A RECONNAISSANCE STUDY TO RELATE LAND USE AND GROUND-WATER QUALITY IN THE GULF COASTAL PLAIN OF LOUISIANA AND MISSISSIPPI

By Donald J. Strickland, Robert B. Fendick, Jr., Gene A. Bednar, and D.E. Everett

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following fsctors:

Multiply inch-pound unit	by	To obtain metric unit
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Gradient	
foot per mile (ft/mi)	18.9	centimeter per kilometer (cm/km)
	Transmissivity	
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)

The conversion from temperature in degrees Fahrenheit (°F) to tempersture in degrees Celsius (°C) is expressed by: °C =5/9 (°F-32).

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ABSTRACT

An 8-month reconnaissance study of the relation between land use and ground-water quality in two areas of the Gulf Coastal Plain was conducted as part of the U.S. Geological Survey Toxic Waste--Ground-Water Contamination Program. The study areas, located in the vicinities of Baton Rouge, Louisiana, and Gulfport, Mississippi, encompassed about 175 and 150 square milea, respectively. A preliminary assessment of shallow aquifer characteristics, ground-water movement, quality of ground water, and contamination, or the potential for contamination of shallow aquifers was made in three areas with specific land-uses. The land-use types--industrial, mixed agricultural-forested, and forest land--are typical of the southwestern part of the Gulf Coastal Plain.

Organic compounds were detected in aquifers in each land-use area and were present in greater number and in higher concentrations in water from wells in the industrial land-use area than in the mixed agricultural-forested land-use area. Organic compounds on the U.S. Environmental Protection Agency priority pollutant list were detected in water from two wells in the industrial land-use area and one well in the mixed land-use area. Chloride concentrations in three wells in the industrial land-use area indicate brine contamination. Trace-element contamination, including barium and manganese, was detected in water from some wells. Barium concentrations of 800, 900, and 2,000 micrograms per liter were present in water from three wells in the industrial land-use area. Manganese concentrations in the industrial area ranged from below detection levels to 2,300 micrograms per liter. Concentrations in water from 9 of 12 wells exceeded U.S. Environmental Protection Agency quality criteria (50 micrograms per liter) for water supplies.

The vertical movement of water through surficial deposits has potential for long-term aquifer contamination from surface and subsurface waste-disposal activities. Further study is needed to better understand the complex geohydrology, chemistry of water and sediments, and the age of resident aquifer water.

INTRODUCTION

This study was conducted from October 1984 to May 1985 as part of the U.S. Geological Survey Toxic Waste--Ground-Water Contamination Program. The objective of the National Program is to assess the current quality of the Nation's ground water and to determine the nature and extent of the ground-water contamination problems (Helsel and Ragone, 1984). Study areas selected encompass a wide variety of geohydrologic and climatic environments, as well as a large diversity of human activities. This report is a preliminary assessment of the effects of man's activities on the quality of shallow ground water in the Gulf Coastal Plain in Louisiana and Mississippi.

The principal shallow aquifers in the study area of the Gulf Coastal Plain are the shallow sands and Upland Terrace deposits (the outcrop of the "400- and 600-foot" sands) of Pleistocene age in Louisiana and the Citronelle and Graham Ferry Formations of Pliocene age in Mississippi. The Citronelle and Graham Ferry Formations are underlain by southerly dipping strata of Pliocene and Miocene age. Although these shallow (200 feet or less) water-table aquifers are not used extensively, an increasing trend in water use as urban growth continues could lead to more development of the shallow aquifers for domestic water supplies. Because most shallow aquifers have little protection from contamination by surface sources, it is important that management practices be considered to protect the shallow ground water of the Gulf Coastal Plain.

Purpose and Scope

This report describes the results of an assessment of ambient ground-water quality and changes in ground-water quality that have occurred as the result of land-use activities. Emphasis was placed on determining the presence or absence of trace elements and organic compounds in shallow ground water. Two areas -- one each in Louisiana and Mississippi -- representing three land-use activities are included in this study. The quality of shallow ground water is described for each land use and compared with that of the other two land-use areas.

Location

The study encompasses about 175 mi^2 (square miles) in Louisiana and 150 mi^2 in Mississippi. The Louisiana part of the study area is in the northern part of East Baton Rouge Parish and extends about 25 miles north into East Feliciana Parish. Ground water in this area is known to be locally contaminated by surface disposal of hazardous waste. The Mississippi part of the study area extends from about 6 miles north of the shore line of the Mississippi Gulf Coast to the Stone County line about 20 miles north of Gulfport (fig. 1).

Climate

The general climatic classification is humid and subtropical. Warm temperatures prevail from May through September with generally mild temperatures during the remainder of the year. Temperatures seldom exceed 100 °F. Freezing weather normally occurs only a few days each year. The average temperature for the area is about 68 °F, with maximum temperatures occurring in July and August and minimum temperatures in January. Average daily maximum and minimum temperatures are about 78 °F and 57 °F, respectively.

The annual precipitation ranges from about 50 to 60 inches. The highest average monthly rainfall occurs in July and the lowest in October. Intense rainfalls of short duration, associated with advection- or convection-type thunderstorms, occur from late spring to early fall. Rainfalls of a less intense and more uniform nature occur along frontal lines during the late fall to early spring months. Torrential storms have produced as much as 12 inches of rain in a 24-hour period.

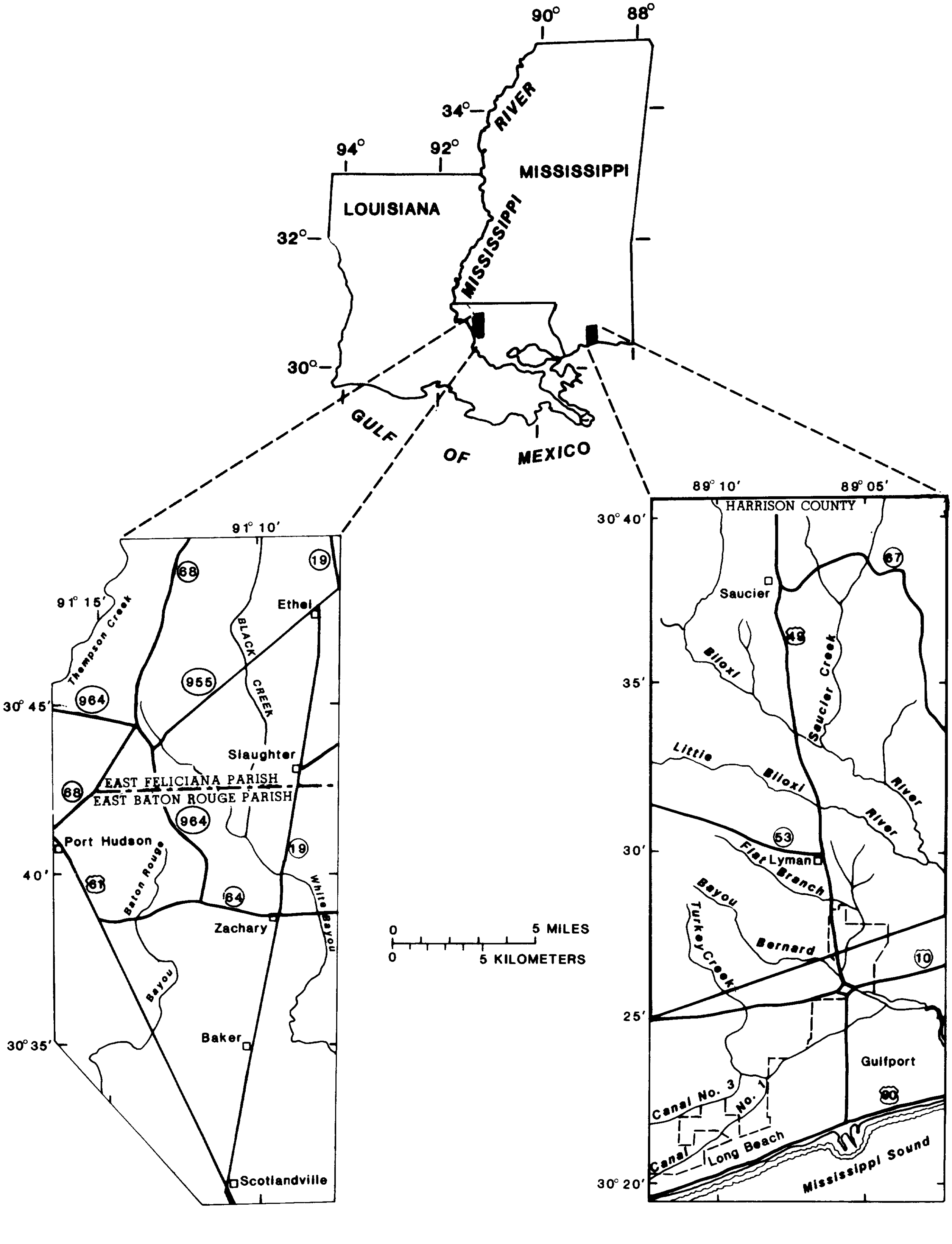


Figure 1.--Location of study area.

