	14	44	236	186	28	144	152	46	110
Sulfate (SO_4)	1.6	12	4.4	1.3	16	3.6	3.4	1.2	1.3
Chloride (Cl)	6.6	16	260	7.8	305	25	12	3.4	14
Fluoride (F)	.0	.1	.2	.1	.1	.1	.2	.1	.1
Nitrate (NO_3)	1.0	44	.2	.2	17	.1	.1	4.7	1.1
Phosphate (PO_4)	.0	.0	.0	.1	.0	.0	.0	.3	.1
Dissolved solids	61	167	634	194	564	176	162	90	138
Hardness as $CaCO_3$	5	71	492	125	382	115	90	28	88
Noncarbonate	0	35	299	0	358	0	0	0	--
Specific conductance	47	180	1100	287	920	265	268	92	208
pH	6.1	6.8	7.3	7.5	6.1	7.2	7.5	6.7	7.2
Color	3	3	3	5	3	15	3	3	10
Map unit	Granite and granodiorite	Granite and granodiorite	Meta-volcanic	Meta-volcanic	Meta-volcanic	Meta-volcanic	Triassic	Meta-volcanic	Argillite-graywacke

	88	100	145	157	169	172	182	183	200	208	224
Date of collection	10/10/50	7/10/50	12/17/62	12/17/62	12/1/61	7/10/58	12/1/61	7/10/58	12/1/61	12/17/62	12/1/61
Silica (SiO_2)	30	39	21	41	20	25	16	25	2.3	31	17
Aluminum (Al)	--	.0	.1	.2	.1	.0	.1	.0	.2	.1	.1
Iron (Fe)	.03	--	.08	.54	--	--	5.0	.17	.23	.90	.64
Manganese (Mn)	.00	--	.03	.05	.00	--	.00	.06	.03	.03	.00
Calcium (Ca)	61	38	27	23	12	25	79	71	45	33	4.2
Magnesium (Mg)	8.0	4.0	41	6.3	4.0	5.8	33	24	22	15	5.3
Sodium (Na)	19	10	20	15	25	7.7	119	43	188	56	24
Potassium (K)	19	.3	.1	.1	1.9	.8	6.3	.6	4.8	.4	.1
Lithium (Li)	--	.0	.0	.0	.3	.0	1.3	.3	1.3	.2	.2
Bicarbonate (HCO_3)	179	122	200	138	100	110	199	201	79	275	18
Sulfate (SO_4)	5.5	11	2.8	1.8	2.8	3.1	9.0	3.0	8.8	14	14
Chloride (Cl)	51	12	75	.2	13	9.9	311	143	384	19	26
Fluoride (F)	.1	.1	.1	.2	.2	.1	.3	.2	.1	.1	.1
Nitrate (NO_3)	.6	5.4	.6	.1	.4	.1	.1	2.2	.4	.8	21
Phosphate (PO_4)	--	.2	.0	.0	.0	.0	.0	.0	.0	.1	.0
Dissolved solids	263	183	287	156	129	136	673	425	696	305	121
Hardness as $CaCO_3$	185	112	236	86	46	67	335	276	206	146	33
Noncarbonate	--	12	72	0	0	0	172	111	142	0	16
Specific conductance	460	258	535	245	160	200	1100	748	1150	535	160
pH	7.0	7.1	7.0	7.3	7.4	6.7	7.3	7.1	7.2	7.6	6.1
Color	2	5	--	--	3	10	5	8	3	7	7
Map unit	Argillite-graywacke	Meta-volcanic	Meta-volcanic	Meta-volcanic	Triassic	Triassic	Meta-volcanic	Meta-volcanic	Triassic	Triassic	Argillite-graywacke

[1] Bromide (Br)--2.3 ppm.

Durham County

(Area 299 square miles; population 111,995)

Durham County is the smallest county in the Durham area. It is bounded on the north by Person County, on the west by Alamance County, on the south by Chatham and Wake Counties, and on the east by Wake and Granville Counties. Durham, the county seat, is the largest city in the Durham area and has a population of 78,302. Other towns include Bethesda and Rougemont. Most of the people in Durham County are employed by industry and supporting services in the city of Durham. The American Tobacco Co. and the Liggett and Myers Tobacco Co. are located in the city of Durham. The northern and eastern parts of the county are still largely devoted to agriculture. Tobacco, corn, small grains, and livestock are the chief agricultural products.

Durham County is drained by the New Hope, Neuse, Eno, Little, and Flat Rivers. The confluence of the Eno and Flat Rivers east of Fairntosh marks the beginning of the Neuse River.

The topography of Durham County is dominated by a lowland developed on Triassic rocks. The Triassic lowland, which occupies most of the county, is bordered on the northwest and the southeast by a distinct excarpment of the resistant volcanic rocks. The undulating, submaturely dissected upland surface developed on the resistant volcanic rocks is similar to that of adjacent counties in the Piedmont province. This surface generally slopes to the southeast. The highest elevations are in the northern part, north and east of Rougemont. The lowest elevations are in the eastern part of the county along the Neuse River and in the southern part of the county along the tributaries of the New Hope River.

Geology

The northwestern third of the county is underlain by rocks included in the metavolcanic unit (pl. 2). The metavolcanic unit in Durham County includes felsic to mafic tuffs and flows and thin interbeds of sedimentary rock. Acidic volcanic rocks predominate in a belt ranging from 2 to 4 miles in width along the Triassic contact. Intermediate to basic volcanic rocks crop out in the northwest corner, and a narrow belt of volcanic rock crops out on the southeast side of the Triassic lowland in eastern Durham County. Rocks of higher metamorphic grade, which occur just east of this narrow outcrop belt of volcanic rock, are included within the mica gneiss and schist unit.

Rocks of the metavolcanic unit are overlain by a dominantly sedimentary unit designated as the argillite-graywacke unit on the geologic map. Argillite, graywacke sandstone, and interbeds of tuff are exposed in synclinal structures along the Orange-Durham County line.

Granodiorite plutons have intruded the metavolcanic unit and are exposed west and north of Durham. The largest of these is exposed from the Triassic contact north of Fairntosh northward to the Durham-Person County line.

Approximately two-thirds of the county is underlain by Triassic rocks. This unit includes maroon to gray, arkosic sandstones, siltstones, shales, and fanglomerates. The rocks dip to the southeast about 15° and are bounded on the southeast by the Jonesboro fault. The Triassic rocks and the adjacent volcanic rocks have been intruded by diabasic dikes of Triassic age.

Ground Water

Most of the industry and more than one-half the people in Durham County obtain their water from surface water impounded in Lake Michie. Water needs outside the city of Durham are supplied by ground water obtained from wells and springs.

Ground water in the county is obtained from fractures and other secondary openings in the rocks or from the overlying mantle of soil and weathered rock. Since the depth of dug wells usually is limited by the depth to unweathered rock, dug wells generally are not deep enough to intersect the water table during periods of drought. Consequently, drilled wells are more dependable sources of ground water, being more easily constructed below the water table. Drilled wells have the added advantage of being less susceptible to contamination by surface water.

Data from 72 wells in Durham County are summarized in table 10.

Comparison of yields in table 10 indicates that rocks of the metavolcanic unit yield nearly twice as much per foot of well

Table 10. Summary of well data in Durham County according to rock type

Map unit	Number of wells	Yield (gallons per minute) Average	Per foot of well	Average depth (feet)	Average water level (feet below LSD 2/)
Granite and granodiorite	5	3.8	0.04	89.6	21.4
Metavolcanic	19	11.7	.11	107.8	30.2
Triassic 1/	45	8.1	.06	137.8	25.2
Triassic diabase	3	8.0	.04	202.0	41.0

1/Does not include Triassic diabase

2/Land-surface datum

as do the Triassic rocks. Average yields tabulated for the granite and granodiorite unit and the Triassic diabase probably are not significant because of the small number of wells inventoried in these units.

Great differences in yield from place to place in the same rock unit have been noted. Figures 15 and 16 show that depth of weathered material has a greater influence on yield in the metavolcanic and argillite-graywacke units than does topography, but figures 17 and 18 indicate that topography has a greater influence on yield in the Triassic and granite and granodiorite units than does depth of weathering. At least three factors—rock type, depth of weathering, and topography—govern the potential yield at any one locality in Durham County.

Plate 1 shows the areal distribution of relative yield in the Durham area. Comparison of this map with plate 2 shows that rocks of the metavolcanic unit northwest of and adjacent to the Triassic lowland have a greater yield per foot of uncased hole than the Triassic rocks have. In the unshaded areas a well 80 feet deep with 30 feet of casing should yield 5 gpm or more. Wells in the areas shown by a horizontal-line pattern should yield less than 5 gpm for the same well and casing depths. Areas in which yields would be expected to be less than 1 gpm for the same depths of well and casing are shown in a crosshatched pattern.

Figure 24 consists of two selected hydrographs which illus-

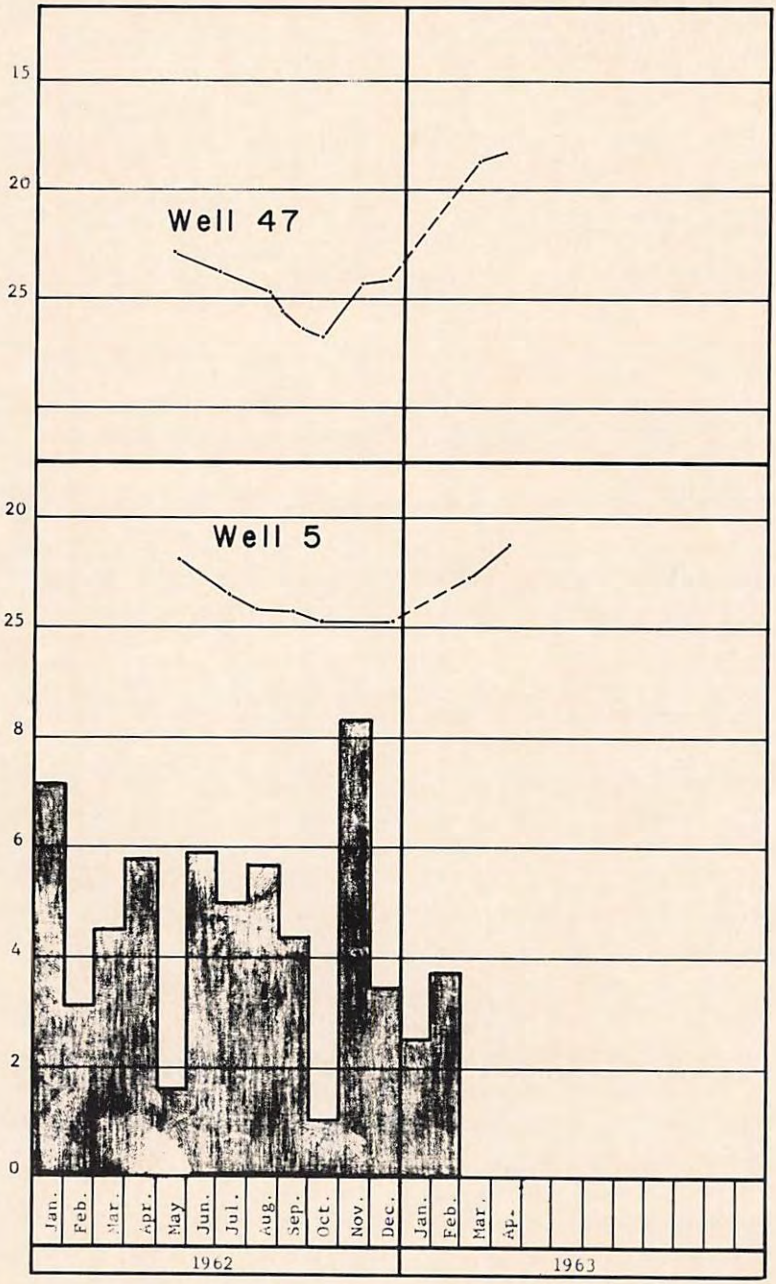


Figure 24. Selected hydrographs showing seasonal fluctuation of the water table in Durham County.

trate the seasonal fluctuation of the water table in Durham County.

Quality of Water

Ground water in Durham County is principally a calcium bicarbonate type and is suitable for most domestic, municipal, and industrial purposes.

Iron exceeded U. S. Public Health Service recommendations of 0.3 ppm in one of the water samples analyzed. Chloride concentrations were below the recommended 250 ppm maximum in all water samples except one. Hardness ranged from 45 ppm to 524 ppm.

Analyses of ground water from nine selected wells in the county are listed in table 12.

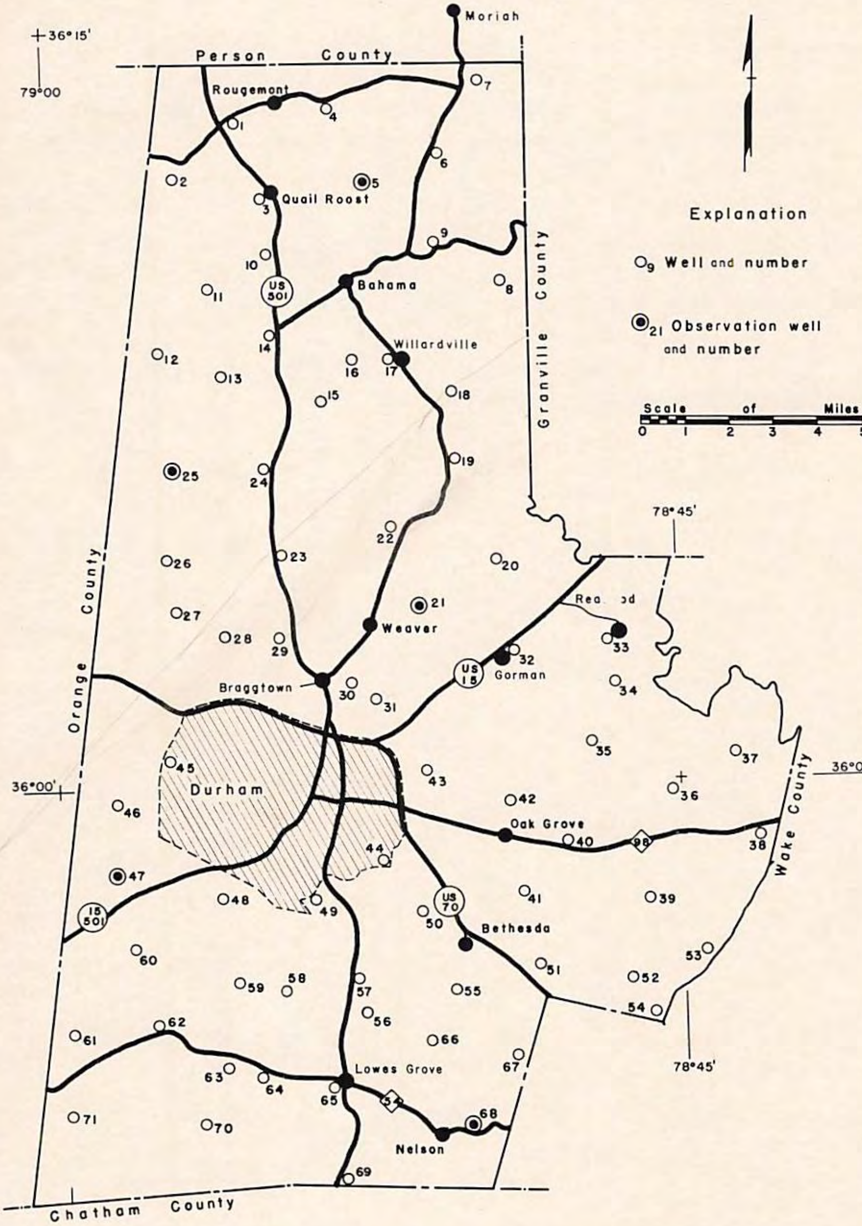


Figure 25. Map of Durham County showing the location of wells.

