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[redacted]ENT OF THE NAVY, U.S. MARINE CORPS,
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COVER PHOTOGRAPH: U.S. Geological Survey Hydrologists and Technicians installing a well casing in one of the wells in the study area at Camp Lejeune Marine Corps Base, North Carolina. (Photograph by Douglas A. Harned, U.S. Geological Survey, Raleigh, North Carolina)

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ASSESSMENT OF HYDROLOGIC AND HYDROGEOLOGIC DATA AT CAMP LEJEUNE MARINE CORPS BASE, NORTH CAROLINA

By Douglas A. Harned, Orville B. Lloyd, Jr., and M.W. Treece, Jr.

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4096

Prepared in cooperation with the

DEPARTMENT OF THE NAVY, U.S. MARINE CORPS,

CAMP LEJEUNE, NORTH CAROLINA

Raleigh, North Carolina

1989

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

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

Multiply inch-pound unit	by	to obtain metric unit
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	3.785	liter (L)
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)
gallon per minute (gal/min)	0.003785	cubic meter per minute (m^3/min)
gallon per minute per foot [(gal/min)/ft]	12.42	liter per minute per meter [(L/min)/m]
	0.01242	cubic meter per minute per meter [(m^3/min)/m]
foot per day (ft/d)	0.3048	meter per day (m/d)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)

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."

The hydraulic gradient in the Castle Hayne aquifer is 5 to 15 feet per mile in areas unaffected by pumping and is as much as 200 feet per mile within major pumping centers. Estimated velocities of ground-water movement range from 0.06 to 16 feet per day.

The specific conductance of water in wells ranged from 251 to 1,213 microsiemens per centimeter. Wells that contained water with specific conductance values greater than 800 microsiemens per centimeter are suspected of being affected by saltwater.

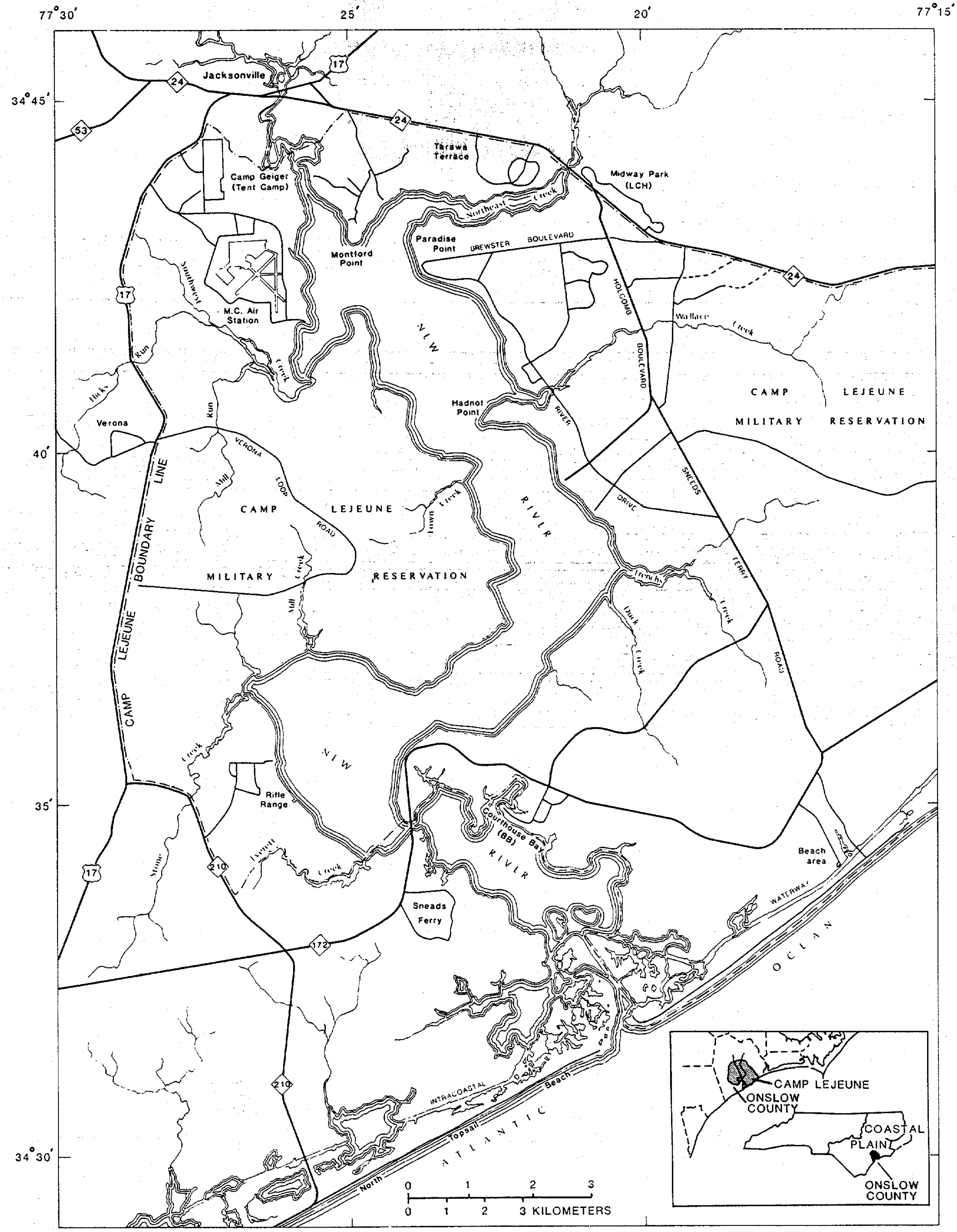
Freshwater bearing deposits consist of two aquifers--the surficial aquifer and the Castle Hayne aquifer. Clay beds within the Castle Hayne aquifer are less than 30 feet thick, are discontinuous, and comprise between 15 and 24 percent of the aquifer.

Additional test holes are needed to fully describe the hydrogeologic framework in the central and southwestern parts of the study area. Observation wells are needed in the beach areas of the Base and near the Air Station.

INTRODUCTION

Camp Lejeune Marine Corps Base is southeast of the city of Jacksonville in Onslow County in the Coastal Plain of North Carolina. The Base is bounded on the north by State Highway 24, the east by State Highway 172 and Bear Creek, the southeast by the Atlantic Ocean, the southwest by the New River and an irregular border that roughly parallels State Highway 172, and on the west by U.S. Highway 17 (fig. 1). Camp Lejeune encompasses an area of approximately 164 mi^2 (square miles), not including offshore weapons-testing impact areas. The Base is bisected by the New River, an estuary that occupies about 18 percent (30 mi^2) of the Base area.

Because the Base is bordered by a 5-mile long segment of the Atlantic Coast and because it extends inland about 20 mi (miles), Camp Lejeune contains a wide variety of coastal environments. These include swamps, estuaries, and savannas, but the Base consists predominately of managed deciduous and pine forest lands.



Base taken from. Defense Mapping Agency Hydrographic Center, Camp Lejeune Special Map, 1:50,000.

Figure 1.--Location of Camp Lejeune Marine Corps Base study area.

Camp Lejeune is a training base for the Marine Corps. The Base is the only military training center in the eastern United States where joint amphibious training exercises can be conducted with all branches of the armed services. A plentiful water supply that is suitable for most uses is vital for meeting Camp Lejeune's needs. Because of the flat terrane and saline estuaries, surface-water impoundments are impractical; therefore, Camp Lejeune relies on ground water for the Base water supply.

Since Camp Lejeune was opened in the late 1930's, water has been supplied from wells that tap freshwater-bearing aquifers (sands and limestone), which are present at depths of about 50 to 300 ft (feet) below land surface. Saltwater is found in deeper sand aquifers beneath the freshwater-bearing aquifers and in the shallow aquifer adjacent to the Atlantic Ocean and tidal reaches of the New River and its tributaries. Clay and silty clay confining beds are interlayered with the aquifer material but generally are thin and discontinuous within the freshwater section beneath the Base.

Throughout its history, more than 100 wells have been drilled and operated to satisfy increasing demands for water as the Base's functions and population have increased. More than 50,000 military personnel were stationed at the Base in 1986, along with 13,000 dependents who lived on the Base and 4,500 civilian employees. The total population of the Base was about 68,000 people in 1986. Ground-water withdrawals at the Base rank among the largest in the State and totaled about 7.5 Mgal/d (million gallons per day) in 1986.

An increase in population and activities at the Base has resulted in the storage and disposal or spillage of substantial quantities of wastes that contain hazardous and toxic organic compounds on the Base. Most of the disposal and spill sites are underlain by sand and lack natural or synthetic barriers to prevent downward movement of waste into the ground-water system. Some of these wastes may have entered the aquifer, because the use of a number of supply wells has been discontinued as a result of the detection of organic compounds in the water.

An ongoing study of the effects of ground-water contamination by waste-disposal sites on the Base is part of the current NACIP (Navy Assessment and

Control of Installation Pollutants) program (Putnam, 1983). The emphasis of the NACIP study is to identify the nature and extent of any contamination of the shallow (0 to 100 ft) aquifer near sites that were identified previously by Putnam (1983) as potential sites of ground-water contamination.

In addition to the contamination of the ground-water system from waste disposal, there is a potential for saltwater encroachment as a result of pumping. Water withdrawals from wells near the tidal reaches of the New River and its tributaries may cause saltwater to move into and through the shallow aquifer toward pumped wells. Saltwater also could be drawn upward from deeper parts of the aquifer system by wells pumping large quantities of ground water from the deep sand aquifers or the lower parts of the sand and limestone aquifer.

In response to the Base's needs for a dependable water supply, the U.S. Geological Survey in cooperation with the U.S. Marine Corps began a study of the hydrogeology of the Base and environs. The study is intended to provide the Marine Corps the with information necessary to determine the best management practices so that the chances of further contamination of the aquifers can be minimized.

The study consists of three phases--(1) the examination of available data; (2) the collection and analysis of additional data and construction of new observation wells, and (3) ground-water modeling to allow testing of the effects of different pumping strategies on the flow system. This report discribes the results of the first phase of the study.

Purpose and Scope

This report presents a review of available ground-water data for the Base and outlines a hydrogeologic framework to guide the later phases of study. Most of the available data were from developed areas on the Base, including Hadnot Point, the Marine Corps Air Station, and Tarawa Terrace.

The data reviewed included records maintained by the Utilities Division on the Base, records from the files of NRCD (the North Carolina Department of Natural Resources and Community Development), and records from U.S. Geological Survey files. These include water-use information, well logs, well construction and pumping data, well-acceptance tests, water-level measurements, and specific conductance data. The data from these sources span the period from the early 1940's to 1986, when most of the water-supply wells on the Base were drilled. Data from a water-quality survey of the Base water-supply wells in October 1986 were obtained from Environmental Science and Engineering, Inc. Borehole geophysical logs for a 1,500-foot test well drilled in 1986 by NRCD for their Hadnot Point Research Station also have been used in this analysis.

Two special surveys of ground-water levels from about 100 wells were made for this study. The first survey was conducted in October of 1986 during a period of relatively low water levels. The second survey was in April 1987 during a period of relatively high water levels.

Six water-level recorders were installed in June and July 1986 at Camp Lejeune. Other hydrologic monitoring equipment installed for this investigation included a stream gage and a rain gage installed in June 1986, and a tide gage installed in August 1986.

Previous Studies

Previous work by LeGrand (1959) involved an examination of well data, the drilling of 22 test wells, and suggestions for future drilling of water-supply wells. LeGrand obtained geophysical logs for the test wells to help identify the best zone to pump; however, he did not trace the zones areally. LeGrand's geologic descriptions and data provided a foundation for a more detailed examination of the aquifer system.

A study by NRCD (1979) of the ground-water quality for the Georgetown Community located near the northwest border of Camp Lejeune included a detailed analysis of the hydrogeology in that area and collection of data from 64 wells. Information from this study is useful in describing the hydrogeology between the Marine Corps Air Station and Montford Point.

Two multi-county ground-water studies by the U.S. Geological Survey provide much of the basic hydrogeologic framework for the proposed flow model for Camp Lejeune. A RASA (Regional Aquifer Systems Analysis) study by Winner and Coble (1989) produced a general hydrogeologic framework for the entire Coastal Plain of North Carolina and furnished additional data that can be used for the proposed ground-water flow model in the third phase of this investigation. A similar study by Winner and Lyke (1989) focused on 14 counties of the Coastal Plain of North Carolina, including Onslow County and refined the framework developed for the RASA study. However, neither study focused primarily on the Castle Hayne aquifer, which is the water-supply aquifer for Camp Lejeune.

Hydrogeologic Setting

The sediments of the Coastal Plain consist of interbedded sands, clays, calcareous clays, shell beds, sandstone, and limestone (LeGrand, 1959). These sediments are layered in interfingering beds and lenses that gently dip and thicken to the east and include 10 aquifers and 9 confining units (fig. 2). In the Camp Lejeune area, the sediments are about 1,500 ft thick and overlie igneous and metamorphic basement rocks. These sediments were deposited in marine or near-marine environments (Brown and others, 1972).

The aquifers of the Camp Lejeune area are the surficial, Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. They are separated by less permeable clay and silt beds (confining units) that serve to impede the flow of ground water between the aquifers. A generalized hydrogeologic section in Jones and Onslow Counties showing these units is given in figure 3.

The surficial aquifer is a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 ft. This unit is not used for water supply on the Base. In some areas, the surficial aquifer is reported to contain water contaminated by waste disposal practices, particularly in the northern and north-central developed areas of the Base (Putnam, 1983).

The principal water-supply aquifer for the Base is the series of sand and limestone beds that occur between 50 and 300 ft below land surface. This series of sediments generally is known as the Castle Hayne aquifer. The Castle Hayne aquifer is about 150 to 350 ft thick in the area and is the most productive aquifer in North Carolina. It is a critical water-supply source, not only for Camp Lejeune but also for the southern coast and east-central Coastal Plain as outlined in figure 4.

GEOLOGIC UNITS			HYDROGEOLOGIC UNITS
SYSTEM	SERIES	FORMATION	AQUIFER AND CONFINING UNIT
Quaternary	Holocene Pleistocene	Undifferentiated	Surficial aquifer
Tertiary	Pliocene	Yorktown Formation[1]	Yorktown confining unit
			Yorktown aquifer
	Miocene	Eastover Formation[1]	
		Pungo River Formation[1]	Pungo River confining unit
			Pungo River aquifer
		Belgrade Formation[2]	Castle Hayne confining unit
	Oligocene	River Bend Formation	Castle Hayne aquifer
	Eocene	Castle Hayne Formation	Beaufort confining unit[3]
	Paleocene	Beaufort Formation	Beaufort aquifer
			Peedee confining unit
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee aquifer
			Black Creek confining unit
		Black Creek and Middendorf Formations	Black Creek aquifer
			Upper Cape Fear confining unit
		Cape Fear Formation	Upper Cape Fear aquifer
			Lower Cape Fear confining unit
			Lower Cape Fear aquifer
	Lower Cretaceous[1]	Unnamed deposits[1]	Lower Cretaceous confining unit
			Lower Cretaceous aquifer[1]
Pre-Cretaceous basement rocks		--	--

[1]Geologic and hydrologic units probably not present beneath Camp Lejeune.
[2]Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.
[3]Estimated to be confined to deposits of Paleocene age in the study area.

Figure 2.--Generalized relation between geologic and hydrogeologic units in the Coastal Plain of North Carolina.

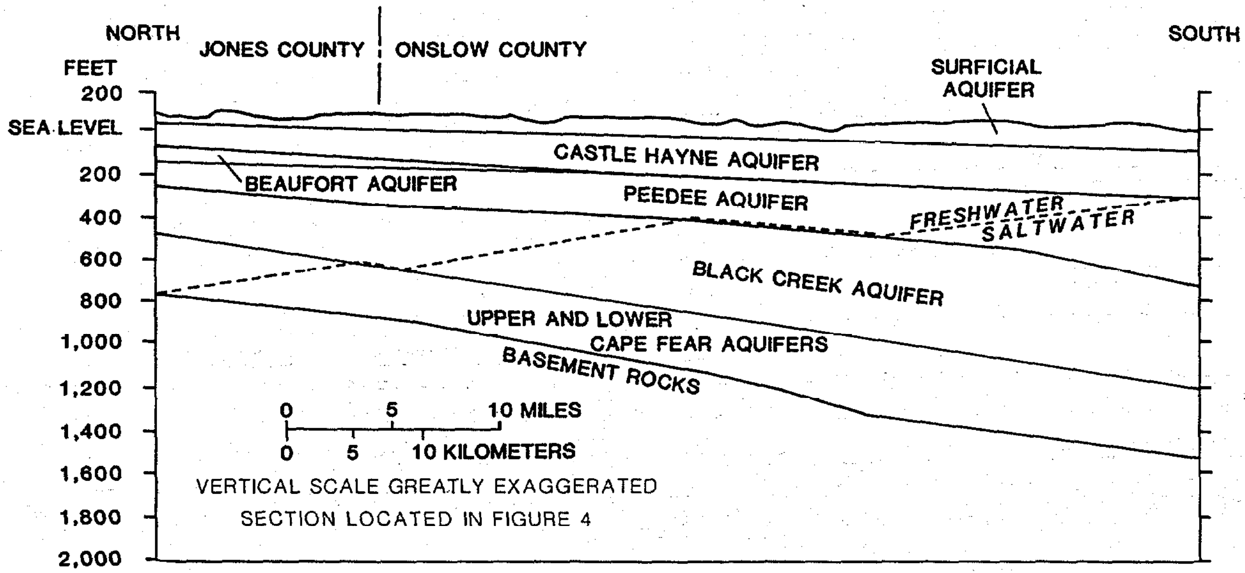


Figure 3.--Generalized hydrogeologic section through Jones and Onslow Counties, North Carolina.

Onslow County and Camp Lejeune lie in an area where the Castle Hayne aquifer contains freshwater (fig. 4), although the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals from the aquifer. Overpumping of the deeper parts of the aquifer could cause upconing of saltwater to occur. The aquifer contains water having less than 250 mg/L (milligrams per liter) chloride throughout the area of the Base.

The aquifers that lie below the Castle Hayne consist of a thick sequence of sand and clay. Although some of these aquifers are used for water supply elsewhere in the Coastal Plain, they contain saltwater in the Camp Lejeune area.

Rainfall that occurs in the Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the water table, which is the top of the saturated zone. In the saturated zone, ground water flows in the direction of lower hydraulic head, moving through the system to discharge areas like the New River and its tributaries (fig. 5) or the ocean.

