UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

THE SOUTHERN HILLS REGIONAL AQUIFER SYSTEM OF SOUTHEASTERN LOUISIANA AND SOUTHWESTERN MISSISSIPPI

By Anthony Buono

Water-Resources Investigations Report 83-4189

Prepared in cooperation with the

U.S. ENVIRONMENTAL PROTECTION AGENCY

Baton Rouge, Louisiana

1983

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon (gal)	0.003785	cubic meter (m^3)
	3.785	liter (l)
million gallons per day (Mgal/d)	3785	cubic meter per day (m^3/d)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

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 Mean Sea Level Datum of 1929; referred to as sea level in this report.

THE SOUTHERN HILLS REGIONAL AQUIFER SYSTEM OF SOUTHEASTERN LOUISIANA AND SOUTHWESTERN MISSISSIPPI

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ABSTRACT

The Southern Hills regional aquifer system that is the primary source of water for public and domestic use in the northern 10 parishes of southeastern Louisiana was named in a petition to the Environmental Protection Agency to be protected as a sole or principal source of drinking water under Section 1424 of Public Law 93-523, the Safe Drinking Water Act. The aquifer system is comprised of a gulfward dipping and thickening wedge of sediments that generally range in age from Pleistocene or Pliocene at the top to Miocene at the base. The system extends from the northern limit of the recharge area in the vicinity of Vicksburg, Mississippi, southward approximately to the Baton Rouge fault in the Baton Rouge area and the southern part of the eastern Florida Parishes of southeastern Louisiana.

In southeastern Louisiana, the aquifer system has been divided into as many as 13 aquifer units that are recognized to decrease in number northward where aquifer units coalesce because many of the separating clay layers disappear or are no longer mappable, or where younger formations in the geologic sequence pinch out in the updip section. Although the system has been locally divided into many aquifer units, these aquifers are recognized to be interdependent, collectively forming the Southern Hills regional aquifer system. Water in the aquifer system is almost exclusively a soft sodium bicarbonate type. In southeastern Louisiana, dissolved-solids concentrations average about 210 mg/L (milligrams per liter). In southwestern Mississippi the Citronelle aquifer has an average dissolved-solids concentration of 51 mg/L. In southern Mississippi the Miocene aquifer system has a median dissolved-solids concentration of 170 mg/L.

Within the study area several streams are available as alternative sources of water for public and domestic supply, the largest of which are the Mississippi and Pearl Rivers. Water from these streams, although of relatively good chemical quality, has not been accepted by local officials as a viable alternative supply. The reason for non-acceptance is the increased costs to users resulting from additional water treatment and the extensive delivery system that would be needed to distribute surface water, especially to users remotely located from a source stream. Based on the additonal water treatment alone, costs to users would nearly double.

In the 10 parishes of southeastern Louisiana, where the Southern Hills regional aquifer system is the primary source of water for public and domestic supply, during 1980 water use for these categories totaled

about 121 Mgal/d (million gallons per day), serving about 744,000 persons. In addition, in southwestern Mississippi, where the aquifer system is also the primary source of water for public and domestic supply, a total of 25 Mgal/d were used for these categories by about 273,000 persons. Based on projected growth, by the year 2000 water use will total about 220 Mgal/d serving a population of about 1.5 million persons in southeastern Louisiana and southwestern Mississippi.

INTRODUCTION

The Capital Area Ground Water Conservation Commission (CAGWCC) was established by the 1974 Louisiana Legislature for the primary purpose of conserving and protecting the ground-water resources of a five-parish area in the vicinity of Baton Rouge in southeastern Louisiana. To ensure the most strict protection of the local ground-water resources from contamination, the commission has petitioned the U.S. Environmental Protection Agency (EPA) to designate the aquifer system serving the area as a sole or principal source of drinking water. The petition was submitted in accordance with Public Law 93-523, known as the Safe Drinking Water Act. Included in the area covered by the petition are the eastern Florida Parishes of southeastern Louisiana and the neighboring Mississippi counties that also depend on the aquifer system for drinking water. The northernmost parishes of southeastern Louisiana and all of the counties in Mississippi that have been included in the petition are in the recharge area for the aquifer system. The recharge area, which also has been included in accordance with Section 1424(e) of the Safe Drinking Water Act, is of particular concern to the petition because this is where the aquifer system intersects land surface, and is where contaminants could most easily enter and degrade water in the system.

The U.S. Geological Survey, under an interagency agreement with the Environmental Protection Agency, was requested to prepare detailed information on the petitioned aquifer system. The information will be used by EPA to determine whether the aquifer should be protected under the sole or principal source designation.

Purpose and Scope

The purposes of the investigation were to develop from available information (1) a description of the regional aquifer system serving as a public supply in the Capital Area Ground Water Conservation Commission district, the Florida Parishes[1] of southeastern Louisiana, and the counties of southwestern Mississippi; and (2) to discuss potential alternative sources of freshwater.

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[1] The Florida Parishes of Louisiana are the parishes of East Baton Rouge, East Feliciana, West Feliciana, Livingston, St. Helena, St. Tammany, Tangipahoa, and Washington, collectively known in 1810 as the "Free and Independent State of West Florida" (Louisiana Legislative Council, 1955, p. 31-32).

The study area (fig. 1) covers about 14,000 mi^2 in southeastern Louisiana and southern Mississippi. The Louisiana parishes and Mississippi counties that compose the study area are as follows:

LOUISIANA PARISHES	
The CAGWCC district parishes	The eastern Florida Parishes
East Baton Rouge	Livingston
West Baton Rouge	St. Helena
East Feliciana	St. Tammany
West Feliciana	Tangipahoa
Pointe Coupee	

MISSISSIPPI COUNTIES		
Adams	Jefferson	Rankin
Amite	Jefferson Davis	Simpson
Claiborne	Lawrence	Warren
Copiah	Lincoln	Walthall
Franklin	Marion	Wilkinson
Hinds	Pike	

These parishes and counties compose the area of the study that extends from the northern limit of the recharge area in southwestern Mississippi to the approximate southern limit of the aquifer system in the vicinity of the Baton Rouge fault zone (fig. 2) in southeastern Louisiana.

Approach

The investigation was made through the use of information from previous investigations reporting on the geohydrology of southeastern Louisiana and southern Mississippi. Information used included: geohydrologic maps and cross sections showing the distribution of and stratigraphic and hydraulic relation of aquifer units within the aquifer system; water-quality data; potentiometric maps and diagrams showing the head distribution or the direction of ground-water movement within the system; and water-use data indicating the sources and quantities of water used. The information was compiled to present a detailed overview of the aquifer system, water use, and the sources of drinking water available to the Capital Area Ground Water Conservation Commission district and the Florida Parishes.

Previous Studies and Agencies Having Water-Resources-Related Functions

The reports of investigations used during this study are too numerous to be individually cited here. Therefore, the reader is referred to the "Selected References" section of this report, and to references cited within the text and on illustrations. This report has been written based on details of the geohydrology and water use obtained from these reports, which are county or parish, state, or regional in scope.

Figure 1.--The location of the study area in Louisiana and Mississippi.

Figure 2.--The extent and recharge area of the aquifer system and locations of detailed geohydrologic sections.

The agencies that have water-resources-related functions in the study area are as follows:

Louisiana

1. Capital Area Ground Water Conservation Commission
2. Louisiana Department of Transportation and Development, Office of Public Works (formerly the Department of Public Works)
3. Louisiana Geological Survey
4. Louisiana Water Resources Institute, Louisiana State University, Baton Rouge
5. U.S. Geological Survey

Mississippi

1. Mississippi Bureau of Land and Water Resources
2. Mississippi Research and Development Center
3. Mississippi Geological Survey
4. U.S. Geological Survey
5. Water Resources Research Institute, Mississippi State University.

SOURCE OF PUBLIC-WATER AND DOMESTIC-WATER SUPPLY

The primary source of water for public and domestic supply in the CAGWCC district and the Florida Parishes is ground water (Walter, 1982, table 3). Within this area, ground water is obtained primarily from the Southern Hills regional aquifer system that underlies and contains freshwater in the northern half of southeastern Louisiana. A secondary source of ground water that is used for rural-domestic self-supplied systems is from isolated local shallow aquifers that occur within the Quaternary alluvial deposits and within the shallow Pleistocene sands overlying the regional aquifer system. The area of the aquifer system named in the petition for protection as a sole or principal source of drinking water encompasses the area of use of the regional aquifer system in southeastern Louisiana and the recharge area affecting the aquifer system of southeastern Louisiana (fig. 2). Emphasis has been placed on the recharge area because this is where the aquifer system intersects land surface and is highly vulnerable to the introduction of contaminants into the system. Included in the study, because they are in the recharge area, are 17 counties in southwestern Mississippi that lie directly north of southeastern Louisiana. Within southwestern Mississippi, the Southern Hills aquifer system is the primary source of public and domestic water supply in 14 of the 17 counties, or about 85 percent of the Mississippi part of the study area.

SOUTHERN HILLS REGIONAL AQUIFER SYSTEM

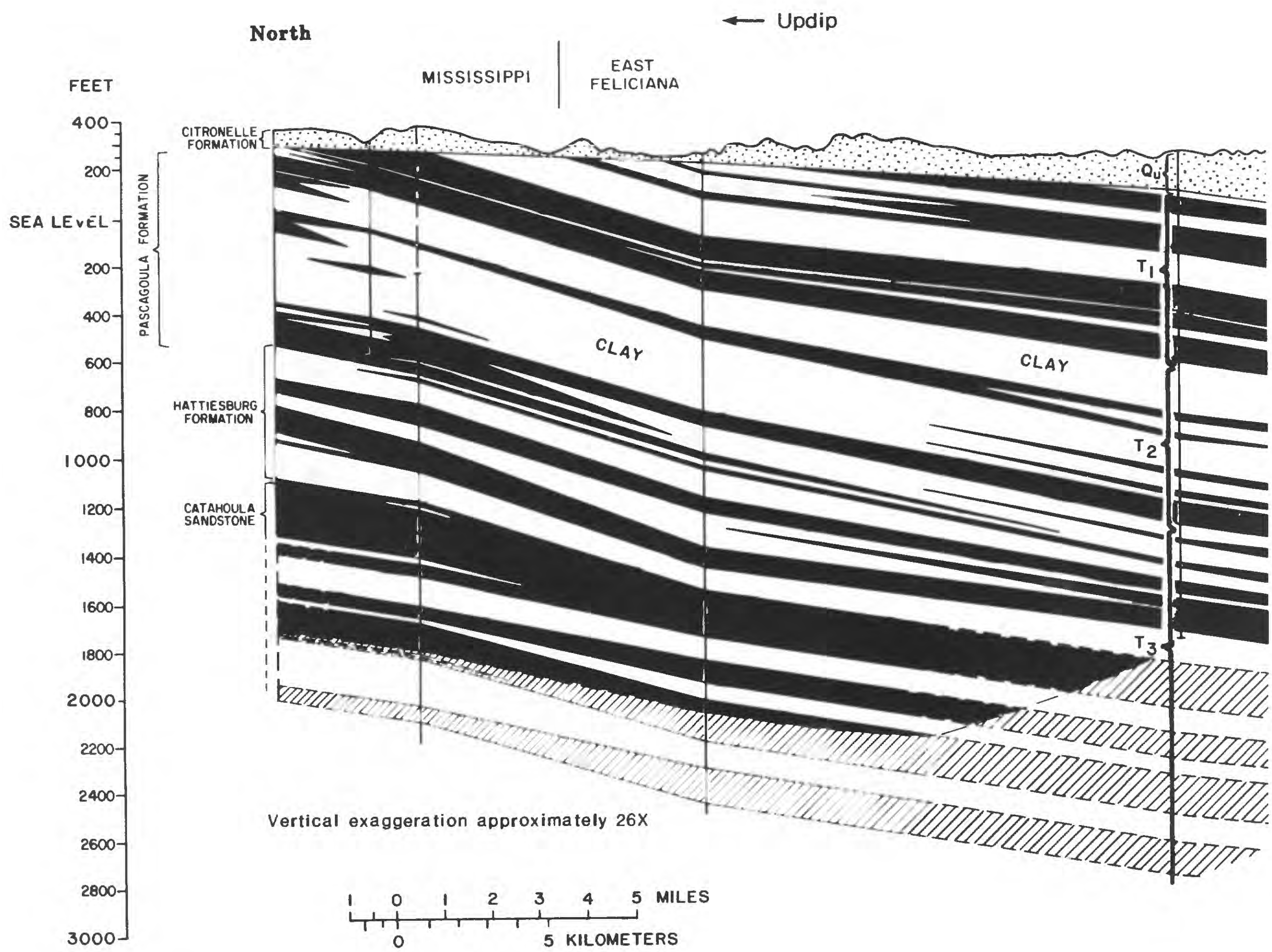
The Southern Hills regional aquifer system extends from the northern limit of the Miocene formations in southwestern Mississippi, in the vicinity of Jackson and Vicksburg, southward to the area of the Baton Rouge fault zone. (See fig. 2.) The fault zone acts as a barrier to groundwater movement and is approximately the southern limit of freshwater in the system. South of the fault zone, water within the formations that compose the aquifer system is saline and not usable for potable water.

