GROUND-WATER PUMPAGE AND WATER-LEVEL DECLINES IN THE PEEDEE AND BLACK CREEK AQUIFERS IN ONSLOW AND JONES COUNTIES, NORTH CAROLINA, 1900-86

By William L. Lyke and Allen R. Brockman

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4197

Prepared in cooperation with

THE NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
HEALTH, AND NATURAL RESOURCES
JONES COUNTY
ONSLOW COUNTY
CITY OF JACKSONVILLE

Raleigh, North Carolina

1990

UNITED STATES DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Post Office Box 2857
Raleigh, North Carolina 27602

Copies of this report can
be purchased from:

U.S. Geological Survey
Books and Open-File Reports
Federal Center, Box 25425
Denver, Colorado 80225

CONTENTS

ILLUSTRATIONS

TABLES

INTERNATIONAL SYSTEM UNITS

The following factors may be used to convert inch-pound units used in this report to metric (International System) units.

Multiply inch-pound unit	By	To obtain metric unit
	Length	
foot (ft)	0.3048	meter
	Volume	
gallon (gal)	3.785	liter (L)
	Flow	
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
foot per year (ft/yr)	0.3048	meter per year (m/yr)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

GROUND-WATER PUMPAGE AND WATER-LEVEL DECLINES IN THE PEEDEE AND BLACK CREEK AQUIFERS IN ONSLOW AND JONES COUNTIES, NORTH CAROLINA, 1900-86

By William L. Lyke[1] and Allen R. Brockman[2]

ABSTRACT

Two aquifers in sediments of Cretaceous age, the Peedee and Black Creek aquifers, have become a major source of freshwater in Onslow and Jones Counties in North Carolina since about 1960. Prior to 1960, most water systems in this area withdrew water from younger sand or limestone beds that overlie the Peedee and Black Creek aquifers. Water-quality and economic considerations related to the treatment of water from these shallower aquifers led to increased use of the Peedee and Black Creek aquifers.

Water withdrawals from the Black Creek and Peedee aquifers were about 10,000 gallons per day in 1933. By 1986, total withdrawals were about 7.8 million gallons per day, about 90 percent of which was supplied from the Black Creek aquifer.

As a result of these withdrawals, ground-water levels have declined throughout Onslow and Jones Counties. The average rate of decline in static water levels in the the Peedee aquifer is about 0.6 foot per year in central Jones County and about 1.4 feet per year in northern Onslow County. Rates of water-level decline in the Black Creek aquifer average about 8.3 feet per year in Jones County to about 12 feet per year in northern Onslow County.

Water levels in the Peedee aquifer have declined as much as 40 feet in Jones County and 80 feet in northern Onslow County since about 1900. During the same period, water levels in the Black Creek aquifer have declined as much as 120 and 160 feet in Jones and northern Onslow Counties, respectively.

---

[1]U.S. Geological Survey.
[2]North Carolina Department of Environment, Health, and Natural Resources.

INTRODUCTION

Ground water is a major source of freshwater in Jones and Onslow Counties. Ground-water withdrawals have increased since 1933, resulting in water-level declines in the two aquifers, the Peedee and Black Creek, which are the major source of freshwater for municipal water systems. As a result of these declines, some water-supply systems have lowered, or will lower in the near future, the intakes of pumps in some of their wells. A number of communities have become concerned about the effect of the water-level declines on the future availability of their ground-water resources.

The U.S. Geological Survey (USGS), in cooperation with the North Carolina Department of Environment, Health, and Natural Resources (DEHNR) and local agencies concerned about the effect of water-level declines on ground-water resources, began a hydrologic investigation of the central Coastal Plain of North Carolina in 1983. The original study area for the Central Coastal Plain Aquifer Study included all or part of Beaufort, Craven, Edgecombe, Greene, Lenoir, Pitt, Wayne, and Wilson Counties. Onslow and Jones Counties were added to the study area in 1986. Information similar to that presented in this report has been presented for the original study area by Winner and Lyke (1986).

This is one of a number of reports resulting from the Central Coastal Plain Aquifer Study conducted by the U.S. Geological Survey. This report was prepared in cooperation with the North Carolina Department of Environment, Health, and Natural Resources; Jones County; Onslow County; and the City of Jacksonville.

Purpose and Scope

This report documents the increased use of the Peedee and Black Creek aquifers as freshwater sources for Onslow and Jones Counties. As a consequence of increased pumpage, water levels have declined in both aquifers. Both past and present pumpage and water-level data in Onslow and Jones Counties are presented, along with estimates of the rates of water-level declines for both aquifers. Information regarding the effects of

pumpage on the ground-water resources of the study area is important to the future management of the resource.

This study was limited to public water-supply systems that withdraw more than 10,000 gallons per day (gal/d) from the Peedee and Black Creek aquifers in Jones and Onslow Counties (fig. 1). Five municipal water-supply systems which met this criterion were the Jones County, Onslow County, City of Jacksonville, Northwest Onslow Water Association, and the Town of Richlands systems.

Data-Collection Methods

Pumpage

A review of municipal ground-water pumpage records and nonpumping ground-water level measurements for wells in the study area was conducted for this study. Ground-water pumpage and ground-water level data are presented in tables 1 and 2, respectively, beginning on page 25 of this report. Ground-water pumpage records were obtained from water system managers and the North Carolina Department of Human Resources, Division of Health Services, in Raleigh. Some records include the amount of water pumped by each well, whereas other records include the total pumpage of a well field or the entire system. For water systems where pumpage was not recorded by well, the withdrawal by each well was estimated by multiplying the field or system's total pumpage by the ratio of the well yield of each well to the total yield of all wells in the field or water system. Values for well yields were obtained from well records written when the well was constructed. These values often represent the minimum design capacity for the well.

Annual pumpage values were not available for some years for the Jones County, Northwest Onslow, City of Jacksonville, and Town of Richlands water systems. Pumpage values for these years were estimated based on well yields, well history, and other methods described in Winner and Lyke (1986).

Some wells in the study area are screened in both the Peedee and Black Creek aquifers and, therefore, withdraw water from both aquifers.

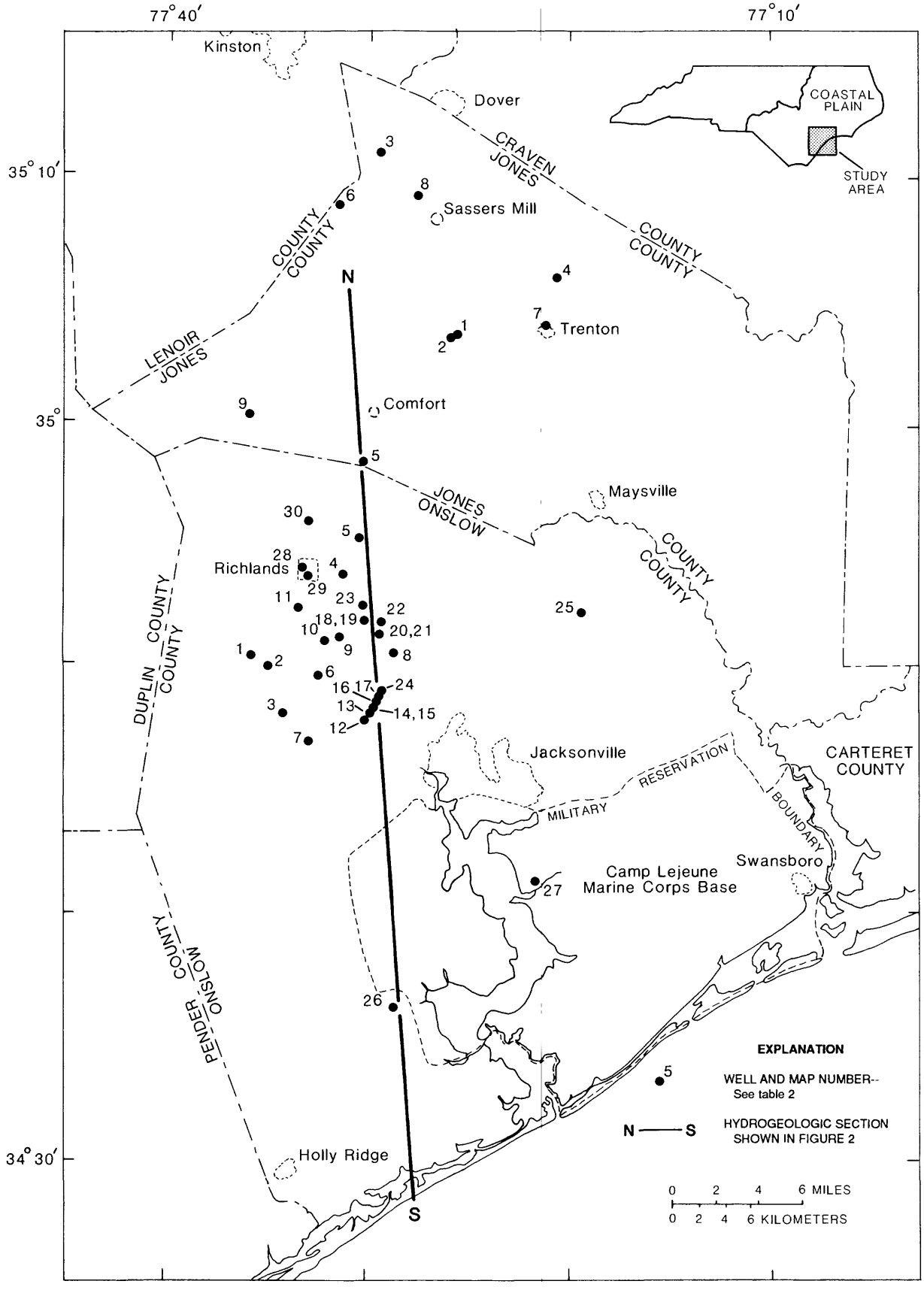

Figure 1.--Location of the Onslow and Jones Counties study area.

