GEOHYDROLOGY, WATER QUALITY, AND EFFECTS OF PUMPAGE ON THE NEW ORLEANS AQUIFER SYSTEM, NORTHERN JEFFERSON PARISH, LOUISIANA

By Don C. Dial and Dan J. Tomaszewski

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 88-4097

Prepared in cooperation with the

JEFFERSON PARISH, DEPARTMENT OF WATER

Baton Rouge, Louisiana

1988

DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who 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 factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per year (ft/yr)	0.3048	meter per year (m/yr)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows: °F = 1.8 X °C + 32.

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

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ABSTRACT

The New Orleans aquifer system includes four areally extensive aquifers (the Gramercy, Norco, Gonzales-New Orleans, and "1,200-foot" aquifers) which are separated by beds of clay. Within the aquifer system in northern Jefferson Parish, only the Gonzales-New Orleans aquifer can be considered as a major source of freshwater; overlying and underlying aquifers generally contain saltwater (water with chloride concentration greater than 250 milligrams per liter). However, in northwestern Jefferson Parish the Gonzales-New Orleans aquifer contains saltwater. Color generally ranges between 50 and 120 platinum cobalt units in freshwater from the Gonzales-New Orleans aquifer. In 1986, about 1 Mgal/d (million gallons per day) of water was withdrawn from the aquifer in northern Jefferson Parish; however, areally (including adjacent parishes) a total of about 40 Mgal/d was withdrawn from the Gonzales-New Orleans aquifer.

A three-dimensional finite-difference ground-water flow model was used to evaluate the effects of increased pumpage on water levels and flow patterns in the Gonzales-New Orleans aquifer. Model simulations included an additional pumpage of 25 Mgal/d over 1986 rates (40 Mgal/d) for 7 days, 30 days, and 20 years, and an additional pumpage of 50 Mgal/d for 1 year. Pumpage was simulated in northeastern Jefferson Parish in areas with the most suitable combination of freshwater and low color, and as far as possible from the present (1987) freshwater-saltwater interface. Results of simulations indicate ground-water velocities at the present freshwater-saltwater interface near Kenner, Louisiana, will increase from the present average of 65 to 200 feet per year and that water levels will decline as much as 166 feet at simulated well sites with an additional pumpage of 50 Mgal/d for 1 year. Increased pumpage would induce northward movement of saltwater about 4 miles south of the simulated pumping, and cause additional vertical leakage of saltwater through clay beds from overlying and underlying aquifers into freshwater in the Gonzales-New Orleans aquifer.

INTRODUCTION

Jefferson Parish needs an alternative source of freshwater to supplement Mississippi River water, the regular source of supply. The parish generally uses about 50 Mgal/d (million gallons per day) of water from the Mississippi River for public supply (D.L. Lurry, U.S. Geological Survey, written commun., 1986). However, because accidental spills of hazardous chemicals into the river sometimes force the closure of water-supply intakes, Jefferson Parish, Department of Water, is interested in developing a contingency plan to withdraw 25 Mgal/d, or about 50 percent of present public water supply from a ground-water source for emergency use.

In 1986, about 1 Mgal/d of water was withdrawn from the Gonzales-New Orleans aquifer in northern Jefferson Parish; areal (including adjacent parishes) withdrawals totaled about 40 Mgal/d. However, water-quality problems have restricted the use of water from the aquifer. The most troublesome water-quality problems are high color, and concentrations of chloride that exceed the U.S. Environmental Protection Agency's (1975) recommended upper limit of 250 mg/L (milligrams per liter) for public supply. Large withdrawals of ground water also could result in declining water levels, saltwater encroachment, vertical leakage of saltwater, and possibly land-surface subsidence.

In October 1985, the U.S. Geological Survey, in cooperation with Jefferson Parish, Department of Water, began a study to evaluate the effect of increased pumpage of freshwater from the Gonzales-New Orleans aquifer. The study area, about 50 mi^2 (square miles), includes all of Jefferson Parish north of the Mississippi River (fig. 1) in southeastern Louisiana. Land surface is generally flat, and altitudes range from about 5 ft (feet) below to 5 ft above sea level. At Kenner, Louisiana, the average annual temperature is about 20 °C (degrees Celsius), and average annual precipitation is about 60 in. (inches) (National Oceanic and Atmospheric Administration, 1984).

Purpose, Scope, and Approach

The purpose of this report is to describe the geohydrology and water quality of the Gonzales-New Orleans aquifer, and to evaluate the effects on the aquifer of additional ground-water pumpage of 25 and 50 Mgal/d.

Physical properties of the New Orleans aquifer system, including extent, thickness, lithology, and hydraulic characteristics, are described. The potentiometric surface and water-level trends in the Gonzales-New Orleans aquifer at present (1987) and as anticipated in the event of several withdrawal scenarios, are defined.

Data for this study were collected, analyzed, and interpreted during October 1985 through March 1987. Water-well and test-hole data that include chemical analyses and electric, driller's, and geologic logs were compiled and used to define the geohydrologic setting. A reconnaissance of the study area was made and field data were collected from wells. In areas where data were not available or additional data were needed, test holes were drilled for collection of water-quality, electric-log, and lithologic data.

Five test holes were drilled as part of this study. Each test hole penetrated to the base of the Gonzales-New Orleans aquifer. Electric logs were made to interpret aquifer lithology, extent, thickness, and to determine the occurrence of saltwater in each aquifer. Confining units between aquifers also were identified from electric-log data. Sand samples from selected intervals in the test holes were collected for lithologic description. Water samples were collected from observation wells subsequently completed at each site to further define the water quality in the Gonzales-New Orleans and Norco aquifers.

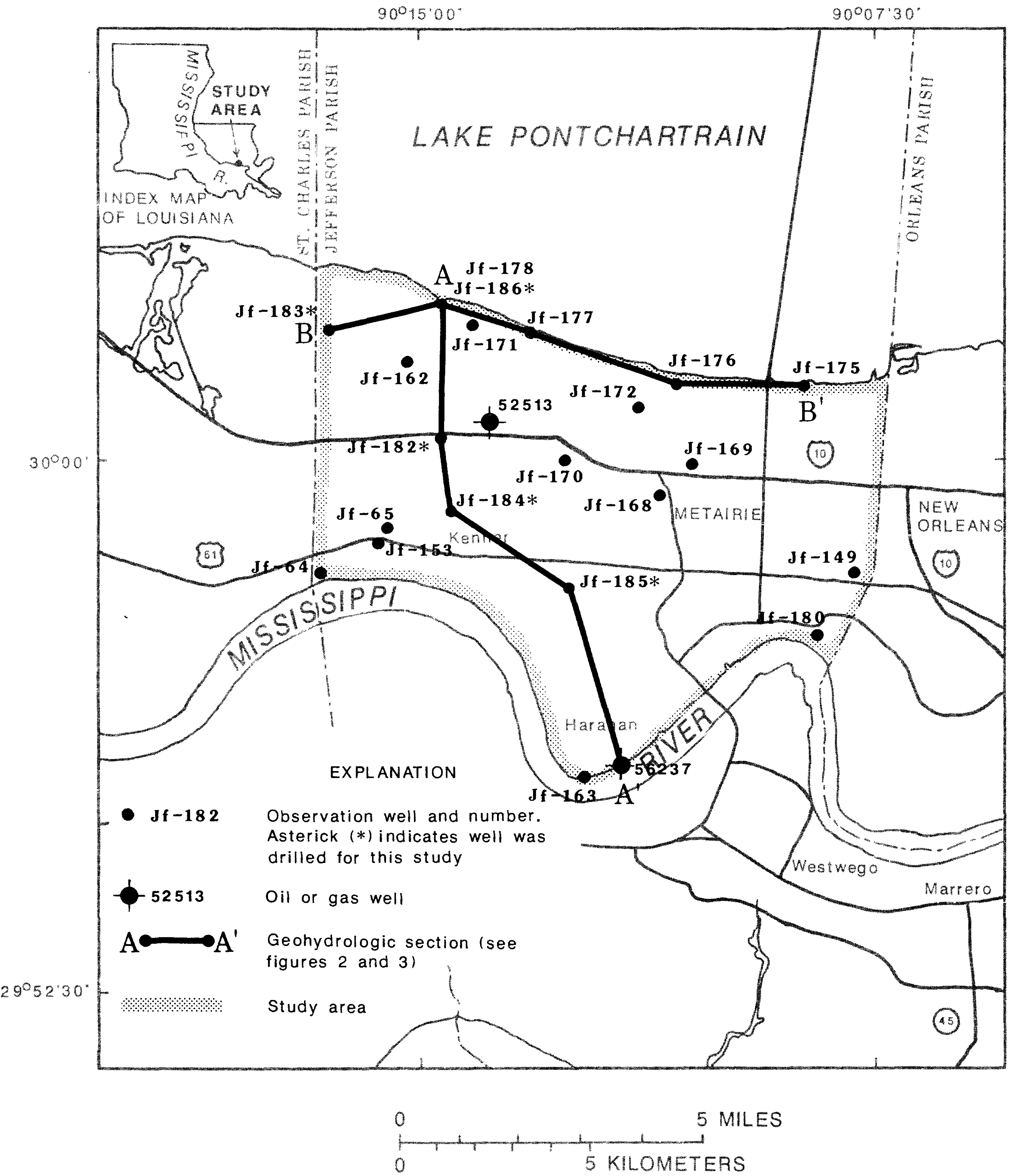


Figure 1.--Location of study area, geohydrologic sections, and observation wells.

Water quality of the Gonzales-New Orleans aquifer is discussed with emphasis on chloride and color, which also are mapped. Water quality of the Gramercy and Norco aquifers are only briefly described because they contain saltwater in most of the study area. As used in this report, saltwater refers to ground water with a chloride concentration greater than 250 mg/L. The "1,200-foot" aquifer, which underlies the Gonzales-New Orleans aquifer, contains saltwater and is only briefly mentioned because wells are not usually drilled to this depth.

A ground-water flow model developed for a previous study of the Greater New Orleans area (Dial and Sumner, 1989) was used to evaluate the water-resources potential of the area under study and to predict water-level declines and flow patterns in the Gonzales-New Orleans aquifer. Aquifer response to four pumpage scenarios was simulated: 25 Mgal/d for periods of 7 days, 30 days, and 20 years, and 50 Mgal/d for 1 year, in addition to areal withdrawals of 40 Mgal/d in 1986 (determined from a water-use survey). Pumping nodes were distributed in areas that were known to have suitable water quality and located as far as possible from the freshwater-saltwater interface.

In this report, wells are identified by the parish abbreviation and sequential number. The abbreviation for Jefferson Parish is Jf. Numbers following this abbreviation indicate the sequential order in which the well was inventoried. Oil and gas wells are identified by a five- or six-digit serial number.

Previous Investigations

Data and published results from previous investigations were reviewed and used in this study. Two reports, a summary of well data for the Mississippi River parishes south of Baton Rouge (Cardwell and others, 1963) and a compilation of water-well and ground-water-quality information for aquifers in the Greater New Orleans area (Dial, 1983), contained information on the study area. Areal reports on ground-water resources in the New Orleans area (Eddards and others 1956; Rollo, 1966) presented the geohydrologic setting. Other ground-water studies on adjoining areas are described in reports on the Lake Pontchartrain area (Cardwell and others, 1967) and the Norco area (Hosman, 1972). These reports include background data that were used to determine geologic, hydraulic, and water-quality characteristics of the aquifers. A complete list of references is given in the "Selected References" section.

Acknowledgments

Well owners in the area were especially cooperative in allowing collection of water-quality and water-level data from wells. Water well contractors supplied some of the driller's- and geophysical-log data used in this study. Special thanks are extended to the city of Kenner and the Jefferson Parish Drainage District for providing test-drilling sites.

GEOHYDROLOGY

The New Orleans aquifer system consists of an alternating series of lenticular clay and sand beds. The sand beds form four areally extensive aquifers which are, from youngest to oldest, the Gramercy, Norco, Gonzales-New Orleans, and "1,200-foot" aquifers. Beds of clay, which act as confining units, separate the individual aquifers and vary in thickness from a few feet to about 200 ft. Two generalized geohydrologic sections through the study area illustrate the complexity and show the relation of the aquifer and confining units to one another (figs. 2 and 3).

The Gonzales-New Orleans aquifer is overlain by localized shallow aquifers, the Gramercy aquifer, and the Norco aquifer. Shallow aquifers consist of point bars, distributary-channel deposits, and isolated near-surface beds of sand, (Rollo, 1966, p. 9-12). These localized shallow aquifers occur in a thick bed of clay (about 100 to 150 ft in thickness) which overlies the Gramercy aquifer. The shallow aquifers do not contain freshwater and are not areally extensive in the study area. The Gramercy and Norco aquifers are present in much of the study area; however, they are not developed because they generally contain saltwater. Locally, the Gramercy and Norco aquifers merge and are in direct hydraulic contact (fig. 3, wells Jf-175 and -176). A thick confining unit of clay separates the Gonzales-New Orleans aquifer from the overlying Norco aquifer. Interpretations of electric and driller's logs indicate the confining unit ranges from 50 to 200 ft in thickness and may be interbedded with sand beds (figs. 2 and 3).

The Gonzales-New Orleans aquifer also is separated from the underlying "1,200-foot" aquifer by a confining unit of clay. Interpretations of electric logs from two oil-test wells, 52513 and 56237 (fig. 1), indicate that the confining unit is about 50 and 150 ft in thickness, respectively, at these wells. Hydraulic connection between the Gonzales-New Orleans and "1,200-foot" aquifers has been proposed as an explanation for declines in water levels observed in the "1,200-foot" aquifer (Rollo, 1966, p. 48). The "1,200-foot" aquifer and underlying aquifers do not contain freshwater in the study area.

