STATE OF LOUISIANA
DEPARTMENT OF PUBLIC WORKS

Water Resources
TECHNICAL
REPORT NO. 10

GEOHYDROLOGY AND WATER QUALITY OF THE MISSISSIPPI RIVER ALLUVIAL AQUIFER, NORTHEASTERN LOUISIANA

Prepared by
UNITED STATES DEPARTMENT OF THE INTERIOR
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In cooperation with
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1975

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By

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U.S. Geological Survey

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CONTENTS

ILLUSTRATIONS

[Plates are at back]

TABLE

FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (METRIC) UNITS

Area, square miles--convert to square kilometres (km^2), multiply by 2.590.

Depth (well), depth to water, depth and thickness of geologic units, or drawdown; feet--convert to metres (m), multiply by 0.3048.

Diameter of well casing, inches--convert to centimetres (cm), multiply by 2.540.

Discharge, gallons per minute (gal/min)--convert to litres per second (l/s), multiply by 0.06309.

Discharge, million gallons per day (Mgal/d)--convert to litres per day (l/d), multiply by 3.785×10^6.

Distance, miles--convert to kilometres (km), multiply by 1.609.

Hydraulic conductivity, feet per day (ft/d)--convert to metres per day (m/d), multiply by 0.3048.

Precipitation, inches--convert to millimetres (mm), multiply by 25.4.

Specific capacity, gallons per minute per foot [(gal/min)/ft]--convert to litres per second per metre [(l/s)/m], multiply by 0.2070.

Temperature, degrees Fahrenheit (°F)--convert to degrees Celsius (°C), multiply °F-32 by 5/9.

Transmissivity, feet squared per day (ft^2/d)--convert to metres squared per day (m^2/d), multiply by 0.0929.

Volume, gallons--convert to litres (l), multiply by 3.785.

GEOHYDROLOGY AND WATER QUALITY OF THE MISSISSIPPI RIVER ALLUVIAL AQUIFER, NORTHEASTERN LOUISIANA

By M. S. Whitfield, Jr.

ABSTRACT

The Mississippi River alluvial aquifer in northeastern Louisiana is in the alluvium of the Mississippi, Arkansas, and Ouachita Rivers and underlies approximately 5,000 square miles (13,000 square kilometers) in the Mississippi River valley. The aquifer, of Pleistocene age, is a southeastward-thickening wedge of sand and gravel that ranges in thickness from about 20 to 135 feet (6 to 41 metres). These sediments are essentially flat lying with an irregular base. Fine sand, silt, and clay of Holocene age overlie and generally confine the aquifer. These fine-grained deposits range in thickness from 0 to 100 feet (0 to 30 metres) but generally do not exceed 40 feet (12 metres).

Water levels in the Mississippi River alluvial aquifer generally are less than 30 feet (9 metres) below land surface. Annual water-level fluctuations have a maximum range of about 20 feet (6 metres) near the Mississippi River and a minimum range of only a few feet in interstream areas. Seasonal declines occur locally, especially in Morehouse Parish, because of large withdrawals for irrigation.

The Mississippi River alluvial aquifer can yield water in sufficient quantity for most uses throughout the area. Aquifer tests indicate that the transmissivity ranges from 13,000 to 45,000 feet squared per day (1,200 to 4,200 metres squared per day). The hydraulic conductivity ranges from 130 to 530 feet per day (40 to 160 metres per day). Storage coefficients range from 0.001 to 0.05. Large-diameter wells yield as much as 7,000 gallons per minute (440 litres per second) near Tallulah in Madison Parish.

The quality of ground water in the Mississippi River alluvial aquifer varies areally and with depth, but generally the water is hard to very hard and high in iron concentration. Where fresh, the water typically is a calcium bicarbonate type generally ranging in hardness from 200 to 600 mg/l (milligrams per litre) and in iron concentration

from 0.00 to 30 mg/l. However, in southern Richland Parish and local areas in adjacent parishes, a hardness of less than 100 mg/l and an iron concentration of less than 0.30 mg/l are common.

Fresh water occurs to or below the base of the alluvial aquifer in most of the area. The chloride concentration typically is less than 50 mg/l. However, chloride concentrations are as high as 4,000 mg/l in parts of the area. At some localities, salty water (chloride concentrations greater than 250 mg/l) occurs in the aquifer at depths less than 30 feet (9 metres). The largest occurrence of salty water is in Franklin Parish near and parallel to the subsurface contact between clays of the Jackson Group and sands of the Cockfield Formation of the Claiborne Group. Thus, salty water moving from the Cockfield into the alluvium may be the source of some of the high-chloride water. Smaller bodies of salty water occur in the aquifer along the Jackson-Cockfield contact in Madison and Caldwell Parishes. Probably some contamination from pits formerly used for disposal of salty water occurs in northern Franklin and southern Richland Parishes. Other small occurrences of salty water in Concordia, Morehouse, Ouachita, and Tensas Parishes may be related to contamination by salt-water disposal pits and wells, leaky oil-well casings, and oil-well drilling mishaps.

INTRODUCTION

The Mississippi River valley of northeastern Louisiana is underlain by the Mississippi River alluvial aquifer, the largest--and in much of this area the only--source of fresh ground water. Approximately 5,000 square miles (13,000 km^2) of northeastern Louisiana is in the valley. The area is approximately 140 miles (230 km) long and varies in width from 70 miles (110 km) in the north-central part to 9 miles (14 km) in the southern part. (See fig. 1.)

In this dominantly agricultural area the major use of water is for irrigation of rice, soybeans, cotton, and corn. Lesser quantities of water are pumped from the aquifer for industrial, municipal, and domestic supplies.

This report describes the geology, hydrology, and water quality of the Mississippi River alluvial aquifer in northeastern Louisiana. The major objective of the report is to assist the potential users in planning the development of water from this aquifer and to identify areas having water-quality problems. Maps show the altitude of the base of the aquifer, thickness of the alluvium, quality of water in the aquifer, and water levels. The most troublesome quality problems--hardness, iron, and chloride--are discussed. Particular emphasis was placed on mapping those areas where water in the alluvium contains high concentrations of chloride.

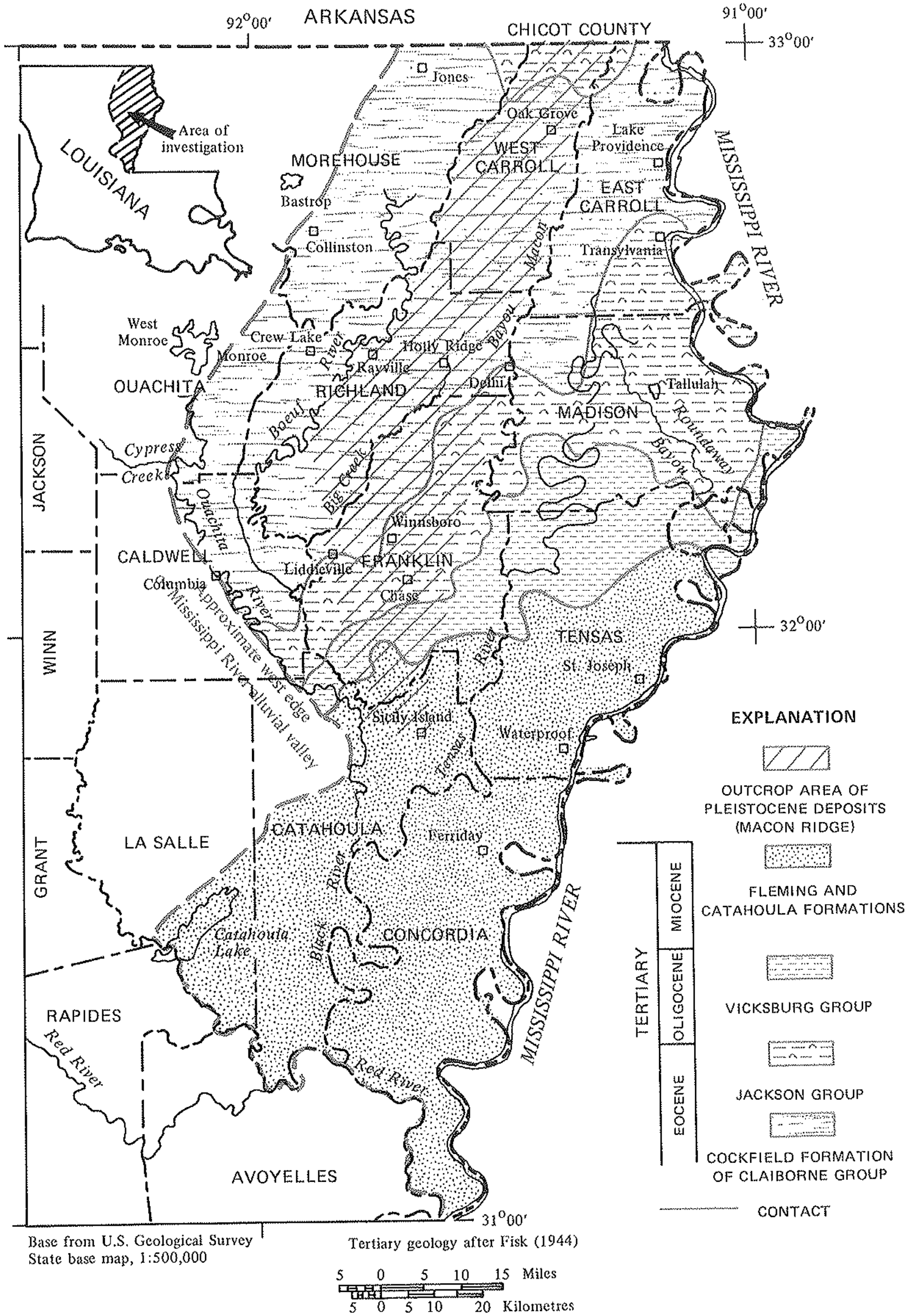


Figure 1.--Area of investigation and distribution of Tertiary formations underlying the Mississippi River alluvial aquifer.

