ABSTRACT

Water-level measurements were made during 1992-94 in 253 wells completed in the Black Creek aquifer in an approximately 2,550-square-mile area of Bladen, Hoke, Robeson, and Scotland Counties in the southern Coastal Plain of North Carolina. Water levels were measured in 56 wells in the fall of 1992, 135 wells in the fall of 1993, and 62 wells in the spring of 1994 to map the potentiometric surface of the Black Creek aquifer for three different parts of these counties. The maps of the potentiometric surface can be used to infer general direction of ground-water flow from recharge areas in the uplands to discharge areas at local streams and wells. Withdrawals from wells at pumping centers, such as areas around Elizabethtown in Bladen County and Maxton and Lumberton in Robeson County, have resulted in cones of depression in the potentiometric surface, causing ground water to flow toward the pumped wells. In southwestern Bladen County, where the Black Creek aquifer is overlain by the Peedee aquifer and the Black Creek confining unit, most ground water does not discharge to local streams but flows southeastward toward the coast or is discharged from pumped wells.

Observed water-level changes in the Black Creek aquifer have been minor throughout most of Bladen, Hoke, Robeson, and Scotland Counties since 1988. However, water-level declines of about 11 feet were recorded near Lumberton during 1993-94.

INTRODUCTION

In 1992, the U.S. Geological Survey (USGS) began a 3-year investigation of water levels in the major water-supply aquifers in the southern Coastal Plain of North Carolina. The study was conducted in cooperation with the Lumber River Council of Governments (LRCOG), which comprises local governments from Bladen, Hoke, Robeson, and Scotland Counties (fig. 1). The objective of the investigation was to assess the effects of ground-water withdrawals on water levels in major aquifers in the LRCOG area, an area covering about 2,550 square miles.

This report describes water-level conditions in the Black Creek aquifer in parts of Bladen, Hoke, Robeson, and Scotland Counties, North Carolina. The results include an assessment of the effects of ground-water withdrawals on the potentiometric surface of the Black Creek aquifer during the fall of 1992, the fall of 1993, and the spring of 1994. Selected hydrographs illustrate seasonal variations and the effects of ground-water withdrawals.

The approach for the investigation was to divide the counties in the study area of the LRCOG into three study units (fig. 2). A different unit was selected for study during each year of the 3-year investigation. Water-level data for the first study unit were collected in parts of Robeson and Bladen Counties during the fall of 1992 and reported by Strickland (1994). Water-level data for the second study unit, which included parts of Hoke, western Robeson, and Scotland Counties, were collected in the fall of 1993. Water levels in the third study unit were collected during the spring of 1994; this unit included the southern parts of Bladen and Robeson Counties. Also, water-level data were collected in a few wells outside of these units to aid in the regional assessment of water-level conditions.

PHYSIOGRAPHIC SETTING

The study area is in the Coastal Plain Province of southeastern North Carolina. Stuckey (1965) recognized two physiographic subdivisions in the Coastal Plain in this area—the Inner Coastal Plain and the Sand Hills (fig. 1). The Inner Coastal Plain is in the eastern part of the study area and includes most of Bladen and Robeson Counties and parts of Hoke and Scotland Counties. This area consists of broad, flat, commonly swampy uplands between major streams. Local topographic relief is generally 5 feet (ft) or less. However, land near the major rivers, such as the Cape Fear and its tributaries, is quite dissected. In some areas, these streams may be incised 50 ft or more into the flat uplands.

The Sand Hills area is in the western part of the study area and includes the northern two-thirds of Hoke County and the northwestern half of Scotland County (Schipf, 1961). This area is characterized by rolling hills, deep sand, and sandy soils (Stuckey, 1965), upon which a dendritic drainage pattern has developed. The larger streams of the area flow eastward or southeastward across the Coastal Plain, and stream valleys are characterized by steep sides and well-developed flood plains.

HYDROGEOLOGIC SETTING

The Coastal Plain Province of North Carolina consists of a southeastward dipping and thickening wedge of predominantly unconsolidated sedimentary deposits of sand and clay underlain by basement rocks. The western boundary of these deposits is the Fall Line (fig. 1). The sedimentary deposits are divided into geologic formations based on their age and lithology. The deposits are further classified according to hydraulic and geologic characteristics and grouped into hydrogeologic units called aquifers and confining units. The basement rocks consist of metamorphic and igneous crystalline rocks of pre-Cretaceous age. The correlation of geologic and hydrogeologic units that underlie the study area is shown in figure 3.

Aquifers are composed of a formation, parts of formations, or groups of formations that (1) contain ample saturated permeable material (sand or gravel in this study area), (2) allow the lateral movement of water within them, and (3) yield significant quantities of water to wells and springs. Confining units are composed of distinctly less permeable material (clay, silty-clay, and sandy-clay beds) that restrict the movement of water between adjacent aquifers.

Winner and Coble (1989) identified six aquifers in the study area—the surficial, Yorktown, Peedee, Black Creek, upper Cape Fear, and lower Cape Fear aquifers—separated by five confining units (figs. 3 and 4). Each confining unit is informally named for the aquifer it overlies. The Yorktown aquifer is not present in most of the study area except in Robeson County near the South Carolina State line.

The surficial aquifer is an unconfined aquifer that consists generally of thin hydrogeologic units near land surface. The water table, which is the upper surface of the water in the surficial aquifer, is at atmospheric pressure. Unconfined conditions may occur in the Yorktown, Peedee, and Black Creek aquifers where they lie at shallow depths and where their respective confining units are missing. An aquifer that occurs beneath confining units is called a confined aquifer. The ground water in a confined aquifer is at a pressure greater than atmospheric.

Where present, the Black Creek confining unit overlies the Black Creek aquifer and is composed of clay, silty-clay, and sandy-clay beds (Winner and Coble, 1989). It ranges in thickness from zero to 50 ft.

The Black Creek aquifer is the major source of water for public, industrial, and agricultural uses in the study area and is emphasized in this report. The Black Creek aquifer ranges in thickness from about 100 to 250 ft and consists mainly of sediments of both the Black Creek and the underlying Middendorf Formations of Cretaceous age (Winner and Coble, 1989). The Black Creek Formation is composed of thinly laminated gray to black clay interlayered with gray to tan sand. The lagoonal or marine origin of the Black Creek Formation is reflected by the shell and organic material, such as lignitized wood, common in these sediments. The Middendorf Formation, which outcrops to the west of the Black Creek Formation in the Sand Hills area, is composed of fluvial sediments of nonmarine origin; these include fine- to medium-grained sand beds, interlayered with silty-clay beds and thinly laminated beds of sand and clay.

DATA COLLECTION AND ANALYSIS

Wells used during the study included North Carolina Department of Environment, Health, and Natural Resources (DEHNR) observation wells and industrial, municipal, county, and privately owned water-supply wells. To ensure that water levels from water-supply wells closely represented stable conditions in the wells, pumps were turned off at least 20 minutes prior to measuring the water levels. If two consecutive measurements taken about 5 minutes apart differed by less than 0.1 ft, then the water levels were considered representative of nonpumping (quasi-static) conditions.