The western extent of the Southern Hills aquifer is marked by a zone of saline water within the Pliocene and Miocene sediments that lie beneath the Mississippi River alluvial valley (Rollo, 1960; Whitfield, 1975). This zone represents the limit of flushing of saline water from the Pliocene and Miocene aquifers by ground water moving southeasterly and southwesterly toward the Mississippi River alluvial valley.

The eastern boundary of the aquifer system is less clearly defined, because detailed potentiometric maps of the aquifer system in southern Mississippi are not available. However, based on potentiometric levels within the aquifer system in southern Mississippi (J. K. Arthur and B. E. Wasson, written commun., 1982), potentiometric maps of the aquifer system in St. Tammany and Tangipahoa Parishes (figs. 8, 9, and 11) and a potentiometric map of the "2,000-foot" sand of the Baton Rouge area (fig. 10), the direction of the ground-water movement within the Southern Hills aquifer is generally southerly or southwesterly toward the southern or western boundary of the study area. (See fig. 10.) East of the study area the direction of ground-water movement is southerly or southeasterly away from the aquifer system. The resulting, somewhat tenuous, ground-water divide forms the eastern boundary and is the basis for limiting the aquifer system to the area of Mississippi directly north of southeastern Louisiana.

Geohydrology

The Southern Hills aquifer system as named in this report is comprised of a gulfward thickening and dipping, complexly interbedded, series of sandy and clayey formations that generally range in age from Pleistocene or Pliocene at the top, to Miocene at the base. (See figs. 3, 4, 5, and 6; table 1.) The base of the aquifer system generally has been considered to be the base of freshwater (diagramatically shown in fig. 6) within the sedimentary sequence, defined as 250 mg/L or less chloride concentration in southeastern Louisiana and 1,000 mg/L or less dissolved-solids concentration in southern Mississippi. Based on these chemical concentrations, the aquifer system attains a thickness of more than 2,500 ft in the southernmost part of the study area (Nyman and Fayard, 1978, pl. 1; and Morgan, 1963, pl. 1). However, in accordance with Public Law 93-523, EPA has established (Federal Register, May 19, 1980, vol. 45, No. 98, sec. 122.3, p. 33424) that all ground water containing dissolved-solids concentrations of 10,000 mg/L or less shall be considered as an underground source of drinking water and protected from endangerment by injection wells. To include all such underground sources of drinking water under a sole-source designation would increase slightly the thickness of the aquifer system to be protected under the petition. Because the mapping used for this report was based on chloride concentrations of 250 mg/L or dissolved-solids concentrations of 1,000 mg/L or less to define the base of freshwater, these limits have been used in this description of the aquifer system.

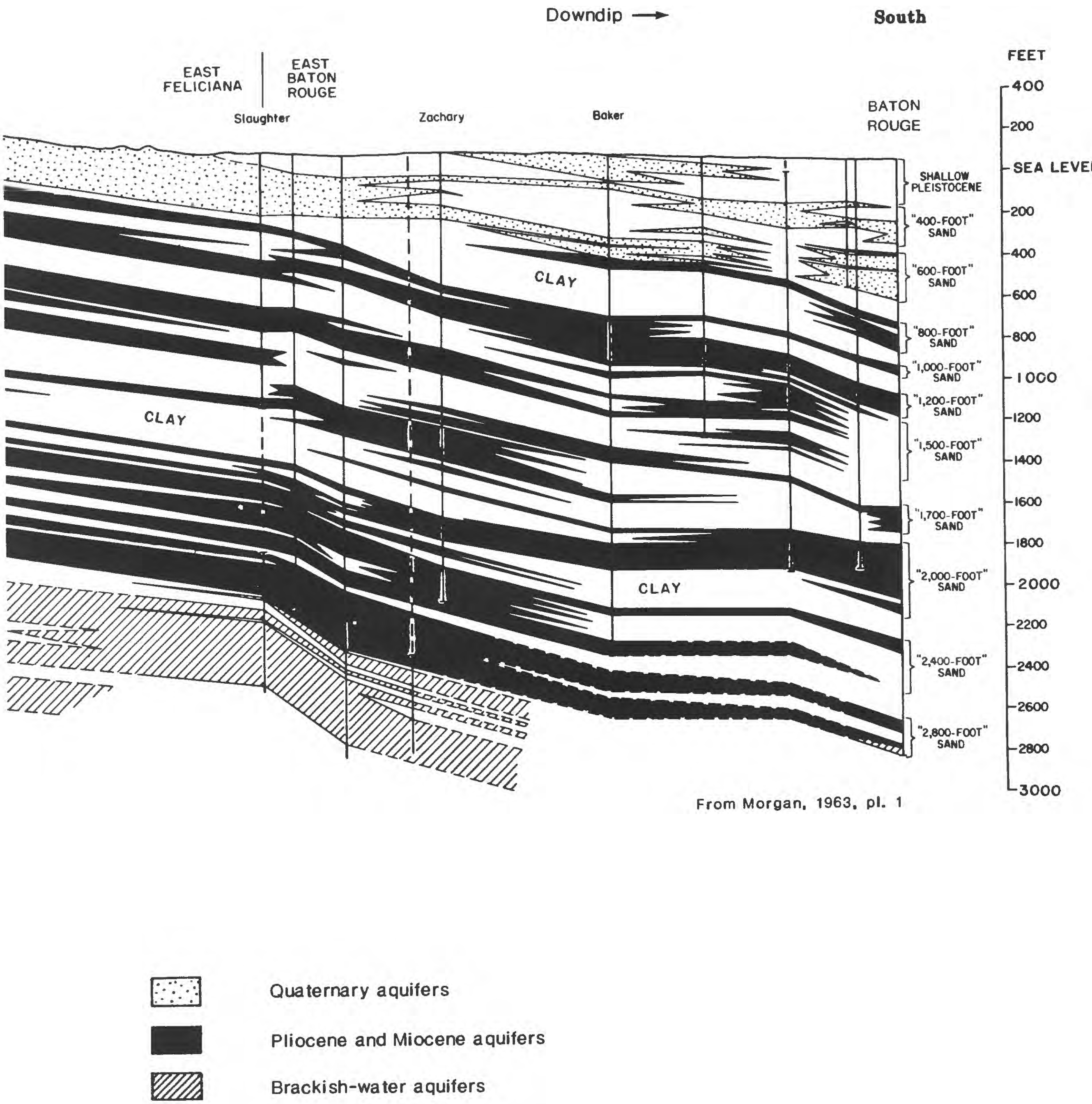


(For section location see figure 2.)

EXPLANATION

Q_u	Quaternary Upland deposits
T_1	Zone 1
T_2	Zone 2
T_3	Zone 3

Figure 3.--Geohydrologic section



from Mississippi to Baton Rouge.

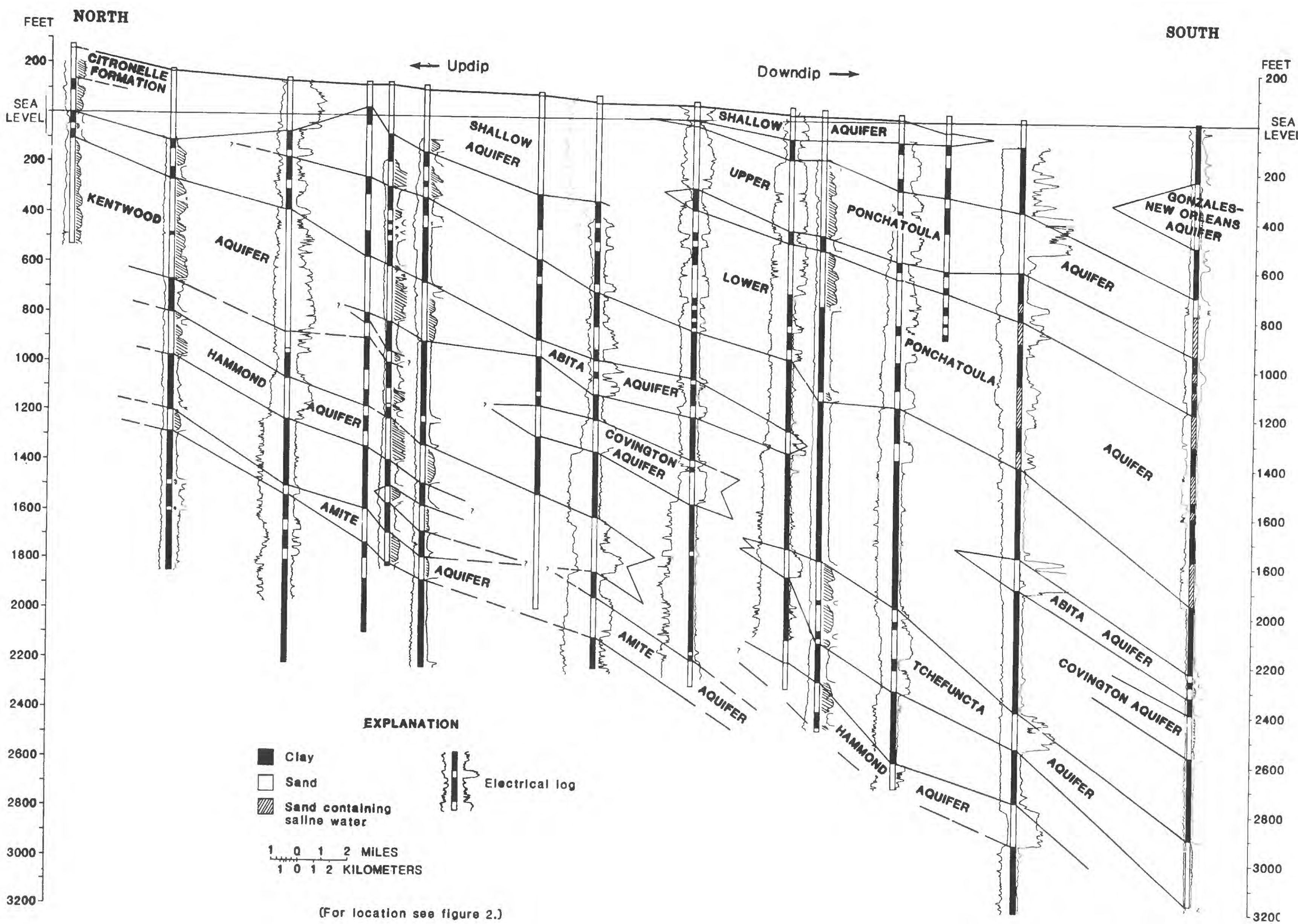


Figure 4.--Geohydrologic section through Tangipahoa Parish in southeastern Louisiana.

