NORTH CAROLINA
DEPARTMENT OF WATER AND AIR RESOURCES
George E. Pickett, *Director*

DIVISION OF GROUND WATER
Harry M. Peek, *Chief*

REPORT OF INVESTIGATIONS NO. 8

# GROUND WATER RESOURCES OF THE BELHAVEN AREA NORTH CAROLINA

By

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PREPARED COOPERATIVELY BY THE GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR
AND THE NORTH CAROLINA
DEPARTMENT OF WATER AND AIR RESOURCES

RALEIGH 1968

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RALEIGH, N. C. 27603
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The Honorable Dan K. Moore
Governor of North Carolina
Raleigh, North Carolina

Dear Governor Moore:

I am pleased to submit Report of Investigations Number 8, "Ground-Water Resources of the Belhaven Area, North Carolina" by Orville B. Lloyd and Edwin O. Floyd, U. S. Geological Survey.

This report contains the results of a study of ground-water conditions in the vicinity of Belhaven and evaluation of possible new sources of water supply for the Town of Belhaven. The study was conducted cooperatively by the U. S. Geological Survey and the North Carolina Department of Water and Air Resources.

Respectfully submitted,

George E. Pickett

# THE GROUND-WATER RESOURCES OF BELHAVEN AND VICINITY, NORTH CAROLINA

By

Orville B. Lloyd, Jr.,

and

Edwin O. Floyd

## ABSTRACT

The area of study is located in northeastern Beaufort County in the Coastal Plain province of North Carolina and is about 150 square miles. Topography is relatively flat and elevations range from near sea level at the streams to about 20 feet above sea level in the northwestern part of the area. Average annual rainfall is about 52.5 inches, and average annual temperature is approximately 61° F.

The sediments that underlie the area are composed of about 2,500 feet of sand, silt, clay, shell, and limestone beds, that range in age from Cretaceous to Recent. Three aquifers of sand, shell, and limestone (herein designated as aquifers A, B, and C) containing fresh water, occur in the sedimentary section between land surface and a depth of about 300 feet. The sediments below 300 feet are saturated with salty water. Ground water occurs under non-artesian conditions in aquifer A (the water-table aquifer), and it occurs under artesian conditions in aquifers B and C. Theoretically, yields from properly constructed wells screening the full thickness of aquifers A, B, and C are less than 1, 10, and about 80 gpm (gallons per minute) per foot of water-level drawdown, respectively. The total of dissolved solids in water from these aquifers is generally below 500 ppm (parts per million), except in the lower part of aquifer C where high concentrations of chloride are encountered. Water containing excessive concentrations of dissolved iron, hardness-causing constituents, and/or hydrogen-sulfide gas is common in each of the fresh water-bearing aquifers in the area.

Large ground-water withdrawals associated with the open-pit mining of phosphate deposits southwest of the area have caused an extensive cone of depression in aquifer C, the major artesian aquifer in the area. At the time of this investigation, water levels had declined about 12 feet in aquifer C in the vicinity of Belhaven; this decline has increased the probability of salt-water contamination where heavy pumpage from this aquifer is anticipated in the Belhaven area. Aquifers A and B, to date, are relatively unaffected by substantial water-level declines and the threat of salt-water contamination. They should be considered as an alternative source of ground-water supply if further withdrawals from aquifer C create water-management problems.

# INTRODUCTION

## PURPOSE AND SCOPE OF INVESTIGATION

The purpose of this investigation was to determine the lithic character, areal extent, depth, thickness, and water-yielding characteristics of the water-bearing formations and the chemical quality of their contained water in the vicinity of Belhaven, North Carolina.

Pronounced lowering of water levels in the principal aquifer, increased municipal water needs, and the possibility of salt-water encroachment have caused extensive problems in this area. Consequently, in 1966 the town of Belhaven requested the U. S. Geological Survey to make a detailed investigation of ground-water resources in the area. The work was done between June 1966 and June 1967 by cooperative agreement between the town of Belhaven, the North Carolina Department of Water Resources and the U. S. Geological Survey.

## DESCRIPTION OF THE AREA

The area of investigation is in the northeastern part of Beaufort County, North Carolina, and is about 150 square miles (fig. 1). About half of the land is cleared and used mainly for agriculture, and the remainder is forested. State Highway 99 enters the area from the north and U. S. Highway 264 crosses the southern part of the area in an east-west direction.

The town of Belhaven, the largest urban center, has a population of 2,365 according to the 1960 census. Estimated total population in the area is 5,000.

## PHYSIOGRAPHY

The project area is in the Atlantic Coastal Plain province of North Carolina. The Coastal Plain is generally characterized by a relatively flat surface that slopes gently to the southeast. This surface is divided into a number of marine terraces that were formed by wave and current action during periods when portions of the Coastal Plain were submerged beneath the sea. The terrace surfaces have been dissected by streams and rivers since the sea retreated.

The Belhaven area is located on the lowermost terrace. In the northern and northwestern part of the area drainage is poorly developed, and a large part of the land is occupied by swamps. Elevations in this vicinity range from 8 to 18 feet above msl (mean sea level). In the southern and southeastern part of the area the terrace is better drained by natural streams and ditches, and swamps are less extensive. Land surface elevations in this vicinity range from near sea level at the streams to about 5 to 13 feet above sea level in the interstream areas. Generally all streams flow to the south and southeast and are tributary to the Pungo River (fig. 1).

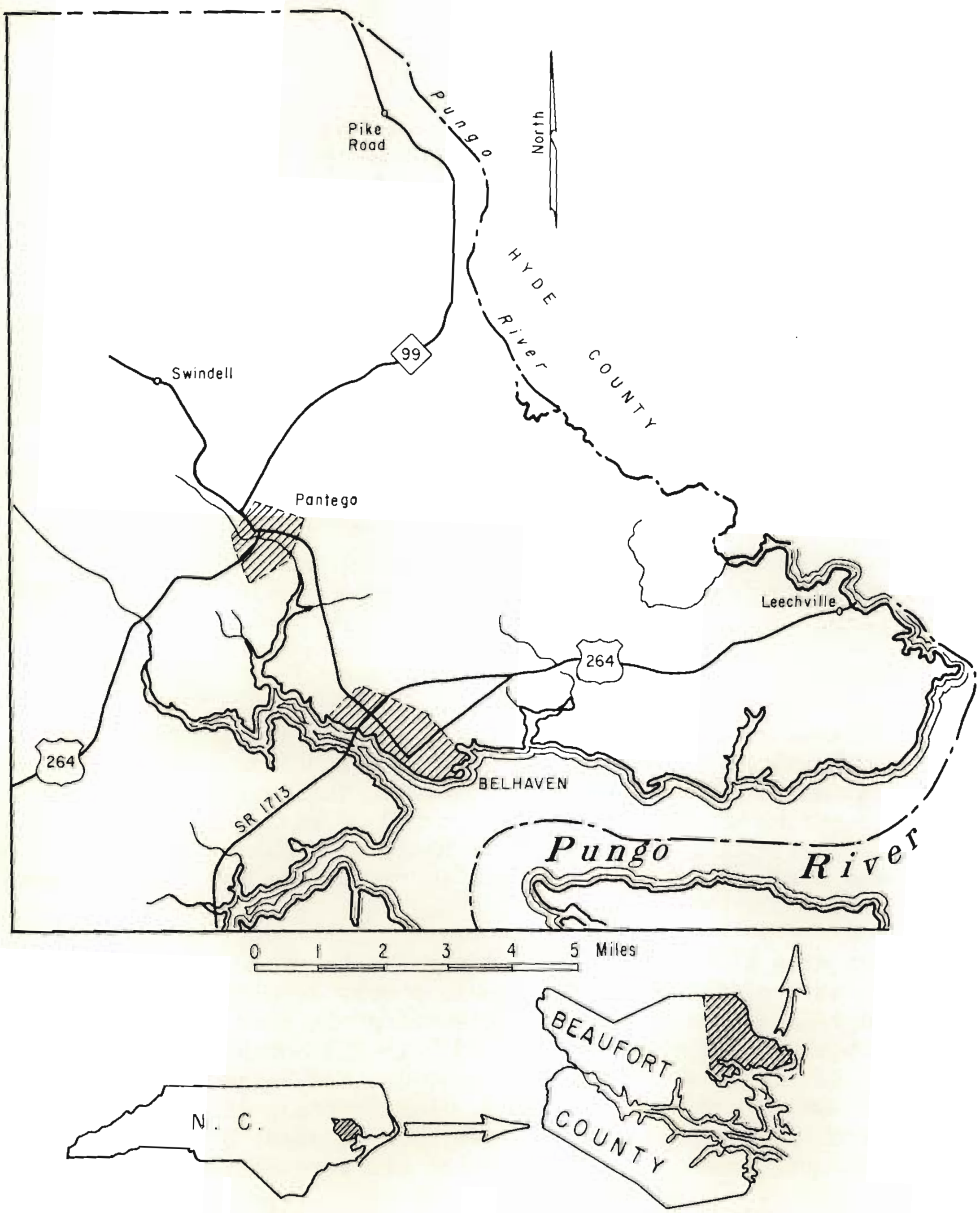



Figure 1.--Map showing the location of the study area.

## CLIMATE

The climate of the area is humid subtropical, characterized by warm summers, relatively mild winters, and precipitation that is well distributed throughout the year. U. S. Weather Bureau records indicate that the average annual temperature is approximately 61° F., and the average annual rainfall is about 52.5 inches. Figure 2 shows a graphic climatic summary for Belhaven.

## PREVIOUS INVESTIGATIONS

Clark and others (1912) briefly described the geology and water resources of Beaufort County in a report on the Coastal Plain of North Carolina. This report includes 13 inventoried wells and 3 chemical analyses of water from wells in the vicinity of Belhaven. Mundorff (1945) reported the Yorktown Formation as the major water-bearing formation in the vicinity of Belhaven. He included 3 inventoried wells and 2 chemical analyses of water from wells in this area in his report. Brown (1958) described the relation of the middle Miocene phosphorite deposits to ground water in Beaufort County, and (Brown, 1959) described the geology and ground-water resources of Beaufort County in an eight-county reconnaissance report. This latter report includes 25 inventoried wells, and 9 chemical analyses of water from wells in the vicinity of Belhaven. Nelson and Peek (1964) described the geology and water-bearing units in Beaufort County with emphasis on the potential effects of phosphate mining near Aurora. Kimrey (1964) proposed the name Pungo River Formation for the middle Miocene phosphorites in Beaufort County, and (Kimrey, 1965) briefly described the ground-water hydrology of the county in a report emphasizing the detailed descriptions of the Pungo River Formation in Beaufort County.

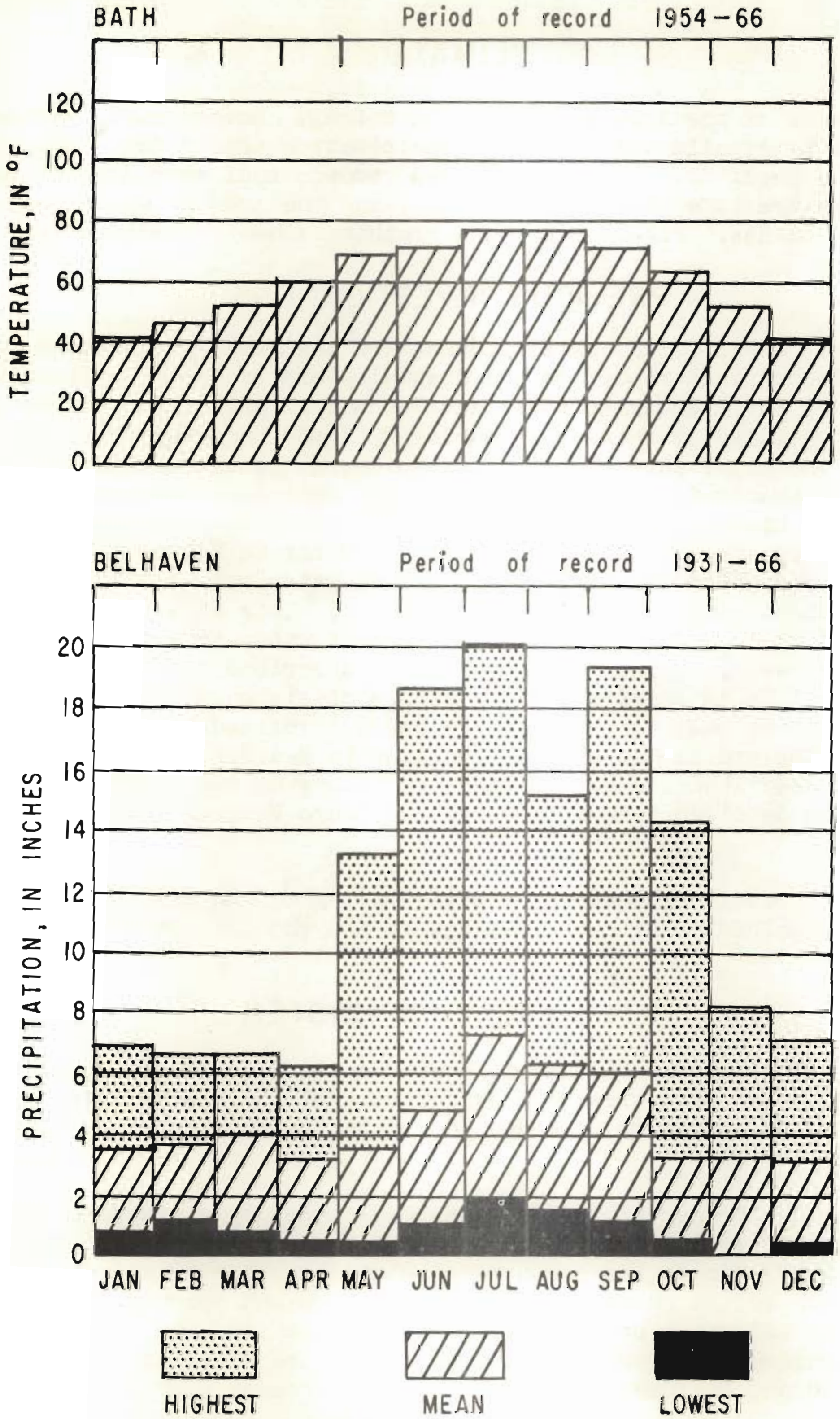
These previous investigations provided accurate and pertinent data that were extremely helpful during the field work and the preparation of this report.

## WELL-LOCATION SYSTEM

The well-location system used in North Carolina conforms to the system adopted by the U. S. Geological Survey for the data card processing of well information. This system is intended to locate the position of a given well on the earth's surface.

Positions on the earth's surface may be located by a system of coordinates known as parallels of latitude and meridians of longitude. The parallels of latitude circle the earth parallel to the equator and are numbered from the equator to the poles in degrees, minutes, and seconds, depending upon the angular distance between them and the equator. The meridians of longitude traverse the earth north and south and are numbered east or west from the Greenwich, England, prime meridian in degrees, minutes, and seconds.

The well-location system derived from latitude and longitude coordinates, is based on a grid of 1-second parallels of latitude and meridians of longitude. The wells in a 1-second quadrangle are numbered consecutively in the order inventoried.




Note: Record of temperature taken at Bath, N. C., for the period from 1954-66. Record of precipitation taken at Belhaven, N.C., for the period from 1931-66.