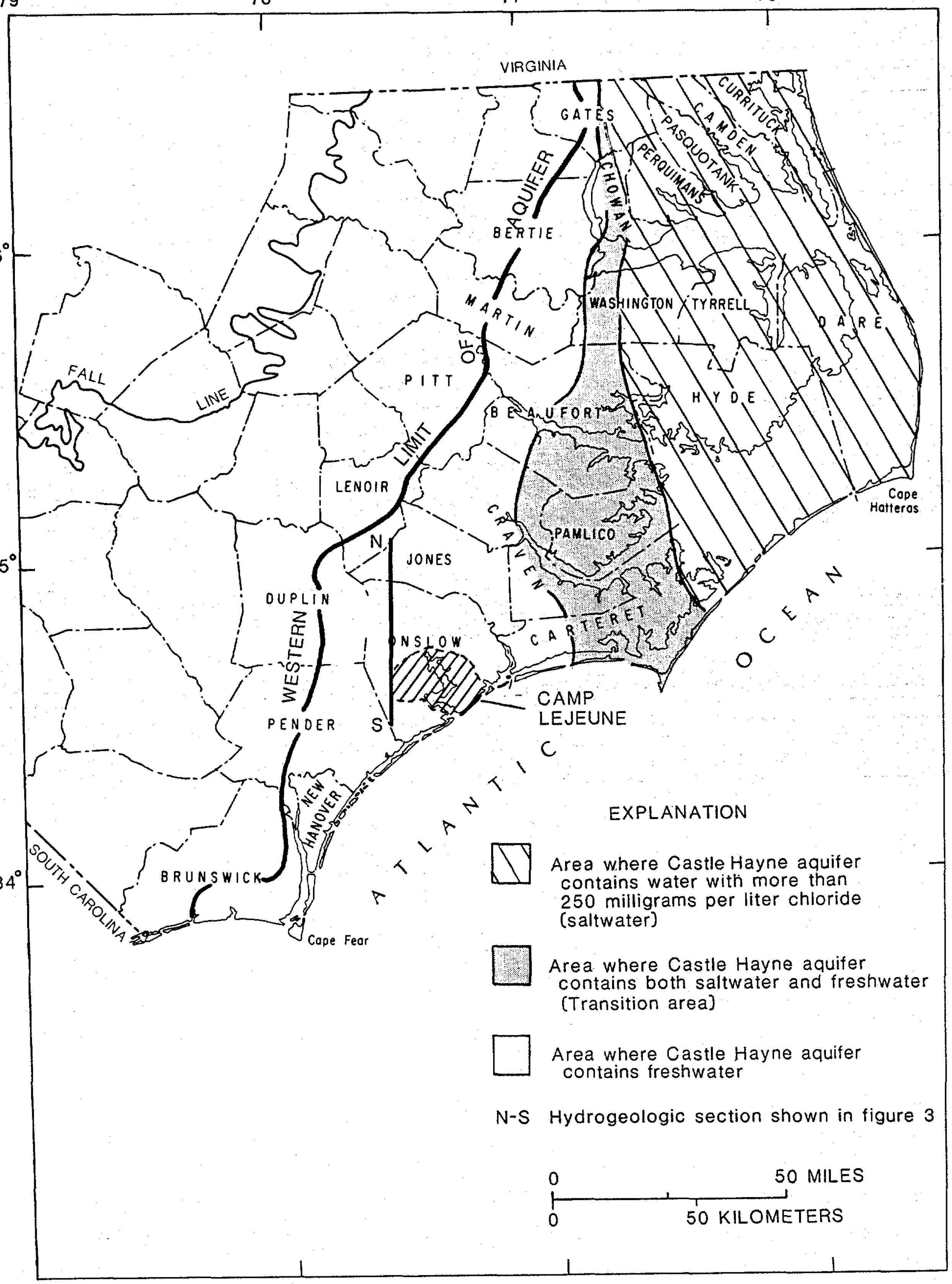


Figure 4.--Freshwater and saltwater areas in the Castle Hayne aquifer.

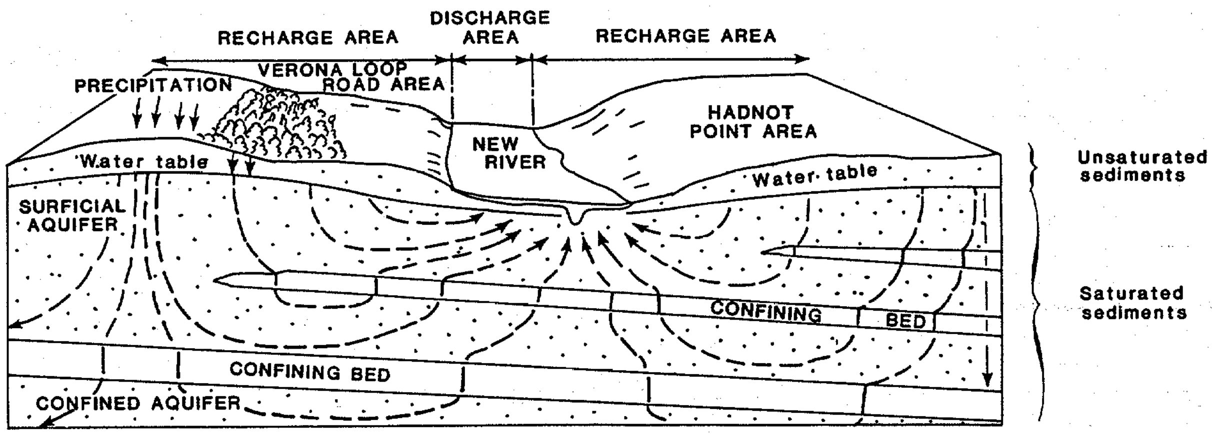


Figure 5.--A generalized sketch of ground-water movement through unconfined and confined aquifers beneath Camp Lejeune (modified from Winner, 1981).

Water levels in wells tapping the surficial aquifer vary seasonally. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the water table generally is highest in the winter months and lowest in summer or early fall.

In confined aquifers, water is under hydraulic pressure or head and the level to which it rises in a tightly cased well is called the potentiometric surface. The hydraulic head in a confined aquifer, such as the Castle Hayne, shows a different pattern of variation over time than that in an unconfined aquifer. Some seasonal variation also is common in the water levels of the Castle Hayne aquifer, but the changes tend to be slower and over a smaller range than for water-table wells.

The principal ways that man causes changes in the ground-water flow system in the Camp Lejeune area include ground-water withdrawal from water-supply wells and covering recharge areas with impervious buildings and pavement, as in the Hadnot Point industrial area. The most significant of these is ground-water pumpage for water supply.

Water Use

Since the establishment of Camp Lejeune in the late 1930's, the sole source of water supply for the Base has been from wells. Initially, there were no treatment facilities, but by 1941 the Hadnot Point Water Treatment System was placed in operation with 21 wells on line. The total capacity of the plant was 7.30 Mgal/d; however, the maximum output from the plant in 1942 was 4.80 Mgal/d. The Hadnot Point Water System served the main part of the Base, including the regimental area, post troops area, industrial area, Naval Hospital, Paradise Point housing, Midway Park housing project, and the Camp Lejeune schools (Robison and Mann, 1977).

Some untreated water was used at scattered locations on the periphery of the Base until the early 1950's when a treatment facility was built at Tarawa Terrace. In the mid 1950's, water treatment plants were constructed at Onslow Beach and Montford Point. In the 1960's, water-treatment facilities were added at the Rifle Range area and at Courthouse Bay. The Holcomb Boulevard Treatment Plant, built in 1971 with a designed capacity of 2.0 Mgal/d, was expanded in 1987 to a total plant capacity of 5.0 Mgal/d. Much of the water demand has shifted from the Hadnot Point Plant to the Holcomb Boulevard Plant. Table 1 shows the physical characteristics of each treatment plant with the plant capacities, number of wells, and population served.

Table 1.--*Water-treatment plant capacity, number of wells, and population supplied, March 1987*
[Mgal/d, million gallons per day; data compiled from Marine Corps files]

Plant	Plant capacity (Mgal/d)	Number of wells	Population supplied
Hadnot Point	5.900	35	37,134
Holcomb Boulevard	2.304	8	8,139
Tarawa Terrace	1.152	6	6,196
Montford Point	.622	8	2,962
Marine Corps Air Station	4.081	26	10,315
Rifle Range	.648	4	348
Courthouse Bay	.864	5	3,091
Onslow Beach	.250	2	248

The amount of water used has increased with time and population. Over the years, more than 100 wells have been drilled to supply water to the Base for drinking and other Base operations. Since World War II, the Base has grown from a service population of around 25,000 to about 68,000 in 1986. However, the population increase and water demand have remained relatively constant over the past two decades.

Historical water-pumpage data for the Base are not available prior to 1970; however, records for the amount of water treated in recent years are complete. The amount of water treated at the water plants and distributed actually is less than the amount pumped due to conveyance losses. Conveyance losses are related to the efficiency of the system and the condition of the distribution lines. Most water-supply systems have an average conveyance loss of between 15 and 20 percent of the water withdrawals (Preston Maynard, NRCD, Division of Water Resources, oral commun., 1987). However, the conveyance loss for Camp Lejeune is unknown.

Most of the change in ground-water withdrawals during the past decade is due to a change in the distribution system instead of increased water demand. Pumping rates have decreased in the Hadnot Point area and increased in the Holcomb Boulevard system, indicating expansion of the latter treatment facility and the discontinuation of many supply wells in the Hadnot Point system. The amounts of raw water treated at each Base treatment plant, presented in figures 6 and 7, reflect these changes in pumpage because the amount of water treated by the individual water-treatment plants is related to the pumpage rate of the well fields.

The amount of raw water treated in 1975 totaled 7.14 Mgal/d for the nine water systems that were in operation (fig. 8). The Camp Geiger Water Treatment Plant was discontinued in 1977, and the supply wells in that system were interconnected with the Marine Corps Air Station (MCAS) system. In 1986, the amount of raw water treated totaled 7.23 Mgal/d for the eight treatment plants in operation. The data indicate that there has not been a substantial change in the amount of water treated in the past 12 years.

Water use varies seasonally, as shown in figure 9, with the greatest use in summer and the least in winter. Unfortunately, there are no data on water withdrawals from individual wells. Well data on pumping capacity,

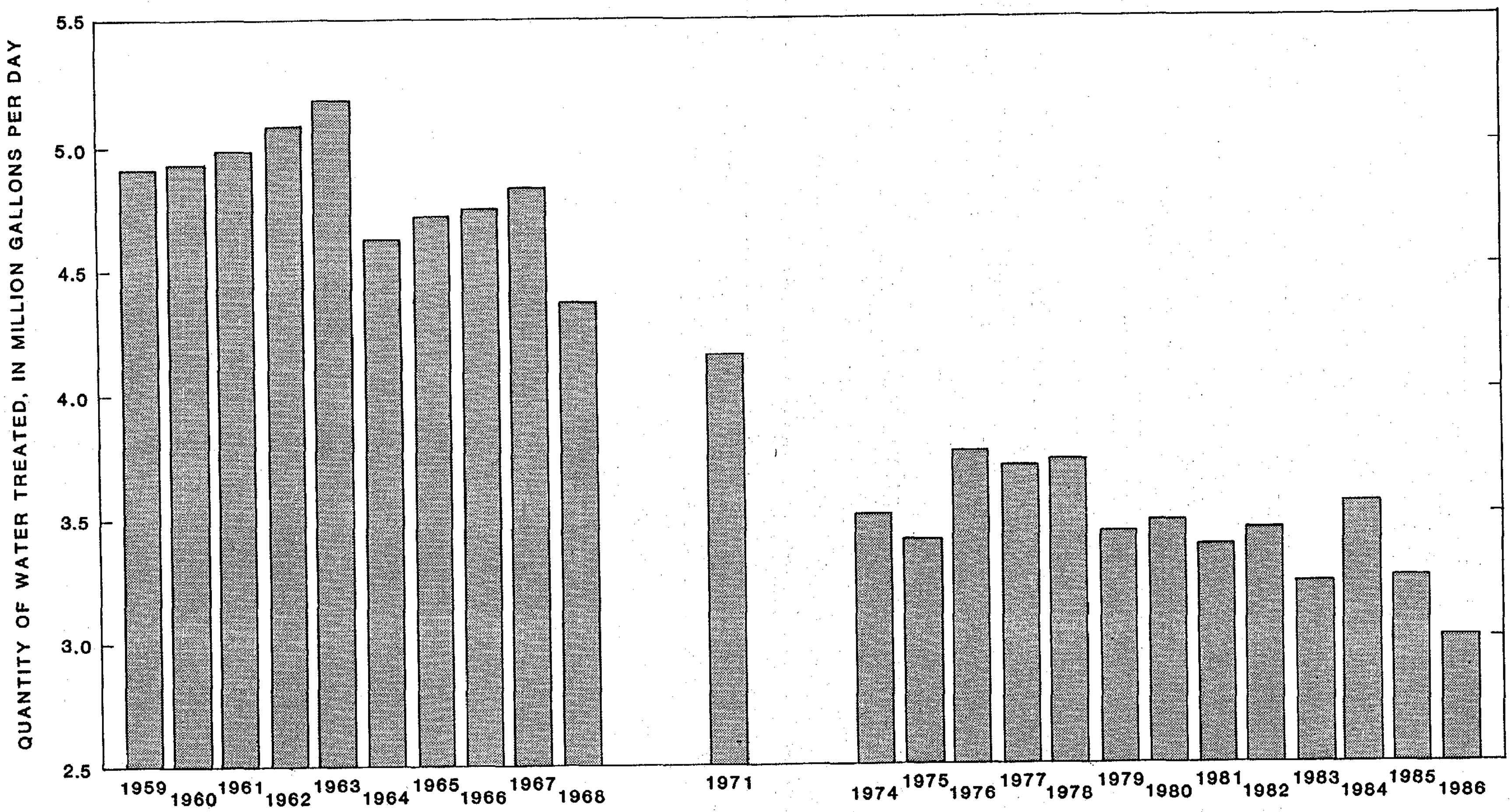


Figure 6.--Quantity of raw water treated by the Hadnot Point Water Treatment Plant, from 1959 to 1986.

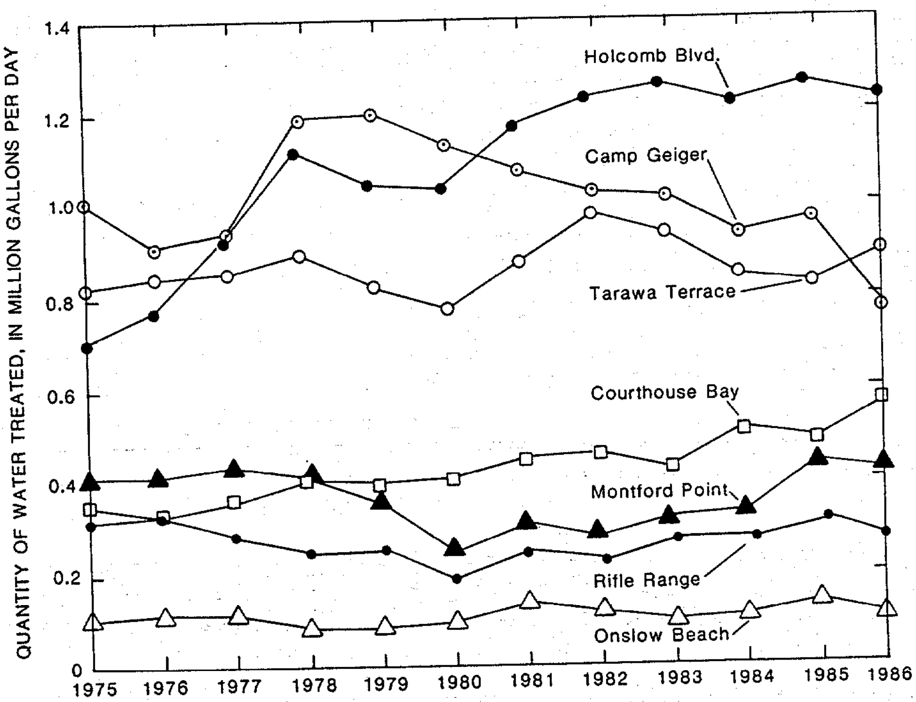


Figure 7.--Quantity of raw water treated by the Holcomb Boulevard, Tarawa Terrace, Montford Point, Rifle Range, Marine Corps Air Station, Courthouse Bay, and Onslow Beach Water Treatment Plants, from 1975 to 1986.

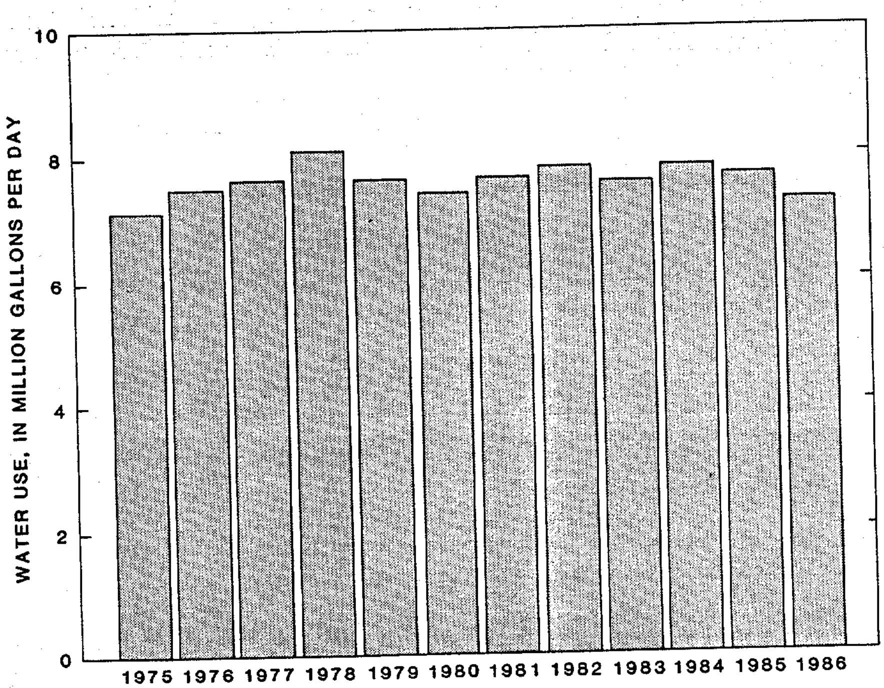


Figure 8.--Average yearly water use for Camp Lejeune.

yield of a well, and time of pumpage can be used to estimate withdrawals of an individual well. This analysis was not possible with the available data but could be incorporated in future studies if pumping records are maintained.