Withdrawals from each aquifer were estimated by multiplying the total pumpage recorded or estimated for each well by the ratio of the vertical length of screen in each aquifer to the total length of screen in the well. This method assumes that (1) the length of screen in each aquifer is directly proportional to the thickness of water-bearing material in each aquifer, (2) all water-bearing material in each aquifer has the same value of transmissivity, and (3) all screens are equally efficient.

Water-Level Measurements

Water-level measurements recorded in this report include static and nonpumping water levels. In this study, static water levels include measurements taken in unpumped observation wells and measurements taken in a water-supply well (1) after it was drilled and prior to its use, (2) prior to performing an aquifer test, and (3) when water pump intakes were lowered in a well. Nonpumping water levels are those measured in water-supply wells in which the pumps were off at least one-half hour prior to the water-level measurement. Values for both types of water-level measurements can be affected by interference from nearby pumping wells.

Nonpumping water-level measurements are affected by the amount of time between when the pump in the well is shut off and when the measurement is made. The more time between when the pump is shut off and when the water level is measured, the better nonpumping water-level measurements represent static water levels. Analysis of water-level recovery data from two aquifer tests conducted on wells in the Black Creek aquifer in Onslow County indicate that after one-half hour, the nonpumping water levels rose about 87 percent of the distance between the maximum depth of the water level during the test and the static water level which existed prior to the tests. After one hour, water levels rose to about 89 percent of this distance.

Historic static water-level measurements (table 2) were obtained from local water system managers' records and records on file at the U.S. Geological Survey in Raleigh. Most of these water levels were measured prior to aquifer tests or during the process of lowering water pump intakes in a well. Recent ground-water levels were measured in December 1986 for

all of the aquifers in rocks of Cretaceous age. Static or nonpumping water-level measurements were collected at DEHNR research stations, municipal wells, and privately-owned wells. At least one-half hour passed prior to measuring water levels at wells where the pump had been running. These recent water levels were collected as part of the Central Coastal Plain Aquifer Study, and the data were used to construct a potentiometric surface map for each of the aquifers in rocks of Cretaceous age (Brockman and others, 1989; Lyke and others, 1989; Winner and others, 1989a and 1989b).

Water levels were measured with steel tape, electric tape, analog-to-digital recorder (ADR), or air line. Tape and ADR measurements were measured to the nearest hundredth of a foot by USGS personnel; however, air-line measurements were not as accurate. In one well where both electric-tape and air-line measurements of water levels could be compared, the air-line measurement was 6 feet (ft) higher than the tape measurement.

Hydrogeologic Setting

Sedimentary rocks in the study area (fig. 1) generally dip and thicken toward the southeast and overlie igneous and metamorphic basement rocks. The sedimentary rocks are composed of permeable sandstone and limestone and relatively impermeable clay. Aquifers have been identified based upon their hydrogeologic characteristics and are composed primarily of sandstone and limestone. Aquifers generally are separated by a confining unit composed of clay and silt beds which impede the vertical flow of water (Winner and Coble, 1987; Lyke and Winner, 1990).

The aquifers have been grouped into two aquifer systems, one in rocks of Quaternary and Tertiary age and the other in rocks of Cretaceous age. The aquifers in rocks of Quaternary and Tertiary age in the study area include, from top to bottom, the surficial aquifer, the Castle Hayne aquifer in the upper part of the Castle Hayne and overlying River Bend Formations, and the Beaufort aquifer in the Beaufort Formation. The surficial and Beaufort aquifers are composed mostly of sand and are relatively thin compared to the thicker, more permeable limestones and sands of the Castle Hayne aquifer (Lyke and Winner, 1990). The Castle Hayne aquifer is a major

source of freshwater for the U.S. Marine Corps Base at Camp Lejeune and some smaller municipal water systems and domestic wells in the eastern part of the study area.

The aquifers in rocks of Cretaceous age in the study area are composed primarily of fine- to medium-grained sand interbedded with some clay layers. These aquifers include, from top to bottom, the Peedee, Black Creek, upper Cape Fear, and lower Cape Fear aquifers in the Peedee, Black Creek, and Cape Fear Formations (fig. 2) (Lyke and Winner, 1990). These aquifers are separated from each other by regional confining units.

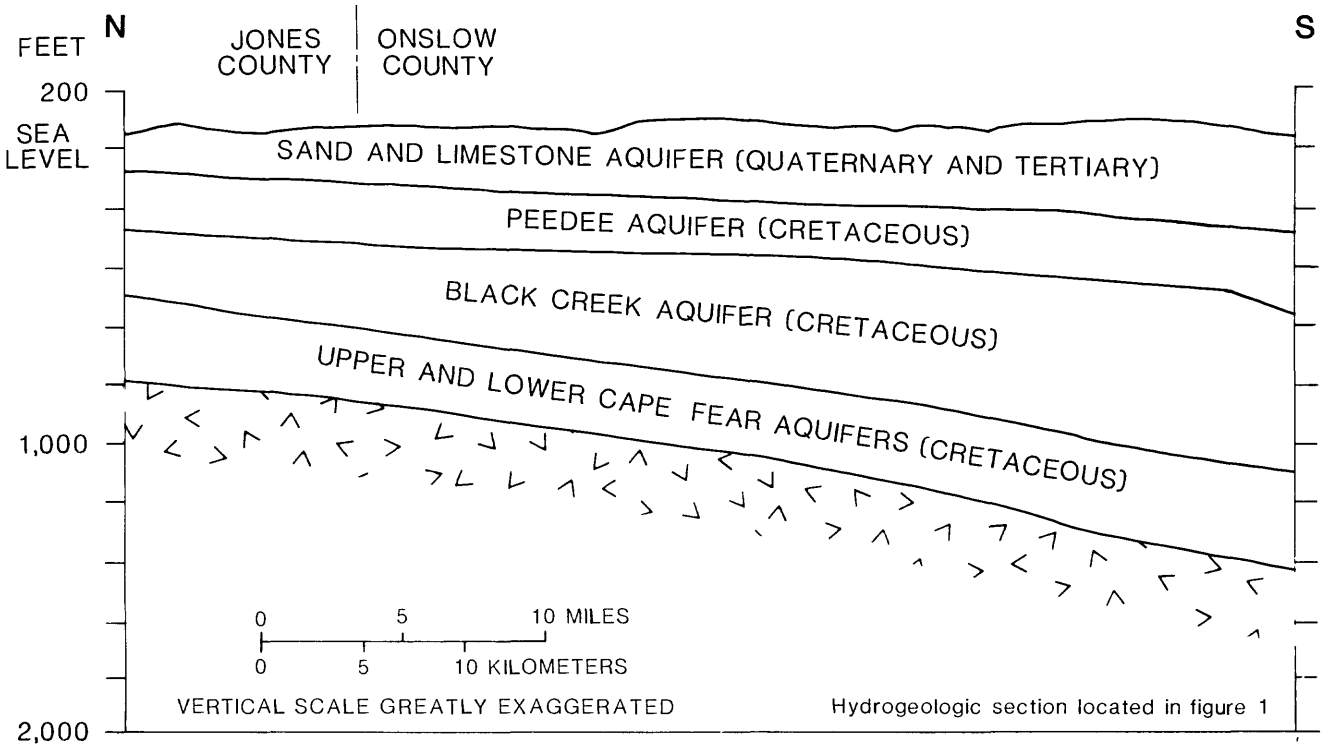

Figure 2.--Hydrogeologic section showing aquifers in the study area.

The Peedee and Black Creek are the only aquifers in rocks of Cretaceous age that supply ground water to water systems in the study area. The upper and lower Cape Fear aquifers are not used as sources of drinking water because they contain saltwater, with chloride concentrations exceeding the 250 mg/L (milligrams per liter) drinking water criterion. Therefore, ground-water withdrawals and water-level declines related only to the Peedee and Black Creek aquifers are the focus of this report.

The boundary between freshwater and saltwater in the Peedee (fig. 3) and the Black Creek (fig. 4) aquifers is shown in map view as a zone. The western limit of this zone represents the freshwater-saltwater interface near the bottom of the aquifer. The eastern limit represents the freshwater-saltwater interface near the top of the aquifer. Freshwater overlies saltwater between these two limits. Freshwater and saltwater (defined in this report as having a concentration of more than 250 mg/L chloride) are separated by a generally concave upward contact. Freshwater is present everywhere in the aquifer west of this zone, and saltwater is present everywhere to the east.

The Peedee and Black Creek aquifers are the major source of freshwater for the western part of Jones and Onslow Counties. Freshwater is present in the Peedee aquifer in the western part of the study area (fig. 3). The boundary between freshwater and saltwater in this aquifer is oriented generally southwest to northeast, extending from the town of Holly Ridge through the city of Jacksonville in Onslow County, toward the town of Maysville in Jones County.

The Peedee aquifer is overlain by the Peedee confining unit in the upper part of the Peedee Formation, which is primarily clay ranging in thickness from 10 to 66 ft in the freshwater area of the Peedee aquifer. The Peedee aquifer and confining unit generally thicken toward the southeast. In the freshwater area of the aquifer, the Peedee ranges in thickness from 88 to 215 ft, averaging about 130 ft thick. The aquifer is composed of about 60 percent sand in this area (Lyke and Winner, 1990).