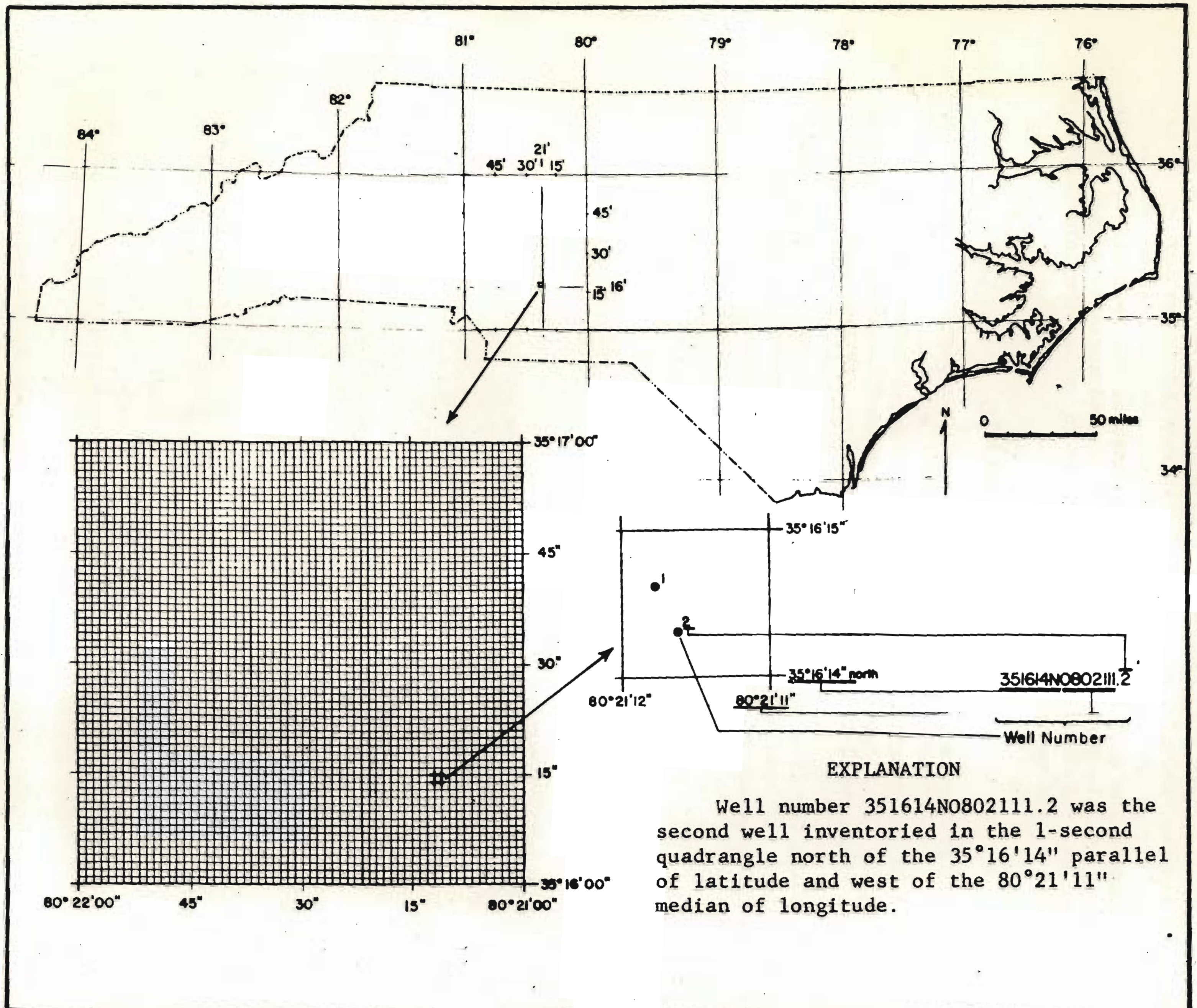
Figure 2.--Climatic summary for Belhaven and vicinity.

The well-location number is composed of fifteen numbers and letters (table 4): the first six numbers and one letter compose the digits of the degrees, minutes, seconds, and indicate northern (N) or southern (S) hemisphere that define the latitude of the 1-second quadrangle; the next seven numbers compose the digits of the degrees, minutes, and seconds that define the longitude on the east side of the 1-second quadrangle; the last number, following a decimal, indicates the order in which wells were inventoried within the 1-second quadrangle (fig. 3)

## ACKNOWLEDGMENTS

Special gratitude is due the residents of northeastern Beaufort County for supplying pertinent information about their wells and for allowing tests to be made on their wells. Heber Wilkerson, Superintendent of Public Utilities of Belhaven, J. M. Hudson, and Joe Ratcliff, well drillers, were especially helpful in making well data available during the investigation.

The North Carolina Department of Water Resources drilled a test well about 2 miles north of Belhaven and supplied drill cuttings, logs, and pertinent data collected during and after the drilling.




EXPLANATION

Well number 351614N0802111.2 was the second well inventoried in the 1-second quadrangle north of the 35°16'14" parallel of latitude and west of the 80°21'11" median of longitude.

Figure 3.--Map of North Carolina showing the method of determining latitude-longitude well numbers.

# GEOLOGY

An understanding of the geology of the area is requisite to the evaluation of the occurrence, availability, and chemical quality of the ground-water resources. The type and distribution of the rock materials determine the capacity of the rocks to store and transmit water, and the chemical character of the rock materials has a great influence on the amount and kind of dissolved mineral matter found in the water.

## GEOLOGIC FORMATIONS

The geologic formations that underlie the area comprise about 2,500 feet of sand, silt, clay, shell, and limestone beds that range in age from Cretaceous to Recent. Figure 4 shows the depths, thickness, and general lithology of the formations penetrated during the test drilling in the area of investigation. The sediments penetrated below the upper half of the Castle Hayne limestone contain brackish and saline water, and for this reason only the units of Eocene and younger age are discussed below.

### TERTIARY SYSTEM

#### Eocene Series

Castle Hayne limestone.--The Castle Hayne limestone (Clark and others, 1912), of middle Eocene age, is not present at the surface in any part of the area of investigation. The top of this formation is an irregular undulatory surface. The formation dips toward the east about 10 feet per mile. Depths to the top of the limestone range from about 175 feet below msl in the west to more than 325 feet below msl in the eastern part of the area (fig. 5). Average thickness is approximately 200 feet.

The upper half of this formation is composed of indurated, light-tan to dark-gray, fossiliferous limestone. The fossils, mainly pelecypods, are in the form of casts and molds; none of the original shell material remains. In the lower half of the formation, hard beds of the indurated limestone described above are interlayered with beds of medium- to coarse-grained, calcareous quartz sand. The sand beds predominate near the base of the formation. Thin layers of calcareous clay, crystalline limestone, and dolomitic limestone are found throughout the lower half of the formation. Glauconite and phosphate (collophane) are the common accessory minerals.

#### Miocene Series

Pungo River Formation.--The Pungo River Formation (Kimrey, 1964), of middle Miocene age, occurs entirely in the subsurface and unconformably overlies the Castle Hayne limestone in the area of study. Generally the top of this formation strikes in a north-south direction and dips about 9 feet per mile toward the east. The depth to the top of this unit ranges from 150 feet below msl in the western part, to about 275 feet below msl in the eastern part of the area (fig. 6). The thickness of these sediments ranges from 25 feet in the west to 50 feet in the east, and averages about 35 feet.

The Pungo River Formation consists of greenish-brown to greenish-gray interbedded layers of phosphatic sand, silt, clay, and limestone. Concentrations of up to 50 percent fine- to medium-grained spherules of brown to black phosphate (collophane) are not uncommon in the phosphatic sands.

Yorktown Formation.--The Yorktown Formation (Clark and others, 1912), of late Miocene age, unconformably overlies the Pungo River Formation. Like the Castle Hayne Limestone and Pungo River Formation, it is confined to the subsurface throughout the area. The top of this formation is found between 20 and 30 feet below land surface, and the thickness of the deposits ranges from about 120 feet in the west to more than 240 feet at the eastern limits of the area. The sediments are composed chiefly of gray, fine- to coarse-grained quartz sands and white to gray shell beds, interlayered with blue-gray silts and clays. Pelecypod, gastropod, coral, and bryozoan remains comprise the major portion of the shell beds. Fine-grained glauconite and phosphate (collophane) are prominent accessory minerals.

## QUATERNARY SYSTEM

### Post-Miocene Series

Surficial deposits.--These sediments overlie the Yorktown Formation throughout the study area. Their top is represented by land surface, their thickness ranges from a thin veneer near the streams and rivers to more than 30 feet in some of the higher interstream areas. These deposits are composed of interbedded and lenticular quartz sand, silt, and clay. Iron-oxide stain is prominent on the sedimentary particles.

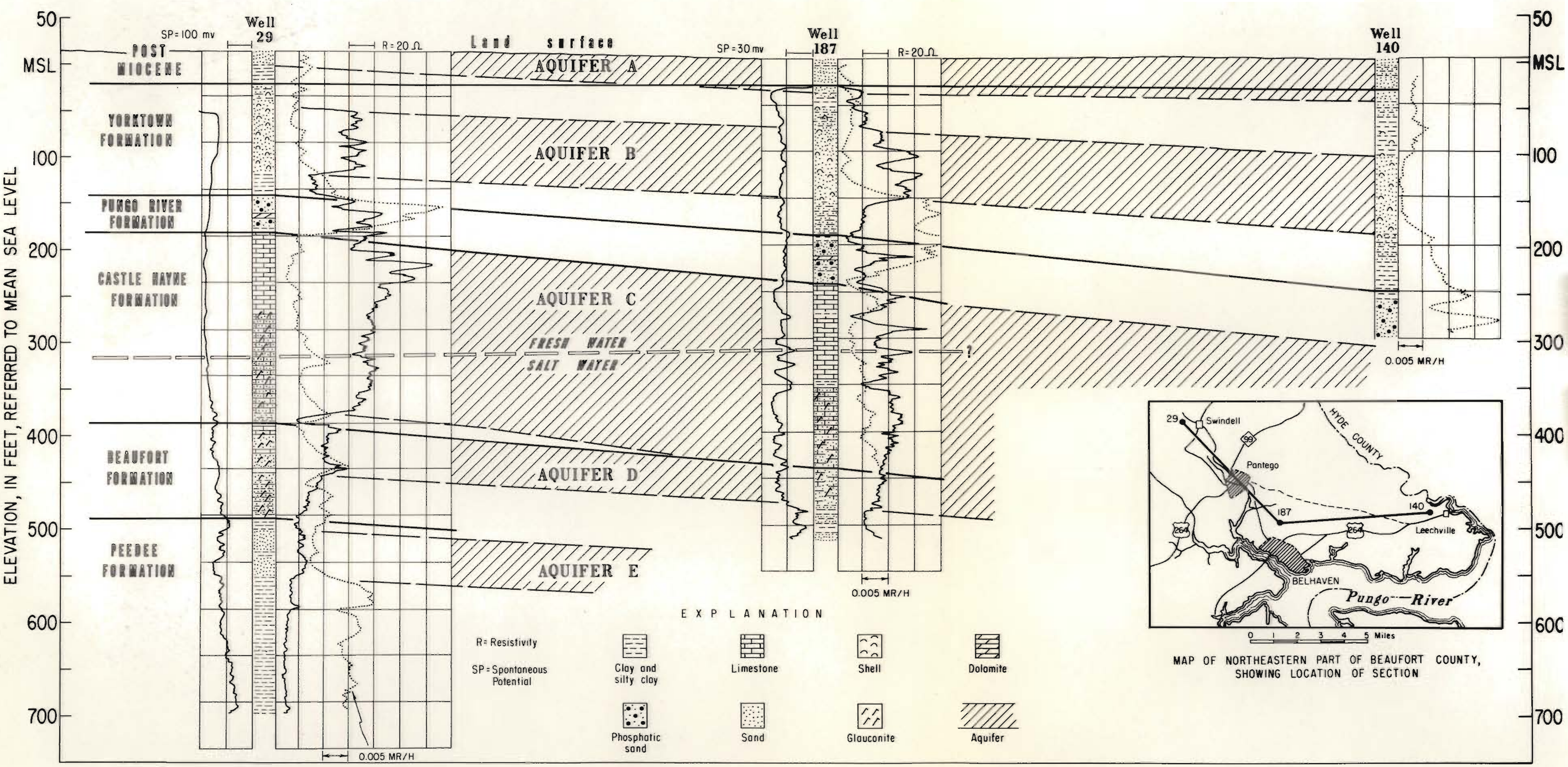



Figure 4.--Section showing the correlation of geologic formations and aquifers by using electric, gamma-ray, and lithic logs in the vicinity of Belhaven, N. C.

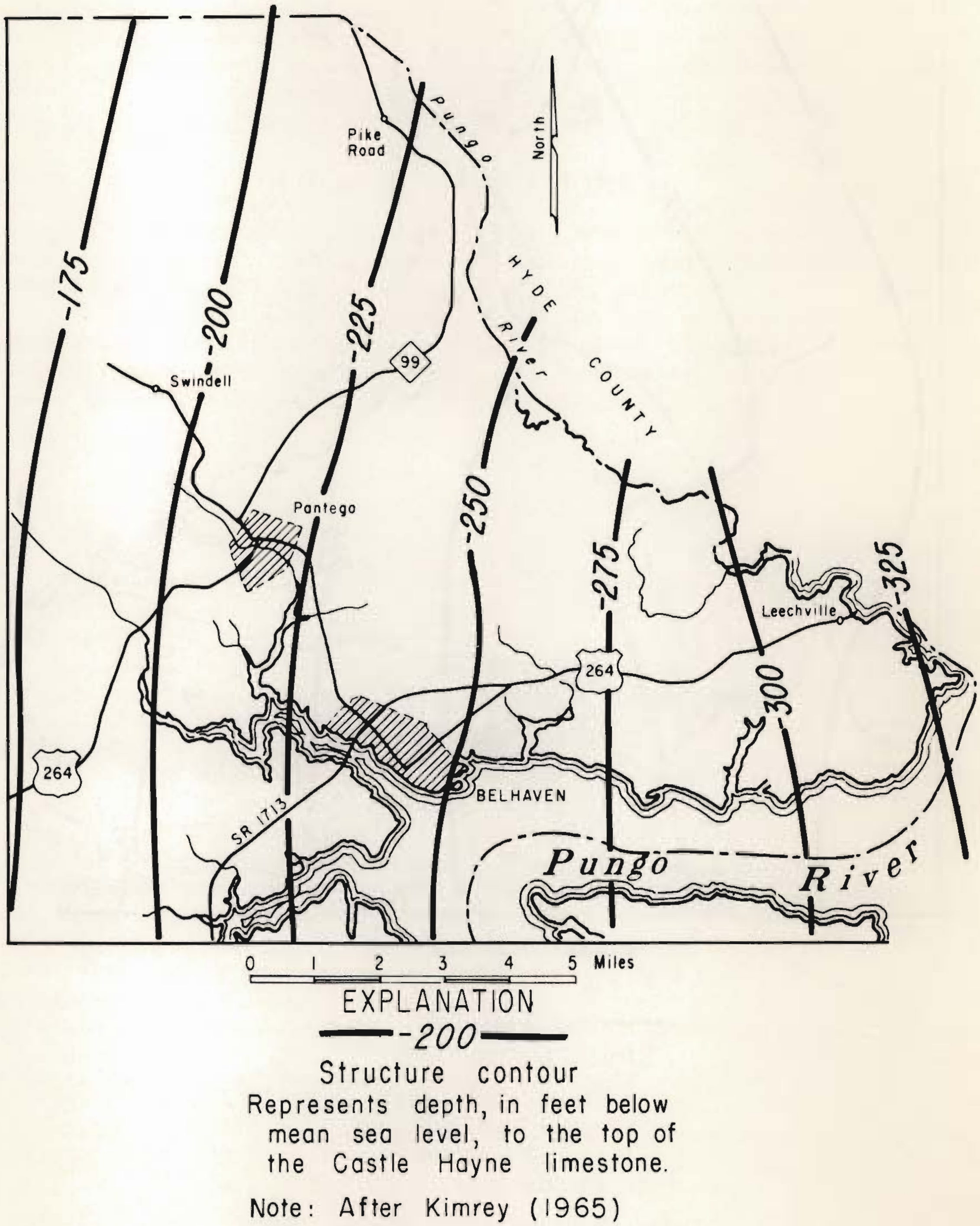



Figure 5.--Map showing the configuration of the top of the Castle Hayne limestone.