Data Collection and Analysis

Water-quality and water-level data were collected from wells at 16 sites in Louisiana and 18 sites in Mississippi (fig. 2). Most of the wells used were constructed during the study (table 1). Wells were sampled at 12 sites each in the industrial and forest land-use areas and at 10 sites in the mixed agricultural-forested land-use area. Water-quality data were obtained from field measurements and common constituent, trace element, and organic scan analyses. In addition, concentrations of purgeable (volatile) organic compounds (32 wells); dissolved-organic carbon (27 wells); insecticides and herbicides (10 wells); aroclors (6 wells); and base, neutral, and acid extractable compounds (6 wells) were determined. Additional ground-water levels were measured at 9 well sites in Louisiana and 12 well sites in Mississippi. Water-levels in eight deep wells were used to prepare a potentiometric-surface map of the Graham Ferry Formation.

Water-quality data were collected in Louisiana from 11 wells at depths ranging from 20 to 82 feet in the shallow Pleistocene sands, 4 wells at depths ranging from 19 to 83 feet in the Upland Terrace, and 1 well at a depth of 230 feet in the "400-foot" sand. In Mississippi, water-quality data were collected from 12 wells at depths ranging from 15 to 71 feet in the Graham Ferry Formation, 5 wells at depths ranging from 11 to 68 feet in the Citronelle Formation, and 1 well at a depth of 11 feet in the Biloxi River alluvium (table 1).

Geohydrologic information was obtained from ongoing studies, published reports, and the U.S. Geological Survey data base. This information was used to select data-collection sites and to determine the movement of shallow ground water. Lithologic information was obtained principally from logs of holes augered during the study and, in small part, from selected driller's logs of existing wells. Although geophysical logs of many deep wells are available, the shallow zones (less than about 200 feet) generally are not logged.

Comparable field and laboratory methods were used in Louisiana and Mississippi to obtain data that best represent the ambient quality of shallow ground water and any changes in water quality that might be associated with a particular land-use activity. Methods used during the study are described in published reports by Wershaw and others (1983) and Fishman and Friedman (1985). Quality-assurance practices used by the laboratories are described in a published report by Friedman and Erdmann (1982).

GEOHYDROLOGY

The shallow aquifers of the Gulf Coastal Plain are a complex sequence of sands, silts, and clays which vary in hydraulic conductivity over very short distances. The system is susceptible to surface contamination because recharge to the shallow aquifers occurs over most of their areal distribution.

The Gulf Coastal Plain is composed of gulfward dipping and thickening beds that range in age from Quaternary at the top to Tertiary deposits of Miocene age at the base. These sediments, of fluvial, deltaic, and estuarine origin, were deposited during the slow subsidence of the Gulf Coast geosyncline and during periods of sea-level fluctuations. These depositional activities resulted in a thick sequence of sand and sand and gravel aquifers interbedded with clay and silt confining zones. Outcrop belts of deposits of both Quaternary and Tertiary age roughly parallel the Gulf Coast from Texas to Florida. The dip of the strata in southeastern Louisiana and in Mississippi is predominantly southwestward, ranging from as much as 85 feet per mile near the Mississippi Coast (Brown and others, 1944) to as little as 20 feet per mile near Baton Rouge (G.T. Cardwell, oral commun., 1984).

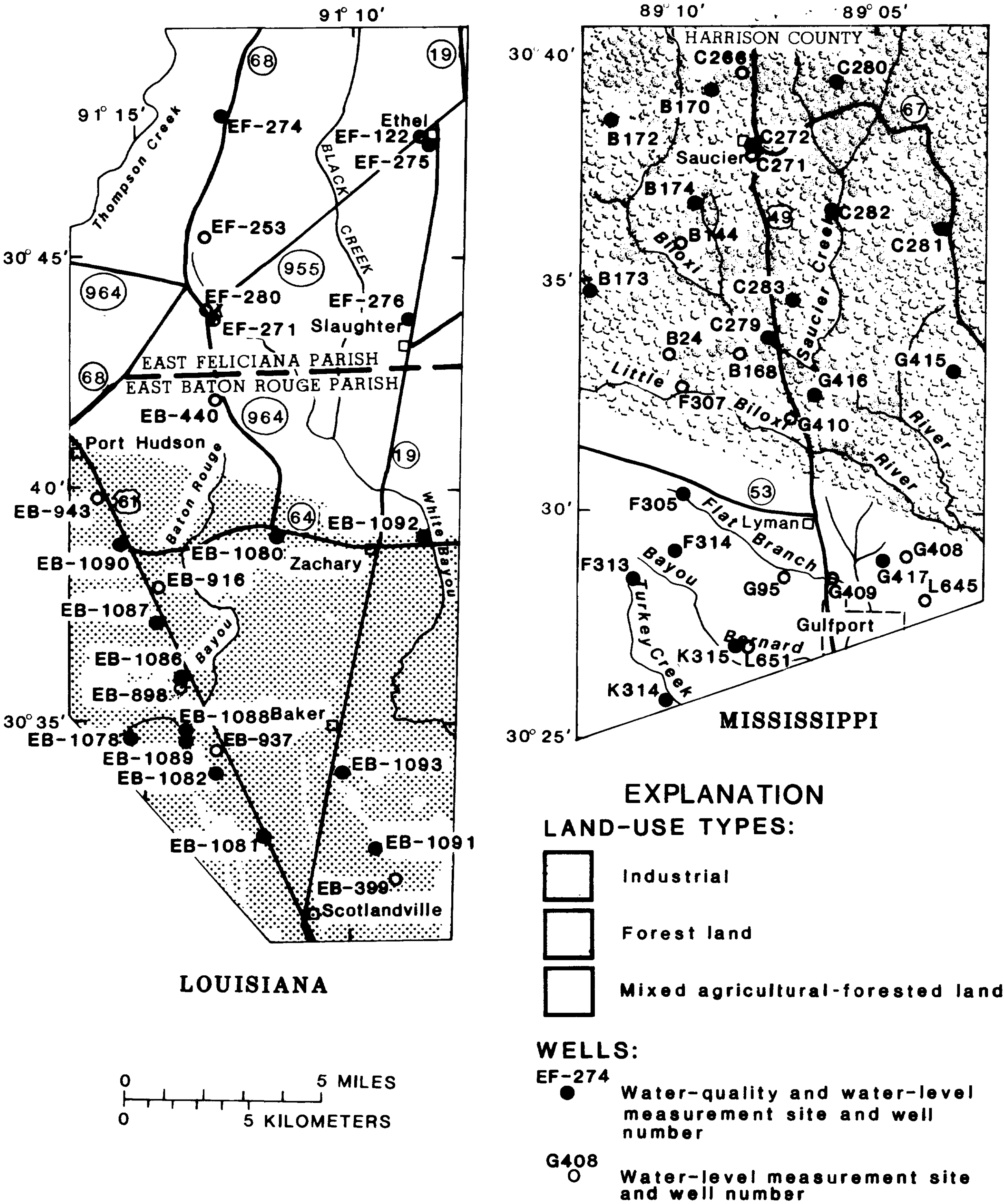


Figure 2.--Land use and location of observation wells sampled for chemical analysis.

