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Strickland, A.G., 1994, Water-level conditions in the Black Creek and upper Cape Fear aquifers, 1992, in parts of Bladen and Robeson Counties, North Carolina

WATER-LEVEL CONDITIONS IN THE BLACK CREEK AND UPPER CAPE FEAR AQUIFERS, 1992, IN PARTS OF BLADEN AND ROBESON COUNTIES, NORTH CAROLINA

By
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ABSTRACT

Water-level measurements were made in 68 wells throughout an area of about 860 square miles in Bladen and Robeson Counties, North Carolina, during September and October 1992. Water levels from 58 wells were used to construct a map of the potentiometric surface of the Black Creek aquifer. This map shows the potential for ground water to flow from recharge areas in the local uplands to discharge areas, such as local streams and wells. Pumping from wells at major pumping centers, such as Elizabethtown in Bladen County and Lumberton in Robeson County, where water-level declines of more than 12 feet were recorded from 1988 to 1992, has resulted in cones of depression in the potentiometric surface. The cones were about 4 and 6 miles long across the major axes beneath the Elizabethtown and Lumberton areas, respectively, in 1992.

Water levels measured in eight wells in 1988 and 1992, supplemented with water levels in two additional wells from driller's well-construction records, were used to estimate average yearly rates of ground-water change for the upper Cape Fear aquifer for part of the study area. During 1988-92, water-level declines occurred in the aquifer throughout much of the area as a result of pumping. The greatest decline, an average of 4.1 feet per year, was in Bladen County.

INTRODUCTION

The U.S. Geological Survey (USGS) is conducting a 3-year (1992-95) ground-water study of major water-supply aquifers in the southern Coastal Plain of North Carolina. The study is being done 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 is to assess the effects of ground-water withdrawals on water levels in major aquifers in the LRCOG area. Planned ground-water development and results from previous potentiometric-surface mapping in 1988 (Strickland and others, 1992) were the basis for selecting parts of Bladen and Robeson Counties for study during the first year (fig. 1). The study area, covering about 860 mi^2, includes the city of Lumberton and the town of Saint Pauls in Robeson County and the town of Elizabethtown in Bladen County.

This report presents an evaluation of water-level conditions in the principal aquifers in parts of Bladen and Robeson Counties, 1992. The assessment includes the effects of ground-water withdrawals on the potentiometric surface of the Black Creek aquifer during the fall of 1992, and the extent of the major cones of depression in the Black Creek aquifer in the Lumberton and Elizabethtown areas. Also documented is an estimate of annual water-level changes in the upper Cape Fear aquifer in the Cape Fear River valley from 1988 to 1992.

HYDROGEOLOGIC SETTING

The Coastal Plain Province of North Carolina consists of a southeastward dipping and thickening wedge of predominantly unconsolidated sediments deposited on sand and clay underlain by basement rocks. The western boundary of these deposits is the Fall Line (fig. 1). The sedimentary deposits have been divided into geologic formations based on their age and lithology. The deposits were 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 relations of geologic and hydrogeologic units that underlie the LRCOG area are shown in figure 2.

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

Winner and Coble (1989) identified five aquifers in the study area--the surficial, Peedee, Black Creek, upper Cape Fear, and lower Cape Fear aquifers--separated by four confining units (fig. 3). The Black Creek and upper Cape Fear aquifers are the major sources of water for public, industrial, and agricultural uses in the study area and are emphasized in this report.

The Black Creek aquifer consists mainly of sediments of 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, which are common in these sediments. The Middendorf Formation is composed of fluvial sediments of nonmarine origin; these include fine- to medium-sand beds, interlayered with silty-clay beds and thinly laminated beds of sand and clay.

The upper Cape Fear aquifer, which is composed of alternating beds of sand and clay, lies below the Black Creek aquifer. This aquifer includes permeable zones in the Cape Fear Formation of Cretaceous age. Winner and Coble (1989) divided the Cape Fear Formation into two distinct hydrogeologic units, the upper and lower Cape Fear aquifers. The upper Cape Fear aquifer is the dominant of the two in the study area.

DATA COLLECTION AND ANALYSIS

Wells used in the study included North Carolina Department of Environment, Health, and Natural Resources (DEHNR) observation wells and industrial, municipal, county, and privately owned wells. Water levels in many of the wells were previously measured in the fall of 1988 (Strickland and others, 1992).