In the Black Creek aquifer, freshwater is present in the northwestern part of the study area. The freshwater-saltwater boundary is farther north and west than in the Peedee aquifer, except in the area northeast of the town of Trenton in Jones County (fig. 4). The boundary is oriented generally southwest to northeast, extending from the Onslow-Pender County border, between the town of Richlands and the city of Jacksonville in Onslow County, toward the city of Trenton in Jones County.

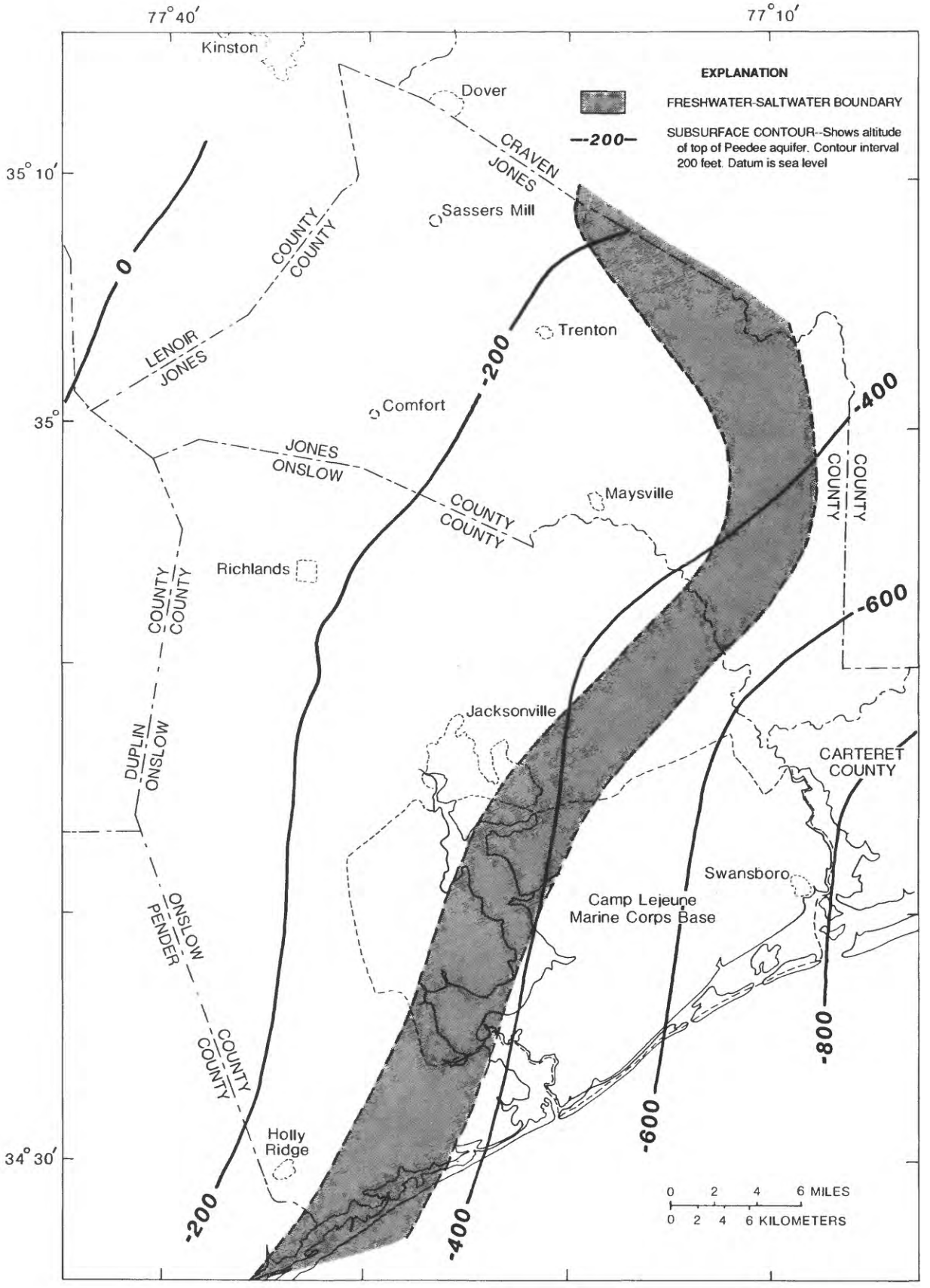

Figure 3.--Location and altitude of top of the Peedee aquifer and location of freshwater-saltwater boundary.

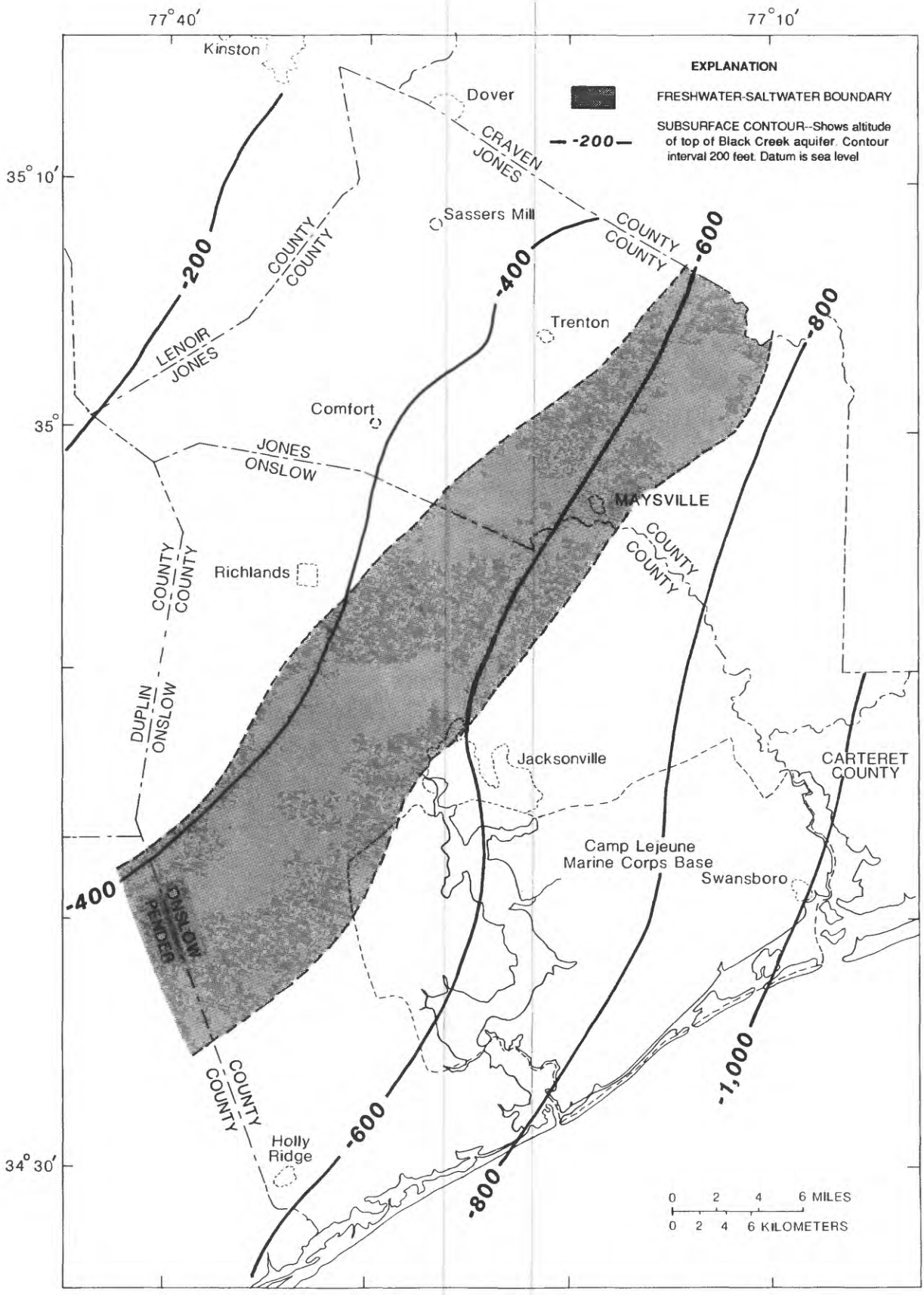

Figure 4.--Location and altitude of top of the Black Creek aquifer and location of freshwater-saltwater boundary.

The Black Creek aquifer is overlain by the Black Creek confining unit in the upper part of the Black Creek Formation, which is primarily composed of clay ranging in thickness from 23 to 134 ft in the freshwater area of the Black Creek aquifer. Both the Black Creek aquifer and confining unit thicken toward the southeast. In its freshwater area, the Black Creek aquifer ranges in thickness from 163 to 436 ft, averaging about 300 ft thick and is composed of about 50 percent sand (Lyke and Winner, 1990).

Acknowledgments

Access to ground-water pumpage data, water-level data, and water wells to obtain water-level measurements was made available by the following people and is greatly appreciated: Mr. Lee Hawkins, Jones County Water System; Mr. Bill Harvey, Onslow County Water System; Mr. Al Hartman, City of Jacksonville Water System; Mr. Wayne Barbee, Northwest Onslow Water Association; and Mr. Fred Bloetscher, Town of Richlands.

GROUND-WATER PUMPAGE

History of Ground-Water Development

During the past 30 years, area water systems have constructed most of their newer wells in the Peedee and Black Creek aquifers. Before the 1960's, most water systems in the study area relied upon wells tapping the Castle Hayne or shallower aquifers. The only wells withdrawing water from the Peedee and Black Creek aquifers during this period were some residential wells located in western Jones County and wells at the town of Richlands in Onslow County (LeGrand, 1960).