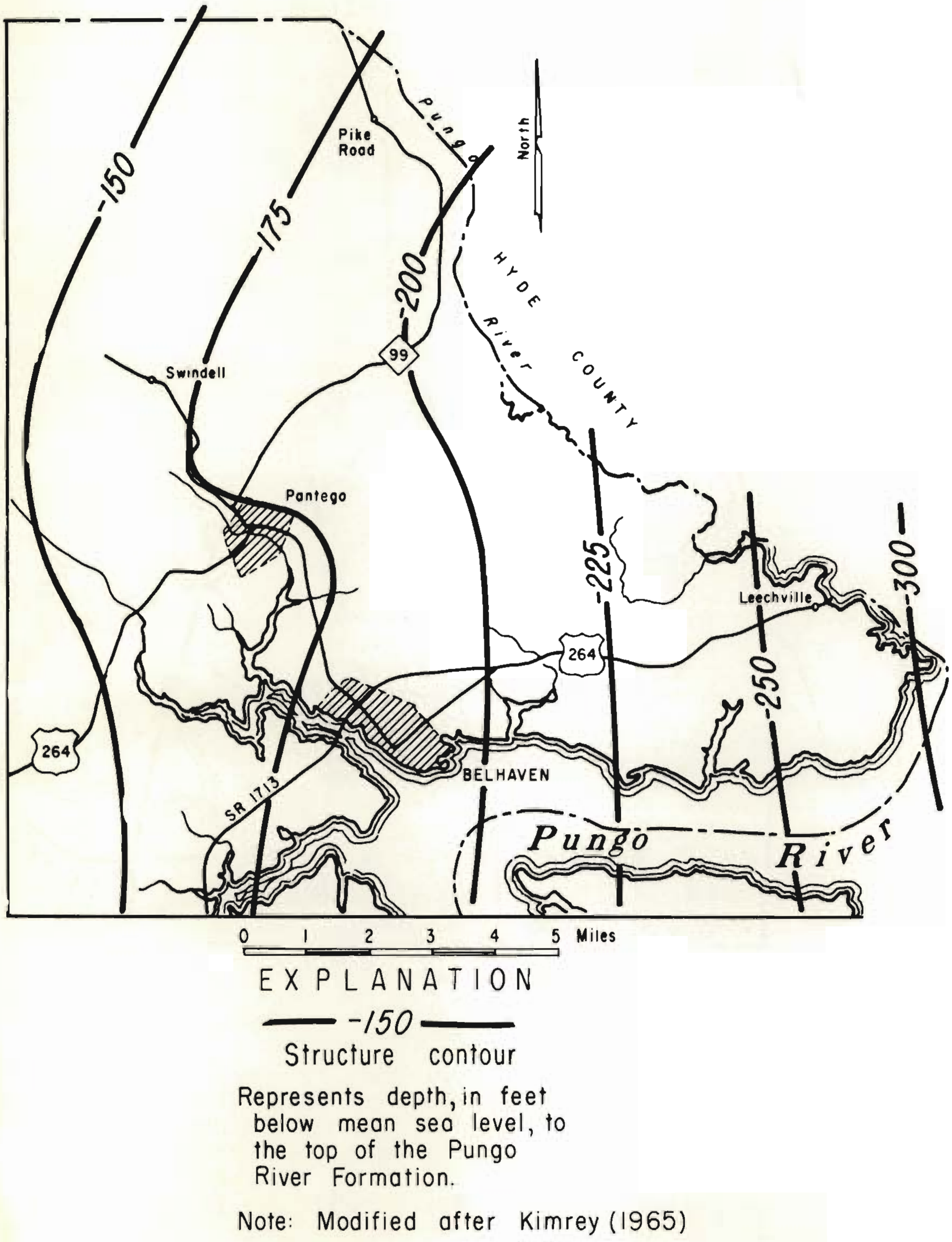



Figure 6.--Map showing the configuration of the top of the Pungo River Formation.

# GROUND WATER

## SOURCE AND OCCURENCE

Of the 52.5 inches of precipitation that falls annually on the area, some runs off overland into the streams and rivers, some is returned to the atmosphere by evaporation or through transpiration by plants, and an estimated 15 to 25 percent of it percolates downward to the zone of saturation and becomes ground water.

The zone of saturation is the zone in which all the pore spaces in rock or soil are filled with water. This zone includes all the sedimentary material in the area between basement rock, about 2,000 feet below land surface, and the water table, about 5 feet below land surface.

Water in the zone of saturation occurs under water-table (unconfined) and artesian (confined) conditions. Water occurs under unconfined or non-artesian conditions in the permeable material between land surface and the first impermeable zone found below land surface. Water at the water table, the upper surface of the unconfined ground water, is at atmospheric pressure. The water table is free to rise and fall in response to changes in climatic factors. Under non-artesian conditions the water level in a well represents the water table.

Ground water in permeable material overlain by impermeable units is confined beneath the impermeable layers and occurs under artesian conditions. The upper surface of artesian water is not free to rise and fall in response to changes in climatic factors because it is fixed by the overlying confining layer. However, the hydraulic or artesian pressure exerted against the confining layer responds to changes in climatic factors. Under artesian conditions the water level in a well will rise above the top of the water-bearing zone to a height nearly equal to the hydraulic pressure in that zone. At any given time, the heights of water levels in wells tapping the same artesian zone define the piezometric surface of the water-bearing formation.

## AQUIFERS

Any formation, part of a formation, or group of formations in the zone of saturation that will transmit usable quantities of water to wells is called an aquifer.

There are many aquifers within the various geologic formations that underlie the area. Those that are known to contain fresh ground water are found between land surface and about 300 feet below land surface, and are of primary importance here. These water-bearing zones are referred to by letter (A, B, and C) rather than by formation because they occur in only part of one formation or include more than one formation (fig. 4). The deeper aquifers that contain brackish or saline water exclusively will be mentioned only briefly below.

## AQUIFER A

Aquifer A is composed of all the saturated permeable sands from land surface to the first impermeable material found below land surface. This generally includes most of the post-Miocene sediments throughout, and both the post-Miocene and the upper part of the Yorktown sediments in the central and eastern part of the area (fig. 4). The average thickness of aquifer A is about 35 feet. Water in this aquifer is unconfined and occurs under non-artesian or water-table conditions. Sustained yields from 1-1/4- to 36-inch diameter wells tapping aquifer A are low, usually less than 10 gpm. The water from this aquifer is generally corrosive and contains excessive concentrations of dissolved iron. Locally it is very hard.

## AQUIFER B

Aquifer B includes the shell and sand beds found near the middle part of the Yorktown Formation, and is separated from aquifer A by lenticular silt and clay layers (fig. 4). The impermeable layers overlying aquifer B confine the water in this aquifer under artesian conditions where the silts and clays are thick, and under semi-artesian or leaky-artesian conditions where they are thin. The top of this aquifer strikes in a general north-south direction and dips about 5 feet per mile toward the east. Depths to its top range from 40 feet below msl in the western part, to about 110 feet below msl in the eastern part of the area (fig. 7). Average thickness is about 70 feet (fig. 4). Yields from existing 1-1/4- to 4-inch diameter wells range from 4 to 75 gpm. A properly constructed 10-inch diameter well screened in this aquifer should yield about 10 gpm per foot of drawdown. The water is generally hard and locally it contains excessive concentrations of dissolved iron.

## AQUIFER C

Aquifer C is composed of the Castle Hayne limestone (fig. 4). It is separated from aquifer B by relatively thick, and continuous layers of gray silt and clay of the lower part of the Yorktown Formation and by layers of dolomitic limestone and clays in the Pungo River Formation. These confining beds range from about 10 to 90 feet thick from the western to the eastern limits of the area, respectively (fig. 4). Water in aquifer C is confined beneath these impermeable beds and occurs under artesian conditions.

The strike, dip, and depths to the top of this aquifer coincide with the top of the Castle Hayne limestone (fig. 6). Average thickness is about 190 feet (fig. 4). Aquifer C is by far the most permeable water-bearing zone that underlies the area. Yields from existing 1-1/4- to 8-inch diameter wells tapping this aquifer range from 5 to 300 gpm. Theoretically, a properly constructed well, 10 inches in diameter, drawing water from the full thickness of this aquifer should yield about 80 gpm per foot of drawdown. Water in the upper part of aquifer C contains excessive concentrations of hardness causing constituents, and locally excessive amounts of dissolved iron are found. Brackish or saline water is generally encountered in the lower part of the aquifer at about 300 feet below msl (fig. 4).

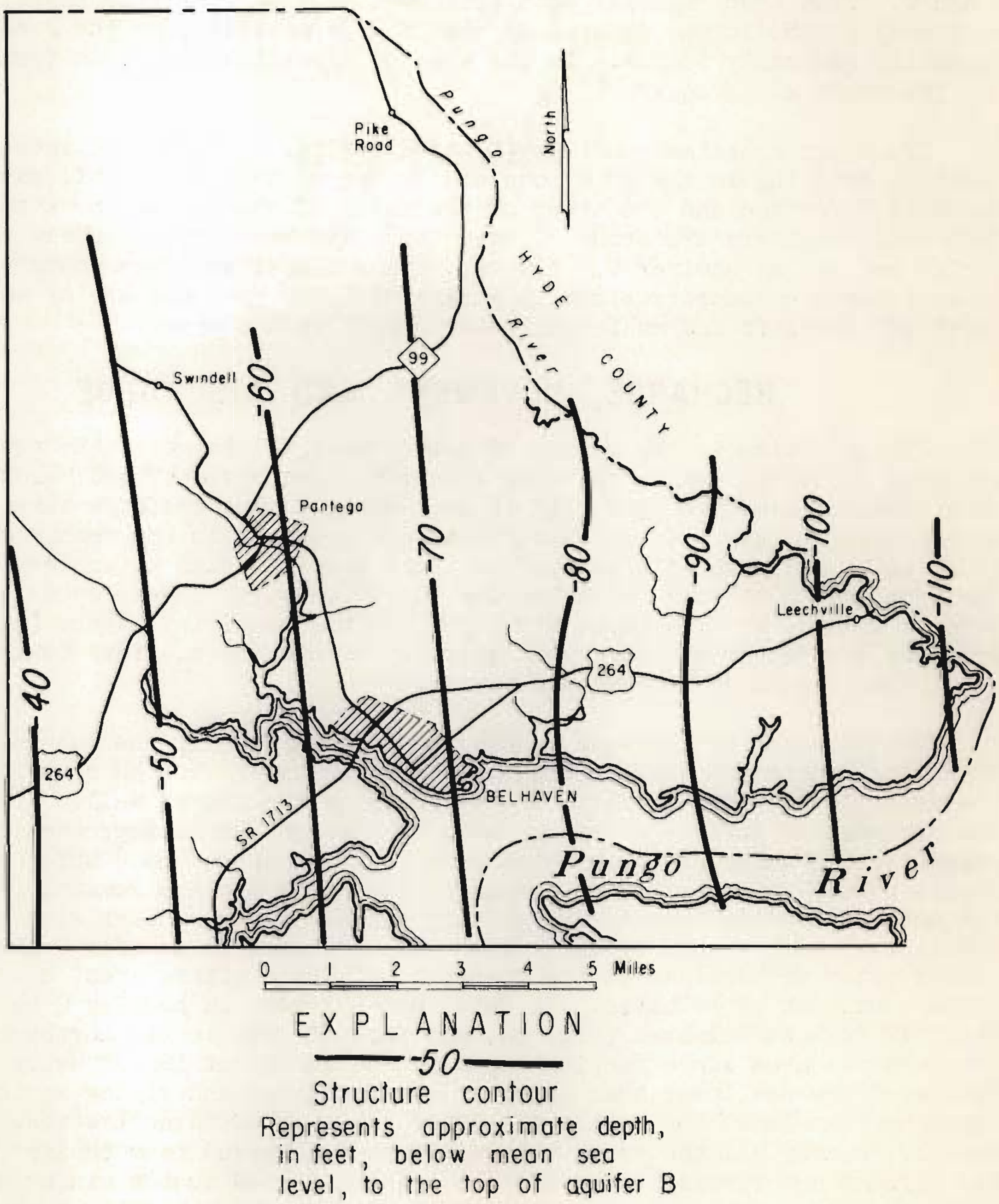



Figure 7.--Map showing the approximate altitude of the top of aquifer B.

### OTHER AQUIFERS

During the investigation, three wells were found that produced water from the Pungo River Formation. Of these wells one was used for domestic supply, one for stock supply, and the other was unused. It was determined that the yields of the two wells in use were low. Chemical analyses indicated that the quality of water from this formation was similar to that from aquifers B and C. From test-drilling data collected as a part of this investigation and by Kimrey (1965) it was determined that the permeability of the Pungo River Formation generally is low. In the area of investigation, this formation is not important as an aquifer.

Two other artesian aquifers (D and E of fig. 4) were penetrated during the test drilling in the area, one consisting of the glauconitic sands of the Beaufort Formation and the other of the sands of the Peedee Formation (fig. 4). Both these aquifers are about 50 feet thick and have approximately the same strike and dip as aquifer C. However, these deeper aquifers contain saline water (chloride concentrations in excess of 6,700 ppm) and are of no value regarding domestic and municipal water supply in the area.

## RECHARGE, MOVEMENT, AND DISCHARGE

Precipitation is the source of ground-water recharge to the aquifers in the area of study. Major recharge occurs between November and March when water loss to evapotranspiration is negligible. Most recharge takes place in the higher areas. As the water enters the ground in the recharge areas, it moves in response to gravity from these areas of high water levels toward the areas along streams and estuaries where low-water levels occur. Thus it moves downward, by slow percolation through the confining layers (aquicludes), from one aquifer to another, and laterally within the aquifers toward areas of discharge such as streams and rivers.

Ground water withdrawals from an aquifer can modify the natural recharge-discharge conditions described above. Pumping water from an aquifer causes the water levels to decline in the vicinity of the pumped well. As a result, the piezometric surface or water-table of the aquifer is depressed so that it resembles the shape of an inverted cone (cone of depression) which has its lowest point at the center of pumping. All other factors remaining the same, the cone of depression will spread very rapidly in an aquifer with high permeability. Such a cone of depression has developed in aquifer C from the ground-water withdrawals at the open-pit phosphate mining area, about 15 miles southwest of Belhaven. To date, water levels in aquifer C have declined about 12 feet at Belhaven (fig. 8), and about 3 feet in the northern part of the Belhaven area since pumping began in the summer of 1965. Water levels in aquifer C are now lower than those in overlying and underlying aquifers throughout at least the southern half of the area of investigation. Consequently, nearly all the water that would be discharged from aquifer C into the streams and rivers in the area is being diverted to the mining area. In addition, some of the water that would be discharged by effluent seepage from the other aquifers is being diverted to aquifer C and through it to the mining area. Figure 9 shows the principal areas of recharge and discharge for aquifers A and B. Aquifer C receives recharge from the overlying aquifers throughout the southern half of the area of study and from the underlying aquifers throughout the area.

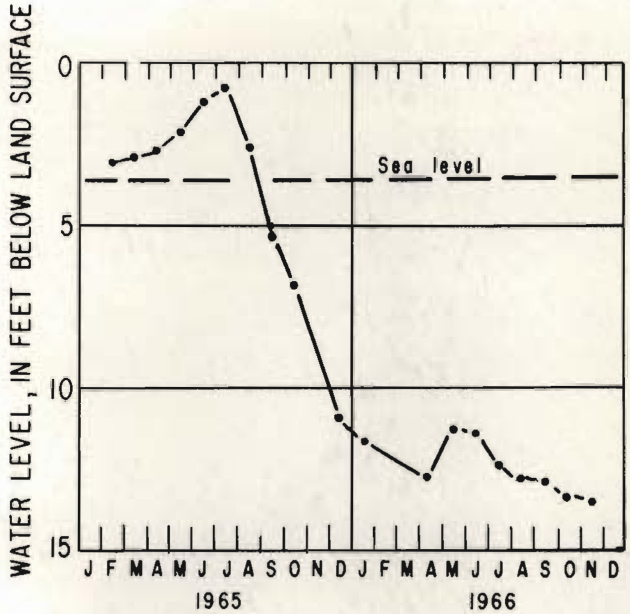



Figure 8.--Water level of aquifer C in observation well at Belhaven, 1965-66.

## AQUIFER TESTS

The ability of an aquifer to transmit water and its capacity to store water can be determined by pumping a well screened in the aquifer in question and measuring the discharge in the pumped well and the amount and rate of water-level decline in observation wells that are screened in that same aquifer. The hydraulic characteristics (coefficients of storage and transmissibility) of the aquifer can then be determined from the collected data by mathematical calculations.

The coefficient of transmissibility is defined as the amount of water, in gallons per day, that will flow through a vertical strip of an aquifer 1 foot wide under a hydraulic gradient of 1 foot per foot, at the prevailing water temperature. The coefficient of storage is defined as the volume of water released from or taken into storage in each column of the aquifer having a base of one square foot and a height equal to the saturated thickness of the aquifer, when the water level is lowered or raised one foot. The field coefficient of permeability is the rate of flow of water, in gallons per day, through a 1 square foot cross-section of the aquifer under a hydraulic gradient of 1 foot per foot at the prevailing temperature.

