Water Resources of Red River Parish Louisiana

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WATER RESOURCES OF RED RIVER PARISH, LOUISIANA

By Roy Newcombe, Jr. and Leland V. Page

ABSTRACT

Red River Parish is on the eastern flank of the Sabine uplift in northwestern Louisiana. The area is underlain by lignitic clay and sand of Paleocene and Eocene age which dip to the east at the rate of about 30 feet per mile. The Red River is entrenched in these rocks in the western part of the parish. Alternating valley filling and erosion during the Quaternary period have resulted in the present lowland with flanking terraces.

In the flood-plain area moderate to large quantities of very hard, iron-bearing water, suitable for irrigation, are available to wells in the alluvial sand and gravel of Quaternary age. The aquifer ranges in thickness from 20 to slightly more than 100 feet. It is recharged by downward seepage of rainfall through overlying clay and silt, by inflow from older sands adjacent to and beneath the entrenched valley, and by infiltration from the streams where the water table is below stream level during flood stages or as a result of pumping. Water levels are highest in the middle of the valley. Ground water moves mainly toward the Red River on the east and Bayou Pierre on the west, but small amounts move down the valley. Computations based on water-level and aquifer-test data indicate that the Quaternary alluvium contains more than 330 billion gallons of ground water in storage and that the maximum discharge of ground water to the streams is slightly more than 30 mgd (million gallons per day). At times of high river stage, surface water flows into the aquifer at a rate that depends in part upon the height and duration of the river stage.

Moderate supplies of soft, iron-bearing water may be obtained from dissected Pleistocene terrace deposits that flank the flood plains of the Red River and Black Lake Bayou. However, the quantity of water that can be pumped from these deposits varies widely from place to place because of differences in the areal extent and saturated thickness of the segments of the deposits; this extent and thickness are governed in turn by the amount of erosion the deposits have undergone.

Beds of fine-grained lignitic sands of Tertiary age contain water of generally good quality to depths of 150 to 450 feet. The thinness and low permeability of the sands restrict their development to low-yield wells. Water from these sands in the western part of the parish, where they lie beneath the alluvial valley, is more mineralized than that from the younger Tertiary sands exposed in the east-central area.

Streamflow records have been collected on the principal streams in Red River Parish since 1939. Additional spot low-flow data were obtained on several small streams originating within the parish for a study made in connection with the preparation of this report. Quality-of-water data for streams in the parish were collected on an occasional spot-sampling basis prior to and during this investigation.

The largest source of surface water in the parish is the Red River, which drains approximately 63,400 square miles upstream from the parish. The Red River

has an average flow of about 13,100 cfs (cubic feet per second), or about 8,500 mgd. Many of the streams that drain the upland area are not dependable sources of supply because their flows are not well sustained during dry seasons.

The average annual precipitation over the parish is about 52 inches, of which about 17 inches becomes runoff; this runoff is equivalent to a continuous flow of about 1.25 cfs per square mile. Seasonal and annual runoff varies, but no significant trends have been noticed.

The principal surface-water problems in the parish pertain to flood control, drainage, irrigation, and navigation. Flood problems have been alleviated considerably by the operation of Denison Dam (Lake Texoma), the completion of levees on the Red River, channel improvements on Bayou Pierre, and the completion of Wallace Lake reservoir on Cypress Bayou. There are wet lands along the Red River that would be very productive if properly drained and protected from floods. The main problem in the use of water from Red River is one of distribution—to make the water available to the more remote areas. Bayou Pierre has been pumped dry at times during the irrigation season.

The Red River affords the most dependable source in the area for surface-water supply without artificial storage. Black Lake Bayou has a fairly well-sustained base flow and is the second best source of supply. During the period 1939–54 the minimum recorded flow at the gaging station on Black Lake Bayou near Castor, about 1¾ miles above the north boundary of the parish, was about 4 mgd. Available data indicate that a daily flow of 6.2 mgd may be expected to be equaled or exceeded 98 percent of the time. Many of the other streams in the parish can probably provide a good surface-water supply for small cities if storage facilities are provided. For instance, the average flow of Loggy Bayou near Ninock for the period 1948–55 was about 1,440 mgd, but inasmuch as there were short periods of no flow in every year except one, proper utilization would require storage facilities.

The chemical character of Red River water varies considerably throughout the year. Because it is rather highly mineralized at times, it would not be very suitable for municipal use nor for most industrial uses, except possibly where large quantities of cooling or processing water are needed for once-through processes. However, during the irrigating seasons the water is generally of moderately good chemical quality. The water in the Red River's tributaries is generally low in dissolved solids and in chloride and sulfate. It would be suitable for public supplies without softening, but would probably need treatment to remove color and suspended material.

Only a little surface water is used for domestic or industrial purposes in Red River Parish. Much more surface water is being used for irrigation purposes in the parish.

The demand for suitable water for irrigation is increasing at a rapid rate. Unless more of the high flow of the smaller streams can be stored for use during the irrigation season, additional surface-water supplies, particularly in the area now served by Bayou Pierre water, will have to come from the Red River.

INTRODUCTION

PURPOSE AND SCOPE

A study of the geology and water resources of Red River Parish was undertaken as a part of the program of water-resources investigations by the U.S. Geological Survey in cooperation with the Louisiana Department of Public Works and the Louisiana Geological Survey, Department of Conservation. The purpose of the study was to determine the geologic and hydrologic conditions relating to the occurrence, quality, quantity, and availability of water in Red River Parish.