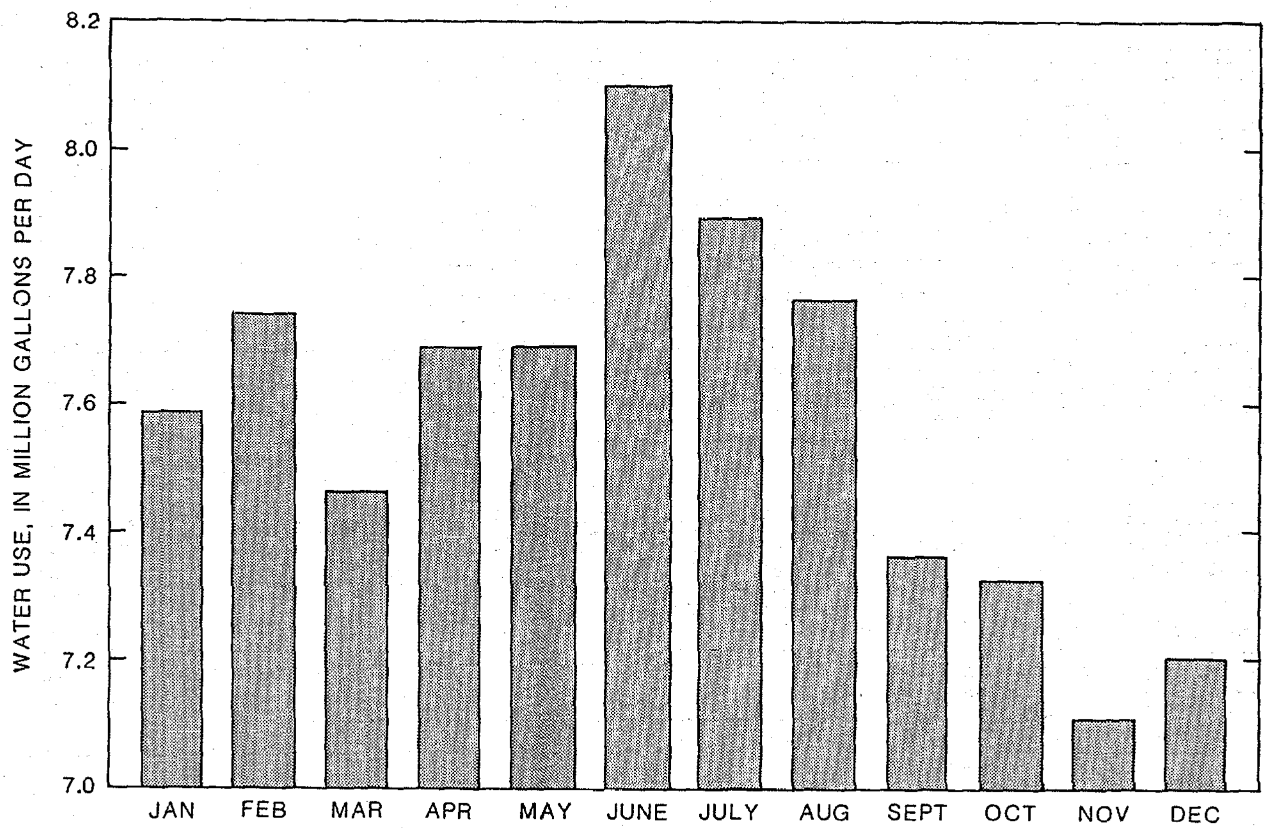


Figure 9.--Average monthly water use for Camp Lejeune, from 1975 to 1986.

An indication of the approximate distribution of ground-water pumpage can be derived from the amount of water treated at each facility. The pumpage for each facility can be estimated by using the plant data and adjusting for estimated conveyance losses of 15 percent. The estimated pumpage is shown for generalized pumping centers for wells serving each water-treatment plant in figure 10.

Per capita water use often is used to compare gross pumpage rates from different systems (Winner and Lyke, 1986). Per capita water use in 1986 ranged from 632 gal/d (gallons per day) for the Rifle Range area to 68 gal/d at the MCAS. The average per capita use for the entire base was 110 gal/d, which is less than the State average (180 gal/d) for public-supply systems in North Carolina.

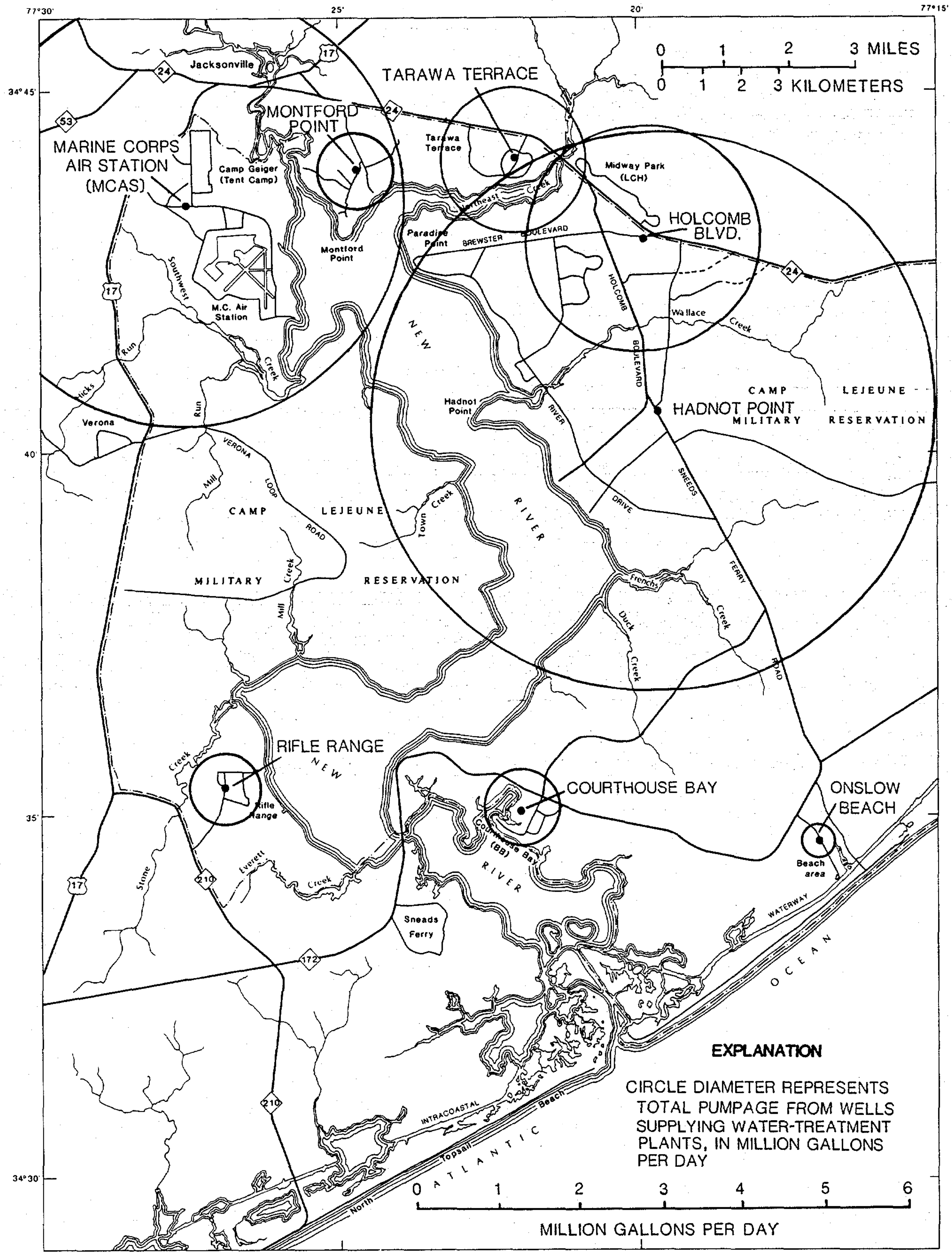


Figure 10.--Approximate centers of pumpage for wells that supply water-treatment plants, April 1987.

The high per capita use for the Rifle Range (632 gal/d) and Onslow Beach (444 gal/d) systems may be misleading because of difficulties in estimating the population served. For example, only 248 people resided at Onslow Beach; however, the beach was frequented by many people who used the facilities for recreational purposes. Whereas, the Hadnot Point and MCAS systems serve most of the commercial water users on the Base and about 69 percent of the total population. The other four systems (Holcomb Boulevard, Tarawa Terrace, Montford Point, and Courthouse Bay) serve residential users almost exclusively and have per capita use values ranging from 140 to 175 gal/d. Because Camp Lejeune is a Federal military installation, the billing and accounting structures are different from other public-supply systems, and accurate records of water distribution are not available.

Acknowledgments

Robert Alexander, of Staff Facilities at Camp Lejeune, served as the principal liaison between staff on the Marine Base, the U.S. Geological Survey, and Environmental Sciences and Engineering, Inc. Byron M. Frazelle and Golden S. Johnson of Camp Lejeune Utilities helped provide access to well-record data.

Richard Shiver, NRCD, Wilmington Office, provided well records and geophysical logs and coordinated the well drilling for the Hadnot Point NRCD Ground-Water Research Station wells. In addition, Michael J. Geden and Robert G. Gregory, of Environmental Sciences and Engineering, Inc., provided water-quality data for the water-supply wells in the NACIP study at the Base and allowed access to shallow monitoring wells.

HYDROLOGIC DATA

The general water-bearing and water-quality characteristics of the ground-water system for the Base can be compiled from a review of the existing hydrologic data. The following sections on well logs, well construction and pumping rates, specific capacity, transmissivity, and ground-water levels define the general water-bearing characteristics of the ground-water system; a section on specific conductance defines the general water-quality characteristics of the system. Most of the data used in this investigation are found in tables A and B in the Supplemental Data section of this report.

Well Logs

Geophysical and lithologic logs are used to determine the depth, thickness, and lithologic characteristics of the sediments that comprise the ground-water flow system. Wells where geophysical or lithologic logs or other data are available are shown in plate 1 and listed in table A. More than 100 logs are available for the developed areas of the Base. Because the average depth of water-supply wells on the Base is 162 ft and available log data seldom are deeper than 300 feet, the hydrology of the lower part of the water-supply aquifer is relatively unexplored. However, there are logs for a few wells in the area of the Base (T8, VPI-15, VPI-15a, RR-97, Y25q2, OT-22, and ON-OT-1-67) that can be used to trace the deeper layers. Borehole geophysical logs of 16 open wells on the Base and two new observation wells were run by the U.S. Geological Survey for this study.

Well Construction and Pumping Rates

Well-construction data and pumping-rate data were obtained for more than 160 wells from Camp Lejeune, NRCD, and U.S. Geological Survey files. These data provided the basis of the hydrogeologic framework analysis. The typical water-supply well on the Base has an average depth of 162 ft, is 8 in. in diameter, and has 37 ft of screen open to the aquifer. Typical supply-well construction is schematically depicted in figure 11 with other construction and production data.

The screened intervals, and in a few cases the open-hole intervals, in the water-supply wells give an indication of which parts of the aquifer are most productive. The screened intervals are spread out over 20 to 150 ft, indicating that the production zone interval in the water-supply aquifer is at least this thick. The average thickness of the screened zone of the 68 water-supply wells for which data were available is 84 ft. However, trends in the thickness of the zone cannot be determined readily from the screen data.

The pumping rate for the 89 Camp Lejeune wells for which data were available averaged 174 gal/min (gallons per minute), ranging from 40 to 450 gal/min. These rates vary from place to place, with Montford Point and MCAS wells having rates of around 130 gal/min and Hadnot Point wells having rates

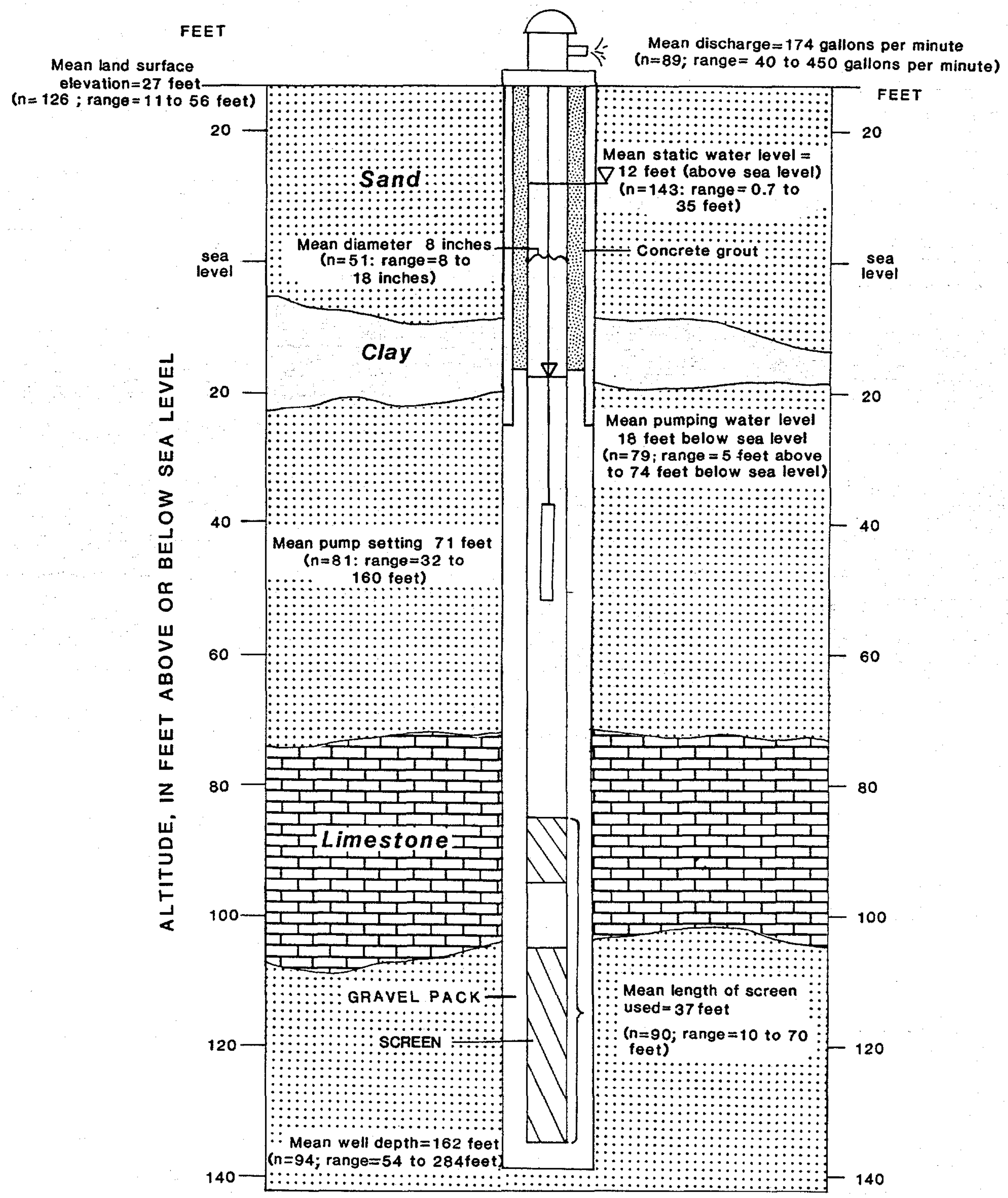


Figure 11.--A schematic drawing of a typical water-supply well at Camp Lejeune.

of around 195 gal/min. The differences may be due to areal variations in stratigraphy, aquifer characteristics, well construction, or pump characteristics.

Specific Capacity

Well-acceptance test data from Camp Lejeune files were reviewed and used to calculate the specific capacity of 33 wells screened in the Castle Hayne aquifer (table B, Supplemental Data section). The specific capacity of a well is computed by dividing the pumping rate (Q) by the drawdown(s) and generally is reported in units of (gal/min)/ft (gallons per minute per foot of drawdown). The specific capacity for 33 wells listed in table B had an average of 6.3 (gal/min)/ft and ranged from 2.2 to 12.2 (gal/min)/ft of drawdown. The length of the well-acceptance tests from which the specific capacities were calculated ranged from 300 to 2,400 min (minutes) and averaged about 1,558 min. No attempt was made to adjust the specific capacities to a common well-acceptance test length.

A comparison of the total aquifer thickness and screen length data in table B indicates that, on average, the wells only screen about 13 percent of the Castle Hayne aquifer. Such wells have specific capacities that are only a fraction of those that could be obtained from wells that screen the entire thickness of the aquifer. The specific capacities that might be expected if the wells screened the entire thickness of the aquifer can be approximated mathematically. The method, described by Driscoll (1986), assumes that (1) water is moving to the well generally along paths perpendicular to the screen and, thus, from a thickness of the aquifer equal to the screen length, (2) the water-yielding characteristics of the screened part of the aquifer are representative of the remainder of the aquifer, and (3) no part of the aquifer will be dewatered during pumping. Kozeny's (1933) equation is used:

$$\left(\frac{Q}{s}\right) = \frac{\left(\frac{Q}{s}\right)_p}{L\left(1 + 7\left(\sqrt{\frac{r}{2bL}}\right)\cos\left(\frac{\Pi L}{2}\right)\right)} \qquad (1)$$

where:

$\left(\frac{Q}{s}\right)$ = maximum possible specific capacity of a well screening the full thickness of the aquifer (see corrected specific capacity column in table B);

$\left(\frac{Q}{s}\right)_p$ = specific capacity of a partially penetrating or partially screened well (from specific capacity column in table B);

L = well screen length divided by aquifer thickness (from screen length and total aquifer thickness columns in table B);

r = radius of well in feet (from well diameter column in table B); and

b = aquifer thickness in feet (from total aquifer thickness column in table B).

The specific capacity for each well listed in table B was adjusted according to this equation, and the results are recorded in the corrected specific capacity column in table B. The corrected values are considerably higher than the unadjusted values. The specific capacity estimated for wells that screen the full thickness of the aquifer averaged 34.6 (gal/min)/ft and ranged from 14.5 to 83.1 (gal/min)/ft of drawdown. These results indicate that higher specific capacities might be obtained at Camp Lejeune with wells that screen larger portions of the aquifer. However, pumping water from the deeper parts of the Castle Hayne aquifer might induce upward movement of saltwater where it occurs in the underlying sand aquifers.

Transmissivity

Transmissivity of an aquifer is defined as the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. Transmissivity is expressed as cubic feet of water moving through a foot width of aquifer each day $(ft^3/ft)/d$, which is algebraically reduced to feet squared per day (ft^2/d).

The corrected specific capacity values in table B were used to approximate the transmissivity of the Castle Hayne aquifer at Camp Lejeune. Several approaches to approximating transmissivity from specific capacity data have been described by Jacob (1945), Theis and others (1954), McClymonds and Franke (1972), Bennett (1976), and Driscoll (1986). For the purposes of this report, Jacob's modified nonequilibrium equation (Cooper and Jacob, 1946):

$$s = \frac{264Q}{T} \log_{10} \left(\frac{0.3Tt}{r^2 S}\right) \qquad (2)$$

is rearranged to obtain an expression for the value of specific capacity:

$$\left(\frac{Q}{s}\right) = \frac{T}{264 \log \left(\frac{0.3Tt}{r^2 S}\right)} \qquad (3)$$

where:

Q = discharge from pumped well, in gal/min;
s = drawdown in the pumped well, in ft;
T = transmissivity, in (gal/d)/ft;
t = time since pumping began, in days;
r = radius of pumped well, in ft; and
S = storage coefficient of the aquifer (dimensionless), defined as the volume of water that an aquifer discharges or takes into storage across a unit surface area with the occurrence of a unit change in water level.

