SHALLOW GROUND-WATER RESOURCES IN THE GRAND STRAND OF SOUTH CAROLINA

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CONVERSION FACTORS AND ABBREVIATIONS OF UNITS

The following factors may be used to convert the inch-pound units published herein to the International System of units (SI).

Multiply inch-pound units	By	To obtain SI units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
pound, avoirdupois (lb)	453.6	gram (g)
square foot per day (ft^2/d)	0.09290	square meter per day (m^2/d)
gallon per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter [(L/s)/m]

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$^{\circ}C = \frac{5}{9}\ (^{\circ}F - 32)$$

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ABSTRACT

The shallow aquifers that underlie the Grand Strand of South Carolina average approximately 60 to 400 feet thick and have variable productivity with some wells producing little water and others producing several hundred gallons per minute. These aquifers are separated from the underlying Black Creek aquifer by a 200 to 300 foot thick clay confining unit. The shallow aquifers are recharged by local rainfall and discharge primarily into the Atlantic Ocean, the Intracoastal Waterway, and other surface waters. In the North Myrtle Beach area a vertical difference in potentiometric levels of less than 1 foot was observed within the shallow aquifers in 1983. However, the difference in potentiometric levels between the shallow aquifers and the Black Creek aquifer was probably from 25 to greater than 50 feet.

The quality of ground water is also variable. Calcium and bicarbonate are generally the predominant ions in solution as a result of the dissolution of calcite in the aquifer sediments. Concentrations of chloride may be high in the vicinity of the salty surface waters. Concentrations of iron range from 5 to 35,000 µg/L, but are generally less than 2,000 µg/L.

INTRODUCTION

The Grand Strand of South Carolina has been developing rapidly as a summertime coastal resort during the last 30 to 40 years. The area consists of a narrow coastal part of Georgetown and Horry Counties bounded by the Atlantic Ocean, the Little River, the Atlantic Intracoastal Waterway, the Waccamaw River, and Winyah Bay (fig. 1).

In Horry County water use for public supply, which is concentrated in the Grand Strand, averaged 16.3 Mgal/d in 1982 with peak daily use of 27.2 Mgal/d (Pelletier, 1985, p. 14). The peak daily use results from the high demand on weekends during the summer tourist season. Because of the expected growth of the area, water use for public supply in Horry County is projected to increase to 40 Mgal/d by the year 2000. (Pelletier, 1985, p. 14).

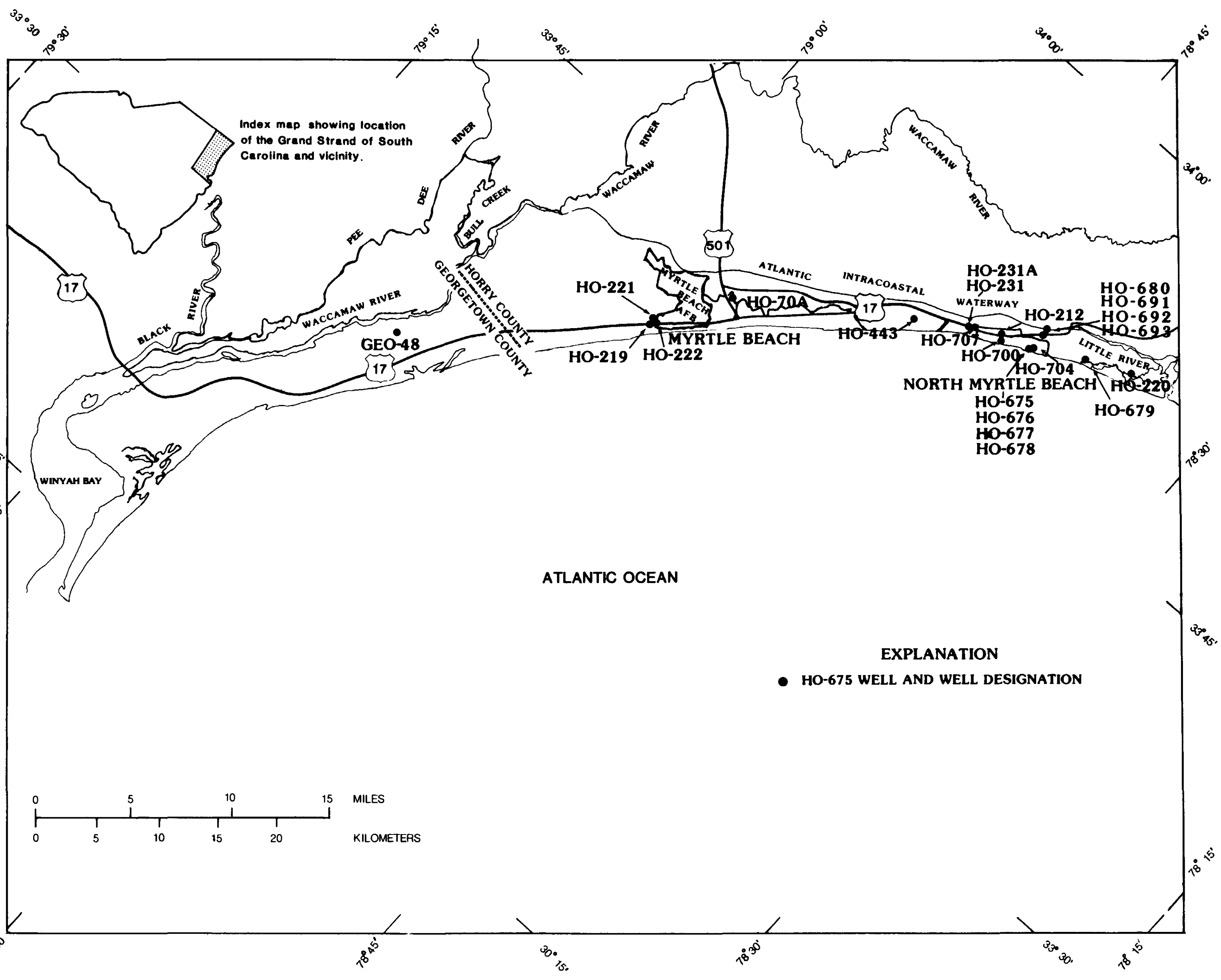

Figure 1.--Locations of principal geographic features of the Grand Strand

Description of the Problem

The principal source of water for public supply for communities on the Grand Strand has been freshwater parts of the Black Creek aquifer. The transmissivity of this aquifer averages about 2700 ft^2/d in the Myrtle Beach area (Zack, 1977, p. 34). Large withdrawals of ground water from the Black Creek aquifer and the low transmissivity of the aquifer have resulted in regional declines in the potentiometric surface of more than 100 ft (Aucott and Speiran, 1985b, sheet 6). The rate of decline is as much as 10 ft/yr (Pelletier, 1985, p. 17). Such declines have increased costs of pumping and well construction and may cause saltwater intrusion into currently fresh parts of the aquifer.

Concentrations of fluoride exceed the primary drinking-water standard (U.S. Environmental Protection Agency, 1983) in ground water from the Black Creek aquifer throughout the Grand Strand (Zack, 1980). Concentrations of chloride exceed the secondary drinking-water standard (U.S. Environmental Protection Agency, 1981) in parts of the aquifer as a result of incomplete flushing of ancient saltwater from the aquifer (Alan Zack, U.S. Geological Survey, written commun. 1986). This flushing results from natural flow patterns in the aquifer (Aucott and Speiran, 1985a and 1985c) but may be reversed by the effects of the decline in potentiometric levels.

The increasing demand for water for public supply will result in a significant increase in problems if the Black Creek aquifer continues to be used as the sole source of water for public supply. Alternative sources of water include surface waters and shallow aquifers. The overall quantity and quality of water, including seasonal and areal variations, limit the usefulness of each of the available sources. Use of the alternative sources of water, individually or combined, may provide the most reliable and economic supply of good quality water for communities on the Grand Strand. An understanding of the quantity and quality of water available from all sources of water is necessary to allow optimum development of the various water resources. Although the quantity and quality of water available from the Black Creek aquifer and other deep, confined aquifers has been evaluated as a part of other investigations (Zack, 1977, 1980; Pelletier, 1985; Aucott and Speiran, 1985a), little information has been published on the ground water of the shallow aquifers.

Purpose and Scope

The purpose of this report is to describe the hydrology of shallow aquifers in the North Myrtle Beach area as an example of the hydrology typical of the entire Grand Strand. The flow and quality of water in the shallow aquifers and the potential yields of the aquifers are described. The relations between the shallow aquifers and the surface waters and the underlying Black Creek aquifer also are discussed.

DESCRIPTION OF THE STUDY AREA

The Grand Strand lies within the Coastal Plain Physiographic Province of South Carolina. The area is nearly level with land-surface altitudes ranging from sea level to about 60 ft above sea level. Since the completion of the Atlantic Intracoastal Waterway in the 1930's, the Grand Strand has been an island surrounded by the Atlantic Ocean, the Little River, the Atlantic Intracoastal Waterway, the Waccamaw River, and Winyah Bay (fig.1).

Climate

The area has a temperate, humid climate typical of the southeastern United States. The annual temperature averages 63.4°F with a low average monthly temperature of 45.3°F in January and a high average monthly temperature of 80.4°F in July (fig.2) (U.S. National Oceanic and Atmospheric Administration, 1984). Total annual precipitation averages 51.09 in. and average monthly precipitation ranges from 2.41 in. in November to 6.15 in. in July (fig.2).

Geology

The Grand Strand is underlain by Coastal Plain sediments of Late Cretaceous age and younger, overlying pre-Cretaceous basement rock. The sedimentary deposits range in thickness from about 1300 to more than 1600 ft. The sediments consist of layers of sand, silt, and clay and mixtures of sand and clay interbedded with limestone. The two shallowest formations consisting of upper Cretaceous sediments are the Peedee and Black Creek Formations (table 1). The Black Mingo Formation and younger Tertiary-age formations overlie the Cretaceous formations primarily in the southern part of the Grand Strand. Quaternary deposits overlie the Cretaceous and Tertiary formations.

