GEOLOGY AND GROUND-WATER RESOURCES of the HERTFORD-ELIZABETH CITY AREA NORTH CAROLINA

By

William H. Harris

Geologist, U. S. Geological Survey

Chemical Quality of Water Section

By

H. B. Wilder, *Chemist,* U. S. Geological Survey

NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES

George E. Pickett, *Director*

Division of Ground Water

Harry M. Peek, *Chief*

Ground Water Bulletin No. 10

PREPARED COOPERATIVELY BY THE GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

DECEMBER 1966

North Carolina
Board of Water Resources

STATE OF NORTH CAROLINA

DEPARTMENT OF WATER RESOURCES

GEORGE E. PICKETT, DIRECTOR
P. O. BOX 9392
RALEIGH, N. C. 27603
TELEPHONE 829-3003

December 29, 1966

The Honorable Dan K. Moore
Governor of North Carolina
Raleigh, North Carolina

Dear Governor Moore:

I am pleased to submit Ground-Water Bulletin Number 10, "Geology and Ground-Water Resources of the Hertford-Elizabeth City Area, North Carolina" by William H. Harris and H. B. Wilder.

This report contains the results of an investigation made by the U. S. Geological Survey in cooperation with the North Carolina Department of Water Resources as a part of the series of reconnaissance studies to provide a general evaluation of ground-water conditions in all parts of the State. It presents the data collected and describes the general geology and the occurrence, availability and quality of ground water in Camden, Currituck, Pasquotank and Perquimans Counties.

This report is a valuable contribution to the knowledge of the geology and hydrology of the area, and will be available to all persons and agencies concerned with development and management of ground-water supplies.

Respectfully submitted,

George E. Pickett

George E. Pickett

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

GEOLOGY AND GROUND-WATER RESOURCES OF THE HERTFORD-ELIZABETH CITY AREA, NORTH CAROLINA

By

William H. Harris and Hugh B. Wilder

ABSTRACT

The Hertford-Elizabeth City area includes Camden, Currituck, Pasquotank, and Perquimans Counties. These counties, in the northeastern part of the North Carolina Coastal Plain, have an area of 1,002 square miles.

The area is underlain by clay, silt, sand, shell, marl, and limestone sedimentary strata of Cretaceous and Tertiary age. These older sediments are not exposed in the area, but their presence beneath surficial post-Miocene marine and fluviatile sand and clay deposits is determined from lithologic and microfossil evidence from well cuttings or from drillers' well logs. The stratified sediments have been subdivided into formations or other mappable sedimentary units as follows: the lower unnamed member of the Black Creek Formation, the upper Snow Hill Marl Member of the Black Creek Formation, and the Peedee Formation of Late Cretaceous age, the Beaufort Formation of Paleocene age, an unnamed unit of middle Miocene age, the Yorktown Formation of late Miocene age, and post-Miocene age, and post-Miocene surficial deposits of Quaternary age. Formation boundaries, determined from microfossil evidence, represent geologic time lines. The vertical Succession and lateral migration of lithofacies units and aquifers across geologic time lines indicate that the sediments were deposited during successive phases of marine transgression and regression.

Ten aquifers are recognized in the Hertford-Elizabeth City area. Of these only three, the Yorktown lower aquifer, the Yorktown upper aquifer - the major artesian aquifer in the area -- and the post-Miocene aquifer, furnish water of generally acceptable chemical quality.

Generally, wells in the post-Miocene aquifer are shallow dug or driven wells that yield from 2 to 10 gpm. Wells constructed by rotary or jetting methods and screened in the Yorktown upper aquifer yield from 1 to 50 gpm for domestic use, and from 95 to 385 gpm for municipal use, depending upon location, depth, and method of construction.

The water-table aquifer generally yields the least mineralized ground water in the Hertford-Elizabeth City area. Mineral constituents of water samples analyzed from this aquifer ranged from 35 to 855 parts

per million; hardness as calcium carbonate ranged from 8 to 621 ppm; and iron concentrations ranged from 0.05 to 27 ppm. Other mineral constituents of the water were not commonly present in objectionable amounts.

The Yorktown upper aquifer contains the only large amounts of useful artesian waters in the area. Chloride concentrations in water samples from this aquifer ranged from 2.2 to 818 ppm, hardness as calcium carbonate ranged from 16 to 524 ppm, iron concentrations ranged from 0.01 to 14 ppm, and silica from 4.3 to 72 ppm. Other dissolved mineral constituents were not present in objectionable amounts in otherwise potable waters.

The Yorktown lower aquifer yields potable water from areas in which the artesian surface of the aquifer is greater than 5 feet above mean sea level. The quality of these waters is similar to that from the Yorktown upper aquifer, except that concentrations of iron are generally not as high.

Saline water is present in the underlying Paleocene and Cretaceous aquifer.

INTRODUCTION

Location of Area

The Hertford-Elizabeth City area is in the northeastern part of North Carolina (fig. 1), and includes Camden, Currituck, Pasquotank, and Perquimans Counties.

Purpose and Methods of Investigation

The purpose of the present investigation was: (1) to delineate aquifers; (2) to obtain data on the lithic character, areal extent, thickness, and water-bearing properties of the stratified sediments; and (3) to relate the chemical quality of water to specific aquifers and their mineral constituents in the Hertford-Elizabeth City area.

The investigation was done on a reconnaissance basis by personnel of the Ground Water Branch and the Quality of Water Branch, U. S. Geological Survey, within the following categories:

Geology - Analyses of well cuttings and mapping of subsurface geology.

Hydrology - Well inventories and construction of water-table and artesian (piezometric) maps.

Hydraulics - Calculation of specific yields of wells from short-term pumping tests of selected wells in the area.

Geophysics - Electric and gamma-ray logs of selected boreholes and log analyses.

Geochemistry - Partial and complete analyses of selected water samples. Construction of geochemical maps showing the chloride content and iron content of ground water from wells screened in the Yorktown upper aquifer.

Previous Work

All water supplies in the area of investigation are obtained from ground-water sources. S. W. Lohman (1936) described the availability of ground water at Elizabeth City in U. S. Geological Survey Water-Supply Paper 773-A. M. J. Mundorff (1947) evaluated ground-water data from the area, including that obtained for several military installations during World War II, in North Carolina Department of Conservation and Development Information Circular 6. H. E. LeGrand and G. E. Siple (1953) described the chemical quality of ground water and the hydrology of the Elizabeth City area in Report on Water Supply of Elizabeth City, North Carolina, J. N. Pease and Company Engineers, Charlotte, North Carolina.

With the exception of the data in these above three reports, little information was available on the areal extent, thickness, and water-yielding capacity of the aquifers and the chemical quality of ground water in the Hertford-Elizabeth City area prior to this reconnaissance investigation.

Cooperation and Direction

This investigation was made by the Ground Water Branch, U. S. Geological Survey, in cooperation with the Division of Ground Water, North Carolina Department of Water Resources. The report was prepared under the immediate supervision of P. M. Brown, District Geologist, Ground Water Branch, U. S. Geological Survey.

Acknowledgments

Many well drillers and town officials cooperated in making well data available during the investigation, also officials and employees of the Layne Atlantic Company, the Sydnor Pump and Well Company, the R. L. Magette Well Company, the Elizabeth City Public Utilities Commission, the Town of Hertford, and H. B. Warren, and E. S. White, local well drillers.

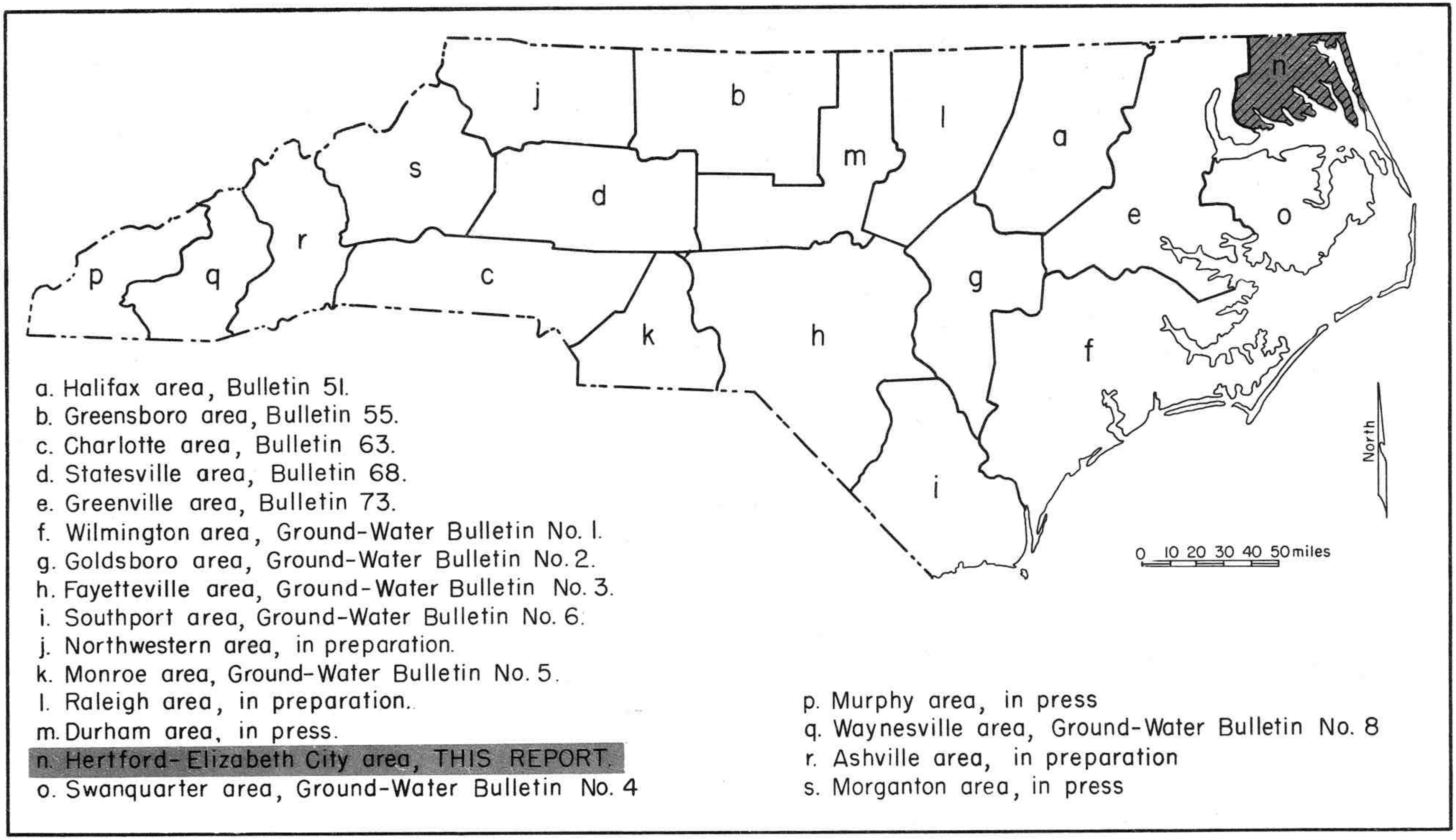


FIGURE 1. INDEX MAP OF NORTH CAROLINA SHOWING AREAS COVERED BY RECONNAISSANCE GROUND - WATER INVESTIGATIONS

GEOGRAPHY

Area and Population

The area described in this report consists of 1,002 square miles, of which 439 square miles is farm land or cleared, and 563 square miles is forested.

The population in the four counties of the area, according to the U. S. Bureau of the Census, was 47,007 in 1960. Urban population is centered in Elizabeth City, which has about 30 percent of the total population for the area. The other 70 percent of the population is rural. The population of the area has not increased appreciably during the past decade.

Physiography

The Hertford-Elizabeth City area lies entirely within the Atlantic Coastal Plain province, which in North Carolina is a submaturely dissected and partly submerged terraced coastal-plain surface that slopes gently toward the southeast. The surface is a landward extension of the present ocean floor that forms the surface of the continental shelf. Broad flat interstream areas, swampland, and linear sand ridges are the dominant topographic features; moderately dissected parts of the area are limited to narrow margins of the major streams and sounds. Altitudes range from about 51 feet on the northwest border of Perquimans County to sea level along Albemarle and Currituck Sounds.

The major rivers that drain the area all originate in the Coastal Plain province. These rivers - the Yeopim, Perquimans, Little, Pasquotank, North Northwest, and North Landing Rivers -- are subparallel and flow southeastward into Albemarle or Currituck Sounds.

Several large swamps - the Great Dismal Swamp, Bear Swamp, Great Swamp, and Maple Swamp - occur along the major rivers. The largest of these, the Great Dismal Swamp, extends northward into Virginia.

The coastal areas consist of salt marshes, beaches, and sand dunes. Salt marshes are prevalent along Currituck Sound and the tidal reaches of its tributary creeks, rivers, and bays. Small sand beaches occur locally along the shores of Albemarle and Currituck Sounds. An extensive beach lies on the seaward side of the barrier spit from near Virginia

Beach, Virginia, to Oregon Inlet, North Carolina. Locally, sand dunes on the spit have a relief of 40 feet.

Climate

The climate of the Herford-Elizabeth City area is characterized by long summers and short, mild winters. The average annual temperature at Elizabeth City recording station of the U. S. Weather Bureau is 61.6° F. Average, extreme maximum, and extreme minimum monthly temperatures at the Elizabeth City station are shown in figure 2.

The precipitation ofr each year of record at Elizabeth City ranges from a minimum of 39.85 to a maximum of 57.28 inches. Precipitation generally is greatest from June through September.

Economy

The economy of the four counties is predominantly agricultural. Products that provide the main source of income are corn, peanuts, cotton, cabbage, livestock, poultry. The largest towns are marketing and processing centers for the agricultural products. Industrial development consists mainly of small locally owned companies engaged in the packaging and processing of farm products. Commercial fishing and seafood processing are major industries in communities along Albemarle and Currituck Sounds and along the major rivers. Small lumber mills are common throughout the area. Elizabeth City has the largest and most diversified group of industries, which include shipbuilding and aircraft construction. There is a rocket research site at Corolla, Currituck County.

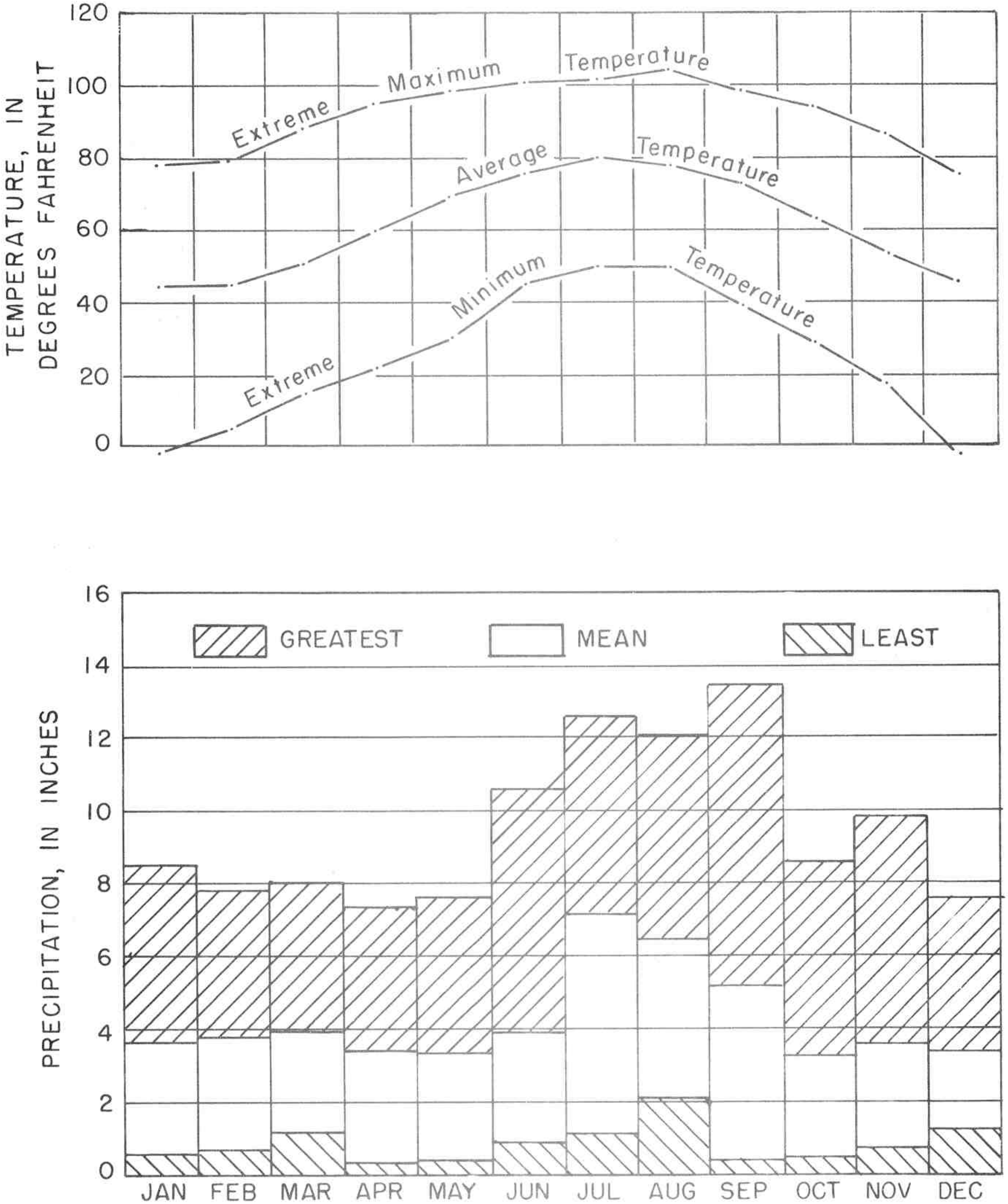


FIGURE 2. CLIMATIC SUMMARY FOR ELIZABETH CITY, PASQUOTANK COUNTY (1931-60)

GENERAL GEOLOGY

The Hertford-Elizabeth City area is underlain by clay, silt, sand, shell marl, and limestone units of Cretaceous and Tertiary age. These sedimentary units are mainly of marine or near-marine origin. None of these sediments is exposed at land surface in the area of investigation, but their presence beneath the post-Miocene marine and fluviatile surficial deposits is indicated by lithologic and microfossil evidence obtained from well cuttings or drillers' well logs (fig. 3).

The primary source of the clays, silts, and sands was the crystalline rocks in the areas, now known as the Blue Ridge and Piedmont provinces. Clay, silt, and sand in some of the younger sediments probably has been reworked from older sediments. Some marls and limestones and the phosphatic or glauconitic sands were formed in marine depositional sites as chemical precipitates mixed with clay, sand, and shell.

The stratified sediments have been subdivided into formations, or other mappable sedimentary units that can be identified from their position in the stratigraphic sequence, their lithology, or microfossil content. Formation boundaries, as determined from microfossil evidence, are recognized as geologic time lines. The vertical succession and lateral migration of lithofacies (the rock record of any sedimantary environment) and aquifers (water-bearing units) across geologic time lines (formational boundaries) indicate several periods of transgression and regression of the sea in northeastern North Carolina. Elevation and tilting have changed the original depositional attitude of the sediments.

The succession of geologic units above the crystalline basement rocks in the Hertford-Elizabeth City area, their water-bearing characteristics, and their Gulf Coast or Atlantic Coastal Plain equivalents are shown in table 1. The stratigraphic succession shown here is general; one or more of the geologic units may be absent in parts of the Hertford-Elizabeth City area.

Test Drilling

In order to obtain geologic and hydrologic data, two deep test holes and 38 auger holes were drilled at selected sites in the area.

The deep test holes were drilled 701 feet (PA-T1-62) and 723 feet (PA-T2-62). Rock cuttings were taken at 5-foot intervals for microfossil and lithologic analyses. When drilling had been completed, electric and gamma-ray logs of the test holes were obtained, water samples for chemical analyses were pumped from selected water-bearing zones, and measurements of artesian levels were made.

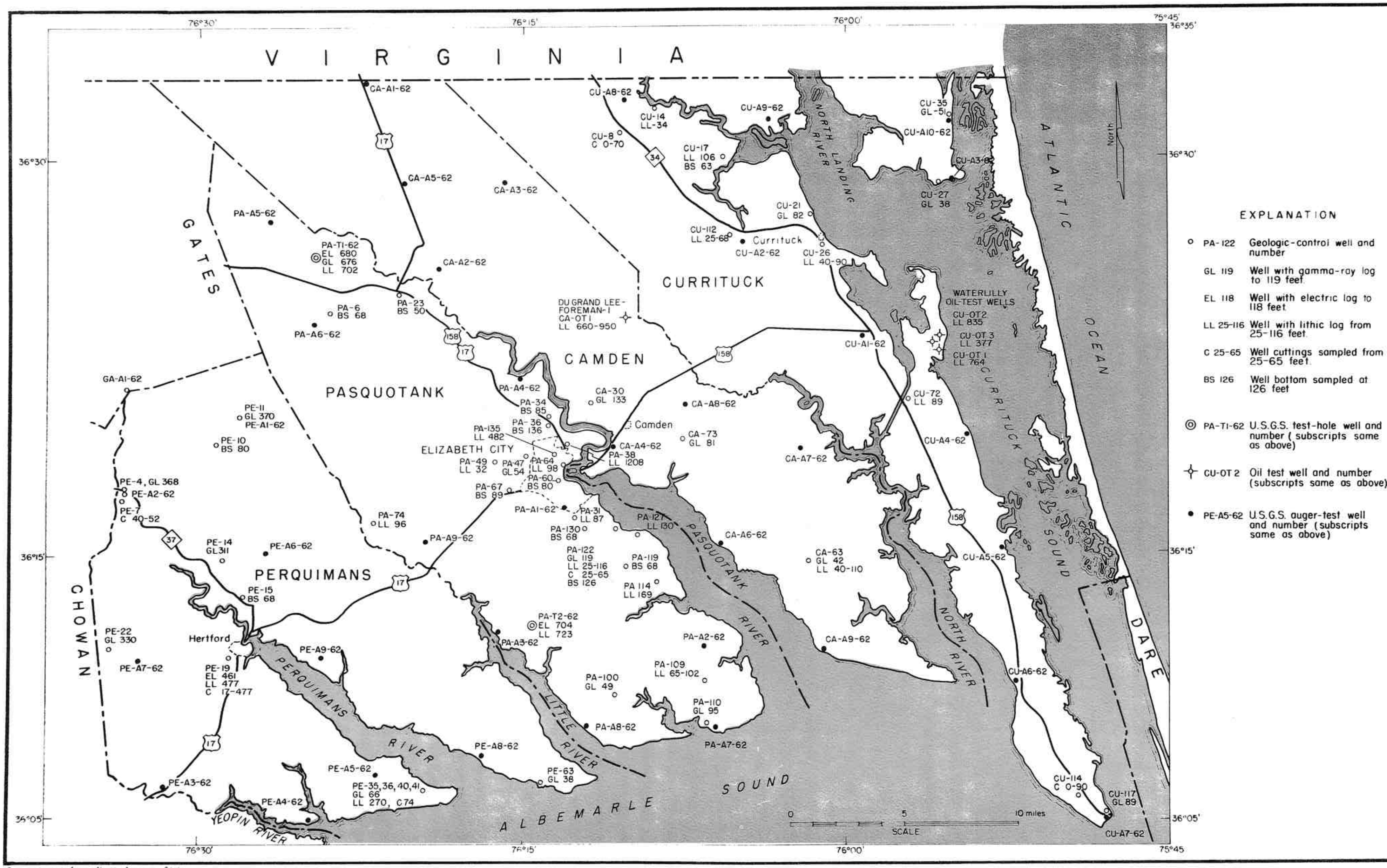
The auger holes ranged in depth from 112 feet to 152 feet. Augered samples of sand and clay were taken at 5-foot intervals for microfossil and lithologic analyses.

Locations of deep test holes, auger holes, and other deep wells and test from which geologic and geophysical data were obtained are shown in figure 3.

Geologic History

The geologic history of the Hertford-Elizabeth City area, prior to the deposition of the sediments, is unknown. However, crystalline basement rocks, probably of Precambrian or early Paleozoic age, were penetrated by the DuGrandlee Foreman-1 oil-test well, 8 miles northeast of Elizabeth City (fig. 3) at 3,072 feet below msl (mean sea level). Well cuttings representative of the basement rocks from this test well consist of green-gray metaquartzite and weathered light-red acidic tuff. The basement rocks that underlie the sediments in the Hertford-Elizabeth City area are probably analogous to similar types of rock in the Piedmont province to the west.

No known Lower Cretaceous or Tuscaloosa sediments were penetrated by the two test holes drilled as part of this investigation in the Hertford-Elizabeth City area. The presence of these units at depth, unconformably overlying basement rocks, is inferred from their presence and stratigraphic relationship to the west in Halifax, Northampton, and Hertford Counties, North Carolina (Mundorff, 1946; Brown, 1962). According to P. M. Brown (oral commun., April 1963), the lower unnamed member of the Black Creek Formation (Austin equivalent) of Late Cretaceous age was deposited during a major regression of the sea. After this regression, the upper Snow Hill Member of the Black Creek Formation (Taylor equivalent) and the Peedee Formation (Navarro equivalent) of Late Cretaceous age were deposited during a minor marine transgression from the southeast to the northwest near the close of the Cretaceous Period. Local uplift in southeastern Virginia during Late Cretaceous time, probably as a result of



Base adapted from North Carolina State Highway Commission maps

FIGURE 3. LOCATION OF AUGER HOLES, TEST HOLES, OIL-TEST WELLS, AND OTHER GEOLOGIC CONTROL WELLS

Subdivided series	Equivalents	Formations and members		Description	Hydrologic properties
post-Miocene, Quaternary and Recent		undifferentiated		Light-colored fine to coarse sand and interbedded clay, lenticular and crossbedded.	Unconfined water for dug or driven wells. Has large amounts of iron and is corrosive.
Upper Miocene		Yorktown Formation		Light-colored sandy shell beds in upper part underlain by gray marl, shell layers and interbedded lenticular sand and clay.	Hard water in moderate amounts from the sand and shell beds.
Middle Miocene	Rocks of Calvert and Choptank age	unnamed formation		Brown phosphatic sand and sandy silt.	Potential yields good, but chloride-ion content usually large.
Paleocene	Rocks of Midway age	Beaufort Formation		Glauconitic green sands predominate, with some argillaceous, fine-grained sand.	Saline water.
Upper Cretaceous	Rocks of Navarro age	Peedee Formation		Coarse glauconitic sand, underlain by gray-green silty sand, limestone, and shell beds. Some deltaic sand deposits.	Saline water.
	Rocks of Austin and Taylor age	Black Creek Formation	Snow Hill Marl Member	Black to gray interbedded clay and marl, locally limestone and clay may be present.	Saline water.
			unnamed member	Gray and black micaceous sand and clay, glauconitic with lignite fragments and pyrite. Sand and clay are lenticular.	Saline water.

Table 1. Geologic units and their water-bearing properties in the Hertford-Elizabeth City area, adapted from Brown (1958).

differential movement along the Hampton Roads-James River Fault (Cederstrom, 1945), resulted in progressive southward offlap of the Late Cretaceous sediments (P. M. Brown, oral commun. April 1963).

After extensive erosion at the close of the Cretaceous Period, the land surface was again submerged, and during the Paleocene Epoch, the Beaufort Formation was deposited (P. M. Brown, oral commun. April 1963). The withdrawal of the early Tertiary sea was followed by an extensive period of erosion prior to the deposition of Middle Miocene sediments.

Middle Miocene sediments probably are present throughout the Hertford-Elizabeth City area. These middle Miocene sediments and most of the overlying Yorktown Formation of late Miocene age were deposited during a major marine transgression from the Northeast (P. M. Brown, oral commun., April 1963). The middle Miocene sediments lie in conformity with the Yorktown Formations. Clay, sand, gravel, coquina, and shell marl in the upper part of the Yorktown Formation were deposited during a major marine regression near the close of late Miocene time.

Unconformably overlying the Yorktown Formation are thin-post-Miocene sediments of Quaternary age.

GEOLOGIC FORMATIONS IN THE HERTFORD-ELIZABETH CITY AREA

Cretaceous System

Upper Cretaceous series

Black Creek Formation

The Black Creek Formation consists of a lower unnamed member and an upper member, the Snow Hill Marl. The term "Black Creek" was used by Sloan (1907, p. 12-14) for typical exposures of black laminated sand and clay along Black Creek in Darlington and Florence Counties, South Carolina. Stephenson (1923, p. 10) proposed the name Snow Hill Marl Member for the upper 100 to 200 feet of the formation. The type locality for the Snow Hill Marl member is along Contentnea Creek near Snow Hill, Green County, North Carolina (Conrad, 1871).

The Snow Hill Marl member belongs to the upper part of the zone of *Exogyra ponderosa* of the Atlantic and Gulf Coastal Plain (Stephenson, 1923, p. 10). The indicated correlation, therefore is with the Taylor Group of the Gulf Coastal Plain and with the Matawan Group of the Atlantic Coastal Plain (Stephenson, 1923, pl. 8). Subsurface evidence based on microfossils -- Ostracoda and Foraminifera indicates that the lower member is pre-Taylor in age and should be correlated with Austin equivalents of the Gulf Coastal Plain and with the Magothy Formation of the Atlantic Coastal Plain (Brown, 1959).

U. S. Geological Survey test holes did not penetrate the Black Creek Formation in the Hertford-Elizabeth City area. It was penetrated by well PA-38 in Pasquotank County, and the DuGrandlee Forman-1 oil-test in Camden County (fig. 3). In well PA-38, the formation consists of interbedded red and yellow clays with iron-stained quartz sands (Snow Hill Marl Member) from 1,040 to 1,115 feet below msl, and of interbedded blue to gray clays and sands and some yellow clay (lower unnamed member) from 1,115 to 1,208 feet below msl. In the DuGrandlee Forman-1 oil-test well, the top of the Black Creek Formation is 1,124 feet below msl, the uppermost occurrence of the ostracod *Brachycythere sphenoides* (Reuss) (Brown, 1958, p. 15).

In the area of investigation, the Black Creek Formation strikes east-northeast with a stratigraphic dip to the south-southeast (P. M. Brown, oral commun., April 1963). Its total thickness is unknown, as only 170 feet of Black Creek sediments was penetrated in well PA-38. Down-basin for the Black Creek Formation is east-northeastward.

Peedee Formation

The name "Peedee" was proposed by Ruffin (1843, p. 6-7) for a sedimentary unit of Cretaceous age in Florence and Horry Counties, South Carolina. Stephenson (Clark and others, 1912, p. 45) used the name "Peedee" for equivalent sediments in North Carolina that he previously (1907, p. 93-99) had referred to as the Ripley Formation.

According to Stephenson (1923, p. 13), the Peedee Formation belongs to the zone of *Exogyra costata* of the Atlantic Coastal Plain, though probably the uppermost part of the zone is not represented. Approximately the lower half of the formation belongs to the *Exogyra cancellata* subzone. Stephenson (1923, p. 48-58) discusses in detail the correlation of the Peedee Formation, which is equivalent in part to the Navarro Group of the Gulf Coastal Plain and in part to the Monmouth Group of the Atlantic Coastal Plain. Recent studies by Brown (1957, p. 1-24) of Ostracoda in the Peedee Formation substantiate Stephenson's correlation.

Only the DuGrandlee Foreman-1 oil-test well and well PA-38 penetrate the Peedee Formation (Navarro equivalent) in the Hertford-Elizabeth City area. In the DuGrandlee Foreman-1 oil-test well, the Peedee Formation consists of interbedded sands and clays between 940 and 1,140 feet below msl (Brown, 1958, p. 15). In well PA-38, the formation consists of interbedded tan, yellow, purple, pink, and red clays and similarly vari-colored iron-stained quartz sands of transitional flood plain tidal flat origin from 860 to 1,040 feet below msl. According to P. M. Brown (oral commun., April 1963), the Peedee Formation is not present in the northern part of the Hertford-Elizabeth City area.

In the area of investigation, the Peedee Formation strikes east-northeast with a stratigraphic dip to the south-southeast (P. M. Brown, oral commun., April 1963). The Peedee Formation conformably overlies the Black Creek Formation

Tertiary System

Paleocene series

Beaufort Formation

The name "Beaufort Formation" was proposed by Brown (1959, p. 13) for sediments of Paleocene age in the Greenville area (fig 1). The name is derived from Beaufort County, where extensive deposits of Paleocene age occur in the subsurface.