ACKNOWLEDGMENTS

The project was a part of the cooperative program of water-resources investigations in Louisiana by the U.S. Geological Survey and the Louisiana Department of Public Works. Most of the electrical logs of oil and gas wells used in the study were made available by the Louisiana Geological Survey, Department of Conservation.

The following governmental agencies aided the project by furnishing data or services: Louisiana Health and Human Resources Administration, Division of Health; the Louisiana Department of Conservation, Geological Oil and Gas Division; the Louisiana Department of Highways, Alexandria, Monroe, and Winnsboro Districts; the Louisiana Department of Public Works, Tallulah District; the Louisiana Wild Life and Fisheries Commission; and the U.S. Army Corps of Engineers, Vicksburg District.

The assistance and cooperation of many individuals and water-well contractors greatly facilitated the collection of field data for this report. Well owners in the area were especially cooperative in providing information about their wells and in permitting collection of water samples.

PHYSICAL FEATURES AND GEOLOGY

The Mississippi Valley of northeastern Louisiana is in the Mississippi Alluvial Plain of the Coastal Plain province. The Mississippi River is the east border of the area; most other major streams flow down the valley in a southerly or southwesterly direction (fig. 1). The valley slopes gently to the south; its surface is relatively flat except for the erosional remnant of a Pleistocene terrace known as Macon Ridge (fig. 1). This ridge is 8 to 20 miles (13 to 32 km) wide and extends in a southerly direction through the central part of the area from Chicot County, Ark., to Sicily Island in Catahoula Parish, La. Locally, the ridge rises approximately 35 feet (11 m) above the adjacent valley floor. Other topographic forms in the area include abandoned stream channels, point-bar deposits, and oxbow lakes.

Most of the valley ranges in altitude from 50 to 90 feet (15 to 27 m) above mean sea level. The maximum altitude, 135 feet (41 m), occurs on Macon Ridge in West Carroll Parish. The lowest altitudes are in backswamp areas, which may be as low as 30 feet (9 m) above mean sea level.

The Mississippi River was the major transport medium for the silt, sand, and gravel that form the Mississippi River alluvial deposits. Lesser amounts were transported by the Ouachita and Arkansas River systems. In general, the alluvium ranges from 80 to 200 feet (24 to 61 m) in thickness; it thickens toward the Mississippi River and also southward. In most of the area the thickness is less than 125 feet (38 m). (See pl. 1.)

The Mississippi River alluvium lies unconformably on the eroded surface of Tertiary sediments. (See pl. 2.) The areal distribution of the Tertiary sediments underlying the alluvium is shown in figure 1. Fisk (1944), Saucier (1967), and Fleetwood (1969) have clearly illustrated the relations between the alluvium and underlying Tertiary sediments in the area by detailed geologic sections.

Although 12 known salt domes underlie the project area, none are known to penetrate the alluvium or the stratigraphic units immediately underlying the alluvium. The depth to the top of the salt in the known domes ranges from about 1,800 to 6,000 feet (550 to 1,800 m).

The Mississippi River alluvium grades downward from silt and clay at the surface to coarse sand and gravel at the base. It is this lower, coarse-grained section of the alluvium that is considered to be the Mississippi River alluvial aquifer. (See "Glossary.") Most geologists now assign the lower section of the alluvium and the entire unit underlying Macon Ridge to the Pleistocene. The overlying silt and clay, except on Macon Ridge, is believed to be Holocene in age. Generally, sediments deeper than 40 feet (12 m) below land surface are of Pleistocene age. Gravel as large as 3 inches (7.6 cm) in diameter is common near the bottom of the aquifer; boulders as large as 10 inches (25 cm) in diameter occur at the base in the eastern part of the area. The base of the aquifer (pl. 3) is generally marked by the deepest occurrence of gravel.

HYDROLOGY OF THE AQUIFER

The earliest evaluation of ground water in the Mississippi River alluvial aquifer was made by Veatch (1906). Poole (1961) described the availability of fresh water in this aquifer in East Carroll and West Carroll Parishes, in the northeastern part of the area studied. Turcan and Meyer (1962) evaluated the hydraulic characteristics of the aquifer near Tallulah, in Madison Parish. Extensive hydrologic data for the aquifer in the lower Mississippi Valley are included in a report by Krinitzsky and Wire (1964).

The silt and clay layer that overlies the sand and gravel ranges in thickness from 0 to 100 feet (0 to 30 m) but is less than 40 feet (12 m) in most of the area. The sand and gravel ranges in thickness from 20 to 135 feet (6 to 41 m). In most of the valley, the upper fine-grained deposits confine water in the aquifer under artesian conditions. Locally, water-table conditions prevail seasonally or perennially. Because the confining beds are irregular in thickness, artesian conditions may exist at one place when at the same time, water-table conditions exist a short distance away. For example, near large-capacity wells, artesian conditions may prevail during the early part of a pumping period; but with continued pumping, water-table conditions may develop locally.

Source and Movement of Ground Water

Rainfall is the major source of recharge to the Mississippi River alluvial aquifer. Generally, the heaviest rainfall occurs from December through May, and the least in September or October. The annual rainfall in the area, 1931-72, has averaged 51 inches (1,300 mm) in the northern part of the area and 53.5 inches (1,360 mm) in the southern part.

The amount of recharge depends not only on the amount and rate of precipitation but also on the permeability and thickness of the silt and clay that overlie the aquifer. These deposits are relatively permeable compared to typical clays because of their high content of organic material and because they have not been fully compacted by heavy overburden. In the low-lying backswamp areas the clayey soils reach their maximum thickness; there the deeper beds are more compact and less permeable. These thick deposits form a low-permeability cap that impedes the downward percolation of rainwater. In such areas, most of the rainfall that is not drained off by streams either evaporates or is transpired by plants. Infiltration into the ground-water reservoir is relatively rapid in the more permeable point-bar and natural-levee deposits near major streams.

Water in the Mississippi River alluvial aquifer generally moves southward (fig. 2) and discharges into the major streams, which are in hydrologic connection with the aquifer along most of their reaches in the report area. The Mississippi River cuts virtually through the aquifer and forms a hydrologic boundary on the east side of the area. Near streams, movement is nearly perpendicular to the direction of streamflow. Natural discharge occurs by seepage into streams during their low stages (dry seasons). During periods of high stream stages (wet seasons) water moves short distances into the aquifer from the streams.

Water moves from underlying Tertiary aquifers into the alluvial aquifer in the southern part of the area of investigation. Water levels in the Cockfield are slightly higher than in the alluvial aquifer in most of Richland Parish, western Franklin Parish, and eastern Caldwell Parish. At Bastrop, in Morehouse Parish, municipal and industrial pumpage from Tertiary aquifers has lowered the water levels in these deeper sands. Thus, the direction of water movement there has been reversed and is from the alluvial aquifer to the Tertiary sands.

Water Levels

Water levels in the Mississippi River alluvial aquifer generally are less than 30 feet (9 m) below land surface. Water levels fluctuate seasonally; levels decline from early summer to late fall or early winter and rise to seasonal highs in March, April, or May. A generalized potentiometric map (fig. 2), based on water-level measurements made in September 1974, gives the approximate shape of the water surface

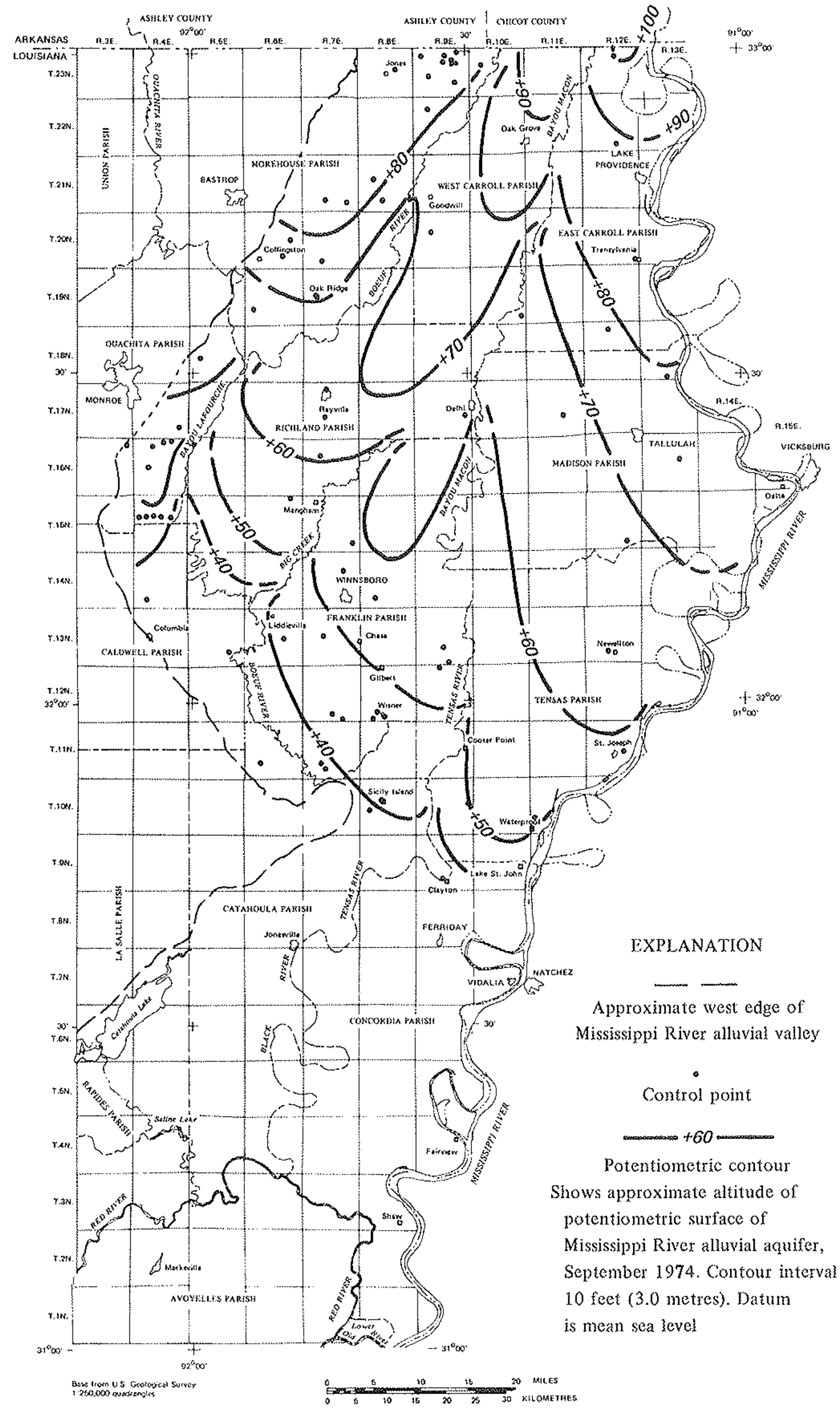


Figure 2.--Approximate potentiometric surface of the Mississippi River alluvial aquifer.