Table 11. Records of Wells in Durham County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1	Rougemont-----	Jack Clayton---	Slope--	-Dr---	88	6	Mafic tuff----	18	8	23	0.33	S	
2	1.6 mi. SW of Rougemont---	G. E. May------	Knoll--	-do---	80	6	Felsic tuff---	27	------	5	.10	S	
3	Quail Roost---	Quail Roost Farms--------	--do---	-do---	190	8	Andesitic tuff	------	------	50	-------	S	Analysis in table.
4	2.5 mi. E of Rougemont---	N. V. Rhew-----	Slope--	-do---	48	6	Granodiorite and tuff----	18	10	2	0.07	S	
5	2.0 mi. E of Quail Roost-	R. R. Tilley---	Hill---	-do---	91	6	Granodiorite--	------	12	12	-------	S	Observation well; analysis in table.
6	3.7 mi. E of Quail Roost-	W. M. Bacon----	Flat---	-do---	96	6	-----do------	10	20	1	0.01	M	Limy taste reported.
7	1.9 mi. S of Moriah------	Owen Howerton--	Hill---	-do---	170	6	Acid crystal tuff--------	30	17	2	.01	---------	Analysis in table.
8	3.5 mi. E of Bahama------	Rufus Roberts--	--do---	-do---	92	6	Mafic sheared tuff--------	41	21	1.5	.03	S	
9	2.0 mi. E of Bahama------	L. O. Ellis----	--do---	-do---	49	6	Acid tuff-----	26	25	3	.13	M	
10	1.3 mi. S of Quail Roost-	W. A. Roseborough------	--do---	-do---	265	6	Mafic tuff----	25	175	15	.06	---------	
11	2.5 mi. SW of Quail Roost-	George Burton--	Slope--	-do---	73	6	Bedded andesitic tuff--	------	20	5	-------	S	
12	4.5 mi. SW of Quail Roost-	Vernon Tilley--	--do---	-do---	54	6	Mafic tuff----	6	24	8.5	0.18	M	
13	3.5 mi. SW of Bahama------	W. G. Matthews-	Hill---	-do---	80	6	Acid tuff and rhyolite----	60	------	22	1.10	S	
14	2.0 mi. SW of Bahama------	Cad Wilkins----	Ridge--	-do---	65	6	Acid tuff-----	------	------	6	-------	M	Limy taste reported.
15	2.9 mi. SW of Bahama------	Coy Ellis------	Slope--	-do---	90	6	-----do-------	------	8	25	-------	S	
16	1.8 mi. S of Bahama------	W. A. Strowd---	--do---	-D----	35	30	Granodiorite--	------	25	----	-------	H	Do.
17	Willardville--	Charlie Crabtree---------	--do---	-Dr---	90	6	-----do------	39	35	1+	0.02	S	

Table 11. Records of Wells in Durham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
18	3.6 mi. SE of Bahama------	Stagville Farm, Inc.	Slope--	-Dr---	105	6	Triassic------	21	7	40	0.48	S	Slight limy taste reported.
19	4.8 mi. SE of Bahama------	Fairntosh Farms	Knoll--	-do---	300	8	-----do-------	------	20	25	-------	H	Analysis in table.
20	2.2 mi. N of Gorman------	E. B. Hudson---	Flat---	-do---	125	5	-----do-------	------	17	12	-------	S	
21	4.0 mi. NE of downtown Durham------	A. G. Dickey---	Slope--	-do---	80	6	-----do-------	------	15	8	-------	S	Observation well.
22	3.8 mi. S of Bahama------	W. C. McFarland	Flat---	-do---	77	6	-----do-------	------	-----	20	-------	M	
23	5.0 mi. SW of Bahama------	E. J. Shaw-----	Slope--	-do---	204	4	Triassic diabase-----	------	20	2	-------	H	Iron reported.
24	4.0 mi. SW of Bahama------	Carver Realty--	--do---	-do---	190	6	Rhyolite and crystal tuff	11	-----	1	-------	--------	
25	5.6 mi. SW of Bahama------	E. T. Garrett--	--do---	-do---	136	6	Lithic crystal tuff--------	------	-----	10	-------	S	Observation well.
26	6.3 mi. NW of downtown Durham------	J. A. Revill---	Flat---	-do---	76	6	-----do-------	------	4	20^+	-------	S	Analysis in table.
27	5.0 mi. NW of downtown Durham------	W. H. Stanley--	Ridge--	-do---	115	6	Felsic tuff---	60	20	4	0.07	--------	
28	4.0 mi. NW of downtown Durham------	S. G. Lindsey--	Hill---	-do---	160	6	Triassic------	25	-----	1.5	.01	--------	
29	4.0 mi. N of downtown Durham------	J. C. Holloway	Flat---	-do---	150	6	-----do-------	14	20	1.5	.01	S	
30	Braggtown-----	Braggtown Baptist Church--	Hill---	-do---	180	6	-----do-------	------	25	15	-------	--------	

Table 11. Records of Wells in Durham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
31	2.5 mi. NE of downtown Durham-------	J. W. Dossett --	Slope--	-Dr---	125	6½	Triassic------	------	-----	2.5	-------	S	
32	Gorman--------	C. C. Edwards--	Hill---	-do---	115	6½	-----do-------	15	17	10	0.10	S	
33	Redwood-------	L. E. Creech---	Low knoll-	-do---	80	6	-----do-------	------	20	7	-------	S	
34	1.2 mi. S of Redwood-----	M. C. Clayton--	Knoll---	-do---	142	6	-----do-------	------	20	7^{+}	-------	S	
35	2.5 mi. S of Redwood-----	L. E. Watson---	Slope---	-do---	102	6	-----do-------	------	------	5	-------	S	
36	3.7 mi. SE of Redwood-----	H. O. Carpenter	Ridge---	-do---	96	6	-----do-------	------	35	10	-------	S	Limy taste reported.
37	3.8 mi. SE of Redwood-----	R. Beddingfield	--do---	-do---	140	6	-----do-------	40	------	8	0.08	M	
38	5.5 mi. SE of Redwood-----	Clarence Carroll------	Slope--	-do---	100	6	Mafic tuff----	------	------	6	-------	S	E of Jonesboro fault
39	4.4 mi. NE of Bethesda----	A. Lopez, Sr.---	Hill---	-do---	140	6	Triassic------	------	25	5	-------	S	Analysis in table.
40	1.5 mi. E of Oak Grove---	Mrs. Husketh---	Slope--	-do---	70	6	-----do-------	------	15	15	-------	H	Limy taste reported.
41	1.3 mi. SE of Oak Grove---	E. S. Sherron--	Hill---	-do---	100	6	-----do-------	------	------	1	-------	H	Do.
42	0.6 mi. N of Oak Grove---	Kenneth Bailey-	--do---	-do---	112	6	-----do-------	-----	40	3	-------	S	Analysis in table.
43	2.2 mi. NW of Oak Grove---	Fred Terrell---	--do---	-do---	125	6½	-----do-------	28	34	3	0.03	S	
44	2.2 mi. SE of downtown Durham------	Martha Rempsey-	Flat---	-do---	105	6½	-----do-------	12	20	10	.11	S	
45	3.2 mi. W of downtown Durham------	T. E. Scholl---	Slope--	-do---	300	6	-----do-------	15	------	3	.01	M	Limy taste reported.

Table 11. Records of Wells in Durham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
46	4.2 mi. W of downtown Durham------	W. L. Daniels--	Slope--	-Dr---	123	6	Granite-------	------	30	3	-------	S	
47	4.6 mi. SW of downtown Durham------	E. P. Garrett--	Low hill-	-do---	223	4	Triassic------	120	25	2	0.01	---------	Observation well.
48	3.0 mi. SW of downtown Durham------	A. L. Warren---	Slope--	-do---	95	6	-----do-------	------	15	10+	-------	M	
49	2.2 mi. S of downtown Durham------	Mack A. Wright-	Hill---	-do---	127	6½	-----do-------	12	14	3	0.03	M	
50	1.2 mi. NW of Bethesda----	A. O. Fowler---	Slope--	-do---	84	6	-----do-------	30	40	20	.04	M	
51	1.8 mi. E of Bethesda----	V. R. Parrish--	--do---	-do---	100	6½	-----do-------	21	19	3	.04	S	
52	4.0 mi. E of Bethesda----	H. W. Nichols--	Flat---	-do---	170	6½	-----do-------	28	30	9	.06	M	
53	5.5 mi. E of Bethesda----	D. P. Poplin---	--do---	-do---	87	6	Quartz dike in tuff-----	60	30	14+	.53	S	E. of Jonesboro fault.
54	4.7 mi. E of Bethesda----	Henry Elliot---	Low knoll	-do---	150	6½	Triassic------	12	27	1	.01	S	
55	1.0 mi. S of Bethesda----	Gerald Downey--	Flat---	-do---	155	6½	-----do-------	19	22	6	.04	S	
56	1.6 mi. N of Lowes Grove-	C. S. Williams-	Slope--	-do---	65	6	-----do-------	22	18	6	.14	S	
57	2.5 mi. N of Lowes Grove-	Edwards Realty-	--do---	-do---	170	6½	-----do-------	12	24	1.5	.01	S	
58	2.5 mi. NW of Lowes Grove-	C. C. Taylor---	Flat---	-do---	165	6½	-----do-------	32	23	2	.02	S	
59	3.2 mi. NW of Lowes Grove-	Clifton Scott--	Draw---	-do---	110	6½	-----do-------	11	10	10	.10	M	

Table 11. Records of Wells in Durham County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
60	5.2 mi. SW of downtown Durham------	R. B. McFarland	Slope--	-Dr---	270	6	Triassic diabase-----	10	90	2	0.01	H	Analysis in table.
61	3.4 mi. E of Chapel Hill-	J. H. Bost-----	Low hill-	-do---	132	6	Triassic shale and diabase-	------	13	20	-------	S	
62	4.4 mi. W of Lowes Grove-	Jack Mangum----	--do---	-do---	125	6	Triassic------	------	40	10	-------	S	
63	2.7 mi. W of Lowes Grove-	Daniel P. Jones	Draw---	-do---	115	6	-----do------	------	0+	----	-------	S	Flows 3-5 gpm.
64	2.0 mi. W of Lowes Grove-	Lowes Grove Fire Tower---	Hill---	-do---	150	6	-----do------	12	40	3	0.02	--------	
65	Lowes Grove---	Worth Goodwin--	Slope--	-do---	120	6¼	-----do------	14	25	10	.10	S	
66	2.4 mi. S of Bethesda----	Mrs. L. H. Jenkins------	Low knoll	-do---	85	5	-----do------	------	42	3	-------	S	
67	2.8 mi. SE of Bethesda----	J. H. Kerr-----	Flat---	-do---	140	6	-----do------	------	40	6	-------	S	
68	0.7 mi. E of Nelson------	Raleigh-Durham Airport------	Draw---	-do---	264	6	-----do------	------	-----	1	-------	--------	Observation well.
69	2.5 mi. SW of Nelson------	Artie High-----	Hill---	-do---	135	6	-----do------	12	33	7	0.06	M	
70	3.2 mi. SW of Lowes Grove-	F. B. McKinney-	Flat---	-do---	109	6	-----do------	------	30	9	-------	H	Analysis in table.
71	3.5 mi. SE of Chapel Hill-	Jessie Jones--	Low hill-	-do---	86	6	-----do------	------	12	6	-------	M	

Table 12. Chemical Analyses of Ground Water from Durham County
(Numbers heading the columns correspond to well numbers in table 11)

(Parts per million)

	3	5	7	19	26	39	42	60	70
Date of collection	1/4/63	1/4/63	1/4/63	1/4/63	1/4/63	1/4/63	1/4/63	1/4/63	12/17/62
Silica (SiO_2)	29	36	29	24	20	40	9.9	17	22
Aluminum (Al)	.1	.4	.0	.1	.1	.2	.0	.0	.2
Iron (Fe)	.09	2.8	.05	.01	.02	.07	.04	.05	.33
Manganese (Mn)	.01	.01	.03	--	--	--	.01	.00	.05
Calcium (Ca)	28	8.1	32	51	87	86	18	46	154
Magnesium (Mg)	14	5.6	5.7	10	18	37	4.3	5.0	34
Sodium (Na)	8.9	6.1	16	30	22	35	135	113	101
Potassium (K)	.2	.1	.8	.7	.1	1.3	.2	.1	.4
Lithium (Li)	.0	.0	.0	.2	.1	.3	.6	.6	.9
Bicarbonate (HCO_3)	124	62	137	203	219	339	222	313	294
Sulfate (SO_4)	8.0	9.4	11	12	7.2	13	9.6	24	10
Chloride (Cl)	14	1.0	9.0	39	102	111	122	71	337
Fluoride (F)	.1	.0	.6	.0	.1	.1	1.5	1.4	.0
Nitrate (NO_3)	21	.2	.0	.2	2.4	.4	.0	.9	1.3
Phosphate (PO_4)	.1	.1	.0	.0	.0	.2	.0	.0	.0
Dissolved solids	184	98	171	267	367	492	410	433	806
Hardness as $CaCO_3$	128	45	102	170	292	370	62	134	524
Noncarbonate	27	0	0	3	113	92	0	0	284
Specific conductance	288	130	268	470	662	860	725	728	1440
pH	7.0	6.8	7.2	7.3	7.8	7.2	8.0	7.4	7.4
Color	3	5	2	2	3	2	3	3	2
Map unit	Meta-volcanic	Granite and granodio-rite	Meta-volcanic	Triassic	Meta-volcanic	Triassic	Triassic	Triassic diabase	Triassic

Orange County

(Area 398 square miles; population 42,970)

Orange County is bounded to the north by Person and Caswell Counties, to the west by Alamance County, to the south by Chatham County, and to the east by Durham County. Hillsboro, the county seat, is the third largest town in the county. Chapel Hill is the largest town with a population of 12,573 according to the 1960 Bureau of the Census report. Other population centers include Carrboro and Efland and Mebane which is on the Orange-Alamance County line.

The county is drained by the Haw, Eno, and Little Rivers and by tributaries of the Flat and New Hope Rivers. The topography or Orange County is typical for counties in the Piedmont province. In general it consists of a rolling to hilly upland surface that slopes to the southeast in the direction of flow of the major streams. Maximum elevations occur on the granite and granodiorite unit in the northwestern part of the county and between Orange Grove and Hillsboro. The lowest elevations are along the creeks in the southeastern corner of the county.

Orange County, for the most part rural, depends on agricultural products for its chief source of income. Textile mills and other small industries are located at Chapel Hill, Carrboro, Hillsboro, Efland, and Mebane.

Geology

Most of Orange County is underlain by rocks that are included in the metavolcanic unit (pl. 2), consisting of felsic to mafic tuffs and flows of volcanic origin interbedded with minor amounts of sedimentary rocks. The more felsic tuffs and flows crop out west and southwest of Carrboro and along a line between Orange Grove and a point 2 miles east of Hillsboro. The metavolcanic unit northwest of this line is more deeply weathered and metamorphosed than elsewhere in the county. Traceable rock units trend approximately N. 40° E. across the county.

Rocks of the metavolcanic unit are overlain by a predominantly sedimentary unit designated as the argillite-graywacke unit. Argillite, graywacke sandstone, conglomerate, and interbedded tuff are exposed in synclinal structures at Efland, northwest and west of Calvander, at Eubanks north of Chapel Hill, and in the northeast corner of the county east of Caldwell. The argillite at

Eubanks and that west of Caldwell is metamorphosed and is properly classed as slate.

Rocks of the metavolcanic and argillite-graywacke units have been intruded by many igneous plutons ranging in composition from granite to gabbro. Those plutons and stocks weathering to light-colored soils, and having discernible quartz in hand specimen or residum, are shown on the geologic map as the granite and granodiorite unit. As mapped, this unit may contain rocks that should be classed as diorite. Two bodies of gabbro are exposed between Chapel Hill and Hillsboro.

Triassic rocks consisting of arkosic sandstones, siltstones, shales, and fanglomerates are exposed in the southeast corner of the county; they dip to the southeast. These rocks as well as the rocks of the metavolcanic unit have been intruded by diabase dikes of Triassic age.

Ground Water

Most water used for domestic and industrial purposes outside the towns of Chapel Hill, Carrboro, Hillsboro, and Mebane is obtained from wells and springs. The towns listed above utilize surface water. Ground water in the county is obtained from secondary openings such as fractures and planes as schistosity in the rocks or from the overlying porous mantle of soil and weathered rock. Because the depth of dug wells usually is limited by the depth to unweathered rock, dug wells generally are not deep enough to intersect the water table during long periods of low rainfall. Consequently, drilled wells constructed far below the water table are more dependable sources of ground water. Drilled wells have the added advantage of being less susceptible to surface-water contamination.

Data from 77 wells in Orange County are summarized in table 13.

Comparison of yields in table 13 indicates that granite and granodiorite yield more water per foot of well than does the metavolcanic unit. The yield tabulated for the argillite-graywacke unit probably is not significant, as only four wells in this unit were inventoried. Figures 15 and 16 show that there is a direct relationship between depth of weathered rock and yield in the metavolcanic and argillite-graywacke units. On the other hand, figures 17 and 18 indicate that topography has a greater influence on yield in the Triassic and granite and granodiorite units. How-

Table 13. Summary of Well Data in Orange County according to Rock Type

Map unit	Number of wells	Yield (gallons per minute)		Average depth (feet)
		Average	Per foot of well	
Granite and granodiorite 1/	21	12.0	0.16	77.4
Argillite-graywacke	4	9.0	.10	94.5
Metavolcanic	52	9.8	.11	91.4

1/ As mapped includes some diorite

Average water level of all wells in Orange County, 22.8 feet below land surface.

ever, large differences in yield exist from place to place in the same rock type. Apparently at least three factors—rock type, depth of weathering, and topography—determine the potential yield at any one locality in Orange County.