The following values, which are representative of the wells and the Castle Hayne aquifer at Camp Lejeune, were substituted into the expression for specific capacity shown above:

T = 112,000 (gal/day)/ft (the approximate equivalent of 15,000 ft^2/d given by Winner and Coble (1989);
t = 1.1 days (average duration of the well-acceptance tests in table B);
r = 0.383 ft (calculated from average value of well diameter in table B); and
S = 0.001 (storage coefficient of a confined aquifer (Driscoll, 1986).

Variations in these estimated values should have only a small effect on the value of the divisor in equation (3) because these values are incorporated in the log term of the equation. The equation was then solved for T, yielding the following expression:

$$T = \frac{2,206Q}{s} \qquad (4)$$

which was divided by 7.48 to convert transmissivity to units of ft^2/d:

$$T = \frac{295Q}{s} \qquad (5)$$

The corrected specific capacity values in table B were substituted into this equation to estimate the transmissivity of the Castle Hayne aquifer. Implicit in this method for estimating transmissivity is the assumption that the wells are near 100 percent efficient. That is, little or no drawdown is caused by the inefficient turbulent flow as the water moves from the aquifer through the screen and into the well and pump.

The estimated transmissivity values are shown in table B. The values for all the wells ranged from 4,300 to 24,500 ft^2/d, with an average of 10,200 ft^2/d. The transmissivity estimates for 24 wells in the Hadnot Point area (the HP-well numbers in table A) also ranged from 4,300 to 24,500 ft^2/d, but had an average of 9,500 ft^2/d. These transmissivities are close to the value of 15,000 ft^2/d estimated for the Camp Lejeune area by Winner and Coble (1989). Transmissivities of the Castle Hayne aquifer and underlying aquifers are given in table B. Transmissivities of the underlying aquifers generally are less than the estimated transmissivity for the Castle Hayne.

An estimate of hydraulic conductivity can be obtained by dividing the transmissivity by the thickness of the aquifer. The hydraulic conductivity of the Castle Hayne aquifer using the transmissivity values derived averaged about 35 ft/d (feet per day), ranging from 14 to about 82 ft/d. These values are similar to hydraulic conductivity values reported by Winner and Coble (1989) for the Camp Lejeune area. Estimates of hydraulic conductivities and transmissivities for the Castle Hayne and aquifers underlying the Castle Hayne are given in table 2. As with the transmissivity estimates, calculations of hydraulic conductivity from specific capacity are subject to error. If some of the water-level drawdown in the well is due to well-construction factors, then these calculations would yield erroneously low values of hydraulic conductivity. Further well testing is needed to confirm these estimates.

Table 2.--*Ranges of transmissivity and hydraulic conductivity for the principal aquifers in the Camp Lejeune area*
[ft^2/d, feet squared per day; ft/d, feet per day]

Aquifer	Transmissivity (ft^2/d)	Hydraulic conductivity (ft/d)
Castle Hayne	4,300-24,500	14-82
Beaufort[1/]	500- 1,500	17-20
Peedee[1/]	6,500- 8,000	28-43
Black Creek [1/]	6,500- 9,500	18-20

[1/]Values for model-derived transmissivity estimates and hydraulic conductivity obtained from G.L. Giese (U.S. Geological Survey, written commun., 1987).

Ground-Water Levels

Ground-water level data from Camp Lejeune files and NRCD files were reviewed for their use in reconstructing historical water levels, but the available data were inadequate to construct synoptic water-level maps. Also, existing data was insufficient for evaluation of the flow system. For these reasons, a network of observation wells was established.

Measurement of water levels in wells is needed for defining the ground-water flow system. It is important to know the natural variation of water levels that occurs within each aquifer due to climatic effects (such as rainfall and barometric pressure changes) and tides in order to assess regional trends caused by pumpage. Synoptic surveys are required to map the water levels in each aquifer. Analyses of these maps allow the calculation of hydraulic gradients, which are needed to determine the velocity and direction of ground-water flow and to estimate the vertical flow between aquifers.

Water-Level Monitoring Network

The ground-water level monitoring network for Camp Lejeune that was installed during the first phase of study consists of six wells equipped with water-level recorders. These stations are shown in figure 12. Well Y25q6 is screened between 18 and 22 ft below land surface in the surficial aquifer, and wells NC-52 and TT-53 are screened in the upper part of the Castle Hayne aquifer, 25 to 66 ft and 45 to 73 ft, respectively. Well HP-630 is screened from 62 to 162 ft below land surface in the Castle Hayne aquifer, and Y25q3 is screened from 150 to 240 ft in the Castle Hayne aquifer.

Well RR-97A is screened from 385 to 425 ft in the Peedee aquifer, which is below the Beaufort and Castle Hayne aquifers. This well is included in the network because data are needed on the hydraulic heads at this depth in order to estimate the effects of withdrawals from the Castle Hayne aquifer on the potential for upward movement of saltwater.

All of the monitoring wells are equipped with automatic digital recorders (ADR) set to record water-level measurements hourly. A similar recorder was used at a tide gage that was installed on the Bachelor Officer's Quarters' pier (fig. 12).

The shallow wells NC-52 and Y25q6 show similar hydrographs (figs. 13 and 14). Both show considerable fluctuation in water levels due to rainfall recharge. Seasonality also is evident in both wells. The relatively low water levels of mid-summer 1986 were followed by much higher levels in August due to unusually wet weather. The low water levels in September and October were followed by higher levels in the winter months as decreased evapotranspiration allowed more rainfall to reach the water table. The change in water level due to seasonal variation is around 4 ft. Some minor fluctuations in water levels at NC-52 may be due to pumpage from nearby wells TC-700 and TC-600, but it is difficult to separate this effect from natural fluctuations.

The hydrograph of well TT-53 (fig. 15) shows considerable variation in water level which, in this case, appears to be a result of both climatic variation and pumpage. Water levels in the month of December 1986, in particular, appear to be low as a result of pumpage. Four wells were pumping (TT-52, TT-31, TT-67, and TT-23) within 1,500 ft of well TT-53. The amount of change in water level due to pumpage is about 1 to 2 ft. Seasonality also is apparent with the water levels of the late summer months being lower than those of the winter months.

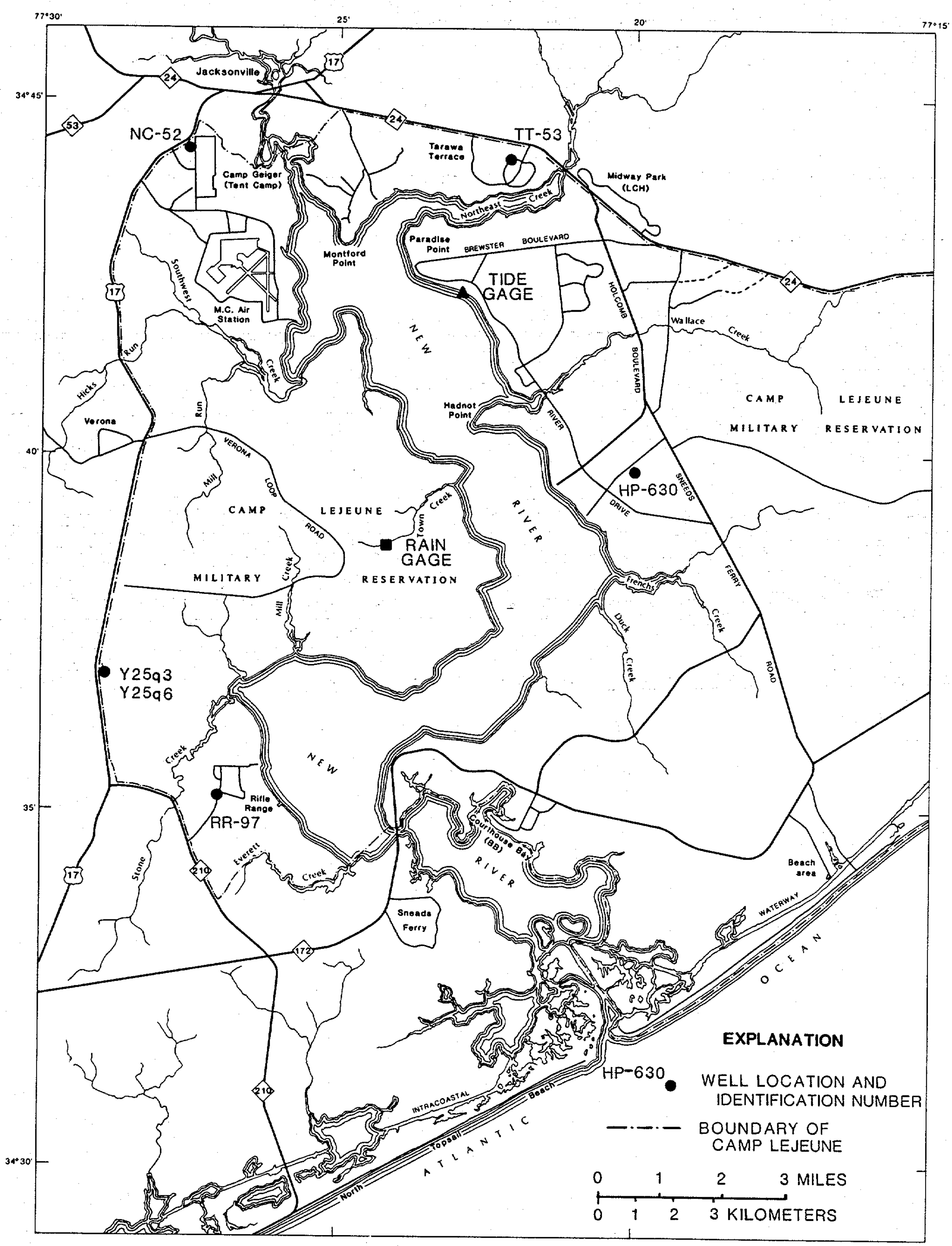


Figure 12.--Locations of data-collection stations at Camp Lejeune.

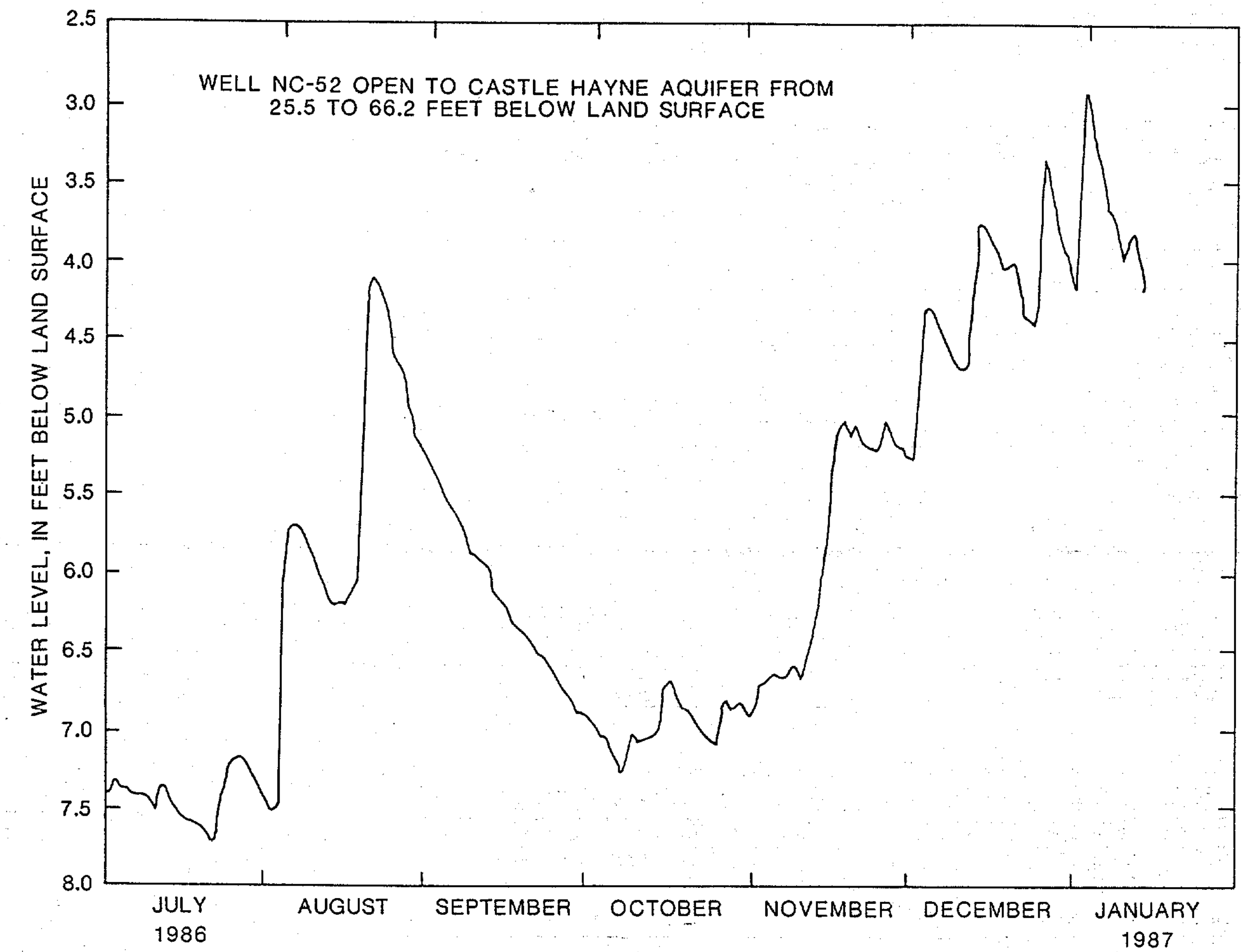


Figure 13.--Water levels in well NC-52, July 1986 through January 1987.

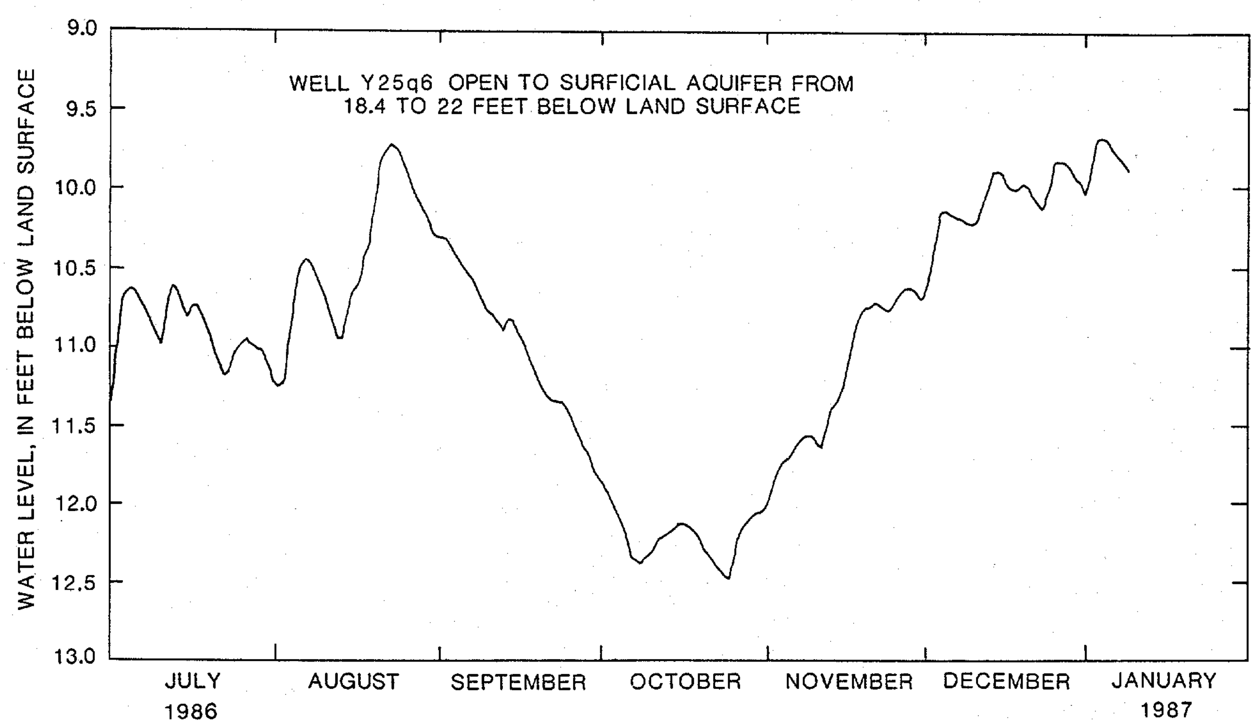


Figure 14.--Water levels in well Y25q6, July 1986 through January 1987.