Gramercy Aquifer

The first extensive aquifer encountered below land surface in Jefferson Parish is the Gramercy aquifer, referred to in earlier reports as the "200-foot" sand of the New Orleans area (Eddards and others, 1956; Rollo, 1966). Locally the aquifer is sometimes missing or discontinuous as shown in figures 2 and 3. The Gramercy aquifer averages about 100 ft in thickness, but ranges from 80 to 150 ft. Thickness values were determined by interpretation of electric and driller's logs. On the basis of interpretation of log data, the Gramercy aquifer ranges from 100 to 300 ft below sea level (figs. 2 and 3). Regionally the aquifer has a general southward dip and also thickens in a southward direction (Hosman, 1972, p. 19). Sand in the Gramercy aquifer ranges from fine to coarse (Hosman, 1972, p. 19).

No quantitative data on aquifer hydraulic properties are available in the study area. Transmissivities determined from two aquifer tests, a few miles southeast of the study area, were 2,600 and 5,300 ft^2/d (feet squared per day), and hydraulic conductivities were 30 and 50 ft/d (feet per day) (Rollo, 1966, p. 15). These hydraulic properties are much lower than those reported

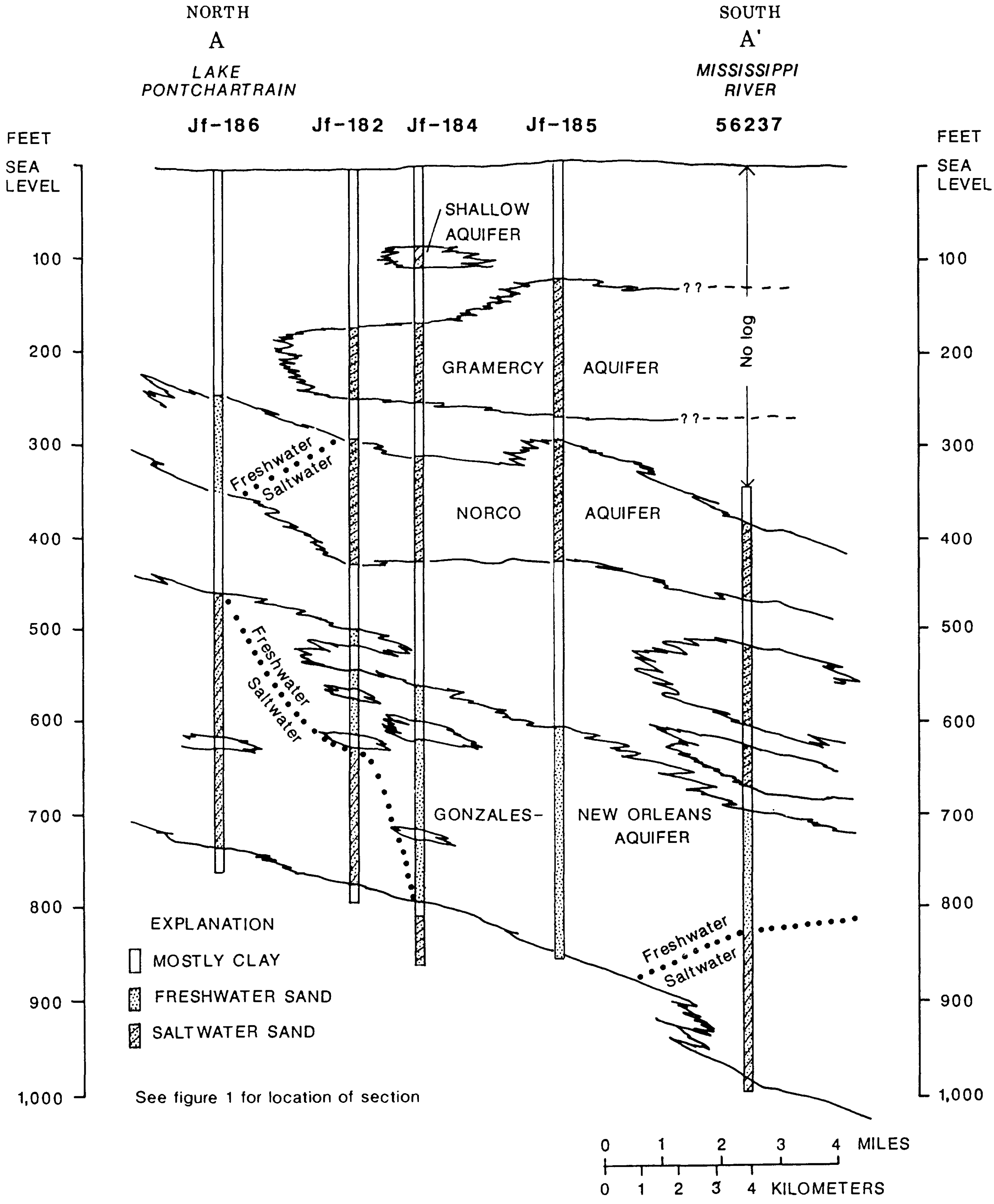


Figure 2.--North-south geohydrologic section from Lake Pontchartrain to the Mississippi River.

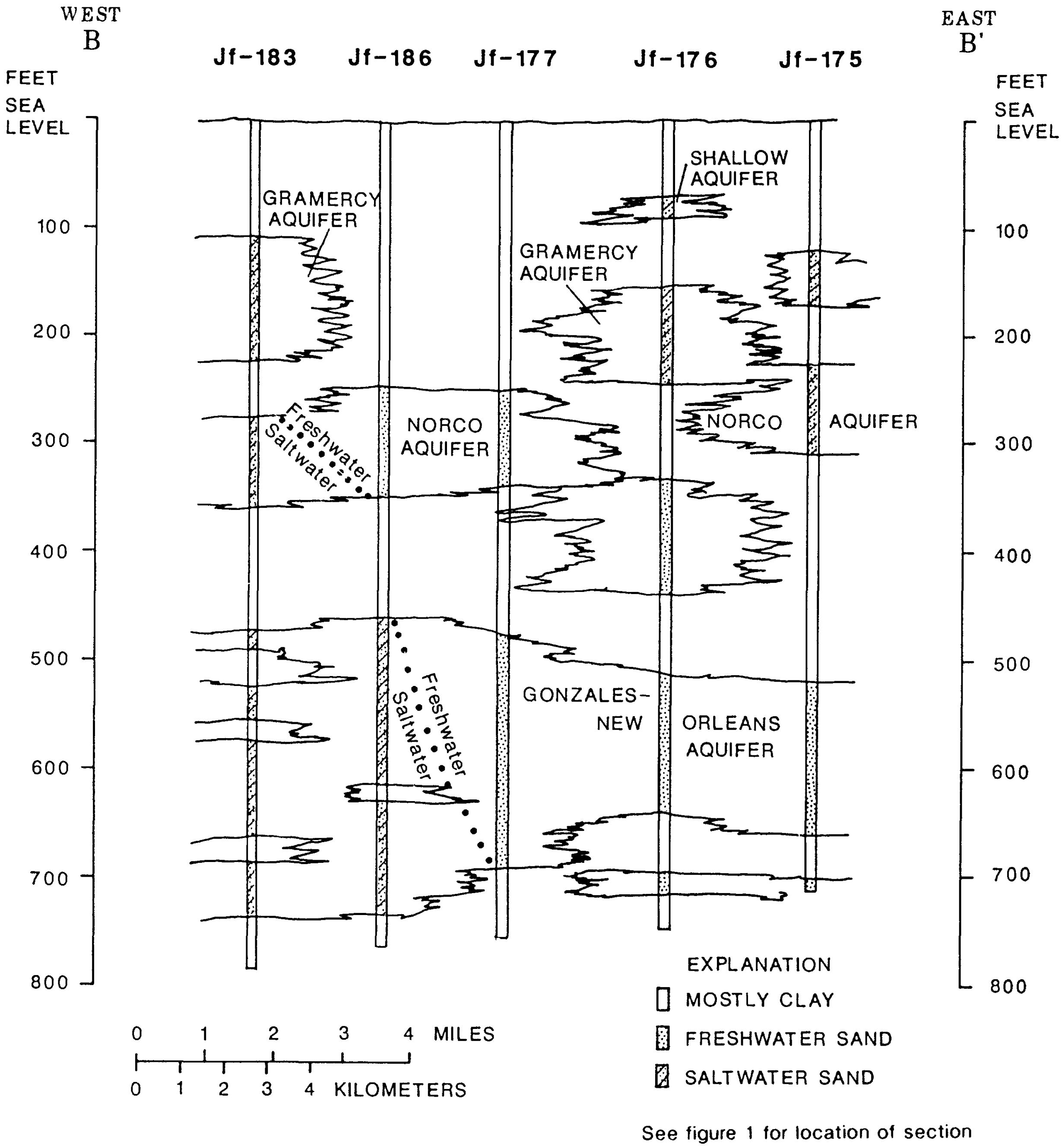


Figure 3.--East-west geohydrologic section near Lake Pontchartrain.

in the Gramercy area where transmissivities from two tests were 9,000 and 30,000 ft^2/d, and hydraulic conductivities were about 100 and 250 ft/d (Dial and Kilburn, 1980, p. 14).

Norco Aquifer

The Norco aquifer, previously named the "400-foot" sand of the New Orleans area (Eddards and others, 1956), underlies the Gramercy aquifer. The Norco aquifer generally is continuous in the study area, but may be missing locally. The aquifer thins and pinches out north of the study area under Lake Pontchartrain and a few miles east of the Jefferson-Orleans Parish line (Hosman, 1972, p. 28). Interpretations of electric and driller's logs indicate that the Norco aquifer ranges from about 75 to 130 ft in thickness in the study area. The aquifer ranges between 225 and 350 ft below sea level near Lake Pontchartrain. The aquifer is deepest at the south end of the study area near Harahan where it is present between about 400 and 500 ft below sea level.

The Norco aquifer is composed of fine to medium sand as determined by sieve analyses of samples collected from test holes for wells Jf-184 and Jf-186. Estimations from specific-capacity data collected south of Kenner indicate the transmissivity of the Norco aquifer is about 6,700 ft^2/d (Rollo, 1966, p. 19, 20). In the Norco area estimates of transmissivity and hydraulic conductivity of 27,000 ft^2/d and 200 ft/d, respectively, were reported by Hosman (1972, p. 41).

Gonzales-New Orleans Aquifer

The Gonzales-New Orleans aquifer extends throughout the study area and into the parishes of Orleans and St. Charles, and under Lake Pontchartrain. The top of the aquifer occurs about 450 to 500 ft below sea level near Lake Pontchartrain. Southward along U.S. Highway 61, the top of the aquifer is about 600 to 650 ft below sea level. Regional dip of the aquifer is 25 to 50 ft/mi (feet per mile) to the south (Hosman, 1972, p. 47).

Interpretations of electric and driller's logs indicate thickness of the aquifer ranges from 100 to 300 ft in the study area. Average thickness of the aquifer is slightly greater than 200 ft. A geohydrologic section (fig. 3) shows that the Gonzales-New Orleans aquifer thins to less than 150 ft in northeast Jefferson Parish at the locations of wells Jf-175 and Jf-176. Maximum thickness is about 300 ft near the Mississippi River at oil-test well 56237 (figs. 1 and 2).

Sieve analyses of samples collected from test holes Jf-182, Jf-184, and Jf-185 (fig. 1) indicate sand in the aquifer is fine- to medium-grained. At aquifer-test sites in the study area and Orleans Parish transmissivity ranges from 12,000 to 24,000 ft^2/d, and hydraulic conductivity ranges from 85 to 110 ft/d (Rollo, 1966, table 3).

Ground-Water Flow

Ground-water movement in the New Orleans aquifer system is part of a regional flow system (Dial and Sumner, 1989). Recharge from precipitation and seepage enters the New Orleans aquifer system in subcrop or outcrop areas, which approximately extend from the northern shore of Lake Pontchartrain northward into Tangipahoa and St. Tammany Parishes. Prior to development, ground water in the aquifer system flowed south or southwesterly into and through the study area and eventually discharged into the overlying Mississippi River alluvial aquifer southwest of the study area or coastal marshes.

Ground-water flow in the Gonzales-New Orleans aquifer is, at present, eastward toward pumping centers in New Orleans. Figure 4 is a potentiometric map showing the water-level surface of the Gonzales-New Orleans aquifer in January 1987. The significant decline in water levels toward New Orleans indicates that ground-water flow is primarily eastward as ground-water flow is generally perpendicular to the potentiometric contours.

Development of the Gonzales-New Orleans aquifer in the New Orleans area has altered the predevelopment flow direction in the aquifer system. Recharge to the New Orleans aquifer system has increased with increased potentiometric gradients induced by pumpage. Additional recharge to the Gonzales-New Orleans aquifer occurs as leakage through overlying and underlying confining units. Water from the overlying Norco aquifer and the underlying "1,200-foot" aquifer flows through confining units into the Gonzales-New Orleans aquifer in response to the head difference between the aquifers. Because most of the pumpage in the study area and nearby New Orleans area is from the Gonzales-New Orleans aquifer, hydraulic head in this aquifer is significantly lower than in the Norco and "1,200-foot" aquifers.