Plate 1 shows the actual areal distribution of relative yields in the Durham area. In the unshaded areas on this map a well 80 feet deep that has 30 feet of casing should yield 5 gpm or more. Wells in the areas having a horizontal-line pattern should yield less than 5 gpm for the same well and casing depths. Areas in which yields would be expected to be less than 1 gpm under the same set of conditions are shown in a crosshatched pattern.

Figure 26 is a hydrograph illustrating the seasonal fluctuation of the water table in Orange County.

Quality of Water

Ground water in Orange County is a combination of sodium, calcium, and magnesium types and is suitable for most domestic, municipal, and industrial uses.

Iron exceeded U.S. Public Health Service recommendations of 0.3 ppm in 45 percent of the water analyzed. Chloride was less than 59 ppm in all water analyzed. Hardness ranged from 18 to 198 ppm.

Analyses of ground water from 11 selected wells are listed in table 15.

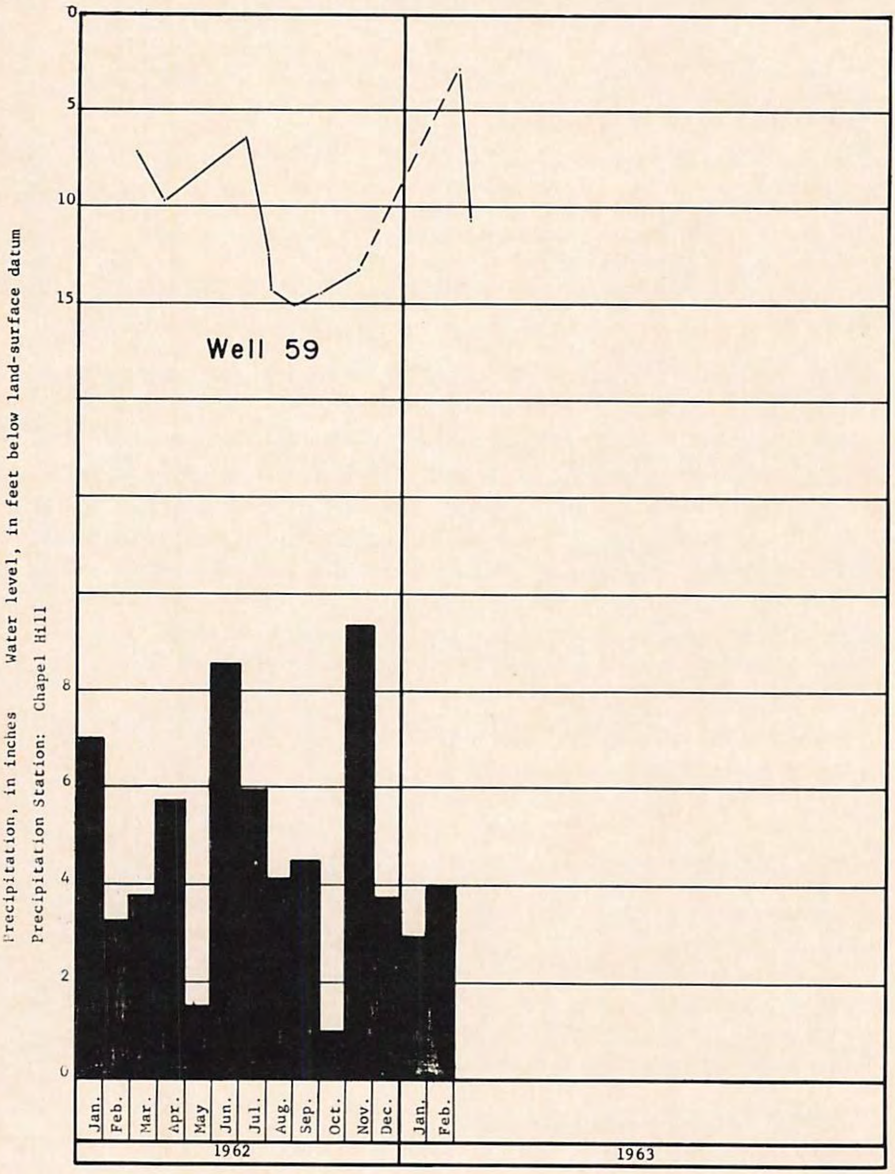


Figure 26. Selected hydrograph showing seasonal fluctuation of the water table in Orange County.

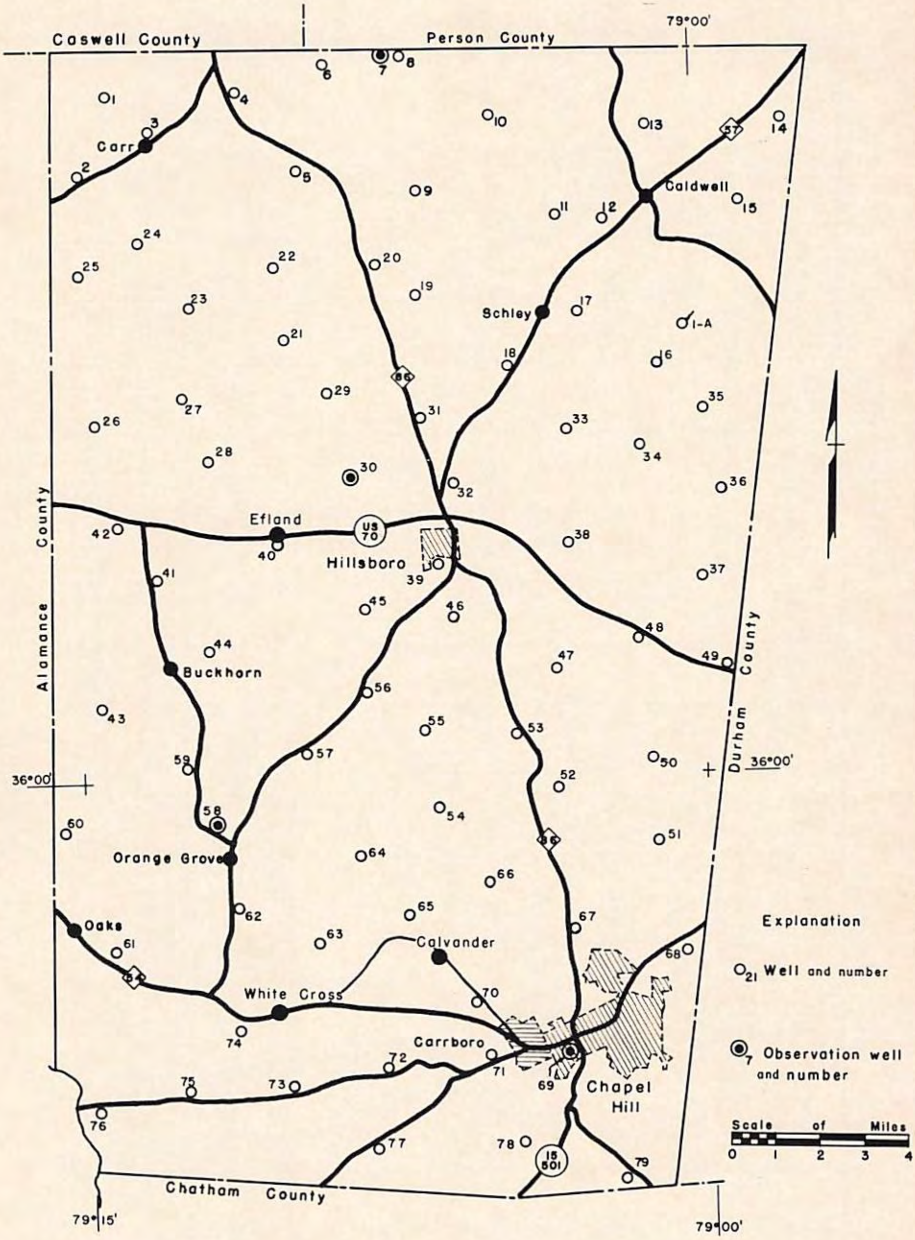


Figure 27. Map of Orange County showing the location of wells.

Table 14. Records of Wells in Orange County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1	1.4 mi. NW of Carr-------	Marvin Rogers--	Low knoll	--B--	30	20	Granite------	30	10	4	--------	S	
2	1.7 mi. SW of Carr-------	C. B. Atkins---	--do---	-Dr--	91	6	-----do------	31	20	7	0.12	S	
3	Carr---------	H. M. Compton--	Flat---	--B--	30	20	-----do------	30	16	8	--------	S	
4	2.2 mi. NE of Carr-------	Z. C. Burton---	Knoll--	-Dr--	76	6	-----do------	60	16	40	2.50	M	Analysis in table.
5	2.4 mi. N of Cedar Grove	W. L. Roberts--	Low knoll	-do--	73	6	-----do------	52	-----	20	1.00	S	
6	4.5 mi. NE of Carr-------	W. L. Phelps---	Flat---	--B--	31	20	-----do------	31	15	8	--------	S	
7	6.0 mi. NE of Carr-------	Alvin Moore----	Hill---	-Dr--	43	6	-----do------	-----	18	5	--------	M	Observation well.
8	6.1 mi. NE of Carr-------	J. C. Monk-----	--do---	-do--	105	5	-----do------	75	20	4	0.13	-------	
9	3.8 mi. NE of Cedar Grove	W. W. Hawkins--	Slope--	-do--	43	6	-----do------	15	20	5	.18	M	
10	4.0 mi. NW of Caldwell---	Roy Webster----	--do---	-do--	49	6	Tuff and granite gneiss--	5	22	5	.11	M	
11	2.1 mi. W of Caldwell---	H. C. Sheppard	--do---	-do--	86	6	Phyllite-----	60	16	15	.59	S	Analysis in table.
12	1.0 mi. SW of Caldwell---	Little River Presbyterian Church-------	Upland knoll	-do--	80	6¼	Schist-------	52	20	20	.72	S	
13	1.8 mi. N of Caldwell---	Eugene Wagner	Slope--	-do--	52	6	Mafic tuff---	21	15	20+	.62	M	
14	3.5 mi. NE of Caldwell---	David W. Robinson---------	--do---	-do--	51	6	Andesitic tuff--------	-----	20	6	--------	S	
15	2.0 mi. E of Caldwell---	Ed Laws--------	Knoll--	-do--	63	6	-----do------	33	30	2.5	0.06	S	
16	3.0 mi. SE of Schley-----	L. B. Gilbert	Slope--	-do--	90	6	Welded flow and tuff---	-----	15	5	--------	M	

Table 14. Records of Wells in Orange County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
17	0.8 mi. E of Schley------	H. C. Johnson	Upland knoll	-Dr--	180	6	Andesitic tuff	12	25	10+	0.06	M	
18	1.5 mi. SW of Schley------	G. O. Reitzel	Slope--	-do--	80	6	Mafic tuff----	------	15	8	--------	S	Analysis in table.
19	3.0 mi. W of Schley------	Harry Woods---	--do---	-do--	62	6	-----do------	------	25	10+	--------	S	
20	2.3 mi. E of Cedar Grove-	B. Earl Bradsher----	Flat---	-do--	85	6	-----do------	61	20	10	0.42	S	
21	1.5 mi. S of Cedar Grove-	C. V. Williams	--do---	-do--	80	6	-----do------	------	-----	30	--------	S	
22	Cedar Grove---	C. H. Pender--	Slope--	--B--	49	20	-----do------	49	35	4	--------	M	
23	2.1 mi. SW of Cedar Grove-	J. F. Thompson	Flat---	-do--	42	16	-----do------	42	25	6	--------	S	
24	2.4 mi. S of Carr, Route1	J. C. Walker--	--do---	-Dr--	125	6	Granite------	38	35	28	0.32	S	
25	3.3 mi. SW of Carr--------	Jack Long-----	--do---	--B--	42	20	-----do------	42	19	4	--------	S	
26	4.8 mi. NW of Efland------	L. P. Hauser--	Hill---	-Dr--	78	6	Mafic tuff----	56	35	3	0.14	S	
27	3.8 mi. NW of Efland------	Roy Jeffries--	Flat---	-do--	115	6	Tuff and phyllite----	101	20	15	1.35	S	
28	2.4 mi. NW of Efland------	W. J. Wright--	Slope--	-do--	115	6	Granodiorite--	60	-----	12	.22	S	Analysis in table.
29	2.9 mi. SE of Cedar Grove-	C. B. Hall----	Flat---	-do--	87	6	Mafic tuff----	40	-----	30+	.62	S	
30	2.5 mi. NW of Hillsboro---	Charles H. Blake-------	Slope--	-do--	160	6	Argillite-----	130	25	6	.20	S	Observation well; analysis in table.
31	2.6 mi. N of Hillsboro---	G. V. Lucas---	Draw---	-do--	72	6	-----do------	10	10	15+	.24	S	

Table 14. Records of Wells in Orange County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
32	1.5 mi. N of Hillsboro---	H. F. Latta---	Knoll--	-Dr--	148	6	Felsic tuff---	37	-----	6	0.05	S	
33	2.7 mi. S of Schley------	F. V. Miller--	Flat---	-do--	76	6	Felsic tuff and flows---	20	26	6	.11	S	
34	3.7 mi. SE of Schley------	J. R. Weaver--	Hill---	-do--	53	6	Mafic tuff---	20	-----	10+	.30	S	
35	4.3 mi. SE of Schley------	J. W. Walker--	Slope--	-do--	160	6	-----do------	27	-----	3	.02	M	
36	5.7 mi. SE of Schley------	Camp Talchi---	--do---	-do--	199	6	-----do------	14	20	25	.14	--------	
37	5.7 mi. E of Schley------	J. Frank Simmons-----	Flat---	-do--	42	6	Felsic tuff---	25	13	6	.36	S	
38	2.7 mi. E of Hillsboro---	D. F. Waters--	Hill---	-do--	80	6	Felsic tuff and rhyolite	58	20	8	.42	S	Analysis in table.
39	Hillsboro-----	Piedmont Mineral Co.-	Slope--	-do--	200	6¼	Sheared felsic tuff-------	-----	35	5	-------	S	
40	Efland--------	Efland Knitting Mill--------	Flat---	-do--	78	6	Argillite-----	38	-----	10	0.25	S	Reported gasoline taste.
41	3.0 mi. SW of Efland------	Gurney Doby---	Low knoll	--B--	30	19	Mafic tuff---	30	-----	4	-------	S	
42	3.6 mi. W of Efland------	Walton Lumber Co.---------	Flat---	-Dr--	100	6	-----do------	91	-----	10	1.11	S	
43	1.8 mi. SW of Buckhorn----	E. B. Phillips	Low knoll	-do--	161	6	Bedded felsic and mafic tuff-------	31	26	1	.01	H	
44	1.0 mi. NE of Buckhorn----	C. L. Davis---	--do---	-do--	79	6	Mafic tuff---	-----	25	10	-------	S	
45	2.5 mi. SW of Hillsboro---	R. W. Mangum--	Slope--	-do--	78	6	Felsic lithic tuff-------	75	8	30+	10.0	S	
46	1.5 mi. S of Hillsboro---	Prison Camp---	Hill---	-do--	170	6	Lithic tuff---	-----	70	6	-------	--------	Analysis in table.
47	3.6 mi. SE of Hillsboro---	W. C. Merritt	Slope--	-do--	40	6	Mafic tuff---	-----	-----	16	-------	S	
48	4.7 mi. SE of Hillsboro---	W. P. Anders--	Flat---	-do--	95	6	-----do------	30	20	8	0.12	S	

Table 14. Records of Wells in Orange County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
49	6.8 mi. SE of Hillsboro--	W. B. Shelton	Flat---	-Dr--	52	6	Granodiorite--	------	-----	4	--------	--------	Bad taste reported.
50	6.6 mi. SE of Hillsboro--	G. W. Widner--	Hill---	--D--	48	20	Mafic tuff----	48	40	5	--------	S	
51	4.9 mi. NE of Chapel Hill-	L. A. Yeargan	--do---	-Dr--	78	6	Diorite-------	------	20	7	--------	S	
52	5.7 mi. N of Chapel Hill-	Mamie D. Scott	Slope--	-do--	60	6	Felsic tuff---	35	-----	2	0.08	S	Analysis in table.
53	4.3 mi. SE of Hillsboro---	E. W. Strayhorn	--do---	-do--	45	6	Crystal lithic tuff--------	------	20	14	--------	H	
54	5.9 mi. S of Hillsboro---	Hubert Neville	--do---	-do--	24	6	Diorite-------	4	10	1.5	0.08	H	
55	4.2 mi. S of Hillsboro---	C. W. Davis---	Hill---	-do--	80	6	Crystal lithic tuff--------	15	-----	10	.60	S	
56	3.8 mi. SW of Hillsboro---	T. L. Gravette	Flat---	-do--	41	6	Felsic lithic tuff--------	22	-----	20	1.05	M	
57	3.0 mi. NE of Orange Grove	Billy Carden--	--do---	-do--	72	6	------do------	9	7	1.5	.02	S	
58	0.7 mi. NW of Orange Grove	Clarence Lloyd	Slope--	-do--	105	6	Andesitic flow	6	14	1	.01	S	Observation well; analysis in table.
59	2.1 mi. NW of Orange Grove	W. M. Albright	Hill---	-do--	76	6	Mafic tuff----	21	40	2	.03	--------	
60	3.8 mi. W of Orange Grove	Eloise Oliver	Slope--	-do--	74	6	------do------	10	20	8	.12	S	
61	3.3 mi. SW of Orange Grove	William G. Stanford----	--do---	-do--	90	6	------do------	15	15	30	.40	S	
62	1.0 mi. S of Orange Grove	C. R. Laws----	Flat---	-do--	65	6	Felsic tuff---	25	21	3	.08	--------	Water reported to be acid.

