NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES

HARRY E. BROWN, *Director*

DIVISION OF GROUND WATER
HARRY M. PEEK, *Chief*

GROUND-WATER BULLETIN NUMBER 1

GEOLOGY AND GROUND-WATER RESOURCES OF WILMINGTON-NEW BERN AREA

By

HARRY E. LeGRAND
Geologist, United States Geological Survey

PREPARED IN COOPERATION WITH THE GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR

1960

Foreword

This bulletin was prepared under a joint water resources investigation conducted by the State of North Carolina and the Geological Survey, United States Department of the Interior.

The report covers data collected in accordance with a cooperative program entered into between North Carolina Department of Conservation and Development and the Geological Survey, United States Department of the Interior.

The responsibilities for the water resources program, formerly vested in the Division of Water Resources, Inlets and Coastal Waterways Department of Conservation and Development, were by action of the 1950 General Assembly transferred to the newly created Department of Water Resources, effective July 1, 1959.

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Letter of Transmittal

The Honorable LUTHER H. HODGES

GOVERNOR of NORTH CAROLINA

DEAR GOVERNOR HODGES:

I am pleased to submit Ground-Water Bulletin No. 1, "Geology and Ground-Water Resources of the Wilmington-New Bern Area," prepared by Harry E. LeGrand, Geologist, United States Geological Survey.

This report gives the results of an investigation made by the U. S. Geological Survey, in cooperation with the North Carolina Department of Conservation and Development, as a part of the program of reconnaissance investigations to evaluate the ground-water resources of the State. The report presents the data collected and describes the general geologic and ground-water conditions in Carteret, Craven, Duplin, Jones, Lenoir, New Hanover, Onslow and Pender 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 those resources.

Respectfully submitted,

HARRY E. BROWN

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GEOLOGY AND GROUND-WATER RESOURCES OF WILMINGTON-NEW BERN AREA

By

HARRY E. LEGRAND

ABSTRACT

This report describes the geology and ground-water resources of an area of 3,988 square miles in southeastern North Carolina, including Carteret, Craven, Duplin, Jones, Lenoir, New Hanover, Onslow, and Pender Counties. The area is a relatively flat, sandy plain, the only steep slopes being in the vicinity of stream valleys. The climate is humid, the average annual precipitation being about 50 inches. In 1950 the population of the area was 293,635.

This area is underlain by nearly flat-lying sedimentary strata, ranging in age from Cretaceous to Recent. Most of these strata are not consolidated. They dip very gently to the southeast, in most places at a slope only slightly greater than that of the land surface, which is also to the southeast. In aggregate the beds may be considered as an immense wedge, whose thin edge lies to the west and whose thick part lies coastward. Except in parts of some stream valleys and in man-made excavations, outcrops of the older formations are rare. This is due to the flat topography and a thin veneer of sand and sandy clay of Pleistocene age. Interbedded sands and clays of Late Cretaceous age, consisting of the Black Creek and Peedee formations, are the near-surface strata in the western extremities of the area. Eastward these strata are overlain by calcareous deposits of Tertiary age. The Tertiary strata consist chiefly of the Castle Hayne limestone, although in Carteret County and in the eastern parts of Craven, Jones, and Onslow Counties, the Yorktown formation overlies the Castle Hayne; collectively, they are considered in this report as the Tertiary limestone unit.

Three major aquifers furnish water to wells, at least two of them being available for use in any part of the area. They are (1) the sand beds of the Cretaceous formations, which contain fresh artesian water in approximately the western half of the area, (2) the Tertiary limestone unit which contains artesian water, and (3) the shallow surface sands throughout the area, which contain water within the reach of shallow drive point wells.

The current withdrawal of ground water is only a fraction of the available supply, and nowhere in the area has there been an overdraft of water from wells. Yields greater than 5 gallons a minute per foot of drawdown can be obtained from completely developed wells throughout the area. The majority of municipal and industrial wells are capable of yielding 1 million gallons of water per day.

Water in the surface sands is soft but corrosive. Water in the Tertiary limestone unit is not corrosive but is hard and in places contains objectionable quantities of iron. The water in the uppermost Cretaceous beds is moderately hard, but water from several beds of sand in the Cretaceous formations is soft and contains no objectionable mineral matter for most industrial and municipal uses of the water. Except in western Lenoir and Duplin Counties, aquifers containing salt water underlie the fresh-water aquifers, but the depth to the salt water is generally not accurately known. The presence of strata containing salt water and the possibility of contamination of the fresh-water aquifers are factors that may limit the quantity of ground water that can be withdrawn safely in some localities.

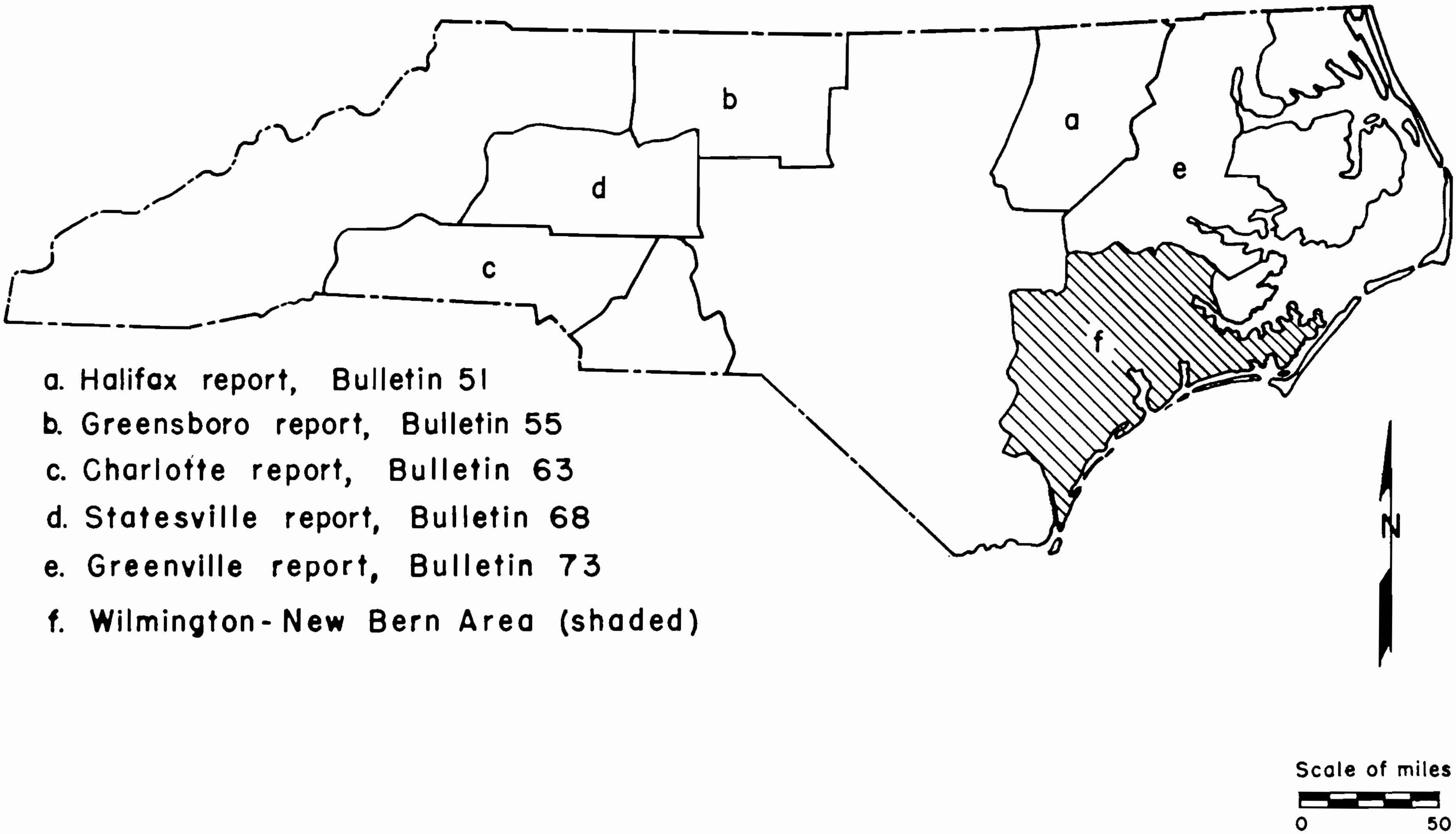


Figure 1. Index map of North Carolina showing where systematic ground-water investigations have been made.

INTRODUCTION

This report is the sixth in a series of areal reports (figure 1) that are designed to give a preliminary or reconnaissance appraisal of ground-water conditions in North Carolina. These reports were prepared by the U. S. Geological Survey in cooperation with the North Carolina Department of Conservation and Development. It deals with the ground-water resources of a part of the southeastern Coastal Plain of North Carolina. The report is named from Wilmington and New Bern, two prominent cities in the area of investigation.

The purpose of this report is to make available some information to the public about ground-water resources of the area. This information will be useful in the planning and development of future water supplies. It should be emphasized, however, that much additional data must be collected and analyzed before detailed answers can be given to many ground-water problems in this area.

The investigations on which the report is based and the preparation of the report itself were under the general direction of A. N. Sayre, former Chief, Ground Water Branch, U. S. Geological Survey and J. L. Stuckey, State Geologist of North Carolina.

Some of the data on which this report is based were collected by M. J. Mundorff, of the U. S. Geological Survey between 1941 and 1948, but most of the field work in the Wilmington-New Bern area was done by the writer intermittently between the spring of 1952 and the fall of 1955. The work consisted of a reconnaissance of the geology of the area, collection of data on 672 wells, and collection of representative samples of water for analysis. Much of the information on wells was given from memory by well owners and drillers. Some of it, therefore, may not be wholly accurate.

During the investigation, samples of rock materials from more than 25 wells in the area were examined by P. M. Brown, Geologist, U. S. Geological Survey, who prepared well logs and cross sections describing the subsurface geology. Water samples were analyzed by the Quality of Water Branch, U. S. Geological Survey, under the direction of G. A. Billingsley, District Chemist.

The writer wishes to acknowledge the courteous and generous assistance of the many well owners and well drillers who have furnished information for this report. The Heater Well Co. at Raleigh, the Carolina Well Drilling Co. at Sanford, and the Layne-Atlantic Co. at Norfolk, Virginia were particularly helpful.

GEOGRAPHY

Area and Population

The area included in this report totals approximately 4,000 square miles, of which about 70 percent is forested. It includes Carteret, Craven, Duplin, Jones, Lenoir, New Hanover, Onslow, and Pender Counties (fig. 1). With the exception of the municipal water supply of Wilmington, the entire area uses ground water.

The total population of the eight counties according to the 1950 census was 293,635, an average of 63 people per square mile. The urban population is centered in six cities or towns that have populations greater than 2,500. The total urban population is 91,500, or about 35 percent of the total for the area. The remaining 65 percent of the population is classified as rural, being centered in and around the 33 other incorporated towns and villages in the area covered by this report. Since 1940 all counties in the area have increased in population, although the increase in Jones, Duplin, and Pender Counties has been slight. The development of military installations in Onslow, Craven, Carteret, New Hanover, and Lenoir Counties was largely responsible for the significant growth in these counties.

Physical Features

The Wilmington-New Bern area is in the Coastal Plain province. The land surface is a plain which slopes gently eastward to the Atlantic Ocean at an overall rate of less than 3 feet per mile. This plain is relatively flat in the broad interstream areas, but is broken by low escarpments adjacent to the stream valleys. The plain represents the part of a former sea floor that has been elevated above the sea in the relatively recent geologic past. As the sea withdrew eastward, the streams extended their courses toward the southeast. Some streams have cut their channels as much as 40 feet below the level of the upland. Commonly a terrace borders the streams at a level below the upland. These terraces vary greatly in area, and range in width from a few tens of feet to as much as a mile. A thick vegetative growth covers both the terraces and the low, poorly drained ground along the coast.

The sea has drowned much low ground in the coastal areas and extends up the streams to form bays and broad estuaries. Waves have built up a long chain of off-shore bars, which border the ocean and are separated from the mainland by narrow shallow sounds.

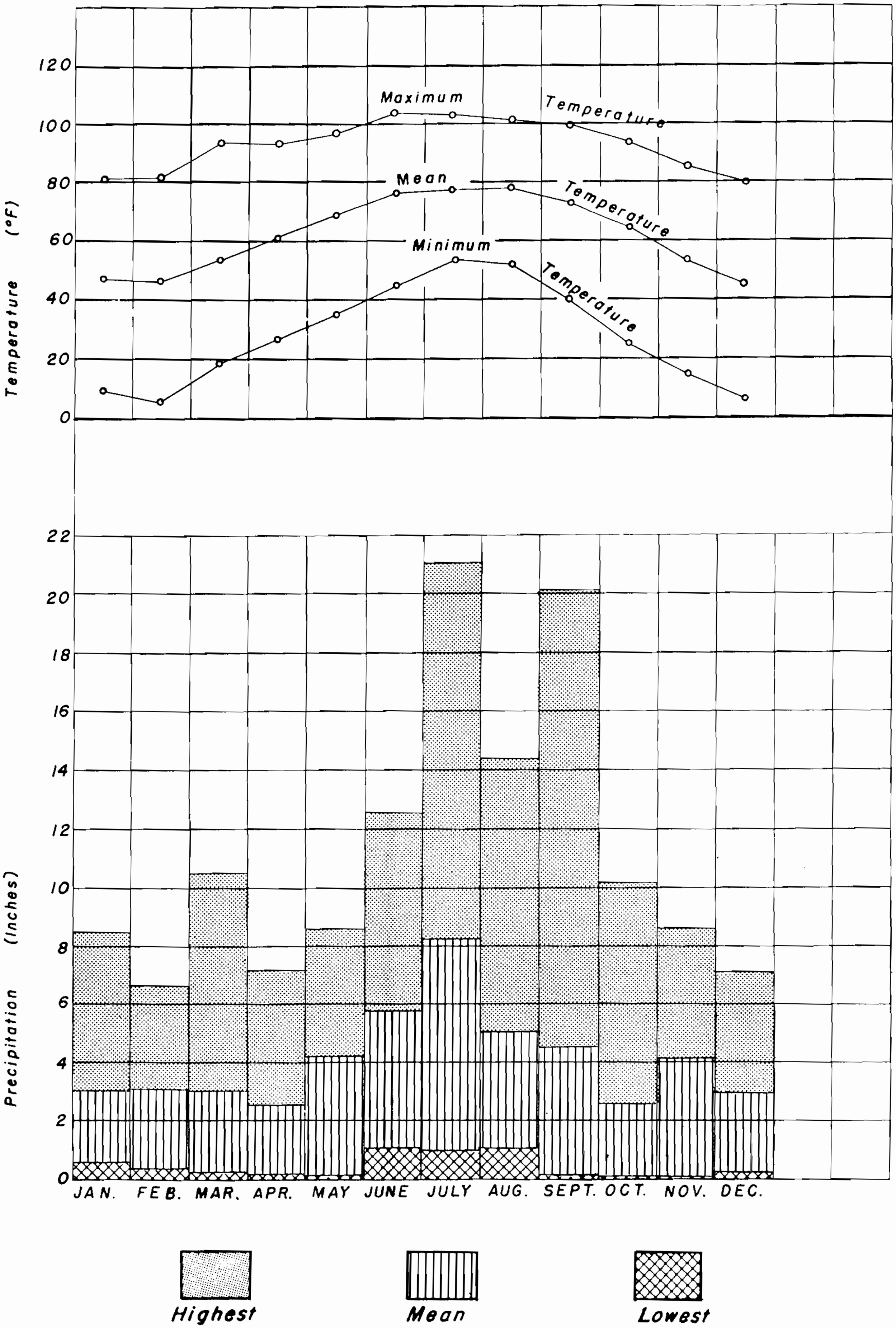


Figure 2. Climatic summary for Kinston, Lenoir County, based on records (1871-1952) of the Kinston station of the U. S. Weather Bureau.

Climate

Yearly precipitation is distributed almost evenly throughout the area, the average being about 50 inches. The monthly distribution of precipitation at the station at Kinston, which is typical for the area, is shown in figure 2. The highest monthly precipitation normally occurs at the height of the growing season from May through September. For the remaining months the precipitation is quite uniformly about 3 inches per month.

The average annual temperature ranges from about 63°F. at Kinston in Lenoir County to about 64°F. in Carteret County. Average, maximum, and minimum monthly temperatures at the Kinston station are shown in figure 2.

OUTLINE OF GEOLOGY

Only those formations which are capable of yielding water of acceptable quality from wells, and those that act as confining layers for artesian aquifers containing usable artesian water are of concern in this report. Excluded are those formations older than Late Cretaceous age which occur at great depths in the coastal counties, because they contain water too salty for use. The deeper formations are described in other reports (Spangler, 1950) and (Swain, 1952).

In the report area, the rock materials containing potable water are chiefly in beds of sand and shell limestone. The water-bearing zones are commonly separated by beds of clay. Generally, these beds slope gently coastward at a rate slightly greater than the land surface. In aggregate the beds may be considered as an immense wedge, whose thin edge lies to the west and whose thick part lies coastward and eastward. Dense igneous and metamorphic rocks lie beneath this wedge, but no wells draw water from them in the report area. The thickness of the wedge of sediments ranges from about 250 feet in the extreme northwest tip of Duplin County to more than 5,000 feet in eastern Carteret County where it includes sediments older than Late Cretaceous.

The sediments consist of several formations, ranging in age from Late Cretaceous to Recent. The oldest formation from which water is drawn is the Tuscaloosa formation of Late Cretaceous age. Overlying the Tuscaloosa is the Black Creek formation, which crops out in western Lenoir and Duplin Counties but which is buried coastward beneath the Peedee formation. The Black Creek and Peedee are also of Late Cretaceous age and together with the Tuscaloosa formation represent a unit of sand and clay, varying greatly in thickness and in degree of assortment of mineral constituents.

Overlying the Peedee formation is the Castle Hayne limestone of Eocene age. The Castle Hayne lies at or near the surface in parts of Craven, Jones, Onslow, Pender, and New Hanover Counties (fig. 3). It is composed chiefly of white to gray shell material and white sand, individual beds varying in degree of consolation from a dense limestone to a loose shell and sand material. In the eastern part of the area the Yorktown formation of late Miocene age overlies the Castle Hayne limestone. It is similar in character to the Castle Hayne but in many places contains dense clay beds.

At the surface throughout the area is a thin layer of sand and sandy clay which differs in appearance from the underlying formations. In some places the surface material is the weathered part of the underlying formation, but at least in the coastward areas the surface material is thought to represent deposits of Pleistocene age. These deposits are commonly less than 20 feet thick, except along the coast where they are somewhat thicker.

A generalized section of the geologic formation and a brief statement of the ground-water conditions in each formation are shown in table 1.

GROUND-WATER HYDROLOGY

Occurrence

Ground water occurs in the openings between the mineral particles in the zone of saturation beneath the land surface. It is recoverable for human use only when these openings are interconnected and large enough to permit flow through them. A formation or rock unit that yields water to wells is called an aquifer. In the Wilmington-New Bern area two chief types of aquifers may be differentiated on the basis of the type of openings, or pore space, that transmit water. Beds of sand are the predominant aquifers, the pore space between the individual sand grains serving as the storage space and means of transmission of water. Beds of shells, characteristic of the Tertiary sediments, have been consolidated in many places into limestone, which is the second type of aquifer in the area. Much of the original pore space between the shells has been filled with fine calcareous and siliceous cement, but the removal by solution of some of the shell material has resulted in a network of large, interconnecting openings in the limestone which store and transmit water freely.

Interlayered with the sand and limestone aquifers

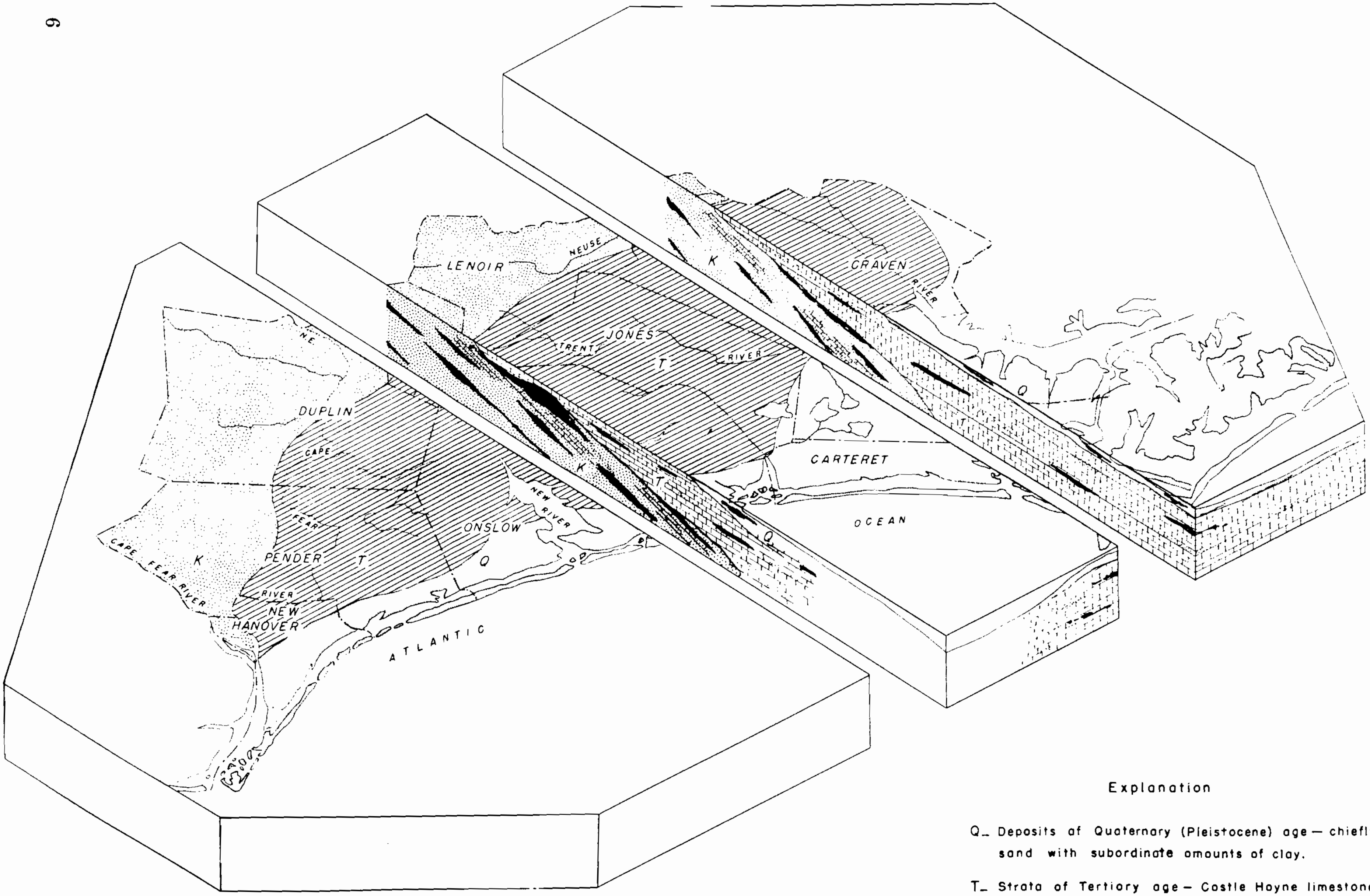


Figure 3. Block diagram showing the surface and subsurface distribution of formations in the area.

Explanation

Q_ Deposits of Quaternary (Pleistocene) age — chiefly sand with subordinate amounts of clay.

T_ Strata of Tertiary age — Castle Hayne limestone overlain by the Yorktown formation locally and both blanketed by a few feet of Pleistocene sand.

K_ Strata of Cretaceous age — chiefly interbedded sands and clays of the Peedee and Black Creek formations.

Geologic Age	Description	Distribution	Water-bearing Properties
Recent, Pleistocene, and Pliocene	The undifferentiated surficial deposits consist chiefly of sand and clay, but near the coast shell rock and loose shells are predominant in the lower part.	The surficial deposits are present everywhere on the interstream areas. They are generally less than 30 feet thick, except in Carteret and in eastern Craven and Onslow Counties where they thicken considerably to the east.	Contains the shallow ground water. Source of water for dug wells and well points. Only a fraction of total available water is used. Recharge facilities are enormous. Water contains very little mineral matter although it is corrosive.
Miocene (late)	The Yorktown limestone consists chiefly of limestone, calcareous sandstone, and sand. Massive marine clay beds and sandy shell beds are locally present.	Local, outlying deposits of the Yorktown occur in all counties, but as a formation its occurrence is restricted to Carteret and adjacent parts of Craven and Onslow Counties.	Both the semi-consolidated shell rock and the interbedded sands are very permeable in Carteret County. Wells at Cherry Point draw water from the Yorktown.
Eocene (late and middle)	The Castle Hayne formation consists of fossiliferous limestone of varying purity and hardness, and some interbedded sand. The limestone normally is soft, cream-colored, and marly. Pebbles rich in calcium phosphate are locally common near the base of the formation.	The Castle Hayne underlies the Yorktown formation in Carteret County and in eastern Craven and Onslow Counties. Westward it is generally covered by clays and sands of Pleistocene age or older. The original thickness of the formation has been greatly reduced by the solvent action of groundwater, and consequently, its present thickness is quite variable. The formation dips gently to the east.	One of the most productive aquifers in the Coastal Plain. Most wells yield 20-60 gallons per minute per foot of drawdown. Water is generally hard and in some cases high in iron content. May not be distinguishable hydrologically from overlying Yorktown formation.
Late Cretaceous	The Peedee formation consists of dark clays interbedded and interlaminated with fine to medium-grained sands and a few thin limestone beds. The sands are dark green and gray, containing varying amounts of glauconite. Fossil shells are common throughout the formation.	The Peedee underlies the Tertiary limestone unit. It lies in the shallow depth in Lenoir, Duplin, and western Pender Counties. To the east it is buried progressively deeper as the overlying Tertiary sediments thicken.	The formation contains several productive water-bearing sands capable, in aggregate, of furnishing more than 500 gallons per minute to individual wells. Principal aquifer, containing water of good chemical quality, in area west of line connecting New Bern, Jacksonville, and Wilmington. East of this line water is salty.
	The Black Creek formation is similar in appearance and lithology to the Peedee formation, although the sands contain less glauconite and the clays contain more carbonaceous material in the Black Creek. Sands, generally fine to medium-grained, are interbedded and interlaminated with black plastic clays.	The Black Creek underlies the Peedee formation. It is exposed in the channel of Neuse River in the western part of Lenoir County. Its gentle southeast dip causes it to lie at shallow depth in western Lenoir and Duplin Counties. It is buried progressively deeper toward the coast.	Not distinguishable hydrologically from overlying Peedee formation. In Lenoir and Duplin Counties and in western Pender, Jones, and Craven Counties many wells are capable of yielding more than 500 gallons per minute of water that is of excellent chemical quality. In the eastern areas water in the Black Creek is salty.
	The Tuscaloosa formation consists of lenticular beds of clay and sand. The sands range from fine to very coarse in texture, and they vary greatly in content of interstitial clay. The beds of clay are generally thicker than those of sand.	Little is known of the character of the Tuscaloosa formation east of Lenoir County because of its great depth. It lies deeper than 100 feet in western Lenoir and Duplin Counties and much deeper to the east.	Only the municipalities of LaGrange and Kinston use water from sands of the Tuscaloosa. However, the sands are capable of furnishing considerable water in Lenoir, Duplin, and northwestern Pender County. Further east the Tuscaloosa water is salty.

Table 1. Generalized table of deposits underlying the Wilmington-New Bern Area.

are beds of clay of varying thickness; the clay contains countless minute pore spaces, which in aggregate are probably capable of holding at least as much water as a comparable volume of sand. However, the clays yield water so slowly to wells that they are not considered as aquifers in the Wilmington-New Bern area.

The uppermost aquifer is the surface sand that covers the entire Wilmington-New Bern area, and in most places rests on clay at depths ranging between 15 and 40 feet. The lower part of the surface sand is saturated with water; the upper part contains water only as it moves downward to the zone of saturation after a period of precipitation. The upper surface of the zone of saturation is known as the water table.

Below the water table all the pores are filled with water, not only in the surface sand but in the underlying beds of clay, sand, and limestone. The beds of clay are sufficiently impermeable to retard the vertical movement of water; consequently, beneath the uppermost bed of clay, water in the beds of sand or limestone is confined under pressure, and movement of water tends to be lateral. The rate of movement varies with the pressure gradient which is controlled by the difference in elevation between the area of entrance of water into the aquifer and the area of escape from it. This confined water is called artesian water. The water level in a well that taps an artesian aquifer stands above the level where the water occurs. The overlying clay bed is called an aquiclude or confining bed. The imaginary surface formed by connecting the heights to which water levels would rise in tightly cased wells that tap the artesian aquifer is called the piezometric surface or static artesian water level. A generalized section illustrating water-table and artesian features is shown in figures 4 and 5.

Natural Discharge Facilities

One of the most significant factors to be considered in the movement of ground water in an aquifer is the discharge facilities. Unless water can move out of an aquifer it cannot move through it. In the surface sand, where water-table conditions exist, discharge of ground water is facilitated by the uneven topography. Streams, having incised their channels into, or below, the surface sand, represent lines along which the water table is exposed to the atmosphere. The discharge of water as springs and seeps in low places results in depressions in the water table and in a significant difference in pressure head between the water table in the interstream and stream areas. The gradient is steeper, and consequently the movement is faster, near the streams than in broad interstream areas. The discharge facilities of the artesian aquifers of the area are much poorer than those of the water-table aquifers. The movement of the artesian water is, in general, eastward and down dip in the permeable sand and limestone beds. Sufficient pressure exists to cause the water to rise to higher levels, even to the ground surface in many places, but its confinement beneath impermeable clay beds prevents any concentrated discharge at the surface. The coastward movement suggests that discharge takes place beneath the sea, perhaps at the edge of the continental shelf, where the beds may crop out. However, the discharge of large amounts of ground water at the edge of the continental shelf has not been established, and it is probably more reasonable to believe that the natural discharge is upward through imperfect confining beds and is dispersed over such large areas that it cannot be measured. Discharge through upward leakage is locally slight but over a large area and through the geologic ages has been sufficient to cause the original connate sea water to be partly flushed and to result in a measurable eastward hydraulic gradient.

Storage and Transmitting Capacities of the Aquifers

Aquifers vary greatly in their ability to store and transmit water. Certain field methods for appraising both the transmitting and storage capacities of aquifers have been developed, but the application of these methods to determine the hydraulic properties of the aquifers has been prevented in the report area by the lack of accurate data. The water that is initially drawn from a well comes from storage but with continual withdrawal the transmitting capacity of the aquifer allows water to move into the well that would have moved toward a natural discharge area or that never would have reached the underground reservoir.

Prior to the withdrawal of water from a well, the water level in the well is about the same as in the aquifer just outside the well and is called the static water level. When a well is pumped the water level in the well drops, and is termed the pumping water level. The distance between the normal static water level and the pumping water level, at any given time, is called the drawdown. The water level is depressed around wells that are pumped, forming a "cone of depression." The lowest point on the sur-

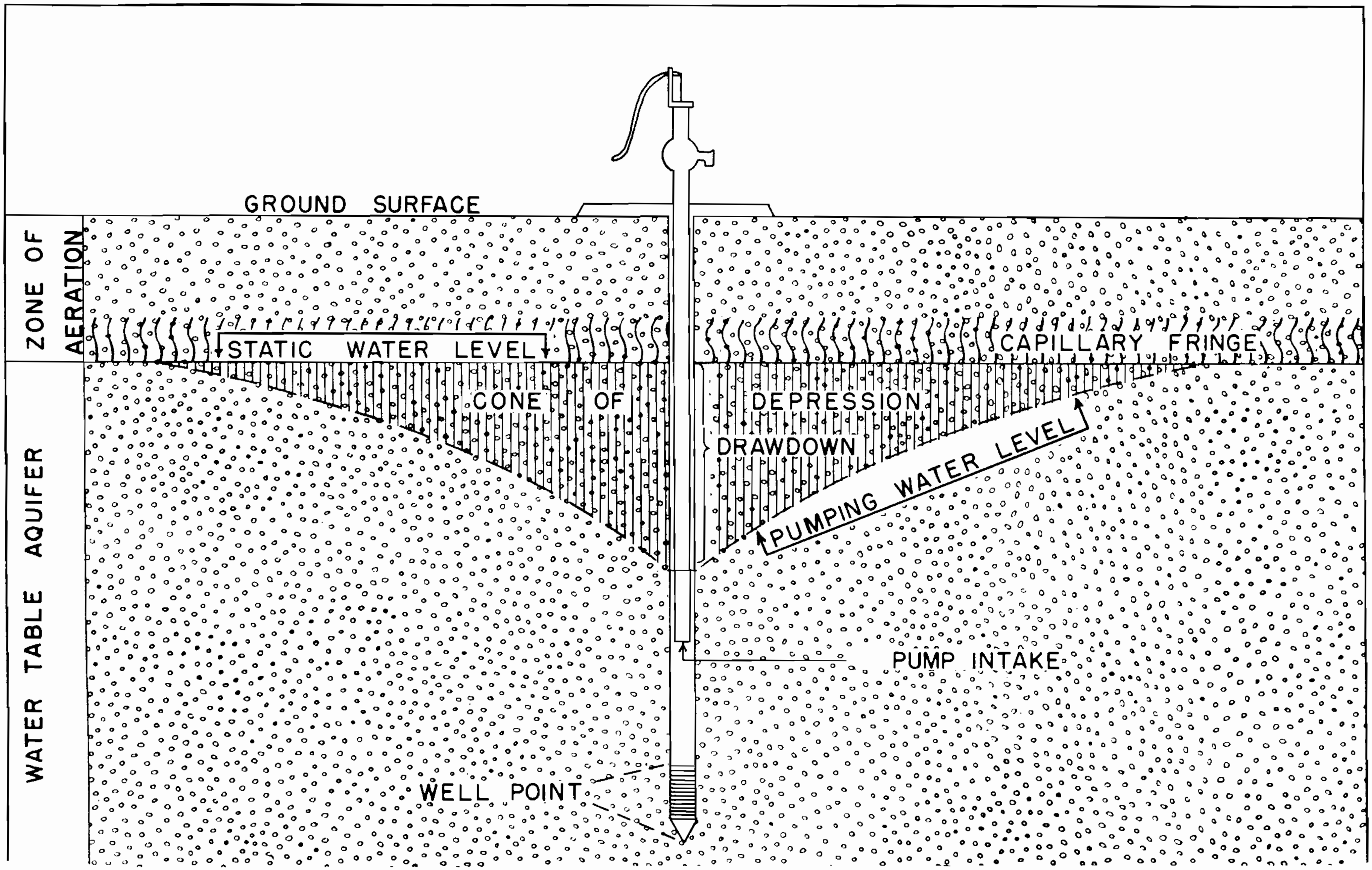


Figure 4. Section showing hydrologic conditions for water-table conditions.