In the study area, water levels in the Gonzales-New Orleans aquifer range from about 30 to 70 ft below sea level in January 1987 (fig. 4). The velocity of ground-water flow in the study area can be approximated from Darcy's law and estimation of the potentiometric gradient from figure 4. In the western part of the study area, the potentiometric surface has a small gradient of about 1.5 ft/mi. In the eastern part of the study area, the potentiometric gradient increases to between 4.5 and 10 ft/mi. Ground-water velocity in the study area may range from 40 to 250 ft/yr (feet per year), assuming that the effective porosity of the aquifer is 30 percent and the hydraulic conductivity is 110 ft/d. Ground-water velocities are smallest near the St. Charles Parish boundary and greatest near the Orleans Parish boundary.

Water-Level Trends

Water-level trends of the Gonzales-New Orleans aquifer are represented by the hydrograph for wells Jf-65 and Jf-153 shown in figure 5. (See fig. 1 for well locations.) At well Jf-65 water levels declined an average of about 2 ft/yr from 1959 to 1974. From 1974 to 1983, water levels rose about 2 ft/yr at well Jf-65. Since 1983, water levels at well Jf-153 appear to be fluctuating only slightly. The general trend shown by these data reflects areal trends (rises and declines) in water levels caused by pumpage from the aquifer, primarily in Orleans Parish. Periods of greatest pumpage generally

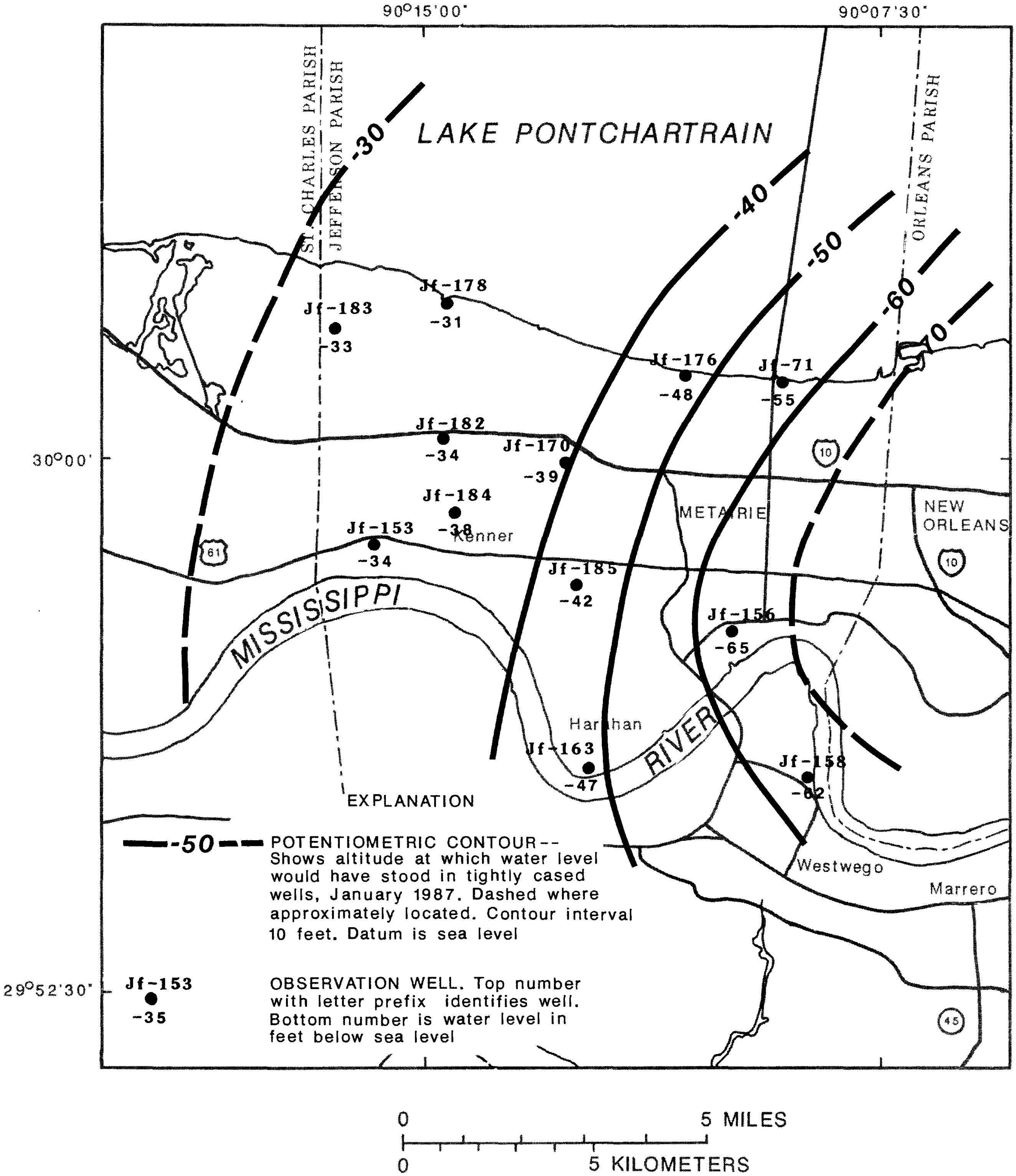


Figure 4.--Potentiometric surface of the Gonzales-New Orleans aquifer, January 1987.

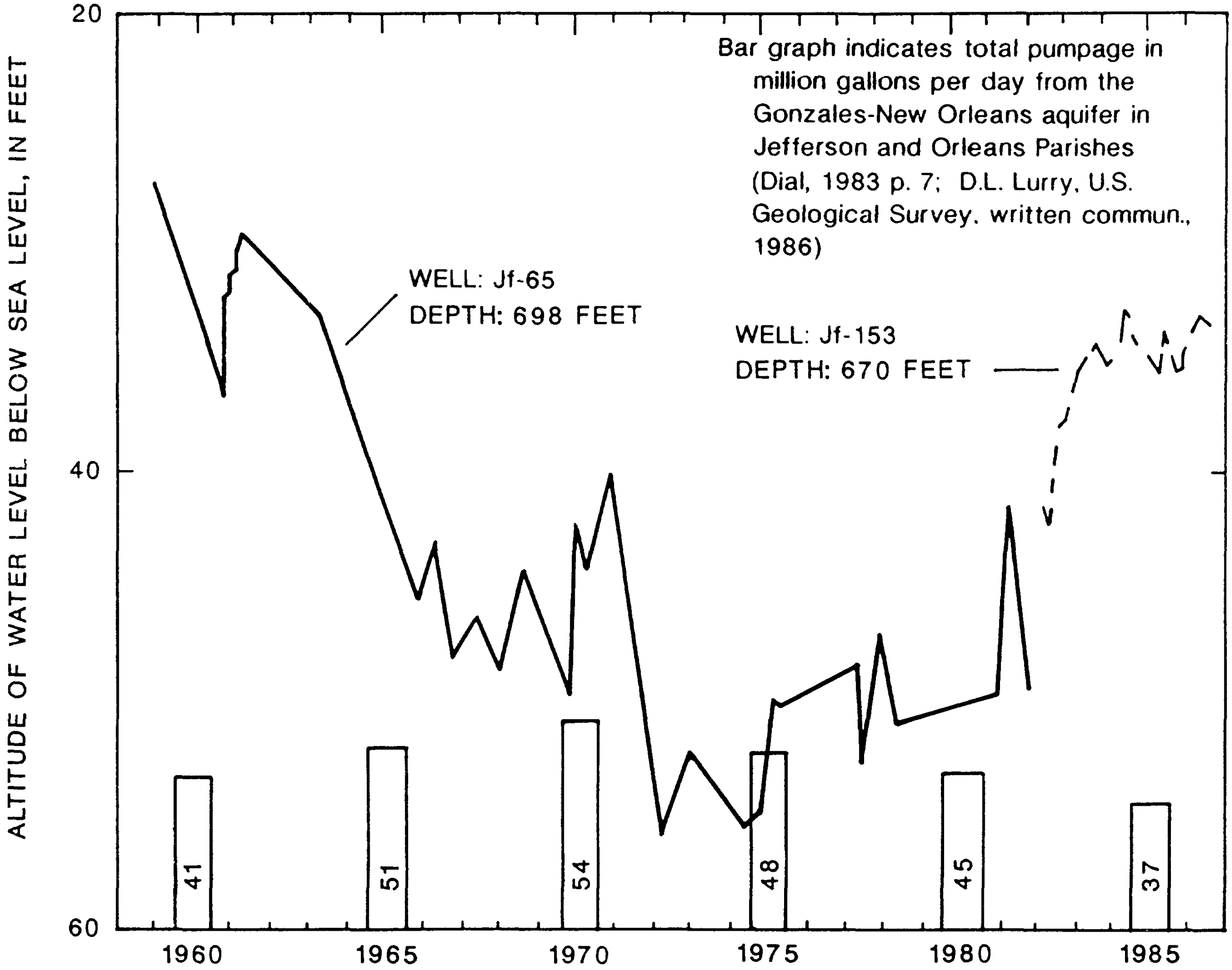


Figure 5.--Hydrograph of water levels in observation wells Jf-65 and Jf-153 completed in the Gonzales-New Orleans aquifer at Kenner, Louisiana.

coincide with declines in water levels, and periods of least pumpage or declines in pumpage when compared to previous years coincide with rises or higher water levels in the aquifer. Because pumpage from the aquifer varies seasonally, hydrographs of wells show an annual decline and recovery that is superimposed on the long-term trends.

WATER QUALITY

The greatest deterrent to ground-water use for public supply in northern Jefferson Parish is the occurrence of saltwater in the aquifers. Saltwater generally occurs in aquifers overlying and underlying the Gonzales-New Orleans aquifer. However, in most of the study area the Gonzales-New Orleans aquifer contains freshwater. In northwestern Jefferson Parish freshwater is locally available in the Norco aquifer.

Gramercy Aquifer

Interpretation of electric logs and chemical analyses of ground water collected during this study indicate that the Gramercy aquifer contains saltwater throughout the study area. Although the Gramercy aquifer in northwestern Jefferson Parish has been described as containing freshwater (Rollo, 1966, p. 15), subsequent test-drilling and electric-log data collected during this study indicate that the aquifer contains saltwater only. In previous reports (Dial, 1983; Rollo, 1960), wells identified as being screened in the Gramercy aquifer had actually been screened in the Norco aquifer. Because the Gramercy aquifer contains saltwater, wells are not completed in this aquifer, and chemical data are limited.

Norco Aquifer

Water from the Norco aquifer generally is saltwater. In most of the study area chloride concentrations range from 250 to less than 1,000 mg/L (Dial, 1983, tables 3 and 4). However, in northwestern Jefferson Parish, data collected during test drilling at well Jf-186 (fig. 1) indicate freshwater is locally available. Chemical analyses of water collected from the Norco aquifer at test well JF-186 indicate a chloride concentration of 130 mg/L (table 1). Water sampled from well Jf-186 was moderately hard, 95 mg/L, and concentrations of iron and manganese were 420 and 36 µg/L (micrograms per liter), respectively. Dissolved solids were about 700 mg/L, and color was 40 platinum cobalt units.

Interpretations of electric log data collected during this study, and review of previously collected chemical data indicate freshwater in the Norco aquifer extends only 1 or 2 mi south of the shore of Lake Pontchartrain (figs. 1 and 2) and extends east from well Jf-186 to well Jf-177 (fig. 3). East of well Jf-177 the Norco aquifer pinches out and is locally replaced by clay (fig. 3, well Jf-176); however, underlying the clay is a freshwater bed of sand. This bed of sand may be in hydraulic contact with the Norco aquifer west of well Jf-177. In northeastern Jefferson Parish, the Norco aquifer contains saltwater.