Nonpumping water levels were measured during September and October 1992. To ensure that water levels from water-supply wells closely represented the nonpumping conditions of the aquifer, 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 conditions.

Well-construction data, including depths of casing and screened intervals, also were collected. 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 were screened in only one aquifer, but several wells were determined to be screened in more than one aquifer.

Water levels in 58 wells were used to construct a map of the potentiometric surface of the Black Creek aquifer (fig. 4). The potentiometric surface of an aquifer is an imaginary surface that represents the altitudes to which water levels would rise in tightly cased wells under static or nonpumping conditions. When referenced to a common datum, such as sea level, the altitudes of the water levels are termed hydraulic heads.

Lines of equal hydraulic head in the Black Creek aquifer are represented by potentiometric contours on the map. Ground water has the potential to flow through the aquifer from areas of high hydraulic head to areas of low hydraulic head. The direction of flow is perpendicular to the potentiometric-contour lines.

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, and reported to the nearest foot (table 1). 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 maps having 5-ft contour intervals.

Ground-water flow in the Black Creek aquifer is controlled by 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 wells were slightly higher than nearby stream altitudes. Therefore, the altitude of the head in the aquifer along a stream was assumed to be slightly greater than the altitude of the stream. Potentiometric contours in these areas were constructed using surface contour values where they crossed streams.

A reliable potentiometric-surface map of the upper Cape Fear aquifer could not be constructed because of the small number of unpumped wells which are screened in this aquifer away from the major areas of pumping. However, a map showing the estimated average yearly rates of ground-water level change was constructed for the upper Cape Fear aquifer (fig. 5) by using water levels measured in eight wells during 1988 and 1992, supplemented with water levels in two additional wells from DEHNR ground-water files and driller's well-construction records. The average yearly rates of change were calculated by dividing the difference between two water-level measurements in a well by the number of years between measurements. For three of the DEHNR observation wells having several water-level measurements, yearly rates of water-level change were determined by linear regression.

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer

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.

Abbreviation: ft/yr, foot per year.

WATER-LEVEL CONDITIONS IN THE BLACK CREEK AQUIFER

The potentiometric surface of the Black Creek aquifer throughout the mapped area in Bladen and Robeson Counties (fig. 4) shows that ground water flows southeast from recharge areas in the local uplands to discharge areas along local streams, such as the Lumber and Cape Fear Rivers and their tributaries, and at pumped wells. Where potentiometric contours cross streams, as in much of Robeson County and northeast of the Cape Fear River in Bladen County, they bend upstream, which indicates that ground water is discharging from the aquifer to the stream. The potentiometric contours along the Cape Fear River indicate that ground water is discharging to that river also.

The natural flow is disrupted around pumping centers where ground water is discharged from pumped wells. Pumping from wells at the major pumping centers, such as in the Lumberton and Elizabethtown areas, has resulted in cones of depression in the potentiometric surface of the Black Creek aquifer.

Ground-water withdrawals in Lumberton increased from 1988 to 1992 as a result of pumping from new wells (John Strickland, City of Lumberton, oral commun., 1992), and observed water levels declined as much as 12.6 ft during this period (RB-195, table 2). The cone of depression beneath Lumberton has shifted northwestward since 1988 (Strickland and others, 1992) in the direction of the new wells. Even with this increased pumpage, the cone of depression, which was about 6 mi long across its major axis in 1992, remained localized in the vicinity of the pumped wells.

At pumping centers in the Elizabethtown area, water-level declines from 8 to 13.6 ft were recorded during the same period (wells BL-121 and BL-131, respectively, table 2). In 1992, the elongated cone of depression in the Elizabethtown area was about 4 mi long. All wells at the major pumping centers in the Elizabethtown area tap the Black Creek aquifer in addition to either the upper Cape Fear or the upper and lower Cape Fear aquifers. Water levels measured in these wells represent a combination of hydraulic heads in the Black Creek aquifer and one or both of the other aquifers. These heads are considered representative of the Black Creek aquifer because this aquifer is a major contributing zone to the production wells in the Elizabethtown area.