Table 1.--Records of selected water wells

[Polyvinyl chloride, PVC; galvanized, Galv.; stainless steel, SS; observation, O; unused, U; destroyed, Z; "400-foot" sand, 11204BR; upland terrace, 112UPTC; shallow Pleistocene, 112SLBR; Graham Ferry Formation, 121GRMF; Citronelle Formation, 121CRNL; alluvium, 111ALUV]

Well number	Year drilled	Well depth (feet)	Well casing: Diameter (inches)	Well casing: Type	Screened interval (feet)	Altitude of land surface (feet)	Water Level: Above sea level (feet)	Water Level: Below land surface (feet)	Date measured	Well use	Water bearing unit
INDUSTRIAL											
EB-399	1944	294	3	Galv.	284-294	65	20.7	44.3	10-12-84	O	11204BR
EB-898	1972	101	1.25	Galv.	98-101	72	44.8	27.2	3- 7-85	O	112SLBR
EB-916	1956	200	2	Iron	190-200	93	39.1	53.9	10-12-84	O	11204BR
EB-937	1967	336	6	Galv.	316-336	66	32.6	33.4	10-11-84	O	11204BR
EB-943	1969	200	2	Galv.	190-200	96	20.3	75.7	10-11-84	O	11204BR
EB-1078	----	230	4	PVC	210-230	77	10.2	66.8	10-19-84	Z	11204BR
EB-1080	1984	82	2	PVC	72- 82	96	62.9	33.1	3- 7-85	O	11204BR
EB-1081	1984	77	2	Galv.	75- 77	71	54.6	16.4	3- 7-85	O	112SLBR
EB-1082	1984	75	2	PVC	65- 75	73	52.4	20.6	3- 7-85	O	112SLBR
EB-1086	1985	25	2	PVC	15- 25	72	66.6	5.4	3- 7-85	O	112SLBR
EB-1087	1985	44	2	PVC	34- 44	85	71.5	13.5	3- 7-85	O	112SLBR
EB-1088	1985	30	2	PVC	20- 30	71	61.5	9.5	3- 7-85	O	112SLBR
EB-1089	1985	20	2	PVC	10- 20	71	70.0	1.0	3- 7-85	O	112SLBR
EB-1090	1985	22	2	PVC	12- 22	91	85.0	6.0	3- 7-85	O	112SLBR
EB-1091	1985	36	2	PVC	26- 36	68	64.6	3.4	3- 7-85	O	112SLBR
EB-1092	1985	31	2	PVC	21- 31	96	80.1	15.9	3- 7-85	O	112SLBR
EB-1093	1985	36	2	PVC	26- 36	70	64.0	6.0	3- 7-85	O	112SLBR
MIXED AGRICULTURAL - FORESTED LAND											
EB-440	1946	195	3	Galv.	179-195	125	77.2	47.8	10-11-84	O	11204BR
EF-122	1956	100	2	-----	95-100	165	142.2	22.8	10-19-84	O	11204BR
EF-253	1976	168	4	Steel	148-168	156	92.9	63.1	5-15-84	O	11204BR
EF-271	1984	83	2	PVC	73- 83	145	76.3	68.7	3- 7-85	O	112UPTC
EF-274	1985	59	2	PVC	49- 59	160	123.1	36.9	3- 7-85	O	112UPTC
EF-275	1985	49	2	PVC	39- 49	167	143.0	24.0	3- 7-85	O	112UPTC
EF-276	1985	19	2	PVC	9- 19	135	132.3	2.7	3- 7-85	O	112UPTC
EF-280	----	165	2	Galv.	155-165	135	105.7	29.3	10-18-84	O	112UPTC
F305	1984	68	2	PVC	-------	125	110.0	15.0	3-29-85	U	121GRMF
F313	1985	48	2	PVC	38- 48	85	74.5	10.5	3-29-85	O	121GRMF
F314	1985	39	2	PVC	29- 39	90	75.6	14.4	3-29-85	O	121GRMF
G95	1967	184	2	Iron	174-184	80	52.1	27.9	10-31-84	U	121GRMF
G408	1974	97	2	Iron	-------	60	41.8	18.2	3-28-85	U	121GRMF
G409	----	101	2	Iron	-------	50	44.2	5.8	3-28-85	U	121GRMF
G417	1985	20	2	PVC	10- 20	65	63.9	1.1	3-28-85	O	121GRMF
K314	1985	15	2	PVC	5- 15	25	24.0	1.0	3-29-85	O	121GRMF
K315	1985	24	2	PVC	14- 24	65	60.2	4.8	3-29-85	O	121GRMF
L645	1970	172	2	Iron	162-172	65	39.1	25.9	10-30-84	U	121GRMF
L651	1965	193	2	Iron	-------	65	39.3	25.7	3-29-85	U	121GRMF
FOREST LAND											
B24	1967	189	2	Iron	179-189	115	69.4	45.6	10- 2-84	U	121GRMF
B144	1983	175	2	Iron	165-175	75	58.4	16.6	3-28-85	U	121GRMF
B168	1958	154	2	Iron	-------	110	55.2	54.8	3-29-85	U	121GRMF
B170	1936	71	2	Iron	-------	130	81.6	48.4	3-28-85	U	121GRMF
B172	1985	40	2	PVC	30- 40	90	76.1	13.9	3-28-85	O	121CRNL
B173	1985	44	2	PVC	34- 44	155	142.9	12.1	3-28-85	O	121CRNL
B174	1985	20	2	PVC	10- 20	95	94.6	0.4	3-28-85	O	121GRMF
C266	1945	19	2	Iron	-------	175	162.3	12.7	3-28-85	U	121GRMF
C271	----	27	2	Iron	-------	165	153.0	12.0	3-28-85	U	121GRMF
C272	1964	36	2	PVC	-------	165	143.7	21.3	3-28-85	O	121GRMF
C279	1985	13	0.625	SS	-------	45	-----	----	--------	Z	111ALUV
C280	1985	11	2	PVC	1- 11	190	185.6	4.4	3-28-85	O	121CRNL
C281	1985	54	2	PVC	44- 54	180	144.0	36.0	3-28-85	O	121CRNL
C282	1985	27	2	PVC	17- 27	65	59.9	5.1	3-28-85	O	121GRMF
C283	1985	37	2	PVC	27- 37	65	51.5	13.5	3-28-85	O	121GRMF
F307	1971	88	2	Iron	-------	60	48.0	12.0	3-29-85	U	121GRMF
G410	----	136	2	Iron	-------	60	33.4	26.6	3-28-85	U	121GRMF
G415	1985	23	2	PVC	3- 13	125	122.4	2.6	3-28-85	O	121GRMF
G416	1985	36	2	PVC	26- 36	45	40.2	4.8	3-28-85	O	121GRMF

The shallow aquifers in the study area have a similar fluvial and marine depositional environment. These aquifers consist of deposits of Pliocene and Pleistocene age and terrace and local alluvial deposits of Holocene age. Sands, silts, and clays, ranging from highly permeable to relatively impermeable, are the primary materials that make up the deposits.

In the study area the hydrology of the shallow sediments is poorly defined because of the limited use of the shallow aquifers. Observations of water-level responses to rainfall indicate that the major source of recharge to the shallow aquifers is by vertical leakage through the surficial deposits. The age of the water at depths of about 50 feet or less is believed to be young enough to reflect land-use activities during the past 50 years.

The shallow Pleistocene sands in Louisiana are a series of thin, laterally discontinuous sandy lenses, which may be 80 feet thick in some areas and extend to a depth of 120 feet below land surface. These sandy lenses do not crop out, and recharge is mainly from infiltration through the surficial materials that consist of clays and silts (fig. 3). The direction of ground-water movement in the shallow water-table aquifers in the Pleistocene sands is to the south-southwest toward the Mississippi River (fig. 4). There also are some unconnected sand beds and perched water tables.