The average hydraulic characteristics for aquifers B and C, the major sources of municipal, irrigation, and domestic water supplies in the area, are listed in table 1. The values for aquifer C have been extrapolated

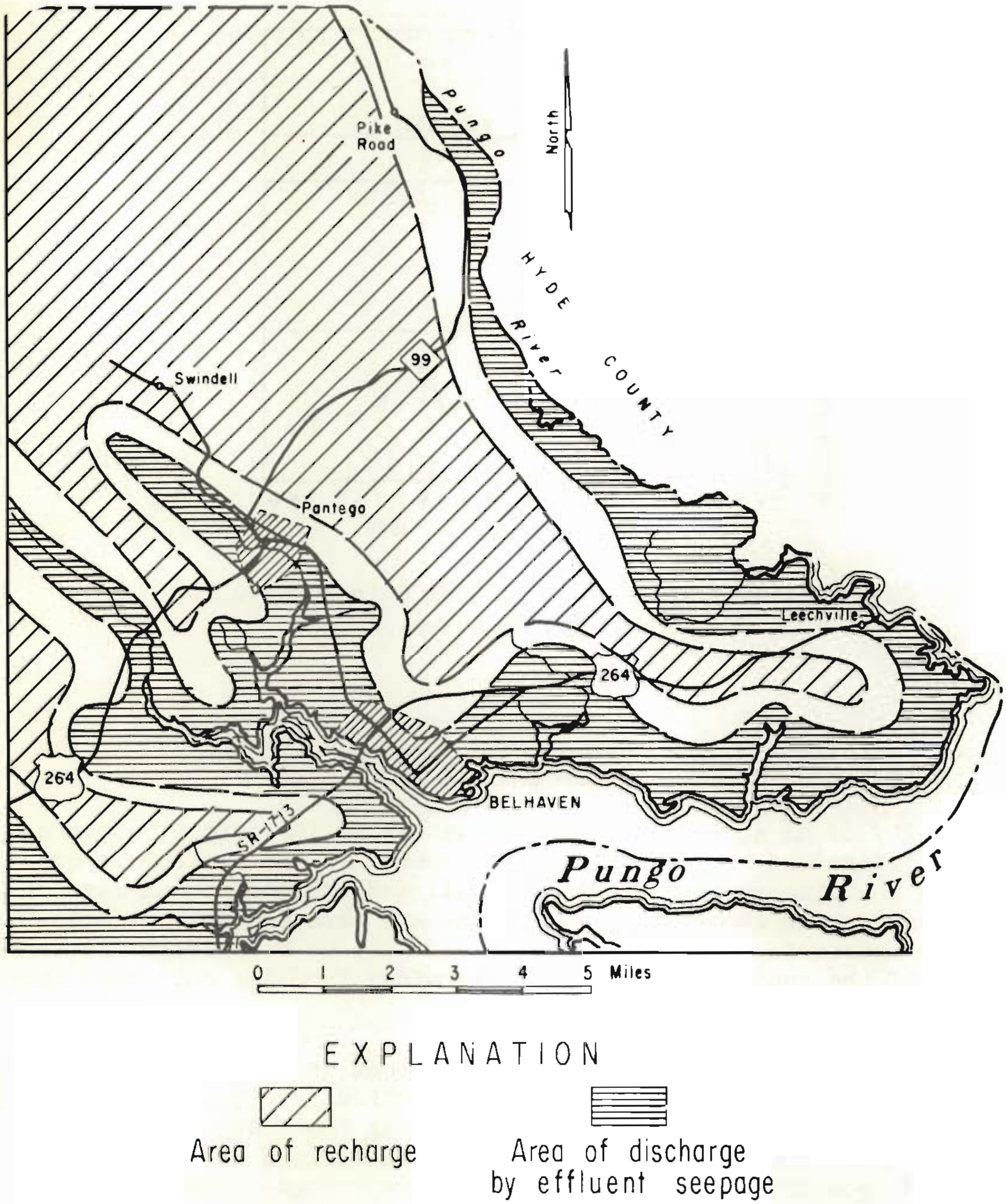



Figure 9.--Principal areas of recharge and discharge for aquifers A and B.

Table 1.--Average quantitative values for aquifers B and C

| | Aquifer B | Aquifer C |
|---|---|---|
| Thickness in feet | 67 | 190 |
| Coefficient of transmissibility, in gallons per day per foot | 20,000 | 180,000 - 230,000 |
| Coefficient of storage, dimensionless | .0004 | .0004 |
| Field permeability, in gallons per day per square foot | 300 | 950 - 1220 |
| Calculated specific capacity, in gallons per minute per foot of drawdown | | |
| for 2" wells | 9 | 60 - 80 |
| for 10" wells | 10 | 82 - 104 |
| for 36" wells | 12 | 95 - 119 |

from pumping and recovery tests made by J. W. Harshbarger and others on wells finished in this aquifer southwest of the area of study. The results of these tests are assumed to be valid approximations for the area of study because there is little or no appreciable change in the lithic character and thickness of the aquifer between Belhaven and the area of the tests. The values for aquifer B were determined from pumping and recovery tests made on wells in the area of investigation.

The coefficients of transmissibility and storage can be used to determine the water-yielding capacity of wells finished in the aquifer, the effects of pumping on water levels in the aquifer, and the volume and velocity of water moving through the aquifer.

As mentioned above, pumping water from a well causes the water level to decline in the vicinity of the pumped well. The relation between the pumping rate and the amount of drawdown in the well is referred to as specific capacity. It is usually reported in gallons per minute per foot of drawdown after some specified period of continuous pumping, generally one day.

Specific capacity is controlled by the coefficients of storage and transmissibility of the aquifer and the efficiency of the well tapping the aquifer. Calculated specific capacities for aquifers B and C, assuming 100 percent well efficiency, are listed in table 1. The measured specific capacity of a well is generally less than the calculated specific capacity and the difference can usually be related to improper construction and/or poor well development. If a well were pumped for 24 hours at 500 gpm, and the drawdown was 100 feet at the end of this time, the measured specific capacity would be 5 gpm per foot of drawdown. If the calculated specific capacity was 10 gpm the efficiency of the well would be 50 percent.

The size, shape, and growth rate of a cone of depression developed by pumping water from an aquifer depend on the rate and duration of pumping, the coefficients of storage and transmissibility of the aquifer, the amount of ground-water recharge to the aquifer, and the location of impermeable boundaries of the aquifer. Other factors remaining the same, relatively flat cones that spread rapidly develop in aquifers with high transmissibility, and steep cones that spread slowly develop in aquifers with low transmissibility. This is true because water can move more freely in aquifers with high transmissibility; thus smaller head differentials are required to move any given amount of water.

Figures 10 and 11 represent half-sections through calculated cones of depression in aquifers B and C, respectively. These graphs show the theoretical drawdown in water level at selected times and various distances from a well being pumped at a constant rate. In the derivation of the formula used for constructing these distance-drawdown plots, it is assumed that the coefficients of storage and transmissibility are constant and the same in all directions, the aquifer is infinite in areal extent, and confined between impermeable beds so that all the water is drawn from storage in the aquifer, the well penetrates and draws water from the full thickness of the aquifer, and that ground water is released from storage instantaneously with a decline in artesian head. Variations from these calculated plots can be expected because the above conditions are seldom, if ever, completely met, and the distance-drawdown graphs are constructed from average values of the hydraulic characteristics of the aquifers. Therefore, when a well is constructed it is important to test-pump it and determine the hydraulic characteristics of the aquifer at the well. Actual drawdown will generally be less than the calculated drawdown after extended periods of pumping except where impermeable boundaries of the aquifer are intercepted by the cone of depression.

During the first few minutes of pumping, the water withdrawn from the well is largely derived from storage in the aquifer. This period is marked by a relatively rapid decline in water level and/or artesian pressure in the vicinity of the pumped well. In artesian aquifers, such as aquifer C, as the artesian pressure declines, the gradient between the pumped aquifer and the overlying aquifers is reduced. This reduction in gradient results in a reduction of the rate of natural discharge through the confining beds. As this natural discharge is diverted to the pumping well there is a corresponding decline in the rate at which water is derived from storage. If a cone of depression in the Belhaven area extends into areas where the aquifers are being recharged, such as the nearby Pantego Swamp, there will be an increase in the rate of recharge. When the reduction in natural discharge and the increase in recharge equal the rate of pumping, the removal of water from storage and the decline in artesian pressure cease, and the cone of depression becomes stabilized.

Figures 10 and 11 may be used for estimating drawdowns at short distances from a pumped well over periods of time up to 100 days. Similar plots can be constructed for any desired yield, because drawdown is approximately proportional to the pumping rate for wells screened in artesian aquifers. To calculate the drawdown for some desired yield other than that shown on the figures, divide the drawdown shown on the graph by the indicated pumping rate, then multiply by the desired pumping rate.

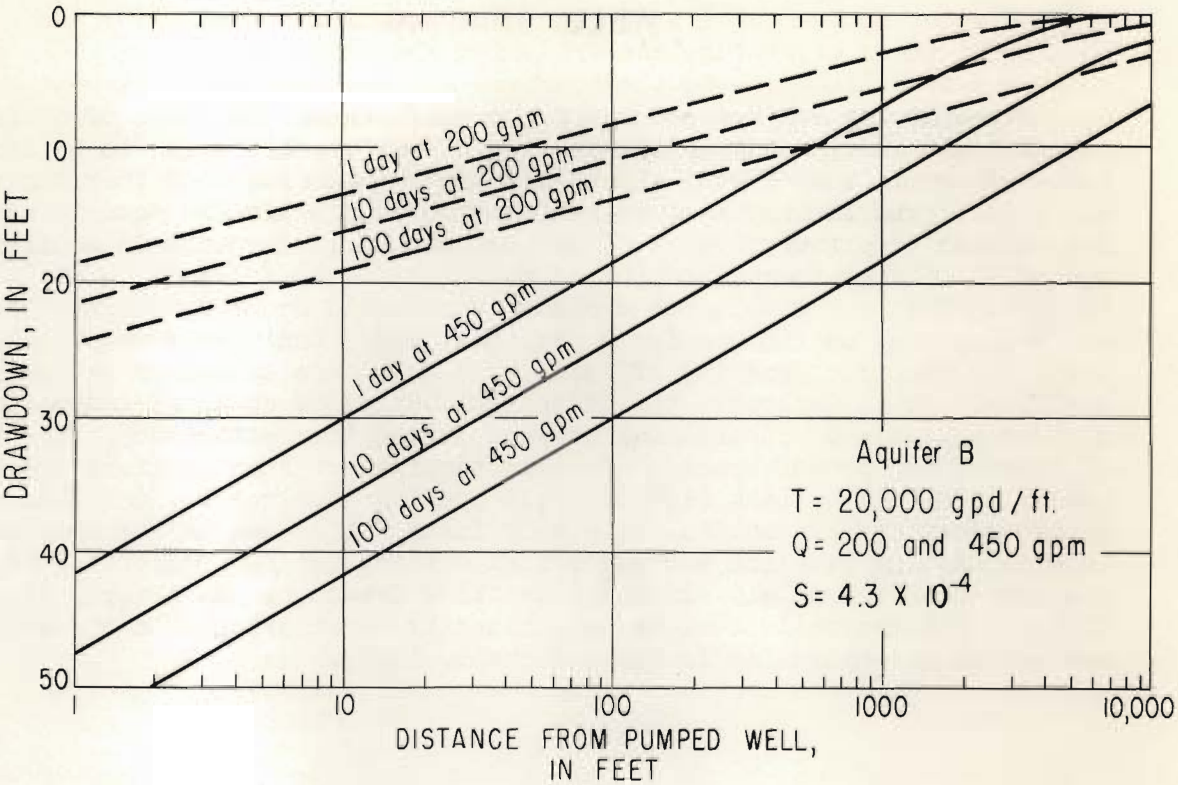



Figure 10.--Calculated distance-drawdown curves determined for pumping from wells finished in aquifer B.

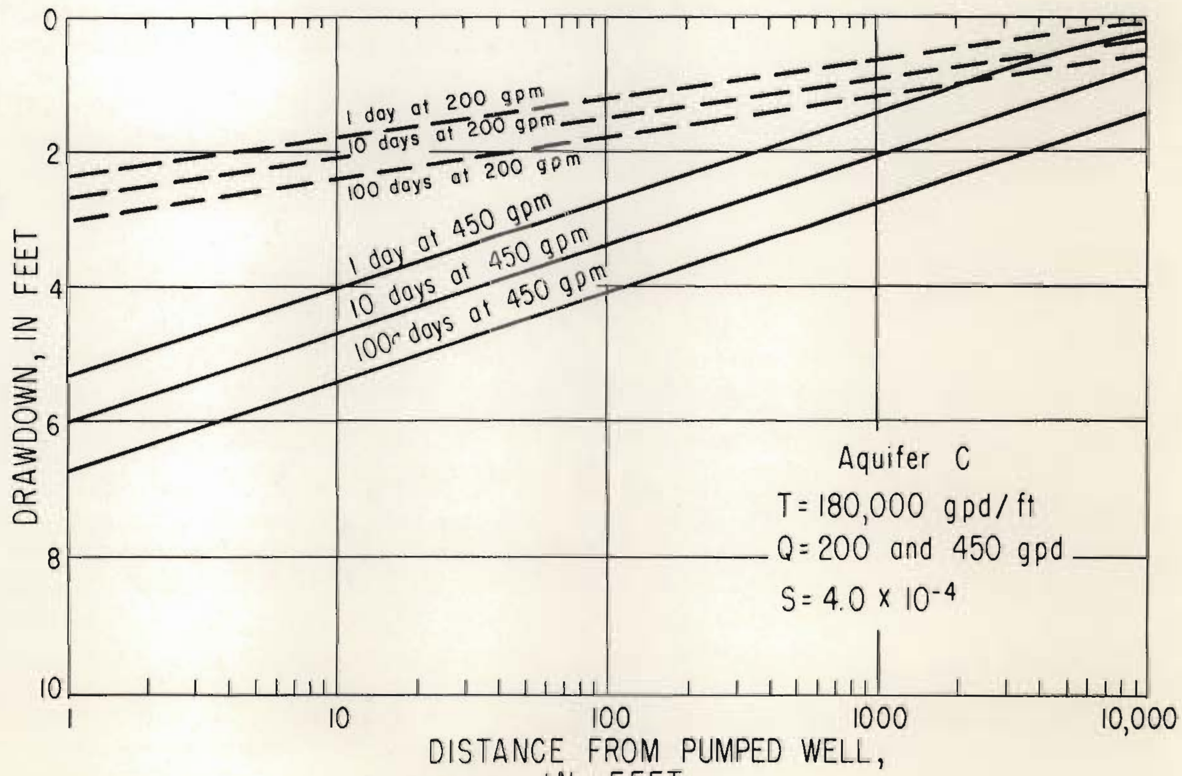



Figure 11.--Calculated distance-drawdown curves determined for pumping from wells finished in aquifer C.

## WELL SPACING

Accurate information about the hydraulic characteristics of aquifers is essential for estimating the spacing of two or more wells to be constructed in the same area. When wells are spaced close together their cones of depression may overlap. Where overlap occurs drawdown is additive. The calculated drawdown half-way between two wells screened in aquifer C, spaced 2,000 feet apart, and pumped at 450 gpm each for 1 day would be about 2.8 feet, or double the drawdown that would occur 1,000 feet from one well pumped at 450 gpm for 1 day (fig. 11). Additive drawdown effects lower the specific capacity of wells, and may cause excessive water-level declines. It is desirable to reduce the overlap of cones of depression as much as possible to insure maximum well and aquifer efficiency. The methods of determining proper spacing of wells tapping artesian aquifers are discussed in detail by Lang (1961). Well spacing involves economics as well as hydrology and hydraulics. Costs of installation and maintenance of interconnecting pipeline and electrical systems may be prohibitive if wells are spaced to completely eliminate additive drawdown. Therefore, the distance between wells must be determined by considering both the economic and hydrologic-hydraulic factors (Bentall, 1963).

# QUALITY OF WATER

The slightly acidic rainwater that percolates to the zone of saturation in the area reacts with and dissolves portions of the soil and rock materials. The amount and kind of dissolved mineral matter in the ground water depend upon such factors as the amount and type of organic material in the soil, the kind of rock or soil through which or over which the water moves, and the length of time the water is in contact with the soil and rocks.

Once in solution, the chemical constituents in ground water generally exist as positively and negatively charged ionic particles called cations and anions, respectively. The amount of these constituents in water is determined by chemical analyses, the results of which are reported by weight concentration of each constituent in a million unit weights of water, or parts per million (ppm). Table 2 shows the source or cause and significance of the principal chemical constituents of water reported in chemical analyses.

Nearly 200 water samples were collected from wells that are finished in the major aquifers of the area, and were analyzed by the Quality of Water Branch, U. S. Geological Survey. Results of the analyses are given in table 3 and table 4.

## QUALITY OF WATER IN THE AQUIFERS

### AQUIFER A

Concentrations of dissolved solids in water from aquifer A are usually below 500 ppm (the maximum amount recommended by the U. S. Public Health Service for public water supplies). The only dissolved mineral matter found in excessive amounts in water from this aquifer were iron and hardness-causing constituents. Dissolved iron concentrations ranged from 0.12 to 19 ppm and were above 0.3 ppm in 95 percent of the observed cases. Hardness values ranged from 15 to 345 ppm and were in the moderately-hard to very-hard range in about 50 percent of the water samples collected from this aquifer. The hard waters were found where wells are screened in lenticular shell beds that occur in the lower part of this aquifer in the central and eastern part of the area. The water is subject to possible contamination from human and animal wastes, fertilizers, detergents, etc., and unusually high concentrations of nitrate, chloride, or phosphate should be regarded as indicators of such contamination. Determinations of pH were made in the laboratory and average about 7.5. A more acidic and corrosive water is expected in such shallow aquifers, and the near neutral values cited above probably resulted from the escape of carbon dioxide during collection and transportation to the laboratory. A typical chemical analysis of water from aquifer A is shown in table 3.