Table 14. Records of Wells in Orange County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
63	2.8 mi. SE of Orange Grove	J. T. Snipes--	Hill---	-Dr--	118	6	Sheared mafic tuff-------	100	-----	7	0.38	--------	
64	3.0 mi. E of Orange Grove	Hugh Wilson---	---do--	-do--	68	6	Tuffaceous argillite and slate	42	-----	5	.20	S	
65	1.0 mi. NW of Calvander---	Roberta Andrews	---do--	-do--	135	6	Diorite------	21	18	15	.13	M	
66	2.0 mi. NE of Calvander---	Ernest J. Rogers	Flat---	-do--	75	6	Felsic tuff--	45	25	10	.33	S	Some iron reported.
67	2.5 mi. N of Chapel Hill-	Orange Methodist Church------	---do--	-do--	35	6	Mafic tuff---	14	18	10	.48	--------	
68	3.2 mi. NE of Chapel Hill-	G. M. Kennon--	Slope--	-do--	80	6	Triassic-----	20	-----	1	.02	M	
69	Chapel Hill---	Chi Psi Fraternity--------	Upland knoll	--D--	48	36	Granite------	-----	42	-----	-------	--------	Observation well.
70	2.3 mi. NW of Chapel Hill-	Eugene Roberts	Slope--	-Dr--	168	6	Rhyolite-----	7	-----	0.1	0.00	--------	
71	2.2 mi. W of Chapel Hill-	Eric D. Cabtree	Hill---	-do--	90	6	Diorite------	41	21	4	.08	S	Analysis in table.
72	4.3 mi. SW of Chapel Hill-	Jessie Neville	---do--	-do--	70	6	Tuff and diorite----	44	-----	10	.38	S	
73	1.6 mi. S of White Cross-	Luther V. Grubb	Flat---	-do--	70	6	Diorite------	15	10	2	.04	S	
74	0.8 mi. SW of White Cross-	J. O. Cecil---	Hill---	-do--	77	$6\frac{1}{4}$	Tuff and granodiorite	31	-----	50	1.11	--------	
75	2.6 mi. SW of White Cross-	Rupert L. Bynum	Flat---	-do--	130	6	Crystal lithic tuff-------	11	20	4	0.03	S	Do.
76	4.6 mi. SW of White Cross-	Mrs. Colen Thompson----	---do--	-do--	140	$6\frac{1}{4}$	Mafic tuff---	38	-----	4	.05	S	
77	5.1 mi. SW of Chapel Hill-	J. Logon Irvin	Knoll--	-Dr--	170	6	Lithic crystal tuff-------	55	35	2	.02	S	
78	2.5 mi. SW of Chapel Hill-	K. B. Cole----	Hill---	-do--	200	6	Granite------	55	-----	20	.44	S	
79	3.3 mi. SE of Chapel Hill-	C. H. Blackwood	Slope--	-do--	95	6	-----do------	61	55	4	.12	S	

Table 14A. Records of Spring in Orange County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1A	3.0 mi. SE of Caldwell---	Clyde Roberts	Draw---	Spring	----	-----	Quartz vein in	-----	-----	10	------	S	

Table 15. Chemical Analyses of Ground Water from Orange County (Numbers heading the columns correspond to well numbers in table 14)

(Parts per million)

	4	11	19	29	31	39	47	53	59	72	76
Date of collection	12/18/62	12/18/62	12/18/63	12/18/62	12/18/62	12/18/62	6/6/50	12/18/62	12/18/62	12/18/62	12/18/62
Silica (SiO_2)	40	23	15	29	16	33	27	19	22	42	39
Aluminum (Al)	.0	.0	.1	.1	.2	.0	--	.0	.1	.1	.0
Iron (Fe)	.04	.62	.36	2.0	.08	.20	.99	1.3	.10	.04	.14
Manganese (Mn)	.00	.01	.04	.00	.03	.00	.00	.01	.02	.01	.04
Calcium (Ca)	6.9	2.9	6.9	5.0	7.7	3.4	15	3.4	5.4	51	31
Magnesium (Mg)	3.5	2.6	8.8	5.3	5.1	2.2	4.9	2.9	3.0	17	5.6
Sodium (Na)	8.1	5.3	4.1	3.1	10	6.4	4.2	5.6	3.6	32	15
Potassium (K)	.1	.1	.1	.1	1.4	.1	4.2	.1	.1	.2	1.1
Lithium (Li)	.0	.0	.0	.0	.1	.0	--	.0	.0	.1	.1
Bicarbonate (HCO_3)	54	30	46	52	44	36	66	28	40	83	127
Sulfate (SO_4)	2.4	.4	13	1.2	11	.8	5.1	1.4	1.8	34	3.4
Chloride (Cl)	2.0	.4	10	1.0	6.0	.2	4.1	7.0	.2	59	21
Fluoride (F)	.0	.0	.1	.0	.0	.2	.1	.0	.0	.1	.3
Nitrate (NO_3)	.8	1.1	.4	.1	5.2	1.1	1.6	.7	.4	75	.0
Phosphate (PO_4)	.1	.1	.0	.0	.4	.2	--	.0	.1	.1	.2
Dissolved solids	91	51	82	71	85	66	99	54	57	353	180
Hardness as $CaCO_3$	32	18	54	34	41	18	58	20	26	198	101
Noncarbonate	0	0	16	0	5	0	0	0	0	130	0
Specific conductance	107	73	132	90	131	67	136	76	83	552	262
pH	6.6	6.5	7.1	6.8	6.6	6.7	6.4	6.3	6.4	6.5	7.2
Color	--	2	--	--	2	--	7	3	--	2	2
Map Unit	Granite and granodiorite	Meta-volcanic	Meta-volcanic	Granite and granodiorite	Argillite-graywacke	Meta-volcanic	Meta-volcanic	Meta-volcanic	Meta-volcanic	Diorite	Diorite

Person County

(Area 400 square miles; population 26,394)

Person County is the northernmost county in the Durham area. It is bounded on the north by the State of Virginia, on the west by Caswell County, on the south by Orange and Durham Counties, and on the east by Granville County. Roxboro, the county seat, has a population of 5,147 and is the largest town. Other population centers include Longhurst, Ca-Vel, Timberlake, Hurdle Mills and Brooksdale.

The county is drained by the Flat, Tar, and Hyco Rivers. The topography of Person County is rolling to hilly; maximum elevations occur in the vicinity of Roxboro, Cunningham, and southeast of Timberlake. Lowlands have developed on the argillite-graywacke unit and on the hornblende gneiss unit. The lowest elevation is north of Bethel Hill, where the Hyco River flows across the Virginia-North Carolina line.

Person County has the highest percentage of land in farms of all the counties in the Durham area. Agricultural products include tobacco, corn, small grains, hay, and livestock.

Geology

The oldest rocks in Person County are the metamorphic rocks in the northwest corner. The mica gneiss and schist unit (pl. 2) is covered with thick saprolite, so that it was not possible to determine its relationship to the hornblende gneiss with which it is in contact to the southeast. The hornblende gneiss dips to the southeast and, if it is conformable to the mica gneiss and schist unit, should be younger than the mica gneiss and schist unit. The hornblende gneiss unit is in contact with the metavolcanic unit along its southeast side. Here, too, the relationship between the two units is not clear, but strike and dip information and difference in metamorphic grade indicate that the metavolcanic unit is the younger.

The metavolcanic unit includes felsic to mafic tuffs and flows that are only slightly metamorphosed. The more felsic tuffs and flows are confined to the southwest corner of the county. The regional trend of traceable rock strata is approximately N. 30° E.

Rocks of the metavolcanic unit are overlain by a predominantly sedimentary unit designated as the argillite-graywacke unit on the geologic map. Argillite, graywacke sandstone, graywacke conglomerate, and interbedded tuff are exposed in a large synclinorium in the eastern half of the county.

The argillite-graywacke unit is overlain by andesitic tuffs and flows that are exposed in two linear outcrop belts along the axial part of the synclinorium.

The hornblende gneiss, metavolcanic, and argillite-graywacke units have been intruded by granite, granodiorite, diorite, and gabbro. The elevated area in the central part of the county is underlain by a pluton that is predominantly granite. Other plutonic masses, mapped as the granite and granodiorite unit in the county, are chiefly granodiorite, but include some granite and diorite. A large gabbro mass is exposed north of Denny Store and a smaller one is exposed in the southeast tip of the county. Diorite is exposed in three separate localities; the largest is at Hurdle Mills and the two smaller ones are south of Hesters Store and north of Dixons Store.

Ground Water

Except for the town of Roxboro, all water used for domestic, public, and industrial purposes is obtained from ground-water sources. Roxboro uses surface water impounded in two lakes northwest of the town.

Ground water in the county is obtained from joints, planes of schistosity, and other secondary openings in the rocks or from the overlying mantle of soil and weathered rock. Because the depth of dug wells generally is limited by the depth to unweathered rock, dug wells usually are not deep enough to intersect the water table during periods of drought. Consequently, drilled wells are more dependable sources of ground water. Drilled wells have the added advantage of being less susceptible to contamination by surface water.

Data from 88 wells in Person County are summarized in table 16.

Comparison of yields in table 16 indicates that the granite and granodiorite and the argillite-graywacke units are better aquifers in Person County than are the metavolcanic and hornblende gneiss units. However, great variations in yield have been noted from place to place in the same rock type. Figures

Table 16. Summary of well data in Person County according to Rock Type

Map unit	Number of wells	Yield (gallons per minute)		Average depth (feet) 1/
		Average	Per foot of well	
Hornblende gneiss	11	4.0	0.06	66.8
Mica gneiss and schist	4	8.8	.07	134.0
Granite and granodiorite	23	7.7	.09	81.7
Diorite	4	4.8	.05	95.5
Argillite-graywacke	19	6.0	.08	78.1
Metavolcanic	27	5.3	.06	96.1

1/ Average water level in wells of Person County is 23.9 feet below land surface.

15 and 16 indicate that there is a direct relation between depth of weathered material and yield in the Durham area for the metavolcanic and argillite-graywacke units. On the other hand, figure 18 indicates that topography has an important bearing on yield in granite and granodiorite. It is apparent that rock type, depth of weathering, and topography are among the important factors that determine the potential yield of a specific locality in the county. The yields tabulated for the diorite and mica gneiss and schist units are probably not significant, as so few data are available for these units.

Plate 1 shows the areal distribution of relative yields in the Durham area. In Person County some relation between relative yield and rock type is apparent. The horizontal-lined area in the northwest corner of the county, representing yields of less than 0.1 gallon per foot, corresponds approximately to the hornblende gneiss and mica gneiss and schist units. The area of higher yields trending north and northeast across the county is underlain chiefly by granite, granodiorite, and mafic tuff. In the unshaded areas a well 80 feet deep that has 30 feet of casing should yield 5 gpm or more. Wells in the areas having a horizontal-line pattern should yield less than 5 gpm for the same well and casing depths. Areas in which yields would be expected to be less than 1 gpm under the same set of conditions are shown by a crosshatched pattern.

Figure 28 consists of three selected hydrographs that illustrate the seasonal fluctuation of the water table in Person County.

Quality of Water

Ground water in Person County is principally of the magnesium and calcium bicarbonate types. Calcium chloride and sodium bicarbonate types also are present.

Sixty-seven percent of the ground-water samples analyzed had iron concentrations below the 0.3 ppm limit set by the U. S. Public Health Service. Chloride concentrations were below 140 ppm. Hardness ranged from 12 ppm to 354 ppm.

Analyses of ground water from 12 selected wells are listed in table 18. Records of wells in Person County are given in table 17.

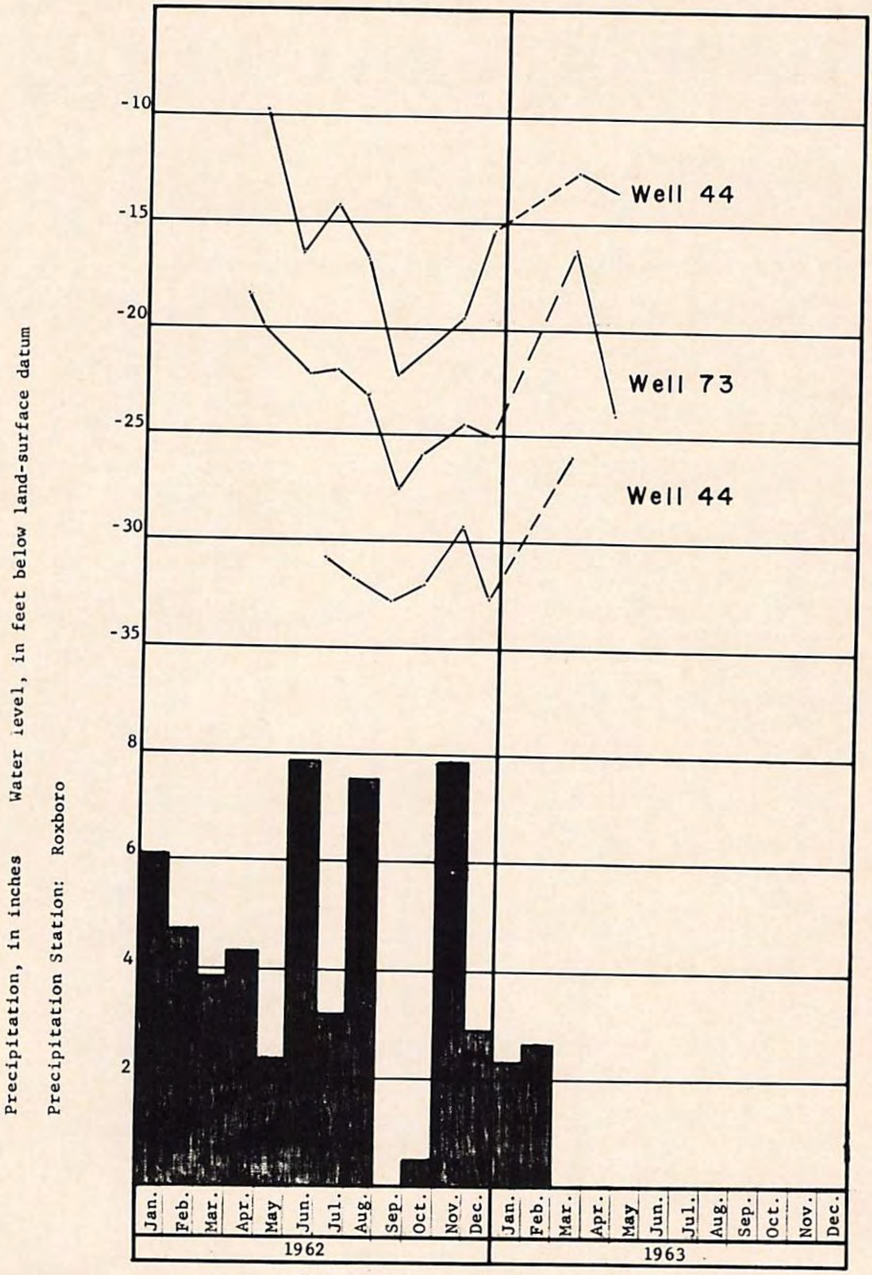


Figure 28. Selected hydrographs showing seasonal fluctuation of the water table in Person County.