The Tertiary and Quaternary sediments generally consist of beds of sand, coquina (loose fossiliferous limestone), and clay. The sands range from beds several feet thick with limited areal extent to layers tens of feet thick that underlie much of the Grand Strand. The coquina, which may have a high permeability, also varies in thickness and areal extent. Clay layers separate many of the beds of sand and coquina.

The composition of surficial sediments varies areally throughout the Grand Strand. Along the Atlantic Ocean and many inland waterways surficial sediments consist of coarse-grained sand and shell deposited in beach, dune, and point-bar environments. In low-lying wetlands adjacent to the inland waterways, sediments contain greater amounts of silt and clay deposited in back-bay, lagoon, and wetland environments. Other areas may contain a mixture of these sediments but generally have a high sand content.

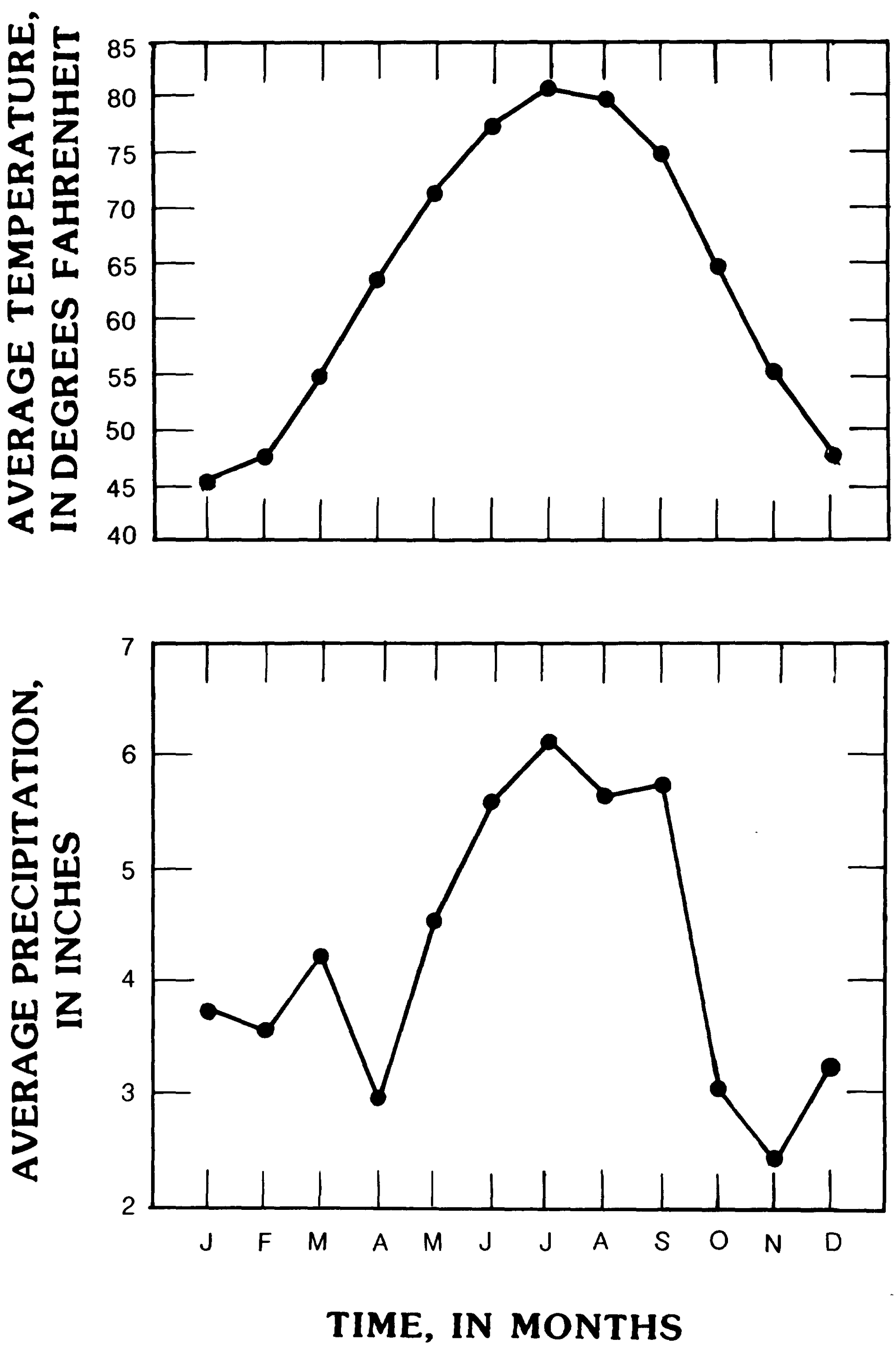

Figure 2.--Average monthly precipitation and temperature through 1983 at Conway, Horry County, South Carolina

Table 1.--Lithology of Quaternary, Tertiary, and shallow Cretaceous formations in the Grand Strand of South Carolina

SYSTEM	SERIES	GEOLOGIC UNIT	DESCRIPTION OF SEDIMENTS
Quaternary	Pleistocene	Surficial deposits	Blue-gray to yellow and brown sandy marl, gray to buff fine-grained quartz sand.
Tertiary	Eocene and Paleocene	Undifferentiated Tertiary deposits and Black Mingo Formation	Greenish-gray glauconitic sands with thick beds of coquina (loose fossiliferous limestone).
Cretaceous	Upper Cretaceous	Peedee Formation	Gray, calcareous, fossilferous clay; gray, glauconitic, calcareous, fine- to medium-grained muddy sand; and coquina.
		Black Creek Formation	Well-sorted calcareous, fine- to medium-grained quartz sand; calcereous silty clay; and glauconitic, calcareous, muddy fine- to medium-grained quartz sand.

Hydrology

Surface Water

Major surface waters affecting the hydrology of the Grand Strand area include the Atlantic Ocean, the Little River, the Atlantic Intracoastal Waterway, the Waccamaw River, Winyah Bay, and the Pee Dee River. The Atlantic Intracoastal Waterway consists of parts of the Little River, the Waccamaw River, and Winyah Bay and a canal constructed in the 1930's between the Little River and the Waccamaw River. Bull Creek is a short creek connecting the Pee Dee River to the Intracoastal Waterway.

Major fresh surface-water flow is provided by the Pee Dee River and the Waccamaw River. The Pee Dee River flows into the Intracoastal Waterway by way of Bull Creek. Flow in the Intracoastal Waterway is to both the north and south, discharging into the Atlantic Ocean through the Little River Inlet and Winyah Bay. These waters are tidally affected. The middle part of the Intracoastal Waterway contains freshwater and the southern and northern parts contain saltwater. The location of the saltwater-freshwater interface in the Intracoastal Waterway depends primarily on the amount of freshwater inflow and the tidal heights.

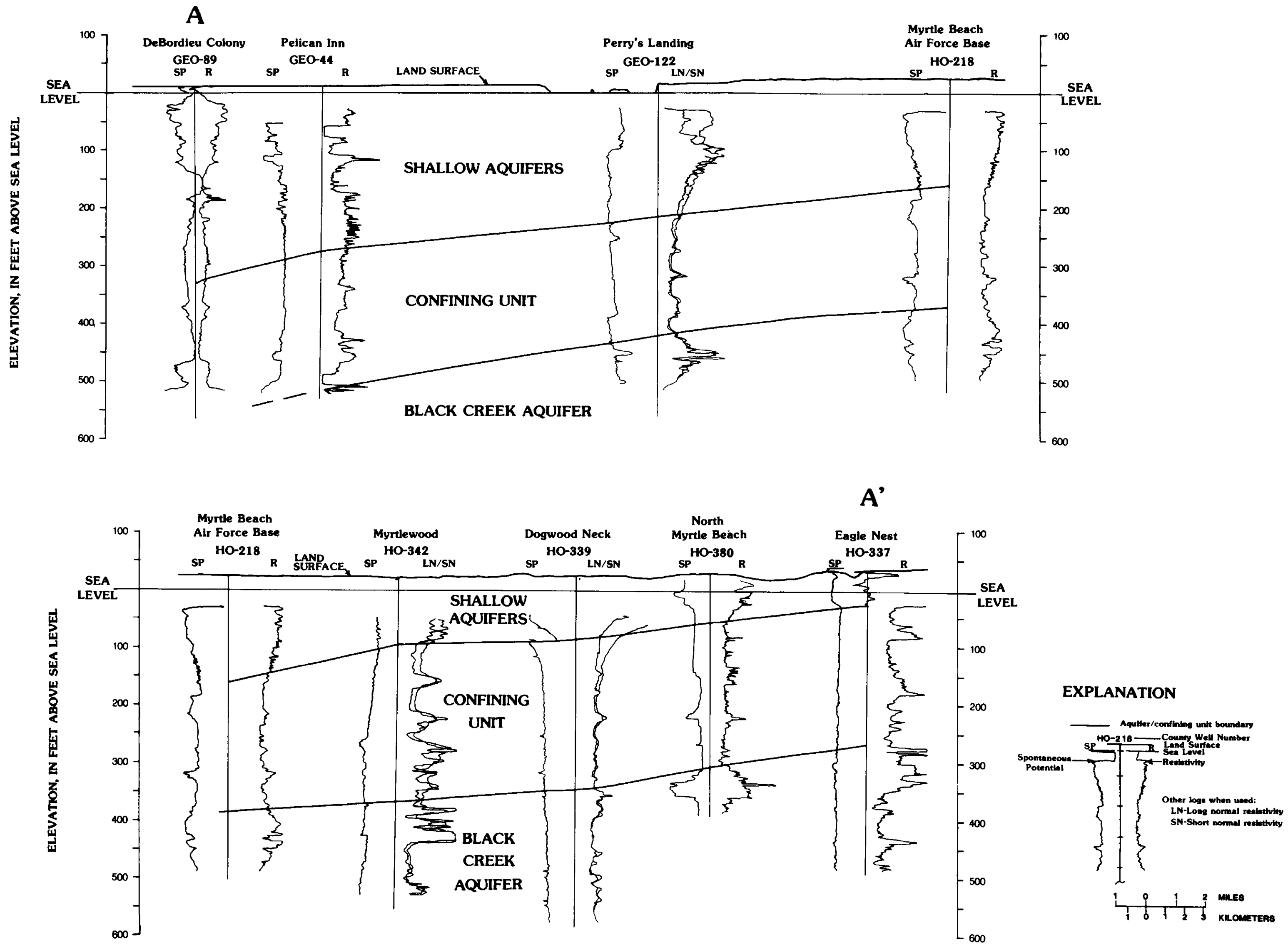

Figure 3.--Geohydrologic section A-A' showing the shallow aquifers, the top of the Black Creek aquifer, and the intervening confining unit

Extensive areas of swamps and wetlands border the surface waters in the vicinity of the Grand Strand. These swamps and wetlands may be inundated by freshwater or saltwater depending on their location. The areas of inundation and depth of water in the swamps and wetlands varies with tidal fluctuations and changes in freshwater inflow.