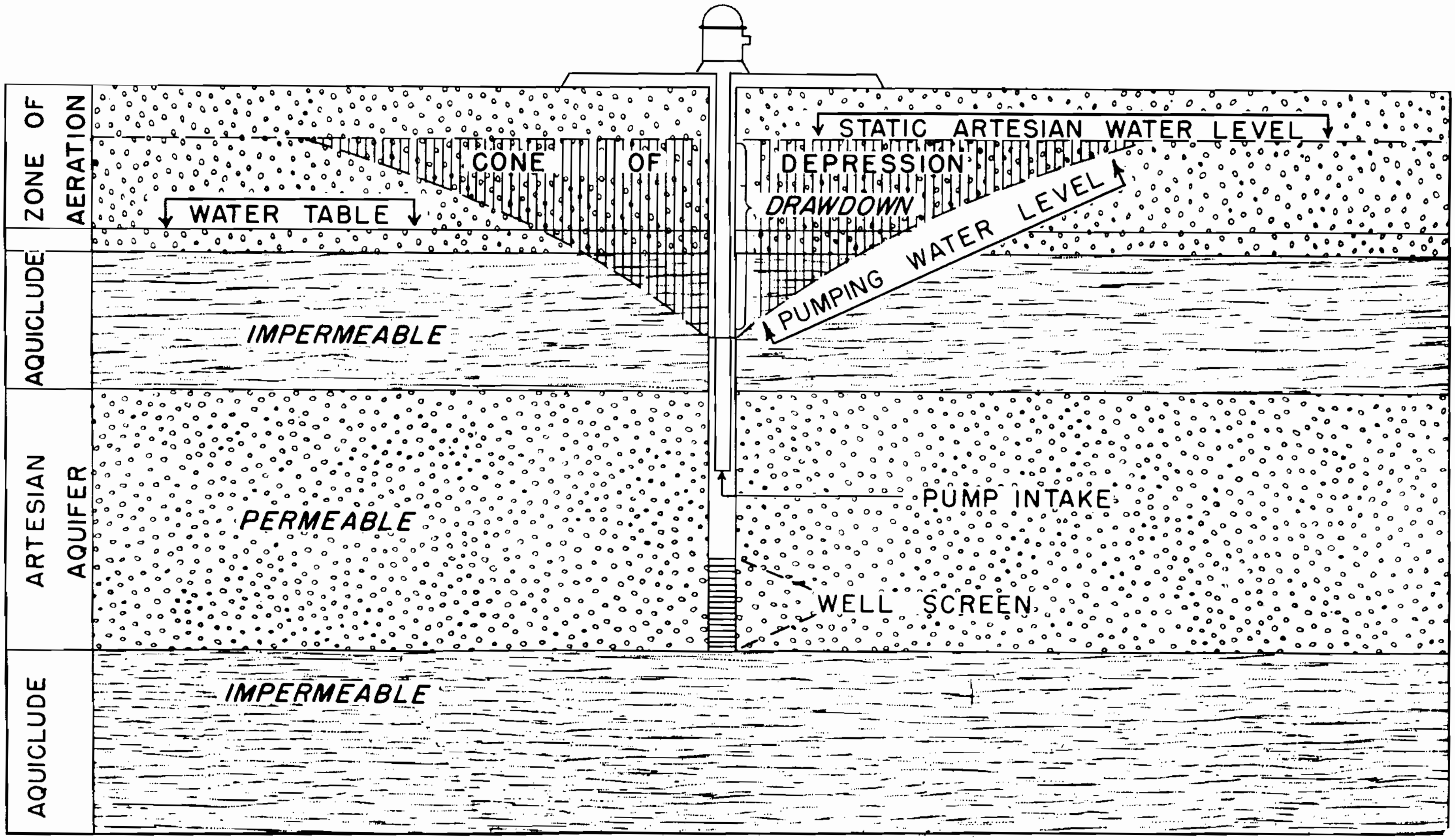


Figure 5. Sections showing hydrologic conditions for artesian conditions.

face of this cone is at the well, and a hydraulic gradient is established which causes water to flow toward the well from the surrounding area. As pumping continues to lower the level of water in the well, the cone of depression extends to increasingly greater distances, allowing water to enter the well that naturally would have discharged elsewhere. If this intercepted water approximates in quantity that which is pumped out, the water level will eventually stop falling and will reach a new state of equilibrium. With the pumping of additional nearby wells, the cone of depression of each well overlaps others and becomes deeper, and a composite cone of depression is developed. Only a trained hydrologist is qualified to appraise the water levels in terms of future perennial withdrawal of water. A decline of the water level is not always detrimental. It is a natural consequence of the withdrawal of water and is necessary to induce a flow of water to the well.

Natural Ground-Water Levels

The water table continuously changes its position, reflecting changes in underground storage. Under natural conditions ground water discharges by seepage into streams, by evaporation, and by transpiration by vegetation. The discharge causes a gradual lowering of the water table except during and immediately after periods of significant precipitation, when recharge to the underground reservoir exceeds the discharge from it, and the water table rises. Figure 6 shows the trends of water-table fluctuations in a well at Maysville, Jones County. The water level in this well is controlled entirely by natural conditions, and its fluctuation is considered typical of fluctuations in the surficial sands of the Coastal Plain. During the 15 years of record the lowest, or base, level of the water was about 9 feet below the ground surface. The low stage of the water table is reached during long periods of fair weather when no water is added to the underground reservoirs. It commonly occurs in the summer months when vegetation is using much of the water from precipitation, and little or no water reaches the water table. Soon after periods of significant precipitation the water table rises quickly, but the following periods of decline are slower. The decline of the water table covers a longer aggregate period during a year and is more gradual than the rise of the water table. In a year of normal rainfall the recharge to the surficial sand is approximately equal to the discharge from it; hence, the water table at the end of the year is at about the same level as at the beginning of the year. Contrary to general belief, the water table is not permanently declining in the coastal areas of North Carolina.

Under natural conditions the piezometric surface of each artesian aquifer fluctuates also, but the effects of each period of precipitation are not evident. As the artesian beds are essentially full of water and do not, therefore, accept all the water available from precipitation, or discharge it relatively soon after it is recharged, artesian water levels under natural conditions vary less with the seasons than does the water table. The water level of each artesian aquifer differs somewhat from that of other aquifers. In most places the artesian water levels are within a few feet of the land surface. On low ground at many places the water level of one or more artesian beds is above the land surface, making flowing wells possible. However, too few measurements of water levels have been made in the report area to determine the artesian pressure in each aquifer.

RECOVERY OF GROUND WATER

Water is obtained from several types of wells in eastern North Carolina; these are briefly described below. A more complete description of types of wells is available in many ground-water reports and from well-development companies.

Dug Wells

A dug well is a large diameter well excavated with tools. Most of the dug wells are lined with cement or tile curbings, or with wood or brick. These wells, which are not common in the area covered by this report, are generally greater than 24 inches in diameter and generally extend only a few feet deeper than the water table.

Dug wells in which the earth material has been removed by machinery are not uncommon. The excavation or pit is shallow but may be several tens of feet or more in diameter. Where the land is flat and the water table lies within a few feet of the surface, these excavations contain water that can be used by livestock and for irrigation.

Bored Wells

Wells bored with a hand or mechanical auger are termed bored wells. Like the dug wells they are relatively shallow and are not common in the report area.

Driven Wells

The driven or drive-point well is the most common source of water supply in eastern North Caro-

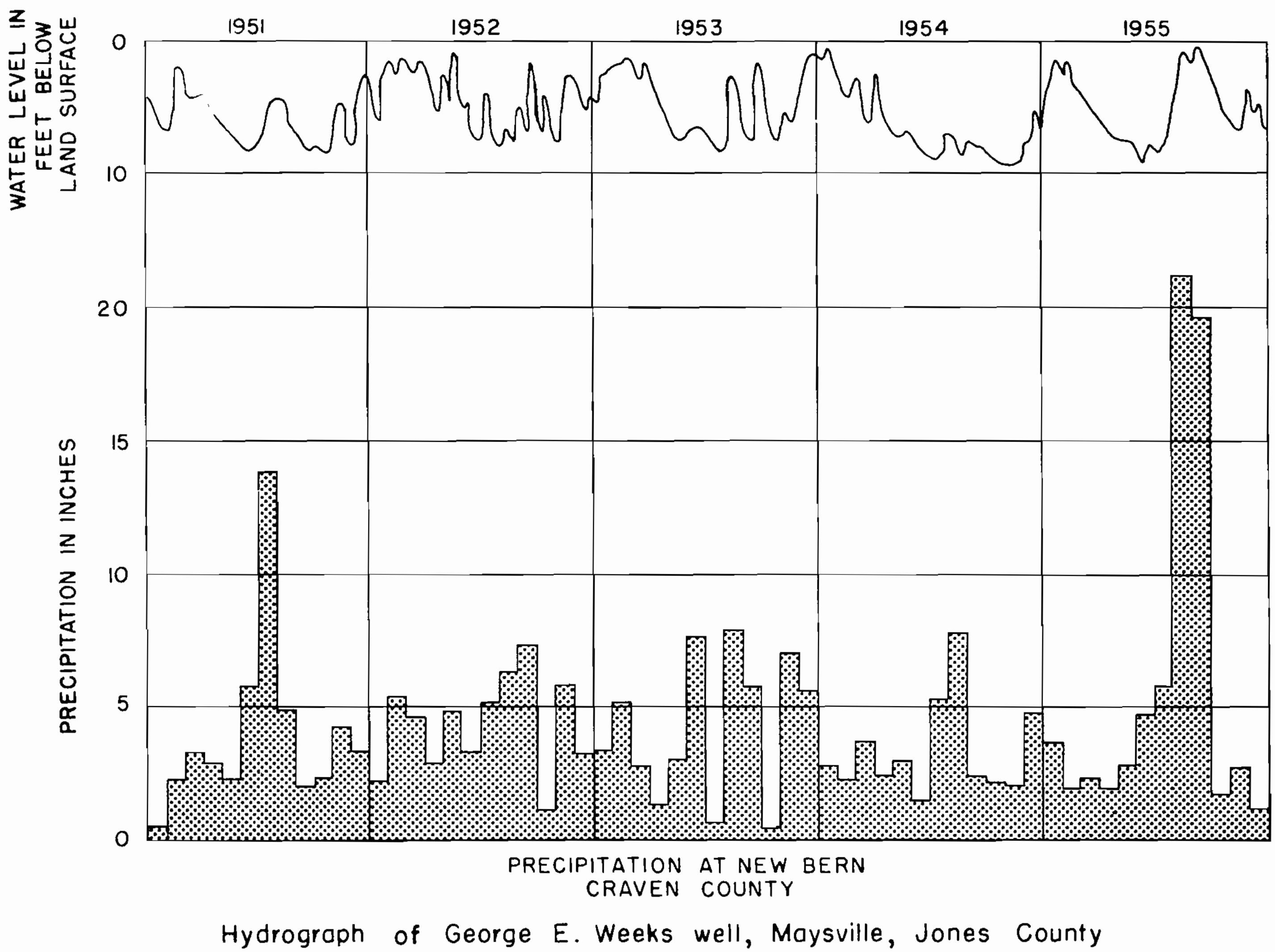


Figure 6. Graph showing fluctuation of water table in well 30 Jones County and precipitation at New Bern, Craven County.

lina. Most driven wells in the area consist of a $1\frac{1}{4}$-inch pipe with a screen-covered drive point on the end. These wells are especially suited for domestic water supply where the water table is within 25 feet of the land surface.

Drilled Wells

Drilled wells furnish large amounts of water for municipal and industrial uses. There are also many 2- to 4-inch drilled wells that furnish water for domestic uses. Wells are drilled by the cable tool method and by the hydraulic-rotary method. In the area covered by this report, wells can generally be drilled by both methods to depths of 500 feet or more without difficulty.

Many of the drilled wells in rural areas end in sand and a screen is placed opposite the bed of sand; others, having no screen, are open ended, the bottom of the casing being set in firm clay or on an indurated calcerous or sand bed. Where consolidated material is present, as in parts of Carteret County, water is obtained from the underlying indurated material, and yields of several hundred gallons of water a minute with only a few feet of drawdown are common. Water is developed from other open-end wells by pumping out with compressed air some of the sand lying below the bottom of the casing; these wells are satisfactory so long as they are not pumped at a rate great enough to continue the pumping of sand.

Many of the larger municipal and industrial wells in this area are gravel-packed wells. There are several methods of gravel packing a well, but in all cases the completed well has a layer of sorted gravel around the well tube opposite the water-bearing sands. A well screen or perforated casing is placed opposite the sand beds, allowing water to flow through the gravel pack from the water-bearing material. Gravel-packed wells are ideally suited to the development of the maximum amount of water from the sands of this area. In many places several beds of medium to fine grained sand occur, and the gravel-walled well tends to tap the beds of sand as one composite aquifer.

Performance of Wells

The depth at which water must be raised from wells in the area rarely is great enough to add appreciably to the cost of water. As a result, the lowering of the water level as a result of pumping is not generally viewed as important. However, in order to evaluate the performance of a well it is necessary to consider the drawdown in relation to the yield This relation is usually referred to as the specific capacity which is expressed in gpm (gallons per minute) per foot of drawdown. The specific capacities of wells considered in this report range from less than 1 to as much as 100 gpm per foot of drawdown. Some of the differences in specific capacities are due to changes in characteristics of water-bearing materials, but the great range is due largely to variations in construction of wells. Figure 7 shows the yield of some individual wells and their respective drawdowns. Although these wells are among the most productive wells in the area of this report, they are representative of specific capacities from completely or nearly completely developed wells. Only a small percentage of the wells listed are developed sufficiently to convey accurately the potential yield of the aquifers; the reported yields of most wells are therefore much less than those indicated in figure 7.

Springs

In an almost continuous line around the upland areas, water leaks out of the upland sand and sandy clay into the adjacent streams. In coves or in reentrants into the upland the seepage may be concentrated sufficiently for a spring to occur. Springs are very common in the area but they are almost all of small yield, generally less than 5 gallons a minute. Along reaches of streams where they have cut into the limestone unit the discharging ground water in many places is concentrated to form larger springs. Perhaps the largest spring of this type is Catherine Lake Spring, Onslow County, which has a reported yield of 1,500 gallons a minute (Pratt, p. 92).

In spite of their abundance, springs are scarcely used. The yields are commonly too small for municipal and industrial use and their occurrence in low, marshy ground discourages their use for rural domestic supplies.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Upper Cretaceous Series

Tuscaloosa formation

Geology.—The Tuscaloosa formation was named by Smith and Johnson (1887, p. 95-116) for beds of Cretaceous age typically exposed in Tuscaloosa and Hale Counties, Alabama. The name Tuscaloosa was first applied to outcropping Cretaceous strata in North Carolina by Cooke (1936, p. 19) to replace the

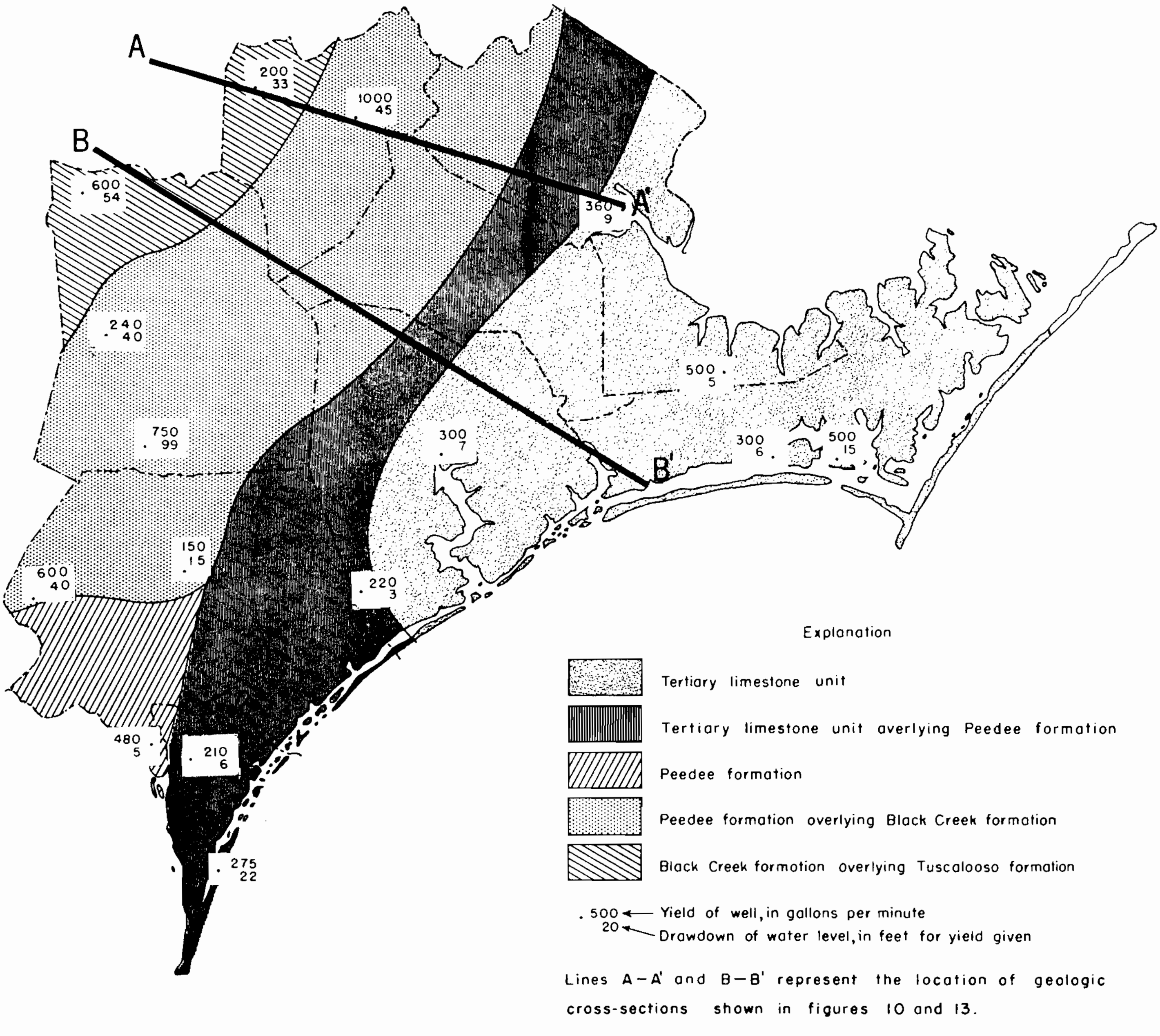


Figure 7. Map showing water-bearing units and representative well yields.

arch was formed "during late Eocene time by a buckling of the earth's crust that arched up the rocks along the axis of the ridge and bent down the rocks on each side of it." This conclusion is an obvious one, but it does not harmonize with such facts as the occurrence of outliers of Miocene age in parts of Robeson and Sampson Counties and with the outlier of Jackson or Claiborne age at Spout Springs, in Harnett County (all of these places are west of this report area). The outlier of clay and silicified limestone at Spout Springs is considered to belong to the Castle Hayne limestone because of the presence of *Trachyleberis davidwhitei* (Stephenson), *Cytheretta alexanderi* Howe and Chambers, and *Loxoconcha jacksonensis* Howe and Chambers; its occurrence at the Fall Line, and more than 60 miles updip from the nearest part of the main body of Eocene rocks, merits primary consideration in an appraisal of structure in the area of the Cape Fear arch. The absence of a blanket of the Castle Hayne over the arch is not easily explained.

The subsurface character of the Cape Fear arch is not well known. Crystalline bedrock encountered at the relatively shallow depth of 1,000 feet below sea level in a well at Wilmington revealed that the Black Creek formation rests on basement rocks at about 1,100 feet below land surface and that the Tuscaloosa formation, which underlies the Black Creek in the outcrop area, is absent. Samples from three other wells reaching basement, extending on a line from Conway, South Carolina to near Jacksonville, North Carolina, indicated the absence of the Tuscaloosa, according to Brown (LeGrand, 1955, p. 2034). The absence of pre-Black Creek materials at Wilmington was considered by Stephenson (Clark and others, 1912, p. 292) as "evidence of a land barrier of some kind in the region about Wilmington."

As more subsurface data become available, more structural anomalies doubtless will be revealed, but present knowledge of the Coastal Plain is only a fraction of that necessary to evaluate all types of structures adequately.

QUALITY OF GROUND WATER

Chemical Constituents in Relation to Use

The following section was adapted largely from Billingsley and others (1957, p. 12-15).

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

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

Generally accepted chemical specifications have been established for waters for domestic use; they are independent of any sanitary specifications established for protection of the public health. In 1946 the U. S. Public Health Service established chemical and physical specifications for drinking water used on interstate carriers as follows:

Iron & manganese together	no greater than	0.3	ppm
Magnesium	no greater than	125	ppm
Chloride	no greater than	250	ppm
Sulfate	no greater than	250	ppm
Fluoride	no greater than	1.5	ppm
Lead	no greater than	.1	ppm
Color	no greater than	20	units
Total solids	no greater than	*500	ppm

* 1,000 ppm permitted if other water is not available.

The above specifications have since been adopted by the American Water Works Association and most municipalities as standard for public water supplies. Water containing less than 500 ppm of dissolved solids generally is satisfactory for most domestic and industrial uses. However, excessive iron content or hardness may cause difficulty in some uses. Waters containing more than 1,000 ppm of dissolved solids are likely to include certain constituents that make them unsuitable for domestic or industrial uses.

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

Iron and manganese in excess of 0.3 ppm are objectionable for several reasons. Excessive amounts of iron and manganese cause reddish-brown stains on white porcelain or enamelware, on fixtures, and on clothing or other fabrics. These two constituents in excessive amounts, interfere with dyeing, tanning, paper manufacturing, and the manufacture of photographic film and many other products.

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

Classification of Waters

During and prior to the period of field work, samples of water were collected and analyzed in the laboratory of the Quality of Water Branch of the Geological Survey. The analyses are given in tables following each county description. These analyses form the basis for most of the following discussions of the chemical quality of ground water.

Many complex factors are responsible for the chemical character of underground water. The quality of ground water differs to some extent with the geologic formation, and also to some extent from place to place within a formation. The ground water of the area studied may conveniently be classified as follows :

1. Water from Cretaceous deposits
2. Water from the Tertiary limestone unit
3. Water from surficial sands
4. **Chloride water**

A table on the following page summarizes the characteristics of water from the (1) Cretaceous, (2) Tertiary, and (3) surficial deposits. Water having a high chloride content occurs in all deposits at certain places. However, analyses of water having considerable chloride content have been omitted from the table because such waters are not characteristic of the individual deposits. Chloride waters are discussed separately on page 46.

Quality of Water in the Cretaceous Strata

Water from the Cretaceous Black Creek and Peedee formations have enough similarity to be grouped together as a relatively high bicarbonate water. The dissolved mineral matter in some of the waters is made up predominantly of calcium and bicarbonate and in others of sodium and bicarbonate. The calcium content is generally greater in the shallow and updip parts of the deposits and the sodium content is generally greater in the deeper and downdip parts of the deposits.

Rain falling on the recharge areas in Lenoir, Duplin, Pender, and adjacent western counties contains free carbon dioxide which dissolves calcium carbonate from the sediments as the water moves eastward in the artesian beds. Thus, as the water moves eastward, down the dip, it gains in mineral content, mostly in calcium bicarbonate and becomes hard. With continued movement there is a tendency toward an exchange of bases—an action that involves the replacement of calcium ions of the water with sodium ions from the sediments. This action takes place with no apparent change in the content of bicarbonate or other acidic constituents. The chemical changes in the water are similar to those in the Cretaceous waters of Virginia (Foster, 1942) and (Cederstrom, 1946). The soft sodium bicarbonate water in the Black Creek formation at Kinston and LaGrange, as well as in the Peedee formation at Richlands and Burgaw, indicates that the downdip exchange of bases at these places is fairly complete.

Although there is a wide range in hardness of the water, only 7 of 55 wells shallower than 300 feet yielded water whose hardness was less than 40 ppm; most of the water from shallower than 300 feet had a hardness ranging between 100 and 200 ppm. On the other hand, of the 9 wells deeper than 300 feet, only one yielded water having hardness greater than 40 ppm.

Aside from consideration of the calcium, sodium, and bicarbonate content, water in the Peedee and Black Creek formations is low in mineral matter. Table 2 shows that such constitutents as silica, iron, and sulfate are rarely present in objectionable quantities.

Table 2. Distribution of the chemical constituents of the ground waters in the Wilmington-New Bern Area.

With the exception of pH value, the figures are in parts per million

	Water in Cretaceous deposits			Water in Tertiary limestone unit			Water in Surficial Sand		
	Median	Range		Median	Range		Median	Range	
		Low	High		Low	High		Low	High
Silica (SiO_2)	17	9.0	29	23	10	51	—	—	—
Iron (Fe)	.22	.04	2.2	.8	.00	7.2	1.1	0.1	21
Calcium (Ca)	34	1.0	103	66	29	178	—	—	—
Magnesium (Mg)	3.0	1.0	19	4.0	2.0	29	—	—	—
Sodium and potassium (Na + K)	14	2.0	130	12	2.0	149	—	—	—
Bicarbonate (HCO_3)	171	25	553	238	6	540	12	2	32
Sulfate (SO_4)	2.0	.4	12	2.0	.0	50	4.0	2.0	20
Chloride (Cl)	4.0	3.0	92	13	4	405	15	3.0	62
Fluoride (F)	.2	.0	1.0	.2	.0	1.4	—	—	—
Nitrate (NO_3)	.1	.0	.6	.1	.0	3.5	—	—	—
Dissolved solids	170	56	408	258	107	1010	—	—	—
Total hardness as $CaCO_3$	114	5	283	192	12	461	21	4	88
pH	7.6	6.1	8.4	7.3	5.7	8.1	5.7	5.2	6.7

Quality of water in the surficial sands

Water in the surficial sands is soft and is low in total mineral matter. The chief objection to its use is corrosiveness. Mundorff (1945, p. 38) in discussing the corrosive water in the shallow sands says:

"Oxygen and carbon dioxide are the principal constituents of ground water causing corrosion. Shallow ground water usually is much more corrosive than the deeper water. As the water percolates downward, the oxygen is quickly used up in oxidation of organic and inorganic materials. The carbon dioxide commonly reacts with carbonates to form bicarbonates. Because of this reaction, hard water is generally less corrosive than water of low mineral content and hardness.

Corrosion causes deterioration of the well casing, pump pipes, pumps, tanks, and water pipes in the distribution system. However, the deterioration is not as objectionable as is the presence of the iron which is dissolved, causing "red water" that stains utensils, plumbing fixtures, and the laundry. It is not always apparent whether the iron is in the water when it enters the well or whether it has been dissolved by corrosion of the well casing and pipes. The problems of iron and corrosiveness in ground water are closely related and both are serious problems for domestic and small municipal and industrial users in the Coastal Plain."

Quality of water in the limestone unit

Water quality in the Castle Hayne and Yorktown formations is closely related to the solubility of these calcareous deposits. Analyses of 72 samples of water in the limestone unit (table 2) indicates that the chief mineral constituents in solution are calcium and bicarbonate. The median hardness of the water is about 190 parts per million. In many places, iron is present in objectionable quantities. Hydrogen sulphide is present in water from the limestone and produces its characteric slight odor in wells throughout most of the area. However, only in the water from deep wells near the coast is the odor strong. Chloride water in the limestone is discussed in the following section.

Chloride Water

Almost all of the deposits of the Coastal Plain originally contained sea water. Water, originating as precipitation, has circulated through many of these deposits flushing out or greatly diluting the former salty water. The extent of flushing depends on several factors, but it is generally ture that salty water has been replaced by fresh water in those deposits which have good discharge facilities, a high permeability, and a significant difference in head between areas of recharge and discharge.

Of about 35,000 ppm of dissolved solids in sea water, about 10,700 ppm are sodium and about 19,300 ppm are chloride. The great amount of fresh water necessary to flush out this salty water is apparent if it is considered a chloride concentration exceeding 250 ppm in public water supplies is not recommended by the U. S. Public Health Service where more suitable supplies are available. A water having chloride concentration of 250 ppm hardly tastes salty, but one having a concentration of about 500 ppm tastes salty. All of the public water supplies in the area considered here have a chloride concentration of less than 250 ppm and most of them contain less than 30 ppm of chloride.

Present distribution of brackish ground water.—Clay beds sufficiently impermeable to separate artesian water below and unconfined, or shallow ground water above, are generally found within 50 feet of the land surface in southeastern North Carolina. The surficial sands contain unconfined ground water that is fresh. However, in the surficial sands of the beaches and of land adjacent to the coastal waters, the water table may be no more than 1 foot above sea level; at such places wells may reach salty water at comparatively shallow depths. Fortunately, the beach inhabitants can generally obtain fresh water from shallow well points.

Wherever brackish water is found in the artesian acquifers of the area, its chloride content increases with depth. Analyses of water from wells of different depths in Wilmington, Jacksonville, and New Bern bear this out. Consequently, it may be futile to drill deeper than the occurrence of brackish water in an attempt to reach fresh water.

Figure 8 shows the probable depth to artesian brackish water containing 250 ppm or more of chloride. The map shows that high-chloride water is found at shallower depths along the major drainage channels, such as the Cape Fear, New, and Neuse Rivers, than in the interstream areas (Mundorff, 1945, p. 33). Mundorff points out that the channels were submerged during late Pleistocene time, resulting in saturation by sea water of those strata exposed in the channel. In addition to submergence during the Pleistocene, the invasion of the sea during Yorktown time and during Castle Hayne time caused the older, and underlying strata to be sub-

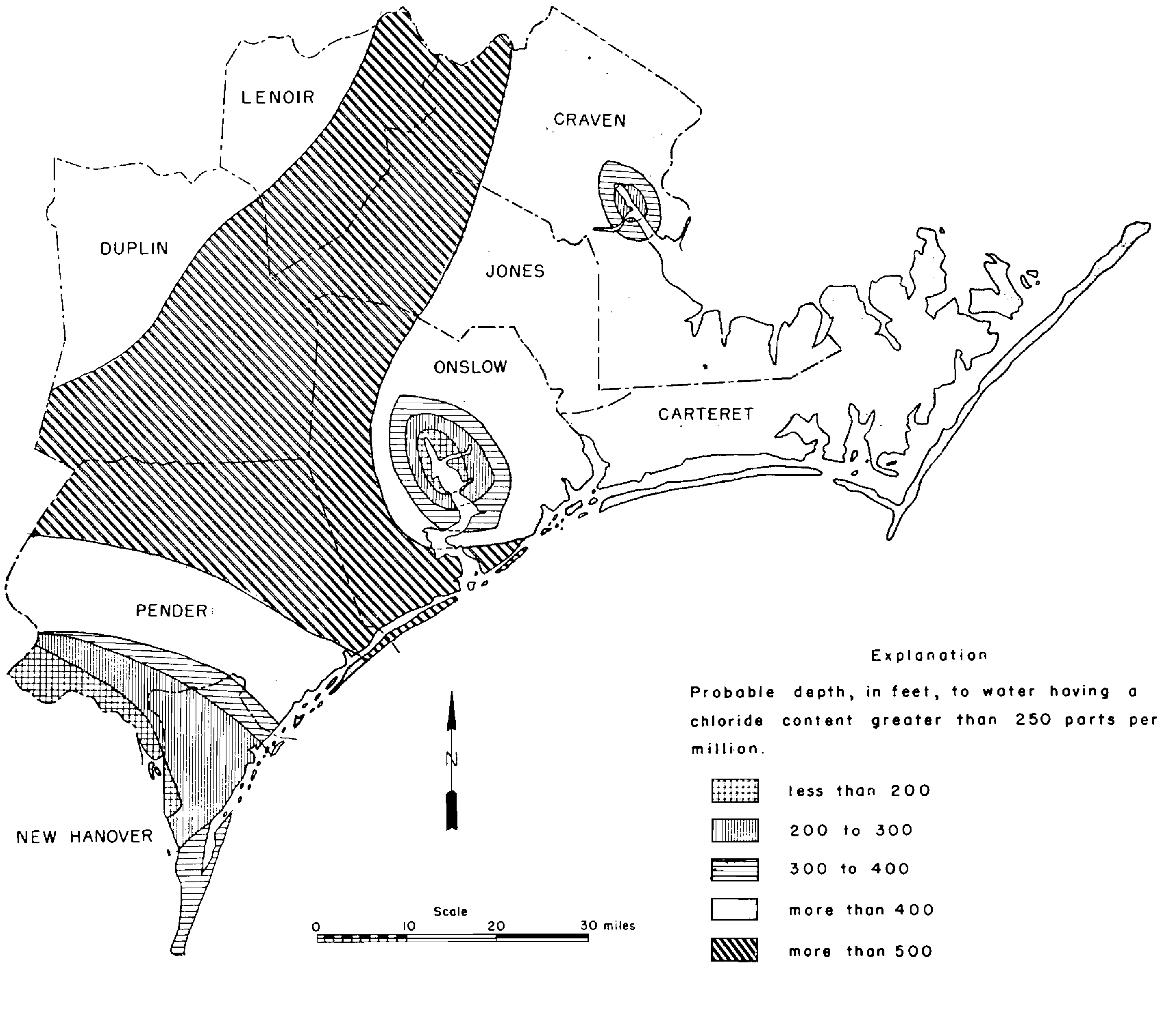


Figure 8. Map showing approximate depth to brackish ground water.

merged. During the periods of submergence the fresh water head was greatly reduced, and consequently the flushing of the brackish water was retarded.

Aside from the local contamination of water in strata adjacent to the major channels during the Pleistocene, the areal differences in depth to brackish water reflect the capacity of the artesian aquifers to act as conduits. For example, the high permeability and relatively good discharge facilities of the Tertiary limestone aquifers in a wide area bordering the Pender and Onslow County line has resulted in a freshening of water to a depth of more than 500 feet. On the other hand, in southwest Pender County and in New Hanover County restricted discharge facilities caused by undetermined structures in the Peedee formation has resulted in the presence of brackish water at relatively shallow depths.

Salt-water encroachment.—The well owner in the coastal area is concerned with the depth to salty water under normal, non-pumping conditions, as shown in figure 8, but he is more directly concerned with the possibility of encroachment of salty water which might impose limitations on the withdrawal of water. If salt-water encroachment is known to be possible in an area, the difference in specific gravity between fresh water and sea water is an important factor to be considered.

As sea water has a specific gravity of about 1.025, 40 feet of sea water will balance about 41 feet of fresh water. This difference in specific gravity of fresh water and sea water has led to the general rule of 40-to-1 ratio. Where the rule can be applied, the depth in feet below sea level to the contact between fresh and salt water theoretically will be 40 times the number of feet the static water level of fresh water is above sea level. Although strict application of the rule requires a stable relation between the fresh and salt water, a condition that probably does not exist in nature, it serves as a useful measure in studying problems of salt-water encroachment.

The withdrawal of fresh water has not been great enough at any place to bring the salt water into the acquifers used. The optimum rate of withdrawal beyond which limit salt water would enter and contaminate the fresh-water aquifer, is not accurately known at any place in the area. The areas most concerned with the possibility of salt-water encroachment have been Wilmington, New Bern, and Camp Lejeune, each a heavily populated center located over near-surface chloride waters.