The lithology of the Beaufort Formation is diverse. In the northern part of the Hertford-Elizabeth City area (test hole PA-T1-62, fig. 3), it consists primarily of loosely consolidated quartz sand and glauconite with a green-to-gray calcareous clay matrix and dense green glauconitic clay in the upper 10 feet of section. This is underlain by medium- to coarse-grained iron-stained quartz sand and gravel with interbedded red-brown and orange-red clay of transitional flood plain tidal flat origin from 15 to 36 feet below the top of the formation. The upper section contains abundant brachiopod shells, coral fragments, sharks' teeth, jaw plates of skates, and the foraminifer Nodosaria affinis (Reuss). Glauconite content ranges from 30 to 50 percent in some of the sands.

In the southern part of the Hertford-Elizabeth City area (test hole PA-T2-62, fig. 3), the Beaufort Formation consists of an impure limestone underlain by glauconitic sand with a calcareous green-to-gray clay matrix grading downward into sandy glauconitic clay. Iron-stained quartz sand is commonly interbedded with the glauconitic sands and clays; thin indurated shell marls occur in the upper part of the glauconitic sand. The glauconitic sand and clay contain abundant brachiopod shell fragments and Nodosaria affinis (Reuss) foraminifer. Angular black fine sand to medium gravel phosphate is prominent in the uppermost part of the limestone. The base of the Beaufort Formation was not penetrated by either of the two Pasquotank County test holes.

The location of the top of the Paleocene is based on Ostracoda occurrence in both of the Pasquotank County test holes. In the DuGrand-lee Foreman-1 test-well in Camden County, the top Paleocene boundary is 674 feet below msl at the uppermost occurrence of Ostracoda Trachyleberis spiniferrima (Jones and Sherborn) and Brachycythere interrasilis Alexander

(Brown, 1958, p. 15). The boundary is the top of a glauconitic sand, shell, and clay unit overlain by 30 feet of limestone. The top of the Paleocene should be raised to include these limestones which formerly were thought to be of Eocene(?) age (Brown, 1958, p. 15).

In well PA-38 in east-central Pasquotank County, blue-to-gray and black clay and shell occurs from 650 to 780 feet below msl within the glauconitic sand.

The Beaufort Formation conformably overlies Upper Cretaceous Taylor and Navarro equivalents in the southern part of the Hertford-Elizabeth City area. The Beaufort Formation unconformably overlies Upper Cretaceous Austin equivalents in the central part and the Upper Cretaceous Tuscaloosa Formation in the northern part of the area (P. M. Brown, oral commun., April 1963).

Test hole PA-T1-62 penetrated 347 feet, and test hole PA-T2-62 penetrated 259 feet of Beaufort Formation. The structural dip of the Beaufort Formation increases rapidly eastward.

Miocene series

Middle Miocene - Undifferentiated - Unnamed Unit

Sediments of probable middle Miocene age in the Hertford-Elizabeth City area differ both in fossil content and lithology from the typical middle Miocene phosphorite deposits (Calvert equivalent of Beaufort County (Brown, 1958, 1959). According to P. M. Brown (written commun., October 1962), guide Foraminifera for the middle Miocene in the area of investigation are not completely tested. *Siphogenerina lamellata* Cushman and other foraminifers, common in the middle Miocene sediments of Beaufort County (phosphorite equivalent) (Brown, 1959) were not found in the area of investigation. Because of the lack of diagnostic fossils, P. M. Brown defined the top boundary of the middle Miocene unit on the basis of abundance of the Foraminifera *Nonionella auris* (d'Orbigny) and *Nonion pizzarense* W. Berry.

In the northern part of the Hertford-Elizabeth City area (test hole PA-T1-62, fig. 3), sediments of probable middle Miocene age between 158 and 340 feet below msl consist of interbedded glauconitic quartz sand, calcareous green-to-gray glauconitic clay and indurated shell marl, and

and green-to-gray sandy clay. The uppermost 16 feet of the middle Miocene unit is phosphatic quartz sand composed of angular polished quartz, glauconite, and 15 to 20 percent angular black phosphate in a gray clay matrix. The gamma-ray log of this test hole indicates a highly phosphatic zone at the base of the middle Miocene unit.

In the southern part of the area of investigation (test hole PA-T2-62, fig. 3), sediments of probable middle Miocene age between 236 and 454 feet below msl consist primarily of hard, blue-gray, slightly calcareous clay and some white clay and scaphopod, pelecypod, and gastropod shells. Gray calcareous quartz sand containing 10 percent angular black phosphate is common within the lower 30 feet. Five feet of medium-grained phosphatic quartz sand and clay containing 15 percent angular black phosphate occurs at the base of the unit. In the southern part of the Hertford-Elizabeth City area, the lithology of the upper part of the middle Miocene unit is similar to that of the overlying Yorktown Formation.

In the area of investigation the middle Miocene unit strikes north-northeast with a stratigraphic dip to the south-southeast. It rests unconformably on the Beaufort Formation of Paleocene age and is overlain with apparent conformity by the Yorktown Formation of late Miocene age. It is 182 and 218 feet thick in test holes PA-T1-62 and PA-T2-62 in the northern and southern parts of Pasquotank County, respectively. About 75 feet of middle Miocene sediments was penetrated by well PA-135 in east-central Pasquotank County at the west margin of the Currituck Basin (Lohman, 1936).

A highly phosphatic zone occurs at the base of the middle Miocene unit in Pasquotank County. Westward in Perquimans County this zone occurs progressively higher in the middle Miocene unit. The phosphatic zone is easily detected from lithic and gamma-ray logs. In Pasquotank County the angular black phosphate has probably been derived from the underlying limestone in the Beaufort Formation.

Yorktown Formation

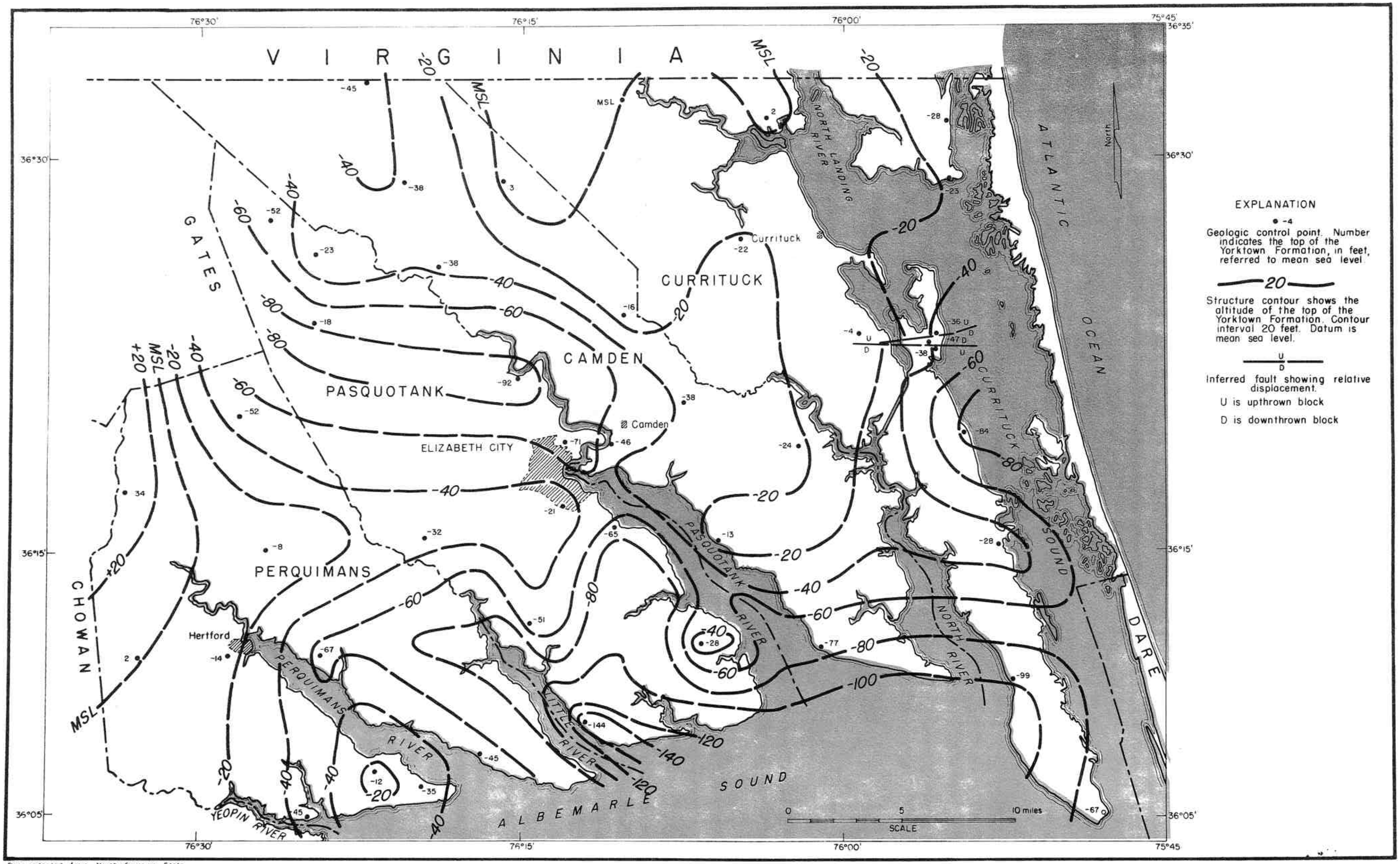
The Yorktown Formation of late Miocene age was named from exposures near Yorktown, Virginia (Clark and Miller, 1906). At its type locality it consists predominantly of coquina beds of fragmental marine molluscan shells cemented by calcium carbonate (Ruhle, 1962a, 1962b). Where it extends into North Carolina from the type locality in Virginia, the Yorktown Formation may include elements mapped elsewhere as the Saint Marys Formation (Brown, 1959).

In the Hertford-Elizabeth City area, the Yorktown Formation consists of soft-to-hard, massive, blue-to-gray, marine clay and sandy clay. These sediments are overlain by coquina, sandy gravel, and clay medium-to coarse-grained quartz sand, and shell with locally intercalated lenses of sandy clay and blue-gray mud. The coquina-gravel-sand part of this section is composed of an indurated shell marl, which contains *Turritella altricostata* Conrad, and is present throughout most of the area of investigation. The upper part of the blue-to-gray sandy clay contains abundant *Turritella*, coral, scaphopod, scallop, oyster, and clam-shell fragments. In parts of the area of investigation, the upper part contains an intercalated medium-to-coarse-grained quartz sand of littoral to near-shore marine origin.

The Yorktown Formation strikes north-northeast with a stratigraphic dip to the east-southeast. In the area of investigation it conformably overlies middle Miocene undifferentiated sediments and is unconformably overlain by sediments of post-Miocene age.

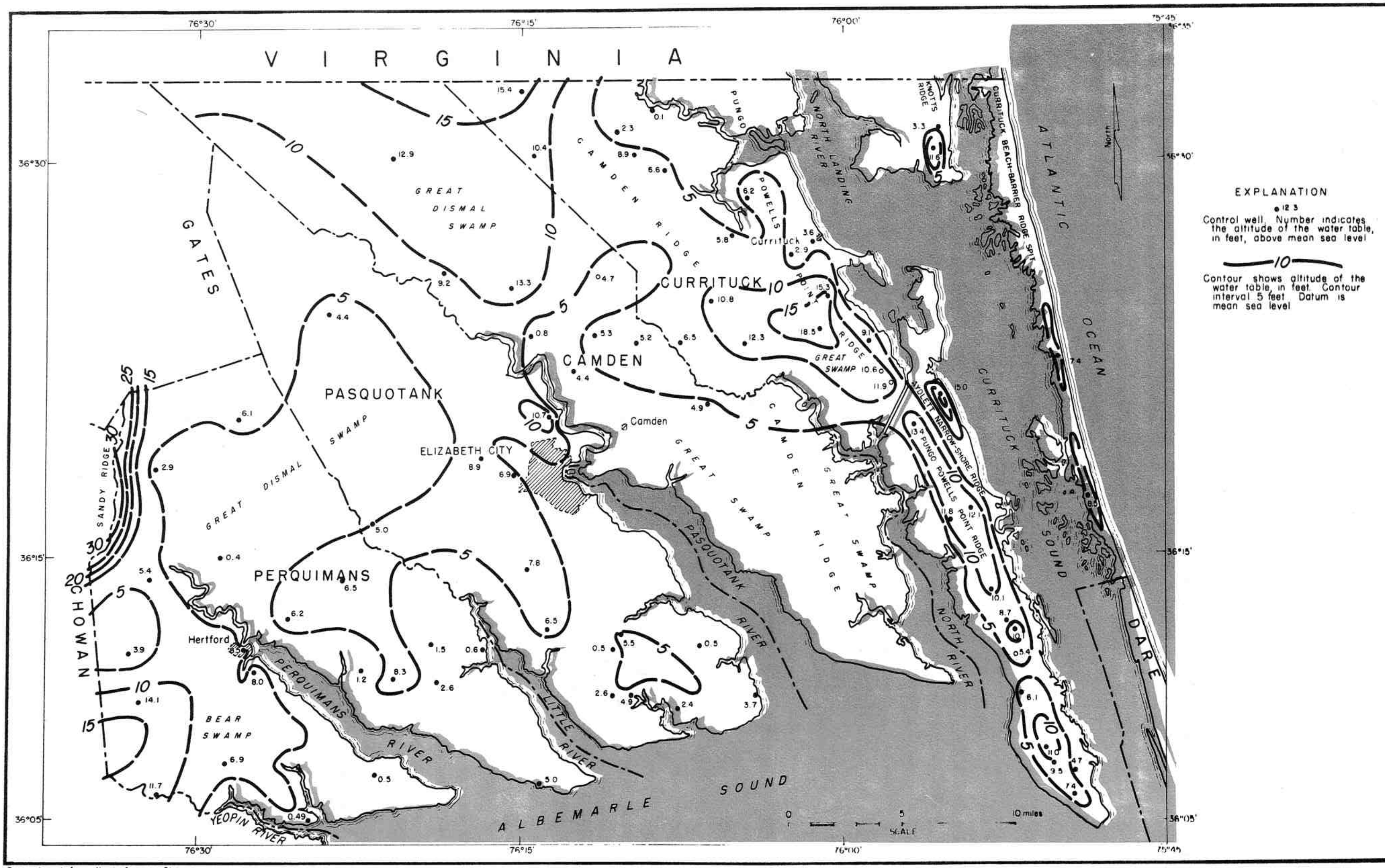
In the western half of the area of investigation, the Yorktown Formation ranges in thickness from 130 to 325 feet. The Yorktown Formation thickens appreciably along strike in the eastern part of the area into the Currituck Basin, where 660 feet of Miocene sediments have been reported by Richards (1945) in the DuGrandlee Foreman-1 oil-test well. No subdivision of the Miocene sediments by microfossil occurrence has as yet been accomplished in the eastern half of the area of investigation.

The top boundary of the Yorktown Formation is highly irregular; relief of more than 160 feet occurs on this surface (fig. 4). The top boundary of the Yorktown Formation was penetrated by auger and test holes and was chosen on the basis of the uppermost occurrence of the Ostracoda *Hemicythere conradi* Howe and McGuirt, *Hemicythere confragosa* Edwards, *Loxoconcha purisubrhomboidea* (instar) Edwards, and *Trachyleberis vaughani* (Brown, 1958) or the Foraminifera *Textularia candeiana*, *Textularia* sp., *Cancris sagra*, *Cpiroplectammina gracilis*, *Massilina mansfieldi*, *Massilina marylandica*, *Cibicides americanus*, *Amphistegina lessoni*, *Astergerina* sp., and *Sipiroloculina depressa* (Henbest, in Henbest, Lohman, and Mansfield, 1939; Cushman and Cahill, 1933). The top boundary of the Yorktown Formation in the Water Lilly oil-test wells is based on lithology.



Base adapted from North Carolina State Highway Commission maps

FIGURE 4. CONFIGURATION OF TOP OF THE YORKTOWN FORMATION



Base adapted from North Carolina State Highway Commission maps

FIGURE 5. RELATION OF THE WATER TABLE TO PHYSIOGRAPHIC FEATURES

Quaternary System

Post-Miocene series

The surficial post-Miocene sediments in the Hertford-Elizabeth City area are barrier and sand-ridge deposits, interridge deposits, recent littoral and supralittoral sediments, swamp deposits, and river alluvium.

The location of post-Miocene barrier sand ridges and the modern Currituck Beach barrier sand ridge in northeastern North Carolina is shown in figure 5. From west to east these are Sandy Ridge, Camden Ridge, Pungo-Powells Point Ridge, Aydlett "Narrow Shore" Ridge, and Knotts Island Ridge. The barrier-ridge deposits consisting of littoral sand, gravel, and shell deposits serve as recharge areas to the unconfined water table, owing to their high permeability due to retaining precipitation with little or no runoff.

A prominent 1.5-foot thick shell bed forms the crest of the Knotts Island Ridge on Currituck Sound at Church Island. The following species of mollusks have been identified from Ruhle (1962): The oyster *Crassostrea virginica* (Gmelin); the clams *Anadara ovalis* (Burguiere), and *Mercenaria campechiensis* (Gmelin); the snails, *Littorina irrorata* (Say), the scallop *Pecten irradians* Lamarck; and the conchs *Busycon canliculatum* (Linne) and *B. caricum* (Gmelin). All suggest that the shell bed is of Pleistocene age. Interridge deposits consist mainly of clay, silt, mud, and sand.

Recent littoral sediments in the area include the beach and dune sands of the modern Currituck Beach barrier ridge. Supralittoral sediments include tidal marsh, lagoon, and bay mud of Currituck and Albemarle Sounds. Swamp deposits consist of clay and peat, probably of fresh-water origin.

GROUND WATER HYDROLOGY

Hydrologic Cycle

The earth has a constant volume of water that is continually being exchanged between the earth and the atmosphere. The continuous circulation of water in its various forms has been termed the hydrologic cycle, and the study of the many complex and interrelation phases of the hydrologic cycle is the science of hydrology.

This report describes some of the physical and geological factors that govern the amount, availability, and chemical quality of water in that part of the hydrologic system beneath the land surface in the Hertford-Elizabeth City area.

Source and Occurrence of Ground Water

Ground water is the subsurface water in the zone of saturation-- the zone in which all pore spaces are filled with water under positive hydrostatic head. The water in the zone of saturation is derived from precipitation. When precipitation reaches the land surface, most of it rusn off on the surface to streams and lakes, some evaporates from the surface, and some percolates into the ground. Of the water that percolates into the ground, some may be later transpired by plants or evaporated from the soil. The remainder moves downward through the zone of aeration to the top of the zone of saturation which is called the water table. Water that has reached the zone of saturation is available to supply springs, streams, and wells and is referred to as ground water.

Water in the zone of saturation moves laterally under the influence of gravity toward a place of discharge at land surface, such as well, spring, stream, swamp, lake, or ocean. The movement of water in an aquifer may take place under artesian or nonartesian (water-table) conditions. Ground water occurs as nonartesian water when its surface is free to rise and fall. Principal factors causing rise or fall of the water table are variations in precipitation, transpiration, and tidal levels. Ground water occurs as artesian water when its surface is not free to rise and fall, owing to impermeable confining layers. The term "artesian" is applied to water, which is under sufficient positive hydrostatic pressure to rise above the top of the permeable zone containing it, although no necessarily above the land surface. The artesian or piezometric surface is the surface that represents the height to which water will rise in tightly cased wells penetrating a given artesian aquifer.

A lithic unit that is capable of storing water and of transmitting usable quantities of water to wells or springs is called an aquifer. Two major classes of aquifers are: water-table and artesian. The term aquifer is relative and denotes no fixed volume of recoverable water. An aquiclude or confining layer is a lithic unit that does not yield water.

Water-Bearing Properties of Aquifers

The quantity of water that may be safely withdrawn from any aquifer is dependent on the water-transmitting and water-storing capacities of the aquifer and the amount of water available for recharge to the aquifer. If discharge of water from an aquifer exceeds recharge to it, the water table or the piezometric surface declines.

Permeability, the capacity of a lithic unit for transmitting fluids, is expressed in terms of the rate of flow of water in gallons a day through an area of 1 square foot under a unit hydraulic gradient. In general, the permeability of a lithic unit is determined by the size and shape of its pore spaces and the manner in which they are connected. Porosity is the ratio of volume of voids, or pore spaces, to the volume of solid material. Porosity is a function of the size, shape, assortment, and cementation of the solid components of a lithic unit. Porosity and permeability are not necessarily proportional. Clay has a high porosity because it has a large volume of pore space. However, because the individual pore spaces in clay are small, little water is transmitted under the hydraulic gradients that normally exist in nature. Lithic units of high permeability are aquifers.

Recharge and Discharge

Areas in which aquifers are replenished are called recharge areas; those in which water is lost from aquifers are called discharge area. Withdrawals from artesian aquifers by wells in recharge areas may increase the gradient between the water-table and the aquifers. This increase in gradient results in an increase in the amount of recharge to the artesian aquifer. Conversely, withdrawals of water in discharge areas by wells salvage a part of the natural discharge.

In the Hertford-Elizabeth City area water is lost from the water-table aquifer by natural discharge into surface streams and sounds, by downward seepage into artesian aquifers of the Yorktown Formation in those areas where the water table stands higher than the artesian pressure head (figs. 5, 6), by withdrawal of water from the water-table aquifer through wells, and by evaporation and transpiration. The water-table aquifer is recharged principally by local rainfall, but it also receives a small amount of recharge from upward seepage of artesian water in areas where the Yorktown, middle Miocene, Beaufort, and Cretaceous aquifer artesian-pressure heads are higher than the water table.

An artesian aquifer may be recharged by precipitation in areas where permeable beds are at the surface, by seepage of water through overlying and underlying semiconfining layers in the subsurface, and by water entering through relatively permeable zones in the confining layers in response to variations in artesian and water-table pressure heads. In the Hertford-Elizabeth City area, the principal artesian aquifers--the Yorktown aquifers--are recharged by the downward seepage of water from the water-table aquifer through confining layers. The Yorktown aquifers are recharged in those parts of the area where the water table stands higher than the Yorktown artesian pressure heads (figs. 5, 6). Water is discharged from the Yorktown artesian aquifers by upward seepage through the confining layers where the artesian pressure heads stand higher than the water table (figs. 5, 6). Wells also withdraw large quantities of water from these artesian aquifers. At Elizabeth City, recharge has been effected by artificially induced infiltration of water from streams into the shallower aquifers. This reversal of the normal

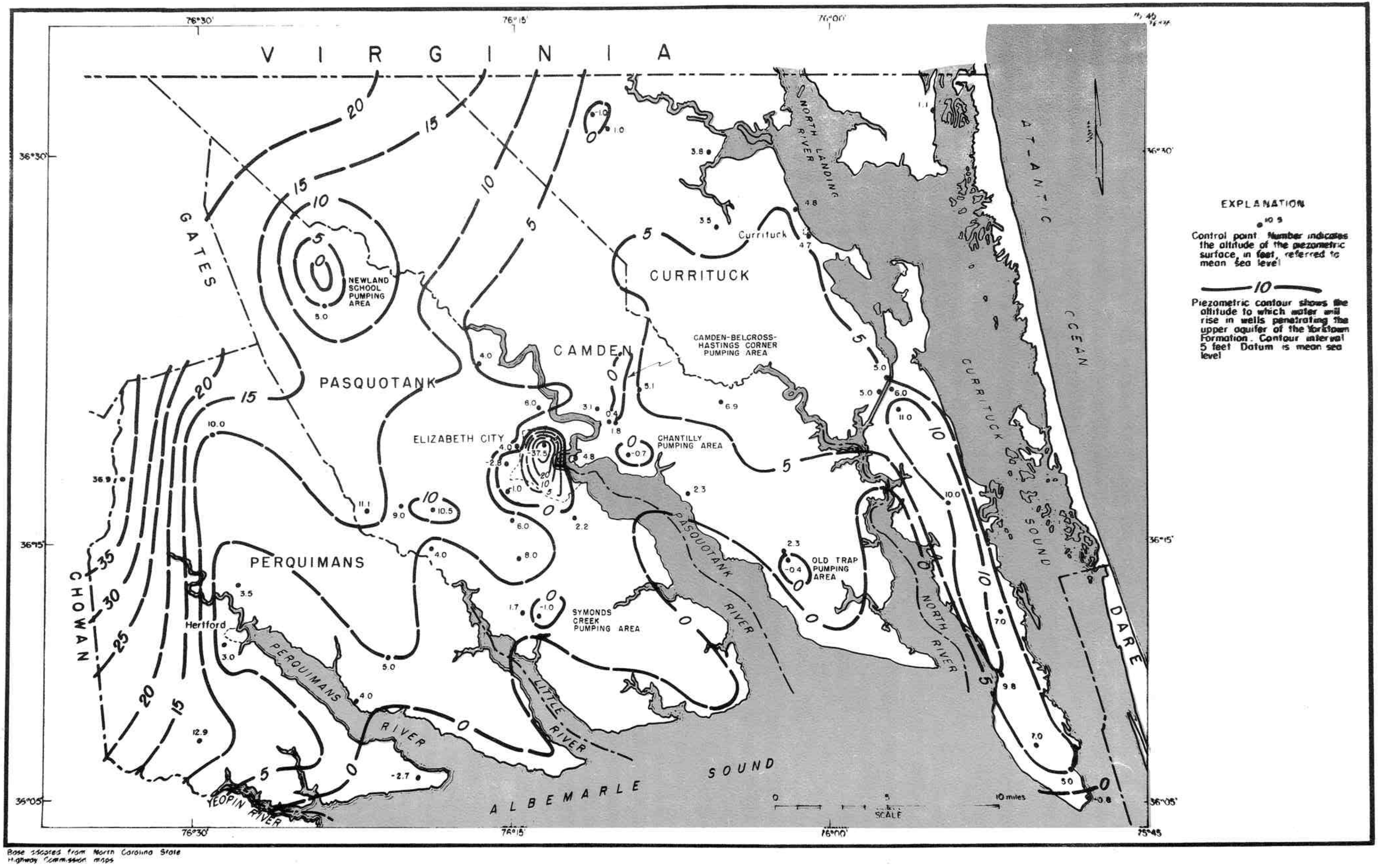


FIGURE 6. PIEZOMETRIC SURFACE OF THE YORKTOWN UPPER AQUIFER

ground-water gradient is caused by the development, because of pumping, of a cone of depression in either the water-table or piezometric surface that has access to a surface stream or other body of water.

In the Hertford-Elizabeth City area, the Miocene strata beneath the Yorktown aquifers consist of nearly impermeable sandy clays containing lenticular sand and shell beds. These Miocene strata are saturated with water, but because of their low permeability they do not yield water to wells. However, these strata are of major hydrologic importance as a source of recharge to the underlying sand and limestone aquifers of Cretaceous and Paleocene age. To some extent the downward leakage of water from the Miocene strata may dilute the saline water that is prevalent in the Cretaceous and Paleocene aquifers of the Hertford-Elizabeth City area. Chloride-ion concentrations ranging from 300 to 1,000 ppm are common for water in these aquifers in some parts of the area. (See fig. 7)

Recovery of Water

General features

Ground water may be recovered from wells or springs. At present, all ground-water supplies in the Hertford-Elizabeth City area are obtained from wells. The springs which originate in peat deposits north of Aydlett along Currituck Sound formerly were a source for domestic water supplies. Wells are classified according to their method of construction; dug wells, bored wells, driven wells, and drilled wells. In order of decreasing prevalence, well types in the Hertford-Elizabeth City area are; dug wells, driven wells, jetted-drilled wells, rotary-drilled wells, and drilled cable-tool wells.

Dug wells

Dug wells are large-diameter holes deep enough to reach the water table. The dug well is excavated manually, and cribbing consisting of terra cotta, wood, tile, brick, concrete, or stone is placed to retain the sides of the wells. Curbing is installed at the top of the hole to prevent surface-water runoff from seeping into the well which might contaminate the ground-water supply. Such wells in the Hertford-Elizabeth City area, 10 to 30 feet deep, are generally dug during the summer and fall when seasonal ground-water levels are at their lowest.

Bored wells

Bored wells are excavated by means of hand or power augers. The depth of such excavations is dependent upon the nature of the material penetrated and upon the location of the water table. The larger holes are lined with tile, concrete, or stone; the smaller holes are cased with a metal pipe perforated at the depth of the water-bearing formation or to which a screened well point is attached.

Driven wells

To construct a driven well, a screened well point attached to a length of pipe is driven into the ground either manually or mechanically. Successive lenghts of pipe are attached and driven until the screened well point is in a water-bearing zone. Driven wells range from 1 to 2 inches in diameter; few are more than 40 feet deep. These wells are common in the Hertford-Elizabeth City area and generally yield 2 to 10 gpm (gallons per minute).

Drilled wells

Drilled wells are of three main types; the jetted well, the cable-tool well, and the rotary well.

Jetted Wells

Jetted wells are constructed by pumping water down a drill stem and out through a drill bit, loosening material by force of the water and bringing it to the surface by the return stream of water. In drilling through consolidated formations, the bit is alternately raised and dropped in the hole. The cutting action of the bit augments the jetting action of the water and the drill stem is "rocked" back and forth during

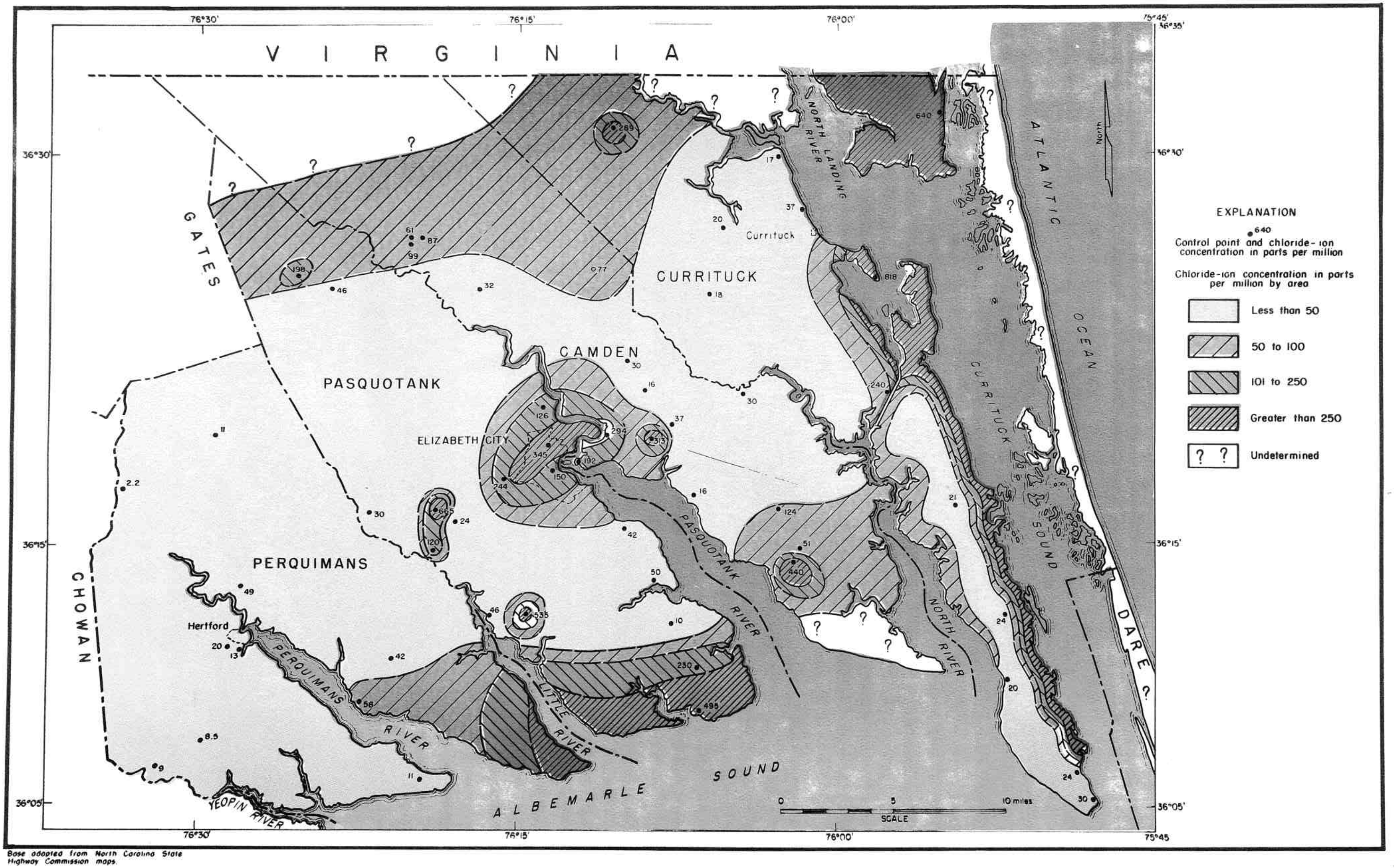


FIGURE 7. CHLORIDE CONCENTRATION OF GROUND WATER IN THE YORKTOWN UPPER AQUIFER

the drilling operation in order to insure a straight hole. Casing is emplaced around the drill stem as the hole becomes progressively deeper, or it may be set in one complete operation after drilling.