Water levels were measured in 56 wells in the fall of 1992 (table 1), 135 wells in the fall of 1993 (table 2), and 62 wells in the spring of 1994 (table 3). Water levels in many of these wells also were measured in the fall of 1988 (Strickland and others, 1992). Of these wells, six are located outside of the LRCOG area—three in Columbus County, North Carolina, and three in Dillon County, South Carolina (fig. 5). Two wells were equipped with water-level recorders set to automatically record water levels at 1-hour intervals, and four wells were measured on a periodic basis to monitor water-level fluctuations in the Black Creek aquifer during the 3-year study (fig. 5).

The water level measured in a well represents the hydraulic head in the screened part of the aquifer. This water level is a function of the elevation of the screened part of the well and the pressure within the aquifer. The water level measured in a well that taps an unconfined aquifer indicates the altitude of the water table in the surrounding aquifer. Below the water table, the pressure is greater than atmospheric and increases with increasing depth. In confined aquifers, which are generally deeper aquifers, the altitude of water in a tightly cased, nonpumped well will stand above the top of the aquifer; this hydraulic head defines a point on the potentiometric surface of an aquifer. A map of the potentiometric surface depicts the areal distribution of hydraulic heads and can be used to infer the direction of ground-water movement in an aquifer. Lines of equal hydraulic head in the aquifer are represented by potentiometric-surface contours on these maps. Ground water flows through an aquifer from areas of high hydraulic head to areas of low hydraulic head. The direction of flow is assumed to be perpendicular to the potentiometric-contour lines.

The water-level data were used to construct three maps of the potentiometric surface of the Black Creek aquifer—one for each study unit (fig. 5). Because water-level data were collected during three different time periods, the maps of the potentiometric surface were constructed such that the potentiometric contours do not cross over into adjacent study units. However, there was some overlap of the study units (fig. 2). Water levels in several wells were measured more than once during different data-collection periods (table 4). Where multiple measurements were available, the latest water-level measurement was used to construct the potentiometric surface. Thus, the potentiometric surface configuration of the Black Creek aquifer during the fall of 1992 is slightly different in some areas from that reported by Strickland (1994) because of the additional water-level data.

Well-construction data, including depths of casing and screened intervals, also were collected. By using the Coastal Plain hydrogeologic framework developed by Winner and Coble (1989), each well was assigned a primary aquifer based on the position of the screened interval. Most wells are screened in only one aquifer, but several wells are screened in multiple aquifers (tables 1 and 3). Water levels measured in these wells represent a combination of hydraulic heads in the screened interval. Hydraulic heads in a single aquifer at some distance from these wells are likely different from the composite hydraulic heads.

The locations of many wells, mainly in the second and third study units, were determined by using the Global Positioning System (GPS). This technology, which uses information from satellites to compute geographic positions, can determine latitude and longitude coordinates. Latitude and longitude coordinates obtained by using GPS are listed in tables 1-3 and may be different from those reported by Strickland (1994). Land-surface altitudes at well sites, which had not been surveyed to the nearest one-tenth of a foot, were estimated to the nearest foot from USGS 7.5-minute topographic quadrangle maps having 5- or 10-ft contour intervals.

Hydraulic heads were computed by subtracting the water levels in the wells, in feet below land surface, from land-surface altitudes at the wells, in feet above sea level. These values are reported to the nearest foot (tables 1-3).

Ground-water flow in the Black Creek aquifer is controlled by recharge, discharge to perennial streams, and pumped wells. In areas away from pumping centers, the natural pattern of ground-water flow is not disrupted, and hydraulic heads in nonpumped wells near streams are slightly to substantially higher than the stream stage. Therefore, to construct potentiometric contours, the hydraulic head in the unconfined part of the aquifer along a stream was assumed to be slightly greater than the altitude of the stream.

Withdrawals from an aquifer can modify the natural pattern of ground-water flow. Pumping water from an aquifer can cause hydraulic heads to decline in the vicinity of the wells being pumped. If the hydraulic heads decline, the potentiometric surface of the aquifer is depressed so that it resembles the shape of an inverted cone which has its lowest point at the center of pumping. Such a configuration is referred to as a cone of depression.

WATER-LEVEL CONDITIONS IN THE BLACK CREEK AQUIFER

The potentiometric surface of the Black Creek aquifer throughout the mapped area in Hoke, Robeson, and Scotland Counties and parts of Bladen County (fig. 5) shows that ground water flows from areas of high hydraulic head to areas of low hydraulic head. Where potentiometric contours cross streams, they bend upstream, indicating that ground water is discharging from the aquifer into the streams. In the highly dissected Sand Hills area, the aquifer is unconfined in stream valleys where streams have cut through the Black Creek confining unit (Winner and Coble, 1989). Evidence for the unconfined condition of the Black Creek aquifer is shown in figure 5 where the orientation of the potentiometric contours are closely spaced and strongly influenced by the topography of the streams. Also, farther east in Bladen County, the channel of the Cape Fear River between the Cumberland-Bladen County Line and Elizabethtown is cut through the Black Creek confining unit to allow direct hydraulic connection between the river and the Black Creek aquifer (Winner and Coble, 1989). Evidence of this hydraulic connection is shown by the closely spaced potentiometric contours along the Cape Fear River.

The natural flow is disrupted around pumping centers where ground water is discharged from pumped wells. Withdrawals from wells at pumping centers in the Elizabethtown and Lumberton areas have resulted in substantial cones of depression in the potentiometric surface of the Black Creek aquifer. In the fall of 1992, the lengths of the major axes of the cones of depression were about 4 and 6 miles (mi) long beneath the Elizabethtown and Lumberton areas, respectively (Strickland, 1994).

At a pumping center in western Robeson County, withdrawals from the Black Creek aquifer 3 mi north of Maxton (area A, fig. 5) averaged 5 to 6 million gallons per day (Mgal/d) during the fall of 1993 (Mr. Myron Neville, oral commun., 1995); however, the cone of depression that developed around this well field was not extensive in the fall of 1993. The effects of pumping on the potentiometric surface at other local pumping centers were not mappable at 10- or 20-ft contour intervals. These included pumping centers at Laurinburg (area C, fig. 5) and east of Laurinburg (area B, fig. 5) in Scotland County, and Raeford (area D, fig. 5) in Hoke County. Withdrawals at these pumping centers averaged 2.7 Mgal/d (Mr. Robert Ellis, oral commun., 1995), 1.1 Mgal/d (Mr. Gary Arnett, oral commun., 1995), and 1.5 Mgal/d (Mr. Jimmy Allen, oral commun., 1995), respectively, during 1993.

In the mapped part of southwestern Bladen County (fig. 5), the Black Creek aquifer is overlain by the Peedee aquifer and the Black Creek confining unit. Most water in this part of the Black Creek aquifer does not discharge to local streams but flows southeastward toward the coast or is discharged from pumped wells, such as those in Clarkton (fig. 5) where the observed water level declined 1 ft between the fall of 1988 and the spring of 1994 (well BL-22, table 5). This change could have been a seasonal response with little or no influence from pumping.