The general areas in which salt-water encroachment might occur under conditions of heavy withdrawal include: New Hanover County, southern Pender County, central and eastern Onslow County, eastern Craven and Jones Counties, and the coastal parts of Carteret County. If heavy withdrawal is contemplated in these areas, the following suggestions may prove helpful:

1. Determine the depth to impotable water under existing conditions.

2. Investigate the subsurface geology to determine the limits of the fresh-water body and the positions and character of impermeable beds that could prevent or retard encroachment.

3. Make periodic determinations of chloride in water from one or more observation wells that draw water from a zone between that of the producing wells and the salt-water body. Any detected increase in chloride content would give sufficient warning so that the rate of pumping could be decreased and an orderly evaluation of the water problem could be made.

4. Disperse the wells so that the drawdown at the apex of the cone of depression will not be excessively great.

COUNTY DESCRIPTIONS

Carteret County

Geology

The surface material in Carteret County is composed chiefly of sand of Pleistocene age. Little is known of the material immediately underlying the surface sands. Logs of some wells drilled in the county indicate that loose sand with varying amounts of clay occur to a depth of 25 feet in some places and to 75 feet in others. With increasing depth, shell fragments and calcareous material are found and are consolidated into a limestone at a depth of less than 120 feet in the area west of Morehead City and at a greater depth east of Morehead City.

Microfossils obtained from well samples indicate that the uppermost limestone unit is part of the Yorktown formation. However, the contact between the Yorktown formation and the overlying material, probably of Pliocene or Pleistocene age, can not be accurately defined in areas where microfossils are absent. The Yorktown formation, generally less than 200 feet thick, lies unconformably on the Castle Hayne limestone. Both formations contain calcareous material that has been consolidated to form impure limestone as well as beds of relatively clean quartz sand.

Both the Yorktown and Castle Hayne formations dip toward the southeast at the rate of a few feet per mile. Underlying the Castle Hayne are older deposits of Tertiary and Cretaceous age. Although these deposits have been detected in several oil tests (Swain, 1951, p. 4), they are thought to contain brackish water and, therefore, are not discussed here.

Ground Water

Two main water-bearing units occur in Carteret County, the surficial sands and the underlying limestone. Both sources are available for use on the mainland, although on parts of the outer banks the surficial sand may be the only usable aquifer because the limestone unit contains salty water.

The surface sands that cover the county yield water freely to well points, supplying water for most domestic uses. The water table almost everywhere is within 10 feet of the ground surface. Although much water is present in the sand, the water is corrosive enough to be objectionable for some uses.

The Yorktown and the underlying Castle Hayne formations are considered together as the Tertiary limestone, or "rock", aquifer. Although the Yorktown locally contains some clay in its upper part and both formations contain some unconsolidated quartz sand and calcareous sand beds, almost all wells entering these formations draw water from the rock. The rock varies in composition from a limestone to a calcareous sand that is slightly consolidated. Consolidation into rock is a local feature; consequently, the degree of induration at one place may not be the same as that at another place. Even though wells are cased to the rock and draw water through the open end from the rock, it is likely that water readily passes through adjacent sand beds into the rock.

The limestone aquifer is capable of yielding large amounts of water. However, the yields of only a few wells in the county are known. Several have been tested at 500 gpm and many others are capable of yielding that amount. The yield per foot of drawdown ranges between 10 and 50 gpm.

The head of the artesian water of the limestone is as much as 5 feet above mean sea level everywhere in the county. At Cape Lookout it is 5 feet, at Atlantic 9 feet, at Beaufort 10 feet, and at Newport 13 feet above sea level (fig. 9). Because of the low elevation of the land surface in relation to mean sea level, the artesian water level ranges from a few feet below the ground surface in the upland areas to as much as a few feet above the ground in low areas.

Water from the limestone is hard to very hard, the chief dissolved mineral constituents being calcium and bicarbonate. Although brackish water occurs at depth everywhere in the county, it is normally not reached by water wells. Examination of the electric log of an oil test well (Laughton No. 1) 3 miles west of Morehead City indicates that fresh water exists to a depth of about 650 feet, and that the water is noticeably brackish below 700 feet. Also, there appears to be no impermeable stratum to separate the salt water from the fresh water above. However, under the present rate of withdrawal, the high permeability of the fresh-water aquifer results in a relatively slight depression of the water level; this prevents encroachment of salt water. Unless a large local withdrawal of ground water is contemplated there is probably no reason for concern about brackish-water encroachment into the aquifer.

Figure 9. Map of Carteret County showing location of wells.

Explanation

⑨ Circled number represents height, in feet, above mean sea level to which water will rise in tightly-cased wells penetrating the limestone aquifer.

Records of Wells in Carteret County

Well no.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	8 miles NW of Bogue	A. L. Morse	Open end	87	2	80	Limestone	8			
2	5 miles SW of Bogue	U. S. Coast Guard Station	do.	548	2	386					Flow of salt water at 286 feet.
3	Bogue	U. S. Marine Corps	do.	260	8	207	Sand and shell		225	18.7	Water level 8.46 feet above mean sea level May 22, 1946.
4	6 miles SW of Newport	J. W. Horton	do.	112	1½		Limestone				Flow
5	2 miles NW of Newport	Lawrence Garner, Jr.	do.	78	2	70	do.				
6	Newport	Town of Newport	do.	172	3	130	do.	12			Analysis
7	do.	do.	do.	87	1¼		do.	16.7			
8	do.	Roy Dennis	do.	120	2		do.	9			
9	do.	L. C. Mann	do.	92.5	1½	90	do.				Water level 0.8 foot below lsd on July 31, 1941.
10	Newport	C. E. Herington	Open end	90	1¼		Limestone				
11	do.	W. H. Bell	do.	100+	4-3		do.	4.5	15		
12	do.	V. M. Rhue	do.	74	1¼	72	do.				
13	do.	Town of Newport	do.	160	8	90	do.	20			
14	1 mile SE of Newport	Prison Camp	do.	80	2	80	do.	4			Analysis
15	7 miles W of Morehead City	Dr. Morey	do.	175	2	120	do.				Flows at high tide.
16	do.	A. C. Hodges	do.	165	2	120	do.	3			
17	do.	Mr. Mitchell	do.	175	2	120	do.				Flows at high tide.
17a	do.	Catholic Orphanage Camp	do.	94	6		do.				
18	6 miles W of Morehead City	Earl Webb	do.	198	4-2	130	do.	8	450		
19	4 miles NW of Morehead City	Lumber Building Supply	do.	203	4	100	do.	12			
20	4 miles W of Morehead City	Viola Tiley	Screen	15			Sand	9			
21	do.	U. S. Army	Open end	290	8	280	Limestone		150		
22	3 miles W of Morehead City	E. N. Copeland	do.	178	2	88	do.	+6.7			Flows 3 gpm
23	2 miles W of Morehead City	Lion Tamers Club	do.	100	1¼	83	do.	+8			Flows 10 gpm
24	do.	Wallace Fisheries Co.	do.	180	5		do.	+1			Reported hardness 240 ppm
25	do.	U. S. Government	do.	230	8	230	do.				Flows at high tide.
26	do.	U. S. Marine Corps	do.	235	8	228	do.		300	6.02	Water level 7.9 feet above msl. in August 1952.
27	8 miles NW of Morehead City	Ball Brothers	do.	170	6		do.				
28	1 mile NW of Morehead City	John Oglesby	do.	200	1½	120	do.				Flow
29	Morehead City	Willis Bottleing Works	do.	214	2	130	do.				Water level 12.3 feet below lsd on August 22, 1941.
30	1 mile N of Atlantic Beach	T. A. Loving Construction Co.	Open end	215	2	140	Limestone	+5			Flows.
31	Atlantic Beach	Mr. Hardesty, Atlantic Beach Service Station	Strainer	22	1¼	22	Sand				Chloride 120 ppm
32	do.	Fred R. W. Reh	Open end	189	1½	130	Limestone				Flows 10 gpm
33	do.	Carteret County	do.	220	1¼		do.				Originally flowed. Hardness 260 ppm
34	do.	S. A. Horton	do.	212	3		do.	8			
35	do.	do.	do.	238	3	168	do.	4			
36	do.	Atlantic Beach and Bridge Co.	do.	190	1¼	190	do.				Analysis
37	do.	B. P. Pollock	do.	224	2		do.				Flows.
38	1 mile NE of Morehead City	Rufus Oglesby	do.	225	2	190	do.	+2			do.
39-43	Morehead City	Carolina Water Co.	do.	250	6-4		do.	0		15-20	Analysis. 750 gpm from 4 wells in draw suction. Each well approximately 250 feet deep.
44	Morehead City	Carteret Ice Co.	Open end	225	10	225	Limestone	+1	550		Analysis
45	do.	Lloyd Fry Roofing Co.	do.	300	6		do.	1	500		
46	do.	do.	do.	296	6	160	do.	1	500+		
47	do.	Aviation Fuel Terminal	do.	281	8	275	do.	6			
48	3 miles E of Atlantic Beach	U. S. Army	do.	160	8	143	do.		110		
49	do.	do.	do.	215	8	192	do.	+1.5	125	15	
50	do.	Fort Macon State Park	do.	192	6-4	187	do.		50	11	Chloride 5150 ppm at 150 feet.
51	8 miles NW of Beaufort	Leonard Saffrit	do.	226	2	220	do.	+1			Flows.
52	do.	A. M. Foreman	do.	173	2	168	do.	+1			do.
53	6 miles N of Beaufort	Earl Campen	do.	200	2		do.	+1			do.
54	2 miles W of Beaufort	Mr. Spate	do.	280	3	140	do.				Flows at high tide.
55	do.	U. S. Government Terminal	Open end	282	8	282	do.	8			
56	Beaufort	U. S. Marine Biological Laboratory	do.	269	3	168	do.	+8			Analysis. Flows 25 gpm
57	do.	do.	do.	235	6		do.				Chloride less than 20 ppm
58	do.	do.	do.	269	2½	169	do.				Flows 20 gpm
59	do.	Town of Beaufort	do.	365	2	60-70	do.				Flows. Chloride less than 20 ppm
60	do.	Noe Service Station	do.	375	4	375	do.	+1			Flows 1 gpm. Chloride less than 20 ppm.
61	1 mile NW of Beaufort	J. H. Smith Fish Meal Co.	do.	297	4	155	do.	+1			Flows.

Records of Wells in Carteret County—Continued

Well no.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	
62	....do....	....do....	...do...	303	4	155	....do....	......	......	......	....do....
63	1 mile N of Beaufort	Berkley Piner	...do...	248	2	170	....do....	......	......	......	....do....
64	2 miles NE of Beaufort	K. W. Wright	...do...	265	2	180	....do....	2	......	......	
65	1 mile NE of Beaufort	Bill Lewis	...do...	315	2	190	....do....	......	......	......	
66	Beaufort	Beaufort Ice Co.	...do...	300	8	......	....do....	1	170+	......	
67	1 mile NE of Beaufort	Bernny Copeland	...do...	222	1½	120	....do....	+1	......	......	Flows 8 gpm
68	....do....	Hugh Jones	...do...	365	2	......	....do....	0.5	......	......	
69	Beaufort	Carolina Water Co.	...do...	440	10-8	440	....do....	8	500	......	Analysis
70	....do....	....do....	...do...	300	8	......	....do....	......	......	......	
71	2 miles SE of Beaufort	C. W. Briton	...do...	318	3	155	....do....	......	......	......	Flowed 75 gpm from 3 inch pipe in 1941.
72	....do....	Chemical Co.	...do...	305	4	157	....do....	......	750	......	
73	....do....	Scarboro-Safrit Lumber Co.	...do...	255	2	168	....do....	8	......	......	
74	Merrimon	Guy Carroway	...do...	285	3	205	....do....	......	......	......	Flows
75	4 miles SE of Merrimon	Open Ground Farm	...do...	268	6	202	....do....	......	......	......	Used for irrigation.
76	7 miles SE of Merrimon	Open Ground Farm	...do...	155	3	......	....do....	4	......	......	
77	6 miles SE of Merrimon	....do....	...do...	278	2	150	....do....	3	......	......	
78	5 miles NE of Beaufort	Dewey Hardesty	...do...	168	2	......	....do....	3	......	......	
79	6 miles NE of Beaufort	Ray Keller	...do...	330	2	300	....do....	+3	......	......	Flows 10 gpm
80	....do....	Earl Arthur	...do...	294	2	170	....do....	+3	......	......	Analysis. Flows 10 gpm
81	3 miles NW of Smyrna	Rowland Satlers	...do...	335	3	170	....do....	+3	......	......	
82	Harkers Island	L. D. Nickel	...do...	297	3	170	....do....	......	......	......	Water level at land surface.
83	....do....	Garris Yeoman	...do...	315	2	210	....do....	12	......	......	Analysis
84	....do....	Latham Wills	...do...	310	2	210	....do....	10	......	......	
85	....do....	James Harker	...do...	90	2	80	....do....	4	......	......	
86	Cape Lookout	Cape Lookout Light Station	...do...	477	3	300	....do....	......	180	16	Flows 5 gpm. Salt water reported shallower than 300 feet.
87	....do....	R. W. Baker	...do...	412	2	255	....do....	+3	......	......	Flows.
88	....do....	U. S. Army	...do...	435	8	337	....do....	......	180	16	
89	2 miles EW of Smyrna	Walter Stewart	...do...	332	2	210	....do....	+5	......	......	Flows.
90	Smyrna	M. L. Smith	...do...	330	2	200	....do....	1	......	......	Chloride 16 ppm
91	2 miles SW of Sea Level	Floyd Brown	...do...	357	2½	160	....do....	......	......	......	Flows.
92	....do....	Wilbert Lewis	...do...	355	2	......	....do....	+2	......	......	Chloride 30 ppm. Flows.
93	....do....	Connie Daniels	...do...	357	2½	160	....do....	......	......	......	Flows.
94	Sea Level	Hospital	...do...	380	2½	230	....do....	+8	......	......	Flows 20 gpm
95	....do....	T. A. Taylor	...do...	358	2	200	....do....	+3	......	......	Flows.
96	Atlantic	U. S. Marine Corps	...do...	408	8	389	....do....	......	240	8	Water level 9.2 feet above msl on May 22, 1946.
97	....do....	John W. Smith	...do...	95	4	......	....do....	0.5	......	......	
98	....do....	Ward Gillikin	...do...	112	2	90	....do....	8	......	......	
99	....do....	Joe Willis	...do...	105	2	90	....do....	8	......	......	

Chemical Analyses of Ground Water From Carteret County

(Numbers at heads of columns correspond to well numbers in table of well data)

(Parts per million)

	6	14	36	39-43	44	56	69-70	80	83
Silica (SiO_2)	......	22	......	42	......	......	44	45	......
Iron (Fe), total	......	.86	......	0.9	......	......	.05	.11	......
Iron (Fe), in solution	......	.14	......	......	......	......	......	.04	......
Calcium (Ca)	......	77	......	84	......	......	78	104	......
Magnesium (Mg)	......	2.3	......	11	......	......	19	21	......
Sodium and Potassium (Na + K)	......	7	......	13	......	......	25	19	......
Bicarbonate (HCO_3)	258	246	358	326	297	365	378	449	458
Sulfate (SO_4)	1	1.1	1	1.1	......	1	1.6	2.3	1
Chloride (Cl)	9	9.1	17	9.5	43	8	9.5	12	10
Fluoride (F)	.6	.3	1.0	.5	......	.6	.6	.3	......
Nitrate (NO_3)	.0	.5	......	.1	......	......	.1	.1	......
Dissolved solids	......	250	......	336	......	......	371	434	......
Hardness as $CaCO_3$	206	202	276	255	154	306	273	346	285
pH	7.5	7.1	......	7.3	7.5	......	7.4	6.9	7.1
Water-bearing material	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone
Date of collection	10/21/41	1/4/50	9/3/41	4/3/37	7/23/38	9/3/41	4/3/47	10/8/52	10/8/52

Analyzed by the Quality of Water Branch, U. S. Geological Survey

Craven County

Geology

Craven County is covered by sand and clay of Pleistocene age, which east of New Bern contains scattered shells. In the western part of the county the Pleistocene sediments are commonly less than 20 feet thick, but in the southeastern part they are somewhat thicker.

Although the Yorktown formation underlies the surficial Pleistocene material in the area east of New Bern, it thins progressively toward the west and has only scattered occurrences west of New Bern. The Yorktown is commonly composed of loose shells in a sand matrix, but in the vicinity of Cherry Point some beds of limestone are present. Beds of yellow to gray clay at shallow depths north of the Neuse River may belong to the Yorktown formation.

The Castle Hayne limestone occurs near the surface in the western part of the county and slopes to the southeast at a rate slightly greater than does the land surface. (fig. 10) As a result, near the Carteret County line the Castle Hayne lies beneath the Yorktown formation at a depth of more than 160 feet. The Castle Hayne varies greatly in lithology and in degree of consolidation. Beds of sand containing disseminated shell fragments, as well as beds of cream-colored marl, are common.

The character and age of the strata underlying the Castle Hayne limestone have been determined in only a few places. In the extreme northwest part of the county the contact between the Castle Hayne and Peedee formation is near the surface, and may be exposed in the Neuse River near the Pitt County line, although a search for an outcrop of the Peedee was not made during the present investigation. In the central and eastern parts of the county a thin wedge of sand and calcareous marl of early Eocene age separates the Castle Hayne and Peedee formations. The Black Creek formation, underlying the Peedee, is buried so deeply, especially in the eastern part of the county, that it has been penetrated only by an oil test well.

Ground Water

Three aquifers yield water to wells in Craven County. They are the surficial sand, the Peedee formation, and the limestone unit.

Sand containing subordinate amounts of clay of Pleistocene age covers the surface of the county. The relatively flat topography and the looseness and high permeability of the sand result in a great infiltration capacity of the sand. In most places the water table lies less than 15 feet below the land surface; consequently, the installation of well points to obtain small domestic water supplies is common and relatively inexpensive.

Sands of the Peedee formation furnish water to several drilled wells in the northwestern part of the county. Its importance as an aquifer is limited eastward because of the presence of highly mineralized water in progressively younger beds toward the east. South and east of New Bern the lower part, and perhaps all, of the Peedee contains salty water. To the west, near the Lenoir County line the underlying Black Creek formation, together with the Peedee, contains several beds of sand. Wells drawing water from all the sand beds may yield as much as 1,000 gpm of fresh water. Salt water occurs in progressively younger beds of the Black Creek formation eastward also, but since no wells have penetrated the Black Creek in the area west of New Bern it is impossible to determine the extent of fresh water in that formation. Figure 8 indicates that fresh water extends deeper than 400 feet in the area west of Cove City, suggesting that the entire Peedee formation, and possibly the upper part of the Black Creek, contains fresh water as far east as Cove City. Where the water is fresh, it is soft and is low in iron content.

The limestone unit is the most important aquifer in the area around New Bern, and southeastward. The Castle Hayne is the predominant limestone, but limestone of the overlying Yorktown formation thickens eastward to such an extent that it forms a significant part of the unit in that area. The great variation in lithology in the limestone unit requires consideration of the proper type of well construction. In some places limestone is so poorly consolidated that wells produce sand unless the aquifer is screened. In other places, especially in the eastern part of the county, the limestone tends to be consolidated and open-end wells are generally satisfactory. Some beds in the limestone unit are more permeable than others and some wells, therefore, yield at a greater rate than nearby wells. However, abundant supplies from the limestone are almost everywhere available, the yield of individual wells commonly ranging between 10 and 50 gpm per foot of drawdown.

The factor that limits the maximum development of ground water is the presence of salt water in deep-lying beds. Figure 8 shows the approximate depth to water having more than 250 ppm of chloride. Unfortunately wells have not been drilled deep enough to determine adequately the thickness of the

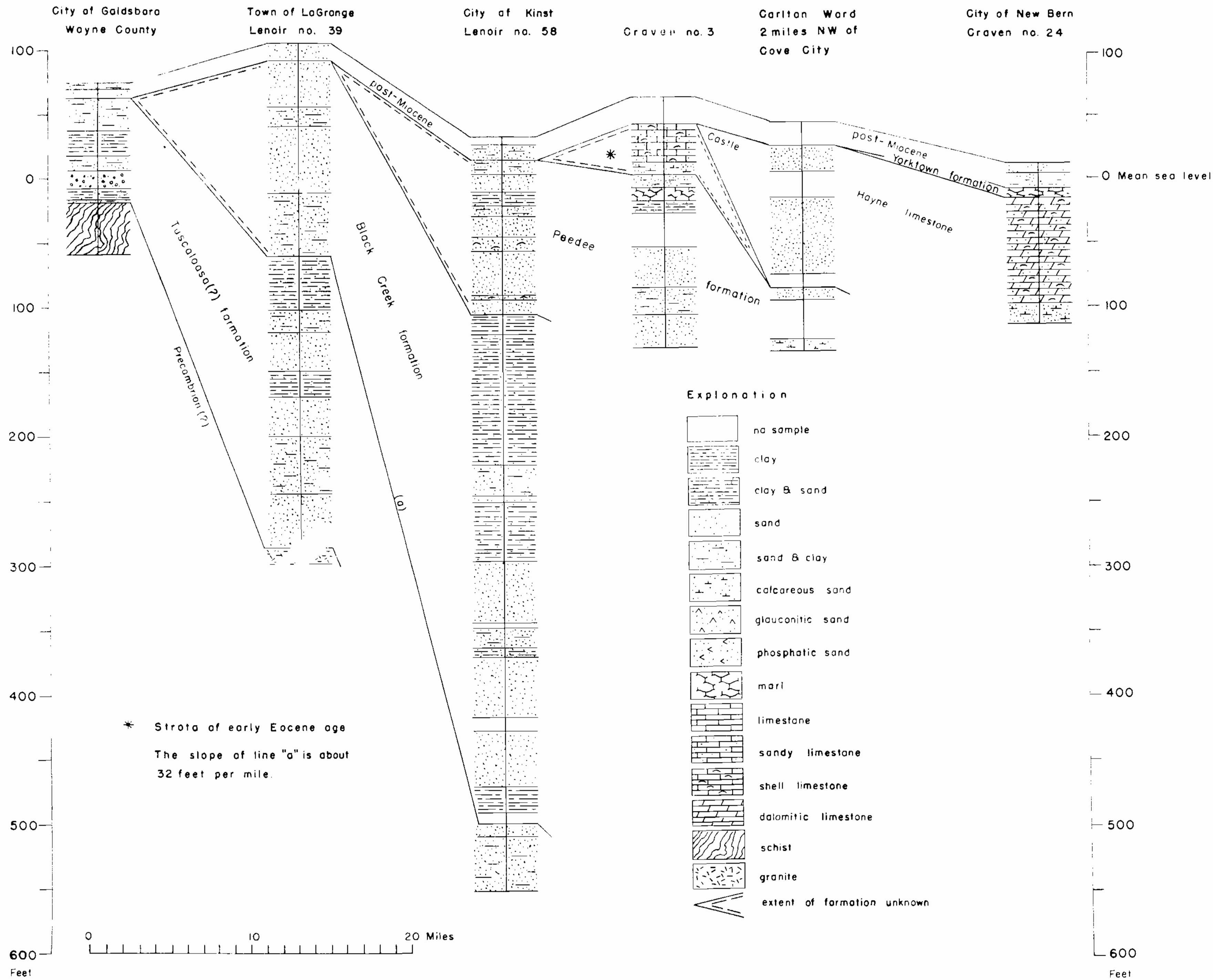


Figure 10. Geologic cross section between LaGrange, Lenoir County and New Bern, Craven County.

deposits containing fresh water lying on the deposits containing salt water.

On several occasions since 1900 the city of New rn has noted an increase in salt content of water from the city wells. The contamination was serious enough to cause new groups of wells to be drilled in 1919, 1932, 1937, 1942, and 1953. Prior to the drilling in 1953 the writer made a special study to determine the probable cause of salt-water contamination of two wells in 1952. The following comments were taken from an open-file memorandum prepared by the writer (1953).

Prior to 1942 the city of New Bern obtained water from wells near the Neuse River; the wells were less than 100 feet deep and penetrated sand and limestone. Many of these wells had to be abandoned eventually because of chloride contamination. Following an investigation by Mundorff in 1941 (unpublished report) in which he pointed out that the wells appeared to be contaminated by lateral flow of salt water from the river rather than from below, the city drilled 8 gravel-walled wells about 100 feet deep much farther from the river. These wells, in general, penetrated fine sand from the surface to 40 feet, limerock from 40-65 feet, and medium sand from 65-85 feet. Each of these wells pumped about 200 gallons a minute with an average drawdown of bout 10 feet. The chloride content of the water was s than 10 ppm but high iron content and high hardness required treatment of the water. In 1952 the city water officials noticed that the treatment was becoming less effective, and on analyzing the well water found that water from two adjacent wells had a chloride content of 90 and 405 ppm respectively and that there was no increase in chloride in the other wells. Two possible sources of the chloride contamination were considered:

1. Intrusion of salt water from an underlying salt-water aquifer.

2. Downward percolation of calcium and sodium chloride from the waste water of the treatment plant that passed in a ditch between the two wells that yielded water of high chloride content.

The evidence suggested that the waste water was the probable source of contamination. The chloride content of shallow ground water (about 10 feet deep) between two wells and near the effluent ditch showed a chloride content of 1,950 ppm, whereas the normal chloride content of the shallow ground water is about 10 ppm. The most convincing evidence that the contamination was due to infiltration of the waste water comes from a geochemical appraisal of waters. Well 20 with a chloride content of 405 ppm had a calcium content of 178 ppm and a magnesium content of 4.2 ppm respectively in 1952. These compare with a calcium content of 72 ppm and magnesium content of 1.9 ppm on water taken from the same well several years previously. The increase of 3 ppm in magnesium and 106 ppm in calcium is not in harmony with normal salt-water contamination in the humid part of the Coastal Plain in which the gain in magnesium is either almost as great or greater than the gain in calcium. Moreover, throughout the Atlantic Coastal Plain records of well waters that contain appreciable chloride show that in all cases the magnesium content is high and more nearly approaches the calcium content than does water in this well at New Bern.

Well 6 was not pumped between November 19, 1952 and June 4, 1953. Between these dates the waste water was diverted away from the wells. On June 4, the pump was started again, and the water was discharged to a ditch. The well was pumped almost continuously for more than 3 months. Listed below are the results of all determinations of chloride in the water from this well by the Quality of Water Laboratory in Raleigh.

Date	Time since pumping started	Chloride content in parts per million
Nov. 19, 1952		405
June 4, 1953—1:38 p.m.	11 minutes	1,300
4 3:20 p.m.	2 hours	1,140
4 5:25 p.m.	4 hours	1,080
4 9:34 p.m.	8 hours	1,060
5 8:18 a.m.	19 hours	1,040
8	4 days	840
10	6 days	780
12	8 days	740
15	11 days	690
16	12 days	675
18	14 days	660
29	25 days	645
July 6, 1953	32 days	570
16	42 days	460
27	53 days	465
Aug. 18, 1953	75 days	378
Sept. 1, 1953	89 days	362
23	111 days	338

Figure 11 shows the trend toward decreasing chloride content in well 6.

The continuous decrease in chloride content with increased time of pumping strengthens the evidence that the contamination is coming from the waste water of the treatment plant. An increasing, rather than a decreasing, trend in chloride would be expected if contamination were coming from a salt water zone below the bottom of the well. The fact that the chloride content was higher in June and July, 1953 than it was the previous November, when the well was abandoned, indicates that the chloride

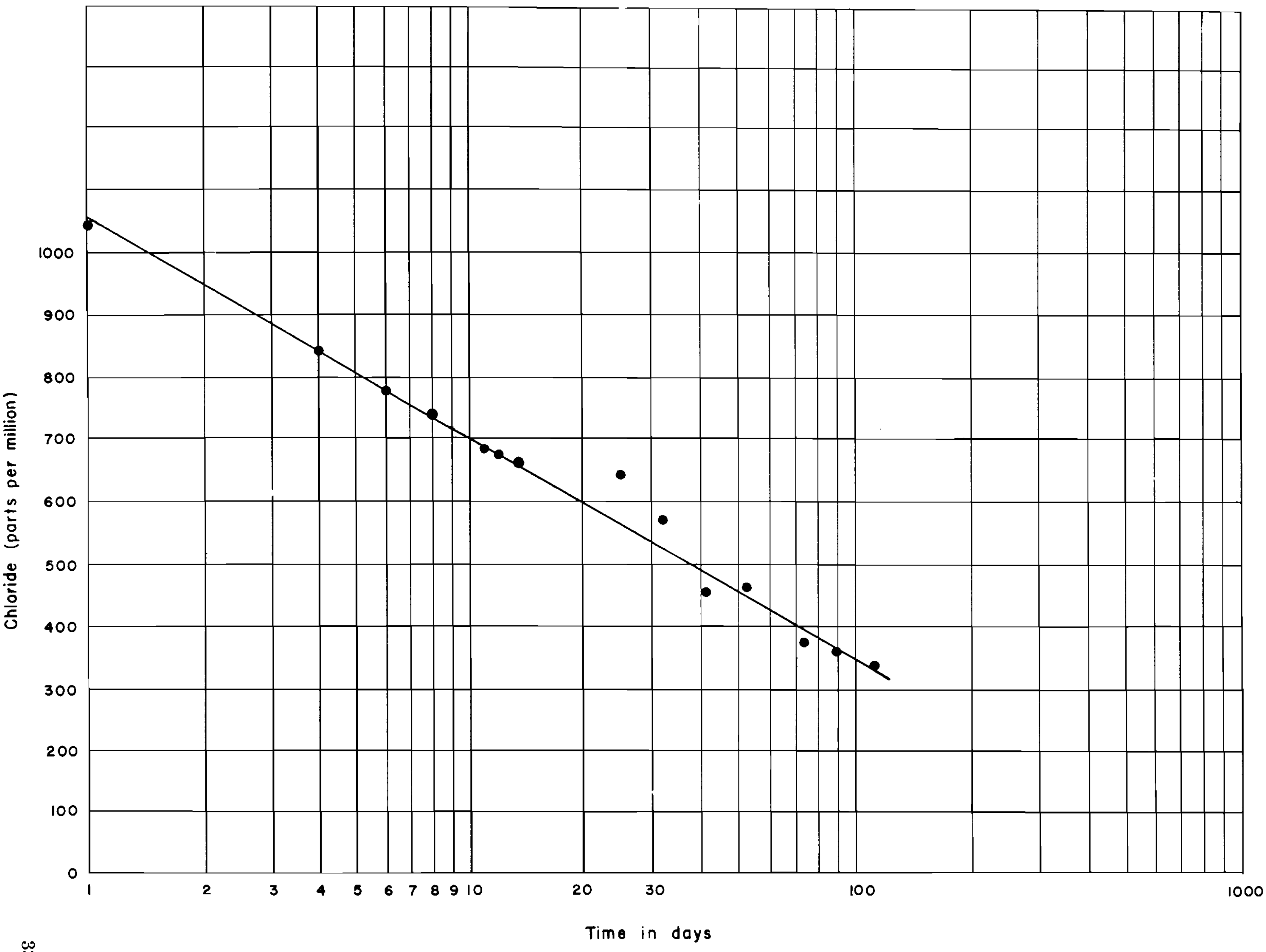


Figure 11. Chloride content of water in Craven County well 20 in City of New Bern, during test from June 4 to September 23, 1953.

water was still moving toward the well even after pumping had stopped. The natural movement of water, unaffected by pumping, is much too slow to ısh the salt water away from the well in periods of a few months.

In 1953 the city of New Bern drilled additional wells (24-27) on a line extending west of the existing well field. The new wells ranged in depth from 98 to 141 feet and each was tested at 300 gallons a minute with less than 10 feet of drawdown. The yields of these wells confirm the conclusions drawn in the writer's memorandum of 1953 that the city is presently using only a small fraction of the ground-water available.

Figure 12. Map of Craven County showing location of wells.

Records of Wells in Craven County

·ll	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	6 miles NE of Vanceboro	H. B. Williams		12	30		Sand	3.6	...	...	Analysis. Temperature 65°.
2	do	do	Open end	128	1¼	80	Limestone	8	...	...	Analysis.
2a	6 miles NW of Vanceboro	M. F. Aldridge	Gravel walled	180	8		Sand	8	350	69	Used for irrigation.
2b	3 miles N of Vanceboro	G. C. Lancaster	do	138	18		Sand and Limestone	12	500	28	Analysis.
3	Dover	Dover School	...	200	4	...	Sand	...	20	...	Analysis.
3a	Fort Barnwell	Francis Barwick	Gravel walled	97	8	...	do	3	300	64	
3b	do	D. F. Braxton	do	120	8		do	3	100	60	
4	5 miles NE of Cove City	H. Wilson	Open end	65	1¼	60	Limestone	...	...	...	Water level at land surface. Well flows in wet seasons.
5	do	Duncan	do	69	1¼	69	do	18	10	...	
6	do	Negro Church	do	65	1¼	60	do	...	1-5	...	Analysis. Temperature 64°.
7	3 miles NW of Cove City	Wells Oates Lumber Co.	...	380	6	...	...	...	...	...	Analysis.
8	Cove City	E. H. White	Open end	115	1¼	95	Limestone	10-15	...	...	
9	2 miles SW of Cove City	W. H. McCoy	do	108	1¼		do	10-15	...	...	
10	2 miles SE of Cove City	E. H. White	...	100	1¼	90	...	10-15		...	Water reported to be slightly hard.
11	Vanceboro	Farm Life School		94	6	...	...	...	...	...	Analysis. Used by school and 14 families.
12	Vanceboro	M. Lancaster		90	1¼		...	...	10-12	...	Analysis. Temperature 62°.
13	do	J. Ewell	...	108	1¼		...	...	12-15		Temperature 62°. Sulphur odor. Chloride 15 ppm Hardness 195 ppm.
14	6 miles S of Vanceboro	Gault Tourist Court	Open end	58	2	55	Limestone		...	...	Two other similar wells on property.
15	7 miles NW of New Bern	McKeel Bros. Dairy	do	50	1¼		do	10	...	...	Water reported to be hard.
16	4 miles NW of New Bern	City of New Bern	Gravel walled	80-115	8		do	...	250	...	Analysis.
17	do	do	do	80-115	8		do	...	250	...	Analysis.
18	3 miles NW of New Bern	do	do	80-115	8		do	...	250	...	Analysis.
19	do	do	do	80-115	8	...	do	...	250	...	Analysis.
20	do	do	do	80-115	8	...	do	...	250	...	Analysis.
21	do	do	do	80-115	8		do	...	250	...	Analysis.
2	do	do	do	80-115	8		do	...	250	...	Analysis.
23	do	do	do	80-115	8		do	...	250	...	Analysis.
24	do	do	do	121	10	40	do	22	300	9	
25	do	do	do	98	10	40	do	19	350	9	520 gpm with 13 foot draw-down.
26	do	do	do	141	10	55	do	19	350	9	
27	do	do	do	141	10	62	do	19	350	6	
28	2 miles NE of New Bern	do	do	100	8	40	do	...	...	...	
29	2 miles NE of New Bern	City of New Bern	Gravel walled	120	8		Limestone	...	...	...	
30	do	do	do	65	8		do	1.5	...	...	
31	do	do	do	100	8	35	do	16		...	With 4 additional, similar wells nearby, furnished about 1.2 million gallons a day for city supply between 1936-1941.
32	5 miles NE of New Bern	T. C. Everington	do	118	1¼	...	do	...	...	...	
33	3 miles NW of New Bern	Kensey Products Co.	...	65	2	...	...	9	30-40	12	
34	1 mile N of New Bern	Prison Camp 203	...	55	6	40	Limestone	...	20	...	Analysis.
35	3 miles W of New Bern	R. D. Runn	Open end	140	1½	135	do	...	...	...	
36	New Bern	New Bern Ice and Fuel Co.	...	110	6	...	Limestone and Sand	7	308	3	
37	do	Masonic Theater	Open end	100	6	40	Limestone	...	150	...	Temperature 63°
38	do	City of New Bern	...	928		...	...	...	...	...	Analysis.
39	do	do	...	100	8		...	...	250	...	
40	do	Kehoe Theater	Open end	70	6	36	Limestone	11	200	6	
41	1 mile E of New Bern	Tom Evans	do	80	1½	75	do	5	...	...	
42	New Bern	Orange Crush Bottling Co.	do	79	1	60	do	8	300	...	
43	New Bern	J. V. Blades	...	52	4	...	...	5	160	...	
44	do	Potato Washing Co.	Open end	68	6	60	...	3	300	...	
45	do	Virginia and Carolina Chemical Corp.	...	165	3	...	...	...	...	...	
46	do	do	...	60	1¼		Limestone			...	
47	4 miles SW of New Bern	R. A. Bosinger	...	65	1¼	65	...			...	Analysis.
48	2 miles SW of New Bern	Golf Course	Open end	100	6	70	Limestone	12	50	...	Drawdown reported to be very slight.
49	3 miles SW of New Bern	Clyde Needham	do	80	1¼	60	do				Analysis. Temperature 65°. Pumped 10 gpm with shallow well pump.
.0	2 miles SW of New Bern	City of New Bern		55	4		Sand	12	100	...	Hardness 10 ppm.