In Saint Pauls, observed water levels in the Black Creek aquifer declined 2.6 ft between 1988 and 1992 (RB-92, table 2). At a well field east of Saint Pauls near the Robeson-Bladen County line, ground water is withdrawn from the Black Creek aquifer. A small cone of depression has developed at that well field.

WATER-LEVEL CONDITIONS IN THE UPPER CAPE FEAR AQUIFER

Pumping has resulted in water-level declines in the upper Cape Fear aquifer throughout much of the mapped area from 1988 to 1992 (fig. 5). During this period, water levels declined the most in Bladen County along the Cape Fear River from the Cumberland-Bladen County Line to Elizabethtown. The greatest recorded decline was 15.5 ft at well BL-72 between December 1988 and October 1992 (table 2), an average rate of 4.1 ft/yr. This decline may be influenced either by pumping at that well or by a major well field near Tar Heel that was developed during 1991. Additional data are needed to determine the cause and extent of this decline.

Hydrographs for the DEHNR observation wells near Littlefield, Bladenboro, and White Lake show water-level fluctuations in the upper Cape Fear aquifer at locations away from the pumping centers (fig. 5). Between 1988 and 1992, water levels declined at wells RB-183 (Littlefield observation well Y42f9) and BL-100 (Bladenboro observation well Z41u2) at rates of 1.7 and 1.2 ft/yr, respectively; but the water level at well BL-109 (White Lake observation well Y38b6) rose an average rate of 1.8 ft/yr during the same period. The reason for this rise has not been determined.

REFERENCES CITED

Strickland, A.G., Coble, R.W., Edwards, L.A., and Pope, B.F., 1992, Ground-water level data for North Carolina, 1988-90: U.S. Geological Survey Open-File Report 92-57, 167 p.

Winner, M.D., Jr., and Coble, R.W., 1989, A hydrogeologic framework of the North Carolina Coastal Plain aquifer system: U.S. Geological Survey Open-File Report 87-690, 155 p.

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

[Well number refers to well locations in figure 4; BL, Bladen County; RB, Robeson County]

Well number	Latitude	Longitude	Altitude of land surface (feet above sea level)	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	20.9	51
BL-98	34°43'33"	78°47'29"	125	25.9	99
[1]BL-121	34°37'26"	78°36'02"	120	105.8	14
[1]BL-127	34°38'37"	78°38'37"	134	180.4	-46
[1]BL-129	34°38'53"	78°38'41"	135	185.6	-51
BL-132	34°45'23"	78°48'26"	130	61.2	69
BL-143	34°45'03"	78°44'09"	84	21.0	63
BL-146	34°38'23"	78°44'22"	139.8	24.7	115
[2]BL-149	34°36'52"	78°36'32"	105	67.2	38
BL-151	34°45'38"	78°48'13"	142	81.3	61
BL-153	34°44'29"	78°48'16"	128	50.1	78
BL-154	34°48'57"	78°50'33"	128	22.6	105
BL-160	34°41'04"	78°47'47"	131	21.5	110
BL-162	34°49'11"	78°48'06"	75	35.1	40
BL-167	34°37'53"	78°43'13"	128	16.1	112
BL-168	34°39'35"	78°45'39"	135	15.1	120
BL-169	34°42'45"	78°48'55"	135	14.7	120
BL-171	34°43'06"	78°45'06"	150	[3]106.1	[3]44
RB-90	34°48'17"	78°58'21"	165	17.9	147
RB-92	34°48'30"	78°59'07"	175	22.7	152
RB-97	34°35'31"	79°00'11"	117	63.5	54
RB-98	34°35'12"	79°00'09"	112	65.5	47
RB-100	34°35'28"	79°00'05"	117	65.2	52
RB-104	34°37'24"	79°04'32"	126.6	6.6	120
RB-113	34°39'05"	78°55'13"	150	42.3	108
RB-115	34°33'56"	78°59'36"	114	54.4	60
RB-117	34°47'55"	78°56'17"	158	18.4	140
RB-127	34°35'36"	78°55'30"	135	48.4	87
RB-130	34°36'08"	79°05'50"	129.6	19.9	110
RB-157	34°42'36"	79°00'07"	149.4	3.2	146
RB-168	34°50'35"	79°05'18"	187.3	5.7	182
RB-185	34°38'40"	78°55'00"	142	29.9	112
RB-195	34°37'52"	79°01'37"	110	27.6	82
RB-198	34°37'50"	79°01'53"	107	28.6	78
RB-200	34°37'53"	79°02'03"	117	17.6	99
RB-202	34°38'00"	79°01'52"	105	22.2	83
RB-207	34°39'28"	79°04'14"	122	-1.1	123
RB-208	34°39'50"	79°05'52"	148	11.2	137
RB-209	34°39'32"	79°06'31"	152	15.4	137
RB-210	34°39'22"	79°05'50"	150	15.0	135
RB-211	34°42'08"	79°01'09"	150	9.8	140
RB-213	34°41'19"	79°03'55"	147	15.4	132
RB-215	34°39'21"	79°03'44"	124	4.7	119
RB-216	34°40'44"	79°07'26"	158	7.8	150
RB-217	34°46'10"	78°55'05"	160	17.8	142
RB-221	34°36'23"	78°58'32"	151	34.6	116
RB-222	34°44'45"	78°57'29"	150	8.6	141
RB-226	34°35'17"	78°58'27"	132	64.5	68
RB-233	34°38'00"	79°02'14"	116	21.8	94
RB-234	34°37'42"	79°01'31"	112	33.8	78
RB-236	34°37'25"	79°01'03"	110	38.9	71
RB-239	34°41'02"	79°03'31"	152	25.0	127
RB-240	34°39'27"	78°55'12"	152	48.2	104
RB-241	34°48'03"	78°54'08"	140	12.5	128
RB-242	34°48'09"	78°53'44"	133	19.5	114
RB-243	34°48'19"	78°53'50"	137	15.8	121
RB-244	34°48'14"	78°53'54"	134	11.6	122
RB-245	34°36'47"	79°00'02"	114	51.2	63