of the aquifer. Water levels range from about 100 feet (30 m) above sea level in the extreme northeastern section of the area to about 30 feet (9 m) above sea level in the southeastern section.

During wet months, high stages in streams and rivers reverse the hydraulic gradient, and instead of water being discharged from the aquifer, the aquifer is recharged. The effects on water levels are greatest near major streams; for example, seasonal fluctuations of water levels are 20 feet (6 m) or more near the Mississippi River. Therefore, water levels within a few miles of major streams may be higher or lower than shown in figure 2. During extremely high flood stages on the Mississippi River, water levels in wells near the river are high enough that the wells may flow. During the 1973 spring flood, an irrigation well in East Carroll Parish flowed about 100 gal/min (6.3 l/s); spring water levels in this well are usually less than 10 feet (3 m) below land surface. During the flood, numerous sand boils developed near the Mississippi River levees from Lake Providence southward to Transylvania as a result of the high stages of the Mississippi River.

Figure 2 shows that drainage to the major streams is a controlling factor in the configuration of the potentiometric surface. The magnitude of water-level fluctuations diminishes with distance from the major streams. Therefore the water-level contours shown in figure 2 are more accurate for predicting water levels for interstream areas. At drainage divides, seasonal fluctuations may be less than 2 feet (0.61 m). The hydrographs for well Ts-9, located approximately 2 miles (3.2 km) from the Mississippi River, and well Ri-92, located in the interstream area between the Boeuf River and Big Creek, illustrate the typical range of natural seasonal fluctuations. (See fig. 3.)

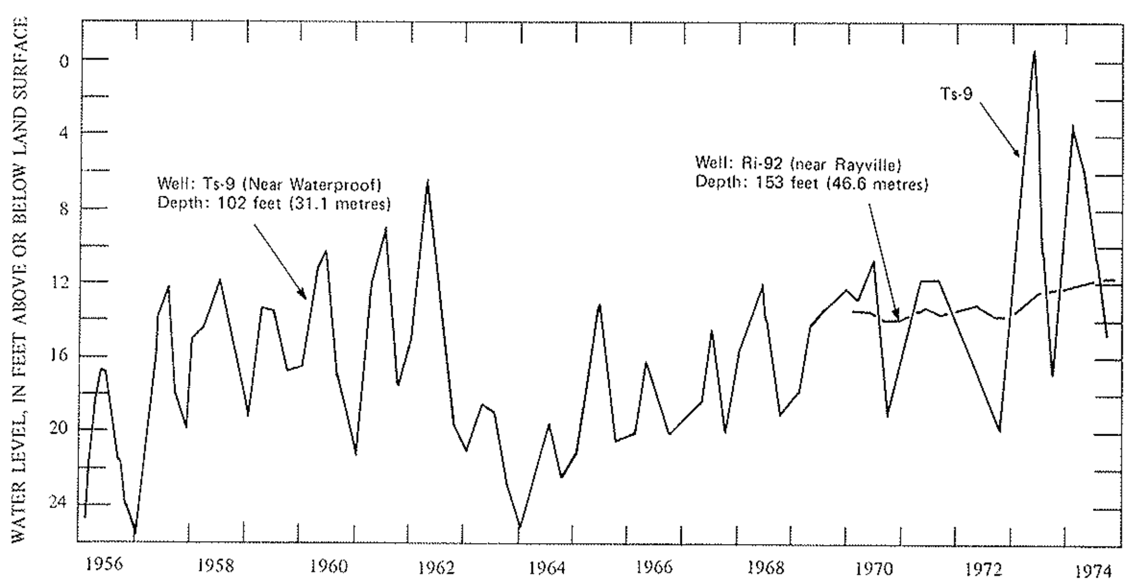


Figure 3.--Water levels in observation wells in the alluvial aquifer.

Water levels in the aquifer--except during flood periods--are below land surface. In some low-lying areas, water levels are near or at land surface. Beneath Macon Ridge, water levels are as much as 45 feet (14 m) below land surface. Except near streams, most of the differences in water levels result from differences in the altitude of land surface and altitude of discharge areas.

Water levels may be drawn down as much as 20 to 40 feet (6 to 12 m) near local areas of heavy pumping for irrigation, as in northeastern Morehouse Parish. Although most of the seasonal drawdown in these areas of intensive pumping is recovered by spring, when pumping in the area is discontinued, water levels may require a year or more to recover fully (Sanford, 1973, p. 18).

Drainage canals constructed in eastern Morehouse Parish for agricultural purposes during the past 20 years have drained shallow deposits locally. Owners of domestic wells report that the water levels are approximately 10 feet (3.0 m) lower than before in areas adjacent to these drains.

Hydraulic Characteristics

The hydraulic characteristics of the Mississippi River alluvial aquifer vary widely, depending on the thickness, size, and sorting of the sand and gravel in the aquifer. Aquifer tests in Madison and Morehouse Parishes indicate that transmissivity ranges from 13,000 to 45,000 ft^2/d (1,200 to 4,200 m^2/d). The hydraulic conductivity ranges from 130 to 530 ft/d (40 to 160 m/d). Storage coefficients range from 0.001 to 0.05.

Properly constructed, large-diameter wells yield as much as 7,000 gal/min (440 l/s) in Madison Parish near Tallulah. However, the average large-capacity well in this area is constructed to yield less than 2,000 gal/min (126 l/s). Measured specific capacities range from 35 to 92 (gal/min)/ft or 7 to 19 (l/s)/m of drawdown. Theoretical specific capacities should range from about 45 to about 150 (gal/min)/ft or 9 to 31 (l/s)/m.

Pumpage

Large quantities of water are pumped from the Mississippi River alluvial aquifer. At present, more water is used for irrigation than all other uses combined. In 1970 the water pumped for irrigation was equivalent to an average rate of 67 Mgal/d ($2.5x10^8$ l/d). About 10.6 Mgal/d ($4.0x10^7$ l/d) was pumped for industrial use in 1970. Municipal use was 3.5 Mgal/d ($1.3x10^7$ l/d), and domestic use was about 3 Mgal/d ($1.1x10^7$ l/d). Most of the water removed from the aquifer is consumed by evapotranspiration or runs off to streams. In irrigated areas where sandy soil extends from the surface down to the aquifer, part of the water returns to the aquifer. Total pumpage from the aquifer could be increased many times because recharge is relatively rapid.

CHEMICAL QUALITY OF THE WATER

The principal control affecting utilization of water from the Mississippi River alluvial aquifer is the quality of the water. In most of the area the water is hard to very hard[1/] and contains high concentrations of iron and manganese; thus treatment is necessary for the water to be satisfactory for domestic, municipal, and many industrial uses.

The quality of the water varies areally and vertically in the aquifer. Generally, water having the highest hardness and iron concentrations occurs in the east half of the area and near the base of the aquifer. In addition, in local areas the water contains high concentrations of chloride and is unsuitable for most uses. Conversely, locally in the northwestern part of the area the water is suitable for many uses without treatment.

Other chemical and physical constituents that determine the suitability of water for domestic and municipal uses--such as sulfate, fluoride, dissolved solids, nitrate, and color--generally are well below limits set by the State health agency for drinking water. Standards of the U.S. Public Health Service (1962) are generally applied.

Water from the aquifer is predominantly a calcium bicarbonate type. In parts of Richland Parish the water is a sodium bicarbonate type, and in the high-chloride areas of the valley the water is a mixed sodium chloride, calcium bicarbonate type. The temperature of water from the alluvial aquifer generally ranges from about 66°F (19.0°C) in the upper part of the aquifer to about 68°F (20.0°C) in the lower part of the aquifer. Chemical analyses of water from selected wells are given in table 1.

Hardness

The hardness of fresh water in the alluvial aquifer generally ranges from 200 to 600 mg/1 (milligrams per litre) but locally may be less than 20 mg/1 and more than 800 mg/1. The hardness may be extremely high in salt-water zones. For example, the hardness of water from a

1/In ground-water studies in Louisiana, the U.S. Geological Survey classifies hardness as follows: Water having a hardness of 0-60 mg/l is considered soft, 61-120 mg/l is moderately hard, 121-180 mg/l is hard, and more than 180 mg/l is very hard. In Louisiana, water that is hard or very hard and(or) that contains an iron concentration exceeding 0.3 mg/l generally is treated for public-supply use.

well (Ou-263) in Ouachita Parish near Monroe is 1,600 mg/1 (table 1). In most of the area, water in the lower part of the aquifer is harder than that in the upper part.