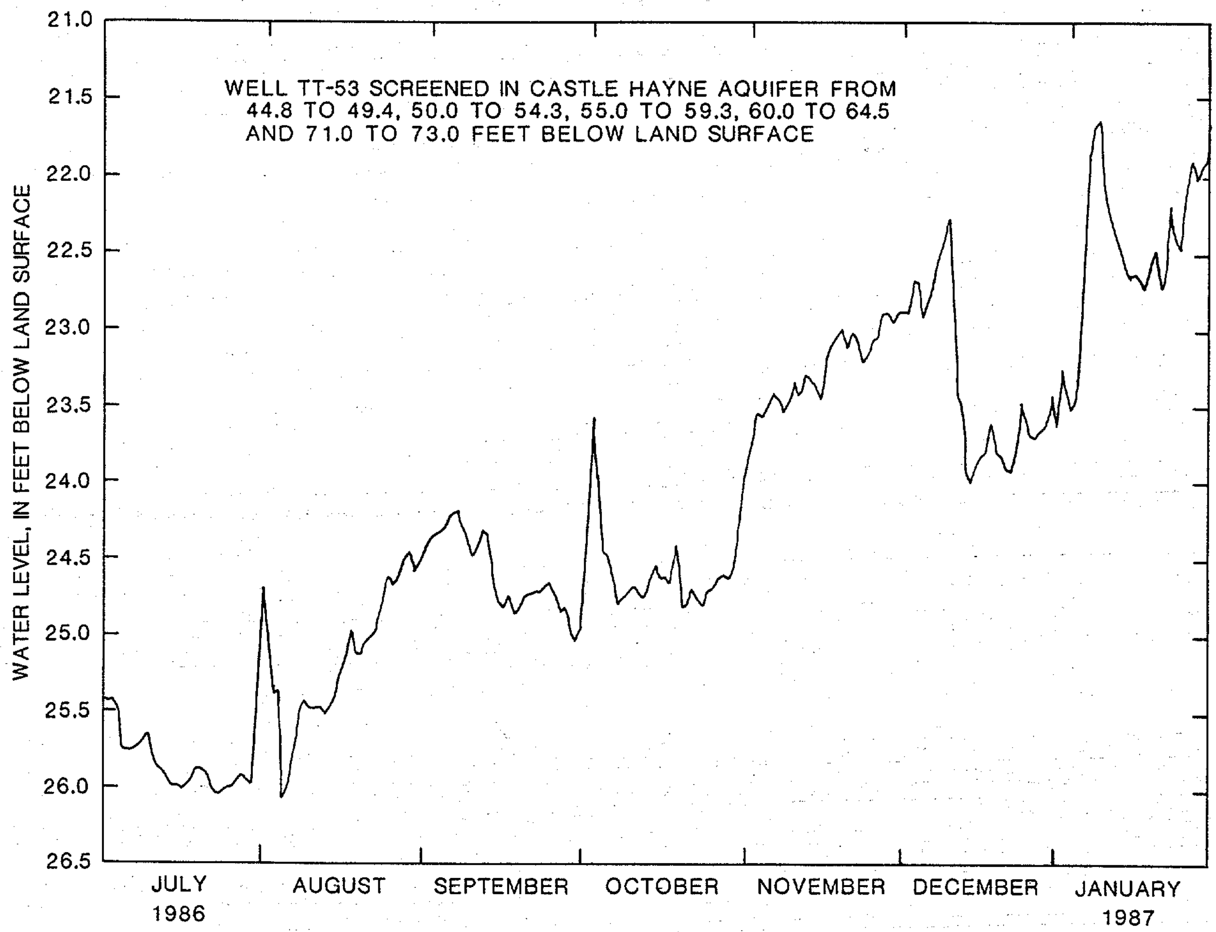


Figure 15.--Water levels in well TT-53, July 1986 through January 1987.

The seasonal response of water levels in wells HP-630 and Y25q3 is evident, but the observed fluctuation is less than the shallow wells (figs. 16 and 17). The amount of change in water level due to seasonal variation is about 1.5 ft. The water level in well HP-630 also appears to vary as a result of pumpage, although the effect of pumpage is much less evident in this well than in well TT-53.

The water-level record in well RR-97A (fig. 18), which is screened in the Peedee aquifer, shows less seasonal variation (about 1 ft) than does well Y25q3. Fluctuations in water levels in this well as a result of withdrawals from the Castle Hayne aquifer are not apparent.

For purposes of comparison, the hydrographs for these wells are plotted together in figure 19. The similarity of the seasonal responses, particularly in wells NC52 and Y25q6, as well as the increasingly subdued response with depth to the bottommost screen are particularly evident. The effect of pumpage on the water level in well TT-53 also stands out.

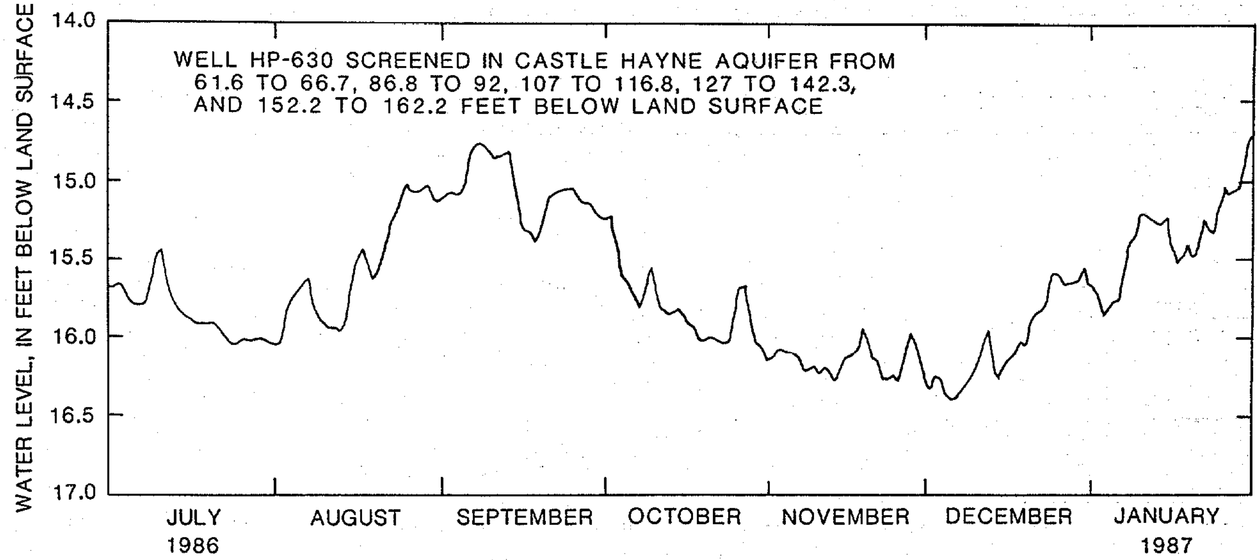


Figure 16.--Water levels in well HP-630, July 1986 through January 1987.

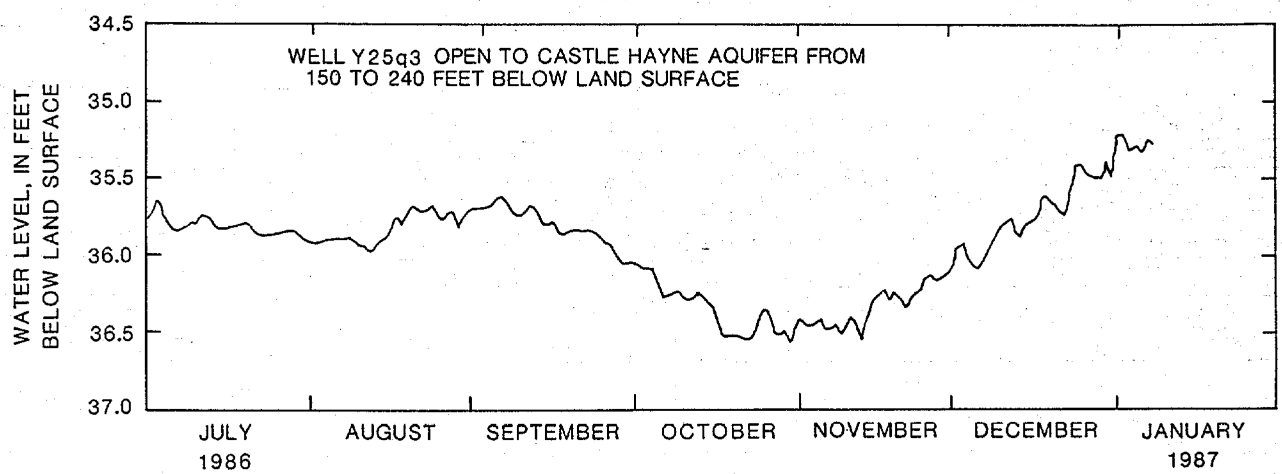


Figure 17.--Water levels in well Y25q3, July 1986 through January 1987.

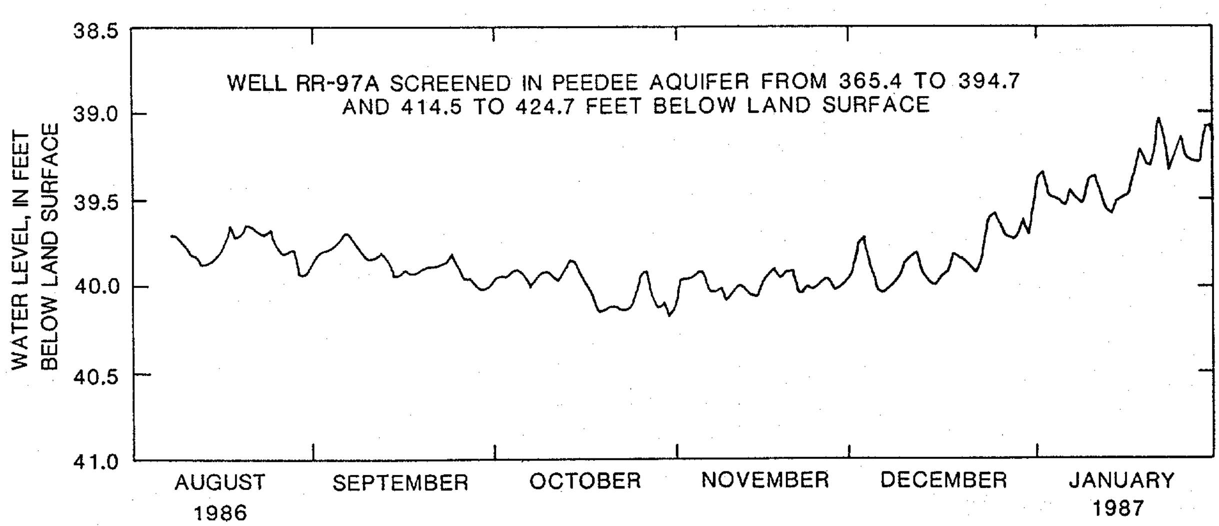


Figure 18.--Water levels in well RR-97A, August 1986 through January 1987.

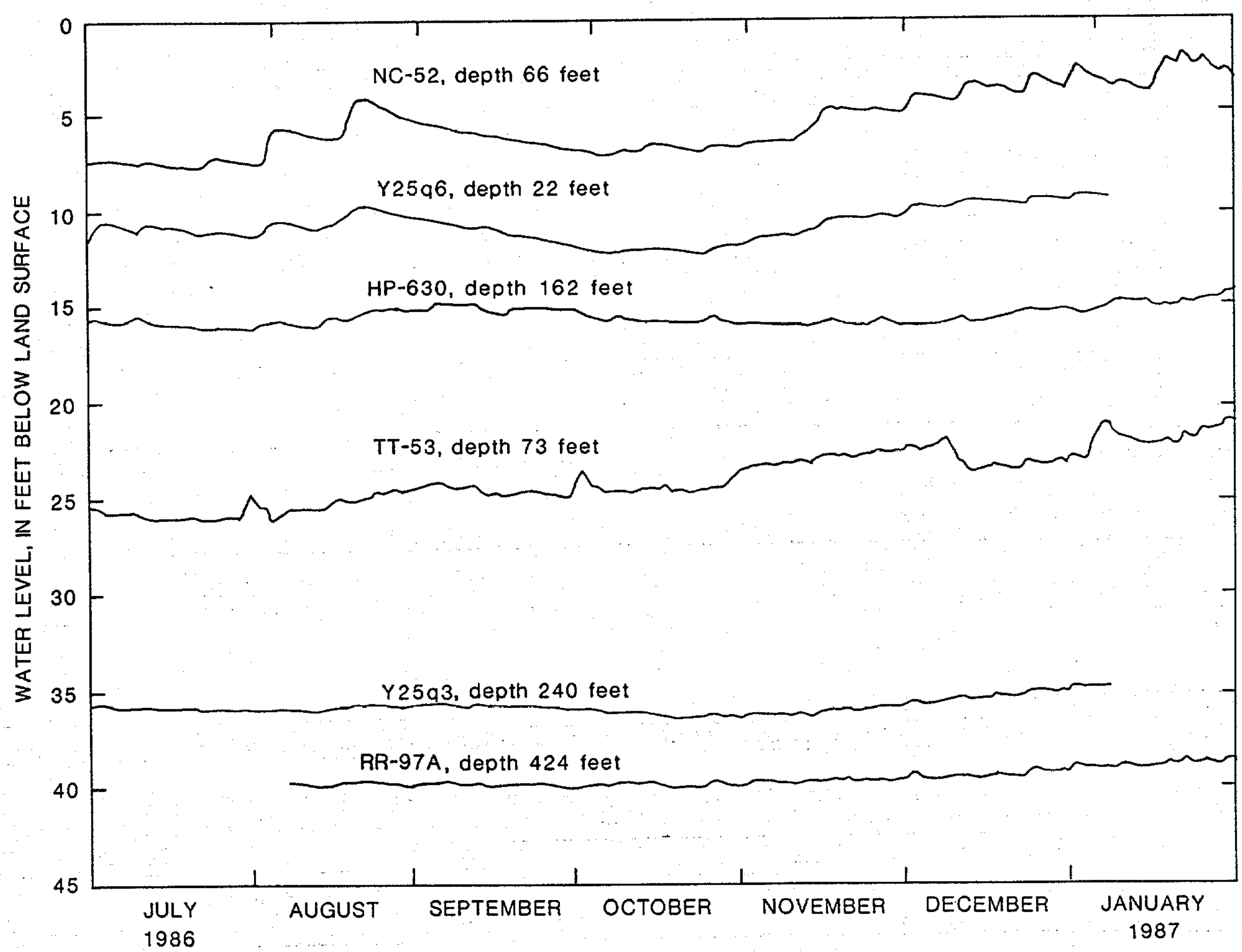


Figure 19.--Water levels in wells NC-52, Y25q6, HP-630, TT-53, Y25q3, and RR-97A, July 1986 through January 1987.

Water-Level Surveys

Water-level surveys of the Castle Hayne aquifer were conducted during the weeks of October 19-25, 1986, and April 7-10, 1987. The October survey was an effort to measure water levels during the seasonal low period, and the April survey was intended to measure water levels during the seasonal high period. Water-level data from both of the surveys are recorded in table A in the Supplemental Data section of this report.

Stability in water level is desirable during a water-level survey. During the October survey the variation in water levels in wells in the Castle Hayne aquifer was minor and probably due to barometric and tidal effects. An examination of the hydrographs of the monitoring wells for the October survey period shows little short-term climatic effects for the wells screened in the Castle Hayne (HP-630 and Y25q3).

This lack of variation in water levels in the Castle Hayne is contrasted by a normal recession in water levels in the shallow wells NC-52 and Y25q6 for the same period, as represented by the hydrograph for well NC-52 in figure 20. Barometric variation and tidal influence are possible explanations for some of the short-term fluctuations seen in the water levels for well NC-52. A trace of the barometric pressure (uncalibrated) for this period also is shown in figure 20. A comparison of the two graphs shows that some peaks in water levels correspond to dips in barometric pressure; diurnal peaks are likely due to tides.

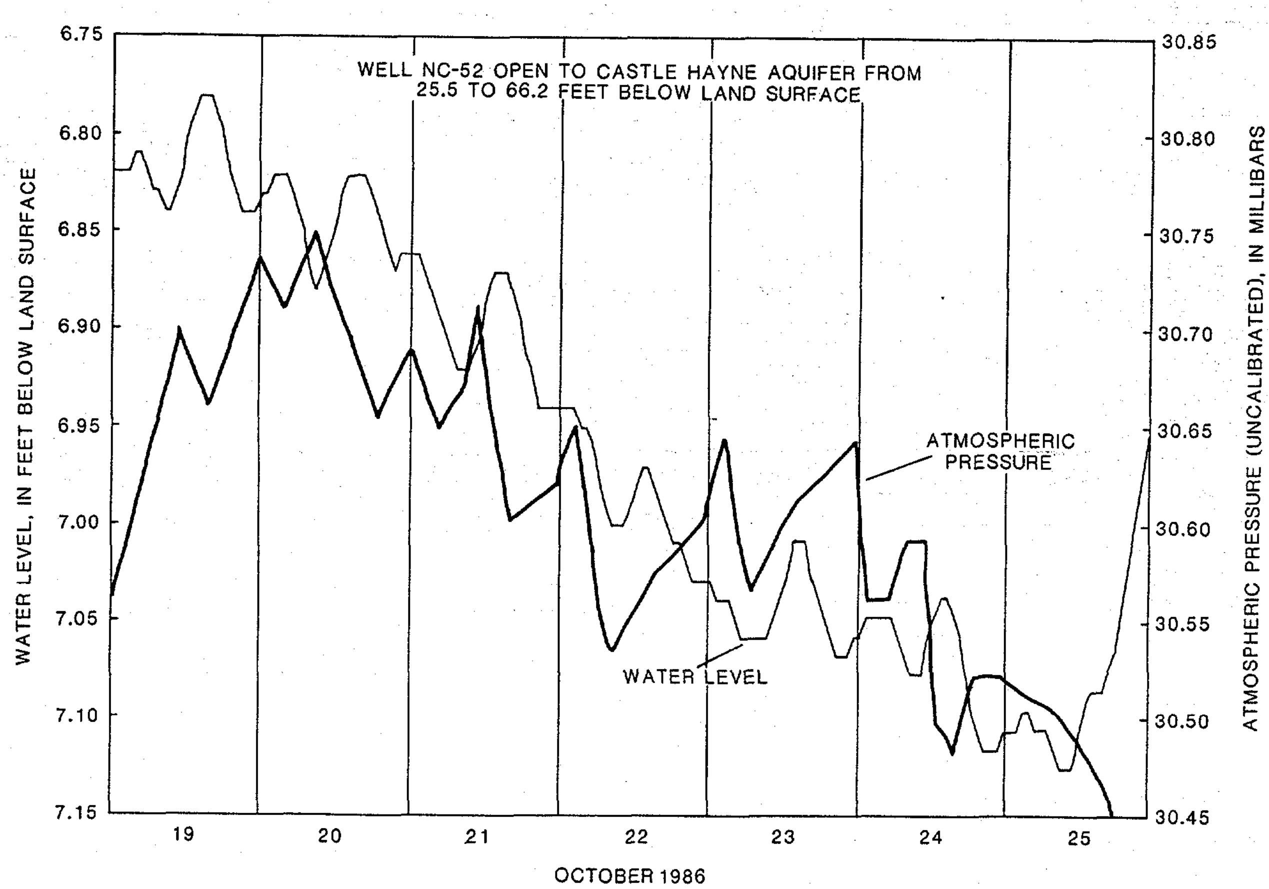


Figure 20.--Water levels in well NC-52 and barograph trace at well site TT-53, October 19-25, 1986.

The water-level surveys included all the available nonpumping wells that tap the Castle Hayne aquifer on the Base. For the October survey 76 wells were measured, and in April 67 wells were measured. Reported water levels for pumped wells were obtained from available records. Water-level measurements were made using steel surveying tapes, and the measuring points on the wells were marked and recorded for future surveys. Because of the paucity of confining material and the multiple-screen construction of most of the wells, all the measured water levels are considered to be representative of the potentiometric surface in the Castle Hayne aquifer.

A potentiometric-surface map based on water levels measured during the April survey is shown in plate 2. A comparison of October and April water levels (table A) indicates that, except in areas where wells were being pumped, water levels measured in April following the winter recharge period generally were higher by 2 to 3 ft than water levels measured in October at the end of the growing season. Water levels in the Hadnot Point area show a localized hydraulic gradient toward pumping wells and a more general gradient toward the New River and Wallace Creek. Thus, it appears that ground water flows to discharge at the wells and area streams.