Cable-Tool Wells

To construct a well by the cable-tool method, a string of tools consisting of cable socket, sinker bar, jars, auger stem, and bit is attached to a cable and alternatley raised and dropped in the hole. The percussion action of the bit, motivated by a walking beam, causes the rock to be broken and crushed in the hole. When sufficient cuttings have accumulated in the hole, the tools are withdrawn and cuttings are removed by a bailer or sand pump. As drilling progresses, casing is emplaced successively until competent rock is reached and caving is no longer a danger. Cable-tool wells are not common in the Hertford-Elizabeth City area.

Rotary Wells

To construct a well by the rotary method, a bit attached to a length of drill stem is rotated in the hole. Drilling fluid of clay suspended in water is pumped down the drill stem, out through the bit, and is returned to the surface through the drilled hole. The drilling fluid carries the well cuttings to the surface and because it contains clay also seals the sides of the hole and serves to prevent caving during drilling. Casing may be set behind the bit as drilling progresses or it may be installed in one complete operation after drilling.

A common type of rotary-constructed well in the Hertford-Elizabeth City area is referred to as a "gravel-wall" well. This well is a standard rotary hole reamed at screening depth to a diameter greater than the desired diameter of the casing. Sized gravel is forced or fed by gravity into the hole to form a gravel envelope about the screens thereby increasing their effective diameter. The advantage of this method is that the outer edge of the gravel envelope serves as a sediment trap for sand-sized particles, thus minimizing some of the error involved in emplacing the well screens and in determining the correct size of screen opening.

Owing to the thin clay-bearing lenticular nature of the Yorktown aquifers and post-Miocene water-bearing zones in the Hertford-Elizabeth City area, difficulty is experienced in placing screens successfully, and ordinary screened wells rarely yield as much water as gravel-walled wells of comparable depth.

Hydrologic Principles

The natural level of water in a well, prior to pumping, is in equilibrium with the water level in the surrounding aquifer and is called the static water level. When pumping commences, the water level in the well falls. The verticle distance that the water level is lowered at any time in or near the well by pumping is termed "drawdown", and is more or less proportional to the pumping rate. As a well is pumped the water table or piezometric surface assumes the approximate shape of an inverted cone having its apex at the center of withdrawal. This is called the "cone of depression" and the area within the perimeter of the cone is termed the "area of influence." The size, shape, and rate of growth of the cone of depression and its corresponding area of influence depend on several factors: (1) the water-transmitting and water-storing capacities of the aquifer, (2) the rate of pumping, and (3) the increase in recharge resulting from the decline in the water levels.

The quantity of water that may be pumped from a well or group of wells in the Hertford-Elizabeth City area is limited by the drawdown that may be maintained without causing the mineral content of the water to become intolerable. In areas adjacent to the sounds and the tidal reaches of rivers, the yield is determined by the extent to which water levels may be lowered without causing brackish or saline water to move into the aquifers. In interstream areas and areas more remote from tidal reaches of surface water, the yield if determined by the depth to which water levels may be lowered without inducing an excessive upward movement of saline water from lower zones of an aquifer or from underlying aquifers.

The capacity of a well defined as the amount of water, measured in gallons per minute, that it will yield continuously over a given period of time depends on permeability and recharge of the aquifer.

The specific capacity of a well is the amount of water produced in gallons per minute per foot of drawdown measured within the well.

Specific yield of a well is the actual amount of water in gallons per minute per foot of drawdown measured in the aquifer adjacent to the well that a well will produce for a given period of pumping.

Well efficiency depends on such variables as choice of screen size, size of gravel in the gravel pack, pressence or absence of clay in the gravel pack, density spacity of gravel in the gravel pack, and turbulence in the pump, pipe, well screens and gravel pack. It is defined as the percent ratio of the specific yield to the specific capacity of a well.

PRINCIPAL AQUIFERS AND THEIR HYDROLOGIC CHARACTERISTICS

Ten aquifers are defined in the Hertford-Elizabeth City area; one aquifer in sands of Cretaceous age, five aquifers in sands and of the Paleocene Beaufort Formation, one aquifer in sands and silts of middle Miocene age, two aquifers in sand and shell beds of the upper Miocene Yorktown Formation, and the unconfined water-table aquifer in sands of post-Miocene age.

Cretaceous Aquifer

The one Cretaceous aquifer is known to contain only saline water of unusable quality. There are no wells in the area which are known to draw water from it.

Beaufort Aquifers

The five Beaufort aquifers yield saline and brackish water in the Hertford-Elizabeth City area to a few wells which provide domestic water supplies.

Water in the Beaufort aquifers under artesian pressure rises from 1 to 8 feet above land surface in wells in the interstream areas. Along Sandy Ridge water levels in wells in these aquifers lie as much as 32 feet below the land surface.

The diameter of most of the wells in the Beaufort aquifers is 2 inches or 4 inches. They yield 10 to 20 gpm; their specific yields range from 0.17 to 0.74 gpm per foot of drawdown.

Middle Miocene Aquifers

Middle Miocene aquifers contain brackish water and are not generally utilized as a source of water supply in the Hertford-Elizabeth City area. At Newland School in northern Pasquotank County, water from these aquifers is under artesian pressure (PA-T1-62). The piezometric surface of middle Miocene aquifer 1 is 2 feet above the land surface, and of aquifer 2, 8 feet below the land surface. Water from middle Miocene aquifer 2, 170 to 180 feet below the land surface, has a chloride content of about 380 ppm and an iron content of about 0.3 ppm. Compared to the quality of water from other aquifers in the Newland School area (table 7, fig. 13), water from middle Miocene aquifer 2 is of better chemical quality and is a potential source of domestic and industrial supply in this part of the Hertford-Elizabeth City area.

Yorktown Aquifers

Two aquifers are defined in the upper part of the Yorktown Formation of the Hertford-Elizabeth City area. The lower aquifer of the Yorktown Formation is absent in most of Pasquotank and Perquimans Counties. The upper aquifer of the Yorktown Formation is present throughout the Hertford-Elizabeth City area with the exception of Harveys Neck in southwestern Perquimans County where auger hole PE-A5-62 penetrated clay at a depth of 129 feet below msl (fig. 6).

Yorktown lower aquifer

Where present, the Yorktown lower aquifer is 10 to 20 feet thick, occurring between 120 feet and 175 feet below land surface. It consists of medium- to coarse-grained quartz sand and shell. In the east-central part of Pasquotank County and in the southern part of Camden County, these quartz sands grade both downward and laterally into loosely consolidated to indurated shell marl. The marl in the east-central part of Currituck County grades laterally into shell limestone, and grades downward into a unit composed of glauconitic quartz sand with interbedded quartz sand and shell marl. The interbedded marl is composed of oyster, scallop, and conch shells. On Church Island in Currituck County, the limestone-glauconitic quartz sand section has a thickness of 100 to 150 feet.

Water in the Yorktown lower aquifer is under artesian pressure. All the wells that obtain water from this aquifer are $1\frac{1}{2}$ to 2 inch-diameter single-screen wells. Individual wells yield 5 to 12 gpm; yields of from 20 to 40 gpm are common where the aquifer is at its greatest depth below mean sea level in southern Camden County. Specific yields range from 0.20 to 0.28 gpm per foot of drawdown in most of the area, but range from 0.80 to 1.60 gpm per foot of drawdown in southern Camden County (tables 2, 4, 6).

The piezometric surface of the Yorktown lower aquifer is above mean sea level in the Hertford-Elizabeth City area, except in southeastern Pasquotank and southwestern Camden Counties where pumping has created large cones of depression. Water from those parts of the aquifer having an artesian head greater than 5 feet above msl generally is fresh.

The Yorktown lower aquifer is recharged locally by downward leakage from the water-table aquifer (post-Miocene surficial sands) and from the Yorktown upper aquifer. In general, the piezometric surface of the Yorktown lower aquifer decreases in altitude to the southeast.

Yorktown upper aquifer

The Yorktown upper aquifer occurs between 45 and 100 feet below land surface. Throughout most of the area it averages 50 feet in thickness, ranging in thickness from 25 to 85 feet. A generalized section of the aquifer at Elizabeth City consists of 20 feet of iron-stained, yellow, medium-grained quartz sand, underlain by 15 feet of yellow, fine- to medium-grained quartz sand, 15 feet of gray to blue mud and clay, 10 feet of gray, fine- to coarse-grained sand, 10 feet of gray coarse-grained quartz sand shell, 7 feet of indurated shell marl, and 5 feet of gray fine-grained quartz sand. The Yorktown upper aquifer is generally separated from the Yorktown lower aquifer by a clay aquiclude 10 to 20 feet thick. In the Dismal Swamp area, to the west of Elizabeth City, neither the clay aquiclude within the Yorktown upper aquifer nor the clay aquiclude between the water-table aquifer and the Yorktown upper aquifer is present. In this area the post-Miocene and Yorktown sand aquifers are both hydrologically and lithologically continuous (Lohman, 1936; Mundorff, 1947).

The water in the Yorktown upper aquifer is under artesian pressure. Most of the wells in this aquifer are jetted or driven, $1\frac{1}{2}$- to 2-inch diameter, single-screen wells. Large diameter 6 to 10 inch, drilled, gravel-walled, multiple screen wells obtain water from the Yorktown upper aquifer for part of the municipal water supply of Elizabeth City and Hertford and for the U. S. Department of Defense at Harveys Point in Perquimans County. Small-diameter wells yield from 1 to 50 gpm; large-diameter gravel-walled wells yield from 95 to 385 gpm. The specific yields for small-diameter wells range from 0.20 to 2.50 gpm per foot of drawdown, and for large diameter wells range from 2.95 to 10.00 gpm per foot of drawdown (tables 2, 4, 6, 8). The artesian head in the Yorktown upper aquifer is above mean sea level throughout most of the aquifer area (fig. 6). However, in areas which have been subjected to heavy pumping the piezometric surface is now below mean sea level. Cones of depression having a maximum negative head of 1 foot below msl have developed near the towns of Moyock in Currituck County, Old Trap, Chantilly, and Camden-Belcross-Hastings Corner in Camden County, and Symonds Creek and Newland School in Pasquotank County (fig. 6). The cone of depression developed in the Yorktown upper aquifer near Elizabeth City has a maximum negative head of 38 feet below msl (fig. 6). Specific yields range from 0.13 to 0.32 gpm per foot of drawdown (tables 2, 4, 6, 8).

The chemical quality of the water from the Yorktown upper aquifer is generally acceptable for domestic purposes except in parts of southern Pasquotank and Camden Counties, along Albemarle Sound and the lower Pasquotank and Little Rivers, and in parts of northeastern Currituck County along Currituck Sound, Tull Creek, and Coinjock Bay where the water is saline (table 9).

Water-Table Aquifer

The uppermost aquifer of the Hertford-Elizabeth City area is in surficial sands of post-Miocene age. These sands, containing unconfined ground water, furnish water to more wells in the area than any other aquifer. Sands in this unit between thin beds of clay range from fine to coarse grained and poorly sorted to well sorted. In the vicinity of Elizabeth City, the aquifer consists of 13 feet of fine-grained sand underlain by 6 feet of medium- to coarse-grained sand. It is generally separated from the underlying Yorktown upper aquifer by 5 to 40 feet of clay, and locally is overlain by about 8 feet of sandy clay and 3 feet of soil.

Water levels in this aquifer show large fluctuations in response to seasonal variations in rainfall and evapotranspiration. Wells in this aquifer are shallow $1\frac{1}{4}$-to 2-inch diameter driven wells or 12- to 30-inch diameter dug wells, generally not greater than 25 to 35 feet deep, which may yield from 2 to 10 gpm. Gravel-walled 2-inch diameter driven wells furnish 7 to 15 gpm each from the Elizabeth City municipal well field.

Gravel-walled 8-inch diameter drilled test wells at the Elizabeth City municipal well field yield 20 to 62 gpm from the water-table aquifer. Specific yields for the large-diameter wells range from 0.88 to 3.33 gpm per foot of drawdown (table 6).

Water-level records show that seasonal fluctuations in the water table are large, but for a 30-year period there has been no long-term rise or decline in water levels (fig. 8).

The chemical quality of water from the water-table aquifer is suitable for domestic use. The water is soft, generally corrosive and highly colored, but it may contain objectionable amounts of iron.

The water-table aquifer is recharged by precipitation and by upward leakage of underlying artesian aquifers. Springs that occur in the peat bed at the base of the Aydlett "Narrow Shore" Ridge north of Aydlett, Currituck County, discharge into Currituck Sound (fig. 5).

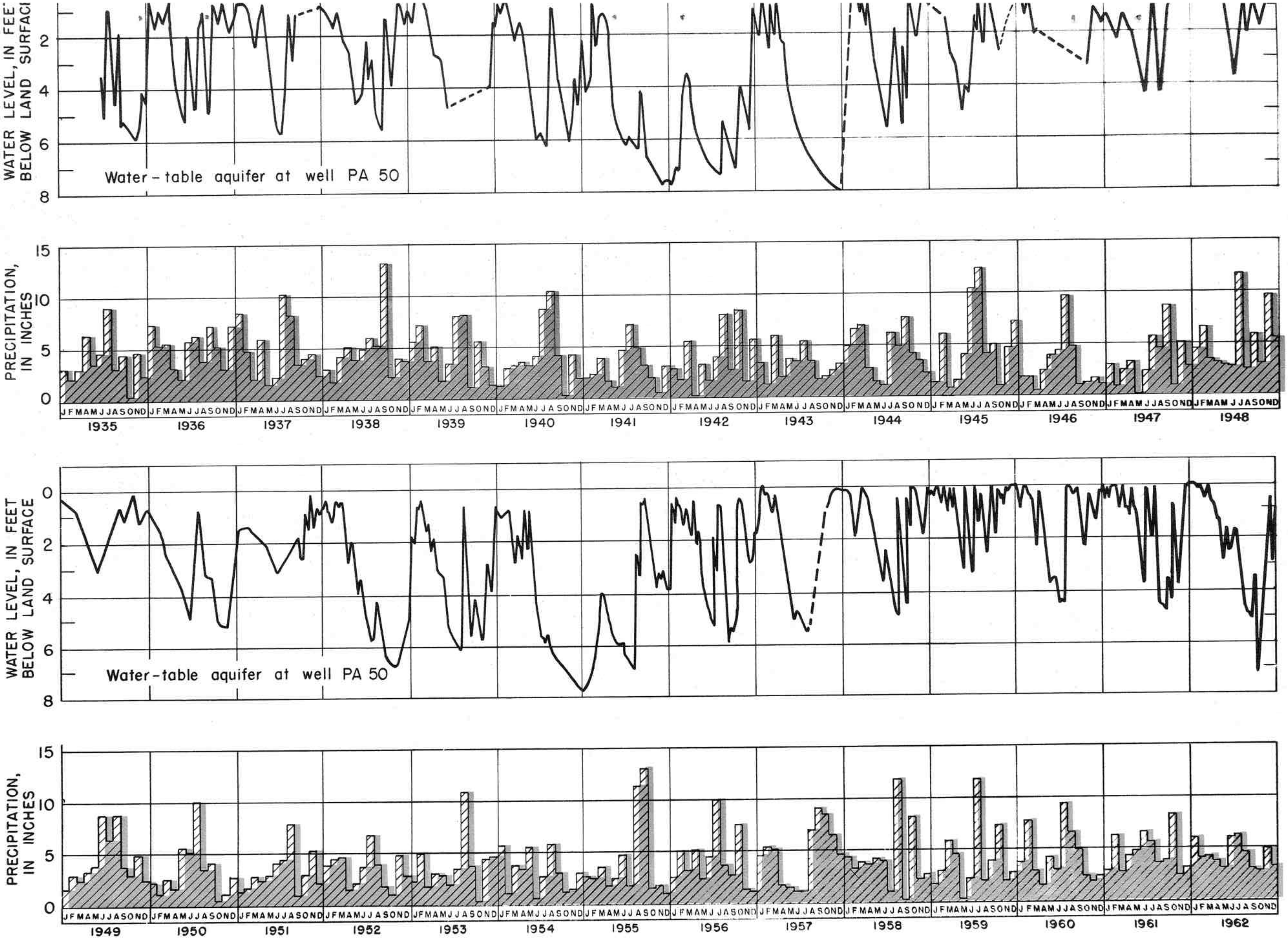


FIGURE 8. HYDROGRAPH OF OBSERVATION WELL 31T (PA-50) IN PASQUOTANK COUNTY AND MONTHLY PRECIPITATION AT ELIZABETH CITY (1935-62)

QUALITY OF WATER

By

H. B. Wilder

Introduction

An adequate appraisal of the ground-water resources of an area must include consideration of data of the quality of water available as well as the quantity. Chemical and physical quality of water govern its use. Chemical quality commonly refers to the types and amounts of mineral constituents dissolved in water, and physical quality to temperatue, taste, odor, and appearance of the water.

Information bearing upon quality of water is an important factor influencing location or relocation of industries in a community. Municipalities that find it necessary to expand public-water supplies require detailed data about the quality of local ground water to ascertain if it can be supplied more economically than surface water. As irrigation becomes more important in farming, the need for data on the mineral content of ground water in agricultural areas becomes critical. This is particularly true in the Coastal Plain province of North Carolina. Although much of the well water available can be used for irrigation, a significant part of it would be harmful to crops and to the physical and chemical properties of the soil.

The Hertford-Elizabeth City area is fortunate, because an adequate amount of water can be obtained from wells anywhere in the area. However, the quality of this water varies greatly both areally and with depth. Decisions concerning its use must be based upon careful study of all the information available relative to quality. Frequently a difference of only a few feet in the depth of a well will determine whether or not the water obtained will be suitable for a specific purpose.

Geochemistry

A discussion of a few basic principles relating to the geology and the chemical quality of water in the Hertford-Elizabeth City area will provide a better understanding of the ground-water problems. The three major objectionable features of the chemical quality of ground water in this area are iron, hardness, and chloride. Each of these is directly related to the geologic environment in which the water exists.

Carbon dioxide (CO_2)

Carbon dioxide in solution reacts with water to form carbonic acid, which increases the solvent action of water on many rocks and minerals. In its passage through the atmosphere rainwater dissolves carbon dioxide from the air in amounts ranging from 0.5 to 2.0 ppm (Nordell, 1961). The pH of rainfall in North Carolina ranges from 4.0 to 5.5 (oral commun., 1963, R. L. Laney, USGS). In the upper soil horizons decaying organic matter and the metabolic processes of plant roots furnish additional carbon dioxide to water percolating to the water table. The amount of gas dissolved after water enters the soil far exceeds that dissolved from the atmosphere (Hem, 1959).

Common compounds of iron and the carbonates of calcium and magnesium are particularly susceptible to solution by slightly acidic waters. The characteristically high iron content and hardness of much of the potable ground waters of the Hertford-Elizabeth City area is indirectly due to carbon dioxide dissolved by water before it reaches the water table.

Shell material

During the deposition of Coastal Plain sediments, a considerable amount of shell material was deposited with the sand, silt, clay, and marl. Shell fragments are found in most of the water-bearing zones in the Hertford-Elizabeth City area. This material is composed primarily of calcium carbonate which is readily soluble in acidic water. Shell fragments are most important, geochemically, in the late Miocene sediments. Slightly acidic waters percolating downward to the water table pass directly into coquina or shell marl of late Miocene age, rapidly dissolve calcium and magnesium carbonate, and become hard. Most, if not all, of the objectionable hard fresh waters in the area are a result of the carbon dioxide-bearing waters reacting with shell material.

Residual sea water

With the exception of parts of the water-table aquifer, all of the water-bearing zones in the Hertford-Elizabeth City area were saturated with sea water either during or subsequent to the time of their deposition. Since the most recent withdrawal of the ocean, fresh water originating from rainfall has gradually been flushing the salt water from these aquifers. In the area of investigation, the deeper aquifers, although partially flushed, still retain this residual sea water, much of which is too saline to be useful.

Chemical Quality

During this investigation 138 water samples were collected in the Hertford-Elizabeth City area and 2 to 15 individual chemical and physical determinations were made on each of the samples. In addition to these samples, other analyses were available for reference in the files of the Quality of Water Branch of the U. S. Geological Survey, and several recorded analyses were obtained from the Elizabeth City Department of Water Works. Samples not collected specifically for this study are not included in the tables of chemical analyses in this report, but they were valuable in formulating the discussions and interpretations of the chemical quality of ground water in the area.

Unless otherwise noted, results of the chemical analyses are reported in parts per million by weight (ppm). For example, a sample with a chloride concentration of 250 ppm would contain 250 pounds of dissolved chloride in each one million pounds of water. Parts per million may be converted to grains per U. S. gallon by dividing the reported ppm by 17.1.

A discussion of the significant analytical determinations made upon the water samples used in this report follows.

Silica (SiO_2)

Silica in ground waters results from chemical and physical decomposition of silicate minerals which are abundant in most rocks. The chemistry of the element silicon when dissolved in water is rather complex, and, for simplicity, it is commonly considered to exist in particles of amorphous silica of subcolloidal size. These particles exhibit some properties of both true solutes and true colloids. Silica is reported in the analyses as being dissolved, but is not considered to enter into the ionic equilibria of the solution.

Silica is of little significance for domestic and most industrial users, but it forms a hard scale in high pressure boilers and steam turbines when present in solution with calcium and magnesium.

Silica in the Hertford-Elizabeth City area ranges from about 4.1 to 72 ppm. The highest concentrations occur in waters obtained from aquifers which have large amounts of shell material.

Iron (Fe)

Iron compounds are present in most lithic units. The amount found dissolved in ground water is controlled to a large extent by the chemical characteristics acquired by a water before it enters the unit. Iron is particularly susceptible to solution by the slightly acidic water most common in the water-table aquifer, therefore, water obtained from this aquifer usually has a high concentration of iron. In areas where the Yorktown upper and lower aquifers are being recharged from the water-table aquifer, dissolved iron is carried down into them and may be retained in solution at considerable depth.

Iron exists in two chemical-oxidation states--ferrous iron, which is soluble in natural waters, and ferric iron, which is insoluble. When water containing large amounts of ferrous (soluble) iron is withdrawn from a well and exposed to the atmosphere, the dissolved iron is oxidized by atmospheric oxygen to ferric (insoluble) iron, and precipitates as red-brown ferric hydroxide ($FeOH_3$). Therefore, water containing dissolved iron may be clear when withdrawn from the ground, but becomes turbid from the rusty iron precipitate.

Iron in amounts as much as 0.3 ppm is not objectionable for most uses. Greater concentrations stain laundry, porcelain fixtures, utensils, etc. Some industries, particularly those producing textiles, processing food, and manufacturing paper require water which is essentially iron free. Iron is not difficult to remove from water, and where more satisfactory supplies are not available it can be economically eliminated.

In the Hertford-Elizabeth City area, iron concentrations in ground water have been observed to range from 0.01 to 27 ppm; in general, the iron content of water becomes progressively less with depth of the aquifers.

Calcium (Ca) and Magnesium (Mg)

Calcium and magnesium, which are dissimilar in many of their chemical reactions, are usually considered together when evaluating the utility of a water because of their parallel importance in hardness and formation of scale.

Because of large amounts of shell in many of the lithic units, fresh ground waters in the Coastal Plain of North Carolina generally contain higher concentrations of calcium than of magnesium. Calcium salts are more insoluble than those of magnesium and, where scale formation is a factor, calcium causes more scale to form than magnesium.

Sea water contains about three times as much magnesium as calcium. High concentrations of magnesium in ground waters of the Hertford-Elizabeth City area are attributable to the presence of residual sea water too saline for most uses. Occasionally, wells may penetrate localized deposits of dolomite or high-magnesium limestone, which also produce water having unusually high ratios of magnesium to calcium.

Calcium concentrations in water from the Hertford-Elizabeth City area range from 1.4 to 226 ppm; magnesium concentrations range from 1.2 to 142 ppm.

Calcium and magnesium may be economically removed from waters which are otherwise suitable for use.

Sodium (Na) and Potassium (K)

Minerals containing sodium and potassium are common in many of the North Carolina Coastal Plain rock units. Generally, these minerals are not very soluble in natural waters; in this area concentrations resulting from direct solution of the aquifer materials seldom exceed 40 ppm of sodium and 10 ppm of potassium. However, much higher amounts of sodium may be contributed to ground waters by either sea-water contamination or base exchange process.

Sodium salts are highly soluble in water, and once this constituent is dissolved it tends to remain in solution. As a result, the oceans are greatly enriched in sodium--their offshore waters containing an average of 10,561 ppm (Rankama and Sahama, 1950). The presence of residual sea water in most of the deeper aquifers in the Hertford-Elizabeth City area accounts for their high concentrations of sodium.

Sodium influences the desirability of water for many uses including irrigation, steam boilers, and domestic purposes. A detailed discussion of these is not included here, because ground waters in the Hertford-Elizabeth City area in which sodium concentrations are significant have other objectionable chemical characteristics which preclude their use.

Potassium-bearing minerals are usually less susceptible to solution by ground water than those containing sodium. When dissolved, potassium tends to recombine with the products of chemical weathering to form other very insoluble minerals. Thus, concentrations of potassium in ground water are usually much lower than those of sodium. In the area of investigation, potassium in fresh waters is not high enough to influence the utility of the water.

Sulfate (SO_4)

In the Hertford-Elizabeth City area a variety of minerals is present containing sulfate or sulfide which may be dissolved or chemically altered to furnish moderate amounts of sulfate to solution by ground water. High concentrations of sulfate are associated with residual sea water which is unsuitable for use. Fresh ground water in the area is not known to contain more than 50 ppm sulfate, which is acceptable for domestic and most industrial uses.

Chloride (Cl)

Chloride is dissolved in moderate amounts from many common rocks, but the amounts attributable to direct solution of aquifer materials in the Hertford-Elizabeth City area does not appear to exceed 50 ppm. Residual sea water represents a more significant source of chloride in this area than solution of aquifer materials.

Chloride is acceptable to most users in concentrations as much as 250 ppm. Greater amounts create serious corrosion problems, and water with such concentrations is not recommended for domestic purposes (USDHEW, Drinking Water Standards, 1962). In this report, water containing 250 ppm of chloride or less is considered as fresh.

In most communities in this area an adequate quantity of fresh water can be obtained, but it is often necessary to treat the water for hardness or dissolved iron.

Much attention is being given to developing large-scale methods for removing salt from water, but at present these methods are expensive and impractical.

Fluoride (F)

Fluoride is a minor constituent in most natural ground waters. However, even in moderately small concentrations, it has sufficient physiological significance to merit special attention. In concentrations, of 1.0 to 1.5 ppm it has been shown to reduce dental caries in children. Amounts much greater than 1.5 ppm may cause permanent mottling of the teeth. Concentrations of fluoride in ground water in the Hertford-Elizabeth City area range from less than 0.1 to 2.8 ppm, but potable waters do not usually contain fluoride in excess of 0.5 ppm.

Nitrate (NO_3)

Generally, nitrate is not an important constituent in unpoluted ground waters. Properly constructed wells in the Hertford-Elizabeth City area seldom contain more than 5.0 ppm nitrate. Shallow or dug wells occasionally contain as much as 21 ppm, and such concentrations are usually the result of contamination by nitrogenous organic matter or fertilizer.

Sum of mineral constituents

The sum of mineral constituents represents the total amount of mineral matter dissolved in a water and expressed in ppm. This value is conventionally determined by evaporating a measured volume of water and weighing the dry residue. However, the chemical character of ground waters in the Coastal Plain of North Carolina is such that direct measurement of total dissolved solids is often unreliable, and a more representative figure can be obtained by complete analyses of the important dissolved constituents and presentation of the sum total of the individual values. In this calculation approximately one-half the value reported for bicarbonate is added.

For municipal supplies the sum should not exceed 500 ppm if other satisfactory supplies are available. Where such alternative sources do not exist sums up to 1000 ppm may be permitted. The total dissolved mineral matter in potable ground waters in the Hertford-Elizabeth City area seldom exceeds 1000 ppm.

Hardness

Waters which do not lather readily with soap and form curds are described as being hard. Such waters usually form scale in boilers, encrustations on cooking utensils, and frequently may leave deposits in water lines. Hardness may be caused by any polyvalent cation in solution, but of these only calcium and magnesium are present in significant amounts in ground waters of the Hertford-Elizabeth City area.

Hardness is reported as the weight in ppm of $CaCO_3$, which is chemically equivalent to the total weight of all hardness-causing constituents dissolved in a water. Industrial requirements vary greatly with respect to the acceptable amounts of hardness. The U. S. Geological Survey uses the following arbitrary ranges to classify the hardness of water:

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

Hardness in potable ground waters in the Hertford-Elizabeth City area ranges from 8 to 790 ppm. Most of the supplies classified as soft or moderately hard according to the above list contain objectionable amounts of iron. Hardness may be economically reduced in water for both domestic and industrial uses.

Hydrogen-ion concentration (pH)

The concentration of free hydrogen ions in a water determines whether the water is acid, basic, or neutral. The amounts of hydrogen ions in water vary so greatly that a negative logarithmic scale (pH) is used to represent the absolute concentration. This scale progresses numerically from 0 to 14. Values of pH less than 7.0 are acid, 7.0 is neutral and values greater than 7.0 are basic.

The pH of a water is important in determining its corrosive potential. In general, acid waters are more corrosive than those which are neutral or basic.

Phosphate (PO_4)

Phosphate in moderate amounts has little significance in determining water quality. In shallow wells high concentrations of phosphate may indicate contamination by household detergents or fertilizer, but such contamination was not observed in the area of investigation. Concentrations of less than 0.1 to 3.1 ppm are reported, but the potable waters analyzed did not contain phosphate in excess of 1.0 ppm.

Alkalinity as bicarbonate (HCO_3)

The property of alkalinity is defined as the ability of a water to neutralize acid. The most important constituent causing alkalinity in ground water is bicarbonate. Borates, phosphates, and other basic radical ions also contribute to alkalinity but their role is usually insignificant.

The most important source of bicarbonate in fresh ground waters of the Hertford-Elizabeth City area is shell material; waters high in calcium, therefore, are alkaline.

Bicarbonate alone has little significance in determining the utility of a water, but when it is in solution with calcium it may serve to form hard deposits in water lines, boilers, and on utensils. Waters having high concentrations of sodium bicarbonate will attain a high pH when heated, particularly under pressure, and often cause difficulty in commercial canning and food-preserving processes.

Specific conductance (micromhos)

The specific conductance of a water is a measure of the amount of electrical current it will conduct. Pure water is a very poor conductor, but highly mineralized waters conduct current readily. Therefore, specific conductance affords a quick approximation of the total amount of mineral matter dissolved in a water. It does not supply any information about the relative amounts of the various constituents commonly found dissolved in ground water. Most potable ground waters in the Hertford-Elizabeth City area have a specific conductance of less than 1200 micromhos.

Physical Quality

Temperature

An important feature of most ground waters is the relative absence of seasonal variation in temperature of the water. This is a particularly valuable characteristic for industrial processes involving heat transfer. The temperature of ground water in the Hertford-Elizabeth City area is usually between 60 and 70° F with seasonal variation seldom exceeding 5° F except in very shallow wells.

Color

Color in water is the brown tea-like stain frequently associated with swamp waters. It is organic in nature, and is believed to result from the decomposition of vegetable matter. Ground waters do not usually contain noticeable amounts of color, but in the Hertford-Elizabeth City area underground peat beds occasionally yield water with objectionable amounts of color.