In the early 1960's, other wells were drilled by area water systems to tap the Peedee and Black Creek aquifers. In 1962, the City of Jacksonville abandoned much of its well field tapping the Castle Hayne aquifer, which dated from the 1940's or earlier, and began withdrawing water from the Peedee and Black Creek aquifers. The Northwest Onslow Water Association and the Jones County Water System began withdrawing water from the Peedee and

Black Creek aquifers in 1974 and 1975, respectively. In 1981, the Onslow County Water Department began operation with wells tapping the Black Creek aquifer.

For some of these water systems, water-quality considerations led to the use of the Peedee and Black Creek aquifers for their present sources of water supply. Water from the Peedee and Black Creek aquifers tends to have lower hardness and iron concentrations than water from the Castle Hayne aquifer (LeGrand, 1960; Mundorff, 1945) and is less expensive to treat. Welcoming signs at the outskirts of Richlands, whose wells tap the Black Creek aquifer, declare it to be the town of "perfect water." In contrast, the hardness and high iron content of water from the Castle Hayne aquifer at some localities (Narkunas, 1980) prompted complaints from customers of area systems with inadequate iron-treatment facilities. Rather than upgrade their treatment facilities, the City of Jacksonville drilled wells in the Peedee and Black Creek aquifers in the early 1960's. Swansboro and Holly Ridge joined the Onslow County Water System in the early 1980's to gain access to water of better quality (Al Hartman, City of Jacksonville Water System, oral commun., 1987; Patti Sue Chandler, Town of Swansboro, oral commun., 1988; and Billy Farmer, Town of Holly Ridge, oral commun., 1988). Thus, concerns about the water quality of the Castle Hayne aquifer led to an increased use of the Peedee and Black Creek aquifers in the study area.

Ground-Water Pumpage

Five water-supply systems (table 1) pumped more than 10,000 gal/d from the Peedee and Black Creek aquifers in the study area in 1986. These systems are the Town of Richlands, City of Jacksonville, Northwest Onslow Water Association, Jones County, and Onslow County. Four of these five water-supply systems are located in northern Onslow County. In 1986, about 94 percent of the total amount of ground water pumped from the Peedee and Black Creek aquifers in the study area was pumped by water systems in northern Onslow County.

Total ground-water withdrawals by public-supply systems from the Peedee and Black Creek aquifers have increased from about 0.01 Mgal/d (million

gallons per day) in 1933, to about 7.8 Mgal/d in 1986 (fig. 5 and table 1). The largest withdrawals were made by the Onslow County and Jacksonville systems, which together accounted for about 91 percent of total ground-water withdrawals in 1986.

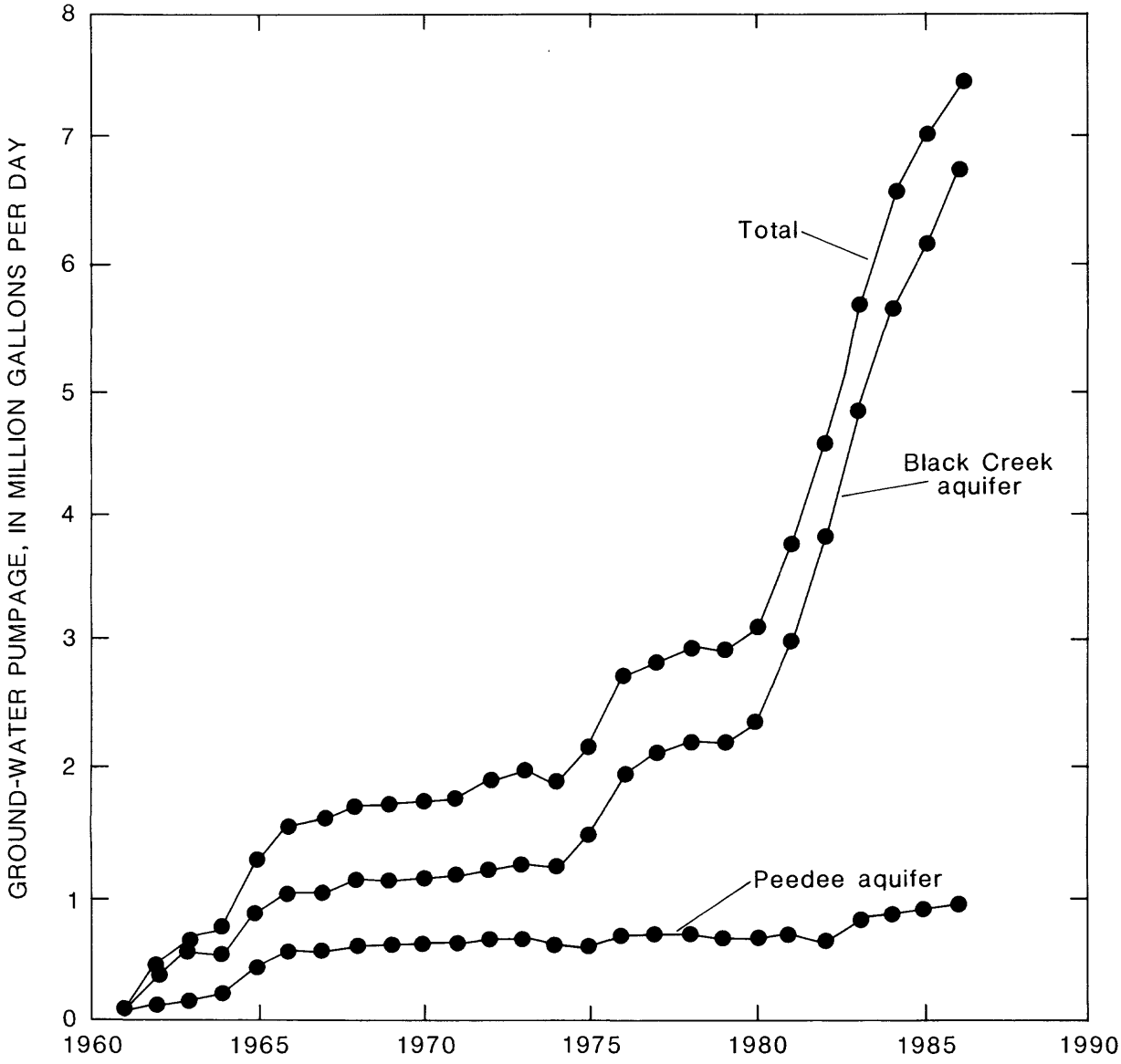

Figure 5.--Ground-water withdrawals from the Peedee and Black Creek aquifers in Onslow and Jones Counties.

The Black Creek aquifer is the major source of ground water in the study area. The amount of water pumped from the Black Creek aquifer has increased over time (fig. 5), while the amount of water pumped from the

Peedee aquifer has remained relatively constant since the mid-1960's. About 90 percent of the total amount of ground water withdrawn from aquifers in Cretaceous rocks was withdrawn from the Black Creek aquifer in 1986. The Peedee aquifer supplied the remaining 10 percent.

Three water systems (Jones County, City of Jacksonville, and Northwest Onslow Water Association) pumped water from both the Peedee and Black Creek aquifers in 1986, but the Black Creek aquifer was the major source of water for these systems. It provided about 81 percent of the ground water for the Jones County system, about 83 percent for the Jacksonville system, and about 64 percent for the Northwest Onslow Water Association. Onslow County and Richlands systems pumped 100 percent of their ground water from the Black Creek aquifer in 1986.

WATER-LEVEL DECLINES

Estimating Rates of Water-Level Declines

Ground-water levels have declined in both the Peedee and Black Creek aquifers throughout the study area as a result of the continued development of ground-water supplies, and some water-supply systems have had to increase the depth of pump intakes in their wells. Average rates of decline for static and nonpumping water levels have been estimated using the water-level measurements presented in table 2. These estimates convey the magnitude of changes in the ground-water system due to the increase in withdrawals and may aid in the future management of the resource.

Sources of error in estimating rates of water-level decline include (1) the use of both static and nonpumping water levels, (2) the effect of nearby pumping wells on measured water levels, (3) incomplete records, and (4) measurement accuracy. Nonpumping water levels tend to be lower than static water levels. If both are used to estimate rates of decline, then the rates may have a higher value than if only static water levels are used. Both types of measurements have been used interchangeably in this report to estimate water-level declines. If pumping wells are in operation close to an observation well, the measured water level may not represent the true static, or nonpumping, water level.

Incomplete records can also detract from the accuracy of the data. For example, the height of the measuring point above land surface is not available for a number of measurements listed in table 2. Another source of error, measurement accuracy, depends on the method of measurement used--whether the water level was measured by use of an air-line gage or was obtained using a steel tape, electric tape, or a float-equipped recorder. Because of these possible errors, values calculated in this report for rates of water-level declines are estimates.

The average yearly rates of decline were calculated by first dividing the numeric difference between two water-level measurements in a single well by the number of months between those measurements. This quotient was then multiplied by 12 to determine the annual rate of decline. Unless noted otherwise, water levels used in estimating average yearly rates of water-level declines (1) included static water levels and nonpumping water levels measured in private and municipal water system wells where water pumps had been turned off for at least 12 hours prior to the measurement; (2) included a known value for the height of the measuring point above land surface; and (3) were measured with a steel tape, electric tape, or ADR.