During the fall of 1993 and the spring of 1994, observed water levels in the Black Creek aquifer at or near pumping centers in southern Bladen, Hoke, western Robeson, and Scotland Counties were similar or slightly higher than those measured in the fall of 1988 (table 5). An example of this is observation well HO-47, which is near water-supply wells in and around the northwestern part of Raeford in Hoke County. The observed water level at this site was 0.3 ft higher in October 1993 than in December 1988 (table 5). The hydrograph for well HO-47 (fig. 6) indicates that the water level in the Black Creek aquifer responded to withdrawals for water supply and seasonal climatic effects from October 1993 through November 1994. The steep water-level declines and rises of about 1 to 2 ft that occurred over time periods of about 1 week were caused by pumping at nearby wells. The more long-term decline and rise of water levels of about 2 to 3 ft represents seasonal fluctuations. Ground-water level declines are caused by discharge, both natural and from pumping, that exceeds recharge to the aquifer, and water-level rises are caused by recharge that exceeds discharge. The observed water-level trend at observation well HO-47 from October 1993 through November 1994 indicates that recharge to the Black Creek aquifer exceeded discharge.

In most areas away from pumping centers, observed water-level changes have been minor since 1988 (fig. 5; table 5). Hydrographs for observation wells CO-125 and RB-168 (fig. 6) indicate that water-level fluctuations are caused largely by seasonal variation in ground-water recharge.

The hydrograph for observation well RB-185 (fig. 6), which is located approximately 4 mi east of Lumberton, shows considerable water-level fluctuations in the Black Creek aquifer from September 1992 through December 1994. These fluctuations appear to be the result of nearby pumping and seasonal variation. During this period of record, water-level declines of about 11 ft were recorded between May 1993 and December 1994. The greatest decline, about 9 ft, occurred from May 1993 through November 1993.

In northwestern Bladen County near Tar Heel, the observed water level in well BL-153 declined about 5 ft between September 1992 and June 1993, and then remained fairly steady through October 1994. Major withdrawals, which began in mid-October 1992, from the aquifer below the Black Creek, the upper Cape Fear aquifer, have increased to approximately 2.3 Mgal/d in 1994 in the Tar Heel area (Strickland, 1995). The observed water level in the upper Cape Fear aquifer near the center of pumping declined 90.6 ft between September 1992 and October 1994 in observation well BL-142, which is located about 1,300 ft northwest of well BL-153 (figs. 5 and 7). The data suggest that this pumping resulted in a large vertical hydraulic gradient between the aquifers near the pumping center and induced leakage of ground water from the Black Creek aquifer through the confining unit into the upper Cape Fear aquifer. This leakage caused the lowering of the hydraulic head in the Black Creek aquifer and, therefore, in the water level in well BL-153. This interpretation is supported by the fact that the large decline in water level in the upper Cape Fear aquifer between September 1992 and June 1993 coincided with the greatest amount of water-level decline in well BL-153 (fig. 7). Also, between June 1993 and October 1994, the relatively small water-level decline in the upper Cape Fear aquifer coincided with a fairly steady water level in well BL-153.

At Rowland in southwestern Robeson County, the observed water level in the Black Creek aquifer declined 1.3 ft in well RB-84 between the fall of 1988 and the spring of 1994 (table 5). However, the water level in observation well RB-148, which is located about 1 mi south-southeast of well RB-84, declined 5.4 ft during this same period (table 5). Observed water-level declines in well RB-148, which declined 11.1 ft between July 1981 and October 1994 (fig. 6), are likely a result of pumping by several users in South Carolina. These withdrawals have caused a regional cone of depression to develop that has extended into North Carolina near Rowland (fig. 5).

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

Table 1. Selected records for wells in the Black Creek aquifer in Bladen and Robeson Counties, September-October 1992

[Well number refers to well location in figure 5; BL, Bladen County; RB, Robeson County]

Well number	Latitude	Longitude	Altitude of land surface (feet above sea level)	Date of water-level measurement	Water level (feet below or above (-) land surface)	Hydraulic head (feet above or below (-) sea level)
BL-56	34°40'45"	78°35'44"	72	9-92	20.9	51
BL-98	34°43'33"	78°47'29"	125	9-92	25.9	99
[a]BL-121	34°37'26"	78°36'02"	120	9-92	105.8	14
[a]BL-127	34°38'37"	78°38'36"	130	9-92	180.4	-50
[a]BL-129	34°38'53"	78°38'43"	135	9-92	185.6	-51
BL-132	34°45'24"	78°48'24"	130	9-92	61.2	69
BL-143	34°45'03"	78°44'09"	84	9-92	21	63
BL-146	34°38'23"	78°44'22"	139.8	9-92	24.7	115
[b]BL-149	34°36'52"	78°36'32"	105	9-92	67.2	38
BL-151	34°45'39"	78°48'12"	142	9-92	81.3	61
BL-153	34°44'30"	78°48'18"	128	9-92	50.1	78
BL-154	34°48'57"	78°50'33"	128	10-92	22.6	105
BL-160	34°41'04"	78°47'47"	131	10-92	21.5	110
BL-162	34°49'11"	78°48'06"	75	10-92	35.1	40
BL-167	34°37'53"	78°43'13"	128	10-92	16.1	112
BL-168	34°39'35"	78°45'39"	135	9-92	15.1	120
BL-169	34°42'45"	78°48'55"	135	9-92	14.7	120
BL-171	34°43'06"	78°45'06"	150	3-93	106.1	44
RB-90	34°48'17"	78°58'21"	165	10-92	17.9	147
RB-92	34°48'30"	78°59'07"	175	10-92	22.7	152
RB-97	34°35'31"	79°00'11"	117	10-92	63.5	54
RB-98	34°35'12"	79°00'09"	112	10-92	65.5	47
RB-100	34°35'28"	79°00'05"	117	10-92	65.2	52
RB-104	34°37'24"	79°04'32"	126.6	10-92	6.6	120
RB-113	34°39'05"	78°55'13"	150	10-92	42.3	108
RB-115	34°33'56"	78°59'39"	114	10-92	54.4	60
RB-117	34°47'55"	78°56'17"	158	10-92	18.4	140
RB-130	34°36'08"	79°05'50"	129.6	10-92	19.9	110
RB-157	34°42'36"	79°00'07"	149.4	10-92	3.2	146
RB-185	34°38'40"	78°55'00"	142	9-92	29.9	112
RB-195	34°37'52"	79°01'37"	110	10-92	27.6	82
RB-198	34°37'50"	79°01'53"	107	10-92	28.6	78
RB-200	34°37'53"	79°02'03"	117	10-92	17.6	99
RB-202	34°38'00"	79°01'52"	105	10-92	22.2	83
RB-207	34°39'28"	79°04'14"	122	10-92	-1.1	123
RB-208	34°39'50"	79°05'52"	148	10-92	11.2	137
RB-209	34°39'32"	79°06'31"	152	10-92	15.4	137
RB-210	34°39'22"	79°05'50"	150	10-92	15	135
RB-211	34°42'08"	79°01'99"	150	10-92	9.8	140
RB-213	34°41'19"	79°03'55"	147	10-92	15.4	132
RB-215	34°39'21"	79°03'44"	124	10-92	4.7	119
RB-216	34°40'44"	79°07'26"	158	10-92	7.8	150
RB-217	34°46'10"	78°55'05"	160	10-92	17.8	142
RB-221	34°36'23"	78°58'32"	151	10-92	34.6	116
RB-222	34°44'45"	78°57'29"	150	10-92	8.6	141
RB-226	34°35'17"	78°58'27"	132	10-92	64.5	68
RB-233	34°38'00"	79°02'14"	116	10-92	21.8	94
RB-234	34°37'42"	79°01'31"	112	10-92	33.8	78
RB-236	34°37'25"	79°01'03"	110	10-92	38.9	71
RB-239	34°41'02"	79°03'31"	152	10-92	25	127
RB-240	34°39'27"	78°55'12"	152	10-92	48.2	104
RB-241	34°48'03"	78°54'08"	140	10-92	12.5	128
RB-242	34°48'09"	78°53'44"	133	10-92	19.5	114
RB-243	34°48'19"	78°53'50"	137	10-92	15.8	121
RB-244	34°48'14"	78°53'54"	134	10-92	11.6	122
RB-245	34°36'47"	79°00'02"	114	10-92	51.2	63