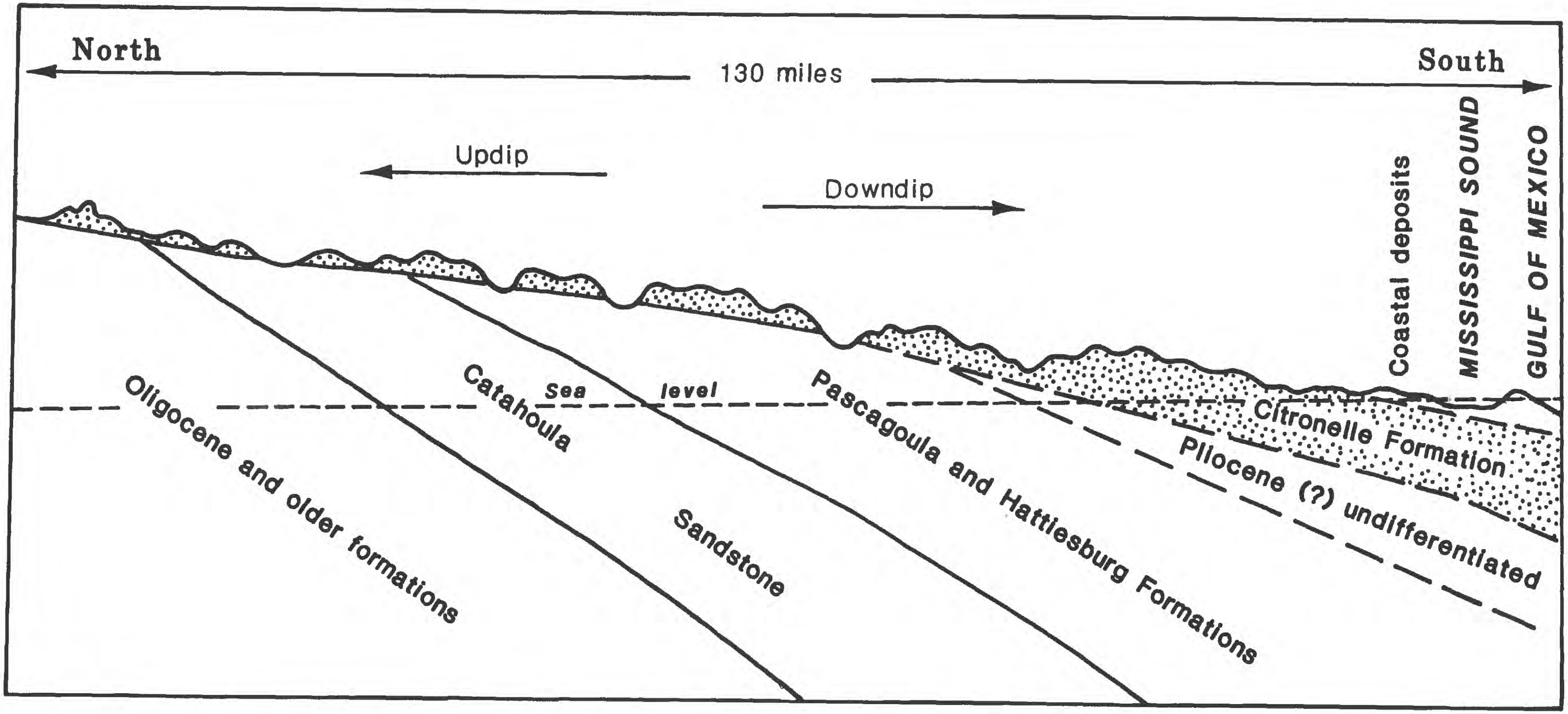


Figure 5.--Generalized geologic section showing the relation of formations in southern Mississippi.

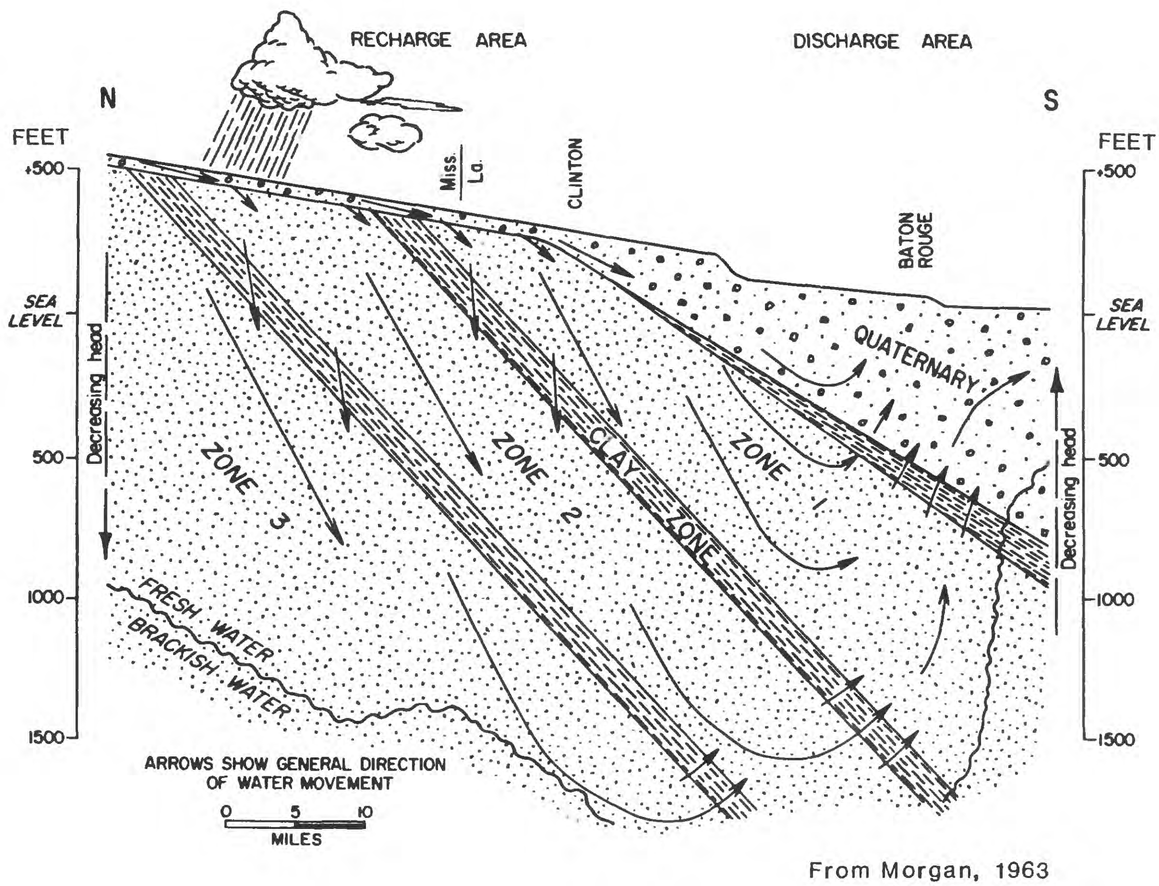


Figure 6.--Generalized section showing movement of ground water from the recharge area to the discharge area in southeastern Louisiana.

Within the study area the aquifer system has been subdivided into as many as 13 recognizable aquifer units (Nyman and Fayard, 1978). The division is based on the presence of clayey confining layers interbedded with sandy aquifer units within the system's sedimentary sequence. Most of these confining layers, however, are only mappable locally and not present throughout the study area. Where these confining layers either become discontinuous or disappear completely, a coalescing of the aquifer units occurs, forming fewer units of thicker proportions. Table 1 shows the stratigraphic relation and correlation of aquifer units in the aquifer system as used in selected reports on parts of the study area. According to these reports, the maximum number of aquifer units is downdip (figs. 3, 4, and 5) within the geologic sequence in the southernmost part of the study area. In the eastern Florida Parishes up to 13 aquifer units compose the aquifer system, depending on local interconnection of the shallow aquifer and upper Ponchatoula aquifer (Nyman and Fayard, 1978, p. 7, pl. 1). These units range in age from Holocene-Pleistocene at the top to Miocene at the base. In the Baton Rouge area up to 12 aquifer units are recognized (Meyer and Turcan, 1955, pl. 2; and Morgan, 1961, pl. 1), depending on localized hydraulic interconnection of the shallow Quaternary aquifers with the deeper Pleistocene "400-foot" and "600-foot" sands. Where the shallow aquifers are not interconnected to the underlying regional aquifer system they are referred to in this report as the isolated local shallow aquifers.

Table 1.--Correlation of aquifer units of the Southern Hills aquifer system in southeastern Louisiana and southern Mississippi

Southeastern Louisiana					Southern Mississippi			
		Aquifer unit						
System	Series	Baton Rouge area,[1] Pointe Coupee Parish[2]	West Feliciana Parish[3]	St. Tammany and Tangipahoa Parishes,[4] Washington Parish[5]	Aquifer unit		Series	System
Quaternary	Holocene	Alluvial deposits	Quaternary alluvium	Shallow	Alluvial deposits			Quaternary
	Pleistocene	Shallow Pleistocene[1]	Quaternary upland deposits		Citronelle Formation[6]		Pliocene	Tertiary
		"400-foot" sand[1]		Upper Ponchatoula				
		"600-foot" sand						
Tertiary	Pliocene	"800-foot" sand	Zone 1	Lower Ponchatoula	Graham Ferry Formation[7]	Miocene aquifer system[7]		
		"1,000-foot" sand						
		"1,200-foot" sand		Big Branch	Pascagoula Formation		Miocene	
		"1,500-foot" sand		Kentwood				
				Abita				
		"1,700-foot" sand	Zone 2	Covington				
				Slidell				
	Miocene	"2,000-foot" sand		Tchefuncta				
		"2,400-foot" sand	Zone 3	Hammond	Hattiesburg Formation			
		"2,800-foot" sand		Amite				
				Ramsay	Catahoula Sandstone			
				Franklinton				

[1]Morgan, 1961; [2]Winner and Forbes, 1968; [3]Morgan, 1963; [4]Nyman and Fayard, 1978; [5]Case, 1979; [6]Boswell, 1979; and [7]Newcome, 1975.