In the upper part of the aquifer, hardness is variable and appears to respond to local influences, primarily local differences in recharge, more than regional influences. In the lower part of the aquifer, however, hardness concentrations follow a mappable pattern (pl. 4) although local variations occur. Beneath the east half of the project area, hardness generally ranges from 200 to more than 400 mg/l. In southern Richland Parish beneath relatively permeable surficial deposits, hardness ranges from less than 10 to 200 mg/l, and values less than 100 mg/l are common. Except for areas of high salinity, hardness concentrations generally are highest in discharge areas.

In areas where the water is very high in hardness (more than 400 mg/l), encrustation of well screens by deposition of calcium and magnesium carbonate, along with iron deposits, creates problems for well owners. Screens in some domestic wells are replaced or cleaned at 6- to 12-month intervals.

Iron and Manganese

The iron concentrations in water from the alluvial aquifer range from 0.00 to about 30 mg/l. As with hardness, the concentration in the lower part of the aquifer tends to follow a general pattern, whereas local variations are typical in the shallow part of the aquifer. In the eastern section of the project area near the Mississippi River, iron concentrations are commonly 10 mg/l or more (pl. 5). Toward the west, concentrations range from 1 to 5 mg/l, generally decreasing in a westerly direction. In the area of Richland Parish where the water is relatively soft, iron concentrations generally are less than 0.30 mg/l. Relatively rapid recharge through older alluvial deposits, which are fairly well oxidized, accounts for the lower concentrations.

The higher iron concentrations appear to occur in areas where water moves through thick organic sediments and where reducing conditions prevail. Biochemical activity in the organic soils may also be an important mechanism for solution of iron in the ground water, as pointed out by Oborn and Hem (1961). The essential ingredients--moisture, heat, and organic matter--exist for optimum microbe activity in the valley. These conditions are especially favorable in backswamp areas.

In general, iron concentrations are related to the ground-water flow regime (recharge and discharge) and to the age and composition of the sediments. The younger sediments have undergone less leaching, and they contribute more iron than older deposits.

Manganese concentrations tend to be highly variable and generally do not follow a mappable pattern, either areally or with depth. The range in concentration from available analyses is 0.00 to 3.4 mg/l; however, concentrations generally are less than 1 mg/l.

Chloride

In most of the study area, fresh water occurs to or below the base of the alluvial aquifer (pl. 6). In ground-water studies in Louisiana, fresh water is generally defined as that containing 250 mg/l or less of chloride; salty water as containing more than 250 mg/l of chloride. In this report these definitions are used to differentiate between fresh and salty water.

Chloride concentrations measured in water from the lower part of the Mississippi River alluvial aquifer (pl. 7), where highest concentrations occur, range from less than 5 mg/l to more than 4,000 mg/l. Except in or near zones of salty water, chloride concentrations in the upper part of the aquifer generally are less than 30 mg/l and in the lower part are less than 100 mg/l.

Zones of high-chloride water occur in several parts of the valley (pl. 6). In these areas, salty water may extend from the base of the aquifer upward to depths less than 30 feet (9.1 m) below land surface. Normally the chloride concentrations increase with increasing depth. The largest salt-water zone in the alluvial aquifer is in central Franklin Parish. This zone trends north-south, is 28 miles (45 km) long, and is 1 to 5 miles (1.6 to 8.0 km) wide. At Chase, in the middle of this zone, concentrations of chloride are about 4,000 mg/l in the lower part of the aquifer and generally exceed 250 mg/l in the upper part. A separate, smaller area of salty water occurs in Franklin Parish 2.5 miles (4.0 km) south of Liddieville. Other areas where shallow salty water was found are only a few square miles in extent and are located as follows: northeastern Morehouse Parish near Jones; northeastern West Carroll Parish; 6 miles (9.7 km) southeast of Monroe, Ouachita Parish; 1 mile (1.6 km) southwest of Delhi, Richland Parish; 1.5 miles (2.4 km) northwest of Tallulah, Madison Parish; 9 miles (14 km) southeast of Columbia, Caldwell Parish; at Cooter Point, southwestern Tensas Parish; and near Fairview and Shaw in southeastern Concordia Parish. The chloride concentration in the lower part of the aquifer in these areas generally does not exceed 1,400 mg/l. Chloride concentrations at the top of the aquifer in these areas may be slightly less than 250 mg/l.

Natural Occurrence of Salty Water

Although most of the water in the Mississippi River alluvial aquifer has chloride concentrations less than 50 mg/l, a zone of water in the aquifer containing 100 mg/l or more of chloride extends 46 miles (74 km) from the Arkansas State line to southern Franklin Parish (pl. 7). This zone is from 1 to 5 miles (1.6 to 8.0 km) wide and encompasses the linear body of salty water in Franklin Parish. In the northern part of this zone near Oak Grove, in West Carroll Parish, chloride concentrations are slightly over 200 mg/l. On each side of the zone, chloride concentrations decrease to 50 mg/l or less within 2 to 3 miles (3.2 to 4.8 km).

Several geohydrologic factors may account for the regional high-chloride zone and some of the local zones of high-chloride water. In much of the area beneath the present Mississippi River flood plain, water in Tertiary aquifers that underlie the alluvial aquifer has high concentrations of chloride. Discharge from these Tertiary aquifers probably has occurred in an area of low head in the alluvial aquifer along the central part of the valley. The high-chloride zone lies along this probable discharge area.

The area where the alluvial aquifer contains salty water in Franklin Parish (pl. 8) lies near and roughly parallel to the underlying contact between salt-water sands of the Cockfield Formation of the Claiborne Group and clays of the Jackson Group (fig. 1 and pl. 8). The pressure gradient in most of the area is from the Cockfield sands into the overlying alluvium; thus, movement of salty water from the Cockfield probably is a major source of the high-chloride water in the alluvial aquifer. The bulk of this salty water probably enters the aquifer in the northwestern part of Franklin Parish where the Jackson-Cockfield contact is closest to the upgradient end of the salt-water body in the alluvial aquifer. The denser salty water apparently tends to flow along the base of the aquifer following the thalwegs of former drainage systems. Thick sections of clay of the Jackson and Vicksburg Groups separate Cockfield sands containing salty water from the alluvial aquifer underneath the southern part of Franklin Parish.

Quality-of-water data indicate lateral and vertical differences in chloride concentrations throughout the regional high-chloride zone. In general, at a given depth, chloride concentrations increase toward the center of the zone. A profile (pl. 8, B-B') across the zone near Winnsboro illustrates the lateral variations in chloride. Resampling of wells along this profile in August 1973 indicates a slight reduction in chloride on the east flank of the salt-water zone. This decrease is probably caused by dilution by above-normal precipitation during the spring. Chloride concentrations increase from the top to the base of the aquifer. For example, in the several wells that were sampled at various depths the chloride concentrations generally increased with greater depth (pl. 8). Data show that chloride concentrations are highest at the base of the aquifer along the axis of the high-chloride zone.

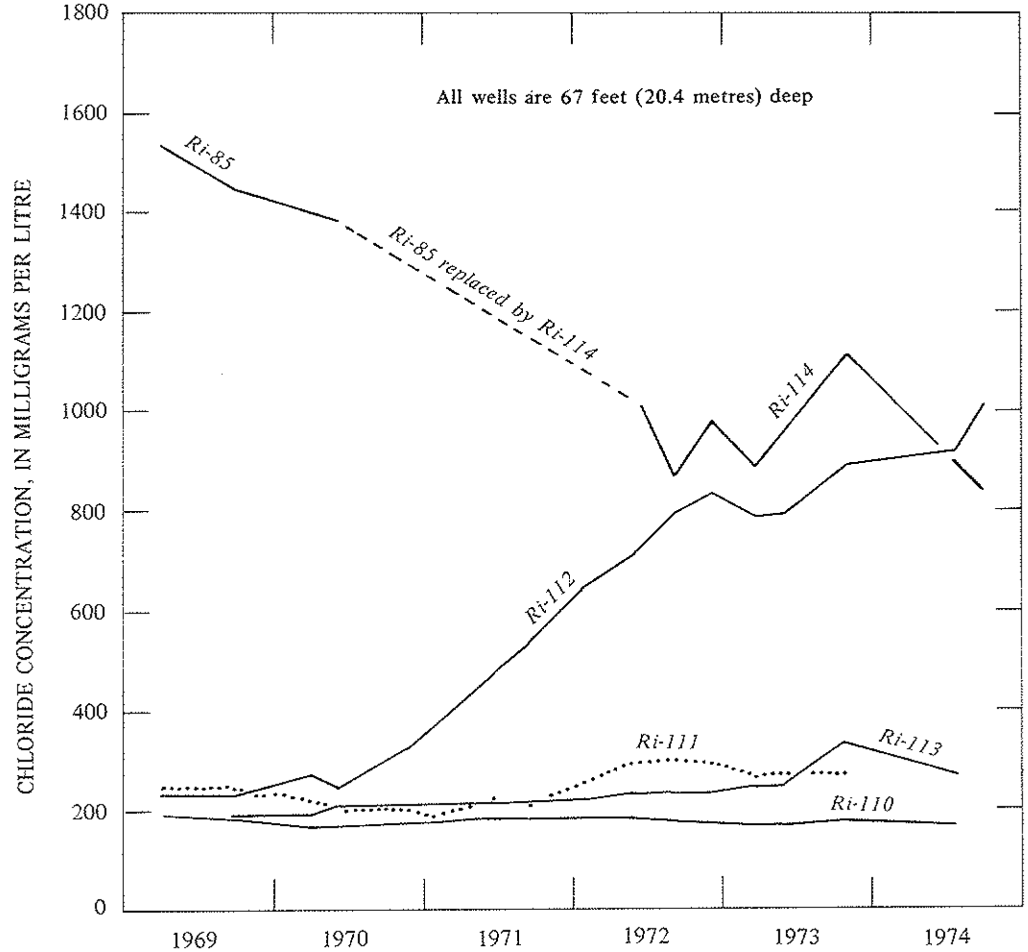
Pollution Caused by Man's Activities

Man's activities can also cause salt-water pollution. Principal activities that are major factors in this area are (1) large-scale pumping from the alluvial aquifer and (2) some activities related to the exploration for and production of petroleum.