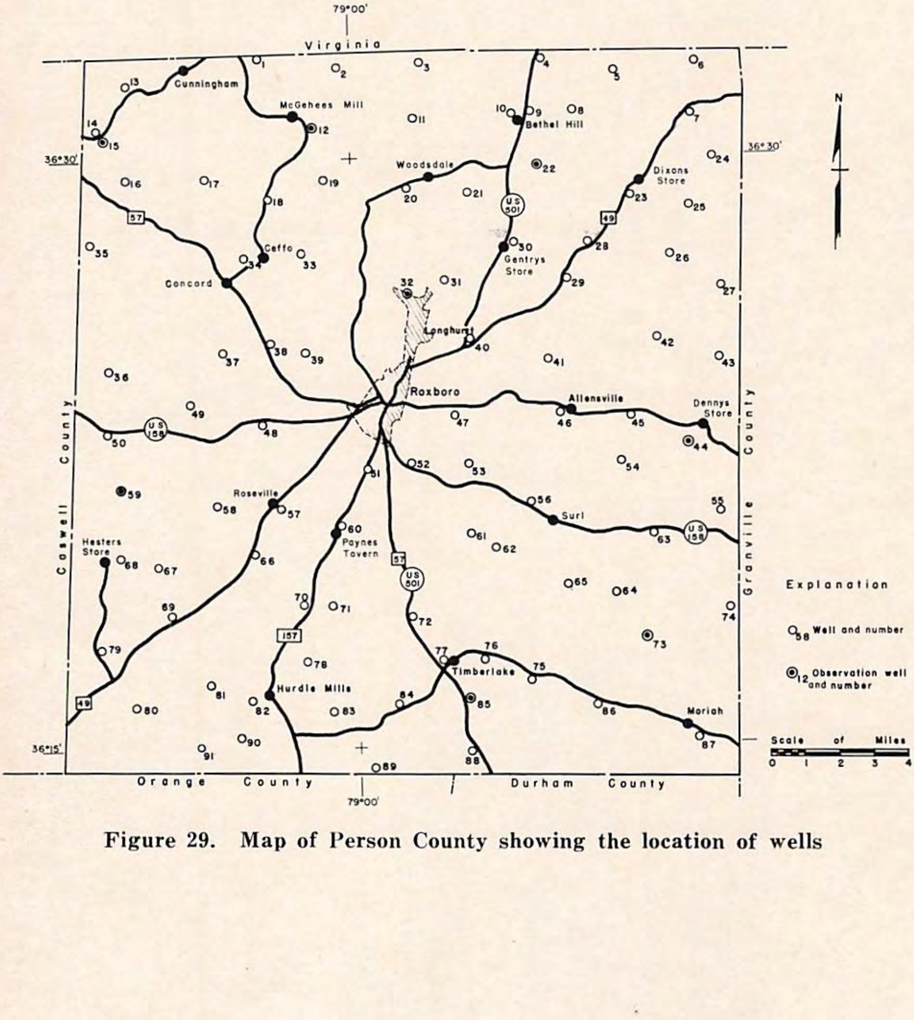


Figure 29. Map of Person County showing the location of wells

Table 17. Records of Wells in Person County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1	2 mi. E of Cunningham--	Ed Reeves-----	Slope-	-Dr--	207	6	Mica gneiss--	-----	60	15+	-------	M	
2	2 mi NE of McGehees Mill--------	James Robertson---------	Hill--	-do--	80	6	Hornblende gneiss-----	-----	20	5	-------	S	
3	3½ mi. N of Woodsdale---	Robert Drumright-------	Slope-	-do--	77	6	-----do------	-----	17	5	-------	S	
4	2 mi. N of Bethel Hill-	G. G. Woody---	Hill--	-do--	87	6	Granodiorite-	-----	-----	16+	-------	S	
5	3 mi. NE of Bethel Hill-	Embery Shepherd--------	--do--	-do--	121	6	Diorite------	28	13	3½	0.04	M	
6	4 mi. NE of Dixons Store	Talmadge Whitlow---------	--do--	-do--	81.5	6	Argillite----	22	30	5	.08	S	
7	2½ mi. NE of Dixons Store	C. T. Gentry--	--do--	-do--	150	6	-----do------	-----	35	1	-------	S	Iron taste reported; analysis in table.
8	1½ mi. E of Bethel Hill-	T. J. Oliver--	--do--	-do--	158	6	Tuff---------	10	50	4	0.03	M	
9	Bethel Hill---	Bethel Hill Baptist Church------	Flat--	-do--	105	6	Mafic tuff---	74	35	10	.32	S	
10	Bethel Hill---	W. W. Rogers, Jr.---------	Slope	-do--	85	6	-----do------	43	31	15	.36	S	
11	1½ mi. N of Woodsdale---	Tobbie Brumright-------	Hill---	-do--	77	6	Hornblende gneiss-----	-----	20	6	-------	S	Analysis in table.
12	½ mi. SE of McGehees Mill--------	N. B. Tuck----	Slope-	-do--	56	6	-----do------	-----	28	1	-------	H	Observation well.
13	1½ mi. SW of Cunningham--	Chestnut Grove Baptist Church------	Hill--	-do--	155	6	Mica gneiss--	20	30	8	0.06	S	

Table 17. Records of Wells in Person County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
14	3 mi. SW of Cunningham--	A. T. Mise-----	Flat---	-Dr---	69	6	Mica gneiss--	------	20	2.5	-------	S	Analysis in table.
15	3 mi. SW of Cunningham--	E. P. Brandon--	Knoll--	-D----	32	36	-----do------	------	10	-----	-------	S	Observation well.
16	4 mi. SW of Cunningham--	Moses Farmer---	--do---	-Dr---	64.5	6	Hornblende gneiss-----	------	28	3	-------	S	
17	3 mi. SW of McGehees Mill--------	Tom Bennett----	Hill---	-do---	94.5	6	-----do------	------	14.5	1	-------	M	
18	2½ mi. S of McGehees Mill--------	Mrs. William Walker-------	Slope--	-B----	23	24	-----do------	------	10	5	-------	S	
19	2 mi. SE of McGehees Mill--------	C. G. Robinson-	Hill---	-Dr---	56.5	6	-----do------	------	50	1	-------	H	Analysis in table; water reported too hard to wash clothes.
20	½ mi. W of Woodsdale---	Belle Warren---	--do---	-do---	71	6	-----do-------	------	20	7	-------	H	
21	1 mi. SE of Woodsdale---	A. G. Baird----	--do---	-do---	70	6	Tuff----------	42	45	8	0.29	S	
22	1½ mi. SE of Bethel Hill-	Beeman Bowman--	--do---	-do---	161	6	-----do-------	15	14	1	.01	M	Observation well.
23	½ mi. SW of Dixons Store	William Long---	Slope--	-do---	59	6	Argillite-----	32	-----	2	.07	---------	
24	2 mi. NE of Dixons Store	Sam Whitt------	Hill---	-do---	55	6	Mafic tuff----	9	15	1.5	.32	S	
25	1½ mi. SE of Dixons Mill-	Elvin Lowery---	--do---	-do---	75	6	-----do-------	54	47	3+	.14	H	

Table 17. Records of Wells in Person County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)

(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topog-raphy	Type of well	Depth (ft.)	Diam-eter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
26	2½ mi. S of Dixons Mill--	Richard Jones-	Knoll--	-Dr--	100	6	Argillite----	------	-----	1	--------	M	
27	6½ mi. E of Gentrys Store	M. B. Adcock--	Hill---	-do--	56	6	Conglomerate-	------	-----	20	--------	S	
28	2½ mi. E of Gentrys Store	R. W. Dixon---	--do---	-do--	80	6	Argillite----	------	25	5	--------	H	
29	2 mi. SE of Gentrys Store	Lem Harris----	--do---	-do--	45	6	Granite------	14	17	3	0.10	M	
30	Gentrys Store-	Frank Gentry--	Flat---	-do--	71	6	Argillite----	21	-----	3	.06	H	
31	2 mi. SW of Gentrys Store	W. A. Gloss---	--do---	-do--	50	6	-----do------	34	25	1	.06	H	
32	Longhurst------	Johnnie Till-man---------	Slope--	-do--	103	6	Mafic tuff---	25	28	1	.01	M	Observation well.
33	1 mi. E of Ceffo--------	Mamie Jordan--	Hill---	-do--	59	6	Granite------	58	-----	2.5	2.50	S	
34	0.5 mi. W of Ceffo--------	T. E. Evans----	--do---	-do--	126	6	-----do------	92	30	2	.06	S	
35	4 mi. NW of Concord------	Lonnie McGhee-	--do---	-do--	96	6	Hornblende gneiss-----	15	36	5	.06	M	
36	4.3 mi. SW of Concord------	Stover Davis--	--do---	-do--	105	6	Mica schist--	------	35	10	--------	S	
37	2.0 mi. S of Concord------	James Winsted--	--do---	-do--	67	6	Granite------	42	23	20	0.84	S	
38	3.5 mi. NW of Roxboro------	Person County School-------	High flat-	-do--	118	6	-----do------	58	-----	7	.11	--------	
39	2.5 mi. NW of Roxboro------	F. O. Clayton--	Hill---	-do--	59	6	-----do------	34	-----	2	.08	M	Analysis in table.
40	2.0 mi. NE of Roxboro------	Archie Wrenn---	--do---	-do--	80	6¼	-----do------	20	-----	13	.68	S	
41	1.5 mi. N of Allensville--	Huel M. Gentry-	Ridge--	-do--	85	6¼	-----do------	29	-----	5.5	.10	--------	

Table 17. Records of Wells in Person County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
42	3.3 mi. NE of Allensville-	A. L. Chaeious-	Flat---	-Dr---	49	6	Mafic tuff----	------	9	5	-------	S	
43	2 mi. N of Dennys Store	J. D. Denny----	Knoll--	-do---	74	6	Argillite and graywacke---	------	15	5	-------	S	
44	0.6 mi. SW of Dennys Store	Edgar Davis----	--do---	-do---	82	6	Conglomerate--	30	16	5+	0.10	S	Observation well; analysis in table.
45	2.2 mi. W of Dennys Store	W. L. Long-----	Flat---	-do---	80	6¼	Conglomerate and graywacke-------	28	2.5	6	.12	M	
46	Allensville---	John O. Yarborough------	Hill---	-do---	106	6	Mafic tuff----	------	------	4	-------	H	
47	2 mi. E of Roxboro-----	R. E. Oakley---	Flat---	-do---	83	6	Granite-------	45	------	2	0.05	S	
48	3.0 mi. W of Roxboro-----	Joseph Oaks----	High slope	-do---	54	6	Mafic tuff----	20	20	12	.36	S	
49	5.5 mi. W of Roxboro-----	J. B. Hester---	Hill---	-do---	168	6	Granite-------	32	25	1	.01	H	Reported corrosive to pipe.
50	3.7 mi. N of Hesters Store-------	W. P. Dixon----	--do---	-do---	50	6	Hornblende gneiss------	30	25	5	.25	S	
51	1.0 mi. S of Roxboro-----	C. W. Hawkins--	Knoll--	-do---	32	6	Mafic tuff----	18	------	3	.21	M	Bad taste reported.
52	1.0 mi. SE of Roxboro-----	A. C. Slaughter	Ridge--	-do---	110	6	Granite-------	12	36	1	.01	---------	
53	2.5 mi. SE of Roxboro-----	Ruben Allen----	Knoll--	-do---	30	6	Argillite and graywacke---	16	15	1.5	.11	M	
54	2.0 mi. SE of Allensville-	Clarence Poole-	--do---	-do---	47	6	-----do-------	30	------	5	.29	S	Flows in wet weather.

Table 17. Records of Wells in Person County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
55	2.5 mi. S of Dennys Store	L. H. Gregory-..	Slope--	-Dr--	86	6	Tuff---------	51	25	1	.03	H	
56	0.8 mi. NW of Surl-------	John L. Ashby-	Hill---	-do--	74	6	Argillite----	13	26	2	.03	S	
57	Roseville----	C. G. Nelson--	Flat---	-do--	112	6	Tuff---------	97	30	20	1.25	S	
58	1.7 mi. W of Roseville--	H. N. Allen---	Hill---	-do--	66	6	Granite------	46	9	12	0.59	S	
59	2.0 mi. N of Hesters Store------	John E. Wrenn-	--do---	-do--	50	6	-----do------	20	32	1	0.03	H	Observation well.
60	Paynes Tavern	Mrs. Iola L. Moore-------	Low slope	-do--	110	6	Tuff---------	31	30	5	0.06	--------	High iron reported.
61	2.5 mi. SW of Surl-------	Mrs. Howard Hamlet------	Knoll--	-do--	68	6	Mafic tuff---	21	-----	0.5	0.01	M	
62	1.8 mi. SW of Surl-------	Dean Evans----	Flat---	-do--	100	6¼	Argillite----	37	15	3	0.05	S	
63	3.0 mi. E of Surl-------	J. L. Thomas--	Slope--	-do--	125	6	Mafic tuff---	20	15	1	0.01	S	
64	2.7 mi. SE of Surl-------	Bernice Mooney	Knoll--	-do--	55	6	-----do------	45	25	11	1.11	S	
65	1.8 mi. S of Surl-------	J. H. Whitlow	High flat-	-do--	85	6	Argillite----	27	31	4	0.07	S	Analysis in table.
66	1.7 mi. SW of Paynes Tavern-----	Ella Lee Snipes	Slope--	--B--	36	24	Granite------	36	15	4	------	M	Limy taste reported; analysis in table.
67	1.5 mi. E of Hesters Store------	L. F. Hester--	Hill---	-Dr--	83	6	-----do------	64	30	20	0.10	S	
68	0.5 mi. E of Hesters Store------	H. W. Hester--	Knoll--	-do--	115	6	-----do------	-----	8	3	------	S	
69	2.5 mi. SE of Hesters Store------	Bernard Long--	--do---	-do--	106	6	-----do------	94	20	10	0.84	S	

Table 17. Records of Wells in Person County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
70	2.3 mi. SW of Paynes Tavern-----	J. W. Villings	Hill--	-Dr--	114	6	Diorite------	20	-----	4	0.04	S	
71	2.0 mi. S of Paynes Tavern-----	S. F. Hamlin--	--do--	-do--	95	6	Tuff---------	36	31	12	0.20	M	
72	1.8 mi. NW of Timberlake-	Guy Timberlake	--do--	-do--	56	6	Mafic tuff---	30	25	2.5	.10	--------	Reported corrosive to Al and turns tea black; analysis in table.
73	2.8 mi. NW of Moriah-----	Gaddis Kidd---	--do--	-do--	35	6	Lithic tuff--	20	18	2.5	.17	S	Observation well.
74	3.5 mi. NE of Moriah-----	Daniel Huff---	--do--	-do--	136	6	Acid tuff----	------	30	5	-------	S	Do.
75	2.5 mi. E of Timberlake-	Clifton Saunders	--do--	-do--	142	6	Andesitic tuff-------	------	40	20	-------	S	
76	1.0 mi. E of Timberlake-	Lem Clayton---	High flat	-do--	80	6	Acid tuffaceous argillite--	4	-----	15	0.20	S	Some iron reported.
77	Timberlake---	C. H. Mason---	Hill--	-do--	185	6	Tuff---------	18	20	1	.01	M	
78	1.5 mi. NE of Hurdle Mills	K. P. Whitfield-------	Flat--	-do--	33	6	Diorite------	28	15	9	.17	M	Analysis in table.
79	3.5 mi. S of Hesters Store------	E. P. Warren--	--do--	-do--	114	6	-----do------	21	15	2	.02	M	
80	4.0 mi. W of Hurdle Mills	A. V. Moore---	--do--	-do--	100	6¼	Tuff---------	27	19	8	.11	S	
81	1.7 mi. W of Hurdle Mills	F. L. Moore---	Hill--	-do--	76	6	-----do------	59	30	7+	.42	S	
82	Hurdle Mills--	W. W. Breeze--	--do--	-do--	125	6	Granodiorite-	12	16	25	.22	S	
83	2.0 mi. E of Hurdle Mills	Wayne Moe-----	Knoll-	-do--	85	6	Tuff---------	15	-----	6	.09	--------	
84	2.0 mi. SW of Timberlake--	R. E. Timberlake--------	Slope-	-do--	73	6	Granite------	17	17	6	.11	S	