Water-level declines in both the Peedee and Black Creek aquifers have been estimated for the study area from 1900 to 1986. These estimates were made by taking the difference in the potentiometric surfaces estimated for prepumping times and those measured in December 1986. Prepumping time is defined as the time prior to the beginning of significant pumping stress in the Cretaceous sediments, considered to be about the year 1900 (Winner and Lyke, 1986). The prepumping potentiometric surface for both the Peedee and Black Creek aquifers was simulated and mapped as part of the North Atlantic Regional Aquifer System Analysis Study (G.L. Giese, U.S. Geological Survey, written commun., 1988). Water levels measured in December 1986 were used to construct potentiometic surface maps for the Peedee aquifer (Brockman and others, 1989) and the Black Creek aquifer (Lyke and others, 1989). Water-level values from these maps were subtracted from values on the respective prepumping water-level maps, and the differences are mapped in figures 6 and 7.

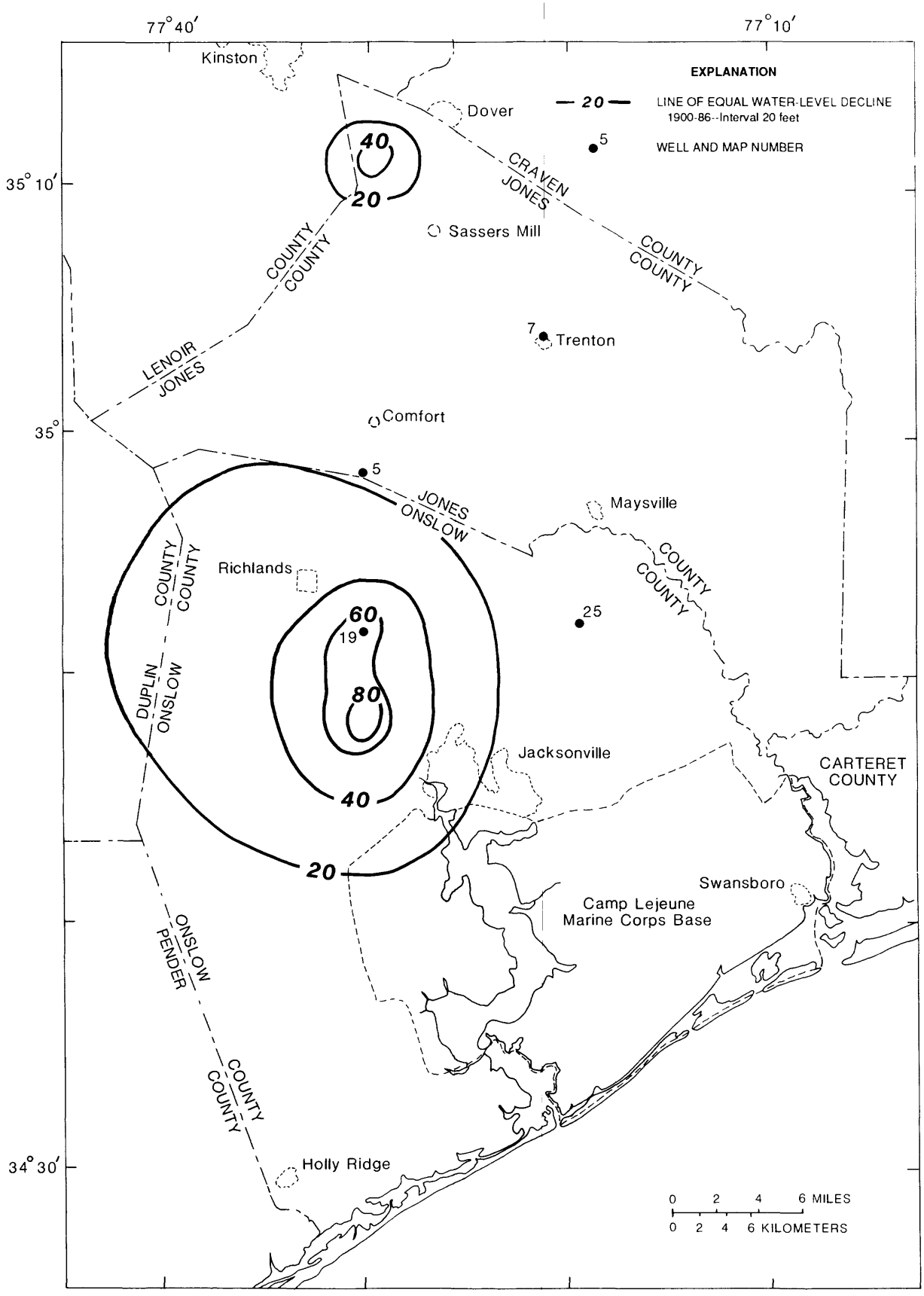

Figure 6.--Total decline in water levels in the Peedee aquifer from 1900 to 1986.

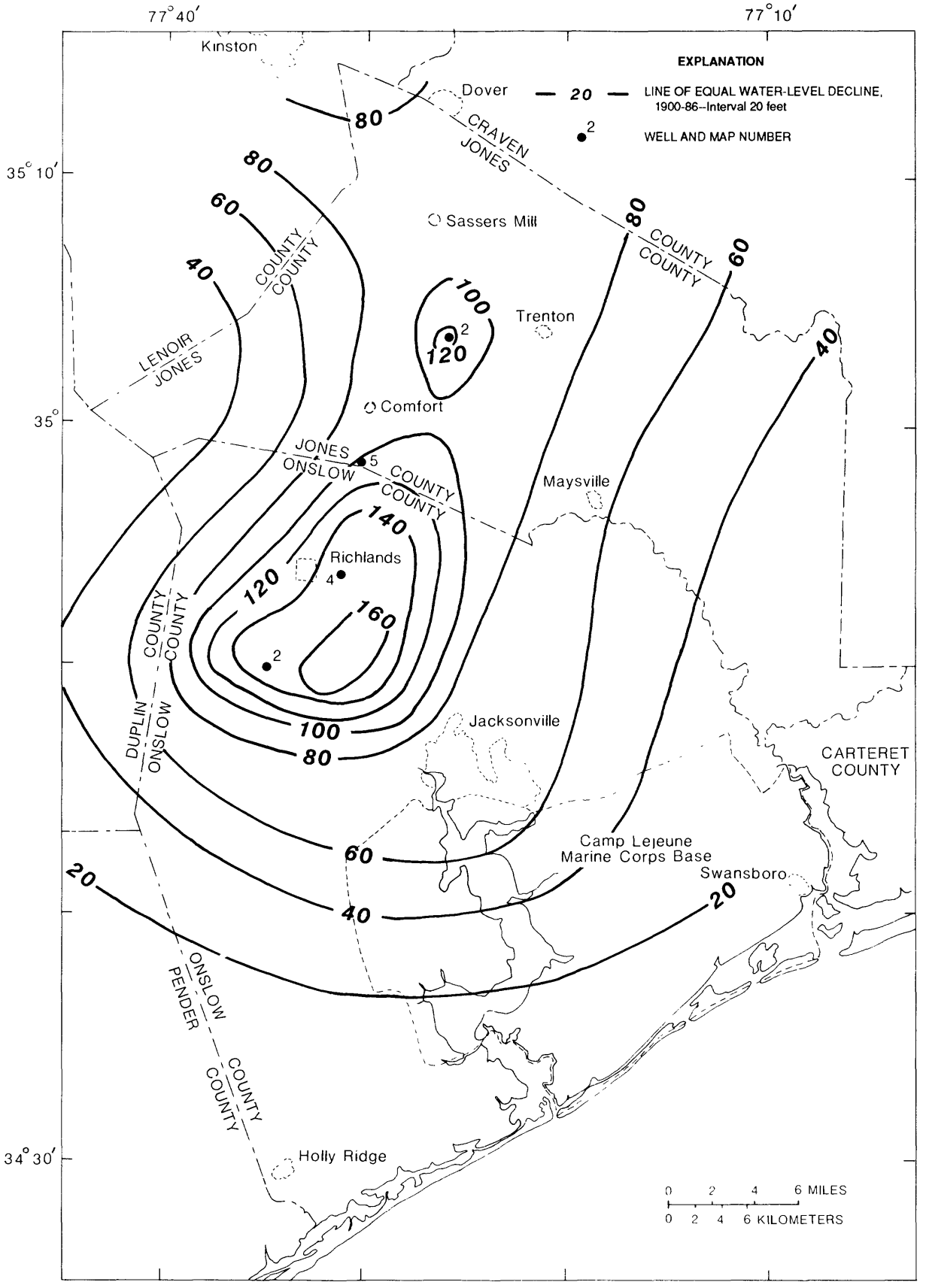

Figure 7.--Total decline in water levels in the Black Creek aquifer from 1900 to 1986.

Peedee Aquifer

The average rate of water-level decline in the Peedee aquifer for the study area is estimated to be about 1 foot per year (ft/yr) from 1974 to 1986. The largest recorded rates of decline are (1) about 1.4 ft/yr from 1979 to 1986 at the DEHNR Comfort Research Station (map no. 5, fig. 6) in Jones County and (2) about 1.5 ft/yr from 1974 to 1986 at the City of Jacksonville Gum Branch Field number 12 well (map no. 19, fig. 6). Minimum rates of decline of about 0.6 ft/yr are estimated for the Hines well in Jones County (map no. 7, fig. 6) and 0.3 ft/yr at the DEHNR Deppe Research Station in Onslow County (map no. 25, fig. 6) (table 2).

The total decline in water levels in the Peedee aquifer since about 1900, or prepumping times, has been greatest in northern Onslow County (fig. 6) corresponding to the major area of ground-water withdrawals there. Water levels have declined as much as 80 ft in northern Onslow County compared with the 40-foot decline in the northwestern part of Jones County.