Ground Water

Ground water beneath the Grand Strand occurs in deep, confined aquifers and shallow aquifers (fig.3). The uppermost of the deep, confined aquifers is the Black Creek aquifer which is part of a regional system of aquifers (Aucott and others, 1985). Potentiometric levels in the Black Creek aquifer were several feet above land surface and flow was from the southwest to the Grand Strand prior to significant pumpage of ground water (Aucott and Speiran, 1985a; 1985c). Pumpage has resulted in declines in potentiometric levels of more than 100 ft in the Grand Strand (Aucott and Speiran, 1985b) and levels continue to decline as much as 10 ft/yr near pumping centers (Pelletier, 1985, p. 17).

The shallow aquifers include the water-table aquifer and the shallow, confined aquifers which are hydraulically separated from the underlying Black Creek aquifer by a clay confining unit. The water-table aquifer occurs throughout the Grand Strand, but its thickness is variable and its depth is limited because of the high horizontal and low vertical permeability of the sediments. The water-table aquifer may include sediments stratigraphically equivalent to the shallow confined aquifers where these sediments are near the surface. Forty wells that are screened in the shallow aquifers provided data for this report (fig. 4, table 2).

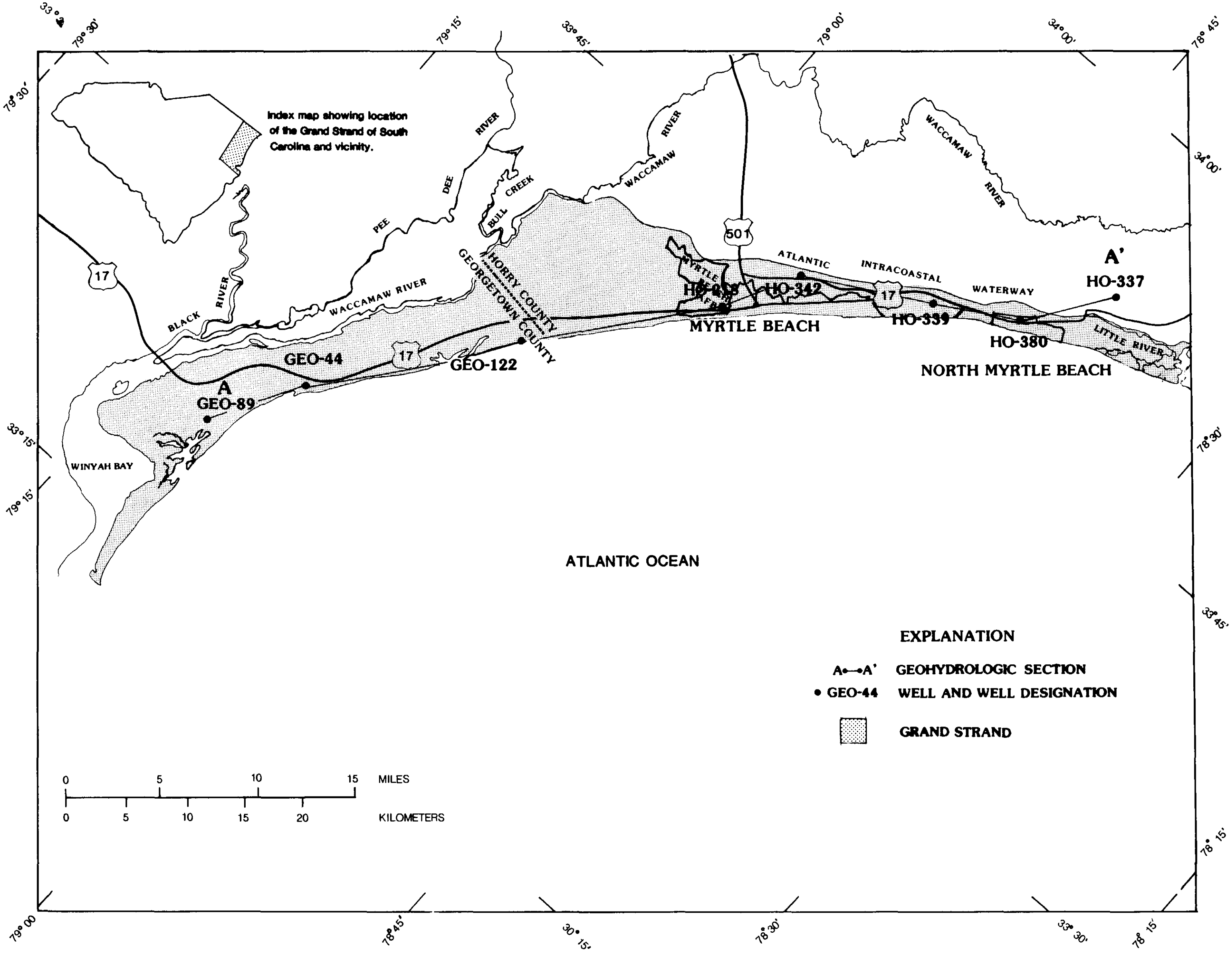

Figure 4.--Locations of selected wells screened in the shallow aquifers of the Grand Strand

Table 2.--Descriptions of wells screened in the shallow aquifers of the Grand Strand of South Carolina

Well Number	Local Identifier	Latitude	Longitude	Altitude of Land Surface (ft)	Depth of Well (ft)	Screened Interval Depth (ft)
GEO- 48	Brookgreen Gardens	33 31 13	79 05 35	--	110	80-110
HO- 70A	City of Myrtle Beach	33 41 15	78 54 00	20	87	--
HO- 212	Ocean Drive Beach, School	33 49 43	78 40 50	30	18	--
HO- 219	Myrtle Beach Air Force Base, next to HO-218T	33 39 40	78 56 30	25	35	--
HO- 220	FFA Camp, North Myrtle Beach	33 51 02	78 36 40	22	60	50-55
HO- 221	Myrtle Beach Air Force Base, Main Gate	33 39 47	78 56 31	25	39	--
HO- 222	Myrtle Beach Air Force Base, Waste-water treatment plant	33 39 52	78 56 07	25	50	--
HO- 231	Briarcliffe Acres, North Myrtle Beach	33 48 05	78 44 00	22	38	35-38
HO- 231A	Briarcliffe Acres, North Myrtle Beach	33 48 05	78 44 00	22	60	--
HO- 443	Dogwood Neck #2	33 47 13	78 46 12	30	94	--

Table 2.--Descriptions of wells screened in the shallow aquifers of the Grand Strand of South Carolina (Continued)

Well Number	Local Identifier	Latitude	Longitude	Altitude of Land Surface (ft)	Depth of Well (ft)	Screened Interval Depth (ft)
HO- 481	Lake Arrowhead #2	33 46 12	78 47 18	30	45	--
HO- 675	North Myrtle Beach, Test well #1	33 49 19	78 40 27	15	120	110-115
HO- 676	North Myrtle Beach, Test well #2	33 49 19	78 40 27	15	40	35-40
HO- 677	North Myrtle Beach, Test well #3	33 49 19	78 40 27	15	105	95-105
HO- 678	North Myrtle Beach, Test well #4	33 49 19	78 40 27	16	109	98-103
HO- 679	North Myrtle Beach, Cherry Grove	33 49 58	78 38 17	10	75	60-70
HO- 680	North Myrtle Beach, Test well	33 50 55	78 39 00	12	45	30-40
HO- 681	North Myrtle Beach, Test well	33 47 58	78 42 44	30	--	--
HO- 691	North Myrtle Beach, Test Well	33 50 55	78 39 01	15	125	95-115
HO- 692	North Myrtle Beach, Test Well	33 50 55	78 39 03	10	150	135-145
HO- 693	North Myrtle Beach, Test Well	33 50 54	78 30 01	10	30	25-30

Table 2.--Descriptions of wells screened in the shallow aquifers of the Grand Strand of South Carolina (Continued)

Well Number	Local Identifier	Latitude	Longitude	Altitude of Land Surface (ft)	Depth of Well (ft)	Screened Interval Depth (ft)
HO- 700	North Myrtle Beach, Test Well, 2nd Ave. and Rosemary Lane	33 49 27	78 40 21	20	115	100-110
HO- 704	North Myrtle Beach, 2nd Ave. and Oak Dr.	33 49 21	78 40 19	15	90	80-90
HO- 707	Surf Golf Course, North Myrtle Beach, Irrigation well	33 49 10	78 42 20	--	110	55-100
HO- 733	N. of Intracoastal Waterway	33 49 18	78 43 18	22	--	--
HO- 736	North Myrtle Beach, Airport #2	33 48 58	78 43 02	23	70	46-56
HO- 741	Leo Bourne #2, North Myrtle Beach	33 49 38	78 43 20	27	80	67-75
HO- 743	North Myrtle Beach	33 49 16	78 41 24	22	--	--
HO- 750	Camp Playmore, North Myrtle Beach	33 48 00	78 43 49	30	30	25-30
HO- 751	Camp Playmore, North Myrtle Beach	33 47 58	78 43 48	30	35	30-35
HO- 752	Azalea Sands Golf Course, North Myrtle Beach	33 48 53	78 47 57	22	--	--