Table 17. Records of Wells in Person County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
85	1.2 mi. SE of Timberlake-	Ora D. Chambers	Slope-	-Dr--	132	6	Argillite and graywacke--	31	12	0.5	0.01	S	Observation well; some iron reported.
86	2.7 mi. W of Moriah-----	J. L. Cothren-	Flat--	-do--	205	6	Acid tuff and rhyolite---	20	20	1	.01	S	Limy taste reported; analysis in table.
87	0.5 mi. E of Moriah-----	H. S. Clayton-	Slope-	-do--	37	6	Granodiorite-	-----	-----	8	-------	M	
88	2.5 mi. S of Timberlake-	R. H. Oliver--	--do--	-do--	52	6	Argillite and graywacke--	24	-----	30	1.11	S	
89	3.8 mi. SW of Timberlake-	Reed Hall-----	--do--	-do--	50	6	Andesitic tuff-------	38	14	10	.84	S	
90	1.5 mi. SW of Hurdle Mills	Lindsey Thompson----	Hill--	-do--	44	6	Granodiorite	36	16	6	.77	S	
91	2.5 mi. SW of Hurdle Mills	D. Lacy Long--	Ridge-	-do--	61	6	-----do------	39	21	7	.32	S	

Table 18. Chemical Analyses of Ground Water from Person County
(Numbers heading the columns correspond to well numbers in table 17)

(Parts per million)

	7	11	14	19	31	39	44	65	66	72	78	86
Date of collection	9/7/62	1/4/63	12/18/62	9/6/62	5/3/63	9/6/62	9/6/62	9/6/62	9/6/62	1/4/63	9/7/62	1/4/63
Silica (SiO_2)	17	47	41	34	22	29	21	15	47	34	35	21
Aluminum (Al)	.1	.2	.0	.1	.2	.1	.1	.0	.0	.1	.1	.2
Iron (Fe)	1.4	.40	.14	.19	--	.21	--	.05	.14	.27	.06	.25
Manganese (Mn)	.00	--	--	.00	.14	.04	.05	.03	.00	.00	.00	--
Calcium (Ca)	28	21	1.8	46	102	6.3	6.2	15	26	25	25	57
Magnesium (Mg)	9.7	15	1.8	42	24	.6	9.3	8.3	3.0	19	28	8.7
Sodium (Na)	16	19	5.6	30	29	9.1	4.0	16	18	19	15	14
Potassium (K)	.1	.9	1.2	3.6	1.4	.7	.1	.1	.1	.1	.1	.1
Lithium (Li)	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.1
Bicarbonate (HCO_3)	74	168	28	252	261	22	72	24	73	142	164	203
Sulfate (SO_4)	10	9.6	2.2	67	8.0	1.0	2.6	4.2	8.2	24	32	7.4
Chloride (Cl)	52	6.0	.2	56	139	7.7	3.0	35	34	25	16	21
Fluoride (F)	.0	.3	.0	.3	.1	.1	.0	.1	.0	.0	.1	.1
Nitrate (NO_3)	1.1	.0	.1	2.8	2.0	13	.0	38	4.2	8.2	18	2.6
Phosphate (PO_4)	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0
Dissolved solids	170	202	68	406	456	79	81	144	177	224	250	232
Hardness as $CaCO_3$	110	115	12	291	354	18	54	72	78	138	179	180
Noncarbonate	49	0	0	84	140	0	0	52	18	22	44	14
Specific conductance	309	305	69	675	850	130	130	248	250	395	405	390
pH	6.8	6.8	6.5	7.0	7.0	6.0	6.8	5.9	6.7	6.4	6.8	7.3
Color	2	4	3	2	5	3	3	2	2	3	2	3
Map Unit	Argillite-graywacke	Hornblende-gneiss	Mica-gneiss and schist	Hornblende-gneiss	Argillite-graywacke	Granite and granodio-rite	Argillite-graywacke	Argillite-graywacke	Granite and granodio-rite	Meta-volcanic	Diorite	Meta-volcanic

Randolph County

(Area 801 square miles; population 61,497)

Randolph County is the largest and westernmost county in the Durham area. It is bounded on the north by Guilford County, on the west by Davidson County, on the south by Montgomery and Moore Counties, and on the east by Chatham and Alamance Counties. Asheboro, the county seat, has a population of 9,449 and is the largest city in the county. Other population centers include Archdale, Liberty, Trinity, Randleman, Staley, Ramseur, Franklinville, Coleridge, and Seagrove.

The county is drained by the Uwharrie, Deep, and Rocky Rivers. The topography of Randolph County is rolling to mountainous. The Uwharrie Mountains are the dominant topographic feature in the central and south-central parts of the county. Streams are deeply incised except for the Uwharrie River, which has carved a fairly broad lowland on argillite that is less resistant than the surrounding metavolcanic unit. Highest elevations are in the Uwharrie Mountains and along the Davidson-Randolph County line. Lowest elevations are at the Uwharrie River in the southwest corner and at the Deep River in the southeast corner of the county.

Randolph County is largely rural but has many textile mills and furniture plants, which employ many part-time farmers. Agricultural products include small grains, hay, corn, and livestock.

Geology

Most of Randolph County is underlain by rocks of the metavolcanic unit (pl. 2). The metavolcanic unit in the county includes felsic to mafic tuffs and flows of volcanic origin interbedded with thin beds of argillaceous tuff and graywacke. The central part of the county in the south of Asheboro is underlain by the more felsic rocks of this unit.

The metavolcanic unit is overlain by the argillite-graywacke unit consisting of argillite, graywacke, graywacke conglomerate, and tuff. Graywacke and graywacke conglomerate are confined to the eastern part of the county. The argillite in the western part of the county is more deeply weathered and less deformed than elsewhere in the Durham area.

The argillite in the southwestern part of the county grades upward into the tuffaceous argillite unit. The contact between the argillite and tuffaceous argillite is drawn where the more massive tuffaceous argillite exceeds 50 percent of the total.

The argillite-graywacke unit is overlain by the mafic tuff and flow unit. This unit, consisting of coarse andesitic tuffs and flows, is present near the axial regions of the argillite-graywacke synclines. Tuffaceous argillite in the western part of the county is interbedded with the rocks of the mafic tuff and flow unit. This may indicate that the tuffaceous argillite unit is a facies of the mafic tuff and flow unit.

The metavolcanic and argillite-graywacke units have been intruded by granite, granodiorite, and gabbro. The large plutonic mass in the northwest corner is chiefly granite. The large ones east of Ramseur and west of Liberty are more mafic in composition. The argillite-graywacke unit west of Asheboro and the metavolcanic unit in the vicinity of Asheboro have been intruded by gabbro dikes and sills. Most of the high ridges in the western part of the county are capped by gabbro.

Ground Water

Most water used for domestic, public, and industrial purposes, other than in the towns of Asheboro and Ramseur, is obtained from ground water. The town of Liberty, in the eastern part of the county, uses ground water from five wells to serve about 1,500 people. Storage is in one elevated tank having a capacity of 275,000 gallons. The water is not treated. Ground water in the county comes from secondary openings in the rocks such as fractures and planes of schistosity or from the overlying porous mantle of soil and weathered rock. Because the depth of dug and bored wells in the county is limited by the depth to unweathered rock, the dug and bored wells generally go dry during periods of drought. Drilled wells are more dependable sources of water in the county, because they are more easily constructed below the water table. Drilled wells have the additional advantage of being less susceptible to contamination by surface water.

Data from 154 wells in Randolph County are summarized in table 19.

Comparison of yields indicates that the metavolcanic unit

Table 19. Summary of well data in Randolph County according to rock type

Map unit	Number of wells	Yield (gallons per minute)		Average depth (feet) 1/
		Average	Per foot of well	
Granite and granodiorite	18	7.5	.07	108.4
Argillite-graywacke	37	8.8	.08	106.1
Metavolcanic	99	12.9	.13	98.5

1/Average water level for wells in Randolph County is 26.7 feet below land surface.

yields the most water per foot of well in Randolph County. However, this is not true of other counties in the Durham area. Figures 15 and 16 show that there is a direct relationship between depth of weathered rock and yield in the metavolcanic and argillite-graywacke units. The metavolcanic unit in the county is deeply weathered and this may account for the higher yields; however, the argillite-graywacke unit is also deeply weathered except in the southeast corner of the county. Figure 18 indicates that topography is the most important yield-controlling factor in the granite and granodiorite unit. It is apparent that rock type, depth of weathering, and topography are among the factors that control the yield in any one locality in the county.

Plate 1 shows the areas distribution of relative yields in the Durham area. Comparison of this map with plate 2 shows that most of the area underlain by the metavolcanic unit yields 0.1 gallon per minute per foot of uncased hole. In the unshaded areas in Randolph County, a well 80 feet deep that has 30 feet of casing should yield 5 gpm or more. Wells in the areas shown by a horizontal-line pattern should yield less than 5 gpm for the same well and casing depths. Areas in which yields would be expected to be less than 1 gpm under the same set of conditions are shown in a crosshatched pattern.

Figure 30 consists of two selected hydrographs which illustrate the seasonal fluctuation of the water table in Randolph County.

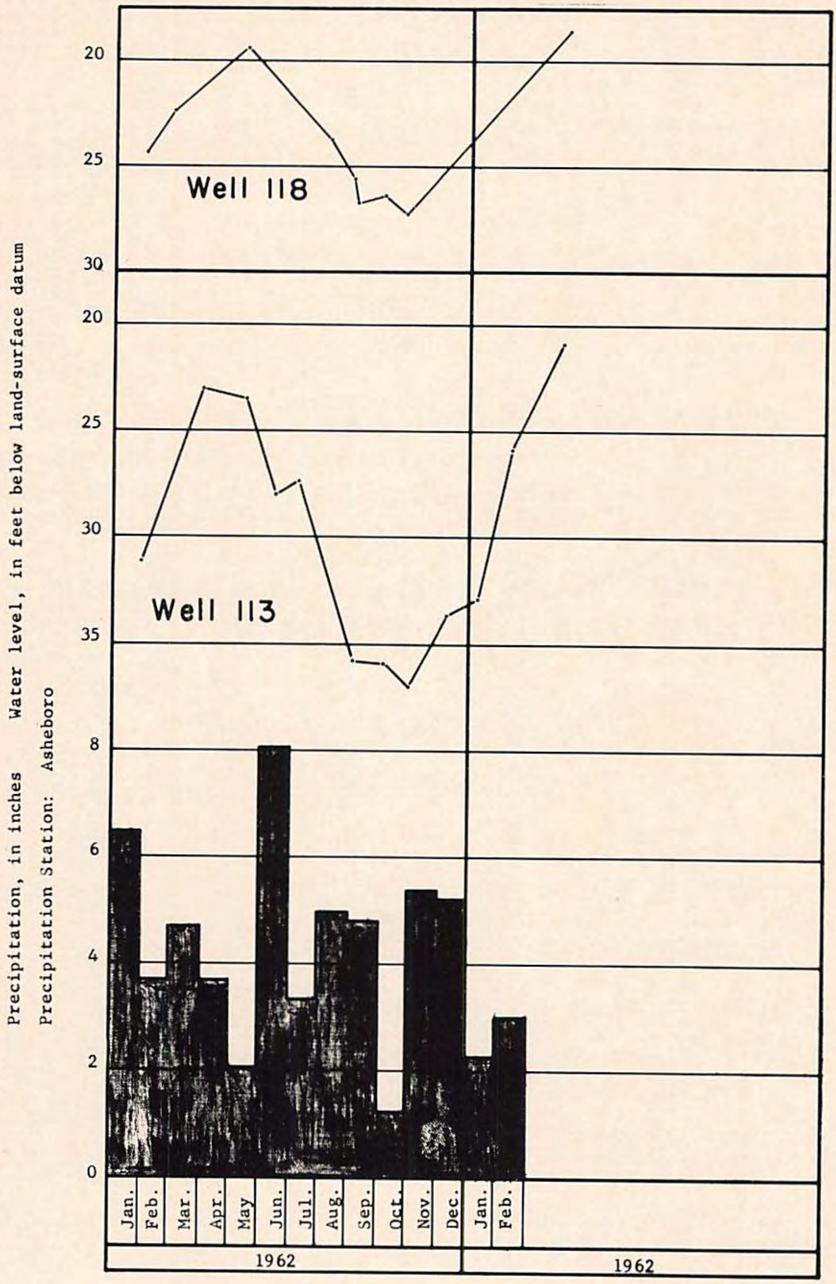


Figure 30. Selected hydrographs showing seasonal fluctuation of the water table in Randolph County.

Quality of Water

Ground water in Randolph County is principally a calcium bicarbonate type. Sodium and magnesium bicarbonate, and calcium chloride types also are present.

Iron concentrations were below the U. S. Public Health Service recommendations of 0.3 ppm in 10 out of 17 of the ground waters analyzed. Chloride was above 250 ppm in only one ground-water sample. Hardness ranged from 8 ppm to 1340 ppm.

Analyses of ground water from 20 selected wells is presented in table 21.

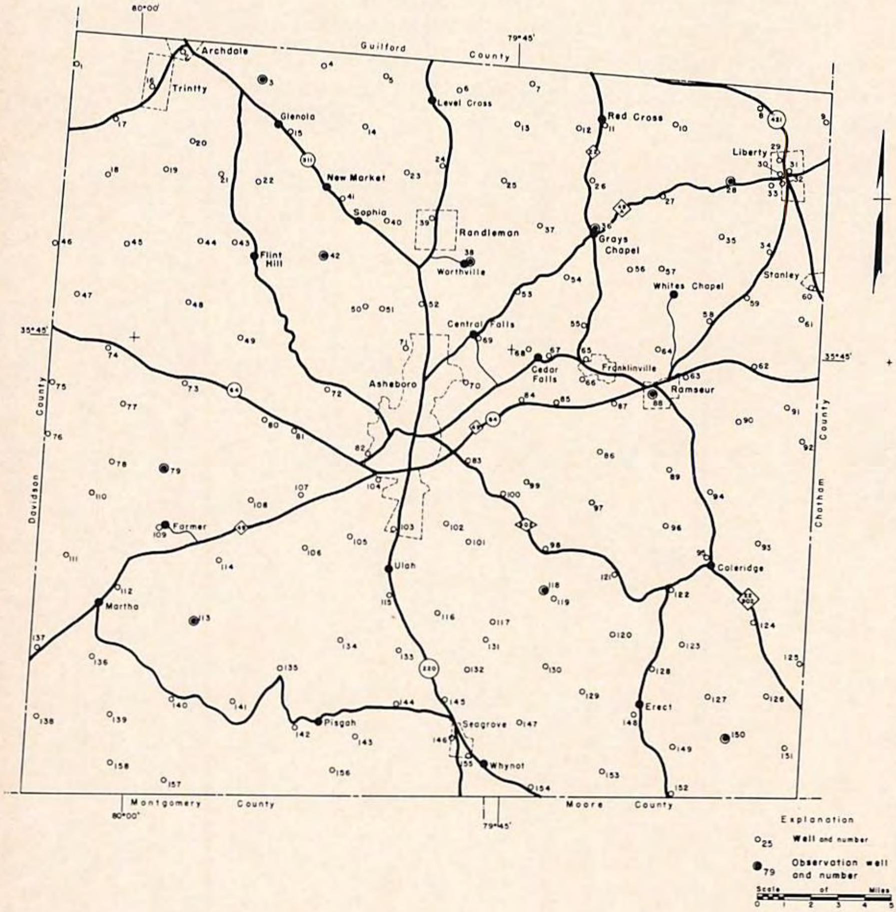


Figure 31. Map of Randolph County showing the location of wells

Table 20. Records of Wells in Randolph County

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
1	3.0 mi. W of Trinity----	Troy Forrester	Upland flat-	--Dr--	79	8	Mafic tuff---	20	40	14	0.24	S	
2	Archdale-----	Randolph County Schools-----	--do---	--do--	92	6	Granite-----	-----	-----	9	--------	S	
3	4.0 mi. E of Trinity-----	J. W. Bundy----	Draw---	---B--	25	24	-----do------	25	11	5		S	Observation well; analysis in table.
4	5.3 mi. E of Archdale---	J. R. Hull-----	Knoll--	--Dr--	150	6	-----do------	50	20	1	--------	S	
5	2.0 mi. NW of Level Cross	Lester L. Crotts	Hill---	--do--	150	6	-----do-----	-----	30	8	--------	M	
6	1.0 mi. NE of Level Cross-	Vera Vickory---	Slope--	--do--	65	3	Diorite------	50	-----	4	0.27	S	
7	2.8 mi. NW of Red Cross---	Tom Hockett----	Flat---	--do--	118	2	Mafic tuff---	-----	18	7	--------	S	
8	2.5 mi. N of Liberty-----	Ray York-------	--do---	--do--	94	6	Granodiorite-	-----	-----	35	--------	S	
9	2.5 mi. NE of Liberty-----	Ervin Workman--	--do---	---B--	40	24	Tuff---------	40	24	5	--------	S	
10	4.4 mi. NW of Liberty-----	R. L. Well-----	Hill---	--Dr--	182	6	Granodiorite--	10	35	10+	0.06	H	
11	Red Cross-----	G. C. Salmon---	--do---	---B--	28	24	Mafic tuff---	28	13	5	--------	S	
12	0.8 mi. SW of Red Cross---	Charles Field	Draw---	--Dr--	117	6	Granodiorite--	-----	12	2.5	--------	S	
13	3.1 mi. W of Red Cross---	J. A. Whitley--	Slope--	---D--	41	36	Mafic tuff---	0	28	4	--------	S	
14	1.6 mi. SW of Level Cross-	B. E. Davis----	Flat---	--Dr--	120	6	-----do-----	-----	30	30+	--------	--------	Reported corrosive, with some iron.