Black Creek Aquifer

The average rate of water-level decline for the Black Creek aquifer is 7.5 ft/yr on the basis of data from the DEHNR Comfort Research Station from 1979 to 1986 (table 2). This research station, located south of the town of Comfort on the Onslow County-Jones County border (map no. 5, fig. 7), lies between pumping centers to the north in Jones and Lenoir Counties and other centers to the south in Onslow County. A similar rate of decline was observed at water-supply well number 2 in Jones County (map no. 2, fig. 7), where water levels declined about 8.3 ft/yr from 1975 to 1986. However, this rate is based on an air-line measurement of a nonpumping water level (table 2).

In northern Onslow County, the rate of decline using nonpumping water-level data is higher than declines observed from static water-level data at the DEHNR Comfort Research Station (map no. 5, fig. 7), averaging 14.1 ft/yr from 1980 to 1986 and 13.2 ft/yr from 1981 to 1986 in Onslow County wells 2 and 5, respectively (map nos. 2 and 4, Onslow County, fig. 7). The average

rate of declines of both static and nonpumping water levels in Onslow and Jones Counties is greater than the average rate of decline of 5 ft/yr identified in the original central Coastal Plain study area (Winner and Lyke, 1986).

The average rate of static water-level declines in the Black Creek aquifer has increased with time. Static water-level decline rates have increased at the DEHNR Comfort Research Station from about 2 ft/yr in 1980 to 11 ft/yr in 1986 (fig. 8). This increasing rate has also been observed at some water-supply wells. Water-level measurements from three wells, the Onslow County well number 5 and Jacksonville well numbers 14 and 15 (table 2), provide estimates of this increase. The average rate of decline from as early as 1974 to 1986 for these three wells is about 12 ft/yr. However, intermediate water-level measurements made in 1983 in the Jacksonville wells and in 1984 in the Onslow County well indicate that the rate of decline averaged about 8 ft/yr through 1983; however, from 1983 to 1986, the average decline in water levels was as much as 17 ft/yr. Although these estimated values may not reflect the true rate of declines in the ground-water system because the extent of any interference by nearby pumping wells

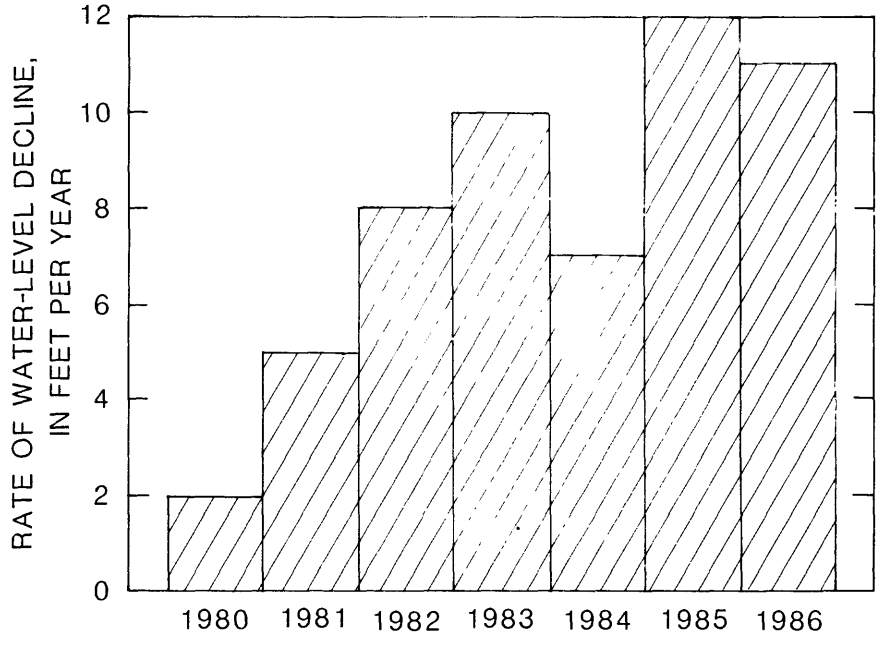

Figure 8.--Histogram showing generally increasing rates of water-level decline in the Black Creek aquifer at the DEHNR Comfort Research Station.

is not known, they do suggest that the rate of water-level decline has been increasing in the Black Creek aquifer as ground-water withdrawals have increased.

The largest total ground-water level decline in the study area (fig. 7) has occurred in the Black Creek aquifer in northern Onslow County. Nonpumping ground-water levels in this area have fallen more than 160 ft from about 1900 to 1986. Water levels in Jones County have declined as much as 120 ft during this same time period.

SUMMARY

Sediments in the Onslow and Jones Counties area have been informally divided into two aquifer systems, one in rocks of Quaternary and Tertiary age and one in rocks of Cretaceous age. The Castle Hayne limestone aquifer in the rocks of Quaternary and Tertiary age is an important source of freshwater for the U.S. Marine Corps Base at Camp Lejeune, small municipal water systems, and domestic wells in the eastern part of Jones and Onslow Counties.

The aquifer system in rocks of Cretaceous age consists of, from top to bottom, the Peedee, Black Creek, upper Cape Fear, and lower Cape Fear aquifers. The Peedee and Black Creek aquifers are the only aquifers in rocks of Cretaceous age used as a source of freshwater in the study area because the upper and lower Cape Fear aquifers contain saltwater in Jones and Onslow Counties.

Both the Peedee and Black Creek aquifers contain freshwater in the western part of Jones County and northwestern part of Onslow County. The Peedee aquifer is about 150 feet thick in the freshwater area and consists of about 60 percent sand. Saltwater generally is present farther west in the Black Creek aquifer than in the Peedee aquifer. The Black Creek aquifer is about 300 feet thick in the freshwater area and contains about 50 percent sand.

Before 1960, most water systems in the study area pumped water from the Castle Hayne or shallower aquifers. Wells were completed in the deeper

Peedee and Black Creek aquifers in the early 1960's because water from these aquifers generally had lower values of hardness and lower concentrations of iron than water from the Castle Hayne aquifer. Therefore, water-quality and economic considerations related to the treatment of water from the Castle Hayne aquifer led to increased use of the Peedee and Black Creek aquifers. The continued development of these aquifers has resulted in water-level declines in Onslow and Jones Counties, and the pump intake settings in some water-supply wells have been lowered as a result of these declines.

Total withdrawals from the Peedee and Black Creek aquifers increased from about 0.01 Mgal/d in 1933 to about 7.8 Mgal/d in 1986. In 1986, 90 percent of the total ground water pumped was from the Black Creek aquifer; the Peedee aquifer supplied the remaining 10 percent. Also, about 94 percent of total water withdrawals from aquifers in rocks of Cretaceous age in the study area was pumped in northern Onslow County.

Water-level declines have occurred in the study area as a result of ground-water withdrawals. Static water levels in the Peedee aquifer declined an average of 1.4 ft/yr from 1979 to 1986 at the DEHNR Comfort Research Station on the Onslow and Jones County border, while declines averaged 0.6 ft/yr from 1981 to 1986 in central Jones County at the Hines well. From 1900 to 1986, water levels declined as much as 80 ft in northern Onslow County between the town of Richlands and the city of Jacksonville. This is double the amount of decline experienced in northwestern Jones County in the same period.

Water-level declines generally were greater in the Black Creek aquifer than in the Peedee aquifer. Nonpumping water levels in the Black Creek aquifer declined about 8.3 ft/yr from 1975 to 1986 at pumping centers in Jones County, while nonpumping water-level declines averaged about 12 ft/yr from 1974 to 1986 at pumping centers in northern Onslow County. The rate of static water-level decline in the Black Creek aquifer at the DEHNR Comfort Research Station averaged 7.5 ft/yr from 1979 to 1986.

The annual rate of decline in water levels in the Black Creek aquifer in northern Onslow County has increased with time, generally corresponding to increasing rates of withdrawals from the aquifer. In three water-supply wells in northern Onslow County, nonpumping water levels declined about 8 ft/yr from 1974 to 1983, whereas between 1983 and 1986 water levels at these wells declined an average of 17 ft/yr. Static water levels declined at the DEHNR Comfort Research Station about 2 ft/yr in 1980, but declined 11 ft/yr in 1986.

From 1900 to 1986, the water-level decline in the Black Creek aquifer was as much as 120 ft in central Jones County. In the same period, the decline in northern Onslow County between the town of Richlands and the city of Jacksonville is estimated to have totaled more than 160 ft.

REFERENCES

Brockman, Allen R., Lyke, William L., and Winner, M.D., Jr., 1989, Potentiometric surface of the Peedee aquifer in the central Coastal Plain of North Carolina, December 1986: U.S. Geological Survey Water-Resources Investigations Report 87-4236, 1 sheet.

LeGrand, Harry E., 1960, Geology and ground-water resources of Wilmington-New Bern area, North Carolina: North Carolina Department of Water Resources, Ground-Water Bulletin No. 1.

Lyke, William L., and Winner, M.D., Jr., 1990, Hydrogeology of aquifers in Cretaceous and younger rocks in the vicinity of Onslow and southern Jones Counties, North Carolina: U.S. Geological Survey Water-Resources Investigations Report 89-4128, 49 p.

Lyke, William L., Winner, M.D., Jr., and Brockman, Allen R., 1989, Potentiometric surface of the Black Creek aquifer in the central Coastal Plain of North Carolina, December 1986: U.S. Geological Survey Water-Resources Investigations Report 87-4233, 1 sheet.

Mundorff, M.J., 1945, Progress report on ground water in North Carolina: North Carolina Department of Conservation and Development Bulletin 47, 78 p.

Narkunas, James, 1980, Groundwater evaluation in the central Coastal Plain of North Carolina: North Carolina Department of Natural Resources and Community Development, 119 p.