Northward within southeastern Louisiana, fewer units are recognized within the regional aquifer system. This decrease in aquifer units results from the disappearance of many of the locally mappable clay layers that exist further south, and because of the pinch out (disappearance) of the younger geologic units updip in the geologic sequence toward the north. In East and West Feliciana Parishes, for example, only five aquifer units were recognized by Morgan (1963, p. 8). Further north, based on reports by Boswell (1979) and Newcome (1975, pl. 1), the aquifer system in Mississippi can be divided into two aquifer units in some areas, while in other areas the system cannot be divided at all. Figure 5 (modified from Boswell, 1979, fig. 2) is a generalized geologic section that shows the formations that compose the aquifer system and their decrease in number toward the north (updip). This north-south geologic section through the southern half of Mississippi to the Gulf of Mexico is representative of the geologic structure in southern Mississippi and southeastern Louisiana. The Miocene, Pliocene, and Pleistocene aquifers of southeastern Louisiana are correlative with the aquifer units named in southern Mississippi (table 1). In addition to the generalized cross section, the geohydrologic sections in figures 3, 4, and 6 show the aquifer units recognized at different locations within the study area.

Although the sedimentary sequence that underlies the study area has been subdivided in some areas into many aquifer units, the units are recognized to collectively operate as a single aquifer system, referred to as the Southern Hills aquifer system. (See fig. 6.) Heavily pumped aquifer units within the system are known to derive part of their water from overlying and underlying aquifer units. The movement of water from one unit to another occurs where aquifer units are not separated by confining layers, as leakage through confining layers, or where the influence of heavy pumping in one aquifer unit extends horizontally beyond the area where an intervening clay layer occurs. This interaquifer connection has been recognized in water-resources investigations made within the study area.

In the Florida Parishes Nyman and Fayard (1978, p. 62) indicate that the rates of water-level decline in the deeper aquifer units reflect pumping inside and outside their report area and adjustments in artesian pressure are occurring throughout the aquifer system. Specifically they state:

> Water is moving from the little-used aquifers that have relatively high artesian heads to heavily pumped aquifers of lower artesian head.

In the Baton Rouge area Torak and Whiteman (1982, p. 4) state:

> The "2,000-foot" sand is the most heavily pumped aquifer in the system of alternating sands and confining layers in the Baton Rouge area. Because of the unequal pumpage distribution among aquifers, the "2,000-foot" sand has the most drawdown. This results in vertical leakage into this aquifer through the confining layer above, from the "1,500-1,700-foot" sand, and through the confining layer below, from the "2,400-foot" sand.

The following excerpt from Morgan (1963, p. 11-13) discusses and illustrates aquifer zone interconnection in southeastern Louisiana and southwestern Mississippi.

> The fresh-water-bearing aquifers in southeastern Louisiana are basically a single hydrologic system (fig. 3 [refer to figure 6 in this report]); however, this system can be divided into several hydraulic zones. Movement of water begins in the highland or outcrop area where a small part of the total precipitation infiltrates the exposed zone. The water moves downward and laterally toward the area of lowest head within the zone or to adjacent zones. A very small quantity of the water moving through hydraulic zone 1 in the recharge area passes downward through the underlying relatively impermeable clay zones into zone 2, which has a lower head or water level. Some water from zone 2 moves downward into zone 3, which in turn has a lower head than zone 2. Thus all three zones receive recharge in the highland area.
>
> * * *
>
> In the discharge area, as shown on figure 3 [refer to figure 6 in this report], the water levels are higher in zone 3 than in zone 2, higher in zone 2 than in zone 1, and higher in zone 1 than in the Quaternary aquifers. This is a reversal of their relative positions as determined in the recharge area. The water in the lower zones of higher head slowly moves upward through the overlying clay zones and aquifers and eventually is discharged as seepage at the land surface. However, the water movement will be downward in discharge areas where withdrawals have lowered the naturally higher artesian pressures in the deeper zones to a level below those in the shallower zones.

In Mississippi, Newcome (1975) found no identifiable or mappable means for separating the Pliocene and Miocene Formations (the Graham Ferry, Pascagoula, Hattiesburg, and Catahoula Sandstone) into separate aquifer units. Newcome therefore included all of these formations as the Miocene aquifer system. Newcome states (1975, sheet 1):

> The Miocene sequence in southern Mississippi has been subdivided by some workers into the Pascagoula Formation, Hattiesburg Formation, and Catahoula Sandstone--from youngest to oldest--but these divisions cannot be reliably identified or traced in the subsurface. Likewise, a 400- to 900-ft-thick (120-270 m) unit at the top in the coastal counties has been identified as Pliocene in age on the basis of fossil evidence and assigned the name Graham Ferry Formation. Again, the unit cannot be distinguished from the next lower formation by lithological, geophysical, or hydrological means. Consequently, all the material between the Citronelle Formation, a blanket deposit of Pliocene age, and the limy Vicksburg Group of Oligocene age is herein considered to compose the Miocene aquifer system.

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In addition, in many areas the Citronelle aquifer is in direct hydraulic contact with the underlying Miocene aquifer units, forming a single aquifer. Boswell (1979) states:

> The Citronelle Formation is very permeable and readily receives and transmits water from precipitation. In Mississippi, water infiltrates to the water table and then either moves laterally to valley walls to be discharged by springs and seeps or it continues downward into underlying aquifers. Where the underlying units are permeable sand (fig. 2 [refer to fig. 5 in this report]), a large part of the water may continue downward and where underlying clays predominate, most of the water moves laterally to discharge points.

Further Boswell states: "The stored water, [referring to water in the Citronelle aquifer] also recharges the underlying confined aquifers that are hydraulically connected to the basal sand and gravel in the Citronelle."

Based on the presently (1983) available information the aquifer units that compose the Southern Hills regional aquifer system are recognized to function as a single hydrologic system. However, results of the Mississippi Embayment--West Gulf Coast Regional Aquifer System Analysis (scheduled for completion in 1986) may more clearly define hydraulic relations between major aquifer units within the aquifer system.

Aquifer Recharge

Aquifer recharge is primarily from direct percolation of precipitation to the water table in areas where the geologic formations that compose the Southern Hills aquifer system intersect land surface (recharge area outlined in plan, fig. 2, and section, fig. 6). Aquifer recharge from stream flow is less significant. Because base flow in local streams is sustained by excess water that is discharged from the aquifer (referred to as rejected recharge), aquifer recharge can only occur during periods when stream stages are above the water level in the aquifer system. Additionally, much of these stream losses enter the aquifer system temporarily as bank storage, and are returned to the stream as stages decline. An example of this is described by Morgan (1963, p. 23) concerning the interaction between the Quaternary alluvium and the stage of the Mississippi River. Based on aquifer water-level and river-stage records for 1958-61, water from the Quaternary alluvial aquifer flows to the river about 80 percent of the time.

The recharge area of the Southern Hills aquifer system extends approximately from the southern boundary of the northern tier of parishes in southeastern Louisiana to the northern limit of the Miocene formations in southwestern Mississippi (fig. 2) and encompasses about 80 percent of the study area. Southward from the recharge area the aquifer system is

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Aquifer recharge is primarily from direct percolation of precipitation to the water table in areas where the geologic formations that compose the Southern Hills aquifer system intersect land surface (recharge area outlined in plan, fig. 2, and section, fig. 6). Aquifer recharge from stream flow is less significant. Because base flow in local streams is sustained by excess water that is discharged from the aquifer (referred to as rejected recharge), aquifer recharge can only occur during periods when stream stages are above the water level in the aquifer system. Additionally, much of these stream losses enter the aquifer system temporarily as bank storage, and are returned to the stream as stages decline. An example of this is described by Morgan (1963, p. 23) concerning the interaction between the Quaternary alluvium and the stage of the Mississippi River. Based on aquifer water-level and river-stage records for 1958-61, water from the Quaternary alluvial aquifer flows to the river about 80 percent of the time.

The recharge area of the Southern Hills aquifer system extends approximately from the southern boundary of the northern tier of parishes in southeastern Louisiana to the northern limit of the Miocene formations in southwestern Mississippi (fig. 2) and encompasses about 80 percent of the study area. Southward from the recharge area the aquifer system is

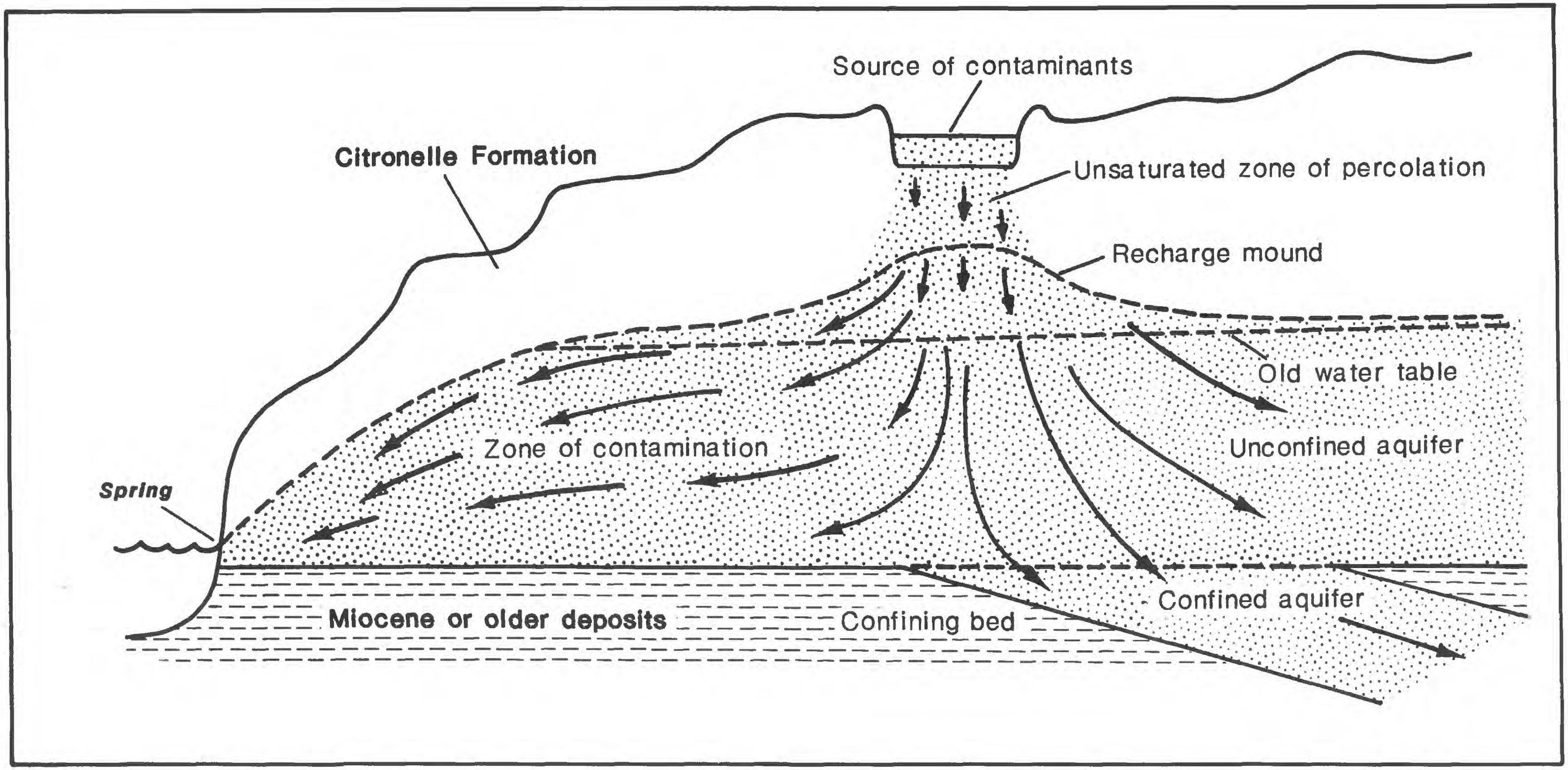

Figure 7.--The movement of a contaminant from a surface source into the aquifer system.