The "400-foot" and "600-foot" sand aquifers of the Baton Rouge area underlie the shallow Pleistocene sands. However, in at least part of the industrial area, the shallow Pleistocene sands are vertically connected to the "400-foot" sand and the predominant direction of ground-water movement is southwest toward the Mississippi River (fig. 5). This vertical connection provides a potential for downward migration of contaminants from the surface.

The "400-foot" and "600-foot" sands merge north of the industrial area near Zachary, East Baton Rouge Parish, Louisiana, to form one hydrologic unit (fig. 6). Northward, in East Feliciana Parish, this aquifer is known as the Upland Terrace which consists of interfingering clays, silts, sand, and gravel.

The Graham Ferry Formation is the oldest of the shallow deposits and crops out over most of the study area in Mississippi. It consists predominantly of a series of deltaic sediments that range in thickness from about 200 to nearly 800 feet in the southern part of the study area. The aquifers of the Graham Ferry Formation are composed of a network of water-bearing sands that differ in areal extent and depth (fig. 7). They are lenticular, varying in both bed thickness and grain size over short distances.

Rates of ground-water movement in the Graham Ferry Formation are variable due to changes in lithology over short distances. The direction of ground-water flow is toward streams and rivers (fig. 8). In some wells at depths less than about 50 feet, water levels indicate the presence of perched water tables.

The Citronelle Formation that overlies the Graham Ferry Formation is a reworked sand that is the source of many of the alluvial deposits in the vicinity of the larger streams. Isolated remnants of the original Citronelle Formation remain as ridges throughout the study area. The sands of the Citronelle Formation are locally very thin and discontinuous, but may be as much as 100 feet thick in these ridge crests. In areas where the Citronelle Formation crops out, it is a brick-red color.

Rates and direction of ground-water movement in the Citronelle Formation and alluvium are difficult to determine because of limited distribution. The limited areal distribution of the Citronelle and alluvial aquifers precludes development.

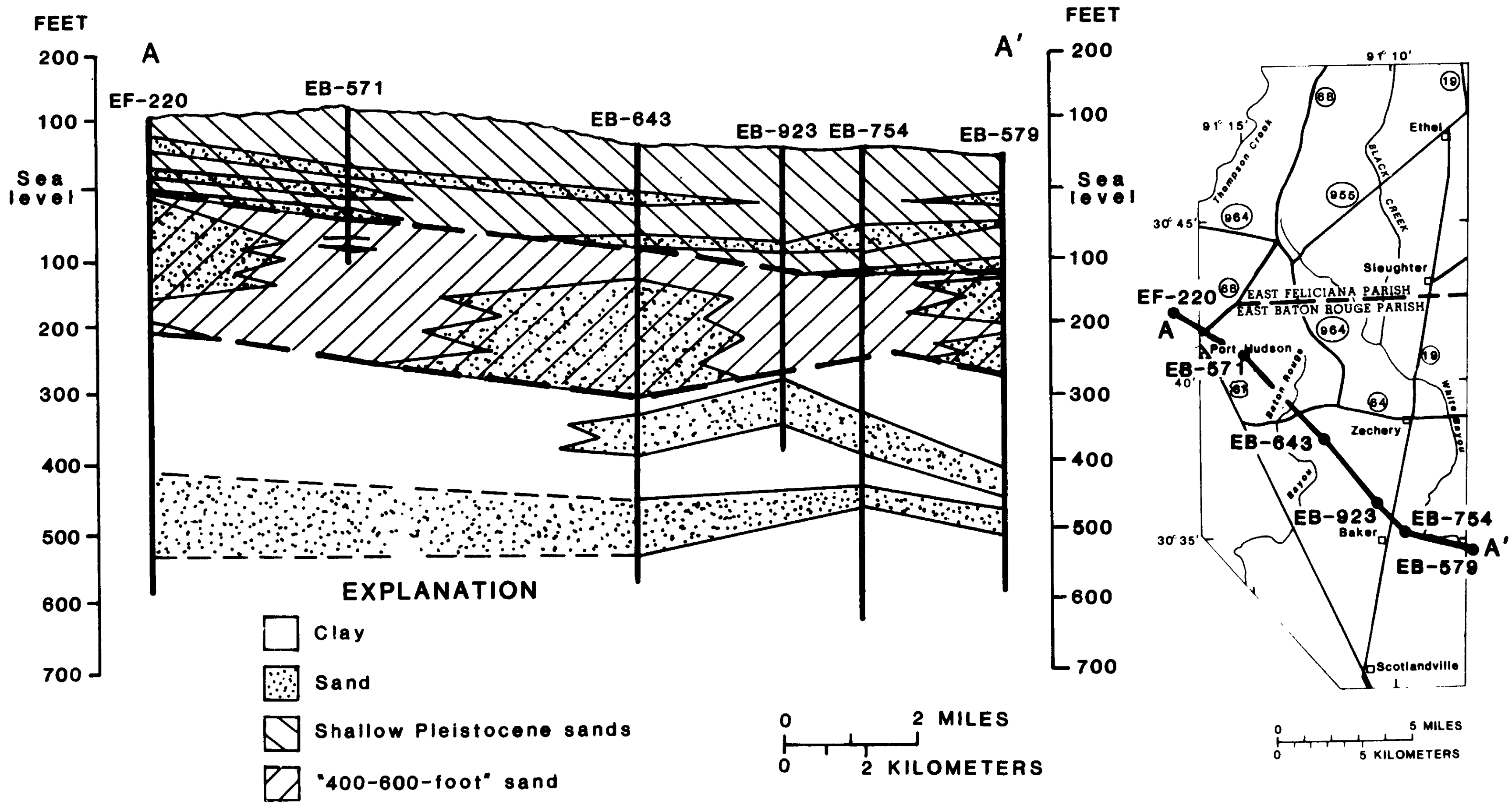


Figure 3.--Geohydrologic section through the Louisiana part of study area.