[a]Well screened in the Black Creek, the upper Cape Fear, and the lower Cape Fear aquifers.
[b]Well screened in the Black Creek and the upper Cape Fear aquifers.

Table 2. Selected records for wells in the Black Creek aquifer in Hoke, Robeson, and Scotland Counties, October-December 1993

[Well number refers to well location in figure 5; HO, Hoke County; RB, Robeson County; SC, Scotland County]

Well number	Latitude	Longitude	Altitude of land surface (feet above sea level)	Date of water-level measurement	Water level (feet below or above (-) land surface)	Hydraulic head (feet above or below (-) sea level)
HO-22	34°58'57"	79°14'01"	258	11-93	34.5	224
HO-32	35°03'17"	79°21'35"	350	12-93	3.2	347
HO-35	34°58'20"	79°14'12"	251	11-93	27.4	224
HO-36	34°59'00"	79°14'16"	276	11-93	52.3	224
HO-37	34°58'07"	79°13'42"	248	11-93	31.1	217
HO-38	34°58'15"	79°13'48"	248	11-93	29.6	218
HO-40	34°59'15"	79°14'43"	290	11-93	66.3	224
HO-47	34°59'34"	79°14'42"	274.4	10-93	42.5	232
HO-48	34°56'52"	79°07'40"	225	10-93	12.1	213
HO-51	34°59'03"	79°16'08"	295.2	11-93	30.8	264
HO-52	34°58'41"	79°15'35"	277.5	11-93	41.5	236
HO-53	34°58'40"	79°16'07"	286.3	11-93	49.6	237
HO-54	34°52'39"	79°17'10"	241	12-93	11	230
HO-55	34°57'27"	79°02'24"	175	10-93	33.8	141
HO-60	34°58'58"	79°14'33"	270	11-93	49.5	221
HO-61	34°59'08"	79°16'49"	296.2	11-93	27.2	269
HO-62	34°58'46"	79°16'55"	284	11-93	30.6	253
HO-64	34°58'18"	79°15'26"	268	11-93	24.5	244
HO-65	34°59'11"	79°14'21"	281	11-93	51.9	229
HO-66	34°58'39"	79°11'45"	190	10-93	20	170
HO-70	34°59'40"	79°19'28"	354	12-93	63	291
HO-72	34°52'33"	79°13'19"	225	12-93	16.6	208
HO-75	34°54'03"	79°14'55"	233	12-93	15.3	218
HO-76	34°56'09"	79°20'43"	265	12-93	30.3	235
HO-77	34°58'33"	79°19'49"	341	12-93	51.6	289
HO-78	34°59'19"	79°11'44"	223	12-93	33.9	189
HO-79	34°53'26"	79°10'42"	218	12-93	13.8	204
HO-80	34°59'33"	79°12'14"	234	10-93	43.3	191
HO-81	34°59'28"	79°11'56"	237	10-93	44.8	192
HO-82	34°56'37"	79°15'17"	232	10-93	5	227
HO-83	34°57'21"	79°02'57"	190	11-93	45.1	145
HO-84	34°57'57"	79°22'04"	254	12-93	22	232
HO-85	34°57'54"	79°21'56"	240	12-93	8.9	231
HO-86	34°59'14"	79°21'30"	316	12-93	32.3	284
HO-87	34°59'52"	79°08'39"	224	10-93	38.8	185
HO-88	35°00'00"	79°08'31"	210	10-93	24	186
HO-89	34°54'15"	79°12'40"	225	10-93	14	211
HO-90	35°01'11"	79°07'50"	175	11-93	4.9	170
HO-92	35°01'16"	79°09'19"	250	10-93	20.3	230
HO-93	35°01'09"	79°08'11"	242	11-93	28.2	214
HO-95	35°01'12"	79°06'54"	250	10-93	36	214
HO-96	35°00'04"	79°06'33"	242	10-93	47.9	194
HO-97	35°02'44"	79°06'48"	271	10-93	42.7	228
HO-100	35°02'49"	79°07'10"	274	10-93	39.1	235
HO-102	34°59'23"	79°04'02"	200	10-93	16	184
HO-103	35°03'33"	79°22'55"	391	12-93	53.3	338
HO-104	35°01'26"	79°22'02"	342	10-93	35.6	306
HO-106	34°52'57"	79°14'00"	231	12-93	14.6	216
HO-107	35°02'12"	79°18'03"	347	12-93	54.4	293
HO-108	35°01'43"	79°22'16"	291	12-93	14.2	277
HO-109	34°59'41"	79°05'49"	224	10-93	27	197
HO-110	35°02'19"	79°06'56"	273	10-93	43.8	229
HO-111	34°52'53"	79°12'30"	233	10-93	24.3	209
HO-113	35°00'55"	79°11'16"	283	10-93	43.1	240
HO-114	35°02'10"	79°06'45"	262	10-93	25.2	237
HO-117	34°57'18"	79°02'23"	130	10-93	5.8	124
HO-119	34°59'58"	79°15'00"	272	10-93	55.2	217
HO-121	34°59'36"	79°11'01"	259	11-93	30.3	229
HO-122	34°59'02"	79°10'48"	236	12-93	33	203
HO-123	34°59'11"	79°10'13"	245	12-93	40.6	204
HO-125	35°02'40"	79°08'20"	251	11-93	35	216