Table 2.-- Descriptions of wells screened in the shallow aquifers of the Grand Strand of South Carolina (Continued)

Well Number	Local Identifier	Latitude	Longitude	Altitude of Land Surface (ft)	Depth of Well (ft)	Screened Interval Depth (ft)
HO- 753	Azalea Sands Golf Course, North Myrtle Beach	33 48 51	78 47 56	22	21	20-21
HO- 754	North Myrtle Beach, Test Well	33 50 01	78 40 59	18	35	30-35
HO- 756	North Myrtle Beach,	33 50 07	78 38 40	15	--	--
HO- 757	Dr. Bethea, North Myrtle Beach	33 51 01	78 36 08	32	35	25-30
HO- 758	North Myrtle Beach	33 49 55	78 36 05	30	--	--
HO- 765	North Myrtle Beach, Cherry Grove	33 50 01	78 38 19	5	--	--
HO- 766	Surf Golf Course #1, North Myrtle Beach	33 50 01	78 39 30	17	80	65-75
HO- 767	Surf Golf Course #2, North Myrtle Beach	33 50 02	78 39 33	20	110	55-60 75-80
HO- 768	North Myrtle Beach, Airport #3	33 48 55	78 43 01	25	90	47-80

The shallow aquifers of the Grand Strand consist of beds of fine-to coarse-grained sand and coquina that dip from north to south (fig. 3). Many of the shallow beds in the southern Grand Strand do not occur in the northern Grand Strand because they either were not deposited or have been eroded. Beds that are water-table aquifers to the north are confined aquifers to the south. The shallow aquifers are comprised of parts of the Peedee and Black Mingo Formations and younger Tertiary and Quaternary deposits. Many of the beds of sand and coqina are separated by layers of clay. Some beds are areally limited and are only local aquifers, but other beds are areally extensive and are parts of regional aquifers.

A confining unit approximately 200 to 300 ft thick separates the shallow aquifers from the underlying Black Creek aquifer. The confining unit consists of parts of the Peedee and Black Creek Formations. The top of the confining unit lies approximately 60 to 400 ft below land surface. Some beds of sand and coquina that exist within the confining unit as in wells HO-337 and HO-342 (fig. 3) may also be locally important aquifers.

Because the nature of the hydraulic independence of the different beds of sand and coquina is not known, the units have not been differentiated (figure 3) and are discussed collectively as the shallow aquifers. They include all water-table, semiconfined, and confined beds overlying the Black Creek aquifer. The thickness, mineralogy, and permeability of individual beds vary throughout the Grand Strand. This variability contributes to significant differences in the quantity and quality of water that can be obtained from the shallow aquifers in different areas. For example, the high permeability coquina present in the North Myrtle Beach area appears to have a low permeability or be absent to the south and quartz sand having little calcite cementation in one area has significant cementation in another area.

Recharge and Discharge

The shallow aquifers are recharged by local rainfall. Discharge from the aquifers occurs as vertical leakage to the Black Creek aquifer, evapotranspiration, and discharge to surface waters.

The amount of recharge is affected by the amount of rainfall, rates of evapotranspiration, and the permeability of the overlying materials. Rainfall and rates of evapotranspiration vary seasonally. Based on a study in the western part of the Coastal Plain near Barnwell, S.C., most of the recharge to Coastal Plain aquifers occurs during rainy periods in winter and early spring when rates of evapotranspiration are low (K. F. Dennehy, U.S. Geological Survey, oral comm., 1985). Little, if any, recharge occurs in the late spring and summer because of the high rates of evapotranspiration.

Surficial materials generally consist of permeable, sandy sediments into which water from rainfall readily percolates. However, the permeability of these sediments may be greatly reduced by compaction or paving. This can be critical on the Grand Strand because decreased permeability results in increased surface runoff and decreased ground-water recharge.

Discharge from the shallow aquifers is by evapotranspiration in areas where the water table is near land surface, to the underlying Black Creek aquifer where vertical potentiometric gradients are downward, and to surface waters. Evapotranspiration is probably greatest in and near wetlands adjacent to the surface waters. It is probably greatest during late spring and summer.

The Black Creek aquifer originally recharged the shallow aquifers, but the shallow aquifers now discharge to the Black Creek aquifer because declines in potentiometric levels in the Black Creek aquifer have reversed the vertical gradient in potentiometric levels from upward to downward. The amount of water discharged to the Black Creek aquifer is probably small relative to other discharges because of the low permeability of the intervening confining unit (W. R. Aucott, U.S. Geological Survey, oral comm., 1985).

Discharge to surface waters is indicated by the configuration of the potentiometric surface of the shallow aquifer in the North Myrtle Beach area (fig. 5). The amount of water discharged to surface waters is probably greater than that discharged to the Black Creek aquifer. However, the total amount of water discharged and the relative amounts discharged to surface waters, to the Black Creek aquifer, and by evapotranspiration are not known.

Ground-Water Flow

The areal extent of horizontal flow of ground water in the shallow aquifer is limited by the location of the surface waters. Flow is from the potentiometric highs between the surface waters, where the aquifers are recharged, to the potentiometric lows at surface-water discharge sites including the Intracoastal Waterway, Atlantic Ocean, and small surface drainages. The potentiometric surface of the shallow aquifers in the North Myrtle Beach area for August 31, 1983 is shown in fig. 5. Data used for this map are listed in table 3. The shallow aquifers on the Grand Strand are essentially a hydrologic island because of the local recharge and discharge.

Vertical flow within the shallow aquifers and to the underlying Black Creek aquifer is controlled by vertical differences in potentiometric levels and vertical permeabilities. Little vertical difference in potentiometric levels occurs within the shallow aquifers, but a significant difference in potentiometric levels exists between the shallow aquifers and the Black Creek aquifer in the North Myrtle Beach area. However, the magnitude of vertical permeabilities is not known although permeabilities within the shallow aquifers are much greater than permeabilities of the confining units between the shallow aquifers and the Black Creek aquifer.

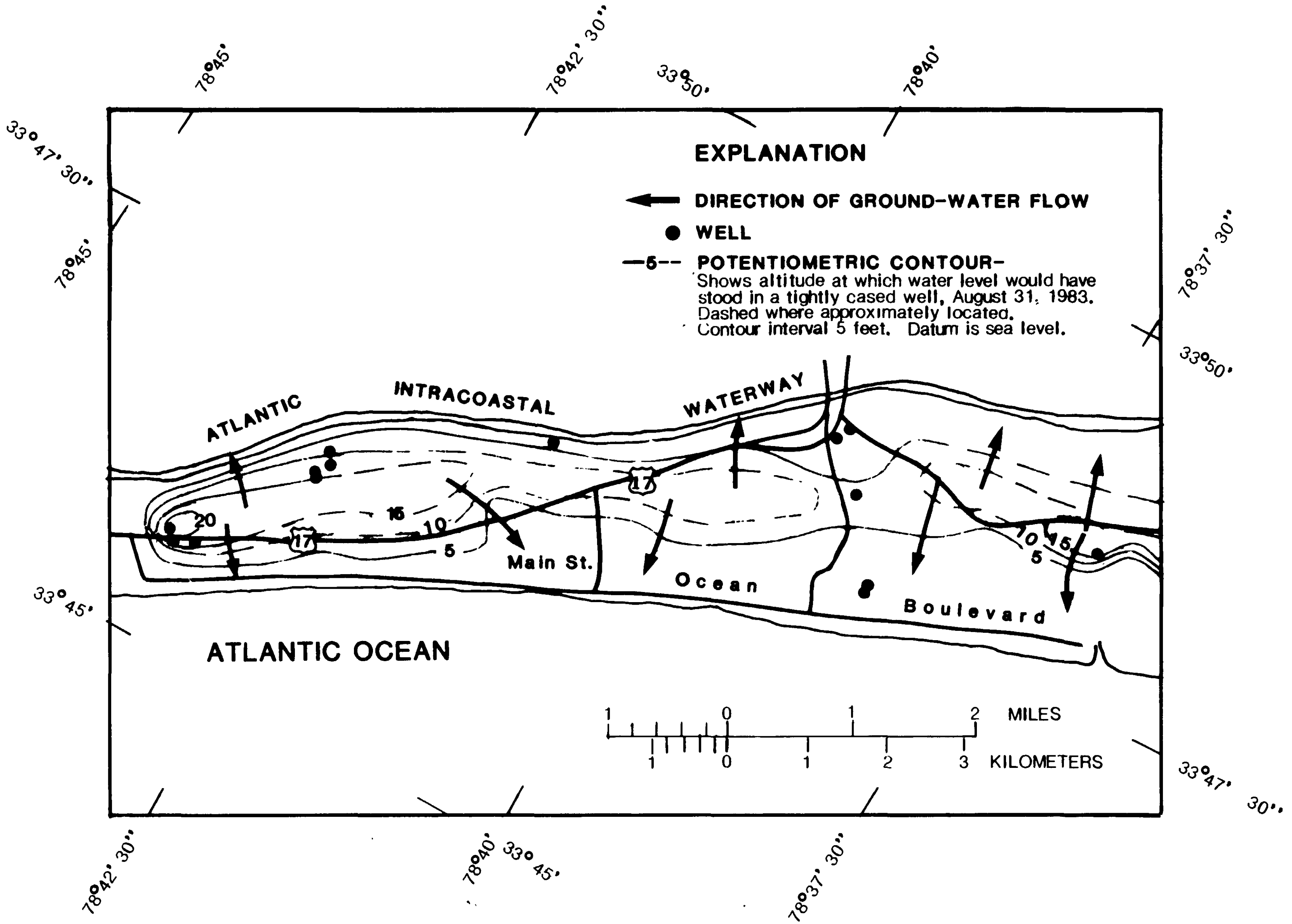

Figure 5.--The potentiometric surface of the shallow aquifer in the North Myrtle Beach area, August 31, 1983

Vertical differences in potentiometric levels in the shallow aquifers at two well clusters ranged from 0.15 to 0.98 ft downward between August 31, and December 7, 1983 (table 3 and fig. 6). The first cluster had 3 wells (HO-675, HO-676, and HO-678) screening intervals from 35 to 115 ft below land surface (table 1). The second cluster had four wells (HO-680, HO-691, HO-692, and HO-693) screening intervals from 30 to 145 ft deep (table 1). The small vertical difference in potentiometric levels within the shallow aquifers probably reflects changes in recharge, discharge, and flow through the aquifer.