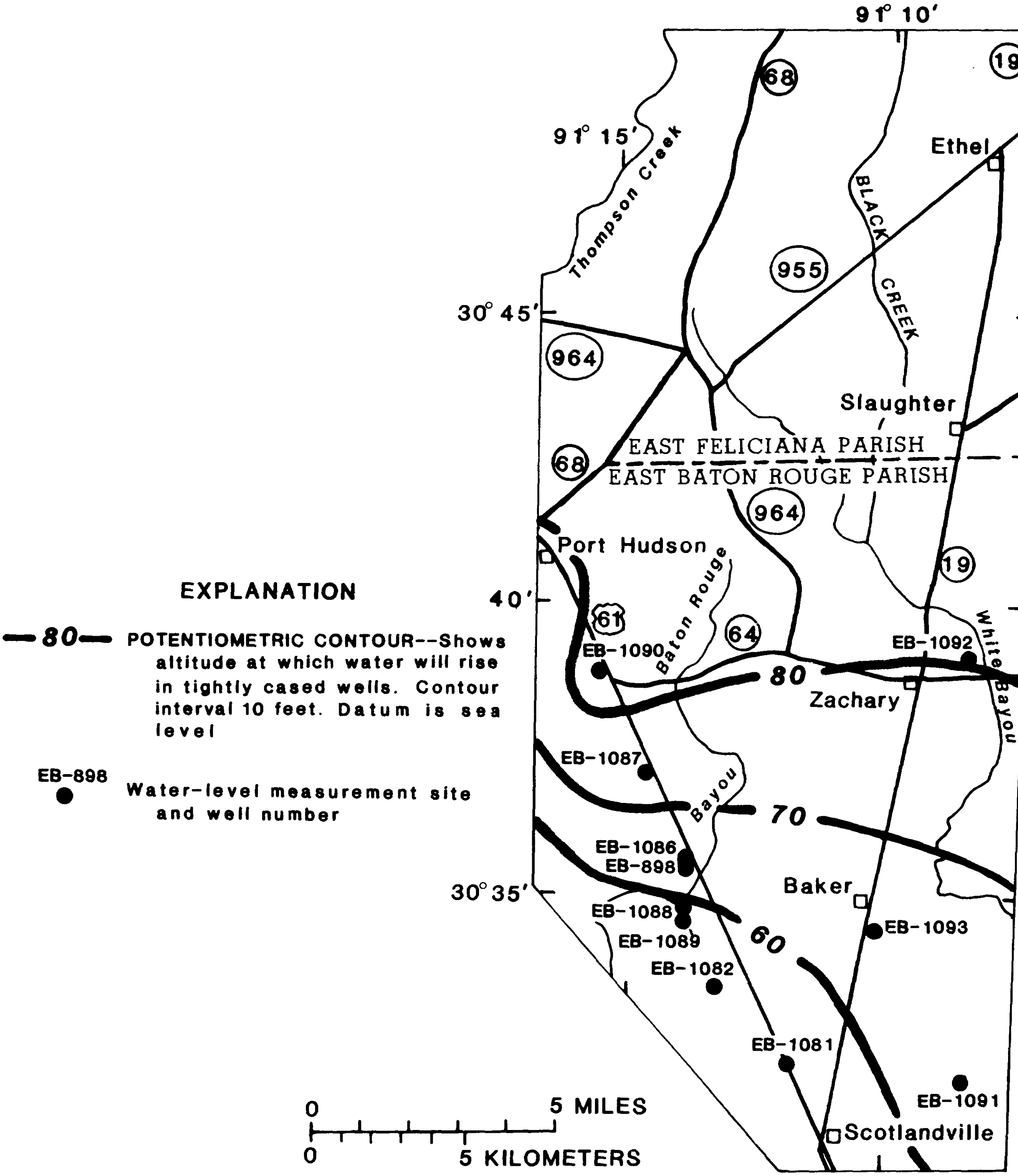


Figure 4.--Potentiometric surface of the shallow Pleistocene sand.

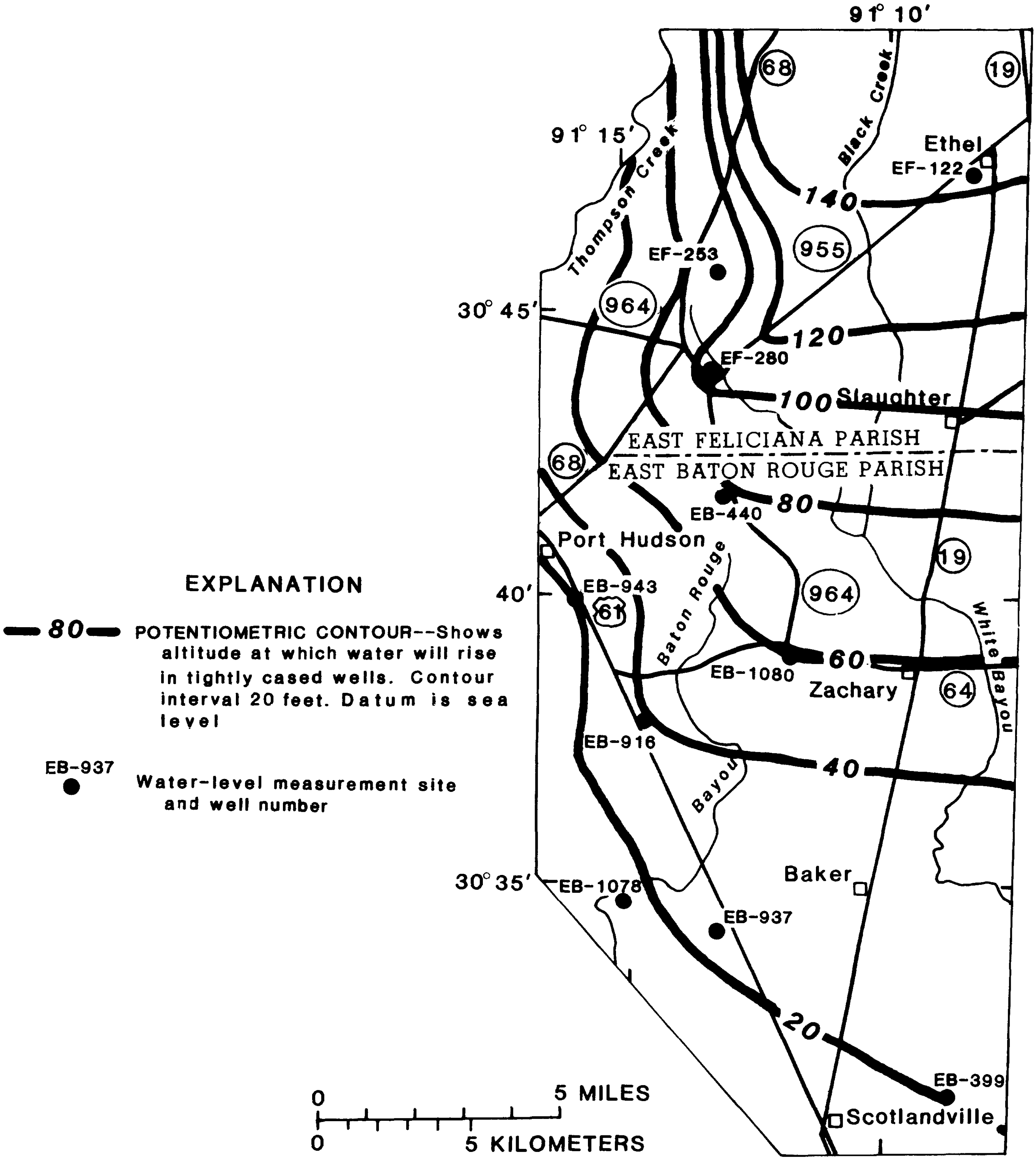


Figure 5.--Potentiometric surface of the "400-foot" sand.