HO-126	34°58'33"	79°07'06"	173	12-93	18	155
HO-128	34°58'37"	79°07'11"	203	12-93	45.5	158
HO-129	34°57'00"	79°02'33"	136	11-93	5.9	130
RB-87	34°40'52"	79°11'42"	172	12-93	12.4	160
RB-106	34°39'08"	79°25'24"	166	12-93	16.5	150
RB-108	34°46'23"	79°19'44"	190	11-93	18.8	171
RB-116	34°52'33"	78°58'40"	180	12-93	28.2	152
RB-121	34°40'46"	79°10'56"	167	12-93	9.3	158
RB-131	34°52'53"	79°06'47"	204	12-93	11.2	193
RB-134	34°48'45"	79°12'38"	205	10-93	14	191
RB-165	34°52'18"	79°05'52"	201	12-93	12.6	188
RB-168	34°50'35"	79°05'16"	187.3	11-93	6.4	181
RB-174	34°54'29"	79°00'24"	184	12-93	5.9	178
RB-205	34°46'52"	79°18'23"	212	11-93	19.5	193
RB-206	34°46'28"	79°18'01"	203	11-93	8	195
RB-246	34°46'38"	79°19'45"	192	11-93	27.2	165
RB-247	34°46'44"	79°19'37"	192	11-93	23.4	169
RB-248	34°46'57"	79°19'37"	193	11-93	26.3	167
RB-249	34°47'07"	79°19'47"	194	11-93	26.2	168
RB-251	34°52'39"	79°05'22"	200	12-93	14.6	185
RB-252	34°52'00"	79°06'14"	186	12-93	3	183
RB-253	34°53'13"	79°00'54"	178	12-93	10.4	168
RB-255	34°48'22"	79°11'36'	204	10-93	20.8	183
RB-256	34°48'24"	79°11'48"	203	10-93	19.6	183
RB-260	34°40'00"	79°12'12"	165	12-93	15.8	149
RB-262	34°41'29"	79°15'22"	160	12-93	-2.7	163
RB-264	34°46'21"	79°19'24"	195	12-93	10	185
RB-265	34°56'50"	79°02'33"	144	11-93	8.2	136
RB-303	34°44'21"	79°21'05"	196	11-93	19.7	176
SC-40	34°45'17"	79°28'03"	210	10-93	21.7	188
SC-61	34°53'15"	79°21'40"	227	12-93	10.8	216
SC-63	34°53'32"	79°26'45"	275	12-93	32.3	243
SC-64	34°54'30"	79°25'01"	276	12-93	10.1	266
SC-65	34°44'28"	79°30'41"	190	12-93	9.2	181
SC-68	34°45'21"	79°27'37"	215	12-93	16.5	199
SC-69	34°44'59"	79°28'03"	212	12-93	23.1	189
SC-70	34°42'37"	79°24'52"	190	11-93	16.2	174
SC-72	34°45'20"	79°36'47"	245	11-93	17.1	228
SC-73	34°45'39"	79°35'53"	252	11-93	26.9	225
SC-74	34°46'41"	79°25'10"	210	12-93	6.4	204
SC-77	34°43'02"	79°23'46"	187	11-93	11.1	176
SC-85	34°44'49"	79°28'16"	206	12-93	20.7	185
SC-86	34°44'33"	79°28'32"	205	12-93	23.2	182
SC-87	34°44'18"	79°28'47"	211	12-93	21.3	190
SC-88	34°44'08"	79°29'12"	207	12-93	13.8	193
SC-89	34°44'51"	79°28'39"	205	12-93	19.7	185
SC-90	34°43'43"	79°29'17"	205	12-93	21	184
SC-92	34°50'14"	79°30'27"	251	12-93	23.5	228
SC-94	34°49'20"	79°31'28"	250	12-93	36.8	213
SC-96	34°41'23"	79°31'41"	200	12-93	23.9	176
SC-97	34°49'13"	79°31'49"	200	12-93	5.5	195
SC-98	34°41'50"	79°29'08"	195	12-93	14.7	180
SC-99	34°49'13"	79°25'08"	197	12-93	2.9	194
SC-100	34°52'06"	79°24'27"	230	12-93	4.7	225
SC-101	34°52'30"	79°25'17"	250	12-93	17.5	233
SC-103	34°57'13"	79°26'47"	360	12-93	44	316
SC-104	34°57'23"	79°26'11"	365	12-93	53	312
SC-105	34°50'07"	79°28'09"	250	12-93	20.4	230
SC-106	34°53'13"	79°22'09"	235	12-93	14.8	220
SC-107	34°53'12"	79°22'21"	235	12-93	15	220
SC-108	34°46'43"	79°29'12"	230	12-93	9.8	220
SC-110	34°48'19"	79°23'10"	220	12-93	24.9	195
SC-111	34°47'51"	79°24'42"	230	12-93	27.9	202
SC-112	34°52'29"	79°20'47"	220	12-93	11.6	208
SC-113	34°52'08"	79°21'06"	221	12-93	8.6	212
SC-115	34°42'36"	79°33'09"	210	12-93	18.5	192
SC-116	34°48'35"	79°31'31"	227	12-93	17.9	209
SC-117	34°48'44"	79°32'42"	241	12-93	28.8	212
SC-118	34°48'20"	79°32'43"	255	12-93	44.1	211
SC-119	34°47'17"	79°21'47"	211	12-93	14.3	197
SC-121	34°46'00"	79°22'12"	212	12-93	32	180
SC-123	34°46'03"	79°22'25"	198	12-93	16.4	182
SC-126	34°46'14"	79°22'29"	186	12-93	16	170
SC-127						