Altitudes of potentiometric levels in the shallow aquifers at these clusters ranged from 1.31 to 2.91 ft above sea level during this period in comparison with potentiometric levels in the Black Creek aquifer of 25 to 50 ft below sea level in September 1982 in the North Myrtle Beach area (Pelletier, 1985a, p.21). This vertical difference in potentiometric levels between the shallow aquifers and the Black Creek aquifer results from declines in the potentiometric levels of the Black Creek aquifer, the low permeability of the intervening confining unit, and local recharge of the shallow aquifers. Although the vertical difference in potentiometric levels is large, the low permeability of the confining unit greatly limits vertical flow to the Black Creek aquifer.

Aquifer Yields

Yields from wells screened in the water-table aquifer range from a few gallons per minute to about 20 gal/min. Yields from wells screened in the shallow confined aquifers between Myrtle Beach Air Force Base and North Myrtle Beach range from little water to several hundred gallons per minute with the highest yielding wells in North Myrtle Beach and at Myrtle Beach Air Force Base screened in sand and coquina. The lowest yielding wells were located in the northern part of Myrtle Beach. The wells in the northern part of Myrtle Beach may not have been deep enough to screen the highly permeable coquina that is screened in wells in North Myrtle Beach.

The yields of 8 wells screened in the permeable parts of the shallow aquifers ranged from 12 to 200 gal/min. Specific capacities of these wells ranged from 1.5 to 10.5 (gal/min)/ft and averaged 4-5 (gal/min)/ft. One well screened in coquina in North Myrtle Beach was pumped at 500 gal/min, but no water levels that can be used to calculate a specific capacity were measured in the well.

As indicated by the range in specific capacities of wells, the hydraulic characteristics of the shallow aquifers are variable. Because of vertical variability, stratigraphically equivalent zones of high permeability may not be screened by the wells at various locations to allow a comparison of equivalent data.

Table 3.--Altitude of potentiometric levels in selected wells in the North Myrtle Beach area, August 31, 1983; November 3, 1983; and December 7, 1983

Well Number	Altitude of water surface, in feet above sea level		
	August 31, 1983	November 3, 1983	December 7, 1983
HO-220	12.10	11.1	11.42
HO-675	2.51	2.79	2.57
HO-676	2.69	2.91	2.83
HO-677	2.42	2.76	2.68
HO-678	2.54	2.82	2.59
HO-679	2.70	1.52	2.57
HO-680	2.17	1.58	2.20
HO-681	19.57	16.96	16.59
HO-691	2.22	1.49	2.18
HO-692	2.06	1.31	1.72
HO-693	2.20	2.29	2.22
HO-700	--	2.86	2.79
HO-704	--	4.04	--
HO-733	4.74	4.52	4.14
HO-736	11.52	10.38	9.82
HO-741	19.20	18.18	17.92
HO-743	3.58	4.44	4.47
HO-750	20.20	18.57	17.98
HO-751	16.69	--	--
HO-752	13.73	9.52	9.44
HO-753	10.35	13.52	13.45
HO-754	0.21	0.33	0.16

Table 3.--Altitude of potentiometric levels in selected wells in the North Myrtle Beach area, August 31, 1983; November 3, 1983; and December 7, 1983 (Continued)

Well Number	Altitude of water surface, in feet above sea level		
	August 31, 1983	November 3, 1983	December 7, 1983
HO-756	7.32	6.86	6.96
HO-757	17.84	--	16.77
HO-758	16.11	15.11	14.15
HO-765	1.01	1.78	2.78
HO-766	--	--	3.90
HO-767	--	2.39	5.36
HO-768	8.62	8.54	8.24

Ground-Water Quality

The quality of water in the shallow aquifers is affected primarily by the initial quality of the recharge water, the mineralogy of the aquifer sediments, the flushing and intrusion of saltwater, and contaminants introduced on or below land surface. Although little information is available, the quality of the recharge water probably has similar concentrations of dissolved constituents throughout the Grand Strand.

The mineralogy of the sediments is probably the most important factor influencing natural ground-water quality. Calcareous materials in the sediments are one of the major contributors to concentrations of dissolved solids. These materials contribute calcium and bicarbonate, resulting in a hard, well-buffered water. In sediments containing little calcareous material concentrations of dissolved solids are low and the water is soft and poorly buffered. Concentrations of total hardness range from 5 to 470 mg/L (as $CaCO_3$) and concentrations of total alkalinity range from 10 to 484 mg/L (as $CaCO_3$) (table 4). These large ranges are probably a result of differences in the calcite content between and within individual sand and coquina beds and of the time of contact between the water and sediments.

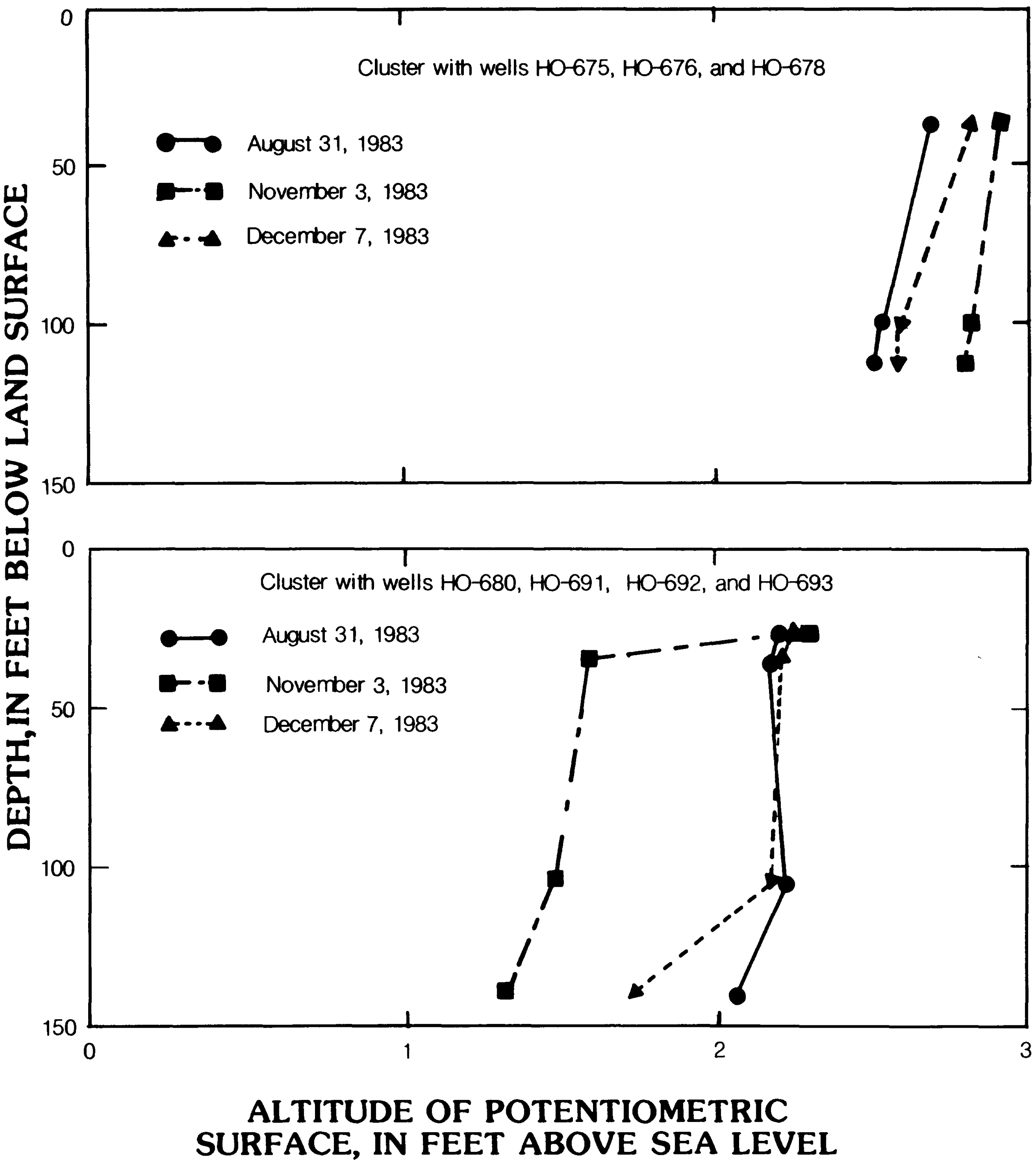

Figure 6.--Altitude of potentiometric levels at selected depths in the shallow aquifers at two well clusters in the North Myrtle Beach area, August 31, 1983; November 3, 1983; and December 7, 1983

Table 4.--Specific conductance, pH, and concentrations of major constituents in ground water of the shallow aquifers of the Grand Strand