Table 1.--Chemical analyses of water from selected wells in northern Jefferson Parish, 1986

[μS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter]

Well number	Latitude	Longitude	Depth of well, total (feet)	Date	Specific conductance (μS/cm)	Specific conductance, lab (μS/cm)	pH (standard units)	Temperature (°C)	Color (platinum-cobalt units)
				Gonzales-New Orleans Aquifer					
Jf- 64	295831	90164601	719	6-18-86	1,730	1,720	8.10	25.5	20
Jf-141	295525	90111701	740	1- 1-86	-----	2,910	----	----	80
Jf-149	295832	90080301	749	5-19-86	971	970	8.40	25.5	120
Jf-162	300135	90151401	628	5- 8-86	5,060	4,980	7.80	24.5	5
Jf-163	295545	90123001	768	5-19-86	920	926	8.30	24.5	100
Jf-168	295940	90110801	744	1-16-86	701	722	8.10	25.0	80
Jf-169	300000	90103501	740	1-16-86	641	663	8.30	25.0	80
Jf-170	300011	90123801	737	1-16-86	621	617	8.20	25.0	100
Jf-171	300210	90141501	557	1-17-86	1,450	1,460	7.90	24.5	5
Jf-172	300040	90104501	628	5- 8-86	702	691	8.30	25.0	60
Jf-175	300110	90083601	640	5- 7-86	719	723	8.40	25.5	60
Jf-176	300111	90104701	610	1-17-86	672	684	8.20	24.0	50
Jf-177	300154	90130001	650	5- 7-86	622	623	8.60	25.0	70
Jf-178	300222	90144601	700	5- 7-86	3,660	3,700	8.10	26.0	5
Jf-180	295738	90084701	730	5-14-86	869	853	8.40	25.0	120
Jf-182	300025	90143901	605	10- 3-86	691	680	8.70	24.0	20
Jf-183	300206	90163101	612	10- 2-86	7,850	7,340	----	24.0	5
Jf-184	295926	90143201	704	9-26-86	661	644	9.10	24.0	30
Jf-185	295823	90123601	766	9-25-86	769	772	8.50	24.0	100
				Norco Aquifer					
Jf-186	300223	90144601	325	10- 2-86	1,190	1,180	7.80	23.0	40

Well number	Hardness (mg/L as $CaCO_3$)	Hardness, noncarb wh wat tot fld (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Percent sodium	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, wh wat total field (mg/L as $CaCO_3$)	Alkalinity, lab (mg/L as $CaCO_3$)
				Gonzales-New Orleans Aquifer						
Jf- 64	74	--	19	6.5	300	--	16	---	---	198
Jf-141	---	--	----	----	----	--	--	---	---	---
Jf-149	15	0	3.4	1.5	200	96	23	3.5	317	319
Jf-162	---	--	----	----	----	--	--	---	---	---
Jf-163	13	0	3.2	1.3	200	96	25	2.5	288	292
Jf-168	9	0	2.6	.7	160	97	24	1.7	250	253
Jf-169	9	0	2.7	.6	140	97	21	1.4	244	245
Jf-170	9	0	2.8	.6	140	96	21	1.6	259	261
Jf-171	43	0	12	3.2	280	93	19	4.4	181	179
Jf-172	---	--	----	----	----	--	--	---	---	---
Jf-175	---	--	----	----	----	--	--	---	---	---
Jf-176	9	0	.4	.7	160	97	24	2.0	221	220
Jf-177	---	--		----	----	--	--	---	---	---
Jf-178	---	--	----	----	----	--	--	---	---	---
Jf-180	11	0	.6	1.1	180	97	24	2.2	299	298
Jf-182	19	--	.9	.3	140	93	15	2.9	207	202
Jf-183	260	1	55	29	1600	93	45	9.5	---	256
Jf-184	22	--	.9	.5	140	92	14	4.1	240	235
Jf-185	14	--	3.8	1.1	180	96	22	1.8	277	271
				Norco Aquifer						
Jf-186	95	0	15	14	220	82	10	8.0	438	420

Table 1.--Chemical analyses of water from selected wells in northern Jefferson Parish, 1986--Continued

Well number	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 180 °C dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, No_2+No_3 dissolved (mg/L as N)
				Gonzales-New Orleans Aquifer					
Jf- 64	0.2	410	---	--	899	---	----	----	----
Jf-141	----	740	---	--	-----	---	----	----	----
Jf-149	.2	120	0.9	28	579	550	0.64	0.01	0.65
Jf-162	----	1,500	---	--	-----	---	----	----	----
Jf-163	.4	120	.8	29	549	530	.62	<.01	.63
Jf-168	.8	78	.6	28	431	420	.28	<.01	.29
Jf-169	1.0	60	.7	28	401	380	.25	<.01	.26
Jf-170	.6	48	.7	28	405	380	.26	<.01	.27
Jf-171	.4	340	.3	29	602	780	.56	<.01	.57
Jf-172	----	84	---	--	-----	---	----	----	----
Jf-175	----	100	---	--	-----	---	----	----	----
Jf-176	.4	88	.5	28	414	420	.33	<.01	.34
Jf-177	----	59	---	--	-----	---	----	----	----
Jf-178	----	1,100	---	--	-----	---	----	----	----
Jf-180	.2	96	1.0	28	519	490	.59	.01	.60
Jf-182	4.9	93	.3	--	413	---	----	----	<.10
Jf-183	22	2,400	.8	--	4,510	---	----	----	----
Jf-184	7.5	63	.3	--	425	---	----	----	.61
Jf-185	11	87	.6	--	455	---	----	----	.42
				Norco Aquifer					
Jf-186	1.2	130	.6	--	697	---	----	----	----

Well number	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)
				Gonzales-New Orleans Aquifer					
Jf- 64	--	--	--	---	----	--	---	--	190
Jf-141	--	--	--	---	----	--	---	--	---
Jf-149	--	--	--	---	----	--	---	--	87
Jf-162	--	--	--	---	----	--	---	--	200
Jf-163	--	--	--	---	----	--	---	--	71
Jf-168	--	--	--	---	----	--	---	--	64
Jf-169	--	--	--	---	----	--	---	--	72
Jf-170	--	--	--	---	----	--	---	--	75
Jf-171	--	--	--	---	----	--	---	--	110
Jf-172	--	--	--	---	----	--	---	--	89
Jf-175	--	--	--	---	----	--	---	--	71
Jf-176	--	--	--	---	----	--	---	--	77
Jf-177	--	--	--	---	----	--	---	--	59
Jf-178	--	--	--	---	----	--	---	--	180
Jf-180	--	--	--	---	----	--	---	--	100
Jf-182	30	<1	<1	66	<0.5	<1	<10	1	34
Jf-183	--	--	--	---	----	--	---	--	---
Jf-184	90	<1	1	110	<.5	<1	<10	2	75
Jf-185	20	<1	<1	110	<.5	<1	<10	<1	340
				Norco Aquifer					
Jf-186	--	--	--	---	----	--	---	--	420

Table 1.--Chemical analyses of water from selected wells in northern Jefferson Parish, 1986--Continued

Well number	Lead, dis- solved (µg/L as Pb)	Manga nese, dis- solved (µg/L as Mn)	Mercury, dis- solved (µg/L as Hg)	Nickel, dis- solved (µg/L as Ni)	Sele- nium, dis- solved (µg/L as Se)	Silver, dis- solved (µg/L as Ag)	Zinc, dis- solved (µg/L as Zn)	Carbon, organic total (mg/L as C)	Carbon, organic dis- solved (mg/L as C)
				Gonzales-New Orleans Aquifer					
Jf- 64	--	90	----	--	--	--	--	---	2.6
Jf-141	--	---	----	--	--	--	--	---	---
Jf-149	--	20	----	--	--	--	--	---	5.6
Jf-162	--	350	----	--	--	--	--	---	---
Jf-163	--	20	----	--	--	--	--	---	5.4
Jf-168	--	10	----	--	--	--	--	4.0	4.0
Jf-169	--	10	----	--	--	--	--	4.8	4.8
Jf-170	--	30	----	--	--	--	--	---	5.0
Jf-171	--	110	----	--	--	--	--	1.7	1.4
Jf-172	--	18	----	--	--	--	--	---	---
Jf-175	--	20	----	--	--	--	--	---	---
Jf-176	--	20	----	--	--	--	--	2.5	2.5
Jf-177	--	32	----	--	--	--	--	---	---
Jf-178	--	120	----	--	--	--	--	---	---
Jf-180	--	20	----	--	--	--	--	---	6.1
Jf-182	<5	3	<0.1	<1	<1	<1	5	---	2.0
Jf-183	--	---	----	--	--	--	--	---	---
Jf-184	<5	3	<.1	<1	<1	<1	4	---	2.4
Jf-185	<5	19	<.1	1	<1	<1	9	---	4.8
				Norco Aquifer					
Jf-186	--	36	----	--	--	--	--	---	---

Gonzales-New Orleans Aquifer

Fresh ground water in the Gonzales-New Orleans aquifer generally is a mixed sodium bicarbonate-chloride type. The freshwater is soft; hardness ranges between 9 and 22 mg/L (table 1). Field determined pH values, measured during this study, range from 8.1 to 9.1 standard units for freshwater. Concentrations of iron and manganese generally are less than 100 µg/L in freshwater but locally may exceed this concentration (well Jf-185, table 1). Dissolved-solids concentrations range between 400 and 600 mg/L (table 1) in freshwater, and concentrations of sodium range between 140 and 200 mg/L.

Chloride concentrations range from 48 to 2,400 mg/L in water from the Gonzales-New Orleans aquifer (table 1). On the basis of available sampling sites and electric-log interpretations, about one-fifth of the study area (10 mi^2 in northwestern Jefferson Parish) is underlain by saltwater in the Gonzales-New Orleans aquifer (fig. 6). The aquifer contains freshwater throughout northern Jefferson Parish except for the area approximately located within 2 mi (miles) of the Jefferson and St. Charles Parishes border. Freshwater in the Gonzales-New Orleans aquifer extends northward under Lake Pontchartrain and eastward into Orleans Parish. Chloride concentration in freshwater from the aquifer generally is less than 150 mg/L; however, this concentration may be exceeded near the freshwater-saltwater interface (figs. 2, 3, and 6). As shown in figures 2 and 3, the freshwater-saltwater interface resembles a wedge extending from the main body of saltwater (areas where the

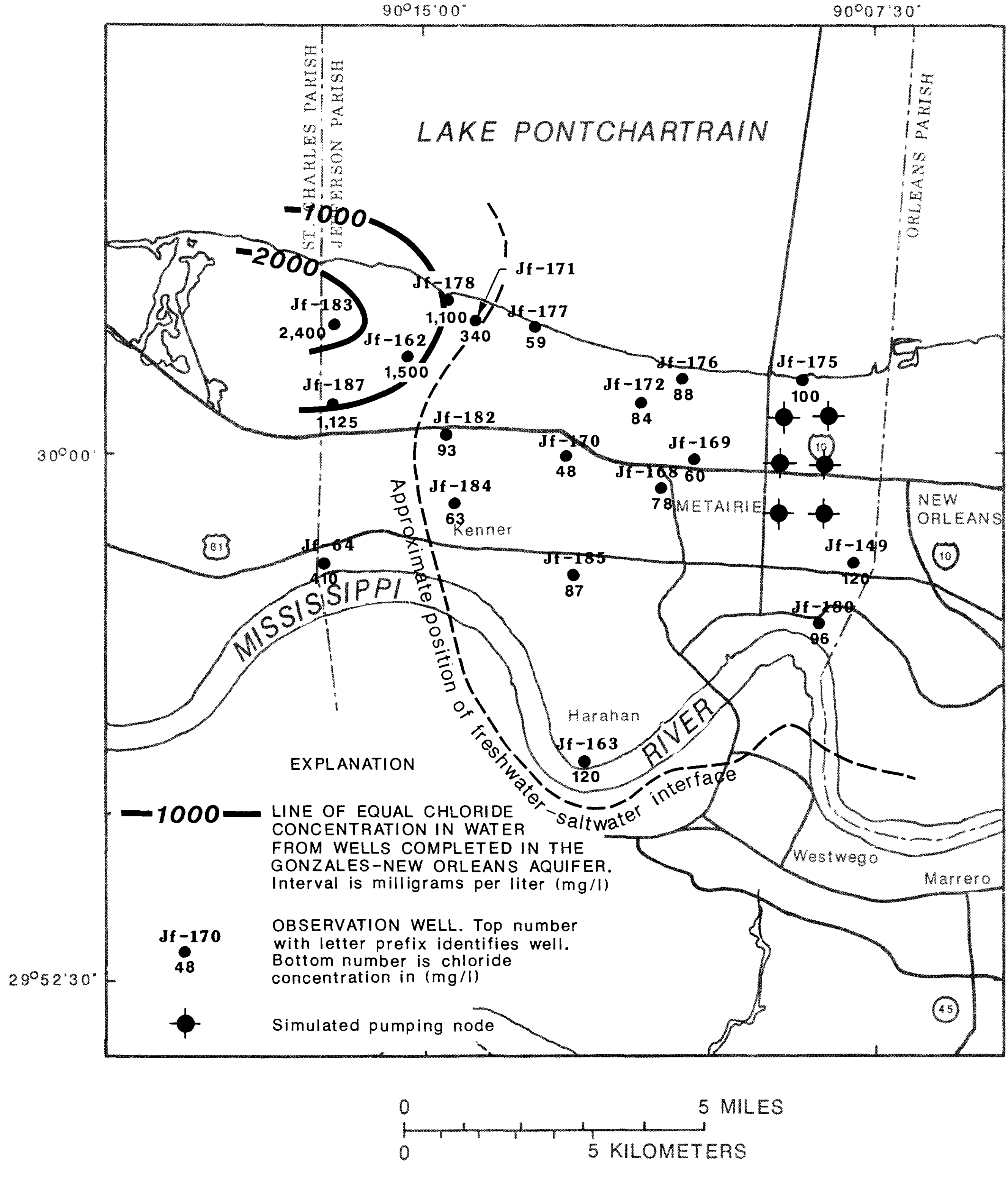


Figure 6.--Distribution of chloride concentration in water from selected wells completed in the Gonzales-New Orleans aquifer, 1987.

aquifer contains saltwater vertically from the base to the top) into freshwater parts of the aquifer. This wedge is variable in width and possibly extends from 1 to several miles under the freshwater in the aquifer. Along this wedge the transition from freshwater to water having very high chloride concentrations (19,000 mg/L or more) in the study area and surrounding areas is gradual. Chloride concentrations are less than 1,000 mg/L in most saltwater wells in the study area and surrounding areas (Dial and Sumner, 1989).

Color in water from the Gonzales-New Orleans aquifer ranges from 5 to 120 units (fig. 7). Low color (less than 30 units) is contained in saltwater or areas near the freshwater-saltwater interface (fig. 7). Color from 50 to 120 units can generally be expected in freshwater from the Gonzales-New Orleans aquifer.

Color in natural water usually results from leaching of organic materials and is usually reported in units as determined by the platinum-cobalt methods (Hem, 1985, p. 152-153). However, no direct connection is associated with the amount of organic material causing the color and the color value. Effects of color on public water supplies are generally aesthetic. Color below 10 units is usually not noticeable. Recommended color of 15 units or less was established by the Public Health Service in 1962 (U.S. Environmental Protection Agency, 1977, p. 52). Coagulation, sedimentation, and filtration can be used to reduce color to 15 units or less when the color of the source water does not exceed 75 units (U.S. Environmental Protection Agency, 1977, p. 52).