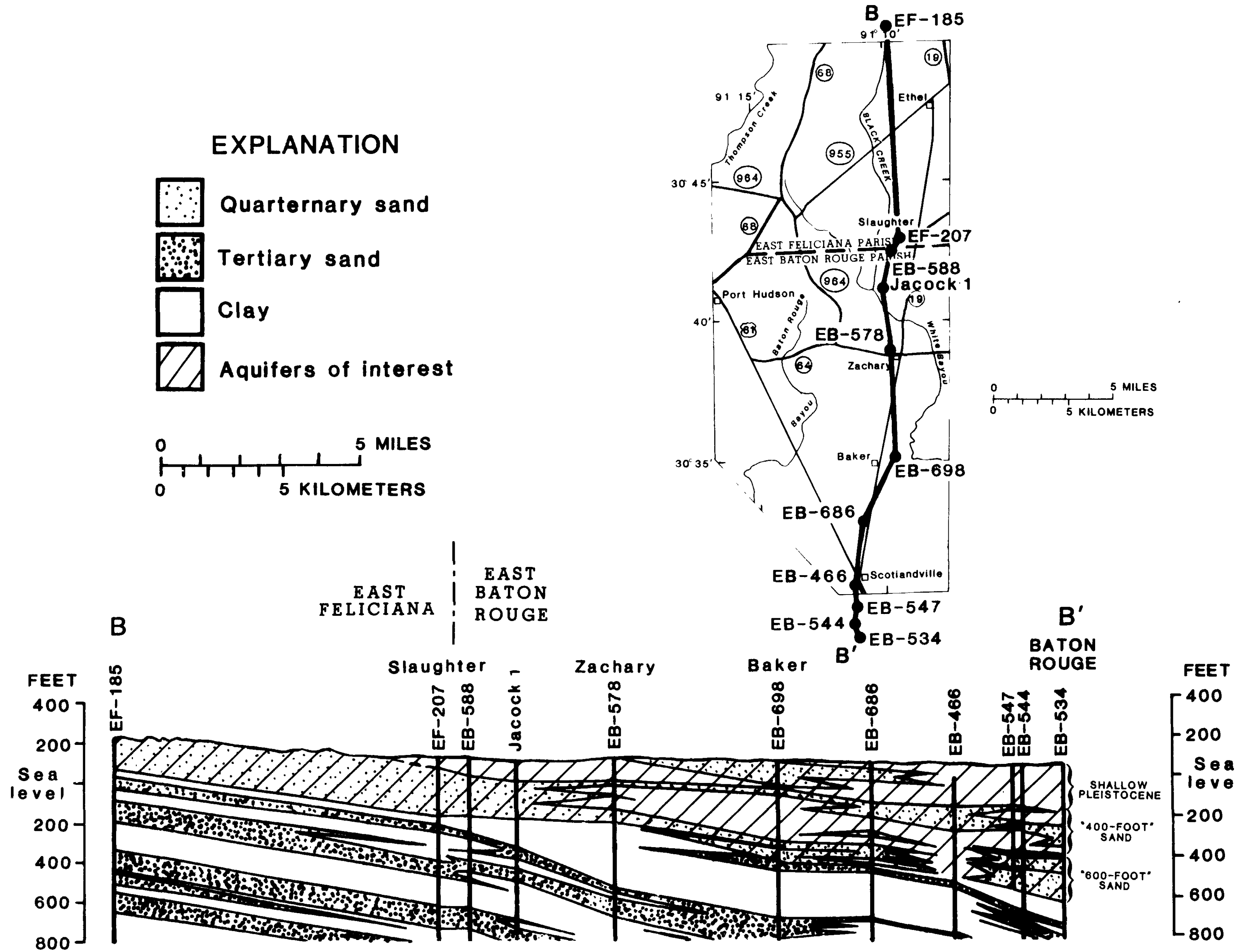


Figure 6.--Geohydrologic section through East Feliciana and East Baton Rouge Parishes, Louisiana.

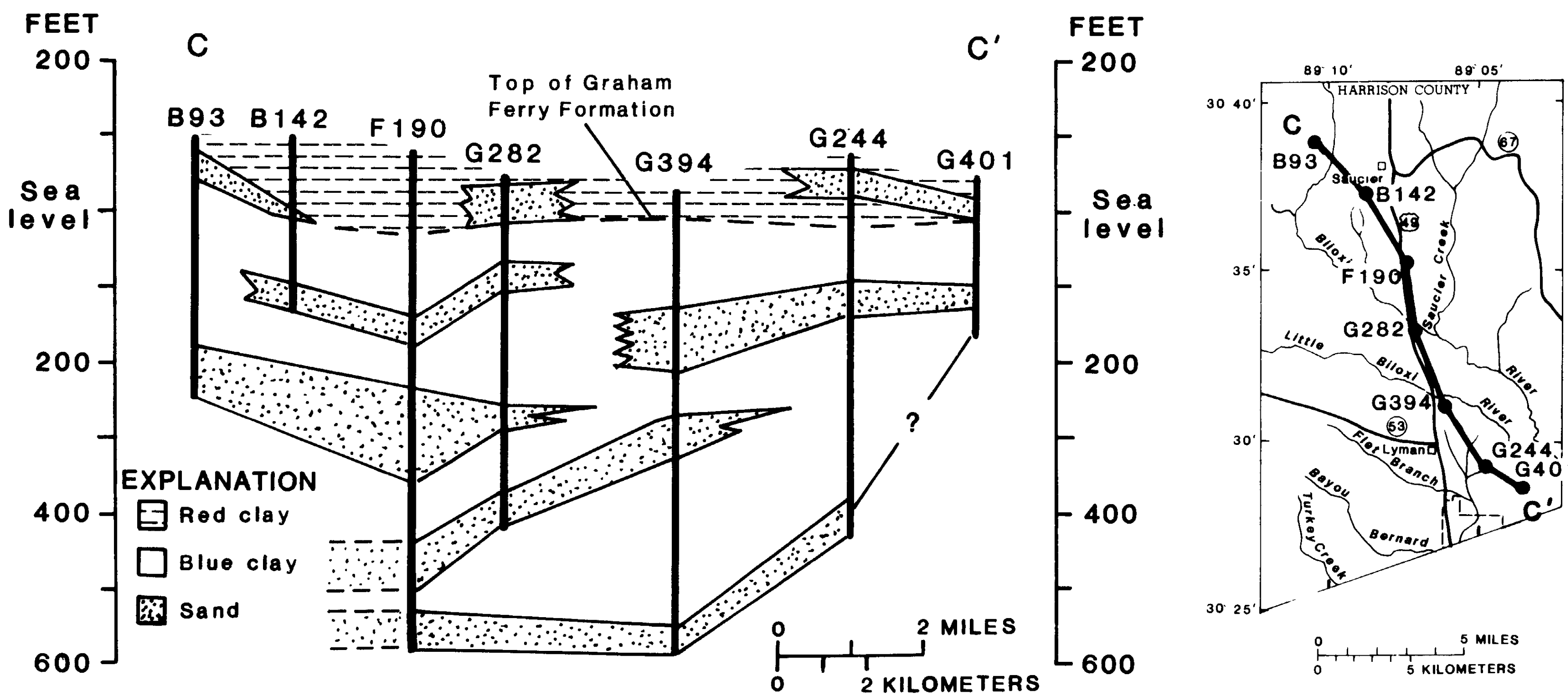
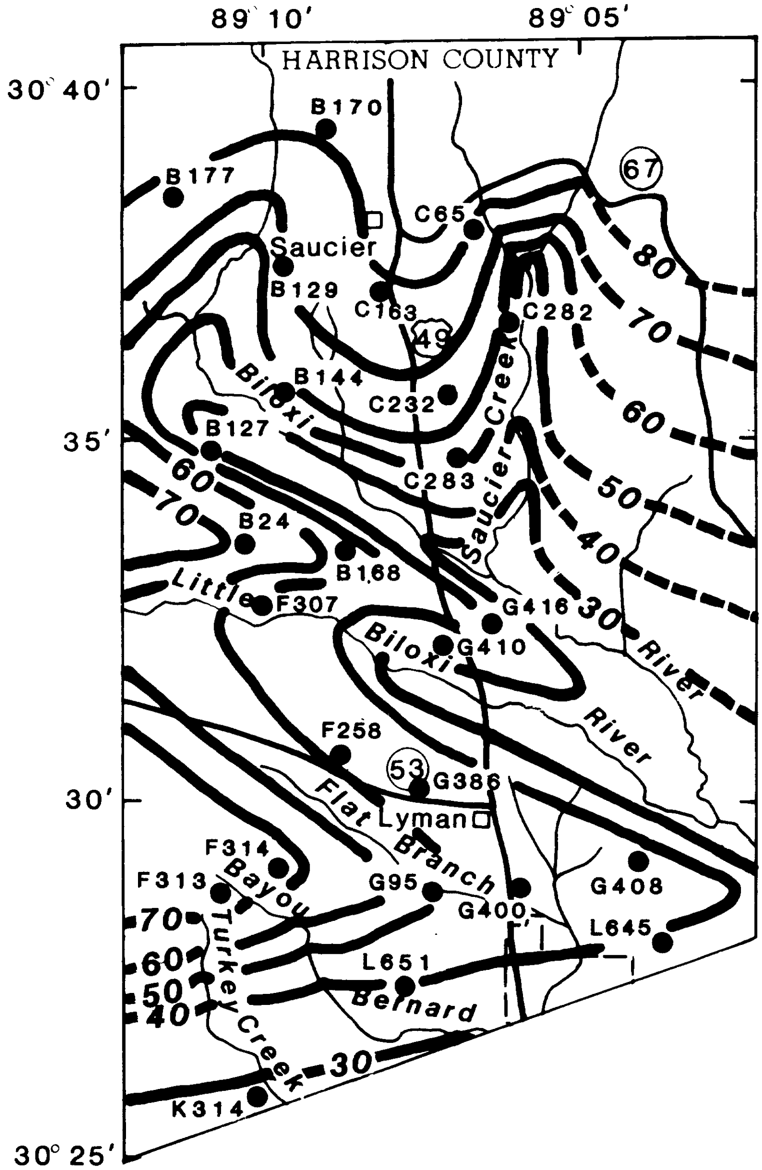


Figure 7.--Geohydrologic section from north to south in the Mississippi part of study area.



EXPLANATION

60 POTENTIOMETRIC CONTOUR--Shows altitude at which water will rise in tightly cased wells. Contour interval 10 feet. Dashed where approximately located. Datum is sea level

F258 ● Water-level measurement site and well number

0 5 MILES
0 5 KILOMETERS

Figure 8.--Potentiometric surface of the Graham Ferry Formation.