Records of Wells in Craven County—Continued

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Drawdown (ft.)	Remarks
51	2 miles S of New Bern	N. D. Lewis	Open end	110	4	86		25			
52	4 miles SE of New Bern	Harry Bennet	do	102	1¼		Limestone				
53	1 mile N of Croatan	Mrs. B. V. Williamson		70	1¼			13			Chloride 30 ppm. Hardness 250 ppm.
54	Croatan	W. A. Tolson	Open end	109	1¼	90	Limestone	3¼-4			Chloride 10 ppm. Hardness 230 ppm.
55	3 miles S of Croatan	CCC Camp		93	2½	93		6½			Hardness 180 ppm.
56	1 mile N of Havelock	Dalton Lee			1¼	38	Sand	15			
57	1 mile W of Havelock	A. D. Rooks Estate	Screen	30	1¼		do				Formerly flowed slightly.
58	3 miles NE of Havelock	Lucky Lodge		22	1¼	22	do	10			Chloride 20 ppm. Hardness 240 ppm.
59	do	do		87	1¼						
60	1 mile SE of Havelock	Heater Well Co.	Gravel walled	250			Limestone		200	3	Tested at 1000 gpm with a 33 foot pumping level.
61	1 mile NE of Harlowe	H. C. Taylor		148	1¼	148		4			Analysis.
62	Cherry Point	Marine Air Base	Open end	190	6	179		*+10.01	200	4.6	Water level on 11/41. Hardness 171 ppm. Chloride 9 ppm. pH 7.5.
63	do	do	do	328	8	301		*+10	413	6.73	Water level on 2/28/42. Hardness 175 ppm. Chloride 10 ppm. pH 7.5.
64	Cherry Point	Marine Air Base	Open end	150	6	150	Sand	*+9.2	165	6.5	Water level in January 1943.
65	do	do	do	240	8	220		*+9.8	400	10.8	Water level on 1/30/42. Hardness 177 ppm. Chloride 8.0 ppm. pH 7.5.
66	do	do	do	275	6	274		*+11.66	300	5.5	Water level on 9/22/41. Hardness 177 ppm.
67	do	do	do	268	6	256	Sand	*+10.8	180	7.9	Water level on 10/24/41. Hardness 159 ppm.
68	do	do	do	309	8	282		*+11.5	47	13.9	Water level in May 1944.
69	do	do	do	95	4	87		* 15.9	200	2.5	Water level on 9/12/41. Hardness 180 ppm.
70	do	do	do	211	4	191		*+10.12	77	4	Water level on 9/23/41. Hardness 173 ppm. Chloride 13 ppm. pH 7.4.
71	Cherry Point	Marine Air Base	Open end	289	8	236	Sand and Limestone	*+11.67	412	4.6	Water level in February 1943.
72	do	do	do	300	8	253	do	*+10.5	257	6.5	Water level in May 1943.
73	do	do	do	250	8	231			180	7.2	100 gallons per minute with 4.75 foot drawdown.
74	do	do	do	220	8	203					
75	do	do	do	155	4	155		*+13.07			Water level on 9/3/41. Hardness 226 ppm. Chloride 12 ppm. pH 7.3.

*Water Level Above Mean Sea Level

Chemical Analyses of Ground Water From Craven County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constitutents in parts per million

	1	2	2b	3	6	7	11	12	16
Silica (Sio_2)		51		28	20	9.7			17
Iron (Fe), total	.10	6.6		.91	2.7	.15			1.3
Iron (Fe), in solution		.08	.40	.01	.17				.04
Calcium (Ca)		50	32	103	65	4.7			84
Magnesium (Mg)		5.3	2.2	6.4	2.8	4.3			2.2
Sodium and Potassium (Na + K)		9.4	9.1	5.6	1.9	140			5.4
Bicarbonate (HCO_3)	28	195	119	349	209	365	232	280	260
Sulfate (SO_4)	20	.4	3	4.0	.5	1.4	2	2	5.3
Chloride (Cl)	18	4.2	5.8	3.2	4.2	7.0	6	6	8.2
Fluoride (F)	.2	.3		.2	.0	1.0	0.3	.1	.1
Nitrate (NO_3)	.8	.1	.2	.3	.1	.2			.0
Dissolved solids		222	140	335	202	369			254
Hardness as $CaCO_3$	29	147	89	283	174	29	156	198	219
pH	6.7	7.1	6.7	7.1	7.2	8.3			7.2
Water-bearing material	Sand	Limestone	Sand and Limestone	Sand	Limestone				Limestone
Date of collection	9-5-52	9-5-52	5-24-55	2-5-53	9-4-52	7-6-49	11-17-43	11-17-43	11-19-52

Analyzed by the Quality of Water Branch, U. S. Geological Survey

Chemical Analyses of Ground Water From Craven County—Continued

(Numbers at heads of columns correspond to well numbers in table of well data)

Constitutents in parts per million

	17	18	19	20	21	22	23	34	38
Silica (SiO_3)	17	13	13	14	16	17	32		9.0
Iron (Fe), total	1.3	.84	.66	3.1	1.7	1.3	2.9	.08	12
Iron (Fe), in solution	.04	.05	.07	.05	.03	.07	.04		
Calcium (Ca)	82	68	59	178	99	67	82		52
Magnesium (Mg)	1.8	1.8	1.7	4.2	2.3	1.7	2.8		60
Sodium and Potassium (Na + K)	5.0	6.0	6.7	149	30	5.5	7.8		3,350
Bicarbonate (HCO_3)	249	202	172	214	208	187	267	221	716
Sulfate (SO_4)	7.7	13	17	37	24	18	2.5	24	233
Chloride (Cl)	7.5	7.8	7.2	405	90	10	8.0	10	4,850
Fluoride (F)	.1	.0	.0	.0	.0	.0	.1		
Nitrate (NO_3)	.0	.0	.0	.0	.0	.0	.0	.0	.0
Dissolved solids	246	212	187	1,010	401	218	274		8,940
Hardness as $CaCO_3$	212	177	154	461	256	174	216	198	376
pH	7.3	7.3	7.3	7.1	7.2	7.2	7.0	7.1	
Water-bearing material	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	
Date of collection	11-19-52	11-19-52	11-19-52	11-19-52	11-19-52	11-19-52	11-19-52	8-19-41	10-21-41

Analyzed by the Quality of Water Branch, U. S. Geological Survey

	47	49	61
Silica (SiO_2)			
Iron (Fe), total			
Iron, (Fe), in solution			
Calcium (Ca)			
Magnesium (Mg)			
Sodium and Potassium (Na + K)			
Bicarbonate (HCO_3)	55	426	424
Sulfate (SO_4)	8	60	1
Chloride (Cl)	3.8	760	12
Fluoride (F)			.7
Nitrate (NO_3)			0
Dissolved solids			
Hardness as $CaCO_3$	51	320	336
pH	7.5	7.2	
Water-bearing material		Limestone	
Date of collection	8-1-53	3-6-53	9-3-41

Analyzed by the Quality of Water Branch, U. S. Geological Survey

Duplin County

Geology

The oldest formation exposed in Duplin County is the Black Creek, which crops out along some of the valley slopes in the northwestern part of the county. It dips gently toward the southeast and is buried progressively deeper in that direction by younger sediments. The Black Creek is composed of black to dark gray carbonaceous clays interbedded with sands.

The Peedee formation which overlies the Black Creek and thickens progressively to the southeast is found in outcrops along many valley slopes in the central and southern parts of the county. The Peedee is similar in lithology to the Black Creek but contains lesser amounts of carbonaceous material. One or more thin beds of calcareous sandstone occur within the formation. Microfossils and casts of large shells are common.

The Castle Hayne limestone, which overlies the Peedee formation, is typically developed at Chinquapin as well as in the extreme eastern part of the county. In the central and western part, it occurs at shallow depth under some of the upland areas; its occurrence as irregular, thin discontinuous patches is due chiefly to removal of a great volume of the readily soluble limestone by circulating underground waters. Numerous sinks occur in the area around Chinquapin and east of the Northeast Cape Fear River.

A variety of deposits are exposed at the surface in Duplin County. Thin deposits of the Duplin marl (p.33) occur locally, of which the one at Natural Well (2 miles west of Magnolia) is best known. Beds of badly weathered mottled clay, less than 20 feet thick, underlie the upland areas; these clays may be of Castle Hayne or Duplin age. A thin soil of sand or sandy loam is developed at the surface from underlying material. Along the larger streams are low, flat, swampy areas that presumably were drowned by the sea during Pleistocene time, receiving at that time a thin layer of sediments.

Ground Water

No serious difficulty has been encountered in developing a water supply from wells in Duplin County. The water table is generally within 20 feet of the surface, and the surficial sands are permeable enough to insure an adequate supply of water for general domestic use from well points. Many smal' diameter wells, ranging in depth from 50 to 250 feet deep, tap artesian sands. The municipal and industrial water supplies of the towns are derived from gravel-walled wells.

In the Black Creek and Peedee formations, beds of sand interlayered with clay contain artesian water. All the municipal wells tap the Black Creek, and all except those at Faison and Warsaw obtain some water from the Peedee also. The sandstone beds represent the "rock" on which the casings of many small diameter wells are set. The Peedee and Black Creek formations are hydrologically similar, the main differences being a slightly greater artesian head and a slightly softer water in the Black Creek. It is probable that a properly developed gravel-walled well drawing water from several beds of sand can yield as much as 500 gpm at any place in the county. Well 85 in Wallace is representative of such wells.

Little is known about the water-bearing character of the Castle Hayne limestone east and south of Chinquapin. The limestone is relatively soft and pure at Chinquapin, where it is slightly more than 100 feet thick. It yields water readily to domestic wells and probably is capable of yielding as much as 200 gpm from individual wells.

The chemical quality of the ground water in Duplin County is satisfactory for most uses. The artesian water in the Peedee and Black Creek formations is a calcium bicarbonate water, whose hardness is generally less than 150 ppm; the total iron content averages less than 0.3 ppm. The only analysis of water from the Castle Hayne limestone suggests that the water from the limestone is similar in chemical character to that in the sands of the Peedee and Black Creek formations. Water in the surficial deposits contains free carbon dioxide, rendering it slightly corrosive. No salty ground water has been found, and according to the chloride map (fig. 8) water containing 250 ppm of chloride is not present at a depth of less than 500 feet anywhere in the county.

Duplin County

Number 2

Location: Town of Calypso, North Carolina
Owner: Town of Calypso
Date drilled: 1955
Driller: Heater Well Co.
Elevation of well: 157 feet above sea level

Hydrologic Information

Diameter of well: 8 inches
Depth of well: 215 feet
Cased to: 215 feet
Finish: gravel wall and screens
Static (nonpumping) water level: 36 feet below land surface (1955)
Yield: 500 gallons a minute with a 42-foot drawdown

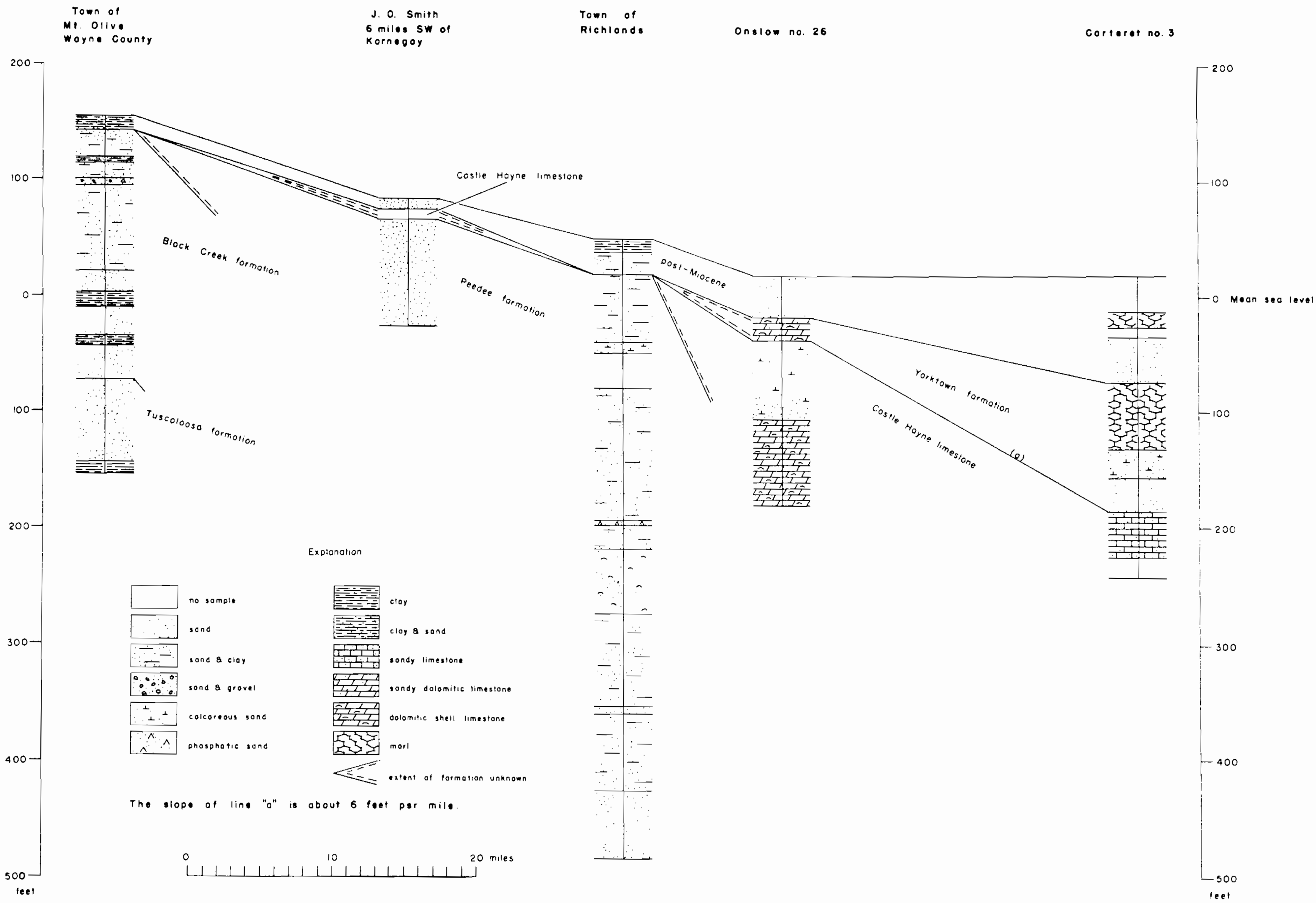


Figure 13. Cross section through northeastern Duplin and Onslow Counties.

Log of Well

Depth (feet)	
	Post-Miocene—surficial sands and clays
0-5	Sand and silt, tan; 65 percent medium to very fine-grained poorly sorted angular quartz sand. 35 percent tan silt and clay matrix, unconsolidated. Fine-grained ilmenite prominent.
5-10	Clay and sand, pink; 45 percent medium to fine-grained subrounded to angular quartz sand. 55 percent pink clay matrix, unconsolidated. Quartz grains stained by hematite prominent. Trace of fine-grained ilmenite.
10-17	Sand and clay, white; 70 percent very coarse to medium-grained subangular to rounded quartz sand. 30 percent white clay matrix, unconsolidated.
	Upper Cretaceous—Black Creek formation
17-21	Sand, dark-gray; 80 percent medium to fine-grained subangular to angular quartz sand. 15 percent gray micaceous clay matrix. 5 percent black lignitized plant remains. Trace of light-green weathered glauconite.
21-32	Same as 17-21-foot interval with slight increase in lignitized fragments.
32-41	Clay, black; 15 percent fine to very fine-grained angular quartz sand. 65 percent black micaceous clay matrix, tight. 20 percent black lignitized plant remains. Trace of dark-green fine-grained glauconite.
41-50	Sand and clay, gray; 70 percent fine to very fine-grained angular quartz sand. 25 percent dark-gray micaceous clay matrix, unconsolidated. 5 percent black lignitized plant remains. Trace of scattered marcasite aggregates.
50-61	Clay, black; Same as 32-41-foot interval.
61-68	Sand, gray; 75 percent fine-grained subangular quartz sand. 20 percent black micaceous silt and clay matrix, unconsolidated. 5 percent black lignitized plant remains. Trace of dark-green glaunconite.
68-82	Clay, black; 5 percent fine-grained angular, quartz sand. 85 percent black micaceous clay matrix, very tight. 10 percent black lignitized plant remains. Trace of dark-green glauconite and marcasite aggregates.
82-91	Sand and clay, black; 70 percent fine-grained angular quartz sand. 25 percent black micaceous clay matrix, unconsolidated. 5 percent black lignitized plant fragments. Trace of dark-green glauconite.
91-101	Sand and clay, black; Same as 82-91-foot interval with some increase in grain size of sand.
101-111	Sand and clay, black; Same as 82-91-foot interval with 25 percent of sand occurring in the medium-grain range.
111-120	Sand, black; 80 percent coarse to medium-grained, subrounded quartz sand. 15 percent black micaceous clay matrix. 5 percent black lignitized plant fragments. Trace of glauconite. Marcasite aggregates prominent.
120-125	Sand, black; Same as 111-120-foot interval with 5 percent increase in clay matrix.
125-132	Sand, black; Same as 111-120-foot interval.
132-143	Sand, black; 75 percent medium to fine-grained subangular quartz sand. 20 percent black clay and silt matrix, unconsolidated. 5 percent black lignitized plant fragments. Trace of glauconite and marcasite aggregates.
143-149	Clay, black; Same as 68-82-foot interval.
149-168	Clay, black; Same as 143-149-foot interval.
168-174	Sand, black; 80 percent coarse to medium-grained subrounded quartz sand. 15 percent black micaceous silt and clay matrix, unconsolidated. 5 percent black lignitized plant fragments. Trace of glauconite and marcasite.
174-181	Sand, black; Same as 168-174-foot interval.
181-201	Sand, black; Same as 168-174-foot interval.
201-215	Sand, black; Same as 168-174-foot interval.

Remarks: No microfossils were obtained from the well cuttings. Correlation is based on lithology and stratigraphic position.

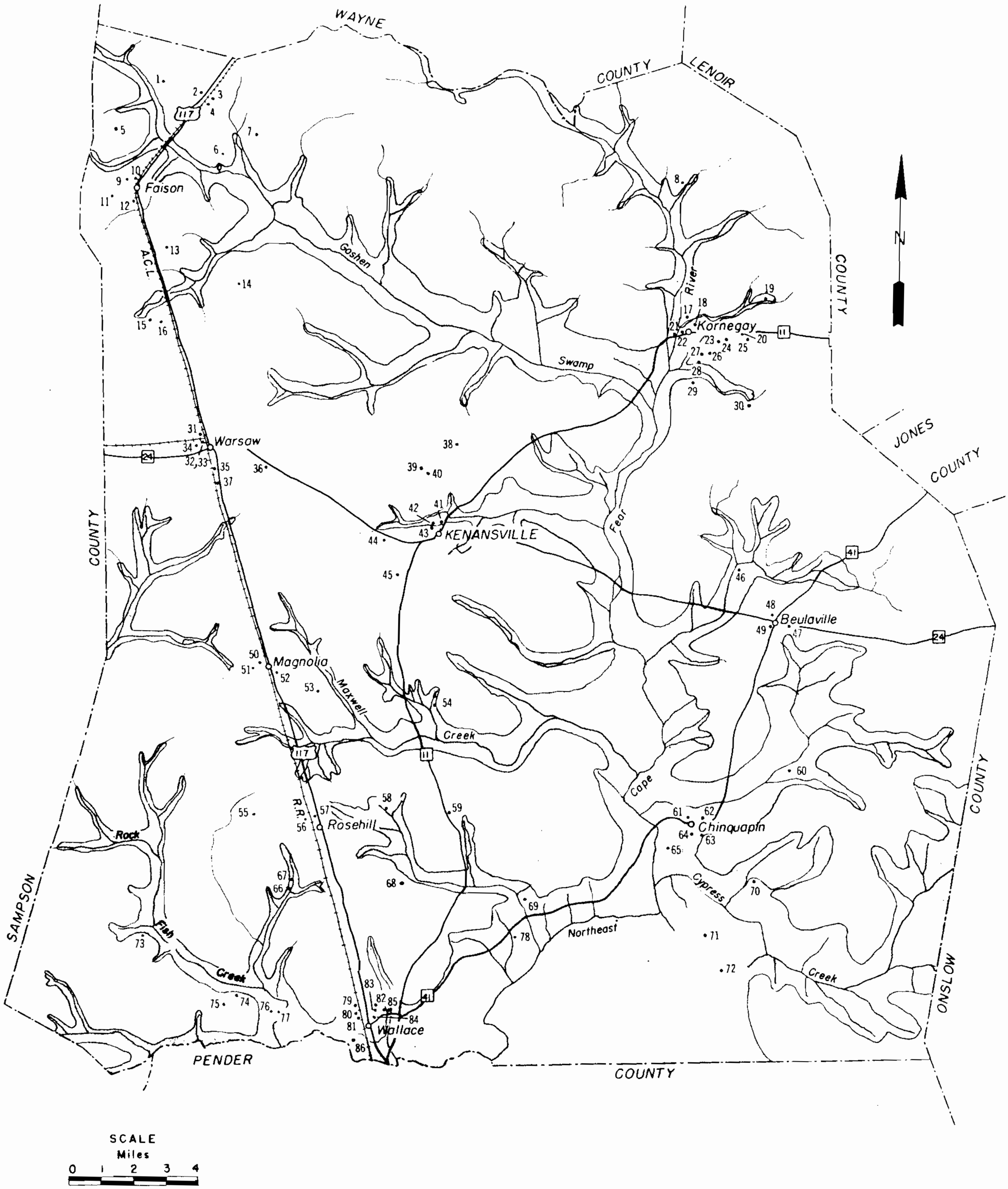


Figure 14. Map of Duplin County showing location of wells and area of artesian flow (shaded).

Records of Wells in Duplin County

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	1 mile [illegible] of Calypso	Virginia Johnston	Open end	133	4		Sand				
2	Calypso	Town of Calypso	Screen	215	208		do	36	600	54	Analysis.
3	do	Calypso Veneer	do	119	6	100	do	35	250		Analysis. Temperature 64°F.
4	do	do	do	30	1¼	25	do	15	23		
5	1 mile NW of Faison	Sam Bass	do	81	4	76	do	30	7		
6	2 miles SE of Calypso	B. E. Albritton	do	255	3		do		10		
7	do	Elbert Davis	do	200	4	175	do	48	5		
8	5 miles [illegible] of Kornegay	Dennis Outlaw	do	65	6		do	40			
9	Faison	Town of [illegible]	do	200	8		do		90		Analysis.
10	do	do	Gravel walled	200	8		do		300		Do.
11	do	Twin Produce Co.	Screen	100	2	90	do	20			
12	do	Town of Faison	do	200	8		do		50		
13	2 miles SE of Faison	Tom Hill	do	133	6	128	do		10		
14	4 miles SE of Faison	Tom Taylor	Gravel walled	202	6		do	52	150	30	
15	Bowdens	Lloyd Lumber Co.	Open end	110	4	110	do	12	60		
16	do	do	do	130	4	130	do	28	60		
17	Kornegay	Mr. Howard	do	247	3	175	do	5	5		
18	do	H. D. Maxwell	do	250	3		do	+5			
19	2 miles NE of Kornegay	Maxwell Mill	do	90	1¼		do	+1			Flows 1 gpm.
20	[illegible]	Earl Smith	Screen	140	4	134	do	40			Supplies 7 homes and 1 service station.
21	Kornegay	Graddy School	Open end	220	2	220	do	+4			Analysis. Flows 30 gpm. Temperature 64°F.
22	do	H. D. Maxwell		230	1¼		do				Flows 15 gpm.
23	1 mile E of Kornegay	P. H. Aldridge	Screen	120	4	116	do	20	10		
24	do	do	Open end	135	4	85	do	18			
25	2 miles [illegible] Korn[illegible]	Roland J. Smith	Screen	148	4	146	do	20	15		
26	1 mile [illegible] of Kornegay	John I. Smith	do	82	4	78	do	16	5		
27	1 mile [illegible] of Kornegay	Ash Miller	do	101	4	97	do	15			
28	do	L. B. Jenkins	do	86	4	82	do	14			
29	2 miles [illegible] Kornegay	H. D. Williams		325	2½		do	+15			Flows 30 gpm.
30	3 miles E [illegible] Kornegay	R. E. Shepherd	Open end	140	4	87	do				
31	Warsaw	Town of Warsaw	Screen	77	8	70	do	32	40	33	
32	do	do	do	118	8		do		80		Analysis.
33	do	do	do	120	8		do		80		
34	do	Warsaw Dress Factory	Open end	153	2		do				
35	do	Quinn Wholesale Co.	Screen	85	4	83	do	25	12		
36	2 [illegible] Warsaw	James McGowan	do	165	4		do	28			
37	1 mile [illegible] of Warsaw	Atlantic Coast Line Railroad	Open end	85	3	85	do	22			
38	3 miles N of Kenansville	W. A. Jones	do	80	3	70	do				
39	2 miles NW of Kenansville	James McGowan	Screen	135	6	130	do	8			
40	do	do	Open end	365	3	135	do	28			
41	Kenansville	H. D. Williams	do	175	4½		do	+14			Flows 250 gpm.
42	do	do	do	175	1½	175	do				Flows 35 gpm.
43	do	Town of Kenansville	Screen	198	8	150	do	22	200		Analysis.
44	2 miles [illegible] of Kenansville	Oates & Wells Lumber Co.	do	130	4	125	do		20		
45	2 miles SW of Kenansville	N. C. State Highway & Public Works Commission	do	140	6	131	do		15		
46	2 miles NW of Beulaville	Tunk Baker		140	1¼		do	+2			Analysis. Flows 1 gpm. Temperature 62°F.
47	Beulaville	Town of Beulaville	Screen	195	8	170	do	27	150		Analysis.
48	do	Garland Edwards	Open end	173	3	80	do	28	10		Supplies 2 homes and a store.
49	do	Mercers & Humphrey	Screen	197	4	197	do	14			Analysis.
50	Magnolia	Town of Magnolina	Gravel walled	189	6		do	36	240	40	
51	do	Mrs. P. J. Heath	Screen	117	4	115	do	35	10	10	
52	do	J. R. Croom		114	4	96	do	35	8	10	
53	1 mile SE of Magnolia	Double Trouble Farms	Screen	145	8	140	do		100		
54	5 miles S of Kenansville	J. H. Carr	Open end	65	2	63	do	+7			Flows 10 gpm.
55	2 miles W of Rose Hill	S. V. Wilkins	do	106	2	80	do	2	10		
56	Rose Hill	Tow nof Roes Hill	Screen	184	8		do	22	120	25	
57	do	do	do	186	8	100	do		150		Analysis.
58	3 miles E of Rose Hill	E. G. Murray	Open end	41	2		do	+7			Analysis. Flows 5 gpm. Temperature 61°F.
59	4 miles E of Rose Hill	T. R. Murphy	Open end	180	4	44	do	38	700		
60	3 miles NE of Chinquapin	George Parker Estate	Gravel walled	261	10-8	255	do	16	700	71	

Records of Wells in Duplin County—Continued

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
61	Chinquapin	Walter Rinenart	Open end	90	1¼	35	Limestone	10			
62	...do	Parker Store	Screen	208	8	198	Sand	15	75		Analysis.
63	...do	George Parker	Gravel walled	235	10	235	...do	8	600	105	
64	...do	G. F. Landen	Open end	95	2	20	Limestone	10			Analysis.
65	1 mile SW of Chinquapin	G. B. D. Parker	...do	105	1	15	...do	+1			Flowed 1 gpm.
66	2 miles SW of Rose Hill	Ray Southerland	...do	162	4	160	Sand	+6			Flows 12 gpm.
67	...do	Lake Tut	Screen	148	6	136	Sand and limestone	+5	220		Analysis. Flows 75 gpm. Temperature 63°F.
68	3 miles SE of Rose Hill	C. W. Brinkley	Open end	90	2	70	Sand	16			
69	6 miles NE of Wallace	North East Baptist Church	...do	85	1¼	35	Limestone	+2½			Flows 2 gpm.
70	2 miles SE of Chinquapin	E. J. Whales	Open end	175	4	140	Sand	+2			Flows 1 gpm.
71	3 miles S of Chinquapin	Homer Jones	...do	161	4	101	do	40	6		
72	5 miles S of Chinquapin	McNeal Sholar	Screen	220	4	200	do	40			
73	8 miles NW of Wallace	Richard Bayee	Open end	75	2	52	Sand	6			Analysis. Temperature 63°F.
74	4 miles W of Wallace	E. S. Williams	do	115	2	50	do	5			
75	...do	do	do	130	2½	60	do	10			Analysis.
76	3 miles W of Wallace	J. D. Carr	...do	100	1¼	60	do	+15			Flows 5 gpm.
77	...do	Pearl Blanchard	...do	100	1¼	60	...do	+15			Flows 5 gpm.
78	5 miles NE of Wallace	R. R. Cavenaugh	do	78	1¼	30	Limestone	+3			Analysis. Flows ½ gpm.
79	Wallace	Wallace Pickle Co.	Screen	160	2		Sand		25		
80	...do	B & R Frozen Food Co.	do	172	6		do	14	80		
81	...do	Wallace Ice & Coal Co.	do	172	6	110	do	14	80		
82	...do	Town of Wallace	do	185	8		do		100		Analysis.
83	...do	...do	Screen	225	6	205	do	31	100	69	Analysis. Temperature 62°F.
84	...do	S. C. Carr	Open end	125	2	100	do	12	10		
85	...do	Town of Wallace	Gravel walled	440	10		do	3	750	99	
86	...do	...do	...do	265	10		...do	+1	450	26	
		RECORDS OF SPRINGS IN DUPLIN COUNTY, NORTH CAROLINA									
A	Kenansville	Town of Kenansville							5		Analysis.

Chemical Analyses of Ground Water From Duplin County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	2	3	9	10	21	32	43	46	47
Silica (SiO_2)	38		29	17	17	18	17	19	16
Iron (Fe), total	.14	1.9	1.1	.34	.16	.36	.18	.07	.35
Iron (Fe), in solution					.01		.01	.01	.05
Calcium (Ca)	8.1		15	6.7	30	56	43	48	35
Magnesium (Mg)	1.5		2.0	.9	3.3	1.0	.9	8.1	6.7
Sodium and potassium (Na +K)	8		6.7	6.5	5.1	5.8	7.2	8.9	16
Carbonate (CO_3)	0		0	0	0	0	0	0	0
Bicarbonate (HCO_3)	40		61	25	110	179	142	203	176
Sulfate (SO_4)	3.8		5.1	7.0	5.1	4.0	4.8	.5	2.6
Chloride (Cl)	3.2		3.1	4.6	2.8	3.9	3.3	3.5	2.5
Fluoride (F)	.4		.2	.1	.0	.0	.1	.2	.1
Nitrate (NO_3)	.1		.0	.0	.0	.1	.2	.1	.0
Dissolved solids	88		96	56	122	177	148	189	164
Hardness as $CaCO_3$	26	5	46	20	88	144	112	153	115
pH	6.5		6.8	6.15	7.7	7.3	7.7	7.8	7.9
Water-bearing material	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
Date of collection	6/3/55	4/14/55	2/10/47	2/10/47	6/2/53	10/22/48	2/23/56	3/10/53	7/8/53

Analyzed by the Quality of Water Branch, U. S. Geological Survey

Chemical Analyses of Ground Water From Duplin County—Continued

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	49	57	58	62	64	67	73	75	78
Silica (SiO_2)	15	18	....	....	11	19	....	....	....
Iron (Fe), total	.17	.21	....	....	.23	.26	....	....	.22
Iron (Fe), in solution	.08	....	....	....	.05	.07	....	....	....
Calcium (Ca)	34	52	....	....	59	66	....	....	....
Magnesium (Mg)	6	1.5	....	....	2.1	2.0	....	....	....
Sodium and potassium (Na + K)	15	2.4	....	....	2.9	3.2	....	....	....
Carbonate (CO_3)	0	0	0	0	0	0	0	0	0
Bicarbonate (HCO_3)	166	164	150	212	160	213	149	191	186
Sulfate (SO_4)	.5	.5	1	5	12	.8	1	1	1
Chloride (Cl)	3.1	4.2	3.8	4.0	13	3.1	5.0	3.0	3.5
Fluoride (F)	.1	.1	....	....	.0	.0	....	....	....
Nitrate (NO_3)	.4	.1	....	....	.1	.0	....	....	....
Dissolved solids	160	166	....	....	188	203	....	....	....
Hardness as $CaCO_3$	110	136	122	164	156	173	100	144	138
pH	7.2	7.7	7.5	7.4	7.4	7.4	7.8	7.5	7.6
Water-bearing material	Sand	Sand	Sand	Sand	Limestone	Sand and Limestone	Sand	Sand	Limestone
Date of collection	7/30/52	5/15/47	6/3/53	....	4/22/53	6/25/52	5/13/54	4/7/54	....