Color gradation is determined by a comparison of the water with standard platinum-cobalt solutions and is reported in color units. Levels up to about 15 units are not troublesome for most uses but at significantly higher units the water becomes esthetically objectionable for drinking purposes and may stain clothing, porcelain fixtures, etc.

Color of ground waters in this area ranges from less than 1 to 90 units, but most samples examined contained less than 15 units.

Tastes and odors

Quantitative determinations of taste and odors are difficult and arbitrary, and no attempt is made to report them here. Most of the fresh ground waters in the Hertford-Elizabeth City area are acceptable in these respects. Some wells produce water having the characteristic "rotten-egg" odor of hydrogen sulfide. Most of the tastes reported in well waters from this area were accounted for by moderately high amounts of sodium chloride.

Quality of Water in the Principal Aquifers of the Hertford-Elizabeth City Area

Water-table aquifer

The water-table aquifer generally yields the least highly mineralized ground water in the Hertford-Elizabeth City area, but the chemical quality of the water is not uniform. Most of the samples analyzed from this aquifer contained objectionable amounts of hardness-causing constituents or iron.

Sums of mineral constituents ranged from 35 to 866 ppm, and about 79 percent was below 500 ppm. Chloride ranged from 3.0 to 726 ppm. Chloride concentrations exceeding 250 ppm were limited to a few areas immediately adjacent to large bodies of brackish surface waters in the eastern and southern parts of the area.

Hardness ranged from 8 to 621 ppm as calcium carbonate; about 26 percent of the samples analyzed was very hard, 6 percent hard, 35 percent moderately hard, and less than 33 percent soft.

Iron concentrations in waters from water-table wells ranged from 0.05 to 27 ppm; less than 10 percent of the samples analyzed contained 0.3 ppm or less of iron and 74 percent exceeded 1.0 ppm.

Other dissolved mineral constituents were not generally present in objectionable amounts. Unusually high nitrate or chloride in a few water-table wells indicated contamination by surface-water drainage. The concentrations found were not great enough to affect the usefulness of the water but point to possibly dangerous pollution by animal wastes.

The chemical quality of water in the water-table aquifer may vary greatly within small areas; no patterns of distribution for any of the dissolved constituents were discernable.

Yorktown upper aquifer

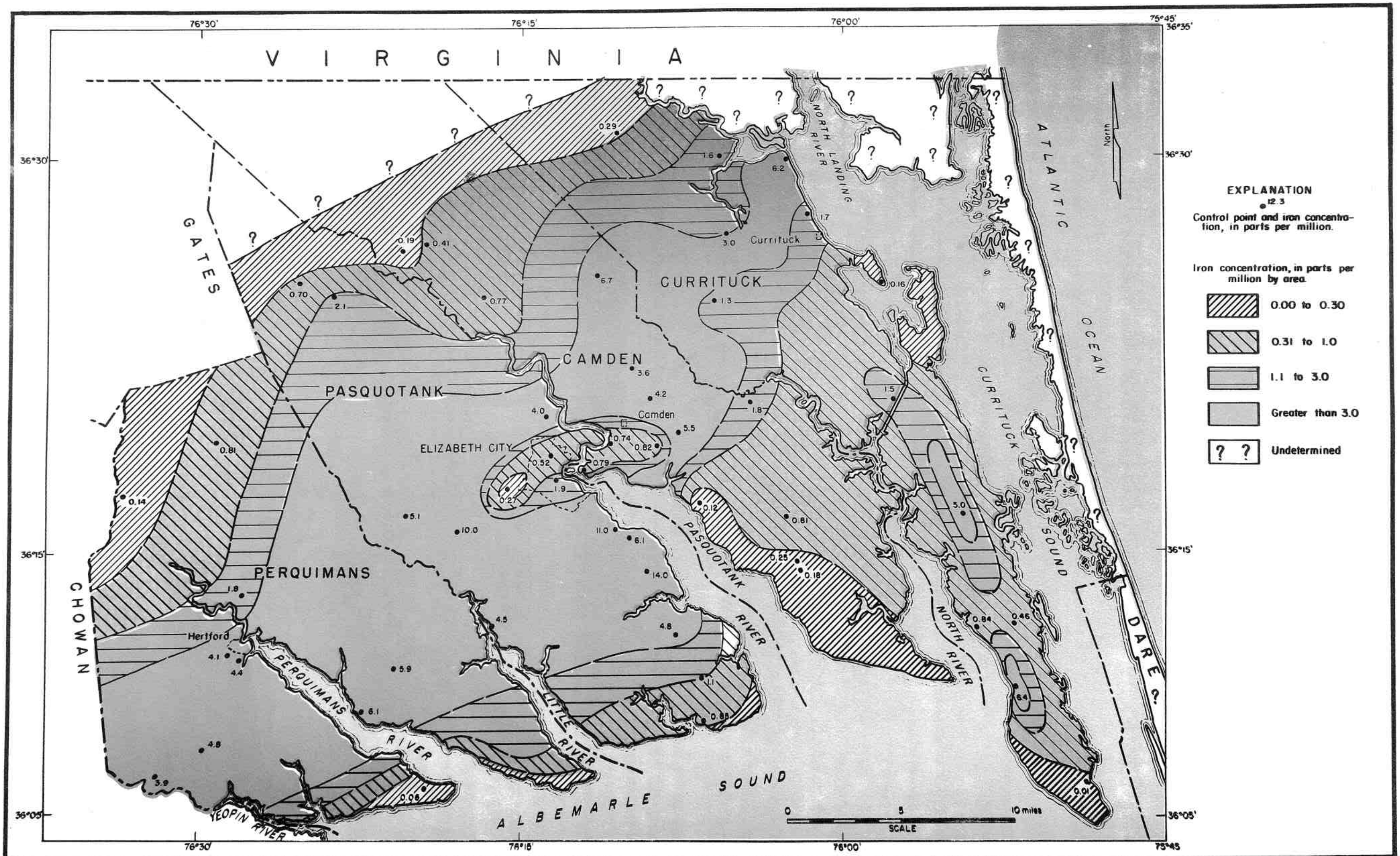
The Yorktown upper aquifer contains the only large amounts of usable artesian water available in the Hertford-Elizabeth City area. Water in this unit is fresh in most localities, but it generally contains objectionable amounts of iron and hardness-causing constituents and requires treatment to be satisfactory for most uses.

Chloride concentrations in water samples from this aquifer ranged from 2.2 to 818 ppm; approximately 85 percent of the samples contained less than 250 ppm. Concentrations of chloride greater than 250 ppm were found only in certain areas adjacent to the sounds, and in communities where heavy pumping of wells has developed large local cones of depression in the piezometric surface of the aquifer. The marked increase of chlorides within the area of influence of the cones of depression indicates that care must be used in future development of water supplies in the Yorktown upper aquifer to avoid the severe contamination that results from overpumping. Figure 7 shows the concentration of chloride to be expected in waters from wells screened in the Yorktown upper aquifer.

The hardness of waters sampled from the Yorktown upper aquifer ranged from 16 to 524 ppm as calcium carbonate. Approximately 60 percent of the wells sampled yielded waters having hardness in excess of 180 ppm and are classified as very hard; about 5 percent were soft, 20 percent moderately hard, and 15 percent hard. There does not appear to be any predictable pattern in the areal distribution of ground-water hardness. The few soft waters observed are pumped from sands which apparently contain very little shell material.

Objectionable amounts of iron are present in most of the waters from the Yorktown upper aquifer; concentrations ranged from 0.01 to 14 ppm in the wells sampled, and about 85 percent were more than 0.3 ppm. In general, iron concentrations follow reasonable well-defined distribution patterns, the greater amounts occurring in recharge areas and lesser amounts in discharge areas. Figure 9 shows the probable iron concentrations of water from wells in this aquifer.

Silica is a major constituent in many of the ground waters in the Yorktown upper aquifer. It ranges from 4.3 to 72 ppm; about 80 percent of the samples analyzed contained from 20 to 60 ppm, about 12 percent less than 20 ppm, and about 8 percent in excess of 60 ppm.



Base adapted from North Carolina State Highway Commission 1965.

FIGURE 9. IRON CONCENTRATION OF GROUND WATER IN THE YORKTOWN UPPER AQUIFER

Sodium concentrations ranged from 6.8 to 533 ppm in the samples analyzed. Concentrations exceeding about 175 ppm occur with chloride concentrations of more than 250 ppm. In figure 7 the zones having chloride concentrations of less than 50 ppm can be expected to contain less than 50 ppm of sodium.

Alkalinity as bicarbonate ranges from 20 to 785 ppm and is the major dissolved constituent in most ground waters of the aquifer; about 45 percent of the samples analyzed ranged from 101 to 300 ppm, about 35 percent from 300 to 500 ppm, about 10 percent from 20 to 100 ppm, and about 10 percent exceeded 500 ppm of alkalinity as bicarbonate.

Fluoride occurs in waters from the Yorktown upper aquifer in amounts ranging from less than 0.1 to 0.5 ppm, about 85 percent of the samples analyzed contained 0.1 to 0.3 ppm.

Other dissolved constituents were not observed to occur in objectionable amounts. Complete analyses of the samples collected for this investigation are found in the tables of water analyses accompanying the discussions of water quality by counties.

Yorktown lower aquifer

The Yorktown lower aquifer contains saline water throughout most of its extent. Chloride concentrations of the samples analyzed ranged from 41 to 1,240 ppm. Comparison of chemical analyses of water samples with water-level data indicates that water containing less than 250 ppm of chloride can generally be obtained in the central and northern parts of Camden County, and in parts of southern Pasquotank County where the piezometric surface of the aquifer is greater than 5 feet above msl. Exceptions to this rule are in areas influenced by the cones of depression in the piezometric surface of the Yorktown upper aquifer where, because of upward leakage, abnormally high chloride concentrations are found in the Yorktown lower aquifer.

Iron content of the fresh waters analyzed from this aquifer ranges from 0.05 to 0.96 ppm. Hardness ranges from 48 to 236 ppm. Other chemical characteristics were satisfactory for most purposes.

Beaufort aquifers

Chloride concentrations in samples from the Beaufort aquifers ranged from 321 to 4,680 ppm. It is believed that no potable water supplies can be obtained from these water-bearing zones.

Cretaceous aquifer

Few wells have been drilled into the Cretaceous formations in the Hertford-Elizabeth City area. One well is known to produce water containing 3,290 ppm of chloride from the Snow Hill Marl Member of the Black Creek Formation at Elizabeth City. There seems to be no possibility of obtaining potable water from the Cretaceous aquifer.

COUNTY DESCRIPTIONS

Camden County

(Area 239 square miles; population in 1960, 5,598)

Introduction

Camden County is in the east-central part of the area of investigation. It is bordered on the north by the Commonwealth of Virginia, on the east by Currituck County, on the south by Albemarle Sound, and on the west by the Pasquotank River and Pasquotank County (fig. 10). Major population centers include Camden, the county seat, and the towns of Belcross, Old Trap, Shiloh, and South Mills.

The county, generally less than 25 feet above sea level, is drained by several small creeks and canals that flow into the Pasquotank and North Rivers, and into Turners Cut and the Dismal Swamp Canal (Intracoastal Waterway). Much of the county is swampland. The Great Dismal Swamp occupies most of the northern part, and Great Swamp, east of the Camden sand ridge, occupies the southeastern and southern parts of the county. The chief source of income in the county is from the sale of agricultural products, and from timber, commercial fishing and trapping.

Geology

The entire county is covered with a thin surficial deposit of post-Miocene sands and clays. A post-Miocene sand ridge, Camden Ridge, forms the west margin of Great Swamp and extends northward into Currituck County (fig. 5). The surficial deposit, composed of light-colored clays and sands, is less than 45 feet thick in the northern part of the county, and about 85 feet thick in the extreme southern part of the county.

Underlying the surficial material are blue-to-gray clays, sands, coquinas, and indurated shell marls of the upper Miocene Yorktown Formation. The thickness of this unit generally increase progressively in the direction of its stratigraphic dip to the east-southeast and along strike to the north-northeast.

In the northwestern part of the county, the upper part of the Beaufort Formation of Paleocene age is probably represented by a glauconitic sand lithofacies; throughout the remainder of the county this glauconitic sand lithofacies is overlain by a limestone lithofacies. The total thickness of the Beaufort Formation in the DuGrandlee Foreman-1 oil-test well is 280 feet. The Beaufort Formation conformably overlies the Upper Cretaceous Peedee and Black Creek Formations in the central and southern part of the county and may unconformably overlie the Black Creek Formation and older Upper Cretaceous sediments in the northern part of the county.

Ground water

Camden County is one of the two counties in the Hertford-Elizabeth City area that has no municipal water systems. All private water supplies are obtained from wells; two or three families often obtain water from a single well. Large to moderate supplies of ground water are available throughout the county. The depth of individual wells depends upon the depth of saline water.

Aquifers in Camden County

Water of generally acceptable chemical quality is obtained from three aquifers in the county; the water-table aquifer, and the Yorktown upper and lower aquifers. The location of the wells inventoried in Camden County is shown in figure 10. Records of these wells are given in table 2. Chemical analyses of ground water are listed in table 3.

The water-table aquifer furnishes water to more wells in the county, and in particular the northern part of the county, than any other aquifer. Dug wells and driven wells in this aquifer range in depth from 5 to 25 feet and yield from 2 to 10 gpm (table 2).

Jetted and driven wells, either single screen or open end, obtain water from sands, coquinas, and indurated shell marls of the Yorktown upper and lower aquifers. Wells in the Yorktown upper aquifer range in depth from 50 to 114 feet and yield from 1 to 30 gpm. Those in the Yorktown lower aquifer range in depth from 130 to 165 feet and yield from 12 to 40 gpm. Specific yields for wells screened in the Yorktwon upper aquifer range from 0.05 to 1.36 gpm per foot of drawdown; and for wells in the Yorktown lower aquifer from 0.55 to 1.60 gpm per foot of drawdown (table 2). None of the wells in the Yorktown aquifers has been pumped more than 40 gpm, but larger yields probably could be obtained from these aquifers.

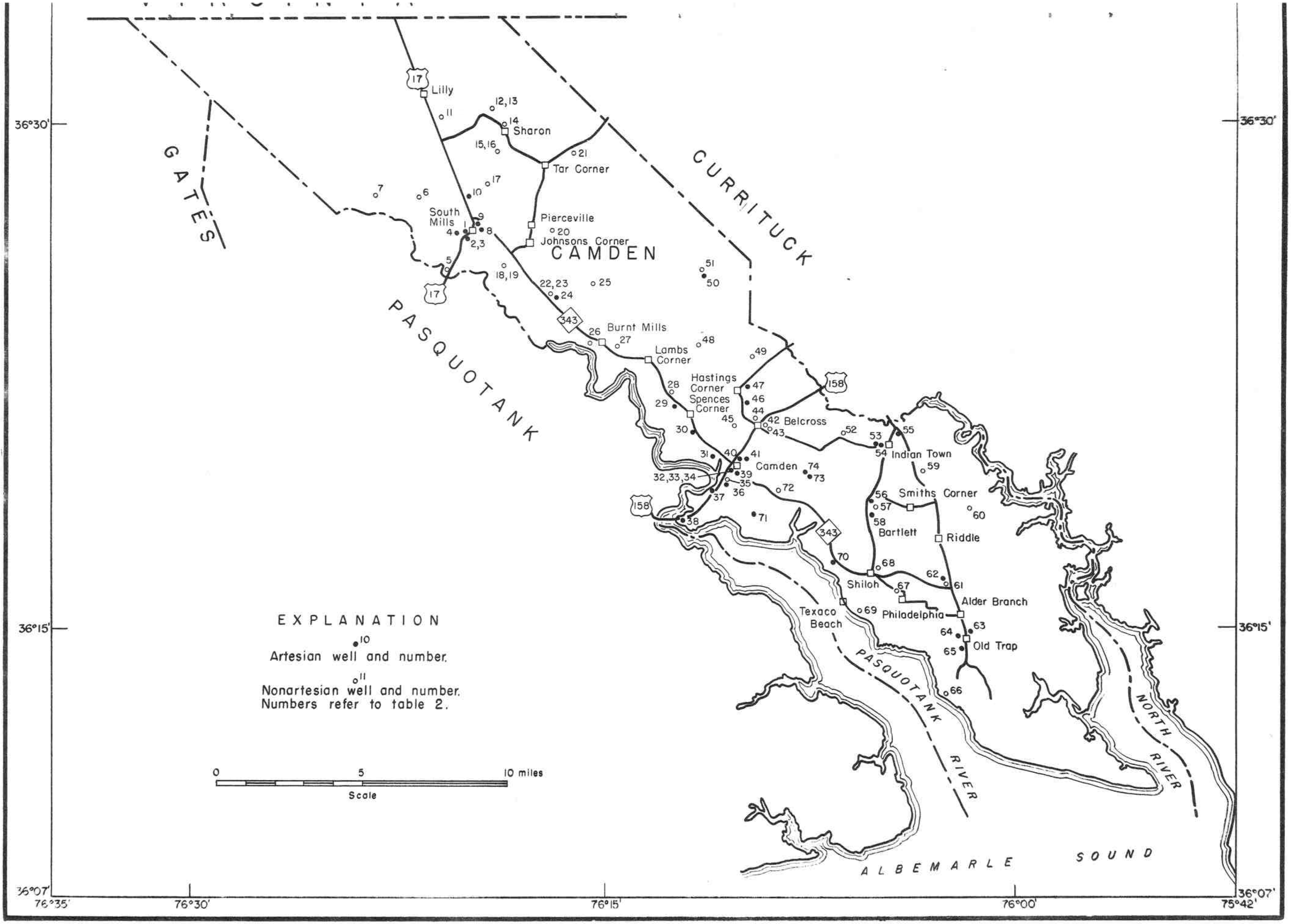


FIGURE 10. LOCATION OF WELLS INVENTORIED IN CAMDEN COUNTY

TABLE 2 - RECORDS OF WELLS IN CAMDEN COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Drawdown (ft.)	Spec. Yield (gpm/ft dd)	Remarks
1	South Mills	W. A. Jones	Jetted	75	$1\frac{1}{4}$	69	Upper Yorktown sand					Analysis --------------------------
2	...do...	US Army Corps of Eng.	..do..	50	$1\frac{1}{4}$	46	...do...					Analysis --------------------------
3	...do...	...do...	..do..	50	$1\frac{1}{4}$	46	...do...					Cl: 20ppm Total hardness 120 ppm Reported by EG Otton 10-8-43.
4	...do...	J. G. Etherdyl		60	$1\frac{1}{4}$		...do...					
5	1.6 mi SW of South Mills	D. Brothers	Driven	11.5	$1\frac{1}{4}$		Water-table sand	-1.95				Water level measured 6-13-62.
6	2.2 mi NW of South Mills	O.R. Fason	..do..	16.5	$1\frac{1}{4}$	13.5	...do...	-3.71				Water level measured 6-13-62.
7	3.5 mi NW of South Mills	M. Sawyer	..do..	17.6	$1\frac{1}{4}$	15.6	...do...	-5.83				Water level measured 6-13-62. Analysis ------------------------
8	South Mills	W.D. Kratz	Jetted	85	$1\frac{1}{4}$	80	Upper Yorktown sand					Analysis ------------------------
9	...do...	H. T. Mullens	..do..	68	$1\frac{1}{4}$	63	U. Yorktown sd & shell	-6	1	22	0.05	30 min pump. test, water level & yield meas. by driller 12-19-61.
10	1.2 mi N of South Mills	M.J. Johnson	..do..	70	$1\frac{1}{4}$	66	Upper Yorktown sand					
11	4.0 mi N of South Mills	J. Whitus	Driven	18.6	$1\frac{1}{4}$		Water-table sand					Analysis ------------------------
12	0.9 mi NW of Sharon	J.H. Whitehurst	Dug	12.5	30		...do...	-2.51				Abandoned; water level measured 6-15-62.
13	...do...	...do...	Driven	19	$1\frac{1}{4}$	15	...do...	-6				
14	Sharon Methodist Ch.	...do...	..do..	12.0	$1\frac{1}{4}$		...do...	-4.38				Water level measured 6-15-62.
15	0.7 mi W of Lilly	C. Hurdle	..do..	16.8	$1\frac{1}{4}$	12.8	...do...	-1.27				Water level measured 6-15-62.
16	...do...	...do...	..do..	21.9	$1\frac{1}{4}$	17.9	...do...	-1.03				Abandoned; water level meas. 6-15-62.
17	1.7 mi NE of South Mills	C.L. McPhearson	..do..	25	$1\frac{1}{4}$	21	...do...					
18	1.0 mi SW of Johnsons Cr.	B. Pritchard	Dug	12	24	12	...do...	-3.33				Obs. well; water level meas. 11-22-61.
19	...do...	...do...	Driven	10.1	$1\frac{1}{4}$	10.1	...do...					Analysis: Temp. 58° F., water level measured 5-14-62.
20	0.8 mi E of Pierceville	G. F. Pearce	Jetted	16	$1\frac{1}{4}$	12	...do...					
21	1.0 mi NE of Tar Corner	B. Pritchard	Driven	16.1	$1\frac{1}{4}$	11.1	...do...	-3.28				Obs. well; Analysis: water level measured 11-22-61.
22	2.0 mi SE of Johnsons Cr.	H. Sawyer	..do..	20	$1\frac{1}{4}$	15	...do...					
23	...do...	...do...	..do..	13.2	$1\frac{1}{4}$	10.2	...do...	-3.01				Water level measured 6-18-62.
24	...do...	W.B. Meiggs	..do..	67	$1\frac{1}{4}$	62	Upper Yorktown sand					Analysis ------------------------
25	2.7 mi SE of Johnsons Cr.	J. Brunson	..do..	10.6	$1\frac{1}{4}$	7.6	Water-table sand	-1.49				Water level measured 6-18-62. Analysis ------------------------
26	Burnt Mills (Jonesville)	N. Sawyer	..do..	13	$1\frac{1}{4}$	10	...do...					
27	0.5 mi E of Burnt Mills	M. Hall	Dug	6.9	18		...do...	-6.34				Water level measured 9-10-62.
28	1.0 mi NW of Spences Cr.	Dr. Bell	..do..	5.2	30		...do...	-3.69				Water level measured 9-10-62.
29	0.6 mi NW of Spences Cr.	R.M. Mansfield, Jr.	Jetted	130	$1\frac{1}{4}$	125	Lower Yorktown sand					
30	0.5 mi S of Spences Cr.	R. Meiggs	..do..	130.3	$1\frac{1}{4}$	125.3	...do...	-7.34				Analysis: Water level measured 9-10-62.

TABLE 2 - RECORDS OF WELLS IN CAMDEN - Continued

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Draw-down (ft.)	Spec. Yield (gpm/ ft dd)	Remarks
31	0.9 mi NW of Camden	Camden Co. (Elem. Sch.)	Jetted	90	1¼	85	Upper Yorktown sand	-6	30	25	1.20	30 min. pump. test. Water level & yield meas. by driller 5-22-62.
32	Camden	F.P. Wood & Son	..do..	89	1¼	84	...do...	-9	25	25	1.00	30 min. pump. test. Water level & yield meas. by driller 6-7-62.
33	...do...	Texas Serv. Station		72.8	1¼		...do...		47			Cl: 125 ppm, Total hard. 175 ppm. Yield and anal. rept. by EG Otton 9-19-50.
34	...do...	Camden High School		85	2	80	...do...					Cl: 108 ppm, HCO_3: 318 ppm. Water level and anal. rept. by Lehman.
35	0.6 mi SW of Camden		Dug	11.1	24		Water-table sand	-6.86				Water level measured 9-10-62.
36	0.8 mi SW of Camden	R. Cuthrell	Jetted	93	1¼	88	Upper Yorktown sand	-8	15	25	0.60	30 min. pump. test. Water level & yield meas. by driller 3-16-62.
37	1.2 mi SW of Camden	C. O. Roberson	..do..	100	1¼	95	...do...					Analysis ----------------------------
38	2.6 mi SW of Camden	J. F. Forehand	..do..	105	1¼	100	...do...	-4	9	25	0.36	Analysis: 30 min. pump. test. Water level meas. by driller 6-20-62.
39	Camden	F.P. Wood & Son	..do..	83.5	1¼	78.5	...do...	-7.60	5	25	0.20	Temp. 61° F. 30 min. pump test. WL & yield meas. 6-19-22.
40	...do...	E. Leary	..do..	80	2	75	...do...	-10	25	23	1.09	30 min. pump. test. Water level & yield meas. by driller 6-7-60.
41	...do...	E.A. Davenport	..do..	137	1¼	132	L. Yorktown sand & marl	-8	12	22	0.55	Analysis: 30 min pump. test. WL & yield meas. by driller 1-18-62.
42	Belcross	E.A. Harris	..do..	131	1¼	126	Lower Yorktown sand	-1	30	25	1.20	Analysis: 1 hr. pump. test. WL & yield meas. by driller 7- -61.
43	...do...	...do...	..do..	87.7	1¼	82.7	Upper Yorktown sand	-2.99 used to flow				Analysis: Abandoned water level 11-21-61. Observation well.
44	...do...	S. McPhearson	Driven	17.9	1¼	14.9	Water-table sand	-3.35				Water level measured 9-10-62.
45	0.8 mi W of Belcross	Sawyer's Crk. Parsonage	Jetted	90	1¼	85	Upper Yorktown sand	-8	20	25	0.80	30 min. pump. test. Water level & yield measured by driller 7-21-60.
46	0.5 mi SE of Hastings Cr.	C. Ferbee	..do..	106	1¼	101	...do...	-8	15	25	0.60	30 min. pump test. WL & yield meas. by driller 5-24-62.
47	0.4 mi E of Hastings Cr.	M.E. Cooke	..do..	114	1¼	109	...do...	-8	6	25	0.24	Analysis: 30 min. pump. test. WL & yield meas. by driller 6-7-62.
48	1.8 mi E of Lambs Cr.	C. Barco	Driven	9.6	1¼	6.6	Water-table sand	-2.30				Water level measured 6-20-62.
49	1.3 mi NE of Hastings Cr.	B. Trafton	..do..	21.9	1¼		...do...	-3.44				Abandoned: WL meas. 6-20-62.
50	3.5 mi NE of Lambs Cr.	G. Wood	Jetted	80	2	75	Upper Yorktown sand					Analysis ----------------------------
51	...do...	...do...	Driven	9.7	1¼	5.7	Water-table sand	-2.96				Analysis: WL meas. 6-20-62.
52	1.6 mi E of Indian Town	A. Spellman	..do..	11.0	1¼	9.0	...do...	-2.47				Analysis: WL meas. 9-10-62.
53	Indian Town	J.P. Forehand	Jetted	145	1¼	140	Lower Yorktown shell	-6	40	25	1.60	Analysis: 30 min. pump. test. WL & yield meas. by driller 8-58
54	...do...	G. Dough	..do..	136	1¼	131	...do...	-6	20	25	0.80	Analysis: 30 min. pump. test. WL & yield meas. by driller 3-57
55	0.6 mi N of Indian Town	N. Kight	..do..	90	1¼	85	Upper Yorktown sand	-0.1	30	22	1.36	Analysis: 30 min. pump. test. WL & yield meas. by driller 1-30-62.
56	1.3 mi W of Smiths Cr.	C.C. Hughes	..do..	165	1¼	160	Lower Yorktown sand					
57	...do...	...do...	Dug	9.0	30		Water-table sand	-4.43				Water level meas. 9-10-62.

58	0.9 mi N of Bartlett	J.T. Kigth	Jetted	162	1¼	159	Lower Yorktown marl	-8	35	25	1.40	Analysis: 30 min. pump. test. WL & yield meas. by driller 4-27-62.
59	1.5 mi SE of Indian Town	S.G. Wright	Dug	9.7	24		Water-table sand	-4.15				Temp. 67° F. WL meas. 11-22-61. Observation well. Analysis.
60	1.5 mi NE of Riddle	H. B. Harrison	..do..	7.0	24		...do...	-3.26				Water level meas. 6-19-62.
61	1.2 mi N of Adler Brch.	J. C. Burgess	..do..	8.3	20		...do...	-3.72				Water level meas. 11-22-61. Observation well.
62	...do...	...do...	Jetted	96	1¼	91	Upper Yorktown shell					Analysis -------------------------
63	Old Trap	G. Needham	..do..	64.0	1¼	59	Upper Yorktown sand	-5.38	24	25	0.96	Analysis: 30 min. pump. test. WL meas. 6-19-62; yield meas. by driller 5-22-61.
64	...do...	W.G. Kight	..do..	97.8	1¼	92.8	...do...	-5.34	8	25	0.32	Analysis: WL meas. 6-19-62; yield measured by driller 1955.
65	...do...	M.L. Pugh	..do..	61	1¼	56	...do...	-8	24	25	0.96	30 min. pump. test. WL & yield measured by driller 5-22-62.
66	2.1 mi S of Old Trap	J.B. Riggs	Driven	18.6	1¼	15.6	Water-table sand	-2.35				Analysis: WL meas. 11-22-61. Obs. well. Temp. 59° F.
67	0.4 mi NW of Philadelphia	V. Brown	Dug	12.4	24		...do...	-7.82				Water level meas. 11-22-61. Observation well.
68	Shiloh	J.W. Ferriell	..do..	10.1	24		...do...	-6.83				Observation well. Water level measured 11-22-61.
69	Texaco Beach	R.C. Boseman	Driven	12.4	1¼		...do...	-4.94				Water level measured 6-20-62.
70	1.4 mi W of Shiloh	E. Cartwright	Jetted	65	2	60	Upper Yorktown sand	-5	20	25	0.80	Analysis: 30 min. pump. test. WL & yield meas. by driller 5-2-61.
71	1.8 mi SE of Camden	D. Toler	..do..	95	1¼	90	...do...	-10	25	25	1.00	Analysis: 30 min. pump. test. WL & yield measured by driller 6-20-60.
72	1.7 mi SE of Camden	B.H. Cartwright	Dug	13.8	24		Water-table sand	-7.48				Analysis: Temp. 64° F. Water level measured 11-21-61. Obs. well.
73	2.4 mi SE of Belcross	E.S. White	Jetted	82.3	1¼	77.3	Upper Yorktown sand	-5.28	12	25	0.80	Analysis: Temp. 80° F. Water level meas. 6-18-62. Yield meas. by driller 4-47. 1 hr. pump. test.
74	2.4 mi SE of Belcross	...do...	..do..	147	2	142	Lower Yorktown sand	-8	25	25	1.00	1 hr. pump. test. Water level & yield meas. by driller 8-1-59. Analysis: Temp. 74° F.
DuGrandlee Foreman-1 Oil Test	2.4 mi N of Hastings Corner	G. Wood	Drilled	5,100								Abandoned; well penetrated Crystalline basement rock.