LAND USE

Land-use information for the study was compiled from aerial photographs, land-use maps, and on-site mapping. In Louisiana, 52 percent of land use is mixed agricultural-forested and 48 percent is industrial; in Mississippi, 70 percent is forest land and 30 percent is mixed agricultural-forested (fig. 2).

The urban development presently scattered throughout the study area is a small percentage of the total land use. Most urban land use is in the southern part of the industrial land-use area in Louisiana and the mixed agricultural-forested land-use area in Mississippi. Although a trend in increased urban growth is expected to continue for the next several years, the largest increase probably will be in the mixed agricultural-forested part of the study area.

Industrial land use is confined to the Louisiana part of the study area (fig. 2). The major industries produce chemical, petrochemical, oil and gas, and wood and paper products. Most industrial growth within the area has occurred in the last 50 years. The locations of areas of potential ground-water contamination have been identified by the Louisiana Department of Environmental Quality (written commun., 1985). Several landfill and hazardous-waste sites are situated in areas where downward movement of water from shallow Pleistocene deposits to deeper aquifers is possible.

The mixed agricultural-forested areas are similar in Louisiana and Mississippi (fig. 2). There are few large farms in the area and less than half of the mixed land-use area is under cultivation. The trend in farming is toward raising beef and dairy cattle; much of the open land is pasture or hay fields. A small amount of land is used for row crops, truck farms, and orchards.

A large part of the forest land is used for tree farming. Conifer forests predominate. Loblolly, slash, short leaf, and spruce pines are the most abundant. Some hardwoods, including oak, magnolia, poplar, gum, elm, ash, and hickory are grown.

RELATION BETWEEN LAND USE AND GROUND-WATER QUALITY

Non-parametric statistical procedures were used to determine the relation between land use and quality of water from the shallow aquifers. Maximum, minimum, and median concentrations, and the interquartile range for selected constituents are summarized in table 2. Interquartile range is the range of the middle 50 percent of the calculated values. For example, the interquartile range for barium in the industrial land-use area indicates that 50 percent of the barium concentrations are between 280 and 800 ug/L (micrograms per liter) (table 2).

Results of the statistical analyses (table 2) show that concentrations of some inorganic constitutents in shallow aquifers in the industrial land-use area are significantly different from those of the mixed agricultural-forested and forest land-use areas. Results of qualitative organic scan analyses suggest the presence of a larger number of organic compounds in water from wells in the industrial land-use area; however, except for dissolved organic carbon (DOC), data are insufficient to apply statistical procedures to relate land use to the concentration of organics in ground water.

Inorganic Constituents

The median dissolved-solids concentration in the industrial land-use area is 370 mg/L (milligrams per liter). The median dissolved-solids concentrations in the mixed agricultural-forested and forest land-use areas are 70 and 32 mg/L, respectively. The median alkalinity is 204 mg/L and pH is significantly higher in water from wells in the industrial land-use area. The median pH value is 6.6 units compared to 5.4 units in both the mixed agricultural-forested and forest land-use areas.

Table 2.--Statistical summary of selected chemical constituents grouped by land use

[N, number of analyses; IQR, interquartile range; uS/cm, microsiemens per centimeter; mg/L, milligrams per liter; ug/L, micrograms per liter]

Constituent or Property	Land-use type											
	Industrial				Mixed Agricultural-Forest				Forested			
	N	Range	IQR	Median	N	Range	IQR	Median	N	Range	IQR	Median
Specific Conductance (uS/cm)	13	97 - 2,970	382 - 960	565	10	28 - 398	45 - 131	97	12	20 - 252	28 - 49	33
pH (standard units)	14	5.3 - 7.3	6.0 - 6.9	6.6	10	4.9 - 5.9	5.2 - 5.6	5.4	13	5.0 - 7.7	5.3 - 5.8	5.4
Color (Platinum -Cobalt units)	12	<1 - 250	<1 - 10	5	10	<1 - 200	<1 - 5	<1	11	<1 - 240	5 - 70	5
Calcium (mg/L)	12	2.2 - 230	30 - 94	54	10	.29 - 9.3	.59 - 4.2	1.1	12	.22 - 24	.59 - 2.3	1.1
Magnesium (mg/L)	12	1.3 - 79	10 - 30	20	10	.16 - 3.6	.49 - 2.3	.90	12	.40 - 8.5	.46 - 1.0	.55
Sodium (mg/L)	12	10 - 350	20 - 124	34	10	2.4 - 72	4.6 - 18	15	12	1.2 - 15	2.6 - 4.8	3.3
Alkalinity (Mg/L as $CaCO_3$)	13	12 - 354	118 - 290	204	10	4.0 - 82	5.0 - 14	10	11	2.0 - 114	3.0 - 11	5.0
Sulfate (mg/L)	12	1.6 - 94	5.9 - 20	10	10	.3 - 24	1.9 - 12	7.0	12	.4 - 18	1.2 - 6.6	1.8
Chloride (mg/L)	12	7.2 - 900	12 - 150	24	10	3.9 - 74	5.3 - 26	6.4	12	2.4 - 8.3	4.0 - 6.2	5.2
Silica (mg/L)	12	16 - 44	31 - 38	37	10	5.8 - 28	8.8 - 24	14	12	3.5 - 61	9.0 - 28	12
Solids, sum of constituents (mg/L)	12	96 - 1,600	250 - 540	370	10	19 - 230	43 - 83	70	11	12 - 200	20 - 59	32
Carbon, organic dissolved (mg/L)	12	.6 - 5.6	1.2 - 2.9	2.2	6	.9 - 2.4	1.0 - 1.3	1.1	9	.80 - 5.5	1.2 - 2.8	1.5
Nitrite + Nitrate (mg/L as N)	10	<.10 - .56	<.10 - .48	<.10	7	<.10 - 1.4	<.10 - .79	<.10	12	<.10 - 4.8	<.10 - .20	<.10
Ammonia (mg/L as N)	10	<.01 - .16	.02 - .07	.05	5	<.01 - .21	<.01 - .14	<.01	12	<.01 - .28	<.01 - .06	.01
Phosphorus (mg/L as P)	12	<.01 - .50	<.01 - .12	<.01	10	<.01 - .07	<.01 - .03	<.01	12	<.01 - .47	<.01 - <.01	<.01
Aluminum (ug/L)	12	<10 - 50	<10 - 20	10	9	<10 - 60	<10 - 45	20	12	<10 - 150	<10 - 20	10
Arsenic (ug/L)	12	<1 - 3	<1 - 1	<1	9	<1 - <1	<1 - <1	<1	12	<1 - 4	<1 - <1	<1
Barium (ug/l)	11	<100 - 2,000	280 - 800	300	6	14 - 86	18 - 58	26	12	16 - 160	20 - 60	38
Cadminum (ug/l)	12	<1 - 3	1 - 1	1	9	<1 - 13	<1 - 8	1	11	1 - 11	2 - 4	2
Copper (ug/l)	12	<1 - 3	<1 - 2	<1	9	1 - 8	1 - 4	2	12	1 - 310	2 - 6	3
Iron (ug/l)	12	<3 - 280	5 - 20	10	10	<3 - 760	5 - 240	18	12	5 - 2,000	12 - 535	46
Lead (ug/l)	12	<1 - 4	1 - 2	2	9	<1 - 6	1 - 3	2	12	1 - 12	1 - 4	2
Manganese (ug/l)	13	<3 - 2,300	10 - 480	140	10	<3 - 160	9 - 37	25	12	4 - 530	9 - 62	27
Mercury (ug/l)	12	<.1 - .6	<.1 - .3	.1	9	<.1 - .3	<.1 - .1	<.1	12	<.1 - .4	<.1 - <.1	<.1
Nickel (ug/l)	12	1 - 8	1 - 6	2	9	1 - 6	2 - 3	3	12	1 - 4	2 - 3	2
Zinc (ug/l)	12	10 - 1,600	25 - 145	50	9	10 - 110	11 - 56	28	12	7 - 120	12 - 22	17

Median chloride concentrations ranged from 5.2 to 24 mg/L in the three land-use areas. Chloride concentrations were 250, 660, and 900 mg/L in water from three wells in the industrial area. Chloride concentrations of this magnitude suggest contamination, from either petroleum or petrochemical wastes. Two wells near the Mississippi Gulf Coast in the mixed land-use area have substantially higher chloride concentrations than background. The higher chloride concentrations may be attributed to salt spray and salt-laden precipitation transported inland by prevailing winds.