[1]Well screened in the Black Creek, upper Cape Fear, and lower Cape Fear aquifers.
[2]Well screened in the Black Creek and upper Cape Fear aquifers.
[3]Water level obtained in March 1993.

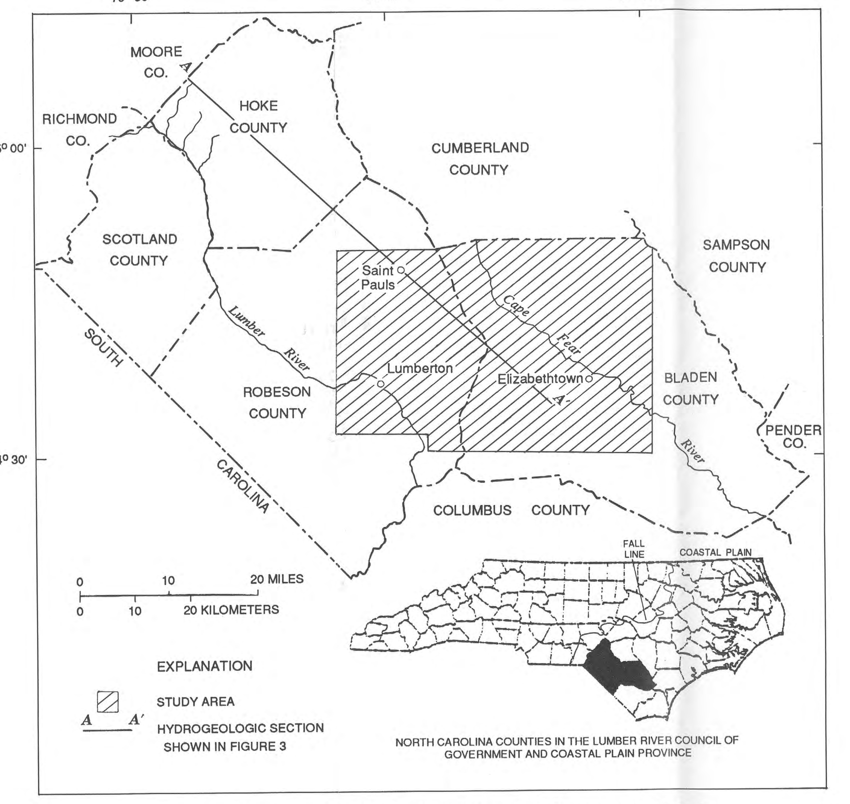


Figure 1.--Locations of the Lumber River Council of Government within the North Carolina Coastal Plain Province, the study area, and hydrogeologic section *A-A'*.