Winner, M.D., Jr., and Coble, R.W., 1987, Hydrogeologic framework of the North Carolina Coastal Plain Aquifer System: U.S. Geological Survey Water-Resources Investigation Open-File Report 87-690, 155 p.

Winner, M.D., Jr., and Lyke, William L., 1986, History of ground-water pumpage and water-level decline in the Black Creek and upper Cape Fear aquifers of the central Coastal Plain of North Carolina: U.S. Geological Survey Water-Resources Investigations Report 86-4168, 32 p.

Winner, M.D., Jr., Lyke, William L., and Brockman, Allen R., 1989a, Potentiometric surface of the upper Cape Fear aquifer in the central Coastal Plain of North Carolina, December 1986: U.S. Geological Survey Water-Resources Investigations Report 87-4235, 1 sheet.

----- 1989b, Potentiometric surface of the lower Cape Fear aquifer in the central Coastal Plain of North Carolina, December 1986: U.S. Geological Survey Water-Resources Investigations Report 87-4234, 1 sheet.

Table 1.--*Historical and estimated values of ground-water pumpage from the Peedee and Black Creek aquifers in Onslow and Jones Counties*

[Mgal/d, million gallons per day]

Year	Total ground-water pumpage (Mgal/d)	Estimated amount of ground-water pumped from the Peedee aquifer (Mgal/d)	Estimated amount of ground-water pumped from the Black Creek aquifer (Mgal/d)
		Jones County Water System	
1975	0.07[a]	0.00[a]	0.07[a]
1976	.15[a]	.00[a]	.15[a]
1977	.15[a]	.00[a]	.15[a]
1978	.15	.00	.15
1979	.17	.00	.17
1980	.22	.00	.22
1981	.26	.00	.26
1982	.27	.00	.27
1983	.31	.02	.29
1984	.36	.09	.27
1985	.40	.07	.33
1986	.45	.09	.36
		Onslow County Water System	
1981	.48	.00	.48
1982	1.47	.00	1.47
1983	2.18	.00	2.18
1984	2.83	.00	2.83
1985	3.06	.00	3.06
1986	3.45	.00	3.45
		City of Jacksonville Water System, Highway 258 Field	
1962	.41[a]	.07[a]	.34[a]
1963	.65[a]	.14[a]	.51[a]
1964	1.00[a]	.24[a]	.78[a]
1965	1.30[a]	.45[a]	.85[a]
1966	1.57	.55	1.02
1967	1.52	.50	1.02
1968	1.72	.60	1.12
1969	1.72	.60	1.12
1970	1.77	.62	1.15
1971	1.80	.63	1.17
1972	1.91	.67	1.24
1973	1.99	.70	1.29
1974	1.84	.65	1.19
1975	1.80	.63	1.17
1976	1.78	.62	1.16
1977	1.75	.61	1.14

[a]Records of ground-water pumpage do not exist; these values were estimated from well yields and well history.

Table 1.--*Historical and estimated values of ground-water pumpage from the Peedee and Black Creek aquifers in Onslow and Jones Counties*--Continued

[Mgal/d, million gallons per day]

Year	Total ground-water pumpage (Mgal/d)	Estimated amount of ground-water pumped from the Peedee aquifer (Mgal/d)	Estimated amount of ground-water pumped from the Black Creek aquifer (Mgal/d)
	City of Jacksonville Water System, Highway 258 Field--Continued		
1978	1.72	0.60	1.12
1979	1.67	.58	1.09
1980	1.66	.58	1.08
1981	1.72	.60	1.12
1982	1.48	.52	.96
1983	1.70	.59	1.11
1984	1.57	.55	1.02
1985	1.65	.58	1.07
1986	1.45	.37	1.08
	City of Jacksonville Water System, Gum Branch Field		
1975	.15	.03	.12
1976	.75	.12	.63
1977	.97	.16	.81
1978	1.00	.16	.84
1979	.95	.13	.82
1980	1.12	.16	.96
1981	1.23	.17	1.06
1982	1.31	.18	1.13
1983	1.51	.21	1.30
1984	1.91	.27	1.64
1985	1.98	.28	1.70
1986	2.20	.27	1.93
	Northwest Onslow Water Association		
1974	.02[a]	.01[a]	.01[a]
1975	.02[a]	.01[a]	.01[a]
1976	.02[a]	.01[a]	.01[a]
1977	.02[a]	.01[a]	.01[a]
1978	.02[a]	.01[a]	.01[a]
1979	.02[a]	.01[a]	.01[a]
1980	.02[a]	.01[a]	.01[a]
1981	.03[a]	.01[a]	.02[a]
1982	.04[a]	.01[a]	.03[a]
1983	.05	.02	.03
1984	.05	.02	.03
1985	.06	.02	.04
1986	.06	.02	.04

[a]Records of ground-water pumpage do not exist; these values were estimated from well yields and well history.

Table 1.--*Historical and estimated values of ground-water pumpage from the Peedee and Black Creek aquifers in Onslow and Jones Counties*--Continued

[Mgal/d, million gallons per day]

Year	Total ground-water pumpage (Mgal/d)	Estimated amount of ground-water pumped from the Peedee aquifer (Mgal/d)	Estimated amount of ground-water pumped from the Black Creek aquifer (Mgal/d)
	Town of Richlands Water System		
1933	0.01[a]	0.01[a]	0.00[a]
1934	.01[a]	.01[a]	.00[a]
1935	.01[a]	.01[a]	.00[a]
1936	.01[a]	.01[a]	.00[a]
1937	.01[a]	.01[a]	.00[a]
1938	.01[a]	.01[a]	.00[a]
1939	.01[a]	.01[a]	.00[a]
1940	.01[a]	.01[a]	.00[a]
1941	.01[a]	.01[a]	.00[a]
1942	.01[a]	.01[a]	.00[a]
1943	.01[a]	.01[a]	.00[a]
1944	.01[a]	.01[a]	.00[a]
1945	.01[a]	.01[a]	.00[a]
1946	.01[a]	.01[a]	.00[a]
1947	.01[a]	.01[a]	.00[a]
1948	.01[a]	.01[a]	.00[a]
1949	.01[a]	.01[a]	.00[a]
1950	.06[a]	.01[a]	.05[a]
1951	.06[a]	.01[a]	.05[a]
1952	.06[a]	.01[a]	.05[a]
1953	.06[a]	.01[a]	.05[a]
1954	.06[a]	.01[a]	.05[a]
1955	.06[a]	.01[a]	.05[a]
1956	.06[a]	.01[a]	.05[a]
1957	.06[a]	.01[a]	.05[a]
1958	.06[a]	.01[a]	.05[a]
1959	.06[a]	.01[a]	.05[a]
1960	.06[a]	.01[a]	.05[a]
1961	.06[a]	.01[a]	.05[a]
1962	.06[a]	.01[a]	.05[a]
1963	.06[a]	.01[a]	.05[a]
1964	.06[a]	.01[a]	.05[a]
1965	.06[a]	.01[a]	.05[a]
1966	.06[a]	.01[a]	.05[a]
1967	.06[a]	.01[a]	.05[a]
1968	.06[a]	.01[a]	.05[a]
1969	.06[a]	.01[a]	.05[a]
1970	.06[a]	.01[a]	.05[a]
1971	.06[a]	.01[a]	.05[a]
1972	.06[a]	.01[a]	.05[a]
1973	.06[a]	.01[a]	.05[a]

[a]Records of ground-water pumpage do not exist; these values were estimated from well yields and well history.

Table 1.--*Historical and estimated values of ground-water pumpage from the Peedee and Black Creek aquifers in Onslow and Jones Counties*--Continued

[Mgal/d, million gallons per day]

Year	Total ground-water pumpage (Mgal/d)	Estimated amount of ground-water pumped from the Peedee aquifer (Mgal/d)	Estimated amount of ground-water pumped from the Black Creek aquifer (Mgal/d)
	Town of Richlands Water System--Continued		
1974	0.12[a]	0.01[a]	0.11[a]
1975	.12[a]	.01[a]	.11[a]
1976	.12[a]	.01[a]	.11[a]
1977	.12[a]	.01[a]	.11[a]
1978	.18[a]	.00[a]	.18[a]
1979	.23[a]	.00[a]	.23[a]
1980	.24[a]	.00[a]	.24[a]
1981	.22[a]	.00[a]	.22[a]
1982	.20[a]	.00[a]	.20[a]
1983	.19[a]	.00[a]	.19[a]
1984	.17	.00	.17
1985	.19[a]	.00[a]	.19[a]
1986	.20	.00	.20

[a]Records of ground-water pumpage do not exist; these values were estimated from well yields and well history.

Table 2.--*Record of water-level measurements in the Peedee and Black Creek aquifers in Onslow and Jones Counties, 1950-86*

[Map number, refers to well locations in figure 1; well number, number used by respective water system to identify well; P, water-level data collected during aquifer test, data in USGS files; U, water-level by USGS or DEHNR personnel; C, water-level by water-system personnel; L, water-level measurement made in process of lowering pump setting, data from water-system personnel; --, data not available]

Map number	Latitude/ longitude	Water system	Well number	Date of water-level measurement	Depth of water-level below measuring point (feet)	Distance of measuring point above land surface (feet)	Altitude of land surface above NGVD of 1929 (feet)	Aquifer
				Jones County				
1	35°03'33" 77°25'43"	Jones County	1	4/75P	40.0	3	47	Black Creek
2	35°03'30" 77°26'45"	Jones County	2	4/75P	35	3	43	Black Creek
				12/86U*	121†	3		
3	35°05'53" 77°20'37"	Jones County	3	6/80P	32.5	1	67	Peedee
				12/86U*	74†	1		
4	35°10'54" 77°29'22"	Jones County	4	2/85P	83.9	2	46	Black Creek
				12/86U	95†	3		
5	34°58'09" 77°30'14"	DEHNR Comfort Research Station		11/79P	69.6	3	71	Black Creek
				12/80U	71.2	3		
				12/81U	75.9	3		
				12/82U	83.6	3		
				12/83U	93.2	3		
				12/84U	100	3		
				12/85U	112	3		
				12/86U	123	3		
				9/79U	22.2	1	67	Peedee
				12/81U	24.4	1		
				11/86U	32.5	1		
6	54°08'21" 77°31'50"	DEHNR Beaver Creek Research Station		11/86U	20.3	3	59	Peedee
7	35°03'53" 77°21'25"	Hines well		12/81U	3.4	6	30	Peedee
				12/86U	6.5	6		

*Pump off one-half hour prior to measurement.
†Measured with air-line gage; all other measurements with steel or electric tape.