PROJECTED EFFECTS OF PUMPAGE

A three-dimensional ground-water flow model, documented by McDonald and Harbaugh (1984), of the New Orleans aquifer system was constructed for a previous study of the Greater New Orleans area (Dial and Sumner, 1989). The aquifer system was simulated in the model by four layers that represented the Gramercy, Norco, Gonzales-New Orleans, and "1,200-foot" aquifers. The resistance to flow of the intervening confining units was incorporated in the model. The modeled area, of which the study area is only a small part, covers much of southeastern Louisiana and southern Mississippi. The preparation of the model included a conceptualization of the aquifer system, calibration of the model by comparison of model output with observed data, and application of the model for predictive purposes. Different pumping stresses were simulated to evaluate possible future water-level declines and flow patterns.

The New Orleans model was predesigned so that the smallest grid blocks (cells) were in Orleans and Jefferson Parishes where detailed resolution was desired. The grid blocks range from 1.0 mi^2 (1 mi on a side) in the study area to a maximum of 281 mi^2 (25 mi X 11.25 mi) at the model boundaries. Therefore, the New Orleans model is well suited to the present study which is near the center of the modeled area and far from any boundary conditions.

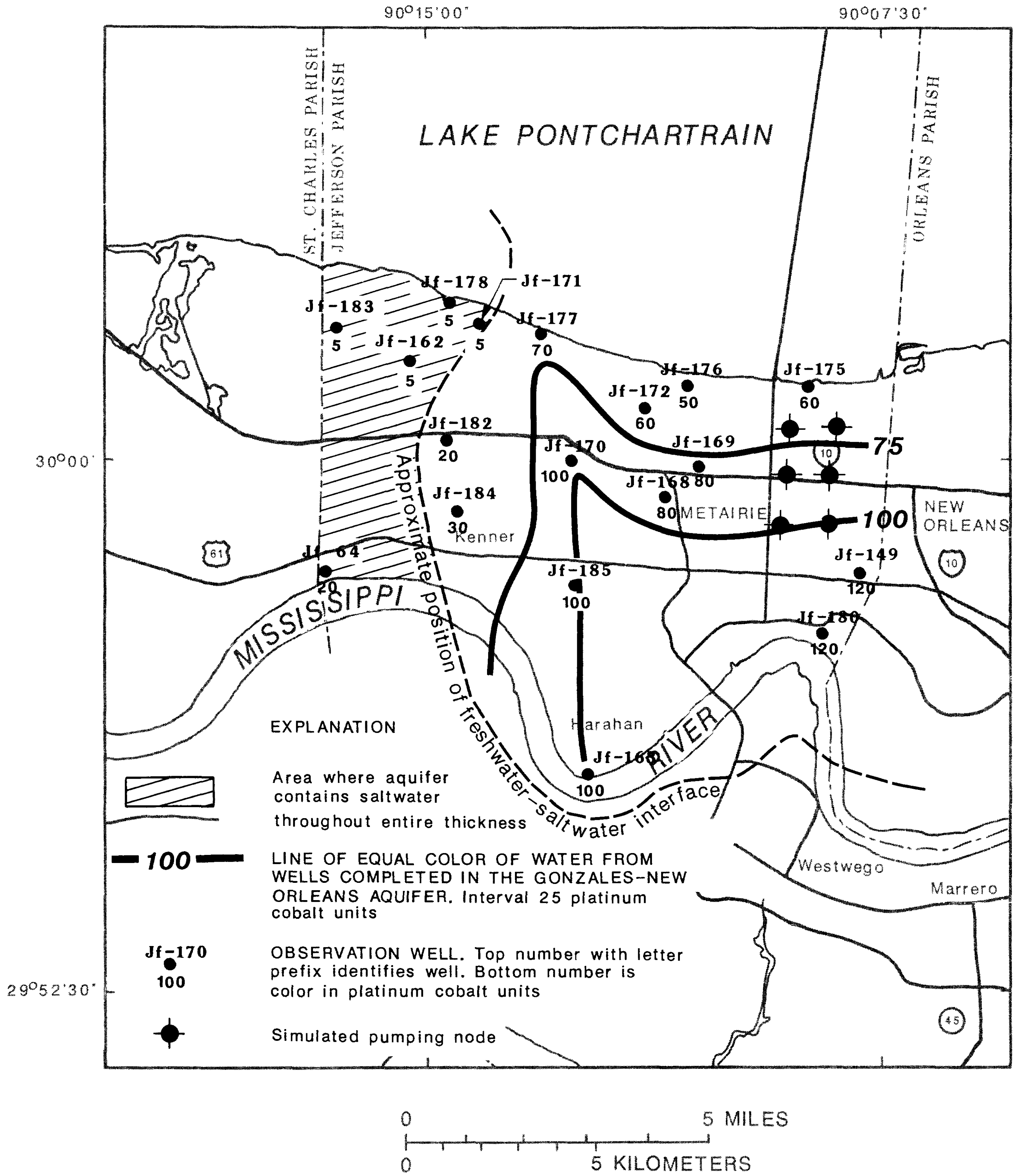


Figure 7.--Distribution of color in water from selected wells completed in the Gonzales-New Orleans aquifer, 1987.

Simulations for this study were done to evaluate the effects on water-level declines and the movement of the freshwater-saltwater interface in the Gonzales-New Orleans aquifer in response to several ground-water pumpage scenarios. These scenarios included an additional pumpage of 25 Mgal/d from the Gonzales-New Orleans aquifer for periods of 7 days, 30 days, and 20 years, and an additional pumpage of 50 Mgal/d for a 1-year period. The pumping rates were added to the current (1986) areal ground-water pumpage of 40 Mgal/d from the Gonzales-New Orleans aquifer. The simulated 25 Mgal/d was evenly distributed in three locations in Jefferson Parish (figs. 8, 9, and 10). The simulated 50 Mgal/d was evenly distributed in six locations in Jefferson Parish (fig. 11). The locations of the simulated pumpage (nodes) are in the center of the finite-difference blocks used in modeling. Each block in the study area had an area of 1 mi^2, and total simulated pumpage at each node was about 6,000 gal/min (gallons per minute). Distribution of simulated pumpage in the Gonzales-New Orleans aquifer was determined by mapping areas where freshwater is available and has relatively low color. The best combination of freshwater (less than 250 mg/L) and color (less than 100 units) appears to be in the northeastern part of Jefferson Parish (figs. 6 and 7). Therefore, simulated node sites were located in that area as far as possible from the area underlain by saltwater to minimize the rate of saltwater encroachment toward the pumping centers (fig. 8).

The node distribution was the same for each simulation involving an additional pumpage of 25 Mgal/d. Thus, the potentiometric surfaces produced by these three pumpage scenarios are similar in configuration because only the duration of pumping was variable. The potentiometric surfaces of the Gonzales-New Orleans aquifer that represent water-level surfaces after an additional pumpage of 25 Mgal/d for 7 days, 30 days, and 20 years are shown in figures 8, 9, and 10, respectively. Maximum water-level declines at simulated pumping nodes are shown in figure 12 and table 2. Localized drawdowns in individual wells or well fields would be greater than shown in the table because the simulated water levels are averages of the whole block.

The locations of the simulated pumping nodes and the potentiometric surface of the Gonzales-New Orleans aquifer after pumping 1 year at 50 Mgal/d are shown in figure 11. The greatest water-level decline in the study area was 166 ft (table 2).

Ground-Water Flow

A comparison of the simulated potentiometric surfaces (figs. 8-11) with the 1987 potentiometric map (fig. 4) indicates an additional 25 and 50 Mgal/d pumpage will alter present-day ground-water flow in the study area and adjacent areas. As shown by the simulated potentiometric surfaces, a cone of depression becomes centered around the simulated pumping nodes. This would result in radial flow of ground water from inside and outside the study area toward the simulated pumping nodes. A significant change in direction of ground-water flow would occur south of the pumping nodes with the additional 25 and 50 Mgal/d pumpage. Ground water south of the pumping nodes would begin to move northward toward the pumping nodes.

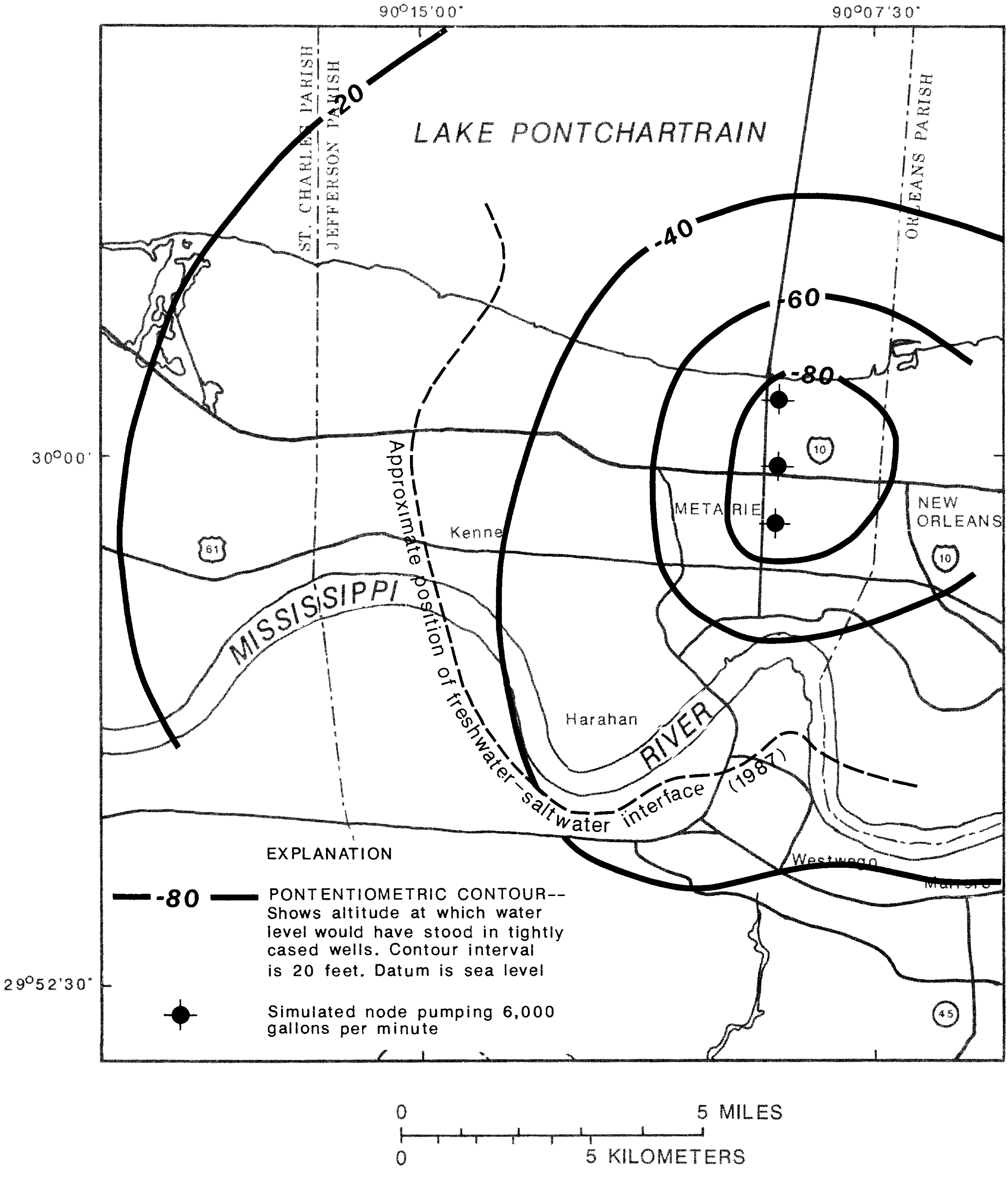


Figure 8.--Simulated potentiometric surface of the Gonzales-New Orleans aquifer after an additional pumpage of 25 million gallons per day for 7 days.