Water from this aquifer will generally require treatment for the removal of excessive concentrations of iron and/or hardness-causing constituents to make it suitable for most uses.

Table 2.--Source and significance of dissolved mineral constituents and properties of ground water

| | Constituent | Source or cause | Significance |
|---|---|---|---|
| Cations | Silica ($SiO_2$) | Dissolved from practically all rocks and soils, usually in small amounts from 1-30 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters. | Forms hard scale in pipes and boilers. Inhibits the action of zeolite-type water softeners. |
| | Iron (Fe) | Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. | On exposure to air, iron in ground water is oxidized to reddish-brown sediment. More than about 0.3 ppm stains laundry and utensils reddish-brown and is objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing, and other processes. U. S. Public Health Service (1962) drinking-water standards state that iron concentration should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria. |
| | Manganese (Mn) | Dissolved from some rocks and soils. Not so common as iron. Large quantities often associated with high iron content and with acid waters. | Same objectionable features as iron. Causes dark brown or black stain. U.S.P.H.S. drinking-water standards provide that maganese should not exceed 0.05 ppm. |
| | Calcium (Ca) and Magnesium (Mg) | Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water. | Cause most of the hardness and scale-forming properties of water; soap consuming. Water low in calcium and magnesium is desired in electroplanting, tanning, dyeing, and in textile manufacturing. These hardness-causing constituents are reported together as equivalent amounts of calcium carbonate ($CaCO_3$). Hardness scale used by U. S. Geological Survey is as follows: 0-60 ppm = soft, 61-120 ppm = moderately hard, 121-180 ppm = hard, above 180 ppm = very hard. |
| | Sodium (Na) and Potassium (K) | Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, some industrial brines, and sewage. | Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium ratio may limit the use of water for irrigation. |
| Anions | Bicarbonate ($HCO_3$) and Carbonate ($CO_3$) | Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite. | Bicarbonate and carbonate cause alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon-dioxide gas. In combination with calcium and magnesium cause carbonate hardness. |
| | Sulfate ($SO_4$) | Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. | Sulfate in water containing calcium forms hard calcium sulfate scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. Drinking-water standards recommend that the sulfate content should not exceed 250 ppm. |

Table 2.--Source and significance of dissolved mineral constituents and properties of ground water--Continued

| | Constituent | Source or cause | Significance |
|---|---|---|---|
| Anions | Chloride (Cl) | Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines. | In large amounts in combination with sodium gives salty taste to water. In large quantities increases the corrosiveness of water. U.S.P.H.S. drinking-water standards recommend that the chloride content should not exceed 250 ppm. |
| | Fluoride (F) | Dissolved in minute quantities from most rocks and soils. | Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, the age of the child, amount of water consumed, and susceptibility of the individual (Maier, F. J., 1950). U.S.P.H.S. drinking-water standards recommend that fluoride not exceed 1.7 ppm where 5 year average of daily maximum air temperature is 53.0° to 53.7°F. |
| | Nitrate ($NO_3$) | Decaying organic matter, sewage, and nitrates in soil. | Concentrations much greater than the local average may suggest pollution. There is evidence that more than 45 ppm of nitrate ($NO_3$) may cause a type of methemoglobinemia in infants, sometimes fatal. Water of high nitrate content should not be used in baby feeding. Nitrate is helpful in reducing intercrystalline cracking of boiler steel, but it encourages growth of algae and other organisms that produce undesirable tastes and odors. |
| | Phosphate ($PO_4$) | Dissolved in very small quantities from rocks and soils. | Concentrations much greater than local averages may indicate contamination from phosphate detergents and/or fertilizers. |

| | |
|---|---|
| Dissolved solids | A measure of all the chemical constituents dissolved in a particular water. Maybe determined by evaporation-weight or computation methods. U.S.P.H.S. drinking water standards recommend that public supplies contain no more than 500 ppm dissolved solids. |
| Specific conductance | A measure, in micromhos at 25°C, of the amount of electrical current that is conducted by one cubic centimeter of the liquid. Can be used as an index to the total amount of dissolved solids in a particular water. Generally multiplying specific conductance by about 0.6 will give a close approximation to total amount of dissolved solids. |
| pH | A measure of the hydrogen-ion concentration or an indication of the acidity of water. A pH of 7 is neutral, above 7 is alkaline and below 7 is acid. Waters with low pH are generally much more corrosive than those whth a pH value of 7 or above. |

Table 3.--Typical chemical analyses of water from aquifers A, B, C, D, and E

| | Aquifers | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Well Number* | 48 | 190 | 186 | 29-D | 29-E |
| Silica ($SiO_2$) | 40 | 40 | 48 | 17 | 10 |
| Iron (Fe) | 3.5 | .19 | .10 | .24 | .38 |
| Manganese (Mn) | -- | .02 | -- | -- | -- |
| Calcium (Ca) | 44 | 53 | 41 | 25 | 145 |
| Magnesium (Mg) | 11 | 16 | 37 | 26 | 163 |
| Sodium (Na) | 20 | 83 | 206 | 612 | 4,180 |
| Potassium (K) | 2 | 14 | 30 | 40 | 108 |
| Carbonate ($CO_3$) | 0 | 0 | 0 | 0 | 0 |
| Bicarbonate ($HCO_3$) | 231 | 444 | 472 | 488 | 460 |
| Sulfate ($SO_4$) | 5 | 3.6 | 22 | 62 | 598 |
| Chloride (Cl) | 15 | 8.0 | 221 | 765 | 6,720 |
| Fluoride (F) | .2 | .4 | .9 | 1.6 | 1.3 |
| Nitrate ($NO_3$) | .0 | .2 | .1 | .3 | .4 |
| Phosphate ($PO_4$) | .0 | -- | .0 | .0 | .0 |
| Dissolved solids | 256 | 436 | 838 | 1,760 | 12,500 |
| Specific conductance | 427 | 700 | 1,500 | 3,140 | 20,300 |
| Hardness as $CaCO_3$ | 154 | 200 | 257 | 170 | 1,030 |
| pH | 7.2 | 7.5 | 7.9 | 8.1 | 7.7 |

*See figure 13 for location of wells and table 4 for well data.

Note: All constituents, except specific conductance and pH reported in parts per million.

TABLE 4. RECORDS OF WELLS IN THE VICINITY OF BELHAVEN, N. C.

OWNERSHIP: F-Federal Government; M-Municipal; P-Private; S-State agency; N-Corporation.
USE: H-Domestic; P-Public supply; S-Stock supply; I-Industrial; U-Unused.
TYPE OF QW ANALYSIS AVAILABLE: P-Partial; C-Complete.
LOG DATA AVAILABLE: J-Gamma-ray log; Y-Geologist, electric, and gamma-ray logs.
WELL FINISH: O-Open-end; S-Screen; T-Sand point.
WATER-BEARING FORMATION: pM-Post Miocene; My-Yorktown; Mpr-Pungo River; Ech-Castle Hayne limestone; Pb-Beaufort; Kpd-Peedee.
AQUIFER: Letter shown is the same as described in this report.
REMARKS: Quality of water reported in parts per million except for specific conductance and pH. Reported well depth noted by *. Diameter of well footnoted by A denotes actual diameter of 1-1/2 inches; B denotes actual diameter of 1-1/4 inches.

| Well location | | Sequence No. | Well No. | Owner | Ownership | Use of water | QW analysis | Log data | Depth (feet) | Depth cased (feet) | Diameter (in) | Finish | Altitude of LSD (feet) | Water level below LSD (feet) | Yield (gallons per minute) | Drawdown (feet) | Specific conductance | pH | Chloride | Fluoride | Iron | Hardness | Water-bearing formation | Aquifer | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lat | Long | | | | | | | | | | | | | | | | | | | | | | | | |
| 354115N | 0763853 | 1 | 1 | J D FLETCHER | P | H | P | | *300 | -- | 2 | O | 14 | -- | 10 | | 627 | 8.3 | 20 | 0.6 | 0.10 | 190 | Ech | C | |
| 354111N | 0763847 | 1 | 2 | E ELLIS | P | H | P | | *375 | -- | 2 | O | 14 | -- | 5 | | 627 | 8.3 | 20 | .6 | .17 | 226 | Ech | C | |
| 354104N | 0763839 | 1 | 3 | I STOKESBURY | P | H | P | | *150 | -- | 2 | O | 14 | -- | 5 | | 700 | 7.8 | 19 | .8 | 1.8 | 170 | My | | |
| 354101N | 0763737 | 1 | 4 | E L DUNBAR | P | H | P | | *300 | -- | 2 | O | 8 | 4 | -- | | 676 | 8.0 | 30 | .6 | .14 | 212 | Ech | C | |
| 354030N | 0763722 | 1 | 5 | D DAVIS | P | H | P | | 260 | 240 | 2 | O | 7 | 3 | 15 | | 680 | 8.3 | 24 | .7 | .07 | 212 | Ech | C | |
| 354009N | 0763645 | 1 | 6 | J B BELL | P | H | P | | 386 | -- | 2 | O | 7 | -- | -- | | 656 | 8.3 | 29 | .5 | .07 | 188 | Ech | C | |
| 353950N | 0763640 | 1 | 7 | TRINITY BAPT CH | P | P | P | | *280 | -- | 2 | O | 7 | -- | -- | | 656 | 8.1 | 26 | .5 | .40 | 208 | Ech | C | |
| 353934N | 0763640 | 1 | 8 | J S WINDLEY | P | H | P | | *280 | -- | A1 | O | 7 | -- | 10 | | 666 | 7.8 | 35 | .5 | .18 | 230 | Ech | C | |
| 353922N | 0763639 | 1 | 9 | S C DAVIS | P | H | P | | *292 | -- | 2 | O | 5 | C | -- | | 676 | 7.9 | 22 | .6 | 3.2 | 232 | Ech | C | |
| 353902N | 0763628 | 1 | 10 | UNKNOWN | P | H | P | | *300 | -- | A1 | O | 4 | 2 | 10 | | 767 | 7.5 | 21 | .3 | 3.9 | 392 | Ech | C | |
| 353846N | 0763640 | 1 | 11 | R C COOPER | P | H | P | | *285 | -- | A1 | O | 5 | -- | -- | | 714 | 8.0 | 28 | .7 | .13 | 228 | Ech | C | |
| 353838N | 0763641 | 1 | 12 | MRS EARL ROSE | P | H | P | | *308 | -- | 2 | O | 4 | -- | -- | | 714 | 8.2 | 42 | .5 | 4.2 | 244 | Ech | C | |
| 353818N | 0763645 | 1 | 13 | L H ALLEN | P | H | P | | *250 | -- | 2 | O | 3 | -- | -- | | 685 | 8.3 | 30 | .5 | .20 | 234 | Ech | C | |
| 353750N | 0763650 | 1 | 14 | W J ALLEN | P | H | P | | *300 | -- | A1 | O | 5 | -- | -- | | 676 | 8.0 | 28 | .6 | .12 | 241 | Ech | C | |
| 353704N | 0763858 | 1 | 15 | R BISHOP | P | H | P | | 247 | -- | 2 | O | 8 | 8 | -- | | 724 | 8.2 | 37 | .6 | .30 | 266 | Ech | C | |
| 353611N | 0763932 | 1 | 16 | J L BOOMER | P | H | P | | 15 | -- | B1 | T | 9 | 4 | -- | | 87 | 5.8 | 10 | .3 | 14 | 18 | pM | A | |
| 353600N | 0763940 | 1 | 17 | E R JONES | P | H | P | | *275 | -- | 2 | O | 10 | -- | -- | | 647 | 7.8 | 30 | .7 | .26 | 231 | Ech | C | |
| 353553N | 0763957 | 1 | 18 | THOMAS DAW | P | H | P | | 241 | -- | B1 | O | 10 | 13 | -- | | 656 | 7.5 | 30 | .7 | 1.0 | 234 | Ech | C | |
| 353602N | 0763950 | 1 | 19 | R H ALLEN | P | H | P | | *250 | -- | B1 | O | 10 | -- | -- | | 637 | 7.7 | 29 | .7 | .55 | 224 | Ech | C | |
| 353604N | 0764005 | 1 | 20 | COASTAL LUM CO | P | H | | | *260 | 240 | 2 | O | 8 | -- | 75 | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353644N | 0764022 | 1 | 21 | F LAUGHINGHOUSE | P | H | | | *50 | 42 | 2 | O | 10 | -- | 50 | | -- | -- | -- | -- | -- | -- | My | B | |
| 353654N | 0763959 | 1 | 22 | F LAUGHINGHOUSE | P | H | | | *50 | 42 | 2 | O | 10 | -- | 50 | | -- | -- | -- | -- | -- | -- | My | B | |
| 353848N | 0764006 | 1 | 23 | MAX GARDNER | P | H | P | | 221 | -- | 2 | O | 14 | 10 | 3 | | 656 | 8.4 | 11 | .6 | .12 | 275 | Ech | C | |
| 353813N | 0764025 | 1 | 24 | EMMA L SPENCER | P | H | P | | 218 | -- | 2 | O | 13 | 10 | 5 | | 676 | 8.1 | 13 | .6 | .90 | 264 | Ech | C | |