Movement of salty water from underlying geologic units is a potential hazard to wells screened in the basal part of the alluvial aquifer. Pumping large-capacity wells in areas where clay beds do not separate the alluvial sands and gravels from Tertiary sands will induce the flow of salty water from these underlying sediments into the alluvial aquifer. For example, at Waterproof, in Tensas Parish, Miocene sands underlying the alluvial aquifer contain salty water. The log of municipal well Ts-13 indicates that the alluvium is separated from the underlying sand by only 2 feet (0.61 m) of clay. The chloride concentration in water from this well increased from 36 mg/l in October 1959 to 302 mg/l in January 1962. The chloride concentration declined to an acceptable level when pumpage from the well was reduced by alternately pumping well Ts-13 and another municipal well. A new well (Ts-52) was constructed in 1970 in an area where the clay separating the alluvium and underlying sands is thicker and thus serves as a barrier to retard the vertical movement of water. Similarly, the chloride concentration in water from well Fr-50 at Winnsboro, in Franklin Parish, has increased from 62 mg/l in early 1960 to 500 mg/l in early 1974. This well was abandoned in late 1973 because the chloride concentration exceeded State standards for public water supplies. (For a detailed discussion of ground water in the Winnsboro area, see Whitfield, 1973.) In addition to inducing vertical movement of salty water, high-capacity wells pumping near salt-water bodies also may induce lateral flow of salty water toward the well.

In a small area of southeastern Ouachita Parish, the Mississippi River alluvial aquifer contains water high in chloride. This area is underlain by fresh-water-bearing sands of Tertiary age; thus contamination from human activities is indicated. Some high chloride concentrations in the alluvial aquifer may be attributed to gas blowouts, salt-water disposal pits, or leaky abandoned wells. Escaping gas may have transported large volumes of salty water upward into the alluvial aquifer. In the past, salty water produced with petroleum was disposed of in salt-water "evaporation pits." Much of this water probably seeped into the aquifer and contributed high concentrations of dissolved minerals. Analyses of brines from oil fields in Richland and Franklin Parishes show that the principal chemical constituents are sodium and chloride, with minor concentrations of calcium, magnesium, and bicarbonate (Hawkins and others, 1963, p. 14-15).

Numerous salt-water pits at oil fields in Richland and Franklin Parishes, although now abandoned, were active until the middle 1960's. Some of these pits are still open; others have been filled in. In eastern Richland Parish 1 mile (1.6 km) south of Delhi (fig. 4), domestic



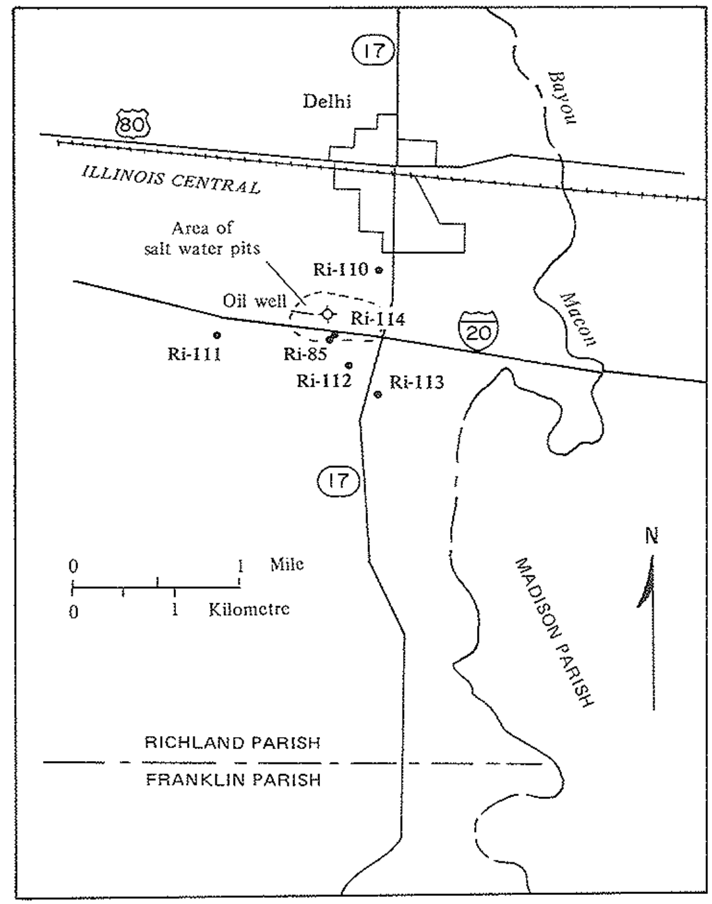


Figure 4.--Chloride concentration in the alluvial aquifer near a salt-water disposal area.

water wells near buried salt-water disposal pits produce brackish water from the Mississippi River alluvial aquifer. Periodic sampling from 1969 to 1973 shows that the chloride concentration increased in some wells and declined in others. (See fig. 4.) Chloride concentrations declined near the pits (wells Ri-85 and Ri-114) and increased downgradient from the pits (wells Ri-111, Ri-112, and Ri-113). These data indicate movement of the salt-water body in a general southerly direction from the source. Infiltration of precipitation may transport more chloride from the buried pit to the aquifer until most of the chloride has been leached.

Salty water percolating downward from disposal pits appears to follow the more permeable zones such as buried stream channels and may bypass wells located only a few hundred feet from the pits. Pits in northern Franklin Parish may provide part of the salty water to the extensive regional salt-water body.

In southwestern Tensas Parish and in southeastern Concordia Parish (pl. 6), local occurrences of salty water in the alluvial aquifer are thought to be associated with the production of oil. In northeastern Morehouse Parish, local areas of high-chloride water occur in the alluvial aquifer where underlying Cockfield sands contain fresh water. This area is heavily pumped for rice irrigation, and the high-chloride water appears to be moving downgradient from Ashley and Chicot Counties, Ark., to this seasonal cone of depression.

Many oil wells were drilled in the area during the early part of this century before adequate standards were developed and enforced to protect fresh ground water. These old wells are potential sources of salt-water contamination.

Pesticides and Nitrates

Silt or sand extends from the surface to the water table locally in the area investigated. In these areas, insecticides, herbicides, and nitrates from agricultural sources are potential contaminants to the Mississippi River alluvial aquifer. In January 1972 three wells, all less than 22 feet (6.7 m) in depth, were drilled and sampled for insecticides, herbicides, and nitrates. One well was drilled in Morehouse Parish near Collinston, one in West Carroll Parish near Goodwill, and one in East Carroll Parish near Transylvania. The samples from the wells in Morehouse and West Carroll Parishes were free of pesticides and had nitrate concentrations of 15 mg/l. The sample from the well in East Carroll Parish had a concentration of 0.02 microgram per litre of the insecticide Diazinon and a nitrate concentration of 49 mg/l. This level of insecticide concentration does not restrict use of the water for human consumption, but the nitrate concentration exceeds the generally recommended limit (45 mg/l) set by the U.S. Public Health Service (1962). The well in East Carroll Parish was resampled in May 1973 when the water level in the well was unusually high as a result of a high Mississippi River stage. No pesticides were found in this sample, and the nitrate concentration had decreased to 34 mg/l. The decrease in chemical concentration probably can be attributed to dilution and dispersion resulting from recharge.

These results suggest that in agricultural areas where permeable sediments extend from the surface to the water table, pesticides and nitrates may percolate into the Mississippi River alluvial aquifer. Because pesticides tend to be adsorbed by fine-grained soil materials (clay and silt), they generally do not reach the water table except in areas where rapid recharge through permeable material occurs. On the other hand, nitrates do reach the water table quite readily in some agricultural areas.

SUMMARY

The shallow Mississippi River alluvial aquifer of northeastern Louisiana is the largest source of fresh ground water in the area. In much of the area it is the only source of fresh ground water. The aquifer consists primarily of fine to medium sand in the upper part and medium to coarse sand and gravel in the basal part. In general, the aquifer ranges from about 20 to 135 feet (6 to 41 m) in thickness and generally is confined by clay, sandy clay, or silt ranging from 0 to 100 feet (0 to 30 m) in thickness.

Water levels in the aquifer generally are less than 30 feet (9 m) below land surface. The maximum annual water-level fluctuations are approximately 20 feet (6.1 m) near the Mississippi River, and the minimum water-level fluctuations are less than 2 feet (0.6 m) in the interstream areas. Pumping causes water-level declines seasonally in irrigated areas of Morehouse Parish.

The Mississippi River alluvial aquifer has an average transmissivity of 19,000 ft^2/d (1,800 m^2/d) and an average hydraulic conductivity of 200 ft/d (61 m/d). Well yields are as much as 7,000 gal/min (440 l/s). Specific capacities range from 35 to 92 (gal/min)/ft or 7 to 19 (l/s)/m of drawdown.

The Mississippi River alluvial aquifer typically yields a hard to very hard, calcium bicarbonate type water that is high in iron. The hardness generally ranges from about 200 to 600 mg/l, and the iron ranges from 0.00 to about 30 mg/l. Treatment is required to produce water suitable for domestic, municipal, and some industrial uses. In the southern part of Richland Parish the water generally has a hardness less than 100 mg/l, and iron concentrations generally are less than 0.30 mg/l.