The rate and direction of ground water movement depends on the slope of the potentiometric surface, called the hydraulic gradient, and on the hydraulic characteristics of the aquifer. These factors vary locally as a result of spatial variability of the hydraulic characteristics of the aquifer and the proximity to a pumping well or natural discharge or recharge area. Hydraulic gradients in the Castle Hayne aquifer can be calculated for the Camp Lejeune area using water-level data from plate 2. In general, the hydraulic gradient in the Camp Lejeune area ranges from 5 to 15 ft/mi for areas unaffected by pumping. Within the cones of depression of pumped wells, the hydraulic gradients are much greater and may be as much as 150 to 200 ft/mi.

The ground-water velocity equation given by Lohman (1972, p. 10) can be used to calculate ground-water velocity. Estimates of hydraulic conductivity derived earlier, ranges of hydraulic gradients from plate 2, and an assumed porosity of 20 percent as estimated by Heath (1980) for the Castle Hayne, as used in this equation, indicate ground-water velocity for the Camp Lejeune area of 2 to 3 ft/d. Near pumped wells, where the hydraulic gradient is steeper, ground water could move 35 to 45 ft/d.

Recharge areas for the Castle Hayne aquifer occur in interstream areas (Heath, 1980). In the Camp Lejeune area, recharge probably occurs in most of the area above the 5-foot water-level contour shown in plate 2, except along streams.

Specific Conductance

Specific conductance, a measure of the ability of water to carry an electric current, is a function of the amount of ionic material dissolved in water and is reported as µS/cm (microsiemens per centimeter at 25 °C). Elevated specific conductance values, therefore, generally are the result of high dissolved constituent concentrations. Specific conductance was measured in 82 Camp Lejeune water-supply wells during a water-sampling survey by Environmental Science and Engineering, Inc.[1/], during October and November 1986. The specific conductance of water in wells sampled during this survey range from less than 300 to more than 1,200 µS/cm and are listed in table A.

In general, the specific conductance of water from wells in the MCAS area are considerably larger (400-1,200 µS/cm) than those of water from wells in the Hadnot Point area (250-800 µS/cm) (plate 3). Tarawa Terrace, Montford Point, the Rifle Range, and Courthouse Bay all had specific conductance values generally between those at Hadnot Point and the MCAS area. The specific conductance of water in a few wells was elevated (800 µS/cm or above), probably due to saltwater contamination. The source these elevated specific conductance values is a subject for future study. Specific conductance generally increases near the New River estuary.

HYDROGEOLOGIC FRAMEWORK

In order to understand the ground-water flow system of the Camp Lejeune area, it is necessary to first understand the hydrogeologic framework of the physical system that governs the occurrence and movement of ground water. This conceptual framework provides the foundation for an understanding of the flow system. The framework consists of layered aquifers and confining units, with regionally varying thicknesses, hydraulic conductivities, storage coefficients, and other physical characteristics. The characterization of the framework for the Camp Lejeune area is limited to the upper 300-400 ft of sediments, including the surficial aquifer, the Castle Hayne aquifer, and the uppermost part of the Beaufort aquifer under the Castle Hayne, to allow for adequate evaluation of the effects of withdrawals.

[1/] The use of firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

A four-step process was used to help develop the hydrogeologic framework. First, a review of previous hydrogeologic studies for the area was completed. Second, available borehole geophysical-log data, well-location data, well-drilling and construction data, lithologic information, and selected data on water quality were compiled. Hydrogeologic sections were drawn from the geophysical-log data, lithologic data, and well-construction data. Third, aquifer and confining units were delineated on the cross sections. These units were identified through examination of the borehole geophysical logs and related data. Fourth, the cross sections and other well-log interpretations were used to map depths and thicknesses of aquifers and confining units. Areas where more data were needed were identified, and a plan for collecting these data was made.

The following discussion describes three hydrogeologic sections that were constructed to help delineate the aquifers and confining units in the area. The locations of these sections are shown in plate 4. These hydrogeologic sections are used to develop the framework, but conclusions regarding aquifer thickness and other physical characteristics based on these sections may be revised in future phases of this investigation as additional data become available.

Hydrogeologic Section A-A′

The delineation of aquifers and confining units in hydrogeologic section A-A′ (plate 5) indicates a southeast dipping series of relatively thick aquifer units (sand and limestone beds) and thin confining units (clay beds) distributed throughout the section. Overall, about 15 percent of the upper 200 ft of the section is identified as potential confining units.

Two aquifers are shown in section A-A′. The surficial aquifer generally occurs in the upper 75 ft of the section and is underlain by the Castle Hayne aquifer. The total thickness of these units ranges from about 275 to 400 ft along section A-A′. It appears that no continuous confining unit or clay bed separates these two aquifers along this section.

The surficial aquifer is composed primarily of sand, silt, and clay of Quaternary and Miocene age, undifferentiated (fig. 2). The thickness of this aquifer ranges from zero in the channels of Northeast and Wallace

Creeks in the northern part of the section to 75 ft in the southern part between wells HP-640 and T-22 (plate 5). The aquifer extends from land surface to the top of the Castle Hayne aquifer or to the top of the first confining bed.

The Castle Hayne aquifer varies somewhat in lithology and thickness along the section (plate 5). The aquifer is composed primarily of sand and limestone of Oligocene and Middle Eocene age (Brown and others, 1972; Carter, 1983). The upper half of the aquifer is unconsolidated sand and the lower half is a mix of consolidated to partly consolidated sand and limestone. Thin clay layers occur throughout. The total thickness of the aquifer ranges from 300 ft in the northern part of the section to about 375 ft in the southern part of the section.

A preliminary evaluation indicates the top of the Castle Hayne aquifer generally corresponds with the upper surface of the Oligocene rocks and the bottom corresponds with the bottom of the Middle Eocene rocks. The altitude of the top of the aquifer ranges from about 20 ft above sea level in the north to 40 ft below sea level in the southern part of the section.

The thickness and distribution of the clay layers throughout the section are an indicator of the degree of hydrologic connection within an aquifer and between aquifers. It is inferred from the thin (5 to 20 ft thick) and discontinuous clay layers along Section A-A′ that considerable leakage of water may occur across and around the clay layers.

Hydrogeologic Section B-B′

The surficial and Castle Hayne aquifers and confining units in hydrogeologic section B-B′ (plate 5) dip gently to the east. The aquifer units are thick relative to the confining units distributed throughout the section. The confining units within and above the Castle Hayne aquifer range from around 24 percent of the section in the MCAS area to less than 20 percent in the area around Brewster Boulevard and State Route 24. The combined total thickness of the surficial and Castle Hayne aquifers ranges from about 195 to 360 ft in this section.

In general, the surficial aquifer occurs in the upper 40 ft of the section. There is a continuous confining unit between the surficial and the

Castle Hayne aquifers only in the easternmost part of the section in the Hadnot Point area. Elsewhere on this section, there appears to be no continuous confining unit or clay bed separating the two aquifers.

The Quaternary and Miocene (undifferentiated) deposits that constitute the surficial aquifer are generally thinner along hydrogeologic section B-B′ than those shown in section A-A′ (plate 5). The surficial aquifer is absent in the New River and Northeast Creek areas and is thickest (40 ft) in the eastern part of the section, in the Hadnot Point area.

The Castle Hayne aquifer varies in thickness and lithology across the section. The aquifer ranges in thickness from around 175 ft in the western part of the section in the MCAS area to almost 340 ft in the Hadnot Point area. As with section A-A′, the lithology of the aquifer varies with depth. The upper part of the aquifer tends to be more unconsolidated than the lower half. Because the upper sandy layers of the Castle Hayne aquifer are not present in the western part of the section, limestone makes up a greater proportion of the aquifer in the MCAS area than in the eastern part of the section. The Oligocene sediments, including the upper part of the Castle Hayne aquifer, are in direct hydraulic connection with the New River and Northeast Creek. The altitude of the top of the aquifer ranges from about 15 ft above sea level to about 10 ft below sea level in the section.

The overall total thickness of the clay layers in this section (5 to 30 ft) is somewhat greater than that observed for section A-A′. The clay layers are thin and discontinuous in the upper and eastern parts of the section, and they are thicker and more continuous in the deeper and western parts of the section. A greater degree of hydraulic connection within the system is likely in the eastern part of section B-B′.

Below the Castle Hayne aquifer lie Paleocene rocks that comprise the Beaufort confining unit and Beaufort aquifer. The thickness of these units is about 30 and 90 ft, respectively, in well T-1 and about 15 and 40 ft, respectively, in well T-12 (plate 5).

Hydrogeologic Section C-C′

The surficial and Castle Hayne aquifers and confining units in hydrogeologic section C-C′ (plate 5) show very little dip; the total thickness of these units ranges from 300 to 360 ft. As in sections A-A′ and B-B′ (plate 5), the aquifer units are thick relative to the confining units in the section. The confining units within and above the Castle Hayne aquifer constitute only about 15 percent of the section.

The surficial aquifer occurs in the upper 40 ft of the section. Although there is a relatively thin (5 ft) confining unit in the eastern part of the section that separates the surficial from the Castle Hayne aquifer, elsewhere in the section this layer is not present or is discontinuous.

The Quaternary and Miocene (undifferentiated) deposits of the surficial aquifer have been cut through in several places by tributaries to Wallace Creek. The thickness of this aquifer ranges from zero in the channels of these tributaries to 40 ft in the eastern part of the section.

The Oligocene and Middle Eocene sediments of the aquifer are nearly 300 ft thick in the vicinity of well X24s2. None of the other wells are deep enough to penetrate the Middle Eocene sediments of the Castle Hayne aquifer along this section. The altitude of the top of the aquifer occurs slightly above sea level throughout the section.

Paleocene rocks lie below the Castle Hayne aquifer. These sediments comprise the Beaufort confining unit and Beaufort aquifer (Winner and Coble, 1989). Identification of the top and thickness of these units are shown in well X24s2 on section C-C′. The top of the Beaufort confining unit occurs at about 280 ft below sea level, and the unit is estimated to be 10 to 15 ft thick. The top of the Beaufort aquifer occurs at about 290 to 295 ft below sea level, and the aquifer is about 25 ft thick.

The dip and the strike of the beds can be calculated from the depths to some of the clay beds on the three sections. The dip is the direction and amount that the beds are sloping, and the strike is the axis of the dip. The strike of the beds in the Camp Lejeune area is north 79 degrees east, and the dip is 17 ft/mi (feet per mile) toward the southeast.

The thickness and distribution of the clay layers throughout the section are similar to that observed for section A-A′. The thin (5-10 ft thick) and discontinuous clay layers indicate that the degree of hydrologic connection between aquifer material may be substantial, and it is likely that considerable leakage of water occurs across and around these thin clay layers.

Additional Data Needs

More hydrogeologic sections are needed to refine the conceptual model of the hydrogeologic framework at Camp Lejeune. In particular, data on the thickness, areal extent, and hydrologic character of the freshwater aquifers and confining units are needed in the central and southwestern parts of the area.

Additional wells are needed to provide data to supplement borehole geophysical and lithologic information for the existing and future hydrogeologic sections. Additional wells in the beach area and Verona Loop Road parts of the study area would be particularly useful. Additional observation wells also are needed near the New River in the area of the Air Station to help identify the source of saltwater contamination in some of the supply wells there.

Surface geophysical techniques can provide additional information for interpretation of the hydrogeologic framework. Seismic profiles along the shore of the New River could be used to help define geological structure and tie together the data interpretations of sections that cross the New River, particularly with respect to the nature of confining units there.

Additional hydrologic information is required to help construct and calibrate the ground-water flow model. Records of water levels through time are needed to define changes in the ground-water flow system in response to changes in withdrawals. The ground-water recharge in the area can be estimated using hydrologic budget information collected in the Town Creek basin. Finally, aquifer tests can be used to refine the estimates of hydraulic characteristics of the aquifers.

SUMMARY

Camp Lejeune Marine Corps Base is in the Atlantic Coastal Plain and is underlain by seven sand or limestone aquifers separated by confining units of clay and silt. The aquifers are the surficial, the Castle Hayne, the

Beaufort, the Peedee, the Black Creek, and the upper and lower Cape Fear. These aquifers have a combined thickness of as much as 1,500 ft beneath the Base.

The principal water-supply aquifer for the Base is the Castle Hayne aquifer, which occurs between 50 and 300 ft below land surface. Aquifers below the Castle Hayne contain saltwater in the vicinity of the Base and are not used for water supply.

Water use by the Base has grown from about 4 Mgal/d in 1941 to about 7.5 Mgal/d in 1986. In recent years, water demand has not increased substantially; however, the pumping scheme and treatment by the eight water plants on the Base have changed. Expansion of the Holcomb Boulevard treatment plant coincided with the discontinuation of many supply wells in the Hadnot Point system.

Data for more than 160 wells were obtained from Camp Lejeune, North Carolina Department of Natural Resources and Community Development, and Survey files. These records include geophysical and lithologic logs, well construction and pumpage data, well-acceptance tests, ground-water levels, and specific conductance data.

A typical water-supply well on the Base has an average depth of 162 ft, is 8 in. in diameter, has 37 ft of screen open to the Castle Hayne aquifer, and is pumped at an average rate of 174 gal/min. Analyses of well records indicate that wells generally are screened in the production zones in the Castle Hayne ranging from 20 to 150 ft total thickness.

Well-acceptance tests for 33 wells screened in the Castle Hayne aquifer indicate an average specific capacity of 6.3 (gal/min)/ft of drawdown. Transmissivity values estimated from the specific-capacity values and adjusted to full aquifer penetration average about 10,200 ft^2/d and range from 4,300 to 24,500 ft^2/d. The average estimated hydraulic conductivity is 35 ft/d.

A ground-water level observation-well network, consisting of six wells equipped with continuous recorders, was installed on the Base to supplement existing data. One well is screened in the shallow surficial aquifer, four are finished in the Castle Hayne aquifer (two at depths of less than 70 ft), and one well is screened in the Peedee aquifer. A seasonal variation in water level is evident in all of the wells, but the seasonal variations range from about 4 ft in the shallow wells to about 1 ft in the deeper wells. Water-level fluctuation due to pumpage is also evident in at least two of the observation wells.

Water-level surveys of the Castle Hayne aquifer were made in October 1986 and April 1987. Water-level maps based on these measurements indicate that ground water in the Hadnot Point area flows toward pumping wells, streams, and the New River.

The hydraulic gradient generally is between 5 and 15 ft/mi outside of areas affected by pumping but is as much as 150 to 200 ft/mi near pumped wells. On the basis of estimates of hydraulic conductivity and hydraulic gradients, the ground-water velocity outside of areas affected by pumping is calculated to range from 0.06 ft/d. Near pumped wells, the ground-water velocity may be around 16 ft/d.

Specific conductance values for water from wells in the Castle Hayne aquifer range from less than 300 to more than 1,200 μS/cm. Wells containing water with specific conductance values greater than 800 μS/cm probably are affected by saltwater.

Three hydrogeologic sections for the Base were constructed to help define the hydrogeologic system for ground-water modeling. The total thickness of the surficial and Castle Hayne aquifers in these sections ranges from 195 ft in the northwestern part of the Base to about 400 ft in the southeastern part.

The surficial aquifer is composed of Quaternary and Miocene sand, silt, and clay that occurs from land surface to an average depth of about 45 ft below land surface. The thickness ranges from zero in the channels of the New River and its tributaries to 75 ft in the southeastern part of the area.

The Castle Hayne aquifer is composed of sand and limestone of Oligocene and Middle Eocene age. The upper half of the aquifer is primarily sand and the lower half is sand and limestone. The top of the aquifer ranges from about 20 ft above sea level in the northern part of the area to about 40 ft below sea level in the southeastern part. The aquifer thickens toward the southeast from 175 ft at the Marine Corps Air Station to about 375 ft in the beach area.

Clay layers occur in both of the aquifers. However, the layers are thin and discontinuous in most of the area, and no continuous clay layer separates the surficial aquifer from the Castle Hayne aquifer. The clay layers range from 5 to 30 ft thick and comprise between 15 and 24 percent of the combined thickness of the two aquifers. The clay layers appear to be thicker and more continuous in the northwestern part of the Base, particularly in the area of the Marine Corps Air Station. It is inferred from their generally thin and discontinuous nature that considerable leakage of ground water occurs across and around the clay layers, particularly in the upper part of the Castle Hayne aquifer.

Additional wells are needed to provide hydrogeologic data to supplement existing borehole geophysical and lithologic information on these and future hydrogeologic sections, particularly in the central and southwestern parts of the area. New observation wells are needed near the shore of the New River in the Air Station area to help identify the source of saltwater contamination in some of the supply wells in that area. Test wells and observation wells are also needed in the beach areas of the Base and in the vicinity of the Verona Loop Road.

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SUPPLEMENTAL DATA

This section of the report contains tables of data that were collected, compiled, and analyzed to produce this report.