Analyzed by the Quality of Water Branch, U. S. Geological Survey

	82	84	A
Silica (SiO_2)	22	25	4.0
Iron (Fe), total	.27	.55	.17
Iron (Fe), in solution	....	.00	.03
Calcium (Ca)	62	74	9.2
Magnesium (Mg)	4.8	8.0	2.0
Sodium and potassium (Na + K)	3.6	11	13
Carbonate (CO_3)	0	0	0
Bicarbonate (HCO_3)	211	288	20
lfate (SO_4)	1.4	.4	16
oride (Cl)	5.0	4.0	9.1
luoride (F)	.2	.0	.0
Nitrate (NO_3)	.3	.1	18
Dissolved solids	213	272	84
Hardness as $CaCO_3$	174	218	31
pH	7.7	7.3	6.1
Water-bearing material	Sand	Sand	....
Date of Collection	5/15/47	4/14/55	6/24/52

Analyzed by the Quality of Water Branch, U. S. Geological Survey

Jones County

Geology

In the extreme west part of Jones County streams have cut into the top of the Peedee formation, but toward the east the Peedee is progressively more deeply buried beneath younger sediments.

Overlying the Peedee is the Castle Hayne limestone. It is generally shallow and is penetrated by wells 50 feet or more in depth except in the extreme western part of the county. The channel of the Trent River is entrenched in the limestone throughout its course in the county, except near the Lenoir County line where it cuts through the Castle Hayne and into the Peedee formation. Tributaries within two miles of the Trent River are fed by water discharged from the limestone. Well 21, three miles west of Pollocksville, penetrated about 250 feet of limestone and calcareous sand of the Castle Hayne. Thus, the Castle Hayne thickens toward the east at an approximate rate of 25 feet per mile.

The undifferentiated surficial deposits consist chiefly of sand and clay. Calcareous deposits of the Yorktown formation are not apparent west of Pollocksville, but undoubtedly they occur beneath the swamps toward the southeast. It is likely that the Sandy clay overlying the Castle Hayne is the insoluble residue left by solution of the Yorktown formation and that the sandy material at the surface is of Pleistocene age.

Ground Water

Jones County is endowed with an abundant supply of ground water that can be developed at relatively low cost. Most of the water supplies come from well points in the sands of the surficial deposits. Some wells have been drilled through the surficial deposits to draw water from the Castle Hayne limestone, and in the western part of the county a few wells obtain water from sands in the Peedee formation.

The topography in the county is so flat that the water table is within 15 feet of the land surface almost everywhere. As a result, attempts to get water from well points driven into sand below the water table have almost always been successful. As much as 10 gallons of water a minute, enough for normal domestic use, can generally be pumped from a well point, but in most cases the water contains enough free carbon dioxide to make it slightly corrosive.

Little is known about the water-bearing character of the Castle Hayne limestone in the western half of the county. Some wells 25 to 60 feet deep west of Trenton draw water from the limestone, but none of these wells has tested the capacity of limestone to yield water. East of Trenton it is highly productive, and yields of 20 gallons a minute per foot of drawdown are normal.

Water in the limestone occurs under water-table or semi-artesian conditions, chiefly because of the relative thinness and permeable nature of the surficial deposits and because of the entrenchment of the Trent River into the limestone. The water level in wells that tap the limestone is approximately the same as the water table in the surficial deposits.

The Peedee formation lies close enough to the surface in the area west of Trenton to be reached by some drilled wells. At depths greater than 50 feet in the extreme western part of the county and at depths greater than 100 feet at Trenton, wells tap sands of the Peedee. As an aquifer it presumably is similar to the Peedee at Richlands, Onslow County. Flowing wells from the Peedee formation can be had in most of the lowland areas of the county.

Jones County

Number 21

Location: Oak Grove Naval Auxillary Air Station at Oak Grove, North Carolina
Owner: U. S. Navy
Date drilled: 1942
Driller: Heater Well Co.
Elevation of well: 30 feet above sea level

Hydrologic Information

Diameter of well: 8 inches
Depth of well: 299 feet
Cased to: Unknown
Finish: Screens
Static (nonpumping) water level: Unknown
Yield: Unknown

Log of Well

Post-Miocene—surficial sand

Depth (feet)	
0-23	Sand, buff to white; 85 percent medium to fine-grained subangular to angular quartz sand. 10 percent buff-colored clay matrix, unconsolidated. 5 percent reworked partially recrystallized calcareous aggregates. No Ostracoda, Foraminifera very rare.
	Upper (?) Eocene—upper part of Castle Hayne limestone
23-45	Sand and limestone, tan; 40 percent fine to medium-grained, angular to subangular quartz sand. 50 percent tan partially-recrystallized calcareous matrix, well consolidated and hard. 10 percent broken recrystallized shell fragments. Ostracoda and Foraminifera common.

45-53 Calcareous sand, light-tan; 65 percent fine to very fine-grained angular quartz sand. 35 percent tan partially recrystallized calcareous matrix, moderately consolidated. Trace of broken recrystallized shell fragments. Ostracoda and Foraminifera common.

53-87 Sand, white; 85 percent fine to very fine-grained angular quartz sand. 15 percent white calcareous matrix, unconsolidated. Trace of white shell and limestone fragments. Ostracoda and Foraminifera abundant.

87-97 Calcareous sand, light-gray; 75 percent fine-grained angular water-polished quartz sand. 25 percent gray recrystallized calcareous matrix, indurated. Trace of recrystallized shell fragments. Ostracoda Foraminifera abundant, recrystallized.

97-140 Calcareous sand, white; 90 percent very fine-grained angular quartz sand. 10 percent white calcareous clay matrix, indurated to very loosely consolidated. Trace of broken shell and limestone fragments. Ostracoda and Foraminifera common. Ostracoda from the 23-140-foot intervals include:

Bairdia sp. B
Cytheriadea (Clithrocytheriadea) caldwellensis Howe and Chambers
Cytheropteron sp. A
Trachyleberis sp. A and *Sp.* B
Loxoconcha sp. A.
Cytheretta alexanderi Howe and Chambers
Monoceratina alexanderi Howe and Chambers

140-220 No sample.

Lower Eocene(?)—unnamed unit

220-235 Sandy limestone, gray; 35 percent medium to fine-grained subangular quartz sand. 45 percent gray calcareous matrix, well consolidated. 15 percent partially-recrystallized broken shell fragments. 5 percent dark-green fine-grained glauconite. Ostracoda and Foraminifera rare.

235-250 Calcareous sand, gray; 65 percent coarse to medium-grained subangular quartz sand. 25 percent white calcareous clay matrix, indurated and well consolidated. 5 percent dark-green medium-grained glauconite. 5 percent coarse phosphate pebbles. Broken shell fragments prominent. Ostracoda and Foraminifera rare.

250-260 Calcareous sand, gray; Same as 235-250-foot interval, very hard. Ostracoda and Foraminifera rare. Ostracoda from the 220-250-foot intervals include:

Brachycythere cf. B. marylandica (Ulrich and Bassler)
Trachyleberis bassleri (Ulrich)
Trachyleberis communis aquia (Schmidt)

Upper Cretaceous—Peedee formation

260-265 Sand, gray; 90 percent coarse to medium-grained subrounded to subangular quartz sand. 10 percent gray calcareous clay matrix, indurated. Ostracoda from the 260-265-foot interval include:

Cytheridea (Haplocytheridea) ulrichi (Berry)
Eucytherura curta (Jennings)
Brachycythere rhomboidalis (Berry)
Velarocythere legrandi Brown
Velanocythere sp. aff. *V. arachoides* (Berry)

Figure 15. Map of Jones County showing location of wells.

Record of Wells in Jones County

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	10 miles NW of Trenton	Dr. John Whitaker	Open end	79	1¼	36	Sand				
2	9 miles NW of Trenton	Mrs. L. B. Jenkins	do	85	2		do	7.5			Water level data obtained 4-24-56.
3	7 miles NW of Trenton	Mac Daniels	do	120	1¼	120	do				
4	3 miles N of Trenton	Charlie McDaniel	do	124	3	106	do				
5	do	E. L. Mallard	do	262	1¼	107	do				
6	3 miles W of Trenton	P. L. Foy	do	92	1¼	80	do	12			Analysis. Temperature 63°F.
7	2 miles W of Trenton	Sally Nobles	do	92	1¼	90	do				
8	Trenton	S. D. Mallard	do	420	2½	120	do				
9	do	Wade Mallard	do	115	1¼	110	do				
10	do	Mac Curtis	do	125	2	124	do	2			
11	do	Jones County Court House	do do	212	3	60	do	12			Analysis.
12	4 miles E of Trenton	F. W. Farcus	do	180	2	178	do				
13	4 miles N of Pollocksville	Floyd Sykes	do	78	1¼	78	Limestone				
14	10 miles W of Trenton	John Small	do	172	1¼	120	Sand				Well flows.
15	6 miles W of Trenton	I. F. Eubanks	do	130	2½	42	do				Slight overflow.
16	9 miles W of Trenton	Dave Hurrey	do	64	1½	12	do				Well flows.
17	13 miles W of Trenton	Rex Blizzard	Open end	184	3	42	Sand				
18	8 miles W of Trenton	Eagle Nest Farm	do	50	1¼	50	do				
19	4 miles NW of Pollocksville	Jack Mallard	do	245	2	230	do				
20	do	U. S. Marines Air Station	do	67	8	52	Limestone		180	85	
21	do	do	do	299	8		Sand				Well abandoned. Driller reported no water.
22	4 miles W of Pollocksville	J. K. Dixon	do	150	2	150	do				Analysis. Temperature 62°F.
23	Pollocksville	J. H. Simmons	do	60	1½	60	Limestone	18			
24	do	Town of Pollocksville	do	62	6	45	do	18	275		Well abandoned.
25	do	Isabelle Henderson	do	55	1¼	45	do	21			
26	do	Williams and McKeithan Lumber C.	do	30	2	20	do	3	100	5	Hardness. 271 ppm total iron 0.6.
27	2 miles S of Pollocksville	C. L. Davis	Gravel walled	115	8		Sand	11	750	39	Temperature 63°F.
28	Maysville	Maysville Public School	Open end	47	2	27	Limestone				
29	do	Bill Bradford	do	42	2	36	do	14			
30	do	Mrs. G. E. Weeks	Dug	9	36		Sand				Water level measurements available since 1942.
31	7 miles SE of Maysville	Jason Morris	Open end	90	6		do	14			

Chemical Analyses of Ground Water From Jones County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	6	11	22
Silica (SiO_2)	24		
Iron (Fe), total	2.2	.03	
Iron (Fe), in solution	.00		
Calcium (Ca)	69		46
Magnesium (Mg)	3.8		.9
Sodium and potassium (Na + K)	8.4		3.5
Carbonate (CO_3)	0		0
Bicarbonate (HCO_3)	242	175	136
Sulfate (SO_4)	.6		4.0
Chloride (Cl)	5.5	7	6.2
Fluoride (F)	.0		.2
Nitrate (NO_3)	.4		
Dissolved solids	242		
Hardness as $CaCO_3$	188	138	118
pH	7.3	7.5	6.9
Water-bearing material	Sand	Sand	Sand
Date of collection	6/15/55	8/1/41	11/13/54

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

Lenoir County

Geology

The Black Creek formation crops out only along the Neuse River between the Wayne County line and a point about 13 miles down stream. Fossils have been described by Stephenson (Clark and others, 1912, p 136-137) from the Snow Hill marl member along this reach of the river. The Black Creek is covered by the overlying Peedee formation and is buried progressively deeper eastward. The dip of the uppermost beds ranges between 10 and 15 feet per mile to the east.

The Peedee formation occurs as a flat-lying wedge, the thin edge of which extends within a few miles of the Wayne County line. It thickens to the east, being about 100 feet thick at Kinston. It is exposed along the Neuse River from a point several miles west of Kinston to the Craven County line and along some parts of Southwest Creek and Contentnea Creek, on the Pitt County boundary. In the interstream areas it is overlain unconformably by younger deposits, north of the Neuse River by clayey sediments of Miocene age and south of the Neuse River by deposits of Eocene age in some places and by deposits of Miocene age in other places. The depth to the top of the Peedee formation is generally less than 40 feet, but in the interstream areas along the Jones County line it lies at a depth of almost 100 feet.

The Peedee formation consists of dark-greenish or grayish, glauconitic and clayey sand containing a few impure limestone beds. Interbedded with the sands are subordinate thicknesses of beds of dark gray clay. It is not known whether any of the beds are extensive enough to be of value in correlation.

Ground Water

Lenoir County is favorably situated for the development of groundwater supplies. Shallow wells 10 to 20 feet deep tapping the surficial sands furnish adequate supplies for most domestic uses. The numerous small springs, located along the valley and scarp slopes, are unused. Deep wells, penetrating sands containing artesian water, are capable of furnishing as much as 500 gpm of water of excellent chemical character throughout the county.

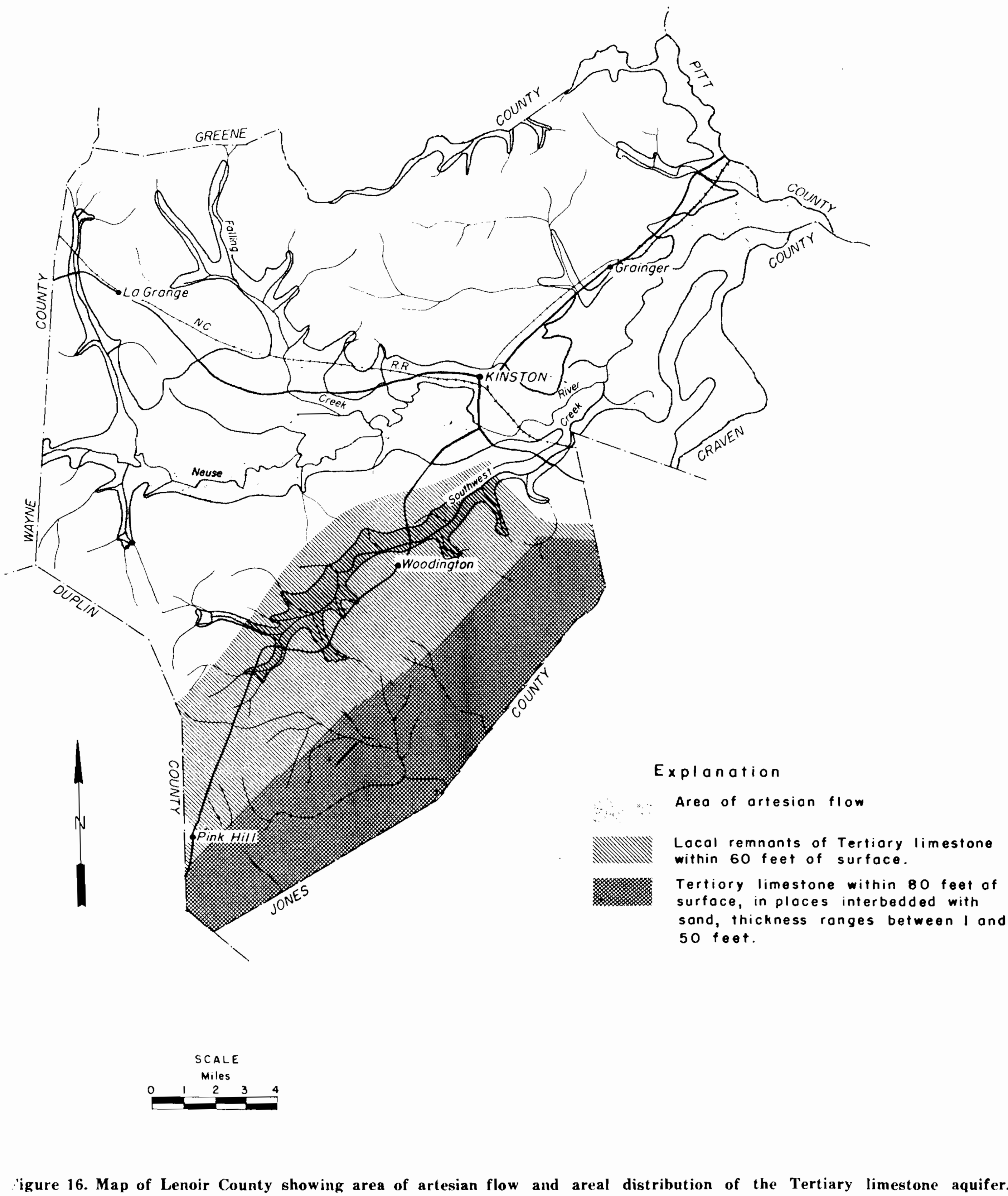
Artesian water underlies the entire county. It occurs in the Black Creek and overlying Peedee formations, which may be considered as a hydrologic unit. This unit consists of beds of sand separated by beds of clay. Although some wells draw water from only one of these sand beds, the existing well data do not indicate whether any of the beds can be traced for any distance.

The only completely developed wells in the county drawing artesian water are gravel-walled wells that yield water from more than one bed of sand. There are many wells that are screened in one bed of sand and others that have the casing open in sand; in the latter type of well, compressed air is generally used to remove much of the sand in the area around the bottom of the well. Many of the screened and open-end wells are capable of yielding as much as 50 gpm.

The artesian head in the Black Creek and Peedee formations is above the land surface in much of the lowland areas of the county, and in these areas flowing wells can be developed (fig. 16). Most of the flows come from the Black Creek formation, but in the valleys east and south of Kinston the Peedee is the source of flows from relatively shallow depths. Owing to the small amount of artesian water used, there has been no regional lowering of head in the county. Local cones of depression exist around the city wells at Kinston and around the wells at the DuPont plant near Grifton (wells 24-29). The extent of the pumpage is great enough to cause some of the previously flowing wells to stop flowing within a radius of a few miles from the center of both cones.

The principal aquifers of the county are beds of sand, but a flat-lying body of limestone east of Southwest Creek furnishes water to some wells in the southeastern part of the county. In the interstream area near the Jones County line the limestone is as much as 25 feet thick and generally within 15 feet of the land surface. The water-bearing character of the limestone is not known, but it is not considered an important aquifer because of its local extent and thinness.

The overall chemical character of artesian water in Lenoir County is excellent. None of the waters analyzed exceed 152 parts per million in hardness. The quality of the water improves with depth as shown by the chemical analyses of the city wells in Kinston and of the DuPont wells. In all the artesian aquifers there is a tendency for ion exchange to take place, sodium from the aquifers replacing calcium and magnesium in the ground waters. This exchange is more complete in the waters of the Black Creek formation than in the waters of the overlying Peedee formation. Shallow wells ending in surficial sands yield water low in dissolved solids, but the water is generally corrosive.



'igure 16. Map of Lenoir County showing area of artesian flow and areal distribution of the Tertiary limestone aquifer.

Lenoir County

Number 29

Location: 1.5 miles west of Grifton, North Carolina
Owner: E. I. DuPont de Nemours
Date drilled: 1955
Driller: Heater Well Co.
Elevation of well: 53.3 feet above sea level

Hydrologic Information

Diameter of well: 12 inches
Depth of well: 687 feet
Cased to: 687 feet
Static (nonpumping) water level: 47 feet below land surface
Yield: 1,000 gallons a minute with a drawdown of 52 feet

Log of Well

Depth (feet)

0-4 No sample.

Upper Cretaceous—Peedee formation

4-6 Shale, light-gray; Very hard slightly-sandy shale. Trace of dark-green glauconite and euhedral pyrite crystals. No Ostracoda, Foraminifera common.

6-14 Shale, light-gray; Same as 4-6-foot interval. No Ostracoda, Foraminifera common.

14-24 Shale, light-gray; Same as 4-6-foot interval. No Ostracoda, Foraminifera common.

24-28 Shale, light-gray; Same as 4-6-foot interval. No Ostracoda, Foraminifera common.

28-32 Shale, light-gray; Same as 4-6-foot interval. No Ostracoda, Foraminifera very rare.

32-43 Sand, gray; 70 percent coarse to medium-grained subrounded to subangular quartz sand. 20 percent gray calcareous clay matrix, indurated in streaks. 10 percent dark-green medium-grained glauconite. Black phosphate pebbles prominent. Ostracoda and Foraminifera very rare.

43-49 Sand, gray; Same as 32-43-foot interval. Ostracoda and Foraminifera very rare.

49-53 Sand, gray; 85 percent coarse-grained subangular quartz sand. 10 percent gray clay matrix, unconsolidated. 5 percent dark-green coarse-grained glauconite. Trace of pyrite aggregates. Ostracoda and Foraminifera very rare.

53-59 Glauconitic sand, dark-green; 55 percent coarse to fine-grained subangular to angular quartz sand. 20 percent gray clay and silt matrix, unconsolidated. 25 percent dark-green medium-grained glauconite. Ostracoda and Foraminifera very rare.

59-68 Glauconitic sand, "salt and pepper", 55 percent medium to fine-grained subrounded to subangular quartz sand. 15 percent gray clay and silt matrix, unconsolidated. 30 percent dark-green medium-grained glauconite. Trace of broken shell fragments. Ostracoda and Foraminifera very rare.

68-84 Glauconitic sand, "salt and pepper"; Same as 59-68-foot interval with a 10 percent increase in glauconite and a 10 percent decrease in quartz sand. Ostracoda and Foraminifera rare.

84-90 Glauconitic sand, "salt and pepper"; Same as 68-84-foot interval. Ostracoda and Foraminifera rare.

90-94 Glauconitic sand, light-gray; 45 percent medium to fine-grained subrounded to subangular quartz sand. 25 percent dark-green fine-grained glauconite. 25 percent gray calcareous silt and clay matrix, indurated. 5 percent broken abraded shell fragments. Ostracoda and Foraminifera rare.

94-105 Sand, gray; 75 percent medium-grained subrounded to subangular quartz sand. 20 percent gray silt and clay matrix, unconsolidated. 5 percent dark-green fine-grained glauconite. Broken abraded shell fragments prominent. Ostracoda and Foraminifera rare.

105-125 Sand, gray; Same as 94-105-foot interval, indurated in streaks. Ostracoda and Foraminifera rare.

125-128 Sand and shell, gray; 50 percent medium to fine-grained angular quartz sand. 40 percent coarse abraded shell fragments. 10 percent gray calcareous clay matrix, indurated. Trace of dark-green glauconite and pyrite aggregates. Ostracoda and Foraminifera very rare.

128-143 Sand, gray; 80 percent medium to fine-grained subrounded to angular quartz sand. 20 percent gray clay matrix, unconsolidated. Trace of dark-green glauconite and broken shell fragments. Ostracoda and Foraminifera common.
Ostracoda from the 32-143-foot interval include:
Cytherelloidea swaini Brown
Cytherelloidea (?) cynciforma Brown
Cytheridea (Haplocytheriadea) Carolinensis Brown
Cytheridea (Haplocytheridea) punctura (Schmidt)
Brachycythere rhomboidalis (Berry)
Brachycythere plena Alexander
Trachyleberis gapensis (Alexander)
Velarocythere arachoides (Berry)

Upper Cretaceous—Black Creek formation (Snow Hill marl member)

143-153 Sand and clay, dark-gray; 65 percent very fine to fine-grained angular quartz sand. 30 percent gray clay matrix, unconsolidated. 5 percent dark-green very fine-grained glauconite. Chalky broken shell fragments prominent. Trace of mica flakes and pyrite aggregates. *Inoceramus* prisms and otoliths. Ostracoda and Foraminifera common.

153-163 Sand and clay, dark-gray; Same as 143-153-foot interval. *Inoceramus* prisms and otoliths. Ostracoda and Foraminifera common.

163-178 Clay and sand, black; 35 percent very fine-grained angular quartz sand. 60 percent black micaceous clay matrix, unconsolidated but very compact. 5 percent broken shell fragments. Trace of dark-green glauconite and black lignitized wood fragments. *Inoceramus* prisms and otoliths prominent. Ostracoda and Foraminifera abundant.

178-183 Sand and clay, dark-gray; 70 percent very fine-grained angular quartz sand. 20 percent gray micaceous silt and clay matrix, unconsolidated. 5 percent dark-green very fine-grained glauconite. *Inoceramus* prisms prominent. Ostracoda and Foraminifera common.

184-193 Clay and sand, black; 35 percent very fine-grained angular quartz sand. 65 percent black micaceous clay matrix, unconsolidated but very compact. Trace of dark-green glauconite, black phosphate pebbles, black lignitized wood fragments, and white chalky shell fragments. *Inoceramus* prisms and otoliths. Ostracoda and Foraminifera common.

193-203 Clay and sand, black; Same as 184-193-foot interval. Ostracoda and Foraminifera common.

203-210 Clay and sand, black; Same as 184-193-foot interval, with dark-green fine-grained glauconite replacing 10 percent of the clay component. Ostracoda and Foraminifera rare.

210-221 Clay and sand, black; Same as 203-210-foot interval. Ostracoda and Foraminifera common.

221-228 Clay and sand, black; Same as 203-210-foot interval. Ostracoda and Foraminifera common.

228-244 Clay and sand, black; Same as 203-210-foot interval with a slight increase in amount of shell fragments. Ostracoda and Foraminifera rare.

244-253 Sand and clay, black; 60 percent medium to fine-grained sub-rounded to angular quartz sand. 35 percent black micaceous clay and silt matrix, unconsolidated. 5 percent dark-green fine-grained glauconite. Trace of chalky shell fragments and pyrite aggregates. *Inoceramus* prisms. Ostracoda and Foraminifera very rare.

253-260 Sand and clay, black; Same as 244-253-foot interval. Ostracoda and Foraminifera very rare.

260-266 Sand and clay, black; Same as 244-253-foot interval. Ostracoda and Foraminifera rare.

266-278 Clay and sand, black; 35 percent very fine-grained angular quartz sand. 60 percent black micaceous clay matrix, unconsolidated but very compact. 5 percent light-green fine-grained glauconite. Black lignitized wood fragments prominent. Trace of acicular gypsum and marcasite aggregates. Ostracoda and Foraminifera rare.

278-285 Sand, dark-gray; 85 percent medium-grained subangular to angular quartz sand. 15 percent dark-gray micaceous clay matrix, unconsolidated. Trace of light-green glauconite black lignitized wood fragments and marcasite aggregates. Ostracoda and Foraminifera common.
Ostracoda from the 143-285-foot interval include:

Cytherella bullata Alexander
Cytheridea (Haplocytheridea) monmouthensis Berry
Cytheropteron (Eocytheropteron) striatum Brown
Brachycythere nausiformis Swain
Brachycythere sphenoides (Reuss)
Brachycythere ledaforma (Israelsky)
Trachyleberis gapensis (Alexander)
Orthonotacythere tarensis Brown
Orthonotacythere sulcata Brown
Protocythere paratriplicata Swain

Upper Cretaceous—Black Creek formation (unnamed member)

285-297 Clay and sand, mottled-yellow and gray; 35 percent fine to medium-grained angular to subangular quartz sand. 65 percent gray and yellow micaceous clay matrix, unconsolidated but very compact. Trace of glauconite and black lignitized wood fragments. No microfossils.

297-303 Clay and sand, dark-gray; 25 percent very fine to fine-grained angular quartz sand. 75 percent gray micaceous clay matrix, unconsolidated but very compact. Black lignitized wood fragments prominent. Trace of glauconite abraded shell fragments and marcasite aggregates. No microfossils.

303-311 Clay and sand, dark-gray; Same as 297-303-foot interval. No Ostracoda, Foraminifera very rare.

11-316 Sand and clay, gray; 75 percent medium-grained subangular to subrounded quartz sand. 25 percent gray micaceous clay matrix, unconsolidated. Trace of glauconite marcasite aggregates and black lignitized plant fragments. No microfossils.

316-322 Sand and clay, gray; Same as 311-316-foot interval. No microfossils.

322-328 Sand, gray; 90 percent medium to coarse-grained subangular to subrounded quartz sand. 10 percent gray micaceous clay matrix, unconsolidated. Trace of dark-green glauconite and black lignitized wood fragments. No Ostracoda, Forminifera rare.

328-337 Sand, gray; Same as 322-328-foot interval. No microfossils.

337-348 Clay and sand, gray; 40 percent fine to medium-grained subangular to subrounded quartz sand. 60 percent gray micaceous clay matrix, unconsolidated but compact. Dark-green glauconite prominent. Trace of abraded shell fragments. No microfossils.

348-353 Sand, gray; 85 percent medium to fine-grained angular quartz sand. 15 percent gray micaceous clay matrix, unconsolidated. Dark-green glauconite prominent. Trace of abraded shell fragments. No Ostracoda, Foraminifera rare.

353-363 Sand, gray; Same as 348-353-foot intervals. No microfossils.

363-373 Sand, gray; Same as 348-353-foot interval with decrease in grain size of quartz sand. No microfossils.

373-381 Sand and clay, gray; 70 percent fine-grained angular quartz sand. 30 percent gray micaceous clay matrix, unconsolidated but very compact. Dark-green glauconite and black lignitized wood fragments prominent. Trace of abraded shell fragments. No Ostracoda, Foraminifera rare.

381-388 Sand and clay, gray; Same as 373-381-foot interval with a 15 percent increase in the clay component. No microfossils.

388-394 Sand and clay, dark-gray; Same as 381-388-foot Interval. Ostracoda rare, no Foraminifera.

394-405 Sand and clay, gray; 65 percent fine-grained angular quartz sand. 30 percent gray micaceous clay matrix, unconsolidated. 5 percent light-green fine-grained glauconite. Trace of abraded shell fragments. No microfossils.

405-415 Sand and clay, dark-gray; Same as 394-405-foot interval. No microfossils.

415-422 Sand and clay, dark-gray; Same as 394-405-foot interval. Ostracoda rare, no Foraminifera.

422-430 Clay and sand, black; 45 percent medium to fine-grained angular quartz sand. 55 percent black micaceous clay matrix, unconsolidated but very compact. Dark-green glauconite abraded shell fragments and black lignitized wood fragments prominent. No microfossils.

430-441 Sand and clay, dark-gray; 70 percent medium to coarse-grained subangular quartz sand. 30 percent gray micaceous clay matrix, unconsolidated. Black lignitized wood fragments prominent. Trace of dark-green glauconite and marcasite aggregates. No Ostracoda, Foraminifera rare.

441-453 Sand, gray; 85 percent coarse to medium-grained subrounded quartz sand. 15 percent gray micaceous silt and clay matrix, unconsolidated. Trace of light-green glauconite. No microfossile.

453-465 Sand, gray; Same as 441-453-foot interval. No microfossils.

465-474 Sand, gray; 75 percent coarse to fine-grained subrounded to angular quartz sand. 20 percent gray micaceous clay matrix, unconsolidated. 5 percent dark-green fine-grained glauconite. Black lignitized wood fragments and marcasite aggregates prominent. Trace of shell fragments. No microfossils.

474-478 Sand, gray; Same as 465-474-foot interval. No Ostracoda, Foraminifera rare.

478-488 Sand, gray; Same as 465-474-foot interval. No microfossils.

488-498 Sand, gray; Same as 465-474-foot interval. No microfossils.

498-503 Sand, gray; Same as 465-474-foot interval. No microfossils.

503-510 Sand, gray; Same as 465-474-foot interval. No microfossils.

510-523 Sand, gray; Same as 465-474-foot interval with a slight increase in clay matrix, No microfossils. Ostracoda from the 285-523-foot interval are as follows:

388-394 *Brachycythere sphenoides* (Reuss)

415-422 *Brachycythere sphenoides* (Reuss)

Upper Cretaceous—Tuscaloosa formation

523-530 Sand and clay, gray to brown; 75 percent coarse to medium-grained subangular quartz sand. 25 percent gray to brown micaceous clay matrix. Red hematite aggregates and dark-green glauconite prominent. Trace of shell fragments and *Inoceramus* prisms. No microfossils.

30-542 Sand, gray; 80 percent medium-grained subangular to angular quartz sand. 20 percent gray micaceous clay matrix, unconsolidated. Trace of dark-green glauconite. No microfossils.

542-551 Sand, gray to pink; 85 percent medium to fine-grained subangular to angular quartz sand. 15 percent gray to pink clay matrix, unconsolidated. Red hematite staining of quartz grains and hematite aggregates prominent. No microfossils.

551-558 Sand, pink; 80 percent medium to coarse-grained subrounded to subangular quartz sand. 15 percent mottled-pink to gray micaceous clay matrix. 5 percent red hematite aggregates. Trace of dark-green medi m-grained glauconite. No microfossils.

558-563 Sand, pink; Same as 551-558-foot interval. No microfossils.

563-572 Sand, pink; same as 551-558-foot interval. Ostracoda rare, no Foraminifera.

581-593 Sand, pink; Same as 551-558-foot interval. No microfossils.

593-603 Sand, yellow; 90 percent coarse to medium-grained subrounded to subangular quartz sand. 10 percent yellow waxy micaceous clay matrix, unconsolidated. No microfossils.

603-607 Sand, yellow; Same as 593-603-foot interval. No microfossils.

607-613 Sand, yellow; Same as 593-603-foot interval. No microfossils.

613-619 Sand, yellow; Same as 607-613-foot interval. No microfossils.

)-631 Clay and sand, red; 40 percent medium to fine-grained subrounded to angular quartz sand. 60 percent red micaceous clay and silt matrix, unconsolidated but compact. Red hematite aggregates prominent. Trace of dark-green glauconite. Ostracoda rare, no Foraminifera.

631-645 Sand and silt, red; 70 percent coarse to fine-grained angular poorly-sorted feldspathic quartz sand. 30 percent red silt and clay matrix, unconsolidated but compact. Red hematite aggregates prominent. Trace of dark-green glauconite. No microfossils.

645-652 Sand and silt, red. Same as 631-645-foot interval. No microfossils.

652-663 Sand and silt, yellow; Same as 631-645-foot interval with a color change as noted. No microfossils.

663-673 Sand and silt, yellow; Same as 652-663-foot interval. No microfossils.

673-680 No sample.

680-691 Sand and clay, tan; 70 percent medium to fine-grained angular quartz sand. 30 percent tan clay matrix, unconsolidated. Light-green fine-grained glauconite prominent. Trace of red hematite and marcasite aggregates. No microfossils.

691-703 Sand and clay, tan; Same as 680-691-foot interval. No microfossils.

703-708 Sand and clay, tan; Same as 680-691-foot interval with slight increase in clay content. No microfossils.

708-713 Sand and clay, tan; Same as 680-691-foot interval. No microfossils.

Ostracoda from the 523-713-foot interval are as follows:

563-572 *Cythereis ornatissima* (Reuss)

619-631 *Cythereis ornatissima* (Reuss)

Lower Cretaceous—unnamed unit

713-723 Sand and clay, brown; 70 percent fine-grained angular quartz sand. 30 percent brown micaceous clay and silt matrix, unconsolidated but very compact. Trace of glauconite and red hematite aggregates. Ostracoda abundant, no Foraminifera.

723-733 Sand and clay, brown; Same as 713-723-foot interval. Ostracoda abundant, no Foraminifera.

733-743 Sand and clay, brown; Same as 713-723-foot interval. Ostracoda abundant, no Foraminifera.

743-746 Sand and clay, brown; Same as 713-723-foot interval. Ostracoda abundant, no Foraminifera.