Table 3.--Chemical analyses of ground water from Camden County

Well number	Aquifer	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
CA 1	Upper Yorktown	--	2.7	51	9.0	--	--	186	--	61	--	--	--	--	166	13	--	6.5	--
CA 2	Upper Yorktown	34	.19	31	13	75	9.5	195	2.4	99	0.2	--	0.7	361	132	0	670	7.6	10
CA 7	Water table	--	2.9	--	--	--	--	--	--	15	--	--	--	--	60	--	230	--	--
CA 8	Upper Yorktown	21	.41	24	19	114	12	291	9.4	87	.2	--	.1	430	138	0	800	7.5	25
CA 11	Water table	--	3.9	--	--	--	--	--	--	22	--	--	--	--	264	--	630	--	--
CA 13	Water table	8.5	1.4	72	22	64	40	390	42	52	.1	10	--	504	270	0	902	7.8	4
CA 21	Water table	22	4.9	8.0	6.9	17	.9	9	36	26	.0	.2	--	124	48	0	201	6.0	2
CA 24	Upper Yorktown	51	.77	68	14	50	6.5	331	.2	32	.2	--	.4	386	226	0	648	7.2	9
CA 25	Water table	--	8.9	--	--	--	--	--	--	6.0	--	--	--	--	56	--	181	--	--
CA 30	Lower Yorktown	29	.05	8.8	6.3	169	14	338	.4	126	.2	--	.2	520	48	0	920	8.1	7
CA 37	Upper Yorktown	44	.74	69	30	180	16	357	4.6	294	.1	--	.3	815	296	3	1500	7.3	10
CA 38	Upper Yorktown	50	.79	42	31	149	20	379	.6	192	.1	--	2.0	674	234	0	1200	7.4	21
CA 41	Lower Yorktown	39	.54	41	48	311	32	467	4.2	456	.2	--	.1	1160	299	0	2130	7.4	9
CA 42	Lower Yorktown	49	.85	57	23	26	12	310	.8	41	.1	--	.0	363	236	0	576	7.6	10
CA 45	Upper Yorktown	16	4.2	66	14	17	7.8	293	2.6	16	.3	--	.0	288	222	0	496	7.5	12
CA 47	Upper Yorktown	42	3.6	54	22	22	13	297	.4	30	.2	--	.0	333	225	0	538	7.4	10
CA 50	Upper Yorktown	8.9	6.7	15	6.2	62	7.5	64	46	77	.1	--	.2	262	62	10	495	6.9	5
CA 51	Water table	--	27	--	--	--	--	--	--	57	--	--	--	--	77	--	430	--	--
CA 52	Water table	--	4.4	--	--	--	--	--	--	21	--	--	--	--	72	--	260	6.3	--
CA 53	Lower Yorktown	34	.38	33	63	875	50	623	11	1210	.3	--	.1	2580	342	0	4700	7.9	25
CA 54	Lower Yorktown	34	.36	40	53	532	38	503	14	744	.3	--	.0	1700	318	0	3100	7.7	22
CA 55	Upper Yorktown	48	1.8	31	9.0	26	6.5	164	1.2	30	.1	--	.1	235	115	0	350	7.3	15
CA 58	Lower Yorktown	24	.26	24	39	1000	30	708	33	1240	.4	--	.0	2740	220	0	5000	7.6	27
CA 59	Water table	5.3	--	9.3	2.4	3.7	1.1	25	14	3.0	.0	1.3	--	56	33	12	100	6.7	2
CA 62	Upper Yorktown	51	.81	32	29	78	28	280	.2	124	.1	--	1.3	482	201	0	848	7.2	25
CA 63	Upper Yorktown	51	.25	21	15	34	14	162	.4	51	.1	--	.5	267	114	0	430	7.0	10
CA 64	Upper Yorktown	43	.18	9.4	33	371	29	369	1.0	440	.3	--	3.0	1110	160	0	2100	7.3	65
CA 66	Water table	19	1.3	28	17	170	45	43	18	299	.0	7.7	--	586	140	106	1200	6.4	3
CA 70	Upper Yorktown	26	.12	2.8	2.2	20	.5	20	14	16	.1	--	.0	92	16	0	160	5.8	2
CA 71	Upper Yorktown	41	.82	72	29	186	15	325	1.0	313	.1	--	.5	818	300	34	1510	7.2	10
CA 72	Water table	22	--	19	13	44	2.0	22	71	70	.1	.8	--	253	100	82	467	6.6	4
CA 73	Upper Yorktown	13	5.5	74	13	26	3.8	294	.2	37	.1	--	.0	318	236	0	508	7.3	2
CA 74	Lower Yorktown	33	.43	29	43	405	38	497	4.2	520	.1	--	.0	1320	250	0	2450	7.7	10

Water Levels in Camden County

The water level in the surficial sands is generally half a foot to 8 feet below the land surface (fig. 11). Figure 5 shows that during September - October, 1962, a period of low water levels in the water-table aquifer (fig. 11), the water-table surface ranged from more than 15 feet above msl in the northern part to less than 5 feet above msl in the southern part of the county. The comparison of hydrographs for the water-table aquifer in Camden County (fig. 11) with precipitation at the Elizabeth City precipitation station (figs. 2, 8) indicates that the water tabel is generally highest during the period December - April (time of lowest seasonal precipitation) and lowest during the period May through November (time of greatest seasonal precipitation). The inverse relationship between water levels in the water-table aquifer and precipitation is probably caused by increased loss of water by evapotranspiration from the soil and plants during the hot summer and warm autumn, the seasons of greatest plant growth.

Water in the Yorktown upper and lower aquifers occurs under artesion conditions. Figure 6 shows that during October 1962, the piezometric surface of the Yorktown upper aquifer ranged from a maximum of about 30 feet above msl in the northwestern part of the county to mean sea level in the southern part of the county. This surface is slightly below mean sea level in the pumping areas of influence of the cone of depression at Old Trap, Chantilly, and Camden-Belcross-Hastings Corner (fig. 6). The hydrograph for well No. CA-43 (fig. 11), screened in the Yorktown upper aquifer, shows that the piezometric surface for this aquifer is generally a half a foot to 3 feet below the land surface, and that the highest water levels occur from February through May. Annual fluctuation of water levels in the Yorktown upper aquifer, however, is not nearly so large as in the overlying water-table aquifer (fig. 11).

The piezometric surface of the Yorktown lower aquifer during October 1962, ranged from about 15 feet above msl in the northern part to near mean sea level in the southern part of the county. The piezometric surface may be below mean sea level in the pumping area of influence of a cone of depression in the west-central part of the county.

Artesian flows, from wells screened in the Yorktown upper and lower artesian aquifers, are reported during spring months in the Dismal Swamp area in the northern part of the county and in the lowlands bordering the rivers, creeks, and Albemarle Sound.

Quality of ground water in Camden County

Fresh water is available in Camden County from the water-table aquifer, the Yorktown upper aquifer, and parts of the Yorktown lower aquifer. Most of these waters contain objectionable amounts of iron or hardness-causing constituents and require treatment in order to be satisfactory for most uses. Analyses of water samples for the county are shown in table 3.

Water-Table Aquifer

The water-table aquifer contains the least mineralized water in the county. Sums of mineral constituents in this aquifer range from 56 to 586 ppm, and values are below 250 ppm in most areas of the county. Chloride concentrations in the samples analyzed ranged from 3.0 to 299 ppm, but did not exceed 70 ppm except at Old Trap where withdrawal of ground water has resulted in upward leakage from the deeper saline aquifers. Iron content ranged from 1.3 to 28 ppm in samples from the water-table aquifer in Camden County. Hardness ranged from 33 to 270 ppm as calcium carbonate. Most water-table waters in the central part of the county were soft to moderately hard. In the northern one-third of the county localized deposits of shell material near ground surface were responsible for a few very hard waters in the water-table aquifer, and in the southern part residual sea water caused the hardness value to be high.

Yorktown Upper Aquifer

The Yorktown upper aquifer contains fresh water in all parts of Camden County except those influenced by the cones of depression in the piezometric surface of this aquifer around Elizabeth City and Old Trap. Comparison with similar areas indicates that salty water may also exist in the Yorktown upper aquifer at Camden Point in the southern extremity

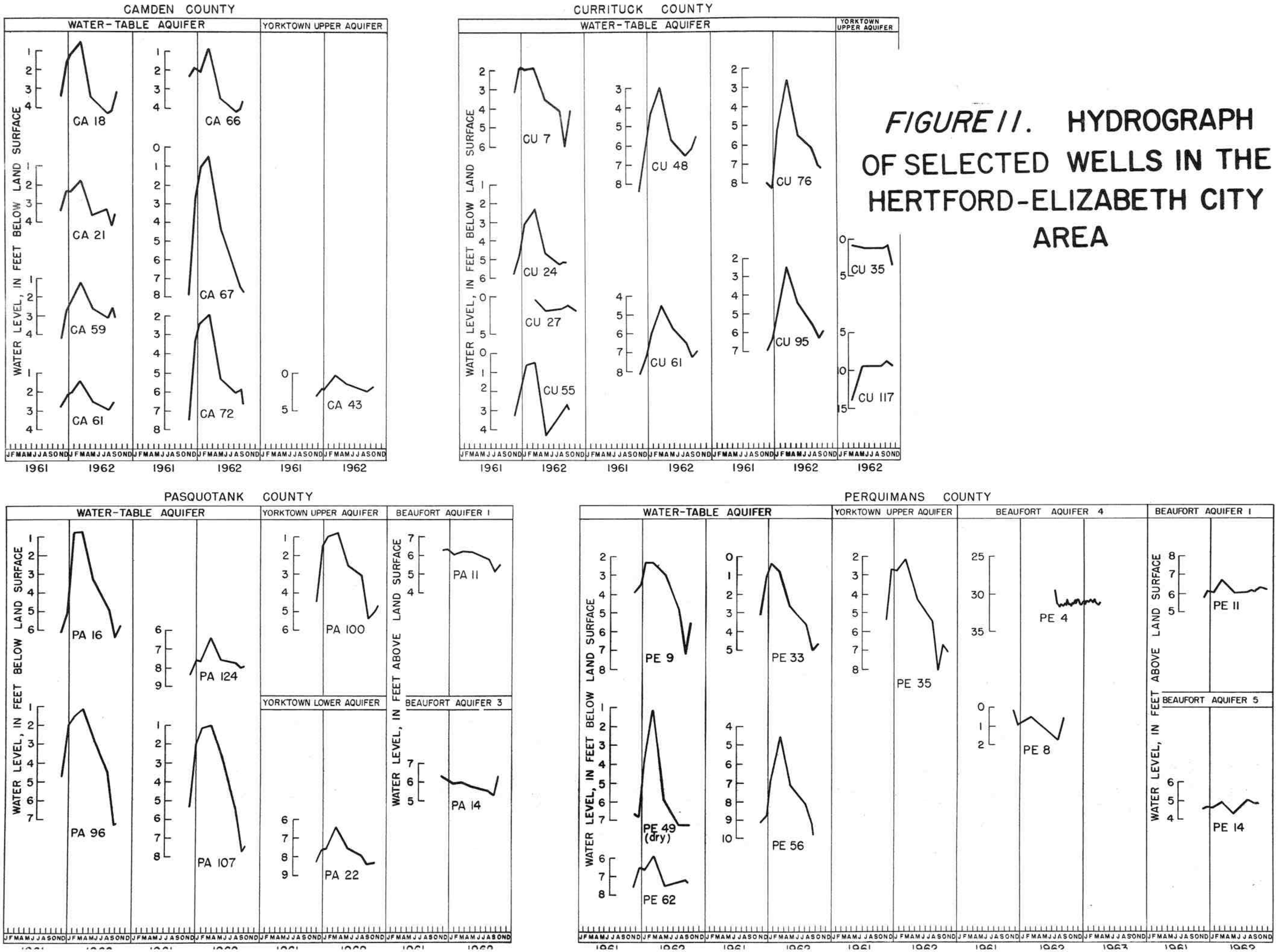


FIGURE 11. **HYDROGRAPH OF SELECTED WELLS IN THE HERTFORD-ELIZABETH CITY AREA**

of the county. The areal distribution of chloride is shown in figure 7. Hardness as $CaCO_3$ ranged from 16 to 300 ppm, and most waters in the aquifer are very hard.

Iron is present in samples from the Yorktown upper aquifer in Camden County in amounts ranging from 0.12 to 6.7 ppm. The areal distribution of iron is shown in figure 9. Well number CA-71 at Taylors Beach is unique, in that it produces water not containing objectionable amounts of either chloride (16 ppm), hardness (16 ppm), or iron (0.12 ppm). The occurrence of such water is probably very limited in this aquifer.

Yorktown Lower Aquifer

The Yorktown lower aquifer yields water containing less than 250 ppm chloride in the central and northern parts of the county. This water is chemically similar to that of the Yorktown upper aquifer, but generally contains lesser amounts of iron.

Beaufort and Cretaceous Aquifers

No wells are known to produce water from the Beaufort or the Cretaceous aquifers in Camden County. However, the water samples collected from these aquifers during the test drilling in Pasquotank County indicate that there is no possibility of obtaining fresh water from these water-bearing zones.

Currituck County

(Area 273 square miles; population in 1960, 6,601)

Introduction

Currituck County is the largest and easternmost county in the area of investigation. It is bordered on the north by the Commonwealth of Virginia, on the east by Currituck Sound and the Atlantic Ocean, on the south by Albemarle Sound, and on the west by the North River and Camden County (fig. 12). Major population centers include Currituck, the county seat, and the towns of Coinjock, Harbinger, Moyock, Point Harbor, Poplar Branch, and Shawboro (fig. 12).

The topography of the county is characterized by northwest to north-trending barrier sand ridges that are separated by low, flat swampy interridge areas that range from less than 5 to about 25 feet above msl (fig. 5). The crests of the sand ridges generally have a maximum altitude of 15 to 25 feet above mean sea level. Prominent sand ridges are; the Camden Ridge in the western part of the county, the Pungo-Powells Point Ridge, and Aydlett "Narrow Shore" Ridge, and the Knotts Island Ridge along the west margin of Currituck Sound. The county is drained by several small creeks and canals that flow into the Northwest and North Rivers and Albemarle and Currituck Sounds. Most of the northern and western parts of the county is swampland. The Great Dismal Swamp and the Great Swamp occupy most of the area between the Camden and Pungo-Powells Point Sand Ridges; Maple Swamp occupies the southern part of the area between the Powells Point Sand Ridge and the Aydlett "Narrow Shore" Ridge (figs. 5, 12). The county includes most of Currituck Sound and its islands and the modern Currituck Beach barrier-ridge spit on the Atlantic Ocean. Savannah are common in parts of Currituck Sound; in the northern part of the sound they connect Knotts Island, Bells Island, and Church Island with the mainland (fig. 12). Relief along the western margin of Currituck Sound is greatest between Aydlett and the north end of Church Island where there are cliffs 15 to 25 feet high.

The main source of income in the county is from the sale of agriculture products, and from timber, commercial fishing, and trapping.

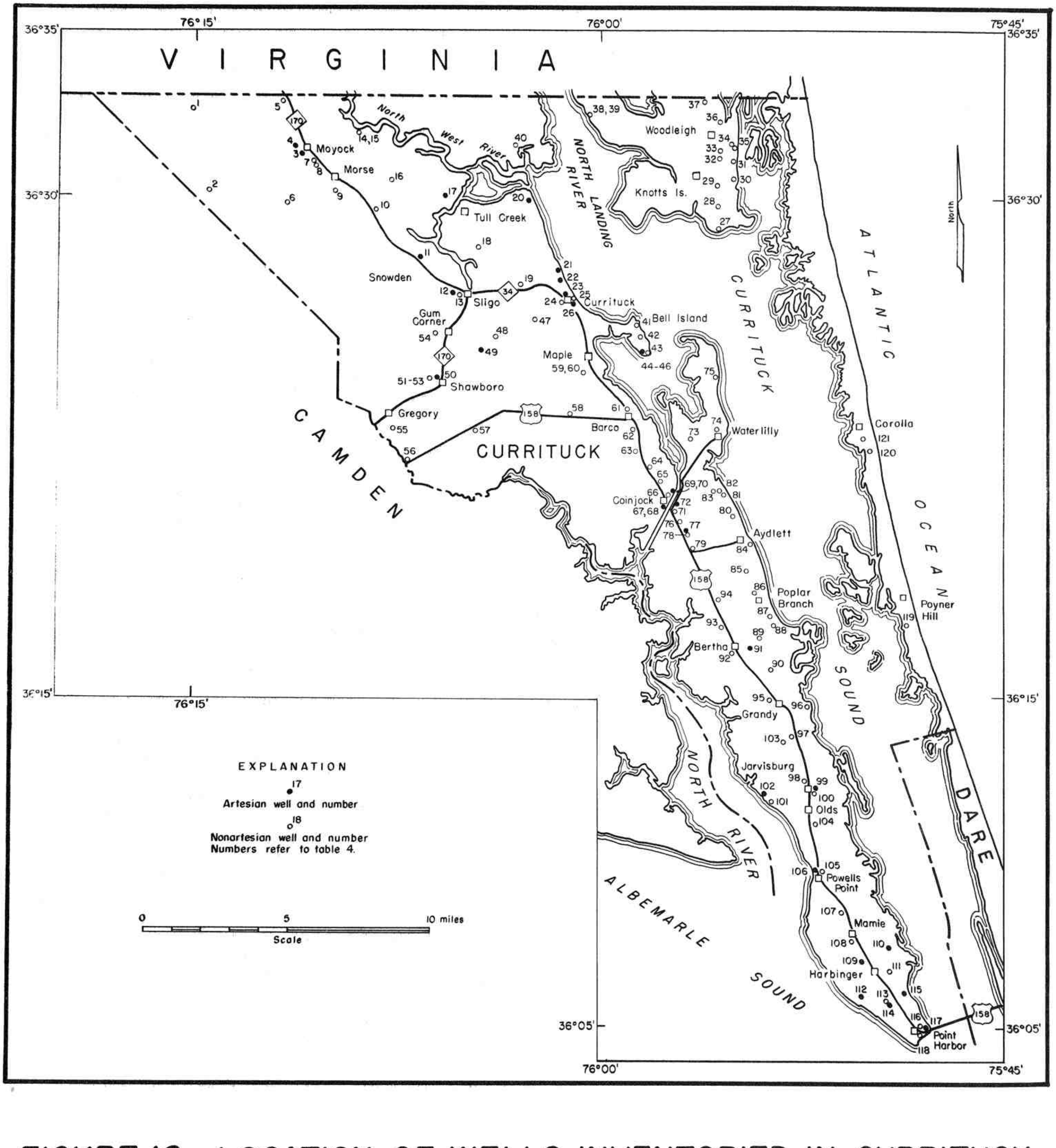


FIGURE 12. LOCATION OF WELLS INVENTORIED IN CURRITUCK COUNTY

Geology

Surficial clay, sand, and gravel deposits of post-Miocene age extend over the entire county. The surficial deposits range in thickness from about 30 feet in the northern part to about 110 feet along the North River in the southern part of the county. Sand ridges are conspicuous topographic features.

The surficial deposits are underlain throughout the county by the upper Miocene Yorktown Formation. This formation consists of blue-to-gray clays, sands, indurated shell marls, and limestones. Glauconitic quartz sands are present at depth in the vicinity of Church Island (Waterlilly oil-test wells) and probably in the central part of the county. The Yorktown Formation generally increases in thickness progressively in the direction of its stratigraphic dip to the east-southeast.

The Miocene units thicken from about 660 feet in the western part of the county to more than 800 feet at Church Island. Miocene sediments are underlain unconformably throughout the county by the Beaufort Formation of Paleocene age.

Ground water

There are no municipal water systems in Currituck County. All domestic supplies in the county are obtained from wells. The depths of privately owned wells depends upon the depth to saline water.

Aquifers in Currituck County

Potable water is obtained from the water-table aquifer and the Yorktown upper aquifer throughout the county; the Yorktown lower aquifer is utilized for domestic water supplies only in the southern part of the county. The locations of the wells inventoried in Currituck County are shown in figure 12. Records of these wells are given in table 4. Chemical analyses of ground water are listed in table 5.

Surficial sands of the water-table aquifer furnish water to more wells in the county, and in particular the central and southern parts of the county, than any other aquifer. Wells range in depth from 3 to 40 feet, and yield from 2 to 10 gpm (table 4).

TABLE 4 - RECORDS OF WELLS IN CURRITUCK COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth to Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Drawdown (ft.)	Spec. Yield (gpm/ft dd)	Remarks
1	4.0 mi NW of Moyock		Driven	12.8	1¼	8.8	Water-table sand	-4.04				Analysis. Water level meas. 6-23-62.
2	3.7 mi W of Moyock	F. Kotzian, Jr.	..do..	23.5	1¼	19.5	...do...	-5.95				Water level meas. 6-23-62.
3	Moyock	Moyock Methodist Church	Jetted	73	1¼	68	Upper Yorktown sand	-6	3	23	0.13	30-min. pump. test. WL & yield meas. by driller 6-20-60.
4	...do...	W.B. Lindsey	..do..	68	1¼	63	U. Yorktown sand & shell	-8	4	25	0.16	30-min. pump. test. WL & yield meas. by driller 3-20-62.
5	1.8 mi N of Moyock	Palm Beach Kennel Club	..do..	40	2	35	Water-table sand					
6	2.0 mi SW of Moyock	J.M. Walcott	Driven	27	1¼	21	...do...					
7	Moyock	J.J. Flora	..do..	17.4	1¼	17.4	...do...	-3.14				Anal., Temp. 53° F. WL meas. 11-20-61 Obs. well.
8	...do...	...do...	Jetted gravel wall	70	1¼	65	Upper Yorktown sand	-5.5	3.3	25	0.13	Anal., Temp. 72° F. 1-hr. pump. test. WL & yield measured 7-21-61.
9	0.5 mi S of Morse	V. Roberts	Dug	10.5	24		Water-table sand	-7.73				Obs. well. WL meas. 11-20-61.
10	1.8 mi SE of Morse		Driven	43.4	1¼	40	...do...	-2.62				Anal., WL meas. 6-22-62.
11	0.7 mi W of Snowden	J.W.B. Ferebee	Jetted	65	1¼	60	Upper Yorktown sand					
12	Sligo	B. Perry	..do..	68	1¼	63	...do...	-5	35	25	1.40	Anal., 30-min. pump. test. WL & yield meas. by driller 6-4-62.
13	...do...	S.A. Walker		18.3	1¼		Water-table sand	-2.69				Water level meas. 6-20-62.
14	2.0 mi E of Moyock	A.B. Coleman	Drilled gravel wall	34	1¼-2		...do...					3 wells. Screen settings of 15-25 ft, 21-25 ft., & 20-25 ft. Obtained from driller.
15	...do...	...do...	Driven	9.6	1¼	4.6	...do...	-4.76				Anal. WL meas. 5-18-62.
16	2.0 mi E of Morse	K.C. Sawyer	..do..	15	1¼	10	...do...					
17	0.8 mi NW of Tull Creek	E.C. Culpepper	Jetted	68	1¼	63	Upper Yorktown sand	-0.25	40	25	1.60	Anal. 30-min. pump. test. WL & yield meas. by driller 3-29-62.
18	1.4 mi S of Tull Creek	A. Bernard	Driven	20.1	1¼	17.1	Water-table sand	-2.87				Anal. Water level meas. 6-22-62
19	1.8 mi E of Sligo	A.W. Dozier	..do..	19	1¼	15	...do...					
20	[illegible] mi E of Tull Creek	J. Tice	Jetted	70	1¼	65	Upper Yorktown sand					Analysis.
21	1.0 mi N of Currituck	C.L. Hall	..do..	82.3	1¼	77.3	...do...	-2.74	12	25	0.48	Anal., 1-hr. pump. test. WL & yield meas. 8-29-62.
22	0.7 mi N of Currituck	M.R. Smith	..do..	83	1¼	78	...do...					
23	Currituck	C.R. Morris	..do..	93	1¼	88	...do...	-4	10	22	0.45	30-min. pump. test. WL & yield meas. by driller 2-13-62.
24	...do...	E.W. Snowden	Dug.	14.7	18		W-T sand	-5.80				Observation well.
25	...do...	L. Mathias	..do..	12.8	24	12.8	...do...	-5.39				
26	...do...	W. Walker	Jetted	90	1¼	85	U. Yorktown sand	-4	20	25	0.80	30-min. pump. test. WL & yield meas. by driller 5-18-62.
27	2.0 mi S of Knotts Island	USGS (GW) NC State Highway Comm.	Drilled	112	1¼	35	W-T sand	-1.97	1.5	22	0.07	Anal., Screen set from 35-38 ft. Temp. 54° F. Obs. well. 1-hr. pump. test. WL & yield meas. 3-13-62.

28	1.1 mi S of Knotts Island	E.H. Beasley	Dug	7.0	18		Water-table sand	-2.78				Water level meas. 3-30-62.
29	0.4 mi S of Knotts Island	H.H. Williams	..do..	10.4	18		...do...	-4.89				WL meas. 3-30-62.
30	0.7 mi E of Knotts Island	A.R. Stowe	Driven	20.3	1¼		...do...	-3.09				WL meas. 3-30-62
31	0.6 mi SE of Woodleigh	Atl. & Gulf Stevedore Corp.	..do..	28.7	1¼	25.7	...do...	-2.17				WL meas. 3-30-62.
32	0.5 mi S of Woodleigh	J.J. Ward	Dug	10.3	24		...do...	-4.46				WL meas. 3-30-62.
33	Woodleigh	J.F. Mathews	..do..	8.4	18		...do...	-3.29				WL meas. 3-30-62.
34	0.5 mi E of Woodleigh	H.S. Hill	..do..	7.9	18		...do...	-2.05				Anal., WL meas. 2-14-62.
35	...do...	USGS (GW) NC ST. Hwy. Comm.	Drilled (bored)	137	1¼	50.6	U. Yorktown sand	-0.85	1.0	22	0.05	Obs. well, Anal., Temp. 51° F. 3-hr. pump. test. WL & yield meas. 3-13-62
36	0.8 mi N of Woodleigh		Dug	8.6	18		W-T sand	-4.05				WL meas. 3-30-62.
37	1.6 mi N of Woodleigh	Warwick	..do..	9.3	18		...do...	-1.24				WL meas. 3-30-62.
38	4.8 mi NW of Knotts Island	O. Reed	Driven	11.9	1¼	8.9	...do...	-5.14				WL meas. 9-7-62.
39	...do...	...do...	..do..	35	1¼	30	W-T sand					Turns rusty after northeaster.
40	2.9 mi NE of Tull Creek		Dug	9.1	24		...do...	-6.71				WL meas. 9-7-62.
41	2.5 mi SE of Currituck	N. Ballance	Driven	14	1¼	10	...do...	-3	5			Anal. WL & yield rept. 6-23-62.
42	2.8 mi SE of Currituck	...do	..do..	8.7	18		...do...	-3.88				WL meas. 6-23-62.
43	3.5 mi SE of Currituck	M. Quinn	..do..	13.2	1¼	8.2	...do...	-1.45				WL meas. 6-23-62.
44	...do...	G.E. Wortman	Jetted	60	1¼	55	U. Yorktown sand					Analysis.
45	...do...	A.E. Wagner	..do..	49.6	1¼	44.6	...do...	-0.37				WL meas. 6-23-62.
46	...do...	H.J. Wilbern	..do..	41	1¼	37	...do...					
47	1.9 mi SW of Currituck	...	Dug	10.7	24		W-T sand	-6.59				WL meas. 6-23-62
48	1.7 mi E of Gum Corner	P. Sawyer	..do..	15.9	24		...do...	-8.39				Obs. well, WL meas. 11-22-61.
49	1.4 mi SE of Gum Corner	W. M. Smithson	Jetted	112	1¼	103	U. Yorktown sand					Analysis.
50	Shawboro	Norf. & Southern Railroad	..do..	60	2	55	...do...					Analysis.
51	...do...	...do...	Drilled	16.2	4		W-T sand	-4.40				WL meas. 6-20-62.
52	...do...	P.R. Gregory	Driven	26	2		...do...		12			Abandoned. 5 wells rept. by Otton.
53	...do...	Norf. & Southern Railroad	..do..	32	1¼		...do...		25			Abandoned. 8 wells, Cl: 13ppm, total hard: 201 ppm & yield rept. by Otton
54	Gum Corner	G.F. Roberts	Dug	10.0	24		...do...	-6.34				WL meas. 6-22-62.
55	0.5 mi S of Gregory	W. E. Forehand	..do..	11.7	24		...do...	-3.36				Obs. well. WL meas. 11-21-61.
56	1.7 mi SE of Gregory	O. J. Stone	Driven	18	1¼	15	...do...					
57	3.0 mi E of Gregory	G. Sanderlin	..do..	15.3	1¼	13.3	...do...	-3.11				Anal. WL meas. 6-22-62.
58	2.0 mi W of Barco	L. Newbern	..do..	7.2	1¼	4.2	...do...	-0.48				Anal, Temp. 60° F. WL meas. 4-18-62.
59	Maple	G. Banks, Jr.	Driven	24	1¼	19	Water-table sand					
60	...do...	G. Banks	Dug	6.3	20		...do...	-3.67				Water level meas. 6-4-62.
61	Barco	A.C. Mathias	..do..	15.9	24		...do...	-8.14				Obs. well. WL meas. 11-20-61.
62	0.5 mi S of Barco	C.C. Sawyer	..do..	10.2	20		...do...	-2.76				WL meas. 3-29-62.

TABLE 4 - RECORDS OF WELLS IN CURRITUCK COUNTY - Continued

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth to Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Draw-down (ft.)	Spec. Yield (gpm/ft dd)	Remarks
63	0.8 mi S of Barco	M. Tarkenton	..do..	10.1	25		...do...	-3.70				WL meas. 3-29-62.
64	0.8 mi N of Coinjock	W.S. Boswood	..do..	9.2	20		...do...	-2.10				WL meas. 3-29-62.
65	0.7 mi N of Coinjock	...	..do..	10.4	20		...do...	-2.67				WL meas. 3-29-62.
66	Coinjock	I. Spry	..do..	12.5	20		...do...	-2.96				Anal., WL meas. 3-29-62.
67	...do...	W. Guard	Jetted	90	$1\frac{1}{4}$	85	U. Yorktown sand	-10	20	25	0.80	Anal., 1-hr. pump. test. WL & yield meas. by driller 7-13-60.
68	...do...	B.C. Kaisey	..do..	100	$1\frac{1}{4}$		...do...		5			Cl: 183 ppm; total hard.: 291 ppm. Rept. by Otton 10-14-43.
69	...do...	R. Crane	..do..	93	$1\frac{1}{4}$	88	...do...	-10	5	25	0.20	1 hr. pump. test. WL & yield meas. by driller 7-13-60.
70	Coinjock	US Coast Guard		95			...do...					Cl: 168 ppm: total Hard.: 249 ppm. Rept. by Otton 10-14-43.
71	0.5 mi S of Coinjock	W. Bray	Dug	7.2	24		W-T sand	-2.10				WL meas. 3-29-62.
72	0.5 mi E of Coinjock	E. Roberts	Jetted	89	$1\frac{1}{4}$	84	U. Yorktown sand	-9	10	22	0.45	30-min. pump. test. WL & yield meas. by driller 3-13-61.
73	1.0 mi W of Waterlilly	C. Snowden & L. Twiford	Dug	2.9	20		W-T sand	-1.63				WL meas. 3-29-62.
74	Waterlilly	I.K. Hooper	Driven	11.9	$1\frac{1}{4}$	9.4	...do...	-1.86				Anal., Temp. 55°F. WL meas. 3-29-62.
75	2.0 mi N of Waterlilly	C. Whitson	..do..	15.8	$1\frac{1}{4}$	12.8	...do...	-11.87				Anal., WL meas. 3-29-62.
76	1.0 mi S of Coinjock	Briggs	Dug	14.1	20		...do...	-7.93				Obs. well.
77	1.2 mi S of Coinjock	R. Midgette	Jetted	94	$1\frac{1}{4}$	89	U. Yorktown sand	-6	15	25	0.60	1-hr. pump. test. WL & yield meas. by driller 4-3-61.
78	1.4 mi S of Coinjock	...do...	Dug	10.2	20		W-T sand	-5.03				WL meas. 4-18-62.
79	1.7 mi W of Aydlett	L. Twiford	..do..	7.3	20		...do...	-2.25				WL meas. 4-18-62.
80	0.8 mi W of Aydlett	H.P. Hempton	..do..	11.2	20		...do...	-6.83				WL meas. 9-18-62.
81	1.7 mi N of Aydlett	K. Dunton	..do..	14.0	20		...do...	-12.33				WL meas. 4-18-62.
82	1.8 mi N of Aydlett	J.W. Foreman	..do..	9.8	18		...do...	-6.74				WL meas. 4-18-62.
83	...do...	...do...	..do..	6.4	18		...do...	-3.08				Abandoned. WL meas. 4-18-62.
84	0.4 mi SE of Aydlett	W. O'Nieil, Jr	..do..	8.4	20		...do...	-5.62				WL meas. 4-18-62.
85	1.0 mi S of Aydlett	C. White	..do..	10.1	20		...do...	-3.13				WL meas. 4-19-62.
86	1.2 mi N of Poplar Brch.	S.W. Parker	..do..	10.6	18		...do...	-4.12				WL meas. 4-19-62.
87	0.3 mi N of Poplar Brch.	B. Gregory	..do..	6.3	20		...do...	-2.30				WL meas. 4-19-62.
88	Poplar Branch	Doxey	..do..	8.8	24		...do...	-3.84				WL meas. 4-19-62.
89	0.5 mi SW of Poplar Brch.	M. Dowdy	Driven	11.2	$1\frac{1}{4}$		...do...	-2.34				Anal., WL meas. 4-19-62.
90	1.2 mi N of Grandy	H. Sunrrell	Dug	7.4	19		...do...	-2.89				WL meas. 4-19-62.
91	0.5 mi E of Bertha	B. Saunders	Jetted	95	2		U. Yorktown sand	-6				Anal. WL rept. by driller 6-62.
92	Bertha	...	Driven	9.6	$1\frac{1}{4}$		W-T sand	-4.16				WL meas. 6-24-62.