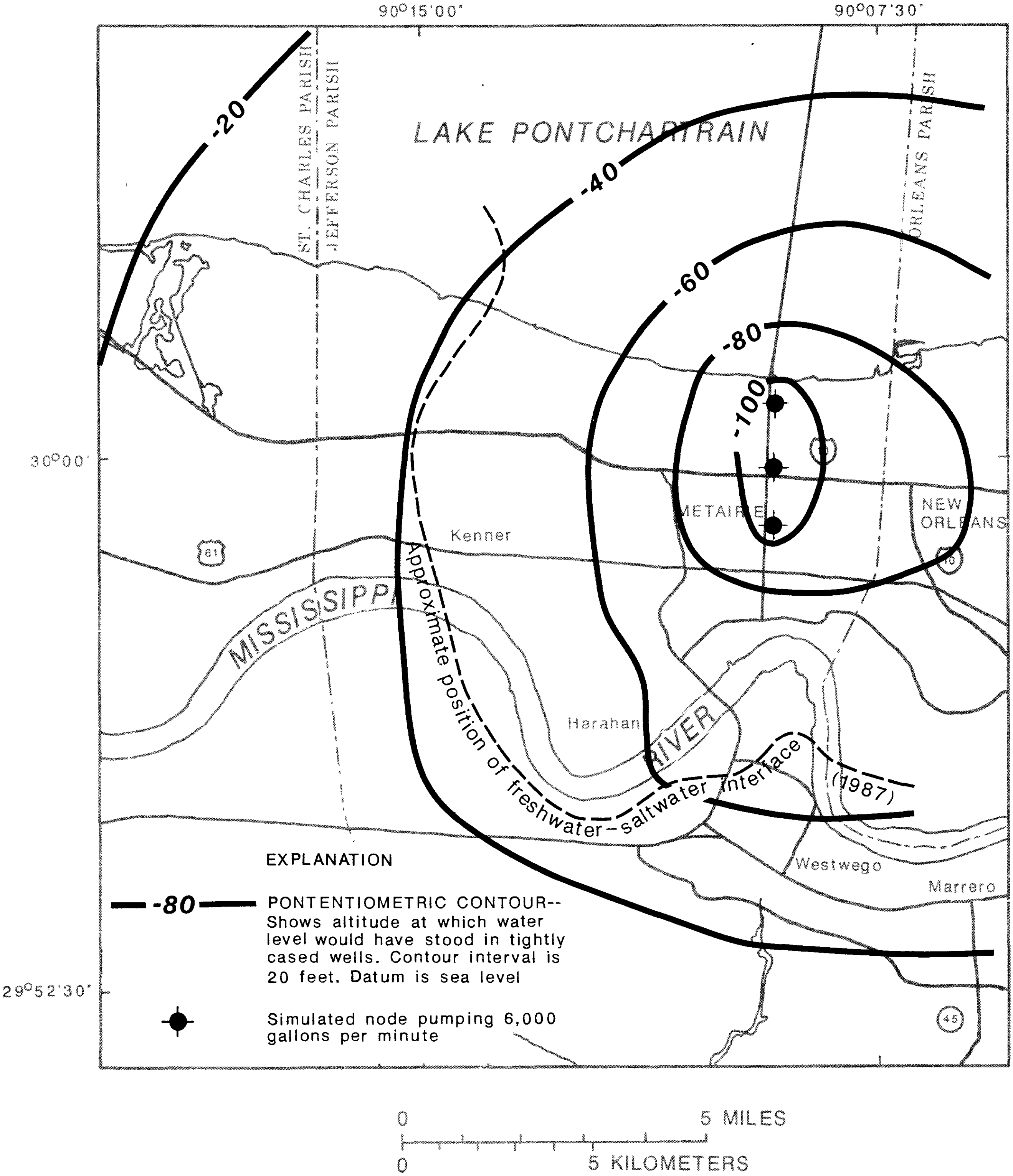


Figure 9.--Simulated potentiometric surface of the Gonzales-New Orleans aquifer after an additional pumpage of 25 million gallons per day for 30 days.

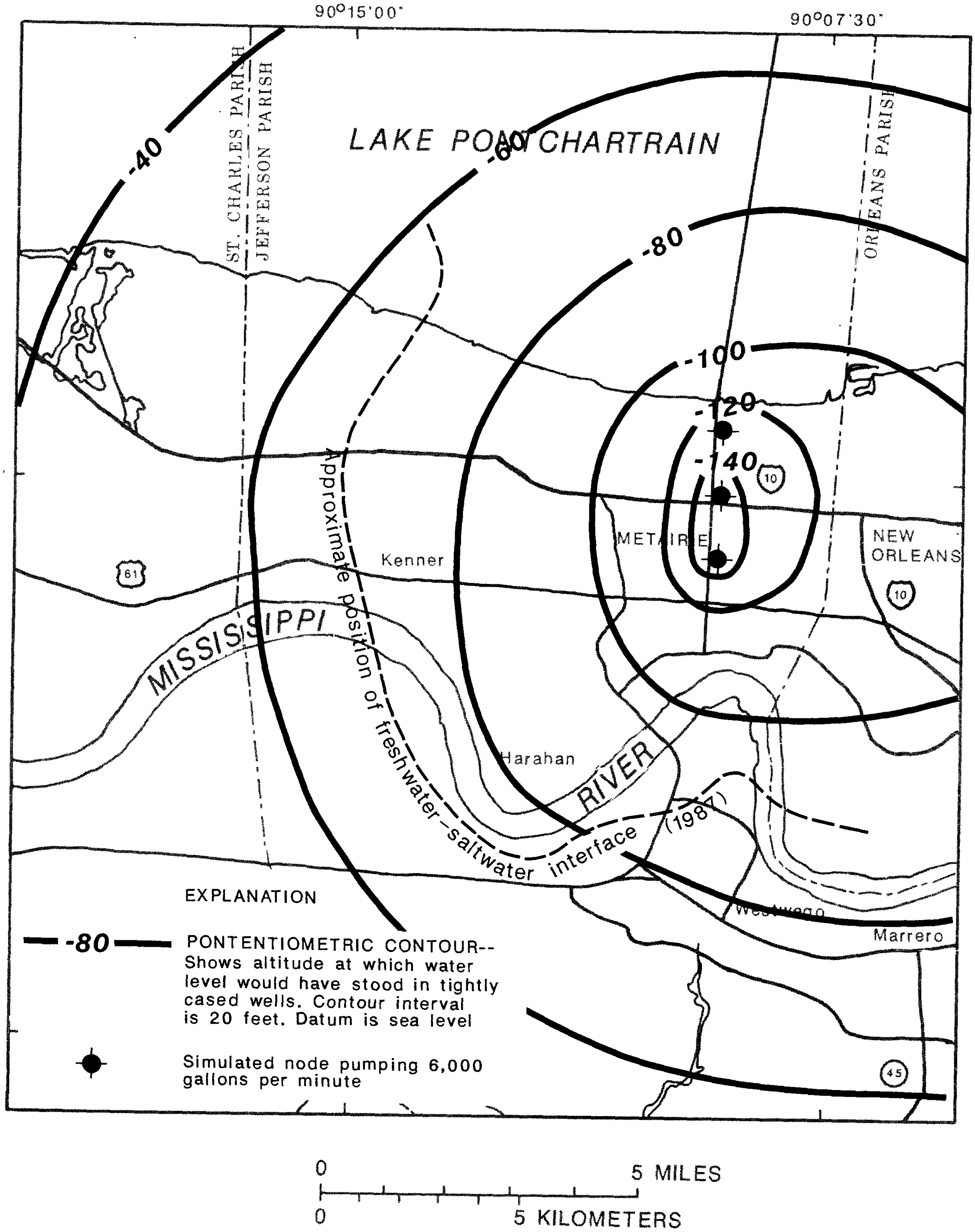


Figure 10.--Simulated potentiometric surface of the Gonzales-New Orleans aquifer after an additional pumpage of 25 million gallons per day for 20 years.

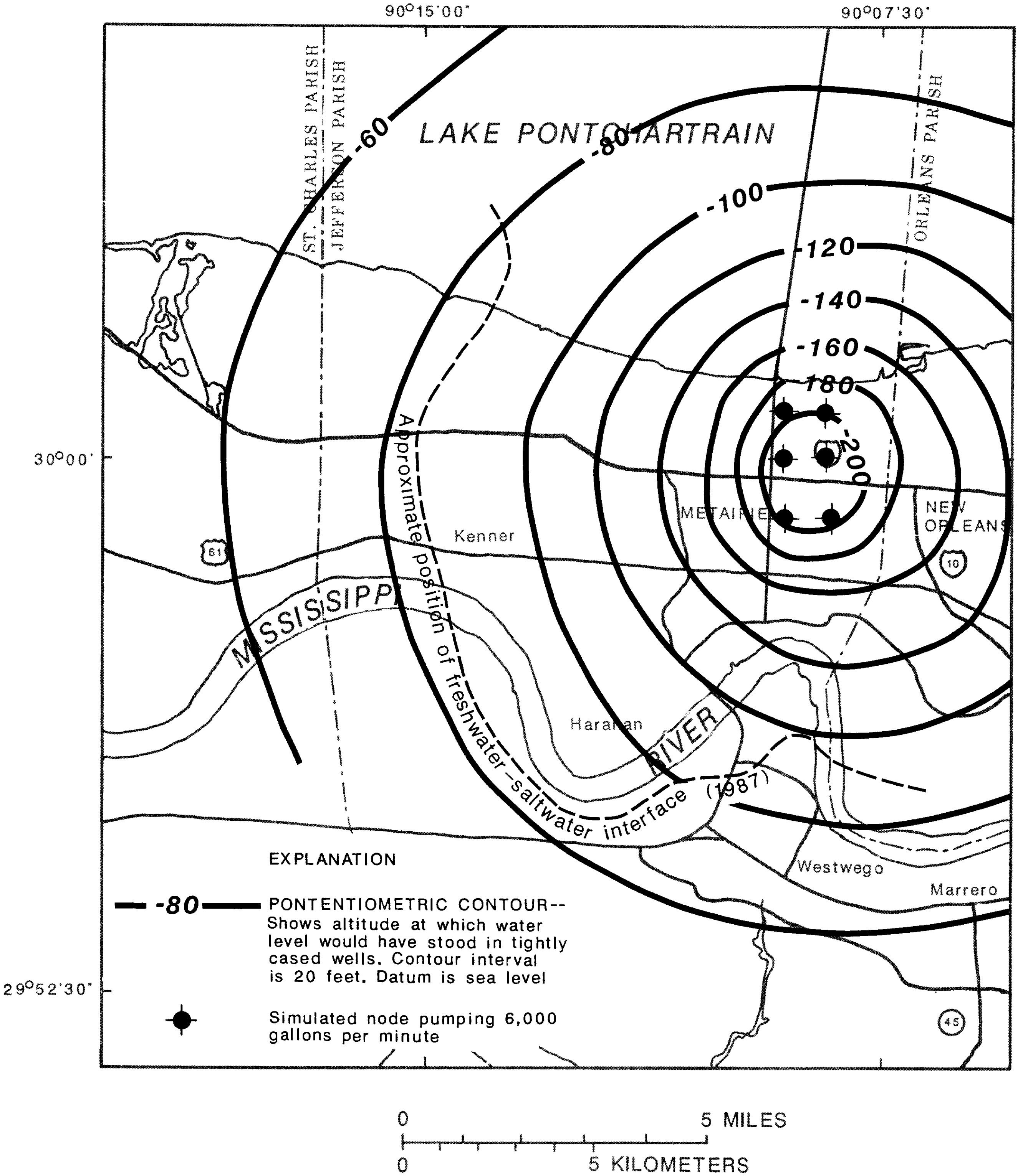


Figure 11.--Simulated potentiometric surface of the Gonzales-New Orleans aquifer after an additional pumpage of 50 million gallons per day for 1 year.

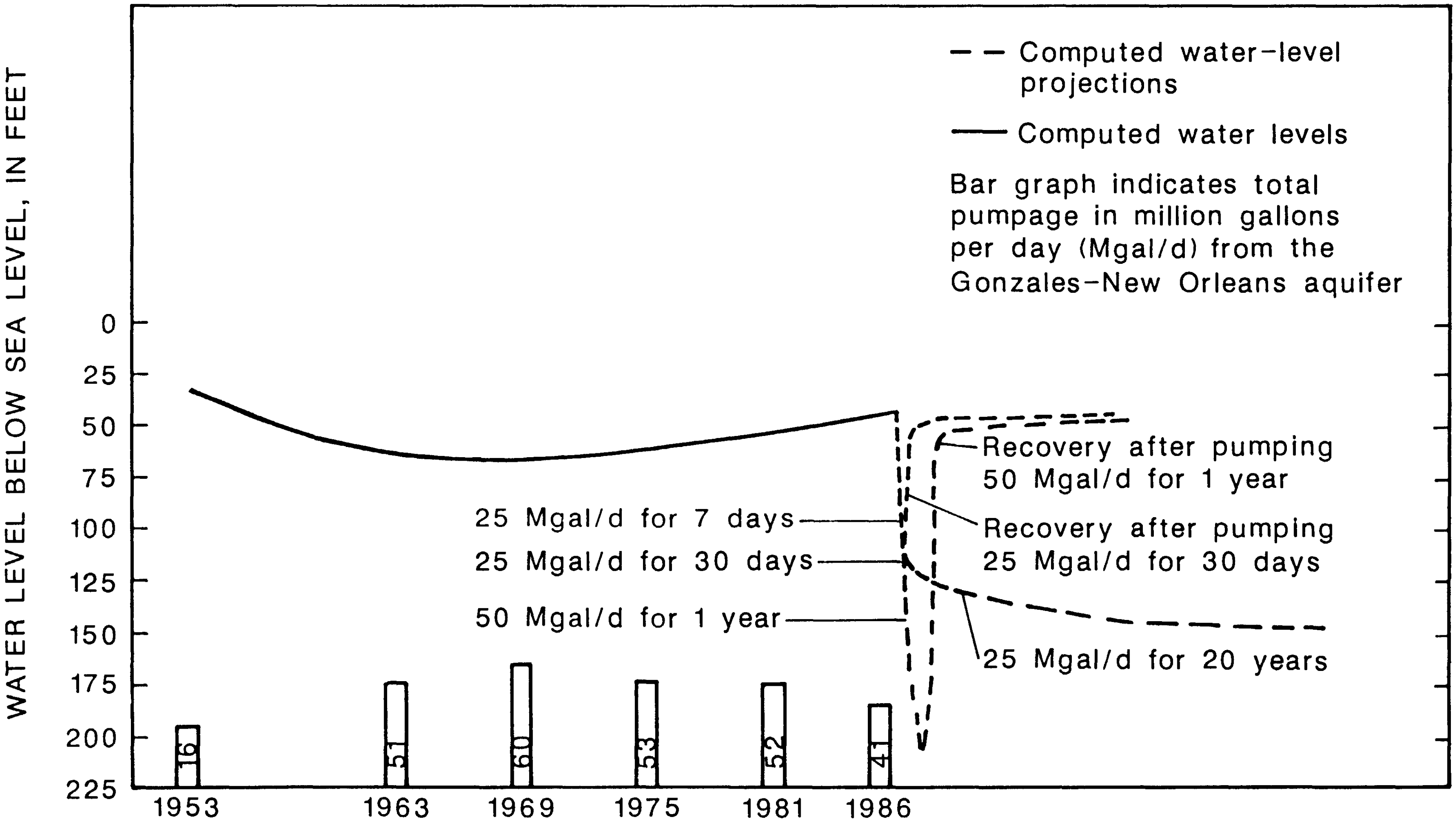


Figure 12.--The relation between water levels and historical and projected pumpage for the Gonzales-New Orleans aquifer in northern Jefferson Parish.