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
15	Glenola------	Clyde R. Spencer	Flat	--B--	44	24	Mafic tuff---	44	20	6	-------	M	Some iron reported.
16	Trinity------	Randolph County Schools------	Knoll--	-Dr--	400	6	Granite------	30	23	22	0.06	S	Analysis in table.
17	2.1 mi. SW of Trinity----	John C. Easter	--do---	-do--	75	3	------do-----	26	10	7	.14	S	
18	4.0 mi. S of Trinity----	J. M. Hill-----	Hill---	--D--	45	48	Mafic tuff---	0	38	3	-------	S	
19	3.4 mi. S of Trinity----	Mary Brunson---	Slope--	-Dr--	30	6	Granite------	9	15	1	0.05	S	
20	2.6 mi. SE of Trinity----	J. M. Elder----	Hill---	-do--	79	6	------do-----	5	40	6	.08	H	
21	2.8 mi. SW of Glenola----	Dr. McLean B. Leath-------	--do---	-do--	90	6	------do-----	15	-----	4	.05	S	
22	2.2 mi. S of Glenola----	M. J. Davis----	--do---	-do--	100	6	Mafic tuff---	------	30	5	-------	M	
23	2.5 mi. NW of Randleman--	L. V. Adams----	Low flat-	-do--	214	6	Diorite------	------	40	10	-------	S	
24	2.4 mi. N of Randleman--	Wood Smith-----	Slope--	--B--	55	24	Argillite----	------	14	4	-------	S	
25	3.0 mi. NE of Randleman--	C. W. Henley---	Hill---	-Dr--	72	3	Mafic tuff---	------	----	25	-------	S	
26	2.4 mi. S of Red Cross--	V. O. Routh----	Knoll--	--B--	35	24	Felsic tuff--	35	6	5	-------	S	
27	4.0 mi. W of Liberty----	Curtiss Dodson-	--do---	-Dr--	72	6	Granodiorite	63	6	5	0.56	S	
28	2.0 mi. W of Liberty----	George York----	Hill---	-do--	68	6	------do-----	34	22	5	.15	S	Observation well; analysis; bitter taste reported.

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
29	Liberty------	Town of Liberty	Flat---	-Dr--	299	10	Mafic tuff---	65	20	40	0.29	--------	
30	-----do------	------do------	--do---	-do--	242	10	-----do-----	135	30	75	.72	--------	
31	-----do------	------do------	--do---	-do--	292	8	-----do-----	125	15	75	.46	--------	
32	-----do------	------do------	--do---	-do--	221	8	-----do-----	150	20	75	1.00	--------	
33	-----do------	------do------	--do---	-do--	600	6	-----do-----	600	12	100	--------	--------	Cased with slotted pipe; analysis in table.
34	3.0 mi. S of Liberty----	M. M. Vickrey--	--do---	-do--	101	6	-----do-----	18	10	10	0.12	S	
35	3.3 mi. SW of Liberty----	H. A. Faust----	Hill---	-do--	68	6	-----do-----	-----	-----	5	--------	S	Some iron reported.
36	Grays Chapel-	Randolph County Schools------	--do---	-do--	223	6	-----do-----	32	22	16	0.08	S	Observation well.
37	2.0 mi. W of Grays Chapel	J. T. Routh----	--do---	-do--	72	2	Felsic tuff--	-----	14	20	--------	S	
38	Worthville---	Leward Cotton Mills--------	--do---	-do--	105	6	Mafic tuff---	75	63	15	0.50	--------	Observation well.
39	Randleman----	Commonwealth Hosiery------	Valley-	-do--	180	6	Felsic tuff--	-----	30	20	--------	H	
40	1.7 mi. W of Randleman--	Jack Garner----	Hill---	-do--	123	6	Mafic tuff---	108	-----	5	0.33	--------	
41	1.0 mi. NW of Sophia-----	Randolph County Schools------	--do---	-do--	130	6	------do-----	-----	-----	22	--------	--------	
42	1.7 mi. SW of Sophia-----	C. W. Sumner---	--do---	--B--	48	24	Sericite schist-----	48	30	3	--------	S	Observation well; analysis in table.
43	0.8 mi. NW of Flint Hill-	Garland-------- Hawkins------	--do---	-Dr--	130	2	Mafic tuff---	-----	-----	1	--------	S	

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H, hard; M, medium; S, soft)
(Type of well: B, bored; D, dug; Dr, drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
44	2.0 mi. W of Flint Hill--	George W. Spencer-----	Slope--	-Dr--	95	3½	Argillite----	20	-----	25	0.33	S	
45	4.7 mi. W of Flint Hill--	L. E. Hoover--	Hill---	-do--	96	6	-----do------	20	20	12	0.16	S	
46	7.4 mi. W of Flint Hill--	Glenn Thomas--	--do--	-do--	125	6	-----do------	46	-----	5	0.06	S	
47	6.7 mi. SW of Flint Hill--	Billy Loftin--	--do--	-do--	96	6	Felsic tuff--	20	-----	20	0.26	M	Limy taste reported.
48	3.0 mi. SW of Flint Hill--	Mt. Pleasant Church------	--do--	-do--	122	6	Andesitic tuff and argillite	6	-----	5	0.04	-------	
49	3.0 mi. S of Flint Hill--	Robert Crotts-	--do--	--B--	51	24	Argillite and tuff-------	51	37	5	-------	S	
50	4.0 mi. SW of Randleman---	Willard W. Cox	Slope--	-Dr--	91	6	Argillite----	-----	50	15	-------	S	
51	4.0 mi. SW of Randleman---	William J. Hylton------	Hill---	-do--	87	2½	-----do------	-----	50	7	-------	M	
52	3.0 mi. S of Randleman---	Hal Garner----	--do---	-do--	150	4	-----do------	125	-----	10+	0.40	S	
53	2.2 mi. SE of Worthville--	Gurney Harrelson---	Draw---	-do--	70	6	Felsic crystal tuff-------	55	4	20	1.25	S	Analysis in table.
54	1.9 mi. SW of Grays Chapel	Whites Memorial Baptist Church------	Knoll--	-do--	100	6	Mafic tuff---	7	-----	3	0.03	-------	
55	1.3 mi. N of Franklinville	E. M. Bass----	Slope--	-do--	70	4	Mafic crystal tuff-------	-----	30	6	-------	S	
56	1.9 mi. SE of Grays Chapel------	J. F. Pugh----	Hill---	-do--	61	6	Argillite----	6	18	9	0.16	S	
57	1.0 mi. N of Whites Chapel------	J. L. York----	--do---	-do--	57	6	Mafic tuff---	54	20	6	2.00	-------	Analysis in table.
58	3.0 mi. NE of Ramseur-----	James Hicks---	--do---	-do--	150	6	-----do------	30	-----	5	0.04	M	

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
59	2.5 mi. W of Staley-----	F. F. Pugh---- ..	Upland flat	--Dr--	65	6	Mafic tuff---	-----	45	5	------	S	
60	Staley-------	Randolph County Schools-----	Hill---	--do--	80	-----	Felsic tuff--	-----	30	8	------	-------	
61	1.2 mi. S of Staley-----	F. M. Lindley-	Slope--	--do--	59	2	Argillite----	-----	-----	4	------	S	
62	3.8 mi. SW of Staley-----	W. Mike York--	Hill---	--do--	200	4	Granodiorite	32	32	3.5	0.02	S	
63	0.8 mi. NE of Ramseur----	V. C. Marley--	--do---	--do--	159	6	Argillite----	45	30	20	.17	S	Analysis in table.
64	1.5 mi. N of Ramseur----	W. H. Jones---	Low flat-	--do--	65	6	Felsic tuff--	28	15	5.5	.15	S	
65	Franklinville	Randolph Mills	Valley-	--do--	65	6	Mafic tuff---	-----	-----	9	------	S	
66	-----do------	Clarence Cheek	--do---	--do--	65	6	-----do------	40	-----	20	0.77	-------	
67	0.5 mi. E of Cedar Falls	Sapona Mfg. Co.	Slope--	--do--	300	8	Quartz veins in mafic tuff-------	-----	88	37	------	-------	
68	0.3 mi. W of Cedar Falls	Jordan Spinning Company-----	Valley-	--do--	202	6	Gabbro-------	-----	-----	11	------	S	
69	Central Falls	Klopman Mills	Slope--	--do--	160	6	Felsic crystal tuff-------	-----	-----	28	------	-------	
70	1.7 mi. S of Central Falls	Ralph Swan----	Hill---	--do--	89	6	Rhyolite-----	-----	35	6	------	S	
71	2.5 mi. W of Central Falls	Joe F. Rich---	--do---	--do--	133	6	Argillite----	80	30	12	0.23	S	
72	3.8 mi. NW of downtown Asheboro---	Bill Bollerd--	--do--	--do--	138	6	-----do------	80	80	17	.30	M	Some iron reported.
73	5.3 mi. S of Flint Hill-	Randolph County Schools-----	Slope	--do--	85	6	-----do------	-----	-----	8	------	S	
74	6.4 mi. SW of Flint Hill-	Wade Yonts----	--do--	--do--	36	6	Mafic tuff---	4	7	3	0.09	H	

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
75	7.0 mi. NW of Farmer-----	Joe Ray Dunn--	Hill--	-Dr--	66	6	Felsic crystal tuff-------	-----	-----	4	--------	S	
76	5.5 mi. NW of Farmer-----	Brink Hunt----	--do--	--B--	34	24	Mafic tuff----	34	15	5	--------	S	
77	4.8 mi. NW of Farmer-----	J. M. Byrum---	Slope-	-Dr--	39	6	Mafic tuff breccia-----	4	9	5	0.14	M	Analysis in table.
78	3.1 mi. NW of Farmer-----	R. S. Ferrer--	Draw--	-do--	125	6	Mafic tuff and argillite---	-----	0	*3	--------	S	*Flows about 3 gpm when not pumped.
79	2.2 mi. N of Farmer-----	R. G. Yates---	Hill--	-do--	283	6	Argillite-----	-----	49	1.5	--------	--------	Observation well; analysis in table
80	5.5 mi. NE of Farmer-----	Howard Sawyer-	--do--	-do--	100	24	-----do------	-----	85	8	--------	S	
81	4.4 mi. W of Asheboro---	S. A. Lowe, Jr.	--do--	-do--	118	6	-----do------	-----	48	7	--------	S	Some iron reported.
82	Asheboro-----	Cólen Auman---	--do--	-do--	50	4	Mafic tuff----	10	20	10	0.25	--------	Analysis in table.
83	2.0 mi. E of Asheboro---	Herbert Shepherd----	Slope-	-do--	85	6	Crystal tuff-- and argillaceous tuff-------	-----	20	5	--------	S	
84	1.8 mi. S of Cedar Falls	Blue Mist Drive Inn---	Hill--	-do--	54	6	Mafic tuff----	32	-----	22	1.00	--------	
85	2.0 mi. SW of Franklinville	Clage Pritchard	--do--	-do--	120	6	-----do------	46	-----	3	.04	--------	
86	3.2 mi. SW of Ramseur----	John H. Williams----	--do--	-do--	80	6	-----do------	28	22	9	.18	S	
87	1.8 mi. W of Ramseur----	Melvin's Drive Inn---------	--do--	-do--	114	4	Argillite-----	40	12	10+	.14	S	
88	Ramseur------	Ramseur Furniture Co.----	Slope-	-do--	58	5	Argillite and graywacke---	-----	7	5	--------	--------	Observation well.

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
89	3.0 mi. S of Ramseur---	P. T. Allen---	Hill--	-Dr--	100	6	Mafic tuff---	95	60	10	2.00	M	
90	3.0 mi. SE of Ramseur---	Mrs. Allene Parks-------	--do--	--D--	51	36	Granodiorite	0	43	3	--------	S	
91	5.0 mi. E of Ramseur---	Earnest Burgess	Slope-	--B--	30	24	-----do------	30	25	1	--------	S	
92	5.5 mi. SE of Ramseur---	I. W. Parks---	--do--	-Dr--	75	6	Argillite----	25	-----	5	0.10	S	Some iron reported.
93	2.0 mi. NE of Coleridge-	H. W. Ferree--	--do--	-do--	125	6	Mafic tuff---	18	55	3	.03	S	Analysis in table.
94	2.8 mi. N of Coleridge-	J. M. Greene--	Knoll-	-do--	47	6	Granodiorite-	37	-----	12	1.25	S	Do.
95	Coleridge---	Randolph County Schools-----	Hill--	-do--	185	6	Argillite----	15	60	22	.13	--------	
96	2.3 mi. NW of Coleridge-	Francis Byrd--	--do--	-do--	74	4	Mafic tuff---	37	28	7	.18	S	
97	5.0 mi. NW of Coleridge-	Archie L. Rumley------	--do--	-do--	75	6	Phyllite-----	45	35	3	.10	S	Reported to have iron and to be corrosive.
98	6.3 mi. W of Coleridge-	T. E. Smith---	Draw--	-do--	72	4	Crystal lithic tuff-------	21	22	10	.20	S	
99	4.5 mi. SE of Asheboro--	Evelyn Smith--	Knoll-	-do--	126	4	Mafic tuff---	26	35	8	.08	S	
100	4.0 mi. E of Asheboro--	E. L. Smith---	Flat--	-do--	71	4	Crystal tuff-	42	28	12	.42	S	
101	4.0 mi. SE of Asheboro--	G. B. Beeson--	Slope-	-do--	62	4	Crystal lithic tuff-------	16	22	8	.17	S	Analysis in table.
102	3.0 mi. SE of Asheboro--	Coy J. Hamilton----	Hill--	-do--	60	4	Mafic tuff---	30	17	10	.33	S	
103	3.5 mi. S of downtown Asheboro--	Arthur Johnson	--do--	-do--	50	6	Crystal tuff-	18	-----	10	.31	S	

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
104	Asheboro-----	H. L. Frye-----	Hill--	-Dr--	75	6	Crystal tuff--	21	18	3	0.06	H	Reported to have iron and to be acid.
105	2.0 mi. NW of Ulah-------	J. E. Allred---	--do--	-do--	76	4	------do------	60	35	8	0.50	M	Reported corrosive.
106	4.4 mi. NW of Ulah-------	Walter Ganter--	--do--	-do--	100	6	------do------	------	-----	8	-------	M	
107	3.3 mi. W of Ulah-------	John J. Hill---	Draw--	-do--	110	6	------do------	22	30	2	0.02	S	
108	3.5 mi. NE of Farmer-----	James Morris---	Upland flat	--B--	80	24	Argillite-----	80	40	1	-------	S	
109	Farmer-------	Randolph County Schools------	Slope-	-Dr--	160	6	------do------	40	35	20	0.17	-------	
110	3.0 mi. W of Farmer-----	E. J. Bailey---	Knoll-	-do--	90	4	Argillite and mafic tuff--	------	6	8	-------	S	
111	3.8 mi. SW of Farmer-----	Paul Apple-----	Slope-	-do--	50	6	Gabbro and mafic tuff--	------	3	8	-------	M	Water reported to be limy.
112	2.8 mi. SW of Farmer-----	E. W. Elliot---	Hill--	-do--	135	2	Argillite-----	35	5	5	0.05	S	Some iron reported.
113	2.4 mi. SE of Farmer-----	T. V. Allman---	Slope-	-do--	99	6	------do------	55	34	25	0.59	S	
114	3.7 mi. SE of Farmer-----	Marshall Quick-	Knoll-	-do--	71	6	Crystal tuff--	------	23	1.5	-------	S	Observation well.
115	0.8 mi. S of Ulah-------	Ervin Cole-----	Hill--	-do--	83	6	Crystal lithic tuff--------	40	20	10	0.23	M	
116	2.4 mi. SE of Ulah-------	Mr. Garner-----	Slope-	-do--	49	4	------do------	36	-----	15	1.10	S	
117	4.3 mi. SE of Ulah-------	Richard E. Taylor-------	--do--	-do--	85	4	------do------	70	15	5	0.33	S	
118	6.3 mi. W of Coleridge--	Tom Brown------	Hill--	--B--	41	24	Crystal tuff--	41	24	3	-------	S	Observation well.