TABLE 4. RECORDS OF WELLS IN THE VICINITY OF BELHAVEN, N. C.--Continued

| Well location: Lat | Well location: Long | Sequence No. | Well No. | Owner | Ownership | Use of water | QW analysis | Log data | Depth (feet) | Depth cased (feet) | Diameter (in) | Finish | Altitude of LSD (feet) | Water level below LSD (feet) | Yield (gallons per minute) | Drawdown (feet) | Specific conductance | pH | Chloride | Fluoride | Iron | Hardness | Water-bearing formation | Aquifer | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 353822N | 0764105 | 1 | 25 | LEONARD BESS | P | H | P | | 22 | 20 | B1 | O | 14 | 10 | 3 | | 124 | 7.9 | 8 | 0.1 | 8.9 | 33 | pM | A | |
| 353804N | 0764048 | 1 | 26 | RUTH CREOLE | P | U | | | 3 | 3 | 36 | O | 10 | 2 | -- | | -- | -- | -- | -- | -- | -- | pM | A | |
| 353752N | 0764057 | 1 | 27 | T SLUNVERSON | P | H | P | | 220 | -- | A1 | O | 12 | 10 | 4 | | 550 | 7.7 | 9 | .3 | .14 | 258 | Ech | C | |
| 353737N | 0764152 | 1 | 28 | H BENSON | P | H | P | | *250 | -- | 2 | O | 14 | -- | 5 | | 579 | 8.3 | 10 | .5 | .38 | 197 | Ech | C | |
| 353730N | 0764200 | 1 | 29 | USGS | F | U | C | Y | 82 | 72 | 4 | S | 12 | 7 | 23 | 5 | 801 | 7.4 | 25 | .4 | 8.5 | 316 | My | B | BE-T1-66 Test well Depth 711 feet |
| 353730N | 0764200 | 1 | 29 | USGS | F | U | C | Y | 128 | 118 | 4 | S | 12 | 7 | 21 | 8 | 839 | 7.6 | 24 | .4 | 3.2 | 419 | My | B | |
| 353730N | 0764200 | 1 | 29 | USGS | F | U | C | Y | 382 | 372 | 4 | S | 12 | 7 | 19 | 45 | 1980 | 7.9 | 386 | 1.4 | .80 | 173 | Ech | C | |
| 353730N | 0764200 | 1 | 29 | USGS | F | U | C | Y | 412 | 402 | 4 | S | 12 | 10 | 20 | 26 | 3140 | 8.1 | 765 | 1.6 | .24 | 170 | Pb | D | |
| 353730N | 0764200 | 1 | 29 | USGS | F | U | C | Y | 555 | 545 | 4 | S | 12 | 11 | 20 | 46 | 20300 | 7.7 | 6720 | 1.3 | .38 | 1030 | Kpd | E | |
| 353706N | 0764119 | 1 | 30 | G A DUNSHEE | P | H | P | | 168 | -- | 2 | O | 11 | 8 | 5 | 7 | 868 | 8.0 | 18 | .5 | 14. | 303 | My | B | |
| 353700N | 0764112 | 1 | 31 | WALTER CANNADY | P | I | | | *80 | -- | 4 | O | 12 | 3 | -- | | -- | -- | -- | -- | -- | -- | My | B | |
| 353659N | 0764121 | 1 | 32 | UNKNOWN | P | U | P | | 205 | -- | 2 | O | 11 | 10 | 4 | | 560 | 8.1 | 14 | .7 | 6.2 | 210 | Ech | C | |
| 353637N | 0764200 | 1 | 33 | C RODMAN | P | H | P | | 172 | -- | 2 | O | 6 | 10 | 3 | | 888 | 8.3 | 16 | .5 | 2.4 | 172 | Mpr | | |
| 353633N | 0764207 | 1 | 34 | WILKINSON | P | S | P | | 181 | -- | B1 | O | 8 | 12 | 3 | | 637 | 7.8 | 15 | .6 | 8.7 | 204 | Mpr | | |
| 353613N | 0764308 | 1 | 35 | NOAH RIDDICK | P | H | P | | *84 | -- | 2 | O | 13 | -- | -- | | 608 | 8.5 | 19 | .5 | .36 | 243 | My | B | |
| 353546N | 0764315 | 1 | 36 | MATTIE RIDDICK | P | H | | | *260 | 240 | 2 | O | 12 | -- | 75 | | -- | -- | -- | -- | -- | | Ech | C | |
| 353605N | 0764146 | 1 | 37 | M O RADCLIFF SR | P | H | P | | *280 | -- | 2 | O | 12 | -- | 10 | | 729 | 8.3 | 14 | .3 | 1.2 | 250 | Ech | C | |
| 353621N | 0764135 | 1 | 38 | PAUL WILLIAMS | P | H | P | J | 215 | -- | 2 | O | 10 | 14 | -- | | 608 | 7.3 | 23 | .9 | .40 | 238 | Ech | C | |
| 353617N | 0764121 | 1 | 39 | MRS P WILKINSON | P | H | P | | *80 | 60 | 2 | O | 10 | 5 | -- | | 772 | 7.3 | 23 | .3 | 19. | 398 | My | B | |
| 353611N | 0764115 | 1 | 40 | MACEDONIA CHURC | P | P | P | | 214 | -- | 2 | O | 10 | 12 | 75 | | 603 | 7.8 | 14 | .4 | .80 | 233 | Ech | C | |
| 353622N | 0764042 | 1 | 41 | WALTER CANNADY | P | H | P | | 293 | -- | 2 | O | 8 | 10 | 10 | | 695 | 8.1 | 21 | .4 | 1.1 | 193 | Ech | C | |
| 353610N | 0764039 | 1 | 42 | VERNON DAW | P | H | P | | *300 | -- | 2 | O | 8 | 11 | 3 | | 656 | 8.2 | 26 | .7 | .58 | 223 | Ech | C | |
| 353557N | 0764026 | 1 | 43 | COASTAL LUM CO | P | H | P | | 105 | -- | 2 | O | 8 | 4 | 35 | | 676 | 7.5 | 12 | .6 | 3.4 | 340 | My | B | |
| 353602N | 0764049 | 1 | 44 | E H BISHOP JR | P | H | P | | *250 | -- | 2 | O | 6 | 8 | 4 | | 608 | 7.8 | 81 | .4 | .-- | 162 | Ech | C | |
| 353555N | 0764044 | 1 | 45 | J SPENCER | P | U | P | | 16 | 13 | B1 | T | 7 | 6 | 4 | | 157 | 6.5 | 12 | .0 | 16 | 58 | pM | A | |
| 353550N | 0764033 | 1 | 46 | T ALLEN | P | H | | | 20 | 17 | B1 | T | 7 | 6 | 5 | | -- | -- | -- | -- | -- | -- | pM | A | |
| 353551N | 0764045 | 1 | 47 | ELLA KING | P | H | P | J | 234 | -- | 2 | O | 8 | 14 | -- | | 627 | 8.0 | 23 | .7 | .16 | 212 | Ech | C | |
| 353521N | 0764045 | 1 | 48 | UNKNOWN | P | U | P | | 28 | 25 | B1 | T | 8 | 7 | 5 | | 550 | 7.2 | 134 | .1 | 19. | 154 | pM | A | |
| 353509N | 0764032 | 1 | 49 | E CAMPBELL | P | H | P | | *220 | -- | 2 | O | 8 | -- | -- | | 241 | 7.7 | 54 | .1 | 6.9 | 34 | Ech | C | |
| 353518N | 0764018 | 1 | 50 | H LILLY | P | U | P | | 23 | -- | B1 | O | 10 | 5 | 1 | | 348 | 7.8 | 51 | .2 | 10. | 78 | pM | A | |
| 353515N | 0764013 | 1 | 51 | H LILLY | P | H | P | | *200 | -- | 2 | O | 8 | -- | -- | | 632 | 7.9 | 24 | .7 | .28 | 218 | Ech | C | |
| 353519N | 0763952 | 1 | 52 | LEES RESTAURANT | P | P | P | | *290 | -- | 2 | O | 7 | -- | -- | | 695 | 8.2 | 34 | .8 | .27 | 158 | Ech | C | |
| 353458N | 0764018 | 1 | 53 | BERTHA ENSLEY | P | H | | | 194 | -- | 2 | O | 10 | 12 | 10 | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353505N | 0764026 | 1 | 54 | P BROWN | P | H | P | | *270 | 250 | 2 | O | 10 | -- | 50 | | 637 | 8.2 | 28 | .7 | .09 | 197 | Ech | C | |
| 353443N | 0764020 | 1 | 55 | J JAMES | P | H | P | | *300 | -- | 2 | O | 9 | -- | 10 | | 500 | 8.1 | 31 | .8 | .10 | 195 | Ech | C | |
| 353432N | 0764003 | 1 | 56 | W H DAW | P | H | P | | *275 | -- | 2 | O | 4 | -- | -- | | 647 | 8.3 | 31 | .8 | .53 | 210 | Ech | C | |

TABLE 4. RECORDS OF WELLS IN THE VICINITY OF BELHAVEN, N. C.--Continued

| Well location Lat | Well location Long | Sequence No. | Well No. | Owner | Ownership | Use of water | QW analysis | Log data | Depth (feet) | Depth cased (feet) | Diameter (in) | Finish | Altitude of LSD (feet) | Water level below LSD (feet) | Yield (gallons per minute) | Drawdown (feet) | Specific conductance | pH | Chloride | Fluoride | Iron | Hardness | Water-bearing formation | Aquifer | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 353437N | 0764026 | 1 | 57 | H SCHAVENDER | P | H | P | | *265 | -- | 2 | O | 8 | -- | 10 | | 598 | 8.2 | 30 | 0.7 | 0.18 | 162 | Ech | C | |
| 353441N | 0764035 | 1 | 58 | T W SAWYER | P | H | P | | *37 | -- | 2 | | 8 | -- | -- | | 114 | 7.7 | 12 | .1 | .76 | 22 | My | A | |
| 353441N | 0764052 | 1 | 59 | H RUSS | P | H | P | | *250 | -- | B1 | O | 9 | -- | -- | | 647 | 8.1 | 31 | .7 | .24 | 184 | Ech | C | |
| 353447N | 0764057 | 1 | 60 | C RADCLIFF | P | H | | | *255 | 231 | 2 | O | 9 | -- | 15 | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353508N | 0764206 | 1 | 61 | G DANIELS | P | H | P | | *200 | -- | 2 | O | 12 | -- | 5 | | 651 | 8.2 | 11 | .5 | .20 | 260 | Ech | C | |
| 353505N | 0764158 | 1 | 62 | DAVID LEE | P | H | P | | 98 | -- | 2 | O | 12 | 5 | 5 | | 627 | 8.2 | 12 | .2 | 8.0 | 272 | My | B | |
| 353458N | 0764152 | 1 | 63 | J T SLADE | P | H | P | | *250 | -- | B1 | O | 11 | -- | -- | | 618 | 8.4 | 14 | .5 | .50 | 222 | Ech | C | |
| 353448N | 0764148 | 1 | 64 | CHURCH | P | P | P | | 80 | -- | 2 | O | 7 | 5 | 5 | | 598 | 7.8 | 10 | .2 | 4.8 | 300 | My | B | |
| 353425N | 0764113 | 1 | 65 | C J CARAWAN | P | H | P | | 29 | 26 | B1 | T | 8 | 5 | -- | | 989 | 7.7 | 64 | .2 | 11 | 89 | pM | A | |
| 353408N | 0764159 | 1 | 66 | G BELLMAN | P | H | P | | *240 | -- | 2 | O | 7 | -- | 10 | | 676 | 8.5 | 22 | .5 | .42 | 234 | Ech | C | |
| 353353N | 0764157 | 1 | 67 | MATTHEW LILLY | P | H | P | | 206 | -- | 2 | O | 9 | 16 | 5 | | 695 | 8.2 | 27 | .7 | .44 | 224 | Ech | C | |
| 353347N | 0764158 | 1 | 68 | W CRADDACK | P | H | P | | *250 | -- | 2 | O | 10 | -- | -- | | 695 | 8.2 | 24 | .7 | .54 | 213 | Ech | C | |
| 353326N | 0764208 | 1 | 69 | ROBERT GASKINS | P | H | P | | *250 | -- | 2 | O | 10 | -- | 40 | | 704 | 8.0 | 30 | .7 | .40 | 237 | Ech | C | |
| 353240N | 0764222 | 1 | 70 | STEVE HARRIS | P | H | P | | *200 | -- | 2 | O | 10 | -- | -- | | 704 | 8.5 | 32 | .6 | .42 | 242 | Ech | C | |
| 353237N | 0764212 | 1 | 71 | S H DAVENPORT | P | H | P | | *300 | -- | A1 | O | 10 | -- | 10 | | 724 | 8.2 | 30 | .6 | .24 | 255 | Ech | C | |
| 353222N | 0764219 | 1 | 72 | J CUTHRELL | P | H | P | | *185 | -- | 2 | O | 10 | -- | -- | | 320 | 7.4 | 43 | .3 | .14 | 84 | Ech | C | |
| 353245N | 0764427 | 1 | 73 | JESSE KEECH | P | H | P | | *195 | -- | 2 | O | 11 | -- | -- | | 733 | 8.4 | 48 | .5 | 1.7 | 231 | Ech | C | |
| 353228N | 0764416 | 1 | 74 | J GADSKINS | P | H | P | | *260 | -- | B1 | O | 10 | -- | -- | | 811 | 8.0 | 53 | .6 | .28 | 245 | Ech | C | |
| 353226N | 0764404 | 1 | 75 | C CLARK | P | H | P | | *185 | -- | 2 | O | 10 | -- | -- | | 801 | 8.0 | 50 | .6 | .09 | 246 | Ech | C | |
| 353213N | 0764348 | 1 | 76 | RALEIGH KEECH | P | S | P | | *180 | -- | A1 | O | 7 | -- | 10 | | 820 | 8.0 | 52 | .6 | .06 | 242 | Ech | C | |
| 353203N | 0764342 | 1 | 77 | IDA KEECH | P | H | P | | 25 | 22 | B1 | T | 7 | 6 | 5 | | 135 | 8.1 | 14 | .1 | 7.4 | 38 | pM | A | |
| 353158N | 0764357 | 1 | 78 | C ATWOOD JR | P | H | P | | *297 | -- | 2 | O | 7 | -- | 10 | | 801 | 8.1 | 52 | .6 | .13 | 250 | Ech | C | |
| 353151N | 0764352 | 1 | 79 | S W JAVESON | P | H | P | | *20 | 17 | B1 | T | 5 | -- | 4 | | 156 | 7.5 | 9 | .6 | .90 | 39 | pM | A | |
| 353148N | 0764324 | 1 | 80 | H LATHAM | P | H | P | | *210 | -- | B1 | O | 8 | -- | -- | | 811 | 8.1 | 51 | .6 | .06 | 246 | Ech | C | |
| 353149N | 0764311 | 1 | 81 | W GAYLORD | P | H | P | | *220 | -- | A1 | O | 10 | -- | -- | | 811 | 8.1 | 54 | .6 | .18 | 249 | Ech | C | |
| 353114N | 0764257 | 1 | 82 | GEORGE WINDLEY | P | H | P | | 25 | 22 | B1 | T | 10 | 4 | 4 | | 133 | 7.9 | 13 | .1 | 9.0 | 55 | pM | A | |
| 353107N | 0764243 | 1 | 83 | J HESSE | P | H | P | | *250 | -- | A1 | O | 8 | -- | 10 | | 830 | 8.4 | 58 | .7 | .21 | 236 | Ech | C | |
| 353100N | 0764237 | 1 | 84 | UNKNOWN | P | U | P | | 19 | 16 | B1 | T | 8 | 2 | 3 | | 502 | 7.6 | 110 | .1 | 5.7 | 18 | pM | A | |
| 353051N | 0764228 | 1 | 85 | ROBERT WINFIELD | P | H | P | | *195 | -- | 2 | O | 9 | -- | 5 | | 1130 | 8.5 | 164 | .7 | .22 | 233 | Ech | C | |
| 353006N | 0764225 | 1 | 86 | R WINFIELD | P | U | | | 181 | -- | A1 | O | 6 | 18 | -- | | -- | -- | -- | -- | -- | -- | Mpr | | |
| 353018N | 0764200 | 1 | 87 | R WINFIELD | P | S | P | J | *200 | -- | 2 | O | 7 | 4 | -- | | 1180 | 7.9 | 150 | 1.1 | .56 | 220 | Ech | C | |
| 353027N | 0764156 | 1 | 88 | R WINFIELD | P | H | P | | *300 | -- | 2 | O | 8 | -- | -- | | 1720 | 8.2 | 312 | 1.0 | .12 | 271 | Ech | C | |
| 353040N | 0764157 | 1 | 89 | LISA BLAND | P | H | P | | *180 | -- | 2 | O | 8 | -- | -- | | 955 | 8.5 | 101 | 1.0 | .05 | 274 | Ech | C | |
| 353040N | 0764150 | 1 | 90 | R WINFIELD | P | H | P | | *150 | -- | A1 | O | 8 | -- | -- | | 422 | 8.1 | 8 | .2 | 1.7 | 216 | My | B | |
| 353038N | 0764135 | 1 | 91 | DENNIS GIBBS | P | H | P | | 93 | -- | 2 | O | 8 | 2 | 5 | | 492 | 8.0 | 8 | .1 | 2.2 | 236 | My | B | |
| 353031N | 0764134 | 1 | 92 | G ROOSEVELT | P | H | P | | *65 | -- | A1 | O | 5 | -- | -- | | 508 | 8.1 | 13 | .2 | 2.3 | 260 | My | B | |