93	0.8 mi N of Bertha	E. Baker	Driven	9	1¼	4	W-T sand					
94	1.7 mi N of Bertha	R.P. Midgette	Dug	9.8	18		...do...	-6.17				Water level meas. 6-24-62.
95	Grandy	A.D. Dowdy	..do..	12.3	24		...do...	-6.88				Obs. well. WL meas. 11-20-61.
96	1.0 mi E of Grandy	Walnut Is. Motel & Rest. S. Pars	Driven	11.7	1¼	10	...do...	-1.62				Anal., WL meas. 6-24-62
97	1.2 mi S of Grandy	G.A. Hall	..do..	13.0	1¼	9	...do...	-5.28				Anal., WL meas. 9-11-62.
98	Jarvisburg	M.G. Wright	..do..	11.8	1¼	7.8	...do...	-4.33				WL meas. 5-21-62. Temp. 60° F.
99	...do...	C. Forbes	Jetted	110	1¼	105	U. Yorktown sand	-6	20	25	0.80	Anal., 30-min. pump. test. WL & yield meas. by driller 8-62.
100	...do...	Jarvisburg Ch of Christ	Driven	10.6	1¼	8	W-T sand	-2.94				Anal., Temp. 56° F. WL meas. 3-28-62.
101	1.4 mi SW of Jarvisburg	N. Lindsey	..do..	15.3	1¼		...do...	-9.10				Anal., WL meas. 6-24-62.
102	1.6 mi W of Jarvisburg	R.E. Bunch	Jetted	100	1¼	95	U. Yorktown sand					Analysis.
103	1.4 mi S of Grandy	O. Woodhouse	Driven	9.6	1¼		W-T sand	-4.01				WL meas. 6-24-62.
104	Olds	C. Dozier	Dug	9.5	18		...do...	-5.68				WL meas. 6-24-62.
105	Powells Point	R.E. Twiford	..do..	8.3	18		...do...	-4.95				WL meas. 6-24.62.
106	...do...	J.T. Killingsworth	Jetted	74	1¼	69	U. Yorktown sand	-1.25				Anal., WL rept. 6-24-62.
107	0.8 mi N of Mamie	J. Sykes	Driven	9.5	1¼		W-T sand	-2.98				WL meas. 5-21-62.
108	Mamie	C. Sawyer	..do..	11.9	1¼	7.9	...do...	-3.46	5.25			Anal., Temp. 60°F. WL & Y meas. 5-21-62
109	1.0 mi S of Mamie	Norf. & Carl. Tel & Tel	Jetted	115	1¼	110	U. Yorktown sand	-6	5	22	0.23	30-min pump. test. WL & yield meas. by driller 12-27-61.
110	1.3 mi N of Harbinger	J.G. Walker	..do..	138	1¼	133	L. Yorktown sand & shell	-6				Anal., WL meas by driller 5-18-60
111	0.5 mi N of Harbinger	T. Melson	Dug	13.5	24		W-T sand	-6.50				WL meas. 3-28-62.
112	1.0 mi W of Harbinger	J.L. Gallop	..do..	8.7	24		...do...	-4.72				Anal., WL meas. 9-11-62.
113	0.6 mi S of Harbinger	C.H. Walker	Driven	20	1¼	15	...do...		12			Cl: 15 ppm; total hard: 50 ppm. yield rept. by Otton.
114	...do...	W.N. Newbern	Drilled	90								Abandoned.
115	0.8 mi E of Harbinger	I. Gallop	Jetted	105	1¼	100	U. Yorktown sand & shell	-6	8	25	0.32	Anal., 30-min. pump. test. WL & yield meas. by driller 8-3-61.
116	Point Harbor	W.S. Griggs	Driven	19	1¼	15	W-T sand					3 wells.
117	...do...	USGS (GW) NC St. Hwy Comm.	Drilled (bored)	137	2	90.4	U. Yorktown sand	-13.78	1.0	22	0.05	Anal., Obs. well. Temp. 62°F. 3-hr. pump test. WL & yield meas. 3-12-62. Screen set from 90.4 - 94.4 ft.
118	...do...	NC St. Hwy.C. Bridge Dept.	Driven	14.6	1¼		W-T sand	-4.84				Anal., WL meas. 3-28-62.
119	5.0 mi E of Pop. Brch. (Poyner Hill CG Station)	Currituck Shooting Club	..do..	18	1¼	15	...do...	-2.42				Anal., WL meas. 1-10-63.
120	0.8 mi S of Corolla	G.T. McLean	..do..	12	2	10	...do...	-2				Analysis.
121	Corolla	J.W. Austin	..do..	8	1¼	6	...do...	-2				Analysis.
CU-OT1-?	Waterlilly	R.P. Midgette	Drilled	764	..	..	Yorktown Fm.	..				Abandoned oil test well.
CU-OT2-?	...do...	...do...	..do..	835			...do...					Abandoned oil test well.
CU-OT3-?	...do...	...do...	..do..	377			...do...					Abandoned oil test well.

Table 5.--Chemical analyses of ground water from Currituck County

Well number	Aquifer	Silica (SiO_2)	Iron (Fe)	Cal-cium (Ca)	Mag-ne-sium (Mg)	Sodium (Na)	Po-tas-sium (K)	Bicar-bonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluo-ride (F)	Ni-trate (NO_3)	Phos-phate (PO_4)	Dissolved solids	Hardness as $CaCO_3$		Specific conduct-ance (micro-mhos at 25°C)	pH	Colo
															Calcium, magne-sium	Non-carbon-ate			
CU 1	Water table	--	3.1	--	--	--	--	--	--	48	--	--	--	--	155	--	555	--	--
CU 7	Water table	20	2.5	226	14	38	1.2	293	338	82	0.2	0.2	--	866	621	381	1260	7.5	5
CU 8	Upper Yorktown	22	.29	38	29	192	23	326	15	269	.2	--	0.2	750	216	0	1400	7.7	10
CU 10	Water table	45	6.9	131	15	37	6.8	466	.2	54	.3	--	.0	526	392	10	842	6.9	90
CU 12	Upper Yorktown	45	3.0	72	18	38	14	392	.2	20	.2	--	.0	403	254	0	645	7.2	10
CU 15	Water table	--	--	--	--	--	--	--	--	105	--	--	--	--	122	--	609	--	--
CU 17	Upper Yorktown	33	1.6	68	36	--	--	254	8.0	630	.3	2.7	--	--	320	112	2800	7.2	12
CU 18	Water table	--	7.4	--	--	--	--	--	--	23	--	--	--	--	13	--	120	--	--
CU 20	Upper Yorktown	46	6.2	31	6.4	19	2.4	145	.6	17	.2	--	.0	200	104	0	295	7.0	7
CU 21	Upper Yorktown	21	1.7	23	5.2	55	6.0	198	.2	37	.1	--	.5	248	78	0	432	7.3	10
CU 27	Water table	--	1.1	7.1	4.5	13	3.1	39	2.2	11	.0	20	--	--	36	4	158	6.8	--
CU 34	Water table	--	--	--	--	14	.6	249	20	24	.0	5.8	--	--	239	35	500	7.9	--
CU 35	Upper Yorktown	--	--	--	--	--	--	266	100	646	.3	--	--	--	125	0	2520	8.3	--
CU 41	Water table	--	.31	--	--	--	--	--	--	35	--	--	--	--	102	--	360	--	--
CU 44	Upper Yorktown	41	.16	144	40	396	30	287	11	818	.0	--	.7	1620	524	290	3100	7.4	13
CU 49	Upper Yorktown	32	1.3	54	13	18	9.5	261	.4	12	.2	--	.0	269	186	0	435	7.3	11
CU 50	Upper Yorktown	4.3	1.3	72	6.4	12	7.3	190	53	18	.0	--	.0	268	164	50	462	7.1	4
CU 57	Water table	--	.68	--	--	--	--	--	--	34	--	--	--	--	194	--	530	--	--
CU 58	Water table	8.7	2.2	1.4	1.2	4.8	.6	4	8.2	4.5	.1	1.0	--	35	8	5	65	5.3	45
CU 66	Water table	--	14	--	--	--	--	--	--	10	--	--	--	--	50	--	153	--	--
CU 67	Upper Yorktown	44	1.5	74	34	156	23	452	.8	240	.1	--	.1	797	324	0	1400	7.0	24
CU 74	Water table	--	.18	--	--	25	1.0	26	49	58	.0	2.0	--	--	104	82	370	6.0	--
CU 75	Water table	3.6	.05	83	2.4	9.3	.2	206	19	16	.1	21	--	256	218	49	473	7.3	3
CU 69	Water table	4.2	.61	12	2.2	5.6	1.5	10	25	9.5	.0	2.6	--	68	40	32	127	6.1	2
CU 91	Upper Yorktown	25	5.0	39	7.2	14	.6	141	.8	21	.1	--	.0	187	126	11	305	6.9	17
CU 96	Water table	--	1.8	--	--	--	--	--	--	31[illegible]	--	--	--	--	317	--	1510	--	--
CU 97	Water table	--	.39	--	--	--	--	--	--	15	--	--	--	--	62	--	209	--	--
CU 99	Upper Yorktown	17	.46	69	6.4	16	1.1	228	.2	24	.0	--	.0	246	200	13	425	7.3	4
CU 100	Water table	--	.45	--	--	6.3	9.7	30	82	28	--	.3	--	--	125	100	323	6.3	--
CU 101	Water table	--	.21	--	--	--	--	--	--	18	--	--	--	--	24	--	179	--	--
CU 102	Upper Yorktown	28	.84	47	11	45	6.2	197	.2	74	.1	--	.2	310	162	1	560	7.4	6
CU 106	Upper Yorktown	13	6.4	55	3.6	12	1.2	185	.2	20	.0	--	.0	202	152	0	355	7.0	4
CU 108	Water table	4.2	1.6	26	5.7	6.4	9.2	5	70	13	.7	18	.0	157	88	84	257	5.4	5
CU 110	Lower Yorktown	27	.34	62	15	35	6.2	242	.8	67	.1	--	.0	333	215	16	590	7.6	5
CU 112	Water table	--	3.1	--	--	--	--	--	--	16	--	--	--	--	16	--	111	--	--
CU 115	Upper Yorktown	26	.01	25	6.8	28	5.1	150	.2	24	.2	--	.4	190	90	0	318	7.6	4
CU 117	Upper Yorktown	--	--	40	5.0	26	5.5	111	33	30	.0	2.5	--	--	121	30	335	7.6	--
CU 118	Water table	4.1	.42	43	2.4	17	3.2	108	15	32	.1	1.8	--	170	118	30	341	7.1	13
CU 119	Water table	--	2.0	--	--	--	--	--	--	12	--	--	--	--	14	--	90	--	--
CU 120	Water table	--	3.1	--	--	--	--	--	--	726	--	--	--	--	294	--	2600	--	--
CU 121	Water table	--	15	--	--	--	--	--	--	38	--	--	--	--	31	--	179	--	--

Wells in the Yorktown upper aquifer range in depth from 41 to 115 feet and yield from 1 to 40 gpm. A well 138 feet, screened in the Yorktown lower aquifer, in the southern part of the county yields about 12 gpm. Specific yields for wells in the Yorktown upper aquifer range from 0.13 to 1.60 gpm per foot of drawdown (table 4).

Water Levels in Currituck County

The water level in the surficial sands is generally half a foot to 8½ feet below the land surface. The water table in the county during September-October 1962, a period of low water levels, ranged from a maximum of 15 feet above msl in the northwestern part of the county and from 10 to 19 feet above msl along several of the post-Miocene barrier sand ridges to less than 5 feet above msl along the sounds and major rivers (fig. 5). North of Aydlett, water from the water-table aquifer discharges directly into Currituck Sound from a peat bed at the base of the cliff formed by the Aydlett "Narrow Shore" Ridge (fig. 11). The water table is generally highest during the period December-April (time of lowest seasonal precipitation) and lowest during the period May through November (time of greatest seasonal precipitation) (figs. 2, 8, 11).

Water in the Yorktown upper and lower aquifers occurs under artesian conditions. In October 1962, the piezometric surface of the Yorktown upper aquifer ranged from a maximum of about 15 feet above msl in the northwestern part of the county, and 5 to 11 feet above msl along most of the Pungo-Powells Point Ridge to mean sea level along the sounds and major rivers. This surface is slightly below mean sea level in the pumping area of influence of the cone of depression near Moyock (fig. 6). The hydrograph for well No. CU-117 shows that the piezometric surface of the Yorktown upper aquifer is generally from 9 to 14 feet below the land surface at Point Harbor (fig. 11). Annual fluctuations of water levels in the Yorktown upper aquifer are not nearly as large as in the overlying water-table aquifer. The hydrograph for well No CU-117 shows that the piezometric surface of this aquifer is highest in September-October and lowest in March-May (fig. 11).

Quality of ground water in Currituck County

In Currituck County, fresh ground water can be obtained in most areas from the water-table aquifer and Yorktown upper aquifer and in some areas from the Yorktown lower aquifer. Much of this water contains objectionable amounts of iron or hardness-causing constituents, but water which is satisfactory for most purposes is available in a few localities. Analyses of water samples from Currituck County are shown in table 5.

Water-Table Aquifer

The water-table aquifer generally contains the least mineralized water in Currituck County. Sums of dissolved mineral constituents vary from about 35 to about 1,000 ppm, but most water table water contain less than 500 ppm total dissolved solids. Chloride concentrations in the samples analyzed ranged from 4.5 to 316 ppm, and were less than 100 ppm except in some areas adjacent to the brackish rivers and sounds which border much of the county. Iron ranges from 0.05 to 15 ppm. Hardness as calcium carbonate ranges from 8 to 621 ppm. Many water-table wells yield water which is classified as soft. These soft waters are from localized sandy zones that contain little shell material, and no areal pattern of distribution can be established for them.

Yorktown Upper Aquifer

The chemical quality of ground water in the Yorktown upper aquifer in Currituck County is not uniform. Sums of dissolved mineral constituents ranged from 187 to 1,620 ppm in the water samples analyzed. However, samples containing less than 250 ppm of chloride did not exceed 1,000 ppm in total dissolved solids. Chloride concentrations ranged from 12 to 818 ppm. The areal pattern of distribution of chloride is shown on figure 7. Iron in this water-bearing zone ranged from 0.01 to 6.4 ppm, and the areal pattern of distribution is shown on figure 9.

Hardness as calcium carbonate ranged from 78 to 524 ppm. Most samples analyzed from the Yorktown upper aquifer were hard to very hard.

Yorktown Lower Aquifer

Few wells are known to produce water from the Yorktown lower aquifer in Currituck County. Fresh water can probably be obtained from this aquifer throughout most of the county.

Beaufort Aquifers

No wells are known to produce water from the Beaufort aquifers in Currituck County. It is believed that there is no possibility of obtaining fresh water from these water-bearing zones.

Pasquotank County

(Area 229 square miles; population in 1960, 25,630)

Introduction

Pasquotank County is the smallest county of the area of investigation. It is located in the west-central part of the area, and is bordered on the north and east by Camden County and the Pasquotank River, on the south by Albemarle Sound, and on the west by the Little River and Perquimans and Gates Counties (fig. 13). Elizabeth City, the county seat (population in 1960, 14,070), is the largest town in the Hertford-Elizabeth City area. Other population centers in the county include Nixton, Weeksville, and the Newland School area near Lynches Corner and Morgans Corner.

The county, nowhere more than 20 feet above msl, is drained by several broad creeks and canals that flow into the Pasquotank and Little Rivers and into Albemarle Sound. Most of the northern part of the county is occupied by the Great Dismal Swamp. A conspicuous wave-cut terrace 5 to 8 feet high is present in the southern part of the county along Albemarle Sound.

Agriculture, commercial fishing, timber, shipbuilding, aircraft construction, and military installations are the main source of income in the county.

Geology

Surficial sands and clays of post-Miocene age blanket the entire county. These surficial deposits are rarely more than 30 feet thick in the northern part, and 60 feet thick in the southern part of the county. Locally they are as much as 140 feet thick along the Pasquotank River and parts of Albemarle Sound.

Lying unconformably beneath the surficial deposits are beds of gray-to-blue clay, sand, shells, marl, and impure shell limestone of the upper Miocene Yorktown Formation. The Yorktown Formation ranges in thickness from 135 feet in the northern part of the county to 185 feet in the southern part of the county.

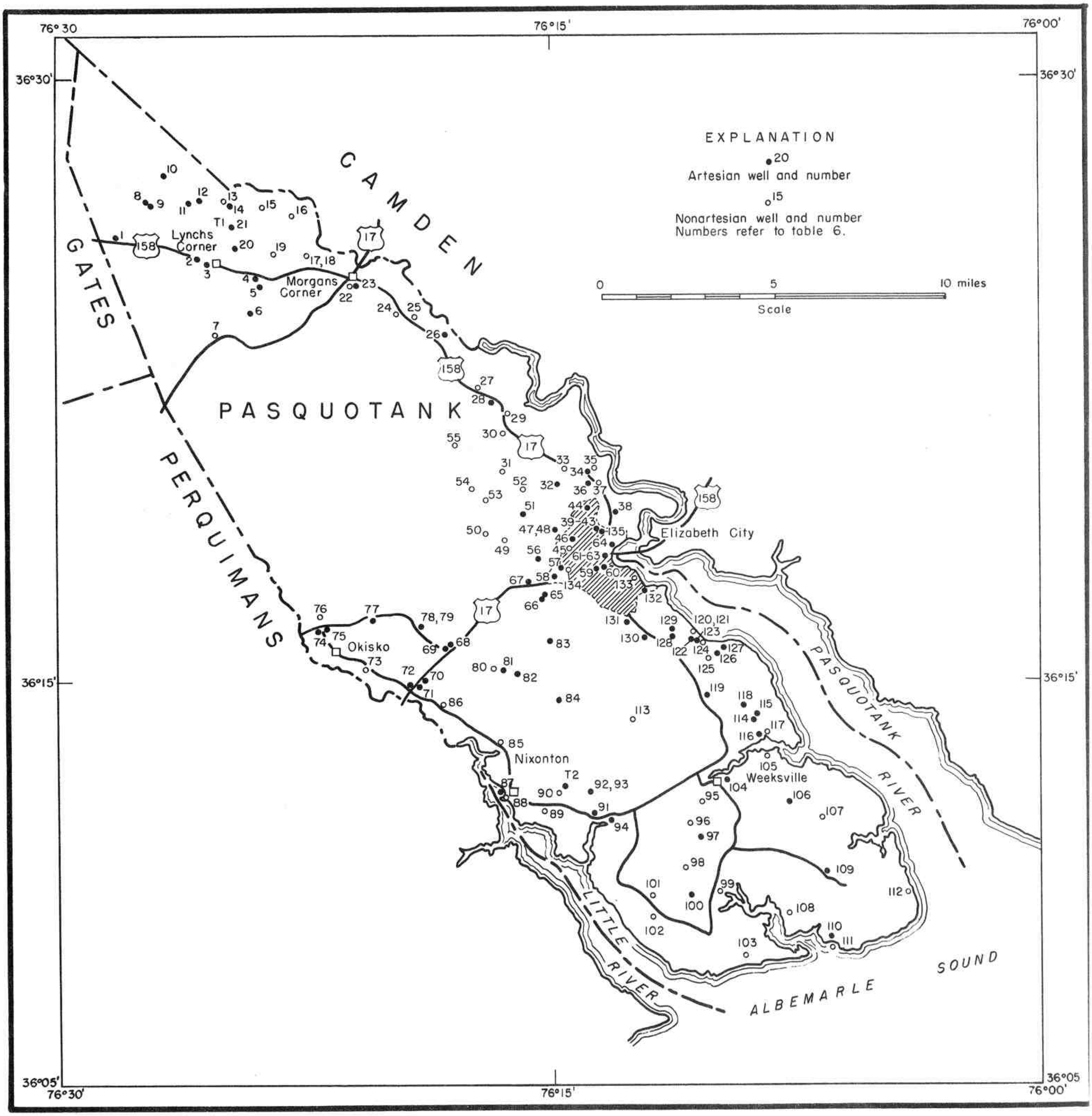


FIGURE 13. LOCATION OF WELLS INVENTORIED IN PASQUOTANK COUNTY

The Yorktown Formation is underlain conformably throughout the county by the middle Miocene undifferentiated unnamed unit. This unit consists of blue-to-gray clays and sandy clays, phosphatic quartz sands, glauconitic clays, glauconite sands, and impure shell limestones. Its unconformable contact with the underlying Beaufort Formation is marked by a persistent phosphatic zone. The thickness of the middle Miocene undifferentiated unnamed unit ranges from 182 feet in the northern part of the county to 218 feet in the southern part of the county.

In the northern part of the county the Beaufort Formation consists of glauconitic sands underlain by iron-stained quartz sands, clayey sands, and red clays. In the southern part of the county, the Beaufort consists predominantly of a limestone section more than 150 feet thick underlain by glauconitic sands and glauconitic clays to 723 feet below land surface. The base of the Beaufort Formation was not penetrated by the test holes drilled in the county as part of the investigation, and its total thickness in this part of the area is unknown. About 350 feet of the Beaufort Formation was penetrated in the northern part of the county and 260 feet in the southern part of the county. The Beaufort Formation is underlain conformably by the Peedee Formation of Early Cretaceous age.

Ground water

All municipal and private water supplies in Pasquotank County are obtained from wells; large to moderate supplies of ground water are available throughout the county. The depth of municipal and private wells depends on the depth to saline water.

Water Supply for Elizabeth City

Elizabeth City uses the most ground water in the county. The maximum use and system capacity for the city as of February 1963, was 2,500,000 gpd (gallons per day); the average consumption was 1,500,000 gpd.

The city obtains its water supply from two aquifers. At the Elizabeth City shallow-well field, about 3 miles west of the city, water is obtained from 240 wells screened in the water-table aquifer. Although individual wells may yield as much as 58 gpm, yields are adjusted from 2 to 3 gpm for all wells in order to limit drawdown. The entire shallow well system is connected into one pumping system with a capacity of 750 gpm and average yield of about 695 gpm. The shallow-well field water has a hardness of 116 ppm and an iron content of 3.0 ppm. It is corrosive; consequently maintenance of the well system is costly. Chloride content averages 10 ppm (table 7).

For the finished water supply, the high-iron low-chloride water from the shallow well field is mixed with a low-iron, high-chloride water obtained from five wells screened in the Yorktown upper aquifer at the filter plant at Elizabeth City. Water from the Yorktown upper aquifer is relatively low in iron, 0.5 to 0.6 ppm, and has a hardness of 300 to 340 ppm. Chloride ranges from 200 to 350 ppm (table 7). In general, hardness and chloride concentrations both increase with depth. Individual wells at the filter plant yield as much as 400 gpm, but their yields are adjusted to 175 gpm to limit drawdown. Except in periods of above-average water demand or of decreased yield from the shallow-well system, only two of the wells screened in the Yorktown upper aquifer are operated at any given time.

For a detailed history of the development of a water supply for Elizabeth City, the reader is referred to Lohman (1936), Mundorff (1947), LeGrand and Siple (1953, in Pease and Co., Engineers), and Parker (1953, in Pease and Co., Engineers).

Aquifers in Pasquotank County

Potable water is obtained from three aquifers in the county; the water-table aquifer, and the Yorktown upper and lower aquifers. The location of the wells inventoried in Pasquotank County is shown in figure 13. Records of these wells are given in table 6. Chemical analyses of ground water are listed in table 7.

Surficial sands of the water-table aquifer furnish water to more wells in the county than any other aquifer. Dug wells, driven wells, and jetted wells in the surficial sands range in depth from 8 to 50 feet and yield from 1.5 to 8 gpm. Rotary-drilled gravel-wall wells yield from 18 to 58 gpm. Specific yields for wells screened in the water-table aquifer range from 0.16 to 3.33 gpm per foot of drawdown (table 6).

TABLE 6 - RECORDS OF WELLS IN PASQUOTANDK COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Draw-down (ft.)	Spec. Yield (gpm/ft dd)	Remarks
1	3.0 mi W of Lynchs Corner	C. A. Banks	Jetted	60	1¼	57	Upper Yorktown sand		3.8			Yield meas. 7-18-61. Temp. 72° F.
2	0.5 mi W of Lynchs Cr.	W.K. Jones	Driven	60	1¼	57	...do...		10			Yield meas. 7-18-61. Temp. 69° F.
3	Lynchs Corner	B. Temple	..do..	60	1¼	57	...do...		6.3			Anal., yield meas. 7-18-61. Temp 65°F
4	1.3 mi E of Lynchs Cr.	J.F. Temple	Jetted	65	1¼	62	...do...					Temp. 79° F.
5	1.5 mi SE of Lynchs Cr.	E.H. Bright	Driven	80	1¼	75	...do...					Anal., Temp. 64° F.
6	1.7 mi SE of Lynchs Cr.	J. M. Sawyer	Jetted	68	1¼	63	...do...	-7	35	63	1.40	30-min. pump test. Yield meas. by driller 8-9-61.
7	2.0 mi S of Lynchs Cr.	G.C. Ballance	Dug	9.5	26		Water-table sand	-7.65				WL meas. 9-25-62. Anal.
8	2.7 mi NW of Lynchs Cr.	T. Hewitt	Driven	22.5	1¼	18	...do...		4			Yield meas. 7-20-61. Temp. 64° F. pH 6.8.
9	2.5 mi NW of Lynchs Cr.	R.F. Hewitt	Jetted	462	2	441	Beau. green sd aquifer 3	Flows				Abandoned.
10	2.9 mi NW of Lynchs Cr.	C.L. Granger	Driven	23.5	1¼	20	W-T sand	-3.05	1.5			WL and yield meas. 7-24-61. Temp. 63° F. pH 6.9.
11	1.9 mi NW of Lynchs Cr.	P.B. Weeks	Drilled	630	2	622	Beau. ferruginous quartz sand Aquif. 1	+6.22 flows	1.0 gmf flows			Obs. well. Anal., WL & yield meas 11-16-61. Temp. 65° F.
12	1.9 mi N of Lynchs Cr.	R. Hewitt	Driven	17	1¼	15	W-T sand		3			Yield meas. 7-20-61. Temp. 66° F. pH 5.4.
13	1.8 mi N of Lynchs Cr.	C.C. Bright	Dug	11.2	24		...do...	-2.21				WL meas. 5-7-62.
14	1.7 mi N of Lynchs Cr.	...do...	Jetted	462	2	442	Beau. green sand Aqui. 3	+6.27	1.1 flows			Anal., WL & yield meas. 11-17-61. Obs. well. Temp. 71° F.
15	2.2 mi NE of Lynchs Cr.	W.O. Etheridge	Driven	14.9	1¼	12	W-T sand	-5.44	4			WL & yield meas. 7-26-61. Temp. 68° F. pH 6.0.
16	2.5 mi NW of Morgans Cr.	R.F. Hewitt NC Forest Ser.	..do..	17.7	1¼	14	...do...	-6.08	4			Anal., WL & yield meas. 11-17-61. Obs. well., Temp. 63° F.
17	1.5 mi NW of Morgans Cr.	G.S. Swayer	Jetted	37	1¼	33	...do...		3.4			Yield meas. 7-26-61. Temp. 77° F. pH 7.4.
18	1.5 mi NW of Morgans Cr.	...do...	..do..	37	1¼	33	...do...		4			Yield meas. 7-26-61. Temp. 69° F. pH 6.6.
19	2.5 mi NW of Morgans Cr.	L. Ballance	Driven	15	1¼	11	...do...		2.8			Yield meas. 7-26-61. Temp. 70° F. pH 6.5.
20	0.8 mi NE of Lynchs Cr.	C.L. Sawyer	Jetted	56	1¼	51	U. Yorktown sand		2.2			Yield meas. 7-26-61. Temp. 69° F. pH 7.4.
21	1.2 mi N of Lynchs Cr.	R.F. Hewitt	Driven	39	1¼	34.5	W-T sand		4.4			Anal., Yield meas. 7-25-61. Temp. 65° F
22	Morgans Corner	M.R. White	..do..	30	1¼	25	...do...		5			Aband. Yield meas. 7-19-61. Temp 69°F
23	...do...	...do...	Jetted	50	1¼	45	U. Yorktown sand	-6	10	25	0.04	30-min. pump. test. Yield & WL meas. by driller 8-30-61.
24	1.6 mi SE of Morgans Cr.	E. Armstrong	Driven	13.3	1¼	10	W-T sand	-3.43	4			WL & yield meas. 9-25-62. Temp. 65° F.
25	2.1 mi SE of Morgans Cr.	S. Murray	..do..	18.4	1¼	14.4	...do...	-3.62				WL meas. 9-5-62.
26	3.1 mi SE of Morgans Cr.	C.M. Hudson	Jetted	90	1¼	85	U. Yorktown sand		5			Yield meas. 7-19-61. Temp. 74° F.
27	4.8 mi SE of Morgans Cr.	M.O. Jackson	Driven	13.5	1¼	10.5	W-T sand		8			Anal., Yield meas. 7-19-61. Temp. 72° F.
28	5.4 mi SE of Morgans Cr.	F. Gibson,Jr.	Jetted	80	1¼	75	U. Yorktown sand & shell	-9	20	25	0.40	30-min. pump test. Yield & WL meas. by driller 6-15-60.