Geologic units		Hydrogeologic units
Geologic age	Formation	Aquifer and confining units
Tertiary	Undifferentiated	Surficial aquifer
Cretaceous		Confining unit
	Peedee Formation	Peedee aquifer
		Confining unit
	Black Creek and Middendorf Formations	Black Creek aquifer
		Confining unit
	Cape Fear Formation	Upper Cape Fear aquifer
		Confining unit
		Lower Cape Fear aquifer
Pre-Cretaceous basement rocks	Undifferentiated	

Figure 2.--Generalized relations of geologic and hydrogeologic units in the study area (modified from Winner and Coble, 1989).

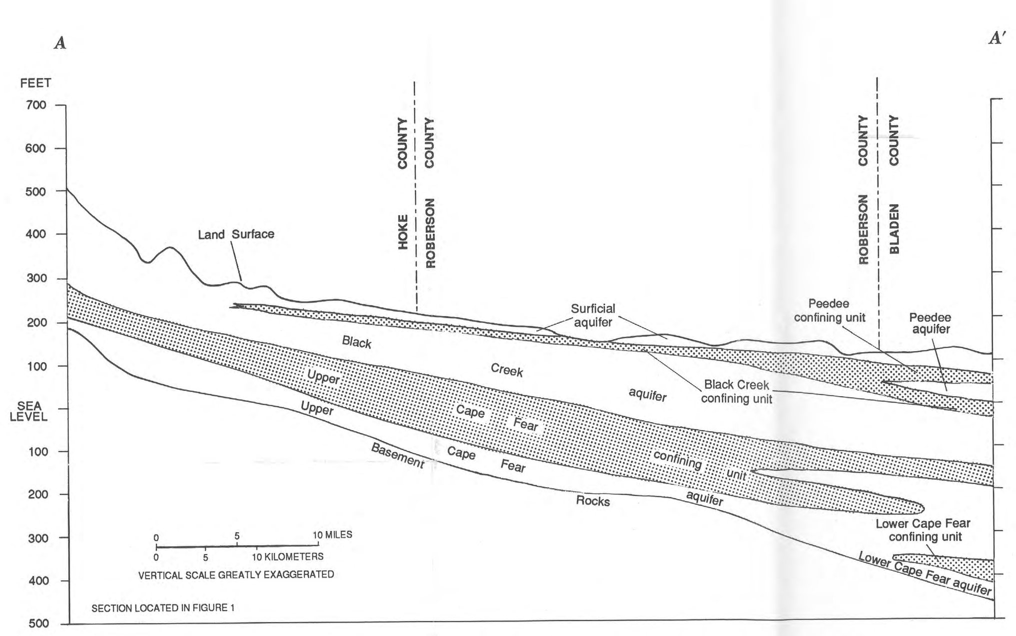


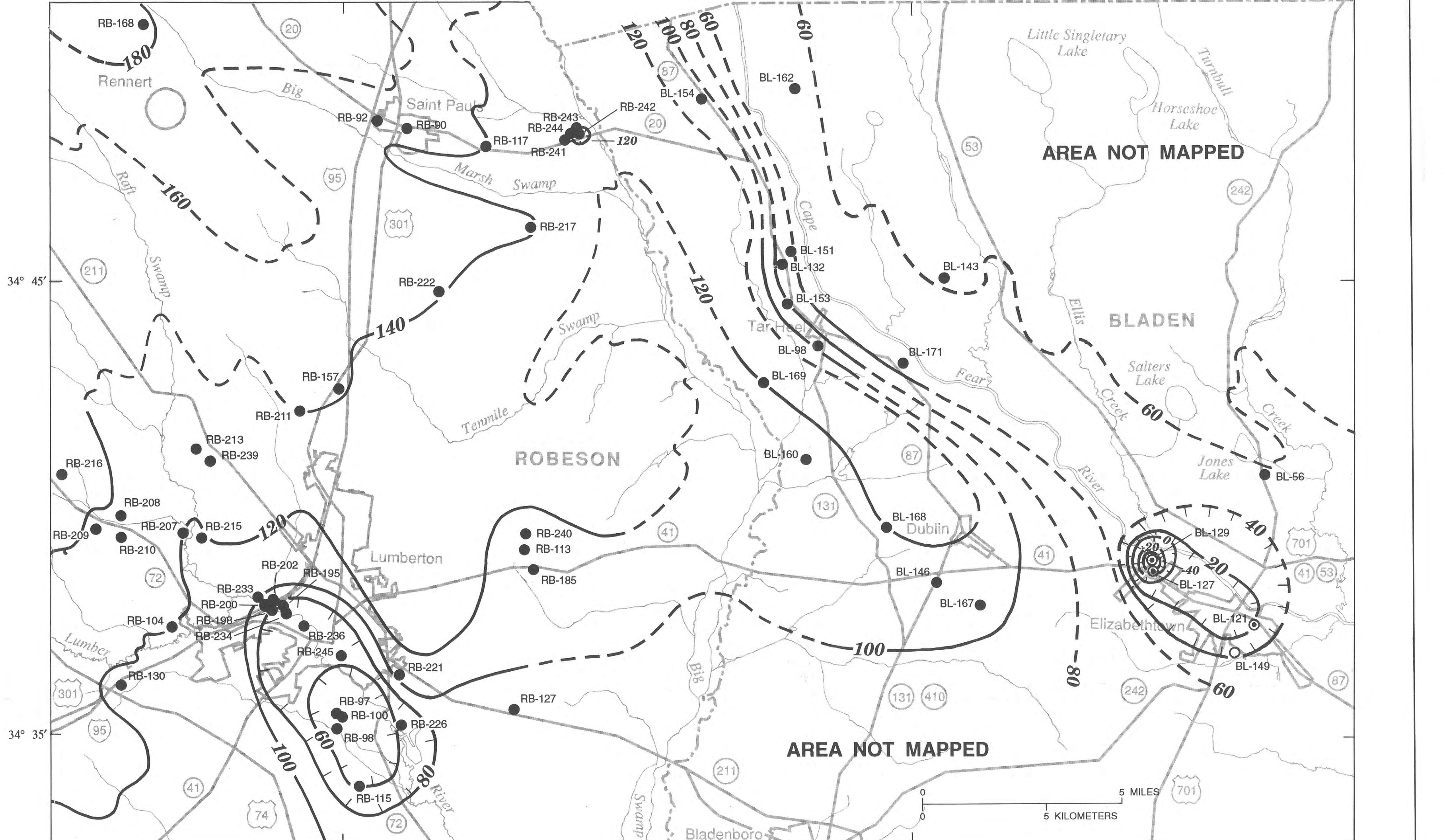
Figure 3.--Generalized hydrogeologic section *A-A'* (modified from Winner and Coble, 1989).

Table 2.--*Water levels and water-level changes in selected wells in the Black Creek and upper Cape Fear aquifers in Bladen and Robeson Counties between 1988 and 1992*

[Well number refers to well locations in figure 4 or 5; BL, Bladen County; RB, Robeson County; Aquifer: Well screened in BKCK, Black Creek aquifer; UCF, upper Cape Fear aquifer; LCF, lower Cape Fear aquifer; ND, not determined]

Well number	Latitude	Longitude	Aquifer	Date of water-level measurement	Water level (feet below land surface)	Date of water-level measurement	Water level (feet below land surface	Water-level change, 1988-92 (feet)