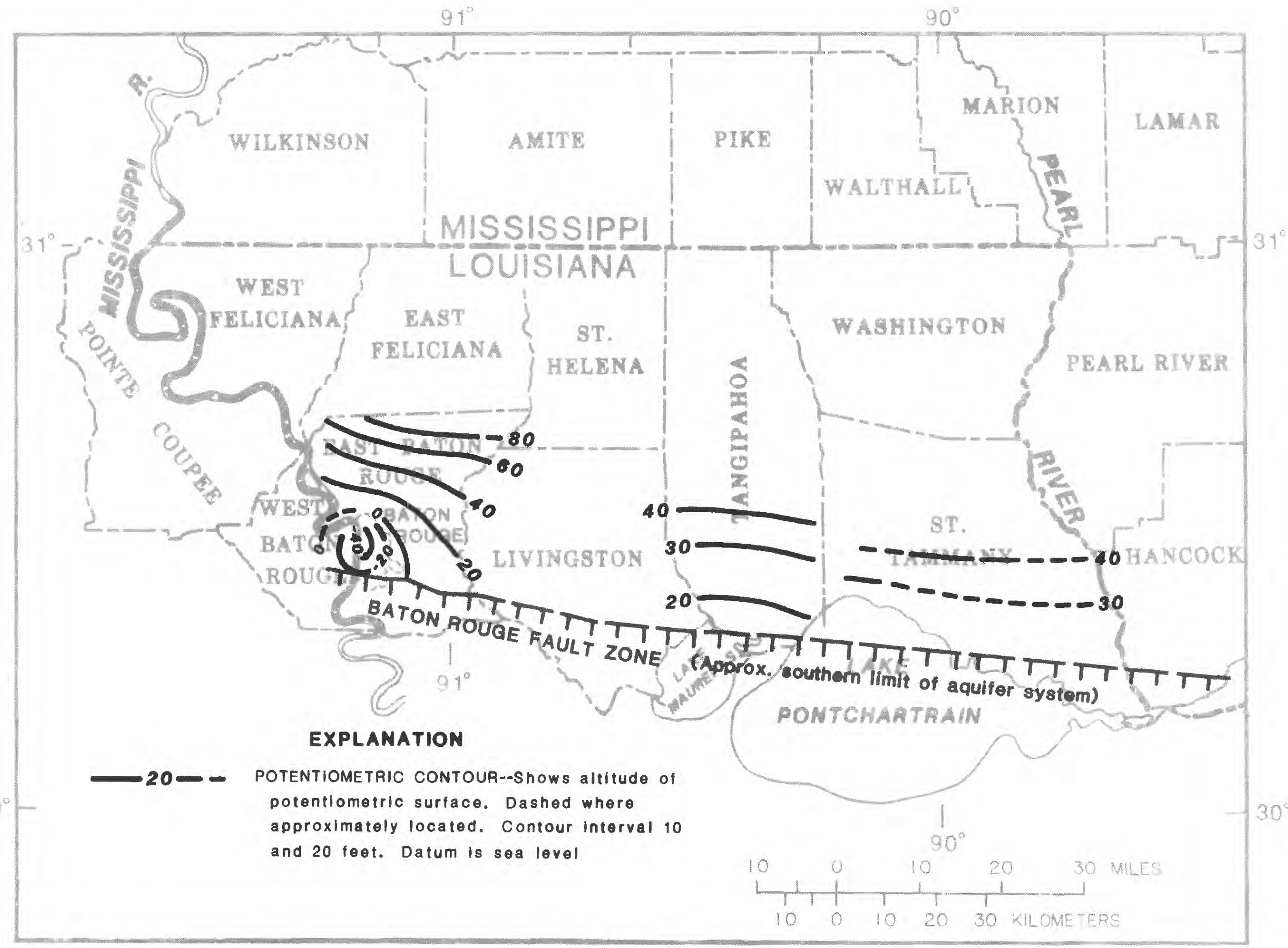

Figure 8.--Potentiometric surface of the "600-foot" sand near Baton Rouge, April 1976, and the Ponchatoula aquifer in the eastern Florida Parishes, May 1969 (after Whiteman, 1979; and Nyman and Fayard, 1978; respectively).

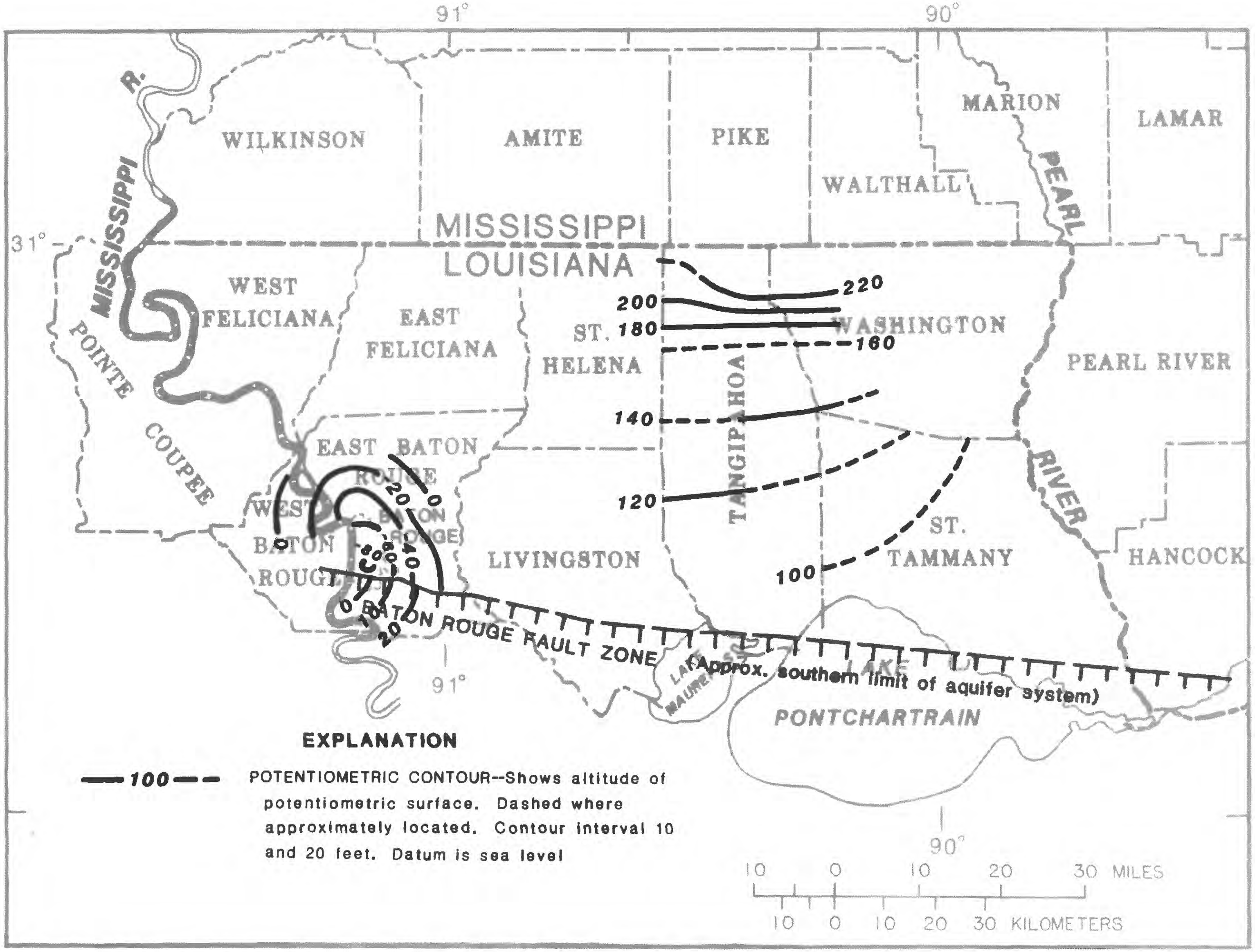

Figure 9.--Potentiometric surface of the "1,500-foot" sand near Baton Rouge, 1979, and the Abita and Kentwood aquifers in the eastern Florida Parishes, May 1974 (after Whiteman, 1979; and Nyman and Fayard, 1978; respectively).