LOCAL IDENT-I-FIER	STATION NUMBER	DATE	TEMPER-ATURE (DEG C)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
GEO- 48 BROOKGREEN NO 1	333113079053501	08-05-81	19.0	197	210	375	50	1.5
HO- 70A MYRTLE BEACH,PS	334115078540000	12-01-50	--	--	--	--	--	--
HO- 70A MYRTLE BEACH,PS	334115078540000	11-08-67	--	151	150	266	1.9	0.1
HO- 212 OCN DR BCH SCHOOL	334943078405000	07-06-56	20.5	38	34	56	3.0	1.1
HO- 219 MRYTL BCH AFB,DRL	333940078563000	10-10-57	21.0	127	120	245	13	3.2
HO- 220 NMB FFA CAMP	335102078364000	09-28-83	20.5	271	250	438	75	2.9
HO- 221 MRTL BCH AFB,D	333947078563100	09-24-58	--	90	86	128	5.6	2.9
HO- 222 MRTL BCH AFB,STP	333952078560700	03-19-57	--	67	69	134	5.3	0.4
HO- 222 MRTL BCH AFB,STP	333952078560700	09-24-58	--	79	75	122	5.6	1.9
HO- 231A BRCLIF ACRE,NMB	334805078440002	06-09-60	--	268	260	426	69	5.2
HO- 443 DOGWOOD NECK #2	334713078461200	02-22-78	17.0	--	290	540	89	2.1
HO- 481 LAKE ARROWHEAD#2	334612078471800	01-27-78	19.0	--	160	320	31	3.1
HO- 676 N.MYRTLE BEACH 2	334919078402702	08-06-81	20.0	589	610	1040	32	4.9
HO- 677 N.MYRTLE BEACH 3	334919078402703	08-06-81	20.5	796	720	1180	73	6.1
HO- 679 NMB CHERRY GROVE	334958078381705	06-16-83	--	--	--	--	--	--
HO- 680 NMB	335055078390001	06-15-83	--	--	--	--	--	--
HO- 691 NMB USGS	335055078390102	06-15-83	--	--	--	--	--	--
HO- 692 NMB USGS	335055078390304	06-15-83	--	--	--	--	--	--
HO- 700 NMB 2ND RSMARY	334927078402106	06-17-83	--	--	--	--	--	--
HO- 704 NMB 2ND OAK	334921078401900	08-25-83	18.0	213	220	315	51	2.8
HO- 707 NMB SURF IRRIG	334910078422000	08-25-83	18.0	295	--	420	88	4.0
HO- 741 NMB L. BOURNE #2	334938078432000	09-27-83	17.5	272	260	352	85	2.2
HO- 757 NMB DR. BETHEA	335101078360800	09-28-83	19.5	210	210	301	50	3.3
HO- 766 NMB SURF #1	335001078393000	09-29-83	18.5	340	330	485	97	4.7
HO- 768 NMB AIRPORT #3	334855078430102	08-26-83	18.0	673	690	830	180	4.2

Table 4.--Specific conductance, pH, and concentrations of major constituents in ground water of the shallow aquifers of the Grand Strand (Continued

LOCAL IDENT-I-FIER	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	PH (STAND-ARD UNITS)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	CAR-BONATE FET-FLD (MG/L AS CO3)	HARD-NESS (MG/L AS CACO3)
GEO- 48 BROOKGREEN NO 1	27	0.86	--	5	7.8	190	0	130
HO- 70A MYRTLE BEACH,PS	--	--	--	--	7.1	72	0	32
HO- 70A MYRTLE BEACH,PS	57	1.8	--	--	6.9	120	0	5
HO- 212 OCN DR BCH SCHOOL	6.5	0.3	130	--	6.4	12	0	12
HO- 219 MRYTL BCH AFB,DRL	28	0.9	3000	--	6.1	45	0	46
HO- 220 NMB FFA CAMP	10	0.9	--	2100	7.2	260	0	200
HO- 221 MRTL BCH AFB,D	12	0.8	580	--	5.2	12	0	26
HO- 222 MRTL BCH AFB,STP	13	0.6	6700	70	5.5	19	0	15
HO- 222 MRTL BCH AFB,STP	14	0.7	1800	--	5.5	26	0	22
HO- 231A BRCLIF ACRE,NMB	19	1.5	10	--	7.6	220	0	190
HO- 443 DOGWOOD NECK #2	19	0.9	320	330	--	260	0	230
HO- 481 LAKE ARROWHEAD#2	29	1.1	0	30	--	130	0	90
HO- 676 N.MYRTLE BEACH 2	240	5.0	--	--	7.6	410	0	100
HO- 677 N.MYRTLE BEACH 3	220	2.6	--	1800	7.2	590	0	210
HO- 679 NMB CHERRY GROVE	3100	--	--	100	--	--	--	--
HO- 680 NMB	32	--	--	5300	--	--	--	--
HO- 691 NMB USGS	44	--	--	1100	--	--	--	--
HO- 692 NMB USGS	32	--	--	2500	--	--	--	--
HO- 700 NMB 2ND RSMARY	17	--	--	330	--	--	--	--
HO- 704 NMB 2ND OAK	28	0.4	--	47	7.6	170	0	140
HO- 707 NMB SURF IRRIG	16	1.2	--	760	--	--	--	240
HO- 741 NMB L. BOURNE #2	5.5	0.4	--	1800	7.2	280	0	220
HO- 757 NMB DR. BETHEA	17	1.2	--	570	7.4	180	0	140
HO- 766 NMB SURF #1	20	1.6	--	600	7.2	330	0	260
HO- 768 NMB AIRPORT #3	20	1.1	--	35000	6.6	410	0	470

Table 4.--Specific conductance, pH, and concentrations of major constituents in ground water of the shallow aquifers of the Grand Strand (Continued

LOCAL IDENT-I-FIER	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SULFATE DIS-SOLVED (MG/L AS SO4)	SILICA, DIS-SOLVED (MG/L AS SIO2)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)
GEO- 48 BROOKGREEN NO 1	20	0.13	6.0	8.1	--	0.18	0.01	0.83
HO- 70A MYRTLE BEACH,PS	17	0.8	--	--	--	--	--	--
HO- 70A MYRTLE BEACH,PS	26	0.3	6.8	0.8	--	--	--	--
HO- 212 OCN DR BCH SCHOOL	10	0.1	1.9	5.3	--	--	--	--
HO- 219 MRYTL BCH AFB,DRL	43	0.1	5.7	8.2	--	--	--	--
HO- 220 NMB FFA CAMP	16	<0.1	9.8	7.7	--	--	--	--
HO- 221 MRTL BCH AFB,D	22	0.1	13	23	--	--	--	--
HO- 222 MRTL BCH AFB,STP	21	0.2	1.6	17	--	--	--	--
HO- 222 MRTL BCH AFB,STP	23	0.1	1.6	15	--	--	--	--
HO- 231A BRCLIF ACRE,NMB	22	0.2	26	12	--	--	--	--
HO- 443 DOGWOOD NECK #2	32	0.1	15	6.5	--	--	--	--
HO- 481 LAKE ARROWHEAD#2	18	0.1	10	6.2	--	--	--	--
HO- 676 N.MYRTLE BEACH 2	110	2.1	12	8.2	--	0.13	--	0.3
HO- 677 N.MYRTLE BEACH 3	95	0.02	16	7.7	--	0.01	1.60	1.0
HO- 679 NMB CHERRY GROVE	6300	1.0	--	--	--	--	--	--
HO- 680 NMB	37	0.1	--	--	--	--	--	--
HO- 691 NMB USGS	68	0.1	--	--	--	--	--	--
HO- 692 NMB USGS	42	<0.1	--	--	--	--	--	--
HO- 700 NMB 2ND RSMARY	22	0.1	--	--	--	--	--	--
HO- 704 NMB 2ND OAK	39	0.1	9.4	5.6	<0.01	<0.10	0.06	0.54
HO- 707 NMB SURF IRRIG	23	<0.1	10	6.9	<0.01	<0.10	0.52	0.08
HO- 741 NMB L. BOURNE #2	9.1	<0.1	7.4	8.3	--	--	--	--
HO- 757 NMB DR. BETHEA	25	<0.1	2.4	17	--	--	--	--
HO- 766 NMB SURF #1	26	<0.1	10	7.3	--	--	--	--
HO- 768 NMB AIRPORT #3	22	0.2	190	29	0.02	<0.10	1.10	1.1

The effect of dissolution of calcite is indicated by the similar concentrations of total hardness and total alkalinity of most samples (fig. 7) and the dominance of calcium and bicarbonate ions in solution (fig. 8). The dominance of calcium and bicarbonate is less in ground water with concentrations of dissolved solids less than about 150 to 200 mg/L because of the effects of sodium chloride relative to calcium bicarbonate (fig. 8). Although concentrations of sodium and chloride generally are similar in most samples, concentrations of calcium and bicarbonate increase with increased concentrations of dissolved solids. The relative effects of sodium chloride on water quality are greatest in wells having low concentrations of dissolved solids and accounts for the grouping of analyses in figure 8 that has a greater percentage of sodium chloride.

The pH and buffering of the ground water are influenced by concentrations of alkalinity and reflected by concentrations of dissolved solids. The pH of ground water with concentrations of dissolved solids less than 150 to 200 mg/L ranges from 5.2 to 6.9. The pH of ground water with concentrations of dissolved solids greater than 200 mg/L ranges from 7.2 to 7.8. The only exception is ground water from well HO-768 which has a concentration of dissolved solids of 673 mg/L and a pH of 6.6. Ground water from this well also has high concentrations of iron, manganese, sulfate, and dissolved solids, probably as a result of the effects of an old landfill in the vicinity of the well.

Sodium chloride in the ground water probably results from salt present in the rainfall near the ocean that recharges the shallow aquifers and from incomplete flushing of saltwater from the aquifer. Intrusion of saltwater probably is not a significant source of sodium chloride because there has been little ground-water pumpage from the shallow aquifers to change potentiometric gradients and induce the intrusion of saltwater (fig. 5).