BL-57	34°41'19"	78°35'42"	UCF	[1]1945	15.0	09-23-92	62.3	ND
BL-72	34°50'05"	78°49'33"	UCF	12-27-88	41.3	10-06-92	56.8	-15.5
BL-86	34°50'39"	78°50'13"	UCF	12-27-88	120.0	10-06-92	133.3	-13.3
BL-94	34°39'06"	78°43'26"	UCF	12-13-88	122.6	09-29-92	128.4	-5.8
BL-100	34°30'24"	78°45'17"	UCF	12-14-88	66.1	09-28-92	70.5	-4.4
BL-109	34°39'17"	78°31'12"	UCF	12-20-88	33.1	09-23-92	26.2	6.9
BL-121	34°37'26"	78°36'02"	BKCK, UCF, and LCF	12-21-88	97.8	09-24-92	105.8	-8.0
BL-131	[2]34°39'00"	[2]78°38'32"	BKCK, UCF, and LCF	12-20-88	171.1	09-29-92	184.7	-13.6
BL-148	34°43'45"	78°41'51"	UCF	[1]12-30-81	44.9	09-28-92	73.8	ND
RB-92	34°48'30"	78°59'07"	BKCK	12-16-88	20.1	10-08-92	22.7	-2.6
RB-117	34°47'55"	78°56'17"	BKCK	11-09-88	13.7	10-22-92	18.4	-4.7
RB-127	34°35'36"	78°55'30"	BKCK	10-27-88	50.3	10-22-92	48.4	1.9
RB-130	34°36'08"	79°05'50"	BKCK	11-02-88	6.4	10-29-92	19.9	-13.5
RB-157	34°42'36"	79°00'07"	BKCK	12-14-88	2.8	10-05-92	3.2	-0.4
RB-183	34°38'40"	78°55'00"	UCF	12-14-88	103.3	09-30-92	109.4	-6.1
RB-185	34°38'40"	78°55'00"	BKCK	12-14-88	24.0	09-30-92	29.9	-5.9
RB-195	34°37'52"	79°01'37"	BKCK	10-25-88	15.0	10-21-92	27.6	-12.6