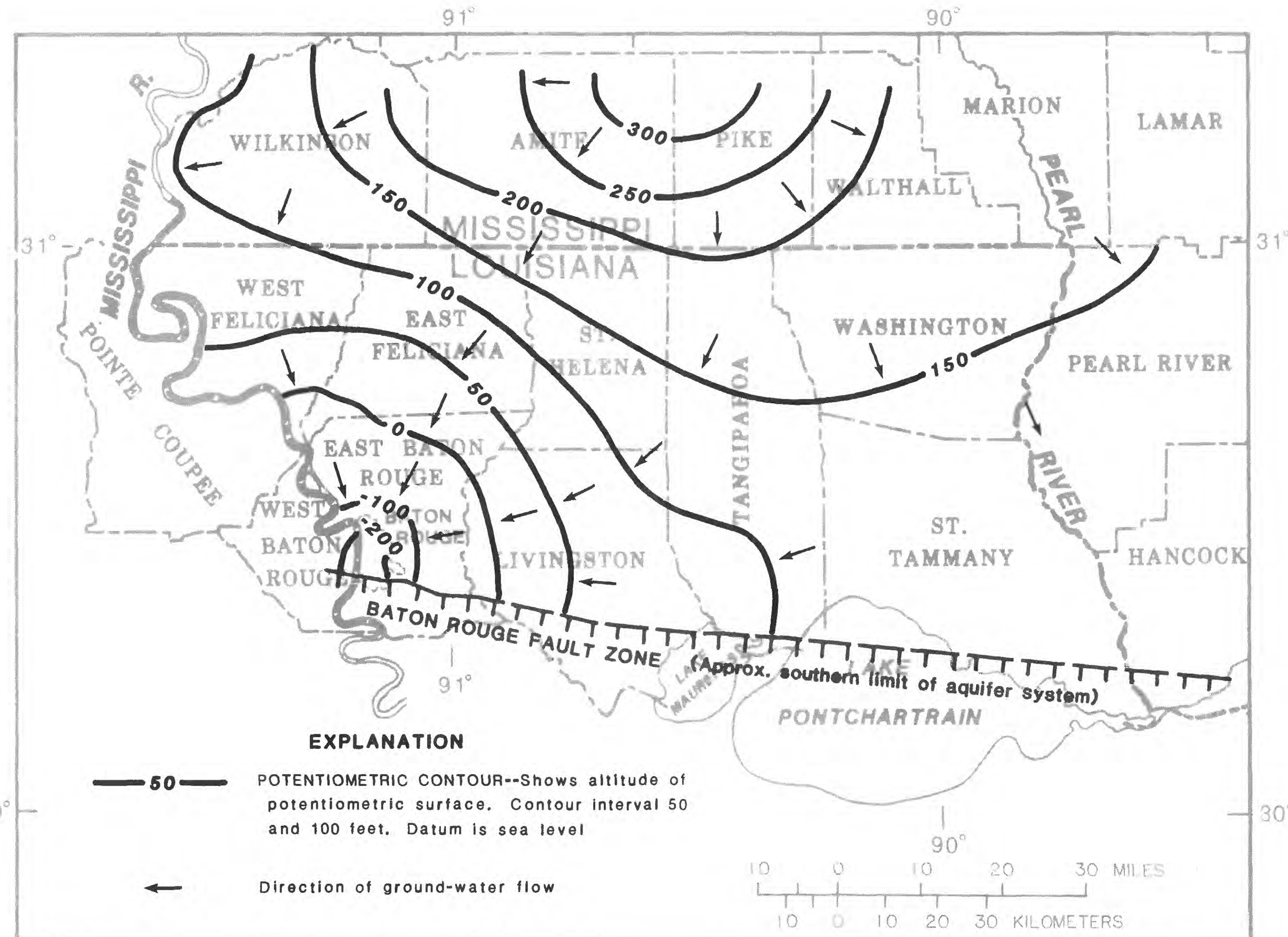

Figure 10.--Potentiometric surface of the "2,000-foot" sand, 1979, computed by a digital ground-water-flow model (after Torak and Whiteman, 1982).

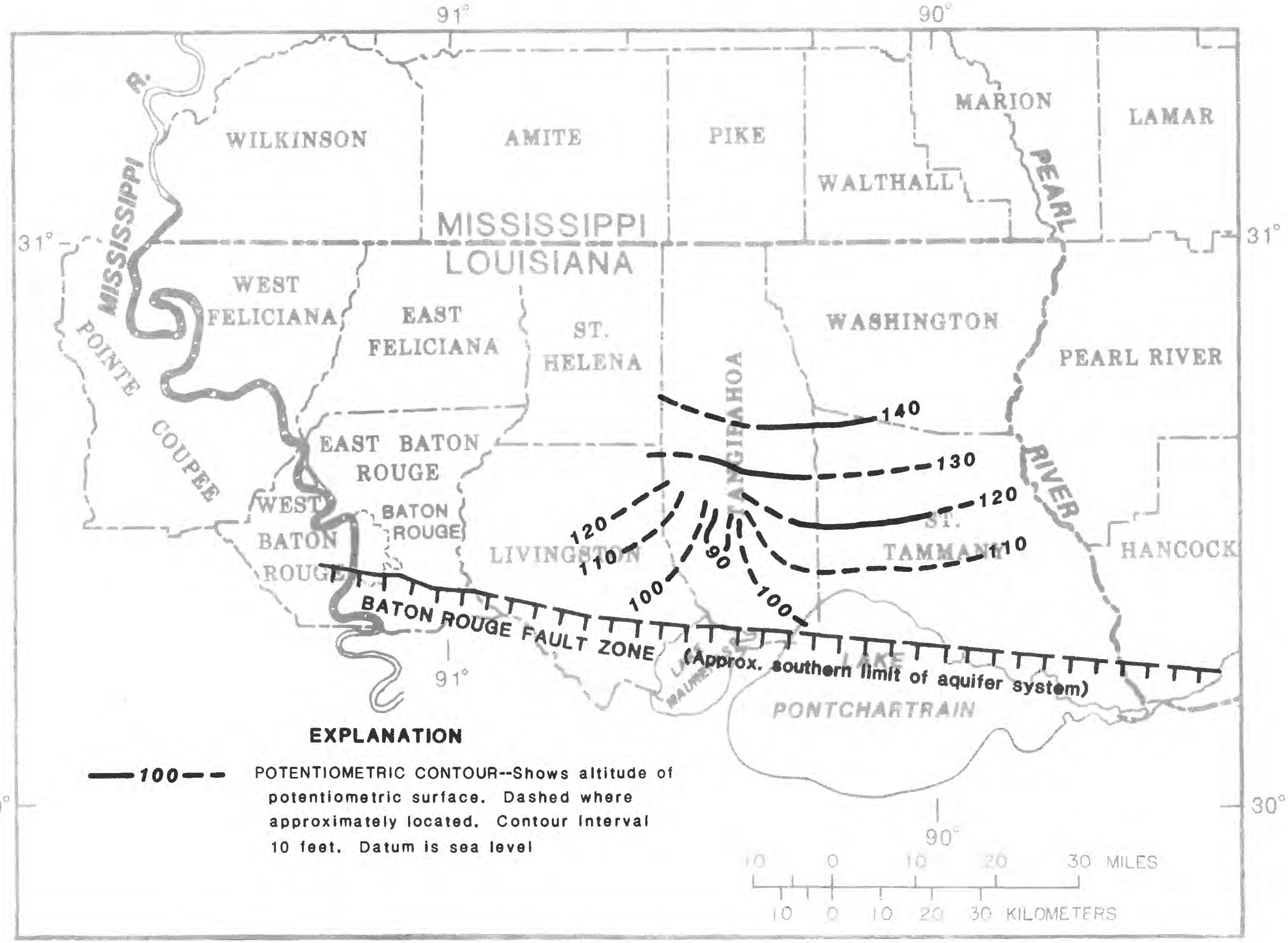

Figure 11.--Potentiometric surface of the Hammond aquifer, May 1974, in southeastern Louisiana (after Nyman and Fayard, 1978).

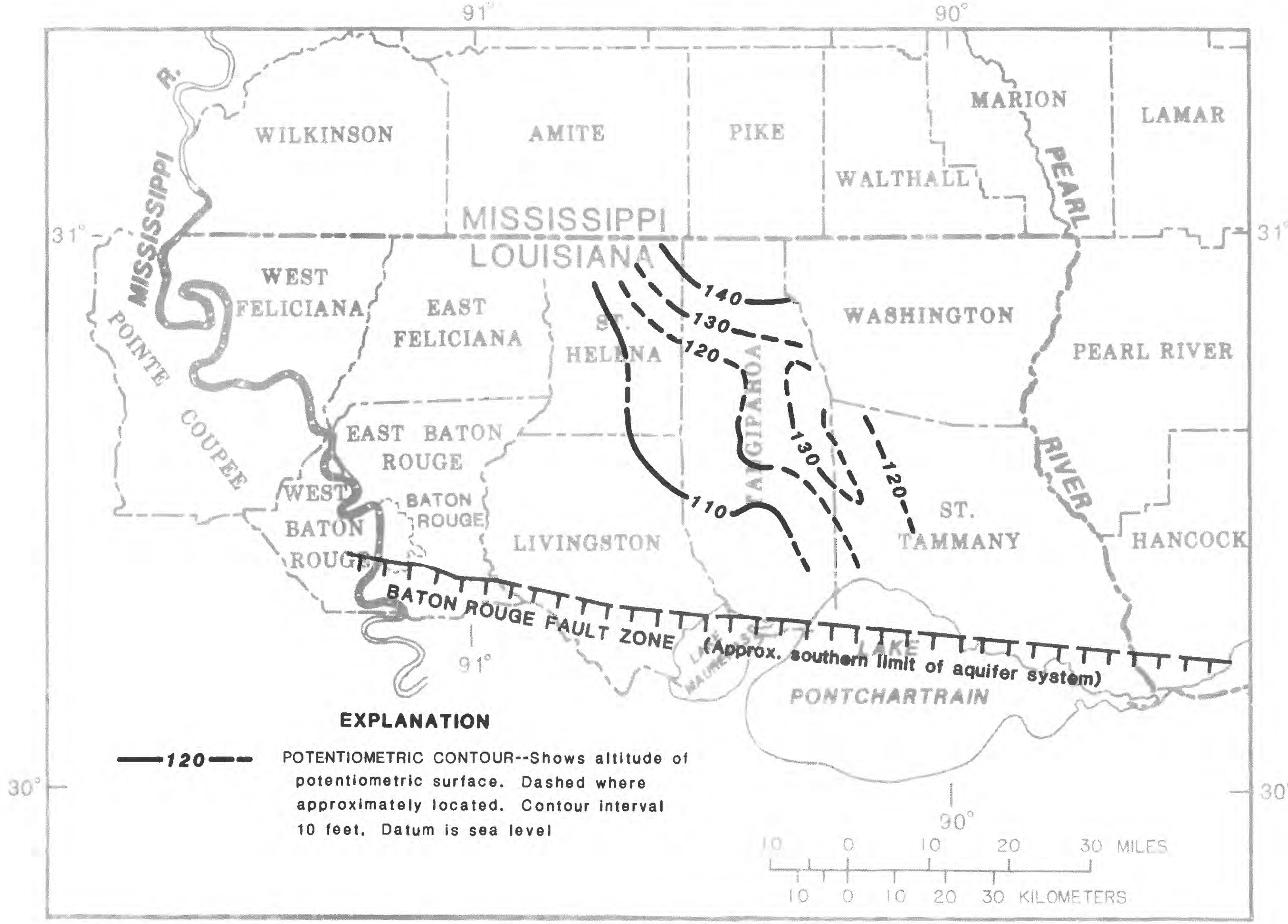

Figure 12.--Potentiometric surface of the Amite aquifer, May 1974, in southeastern Louisiana (after Nyman and Fayard, 1978).

Water within the aquifer system moves very slowly, ranging from a few tens of feet per year to several hundreds of feet per year. The rate of ground-water movement for each aquifer unit within the system can be estimated using values of hydraulic conductivity, hydraulic gradient, and effective porosity of the unit. Values of hydraulic conductivity for the aquifer units within the system are shown in table 2. Hydraulic gradients can be obtained from available potentiometric maps of the aquifer units (figs. 8-12). The effective porosity for each of the aquifer units was assumed to be 0.20 (20 percent) of the aquifer volume. Effective porosity is the interconnected pore space available for fluid transmission expressed as a decimal fraction of the volume of aquifer material. These data can be substituted in the following equation to estimate the average velocity of the ground water.

$$V_{gw} = \frac{365 \text{ d/yr } K\frac{dh}{dl}}{N_e}$$

Where: V_{gw} = the average velocity of ground-water movement in feet per year,

K = the hydraulic conductivity of the aquifer in

feet per day,

$\frac{dh}{dl}$ = the hydraulic gradient of the aquifer unit along a flow path (dimensionless), and

N_e = the effective porosity of the aquifer unit as a decimal fraction (dimensionless).