Table A.--*Records of selected wells*

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data (log bottom, feet below land surface): Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
							Water-supply wells						
A-5	3435300772234.1	Layne Atlantic Co.	1942	116	8	Gravel pack	46.5-61.5 101-116	12.71	8.3	1942	(116)	Electric (247) Gamma (247)	362
BA-164	3435510771704.1	--	--	110	--	--	--	17 (topo)	4.5 7.2	4-7-87 10-19-86	--	--	365
BA-190	3434320771651.1	Carolina Well and Pump Co.	1977	105	8	Screen	55-70 80-100	12 (topo)	3.6 5.6	4-7-87 10-19-86	--	Electric (115)	383
BB-43	3434550772148.1	Layne Atlantic Co.	1942	60	8	Gravel pack	30-60	13.1	10.4 13.4	4-7-87 10-19-86	(63)	--	--
BB-44	3435040772143.1	Layne Atlantic Co.	1942	62	8	Gravel pack	32-62	17.8	13.4 14.8	4-7-87 10-19-86	(69)	--	346
BB-45	3434560772148.1	East Coast Construction Co.	1983	150?	--	Screen	40-55 102-125	13 (topo)	10.1	10-13-83	(200)	Electric (200) Gamma (200)	431
BB-220	3435140772136.1	Carolina Well and Pump Co.	1975e	150	--	Gravel pack	55-70 85-95 130-145	37 (topo)	10.2 42 P	4-7-87 10-19-86	(110)	Electric (110)	285
BB-221	3435220772122.1	Carolina Well and Pump Co.	--	200	--	--	60-80 135-155	40 (topo)	33.5 P 48 P	4-7-87 10-19-86	(205)	Electric (200)	388
BB-222	3500010772049.1	Carolina Well and Pump Co.	1985	185	10	Gravel pack	64-94 148-168	40 (topo)	55 P 20.0	4-7-87 1-23-85	(250)	--	396
CCC-1	3443520772322.1	Virginia Machinery & Well Co.	1941	103	10	Open hole	--	24 (topo)	21	4-15-41	(103)	--	--

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface) Lithologic	Log data Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
						Water-supply wells--Continued							
CCC-2	3444070772327.1	Virginia Machinery & Well Co.	1942	102	8	Screen Gravel pack	50-60 70-75 85-90	22 (topo)	15.5	6-42	(102)	--	--
HP-601	3440180772020.1	Layne Atlantic Co.	9-1941	195.0	8	Gravel pack	45.0-60.0 95-100 115-130 175-195	22 (topo)	11.3 13.2	4-7-87 10-19-86	(195)	Electric and Gamma (200)	567
HP-602	3440180772007.1	--	1941e	160	8	Gravel pack	70-80 100-105 120-125 145-150 155-160	25 (topo)	8.7 11.0	4-7-87 10-19-86	(160)	--	789
HP-603	3440100772032.1	--	1941e	195	8	Gravel pack	70-80 100-110 130-140 160-170 190-195	24.8	51 P 43 P	4-7-87 10-19-86	(251)	--	531
HP-606	3439490771910.1	Layne Atlantic Co.	12-1941	210	8	Gravel pack	80-90 110-120 140-150 170-180 200-210	30.4	13.7 32 P	4-7-87 10-19-86	(230)	--	386
HP-608	3439530772019.1	Layne Atlantic Co.	3-1941	161.5	8	Gravel pack	61.5-81.5 91.5-101.5 121.5-131.5 151.5-161.5	29.7	19.4 21.1	4-7-87 10-19-86	(162)	--	408
HP-609	3439260771854.1	--	1942e	150	8	Gravel pack	65-80 100-110 130-150	33 (topo)	9.7 38 P	4-7-87 10-19-86	(150)	--	325
HP-610	3441120771954.1	Layne Atlantic Co.	4-1942	190	8	Gravel pack	60-70 90-110 130-140 180-190	20 (topo)	14.1 16.9	4-7-87 10-19-86	(198)	--	349

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface) Lithologic	Log data (log bottom, feet below land surface) Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
							Water-supply wells--Continued						
HP-611	3442090772107.1	Layne Atlantic Co.	6-1942	161	8	Gravel pack	61-71 91-101 121-136 156-161	31.0	16.3 21.9	4-7-87 10-19-86	(161)	Electric (254), Gamma (240)	357
HP-612	3442260772048.1	Layne Atlantic Co.	6-1942	190	8	Gravel pack	60-70 90-95 115-120 140-145 155-160 170-175 185-190	31.8	22.2	4-7-87	(190)	--	383
HP-613	3442290772020.1	Layne Atlantic Co.	5-1942	150	8	Gravel pack	60-70 90-95 115-120 130-135 145-150	24 (topo)	33 P 13.4	4-7-87 10-19-86	(150)	--	346
HP-614	3442470772124.1	--	--	235	8	Gravel pack	105-120 150-170 217-227	31.4	18.2	10-19-86	(167)	Electric and Gamma (260)	--
HP-615	3442450772102.1	Layne Atlantic Co.	6-1942	158	8	Gravel pack	58-68 88-98 108-128 148-158	32	16	1942	(162)	--	--
HP-616	3442470772028.1	Layne Atlantic Co.	7-1942	170	8	Gravel pack	95-115 130-140 160-170	33.3	47 P 41 P	4-7-87 10-19-86	(170)	--	339
HP-620	3442300771852.1	Layne Atlantic Co.?	9-1944e	54	18	Open hole	--	35 (topo)	29 P 27 P	4-7-87 10-19-86	(170)	--	380
HP-621	3442530771916.1	Layne Atlantic Co.	10-1942	77	8	Gravel pack	57-77	40.8	--	--	--	--	--

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data (log bottom, feet below land surface): Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Water-supply wells--Continued													
HP-626	3439040771838.1	--	--	159	8	Screen	58-63 82-92 108-123 129-139 144-154 154-159	28.3	15.0	1966	(75)	Electric (75)	--
HP-627	3438370771819.1	--	--	163	8	Screen	65-75 92-102 117-122 133-158	30.7	--	--	--	--	--
HP-628	3439040771838.1	Carolina Well and Pump Co.	1984	200	8	Gravel pack	60-70 85-89 110-120 135-145	26 (topo)	12.0 56 P	4-7-87 10-19-86	(201)	Electric (85)	252
HP-629	3442540771912.1	Carolina Well and Pump Co.	1982	240	8	Gravel pack	60-70 125-140 160-170 220-230	41 (topo)	22.6 20.3	4-8-87 3-8-83	--	Electric (250)	368
HP-630	3440030771948.1	--	--	176	8	Gravel pack	62-67 87-92 107-117 127-142 152-162	26 (topo)	14.4 13.5	10-19-86 5-14-86	--	Gamma, Caliper, Neutron, Density, Temperature (175)	--
HP-632	3437110771736.1	--	1957	75	--	--	--	34 (topo)	38 P 44 P	4-3-87 10-19-86	--	--	323
HP-633	3441580772006.1	--	1959	205	8	Screen	55-65 75-80 95-105 123-133 138-143 158-168 178-183 195-205	23 (topo)	16.9 19.1	4-7-87 10-19-86	(205)	--	373

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data: Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Water-supply wells--Continued													
HP-634	3440300771935.1	--	1959e	225	8	Gravel pack	65-70 73-78 83-88 93-98 107-117 124-129 135-140 153-163 170-175 195-200 215-225	31 (topo)	8.6 12.4	4-7-87 10-19-86	(225)	--	361
HP-635	3440550771933.1	--	1959e	215	8	Gravel pack	65-75 93-108 122-127 136-146 150-155 170-175 185-190 210-215	17 (topo)	3.1 18.7	4-7-87 10-19-86	(215)	--	331
HP-636	3441190771929.1	--	1959e	227	8	Gravel pack	90-100 115-125 130-135 140-150 158-163 170-175 185-190 200-210 222-227	28 (topo)	11.8	10-19-86	(227)	--	--
HP-637	3440390771954.1	Hartsfield Water Co.	1969	172	8	Gravel pack	90-98 102-114 120-128 140-148 156-172	31 (topo)	16.1 20.6	4-7-87 10-19-86	(227)	Electric (191) Caliper (94) Temperature (98) Gamma (98)	--

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data (log bottom, feet below land surface): Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
						Water-supply wells--Continued							
HP-638	3439120771943.1	Hartsfield Water Co.	1969	196	8	Gravel pack	106-114 126-134 150-158 162-170 176-184 188-196	24 (topo)	99 P 20.1	4-7-87 10-19-86	--	Electric (210)	299
HP-639	3438050771800.1	Hartsfield Water Co.	1969	176	8	Gravel pack	62-70 85-93 120-132 136-148 155-163 168-176	23 (topo)	3.4 5.2	4-7-87 10-19-86	(183)	Electric (257) Gamma (257)	308
HP-640	3437380771746.1	Hartsfield Water Co.	1969	176	8	Gravel pack	64-72 76-80 92-100 112-120 130-134 140-148 157-165 172-176	30 (topo)	3.1 28 P	4-7-87 10-19-86	(200)	Electric (200) Gamma (200)	298
HP-641	3442290771922.1	Sydnor Hydro-dynamics	1971	178	8	Gravel pack	108-118 128-150 158-168	32 (topo)	19.5	4-7-87	--	Electric (210) Gamma (210)	--
HP-642	3440100771924.1	Sydnor Hydro-dynamics	1971	210	8	Gravel pack	112-124 136-144 157-163 174-178 188-196	29 (topo)	9.8	4-7-87	(200)	Gamma (200)	448
HP-643	3443030772118.1	Layne Atlantic Co.	1971	250	10	Gravel pack	90-100 138-148 230-240	28 (topo)	16.0 47 P	4-7-87 10-19-86	(302)	Electric (298)	411
HP-644	3443040772100.1	Layne Atlantic Co.	1971	255	10	Gravel pack	85-100 235-250	26 (topo)	21.0 52 P	4-7-87 10-19-86	(310)	--	418

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface) Lithologic	Log data Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
							Water-supply wells--Continued						
HP-645	3443050772043.1	Layne Atlantic Co.	1971	245	10	Gravel pack	90-100 138-148 230-240	25 (topo)	15.9 47 P	4-7-87 10-19-86	(309)	Electric (307)	402
HP-646	3443160772035.1	Layne Atlantic Co.	1971	270	10	Gravel pack	90-100 240-250 255-265	26 (topo)	23.0	6-23-71	(310)	Electric (306)	--
HP-647	3443030772017.1	Corbin Construction Co.	1970	200	10	Gravel pack	105-115 138-143 175-190	33 (topo)	18.4 38 P	4-7-87 10-19-86	(305)	Electric (304)	361
HP-648	3442510771848.1	Corbin Construction Co.	1971	265	10	Gravel pack	107-122 245-260	36 (topo)	9.4 76 P	4-7-87 10-19-86	(309)	Electric (308)	587
HP-649	3442440771822.1	Corbin Construction Co.	1971	284	10	Gravel pack	126-136 159-164 205-210 232-237 274-279	37 (topo)	13.0 19.7	4-7-87 10-19-86	(310)	Electric (306)	443
HP-650	3442390771800.1	Corbin Construction Co.	1971	179	10	Gravel pack	128-133 140-150 155-165 169-174	38 (topo)	12.2 78 P	4-7-87 10-19-86	(310)	Electric (308)	361
HP-651	3441410771927.1	Corbin Construction Co.	1971	199	10	Gravel pack	125-135 140-155 189-194	32 (topo)	16.1 17.9	4-7-87 10-19-86	(310)	Electric (301)	298
HP-652	3440190771848.1	Corbin Construction Co.	1971	183	10	Gravel pack	120-130 148-158 163-168 173-178	30 (topo)	4.9 9	4-7-87 10-19-86	(310)	Electric (310)	337
HP-653	3442100771925.1	Carolina Well and Pump Co.	1978	270	--	--	--	32 (topo)	65 P 65 P 15	4-7-87 10-19-86 5-78	(270)	Electric (250)	410

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data: Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Water-supply wells--Continued													
HP-654	3442270771953.1	Carolina Well and Pump Co.	1978	250	--	--	--	32 (topo)	36 P 51 P 15	4-7-87 10-19-86 3-16-78	(250)	Electric (250)	251
HP-655	3439080771905.1	East Coast Construction Co.	1980	145	8	--	--	26 (topo)	10.3 12.4	4-7-87 10-19-86	(200)	Electric (200)	281
HP-661	3438370771819.2	C.W. Brinkley and Son	1983	140	10	Gravel pack	50-65 87-102 125-135	30 (topo)	61 P 17.9	4-7-87 10-19-86	(260)	Electric (258) Gamma (258)	277
HP-662	3438040771758.1	--	--	100?	--	--	--	20 (topo)	71 P	4-7-87	--	--	261
HP-663	3442270771758.1	R.L. Magette	1986	180	10	Gravel pack	130-180'	35 (topo)	64 P 20.1	4-7-87 10-19-86	(250)	Electric (250)	--
HP-698	3443000772128.1	R.L. Magette	1985	124	10	Gravel pack	84-124	26 (topo)	66 P 13.2	4-7-87 10-19-86	(250)	Electric (250)	--
HP-699	3443000772141.1	R.L. Magette	1985	124	10	Gravel pack	84-124	23 (topo)	57 P 11.1	4-7-87 10-19-86	(250)	Electric (250)	--
HP-700	3442580772150.1	R.L. Magette	1985	130	10	Gravel pack	100-130	20 (topo)	69 P 15.7	4-7-87 10-19-86	(250)	Electric (250)	--
HP-701	3442330772204.1	R.L. Magette	1985	110	10	Gravel pack	70-100	24 (topo)	27 P 18.0	4-7-87 10-19-86	(250)	Electric (250)	--
HP-703	3443330772100.1	R.L. Magette	1985	--	--	--	--	31 (topo)	59 P 20.5	4-7-87 10-19-86	--	--	--
HP-704	3443490772102.1	R.L. Magette	1985	124	10	Gravel pack	84-114	26 (topo)	20.9	4-7-87	(250)	Electric (250)	--
HP-705	3443060772000.1	R.L. Magette	1986	160	10	Gravel pack	120-160	34 (topo)	26.7 24.7	4-7-87 10-19-86	(300)	Electric (300)	--

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface) Lithologic	Log data Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
						Water-supply wells--Continued							
HP-706	3442580771930.1	R.L. Magette	1985	176	10	Gravel pack	126-176	41 (topo)	86 P 19	4-7-87 4-21-86	(250)	Electric (250)	--
HP-707	3442410772134.1	R.L. Magette	1986	150?	10?	Gravel pack?	80-140	27 (topo)	28 P	4-7-87	(250)	Electric (250)	--
HP-708	3442300771721.1	R.L. Magette	1986	176	10	Gravel pack	126-176	41 (topo)	74 P 9.9	4-7-87 10-19-86	(250)	Electric (250)	--
HP-709	3442130771859.1	R.L. Magette	1985	140	10	Gravel pack	70-90 110-140	28 (topo)	56 P 14.5	4-7-87 10-19-86	(250)	Electric (250)	--
HP-710	3442110771843.1	R.L. Magette	1985	140	10	Gravel pack	70-90 110-140	32 (topo)	46 P 19.6	4-7-87 10-19-86	(250)	Electric (250)	--
HP-711	3442190771823.1	R.L. Magette	1985	150	10	Gravel pack	60-80 110-150	36 (topo)	44 P 19.4	4-7-87 10-19-86	(250)	Electric (250)	--
LCH-4006	3443270772017.1	--	--	140	8	Gravel pack	90-114 116-134	33 (topo)	19.2 23.3	4-7-87 10-19-86	(125)	--	328
LCH-4007	3443110771953.1	--	--	145	8	Gravel pack	50-60 69-99 120-130 140-145	41 (topo)	25.1 28.4	4-7-87 10-19-86	(150)	--	--
M-142	3443470772430.1	Layne Atlantic Co.	1942	69	8	Open hole	--	17 (topo)	33 P	10-19-86	(69)	--	406
M-161	3444120772439.1	Carolina Well and Pump Co.	1983	250	--	Gravel pack	--	20 (topo)	17.4 18.2	4-7-87 10-19-86	(250)	Electric (210) Gamma (245)	--
M-168	3444120772438.1	Heater Well Co.	1953	151	8	Screen	46-61 76-86 137-142	19 (topo)	11.4	6-53	--	--	478

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data (log bottom, feet below land surface): Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Water-supply wells--Continued													
M-197	3443580772438.1	Carolina Well and Pump Co.	1971	200	8	Screen	54-64 76-92 124-129 136-145	20.6	14.1 9.1	10-70 3-71	(203)	Electric (198) Gamma (198)	--
M-243	3443420772449.1	--	--	95	8	Gravel pack	60-65 75-90	22.5	--	--	(95)	--	--
M-267	3443360772451.1	Carolina Well and Pump Co.	1981	150	8	Gravel pack	50-70 125-145	17 (topo)	13.6 61 P	4-7-87 10-19-86	(200)	Electric (197) Gamma (194)	373
M-628	3444100772417.1	Layne Atlantic Co.	1942	67	8	Open hole	43-67 (Open hole)	15 (topo)	11.5 7.4	10-1942 1956	(69)	--	465
M-629	3443470772450.1	Carolina Well and Pump Co.	1975e	70	--	--	--	16 (topo)	11.4 33 P	4-7-87 10-19-86	(185)	--	431
M-630	3443560772457.1	Carolina Well and Pump Co.	--	80	--	--	--	17 (topo)	12.2 42 P	4-7-87 10-19-86	--	--	619
MCAS-106	3443260772701.1	--	1954e	--	--	--	--	17 (topo)	15.6 26 P	4-7-87 10-19-86	--	--	500
MCAS-131	3443090772648.1	--	--	200	--	--	--	17 (topo)	15 17.3	4-7-87 10-19-86	--	--	1,213
MCAS-203	3443230772653.1	--	--	173	--	--	--	17 (topo)	14.4 33 P	4-7-87 10-19-86	--	--	537
MCAS-4140	3442570772716.1	--	--	--	--	--	--	22 (topo)	20.3 34	4-7-87 1-3-85	--	--	561
MCAS-4150	3442380772724.1	--	--	--	--	--	--	21 (topo)	25 P	10-19-86	--	--	408

Table A.--*Records of selected wells*--Continued

Table A.--Records of selected wells--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data: Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
							Water-supply wells--Continued						
MCAS- 5001	3442230772728.1	--	--	193	--	--	--	21 (topo)	34 P	10-8-85	--	--	552
MCAS- 5009	3442200772719.1	--	--	196	--	--	--	20 (topo)	66 P 66 P	4-7-87 10-8-85	--	--	534
NC-52	3444180772729.1	Layne Atlantic Co.	1941	70	--	Open hole	25-66	17 (topo)	4.4 4.1	4-7-87 10-19-86	(70)	--	--
RR-45	3435200772658.1	Layne Atlantic Co.	1942	130	8	Gravel pack	75-80 90-95 105-115 125-130	56 (topo)	49.6 53.2	4-7-87 10-19-86	(133)	--	411
RR-47	3435380772659.1	--	1943	85	8	Gravel pack	71-81	50 (topo)	57 P 49.2	4-7-87 10-19-86	(85)	--	651
RR-97	3435120772656.1	Carolina Well and Pump Co.	1977	200	8	--	45-60 80-100	56 (topo)	51 P 51 P	4-7-87 10-19-86	(200)	Electric (200)	372
RR-97A	3435120772656.2	--	--	437	8	--	365-395 415-425	56 (topo)	36.5	6-27-86	--	Caliper, Density, Gamma, Temp (435)	--
RR-229	3435170772642.1	C.W. Brinkley and Son	1983	253	10	Gravel pack	190-210 223-233 247-252	31 (topo)	21.1 22.9	4-7-87 10-19-86	(260)	Electric (250) Gamma (251)	521
TC-100	3444280772729.1	Layne Atlantic Co.	1941	67	18	Open hole	--	19.5	6.1 3.9	4-7-87 10-19-86	--	Gamma (64) Caliper, Temp.	--
TC-104	3444300772729.1	Virginia Machine and Well Co.	1941	182	10	Open hole	107-182 (Open hole)	18.4	14.4	1941	(182)	--	--