The interquartile range (5.9 - 20 mg/L) and median concentration (10 mg/L) for sulfate indicates the presence of higher concentrations in shallow ground water in the industrial land-use area. Median sulfate concentrations are 7.0 and 1.8 mg/L in the mixed agricultural-forested and forest land-use areas, respectively.

Nutrient concentrations in water from most wells were low. The median ammonia value is 0.05 mg/L for the industrial land-use area and less than 0.01 mg/L for the other land-use areas. Median nitrite plus nitrate and phosphorus values are less than 0.01 mg/L for all land-use areas (table 2).

Organic Compounds

Statistically, there is no significant difference in the DOC concentrations in water from wells in the three land-use areas; however, DOC concentrations were determined in water from only five wells in the mixed agricultural-forested land-use area. There is need for more data to evaluate DOC in terms of land-use effects. The median DOC concentrations were 2.2, 1.1, and 1.5 mg/L in the industrial, mixed agricultural-forested, and forest land-use areas, respectively.

Although some organic compounds were present in water from all wells sampled, concentrations often were too low to identify or quantify specific compounds. Most of the wells sampled in the industrial land-use area are deeper than 30 feet. If organic compounds are present and are migrating downward from the land surface, water from shallower wells may contain organic compounds in concentrations large enough to identify and quantify. In general, more organics were found in water from wells in the industrial area than in the other two land-use areas. There was an average of seven organic compounds per well in the industrial area, compared to an average of five and three compounds for wells in the mixed agricultural-forested and forest land-use areas, respectively. This could be due to the presence of organic materials generated by industrial activities; however, some compounds common to the three land-use areas apparently occur naturally and do not reflect a particular land-use activity.

The concentration of trichloroethylene, a purgeable organic compound, in water from one well was 6.4 ug/L. Trichloroethylene has many industrial applications and also is used as a degreasing agent in septic tanks. The well is near a farm house in a relatively isolated rural area. No other purgeable organic compounds were present in water from any wells sampled.

Pesticides were present in trace amounts in water from two wells sampled. One well in the industrial land-use area contained dicamba (0.04 ug/L) and one well in the mixed agricultural-forested land-use area contained diazinon (0.02 ug/L). Aroclors were below the level of detection in water from all wells sampled.

Organic compounds, di-n-butyl phthalate and bis (2-ethylhexyl) phthalate, that are on the U.S. Environmental Protection Agency (USEPA) priority pollutant list (1979) were detected in three wells, two in the industrial land-use area and one in the mixed agricultural-forested land-use area. Organic compounds that are not on the priority pollutant list also were identified in two wells in the industrial land-use area. These included 2-(ethoxyethoxy) ethanol, a solvent for cellulose esters, in concentrations of 3 to 5 ug/L. Also identified in water from wells in the industrial land-use area were 10 ug/L of 1-methyl-2-cyclopentencarbonic acid, 3 ug/L of 1-bromo-2-chloro-cis cyclohexane, 22 ug/L of 2,5-diethy-tetrahydro furan, and 14 ug/L of 2-bis-cyclohexene. These organic compounds or their derivatives commonly are used as industrial type solvents. Caprolactam (73 ug/L), a high molecular weight solvent used in the manufacture of synthetic fibers of the polyamide type, was present in water from the deepest well sampled in the industrial land-use area.

Trace Elements

Barium concentrations in water from wells in the industrial land-use area were significantly higher than in the other land-use areas. Median concentrations of barium were 300, 19, and 38 ug/L for wells in industrial, mixed agricultural-forested, and forest land-use areas, respectively. The higher median barium concentration for wells in the industrial land-use area indicates manmade contamination. For many years there has been extensive oil exploration and production in the Louisiana part of the study area. Barium is a major constituent of most drilling muds, and the intensity of oil drilling in the area may be reflected by elevated barium levels in shallow ground water. A well with a barium concentration of 800 ug/L is located less than a mile from an abandoned oil-test well. The water from this well had a chloride concentration of 250 mg/L, which also is indicative of oil-field brines mixing with freshwater in shallow aquifers.

Median manganese concentrations are 140, 25, and 27 ug/L for the industrial, mixed agricultural-forested, and forest lands, respectively. Although manganese concentrations in water from wells in the industrial land-use area are higher than those in the other two land-use areas, this difference is not statistically significant because of the large variation in manganese concentrations in the industrial land-use area. Land-use practices in the industrial land-use area rather than a difference in formation lithology probably is the cause of elevated manganese concentrations. Manganese concentrations exceeded 50 ug/L, the USEPA (1986) criteria for drinking water, in nine wells in the industrial land-use area, four wells in the forest land-use area, and one well in the mixed agricultural-forested land-use area. Manganese concentrations exceeded 100 ug/L in water from seven of the wells in the industrial land-use area.

Iron exceeded the 300 ug/L quality criteria (USEPA, 1986) for water in 25 percent of the wells sampled in the forest land-use area and 20 percent of the wells in the mixed agricultural-forested land-use area. Iron concentrations in the water from wells in the industrial land-use area were less than 300 ug/L (table 2).

Trace-element concentrations in water from most wells were less than maximum quality criteria (USEPA, 1986) or below analytical detection limits for water from most wells sampled. Cadmium concentrations in two wells in the forest land-use area exceeded the 10 ug/L quality criteria (USEPA, 1986). Concentrations in all other wells were 3 ug/L or less.

SUMMARY AND CONCLUSIONS

Water-table aquifers in the study area are comprised of sand lenses that are partially interconnected and probably connect to underlying aquifers. There is potential for contamination to move into the shallow aquifers.

Land uses in the study area are typical of the southwestern part of the Gulf Coastal Plain. The land-use types were divided into three major categories that best represent land-use activities in the study area during the past 50 years. In Louisiana, 52 percent is mixed agricultural-forested and 48 percent is industrial. In Mississippi, 70 percent is forest land and 30 percent is mixed agricultural-forested. Wells were sampled at 34 sites in the three land-use areas in order to assess changes in shallow ground-water quality that occur as a result of a particular land-use activity.

Water from 16 wells in Louisiana and 18 wells in Mississippi was sampled and analyzed for common constituents, organic compounds, nutrients, and trace elements. Concentrations of pesticides, aroclors, and base, neutral, and acid extractable organic compounds were low or below the detection limit in water from selected wells in all land-use areas.

Alkalinity (as $CaCO_3$) and dissolved-solids, chloride, manganese, and barium concentrations, as well as pH, usually were higher in water from wells in the industrisl land-use area than from the other two land-use areas. The high chloride and barium may have originated from oil-field brine contamination of wells in the industrial land-use area.

Although dissolved-organic-carbon concentrations were higher in water from wells in the industrial and forest land-use areas than the wells in the mixed agricultural-forested land-use area, more data are needed to evaluate the statistical significance of the difference. A greater number of organic compounds were present in water from wells in the industrial land-use area. Most of the organic compounds in water from all land-use areas were too low to identify. Priority pollutants di-n-butyl phthalate and bis (2-ethylhexyl) phthalate were found in water from two wells in the industrial and one well in the mixed agricultural-forested land-use areas. Several other organic compounds commonly used for industrial purposes also were present in water from two wells in the industrial land-use area. The purgeable organic compound trichloroethylene was detected in water from one well in the mixed agricultural-forested land-use area. In the industrial land-use area, manganese concentrations in water from several wells were high. Moat other trace elements in the water from virtually every well sampled were within limits recommended by USEPA quality criteria for water. Toxic trace elements and organic compounds present at shallow depths in the industrial land-use area may be migrating downward.

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