For example, using data for the "600-foot" sand in the Baton Rouge area (table 2, fig. 8) an estimate of the average velocity of ground-water movement can be made as follows:

$$K = 90 \text{ ft/d}$$

$$\frac{dh}{dl} = \frac{7.5 \text{ ft}}{5{,}280 \text{ ft}} = 0.00142$$

$$N_e = 0.20$$

$$V_{gw} = \frac{365 \text{ d/yr } (90 \text{ ft/d})\ (0.00142)}{0.20} = 233 \text{ ft/yr}$$

Table 2.--Thickness and hydraulic conductivity of aquifers in southeastern Louisiana and southern Mississippi

[Hydraulic conductivity, K, in feet per day]

Baton Rouge area[1]

Aquifer unit	Hydraulic conductivity	Unit thickness (feet)
Alluvial deposits	230	250-600
Shallow Pleistocene	---	200-400
"400-foot" sand	50	25-200
"600-foot sand	84	25-200
"800-foot" sand	36	80-150
"1,000-foot" sand	---	50- 80
"1,200-foot" sand	75	100-200
"1,500-foot" sand	140	100-300
"1,700-foot" sand	32	20-240
"2,000-foot" sand	170	150-300
"2,400-foot" sand	79	80-259
"2,800-foot" sand	---	190-350

East and West Feliciana Parishes[2]

Aquifer unit	Hydraulic conductivity	Unit thickness (feet)
Quaternary alluvium	200	0-300
Quaternary upland deposits	70	0-300
Zone 1	40, sand unit 1; 115, sand unit 3	485-670 (combined units)
Zone 2	115	410-660 (combined units
Zone 3	200	85-400 (combined units)

St. Tammany and Tangipahoa Parishes[3]

Aquifer unit	Hydraulic conductivity	Unit thickness (feet)
Shallow	70-140	100-400
Upper Ponchatoula	180	200-300
Lower Ponchatoula	35- 65	100-200
Big Branch	70	50-150
Kentwood	135	400-500
Abita	120	50-100
Covington	220	100-200
Slidell	190	100-200
Tchefuncta	65-135	100-150
Hammond	85-200	100-200
Amite	150	100-150
Ramsay	210	100-250
Franklinton	290	100-250

Southern Mississippi

Aquifer unit	Hydraulic conductivity	Unit[4] thickness (feet)
Citronelle Formation	125-200[5]	0- 100
Graham Ferry Formation	95[6]	0- 200
Pascagoula Formation	95[6]	0-1,000
Hattiesburg Formation	95[6]	0- 400
Catahoula Sandstone	95[6]	0- 900

[1]Morgan, 1961; [2]Morgan, 1963; [3]Nyman and Fayard, 1978; [4]Shows, 1970; [5]Boswell, 1979; [6]Newcome, 1975.

The calculated value of ground-water velocity in turn can be used to estimate the minimum residence time[2] of water in the aquifer unit as it moves from the recharge area to a point of discharge. Points of discharge are where water (1) is pumped from a well open to the aquifer unit, (2) moves through a confining layer to an overlying or underlying aquifer unit that has a lower potentiometric level, or (3) discharges to land surface or to streams, where the potentiometric level of the aquifer unit is above land surface or above the water level in streams, either where the aquifer is unconfined or as upward leakage through a confining layer.

Water Quality

Table 3 shows dissolved-solids concentrations and water types for the aquifer units within the system in southeastern Louisiana and southwestern Mississippi. Ground water is of good quality and almost exclusively a soft, sodium bicarbonate type. In southeastern Louisiana, the dissolved-solids concentration in water from the Southern Hills aquifer system averages about 210 mg/L, ranging from 27 mg/L in the Quaternary upland deposits of the Feliciana parishes (Morgan, 1963, table 10) to 531 mg/L in the alluvial deposit in the Baton Rouge area (Morgan, 1961, table 1). In southern Mississippi, dissolved-solids concentrations were reported by Boswell (1979) and Newcome (1975). In southwestern Mississippi the Citronelle aquifer had an average dissolved-solids concentration of 51 mg/L in water from 19 wells within the study area that ranged from 22 to 135 mg/L. In southern Mississippi the Miocene aquifer units had a median dissolved-solids concentration of 170 mg/L in water from 609 wells located within and outside the study area that ranged from 13 to 1,390 mg/L.[3]

ALTERNATE SOURCE OF WATER SUPPLY

In southeastern Louisiana several streams (fig. 13) are available as alternate sources of freshwater for public and domestic supply. Table 4 shows discharge and dissolved-solids concentrations for these streams.

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[2]This method of estimating the minimum residence time should not be used as a strict measure of the time of travel of water within the system, because it assumes a straight path of flow between two points and a homogeneous and isotropic aquifer of uniform thickness. In actuality, water may travel in a more tortuous path between two points, varying in velocity in response to changes in aquifer properties and thickness. The equation should therefore be limited to making gross approximations of the minimum residence time of water between two points.

[3]Data used from Newcome (1975) indicated a maximum dissolved-solids concentration of 1,390 mg/L in the Miocene aquifer units in Jefferson County, Miss. Although this value is in excess of the 1,000 mg/L dissolved-solids concentration indicated in that report as the limit of freshwater, the values were reported as a median and range and therefore retained in this report.

Table 3.--Water types and dissolved-solids concentrations in aquifers in southeastern Louisiana and southwestern Mississippi

[Dissolved-solids concentration in milligram per liter]

<table>
<tr><th colspan="3">Baton Rouge area[1]</th><th colspan="3">East and West Feliciana Parishes[2]</th><th colspan="3">St. Tammany and Tangipahoa Parishes[3]</th><th colspan="3">Southern Mississippi</th></tr>
<tr><th>Aquifer unit</th><th>Water type</th><th>Dissolved solids</th><th>Aquifer unit</th><th>Water type</th><th>Dissolved solids</th><th>Aquifer unit</th><th>Water type</th><th>Dissolved solids</th><th>Aquifer unit</th><th>Water type</th><th>Dissolved solids</th></tr>
<tr><td>Alluvial deposits</td><td>Hard calcium bicar-bonate</td><td>Mean: 387
Range: 172-719
(samples: 8)</td><td>Quaternary alluvium</td><td>Hard calcium bicar-bonate</td><td>Mean: 441
Range: 152-515
(samples: 6)</td><td rowspan="2">Shallow</td><td rowspan="2">Mixed type in northern areas; predominantly sodium bicar-bonate in southern areas</td><td rowspan="2">Mean: 108
Range: 29-255
(samples: 10)</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Pleistocene</td><td>Hard calcium bicar-bonate</td><td>Mean: 415
Range: 277-508
(samples: 5)</td><td rowspan="3">Quaternary upland deposits</td><td rowspan="15">All soft, sodium-bicar-bonate type</td><td rowspan="3">Mean: 79
Range: 27-163
(samples: 14)</td><td rowspan="3">Citronelle Formation</td><td rowspan="3"></td><td rowspan="3">Mean: 51[4]
Range: 22-135
(samples: 19)</td></tr>
<tr><td>"400-foot" sand</td><td rowspan="12">All soft, sodium-bicar-bonate type</td><td>Mean: 245
Range: 184-403
(samples: 4)</td><td rowspan="2">Upper Ponchatoula</td><td rowspan="14">All soft sodium-bicarbonate type</td><td rowspan="2">Mean: 196
Range: 188-206
(samples: 3)</td></tr>
<tr><td>"600-foot" sand</td><td>Mean: 324
Range: 185-593
(samples: 6)</td></tr>
<tr><td>"800-foot" sand</td><td>Mean: 201
Range: 182-213
(samples: 3)</td><td rowspan="5">Zone 1</td><td rowspan="5">Mean: 117
Range: 40-195
(samples: 33)</td><td rowspan="2">Lower Ponchatoula</td><td rowspan="2">Mean: 220
Range: 144-354
(samples: 3)</td><td rowspan="2">Graham Ferry Formation</td><td rowspan="12">Almost exclu-sively soft, sodium-bicar-bonate type</td><td rowspan="12">Median: 170[5]
Range: 13-1390
(samples: 609)</td></tr>
<tr><td>"1,000-foot" sand</td><td>248
(sample: 1)</td></tr>
<tr><td>"1,200-foot" sand</td><td>Mean: 218
Range: 181-426
(samples: 8)</td><td>Big Branch</td><td>Mean: 244
Range: 138-401
(samples: 3)</td><td rowspan="6">Pascagoula Formation</td></tr>
<tr><td rowspan="2">"1,500-foot" sand</td><td rowspan="2">Mean: 260
Range: 193-666
(samples: 9)</td><td>Kentwood</td><td>Mean: 93
Range: 62-129
(samples: 4)</td></tr>
<tr><td>Abita</td><td>Mean: 257
Range: 171-383
(samples: 5)</td></tr>
<tr><td rowspan="2">"1,700-foot" sand</td><td rowspan="2">Mean: 206
Range: 197-235
(samples: 5)</td><td rowspan="3">Zone 2</td><td rowspan="3">Mean: 192
Range: 122-308
(samples: 29)</td><td>Covington</td><td>Mean: 187
Range: 154-223
(samples: 6)</td></tr>
<tr><td>Slidell</td><td>Mean: 219
Range: 175-262
(samples: 2)</td></tr>
<tr><td>"2,000-foot" sand</td><td>Mean: 285
Range: 178-635
(samples: 6)</td><td>Tchefuncta</td><td>Mean: 168
Range: 138-187
(samples: 4)</td></tr>
<tr><td>"2,400-foot" sand</td><td>Mean: 260
Range: 188-322
(samples: 7)</td><td rowspan="4">Zone 3</td><td rowspan="4">Mean: 264
Range: 175-531
(samples: 12)</td><td>Hammond</td><td>Mean: 169
Range: 139-209
(samples: 5)</td><td rowspan="2">Hatties-burg Formation</td></tr>
<tr><td>"2,800-foot" sand</td><td>Mean: 364
Range: 192-538
(samples: 8)</td><td>Amite</td><td>Mean: 206
Range: 160-294
(samples: 7)</td></tr>
<tr><td colspan="3" rowspan="2"></td><td>Ramsay</td><td>Mean: 165
Range: 151-184
(samples: 3)</td><td rowspan="2">Catahoula Sandstone</td></tr>
<tr><td>Franklinton</td><td>Mean: 251
Range: 236-279
(samples: 3)</td></tr>
</table>

[1]Morgan, 1961;
[2]Morgan, 1963;
[3]Nyman and Fayard, 1978;
[4]Boswell, 1979;
[5]Newcome, 1975.

Figure 13.--Major streams in southeastern Louisiana.