746-813 Sand and clay, brown; 55 percent coarse to very fine-grained subrounded to angular quartz sand. 40 percent brown micaceous clay matrix, unconsolidated but very compact. 5 percent red hematite aggregates. Trace of dark-green medium-grained glauconite and broken shell fragments. Ostracoda abundant, no Foraminifera.

813-823 Sand and clay, brown; 60 percent coarse to very fine-grained subrounded to subangular quartz sand. 30 percent brown micaceous and silty-clay matrix, unconsolidated. Trace of dark-green glauconite and broken shell fragments. Ostracoda abundant, no Foraminifera.

Remarks: The log given is that of the test well drilled to a depth of 823 feet. The production well was finished in the same hole at a depth of 687 feet.

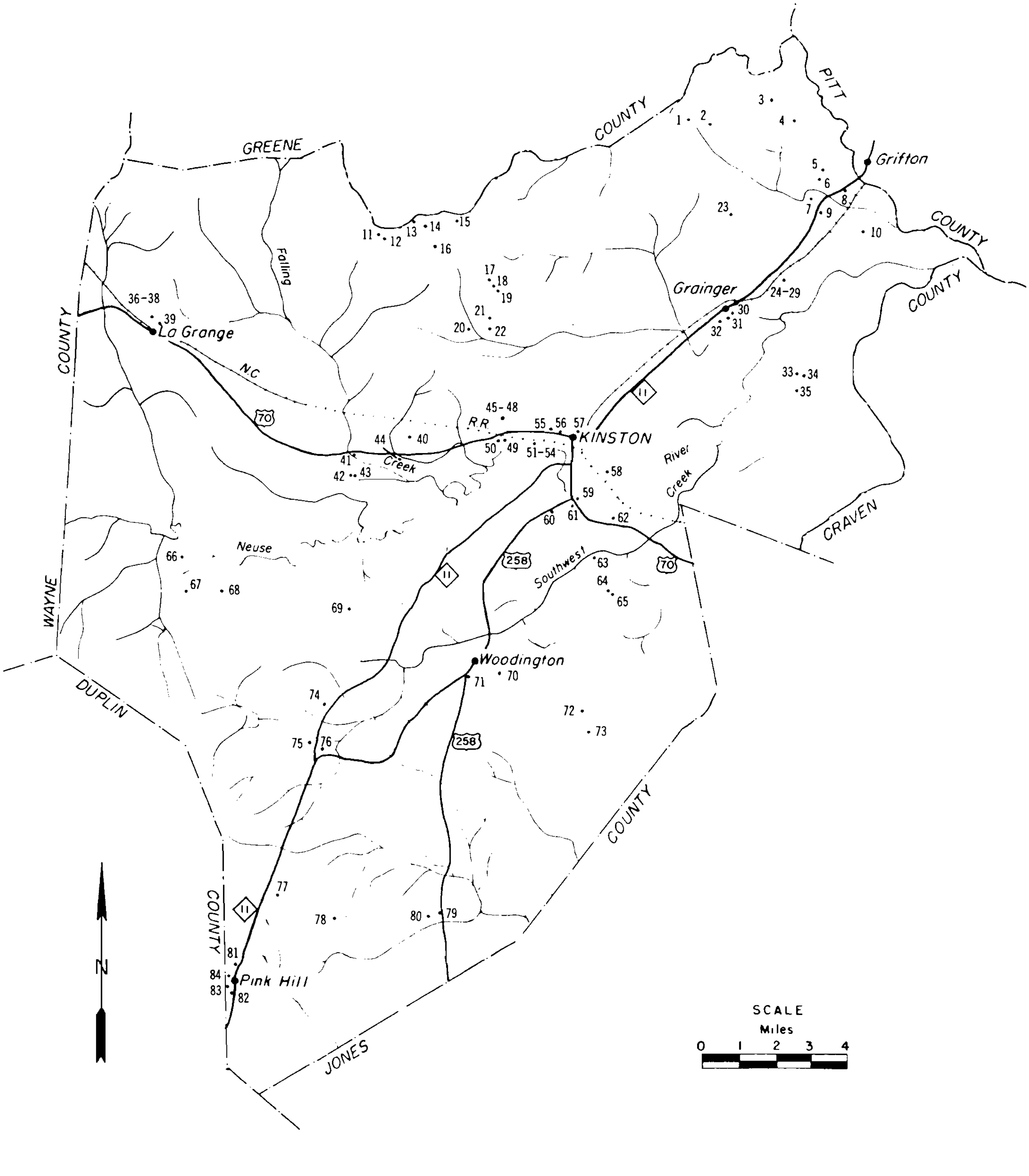


Figure 17. Map of Lenoir County showing location of wells.

Records of Wells in Lenoir County

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	5 miles W of Grifton	Buck Smith	Open end	140	4		Sand	10.54			Water level data obtained 3-9-54
2	do	Lyman Harris	do	148	4		do	10.95			do
3	4 miles NW of Grifton	Dan Sutton	do	95	4	80	do	18			
4	2 miles NW of Grifton	L. R. Rouse	do	350	2		do	1			Flowed prior to 1951
5	1 mile W of Grifton	Dave Worthington	Screen	285	2	270	do	6			Analysis. Flowed 30 gpm until 1951
6	do	do	Open end	104	4		do	10.51			Water level data obtained 3-9-54
7	do	Savannah School	do	165	4	125	do				
8	Grifton	Sol Worthington	do	286			do				Flowed 30 gpm in 1915. No longer flows.
9	do	W. H. Smith	do	105	4	100	do				
10	1 mile S of Grifton	J. H. Barwick	do	280	4	280	do				Flowed 2 gpm in 1943. No longer flows.
11	6 miles NW of Kinston	Wheat Swamp School	Screen	41	6	32	do		15		
12	do	do	Open end	220	6	200	do		18		
13	do	Edwards Store	do	65	1¼	40	do	+8	5		Temperature 63°F.
14	6 miles NW of Kinston	Raymond Gray	Open end	50	1½		Sand	+2			
15	do	F. D. Kennedy	do	65	1¼		do	+4			
16	do	do	do	84	1¼	84	do	20			Analysis.
17	5 miles NW of Kinston	Kinston Airport	Screen	95	8	75	do	35	80		do
18	do	do		470	10						Unable to develop water. Well never used.
19	do	do	Gravel walled	425	12		Sand		270		Analysis. Screens set at 350 feet and 425 feet.
20	do	Dobbs Farm	Screen	121	6		do	34	100		
21	do	E. L. Johnston	do	84	4	82	do	15	3		
22	do	do	Dug	12	24		do				Analysis.
23	8 miles NE of Kinston	Ray Cameron	Open end	128	4	100	do				
24	7 miles NE of Kinston	DuPont Company	Gravel walled	509	10		do	29	530	88	
25	do	do	do	498	10		do	29	590	60	
26	do	do	do	509	10		do		520	83	
27	do	do	do	509	10		do		575	71	
28	do	do	do	627	10		do	52	605	30	Temperature 67°F.
29	do	do	do	823	10		do	47	1000	52	Temperature 66°F.
30	do	R. W. Hamilton	Screen	125	4		do				Water level 49.19 feet 6-15-55
31	7 miles NE of Kinston	R. W. Hamilton	Screen	137	4		Sand	48			Analysis.
32	6 miles NE of Kinston	Contentnea School	Open end	125	4		do				Well flows, but hydraulic ram pumps water.
33	do	Lot West	do	350	4	260	do		6		Water level data obtained 7-28-52. Temperature 69°F.
34	do	do	do	130	2	130	do				
35	do	Norma West	do	149	3	105	do				Hardness by field test 78 ppm
36	La Grange	Town of LaGrange	Gravel walled	332			do		175	11	Temperature 63°F.
37	do	do	Screen	343	10		do	20	150		Pumps some sand.
38	do	do	do	180	10		do	20	125		
39	do	do	Gravel walled	353			do	44	200	33	Analysis. Screens set at 224-229, 240-255, 280-290, 300-305, 348-353 feet.
40	3 miles W of Kinston	Earnest Johnson	Open end	200	4	105	do	10.5			Water level data obtained 2-25-53.
41	4 miles W of Kinston	Roland Dawson	Open end	120	2		Sand	+5			Analysis. Temperature 64°F.
42	do	Kennedy Home	Screen	402	6	382	do		45		
43	do	do	do	399	8	306	do		100		
44	3 miles W of Kintson	James Parrott	Open end	245	2	190	do	+2			
45	Kinston	Caswell Training School	do	1300	6						Drilled in 1913. Originally flowed salty water. Abandoned.
46	do	do	Screen	600	6		do	22			Drilled in 1923. Well was never used due to insufficient water.
47	do	do		600	6		do		110		Analysis.
48	do	do	Gravel walled	310			do	60	350	40	Analysis. Screens set at 119-139, 250-253, and 305-310 feet.
49	do	do		350	6		do				Located on terrace adjacent to river. Originally flowed 60 gpm.

Records of Wells in Lenoir County—Continued

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
50	Kinston	City of Kinston		350?	1½		Sand	0			Flowed prior to 1952. Periodic water level measurements available.
51	....do	do	Gravel walled	375			..do	2	900		Analysis.
52	....do	....do	..do	370			....do	3	700		
53	....do	....do	..do	375	8		....do		460	45	Two other wells nearby of similar depth and size. Aggregate natural flow from the 3 wells is about 150 gpm.
54	....do	....do	Open end	300	4		....do				
55	....do	Dr. Pepper Bottling Co.	Screen	92	6		....do	40			
56	..do	... do	Gravel walled	278	10		....do	36	250	70	Screen settings 195-200, 208-213, 255-260, 267-270, and 275-278 feet.
57	....do	City of Kinston	..do	552	10		....do	53	900	53	
58	....do	....do	..do	483	10		....do	25	1000	45	Analysis.
59	1 mile S of Kinston	J. C. Sutton	Open end	200	2						Hardness (field test) 45 ppm.
60	....do	N. C. Prison Camp	Screen	214	6		Sand	0			Analysis.
61	....do	Allie Taylor	Open end	263	2		....do				Temperature 62°F.
62	....do	T. Stroud	..do	230	2		....do				Temperature 62°F.
63	2 miles S of Kinston	K. W. Loftin	Screen	240	4		....do				
64	3 miles S of Kinston	Southwood School	Open end	25	4	10	....do	2			
65	....do	do	do	155	4		....do		35		
66	5 miles S of La Grange	L. P. Hardy	do	88	1½	40	....do	+8	6		Analysis. Temperature 63°F.
67	6 miles S of La Grange	George Newman	do	115	1¼	95	....do				Well flows.
68	7 miles S of La Grange	Margaret Tyndall	do	160	3	80	....do	15	15		
69	7 miles SW of Kinston	J. M. Ponse	Open end	84	4	68	Sand				
70	Woodington	Negro School	do	190	4	140	....do	50			
71	....do	J. J. Harper	Drive point	15	1¼	15	....do				Temperature 62°F.
72	3 miles SE of Woodington	Jarmen Becton	Open end	169	3	100	....do				Analysis.
73	....do	Farley Garner	..do	70	2	20	....do	10			
74	3 miles SW of Woodington	Nannie Barwick	Screen	84	4	78	....do		15		
75	4 miles SW of Woodington	Deep Run School	Open end	102	6	95	....do		30		
76	....do	T. I. Stroud	..do	145	4		....do				Hardness (field test) 35 ppm. Temperature 64°F.
77	3 miles N of Pink Hill	Quenton Stroud	Screen	160	3		....do				
78	3 miles E of Pink Hill	J. J. Smith	Open end	80	2	80	....do	25			
79	4 miles E of Pink Hill	W. W. Jones	..do	43	1¼	42	....do				Hardness (field test) 50 ppm.
80	....do	Mrs. Della Tyndall	Screen	56	4	54	....do				
81	Pink Hill	E. R. Maxwell	Open end	51	2		....do		1		Hardness (field test) 115 ppm.
82	....do	Pink Hill School	..do	195	4	125	....do	60			
83	....do	... do	Drive point	30	1¼		....do				
84	Pink Hill	Town of Pink Hill	Gravel walled	220	8		Sand	55	200	34	Analysis.

Chemical Analyses of Water From Lenoir County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	5	16	17	19	21	31	39	41	47
Silica (SiO_2)	......	21	19	18	......	18	26	......	10
Iron (Fe), total	......	.81	1.1	......	......	.47	.31	......	.12
Iron (Fe), in solution	.04	.09	.05	.03	......	.00	.27	......	.01
Calcium (Ca)	2.0	14	47	19	......	44	2.4	......	.8
Magnesium (Mg)	1.2	.9	1.6	2.6	......	2.3	1.2	......	.7
Sodium and potassium (Na + K)	74	4.7	6.0	37	......	12	38	......	76
Bicarbonate (HCO_3)	169	35	156	145	176	170	89	118	128
Sulfate (SO_4)	4.5	12	.6	3.5	1	1.1	5.6	2	12
Chloride (Cl)	11	4.8	5.5	6.5	6	4.0	7.8	3.5	36
Fluoride (F)	.5	.3	.1	.2	......	.1	.1	......	.7
Nitrate (NO_3)	.3	.1	.6	.0	......	.4	1.2	......	.4
Dissolved solids	......	75	160	159	......	174	127	......	207
Hardness as $CaCO_3$	10	39	124	57	......	120	11	......	5
pH	......	6.6	6.9	7.7	......	7.4	7.3	7.4	8.1
Water-bearing material	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
Date of collection	12/7/43	12/25/53	7/17/53	9/?/54	10/1/43	4/13/55	1/3/55	6/25/52	4/9/54

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

	48	51	58	60	66	72	84
Silica (SiO_2)	16	11	11	9.7	......	17	12
Iron (Fe), total	.98	.06	.15	.10	.78	.20	.26
Iron (Fe), in solution	.02	.03	.04	.04	......	.10	.04
Calcium (Ca)	34	5.9	5.6	6.8	......	45	48
Magnesium (Mg)	4.2	2.5	3.9	3.5	......	9.6	.7
Sodium and potassium (Na + K)	11	43	47	39	......	11	3.9
Bicarbonate (HCO_3)	143	126	136	125	102	206	150
Sulfate (SO_4)	2.6	2.6	1.2	5.7	10	.4	1.5
Chloride (Cl)	3.5	7.0	3.2	4.8	4.0	4.2	3.2
Fluoride (F)	.0	.3	.2	.1	......	.0	.1
Nitrate (NO_3)	.1	.1	.9	.4	......	.6	.0
Dissolved solids	143	138	134	133	......	189	151
Hardness as $CaCO_3$	102	25	30	31	......	152	123
pH	7.4	8.1	7.7	7.5	7.8	7.3	7.5
Water-bearing material	Sand	Sand	Sand	Sand	Sand	Sand	Sand
Date of collection	3/3/54	3/1/56	2/21/56	1/5/50	12/3/53	8/19/52	2/1/55

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

New Hanover County

Geography and geology

New Hanover County extends southward from Pender County, forming a peninsula between the Cape Fear River and the Atlantic Ocean. Livestock products and the growing of crops represent the chief source of rural income. Wilmington, the only city, is noted as a tourist and port center.

The topography is relatively flat, the altitude exceeding 40 feet above sea level in only a small part of the county. The topography of the county is largely the result of the withdrawal of the sea from a former position about 25 to 35 feet above its present level. During that stand of the sea, at least one long bar extended northeastward, coinciding with U. S. Highway 17 in the northeastern part of the county. To the west of this bar, which now includes the drainage area of the Northeast Cape Fear River, was a broad shallow lagoon. As the sea withdrew to its present position the Cape Fear River extended its coarse seaward and the lagoon was drained. The Northeast Cape Fear River was also extended seaward but its course was diverted westward toward the Cape Fear River by the elevated bar. Both rivers now have entrenched channels and the bordering land is somewhat dissected. The land surface is almost everywhere coated with sand. The sand has a considerable thickness on some upland areas where wind has shifted it into dunes in the recent geologic past. Small shallow sinks, apparently resulting from solution of near-surface limestone beds, are common in the area around Castle Hayne.

The only well in the county to penetrate the entire Coastal Plain section is the well at Hilton Park, Wilmington, which penetrated crystalline rocks at 1,100 feet below sea level. In it only the Upper Cretaceous Black Creek and Peedee formations are present. The Tuscaloosa formation was reported by Stephenson to be missing in the well, (Clark et. others, 1912, p. 166), but it may underlie the Black Creek formation in the eastern part of the county.

Ground Water

Water for domestic use is obtained from wells 10 to 25 feet deep in the surficial sand throughout the county. Driven wells 2 inches or less in diameter are common. The water obtained from wells in the surficial sand is soft and is low in mineral content.

A large potential source of water is the Castle Hayne limestone. Although the Castle Hayne is absent in much of the area west and northwest of Wilmington, it thickens as a wedge to the east. Although few wells pump as much as 100 gallons of water a minute from the Castle Hayne, the potential supply is great. Wells capable of yielding more than 300 gpm are possible where the formation is thicker than about 80 feet. As a unit the Castle Hayne is an excellent water-bearing formation. Although the formation contains limestone and sands in varying degrees of assortment, distinct and extensive beds are not known. Movement of ground water through the formation for long periods has caused much of the limestone to be dissolved and removed, resulting in a very permeable sandy limestone. Some of the limestone is consolidated sufficiently to allow open-end type wells to be satisfactory.

Water from the Castle Hayne is moderately hard to very hard, the hardness ranging from 54 to 390 ppm. The average hardness is about 180 ppm. With the exception of iron, the other mineral constituents do not occur in objectionable amounts. The iron content of the water ranges between 0.09 and 3.3 ppm; unfortunately, it is not possible to predict the approximate iron content.

The Peedee formation, which underlies the Castle Hayne, contains water-bearing beds of sand and limestone, although only a few deep wells draw water from this formation. The contact between fresh water and the underlying salt water lies within the Peedee everywhere in the county. The upper part of the formation contains fresh water, but the base of the fresh water zone is not accurately known. At Castle Hayne, well 6 yields water from a depth of 367 feet that had a chloride content of 3,480 ppm, and it is reported (Clark and others, 1912, p. 441) that salty water occurs below 270 feet. In the deep well (20) at Wilmington, salty water was reported first at a depth of 379 feet. Near the southern extremity of the county, at Fort Caswell, Brunswick County, salty water occurs at 365 feet.

The municipal supply of Wilmington comes from the Cape Fear River. Prior to 1942 the city obtained water from Toomers Creek, about two miles west of the city treatment plant. The drought of 1940, which caused salty water from the Cape Fear River to contaminate the water supply, prompted an investigation of other possible sources of supply. D. G. Thompson, of the U. S. Geological Survey, made a preliminary study of the ground-water resources in the Wilmington area (unpublished manuscript) in 1941. Thompson pointed out the large potential supply available both from the limestone and from the surface sands.

An area under consideration by Thompson has been studied further. This is the sand hills area between the Cape Fear River and Northeast Cape Fear River, extending from about two miles northeast of Hilton Park northwestward for several miles. Rolling hills of wind-blown sand result in an absence of surface runoff. When the Carolina Power and Light plant was built in this area during 1952 about 1,100 gpm was pumped from an excavation about 30 feet deep in the sand for several weeks while the foundation area of the building was dewatered. Also, a development well (10) at the plant which tapped the dune sand was tested at 480 gallons a minute with only 5 feet of drawdown. A test hole drilled about two miles north of the Carolina Power and Light plant indicated that the coarse sand extended to a depth of 14 feet below river level; underlying this sand was 13 feet of clayey sand with shell fragments and 7 feet of limestone, all belonging to the Peedee formation.

In this sand hill area almost all precipitation seeps into the sand and discharges laterally into both rivers. Because of the great permeability of the sand the ground water discharges readily into the swamps bordering the rivers, and the water table in the interstream area is nowhere more than a few feet above river level. The amount of water in storage in the sand hill area cannot be determined because the depth to the base of the sand is not known. However, a fair estimate can be made of recharge of water to the sand, which, of course, should be the basis for ground-water development. The sparse vegetation and the ease with which water soaks into the sands suggest that about 90 percent of the precipitation becomes ground water. Recharge to the sand hills area is estimated to be about 730 million gallons a year per square mile. Additional recharge from either river can be induced if water levels at the pumping wells are drawn down below river level. If induced recharge from the river occurs, some thought needs to be given to the chemical quality of the river water. The chloride content of water from both the Cape Fear River and Northeast Cape Fear River normally is less than 20 parts per million. However, during the drought of 1940, salty water was reported in both rivers upstream from the sand hills area. If a large percentage of pumped water is induced by infiltration from the rivers, care should be taken during extreme droughts to guard against drawing salty water into the aquifer. This consideration need not deter the development of large ground-water supplies in the interstream areas.

New Hanover County

Location: Stratigraphic test hole at the town of Wrightsville Beach, North Carolina. (near well 54)
Owner: Town of Wrightsville Beach
Date drilled: 1953
Driller: Layne Atlantic Co.
Elevation of well: 5 feet above sea level

Hydrologic Information

No single well furnishes hydrologic information which could be considered as average for the area in and around Wrightsville Beach.

Log of Test Hole

Depth (feet)	
	Post-Miocene—beach gravels and marls
0.10	Beach gravel, tan; 55 percent fine to medium rounded gravel; 45 percent broken angular to rounded shell fragments. No discernable matrix.
10-23	Beach gravel, tan; Same as 0-10-foot interval.
23-35	Beach gravel, tan; 40 percent fine to medium rounded to subrounded gravel. 60 percent broken angular to subrounded shell fragments. No discernable matrix.
35-43	Marl, dark-gray; 20 percent coarse to fine-grained subrounded to subangular quartz sand. 55 percent coarse broken abraded shell fragments. 25 percent gray clay and silt matrix, unconsolidated. No Ostracoda, Foraminifera rare.
43-55	Marl, dark-gray; 30 percent fine to very fine-grained angular to subangular quartz sand. 20 percent chalky shell fragments. 50 percent gray clay and silt matrix, indurated to loosely consolidated. No Ostracoda, Foraminifera rare.
55-69	Marl, dark-gray; Same as 43-55-foot interval with slight increase in percentage of quartz sand. No Ostracoda, Foraminifera rare.
	Upper (?) Eocene—upper part of Castle Hayne limestone
69-81	Shell limestone, gray; 10 percent fine-grained angular quartz sand. 70 percent broken shell fragments, coral forms predominant. 20 percent calcareous matrix, indurated and moderately hard with partial recrystallization of the shell fragments. Ostracoda and Foraminifera rare.
81-85	Shell limestone, gray; Same as 69-81-foot interval. Ostracoda rare, Foraminifera common.
85-94	Shell limestone, gray; Same as 69-81-foot interval. Ostracoda and Foraminifera common.
94-107	Shell limestone, gray; Same as 69-81-foot interval. Ostracoda and Foraminifera common.
107-118	Shell limestone, light-gray; 15 percent medium to fine-grained subangular quartz sand. 50 percent broken recrystallized shell fragments. 35 percent calcareous matrix, indurated. Dark-green weathered glauconite prominent. Ostracoda and Foraminifera common. Ostracoda occurring in the 69-107-foot intervals include: *Cytherella* sp. B. *Cytherelloidea danvillensis* Howe var. *Trachyleberis* sps. A, B, and C. *Cytheretta alexanderi* Howe and Chambers *Upper Cretaceous*—Peedee formation

118-122 Calcareous sand and clay, dark-gray; 55 percent fine to very fine-grained angular quartz sand. 35 percent calcareous clay matrix, indurated and moderately hard. 10 percent fine broken-limestone fragments. Dark-green fine to medium-grained glauconite prominent. Ostracoda and Foraminifera rare.

122-127 Calcareous sand and clay, dark-gray; Same as 118-122-foot interval but slightly more consolidated. Ostracoda and Foraminifera very rare.

127-141 Sand, dark-gray; 85 percent fine to medium-grained angular to subangular quartz sand. 15 percent gray calcareous clay matrix, unconsolidated. Trace of dark-green fine-grained glauconite. Fine broken shell fragments prominent. Ostracoda and Foraminifera common.

141-160 Sand and clay, dark-gray; 65 percent very fine to fine-grained angular quartz sand. 35 percent gray silt and clay matrix, unconsolidated. Dark-green fine-grained glauconite and broken shell fragments common. Ostracoda and Foraminifera rare.

160-166 Calcareous sand, gray; 65 percent coarse to medium-grained subrounded to subangular quartz sand. 25 percent calcareous clay matrix. 10 percent broken shell fragments. Trace of dark-green medium-grained glauconite. Ostracoda and Foraminifera rare.

166-177 Sand and shell, gray; 45 percent coarse to medium-grained subrounded to subangular quartz sand. 40 percent coarse broken shell fragments. 15 percent calcareous clay matrix, indurated and very compact. Ostracoda and Foraminifera rare.

177-187 Calcareous sand, gray; Same as 160-166-foot interval. Ostracoda and Foraminifera common.

187-197 Calcareous sand, gray; Same as 160-166-foot interval with a slight increase in shell content. Ostracoda and Foraminifera common.

197-207 Sand, gray; 80 percent fine to very fine-grained angular quartz sand. 20 percent gray micaceous clay matrix, unconsolidated. Trace of fine-grained glauconite and phosphate. Broken shell fragments prominent. Ostracoda and Foraminifera common.

207-217 Sand, gray; Same as 197-207-foot interval. Ostracoda and Foraminifera common.

217-228 Sand, gray; Same as 197-207-foot interval. Ostracoda and Foraminifera common.

228-238 Sand, gray; Same as 197-207-foot interval. Ostracoda and Foraminifera common.

238-248 Sand, gray; Same as 197-207-foot interval. Ostracoda common, Foraminifera rare.

248-257 Sand, gray; Same as 197-207-foot interval. Ostracoda and Foraminifera common.

257-289 Sand, gray; Same as 197-207-foot interval. Ostracoda and Foraminifera rare.

289-310 Sand and clay, dark-gray; 60 percent fine to very fine-grained angular quartz sand. 40 percent gray clay matrix, unconsolidated. Dark-green glauconite prominent. Trace of black phosphate pebbles and broken shell fragments. Ostracoda and Foraminifera rare.

310-343 Sand and clay, dark-gray; Same as 289-310-foot interval. Ostracoda and Foraminifera rare.

343-351 Sand, gray; 85 percent coarse to medium-grained subrounded quartz sand. 15 percent gray clay matrix, unconsolidated. Dark-green medium-grained glauconite prominent. Trace of broken shell fragments and phosphate pebbles. Ostracoda and Foraminifera rare.

351-361 Sand, gray; Same as 343-351-foot interval with increase in glauconite. Ostracoda and Foraminifera rare.

361-371 Sand, gray; Same as 343-351-foot interval with glauconite increasing to 5 percent. Ostracoda and Foraminifera very rare.

371-380 Sand, gray; Same as 343-351-foot interval but with sand predominantly medium-grained. Ostracoda and Foraminifera very rare.

380-392 Sand, gray; Same as 371-380-foot interval. Ostracoda and Foraminifera very rare.

392-404 Sand, gray; Same as 371-380-foot interval. Ostracoda and Foraminifera very rare.

404-412 Sand and clay, dark-gray; 60 percent fine-grained angular quartz sand. 40 percent gray micaceous clay matrix, unconsolidated. Dark-green fine-grained glauconite prominent. Trace of fine broken shell fragments and phosphate pebbles. Ostracoda and Foraminifera very rare.

Ostracoda occurring in the 118-412-foot intervals include:

Cytheridea (Haplocytheridea) ulrichi (Berry)
Cytheridea (Haplocytheridea) monmouthensis Berry
Cytheridea (Haplocytheridea) councilli Brown
Eucytherura curta (Jennings)
Cytheropteron (Cytheropteron) pe[illegible]derensis Brown
Trachyleberis pidgeoni (Berry)

New Hanover County

Number 20

Location: Clarendon Waterworks Company well in Hilton Park, Wilmington, North Carolina

Owner: City of Wilmington

Date drilled: 1899

Driller: Unknown

Elevation of well: 9 feet above sea level

Hydrologic Information

Depth of well: 1,330 feet. Well abandoned because of excessive chloride content of the water.

Log of Well

Depth (feet)

Post-Cretaceous—surficial sands

0-10 Sand, dark-brown; 85 percent medium to fine-grained subangular to angular quartz sand. 15 percent brown silt and clay matrix, unconsolidated. Trace of dark-green glauconite. No Ostracoda. Foraminifera very rare.

Upper Cretaceous—Peedee formation

10-20 Sand and clay, yellow to brown; 65 percent fine to very fine-grained angular quartz sand. 35 percent yellow-brown clay and silt matrix, unconsolidated but compact. Trace of fine mica flakes and dark-green glauconite. Limonitic staining of quartz grains prominent. No microfossils.

20-30 Sand, brown; 85 percent medium-grained subangular quartz sand. 15 percent brown silt and clay matrix, unconsolidated. Small red hematite aggregates prominent. Trace of fine mica flakes and dark-green glauconite. Hematite staining on quartz grains prominent. Ostracoda very rare, Foraminifera rare.

30-40 Calcareous sand, light-gray; 75 percent medium to fine-grained angular quartz sand. 25 percent gray clacareous silt matrix, indurated. Trace of light-green glauconite and broken shell fragments. Ostracoda and Foraminifera rare.

40-50 Sand, light-gray; 85 percent medium-grained angular to subangular quartz sand. 15 percent calcareous clay matrix, unconsolidated. Trace of fine-grained glauconite phosphate and broken shell fragments. Ostracoda and Foraminifera common.

50-60 Sand, light-gray; Same as 40-50-foot interval. Ostracoda and Foraminifera common.

60-70 Calcareous sand, gray; 65 percent medium to very fine grained angular quartz sand. 35 percent partially recrystallized, calcareous clay matrix, indurated. Ostracoda and Foraminifera rare.

70-80 Sand, gray; 85 percent medium-grained subangular well-sorted quartz sand. 15 percent gray calcareous clay matrix, unconsolidated. Dark-green glauconite prominent. Trace of fine mica flakes, black phosphate grains and broken shell fragments. Ostracoda and Foraminifera common.

80-140 Sand and clay, dark-gray; 75 percent fine to very fine-grained angular quartz sand. 25 percent dark-gray micaceous clay matrix, unconsolidated but compact. Trace of dark-green glauconite black phosphate pebbles and broken shell fragments. Several thin indurated layers occur below 100 feet. Ostracoda and Foraminifera abundant.

140-200 Sand and clay, black; 60 percent very fine to fine-grained angular quartz sand. 40 percent black micaceous clay matrix, unconsolidated but very compact. Trace of dark-green glauconite and chalky shell fragments. Ostracoda and Foraminifera abundant.

200-210 Sand, light-gray; 80 percent medium to very fine-grained subangular to angular quartz sand. 20 percent gray micaceous clay matrix, unconsolidated. Trace of light-green glauconite and black phosphate pebbles. Ostracoda and Foraminifera abundant.

210-280 Sand and silt, black; 65 percent fine to very fine-grained angular quartz sand. 35 percent black micaceous silt and clay matrix, unconsolidated but very compact. Trace of light-green glauconite black phosphate pebbles and white chalky shell fragments. Ostracoda and Foraminifera common.

280-400 Sand, gray; 80 percent medium to fine-grained subrounded to angular quartz sand. 20 percent gray calcareous and micaceous clay matrix, unconsolidated to indurated in thin layers. Black lignitized wood fragments and broken shell fragments prominent. Trace of glauconite and acicular gypsum. Ostracoda and Foraminifera rare.

400-490 Sand and clay, dark-gray; 70 percent medium to fine-grained subangular to angular quartz sand. 30 percent dark-gray micaceous clay and silt matrix, unconsolidated. Shell fragments and black lignitized wood fragments prominent. Trace of light-green glauconite. Ostracoda and Foraminifera common.

490-570 Sand, gray; 85 percent fine to medium-grained angular to subangular quartz sand. 15 percent gray micaceous clay matrix, unconsolidated. Broken shell fragments prominent. Trace of black lignitized wood fragments marcasite aggregates and glauconite Ostracoda and Foraminifera rare.

570-595 Glauconite sand, "salt and pepper"; 55 percent fine to medium-grained subangular quartz sand. 25 percent dark-green fine-grained glauconite. 20 percent gray micaceous clay matrix, unconsolidated but compact. Small aggregates of fine-grained red sandstone prominent. Trace of broken shell fragments. Ostracoda very rare, no Foraminifera.

595-630 Sand and clay, dark-gray; 65 percent fine to very fine-grained angular quartz sand. 30 percent dark-gray micaceous clay and silt matrix, unconsolidated but very compact. 5 percent light-green fine-grained glauconite. Small aggregates of fine-grained red sandstone prominent. Trace of black, lignitized wood fragments and broken shell fragments. Ostracoda and Foraminifera very rare.

630-670 Glauconitic sand, "salt and pepper"; 45 percent fine-grained angular quartz sand. 25 percent dark-green fine-grained glauconite. 25 percent gray micaceous clay matrix, unconsolidated but compact. 5 percent brown phosphate spherules and shards. Small aggregates of fine-grained red sandstone prominent. Trace of broken shell fragments. Ostracoda and Foraminifera rare.

Ostracoda from the 20-360-foot intervals include:

Cytheridea (Haplocytheridea) ulrichi (Berry)
Cytheridea (Haplocytheridea) fabaformis (Berry)
Eucytherura curta (Jennings)
Cytheropteron (Eocytheropteron) straitis Brown
Brachycythere rhomboidalis (Berry)
Brachycythere raleighensis Brown
Trachyleberis communis (Israelsky)
Velarocythere scuffeltonensis Brown
Orthonotacythere hannai (Israelsky)

670-840 No sample.

Upper Cretaceous—Black Creek formation

840-900 Clay and sand, black; 30 percent very fine to fine-grained angular quartz sand. 55 percent black micaceous clay matrix, unconsolidated but very compact. 10 percent shell and shell fragments. 5 percent black lignitized wood fragments. Small aggregates of fine-grained red sandstone prominent. Trace of acicular gypsum and marcasite aggregates. Ostracoda and Foraminifera abundant.

Ostracoda from the 840-900-foot interval include:

Cytheropteron (Eocytheropteron) striatum Brown
Brachycythere nausiformis Swain
Brachycythere sphenoides (Reuss)
Brachycythere ledaforma (Israelsky)
Trachyleberis gapensis (Alexander)

900-1330 No sample.

Remarks: Samples from this well are available at 10-foot intervals. The present log reflects only the major lithologic breaks because of space limitations.

A log of this well, including fossil determinations by Dr. T. W. Stanton, was published in the North Carolina Geological and Economic Survey, vol. 3, pt. 1, p. 163-166. The Peedee-Black Creek contact was placed at 720 feet and material equivalent to the Black Creek formation, as presently classified, extended to 1,109 feet where granite was encountered.

The original samples from this well were deposited with the North Carolina State Museum. Unfortunately, in 1954, the museum moved to a new location and the samples between 670 and 840 feet and 900 and 1065 feet were temporarily misplaced or lost.