Concentrations of chloride are generally less than the 250 mg/L secondary drinking-water standard (U.S. Environmental Protection Agency, 1981). Well HO-679 (fig. 4), the only well sampled with a concentration greater than the standard, had a concentration of chloride of 6,300 mg/L. This well is in an area along the coast that was originally a surface-water outlet to the ocean that has been filled either naturally or as a part of development of the area. The aquifer in this vicinity probably contained saltwater as a result of the overlying saltwater and probably has not been completely flushed since the area has been filled by sediment. Other areas immediately adjacent to the ocean, the Intracoastal Waterway, salty surface water, and surface water channels that have been filled probably have concentrations of chloride greater than the drinking-water standard. However, it appears that the aquifers generally contain water with concentrations of chloride less than the standard.

The similarity in the concentrations of total alkalinity and total hardness (fig. 7) and the usual dominance of calcium over other cations (fig. 8) indicates that little calcium-sodium exchange occurs on sodium-rich clays as in the Black Creek aquifer (Zack, 1980). Concentrations of sodium are generally less than 50 mg/L and appear to result from the presence of saltwater in samples in which concentrations of sodium are less than 50 mg/L (fig.9). The major exceptions to this are well HO-70A and wells HO-676 and HO-677 in which concentrations of sodium appear to be greater than 200 mg/L as a result of calcium-sodium exchange.

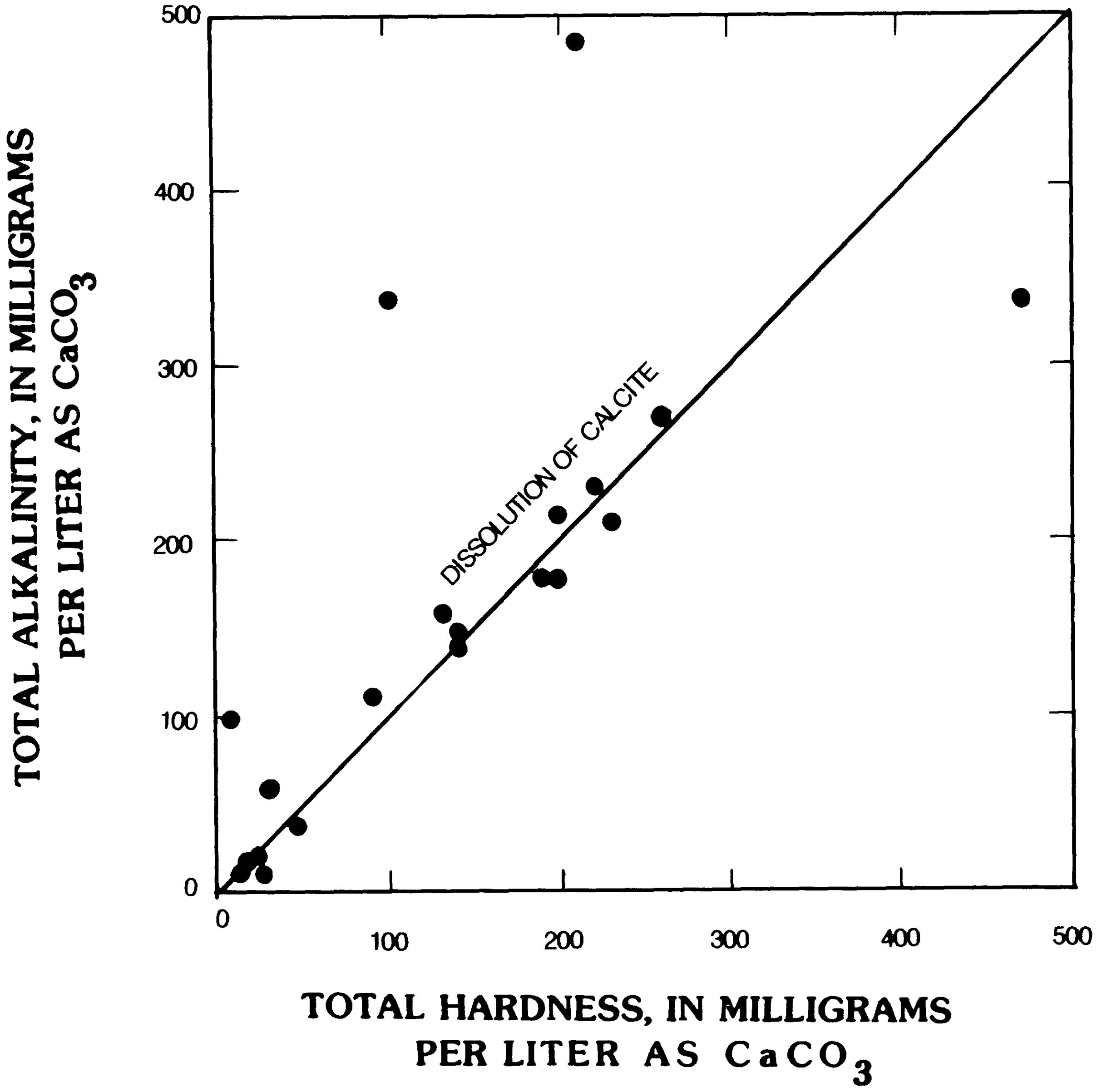

Figure 7.--Relation between concentrations of total hardness and total alkalinity in ground water of the shallow aquifers of the Grand Strand

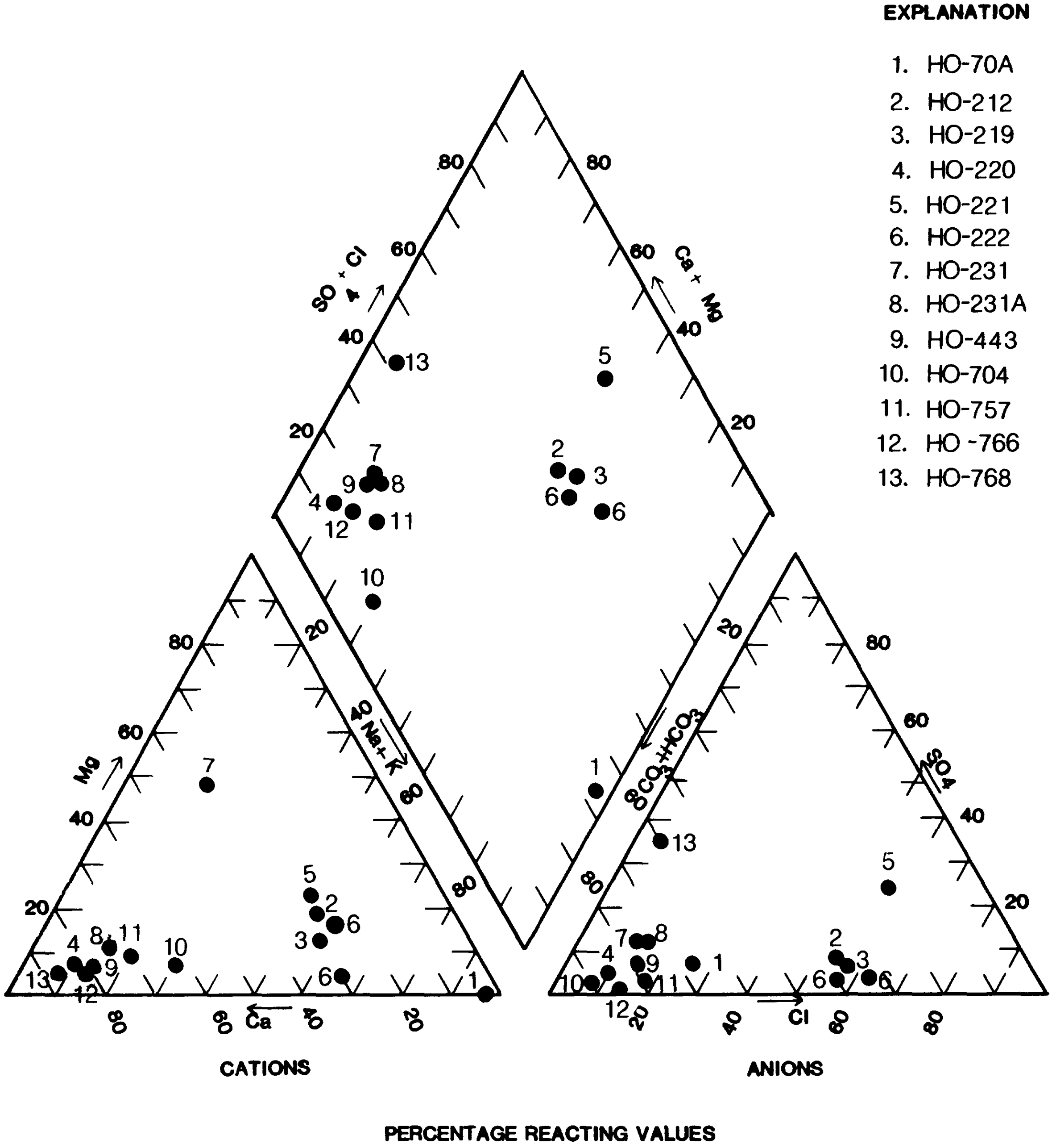

Figure 8.--Relative concentrations of major consituents in ground water of the shallow aquifers of the Grand Strand

Concentrations of fluoride are generally 0.2 mg/L or less throughout the area (table 4), much less than the maximum of 1.6 mg/L permitted by the primary drinking-water standard (U.S. Environmental Protection Agency, 1983). Water from well HO-676 with a concentration of fluoride of 2.1 mg/L was the only sample with concentrations of fluoride greater than the standard.