Table A.--*Records of selected wells*--Continued

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Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data (log bottom, feet below land surface): Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Water-supply wells--Continued													
TC-190	3443170772737.1	Carolina Well and Pump Co.	1978e	180	--	Screen	130-140 150-180	28 (topo)	42 P 28 P	10-19-86 4-5-78	--	--	865
TC-191	3443070772729.1	Carolina Well and Pump Co.	1977e	180	--	Screen	130-140 150-180	27 (topo)	26.5 52 P	4-7-87 10-19-86	(190)	Electric (260)	558
TC-201	3443280772831.1	Layne Atlantic Co.	1941	68	8	Gravel pack	46-66	33 (topo)	20.5 11.3	4-7-87 10-19-86	(66)	--	424
TC-202	3444120772755.1	--	1942	80	8	Screen	35-40 45-50 55-60 65-70 75-80	20.9	5	1959	(81)	--	--
TC-325	3444120772755.2	Carolina Well and Pump Co.	1980	--	--	--	--	21 (topo)	49.0 P	4-7-87	(200)	Electric (200)	518
TC-502	3444070772728.1	Virginia Machine and Well Co.	1941	184	10	Open hole	110.0-184 (Open hole)	19 (topo)	24 P	4-7-87	(184)	--	--
TC-504	3444090772804.1	Layne Atlantic Co.	1942	113	8	Gravel pack	50-60 75-85	24 (topo)	48 P 48 P	4-7-87 10-19-86	(113)	--	525
TC-600	3444050772728.1	Layne Atlantic Co.	1941	70	8	Gravel pack	48-70	19 (topo)	37 P 6.0	4-7-87 10-19-86	(70)	--	814
TC-604	3444000772811.1	Layne Atlantic Co.	1942	113	8	Screen	45-50 60-65 82-87 97-102 108-113	26.5	4.4 37 P	4-7-87 10-19-86	(138)	--	439

Table A.--*Records of selected wells*--Continued

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Water-supply wells--Continued													
TC-700	3443560772727.1	--	1941	76	18	Open hole	27.5-76 (Open hole)	22.1	38 P 38 P	4-7-87 10-19-86	(76)	--	957
TC-901	3443450772727.1	Layne Atlantic Co.	1941	77	8	Screen	46-56 66-76	21.4	4.3 6.9	4-7-87 10-19-86	(81)	Temperature, Gamma (72), Caliper	--
TC-1000	3443430772825.1	Layne Atlantic Co.	1942	137	8	Gravel pack	86-96 116-136	35 (topo)	38 P 38 P	4-7-87 10-19-86	(136)	--	451
TC-1001	3444270772729.1	Layne Atlantic Co.	1942	100	8	Gravel pack	70-100	32.7	9.5	4-7-87	(104)	--	--
TC-1251	3443290772710.1	Carolina Well and Pump Co.	1975	240	--	Screen	120-140 160-170	20 (topo)	27 P 27 P	4-7-87 10-19-86	--	Electric (215)	882
TC-1253	3443370772729.1	Carolina Well and Pump Co.	1975	250	--	Screen	120-135 155-170	22 (topo)	32 P 32 P 16.6	4-7-87 10-19-86 8-11-75	--	Electric (220)	789
TC-1254	3443290772736.1	Carolina Well and Pump Co.	1975	195	--	Screen	118-122 145-160 175-185	27 (topo)	32 P 32 P	4-7-87 10-19-86	--	Electric (217)	886
TC-1255	3443290772754.1	Carolina Well and Pump Co.	1975	250	--	Screen	124-132 156-166 180-190	31 (topo)	58 P 58 P 21	4-7-87 10-19-86 8-11-75	(250)	Electric and Gamma (245)	844
TC-1256	3443350772805.1	Carolina Well and Pump Co.	--	204	--	Screen	124-134 154-164 182-192	31 (topo)	54 P 54 P 23	4-7-87 10-19-86 7-9-75	(204)	Electric and Gamma (245)	834
TT-23	3444220772148.1	East Coast Construction Co.	--	263	--	--	--	24 (topo)	14.5 22.4	4-7-87 10-19-86	--	Electric and Gamma (263)	448

Table A.--*Records of selected wells*--Continued

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Water-supply wells--Continued													
TT-25	3444190772143.1	East Coast Construction Co.	1980	200	8	Gravel pack	70-95 155-170	31 (topo)	20.8 28.7	4-7-87 10-19-86	(200)	Electric (200)	419
TT-26	3444220772152.1	--	1958e	100	--	--	--	31 (topo)	20.0 26.6	4-7-87 10-19-86	--	--	394
TT-31	3444020772210.1	--	--	94	--	--	--	25 (topo)	20.5 25.9	4-7-87 10-19-86	--	--	--
TT-52	3444030772220.1	Hartsfield Water Co.	1961	98	--	--	--	24 (topo)	19.9 23.2	4-7-87 10-19-86	--	Electric (100) Gamma (72)	482
TT-53	3444140772212.1	Hartsfield Water Co.	1961	90	10	Gravel pack	45-49 50-54 55-59 60-65 71-73	24 (topo)	14.9 18.2	4-7-87 10-19-86	--	Electric (100) Gamma (72) Caliper and Temperature (72)	--
TT-54	3444020772202.1	Hartsfield Water Co.	1961	104	--	--	--	18 (topo)	15.4 21.8	4-7-87 10-19-86	--	--	920
TT-67	3444090772207.1	--	--	98	--	--	--	26 (topo)	19.1 58 P	4-7-87 10-19-86	--	--	478
Test wells													
ON-OT1-67	3439360772844.1	N.C. Oil and Gas Co.	1967	1,400	9 to 6	Open test hole	--	62 (topo)	--	--	--	Electric and Gamma (1,400)	--
ON-OT4-66	3433000772230.1	N.C. Oil and Gas Co.	1966	1,681	8 to 6	Open test hole	--	30 (topo)	--	--	(1,670)	Electric and Gamma (1,680)	--
ON-OT-22	3439300772850.1	N.C. Oil and Gas Co.	--	1,249	--	Open test hole	--	66 (topo)	--	--	--	Electric and Gamma (1,249)	--

Table A.--*Records of selected wells*--Continued

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Test wells--Continued													
ON-T2-87	3442410772240.1	C.W. Brinkley and Son	1987	260	5.0	Open test hole	--	20 (topo)	--	--	--	Electric and Gamma (250)	--
OW-2	3439400772059.1	--	--	90	4	--	--	11 (topo)	4.0 5.7	4-7-87 10-19-86	--	Caliper, Temperature, Gamma (90)	--
OW-3	3442280772018.1	--	--	75	4	--	--	23 (topo)	11.7 6.8	4-7-87 10-19-86		Caliper, Temperature, Gamma (72)	--
OW-4	3440560771935.1	--	--	106	4	--	--	18 (topo)	4.3 18.5	4-7-87 10-19-86	--	Caliper, Temperature, Gamma (106)	--
OW-5	3439070771947.1	--	--	110	4	--	90-100	26 (topo)	17.5 17.6	4-7-87 10-19-86	--	Caliper, Temperature, Neutron, Gamma (105)	--
T-1	3442490771838.1	Heater Well Co.	1959	477	--	Open test hole	--	30 (topo)	--	--	(477)	Electric (477)	--
T-2	3440260771931.1	Heater Well Co.	1959	240	--	Open test hole	--	29 (topo)	--	--	(240)	Electric (237)	--
T-3	3441330771929.1	Heater Well Co.	1959	232	--	Open test hole	--	31 (topo)	--	--	(232)	Electric (226)	--
T-4	3441190771931.1	Heater Well Co.	1959	262	--	Open test hole	--	26 (topo)	--	--	(262)	Electric (250)	--
T-5	3440550771929.1	Heater Well Co.	1959	232	--	Open test hole	--	15 (topo)	--	--	(232)	Electric (228)	--
T-6	3441080771918.1	Heater Well Co.	1959	202	--	Open test hole	--	34 (topo)	--	--	(202)	Electric (202)	--
T-7	3442000772007.1	Heater Well Co.	1959	225	--	Open test hole	--	26 (topo)	--	--	(225)	Electric (214)	--
T-8	3439200771950.1	Heater Well Co.	1959	500	--	Open test hole	--	20 (topo)	--	--	(500)	Electric (500)	--

Table A.--*Records of selected wells*--Continued

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							Test wells--Continued						
T-9	3444270772209.1	Heater Well Co.	1959	177	8	Gravel pack	37-42 50-60 68-72 83-88 120-127 135-140 162-167 172-177	28 (topo)	5.4 9.6	4-7-87 10-19-86	(202)	Electric (200)	--
T-10	3444340772251.1	Heater Well Co.	1959	250	--	Open test hole	--	25 (topo)	--	--	(250)	Electric (248)	--
T-11	3444360772313.1	Heater Well Co.	1959	202	--	Open test hole	--	25 (topo)	--	--	(202)	Electric (200)	--
T-12	3443030772459.1	Heater Well Co.	1959	352	--	Open test hole	--	6 (topo)	--	--	(352)	Electric (352)	--
T-13	3444240772346.1	Heater Well Co.	1959	250	--	Open test hole	--	19 (topo)	--	--	(250)	Electric (250)	--
T-14	3444180772442.1	Heater Well Co.	1959	200	--	Open test hole	--	20 (topo)	--	--	(200)	Electric (200)	--
T-15	3444250772707.1	Heater Well Co.	1959	477	--	Open test hole	--	15 (topo)	--	--	(477)	Electric (420)	--
T-18	3435370772705.1	Heater Well Co.	1959	302	--	Open test hole	--	52 (topo)	--	--	(302)	Electric (300)	--
T-19	3435100772659.1	Heater Well Co.	1959	161	--	Open test hole	--	55 (topo)	--	--	(151)	Electric (156)	--
T-20	3435040772124.1	Heater Well Co.	1959	121	--	Open test hole	--	41 (topo)	--	--	(121)	Electric (112)	--
T-21	3434530772135.1	Heater Well Co.	1959	120	--	Open test hole	--	31 (topo)	--	--	(120)	Electric (116)	--

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface) Lithologic	Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Test wells--Continued													
T-22	3435010771720.1	Heater Well Co.	1959	161	--	Open test hole	--	23 (topo)	--	--	(161)	Electric (156)	--
X(1950)	3434570771720.1	--	--	33	18	Open hole	--	23 (topo)	8.5	8-86	--	Gamma (33)	--
X-24, C-2	3444160772203.1	--	1972	240	6	--	--	26 (topo)	18?	10-10-72	--	Electric and Gamma (238)	--
X-24, S-1	3441290772104.2	N.C. Div. of Envir. Mgmt.	1987	90	4	Screen	80-90	23 (topo)	15.0	6-15-87	--	--	--
X-24, S-2(X)	3441290772104.1	N.C. Div. of Envir. Mgmt.	1986	1,526	--	Open test hole	--	23 (topo)	--	--	(1,500)	Electric, Gamma, Neutron, Density, Acoustic, Caliper, Temperature (1,526)	--
X-24, S-2a	3441290772104.3	N.C. Div. of Envir. Mgmt.	1987	918	8 to 4 to 2.5	Screen	908-918	23 (topo)	14.8	6-15-87	--	--	--
X-24, S-4	3441290772104.4	N.C. Div. of Envir. Mgmt.	1987	527	8 to 4 to 2.5	Screen	517-527	23 (topo)	19	6-15-87	--	--	--
X-24, S-5	3441290772104.5	N.C. Div. of Envir. Mgmt.	1987	295	4 to 2.5	Screen	285-295	23 (topo)	20.5	6-15-87	--	--	--
X-24, S-6	3441290772104.6	N.C. Div. of Envir. Mgmt.	1987	130	6	Screen	120-130	23.47	18.2 17.0	8-19-87 6-15-87	--	--	--
X-24, S-7	3441290772104.7	N.C. Div. of Envir. Mgmt.	1987	40	4	Screen	30-40	23 (topo)	17.8	6-15-87	--	--	--
X-25, b-16	3444350772640.1	N.C. Div. of Envir. Mgmt.	1978	185	4	Open test hole	--	15 (topo)	--	--	--	Electric and Gamma (185)	--

Table A.--*Records of selected wells*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ft, foot; in., inch; --, no data available; topo, data estimated from a topographic map with a 5-foot contour interval; ?, information uncertain; e, estimated; P, pumping water level (measured where given to tenths of a foot, reported where given to nearest foot)]

Well number	USGS identification number	Driller	Date drilled	Total depth (ft)	Diameter (in.)	Type of finish	Screened intervals (ft)	Altitude of land surface (ft)	Water level (feet below land surface)	Date of water-level measurement	Log data (log bottom, feet below land surface): Lithologic	Log data (log bottom, feet below land surface): Geophysical	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)
Test wells--Continued													
X-25, M-2	3442180772734.1	Hartsfield Water Co.	1968	156	--	--	--	15 (topo)	--	--	--	Electric and Gamma (156)	--
Y-25, Q1	3436410772901.2	N.C. Div. of Envir. Mgmt.	1982	80	4	Screen	58-80	67 (topo)	31.6	5-12-86	--	--	--
Y-25, Q2(X)	3436410772901.1	N.C. Div. of Envir. Mgmt.	1982	1,355	5.5	Open test hole	--	67 (topo)	--	--	(1,340)	Electric and Gamma (1,210)	--
Y-25, Q3	3436410772901.3	N.C. Div. of Envir. Mgmt.	1982	240	4	Screen	150-240	66.83	34.8 33.4	4-7-87 5-12-86	--	--	--
Y-25, Q4	3436410772901.4	N.C. Div. of Envir. Mgmt.	1982	550	8 to 2	Screen	525-550	67 (topo)	39.9	5-12-86	--	--	--
Y-25, Q6	3436410772901.6	N.C. Div. of Envir. Mgmt.	1982	23	4	Screen	18-22	67 (topo)	10.4	5-12-86	--	--	--
VPI-15	3439030771916.1	Gruy Federal, Inc.	1978	1,678	2.5	Cased to total depth	No openings to aquifer	30 (topo)	Casing full of water	--	--	--	--
VPI-15A	3431300772723.1	Gruy Federal, Inc.	1979	1,575	4	Cased to total depth	No openings to aquifer	26 (topo)	Casing full of water	--	--	Gamma (1,575)	--
Z-5	3444100772417.2	J.C. Hartsfield	1957	246	--	--	--	--	--	--	--	Electric (246)	--

Table B.--*Records of construction, acceptance-test, specific-capacity, and estimated transmissivity data for selected wells in the Castle Hayne aquifer*

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ?, information uncertain]

						Well-acceptance test data					
Well number	USGS identification number	Well depth (feet)	Well diameter (inches)	Total aquifer thickness (feet)	Screen length (feet)	Water-level drawdown during pumping (feet)	Pumping rate (gallons per minute)	Duration of pumping (minutes)	Specific capacity (pumping rate / drawdown)	Corrected specific capacity (corrected for partial penetration)	Estimated transmissivity (feet squared per day)
BB-43	3434550772148.1	60	8	275	30	34	170	1,560	5.0	30.3	8,900
BB-44	3435040772143.1	62	8	275	30	45	450	2,400	10.0	60.6	17,900
BB-222	3500010772049.1	185	10	275	50	34.9	329	1,440	9.4	36.0	10,600
HP-612	3442260772048.1	190	8	285	40	50.9	275	1,440	5.4	26.8	7,900
HP-614	3442470772124.1	235	8	285	45	65	323	1,440	4.9	22.4	6,600
HP-621	3442530771916.1	77	8	300	20	22	200	480?	9.1	83.1	24,500
HP-628	3439040771838.1	200	8	320	34	46.6	160	1,440	3.4	21.6	6,400
HP-629	3442540771912.1	240	8	300	45	36.7	210	1,250	5.7	26.9	7,900
HP-634	3440300771935.1	225	8	300	70	36	163	1,845	4.5	14.5	4,300
HP-636	3441190771929.1	227	8	300	65	31	211	2,160	6.8	23.5	6,900
HP-643	3443030772118.1	250	10	295	30	52	278	2,100	5.3	33.0	9,700
HP-644	3443040772100.1	255	10	300	30	57.2	246	1,920	4.3	27.3	8,100
HP-646	3443160772035.1	270	10	305	30	28.7	304	2,295	10.6	68.6	20,200
HP-647	3443030772017.1	200	10	305	30	50.8	500	1,590	9.8	63.4	18,700
HP-648	3442510771848.1	265	10	310	30	85.8	250	1,800	2.9	19.0	5,600
HP-649	3442440771822.1	284	10	310	30	97.7	257	1,680	2.6	17.0	5,000
HP-651	3441410771927.1	199	10	305	30	72	270	1,440	3.8	24.6	7,300
HP-652	3440190771848.1	183	10	320	30	99.0	218	1,950	2.2	14.8	4,400
HP-663	3442270771758.1	180	10	325	50	73.3	350	1,440	4.8	21.7	6,400

Table B.--*Records of construction, acceptance-test, specific-capacity, and estimated transmissivity data for selected wells in the Castle Hayne aquifer*--Continued

[Well number: Numbers are shown on well-location map (plate 1) and are those assigned by the U.S. Marine Corps or its contractors to identify wells constructed at the Base. USGS identification number: Numbers are comprised of degrees, minutes, and seconds of latitude (first 6 numbers) north of the equator and longitude (next 7 numbers) west of the zero meridian. Number right of decimal point is a sequential number for wells at designated location. ?, information uncertain]

						Well-acceptance test data					
Well number	USGS identification number	Well depth (feet)	Well diameter (inches)	Total aquifer thickness (feet)	Screen length (feet)	Water-level drawdown during pumping (feet)	Pumping rate (gallons per minute)	Duration of pumping (minutes)	Specific capacity (pumping rate / drawdown)	Corrected specific capacity (corrected for partial penetration)	Estimated transmissivity (feet squared per day)
HP-699	3443000772141.1	124	10	275	40	44	250	1,440	5.7	26.2	7,700
HP-700	3442580772150.1	130	10	270	30	36.6	250	1,440	6.8	38.9	11,500
HP-701	3442330772204.1	110	10	275	30	34.5	250	1,440	7.2	41.9	12,400
HP-705	3443060772000.1	160	10	295	40	27.8	250	1,440	9.0	44.3	13,100
HP-706	3442580771930.1	176	10	300	50	66.6	250	1,440	3.8	15.8	4,700
HP-709	3442130771859.1	140	10	310	30	45.3	200	1,440	4.4	28.8	8,500
HP-710	3442110771843.1	140	10	310	30	39.1	200	1,440	5.1	33.4	9,900
HP-711	3442190771823.1	150	10	320	40	29.4	200	1,440	6.8	36.4	10,700
LCH-4006	3443270772017.1	140	8	295	42	54	540	1,440	10.0	49.2	14,500
LCH-4007	3443110771953.1	145	8	295	55	23.3	275	2,160	11.8	46.3	13,700
M-267	3443360772451.1	150	8	260	40	22	170	300	7.7	34.8	10,300
M-628	3444100772417.1	67	8	260	24 (Open hole)	23.4	70	1,440	3.0	20.7	6,100
RR-229	3435170772642.1	253	10	290	35	35.2	429	1,440	12.2	65.9	19,400
TT-25	3444190772143.1	200	8	280	40	30	150	1,440	5.0	24.3	7,200