Although fresh water occurs to or below the base of the aquifer in most of the study area, locally, salty water occurs at shallow depths within the aquifer. High chloride concentrations in Franklin and Madison Parishes occur near the boundary between clay of the Jackson Group and permeable, salt-water-bearing sands of the Cockfield Formation. This boundary may provide the lithologic control for upward movement of salty water from the Cockfield into the alluvium. However, part of the salty water may result from downward percolating salty water from buried pits formerly used for disposal of salty water in northern Franklin Parish. Smaller bodies of salty water occur at shallow depths in Ouachita, West Carroll, Richland, Tensas, Franklin, and Concordia Parishes. These apparently represent contamination by salt-water disposal wells, pits, or oil-well drilling mishaps.

Development of large-capacity irrigation and municipal wells in the aquifer near salt-water bodies may create quality-of-water problems because of salt-water encroachment.

GLOSSARY

Aquifer
: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Confined
: The water level in a well in a confined aquifer stands above the top of the water body it taps. Synonymous with artesian.

Confining bed
: A body of "impermeable" material stratigraphically adjacent to one or more aquifers.

Gaining stream
: A stream which receives water from adjacent aquifers.

Hydraulic conductivity
: The volume of water at the existing kinematic viscosity that will move through a unit area of an isotropic porous medium in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Replaces the term "field coefficient of permeability."

Milligrams per litre (mg/l)
: For the purpose of converting to the metric system, the unit "milligrams per litre" replaces the unit "parts per million," formerly used by the U.S. Geological Survey. The two units are equivalent at dissolved-solids concentrations less than about 7,000 mg/l.

Potentiometric surface

The surface which represents the static head. As related to an aquifer, it is defined by the levels to which water will rise in tightly cased wells. The water table is a particular potentiometric surface.

Specific capacity

The rate of discharge of water from the well divided by the drawdown of water level within the well. It varies slowly with duration of discharge, which should be stated when known.

Storage coefficient

The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Transmissivity

The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths. (Formerly termed "transmissibility," defined as the rate of flow of water, at the prevailing water temperature, in gallons per day, through a vertical strip of the aquifer 1 foot (0.305 m) wide extending the full saturated height of the aquifer under a unit hydraulic gradient.)

Unconfined ground water

Water in an aquifer that has a water table.

Water table

That surface in an unconfined water body at which the pressure is atmospheric. It is defined by the levels at which water stands in wells that penetrate the water body just far enough to hold standing water.

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CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS TAPPING THE MISSISSIPPI RIVER ALLUVIAL AQUIFER (TABLE 1)

The analyses in table 1 are of water from the Mississippi River alluvial aquifer. The chemical constituents are expressed in milligrams per litre (mg/l). The unit "milligrams per litre" replaces the unit "parts per million," formerly used by the U.S. Geological Survey. The two units are equivalent at dissolved-solids concentrations less than about 7,000 mg/l.

Noncarbonate hardness was zero in samples from all wells listed in table 1.

In the column headed "pH" the symbol "F" indicates that the pH was measured in the field. Where the field pH was not determined, the laboratory value generally is given, as indicated by the symbol "L."

In the column headed "Screened interval," where the interval is unknown, the figure on the right side of that column is the well depth, in feet. For those readers who prefer to use International System (metric) units rather than English units, the screened interval, in feet, may be converted to metres by multiplying by 0.3048.

Analyses were by the U.S. Geological Survey unless otherwise indicated by footnote.

Table 1.--Chemical analyses of water from selected wells tapping the Mississippi River alluvial aquifer

Well No.	Location Sec.	Location T. (N.)	Location R. (E.)	Date of collection	Screened interval (depth, in feet)	Temperature (°F)	Temperature (°C)	Silica (SiO_2), dissolved	Iron (Fe), dissolved	Manganese (Mn), dissolved	Calcium (Ca), dissolved	Magnesium (Mg), dissolved	Sodium (Na), dissolved	Potassium (K), dissolved	Bicarbonate (HCO_3)	Sulfate (SO_4), dissolved	Chloride (Cl), dissolved	Fluoride (F), dissolved	Nitrate (NO_3), dissolved	Dissolved solids, calculated, sum of determined constituents	Hardness as $CaCO_3$ (Ca, Mg)	Specific conductance (micromhos/cm at 25°C)	pH (units)	Color (platinum-cobalt units)
								Milligrams per litre																
											CALDWELL PARISH													
Ca-20	45	14	4	10-21-64	69-104	--	----	22	3.2	0.60	66	16	29	1.0	302	25	14	0.3	0.1	323	230	530	6.9L	0
Ca-75	29	14	5	12-19-70	65	--	----	19	3.0	1.2	31	3.1	11	2.0	122	.0	11	.1	.1	137	90	224	7.1L	5
Ca-77A	26	13	5	9-14-71	30- 35	66	19.0	20	25	1.4	250	91	760	12	433	6.0	1,600	.3	----	2,950	1,000	5,550	6.9F	10
Ca-77B	26	13	5	9-13-71	67- 76	67	19.5	20	22	.62	260	100	2,400	20	385	28	4,100	.3	----	7,090	1,000	12,500	6.8F	15
											CATAHOULA PARISH													
Ct-9	38	10	8	5-28-45	50	68	20.0	--	0.05	----	32	14	25	----	176	15	21	---	3.2	269	140	------	7.6L	--
Ct-11	16	5	6	2- 5-54	117-120	67	19.5	40	4.4	0.00	98	41	86	2.3	622	.3	55	0.6	4.5	629	410	1,070	7.2F	20
Ct-27	39	10	8	10-29-65	105-115	68	20.0	42	.35	.5	45	22	25	2.3	246	25	23	.3	.5	307	200	490	7.4F	5
Ct-47	37	8	6	7-25-68	85-125	--	----	32	8.9	----	82	26	20	2.5	389	6.2	18	.3	1.4	380	310	653	7.6L	5
Ct-49	29	11	6	8-16-68	97-100	67	19.5	25	9.5	----	32	10	88	.5	344	.4	25	.5	.0	350	120	593	7.4L	15
Ct-66A	27	9	9	10- 7-71	83- 93	68	20.0	44	6.9	.39	79	24	84	6.2	477	3.0	66	.3	.0	542	300	888	7.1L	5
Ct-66B	27	9	9	10- 6-71	134-144	--	----	43	5.6	.36	100	29	170	3.5	548	6.0	210	.4	.0	830	370	1,390	7.6L	5
											CONCORDIA PARISH													
Co-6	34	9	9	5-28-45	90	--	----	--	6.1	----	110	37	34	----	549	17	23	---	2.2	541	430	------	7.4L	--
Co-14	48	5	9	2- 5-54	80- 85	68	20.0	52	9.8	0.13	100	34	26	12	523	19	6.8	0.3	14	528	400	852	7.0L	15
Co-22	3	7	9	3- 4-68	106-136	68	20.0	37	12	----	120	26	33	3.2	539	29	16	.2	.2	535	420	898	6.8L	10
Co-31	57	8	9	3- 5-68	85-145	68	20.0	36	6.5	----	94	30	26	2.7	482	4.8	17	.2	.3	448	360	775	7.5L	10
Co-33	34	9	9	3-28-68	106-136	67	19.5	52	12	----	91	51	98	8.0	593	70	74	.2	3.1	739	440	1,270	6.8F	5
Co-45	50	8	10	7-31-68	93-133	--	----	37	16	----	130	44	39	4.0	682	.2	12	.3	1.6	600	500	992	7.8L	5
Co-52	24	6	9	3-29-71	136-141	--	----	45	12	.75	90	27	22	2.7	450	13	6.4	.1	.2	428	340	696	7.5L	5
Co-53A	35	3	8	3-30-71	135-140	--	----	35	.53	1.3	120	40	50	5.7	694	5.0	8.8	.0	5.9	616	480	1,020	7.7L	5
Co-53B	35	3	8	3-30-71	198-203	--	----	22	2.0	.60	70	19	360	4.9	718	6.6	310	.1	3.2	1,150	260	2,060	7.7L	5
											EAST CARROLL PARISH													
EC-65	12	18	12	4-12-55	70-110	--	----	32	10	1.3	100	33	38	4.6	522	18	21	0.0	2.5	514	390	844	7.1L	--
EC-154A	4	18	12	2- 3-71	41- 44	--	---	27	6.1	3.4	170	51	38	3.7	649	41	93	.3	.0	740	620	1,250	----	5
EC-154B	4	18	12	2- 2-71	97-100	--	----	32	.83	.10	70	29	160	5.5	646	.2	89	.3	.0	709	300	1,190	----	5
EC-155	10	23	12	4- 1-71	93- 98	--	----	33	.08	.34	110	30	34	2.4	538	15	11	.1	.4	500	400	834	----	5
EC-159	71	20	13	1-21-72	13- 16	67	19.5	22	.18	.03	71	22	12	1.4	272	34	4.9	.4	49	351	270	553	8.2L	0
				5-17-73	13- 16	64	18.0	22	.15	.00	86	29	10	1.5	338	53	6.2	.3	34	408	330	649	6.9F	5

Table 1.--Chemical analyses of water from selected wells tapping the Mississippi River alluvial aquifer--Continued