TABLE 6 - RECORDS OF WELLS IN PASQUOTANK COUNTY - Continued

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Draw-down (ft.)	Spec. Yield (gpm/ft dd)	Remarks
29	5.0 mi NW of Elizabeth City	M. Gregory	Dug.	7.9	24		W-T sand	-5.64				Abandoned. WL meas. 9-5-62.
30	4.6 mi NW of Elizabeth City	Berea Baptist Church	Driven	30	1¼		...do...		7.5			Yield meas. 7-19-61. Temp. 67° F.
31	3.9 mi NW of Eliz. City	E. Bray	Dug	9.6	24		...do...	-6.44				WL meas. 9-12-62.
32	2.4 mi NW of Eliz. City	C. Mathews	Jetted	90	1¼	85	U. Yorktown sand		4			Yield meas. 7-18-61. Temp. 69° F.
33	2.6 mi NW of Eliz. City	W.C. Morse Watson Est.	Driven	25	1¼		W-T sand		2.6			Yield meas. 7-18-61. Temp. 76° F.
34	2.3 mi N of Eliz. City	Dr. B.C. West, Jr.	Jetted	85	1¼	80	U. Yorktown sand	-9	4	23	0.17	2 hr. pump test. WL & Yield meas. by driller 8-3-61. Anal: Eliz City Water Works 10-31-61. Cl: 126 ppm; Fe: 4.0 ppm; t. Hard. 122 ppm; pH 6.7
35	2.3 mi N of Eliz. City	J. Clark	Driven	18.1	1¼	15.1	W-T sand	-4.27				Abandoned. WL meas. 4-26-62.
36	1.9 mi N of Eliz. City	C.W. Raper	Jetted	136	1¼	136	L. Yorktown shell	-9	5	15	0.20	Anal., 1 hr. pump test. WL & yield meas. by driller 6-14-60. Temp. 80° F.
37	1.8 mi N of Eliz. City	B. Dunford	Driven	42	1¼		W-T sand		3.4			Yield meas. 7-18-61. Temp. 70° F.
38	1.4 mi N of Eliz City	L. R. Forman & Sons Lmbr. Co.	Drilled	1207.8	10-8-6	1124	Black Creek mud, sd, clay	Flows				Anal., Aband., Water rept. by drill. to coming from 1130 - 11-40 feet.
39	Elizabeth City	E. City Pub. Util Com. Well 1	Drilled	100	10-6	75	U. Yorktown sd. & shell	-45	175	20	8.75	Anal. WL & yield meas. by driller 5-59. 1-hr pump test. Temp 62° F.
40	...do..	E City Pub U. Comm. Well 2	..do..	100	10-4	75	...do...					Standby well.
41	...do...	E City Pub U. Comm. Well 3	..do..	102	10	71	...do...					Anal. Temp. 65° F.
42	...do...	E City Pub U. Comm. Well 4	..do..	100	10-6	75	...do...	-45	175	20	8.75	WL & yield rept. by driller 5-59. 1-hr pump test. Temp. 62° F.
43	...do...	E City Pub U. Comm. Well 5	..do..	106.5	10-8	75	...do...	-32	260	54	4.81	WL & yield meas. by driller 10-4-55. 8-hr. pump. test.
44	...do...	H. Brickhouse	Jetted	86.4	1¼	81.4	...do...	-13.39				WL meas. 5-10-62.
45	...do...	S.T. Cooper	..do..	50	1¼	45	W-T sand	-4	20	22	0.91	30-min pump test. WL & yield meas. by driller 12-20-61.
46	...do...	A.W. Winslow	..do..	85	1¼	80	U. Yorktown sand & shell	-12	12	25	0.48	30-min pump test. WL & yield meas. by driller 5-24-60.
47	1.7 mi W of Eliz. City	C. Johnson	..do..	58.4	1¼	53.4	U. Yorktown sand	-3.26				Abandoned. WL meas. 10-29-62.
48	...do...	...do...	..do..	85	1¼	80	...do...	-9	8	25	0.32	30-min. pump. test. WL & yield meas by driller 6-8-62.
49	3.0 mi W of Eliz. City	E City Pub U. Comm.	Jetted gravel wall	32	2	27	W-T sand		3			Anal., Yield rept. by Public Util. Comm. 7-12-61, 240 wells, well field; ind. yield held to 3 gpm, 7-15 gpm maximum.
49A	...do...	...do...	Drilled gvl wall	29.5	2	22.5	...do...	-10	58	18	3.33	WL & yield meas by driller 9-3-37.
49B	...do...	...do...	..do..	32	2	25	...do...		18.8			Yield meas. by deiller 12-5-39.
49C	...do...	...do...	..do..	32	2	25	...do...		34.4			...do...
49D	...do...	...do...	..do..	32	2	25	...do...		29.6			...do...
49E	...do...	...do...	..do..	32	2	25	...do...		23			...do...
49F	...do...	...do...	..do..	32	2	25	...do...		22.9			...do...
49G	...do...	...do...	..do..	32	2	25	...do...		41.3			...do...
49H	...do...	...do...	..do..	32	2	25	...do...	-4	40.8	26	1.57	WL & yield meas. by driller 12-5-39

49J	3.0 mi W of Eliz. City	E City Pub Util Comm.	Drilled grv wall	32	2	25	W-T sand	-4	22.9	26	0.88	WL & yield meas by driller 12-5-39.
49K	...do...	...do...	..do..	32	2	25	...do...	-4	29.1	26	1.12	...do...
49L	...do...	...do...	..do..	32	2	25	...do...	-4	41.8	26	2.61	...do...
49M	...do...	...do...	..do..	32	2	25	...do...	-4	42.8	26	1.65	...do...
49N	...do...	...do...	..do..	32	2	25	...do...	-4	23.4	26	0.90	...do...
49P	...do...	...do...	..do..	32	2	25	...do...	-4	33	26	1.27	...do...
50	3.6 mi W of Eliz. City	T. Winslow	Dug	8.8	12		...do...	-1.61				Obs. well 31T. Fed. Key Well US # 9 continuous recorder--MP 2.70 ft. above lsd. WL meas 7-16-62.
51	2.7 mi NW of Eliz City	D.L. Sylvester	Jetted	65	1¼	60	U. Yorktown sand		3.4			Yield meas. 7-17-61. Temp 70° F.
52	3.1 mi NW of Eliz City	R. Spence	Driven	16	1¼		W-T sand		5			Yield meas 7-17-61. Temp 70° F.
53	3.8 mi NW of Eliz City	B. Jennings	Dug	9.4	18		...do...	-7.14				WL meas. 9-12-62.
54	4.3 mi NW of Eliz City	A.R. Temple	Driven	20	1¼		...do...		2.4			Yield meas. 7-17-61. Temp 75° F.
55	5.4 mi NW of Eliz City	A.C. Lilly	Jetted	18	1¼		...do...		3.4			...do...
56	2.0 mi W of Eliz City	C. Jennings	..do..	90	1¼		U. Yorktown sd & shell	-12	5	25	0.20	30-min pump. test. WL & yield meas by driller 6-23-60.
57	Eliz. City	Davis Hard-ware Co.	..do..	84	1¼	79	...do...	-14	15	25	0.60	1 hr. pump test. WL & yield meas by driller 7-14-60.
58	...do...	Winslow Rest Home	..do..	80	2	75	...do...	-14	50	22	2.27	30-min pump. test. WL & yield meas by driller 6-6-60.
59	...do...	Mildred's Flor-ist Shppe	..do..	84	1¼	79	...do...	-12	15	25	0.60	30-min pump. test. WL & yield meas by driller 5-17-62.
60	...do...	E.T. Stafford (Col. Clean.)	..do..	79.3	2	74.3	U. Yorktown sand	-7.70	15	25	0.60	Anal. 30-min pump test. WL meas. 4-3-62. Y meas by driller 3-23-62.
61	...do...	Culpepper Hardware Co.	..do..	80	2	75	...do...	-21	5	25	0.20	WL & yield meas by driller 7-22-60. 30-min pump test.
62	...do...	E.S. Chesson & Son	..do..	80	2	75	...do...	-21	5	25	0.20	30-min pump test. WL & yield meas. by driller 7-15-60.
63	...do...	E City Pub Util Comm.	..do..	80	2	75	...do...	-21	5	25	0.20	30-min pump test. WL & yield meas. 7-5-60.
64	...do...	Crystal Ice & Coal Corp.	Drilled	83	8	63	...do...	-7.5	165	56.5	2.95	4-hr. pump. test. WL & yield meas. by driller 3-46.
65	2.1 mi SE of Eliz. City	R.E. Chappell	Jetted	83	1¼	78	...do...	-8	30	25	1.20	30-min pump test. WL & yield meas. by driller 5-10-60.
66	2.3 mi SW of Eliz. City	C. Cartwright	..do..	85	1¼	80	...do...	-10	20	25	0.80	30-min pump test. WL & yield meas. by driller 4-5-61.
67	2.4 mi W of Eliz. City	R. L. Parker	..do..	89	1¼	84	...do...	-9	8	25	0.32	30-min pump test. WL & yield meas. by driller 8-62. Anal.
68	3.3 mi E of Okisko	C.M. Chappell	Driven	80	1¼	75	...do...					Anal. Temp. 63° F.
69	3.2 mi E of Okisko	D.T. White-hurst	..do..	65	1¼	60	U. Yorktown sd. & shell					
70	2.6 mi SE of Okisko	W. Stutz	..do..	75	1¼	70	U. Yorktown sd & gravel					
71	...do...	T. Maston	Jetted	68	1¼	63	U. Yorktown sand	-4	40	25	1.60	Anal. 30-min pump test. WL & yield meas by driller 5-17-70. T. 63° F.
72	2.4 mi SE of Okisko	J. E. White	Driven	75	1¼	70	U. Yorktown sd & shell					
73	1.0 mi SE of Okisko	H. Farrell	..do..	13.2	1¼	10.2	W-T sand	-2.59				WL meas. 5-10-62.
74	1.0 mi N of Okisko	R. Gregory	..do..	80.4	1¼	75.4	U. Yorktown sand	-1.91	11	25	0.48	Anal. WL meas by driller 5-10-62. yield meas. 12-61. Screen reset at 90-95 ft. 5-16-62.
75	...do...	J. Perry	..do..	75	1¼	70	...do...					
76	1.2 mi N of Okisko	A. Winslow	Jetted	20	1¼	15	W-T sand	-8	4	25	0.16	WL & yield meas by driller 4-27-62. Temp. 73° F.

TABLE 6 - RECORDS OF WELLS IN PASQUOTANK COUNTY - Continued

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Drawdown (ft.)	Spec. Yield (gpm/ft dd)	Remarks
77	1.4 mi NE of Okisko	R. Chappell, Jr.	Driven	85	1¼	80	U. Yorktown sand	-4				Anal. WL rept. by driller
78	2.5 mi E of Okisko	L. Bundy	..do..	115	1¼	110	...do...	-2.5	12	25	0.48	Anal. 30-min pump test. WL & yield rept. by driller. Temp. 63° F.
79	...do...	...do...	..do..	68	1¼	63	...do...					
80	4.6 mi SW of Eliz. City	Moses Temp AMF Zion Church	..do..	13.2	1¼	10.2	W-T sand	-6.94				WL meas. 9-11-62.
81	...do...	D.B. Barelift	..do..	80	1¼	75	U. Yorktown sand					
82	4.3 mi SW of Eliz. City	H. Bailey	..do..	70	1¼	65	...do...					
83	3.0 mi SW of Eliz. City	B. Harrell, Jr	Jetted	89	1¼	84	...do...	-8	22	22	0.68	30-min pump test. WL & yield meas. by driller 3-7-61.
84	3.0 mi NE of Nixonton	O. Brothers	..do..	75	1¼	70	...do...	-4	35	22	1.59	30-min pump test. WL & yield meas. by driller 12-20-61.
85	1.5 mi N of Nixonton	G. Maston	Driven	8	1¼	5	W-T sand					
86	3.2 mi NW of Nixonton	J. Pike	..do..	15	1¼	11	...do...					
87	Nixonton	Dr. T.P. Nash	Jetted	52	1¼	47	U. Yorktown shell					Cl: 46ppm; Fe: 4.5ppm, T. Hard: 244 ppm rept. by E. City Wtr Wks 4-4-61
88	...do...	...do...	..do..	20	1¼	17	W-T sand					Cl: 14ppm; Fe: Trace; T. Hard: 48 ppm rept. by E. City Wtr Wks 10-25-61. Temp. 67° F. pH 5.7.
89	1.0 mi E of Nixonton	Whiteville Grv. AMEZ Church	Driven	15.5	1¼	12.5	...do...	-4.72				WL meas. 5-24-62.
90	1.4 mi E of Nixonton	R.E. Stanton	Jetted	25	1¼	22	...do...	-3.49				Anal. WL 7-29-62 in PA-T2-62. Temp. 65° F.
91	2.4 mi E of Nixonton	C.H. Meades	Driven	105	1¼	100	U. Yorktown sand					
92	2.3 mi E of Nixonton	H. Pritchard	Jetted	123	1¼	113	U. Yorktown sd & shell	-9	4	25	0.15	30-min pump test. WL & yield meas. by driller 7-19-62.
93	...do...	E.P. Meads	..do..	111	1¼	101	...do...	-9	8	25	0.32	30-min pump test. WL & yield meas. by driller 7-5-62.
94	3.0 mi E of Nixonton	J.N. Keaton	..do..	100	1¼		...do...					
95	0.8 mi SW of Weeksville	M.T. Harris	Dug	12.1	36		W-T sand	-6.27				Aband. WL meas. 11-18-61.
96	1.6 mi SW of Weeksville	...do...	..do..	13.6	24		...do...	-4.69				Obs. well, Anal., WL meas. 11-17-61
97	1.8 mi SW of Weeksville	C. Sanders	Jetted	124	1¼	119	L. Yorktown sand	-8	5	25	0.20	Anal., 30-min pump test. WL & yield meas. by driller 7-18-62.
98	2.8 mi SW of Weeksville	M.S. Cartwright	..do..	45	1¼	45	W-T sand	+0.5 Flows				Cl: 30ppm; T. Hard: 150ppm rept. by Mundorf.
99	3.3 mi S of Weeksville	Union Methodist Church	Driven	28	1¼	25	U. Yorktown sand	-3.17				WL meas. 5-24-62.
100	3.4 mi SE of Weeksville	V.G. James	Jetted	52	1¼	47	...do...	-5.09	10			Anal., Obs. well. Temp. 62° F. WL & yield meas. 11-18-61.
101	4.0 mi SW of Weeksville	W.D. Lister	..do..	45	1¼	45	W-T sand & gravel	Flows	15			Cl: 30ppm; T. Hard: 150ppm & yield rept. by Mundorf.
102	4.4 mi SW of Weeksville	J. Cartwright	Dug	9.4	30		W-T sand	-5.88				WL meas. 5-24-62.
103	5.2 mi S of Weeksville	C.H. Roberson	Driven	18.4	1¼		...do...	-5.37	2.7			Temp. 59° F. WL & yield meas 5-24-62 Anal.
104	Weeksville	F. Jennings, Jr.	Jetted	60	2	55	U. Yorktown sand	-4	2	25	1.60	30-min pump test. WL & yield meas. by driller 6-14-60.

105	1.6 mi NE of Weeksville	W. James	Jetted	20.1	1¼		W-T sand	-7.48				WL meas. 9-11-62.
106	2.1 mi SE of Weeksville	Berry Bros.	..do..	68	2	63	U. Yorktown sand	-4	50	20	2.50	Anal., Temp. 64°F. 30-min pump test WL & yield meas by driller 5-9-60.
107	3.2 mi SE of Weeksville	R.C. James	Driven	22.5	1¼	20	W-T sand	-5.21				Obs. well. WL meas. 11-17-61.
108	4.4 mi SE of Weeksville		..do..	16.5	1¼		...do...	-3.35				WL meas. 5-25-62. Temp. 67° F.
109	4.1 mi SE of Weeksville	M. L. Meads	Jetted	96.5	1¼	91.5	U. Yorktown sd & shell	-8	4			Anal. WL & yield meas. 2-7-62. Temp. 69° F.
110	5.6 mi SE of Weeksville	W. Styles	..do..	94.9	1¼	90	U. Yorktown sand	-0.30 sometimes flows				Anal. Temp. 76° F. WL meas. 5-8-62.
111	5.9 mi SE of Weeksville	Davis	Driven	13	1¼	10	W-T sand					Temp. 71° F.
112	6.4 mi SE of Weeksville		..do..	18.4	1¼		...do...	-3.40				Anal. Temp. 67°F. WL meas 5-25-62.
113	3.0 mi NW of Weeksville		..do..	9.7	1¼		...do...	-4.81				WL meas. 9-11-62.
114	U.S.N.A.A.A. 2.0 mi NE of Weeksville	US Navy Hayes Aircraft Corp.	Jetted	169			L. Yorktown sand					Abandoned.
115	...do...	...do...	Drilled gvl wall	52.25	12-8	52.25	U. Yorktown sand	-6.5	17	19.2	0.88	Aban. Cl: 165ppm, Fe: 22ppm, pH 6.7 Rept by NC St Bd Health 8-15-41.
116	U.S.N.A.A.S. 1.9 mi NE of Weeksville	...do...	Drilled	73.30	12-8	73.30	...do...	-5.5	50	90	1.25	Aban. Cl: 50ppm, Fe: 2.2ppm, Total Hard: 150ppm. Rept. by Mundorf.
117	...do...	...do...		30	12-8		W-T sand	-4.59	8.5	10	0.85	Aban. WL meas 9-15-41 by Mundorf.
118	2.2 mi NE of Weeksville	C & V Brothers	Jetted	68	2	63	U. Yorktown sand	-6	35	25	1.40	Anal. Temp. 69° F. 30-min pump test. WL & yield meas by driller 6-9-60.
119	2.3 mi N of Weeksville	B. Fletcher	..do..	68	1¼	63	...do...	-4	25	22	1.14	30-min pump test. WL & yield meas. by driller.
120	U.S.C.G.A.S. 3.3 mi SE of Eliz. City	U.S. Coast Guard	Drilled gravel wall	34	-2	24	W-T sand	-11	30	12	2.50	WL & yield rept. by driller 9-39. Aband.
121	...do...	...do...	..do..	34	-2	24	...do...	-11	18	12	1.50	...do...
122	U.S.C.G.A.S. 3.5 mi SE of Eliz. City	...do...	Jetted	125.2	2	120.2	L. Yorktown sd & shell	-8.23	7	25	0.28	Anal., Obs. well. Temp. 70°F. 30-min pump test. WL meas. 11-16-61. Yield meas by driller 9-15-61.
123	...do...	...do...	..do..	47	2	42	U. Yorktown sand	-6	45	25	1.40	Anal. WL & yield meas. by driller 6-14-60.
124	...do...	...do...	Driven	23.6	2	23.6	W-T sand	-8.33				Anal. Obs. well. WL meas. 9-18-61.
125	U.S.C.G.A.S. 4.3 mi SE of Eliz. City	...do...	Drilled	107	8	88	U. Yorktown sand	-5	264			Cl: 83 ppm; Fe: 0.59 ppm. WL & yield rept. by Mundorf.
126	...do...	...do...	..do..	109	8	76	...do...	-6	220			Cl: 72ppm; Fe: 6.6ppm; WL rept. by Mundorf. Analysis.
127	...do...	...do...	..do..	130	8	117	L. Yorktown sd & shell		47			Aband. Yield rept. by Mundorf.
128	U.S.C.G.A.S. 3.0 mi SE of Eliz. City	...do...	..do..	80	8	65	U. Yorktown sd & gravel	-2.5	188			Aband. WL & yield rept. by Mundorf.
129	...do...	...do...	..do..	84.3	6	43.5	U. Yorktown sand	-6	165			...do...
130	2.6 mi SE of Eliz. City	W.R. Thomas	Jetted	68	1¼	63	...do...	-6	15	25	0.60	30-min pump test. WL & yield meas. by driller 9-15-61.
131	2.0 mi SE of Eliz. City	Supak & Sons Mfg. Co. Albemarle Indust., Inc.	Drilled	87	8-6	70.3	...do...	-10.6	94	9.7	9.69	WL & yield meas by driller 1-29-55.

TABLE 6 - RECORDS OF WELLS IN PASQUOTANK COUNTY - Continued

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Drawdown (ft.)	Spec. Yield (gpm/ft dd)	Remarks
132	Elizabeth City	C. Foreman	Jetted	80	2	75	U.Yorktown sd	-8				WL meas by driller 5-30-60.
133	...do...	J.B. Merritt	Driven	10.8	$1\frac{1}{4}$	10.8	W-T sand	-2.49				Obs. well. WL meas 3-29-62.
134	...do...	Allen	Dug	7.6	24		...do...	-6.85				WL meas 9-11-62. Aband.
135	...do...	E. City lub Util Comm.	Drilled	482	6		Beaufort quartz sand	-3.8	62	6.7	9.25	Aband. 3.280 ppm Cl. Yielded 400 gpm from 80 ft.
PA-T1-62	1.2 mi N of Lynchs Corner	U.S.G.S. R.F. Hewitt	Drilled gravel wall	702	4-2	577.8	Beaufort ferruginous quartz sand Aquifer 2	+7.80 flows				Aband. Screen set from 577.8-588 ft. below lsd. WL meas. 7-13-62. Anal. Temp. 66° F.
PA-T1-62	...do...	...do...	..do..	702	4-2	355.5	Beaufort green sand Aquf. 4	+3.14 flows				Aband. Screen set from 355.5-365.7 ft. below lsd. Anal. Temp. 63° F. WL meas. 7-19-62.
PA-T1-62	...do...	...do...	..do..	702	4-2	291.8	Middle Miocene glauconitic sand & shell rock Aquifer 1					Aband. Screen set from 291.8-302 ft. below lsd. Anal. Temp. 63° F WL meas. 7-24-62.
PA-T1-62	...do...	...do...	..do..	702	4-2	165.7	Middle Miocene phosphatic quartz sand	-8.12				Aband. Screened from 165.7-175.9 ft. below lsd. Anal. WL meas. 7-25-62. Temp. 65° F.
PA-T2-62	1.6 mi E of Nixonton	U.S.G.S. R.E. Stanton	..do..	723	4-2	500	Beaufort limestone Aquifer 5	-1.24	12	16	0.75	Aband. Screen set from 500.0-510.2 ft. below lsd. Anal. 1.5 hr pump test. Temp. 67° F. WL & yield meas. 8-1-62.
PA-T2-62	...do...	...do...	..do..	723	4-2	101.9	U. Yorktown sd & shell	-8.28	4.3			Aband. Screen set from 101.9-112.1 ft. below lsd. Anal. 30-min pump test. Temp. 65° F. WL & yield meas. 8-2-62.

Table 7.--Chemical analyses of ground water from Pasquotank County

Well number	Aquifer	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
PA 3	Upper Yorktown	53	0.70	67	40	252	21	785	1.8	198	0.2	0.4	1.4	1020	334	0	1650	7.2	25
PA 5	Upper Yorktown	53	2.1	29	11	46	6.8	200	.6	46	.3	.0	.4	294	119	0	461	6.9	10
PA 7	Water table	--	--	--	--	--	--	--	--	150	--	--	--	--	120	--	844	--	--
PA 11	Beaufort	20	.94	4.0	2.5	525	16	845	95	321	2.4	.0	.2	1400	20	0	2390	8.1	15
PA 14	Beaufort	13	.51	7.9	9.0	872	28	1130	111	697	2.6	.0	.1	2300	56	0	3880	8.0	3
PA 16	Water table	32	.63	68	11	16	1.6	262	1.5	20	.3	.1	.5	281	214	0	472	7.4	--
PA 21	Water table	60	9.3	23	9.2	41	1.2	122	13	49	.3	.0	.0	266	96	0	401	6.4	5
PA 27	Water table	--	--	--	--	--	--	--	--	36	--	--	--	--	95	--	400	--	--
PA 36	Lower Yorktown	43	.63	65	46	271	25	404	8.2	460	.2	--	.0	1120	351	20	2200	7.4	9
PA 38	Cretaceous	35	3.9	49	78	2400	88	757	284	3290	.7	2.4	.0	6600	442	0	10900	7.3	15
PA 39	Upper Yorktown	72	.49	70	40	206	21	398	12	345	.1	.0	.6	963	338	13	1600	7.4	15
PA 41	Upper Yorktown	46	.55	66	34	136	20	391	1.6	215	.1	3.3	.7	716	306	0	1240	7.4	15
PA 49	Water table	34	3.0	33	8.4	16	1.4	131	38	9.6	.2	.0	.6	210	116	9	300	6.6	--
PA 60	Upper Yorktown	48	1.9	18	59	105	18	385	.5	150	.1	4.5	--	595	290	0	1030	7.2	--
PA 67	Upper Yorktown	41	.27	61	36	173	17	426	1.2	244	.0	--	.5	784	299	0	1410	7.4	17
PA 68	Upper Yorktown	62	10	108	41	43	5.1	589	1.4	24	.5	.6	.1	586	435	0	928	7.0	20
PA 71	Upper Yorktown	46	1.2	104	40	108	13	601	1.8	120	.1	.2	1.2	732	423	0	1200	7.2	20
PA 74	Upper Yorktown	--	--	111	4.1	--	--	350	--	30	--	--	--	--	294	7	628	7.6	--
PA 77	Upper Yorktown	--	5.1	101	43	--	--	563	.4	--	--	--	--	--	428	0	1200	7.5	--
PA 78	Upper Yorktown	29	1.3	40	70	533	40	724	44	665	.2	.4	.1	1780	386	0	3100	7.6	30
PA 90	Water table	36	9.7	12	6.1	34	1.2	50	32	43	.1	.0	.0	199	54	14	293	6.4	0
PA 96	Water table	9.4	.99	5.0	3.3	7.8	3.6	27	7.0	11	.0	.7	.1	62	26	4	115	6.7	--
PA 97	Lower Yorktown	35	6.1	35	55	329	35	448	2.8	530	.1	--	.4	1250	313	0	2350	7.5	10
PA 100	Upper Yorktown	45	3.7	48	15	23	2.8	224	2.4	31	.2	.1	.1	281	180	0	445	7.1	10
PA 103	Water table	27	4.4	12	9.5	23	2.0	17	62	27	.1	.0	.0	175	69	55	260	6.6	5
PA 106	Upper Yorktown	31	4.8	6.4	3.2	17	.9	51	14	10	.1	.0	.0	112	29	0	140	6.6	5
PA 109	Upper Yorktown	52	1.1	46	31	138	23	328	2.8	230	.2	.1	.8	687	242	0	1190	7.4	10
PA 110	Upper Yorktown	46	.85	63	57	280	28	437	6.0	495	.2	.0	.2	1190	392	34	2100	7.4	10
PA 118	Upper Yorktown	43	14	13	6.8	9.6	2.0	90	.2	9.4	.1	.0	.0	142	61	0	173	6.8	5
PA 122	Lower Yorktown	5.3	.96	17	11	124	10	129	14	191	.2	.2	.0	438	88	0	867	7.1	30
PA 123	Upper Yorktown	26	11	12	6.9	30	3.5	71	14	47	.1	.1	.0	186	58	0	282	6.4	--
PA 124	Water table	41	1.3	4.8	2.9	18	1.0	41	5.5	17	.0	2.4	.0	114	24	0	143	6.5	--
PA 126	Upper Yorktown	45	6.1	79	12	42	3.8	336	4.5	42	.1	.1	.1	401	247	0	648	7.3	--
T1-62 [a]	Lower Yorktown	4.2	0.32	13	5.6	369	19	324	67	379	1.7	0.8	0.0	1020	56	0	1800	7.9	25
T1-62 [b]	Lower Yorktown	11	1.5	11	16	1000	38	1043	128	896	2.2	1.0	.0	2620	95	0	4310	8.0	10
T1-62 [c]	Beaufort	18	2.4	11	14	992	39	1052	107	887	2.1	.9	.0	2590	84	0	4270	7.9	15
T1-62 [d]	Beaufort	12	2.1	5.2	4.3	675	25	993	116	404	2.3	.9	.0	1740	31	0	2890	8.1	3
T2-62 [e]	Upper Yorktown	29	.16	35	43	360	40	400	14	535	.2	.9	.1	1250	267	0	2230	7.6	--
T2-62 [f]	Beaufort	27	2.3	83	142	3030	111	629	324	4680	.7	1.0	.0	8710	790	274	13900	7.3	--

a/ Sample collected at depth of 165.7 feet.
b/ Sample collected at depth of 291.8 feet.
c/ Sample collected at depth of 395.5 feet.
d/ Sample collected at depth of 577.8 feet.
e/ Sample collected at depth of 101.9 feet.
f/ Sample collected at depth of 500 feet.

Jetted and driven wells, screened or open end, obtain water from sands, coquinas, and indurated shell marls of the Yorktown upper and lower aquifers. Artesian wells screened in the Yorktown upper aquifer are almost as numerous as water-table wells. Wells in the Yorktown upper aquifer range in depth from 60 to 123 feet and yield 2 to 50 gpm from wells with diameters of 2 inches, 94 to 400 gpm for single- or multiple-screen wells with diameters of 2 inches, and 94 to 400 gpm for single- or multiple-screen wells with diameters of 6 to 10 inches (table 6). Wells in the Yorktown lower aquifer range in depth from 124 to 169 feet and yield from 5 to 47 gpm (table 6). The Yorktown lower aquifer is present only in the southern and east-central parts of the county. Specific yields of wells screened in the Yorktown upper aquifer range from 0.15 to 2.50 gpm per foot of drawdown for wells of 2 inch diameter and from 0.88 to 9.67 gpm per foot of drawdown for wells of 6 to 10 inch diameter. Specific yields of wells screened in the Yorktown lower aquifer range from 0.20 to 0.28 gpm per foot of drawdown (table 6).

In the Newland School area in the northern part of the county, brackish water containing 321 to 697 ppm chloride from wells screened in the Beaufort aquifers is used for domestic supplies. The chloride content of ground water in this part of the county decreases with increase in depth in the Beaufort aquifers owing to the increase in aquifer permeability with depth.

In the southern part of the county no potable water-bearing aquifers occur below the Yorktown upper aquifer.

All wells screened in the Beaufort aquifers flow by artesian pressure. No appreciable change in the concentration of chloride in water from these wells is discernible with change in artesian pressure.

Water Levels in Pasquotank County

The water levels in the surficial sands are generally 1 to 8 feet below the land surface (fig. 11). Figure 5 shows that the water table during September-October 1962, a period of low water levels in the water-table aquifer (figs. 8, 11) ranged from 5 to 10 feet above msl in the northern part of the county, and from near sea level to 5 feet above msl in the southern part of the county. Hydrographs for the water-table aquifer in Pasquotank County (fig. 8), indicate that the water table is generally highest during the period December-April (time of lowest seasonal precipitation) and lowest during the period May-November (time of greatest seasonal precipitation). Flowing wells are common during the period December-April in the lowlands along New Begun and Symonds Creeks in the southern part of the county, where the water-table aquifer is partly under artesian pressure.

Water in the Yorktown upper and lower aquifers occurs under artesian pressure. The piezometric surface of the Yorktown upper aquifer during October 1962, ranged from a maximum of about 20 feet above msl in the northern part of the county to mean sea level in the southern part of the county along Albamarle Sound and the Pasquotank and Little Rivers. The surface is slightly below mean sea level in the areas of influence of the cones of depression at Newland and Symonds Creek, and is as great as 38 feet below msl within the Elizabeth City area of pumping influence (fig. 6). The highest water levels occur from December through April, and the lowest from May through November (fig. 11).

Artesian flows from wells screened in the Yorktown upper aquifer have been recorded during spring months on the lowlands bordering Albemarle Sound.

Beaufort aquifer water levels in the northern part of the county are above the land surface. The highest water levels occur from October through February, and the lowest during September (fig. 11).

Quality of ground water in Pasquotank County

Adequate supplies of fresh ground water can be obtained from either the water-table aquifer or the Yorktown upper aquifer in most areas in Pasquotank County. Parts of the Yorktown lower aquifer also contain water with less than 250 ppm chloride. Few potable waters are available that do not contain large quantities of iron or hardness-causing constituents, and treatment is required to make these waters satisfactory for most uses. Analyses of water samples from Pasquotank County are shown in table 7.

Water-Table Aquifer

The least mineralized water in Pasquotank County is found in the water-table aquifer. The sums of mineral constituents are generally below 300 ppm, and chloride concentrations are belwo 50 ppm. Hardness as calcium carbonate ranged from 24 to 214 ppm in the samples analyzed. Iron ranged from 0.63 to 9.3 ppm; most water-table wells yield water containing more than 1.0 ppm. No areal pattern of distribution for hardness or iron is apparent. Most of the water-table waters are acidic, and corrosion is a common problem accompanying their use.

Yorktown Upper Aquifer

In Pasquotank County the Yorktown upper aquifer generally yields fresh waters which are very hard and contain objectionable amounts of iron. Chloride ranged from 9.4 to 365 ppm in the samples analyzed. Throughout most of the county, chloride concentrations in this aquifer are less than 50 ppm. Higher amounts were found in samples from the northern and southern extremities of the county, and in areas influenced by the cones of depression in the piezometric surface of the aquifer around Elizabeth City, Newland, and Symonds Creek. The distribution of chloride in waters in the Yorktown upper aquifer is shown in figure 7. Sums of the dissolved mineral constituents ranged from 112 to 1,780 ppm, but were less than 1,000 ppm in samples containing less than 250 chloride. Hardness as calcium carbonabe in this aquifer varied from 29 to 435 ppm, but no areal pattern of distribution was apparent. Iron ranged from 0.27 to 14 ppm. Figure 9 shows the probable concentration of iron in waters from the Yorktown upper aquifer. Other chemical constituents were not present in amounts objectionable to most water users.

Yorktown Lower Aquifer

Few wells are available for sampling in the Yorktown lower aquifer. These waters are chemically similar to those of the Yorktown upper aquifer, but may contain less iron.

Beaufort and Cretaceous Aquifers

The Beaufort and Cretaceous aquifers contain brackish or saline water throughout the county.

Perquimans County

(Area 261 square miles; population in 1960, 9,178)

Introduction

Perquimans County is the western most county in the area of investigation. It bordered on the north by Gates County, on the east by Pasquotank County and the Little River, on the south by Chowan County, the Yeopim River and Albemarle Sound, and on the west by Chowan County (fig. 14). Hertford, the county seat and second largest town in the Hertford-Elizabeth City area, had a population of 2,068 in 1960. Other population centers in the county include Belvidere, Durants Neck, Nicanor, Winfall, and Woodville.

Land-surface elevation ranges from more than 50 feet along Sandy Ridge (fig. 5) in the northwestern part of the county near sea level in the southern part of the county along Albemarle Sound. A conspicuous wave-cut terrace 5 to 8 feet high is present in parts of Durants and Harveys Necks along Albemarle Sound and the lower Perquimans River. Most of the northern part of the county is occupied by the Great Dismal Swamp, and the southwestern part of the county by Bear Swamp.

The sale of agricultural products provides the major source of income in the county. Commercial fishing, timber and military installations provide additional income.

Geology

The county is covered with thin surficial deposits of sands and clays of post-Miocene age. These surficial deposits range in thickness from about 65 feet in the northern part of the county to about 2 feet in the southwestern part of the county. They are underlain unconformably by blue-to-gray clay, sandy clay, sand, coquina, and indurated shell marl of the upper Miocene Yorktown Formation.