[1]Water level obtained from well construction records.
[2]Approximate location of well.



Base from digital files of
U.S. Department of Commerce, Bureau of Census, 1990 Precensus TIGER/Line Files, 1991
U.S. Environmental Protection Agency Reach File, Version 3, 1990
U.S. Geological Survey, 1: 100,000 scale Digital Line Graph - Transportation, Region 3

EXPLANATION

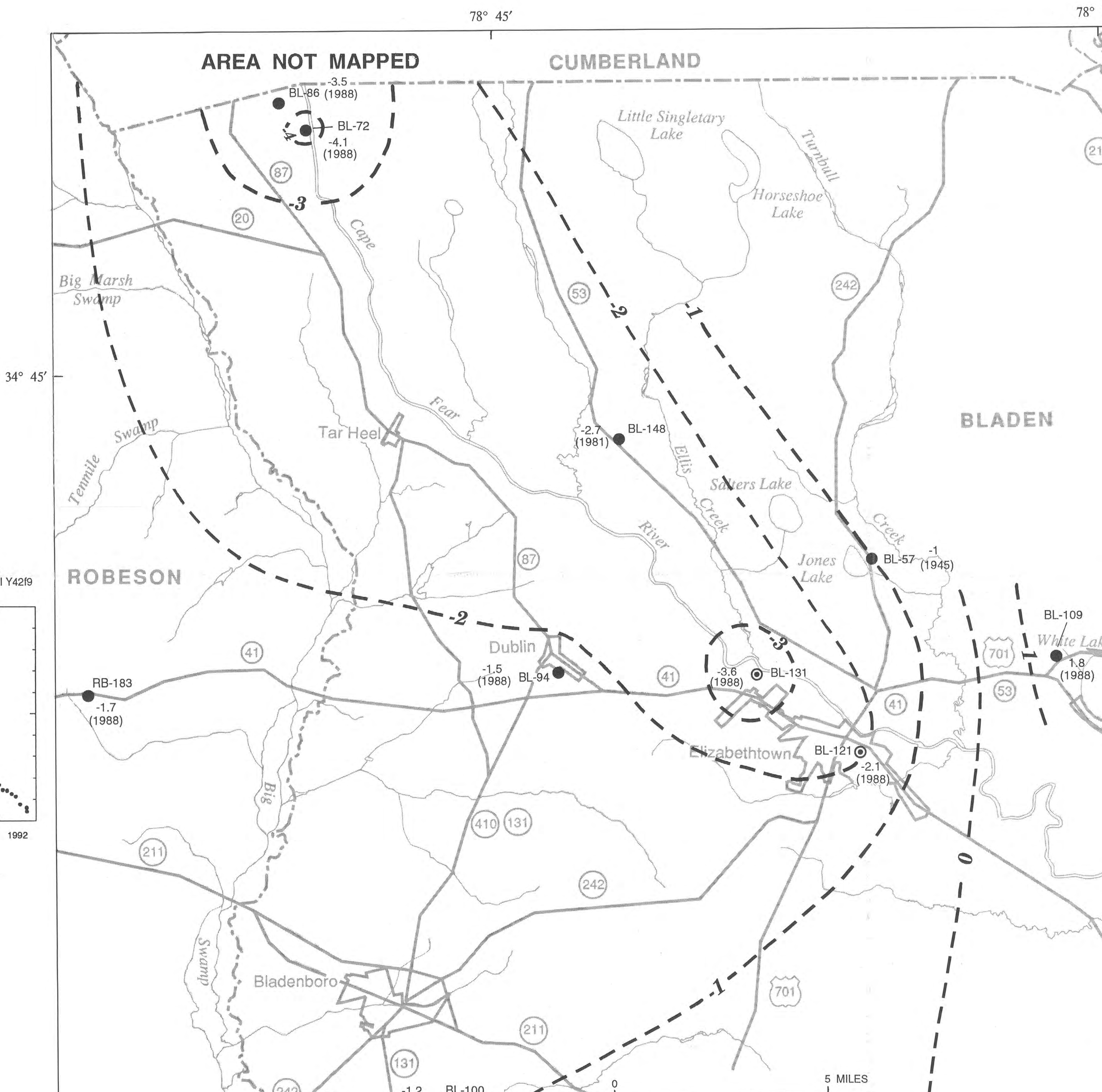
140 — POTENTIOMETRIC CONTOUR--Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 20 feet. Hachured to indicate depressions. Datum is sea level