Table 2.--*Record of water-level measurements in the Peedee and Black Creek aquifers in Onslow and Jones Counties, 1950-86*--Continued

[Map number, refers to well locations in figure 1; well number, number used by respective water system to identify well; P, water-level data collected during aquifer test, data in USGS files; U, water-level by USGS or DEHNR personnel; C, water-level by water-system personnel; L, water-level measurement made in process of lowering pump setting, data from water-system personnel; --, data not available]

Map number	Latitude/ longitude	Water system	Well number	Date of water-level measurement	Depth of water-level below measuring point (feet)	Distance of measuring point above land surface (feet)	Altitude of land surface above NGVD of 1929 (feet)	Aquifer
				Jones County--Continued				
8	35°08'53" 77°27'42"	McDaniels Chapel		12/86U	17.4	2	53	Peedee
9	35°00'51" 77°35'18"	Weyerhaeuser	2	1/74P	5.5	2	67	Peedee
				12/86U	15†	3		
				Onslow County				
1	34°50'25" 77°35'50"	Onslow County	1	6/80P	85.9	--	82	Black Creek
				4/84L	136.8	--		
				12/86U*	197.9	3		
2	34°49'55" 77°34'55"	Onslow County	2	7/80P	88.9	0	82	Black Creek
				12/86U	178.3	3		
3	34°47'35" 77°33'30"	Onslow County	4	1/81P	70.3	--	69	Black Creek
				3/84C	75†	--		
				12/86U	131	3		
4	34°53'45" 77°31'05"	Onslow County	5	7/81P	69.7	3	32	Black Creek
				4/84L	94.5	--		
				12/86U	140.3	3		
5	34°55'05" 77°30'30"	Onslow County	6	1/81P	89.8	--	62	Black Creek
				2/81P	92.6	--		
				12/86U*	184	3		
6	34°49'25" 77°32'30"	Onslow County	7	10/81P	104.1	--	75	Black Creek
				4/84L	139	--		
				12/86U ‡	200.2	2		

*Pump off one-half hour prior to measurement.
†Measured with air-line gage; all other measurements with steel or electric tape.
‡Pump off one hour prior to measurement.

Table 2.--*Record of water-level measurements in the Peedee and Black Creek aquifers in Onslow and Jones Counties, 1950-86*--Continued

[Map number, refers to well locations in figure 1; well number, number used by respective water system to identify well; P, water-level data collected during aquifer test, data in USGS files; U, water-level by USGS or DEHNR personnel; C, water-level by water-system personnel; L, water-level measurement made in process of lowering pump setting, data from water-system personnel; --, data not available]

Map number	Latitude/ longitude	Water system	Well number	Date of water-level measurement	Depth of water-level below measuring point (feet)	Distance of measuring point above land surface (feet)	Altitude of land surface above NGVD of 1929 (feet)	Aquifer
				Onslow County--Continued				
7	34°46'45" 77°32'42"	Onslow County	8	2/85P	97.4	--	46	Black Creek
				5/85P	97.1	2		
				11/86P	98	3		
				12/86U	100.2	2		
8	32°50'30" 77°28'30"	Onslow County	9	5/86P	130	0	32	Black Creek
				12/86U	138.6	1		
9	34°50'55" 77°31'20"	Onslow County	10	4/86P	141	2	46	Black Creek
10	34°50'47" 77°32'07"	Onslow County	11	4/86P	151	2	52	Black Creek
				12/86U	157.7	2		
11	34°52'04" 77°33'15"	Onslow County	12	12/86U	131.2	1	40	Black Creek
12	34°49'30" 77°31'45"	Jacksonville High-way 258 Field	1	12/61P	5.7	--	50	Black Creek
				11/78C	98†	--		
				1/83P	120	--		
13	34°47'52" 77°29'49"	Jacksonville High-way 258 Field	2	1/83P	108.5	--	45	Peedee and Black Creek
				8/86C	125	--		
				11/86C	107	1		
14	34°48'04" 77°29'42"	Jacksonville High-way 258 Field	3	1/84C	120	--	39	Peedee and Black Creek
				7/84C	112	--		
				9/86C	119	--		
				11/86C	123	1		
15	34°48'04" 77°29'42"	Jacksonville High-way 258 Field	3a	7/62C	9	--	39	Black Creek

†Measured with air-line gage; all other measurements with steel or electric tape.

Table 2.--*Record of water-level measurements in the Peedee and Black Creek aquifers in Onslow and Jones Counties, 1950-86*--Continued

[Map number, refers to well locations in figure 1; well number, number used by respective water system to identify well; P, water-level data collected during aquifer test, data in USGS files; U, water-level by USGS or DEHNR personnel; C, water-level by water-system personnel; L, water-level measurement made in process of lowering pump setting, data from water-system personnel; --, data not available]

Map number	Latitude/ longitude	Water system	Well number	Date of water-level measurement	Depth of water-level below measuring point (feet)	Distance of measuring point above land surface (feet)	Altitude of land surface above NGVD of 1929 (feet)	Aquifer
				Onslow County--Continued				
16	34°48'15" 77°29'32"	Jacksonville High- way 258 Field	4	1964P	80.0	--	33	Peedee and Black Creek
				1/83P	110.5	--		
				11/83C	120	--		
				4/84C	140	--		
				10/84C	140	--		
				7/85C	150	--		
17	34°48'26" 77°29'12"	Jacksonville High- way 258 Field	5	1964P	40	--	35	Peedee and Black Creek
				10/86C	93	--		
				11/86C	104	1		
18	34°52'28" 77°30'08"	Jacksonville Gum Branch Field	11	4/74P	25	--	39	Black Creek
				11/86C	167	1		
19	34°52'28" 77°30'08"	Jacksonville Gum Branch Field	12	10/74P	53	--	39	Peedee
				11/86C	71	1		
20	34°51'08" 77°29'15"	Jacksonville Gum Branch Field	13	6/74P	19	--	35	Peedee
21	34°51'08" 77°29'15"	Jacksonville Gum Branch Field	14	3/74P	26	--	35	Black Creek
				6/74P	26.5	--		
				1/83P	97.4	--		
				9/86C	160	--		
				11/86C	168	1		
22	34°51'31" 77°29'16"	Jacksonville Gum Branch Field	15	4/78P	77	--	50	Black Creek
				1/83P	111.4	--		
				8/86C	181	--		
				9/86C	174	--		
				11/86C	184	1		
23	34°52'28" 77°30'08"	Jacksonville Gum Branch Field	16	8/86C	165	--	52	Black Creek
				10/86C	176	--		
				11/86C	168	1		

Table 2.--*Record of water-level measurements in the Peedee and Black Creek aquifers in Onslow and Jones Counties, 1950-86*

[Map number, refers to well locations in figure 1; well number, number used by respective water system to identify well; P, water-level data collected during aquifer test, data in USGS files; U, water-level by USGS or DEHNR personnel; C, water-level by water-system personnel; L, water-level measurement made in process of lowering pump setting, data from water-system personnel; --, data not available]

Map number	Latitude/ longitude	Water system	Well number	Date of water-level measurement	Depth of water-level below measuring point (feet)	Distance of measuring point above land surface (feet)	Altitude of land surface above NGVD of 1929 (feet)	Aquifer
				Onslow County--Continued				
24	34°48'37" 77°29'16"	DEHNR Jacksonville Research Station		10/86U	97.5	3	26	Black Creek
				11/86U	98.6	3		
				12/86U	99.4	3		
				1/87U	99.7	3		
				2/87U	100.6	3		
				3/87U	101.4	3		
				4/87U	101.8	3		
				11/86U	61.1	3	26	Peedee
25	34°50'16" 77°18'14"	DEHNR Deppe Research Station		11/79U	15.3	2	45	Peedee
				7/81U	15.9	2		
				11/86U	17.7	2		
				11/79U	25.2	5	45	Black Creek
26	34°36'40" 77°29'01"	DEHNR Folkstone Research Station		8/82U	35.3	5	67	Peedee
				11/82U	41.1	2	67	Black Creek
				11/86U	42.5	2		
27	34°41'29" 77°21'04"	DEHNR Hadnot Point Research Station		11/86U	5.2	4	19	Peedee
				11/86U	42.1	5	19	Black Creek
28	34°53'59" 77°32'59"	Town of Richlands	2	1950P	8	--	60	Black Creek
				12/86U	144.9	1		
29	34°53'39" 77°32'37"	Town of Richlands	3	1973P	35	--	52	Black Creek
				12/86U*	137.9	1		
30	34°56'04" 77°33'10"	Northwest Onslow Water Association	1	12/86U	48.8	3	66	Peedee

*Pump off one-half hour prior to measurement.