Table 4.--Discharge data and dissolved-solids concentrations for streams that are possible alternative sources of freshwater in southeastern Louisiana

Site No. (fig. 13)	Stream and data-collection site	Discharge in cubic feet per second[1]				Dissolved solids in milligrams per liter		
		Average	Minimum	Maximum	Period of record	Minimum	Maximum	Period of record
1	Mississippi River:							
	At Tarbert Landing, Miss--	537,000	160,000	1,500,000	1972-80	---	---	-------
1a	Near St. Francisville, La-	-------	---------	---------	-------	150	321	1954-81
2	Atchafalaya River:							
	At Simmesport, La---------	256,800	22,000	781,000	1972-80	---	---	-------
2a	At Melville, La-----------	-------	---------	---------	-------	120	366	1979-81
3	Pearl River near Bogalusa, La.	9,671	1,020	129,000	1938-81	13	142	1962-81
4	Amite River:							
	Near Denham Springs, La---	1,980	271	110,000	1938-81	---	---	-------
4a	At 4-H Camp, near Denham Springs, La.	-------	---------	---------	-------	24	131	1973-81
5	Bogue Chito near Bush, La---	1,927	366	57,400	1937-81	11	347	1974-81
6	Tangipahoa River at Robert, La.	1,134	245	50,500	1938-81	25	58	1979-81
7	Tickfaw River at Holden, La-	368	65	19,000	1940-81	---	---	-------
8	Natalbany River at Baptist, La.	115	1.8	9,550	1943-81	---	---	-------

[1]Cubic foot per second equals 0.646 million gallons per day.

Although these streams are local sources of abundant freshwater, they have not been considered as practicable alternative sources of water for public and domestic supply. The reasons cited in the petition to EPA are the increased cost of water to the users because of (1) the additional water treatment, and (2) the extensive distribution system necessary to deliver the water, especially to areas remotely located from a source stream. Ground water, on the other hand, is available from wells located in the vicinity of the users and can be delivered at nearly half the cost of river water when considering water treatment alone. For example, in Baton Rouge, where ground water is presently used (1983), water costs about 12 cents per 1,000 gal (Ike Peairs, Baton Rouge Water Works, oral commun., 1982). In New Orleans, because of the water treatment needed prior to the delivery of Mississippi River water into the public-supply system, water costs about 22 cents per 1,000 gal (J. Sullivan, New Orleans Sewerage and Water Board, oral commun., 1982). In addition to the increased cost of drinking water because of required treatment, an accidental spill of hazardous chemicals in the Mississippi River could temporarily disrupt the New Orleans water supply.

POPULATION AND WATER USE

In 1980 about one million persons resided in the 10 parishes of southeastern Louisiana and 14 counties of southwestern Mississippi, where the Southern Hills aquifer system is the primary source of water for public and domestic supply. The average water use for these categories in the area was about 146 Mgal/d during 1980. Based on projected population (K. McGinnis, Louisiana State Planning Office, oral commun., 1982) and water use (Urban System Associates, Inc, 1982), by the year 2000 the population of this area will reach about 1.5 million persons, and public- and domestic-supply water use will be about 220 Mgal/d.

Southeastern Louisiana

Table 5 shows the average daily use of water for public supply and domestic purposes and population data for each of the 10 parishes within the study area. The table shows actual data for the years 1970 and 1980, and projections for the years 1990 and 2000.

In 1970 the population of the CAGWCC district and the Florida Parishes totaled about 571,000 persons, and the average public supply and domestic use was 91 Mgal/d. By 1980, the population increased to about 744,000 persons and public supply and domestic use increased to about 121 Mgal/d. According to growth projections, from 1980 to the year 2000 the population will increase an additional 51 percent, reaching 1,123,000 persons for the 10-parish area. Water use for public and domestic supply is expected to increase 57 percent during this 20-year period, reaching about 190 Mgal/d.

Table 5.--Population and water use in southeastern Louisiana, 1970 and 1980, and projected to 1990 and 2000

[Data in millions of gallons per day]

Parish	1970		1980		1990 (Projected)		2000 (Projected)	
	Population	Public and domestic supply	Population	Public and domestic supply	Population[1]	Public and domestic supply[2]	Population[1]	Public and domestic supply[2]
East Baton Rouge--	285,167	32.75	366,164	55.63	444,076	61.23	514,822	70.38
East Feliciana----	17,657	.84	19,015	1.47	21,807	1.66	25,504	1.83
Livingston--------	36,511	5.12	58,655	5.74	83,928	10.04	113,844	14.64
Pointe Coupee-----	22,002	1.02	24,045	1.56	26,740	1.79	29,306	1.99
St. Helena--------	9,937	.37	9,827	.73	10,087	.96	10,265	1.16
St. Tammany-------	63,585	25.98	110,554	23.50	162,856	39.32	227,777	50.74
Tangipahoa--------	65,875	12.75	80,698	12.84	96,134	15.51	112,368	18.62
Washington--------	41,987	8.73	44,207	12.13	47,062	17.04	48,772	21.54
West Baton Rouge--	16,864	2.46	19,086	5.53	22,241	6.19	24,959	6.80
West Feliciana----	11,376	.55	12,186	1.91	13,099	2.09	15,384	2.25
Total--------	570,961	90.57	744,437	121.04	928,030	155.83	1,123,001	189.95

[1]Louisiana State Planning Office.

[2]Urban Systems Associates, Inc.

Southwestern Mississippi

Table 6 shows the average daily use of water and population data for the 14 Mississippi counties within the study area where the aquifer system is the primary source of water for public and domestic supply. The population and water-use data used in this report was limited to county totals for the 14 counties directly north of southeastern Louisiana. In the northern three counties of the study area (Hinds, Rankin, and Warren), ground-water withdrawals (Callahan, 1983) are primarily from the Oligocene and Eocene aquifers underlying the Catahoula Sandstone, the basal unit of the Miocene aquifer system in Mississippi or from the Quaternary alluvium (Warren Co.). Between the years 1970 and 1980 the total population of the 14 counties increased from about 252,000 to about 273,000 persons, about an 8-percent growth for the period. In 1980 water use for public and domestic supply averaged about 25 Mgal/d.

Table 6.--Population and water use in southwestern Mississippi

[Data in million of gallons per day]

County	1970	1980	
	Population	Population	Public and domestic supply
Adams----------------	37,293	38,035	4.30
Amite----------------	13,763	13,369	1.02
Claiborne------------	10,086	12,279	1.22
Copiah---------------	24,749	26,503	2.96
Franklin-------------	8,011	8,208	.68
Jefferson------------	9,295	9,181	.73
Jefferson Davis------	12,936	13,846	1.04
Lawrence-------------	11,137	12,518	.84
Lincoln--------------	26,198	30,174	2.30
Marion---------------	22,871	25,708	1.92
Pike-----------------	31,756	36,173	4.63
Simpson--------------	19,947	23,441	2.12
Walthall-------------	12,500	13,761	1.00
Wilkinson------------	11,099	10,021	.56
Total-----------	251,641	273,217	25.32

Data projections for water use and population were not available for southwestern Mississippi. For the purposes of this report, projections for southwestern Mississippi were made by the author based on growth trends projected for southeastern Louisiana. The Mississippi growth projections were determined based on the ratio of population growth for southwestern Mississippi versus southeastern Louisiana between 1970 and 1980 (1:3.5). This ratio was then applied to the percentage growth that was projected for southeastern Louisiana to obtain the estimate of percent growth for southwestern Mississippi. Based on this growth assumption, the population total for the 14 counties of Mississippi will increase 15 percent from the 1980 level of 273,000 to about 314,000 persons by the year 2000. Correspondingly, water use for public and domestic supply will increase 20 percent from the 1980 level of 25 Mgal/d to about 30 Mgal/d by the year 2000.

SUMMARY AND CONCLUSIONS

The Southern Hills regional aquifer system, which ranges in age from Pleistocene or Pliocene at the top to Miocene at the base, is the primary source of water for public and domestic supplies in the Capital Area Ground Water Conservation Commission (CAGWCC) five-parish district in the Baton Rouge area and in the Florida Parishes of southeastern Louisiana. A secondary source of ground water that is used for rural self-supplied systems is from local shallow aquifers that occur within the Quaternary alluvial deposits and the shallow Pleistocene sands overlying the regional aquifer system. The CAGWCC has petitioned the U.S. Environmental Protection Agency to designate the Southern Hills regional aquifer system as a sole or principal source of drinking water under Section 1424(e) of the Safe Drinking Water Act, Public Law 93-523. Included in the area covered by the petition is the recharge area that is the source of water for the aquifer system. Inclusion of the recharge area was emphasized because this is the most vulnerable area for the introduction of contaminants into the aquifer. The recharge area extends northward beyond southeastern Louisiana into southwestern Mississippi. In about 85 percent of the Mississippi part of the study area, the aquifer system is the primary source of water for public and domestic supply.

The aquifer system is comprised of a gulfward dipping and thickening sedimentary sequence that extends from the northern limit of the Miocene outcrop in southwestern Mississippi southward approximately to the Baton Rouge fault in the Baton Rouge area and to the southern part of the Florida Parishes of southeastern Louisiana. In the southernmost part of the area, the aquifer system achieves a thickness of more than 2,500 ft to the base of the freshwater within this sedimentary sequence. (Freshwater is defined as having a chloride concentration of 250 mg/L or less.) In southeastern Louisiana, the system has been divided into as many as 13 aquifer units, based on the presence of locally mappable clay layers. These aquifer units are recognized to decrease in number northward where many of the clay layers either disappear completely or are no longer mappable, or where younger formations in the geologic sequence pinch out in the updip section. Although the system has been subdivided into many aquifer units, they are recognized to operate as a single hydraulic system. The relations between major aquifer units may be more clearly defined by the Mississippi Embayment--West Gulf Coast Regional Aquifer System Analysis that is scheduled for completion in 1986.

Water in the aquifer system is almost exclusively a soft, sodium bicarbonate type and low in dissolved solids. In southeastern Louisiana dissolved-solids concentrations average about 210 mg/L. In southwestern Mississippi the Citronelle aquifer has an average dissolved-solids concentration of 51 mg/L. In southern Mississippi, the Miocene aquifer unit has a median dissolved-solids concentration of 170 mg/L.

As an alternative to the use of ground water for public and domestic supply, several streams, the largest of which are the Mississippi and Pearl Rivers, are local sources of abundant freshwater. Although these waters are of relatively good quality, ranging from 11 to 366 mg/L in dissolved-solids concentration, they have not been considered by local officials as a practicable alternative for public and domestic supply. The major reasons for nonacceptance are the additional cost to the user because of water treatment and the extensive distribution system necessary to deliver water to users remotely located from the streams. Ground water, on the other hand, generally requires less treatment and wells can be located close to users. Using surface water would nearly double the cost to users, based on the required water treatment alone.

In the 10 parishes of southeastern Louisiana where the Southern Hills aquifer system is the primary source of water for public and domestic supply, water use for these categories for 1980 totaled about 121 Mgal/d, serving about 744,000 persons. In the 14 counties of southwestern Mississippi, where the aquifer system is also the primary source of water for public and domestic supply, water use for these categories in 1980 totaled about 25 Mgal/d serving about 273,000 persons. Based on growth in southeastern Louisiana and southwestern Mississippi from 1970 to 1980 and growth projections for southeastern Louisiana, water use for public and domestic supply for the 10 southeastern Louisiana parishes and 14 Mississippi counties will total about 220 Mgal/d serving about 1.5 million persons by the year 2000.

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