Well No.	Location: Sec.	Location: T. (N.)	Location: R. (E.)	Date of collection	Screened interval (depth, in feet)	Temperature (°F)	Temperature (°C)	Silica (SiO_2), dissolved	Iron (Fe), dissolved	Manganese (Mn), dissolved	Calcium (Ca), dissolved	Magnesium (Mg), dissolved	Sodium (Na), dissolved	Potassium (K), dissolved	Bicarbonate (HCO_3)	Sulfate (SO_4), dissolved	Chloride (Cl), dissolved	Fluoride (F), dissolved	Nitrate (NO_3), dissolved	Dissolved solids, calculated, sum of determined constituents	Hardness as $CaCO_3$ (Ca, Mg)	Specific conductance (micromhos/cm at 25°C)	pH (units)	Color (platinum-cobalt units)
								Milligrams per litre																
FRANKLIN PARISH																								
Fr-47	4	12	8	12-13-68	66-108	--	----	28	2.0	----	75	36	93	2.8	489	7.4	94	0.2	4.0	581	330	1,020	7.6L	5
Fr-49	26	14	7	5- 2-68	44- 80	--	----	29	12	----	54	21	54	2.8	191	8.6	120	.5	.0	388	220	714	6.8L	5
Fr-68	28	11	7	10-26-61	80-120	67	19.5	20	1.1	0.00	46	17	19	2.6	240	7.6	15	.3	.8	247	180	401	7.3L	5
Fr-146	11	12	7	6-18-64	20- 23	--	----	33	.41	.22	180	140	340	4.7	537	4.2	930	.1	----	1,890	1,000	3,460	7.5L	0
Fr-156	1	12	7	6-18-64	37- 40	--	----	28	1.3	.41	210	67	290	3.9	541	5.6	670	.2	----	1,540	800	2,730	7.4L	0
Fr-162	23	12	7	6-18-64	37- 40	--	----	35	1.7	.52	120	45	200	4.3	586	5.0	320	.2	----	1,020	500	1,780	7.2L	5
Fr-189	8	12	6	3-20-64	67- 70	67	19.5	33	.68	.09	17	7.7	43	1.7	176	.0	18	.0	.1	208	74	323	7.0L	0
Fr-197	13	13	7	6-18-64	39- 42	69	20.5	36	5.1	1.2	140	47	220	4.3	372	31	460	.2	----	1,110	530	1,970	7.7L	0
Fr-213	10	14	8	8- 3-72	22- 25	66	19.0	32	7.9	.23	210	100	640	7.0	653	5.8	1,300	.3	.0	2,620	920	4,860	7.3L	0
Fr-262	30	13	8	8-13-64	93- 96	67	19.5	25	8.2	.04	49	150	860	7.8	259	10	1,700	.2	.0	2,920	740	5,520	7.4L	10
Fr-269	31	16	9	8- 3-72	37- 40	--	----	28	.05	.12	98	45	230	3.0	544	28	310	.4	6.2	1,020	430	1,940	7.3F	0
Fr-291	1	12	7	8- 3-72	80-100	66	19.0	25	12	.36	270	90	550	8.0	459	7.0	1,300	.2	.2	2,480	1,000	4,660	7.3F	0
Fr-295	36	15	7	4-17-68	99-109	67	19.5	28	3.0	----	30	18	280	6.6	631	.0	360	.2	.1	1,130	400	2,010	7.5F	50
Fr-297	14	14	7	4-24-68	80- 90	--	----	36	7.6	----	92	26	100	4.5	420	8.0	150	.2	.5	622	340	1,130	7.5L	5
Fr-298	14	14	7	4-29-68	70- 80	--	----	31	6.5	----	63	38	67	3.8	404	1.2	100	.2	.1	507	320	938	7.5L	10
Fr-301	4	14	7	5-20-68	76- 96	--	----	26	4.1	----	96	32	200	5.0	516	.0	290	.2	.0	903	370	1,660	8.0L	5
Fr-302	14	14	7	8-14-68	27- 29	68	20.0	33	13	----	56	26	68	.8	312	4.6	96	.2	.0	439	240	788	7.8L	10
Fr-304	14	14	7	8-14-68	38- 40	68	20.0	32	8.7	----	72	27	52	1.1	340	3.4	84	.1	.0	439	290	783	7.7L	15
Fr-305	14	14	7	8-12-68	58- 60	69	20.5	34	1.6	----	80	25	45	1.3	388	5.6	57	.1	.0	439	300	762	7.8L	10
Fr-306	14	14	7	8-15-68	76- 96	67	19.5	34	4.8	----	95	27	80	1.2	367	.8	160	.1	.0	576	350	1,090	7.6L	15
Fr-310	32	12	8	2-12-70	103	67	19.5	37	.31	.90	44	18	27	1.8	258	2.2	16	.2	6.8	280	190	457	8.1L	0
Fr-311	16	13	7	1-19-71	82- 85	--	----	30	.32	.17	39	11	51	1.6	246	.0	38	.2	.0	292	140	480	7.2F	0
Fr-312A	33	12	7	1-20-71	55- 58	--	----	34	12	1.7	56	17	46	2.0	266	.2	58	.2	.0	354	210	602	7.1F	5
Fr-312B	33	12	7	1-20-71	79- 82	--	----	24	3.7	.17	55	19	120	3.8	356	.4	140	.2	.0	533	210	952	7.2F	5
Fr-313A	34	12	7	1-21-71	37- 40	--	----	29	.49	.32	42	16	26	3.0	234	7.2	23	.3	.0	262	170	438	7.1F	5
Fr-313B	34	12	7	1-21-71	68- 71	--	----	27	1.2	.10	70	31	81	5.6	405	.8	100	.2	.0	524	300	917	7.5F	5
Fr-314A	22	13	6	1-22-71	36- 39	--	----	27	3.7	.12	130	46	310	6.0	487	.4	550	.2	.0	1,310	510	2,440	----	5
Fr-314B	22	13	6	1-22-71	58- 61	--	----	27	6.6	.09	130	51	440	7.2	549	.4	730	.3	.0	1,660	530	3,090	----	5
Fr-315A	28	13	9	6-23-72	53- 56	--	----	32	1.7	1.3	46	61	25	2.8	418	49	19	.3	.2	441	370	744	8.1L	5
Fr-315C	28	13	9	6-22-72	70- 73	66	19.0	37	4.0	.61	67	19	16	3.4	318	5.8	7.8	.3	.2	314	240	512	7.3L	5
Fr-316	34	13	9	6-27-72	86- 89	--	----	30	4.2	2.0	52	40	32	2.1	404	16	10	.4	.2	382	290	654	7.6L	5
Fr-318	33	12	8	8-11-72	89- 99	68	20.0	40	6.8	.35	81	23	36	2.6	337	1.2	66	.3	.1	416	300	727	6.6F	0
Fr-319	32	12	8	10-30-72	120-130	69	20.5	30	1.5	.02	61	25	46	4.8	380	.0	32	.2	.1	386	260	665	6.7F	0

MADISON PARISH																								
Ma-1	36	17	12	3-22-55	90-130	67	19.5	41	2.6	0.00	88	36	85	4.1	613	23	25	0.2	5.1	613	370	1,000	7.8L	5
Ma-2	5	16	13	11-22-55	94-136	67	19.5	40	8.6	.00	110	34	21	4.3	532	.1	7.8	.1	.2	454	410	794	7.2L	0
Ma-17	41	17	13	11-22-55	100	67	19.5	36	15	.14	120	36	14	4.0	563	.0	5.0	.1	.0	482	440	830	7.0L	5
Ma-18	44	16	14	11-22-55	66- 80	67	19.5	16	7.5	.00	100	32	16	3.0	487	10	2.5	.2	5.8	428	380	735	7.1L	0
Ma-25	49	17	13	9-12-57	110-160	67	19.5	33	19	1.0	110	27	12	3.7	494	.8	5.2	.2	.0	426	380	735	7.3L	0
Ma-28	31	16	12	6- 5-68	88-128	--	----	23	14	----	52	26	29	1.9	340	8.2	9.0	.3	.3	317	240	652	7.8L	15
Ma-29	15	16	15	6- 9-60	100-130	68	20.0	17	11	.00	83	48	16	1.7	493	14	11	.1	.0	434	400	751	7.0L	5
Ma-48	25	16	14	6- 5-68	90-100	--	----	28	11	----	80	37	29	2.7	453	22	16	.2	.1	438	350	------	7.7L	15
Ma-49A	22	17	11	2- 1-71	49- 52	--	----	41	1.3	.16	59	20	19	1.6	318	8.8	4.3	.4	.0	311	230	485	----	5
Ma-49B	22	17	11	2- 1-71	79- 82	--	----	42	1.0	.17	62	24	19	2.2	349	5.0	3.1	.3	.0	330	250	518	----	5
Ma-50	39	18	13	4- 1-71	99-109	68	20.0	32	12	.44	-----	-----	89	7.2	764	360	39	.6	.0	-----	880	1,740	7.2L	10
Ma-51	3	15	12	3-31-71	114-119	--	----	35	6.3	.29	110	30	41	4.2	572	7.2	11	.1	3.8	523	400	868	7.8L	5
Ma-53	29	17	12	1-10-72	97-100	--	----	38	6.4	.40	240	120	720	14	797	7.2	1,400	.2	----	2,930	1,100	5,350	8.0L	5
MOREHOUSE PARISH																								
Mo-95	18	23	10	3- 9-67	90-120	64	18.0	29	6.6	----	110	43	71	2.8	473	62	110	0.4	0.0	664	450	1,140	7.0L	5
Mo-170	23	20	6	7- 4-68	52- 80	64	18.0	28	.76	----	68	17	27	1.4	348	.4	11	.2	.1	324	240	563	7.1F	15
Mo-314	22	23	8	7-11-68	80	66	19.0	28	29	----	29	8.6	10	1.7	154	.0	6.0	.1	.0	159	110	266	7.0L	--
Mo-357A	20	19	7	11-18-69	101-111	--	----	38	.16	0.02	22	8.0	17	2.2	56	19	25	.1	37	196	88	281	6.9L	5
Mo-358A	5	19	6	1-20-72	10- 13	62	16.5	27	.44	.06	9.5	2.5	15	.6	33	21	6.1	.1	15	113	34	157	5.5F	15
OUACHITA PARISH																								
Ou-135	18	15	4	5- -46	77- 80	--	----	--	-----	----	43	30	-------	----	459	1.0	27	---	7.7	492	230	------	8.8L	--
Ou-263	2	16	4	8- 2-66	49- 52	--	----	20	3.5	----	380	160	630	6.7	594	510	1,400	0.2	----	3,420	1,600	5,860	----	10
Ou-290[a]	17	18	5	7-23-64	24	--	----	48	1.1	0.54	340	130	940	5.9	282	470	1,800	.3	----	3,920	1,400	6,430	6.8L	5
RICHLAND PARISH																								
Ri-1	4	17	7	5-29-45	66- 86	67	19.5	--	0.10	----	58	23	17	----	214	14	37	---	7.9	351	240	------	8.0L	--
Ri-6	4	17	7	5-29-45	60	68	20.0	--	.10	----	43	16	8.9	----	150	7	24	---	15	274	170	------	8.3L	--
Ri-18	18	17	10	1- 7-60	82- 94	68	20.0	35	.14	0.04	96	36	86	1.9	410	23	150	0.5	7.0	636	380	1,110	7.4L	10
Ri-19	5	15	7	4-29-68	80-100	--	----	40	.34	----	41	15	10	1.9	207	1.8	14	.1	2.1	228	170	401	7.5L	5
Ri-35	28	16	7	10-21-68	79-100	67	19.5	36	.06	----	46	18	19	.8	229	9.0	25	.2	2.6	270	190	448	7.2L	10
Ri-37	32	16	7	10-21-68	79-100	67	19.5	31	.07	----	44	18	20	.9	221	8.2	25	.2	1.4	258	190	430	7.6L	10
Ri-61	2	15	6	5- 3-68	153-163	--	----	27	.64	----	29	9.6	60	3.1	276	.0	19	.2	.0	284	110	514	7.7L	5
Ri-74	18	15	7	10-22-68	65- 80	--	----	41	.06	----	10	3.6	6.9	.6	55	.2	1.0	.2	13	104	40	117	6.8L	10
Ri-81	19	15	7	2-18-69	81- 83	--	----	28	.04	.02	49	19	16	1.0	224	2.2	26	.2	.1	260	200	432	8.5L	10
Ri-82	25	15	6	2-19-69	74- 76	--	----	29	.62	.27	53	20	23	1.1	248	2.0	38	.2	.0	293	210	488	8.3L	10
Ri-83	30	15	7	2-18-69	55- 60	--	----	31	.16	.02	22	9.7	31	1.8	57	9.2	70	.2	11	214	95	365	6.6L	10
Ri-84	30	15	7	2-18-69	28- 30	--	----	35	2.3	.07	5.5	1.5	26	1.0	34	3.6	21	.2	20	131	20	175	6.5L	10
Ri-92	16	17	7	12- 5-69	143-153	68	20.0	33	1.3	.15	48	16	40	1.1	293	3.4	21	.2	.0	307	190	498	7.7L	5
Ri-102	17	16	7	8-26-70	140-150	68	20.0	28	.77	.35	63	23	35	1.7	357	13	12	.2	.0	352	250	577	8.0L	5
Ri-114[b]	24	17	9	6-22-72	63- 66	--	----	32	.46	.61	130	53	530	6.0	400	.4	960	.2	----	1,910	550	3,630	7.6L	5
TENSAS PARISH																								
Ts-1	3	13	12	5-25-45	100-120	67	19.5	--	5.4	----	98	33	4.4	----	407	6	35	---	0.5	436	380	------	7.3L	--
Ts-9	37	10	10	5-16-73	102	65	18.5	35	10	0.43	110	49	33	3.7	663	2.8	13	0.2	2.3	576	480	962	7.2F	50