TABLE 4. RECORDS OF WELLS IN THE VICINITY OF BELHAVEN, N. C.--Continued

| Well location | | Sequence No. | Well No. | Owner | Ownership | Use of water | QW analysis | Log data | Depth (feet) | Depth cased (feet) | Diameter(in) | Finish | Altitude of LSD (feet) | Water level below LSD (feet) | Yield (gallons per minute) | Drawdown (feet) | Specific conductance | pH | Chloride | Fluoride | Iron | Hardness | Water-bearing formation | Aquifer | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lat | Long | | | | | | | | | | | | | | | | | | | | | | | | |
| 353031N | 0764123 | 1 | 93 | RANDOLPH MOORE | P | H | P | | *130 | -- | A1 | O | 8 | -- | 5 | | 507 | 7.7 | 16 | 0.2 | 4.3 | 243 | My | B | |
| 353035N | 0764049 | 1 | 94 | L M EBOR | P | H | P | | 40 | 37 | B1 | T | 5 | 4 | -- | | 262 | 8.2 | 14 | .1 | 3.3 | 110 | My | B | |
| 353036N | 0764033 | 1 | 95 | JOE EBOR | P | H | P | | *100 | -- | 2 | O | 5 | -- | 4 | | 367 | 8.0 | 22 | .1 | 11 | 166 | My | B | |
| 353020N | 0764032 | 1 | 96 | P SPENCER | P | H | P | | *237 | -- | 2 | O | 3 | -- | -- | | 1000 | 8.2 | 108 | .7 | .08 | 258 | My | C | |
| 353040N | 0764058 | 1 | 97 | L EBOR | P | H | P | | 33 | 30 | B1 | T | 5 | 4 | 3 | | 347 | 8.3 | 5 | .1 | 5.2 | 160 | pM | A | |
| 353043N | 0764045 | 1 | 98 | C MARSLENDER | P | H | P | | *260 | -- | 2 | O | 5 | -- | 10 | | 1270 | 8.5 | 114 | .8 | .13 | 244 | Ech | C | |
| 353046N | 0764031 | 1 | 99 | DALLAS PAUL | P | H | P | | *255 | -- | 2 | O | 6 | -- | -- | | 1010 | 8.0 | 119 | .8 | .10 | 260 | Ech | C | |
| 353047N | 0764019 | 1 | 100 | G C CORDEN | P | H | P | | *200 | -- | 2 | O | 7 | -- | -- | | 965 | 7.9 | 96 | .7 | .10 | 274 | Ech | C | |
| 353100N | 0764007 | 1 | 101 | E SMITH | P | U | P | | 22 | 20 | B1 | T | 4 | 2 | 3 | | 106 | 7.3 | 10 | .1 | 22 | 26 | pM | A | |
| 353113N | 0763952 | 1 | 102 | FRED SMITH | P | H | P | | *260 | -- | 2 | O | 5 | -- | 10 | | 1270 | 8.2 | 198 | .7 | .01 | 259 | Ech | C | |
| 353154N | 0764053 | 1 | 103 | HARRY OLSEN | P | H | P | | 192 | -- | 2 | O | 6 | 14 | 5 | | 1010 | 8.4 | 139 | .9 | .38 | 208 | Ech | C | |
| 353158N | 0764051 | 1 | 104 | H D OLSEN | P | H | P | | *225 | -- | 2 | O | 6 | -- | 10 | | 647 | 8.2 | 25 | .4 | 5.5 | 287 | Ech | C | |
| 353208N | 0764107 | 1 | 105 | C D ALLIGOOD | P | H | P | | *267 | -- | 2 | O | 5 | 15 | 10 | | 893 | 8.3 | 91 | .7 | .26 | 260 | Ech | C | |
| 353208N | 0764114 | 1 | 106 | C D ALLIGOOD | P | H | P | | *105 | -- | 2 | O | 6 | -- | 5 | | 695 | 8.0 | 29 | .3 | 5.6 | 307 | My | B | |
| 353213N | 0764120 | 1 | 107 | J H GADSTON | P | H | P | | *190 | -- | 2 | O | 6 | -- | 10 | | 811 | 8.3 | 74 | .7 | .10 | 216 | Ech | C | |
| 353143N | 0764017 | 1 | 108 | ALICE BESS | P | H | P | | *300 | -- | 2 | O | 6 | -- | 5 | | 1150 | 8.2 | 176 | .7 | .12 | 198 | Ech | C | |
| 353136N | 0764008 | 1 | 109 | M MIDGETT | P | H | P | | *380 | -- | 2 | O | 6 | -- | -- | | 907 | 8.3 | 75 | 1.0 | .08 | 279 | Ech | C | |
| 353059N | 0763904 | 1 | 110 | HUBS RECK | P | P | P | | 70 | -- | B1 | O | 6 | 4 | -- | | 492 | 8.1 | 17 | .1 | 2.8 | 194 | My | B | |
| 353135N | 0763912 | 1 | 111 | E S MARSLANDER | P | H | P | | *75 | -- | A1 | O | 5 | -- | 10 | | 294 | 7.6 | 46 | .1 | 4.6 | 102 | My | B | |
| 353138N | 0763931 | 1 | 112 | ALVA SMITH | P | H | P | | *260 | -- | 2 | O | 6 | -- | -- | | 1120 | 8.3 | 165 | .7 | .13 | 243 | Ech | C | |
| 353146N | 0763915 | 1 | 113 | C SMITH | P | H | P | | *30 | -- | B1 | T | 5 | -- | -- | | 218 | 7.3 | 45 | .1 | 8.6 | 56 | pM | A | |
| 353151N | 0763905 | 1 | 114 | C SMITH | P | H | P | | *30 | -- | B1 | T | 5 | -- | 10 | | 232 | 7.5 | 56 | .1 | 10 | 36 | pM | A | |
| 353308N | 0763823 | 1 | 115 | W EDWARDS | P | H | P | | *87 | -- | 2 | O | 5 | -- | 5 | | 627 | 7.5 | 10 | .4 | 2.2 | 282 | My | B | |
| 353317N | 0763830 | 1 | 116 | CLEMENT SPELLER | P | H | P | | 13 | 10 | B1 | T | 5 | 3 | -- | | 507 | 6.0 | 56 | .1 | .78 | 56 | pM | A | |
| 353322N | 0763831 | 1 | 117 | P FRANCIS | P | H | P | | *30 | -- | A1 | T | 5 | -- | -- | | 135 | 6.8 | 8 | .1 | .50 | 15 | pM | A | |
| 353323N | 0763821 | 1 | 118 | L M COX | P | H | P | | *380 | -- | 2 | O | 6 | -- | -- | | 685 | 7.6 | 57 | .8 | .14 | 206 | Ech | C | |
| 353330N | 0763839 | 1 | 119 | REBECCA SLADE | P | H | P | | 6 | -- | 24 | O | 3 | 2 | -- | | 294 | 6.0 | 30 | .2 | .95 | 48 | pM | A | |
| 353338N | 0763840 | 1 | 120 | W BURST | P | H | P | | 73 | -- | B1 | O | 5 | 4 | 5 | | 285 | 6.8 | 30 | .0 | 1.1 | 29 | My | B | |
| 353353N | 0763841 | 1 | 121 | L D WARREN | P | H | P | | 17 | 14 | B1 | T | 5 | 3 | -- | | 704 | 7.8 | 27 | .3 | 1.4 | 311 | pM | A | |
| 353355N | 0763854 | 1 | 122 | N W WARREN | P | U | | | 18 | 15 | B1 | T | 3 | 2 | -- | | -- | -- | -- | -- | -- | -- | pM | A | |
| 353428N | 0763843 | 1 | 123 | E S WHITLEY | P | H | | | 20 | 18 | 1 | T | 5 | 3 | -- | | -- | -- | -- | -- | -- | -- | pM | A | |
| 353438N | 0763843 | 1 | 124 | D TAYLOR | P | H | P | | *275 | -- | 2 | O | 4 | -- | 10 | | 676 | 7.9 | 37 | .6 | .10 | 237 | Ech | C | |
| 353455N | 0763854 | 1 | 125 | A D JOHNSON | P | H | P | | 256 | -- | 2 | O | 7 | 8 | -- | | 695 | 7.9 | 38 | .7 | .10 | 243 | Ech | C | |
| 353500N | 0763900 | 1 | 126 | PANTEGO PROVISI | P | U | | | 230 | -- | 2 | O | 8 | 7 | -- | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353506N | 0763859 | 1 | 127 | L WHITLEY | P | H | P | | 23 | 20 | 1 | T | 8 | 4 | 3 | | 110 | 6.1 | 10 | .0 | 5.0 | 22 | pM | A | |
| 353512N | 0763855 | 1 | 128 | D W ALLEN | P | H | P | | *300 | -- | 2 | O | 11 | -- | -- | | 753 | 8.1 | 43 | .7 | .28 | 175 | Ech | C | |

TABLE 4. RECORDS OF WELLS IN THE VICINITY OF BELHAVEN, N. C.--Continued

| Well location Lat | Well location Long | Sequence No. | Well No. | Owner | Ownership | Use of water | QW analysis | Log data | Depth (feet) | Depth cased (feet) | Diameter(in) | Finish | Altitude of LSD (feet) | Water level below LSD (feet) | Yield (gallons per minute) | Drawdown (feet) | Specific conductance | pH | Chloride | Fluoride | Iron | Hardness | Water-bearing formation | Aquifer | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 353453N | 0763745 | 1 | 129 | H T SPENCER | P | H | P | | *325 | -- | 2 | O | 10 | -- | -- | | 907 | 8.2 | 79 | 0.7 | 0.12 | 188 | Ech | C | |
| 353440N | 0763714 | 1 | 130 | G C SPENCER | P | H | P | | *275 | -- | A1 | O | 10 | -- | -- | | 796 | 7.7 | 66 | .8 | .87 | 241 | Ech | C | |
| 353446N | 0763703 | 1 | 131 | H T SPENCER | P | U | P | | 98 | -- | B1 | O | 11 | 5 | -- | | 555 | 7.2 | 5 | .2 | 16 | 344 | My | B | |
| 353418N | 0763605 | 1 | 132 | RONALD LANIER | P | S | P | | 21 | 19 | B1 | T | 10 | 4 | -- | | 332 | 6.8 | 12 | .2 | 5.0 | 150 | pM | A | |
| 353423N | 0763554 | 1 | 133 | RONALD LANIER | P | H | P | | 25 | 23 | B1 | T | 11 | 5 | -- | | 492 | 7.1 | 22 | .3 | 11 | 239 | pM | A | |
| 353423N | 0763540 | 1 | 134 | DOUGLAS SPENCER | P | H | P | | 26 | 23 | B1 | T | 10 | 5 | -- | | 381 | 7.7 | 29 | .2 | 14 | 146 | pM | A | |
| 353421N | 0763531 | 1 | 135 | W HACKETT | P | H | P | | *165 | -- | A1 | | 11 | -- | 10 | | 656 | 8.5 | 37 | .6 | .03 | 234 | My | B | |
| 353405N | 0763522 | 1 | 136 | W HACKETT | P | I | P | J | 250 | -- | 2 | O | 5 | 9 | 10 | | 603 | 9.0 | 68 | 1.2 | 19 | 50 | Ech | C | |
| 353427N | 0763504 | 1 | 137 | W HACKETT | P | H | P | | 82 | -- | 2 | O | 11 | 8 | 5 | | 579 | 7.7 | 9 | .1 | 4.8 | 266 | My | B | |
| 353356N | 0763202 | 1 | 138 | J D COX | P | H | P | | 79 | -- | A1 | T | 9 | 8 | -- | | 695 | 8.1 | 12 | .4 | .09 | 170 | My | B | |
| 353355N | 0763144 | 1 | 139 | CHURCH | P | H | P | . | 105 | -- | B1 | O | 9 | 5 | 5 | | 608 | 8.0 | 14 | .3 | .06 | 214 | My | B | |
| 353409N | 0763110 | 1 | 140 | AXON SMITH | P | S | | J | *350 | 310 | 2 | O | 5 | 6 | -- | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353413N | 0763048 | 2 | 141 | ETHEL BLUNT | P | H | P | | 32 | -- | B1 | | 4 | 2 | -- | | 262 | 8.2 | 7 | .4 | 1.1 | 121 | pM | A | |
| 353418N | 0763029 | 1 | 142 | DOTTIE MALSCH | P | U | P | | 122 | -- | B1 | O | 4 | 1 | 5 | | 917 | 8.1 | 29 | .2 | 1.2 | 410 | My | B | |
| 353420N | 0763017 | 1 | 143 | S KEIFER | P | H | P | | *100 | -- | 2 | O | 4 | -- | 5 | | 868 | 7.9 | 29 | .2 | 1.4 | 284 | My | B | |
| 353413N | 0763007 | 1 | 144 | H C HARRIS | P | H | P | | *300 | -- | 2 | O | 3 | -- | 3 | | 878 | 8.3 | 30 | .4 | 4.2 | 298 | Ech | C | |
| 353405N | 0763007 | 1 | 145 | DOTTIE MALSCH | P | U | | | 4 | -- | 36 | O | 4 | 2 | -- | | -- | -- | -- | -- | -- | -- | pM | A | |
| 353400N | 0763006 | 1 | 146 | R L MARTIN JR | P | H | P | | 102 | -- | A1 | O | 3 | 0 | 5 | | 917 | 8.2 | 30 | .2 | 3.9 | 345 | My | B | |
| 353349N | 0762949 | 1 | 147 | E GRIFFIN | P | H | P | | 92 | -- | B1 | O | 3 | 1 | -- | | 936 | 7.8 | 32 | .5 | 4.2 | -- | My | B | |
| 353411N | 0763026 | 1 | 148 | M JONES | P | H | P | | 120 | -- | B1 | O | 4 | 1 | 4 | | 897 | 8.3 | 29 | .3 | 1.1 | 389 | My | B | |
| 353317N | 0763208 | 1 | 149 | FRANK BILLUPS | P | H | P | | 25 | 22 | B1 | T | 5 | 1 | -- | | 253 | 7.7 | 10 | .2 | .36 | 102 | pM | A | |
| 353313N | 0763218 | 1 | 150 | FRANK BILLUPS | P | H | P | | *100 | -- | 2 | O | 5 | -- | -- | | 618 | 8.0 | 13 | .3 | .40 | 129 | My | B | |
| 353325N | 0763229 | 1 | 151 | HARRY PETERSON | P | H | P | | *150 | -- | 2 | O | 6 | -- | -- | | 618 | 8.4 | 13 | .3 | 4.8 | 328 | My | B | |
| 353155N | 0763255 | 1 | 152 | MAGNEBAR MINING | N | U | | | 280 | -- | 10 | O | 0 | 6 | -- | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353321N | 0763252 | 1 | 153 | F O DAVIS | P | H | P | | *325 | -- | 2 | O | 8 | -- | -- | | 1370 | 8.5 | 216 | 1.1 | .10 | 204 | Ech | C | |
| 353328N | 0763258 | 1 | 154 | LULA CARY | P | H | P | | 25 | 22 | B1 | T | 8 | 0 | -- | | 304 | 8.3 | 13 | .1 | 4.4 | 140 | pM | A | |
| 353329N | 0763311 | 1 | 155 | CARTER ADAMS | P | H | P | | *150 | -- | A1 | O | 8 | -- | -- | | 565 | 8.2 | 13 | .3 | 5.2 | 307 | My | B | |
| 353331N | 0763323 | 1 | 156 | M NIXON | P | H | P | | *150 | -- | 2 | O | 7 | -- | 10 | | 589 | 8.2 | 13 | .3 | 3.5 | 302 | My | B | |
| 353340N | 0763413 | 1 | 157 | L M DILDAY | P | S | P | | 95 | -- | 2 | O | 4 | 2 | 3 | | 656 | 8.5 | 16 | .2 | 3.8 | 345 | My | B | |
| 353340N | 0763426 | 1 | 158 | CLARA DILDAY | P | H | P | | 87 | -- | 2 | O | 4 | 2 | -- | | 651 | 8.4 | 14 | .2 | 3.0 | 334 | My | B | |
| 353331N | 0763429 | 1 | 159 | M ARMSTRONG | P | H | P | | 96 | -- | 2 | O | 3 | -- | -- | | 299 | 8.1 | 16 | .1 | 3.4 | 133 | My | B | |
| 353327N | 0763447 | 1 | 160 | MRS PINNEFORD | P | S | P | | 24 | 21 | B1 | T | 4 | 2 | -- | | 378 | 8.7 | 20 | .1 | 11.4 | 164 | pM | A | |
| 353330N | 0763504 | 1 | 161 | J PINNEFORD | P | H | P | | 18 | 15 | B1 | T | 4 | 1 | 5 | | 63 | 8.1 | 2 | .1 | .12 | 28 | pM | A | |
| 353329N | 0763522 | 1 | 162 | J DAVIS | P | H | P | | 53 | -- | B1 | O | 4 | 2 | -- | | 671 | 8.2 | 11 | .3 | 3.3 | 345 | My | A | |
| 353326N | 0763540 | 1 | 163 | MARY EBOR | P | H | | | 79 | -- | B1 | O | 4 | 4 | -- | | 651 | 7.4 | 8 | .4 | 3.0 | 328 | My | B | |
| 353318N | 0763555 | 1 | 164 | MARION HARRIS | P | H | P | | *100 | -- | B1 | O | 4 | -- | 5 | | 618 | 8.2 | 7 | .3 | 1.9 | 308 | My | B | |