Table 2.--Summary of estimated ground-water velocity near the freshwater-saltwater interface and simulated maximum water-level declines in the Gonzales-New Orleans aquifer at pumping nodes

Pumping rate and period of with-drawal (million gallons per day)	Estimated average linear ground-water velocity (feet per year) at end of simulated pumpage (near present fresh-water-saltwater interface)		Simulated maximum water-level decline (feet) at simulated pumping nodes[1]
	South of pumping nodes	Near Kenner	
Present (1986)-------	---	65	----
Present pumpage continued for 20 years.	---	60	none
Present pumpage and additional 25 Mgal/d for 7 days.	150	80	57
Present pumpage and additional 25 Mgal/d for 30 days.	150	170	74
Present pumpage and additional 25 Mgal/d for 20 years.	230	170	99
Present pumpage and additional 50 Mgal/d for 1 year.	500	200	166

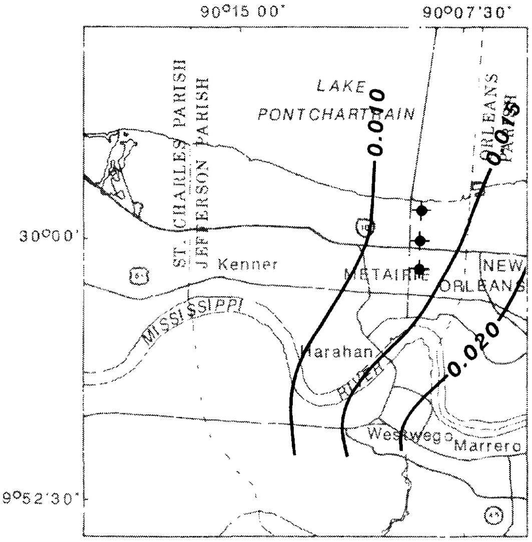
[1] Declines are the differences between simulated water levels for 1986 and the end of each pumpage scenario.

Short periods of additional pumpage, such as the simulated 7- and 30-day periods (figs. 8 and 9) would not have long-term effects on ground-water flow in the Gonzales-New Orleans aquifer. At the end of the 7- and 30-day periods, when the additional 25 Mgal/d pumpage is ceased, ground-water levels would begin to recover to levels prior to the simulated pumpage (cones of depression would diminish) and the present-day flow regime would be reestablished. Longer periods of simulated pumpage, 20 years with an additional 25 Mgal/d and 1 year with an additional 50 Mgal/d, would cause the formation of deeper cones of depression (figs. 10 and 11) when compared to shorter periods (figs. 8 and 9). Larger periods would cause the hydraulic gradient to steepen in the direction of the pumping nodes. In the Gonzales-New Orleans aquifer, the present-day freshwater-saltwater interface would move toward the simulated pumping nodes and the volume of saltwater entering the aquifer by vertical leakage across overlying and underlying clays may increase.

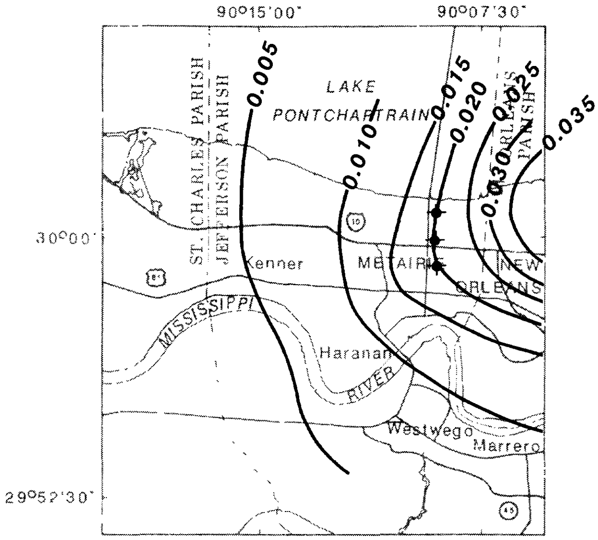
The present-day net ground-water inflow and outflow in the freshwater area of the Gonzales-New Orleans aquifer in northern Jefferson Parish and the effects of simulated pumpage on this flow are shown in table 3. At present pumpage rates, lateral inflow of saltwater from western parts of the study area and areas south of the Mississippi River into the freshwater area totals about 3.9 Mgal/d (59 percent of the net ground-water inflow). Additional freshwater, 1.7 Mgal/d (27 percent of the net inflow), enters the study area by lateral flow from north and east of the study area. Vertical leakage through confining units from the overlying and underlying aquifers at present supplies about 0.8 Mgal/d (14 percent of the net inflow) of water daily. Discharge (net outflow) from the freshwater parts of the study area is by pumping and lateral outflow east and south. Present-day pumpage if continued for 20 years would not alter the present flow pattern. As shown in table 3, there is no change in water taken from or going to storage in the Gonzales-New Orleans aquifer. Therefore, the aquifer under present (1986) pumping conditions is in steady state.

The effects of additional pumpage of 25 Mgal/d and 50 Mgal/d on the net inflow and outflow on the freshwater area of the Gonzales-New Orleans aquifer can be seen in table 3. For example, with an additional pumpage of 50 Mgal/d for 1 year about 17.2 Mgal/d (30 percent of the net inflow) is from lateral flow of saltwater from the Gonzales-New Orleans aquifer in the western part of the study area and south of the Mississippi River. Lateral flow of freshwater from the Gonzales-New Orleans aquifer north and east of the study area would supply a total of 35.7 Mgal/d (63 percent of the net inflow). Vertical leakage from overlying and underlying aquifers would total about 3.5 Mgal/d (6 percent of the total net inflow). About 0.3 Mgal/d (less than 1 percent of the net inflow) would come from aquifer storage. Outflow of freshwater does not change significantly during the simulations except for additional pumpage from the simulated pumping nodes.

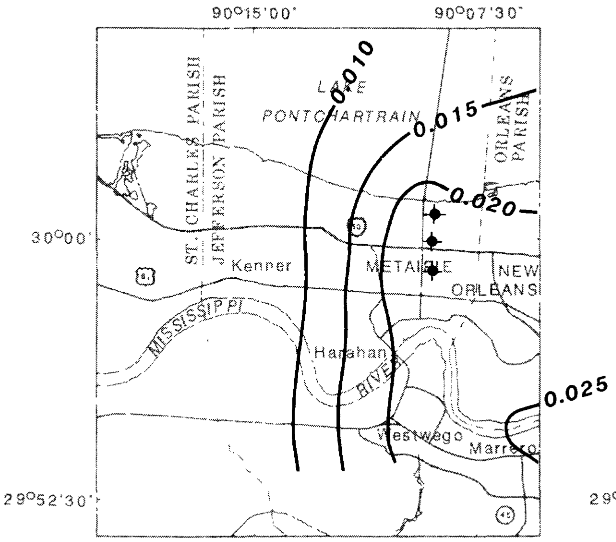
Vertical leakage through overlying and underlying confining units into freshwater in the Gonzales-New Orleans aquifer is important because it is a possible source of saltwater. The net inflow of saltwater from vertical leakage would increase with additional pumpage rates and the duration of pumpage (figs. 13 and 14, table 3). Although the increased vertical leakage appears to be small when compared to increased inflow from lateral flow, it is important to determine where the vertical leakage may be concentrated. A series of vertical leakage maps shown in figures 13b, 13d, 14b, and 14d indicate most of the vertical leakage into the Gonzales-New Orleans aquifer from overlying aquifers would be concentrated in the northeastern quarter of the study area. Present-day vertical leakage from overlying aquifers is concentrated here because of nearby pumpage in Orleans Parish. Selected vertical leakage maps for model simulations of 25 Mgal/d for 7 days and 30 days, and 50 Mgal/d for 1 year indicate additional pumpage would increase vertical leakage from overlying aquifers in this area. To determine how additional pumpage will affect the amount of vertical leakage from overlying or underlying aquifers one may refer to table 3 and figures 13 and 14. For example, table 3 indicates that an additional pumpage of 50 Mgal/d for 1 year will increase inflow (vertical leakage) from overlying aquifers from 0.4 Mgal/d at present to 1.9 Mgal/d (about five times the present rate). The leakage map shown in figure 13b indicates that vertical leakage from overlying aquifers at present is about 0.020 (Mgal/d)/mi^2 at simulated pumping nodes. With an additional pumpage of 50 Mgal/d for 1 year, vertical leakage from overlying aquifers (fig. 14d) would increase to about 0.10 (Mgal/d)/mi^2 (five times the present-day rate).



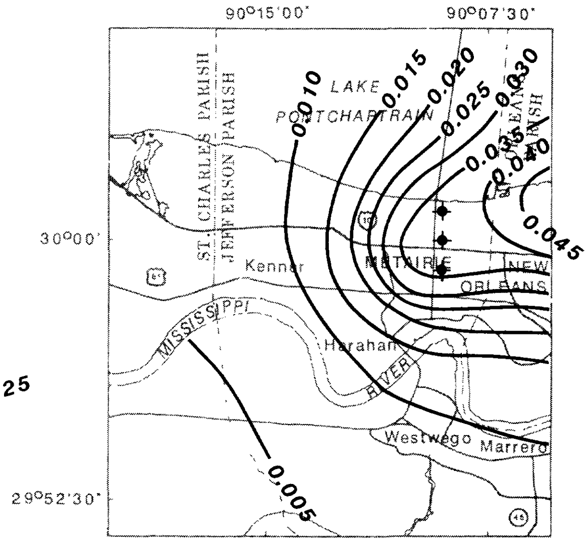
a. Leakage from underlying aquifers present day (1986) and after present day pumpage continued for 20 years.



b. Leakage from overlying aquifers present day (1986) and after present day pumpage continued for 20 years.



c. Leakage from underlying aquifers after additional pumpage of 25 Mgal/d for 7 days.



d. Leakage from overlying aquifers after additional pumpage of 25 Mgal/d for 7 days.

EXPLANATION

—0.020— Line of equal vertical flow at end of simulation period. Interval is 0.005 million gallons per day (Mgal/d) per square mile

Simulated pumping node

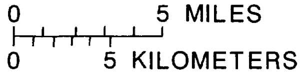
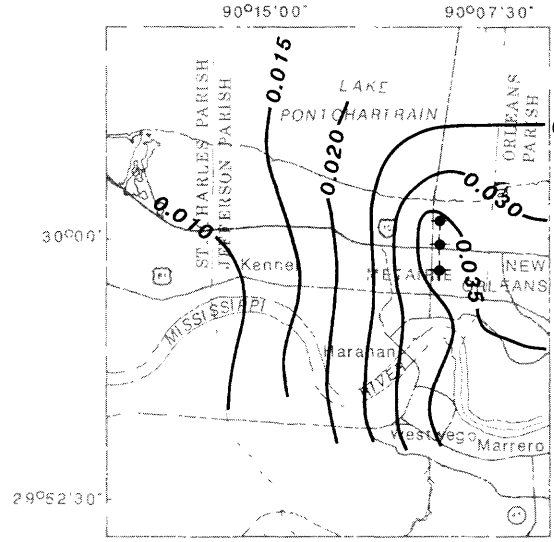
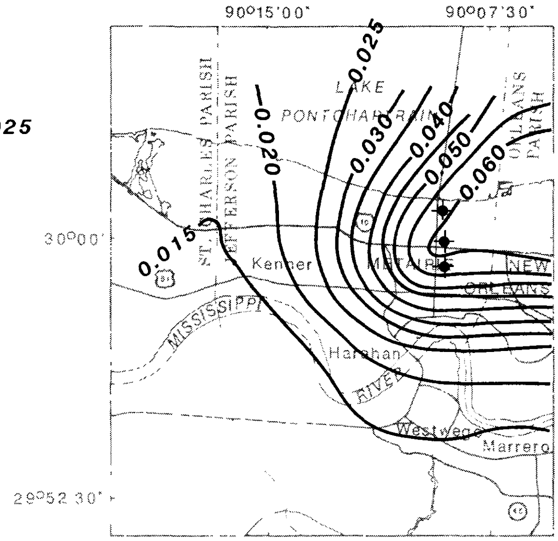


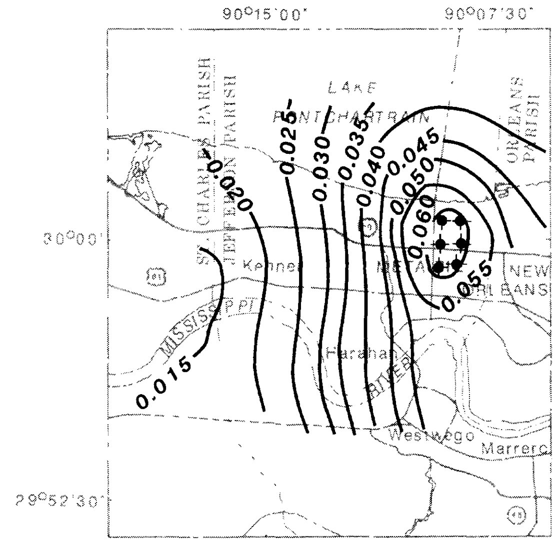
Figure 13.--Simulated vertical leakage into the Gonzales-New Orleans aquifer for present-day pumpage (1986), after present-day pumpage continued for 20 years, and after an additional pumpage of 25 million gallons per day for 7 days.