Table 3. Selected records for wells in the Black Creek aquifer in Bladen, Columbus, and Robeson Counties, North Carolina, and Dillon County, South Carolina, March-April 1994

[Well number refers to well location in figure 5; BL, Bladen County; CO, Columbus County; RB, Robeson County; DIL, Dillon County]

Well number	Latitude	Longitude	Altitude of land surface (feet above sea level)	Date of water-level measurement	Water level (feet below or above (-) land surface)	Hydraulic head (feet above or below (-) sea level)
North Carolina						
BL-22	34°29'24"	78°39'30"	95	03-94	23.2	72
BL-23	34°29'38"	78°39'19"	90	03-94	30.1	60
[a]BL-27	34°31'46"	78°47'57"	117	03-94	8.9	108
[a]BL-79	34°29'11"	78°39'39"	92	03-94	17.8	74
BL-173	34°31'33"	78°44'45"	121	03-94	26.5	95
BL-174	34°35'49"	78°44'02"	125	03-94	14.2	111
BL-175	34°33'40"	78°44'39"	118	03-94	1	117
BL-178	34°31'20"	78°37'00"	116	04-94	37.5	79
BL-179	34°38'00"	78°42'09"	130	04-94	19.8	110
BL-181	34°35'21"	78°40'29"	125	04-94	18.5	107
BL-183	34°28'56"	78°42'46"	125	04-94	40.6	84
BL-184	34°32'38"	78°51'02"	106	04-94	7.1	99
BL-185	34°29'03"	78°49'57"	106	04-94	3.9	102
BL-186	34°36'03"	78°48'27"	120	04-94	7.4	113
CO-88	34°18'41"	79°01'47"	64	03-94	7.5	57
CO-125	34°25'07"	78°36'10"	105.8	04-94	34.4	71
CO-148	34°28'25"	78°51'15"	104	04-94	5.9	98
RB-29	34°38'07"	79°14'49"	163	04-94	13.9	149
RB-69	34°33'23"	79°08'36"	138	03-94	25.8	112
RB-83	34°29'50"	79°06'38"	118	03-94	32.1	86
RB-84	34°32'32"	79°17'38"	150	03-94	36.7	113
RB-119	34°35'53"	79°12'15"	150	03-94	26.9	123
RB-122	34°29'19"	79°02'52"	126	03-94	22.1	104
RB-123	34°30'40"	79°08'16"	130	03-94	31.6	98
RB-124	34°26'38"	79°04'44"	129	03-94	36.9	92
RB-127	34°35'35"	78°55'29"	135	03-94	46.4	89
RB-139	34°22'23"	79°07'39"	90.6	04-94	13.3	77
RB-148	34°31'55"	79°17'47"	143.2	04-94	39.2	104
RB-161	34°30'31"	79°07'08"	129	03-94	35.7	93
RB-162	34°40'46"	79°14'13"	158	04-94	-3.3	161
RB-250	34°28'03"	79°12'14"	152	03-94	62.7	89
RB-257	34°37'42"	79°22'15"	150	03-94	14.1	136
RB-258	34°37'29"	79°23'11"	160	03-94	23.5	137
RB-266	34°30'19"	79°18'19"	131	03-94	38.9	92
RB-267	34°34'49"	79°09'34"	148	03-94	23.6	124
RB-269	34°35'14"	79°19'13"	136	03-94	3.4	133
RB-270	34°33'27"	79°01'52"	123	03-94	37.4	86
RB-273	34°33'28"	79°15'03"	118	03-94	-0.9	119
RB-275	34°23'32"	79°02'22"	114	03-94	34.7	79
RB-276	34°25'57"	79°12'57"	120	03-94	30.8	89
RB-27[illegible]	[illegible]	[illegible]	142	03-94	20.3	122
RB-2[illegible]	[illegible]	[illegible]	115	03-94	18.1	97
RB-280	34°27'55"	79°00'40"	106	03-94	16	90
RB-282	34°23'29"	79°00'23"	115	03-94	37.1	78
RB-283	34°31'24"	78°52'41"	94	04-94	1.9	92
RB-284	34°30'59"	78°57'48"	108	04-94	15.4	93
RB-285	34°34'10"	78°53'25"	106	04-94	7.3	99
RB-286	34°27'46"	79°05'49"	95	04-94	-1.2	96
RB-288	34°26'34"	79°10'11"	106	04-94	20.5	86
RB-290	34°32'19"	79°14'07"	125	04-94	15.6	109
RB-291	34°25'48"	79°11'48"	124	04-94	32.6	91
RB-293	34°30'07"	79°12'47"	125	04-94	24.3	101
RB-294	34°28'44"	79°10'49"	118	04-94	20.8	97
RB-295	34°21'43"	79°05'00"	82	04-94	18.9	63
RB-297	34°30'31"	79°11'24"	130	04-94	29.2	101
RB-298	34°28'21"	79°12'46"	145	04-94	49.1	96
RB-299	34°36'54"	79°21'48"	159	04-94	25	134
RB-301	34°32'03"	78°59'12"	120	04-94	28.8	91
RB-302	34°35'07"	79°14'27"	146	03-94	[b]24	122
South Carolina						
DIL-116	34°30'07"	79°20'38"	134	04-94	43.4	91
DIL-117	34°29'42"	79°18'30"	128	03-94	39.6	88
DIL-118	34°29'44"	79°18'16"	131	03-94	41.1	90

[a]Well screened in the Peedee and the Black Creek aquifers.
[b]Water level obtained from driller.

Table 4. Water levels in selected wells in the Black Creek aquifer in Robeson County, 1992-94

[Well number refers to well location in figure 5; RB, Robeson County]

Well number	Date of water-level measurement	Water level (feet below or above (-) land surface)
RB-69	10-22-92 03-17-94	24.6 25.8
RB-124	10-22-92 03-23-94	36.4 36.9
RB-127	10-22-92 03-24-94	48.4 46.4
RB-139	10-22-92 04-16-94	14 13.3
RB-148	10-05-92 04-10-94	38.1 39.2
RB-162	12-20-93 04-08-94	-2 -3.3
RB-257	12-28-93 03-23-94	15.2 14.1
RB-258	12-28-93 03-23-94	24.5 23.5

Table 5. Water levels and water-level changes in selected wells in the Black Creek aquifer, 1988-94

[Well number refers to well location in figure 5; BL, Bladen County; CO, Columbus County; HO, Hoke County; RB, Robeson County; SC, Scotland County]

Well number	Date of water-level measurement	Water level (feet below or above (-) land surface)	Date of water-level measurement	Water level (feet below or above (-) land surface)	Water-level change (feet)
Bladen and Robeson Counties, 1988-92					
BL-98	12-13-88	28.4	09-29-92	25.9	2.5
RB-92	12-16-88	20.1	10-08-92	22.7	-2.6
RB-117	11-09-88	13.7	10-22-92	18.4	-4.7
RB-130	11-02-88	6.4	10-29-92	19.9	-13.5
RB-157	12-14-88	2.8	10-05-92	3.2	-0.4
RB-185	12-14-88	24	09-30-92	29.9	-5.9
RB-195	10-25-88	15	10-21-92	27.6	-12.6
Hoke, Robeson, and Scotland Counties, 1988-93					
HO-32	12-19-88	3.9	12-27-93	3.2	0.7
HO-47	12-13-88	42.8	10-22-93	42.5	0.3
RB-87	10-27-88	12.8	12-28-93	12.4	0.4
RB-165	12-15-88	14.7	12-04-93	12.6	2.1
RB-168	12-14-88	6.3	11-19-93	6.4	-0.1
RB-174	12-15-88	5.3	12-02-93	5.9	-0.6
RB-205	10-26-88	19.1	11-16-93	19.5	-0.4
SC-61	12-22-88	10.8	12-02-93	10.8	0
SC-64	12-21-88	9.8	12-17-93	10.1	-0.3
SC-68	12-21-88	17.8	12-28-93	16.5	1.3
SC-74	12-21-88	10.1	12-21-93	6.4	3.7
SC-77	11-10-88	12.2	11-16-93	11.1	1.1
Bladen, Columbus, and Robeson Counties, 1988-94					
BL-22	12-14-88	22.2	03-24-94	23.2	-1
CO-125	11-30-88	33.9	04-01-94	34.4	-0.5
RB-69	11-09-88	21.1	03-17-94	25.8	-4.7
RB-84	10-26-88	35.4	03-23-94	36.7	-1.3
RB-124	11-03-88	35.4	03-23-94	36.9	-1.5
RB-127	10-27-88	50.3	03-24-94	46.4	3.9
RB-139	12-15-88	14.1	04-16-94	13.3	0.8
RB-148	12-14-88	33.8	04-10-94	39.2	-5.4
RB-162	12-13-88	-2.9	04-08-94	-3.3	0.4