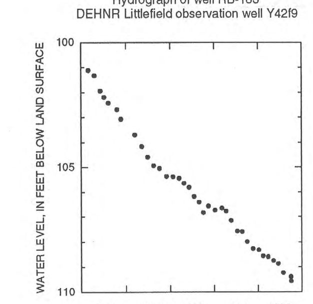
BL-56 ● WELL COMPLETED IN THE BLACK CREEK AQUIFER AND WELL NUMBER

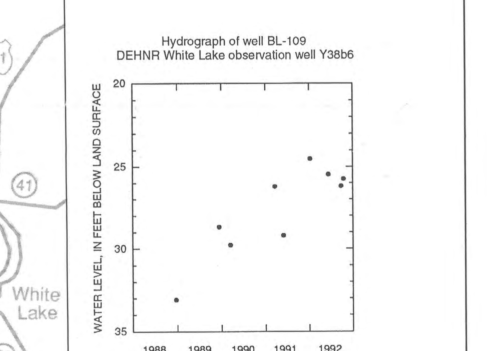
BL-149 ○ WELL COMPLETED IN THE BLACK CREEK AND UPPER CAPE FEAR AQUIFERS AND WELL NUMBER

BL-121 ⊙ WELL COMPLETED IN THE BLACK CREEK, UPPER CAPE FEAR, AND LOWER CAPE FEAR AQUIFERS AND WELL NUMBER

Figure 4.--Potentiometric surface of the Black Creek aquifer in parts of Bladen and Robeson Counties, September-October 1992.







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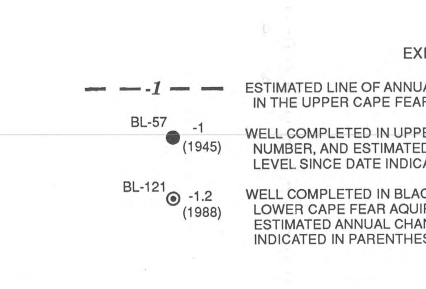

EXPLANATION

-1 — ESTIMATED LINE OF ANNUAL EQUAL WATER-LEVEL CHANGE IN THE UPPER CAPE FEAR AQUIFER--Interval 1 foot

BL-57 ● -1 (1945) WELL COMPLETED IN UPPER CAPE FEAR AQUIFER, WELL NUMBER, AND ESTIMATED ANNUAL CHANGE IN WATER LEVEL SINCE DATE INDICATED IN PARENTHESIS

BL-121 ⊙ -1.2 (1988) WELL COMPLETED IN BLACK CREEK, UPPER CAPE FEAR, AND LOWER CAPE FEAR AQUIFERS, WELL NUMBER, AND ESTIMATED ANNUAL CHANGE IN WATER LEVEL SINCE DATE INDICATED IN PARENTHESIS

Figure 5.--Estimated annual water-level changes in the upper Cape Fear aquifer in Bladen and Robeson Counties, 1988-92, and selected hydrographs.