The Yorktown Formation ranges in thickness from about 210 feet in the southwestern part of the county to 125 feet in the northeastern part of the county, and from about 250 feet in the northwestern to about 185 in the southeastern part of the county.

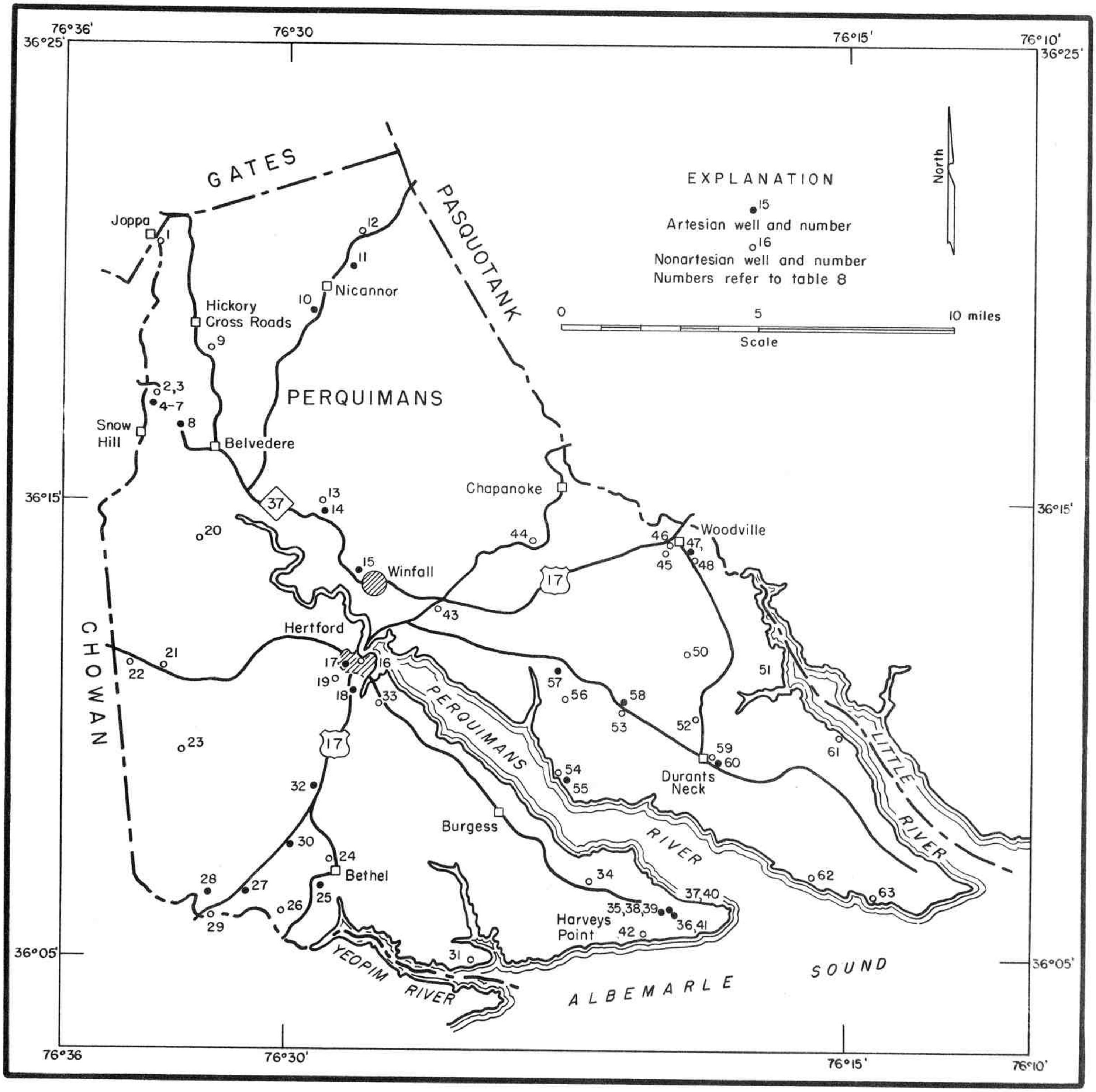


FIGURE 14. LOCATION OF WELLS INVENTORIED IN PERQUIMANS COUNTY

Clay, sandy clay, and phosphatic quartz sand of the middle Miocene undifferentiated unnamed unit lie conformably under the Yorktown Formation. The thickness of this unit ranges from about 25 feet in the southwestern part of the county and from 10 feet in the northwestern part of the county to 155 feet in the northeastern par tof the county and from 10 feet in the northwestern to about 218 feet in the southeastern part of the county. The middle Miocene undifferentiated unnamed unit is unconformably underlain by the Beaufort Formation of Paleocene age.

In the northern part of the county, the Beaufort Formation consists of glauconitic sand underlain by iron-stained quartz sand, clayey sands, and red clays. The Beaufort Formation ranges in thickness from about 290 feet in the southwestern part of the county to about 500 feet in the northwestern part and to about 400 feet in the northeastern part of the county. The Beaufort Formation is probably underlain by Upper Cretaceous sedimentary units.

Ground water

All water supplies in Perquimans County are obtained from wells; large to moderate supplies of ground water are available throughout the county. The largest users are the town of Hertford with a maximum consumption of 150,000 gpd, and the U. S. Department of Defense at Harveys Point with a maximum consumption of 10,000 gpd and an average consumption of 8,000 gpd. The depth of wells depends upon the depth to saline water.

Aquifers in Perquimans County

Potable water is obtained from two aquifers in the county, the water-table aquifer and the Yorktown upper aquifer. The location of wells inventoried in Perquimans County is shown in figure 14. Records for these wells are given in table 8. Chemical analyses of ground water are listed in table 9.

Surficial sands of the water-table aquifer furnish water to more wells in the county than any other aquifer. These sands are discontinuous, occurring as lenses. Dug, driven, and jetted wells in the surficial sands range in depth from 6 to 48 feet and yield from 5 to 15 gpm (table 8).

TABLE 8 - RECORDS OF WELLS IN PERQUIMANS COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (ft.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Drawdown (ft.)	Spec. Yield (gpm/ft dd)	Remarks
1	0.7 mi S of Joppa	J. Stallings	Dug	6.8	18		W-T sand	-5.50				WL meas. 9-13-62.
2	1.3 mi N of Snow Hill	C. Chappell	Driven	10.8	1¼	6.8	...do...	-2.72				WL meas. 4-4-62.
3	...do...	...do...	Jetted	30	1¼	25	...do...	-2				Anal. WL rept by driller 2-15-62.
4	...do...	...do...	..do..	365.1	4	345.1	Beau. Aquifer 4 glauc. sd	-31.26	13			Anal. WL & yield (con. rec) meas. 8-7-62. Obs well. Temp 64° F.
5	...do...	...do...	Drilled (bored)	137	1¼	38	U. Yorktown sand	-11.25				WL meas 4-4-62. Aband. Screen set 38-47 ft.
6	...do...	...do...	Jetted	50	1¼	45	...do...					Analysis.
7	...do...	C. Chappell, Jr.	..do..	52	1¼	47	...do...	-12	2	25	0.08	30-min pump test. WL & yield meas by driller 5-4-62
8	1.0 mi NW of Belvidere	J.C. Monds	..do..	290	2	270	Beau. Aquifer 4 glauc. sd	-0.09 flows	0.25 GMF			WL meas 11-28-61. Obs. well. Temp 66° F. Anal.
9	1.0 mi S of Hickory X-Rd	Riddick's Grove Ch.	Driven	24	1¼		W-T sand	-3.13				WL meas 11-17-61. Obs. well.
10	0.7 mi SW of Nicanor	A. White	Jetted	80	1¼	75	U. Yorktown shell	-5	15	25	0.60	Anal. 30-min pump test. WL & yield meas by driller 6-21-60. Temp. 66° F.
11	0.8 mi NE of Nicanor	N. Riddick	..do..	620	2	600	Beau. Aquifer 1 sand	+5.77 flows				Anal. WL meas 11-28-61. Obs. well
12	1.7 mi NE of Nicanor	...	Dug	6.7			W-T sand	-5.72				WL meas. 9-13-62.
13	2.4 mi NW of Winfall	J.A. Winslow	..do..	13.0	24		...do...	-8.92				WL meas. 8-30-62.
14	...do...	...do...	Jetted	323.5	2	303.5	Beau. Aquifer 5 limestone	+4.60 flows	0.5 GMF			Anal. Temp. 61°F. WL meas 11-28-61. Obs. well.
15	Winfall	Perq. Union Co. School	..do..	68	2	63	U. Yorktown sand	-12	25	25	1.00	Anal. 30-min pump test. WL & yield meas. by driller 3-28-62.
16	Hertford	Town of Hert.	..do..	29.7	1¼	27.7	W-T sand	-0.63	10			WL & yield meas. 9-28-62.
16A	...do...	...do...	Driven	45	1¼		...do...		14			T Hard: 180 ppm, Cl: 38 ppm, Fe: 9 ppm, rept by Lohman. Aband.
17	...do...	...do...	Drilled	600	10-8		Beau. Aqui. 1	-1.5	20	26.5	0.75	40-min pump test. WL & yield rept. by Mundorf 9-4-43. Cl: 3020 ppm.
18	0.7 mi S of Hertford	Y.L. Brown	Driven	64	1¼	59	W-T sand	-8.34	40	25	1.60	30-min pump test. WL meas 5-16-62. yield rept by dlr. T. 64°F. Anal.
19	1.0 mi SW of Hertford	Town of Hert.	Drilled grv wall	447	10-8	Multi. Screens	U. Yorktown sd & shell	-15	385	30	10.00	Anal. 24 hr pumt t. WL & yld meas by dlr. 9-1-58. Scns. set from 57-62, 72-77, 84-89, 102-107, 117-122 ft. Temp 62° F. Cl at 84-94 ft.: 28 ppm; Cl at 313-325 ft.: 2310 ppm; Cl at 420-430 ft.: 2470 ppm.
20	2.3 mi S of Belvidere	M.H. Chappell	Dug	7.9	30		W-T sand	-6.76				WL meas. 9-13-62.
21	2.8 mi W of Beach Springs	Great Hope Baptist Ch.	Driven	21.8	1¼	17.8	...do...	-8.21				WL meas 8-25-62.
22	3.6 mi W of Beach Springs	T. R. Harrell	Drilled	335.5	2	327.5	Beau. Aqui. 5 limestone	+0.63 flows	2.9	17.3	0.17	Anal. Temp 67°F. 10-min pump test. WL & yield meas 5-16-62.
23	5.0 mi NW of Bethel	M.L. Goodman	Dug	7.0	36		W-T sand	-4.16				WL meas 9-13-62.
24	Bethel	L. Hobbs	..do..	11.6	24		...do...	-3.89				Temp. 68°F. WL meas 4-9-62.
25	0.5 mi SW of Bethel	E.J. Proctor	Jetted	99			U.Yorktown sd		7			Cl: 25 ppm; T. Hard: 214 ppm; Rept by E City Wtr Wks. 10-22-42.
26	1.7 mi SW of Bethel	M. Fleetwood	Driven	70	1¼		...do...					Use to flow.

27	2.3 mi W of Bethel	M.T. Griffin	Driven	80	1¼	75	U.Yorktown sd					
28	3.3 mi W of Bethel	H.B. Warren	..do..	94	1¼	89	...do...		12	25	0.48	Anal. 30-min pump test. Yield meas by driller 5-18-62.
29	3.3 mi SW of Bethel	A.M. Proctor	Dug	9.1	24		W-T sand	-5.33				WL meas. 9-28-62.
30	1.4 mi NW of Bethel	J.W. Byrum	Driven	60.4	1¼	55.4	U.Yorktown sd	-2.12	4.8			Anal. Temp. 65°F. WL & yield meas. 5-16-62.
31	4.0 mi SE of Bethel	L. Simpson	Dug	7.8	24		W-T sand	-6.08				WL meas 8-25-62.
32	2.3 mi N of Bethel	M. Dail	Jetted	91	1¼	86	U. Yorktown sd & shell		8			Cl: 11 ppm. T.Hard: 215 ppm. Yield rept. by Mundorff.
33	1.0 mi SE of Hertford	F. Long	Dug	6.0	24		W-T sand	-3.07				Anal. Obs. well. WL meas 11-21-61.
34	2.8 mi SE of Burgess		..do..	11.0	24		...do...	-7.52				WL meas. 9-13-62.
35	5.0 mi SE of Burgess (Harveys Pt. Spec. Testing Act.)	U.S. Dept. of Defense (Harveys Point)	Drilled	66	8		U.Yorktown sd	-5.4				Obs. well. WL meas. 11-17-61.
36	...do...	...do...	..do..	75	8-6	Multi. Screens	...do...	-3	171	23	7.31	35-hr. pump test. WL & yield meas by dlr. 1-16-59. Anal. Screens set 30-40, 50-70 ft.
37	...do...	...do...	..do..	73.7	8-6	..do..	...do...	-3	156	23	6.78	27-hr. pump test. WL & yld meas by dlr. 1-30-59. Scns set 32-42, 50-70 ft.
38	...do...	...do...	..do..	75	8-6	..do..	...do...	-4	162	22	7.59	27-hr. pump test. WL & yld meas by dlr. 4-1-59. Anal. Scns set 30-40, 50-70 ft.
39	...do...	...do...	..do..	76	8-6	..do..	...do...	-3	178	23	7.82	27-hr. pump test. WL & yld meas by dlr. 4-9-59. Anal. Scns set 30-40, 50-70 ft.
40	...do...	...do...	..do..	75	8-6	..do..	...do...	-2	151	24	6.29	27.5 hr pump test. WL & yld meas by dlr. 2-13-59. Anal. Scns. set 32-42, 50-70 ft.
41	...do...	...do...	..do..	271	8-6	..do..	...do...					Aband. test hole. Cl: 1440-1480 at 271 ft.
42	4.8 mi SE of Burgess	V.L. Proctor	Dug	12.4	24		W-T sand	-8.70				WL meas. 8-25-62. Temp. 64° F.
43	1.7 mi SE of Winfall	NC Forest Service	Driven	17.8	1¼	12.8	...do...	-7.23				Temp. 65° F. WL meas 8-24-62.
44	1.5 mi SW of Chapanoke	M. Riddick	..do..	8.5	1¼		...do...	-4.82				Temp. 72° F. WL meas. 8-25-62.
45	Woodville	L. Willey	..do..	22.3	1¼	19.3	...do...	-3.77				WL meas. 4-9-62.
46	...do...	F. Wilson	..do..	12.7	1¼	9.7	...do...	-0.61				Anal. WL meas. 4-9-62.
47	0.5 mi S of Woodville	NC St. Hwy Pub Wks Com.	Drilled	280	2		Middle miocene		20			Cl: 135 ppm, T. Hard: 338 ppm, pH: 6.9. Rept by USGS, QW 8-26-49.
48	...do...	...do...	..do..	245	2		...do...		20			...do...
49	...do...	Perq. Co. Prison Camp	..do..	7.1	3	7.1	W-T sand	-6.60				Obs. well. WL meas. 11-20-61.
50	2.8 mi N of Durants Neck	Assembly of God Church	Driven	11.0	1¼		...do...	-6.99				WL meas. 8-25-62.
51	3.0 mi NE of Durants Neck	J. Colson	..do..	11.6	1¼	6.6	...do...	-2.70				Temp. 68° F. WL meas. 8-25-62.
52	1.0 mi N of Durants Neck	W. Dail	Jetted	48.2	1¼	43.2	W-T sand	-5.37	15			Anal. Temp. 62° F. WL & yield meas. 8-6-62.
53	2.5 mi NW of Durants Neck	Powell	Driven	11.1	1¼	8.1	...do...	-4.38	4.8			Anal. Temp. 57° F. WL & yield meas. 5-18-62.
54	1.8 mi NE of Burgess	Dickerson	..do..	13.7	1¼		...do...	-9.19				WL meas. 8-25-62.

TABLE 8 - RECORDS OF WELLS IN PERQUIMANS COUNTY - Continued

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing	Aquifer	Water Level (ft.)	Yield (gpm)	Drawdown (ft.)	Spec. Yield (gpm/ ft dd)	Remarks
55	...do...	T. McDaniel	Jetted	71	$1\frac{1}{4}$	66	U.Yorktown sd	-6	40	25	1.60	Anal. Temp. 64° F. 30-min pump. test. WL & yield meas by driller 5-5-60.
56	3.9 mi NW of Durants Neck	G. Webb	Dug	10.8	36		W-T sand	-8.75				Anal. Obs. well. WL meas. 11-21-61
57	4.4 mi NW of Durants Neck	A.C. Caddy	Jetted	90	$1\frac{1}{4}$		U.Yorktown sd					Cl: 26 ppm, T. Hardness: 250 ppm. Rept. by Mundorff.
58	2.6 mi NW of Durants Neck	H.H. Caddy	..do..	77	$1\frac{1}{4}$	72	...do...	-6	40	25	1.60	Anal. 30-min pump. test. WL & yield meas. by driller 8-30-62.
59	Durants Neck	E.A. Turner	Driven	20.0	$1\frac{1}{4}$		W-T sand	-5.50				Temp. 64° F. WL meas 8-25-62.
60	...do...	L.R. Webb	Jetted	100	$1\frac{1}{4}$	95	U.Yorktown sd					Cl: 152 ppm. Rept. E City Wtr Wks.
61	3.5 mi E of Durants Neck	Taylor Bros.	Driven	10.8	$1\frac{1}{4}$		W-T sand	-6.38				Temp. 69° F. WL meas 8-25-62.
62	4.0 mi SE of Durants Neck	Jones	Dug	10.1	24	10	...do...	-7.45				Anal. Obs. well. WL meas 11-21-61
63	3.5 mi SE of Durnats Neck	J.A. White	Jetted	39.1	$1\frac{1}{4}$		...do...	-4.30				Anal. Temp. 62° F. WL meas. 8-25-62.

Table 9.--Chemical analyses of ground water from Perquimans County

Well number	Aquifer	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Col
PE 3	Water table	4.8	2.0	15	8.8	13	10	20	62	35	0.0	--	0.0	161	74	57	322	5.9	--
PE 4	Beaufort	19	.04	12	13	860	40	670	49	984	2.8	3.1	--	2310	84	0	4250	7.7	--
PE 6	Upper Yorktown	44	.14	22	7.8	6.8	2.6	120	.5	2.2	.0	2.8	.0	149	88	0	208	7.3	--
PE 9	Beaufort	34	2.4	32	32	792	41	567	110	1050	.6	.0	.0	2370	212	0	4220	7.7	10
PE 10	Upper Yorktown	46	.81	60	7.3	12	1.9	230	1.6	11	.1	.2	.2	254	181	0	377	7.5	5
PE 11	Beaufort	18	1.3	34	16	1360	60	831	190	1540	1.5	4.2	.0	3630	152	0	6000	7.8	5
PE 14	Beaufort	--	5.6	--	--	--	--	679	195	1340	.8	5.4	--	--	235	0	5080	7.4	--
PE 15	Upper Yorktown	53	1.8	73	21	69	11	412	1.8	49	.1	.5	.6	484	268	0	820	7.5	15
PE 18	Upper Yorktown	33	4.4	76	4.3	12	1.0	257	2.6	13	.1	.2	.1	274	206	0	421	7.7	5
PE 19	Upper Yorktown	30	4.1	66	4.1	13	1.2	215	3.6	20	.1	.0	.5	249	183	6	400	7.7	0
PE 22	Beaufort	16	.58	24	23	628	35	317	24	979	1.8	.1	.0	1890	154	0	3540	7.9	0
PE 28	Upper Yorktown	62	3.9	106	12	22	2.1	414	2.4	9.0	.2	.3	.1	424	312	0	630	7.3	5
PE 30	Upper Yorktown	64	4.8	101	13	18	2.9	400	1.4	8.5	.3	.4	.1	411	308	0	600	7.2	5
PE 33	Water table	10	--	11	8.5	13	2.5	24	50	15	.0	.7	.0	124	63	44	215	5.9	--
PE 36-40	Upper Yorktown	24	.06	22	3.5	11	1.2	81	9.4	11	.0	2.9	.0	125	68	2	188	6.7	0
PE 46	Water table	36	3.4	22	14	40	2.2	62	60	48	.2	.2	--	257	112	61	442	6.1	4
PE 52	Water table	53	4.3	63	15	21	5.0	278	1.2	24	.1	.5	.4	324	218	0	490	7.2	10
PE 53	Water table	37	4.3	22	73	147	3.0	450	53	188	1.6	.0	.4	749	356	0	1270	8.0	5
PE 55	Upper Yorktown	55	6.1	89	16	32	4.4	341	2.4	58	.1	.2	.1	429	289	10	685	7.1	5
PE 56	Water table	30	--	60	8.9	172	5.0	68	70	298	.0	6.2	.0	684	186	130	1250	6.2	--
PE 58	Upper Yorktown	43	5.9	114	15	25	4.8	410	.2	42	.1	--	.0	452	346	10	740	6.9	5
PE 62	Water table	9.0	--	9.3	9.0	20	3.6	59	16	24	.1	3.3	.0	123	60	12	230	6.6	--
PE 63	Water table	42	1.8	32	7.9	19	1.4	152	2.2	18	.1	.2	.1	200	112	0	290	7.4	5

Driven wells and jetted-drilled wells, screened or open end, obtain water from sands, coquinas, and indurated shell marls of the Yorktown upper aquifer. Wells in this aquifer range in depth from 47 to 122 feet and yield from 2 to 40 gpm from wells $1\frac{1}{2}$ to 2 inches in diameter, and from 151 to 385 gpm for multiple-screen, gravel-wall, rotary-drilled wells of 6 to 10 inch diameter (table 8). Specific yields for wells screened in the Yorktown upper aquifer range from 0.8 to 1.60 gpm per foot of drawdown for wells 2 inches in diameter, to 6.29 to 10.00 gpm per foot of drawdown for wells of 6 to 10 inches in diameter.

Several domestic wells in the northern and western part of the county are screened in Beaufort aquifers. These wells range in depth from 290 to 620 feet and yield from 3 to 20 gpm. Almost all the wells screened in the Beaufort aquifers flow at rates ranging from 0.25 to 0.50 gpm. Specific yields of wells screened in the Beaufort aquifers range from 0.17 gpm per foot of drawdown to 0.75 gpm per foot of drawdown (table 8).

Water Levels in Perquimans County

The water levels in the surficial sands are generally half a foot to 10 feet below the land surface (fig. 11). The water table during September-October 1962, a period of low water levels (fig 11), ranged from a maximum of 50 feet above msl along Sandy Ridge in the northwestern part of the county to near mean sea level throughout the remainder of the county (fig. 5). The water table is generally highest during the period January-April (time of lowest seasonal precipitation) and lowest during the period May-December (time of greatest seasonal precipitation).

Water in the Yorktown upper aquifer is under artesian pressure. The piezometric surface of the Yorktown upper aquifer during October 1962 ranged from a maximum of 36 feet above msl along Sandy Ridge in the northwestern part of the county to mean sea level along Albemarle Sound and the lower parts of the major rivers in the southeastern part of the county. Well No. PE-35 (fig. 11), screened in the Yorktown upper aquifer (table 8), shows an annual fluctuation of about 6 feet in the piezometric surface at Harveys Point. The highest water levels occur from December through April, and the lowest from May through November. Artesian flows occur from wells along parts of Albemarle Sound and the lower Yeopim, Perquimans and Little Rivers when the piezometric surface of the Yorktown upper aquifer is highest.

No wells in Perquimans County obtain water from the Yorktown lower aquifer which is present in the extreme southwestern part of the county at about 110 to 135 feet below land surface.

Several wells produce water from the Beaufort aquifers in Perquimans County. The water levels in these wells range from 32 feet below land surface along Sandy Ridge to 6.7 feet above land surface in the northeastern part of the county. There is little annual fluctuation in the artesian pressure of these wells (fig. 11).

Quality of ground water in Perquimans County

Ground water containing less than 50 ppm of chloride is available from the water-table and Yorktown upper aquifers throughout most of Perquimans County. These fresh waters usually contain objectionable amounts of iron or hardness-causing constituents, requiring treatment for most uses. Analyses of water samples from this county are shown in table 9.

Water-Table Aquifer

Waters from the water-table aquifer are usually less highly mineralized than those from other water-bearing zones. In Perquimans County the sums of dissolved mineral constituents in waters from the water-table aquifer range from 123 to 749 ppm. Wells PE-53 and PE-56 contained waters with 749 and 684 ppm of dissolved solids, respectively. These wells are very shallow and contamination from surface-water drainage may account for these abnormally high mineral concentrations. The total dissolved mineral matter in uncontaminated waters from the water-table aquifer probably does not exceed 500 ppm, except in a few localities immediately adjacent to Albemarle Sound. Most water-table wells in the interior of the county yield waters having dissolved-solid sums less than 250 ppm. Hardness of waters in the water-table aquifer ranges from 60 to 365 ppm, but is less than 100 ppm in most inland wells. Iron concentrations range from 1.3 to 4.3 ppm, except in open dug wells where it has oxidized and occurs as a precipitate. Most water-table waters are slightly acidic and usually corrosive to metal plumbing fixtures.

Yorktown Upper Aquifer

The Yorktown upper aquifer yields water containing less than 50 ppm chloride in all parts of Perquimans County, except in the vicinity of Durants Neck, and in some areas immediately adjacent to the lower Perquimans River and Albemarle Sound. Chloride concentrations of water from this aquifer are shown in figure 7. The samples analyzed from the Yorktown upper aquifer in Perquimans County are generally very hard. In figure 9 the zones in which iron is less than 0.3 ppm are also zones in which hardness is less than average for the Yorktown upper aquifer in this county. Most of the water from the Yorktown upper aquifer in Perquimans County contains large amounts of iron; concentrations range from 0.06 to 6.1 ppm.

Beaufort Aquifers

The Beaufort aquifers contain brackish or saline water in Perquimans County. Chloride concentrations in samples analyzed ranged from 979 to 1,540 ppm.

SELECTED REFERENCES

Brown, P. M., 1957, Upper Cretaceous Ostracoda from North Carolina: North Carolina Dept. Conserv. Devel. Bull. 70, 28 p.

__________, 1958, Well logs from the Coastal Plain of North Carolina: North Carolina Dept. Conserv. Devel. Bull. 72, 68 p.

__________, 1959, Geology and ground-water resources in the Greenville area, North Carolina: North Carolina Dept. Conserv. Devel. Bull. 73, 87 p.

__________, 1962, Evidence of a marine Cretaceous basin in northeastern North Carolina (abs.): Geol. Soc. America program of 1962 annual meeting, Houston, Texas, p. 24A-25A.

Brown, R. H., 1953, Selected procedures for analyzing aquifer test data: Am. Water Works Assoc. Jour., v 45, no. 8, p. 844-866.

Cederstrom, D. J., 1945, Structural geology of southeastern Virginia: Am. Assoc. Petroleum Geologist Bull., v. 29, no. 1, p. 71-95.

Clark, W. B., and Miller, B. L., A brief summary of the geology of the Virginia Coastal Plain: in Ries, Heinrich, 1906, The clay deposits of the Virginia Coastal Plain: Virginia Geol. Survey, Geol. Series, Bull. 2, p. 11-24

Clark, W. B., Miller, B. L., Stephenson, L. W., Johnson, B. L. and Parker, H. N., 1912, The Coastal Plain of North Carolina: North Carolina Geol. and Econ. Survey, v.3, 552 p.

Conrad, T. A., 1871, Points connected with the Cretaceous and Tertiary of of North Carolina (letter excerpt): Am. Jour. Sci., 3rd ser., v. 1, p. 468-469.

Cushman, J. A., and Cahill, E. D., 1933, Miocene Foraminifera of the Coastal Plain of the eastern United States: U. S. Geol. Survey Prof. Paper 175-A, p. 1-50.

Hem, J. D., Study and interpretation of the chemical characteristics of natural water: U. S. Geol. Survey Water-Supply Paper 1473, 269 p.

Henbest, L. G., Lohman, K. E., and Mansfield, W. C., 1939, Foraminifera, diatoms, and mollusks from test wells near Elizabeth City, North Carolina: U. S. Geol. Survey Prof. Paper 189-G, p. 216-227.

LeGrand, H. E., 1961, Summary of geology of Atlantic Coastal Plain: Am. Assoc. Petroleum Geologist Bull., v. 45, no. 9, p. 1557-1571.

____________, and Brown, P. M., 1955, Guidebook of escursion in the Coastal Plain of North Carolina: Carolina Geol. Soc., 43 p.

____________, and Siple, G. E., 1953, Memorandum relating to ground-water investigation in the Elizabeth City area, North Carolina, during 1950 and early part of 1951: in Pease, J. N. and Co., Engineers, 1953, Report on water supply of Elizabeth City North Carolina: Charlotte, N. C., p. 187-200.

Lohman, S. W., 1936, Geology and ground-water resources of the Elizabeth City area, North Carolina: U. S. Geol. Survey Water-Supply Paper 773-A, 57 p.

Luther, R. W., 1949, Report to the Public Utility Commission of Elizabeth City, North Carolina: in Pease, J. N., and Co., Engineers, 1953, Report on water supply of Elizabeth City, North Carolina: Charlotte, N. C., p. 161-183.

Mann, V. I., 1962, Bouger gravity map of North Carolina: Southeastern Geology, v. 3, p. 207-220, pl. 1.

Meinzer, O. E., 1923, Outline of ground-water hydrology with definitions: U. S. Geological Survey Water-Supply Paper 494, 71 p.

____________, (ed.), 1942, Hydrology: New York, McGraw-Hill Book Co.

Mundorff, M. J., 1946, Ground water in the Halifax area, North Carolina: North Carolina Dept. Conserv. Devel. Bull. 51, 76 p.

____________, 1947, A possible new source of ground-water supply in the Elizabeth City area, North Carolina: North Carolina Dept. Conserv. and Devel. Inf. Circ. 6, 18 p.

Nordell, Eskel, 1961, Water treatment for industrial and other uses: New York, Reinhold Publishing Corp., 598 p.

Oaks, R. Q., Jr., and Coch, N. K., 1963, Pleistocene sea levels, southeastern Virginia: Science, vol. 140, no. 3570, p. 979-983.

Parker, J. C., 1953, History of the Elizabeth City water supply: in Pease, J. N. and Co., Engineers, 1953, Report on water supply of Elizabeth City, North Carolina: Charlotte, N. C., p. 64-78.

Pease, J. N. and Co., Engineers, 1953, Report on water supply of Elizabeth City North Carolina: Charlotte, N. C., Pease and Co., Engineers, 212 p.

Rankama, K. K., and Sahama, Th. G., 1950, Geochemistry: Chicago, University Chicago Press, 912 p.

Richards, H. G., 1945, Subsurface stratigraphy of Atlantic Coastal Plain between New Jersey and Georgia: Am. Assoc. Petroleum Geologists Bull., v. 29, no. 7, p. 885-955.

____________, 1950, Geology of the Coastal Plain of North Carolina: Am. Philos. Soc. Trans., n. s., v. 40, pt. 1, 83 p.

Ruffin, Edmund, 1843, Report of the commencement and progress of the agricultural survey of South Carolina: South Carolina Dept. Agriculture, 56 p.

Ruhle, J. L., 1962a, Selected Tertiary fossil localities of the Virginia Coastal Plain: Virginia Minerals, v. 8, no. 3, p. 2-9.

____________, 1962b, Guidebook to the Coastal Plain of Virginia north of the James River: Virginia Dept. of Conserv. Econ. Devel. Div. Mineral Resources Inf. Circ. 6, 46 p.

Sanders, J. E., and Oaks, Jr., R. Q., 1962, Origin and significance of sand-ridge and mud-flat complex, Back Bay area, southeastern Virginia (abs.): Am. Assoc., Adv. Sci. program of 1962 annual meetings, Philadelphia, Pa., p. 27-28.

Sloan, Earle, 1907, A summary of the mineral resources of South Carolina: South Carolina Dept. Agriculture, 66 p.

Stephenson, L. W., 1907, Some facts relating to the Mesozoic deposits of the Coastal Plain of North Carolina: Johns Hopkins Univ. Circ., n. s., no. 7, p. 93-99.

____________, 1923, The Cretaceous formations of North Carolina, pt. 1, Invertebrate fossils of the Upper Cretaceous formations: North Carolina Geol. & Econ. Survey Bull., v. 5, 604 p.

U. S. Department of Health, Education, and Welfare; Public Health Service, 1962, Public Health Service drinking water standards: Public Health Service Pub. 956, 61 p.