Concentrations of iron exceed the secondary drinking-water standard of 300 µg/L (U.S. Envrionmental Protection Agency, 1981) in many parts of the aquifers. Concentrations of iron range from 5 to 35,000 µg/L but are generally less than 2,000 µg/L (table 4). Differences in concentrations of iron probably result from differences in the geochemical environment, which in some instances may be affected by contamination of the ground water. Leachates from an old landfill may account for the concentration of 35,000 µg/L of iron in the ground water at well HO-768.

Ground-water samples from ten wells screened in the shallow aquifers also were analyzed for concentrations of heavy metals. Concentrations of beryllium, cadmium, chromium, lithium, cooper, and vanadium were less than the laboratory detection limits in samples from most wells (table 5). Of those above the detection limits, all were less than the maxim contaminant levels given in the applicable primary or secondary drinking-water standards (U.S. Environmental Protection Agency, 1981; 1983).

DISCUSSION

The shallow aquifers may be developed to meet at least part of the water-supply needs of communities in the area. Development of well fields that will yield several hundred gallons per minute of good quality water from each well depends on several factors. Well fields developed in areas of thick, areally extensive layers of high permeability coquina or coarse-grained sand would provide the greatest yields with the least drawdown. In each well field, information from test holes drilled through the full thickness of the shallow aquifers would help in determining which zones have the highest permeability.

Natural and man-induced water quality problems can be minimized by careful development of the shallow aquifers. Well fields located along the high in the potentiometric surface away from salty surface waters will have the least potential for problems resulting from saltwater intrusion. Iron may be removed by appropriate treatment if a well field is developed in an area in which concentrations are high. Contamination of wells screened in the shallow aquifers may be minimized if existing contaminant plumes such as that in the vicinity of well HO-768 are identified and avoided. Measures to minimize the potential for further contamination of the aquifers are also important because the shallow aquifers are recharged locally.

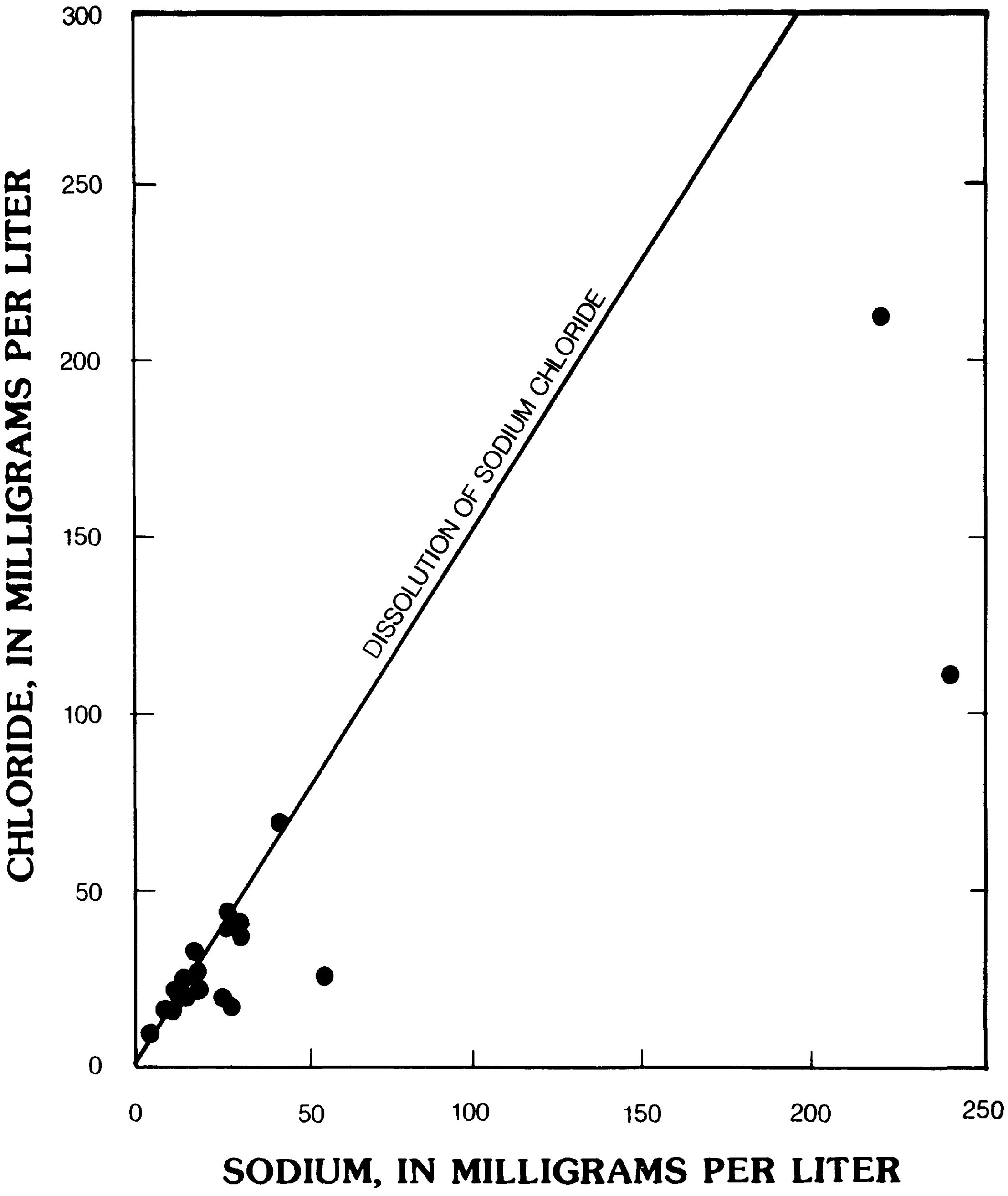

Figure 9.--Relation between concentrations of dissolved sodium and chloride in ground water of the shallow aquifers of the Grand Strand

Table 5.--Concentrations of heavy metals in ground water of the shallow aquifers of the Grand Strand

LOCAL IDENT-I-FIER	STATION NUMBER	DATE	ARSENIC DIS-SOLVED (UG/L AS AS)	BARIUM, DIS-SOLVED (UG/L AS BA)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)
GEO- 48 BROOKGREEN NO 1	333113079053501	08-05-81	--	30	<1	<1	--	<3
GEO- 82 BROOKGREEN NO 2	333059079053201	08-05-81	--	150	<1	<1	--	<3
HO- 220 NMB FFA CAMP	335102078364000	09-28-83	2	22	<0.5	<1	7	20
HO- 677 N.MYRTLE BEACH 3	334919078402703	08-06-81	--	70	<1	<1	--	20
HO- 704 NMB 2ND OAK	334921078401900	08-25-83	2	27	<0.5	<1	<1	<3
HO- 707 NMB SURF IRRIG	334910078422000	08-25-83	2	34	<0.5	<1	<1	<3
HO- 741 NMB L. BOURNE #2	334938078432000	09-27-83	2	52	<0.5	<1	<1	10
HO- 757 NMB DR. BETHEA	335101078360800	09-28-83	3	38	<0.5	<1	<1	5
HO- 766 NMB SURF #1	335001078393000	09-29-83	2	48	<0.5	<1	<1	6
HO- 768 NMB AIRPORT #3	334855078430102	08-26-83	3	64	<0.5	2	<1	<3

LOCAL IDENT-I-FIER	COPPER, DIS-SOLVED (UG/L AS CU)	LEAD, DIS-SOLVED (UG/L AS PB)	LITHIUM DIS-SOLVED (UG/L AS LI)	MERCURY DIS-SOLVED (UG/L AS HG)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	VANA-DIUM, DIS-SOLVED (UG/L AS V)	ZINC, DIS-SOLVED (UG/L AS ZN)
GEO- 48 BROOKGREEN NO 1	<10	16	4	0.2	<10	<6	<4
GEO- 82 BROOKGREEN NO 2	<10	<10	13	0.1	<10	<6	<4
HO- 220 NMB FFA CAMP	<10	10	<4	<0.1	10	7	10
HO- 677 N.MYRTLE BEACH 3	<10	14	<4	0.2	60	35	45
HO- 704 NMB 2ND OAK	<10	30	<4	0.1	<10	<6	5
HO- 707 NMB SURF IRRIG	<10	20	<4	<0.1	<10	<6	<3
HO- 741 NMB L. BOURNE #2	<10	<10	<4	<0.1	10	7	7
HO- 757 NMB DR. BETHEA	<10	<10	<4	<0.1	10	<6	94
HO- 766 NMB SURF #1	<10	<10	<4	0.1	10	<6	<3
HO- 768 NMB AIRPORT #3	<10	20	21	0.2	<10	<6	9

Maintaining and enhancing ground-water recharge in selected areas is also important for developing well fields because the aquifers are recharged locally. This can be critical because development on the Grand Strand increases the amount of surface area having a low permeability, which results in increased surface runoff and decreased ground-water recharge. Dedicating selected areas to water supply and zoning selected areas for specific uses could assist in maintaining and enhancing recharge and in minimizing the potential for contamination of the aquifers.

SUMMARY

The shallow aquifers underlying the Grand Strand have variable productivity ranging from little water to several hundred gallons per minute. These aquifers are separated from the underlying Black Creek aquifer by a 200 to 300 ft thick clay confining unit consisting of parts of the Peedee and Black Creek Formations. The shallow aquifers are recharged by local rainfall and discharge primarily into the Atlantic Ocean, the Intracoastal Waterway, and other surface waters. As a result, the shallow aquifers are essentially a hydrologic island. In the North Myrtle Beach area a vertical difference in potentiometric levels of less than 1 ft was observed within the shallow aquifers in 1983. However, vertical differences in potentiometric levels between the shallow aquifers and the Black Creek aquifer were probably from 25 to greater than 50 ft.

The quality of ground water is also variable. Calcium and bicarbonate are generally the predominant ions in solution as a result of the dissolution of calcite in the aquifer sediments. This results in a hard and well-buffered ground water. Concentrations of chloride are high in the vicinity of the salty surface waters. Concentrations of iron range from 5 to 35,000 μg/L, but are generally less than 2,000 μg/L.

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