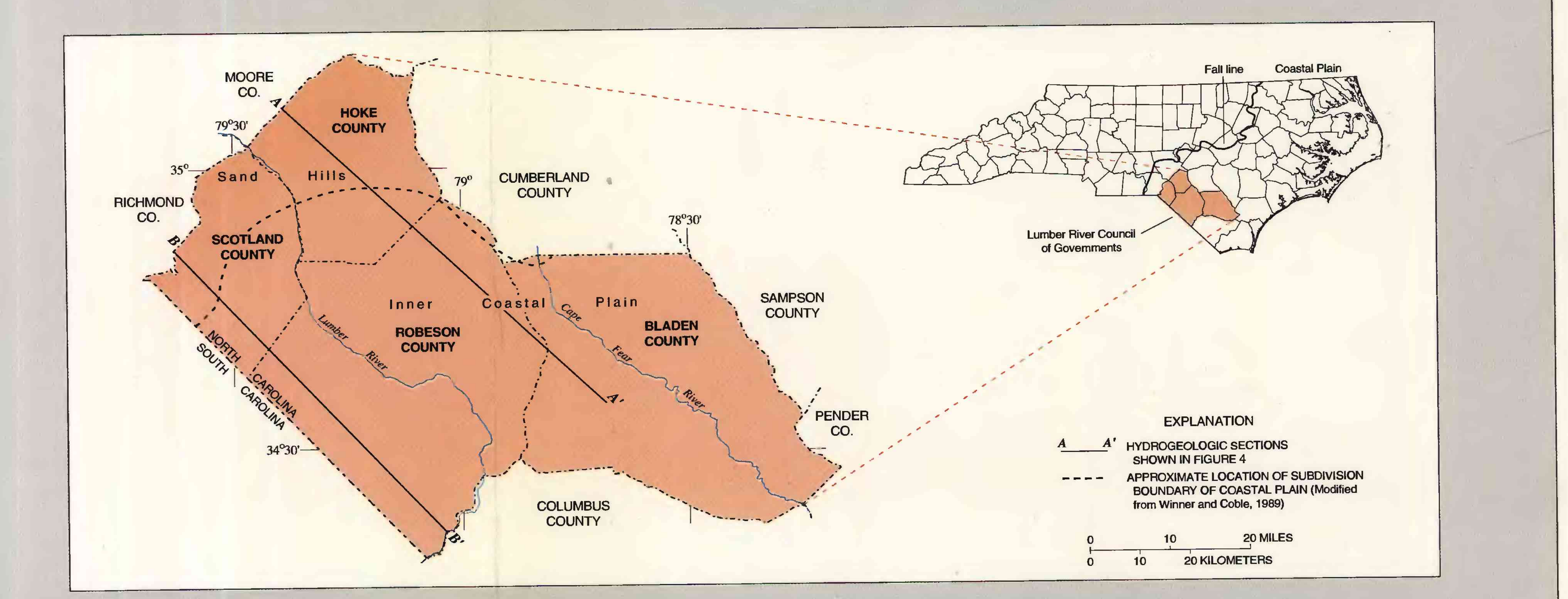

Figure 1.--Physiographic divisions within the Lumber River Council of Governments in the Coastal Plain of North Carolina, and lines of hydrogeologic sections A-A' and B-B'.

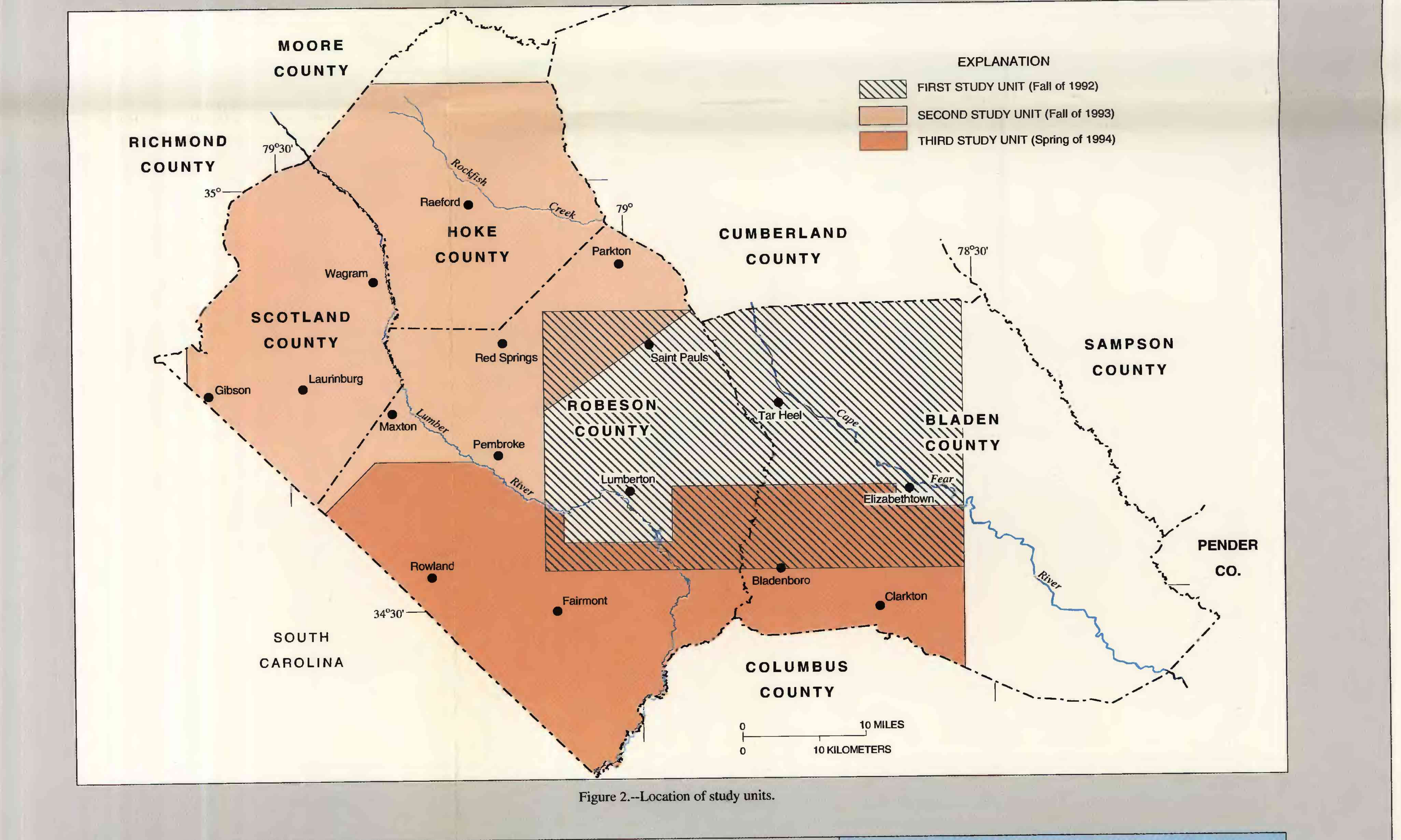

Figure 2.--Location of study units.