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
119	6.0 mi. W of Coleridge--	Ray Brown-----	Hill--	-Dr--	134	6	Crystal tuff-	123	17	5	0.46	S	
120	4.5 mi. SW of Coleridge--	E. A. Bean----	--do--	-do--	91	6	Felsic tuff--	------	------	9	-------	S	Analysis in table
121	3.5 mi. W of Coleridge--	Luther Owens--	Flat--	-do--	32	4	------do-----	------	11	8	-------	S	
122	1.9 mi. SW of Coleridge--	Mrs. Van Oldham------	--do--	--B--	24	24	------do-----	34	12	3	-------	S	
123	3.1 mi. S of Coleridge--	N. L. Rumley--	Slope-	-Dr--	42	6	------do-----	15	15	7	0.26	M	
124	2.7 mi. SE of Coleridge--	D. E. Brown---	Hill--	-do--	60	6	Mafic argillite--	------	30	5	-------	M	Limy taste reported.
125	4.9 mi. SE of Coleridge--	L. B. Goins---	Slope-	-do--	36	6	Mafic tuff---	20	30	1.5	0.09	-------	
126	5.2 mi. SE of Coleridge--	Albert Brown--	Hill--	-do--	126	6	------do-----	14	46	0.1	.00	H	
127	4.8 mi. S of Coleridge--	Roy Macon-----	--do--	-do--	80	6	Mafic argillite--	53	------	20	.72	S	
128	1.2 mi. N of Erect------	M. D. Chrisco-	--do--	--B--	31	22	Felsic tuff--	31	21	5	-------	S	
129	2.2 mi. W of Erect------	Clinton Richardson--	Slope-	-Dr--	64	6	Mafic crystal tuff-------	30	------	20	0.60	S	
130	2.3 mi. NW of Erect------	E. E. Hammer--	Hill--	--D--	38	30	Welded flow	38	32	1	-------	S	
131	4.0 mi. N of Seagrove---	F. L. Allen---	--do--	-Dr--	81	4	Crystal lithic tuff-------	35	18	8	0.18	S	
132	2.7 mi. N of Seagrove---	Huldah Baptist Church------	--do--	-do--	80	4	Lithic crystal tuff-------	------	-----	8	-------	S	
133	2.9 mi. S of Ulah-------	C. C. Boling--	--do--	--B--	40	24	Crystal tuff-	40	23	4	-------	S	

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
134	3.2 mi. SW of Ulah-------	Ervin Parks---	Slope-	-Dr--	155	6	Crystal tuff-	17	20	20	0.14	M	Limy water reported; analysis in table.
135	5.5 mi. SW of Ulah-------	High Pines Church-----	Flat--	-do--	64	6	Welded flow tuff-------	-----	30	10	-------	S	
136	2.0 mi. S of Martha-----	Jack Lanlier--	Knoll-	-do--	100	6	Argillite----	45	35	4	0.07	S	
137	2.9 mi. SW of Martha-----	Roscoe Miller-	Flat--	-do--	100	4	Tuffaceous argillite--	60	4	6	0.15	S	
138	4.9 mi. SW of Martha-----	J. B. Surratt-	Slope-	--D--	25	40	-----do------	0	19	1	-------	M	
139	4.2 mi. S of Martha-----	C. A. Lanier--	Knoll-	-Dr--	170	4	Argillite----	40	-----	0.5	0.00	--------	
140	4.4 mi. SE of Martha-----	R. C. Millkan-	Hill--	-do--	125	6	-----do------	40	57	12	0.14	S	Analysis in table.
141	3.3 mi. W of Pisgah-----	Arthur Hill---	--do--	-do--	129	6	Crystal tuff	70	-----	5	0.08	--------	
142	1.0 mi. W of Pisgah-----	Lacy Strider--	Flat--	-do--	100	6	-----do------	12	7	7	0.08	S	
143	1.5 mi. E of Pisgah-----	Gray Lambert--	Slope-	-do--	70	6	-----do------	15	-----	8	0.14	S	
144	2.6 mi. NW of Seagrove---	Grady Auman---	Knoll-	-do--	70	6	-----do------	60	-----	8	0.77	S	
145	1.5 mi. NW of Seagrove---	Arthur Latham-	Flat--	-do--	124	6	Crystal tuff-	28	30	3.5	0.04	S	
146	Seagrove-----	C. R. Richardson---------	Knoll-	-do--	75	6	-----do------	40	20	20	0.56	M	
147	2.4 mi. NE of Seagrove---	J. E. Spivey--	Slope-	-do--	40	6	-----do------	35	20	5	1.00	S	Reported to be corrosive to copper.

Table 20. Records of Wells in Randolph County (Continued)

(Reported hardness: H,hard; M,medium; S,soft)
(Type of well: B,bored; D,dug; Dr,drilled. Relative yield: gallons per minute per foot of uncased hole.)

Well no.	Location	Owner	Topography	Type of well	Depth (ft.)	Diameter (in.)	Water-bearing material	Depth of casing (ft.)	Water level (ft.)	Yield (gpm)	Relative yield (gallons per foot)	Reported hardness	Remarks
148	Erect--------	Lewis Teague---	Slope--	-Dr--	102	6	Felsic tuff--	18	40	17	0.20	S	Reported to have iron.
149	2.0 mi. SE of Erect------	Robert Garner--	Hill---	-do--	95	6	-----do------	90	25	18	3.33	S	
150	3.4 mi. SE of Erect------	Frank Kiser----	Flat---	-do--	71	5	Mafic argillite--	11	19	0.5	.01	--------	Observation well.
151	5.5 mi. SE of Erect------	Sam Caviness---	Knoll--	-do--	55	6	Mafic tuff---	-----	20	4	------	H	Some iron reported.
152	3.4 mi. S of Erect------	J. W. Culler---	Hill---	-do--	82	6	Sheared felsic tuff	70	37	20	1.66	S	Encountered quartz veins.
153	2.7 mi. SW of Erect------	Everett Stutts-	--do---	-do--	111	6	Phyllite-----	54	31	14	.24	S	Some iron reported; analysis in table.
154	3.1 mi. SE of Seagrove---	F. L. Gatlin---	Flat---	--B--	54	24	Felsic tuff--	54	20	7	------	S	
155	Seagrove-----	Lucks, Inc.----	Slope--	-Dr--	275	6	Rhyolite-----	35	-----	25	0.10	--------	Analysis in table.
156	1.8 mi. S of Pisgah-----	Barnett Payne	Flat---	-do--	103	6	Crystal tuff-	93	30	20	2.00	S	
157	6.2 mi. SW of Pisgah-----	Everett Simmons	Slope--	-do--	95	4	Argillite----	-----	25	3	------	--------	Reported to be corrosive.
158	5.9 mi. S of Martha-----	Ratio Cranford	Knoll--	-do--	135	4	-----do------	-----	32	1.5	------	S	

Table 21. Chemical Analyses of Ground Water from Randolph County (Numbers heading the columns correspond to well numbers in table 20)

(Parts per million)

	3	16	28	33	42	53	57	63	77	79	82	93	94	101	120	134	140	150	153[1]	155
Date of collection	12/17/62	12/17/62	12/17/62	5/13/59	12/17/62	12/17/62	12/17/62	12/18/62	1/4/63	12/17/62	10/17/62	10/17/62	12/18/62	10/17/62	10/17/62	10/17/62	10/17/62	1/15/62	10/17/62	10/17/62
Silica (SiO_2)	43	34	42	31	6.6	31	28	28	17	14	31	23	19	29	22	27	23	--	29	28
Aluminum (Al)	.0	.1	.0	.0	.0	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.1	.0	--	.1	.0
Iron (Fe)	.07	.04	.07	.06	.69	1.4	5.0	.22	.18	.04	.10	.03	.33	2.0	--	3.2	--	--	5.4	.00
Manganese (Mn)	.01	.05	.01	.01	.00	.05	.01	.05	--	--	--	--	.03	--	--	--	--	--	--	--
Calcium (Ca)	22	67	10	23	1.9	22	37	24	13	7.0	19	44	2.6	5.0	6.5	52	6.7	388	38	9.8
Magnesium (Mg)	7.5	30	7.9	6.0	.7	6.3	28	10	14	4.6	7.0	16	2.2	1.3	2.9	6.4	4.2	89	19	3.5
Sodium (Na)	2.8	18	11	11	.2	8.7	15	11	6.1	2.2	14	18	2.3	6.8	8.2	13	7.2	--	24	8.8
Potassium (K)	.1	2.0	.2	1.1	.1	.2	.1	1.4	.1	.1	1.0	.3	.2	1.1	.6	3.8	.4	--	.8	1.7
Lithium (Li)	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.1	.0	--	.2	.0
Bicarbonate (HCO_3)	102	291	64	120	11	116	166	139	82	34	106	192	20	29	46	183	40	412	136	53
Sulfate (SO_4)	5.4	26	14	1.0	.8	7.6	3.0	2.6	22	1.0	4.4	7.8	.4	2.6	3.8	13	2.8	--	6.8	4.0
Chloride (Cl)	1.0	42	6.6	1.1	.2	.2	71	6.0	6.6	4.0	9.0	27	1.0	2.3	2.0	16	4.7	750	78	6.8
Fluoride (F)	.0	.1	.2	.0	.0	.1	.2	.1	.0	.1	.0	.1	.0	.1	.0	.1	.1	--	.1	.1
Nitrate (NO_3)	1.0	2.7	8.2	.1	.2	.2	.9	.9	5.4	13	1.5	11.	4.6	5.0	1.6	1.7	13	.1	1.8	1.7
Phosphate (PO_4)	.0	.3	.1	.1	.0	.0	.0	.0	.0	.1	.1	.1	.0	.0	.0	.0	.2	--	.0	.0
Dissolved solids	133	365	132	130	16	134	265	152	125	63	139	242	42	67	71	223	82	--	265	89
Hardness as $CaCO_3$	86	291	58	81	8	82	207	100	90	36	76	174	16	18	28	156	34	1340	174	36
Noncarbonate	2	52	6	0	0	0	71	0	23	8	0	16	0	0	0	6	1	998	63	0
Specific conductance	179	610	188	200	22	190	478	258	255	92	180	375	53	72	85	338	107	3100	458	112
pH	6.9	7.2	6.5	8.0	6.2	7.2	6.9	7.4	6.6	6.6	6.9	6.9	6.4	6.1	6.4	7.2	6.6	7.2	6.6	6.5
Color	--	--	--	5	--	--	--	--	3	3	3	3	--	3	3	3	3	--	3	3
Map unit	Granite and granodiorite	Granite and granodiorite	Granite and granodiorite	Meta-volcanic	Meta-volcanic	Meta-volcanic	Meta-volcanic	Argillite-graywacke	Meta-volcanic	Argillite-graywacke	Meta-volcanic	Meta-volcanic	Granite and granodiorite	Meta-volcanic	Meta-volcanic	Meta-volcanic	Argillite-graywacke	Argillite-graywacke	Meta-volcanic	Meta-volcanic

[1] Bromide (Br)--0.17 ppm.

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Argillite-Graywacke Unit

Tuffaceous Argillite Unit

Mafic Tuff and Flow Unit

Granite and Granodiorite Unit

Diorite Unit

Gabbro Unit

Triassic Unit

J. M. Parker

GEOLOGY AND GROUND-WATER
in the
DURHAM AREA, NORTH CAROLINA

PLATE I

MAP OF THE DURHAM AREA
SHOWING
AREAL DISTRIBUTION
OF
YIELDS PER FOOT OF DEPTH

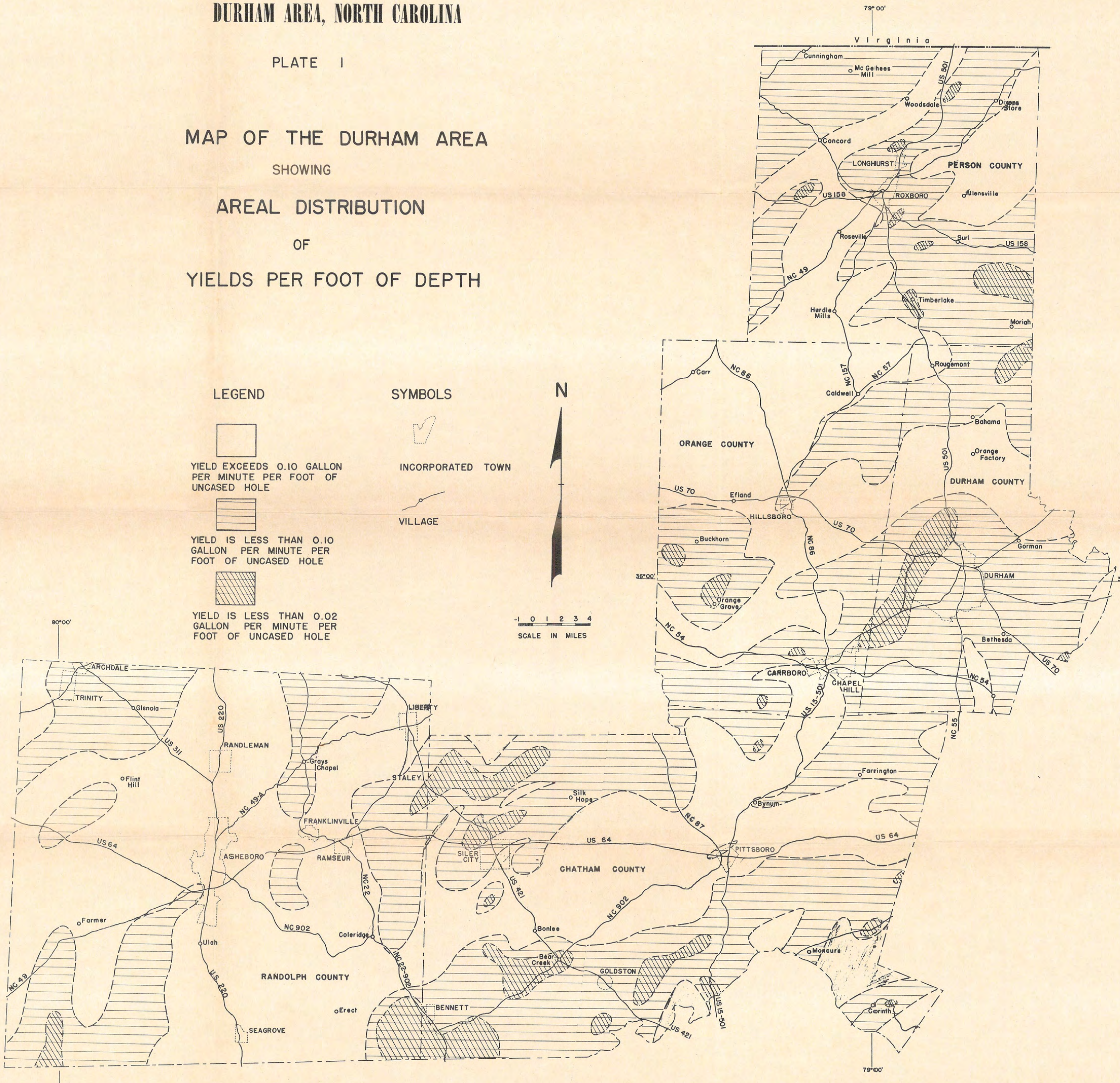

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PLATE 2

RECONNAISSANCE GEOLOGIC MAP

OF THE

DURHAM AREA, NORTH CAROLINA

EXPLANATION

TRIASSIC

Newark Group

Triassic unit

₸s, shale and sandstone; ₸d, diabase

MISSISSIPPIAN (?)

Mgr — Granite and granodiorite unit

Mgd — Gabbro and diorite units

ORDOVICIAN (?)

Mafic tuff and flow unit

Ota — Tuffaceous argillite unit

Oa — Argillite — graywacke unit

Omv — Metavolcanic unit

PRECAMBRIAN

p€hg — Hornblende gneiss unit

p€mg — Mica gneiss and schist unit

Reconnaissance Geology by George Bain

SYMBOLS

APPROXIMATE LOCATION OF CONTACT

GRADATIONAL CONTACT

ANTICLINAL AXIS

SYNCLINAL AXIS

FAULT

Dashed where approximate. U, upthrown block; D, downthrown block.

Geology in part after Reinemund, 1955