[a] Open hole.
[b] Near salt-water pit.

Table 1.--Chemical analyses of water from selected wells tapping the Mississippi River alluvial aquifer--Continued

Well No.	Location Sec.	Location T. (N.)	Location R. (E.)	Date of collection	Screened interval (depth, in feet)	Temperature (°F)	Temperature (°C)	Silica (SiO_2), dissolved	Iron (Fe), dissolved	Manganese (Mn), dissolved	Calcium (Ca), dissolved	Magnesium (Mg), dissolved	Sodium (Na), dissolved	Potassium (K), dissolved	Bicarbonate (HCO_3)	Sulfate (SO_4), dissolved	Chloride (Cl), dissolved	Fluoride (F), dissolved	Nitrate (NO_3), dissolved	Dissolved solids, calculated, sum of determined constituents	Hardness as $CaCO_3$ (Ca, Mg)	Specific conductance (micromhos/cm at 25°C)	pH (units)	Color (platinum-cobalt units)
								Milligrams per litre																
TENSAS PARISH--Continued																								
Ts-10	15	11	12	12-13-68	116-151	--	----	32	9.1	----	110	36	44	2.6	624	0.2	15	0.3	0.1	550	430	915	7.2L	5
Ts-12c/	16	10	11	1-20-69	90-130	--	----	--	13	0.8	-----	-----	60	3.5	---	-----	28	.2	----	770	560	------	7.3L	20
Ts-14	3	13	12	10-28-59	133	67	19.5	33	11	.06	67	40	16	2.1	388	11	22	.5	.0	383	330	653	6.9L	40
Ts-25	11	12	13	3-10-64	75- 80	--	----	34	17	1.6	110	33	6.0	3.2	510	.0	1.4	.2	.1	440	410	731	6.9L	15
Ts-26	11	12	13	3-10-64	35- 40	--	----	37	22	1.2	120	30	9.7	2.0	554	.0	2.6	.1	.1	481	440	794	7.2L	15
Ts-38	3	11	12	6-11-68	41- 44	69	20.5	27	2.4	----	75	34	7.0	2.2	360	3.2	.8	.1	.0	326	280	547	7.5F	5
Ts-39	27	11	12	6-12-68	40- 45	--	----	--	4.0	----	-----	-----	-------	----	---	-----	1.8	---	----	-----	230	579	----	--
Ts-40	2	11	12	6-12-68	87- 92	--	----	--	3.3	----	-----	-----	-------	----	---	-----	1.6	---	----	-----	200	411	----	--
Ts-42	9	11	12	9-12-68	126-146	68	20.0	38	11	----	100	34	44	2.5	561	.8	22	.3	.1	518	390	914	7.8L	30
Ts-44	4	13	12	12-13-68	94-124	--	----	29	14	----	89	35	13	2.1	442	11	16	.3	.2	414	370	703	7.3L	5
Ts-52	16	10	11	11-19-69	150-170	65	18.5	42	3.2	.28	66	22	170	5.4	620	.0	78	.2	.0	691	260	1,030	8.0L	10
Ts-53	13	10	9	1-13-72	56- 76	68	20.0	51	2.5	.40	66	20	15	4.2	346	3.0	3.7	.4	.3	334	250	506	7.0F	20
WEST CARROLL PARISH																								
WC-3	11	23	11	12- 3-41	40	--	----	--	-----	----	-----	-----	-------	----	372	2	23	0.2	0.0	-----	330	------	----	--
WC-4	30	19	10	10-25-50	60- 65	67	19.5	30	1.2	----	130	50	87	1.2	618	26	120	.0	3.5	744	520	1,290	7.5L	--
WC-5	20	19	9	10-25-50	30	67	19.5	34	1.9	0.0	-----	-----	-------	----	421	18	13	---	.0	406	350	678	7.6L	--
WC-7	20	19	9	6-19-56	84- 96	67	19.5	32	3.8	.00	100	38	40	1.5	473	68	27	.4	.3	528	410	886	7.3L	0
WC-8	24	19	10	10-26-50	50	67	19.5	45	.72	.4	-----	-----	-------	----	361	6	38	---	.0	405	300	661	7.3L	--
WC-9	23	19	10	10-26-50	65	68	20.0	52	.54	.0	-----	-----	-------	----	144	4	17	---	2.0	223	96	291	6.9L	--
WC-10	11	19	10	10-26-50	45	66	19.0	56	4.7	.0	-----	-----	-------	----	106	2	12	---	35	220	100	270	6.9L	--
WC-11	33	23	11	10-26-50	55	68	20.0	42	.63	.0	-----	-----	-------	----	570	27	120	---	9.5	788	460	1,290	7.7L	--
WC-12	18	23	12	10-26-50	60	69	20.5	57	-----	.0	-----	-----	-------	----	66	30	4	---	1.5	123	30	123	6.8L	--
WC-13	13	23	11	10-26-50	60	68	20.0	44	8.3	.0	-----	-----	-------	----	376	3	28	---	.0	385	110	655	7.4L	--
WC-14	15	23	10	10-26-50	30	--	----	70	.82	.0	-----	-----	-------	----	122	7	60	---	31	346	120	490	6.8L	--
WC-15	9	22	10	10-26-50	19	67	19.5	39	2.8	.2	-----	-----	-------	----	430	17	66	---	.0	575	400	946	7.7L	--
WC-19	22	19	10	5- 3-55	69- 94	67	19.5	44	1.3	.98	100	43	41	2.5	485	13	91	.1	.2	605	440	1,010	7.1L	0
WC-20	10	22	11	6-18-56	82-112	66	19.0	44	2.3	.4	55	26	21	1.7	307	5.4	26	.4	.1	323	240	552	7.2L	10
WC-79	33	20	9	10- 2-70	49- 52	67	19.5	39	5.9	.35	86	27	19	1.1	373	32	23	.2	1.7	413	320	665	7.4F	10
WC-82	23	22	9	1-12-72	30- 33	--	----	36	.05	.01	93	53	80	1.3	476	61	110	.7	16	688	450	1,150	7.9L	5
WC-83A	8	20	9	1-19-72	19- 22	67	19.5	30	.16	.03	84	41	27	.4	500	21	2.3	.4	15	467	380	759	7.9L	5
WC-83B	8	20	9	1-19-72	80- 83	65	18.5	30	2.3	.14	110	42	69	1.4	544	80	52	.3	.1	655	450	1,060	8.0L	5

c/Analysis by Louisiana Division of Health.

INDEX

[Underlined numbers refer to figures]