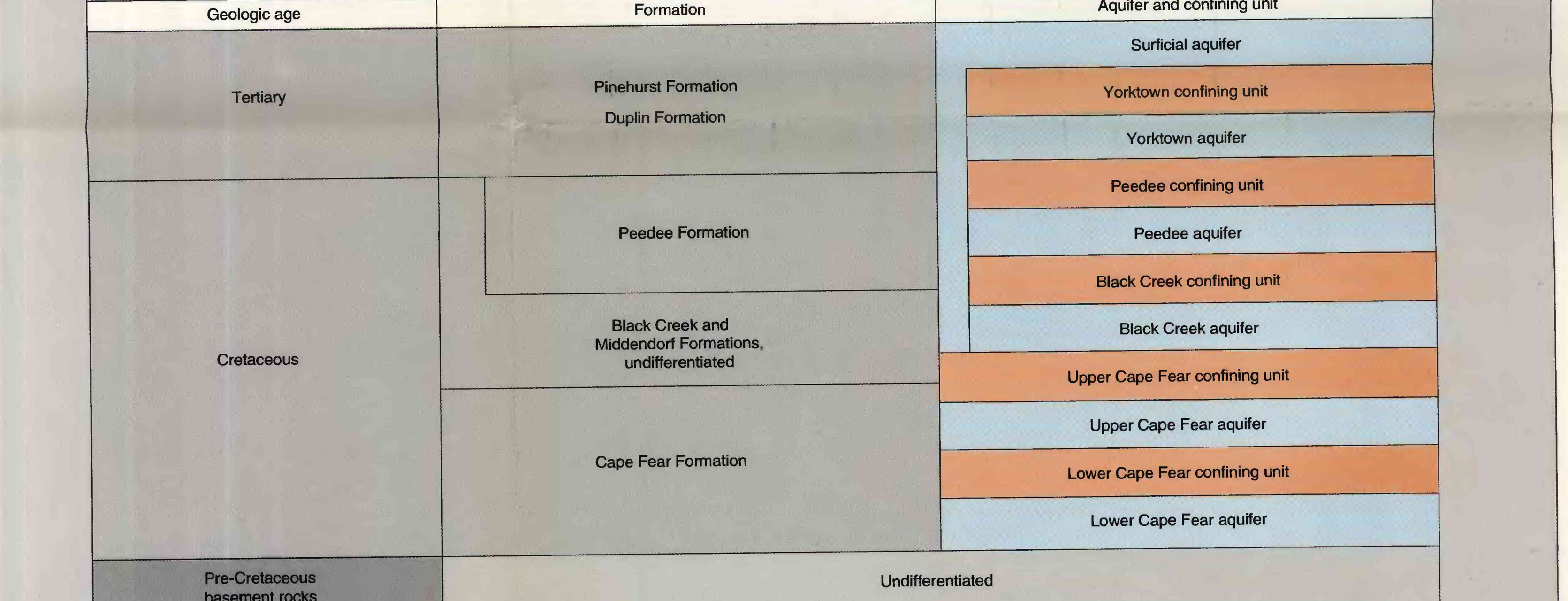

Figure 3.--Generalized relations of geologic and hydrogeologic units in the study area (Modified from North Carolina Department of Natural Resources and Community Development, 1985, and Winner and Coble, 1989).

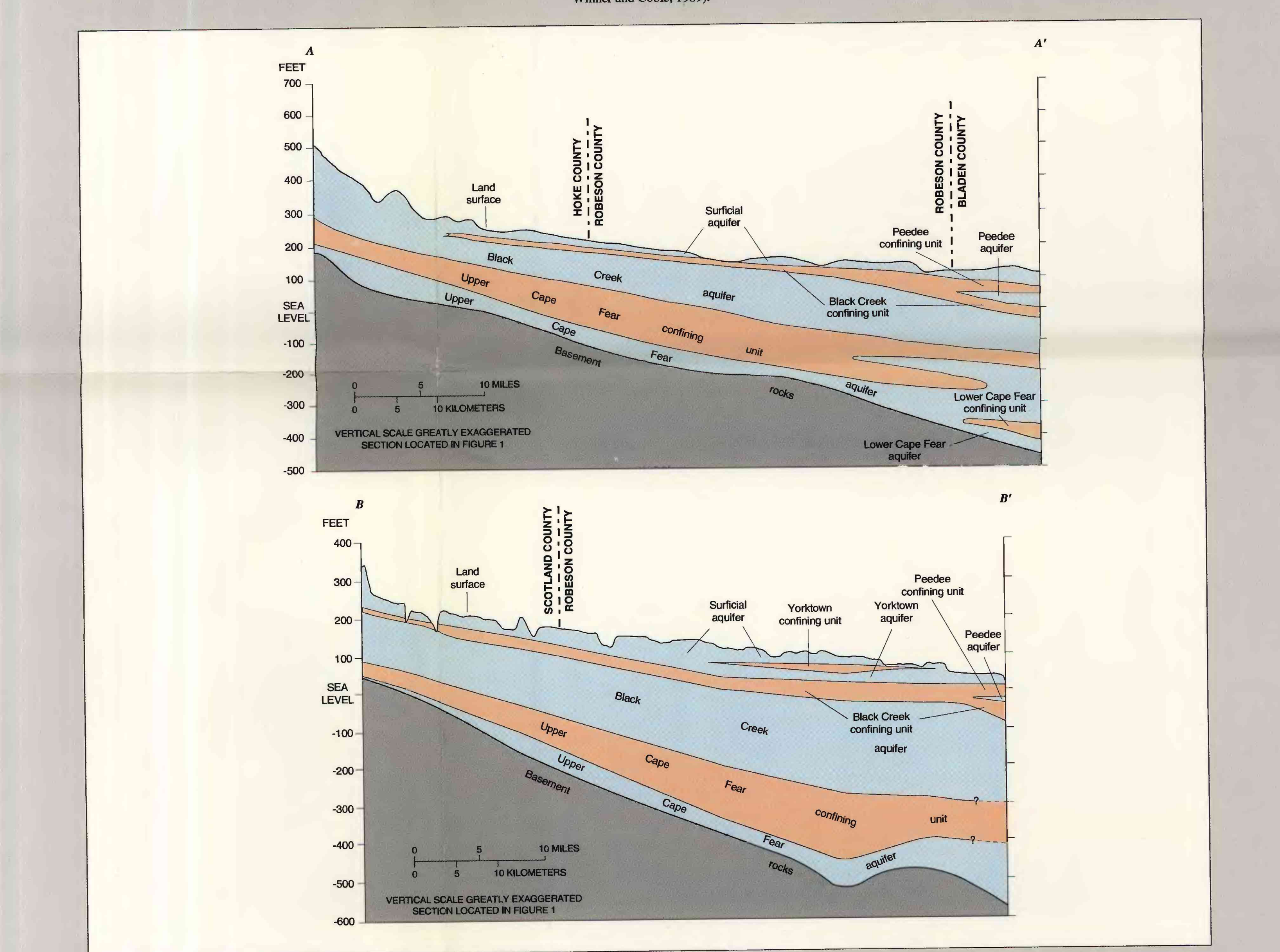

Figure 4.--Generalized hydrogeologic sections A-A' and B-B' (Modified from Winner and Coble, 1989).

WATER-LEVEL CONDITIONS IN THE BLACK CREEK AQUIFER, 1992-94, IN PARTS OF BLADEN, HOKE, ROBESON, AND SCOTLAND COUNTIES, NORTH CAROLINA

By A.G. Strickland

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