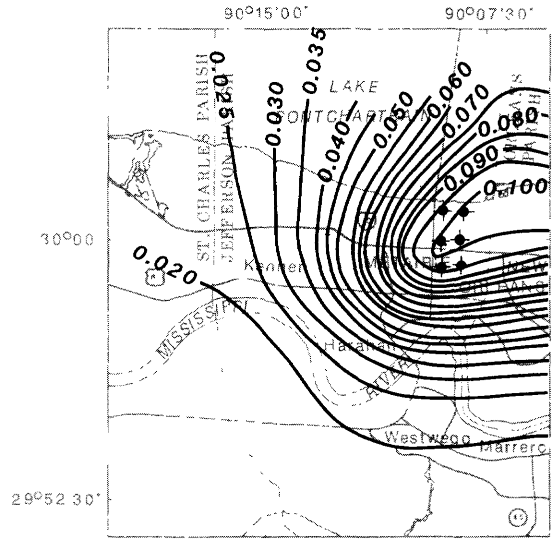
a. Leakage from underlying aquifers after additional pumpage of 25 Mgal/d for 20 years.



b. Leakage from overlying aquifers after additional pumpage of 25 Mgal/d for 20 years.



c. Leakage from underlying aquifers after additional pumpage of 50 Mgal/d for 1 year.



d. Leakage from overlying aquifers after additional pumpage of 50 Mgal/d for 1 year.

EXPLANATION

—0.020— Line of equal vertical flow at end of simulation period. Interval is 0.005 million gallons per day (Mgal/d) per square mile

Simulated pumping node

0 5 MILES

0 5 KILOMETERS

Figure 14.--Simulated vertical leakage into the Gonzales-New Orleans aquifer after an additional pumpage of 25 million gallons per day for 20 years and after an additional pumpage of 50 million gallons per day for 1 year.

Table 3.--Water budgets from model simulations showing net ground-water inflow and outflow in the freshwater area of the Gonzales-New Orleans aquifer in northern Jefferson Parish

[Rates given in million gallons per day Mgal/d at end of model simulation: number in parenthesis, ( ), is percent of net flow]

	Present rate 1986	Pumping rate and period: Present rate continued for 20 years	Additional 25 Mgal/d, continued for: 7 days	30 days	20 years	Additional 50 Mgal/d continued for 1 year
Inflow (recharge)						
Overlying aquifers[1]	0.4 (7)	0.4 (7)	0.8 (3)	1.0 (3)	1.3 (4)	1.9 (3)
Gonzales-New Orleans aquifer north and east of study area	1.7 (27)	1.7 (27)	14.6 (49)	16.4 (55)	16.8 (56)	35.7 (63)
Gonzales-New Orleans aquifer in north western Jefferson Parish and south of the Mississippi River[1]	3.9 (59)	3.9 (59)	6.9 (23)	9.7 (33)	10.8 (36)	17.2 (30)
Underlying aquifers[1]	.4 (7)	.4 (7)	.7 (2)	.9 (3)	1.0 (4)	1.6 (3)
Aquifer storage	.0 (0)	.0 (0)	6.7 (23)	1.8 (6)	<.1 (<1)	.3 (1)
Net inflow	6.4	6.4	29.7	29.8	29.9	56.7
Outflow (discharge)						
Pumpage	1.1 (17)	1.1 (17)	26.1 (88)	26.1 (88)	26.1 (87)	51.1 (90)
Gonzales-New Orleans aquifer east of study area	3.2 (50)	3.2 (50)	1.9 (6)	2.1 (7)	2.1 (7)	3.5 (6)
Gonzales-New Orleans aquifer south of study area	2.1 (33)	2.1 (33)	1.7 (6)	1.6 (5)	1.7 (6)	2.1 (4)
Aquifer storage	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)	.0 (0)
Net outflow	6.4	6.4	29.7	29.8	29.9	56.7

[1] Indicates saltwater.

Vertical leakage from underlying saltwater aquifers at the present rate of pumping is concentrated in the eastern half of the study area as shown in figure 13a. Figures 13c and 14a show that an additional pumpage of 25 Mgal/d for 7 days and 20 years would increase vertical leakage throughout the study area; however, vertical leakage from underlying aquifers would still be concentrated in the eastern half. With an additional pumpage of 50 Mgal/yr for 1 year vertical leakage from underlying aquifers would be concentrated around the pumping nodes (fig. 14c).

Estimated Movement of the Freshwater-Saltwater Interface

The main problem in the development of the Gonzales-New Orleans aquifer as an alternative water supply is the occurrence of saltwater in the western part of the study area and south of the Mississippi River (fig. 6). Additional pumpage in eastern Jefferson Parish would increase the eastward rate of movement of the freshwater-saltwater interface in the western part of the study area and cause the freshwater-saltwater interface about 4 miles south of the simulated pumping nodes to begin to move north. The velocity of ground-water flow can be estimated by application of Darcy's law, which is given as:

$$V = \frac{KI}{\theta}$$

where V = ground-water velocity, in feet per day;
K = aquifer hydraulic conductivity, in feet per day;
I = potentiometric gradient, in feet per foot;
θ = aquifer porosity, dimensionless.

Application of Darcy's law to estimate the rate of movement of the freshwater-saltwater interface assumes no dispersion and density effects. These assumptions were tested in the New Orleans area by a comparison of historically observed rates of saltwater encroachment and those estimated by Darcy's law. The results showed that Darcy's law gave close estimates of observed rates of saltwater encroachment (Dial and Sumner, 1989). Thus, in the present analysis, Darcy's law is applied to the various pumpage scenarios to arrive at estimates of anticipated rates of saltwater encroachment. These estimates, based on assumed values of aquifer hydraulic conductivity and porosity of 110 ft/d and 0.30, respectively, are summarized in table 2.

Short durations of increased pumpage, 7 days and 30 days, would have little effect on the present freshwater-saltwater interface as the average linear ground-water velocity at the interface would slow and return to or nearly to steady-state conditions when the additional pumpage is ceased. Table 2 shows a comparison of ground-water velocities at 1986 pumping conditions with the added pumping rates of 25 and 50 Mgal/d. The present velocity near the freshwater-saltwater interface in western Jefferson Parish near Kenner is about 65 ft/yr. If an additional 25 Mgal/d were added to the present pumpage for a 20-year period, the velocity at the interface near Kenner would increase to about 170 ft/yr. However, the average velocity of ground water would be about 230 ft/yr at the freshwater-saltwater interface about 4 mi south of the simulated pumpage. Assuming no dispersion or diffusion, the freshwater-saltwater interface would travel northward about 0.9 mi by the end of the 20-year period. The interface in western Jefferson Parish would travel about 0.6 mi in an eastward direction by the end of the 20 year pumping period. If an additional 50 Mgal/d were added to the present pumpage for 1 year, the average velocity would be about 500 ft/yr at the freshwater-saltwater interface south of the pumping nodes. However at the end of the 1-year pumping period when simulated pumpage is ended, water levels in the Gonzales-New Orleans aquifer would begin to recover and the ground-water velocity at the freshwater-saltwater interface would slow. The location of well sites in the eastern part of the study area would allow the maximum time before saltwater would reach the wells.

Land Subsidence

Much of the land subsidence in Jefferson Parish has been relatively recent, occurring after the marshland was drained and urbanization began. The three most probable causes of subsidence in the study area are related to (1) sediment loading and associated compaction of sediments as they become more deeply buried, (2) dewatering of marshy areas where surficial materials were formerly saturated, and (3) pumpage of ground water in the New Orleans area. Because pumpage of ground water is related to subsidence, the development of ground water as a public-supply source can only be evaluated by monitoring pumpage and subsidence concurrently.

The first two causes, sediment loading and dewatering, have been investigated by Saucier (1963) and Snowden and others (1977); the reader is referred to these sources for additional information. The natural subsidence resulting from sediment loading is area wide in scope, and its effects locally are not believed significant. Saucier (1963, p. 13) estimated a subsidence rate of 0.39 foot per century in the Lake Pontchartrain basin. This subsidence is attributed mostly to the combined effects of sediment loading, compaction, and faulting. The drainage of swamps and marshy areas for development of suburban areas in Jefferson Parish has caused the most dramatic short-term problem of land subsidence. Differential subsidence of up to 3.3 ft was reported in some areas by Snowden and others (1977, p. 173).

Because this study involves increased ground-water pumpage, an evaluation of its effects on subsidence would be useful. Increased pumpage of ground water in Jefferson Parish would cause some subsidence, but no records are available to determine how much. In the downtown area of New Orleans, land subsidence of 1.7 ft was reported between 1938 and 1964 on the basis of published bench-mark records (Kazmann and Heath, 1968, p. 111). They attributed most of the subsidence to water-level decline in the Gonzales-New Orleans aquifer. They concluded that the ratio of land subsidence to water-level decline was 1 ft of subsidence for every 50 ft of water-level decline, assuming the bench-mark data were valid. Since the early 1970's, pumpage in the New Orleans area has declined and water levels have been recovering. Information is not available to determine whether water-level recovery in the New Orleans area has been accompanied by a rise in altitude of land surface.

In the Baton Rouge area where local subsidence was monitored with extensometers from 1975 to 1979, only a small amount of permanent compaction occurred during the period when water-level recoveries occurred in the "600-foot" aquifer (Whiteman, 1980, p. 11-12). However, more than 1 ft of subsidence in the Baton Rouge area occurred during the period 1934-76 and is believed to be mostly permanent. This subsidence was a result of irreversible compaction of clays primarily caused by ground- water pumpage (Whiteman, 1980, p. 1-2). It is reasonable to assume that conditions of subsidence and recovery would be similar in the aquifer system in the study area. Thus, short periods of small rates of pumping would probably cause a minimal subsidence effect when compared to long continuous periods of large pumpage.

SUMMARY AND CONCLUSIONS

The New Orleans aquifer system is composed of a complex series of alternating interbedded clay and sand beds which form four areally extensive aquifers. From youngest to oldest, they are the Gramercy, Norco, Gonzales-New Orleans, and "1,200-foot" aquifers. Generally, these aquifers are separated by confining units of clay. Although freshwater is locally available near the shore of Lake Pontchartrain in northwestern Jefferson Parish from the Norco aquifer, the Gonzales-New Orleans aquifer is the only major source of fresh ground water.

Because the public-water supply from the Mississippi River is sometimes interrupted, planners and managers have begun to consider the Gonzales-New Orleans aquifer as an alternative source of water. However, about one-fifth of the study area is underlain by saltwater in the Gonzales-New Orleans aquifer. Saltwater generally occurs in the western part of the study area. Color, although its effects are mostly aesthetic, also generally exceeds 15 platinum-cobalt units. Color generally ranges between 50 to 120 units where the aquifer contains freshwater (all of the study area except the western one-fifth).

Freshwater from the Gonzales-New Orleans aquifer is generally a mixed sodium bicarbonate-chloride type. The ground water is soft, and pH generally ranges from 8.1 to 9.1 standard units. Both iron and manganese generally are less than 100 µg/L. Dissolved-solids concentrations range between 400 and 600 mg/L. Sodium concentrations range between 140 and 200 mg/L in freshwater from the Gonzales-New Orleans aquifer.

Analysis of sand, collected from the Gonzales-New Orleans aquifer, indicates grain size ranges from fine to medium. Transmissivity and hydraulic conductivity ranging from 12,000 to 24,000 ft^2/d and 85 to 110 ft/d, respectively, have been determined from aquifer tests in the study area and nearby areas. The aquifer averages slightly greater than 200 ft in thickness.

By use of a three-dimensional finite-difference ground-water flow model, an additional pumpage of 25 Mgal/d of water for 7 days, 30 days, and 20 years, and a pumpage of 50 Mgal/d for 1 year from the Gonzales-New Orleans aquifer were simulated to evaluate the effect on water levels and flow patterns. The simulated pumpage was located in northeastern Jefferson Parish where the best combination of low chloride concentration (less than 250 mg/L chloride) and relatively low color (less than 100 platinum-cobalt units) was available. Pumpage was located as far as possible from areas underlain by saltwater to decrease the rate of encroachment and maximize the time required for saltwater to reach the well fields.

Results of simulations indicate average ground-water velocities will increase at the present freshwater-saltwater interface near Kenner from the present velocity of 65 ft/yr to a maximum of 200 ft/yr with an additional 50 Mgal/d withdrawal for 1 year. Simulation results also indicate the freshwater-saltwater interface located about 4 mi south of the pumping nodes will begin to move northward between 150 to 500 ft/yr. Short pumping periods, 7 days and 30 days at 25 Mgal/d, will have little effect on the movement of the freshwater-saltwater interface. However, if additional pumpage of 25 Mgal/d is continued for 20 years, the freshwater-saltwater interface would encroach northward about 0.9 mi. The maximum rate of northward encroachment, 500 ft/yr, would occur during the additional pumpage of 50 Mgal/d for 1 year. Simulation results indicate maximum water-level declines from 57 to 166 ft will occur at hypothetical well fields. Simulation results also indicate vertical leakage of saltwater through overlying and underlying clays into freshwater areas of the Gonzales-New Orleans aquifer in northern Jefferson Parish may increase with additional pumpage.

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