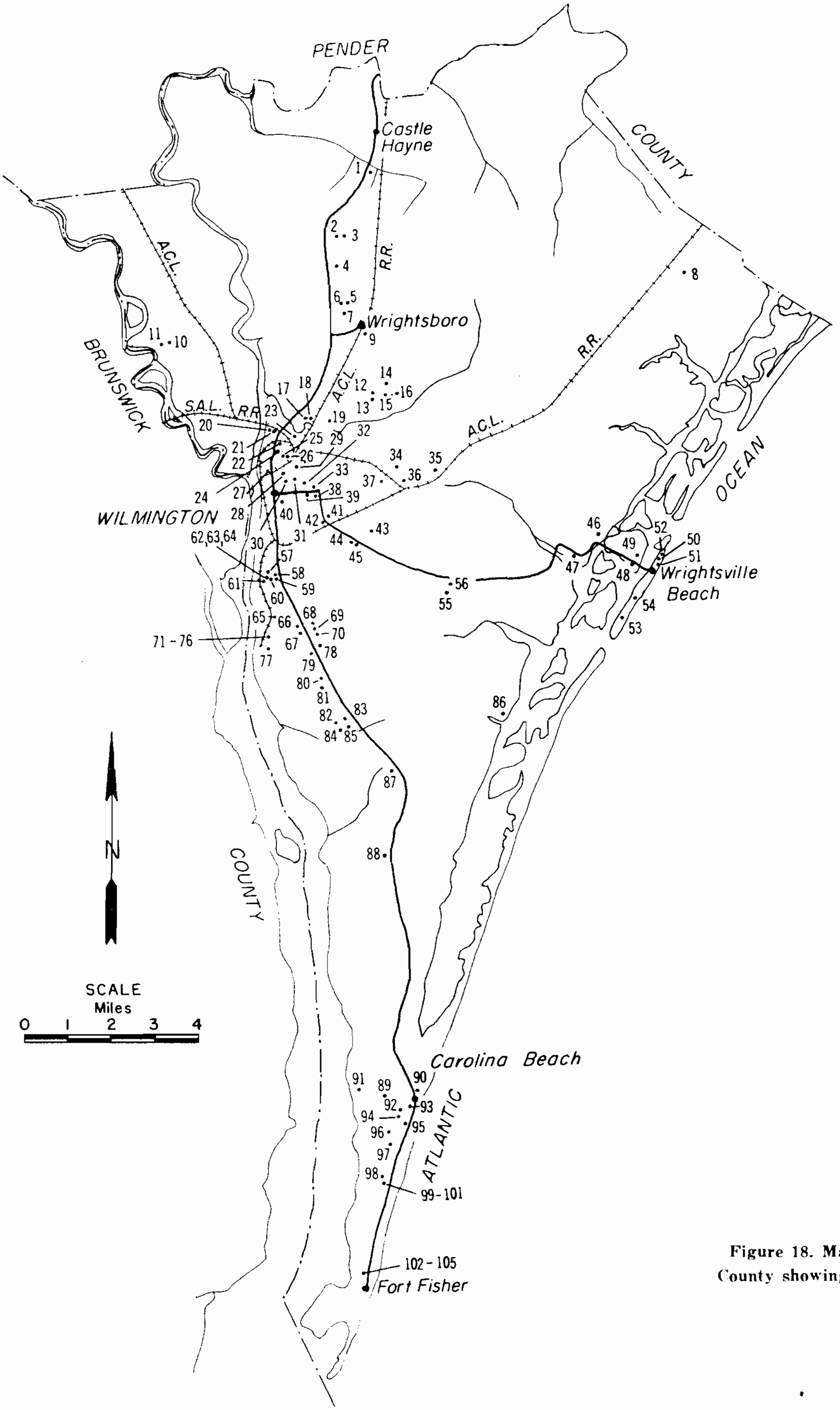


Figure 18. Map of New Hanover County showing location of wells.

Records of Wells in New Hanover County

Well	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	1 mile S of Castle Hayne	Moore's Packing Co.	Open end	45	6		Limestone	16			Analysis.
2	3 miles S of Castle Hayne	N. C. Agricultural Experiment Station	do	40	4	35	do	5	100	10	Hardness 120 ppm; iron 3.0 ppm.
3	do	do	do	40	4	35	do	5	100	10	Chloride 13 ppm.
4	4 miles S of Castle Hayne	W. B. Chadwick	do	79		76	do	15	12	5	
5	Wrightsboro	D. Swart Dairy	do	90	6	40	do				
6	do	do	do	367	8	309	Sand and limestone	1	30	20	Chloride 3,480 ppm.
7	do	Tinga Nursery	do	190	6	86	Limestone				
8	10 miles E of Wilmington on Route 17	A. Abrams	do	62			do	14	20	7	0-54 feet sand, 53-62 feet limestone.
9	Wrightsboro	G. W. Trask	do	93	8	57	do		250	10	Analysis.
10	4 miles NW of Wilmington	Carolina Power and Light Co.	Screen	53	10	33	Dune sand	9	480	5	Hardness 20 ppm; chloride 20 ppm; Chloride 20 ppm. pH 5.8.
11	do	do	Open	30			do		1100	15	Analysis. Multiple well points dewatering area 100 feet square.
12	Wilmington	Bluethenthal Air Field	Open end	105	8	65	Limestone	15	211	6	
13	do	do	do	102	8	93	do	17	300	25	
14	do	R. L. Stevens	do	117	4-2½	90	do	4	160		
15	do	Bluethenthal Air Field	do	96	8	74	do	8	343	9	
16	do	M. L. Blake	Strainer	40	1¼	35	Sand and limestone				
17	do	Corbett Package Co.	Open end	44	6	38	Limestone				
18	do	do	do	47	6	34	do				
19	do	New Hanover County Farm		72	1½		do	4			
20	do	City of Wilmington	Open end	1330							Analysis. Flows about 20 gpm. Casing leak at 385 feet.
21	do	Hilton Lumber Co.	do	80	10	80	Limestone	6	400		
22	do	G. W. Broadfoot	do	69	3		do				Interbedded sands and semi-consolidated shell layers.
[illegible]	do	Boyle Ice Co.	do	65	8		do		650		Hardness 200 ppm; chloride 86 ppm.
[illegible]	do	W. G. Broadfoot	do	77	3-2	66	do				
25	do	Independent Ice Co.	do	120	12	75	do		325	6	Hardness 250 ppm; chloride 89 ppm.
26	do	do	do	113	10		do		200		
27	do	Wilmington Cold Storage Co.	do	104	10		do	18	300		Hardness 370 ppm; chloride 154 ppm.
28	do	Hotel Cape Fear	do	85	1½		do	22	28		
29	do	Sam Bear	do	97	4		do				
30	do	McMillan and Cameron Co.	do	80	4	67	do	16	100		
31	do	City of Wilmington	do	75				37			Analysis.
32	do	Coca Cola Bottling Co.	do	147	4	147	Limestone	40	120		Hardness 170 ppm; chloride 51 ppm; iron 0.2 ppm.
33	do	Hughes Brothers	do	48	4		do				
34	do	Underwood Typewriter Co.	do	65	4		do	3			
35	do	Blue Top Tourist Co.	do	170	4		do		75		
36	do	Troy Johnson	do	105	4		do		180	10	Hardness 228 ppm; chloride 17 ppm; bicarbonate 228 ppm.
37	do	Blake Brothers	do	65	2½		do				Chloride 18 ppm.
38	do	Rose Ice Co.	do	96	6		do				Hardness 210 ppm; chloride 62 ppm.
39	do	Carolina Apartments	do	135	5		do	57	35		
40	do	J. D. Bellany, Jr.	do	101			do				
41	do	Dr. Pepper Bottling Co.	do	100	3			20			
42	do	White Ice Cream Co.			8		Limestone		150		Hardness 210 ppm; chloride 62 ppm.
43	do	F. G. Edwards	Open end	167	4	137	do		100		
44	do	Oleander Apartments	do	146	6		do	21	150		Hardness 132 ppm; chloride 9 ppm.
45	do	do	do	152	6		do	21	150		Hardness 148 ppm; chloride 28 ppm.
46	1 mile NW of Wrightsville Beach	Airlie Gardens	do	174	4		do				Flows at high tide.
47	do	do	do	176	8		do				Do.
48	Wrightsville Beach	Town of Wrightsville Beach	do	170	8	125	do		250	22	Analysis.
49	do	Coluccis	do	172	3-2	117	do				
[illegible]	do	Town of Wrightsville Beach	do	176	10	146	do		300		Analysis.
51	do	do	do	193	8-6	156	do	4	428		

Records of Wells in New Hanover County—Continued

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Drawdown (ft.)	Remarks
52	do	do	do	179	10-8	163	do	8			
53	do	do	Screen	177	12-8	164	Sand and limestone	5	150		Drawdown 90 feet.
54	do	do	Open end	160	12	125	Limestone		150		Analysis.
55	Wilmington	Ralph Gillette	do	65	2	65	do				Do.
56	do	Municipal Golf Course	do	196	4		do		25		Hardness 120 ppm; chloride 10 ppm; 7.8. pH.
57	do	The Sunset Co.	do	140	6		do		150		Chloride 32 ppm.
58	do	do	do	114	6		do		118		Pumping level about 38 feet.
59	do	do	do	122	6		do		112		
60	do	do	do	140	6		do		132		Analysis.
61	do	do	do	140	6		do		126		
62	do	do	do	143	4½		do		60		
63	do	do	do	112	8		do	22	150	18	
64	do	do	do	91	6		do		150+		
65	do	Coluccis	do	88	3-2	79	do				
66	do	Wilmington Housing Authority	Slotted pipe	175	10		do	9	150	36.6	
67	do	do	do	186	10		do	48.8	150	32.2	
68	do	National Youth Authority Center	do	187	6	185	do		280		
69	do	do	do	123	10	70	do	20	275	58	
70	do	do	do	150		65	do	26	50		
71	do	Carolina Shipyard Co.	Screen	103	10	103	Sand and limestone	28	300	48	Analysis.
72	do	do	do	105	10		do	20±	200		
73	do	do	do	135.5	10	50	do	21	230	43	
74	do	do	do	123	10	70.5	do	20	275	58	
75	do	do	do	130.5	10	130.5	do	21	300+	43	
76	do	do	do	129.3	10		do	18	346+	72	
77	do	Texas Oil Co.		120	6			38-41	100		
78	do	J. M. Bordeaux		87	3		Limestone	10±	40		Chloride 18 ppm.
79	do	Plantation Night Club	Open end	100	4	78	do	8±	50		
80	do	A. M. Blake	do	104	8	55	do				
81	do	do	do	42	8	27	do				Well flows slightly.
82	do	A. O. McEachern	do	167	2	50	do	6	30		Analysis.
83	do	do	do	150	6	50	do	6±	65		
84	do	do	do	160	2	50	do	6±	30		
85	do	do	do	160	2	40	do	4			
86	5 miles SW of Wrightsville Beach	Mr. Davis	do	125			do				Hardness 160 ppm; chloride 20 ppm.
87	1 mile SE of Wilmington	Jack Core Service Station	do	138	2		do	14			Hardness 160 ppm; chloride 16 ppm.
88	3 miles SE of Wilmington	C. F. Cline Construction Co.	do	68	6	66	do	15			
89	Carolina Beach	Town of Carolina Beach	do	201	8	90	do	10±	200		Analysis.
90	do	Cassady (Amusement Park)	do	142	3	127	do		11		Analysis.
91	do	Town of Carolina Beach	do	160	10	60	do	27	150		
92	do	do	do	200	8		do		150		Do.
93	do	Mr. Plummer	do	133	3	73	do	9	6		
94	do	Town of Carolina Beach	do	200	8	200	do	2±			Analysis.
95	do	do	do	195	8	125	do		300		Do.
96	1 mile SW of Carolina Beach	Mr. Kure	do	135	8	100	do	12	350		
97	do	L. C. Kure	do	153	8	147	do	12	450		
98	2 miles SW of Carolina Beach	Ethyl-Dow Chemical Co.	do	145	8	103	do		140		Analysis. 4 other wells of similar character.
99	do	L. C. Kure	do	186	8		do		75±		Analysis.
100	do	do	do	186	4		do	14			
101	do	do	do	196	8	120±	do	27	75±		Analysis.
102	4 miles SW of Carolina Beach	U. S. Army	do	135	6	135	do	15	239		Do.
103	do	do	do	177	8	62	do	14	275	21.5	
104	do	do	do	207	8	83	do	19.3	250	56	
105	do	do	do	177	8	81	do	19	250	22	

Chemical Analyses of Ground Water From New Hanover County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	1	9	11	20	31	48	50	52	54
Silica (SiO_2)	41	33	...	...	...	18	16	17	17
Iron (Fe), total	.92	3.3	.14	...	...	.35	1.5	.09	.14
Iron (Fe), in solution	.06	.12	...	...	...	...	...	.07	...
Calcium (Ca)	84	73	...	...	...	49	52	65	51
Magnesium (Mg)	8.5	4.2	...	...	...	14	13	15	15
Sodium and potassium (Na + K)	58	8.1	...	...		62	71	96	127
Carbonate (CO_3)	0	0	0	...	...	0	0	0	0
Bicarbonate (HCO_3)	305	240	6	383	190	216	220	243	216
Sulfate (SO_4)	2.4	2.9	4	440	18	6.6	6.7	14	24
Chloride (Cl)	84	12	3.0	7,050	475	92	106	155	186
Fluoride (F)	.1	.1	...	...	...	.4	.4	.2	.4
Nitrate (NO_3)	.7	.2	...	...	0	.6	.6	.1	.0
Dissolved solids	446	262	...	...	...	354	378	497	532
Hardness as $CaCO_3$	245	199	8	960	390	180	183	224	189
pH	7.1	7.0	5.7		...	7.6	7.5	7.3	7.6
Water-bearing material	Limestone	Limestone	Dune sand	Limestone		Limestone	Limestone	Sand and limestone	Limestone
Date of collection	5/20/52	5/21/52	...	12/20/41	12/20/41	5/8/47	5/8/47	5/12/53	5/8/47

Analyzed by the Quality of Water Branch, U. S Geological Survey.

	55	60	71	82	89	91	92	94	95
Silica (SiO_2)	...	...	...	...	20	29	21	25	33
Iron (Fe), total	...	...	0	0	.45	.46	.17	.98	.22
Iron (Fe), in solution	...	...	...	...	.18	.11	...	...	.15
Calcium (Ca)	...	...	...	...	48	46	45	43	55
Magnesium (Mg)	...	...	...	...	8	16	7.5	18	21
Sodium and potassium (Na + K)	...	...	...	...	16	23	28	26	21
Carbonate (CO_3)	0	...	...	...	0	0	0	0	0
Bicarbonate (HCO_3)	62	133	118	179	175	237	168	225	254
Sulfate (SO_4)	2	...	2	17	.7	.8	.8	1.8	1.2
Chloride (Cl)	6.0	34	25	29	30	24	46	37	42
Fluoride (F)	...	...	.4	.4	.2	.0	.2	.1	.3
Nitrate (NO_3)	...	...	0	.25	.1	1.1	.0	.0	.2
Dissolved solids	...	...	...	...	216	262	245	267	300
Hardness as $CaCO_3$	54	96	111	165	153	181	143	181	224
pH	7.4	...	...	...	7.4	7.5	7.65	7.6	7.3
Water-bearing material	Limestone	Limestone	Sand and limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone
Date of collection	6/24/53	1/15/41	12/20/41	12/20/41	5/7/52	4/22/52	11/5/47	11/5/47	4/22/52

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

	98	99	101	102
Silica (SiO_2)	...	50	47	...
Iron (Fe), total	...	.22	.22	...
Iron (Fe), in solution	...	...	...	...
Calcium (Ca)	...	62	60	...
Magnesium (Mg)	...	28	29	...
Sodium and potassium (Na + K)	...	18	41	...
Carbonate (CO_3)	...	0	0	...
Bicarbonate (HCO_3)	420	321	326	210
Sulfate (SO_4)	1	1.3	.8	1
Chloride (Cl)	48	31	63	21
Fluoride (F)	.5	.1	.1	.6
Nitrate (NO_3)	...	.2	.1	...
Dissolved solids	...	356	422	...
Hardness as $CaCO_3$	369	270	269	162
pH	...	7.4	7.3	...
Water-bearing material	Limestone	Limestone	Limestone	Limestone
Date of collection	1/8/42	12/9/47	12/9/47	1/8/42

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

Onslow County

Geology

The oldest formation penetrated by a water well in Onslow County is the Peedee. It is not known to crop out but lies within 30 feet of the surface in some valleys northwest of Richlands. Coastward the Peedee is more deeply buried, lying under a wedge of Castle Hayne limestone that thickens toward the coast. The Castle Hayne is exposed at many places along New River between Richlands and Jacksonville. Southwest Creek and White Oak River are other streams whose channels lie in the limestone in the northern part of the county. The Yorktown formation overlies the Castle Hayne, but it has been eroded away in parts of the county north of Jacksonville. Along the coast the Yorktown reaches a thickness of about 60 feet but inland it is thinner. The Yorktown is exposed in several ravines near Silverdale (Brown, P. M., personal communication) and occurs within 60 feet of the surface in several wells at Camp Lejeune. A thin layer of sand and clay—chiefly sand—of Pleistocene age conceals the older formations in the interstream areas.

Ground Water

Three main aquifers furnish water to wells in Onslow County. These are the surficial sands, the sands of the Peedee, and the Tertiary limestone unit.

The surficial sand covers the entire county to a depth generally ranging from 10 to 30 feet. As the water table almost everywhere is within 15 feet of the surface, well points penetrate enough saturated sand of the surficial deposits to yield sufficient water for domestic purposes.

Sands of the Peedee formation furnish water to drilled wells in the northwest part of Onslow County. The ability of the sands of the Peedee to yield water is shown by a city well 535 feet deep at Richlands, which yields 500 gpm at a drawdown of about 80 feet. Except for 30 feet of sand and clay at the surface, the well tapped only the Peedee formation. The water-bearing unit consists of sand, interbedded with clay and indurated calcareous beds. South and east of Richlands little water is pumped from the Peedee because the overlying Tertiary limestone aquifer furnishes adequate water. Except in the northwestern third of the county, salty water probably occurs in the lower part of the Peedee formation, and the entire formation may contain salty water in the vicinity of New River to the south of Jacksonville.

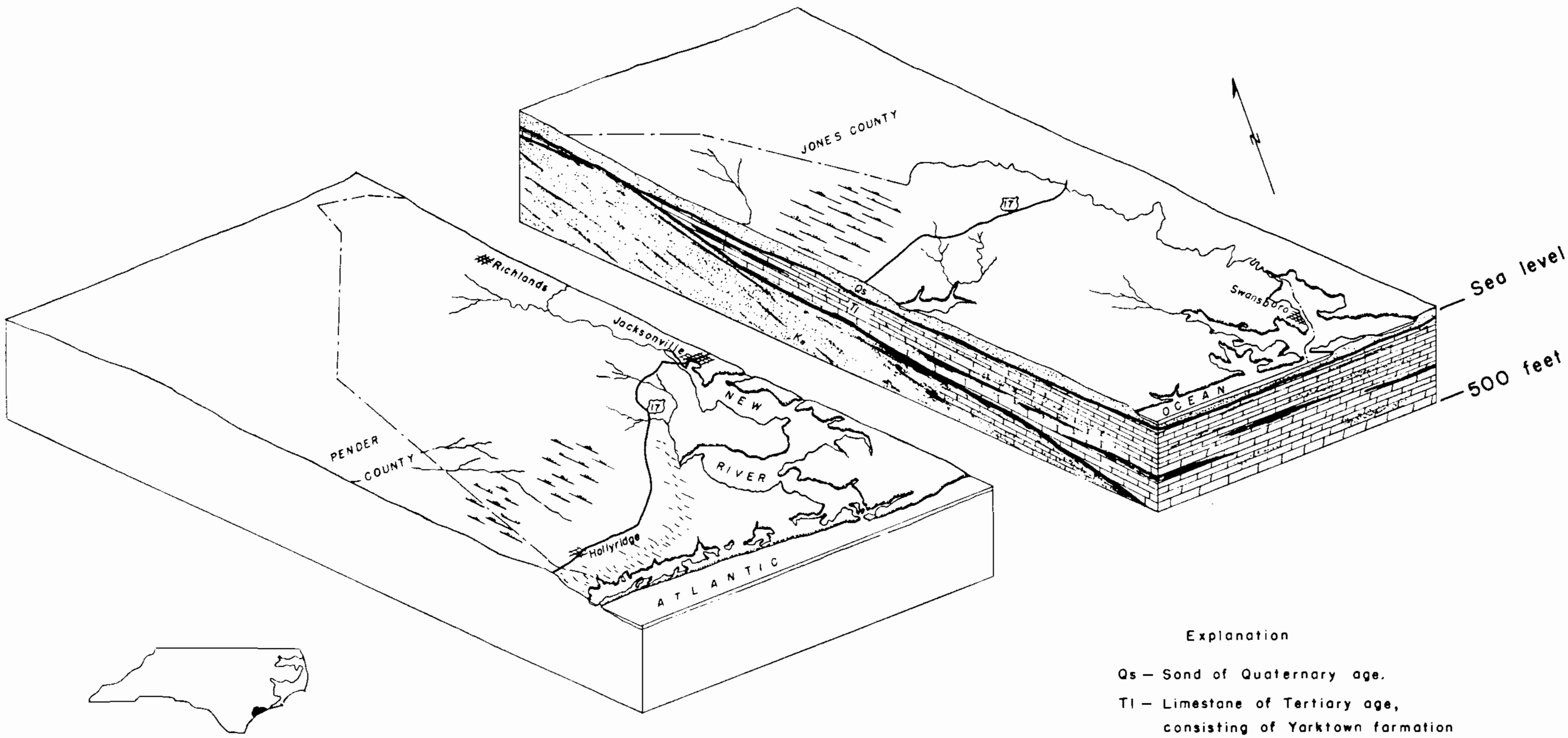
The Tertiary limestone unit, represented largely by the Castle Hayne limestone, is the aquifer which drilled wells tap south of U. S. Highway 17. The limestone thins toward the north, but it is an important aquifer as far north as Richlands. The New River is entrenched in the limestone between Richlands and Jacksonville, resulting in a large aggregate discharge of ground water from the limestone into the river. Some of the discharge is in the form of springs in the vicinity of Catherine Lake. One spring, 1½ miles south of Catherine Lake is reported to have flowed 1,500 gallons a minute (Pratt, 1908, p. 92). The limestone unit varies considerably in composition and degree of consolidation from place to place. Almost everywhere one or more indurated beds occur, and open-end wells can be used. At Camp Lejeune, however, consolidated beds are not prominent, and gravel-wall wells are used.

The permeability of the limestone differs greatly from place to place. The wells at Camp Davis (Holly Ridge) are between 100 and 180 feet deep and draw water from the limestone. The specific capacity of wells ranged from about 18 to 125 gpm per foot of drawdown. One well yielded 250 gpm at a drawdown of only 4 feet, whereas one of the poorer wells yielded 200 gpm at a drawdown of 11 feet.

At Camp Lejeune the permeability of the limestone is considerably less than at Holly Ridge. Individual gravel-walled wells drawing water from sand and semiconsolidated limestone yield as much as 250 gpm. In most of the wells the specific capacity is 5 to 10 gpm per foot of drawdown. In order to guard against salt-water encroachment the wells are pumped so that the pumping level does not get below about 20 feet below sea level.

As in adjacent counties, the surficial sand yields water that is soft and is low in dissolved mineral matter. The water generally contains enough dissolved carbon dioxide to render it corrosive. The water in sand of the Peedee is a soft, sodium bicarbonate water that is satisfactory for almost all uses. A hard, calcium bicarbonate water characterizes the Tertiary limestone aquifer. In places the water in the limestone contains objectionable amounts of iron.

The most serious problem concerning the quality of water in Onslow County is the possibility of salt-water encroachment. Figure 8 shows the approximate depth to water containing as much as 250 ppm of chloride. This map indicates that care must be taken to keep pumping levels relatively shallow in the general area surrounding Jacksonville and Camp Lejeune. There is no evidence that salt-water encroachment has occurred, and there is no cause for



Explanation

Qs — Sand of Quaternary age.

Tl — Limestone of Tertiary age, consisting of Yorktown formation and Castle Hayne limestone.

Ks — Peedee formation of Cretaceous age.

Figure 19. Block diagram of Onslow County showing geologic section cut through a line connecting Richlands and Jacksonville and extending to the ocean.

alarm, as long as the wells are dispersed and the pumping level is controlled.

Onslow County

Number 54

Location Jacksonville, North Carolina in Camp Lejeune just south of N. C. Route 24 at bridge crossing over Northeast Creek.

Owner: Rural Electrification Authority

Date drilled: 1941

Driller: C. W. Laumon Co.

Elevation of well: 22 feet above sea level

Hydrologic Information

Diameter of well: 8 inches

Depth of well: 588 feet

Cased to: 253 feet

Finish: screens

Static (nonpumping) water level: 7 feet below land surface (1941)

Yield: Unknown

Log of Well

Depth

(feet)

0-58 No sample.
Post-Miocene (?) surficial sand

58-73 Sand, white; 85 percent fine-grained angular quartz sand. 15 percent white clay matrix, unconsolidated. No microfossils.
Upper (?) Eocene—upper part of Castle Hayne limestone

73-79 Sandy, shell, limestone, white; 35 percent medium to fine-grained subrounded to subangular quartz sand. 25 percent broken partially-recrystalized shell fragments. 40 percent white calcareous matrix, well consolidated and hard. Ostracoda and Foraminifera very rare.

79-83 Calcareous sand, and clay, light-gray; 60 percent medium to fine-grained subrounded to subangular quartz sand. 35 percent calcareous clay matrix, moderately consolidated. 5 percent dark-green fine-grained glauconite. Trace of black phosphate grains. Ostracoda and Foraminifera very rare.

83-88 Sandy, shell limestone, white; 30 percent coarse to medium-grained subrounded water-polished quartz sand. 20 percent coarse broken recrystallized shell fragments. 50 percent white calcareous matrix, well consolidated and hard. Black phosphate pebbles prominent. Ostracoda and Foraminifera rare, recrystallized.
Ostracoda from the 73-88-foot intervals include:
Cytherelloides danvillensis Howe *var.*
Bairdia sp. B.
Cytherura sp. B.
Trachyleberis sp. A.
Cytheretta alexanderi Howe and Chambers

Middle Eocene—lower part of Castle Hayne limestone

88-135 Calcareous sand and clay, light-gray; 75 percent fine-grained angular quartz sand. 25 percent calcareous clay matrix, moderately consolidated. Dark-green glauconite and black phosphate prominent. Ostracoda and Foraminifera rare.

135-199 Calcareous sand and clay, light-gray; Same as 88-135-foot interval with glauconite increasing to 5 percent. Ostracoda and Foraminifera rare.

199-225 Calcareous sand and clay, light-gray; Same as 135-199-foot interval. Ostracoda and Foraminifera rare.

225-253 Calcareous sand and clay, light-gray; Same as 135-199-foot interval. Ostracoda and Foraminifera rare.

253-273 Calcareous sand and clay, light-gray; Same as 135-199-foot interval. Ostracoda and Foraminifera rare.
Ostracoda from the 88-253-foot intervals include:
Brachycythere martini Murray and Hussey
Trachyleberis rukasi (Gooch)
Pterygocythereis washingtonensis Swain
Actinocythereis hilgardi (Howe and Garrett)
Actinocythereis stenzeli (Stephenson)
Upper Cretaceous—Peedee formation

273-307 Clay and sand, dark-gray; 40 percent fine to very fine-grained angular quartz sand. 60 percent gray micaceous clay matrix, unconsolidated but compact. Trace of dark-green fiine-grained glauconite pact. Trace of dark-green fine-grained glauconite and broken shell fragments. Ostracoda and Foraminifera very rare.

307-319 Clay and sand, dark-gray; Same as 273-307-foot interval. Ostracoda and Foraminifera very rare.

319-327 Calcareous sand, dark-gray; 75-percent fine-grained angular quartz sand. 25 percent gray calcareous clay matrix, indurated and well consolidated. Dark-green fine-grained glauconite prominent. Trace of broken shell fragments. No microfossils.

327-335 Sand, dark-gray; 80 percent medium to fine-grained angular quartz sand. 15 percent gray clay matrix, unconsolidated. 5 percent dark-green glauconite. Trace of fine mica flakes and broken shell fragments. Ostracoda and Foraminifera rare.

335-367 Sand, dark-gray; Same as 327-335-foot interval. Ostracoda and Foraminifera very rare.

367-388 Sand and clay, dark-gray; 70 percent fine to very fine-grained angular quartz sand. 30 percent gray clay matrix, unconsolidated. Trace of dark-green glauconite and fine mica flakes. Ostracoda and Foraminifera rare.

388-391 Sand, gray; 90 percent medium to fine-grained angular quartz sand. 10 percent gray clay matrix, unconsolidated. Broken and abraded shell fragments prominent. Trace of dark-green glauconite and black phosphate. Ostracoda and Foraminifera common.
Ostracoda from the 273-388-foot intervals include:
Cytherelloidea swaini Brown
Cytheridea (Haplocytheridea) ulrichi Berry
Alatacythere alata atlantica (Schmidt)
Trachyleberis communis (Israelsky)
Platycythereis constatana angula (Schmidt)
Velarocythere eikonata Brown
Velarocythere cacumenata Brown

Remarks: No samples are available below a depth of 391 feet.

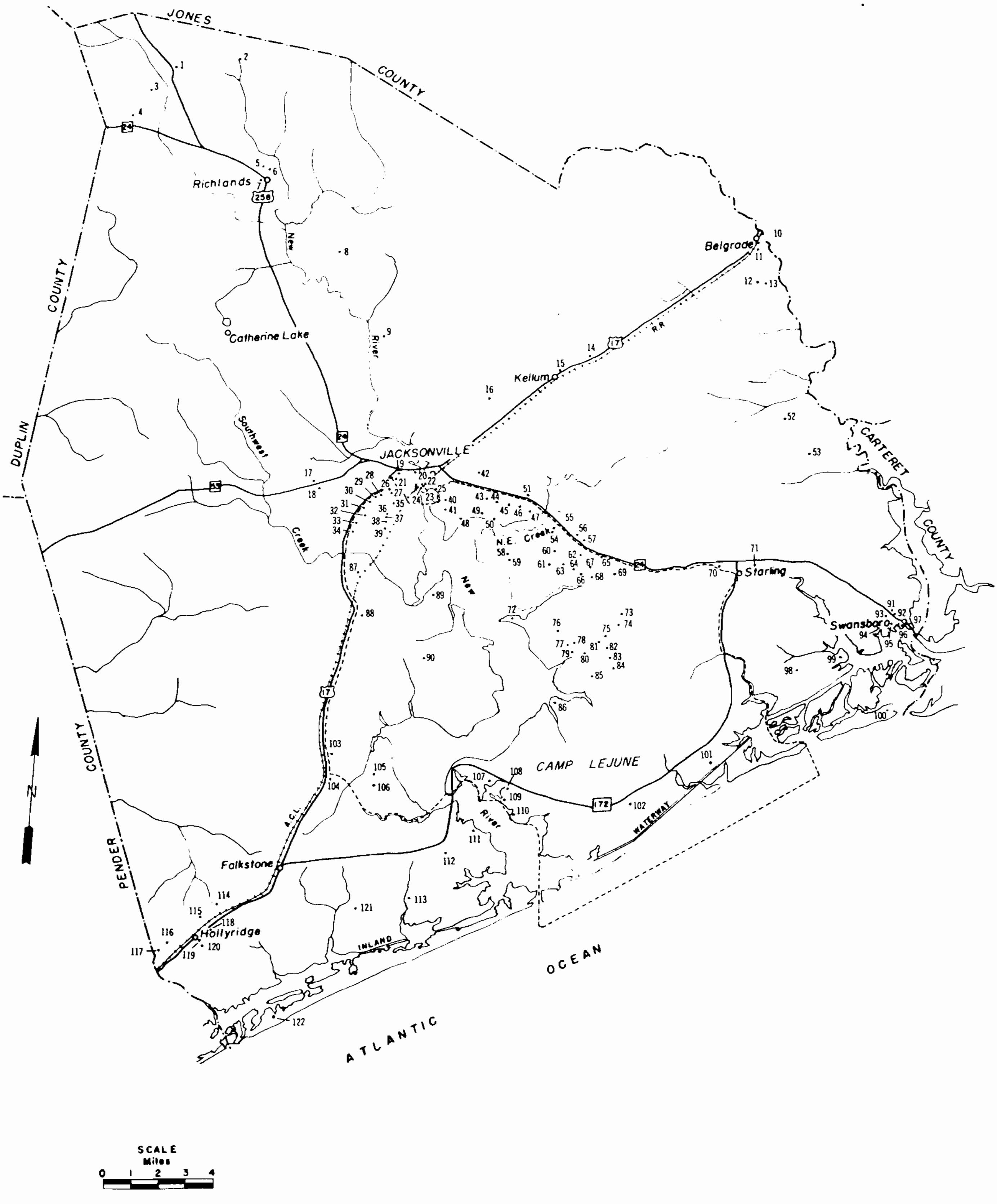


Figure 20. Map of Onslow County showing location of wells.