TABLE 4. RECORDS OF WELLS IN THE VICINITY OF BELHAVEN, N. C.--Continued

| Well location: Lat | Well location: Long | Sequence No. | Well No. | Owner | Ownership | Use of water | QW analysis | Log data | Depth (feet) | Depth cased (feet) | Diameter (in) | Finish | Altitude of LSD (feet) | Water level below LSD (feet) | Yield (gallons per minute) | Drawdown (feet) | Specific conductance | pH | Chloride | Fluoride | Iron | Hardness | Water-bearing formation | Aquifer | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 353258N | 0763609 | 1 | 165 | PURNELL BARBER | P | H | P | | 79 | -- | B1 | O | 4 | 2 | -- | | 618 | 7.4 | 12 | 0.3 | 11 | 316 | My | B | |
| 353253N | 0763606 | 1 | 166 | IRVING WHITE | P | H | P | | 23 | 21 | B1 | T | 4 | 2 | 3 | | 160 | 8.1 | 28 | .1 | 5.1 | 36 | pM | A | |
| 353247N | 0763600 | 1 | 167 | LLOYD HUDNAL | P | H | P | | *100 | -- | A1 | O | 4 | -- | -- | | 647 | 8.2 | 10 | .3 | 3.5 | 324 | My | B | |
| 353245N | 0763552 | 1 | 168 | J E MCKINNEY | P | H | P | | *360 | -- | 2 | O | 4 | 13 | 10 | | 1050 | 8.3 | 117 | .8 | .22 | 276 | Ech | C | |
| 353240N | 0763600 | 1 | 169 | REGINALD BISHOP | P | S | P | | 240 | -- | 2 | O | 5 | 9 | -- | | 1110 | 8.2 | 101 | 1.2 | 11 | 158 | Ech | C | |
| 353243N | 0763628 | 1 | 170 | D N ROUSE | P | H | P | | *105 | -- | 2 | O | 4 | -- | -- | | 618 | 7.4 | 28 | .4 | .50 | 322 | My | B | |
| 353245N | 0763649 | 1 | 171 | WALTER JOHNSON | P | H | P | J | 230 | -- | 2 | O | 4 | 9 | -- | | 3660 | 8.3 | 1050 | .8 | 1.8 | 674 | Ech | C | |
| 353237N | 0763657 | 1 | 172 | AXOOM SMITH | P | H | P | | *220 | -- | 2 | O | 4 | -- | 10 | | 656 | 8.0 | 14 | .3 | 1.0 | 338 | Ech | C | |
| 353217N | 0763655 | 1 | 173 | CTY OF BELHAVEN | M | U | P | | *275 | 250 | 4 | O | 5 | -- | 150 | | 1380 | 7.6 | 220 | 1.0 | .18 | 262 | Ech | C | |
| 353212N | 0763653 | 1 | 174 | CTY OF BELHAVEN | M | P | P | | 265 | -- | B1 | O | 4 | 11 | -- | | 762 | 8.1 | 154 | .1 | 4.1 | 200 | Ech | C | |
| 353210N | 0763645 | 1 | 175 | A B CUTHRELL | P | H | P | | *275 | 245 | 2 | O | 4 | -- | 50 | | 965 | 8.1 | 84 | .7 | -- | 211 | Ech | C | |
| 353207N | 0763659 | 1 | 176 | CTY OF BELHAVEN | M | P | P | | 28 | 25 | A1 | T | 4 | -- | 5 | | 540 | 8.1 | 70 | .2 | 13 | 98 | pM | A | |
| 353207N | 0763709 | 1 | 177 | CTY OF BELHAVEN | M | P | P | | 131 | -- | B1 | O | 4 | 2 | 5 | | 531 | 7.6 | 116 | .3 | 37 | 102 | My | B | |
| 353210N | 0763703 | 1 | 178 | CTY OF BELHAVEN | M | P | P | | 223 | -- | 2 | O | 4 | 11 | 5 | | 1180 | 7.4 | 260 | .0 | 26 | 378 | Ech | C | |
| 353214N | 0763708 | 1 | 179 | CTY OF BELHAVEN | M | P | P | | 221 | -- | 2 | O | 4 | 5 | 5 | | 811 | 7.9 | 136 | 1.0 | 18 | 105 | Ech | C | |
| 353215N | 0763725 | 1 | 180 | JACK LEE | P | H | P | | 133 | -- | 2 | O | 4 | -- | -- | | 840 | 8.2 | 26 | .4 | .06 | 205 | My | B | |
| 353231N | 0763727 | 1 | 181 | CTY OF BELHAVEN | M | P | | | 265 | -- | 2 | O | 4 | 11 | -- | | -- | -- | -- | -- | -- | -- | Ech | C | |
| 353235N | 0763718 | 1 | 182 | CTY OF BELHAVEN | M | P | P | | 255 | -- | 2 | O | 4 | 11 | 4 | | 666 | 8.4 | 117 | .5 | .56 | 54 | Ech | C | |
| 353253N | 0763745 | 1 | 183 | CTY OF BELHAVEN | M | P | C | | *275 | 250 | 4 | O | 5 | -- | 150 | | 1300 | 7.7 | 186 | -- | .03 | 226 | Ech | C | Analysis 4/29/65 |
| 353253N | 0763746 | 1 | 184 | CTY OF BELHAVEN | M | P | C | | *275 | 250 | 4 | O | 5 | -- | 150 | | 1500 | 7.6 | 225 | -- | .01 | 238 | Ech | C | " |
| 353253N | 0763747 | 1 | 185 | CTY OF BELHAVEN | M | P | C | | *275 | 250 | 4 | O | 5 | -- | 150 | | 1300 | 8.1 | 185 | -- | .04 | 206 | Ech | C | " |
| 353253N | 0763748 | 1 | 186 | CTY OF BELHAVEN | M | P | C | | *275 | 250 | 8 | O | 5 | -- | 300 | | 1500 | 7.9 | 221 | -- | .10 | 257 | Ech | C | " |
| 353343N | 0763718 | 2 | 187 | N C WATER RES | S | U | P | Y | *340 | 335 | 4 | O | 4 | -- | -- | | 2900 | -- | -- | -- | -- | -- | Ech | C | |
| 353343N | 0763718 | 2 | 187 | N C WATER RES | S | U | P | Y | *370 | 365 | 4 | O | 4 | -- | -- | | 3000 | -- | 820 | -- | -- | -- | Ech | C | NCDWR test well |
| 353343N | 0763718 | 2 | 187 | N C WATER RES | S | U | P | Y | *467 | 462 | 4 | O | 4 | -- | -- | | 7800 | -- | 3540 | -- | .08 | 615 | Ech | C | Depth 580 feet Casing set at 298' |
| 353343N | 0763718 | 1 | 188 | N C WATER RES | S | U | P | | 24 | -- | 2 | T | 4 | 4 | 20 | | 396 | 7.7 | 20 | -- | 5.4 | 171 | pM | A | |
| 353343N | 0763718 | 3 | 189 | N C WATER RES | S | U | | | 124 | 114 | A1 | S | 4 | 4 | -- | | -- | -- | -- | -- | -- | -- | My | B | |
| 353343N | 0763718 | 4 | 190 | N C WATER RES | S | U | P | | 150 | 100 | 4 | O | 4 | 3 | 75 | 16 | 700 | -- | 33 | -- | .17 | 171 | My | B | |

## AQUIFER B

In nearly all cases, concentrations of dissolved solids in water from aquifer B were below 500 ppm and averaged about 380 ppm. However, hardness-causing constituents, dissolved iron, and hydrogen-sulfide gas were found in objectionable amounts in the majority of the water samples collected from this aquifer. Hardness ranged from 29 to 419 ppm and was above 180 ppm throughout most of the area. Concentrations of dissolved iron ranged from 0.03 to 37 ppm and were above 0.3 ppm in 85 percent of the samples analyzed for this constituent. The pH values of the water were above 7.0 in most cases. A typical chemical analysis of water from aquifer B is shown in table 3.

Generally, treatment for the removal of excessive hardness, iron, and hydrogen-sulfide gas will be required to make this water suitable for domestic use.

## AQUIFER C

The concentration of dissolved solids in water from aquifer C ranged from 150 to 4,680 ppm and averaged about 575 ppm. Excessive amounts of iron, chloride, hardness-causing constituents, and hydrogen-sulfide gas were encountered in various places throughout the area. Concentrations of dissolved iron ranged from 0.01 to 19 ppm and were above 0.3 ppm in about 50 percent of the observed cases. Hardness ranged from 34 to 674 ppm and averaged 234 ppm. Ninety percent of the water samples collected from wells finished in this aquifer contained more than 180 ppm hardness. Chloride content ranged from 9 to 3,540 ppm. Concentrations of chloride are generally below 250 ppm in water in the upper part of aquifer C. However, concentrations of this anion are very near 250 ppm in the extreme southern part of the area, and have equaled or exceeded this limit at various times in water from the municipal wells at Belhaven. Figure 12 shows the approximate distribution of chloride concentrations in water contained by the upper part of this aquifer. The lower part (below about 280-300 feet below land surface) is saturated with brackish and saline water. Observed pH values of water samples collected from aquifer C averaged 8.1 and were above 7.0 in all cases. A typical analysis of water from the upper part of aquifer C is shown in table 3.

Where concentrations of chloride are within acceptable limits, the removal of hardness-causing constituents and excessive concentrations of iron and hydrogen sulfide will make water from this aquifer suitable for most uses.

## OTHER AQUIFERS

The waters in the deeper artesian aquifers of the area contain large amounts of dissolved solids (up to 12,500 ppm) mainly due to excessively high concentrations of sodium and chloride. Observed chloride content ranged up to 6,720 ppm and was well above 250 ppm in all cases. In addition, excessive concentrations of iron, sulfate, and hardness-causing constituents are common, and there is no economical way to make this water suitable for domestic use. Table 3 shows a typical chemical analysis of water from aquifers D and E.

# FACTORS AFFECTING FUTURE USE AND DEVELOPMENT

There are several factors that must be considered when planning the development of ground-water supplies from the various aquifers in the area of investigation. The most important factors are the lowering of water levels and the change in chemical quality of the waters as a result of pumping.

Large quantities of water are pumped from aquifer C, about 15 miles southwest of the area of investigation, to allow the open-pit mining of phosphate deposits that occur in the overlying Pungo River Formation. The influence of this concentrated pumpage has spread for some 30 miles from the center of pumping. Within the area of influence, the withdrawals have reduced the artesian pressure, caused water levels to decline, and induced the movement of water from all directions toward the center of pumping. To date this pumping has caused water levels in aquifer C to decline about 12 feet in the vicinity of Belhaven. Data collected during this investigation indicate that there is little immediate threat of lateral salt-water encroachment in the upper part of aquifer C in the Belhaven area under the present hydrologic conditions. In fact, it appears that fresher water in the upper part of aquifer C in the north and northeastern part of the area of study is moving toward Belhaven as a result of pumping in the mine area (fig. 12).

However, the lower part of aquifer C, in this area, contains water having chloride concentrations in excess of 250 ppm. In response to the lowered water levels, this salt water is probably moving slowly towards the upper part of the aquifer. Under the present hydrologic conditions it is possible that the entire aquifer in the area may eventually become contaminated from this source.

Aquifers A and B are separated from aquifer C by layers of dolomitic limestone and clay in the Pungo River Formation and by silt and clay layers found near the base of the Yorktown Formation. Aquifer D is separated from aquifer C, in the western part of the area, by a layer of tight silty clay about 10 to 15 feet in thickness. This clay layer thins towards the southeast and pinches out between Pantego and Belhaven where aquifers C and D become one hydrologic unit. Some leakage of ground water from aquifers A and B to aquifer C occurs due to higher water levels in the shallower aquifers. However, because of ample recharge, the water levels in the shallower aquifers are essentially the same as they were prior to the decline of water levels in aquifer C. Ground-water withdrawals from aquifers A and B are well distributed and relatively small throughout the area of study. Thus, these shallow aquifers, particularly the more productive aquifer B, should be considered as good alternative sources of ground water if salt-water contamination prohibits the use of aquifer C.

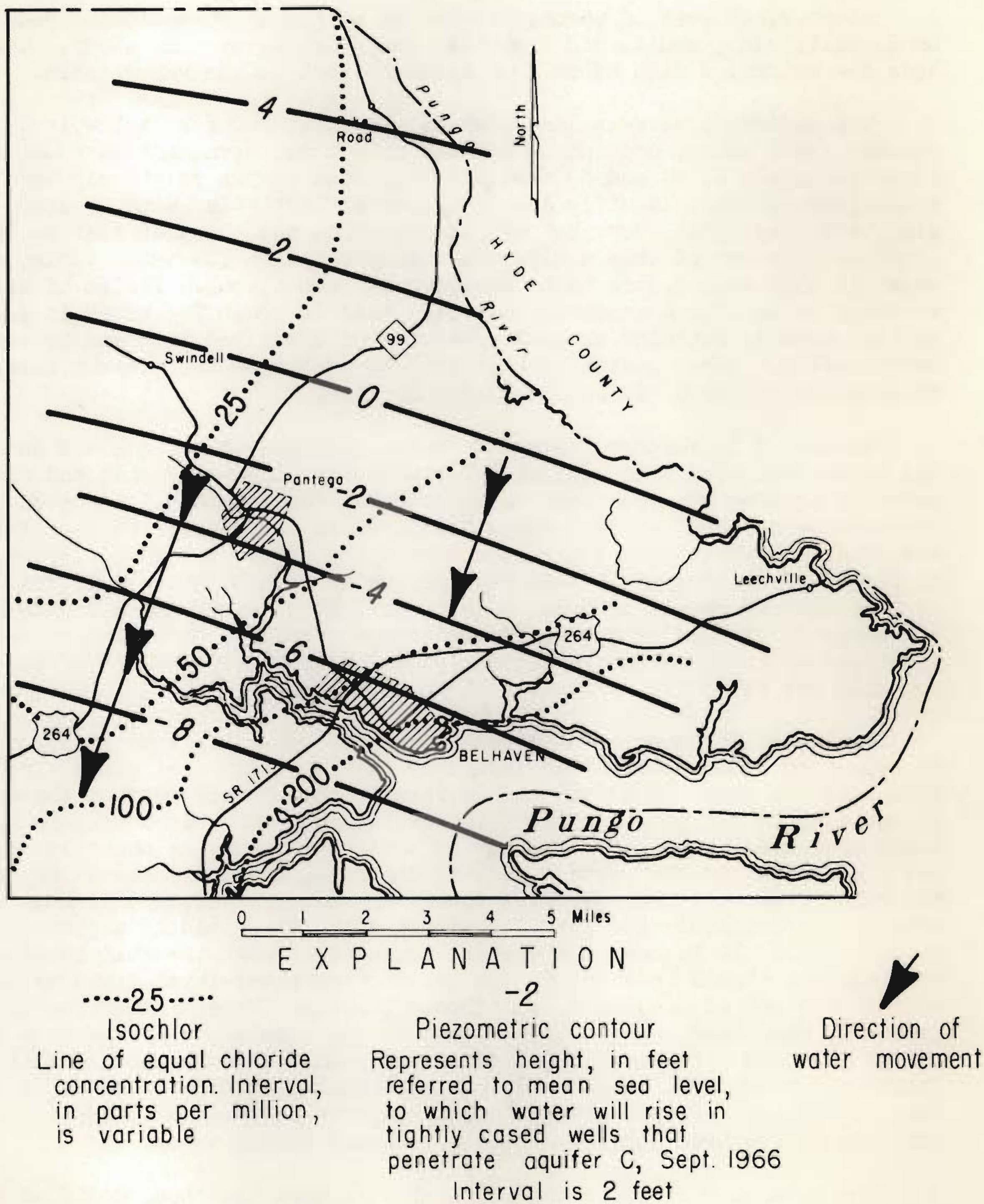



Figure 12.--Map showing the approximate distribution of chloride concentrations, water level, and water movement in the upper part of aquifer C, 1966.

# SUMMARY AND CONCLUSIONS

About 2,500 feet of unconsolidated to partially consolidated beds of sand, silt, clay, shell, and limestone underlie the area of study. These beds are saturated with water from basement rock to the water table.

The sediments between land surface and about 300 feet below land surface contain fresh water, and can be divided into three permeable water-bearing zones (aquifers A, B, and C) that are separated by two relatively impermeable zones (aquicludes). Aquifer A is composed of lenticular beds of sand, silt, clay, and shell that occur between land surface and about 35 feet below land surface. The top of this aquifer is coincident with the water table, and water in this zone occurs under non-artesian conditions. Yields of wells screened in aquifer A generally are less than 10 gpm. The water in this aquifer usually contains excessive amounts of dissolved iron and is very hard locally. Other dissolved constituents are below the maximum amounts recommended by the U. S. Public Health Service.

Aquifer B is composed of about 70 feet of permeable shell and sand beds, and it is separated from aquifer A by lenticular layers of silt and clay. The water in aquifer B is confined under artesian conditions. The top of this zone occurs at about 40 feet below sea level in the western part of the area, and it slopes about 5 feet per mile toward the east. Theoretically, yields of properly constructed 10-inch diameter wells screening the full thickness of this aquifer should be about 10 gpm per foot of water-level drawdown in the wells at the end of one day's continuous pumping. Excessive concentrations of dissolved iron, hardness-causing constituents and hydrogen-sulfide gas commonly are found in the water in this aquifer.

Aquifer C is composed of shell limestone, and calcareous sand beds. It is separated from aquifer B by layers of silt and clay that range from 60 to more than 100 feet thick from the western to the eastern part of the area, respectively. Water in aquifer C is confined beneath this aquiclude and is under artesian conditions. The top of aquifer C occurs at about 160 feet below sea level in the western part of the area, and increases in depth at the rate of about 9 feet per mile toward the east. Average thickness of this zone is approximately 190 feet. Theoretically, the yield of a properly constructed well, 10-inches in diameter, screened through the full thickness of this aquifer should be about 80 gpm per foot of water-level drawdown in the well at the end of one day of continuous pumping. Water in aquifer C is generally very hard, and in many places it contains excessive amounts of dissolved iron and hydrogen-sulfide gas. Water in the lower part of this aquifer (below about 300 feet below msl), contains concentrations of chloride in excess of 250 ppm. Deeper artesian aquifers were penetrated during the test drilling in the area and were found to contain saline water.

The natural hydrologic conditions in the area have been modified by large and concentrated ground-water withdrawals from aquifer C during recent years. Water-level declines and the threat of salt-water contamination in aquifer C (the major artesian aquifer in the area), have concerned all those who use this aquifer for water supply. If ground-water withdrawals from aquifer C intensify these problems, aquifers A and B afford good alternative sources of ground water.

# BASIC DATA

The wells listed in table 4 were inventoried during the investigation and are representative of the types, depth, yields, etc., of wells found in the vicinity of Belhaven. Figure 13 shows the location of the inventoried wells.

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Figure 13.--Map showing inventoried wells in the vicinity of Belhaven, N. C.