Records of Wells in Onslow County

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	6 miles NW of Richlands	Fountain Taylor	Open end	220	4	110	Sand	10	50		Analysis.
2	5 miles NW of Richlands	W. R. Huffman	Strainer	48	1¼	45	do				
3	6 miles NW of Richlands	J. A. Williams	Open end	70	2	70	do				
4	do	Jefferson Brinson	do	30	1¼	30	do				Analysis.
5	Richlands	Town of Richlands	Screen	550	8		do		100		Analysis.
6	do	R. D. Thompson	Open end	19	24	19	do				
7	do	Town of Richlands	Gravel walled	535	10		do	6	500	76	Analysis.
8	2 miles SE of Richlands	Ed Venters	Strainer	55	1¼	52	do				
9	5 miles N of Jacksonville	Farm Security Administration	Open end	77	4	54	do				
10	Belgrade	Superior Stone Co.	do	50	4	10	Limestone				
11	do	do	do	41	4	40	do		50	1	
12	do	Roy Dickerson	do	50	1¼	49	do				
13	do	do	do	60	1¼	55	do	11	20		
14	6 miles SW of Belgrade	New Motel	Screen	121	6		Sand				Well screened at 40 feet.
15	7 miles SW of Belgrade	B. W. Morton	Open end	95	1¼	95	do				
16	4 miles NE of Jacksonville	Farm Security Administration	do	36	3	28	Limestone				
17	3 miles W of Jacksonville	George Walton	do	309	2	309	do	4			
18	do	do	do	198	3	100	do	13			
19	Jacksonville	Bob Young	do	142	1¼	113	do		65		
20	Jacksonville	A. A. Murdock	Open end	134	6	132	Limestone	+8.7	140		Temperature 63°F. Water level and yield data obtained 8/7/41.
21	do	State Prison Camp	do	138	6	138	do		40		Analysis.
22	do	Town of Jacksonville	do	200	4	198	do	+3			
23	do	do	do	198	6	180	do	+3			Flowed 120 gpm in 1941.
24	do	do	do	185	8	152	do	0	300	7	Analysis.
25	do	Jacksonville Lumber Co.	do	165	3	30	do	+5			Water flowed 5 feet above land surface or 11 feet above sea surface in 1941.
26	do	U. S. Marine Corps	do	182	10	107	do		540	13	Water level 14.4 feet above sea level on 5/23/46.
27	do	do	do	66	18	24	do	6	65	24	
28	do	do	Gravel walled	67	8	46	Sand and shells	9	55	35	
29	1 mile SW of Jacksonville	do	Open end	76	18	17	Limestone	4	150	46	Coquina between 16 and 76 feet.
30	do	do	Screen	110	18	110	Sand and shells	3	250	45	Shell rock and sand between 43 and 104 feet.
31	do	do	Open end	138	18	73	Limestone	6	250	57	
32	2 miles SW of Jacksonville	U. S. Marine Corps	Screen	100	8		Limeston and sand	4	245	55	Serene settings 50-60 and 80-100 feet.
33	do	do	do	136	8		do		150	37	Screen settings 86-96 and 116-136 feet. Water level 24.83 feet above sea level on 5/24/46.
34	do	do	do	84	8		Limestone	4	60	33	Screen setting 64-84 feet.
35	do	do	Open end	70	18	23	do	5	75	35	
36	do	do	do	184	10	110	do	3	400	26	Analysis.
37	do	do	Screen	70	8		do	4	130	24	Screen and gravel wall between 50 and 70 feet.
38	do	do	Open end	76	18	27	do	4	188	43	
39	do	do	Screen	76	8		do	4	100	27	Screen settings 46-56 and 66-76 feet.
40	1 mile SE of Jacksonville	do	Open end	227	8	164	do	9	150	15	
41	do	do	Screen	64	8		Sand and Shells		50	32	Screen setting 59-64 feet. Water level 16.0 feet above sea level on 5/23/46.
42	1 mile E of Jacksonville	Tarawa Terrace Development		101	8		Limestone	15	90	35	
43	2 miles E of Jacksonville	do	Gravel walled	162	8		Limestone and Sand	14	150	45	
44	do	do		186			do	13	125	45	Analysis.
45	do	do	Gravel walled	167	8		do	8	257	70	
46	3 miles E of Jacksonville	do	do	95	8		do	8	156	70	Analysis.
47	3 miles SE of Jacksonville	do	do	190	8	91	do	20	211	69	Drilled to 190 feet, filled with gravel to 105 feet.
48	2 mile SE of Jacksonville	U. S. Marine Corps	Screen	100	8		do	21	150	24	Screen settings 35-40, 50-55, 65-70, 80-85, and 95-100 feet.
49	do	do	do	90	8		do	15	150	26	Screen settings 50-60, 70-75, and 85-90 feet.
50	do	do	Open end	75	10	52	Limestone	21	108	9	
51	3 miles E of Jacksonville	Dairy Queen Ice Cream Co.	do	80	2	60	do	11	34		
52	6 miles S of Belgrade	Carl Asken	do	66	1¼	62	do	12	17		

Well no.	Location	Owner	Type of well	Depth (ft.)	Diam-eter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
53	7 miles S of Belgrade	Charlie Corton	do	70	1¼	60	do	12			
54	4 miles SE of Jacksonville	Rural Electrification Assoc.	Open end	588	6		Limestone and Sand	7			Analysis. Well abandoned.
55	do	do	Gravel walled	88	8		do				
56	5 miles SE of Jacksonville	U. S. Marine Corps	Screen	125	8		do	6	300	25	Screen settings 25-40, 60-70, 75-95, and 115-125 feet.
57	do	do	do	145	8		do	23	300	26	Screen settings 49-59, 69-99, 120-130, and 140-145 feet.
58	do	do	Open end	265	8		Limestone	+1	420	19	Chloride 126 ppm.
59	do	do		100	8		do		250		
60	do	do		160	8		do		250		Analysis. Drawdown below sea level 1.3 feet reported.
61	do	do		167	8		do		250		Drawdown below sea level 13.3 feet reported.
62	do	do		170	8		do		250		Drawdown below sea level 10.7 feet reported.
63	5 miles SE of Jacksonville	U. S. Marine Corps		190	8		Limestone		200		Drawdown below sea level 14.0 feet reported.
64	do	do		150	8		do		250		Drawdown below sea level 14.1 feet reported.
65	6 miles SE of Jacksonville	do		77	8		do		250		Drawdown below sea level 4.0 feet reported.
66	do	do		187	8		do		250		Drawdown below sea level 25 feet reported.
67	do	do		190	8		do		200		Drawdown below sea level 12.5 feet reported.
68	do	do		163	8		do		200		Drawdown below sea level 19.8 feet reported.
69	do	do		54	8		do		200		
70	6 miles NW of Swansboro	Paul Wynn	Open end	125	1¼		do	15			
71	do	S. A. Starling	do	44	1¼		do				
72	6 miles SE of Jacksonville	U. S. Marine Corps		102	8		do		100		Drawdown below sea level 50.8 feet reported.
73	do	do		190	8		do		250		Drawdown below sea level 11.7 feet reported.
74	do	do		195	8		do		150		Drawdown below sea level 51.0 feet reported.
75	6 miles SE of Jacksonville	U. S. Marine Corps		520	8						Test well only. Abandoned. Chloride reported 4900 ppm.
76	do	do	Open end	325	8	275	Limestone	15	100	34	Test well only. Abandoned. Chloride reported 580 ppm.
77	7 miles SE of Jackosnville	do		195	8		do		250		Analysis. Drawdown below sea level 33.0 feet reported.
78	do	do		195	8		do		250		Drawdown below sea level 16.6 feet reported.
79	do	do		160	8		do		250		Drawdown below sea level 17.0 feet reported.
80	do	do		190	8		do		200		Drawdown below sea level 27.0 feet reported.
81	8 miles SE of Jacksonville	do		160	8		do		150		Drawdown below sea level 22.0 feet reported.
82	do	do		200	8		do		250		Drawdown below sea level 31.0 feet reported.
83	8 miles SE of Jacksonville	U. S. Marine Corps		210	8		Limestone		200		Drawdown below sea level 22.0 feet reported.
84	do	do		150	8		do		200		Drawdown below sea level 17.0 feet reported.
85	do	do	Open end	567	8	275	do	20	50	125	
86	10 miles SE of Jacksonville	Sydney Weil	do	260	1¼	140	do				
87	3 miles S of Jacksonville	U. S. Marine Corps	do	75	2	50	do				Slight overflow.
88	5 miles S of Jacksonville	Atlantic Service Station	do	50	1¼		do	20			
89	do	Henry Grove	do	185	2½						Analysis. Slight overflow.
90	6 miles S of Jacksonville	Lewis Creek School	Drive point	13	1¼	13	Sand	3			
91	Swansboro	Swansboro High School	Open end	125	3	112	Limestone	16			
92	do	M. E. Jones	do	136	2	88	do				Hardness 210 ppm.
93	do	Town of Swansboro	do	189	8	90	do	17	250		Analysis. Pumps set at 60 feet.
94	do	Hammock Beach Corp.	do	174	6	148	do	25	100		
95	do	C. B. Manas	do	100	2	95	do	18	17		
96	do	James Parkins	do	85	3	80	do				Water level 1.9 feet above land surface 8/22/41.
97	do	S. F. Milstead	do	140	3	85	Limestone and Sand	0			Analysis.
98	3 miles W of Swansboro	W. N. Henderson	Open end	90	1¼		Limestone				

Records of Wells in Onslow County—Continued

Well No.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
99	do	do	do	127	1¼	115	do	30			Large cavities in rock between 85 and 127 feet.
100	3 miles S of Swansboro	Dr. G. Spalding	do	175	3	100	do	2			Water reported to be salty.
101	8 miles SW of Swansboro	A. P. & G. Dredging Co.	do	528	3	500					Overflowed 3 gpm. Struck salt water at 350 feet. Water below 500 feet reported not salty.
102	10 miles SW of Swansboro	U. S. Marine Corps	do	40	18	30	Limestone	9	50	11	Chloride 22 ppm. Hardness 220 ppm.
103	4 miles N of Folkstone	L. F. Dixon	do	170	3	94	do	35			Analysis.
104	do	Dixon School	do	528	3	135		35			Analysis.
105	do	U. S. Marine Corps	Screen	130	8		Limestone and Sand	31	150	32	Screen settings 75-80, 90-95, 105-115, and 125-130 feet.
106	do	do	do	452	8		do	35	200	50	Screen settings 382-392, 412-422, and 442-452 feet.
107	6 miles E of Folkstone	U. S. Marine Corps	Screen	116	8		Limestone and Sand	8	450	39	Screen settings 46-61, and 101-116 feet. Chloride 50 ppm.
108	do	do	do	62	8		do	10	460	45	Screen setting 32-62 feet.
109	do	do	do	60	8		do	6	150	30	Screen setting 30-60 feet.
110	do	T. G. Samworth	Open end	375	3	350	Limestone				Analysis. Water at 250 feet reported to be salty. Water at 350 feet fresh.
111	do	James Fulchers	do	85	1¼	85		2			Good yield from pitcher pump.
112	do	H. U. Justis	do	55	1¼	50	Limestone	17			
113	4 miles E of Folkstone	Harry Grant	do	50	1¼	50	do				Slight overflow.
114	Holly Ridge	Camp Davis (U. S. Army)	do	175	8	136	do	27	220	20	
115	do	do	do	175	8		do	30	220	6	Chloride 16 ppm.
116	do	do	do	175	8	116	do	34	220	2	
117	do	do	do	177	8	112	do	35	220	2.5	Analysis. A total of 14 wells were used at Camp Davis during World War II. The wells averaged 67 gpm per foot drawdown.
118	Holly Ridge	C. C. Hines	Open end	213	1¼	132	Limestone	32			
119	do	Mike Medinas	do	177	2½	177	do	38	330	9	Analysis.
120	do	Town of Holly Ridge	do	180	8	138	do	38			
121	4 miles E of Holly Ridge	L. D. Harvard	do	53	1¼		do	16			
122	4 miles SE of Holly Ridge	U. S. Army	Screen	320	8		Sand				Analysis. Water level 3.94 feet above surface 5/19/48 Overflows 4 gpm. Temperautre 68°F.

Chemical Analyses of Ground Water From Onslow County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	1	4	5	7	21	24	36	44	46
Silica (SiO_2)			10	11	45	35	42	11	16
Iron (Fe), total			.08	.12	.10	.08	.23	.63	1.1
Iron (Fe), in solution				.04	.03	.04		.04	.05
Calcium (Ca)			4.6	2.0	9.9	53	17	29	64
Magnesium (Mg)			2.9	1.1	5.3	16	8.1	2.1	2.0
Sodium and Potassium (Na + K)			97	126	380	104	476	4.3	4.1
Bicarbonate (HCO_3)	227	101	254	304	504	460	524	90	200
Sulfate (SO_4)	1	6	1.4	1.0	17	3.3	126	2.1	3.1
Chloride (Cl)		24	4.5	5.5	310	30	370	8.2	6.2
Fluoride (F)			.3	.6	1.3	.9	2.4	.0	.3
Nitrate (NO_3)			.1	.4	.5	.2	.5	3.5	.1
Dissolved solids				317	1,020	475	1,300	107	194
Hardness as $CaCO_3$	164	100	23	10	46	198	76	81	168
pH	7.5	6.6	8.1	8.4	7.8	7.2		6.5	7.1
Water-bearing material	Sand	Sand	Sand	Sand	Limestone	Limestone	Limestone	Sand and Limestone	Sand and Limestone
Date of collection	7/2/53	7/1/53	1/2/48	4/12/51	1/4/50	8/18/49	10/22/41	4/30/52	4/30/52

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

Chemical Analyses of Ground Water From Onslow County—Continued

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	54	60	77	89	93	97	103	104	110
Silica (SiO_2)	18	19	17	....	25	....	....	....	....
Iron (Fe) total	....	2.5	1.0	....	1.9	....	3.9	3.7	.20
Iron (Fe) in solution	....	.01	.01	....	.01	....	....	....	....
Calcium (Ca)	10	69	73	....	69	....	....	....	....
Magnesium (Mg)	28	2.2	2.5	....	2.0	....	....	....	....
Sodium and Potassium (Na + K)	2,120	6.7	10	....	11	....	....	....	....
Bicarbonate (HCO_3)	440	222	234	372	226	231	271	262	482
Sulfate (SO_4)	786	3.6	7.8	45	2.1	1	0	0	50
Chloride (Cl)	2,450	7.3	8.9	518	15	20	11	11	74
Fluoride (F)	....	.2	.1	1.0	.2	.5	0	0	1.4
Nitrate (NO_3)	....	.0	.0	.0	.1	0	....	....	....
Dissolved solids	....	220	236	....	237	....	....	....	....
Hardness as $CaCO_3$	....	182	193	204	182	192	201	198	34
pH	8.2	7.2	7.3	....	7.2	....	7.1	7.2	8.1
Water-bearing material	Sand and Limestone	Limestone	Limestone	....	Limestone	Sand and Limestone	Limestone	Limestone	Limestone
Date of collection	....	2/23/56	2/23/56	9/3/41	2/22/56	9/3/41	4/3/41	4/3/41	4/3/41

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

	117	119	122
Silica (SiO_2)	210	46	....
Iron (Fe), total	.3	7.2	.41
Iron (Fe), in solution	....	....	....
Calcium (Ca)	....	85	....
Magnesium (Mg)	....	6.7	....
Sodium and Potassium (Na + K)	....	30	....
Bicarbonate (HCO_3)	....	282	314
Sulfate (SO_4)	....	4.9	1
Chloride (Cl)	14	47	35
Fluoride (F)	....	.8	.3
Nitrate (NO_3)	....	.0	.1
Dissolved solids	....	390	....
Hardness as $CaCO_3$	....	240	192
pH	7.3	....	....
Water-bearing material	Limestone	Limestone	....
Date of collection	....	10/24/41	5/19/48

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

Pender County

Geology

The oldest outcropping formation in Pender County is the Peedee. It is exposed in several road cuts and ravines in the area lying west of a line extending north and south through the town of Burgaw. The Peedee formation contains alternate beds of gray to black clay and glauconitic sands. Calcareous material has indurated some beds locally. The uppermost beds of the Peedee dip eastward 10 to 15 feet per mile and are buried progressively deeper beneath Tertiary sediments toward the east. Little is known about the thickness of the Peedee formation, although it is probably less than 100 feet thick in the western part of the county and probably more than 600 feet thick in the extreme southeastern corner. It is underlain by the Black Creek formation, which it resembles in lithology.

Overlying the Peedee in the eastern half of the county is the Castle Hayne limestone which is a white to gray limestone that differs greatly in degree of consolidation from place to place. Large nodules of phosphate are common in the lower part of the formation. Shallow excavations at Rocky Point and Maple Hill have exposed soft creamy limestone, which, in past years, was used as a soil amendment. he Castle Hayne varies in thickness locally; at Rocky Point it is from 10 to 40 feet thick and at Maple Hill it is from 40 to 100 feet thick. Toward the coast it thickens progressively, although it is only 70 feet thick at Topsail Beach.

The Yorktown formation overlies the Peedee formation in the central and western parts of Pender County, but unlike other formations, it does not thicken as a wedge toward the east. In fact, it is absent at Castle Hayne, Rocky Point, Maple Hill, and New Topsail Beach. Although the Yorktown formation is exposed along many slopes in the western part of the county, its true character is not easy to define. It is composed of yellow to gray bedded clays and thin bands of fine sand, being similar to weathered parts of the Peedee formation. Richards (1950, p. 29) has described a marl pit in the Duplin (Yorktown) formation of this report) about 1 mile south of Watha.

A thin veneer of Pleistocene deposits covers the older formations in most places. These deposits are composed chiefly of loose sand; however, some thin underlying clay beds are common. Dunes of sand are conspicuous along the coast and along the Atlantic Coast Line Railroad southeast of Currie.

Ground Water

Three aquifers yield water to wells in Pender County. These are the surficial sands, the Peedee formation, and the Castle Hayne limestone.

The water table almost everywhere is within 15 feet of the land surface. It represents the top of the zone of saturation in the surficial sands. Consequently, well points, drawing water from the surficial sands, are the chief source of rural domestic water supply.

Sands of the Peedee formation furnish water to most of the drilled wells west of the Northeast Cape Fear River. A municipal well at Burgaw, drawing water from the Peedee, has been tested at 300 gpm with only a 15-foot drawdown. The specific capacity of the wells that tap several sands of the Peedee should range between 5 and 20 gpm per foot of drawdown. Most of the rural wells penetrating the Peedee range in depth from 50 to 200 feet. These wells, generally less than 3 inches in diameter, are cased to a bed of hard rock and are open holes to an underlying bed of sand which furnishes water to the wells. Between the Cape Fear and Black Rivers most of the Peedee formation contains brackish water; only the uppermost sand beds contain water of potable quality. Also, it is likely that the lower part of the Peedee contains brackish water in the southern and eastern parts of the county, but the position of the fresh-and salt-water contact in the formation has not been determined.

The limestone unit, which is composed chiefly of the Castle Hayne limestone, but includes also the Yorktown formation in some places, is a potentially important aquifer in the northeastern and southeastern parts of the county. The aquifer, although referred to as the limestone unit, is composed largely of sand and shell fragments, showing various degrees of consolidation. It generally underlies less than 25 feet of permeable sand, which mantles the land surface. Because of the sparse population, very little water is withdrawn from the limestone unit. The high permeability and excellent recharge facilities indicate that large perennial supplies are available in the eastern part of the county.

Pender County

Number 70

Location: New Topsail Inlet
Owner: U. S. Army
Date drilled: 1942
Driller: Heater Well Co.
Elevation of well: 7 feet above sea level

Hydrologic Information

Diameter of well: 6 inches
Depth of well: 235 feet
Cased to: 168 feet
Finish: open end
Static (nonpumping) water level: Unknown
Yield: Unknown

Log of Well

Depth
(feet)

Post-Miocene—surficial beach deposits

1-7 Sand and shell, white; 50 percent fine-grained subangular quartz sand. 35 percent tan rounded shell fragments. 15 percent tan clay matrix, unconsolidated. No microfossils.

7-15 Sand and shell, tan; 35 percent fine to medium-grained subangular quartz sand. 55 percent tan rounded shell fragments. 10 percent tan clay matrix, unconsolidated. No microfossils.

15-30 Sand and eshell, tan; Same as 7-15-foot interval. No microfossils.

30-47 Sand and shell, tan; Same as 7-15-foot interval with 20 percent decrease in shell content and increase in sand content. No Ostracoda, Foraminifera very rare.

Upper (?) Eocene—upper part of Castle Hayne limestone

47-70 Calcareous sand, cream; 45 percent fine to medium-grained subrounded quartz sand. 40 percent coarse broken shell and limestone fragments. 15 percent calcareous clay matrix, unconsolidated. Trace of dark-green glauconite. Ostracoda and Foraminifera common.

70-73 Calcerous sand, cream; 65 percent fine-grained subangular quartz sand. 15 percent fine broken shell and limestone fragments. 20 percent calcareous clay matrix, indurated. Ostracoda and Foraminifera common.

73-76 Sandy dolomite, gray; 15 percent fine to medium-grained subangular quartz sand. 85 percent dolomitic partially recrystallized shell fragments and dolomite matrix, very hard and well consolidated but porous. Ostracoda and Foraminifera very rare, recrystallized.

76-80 Sandy dolomite, gray; Same as 73-76-foot interval. Ostracoda and Foraminifera very rare, recrystallized.

80-90 Sandy limestone, white; 25 percent fine to medium-grained subangular quartz sand. 50 percent broken shell and limestone fragments. 20 percent calcareous clay matrix, well consolidated but very porous. 5 percent black fine-grained phosphate. Ostracoda and Foraminifera common, recrystallized.

90-100 Sandy limestone, white; Same as 80-90-foot interval. Ostracoda and Foraminifera common, recrystallized.

104-112 Sandy limestone, white; 35 percent fine-grained angular water-polished quartz sand. 45 percent broken shell and limestone fragments. 15 percent calcareous clay matrix, indurated and moderately consolidated. 5 percent black fine-grained phosphate. Trace of dark-green fine-grained glauconite. Ostracoda and Foraminifera common, recrystallized.

Ostracoda from the 47-104-foot intervals include:
Cytherelloidea sp. *A.*
Cytheridea (*Clithrocytheridea*) *caldwellensis* Howe and Chambers
Brachycythere watervalleyensis Howe and Chambers
Trachyleberis sps. *A.* and *B.*
Trachyleberis montgomeryensis (Howe and Chambers)
Leguminocythereis scarabaeus Howe and Law

Lower Eocene—unnamed unit

116-125 Glauconitic sand, "salt and pepper"; 70 percent fine-grained angular quartz sand. 20 percent dark-green fine-grained glauconite. 5 percent green calcareous clay matrix, unconsolidated. Ostracoda and Foraminifera common.

125-128 Calcareous sand, light-gray; 50 percent medium to fine-grained subrounded to angular quartz sand. 25 percent broken abraded shell and limestone fragments. 20 percent calcareous clay matrix, hard and well consolidated. 5 percent dark-green medium-grained glauconite. Trace of black phosphate grains. Ostracoda and Foraminifera common.

128-142 Calcareous sand, light-gray; Same as 125-128-foot interval. Ostracoda and Foraminifera common.

142-154 Sandy limestone, cream; 25 percent fine to medium-grained subangular quartz sand. 30 percent partially-recrystallized shell and limestone fragments. 40 percent calcareous matrix, hard and well consolidated but very porous. 5 percent dark-green medium-grained glauconite. Ostracoda and Foraminifers rare.

154-162 Sandy limestone, cream; Same as 142-154-foot interval with a slight increase in percentage of quartz sand. Ostracoda and Foraminifera rare, recrystallized.

162-182 Sandy limestone, cream; Same as 154-162-foot interval. Ostracoda and Foraminifera rare, recrystallized.

182-192 Calcareous sand, gray; 55 percent fine-grained angular to subangular quartz sand. 15 percent broken shell and limestone fragments. 20 percent gray calcareous clay matrix, unconsolidated. 10 percent dark-green fine-grained glauconite. Trace of black phosphate grains. Ostracoda and Foraminifera common.

192-220 Calcareous sand, gray; Same as 182-192-foot interval but indurated. Ostracoda and Foraminifera rare, recrystallized.

220-235 Calcareous sand, gray; Same as 192-220-foot interval. Ostracoda and Foraminifera rare.

Ostracoda from the 116-220-foot interval include:
Cytheridea (*Clithrocytheridea*) *virginica* (Schmidt)
Brachycythere marylandica (Ulrich)
Trachyleberis bassleri (Ulrich)
Trachyleberis communis aquia (Schmidt)
Eucythere triordinis Schmidt

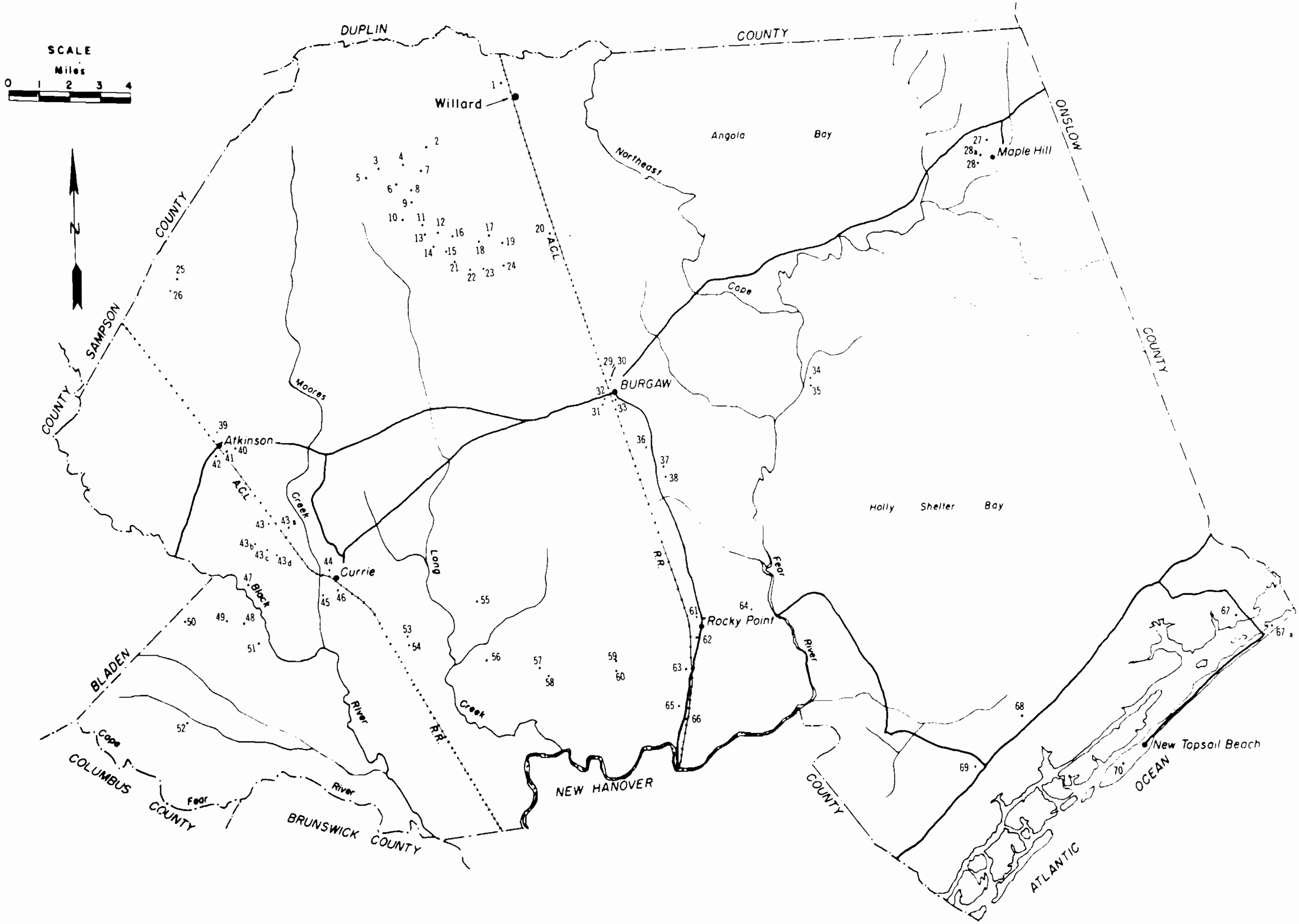


Figure 21. Map of Pender County showing location of wells.

Records of Wells in Pender County

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
1	1 miles N of Willard	Coastal Plains Experimental Station	Screen	109			Sand		60		
2	3 miles W of Willard	Pender Lea Farms	Open end	126	3	100	do	11	12		
3	5 miles SW of Willard	do	do			55	do	6	6		
4	4 miles SW of Willard	do	do	142	3-2	130	do	15	7		
5	5 miles SW of Willard	do	do	76		67	do	6			
6	4 miles S of Willard	do	do	84	3	72	do		6		
7	3 miles SW of Willard	do	do	105	3	93	do		12		
8	4 miles SW of Willard	do	do	116		102	do	11			
9	do	do	do	105	3	84	do		20		
10	5 miles SW of Willard	do	Screen	40	3	31	do				
11	do	do	Open end	152		135	do	17			
12	4 miles SW of Willard	do	do	115	3	105	do	14	9		
13	5 miles SW of Willard	do	do	201	3	174	do	15	12		
14	do	do	do	128	3	105	do	14	15		
15	do	do	do	35		32	do				
16	4 miles SW of Willard	do	do			105	do		5		
17	do	do	do	112		100	do		10		
18	do	do	do	179	3-2	154	do		9		
19	do	do	do	140	3	111	do	10	18		
20	4 miles S of Willard	do	do	149	3	126	do	12			
21	5 miles SW of Willard	do	do	132	3	112	do	14	22		
22	do	do	do		3	111	do	14	12		
23	do	do	do			125	do	14	15		
24	do	do	Screen	135	3	80	do		15		
25	5 miles N of Atkinson	Gabe Harrison	Gravel pack	310	24		do		600	40	
26	do	do	Open end	125		93	do	29			Analysis. Temperature 65°F.
27	Maple Hill	Maple Hill School	do	50	1¼	50	Limestone	9	6		
28	do	A. J. Wooten	Screen	113	4	109	Sand	14	6		
28a	do	do	do	130	4	126	do				Castle Hayne limestone to 97 feet, glauconitic sand of Peedee formation below.
29	Burgaw	Town of Burgaw	do	264	18-8	242	do	9	75		Not used.
30	do	do	Gravel pack	220	24	220	do	20	150	15	Analysis.
31	do	do	do	250	8		do		400		
32	do	Wallace Ice Plant	Screen	88	6	73	do		35		
33	do	Burgaw School	do	50	1¼	50	do	12			
34	6 miles E of Burgaw	N. C. Division of Game and Inland Fisheries	do	300	6	287	do	30	2	165	Water reported to be brackish.
35	do	do	do	70	4		do		12		
36	2 miles SE of Burgaw	E. and B. Oil Co.	do	140	4	138	do		10		
37	3 miles SE of Burgaw	Mr. Sheoloh	Open end	134		115	do		12		
38	do	J. T. Leimone	Screen	235	4	231	do	15	9		Analysis. Temperature 63°F.
39	Atkinson	Atkinson High School	Open end	120	3½-2	60	do	22	6		
40	do	Baptist Church	do	103	3	101	do	25			
41	do	Mrs. Maggie Haws	do	180	3	146	do	25			Analysis.
42	do	Dr. Shaw	do	140	3	127	do				
43	3 miles NW of Currie	Colored Church	do	140	3	135	do	3.5			Analysis. Temperature 64°F.
43a	do	C. D. Simpson		168	2		do	18			Analysis. Temperature 66°F.
43b	do	Joe Simpson	Open end	120	3	120	do	30			
43c	do	E. K. Ward	do	120	2	80	do	15			
43d	2 miles NW of Currie	D. H. McDuffie	do	150	2	120	do	20			
44	Currie	Lacy Bell	do	165	4½-2	146	do		3		
45	do	Moores Creek National Military Park	do	150	2		do	16			Flows 12 gpm.
46	do	do	do	146	2		do				Chloride 27 ppm.; hardness 3 ppm.
47	3 miles W of Currie	Red Star Fishing Camp	do	122	3-2	76	do	+8			Analysis. Flows 3 gpm.
48	4 miles SW of Currie	Ray Hilburn	do	82	2	42	do	+5			Analysis. Temperature 64°F. Flows 10 gpm.
49	do	do	do	60	2	20	do	+2			Analysis. Temperature 64°F. Flows 3 gpm.
50	5 miles SW of Currie	H. C. Corbett	do	65	1¼		do				Analysis. Well flows.
51	3 miles SW of Currie	James Keith	do	135	1¼		do				Do.
52	6 miles SW of Currie	French Bordeaux	do	178	2		do				Do.
53	4 miles SE of Currie	George Spayde	Screen	44	4	42	do		15		

Records of Wells in Pender County—Continued

Well no.	Location	Owner	Type of well	Depth (ft.)	Diameter (in.)	Depth of casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Remarks
54	do	do	do	46	8	38	do		85		
55	7 miles W of Rocky Point	Long Creek Consolidated School	Open end	175	2		do				Flows 5 gpm. Chloride 82 ppm.
56	6 miles W of Rocky Point	Mrs. O. F. Woodcock	do	240	3		do	+7			Flows 7 gpm. Chloride 182 ppm.
57	5 miles W of Rocky Point	Rook Meat Produce Co.	do	233	6	25	do	11	35		
58	do	do	Screen	41	6	24	do	11	25		
59	3 miles SW of Rocky Point	Mueller Farms	do	201	20-8	140	do	8	85	94	
60	do	do	do	600	8-4	284	do		144		Well abandoned.
61	Rocky Point	Rocky Point School	Open end	50	1¼	50	Limestone	8			
62	do	Casey Lumber Co.	do	20-30	1¼	20-30	do		30		Analysis.
63	do	do	Screen	80	8	70	do	5	70		Well abandoned.
64	2 miles E of Rocky Point	Ivershiel Farm		339	4		Sand	+8			Analysis. Flows 10 gpm. Temperature 65°F.
65	3 miles S of Rocky Point	B. A. Paul	Screen	32	4	22	do		20		
66	do	A. A. Miller	Open end	38	1½	38	do	15			
67	Topsail Beach	U. S. Government		387	8-4		do				
67a	do	Town of Topsail Beach	Screen	320	8		do	0			Flows 150 gpm. Yield 60 gpm. with 50-foot drawdown, screen 290-310 feet.
68	9 miles SW of Topsail Beach	Topsail High School	do	50	1¼	50	do				
69	11 miles SW of Topsail Beach	Z. R. Thompson	Open end	80	1¼		do	11			
70	7 miles SW of Topsail Beach	U. S. Government	do	235	6-4½	168	Limestone				

Chemical Analyses of Ground Water From Pender County

(Numbers at heads of columns correspond to well numbers in table of well data)

Constituents in parts per million

	26	30	38	41	43	43a	47	48	49
Silica (SiO_2)	27	26	15					10	
Iron (Fe), total	.19	.05	.08					.38	
Iron (Fe), in solution	.65	.05	.04					.01	
Calcium (Ca)	54	48	38					27	
Magnesium (Mg)	11	9.7	19					21	
Sodium and potassium (Na + K)	4.8	54	97					856	
Carbonate (CO_3)	0	0	0	0	0	0	0	0	0
Bicarbonate (HCO_3)	221	315	446	226	290	358	437	491	496
Sulfate (SO_4)	2.3	3.2	.7	1	1	1	3	57	25
Chloride (Cl)	4.5	9.2	12	4.5	3.8	10	33	1,100	450
Fluoride (F)	.2	.7	.3					.4	
Nitrate (NO_3)	.1	.2	.4					.1	
Dissolved solids	211	313	408					2,370	
Hardness as $CaCO_3$	180	160	173	176	181	72	39	154	36
pH	7.4	7.6	7.8	7.6	7.7	7.8	8.1	7.7	8.1
Water-bearing material	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
Date of collection	6/11/53	2/18/50	3/10/54	6/10/53	3/10/54	6/9/54	7/13/54	3/11/53	

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

	50	51	52	62	64
Silica (SiO_2)					16
Iron (Fe), total					.12
Iron (Fe), in solution					.03
Calcium (Ca)					7.5
Magnesium (Mg)					7.6
Sodium and potassium (Na + K)					777
Carbonate (CO_3)	0	0	0		0
Bicarbonate (HCO_3)	498	564	559	278	926
Sulfate (SO_4)	16	22	26	3	53
Chloride (Cl)	445	510	935	15	650
Fluoride (F)					2.7
Nitrate (NO_3)				.35	1.2
Dissolved solids					2,021
Hardness as $CaCO_3$	34	48	108	255	50
pH	8.2	8.0	7.8		8.0
Water-bearing material	Sand	Sand	Sand	Sand	Limestone
Date of collection	6/10/53	6/10/53	6/10/53	12/23/41	2/4/53

Analyzed by the Quality of Water Branch, U. S. Geological Survey.

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