This report presents an evaluation of the water resources of Red River Parish with respect to present and potential use. It is intended for initial guidance in future development of water supplies in the parish.

LOCATION AND EXTENT OF AREA

Red River Parish is in the northwestern part of Louisiana (pl. 1). It includes an area of 413 square miles in Townships 11 through 14 North and Ranges 7 through 12 West. It is bounded on the north by Caddo, Bossier, and Bienville Parishes, on the east by Bienville and Natchitoches Parishes, on the south by Natchitoches Parish, and on the west by De Soto Parish. The entire western boundary and part of the southern boundary are formed by Bayou Pierre. The eastern boundary is formed mainly by Black Lake Bayou. About two-fifths of the parish (160 square miles) lies in the alluvial valley of the Red River, which flows southeastward through the western part of the parish.

The entire parish has been mapped topographically by the U.S. Geological Survey in cooperation with the Louisiana Department of Public Works, and maps have been published at a scale of 1:62,500 for the Mansfield, Coushatta, Ashland, Hanna, and Campti 15-minute quadrangles.

DEVELOPMENT OF AREA

The 1960 census shows the population of Red River Parish as 9,950, a decrease of 17.9 percent since 1950. In the same period the population of the town of Coushatta increased 12 percent. This apparent shift in population from rural farm to rural nonfarm tends to be confirmed by the statewide trend from rural to urban. Red River Parish is classified as rural, inasmuch as by definition urban areas are those cities, towns, or villages having 2,500 or more inhabitants.

The parish is served by two railroads, four motor freight lines, three passenger bus lines, and a network of federal, State, and parish highways. No airlines serve the parish directly. The Red River is navigable only for light craft having drafts of less than 2 feet, but navigation may develop in the future as a result of the proposed Overton-Red River lateral canal.

The resources of Red River Parish are mainly agricultural, the principal crops being corn and cotton. Timber is grown extensively.

The mineral resources are gravel, oil, and natural gas. Industry includes cotton ginning, lumbering, ice making, processing of dried shrimp and fish, printing, welding, and cutting of poles, piling, and pulpwood.

PREVIOUS INVESTIGATIONS

A general discussion of ground water in Red River Parish is contained in a report by Veatch (1906). The Red River Parish planning report of the Louisiana Department of Public Works (1948) contains brief summaries of ground-water conditions and surface-water resources. A detailed geological report by Murray (1948), covering both De Soto and Red River Parishes, contains geologic maps that have been of much use in this investigation. Data from project borings made by the Corps of Engineers (Kalb, 1950) were used to supplement those obtained during this investigation.

Results of the regular stream-gaging program, carried on for a number of years by the U.S. Geological Survey and published in annual water-supply papers, were available for this study.

ACKNOWLEDGMENTS

A large amount of the information compiled in this study was furnished by well owners and drillers. Gratitude is expressed for their courtesy and cooperation. Special thanks are due the landowners who permitted the drilling of test holes and the running of pumping tests on their property.

Acknowledgment is made of the aid furnished by the agencies cooperating with the U.S. Geological Survey in the continuing program of ground-water investigations in Louisiana. The Louisiana Department of Public Works determined the elevations of many observation wells in Red River Parish. The Louisiana Geological Survey made available its excellent files of electrical logs and other well data, which were invaluable in the preparation of this report.

The author of the surface-water section was assisted in the analysis of data and preparation of illustrations by Mr. Miles L. Eddards.

GEOGRAPHY

LANDFORMS

Three distinct types of landforms are present in this parish: the low-lying flood plains of the meandering Red River in the west and of Black Lake Bayou in the east, the benchlike terraces flanking the flood plains, and the rolling upland of Tertiary rocks in the east-central part (fig. 1).

The flood-plain areas comprise the valleys of the Red River and Bayou Pierre in the western part of the parish and of Black Lake

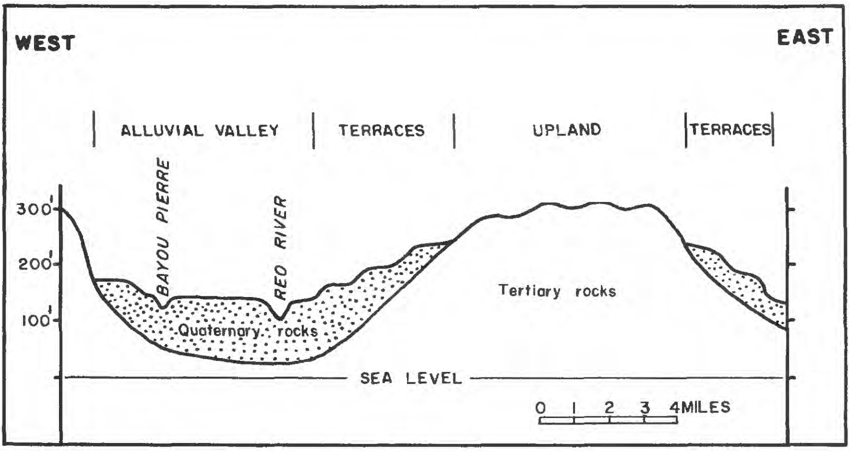

FIGURE 1.—Generalized section showing the topography of Red River Parish.

Bayou on the eastern margin. In these areas the general appearance is that of a featureless plain (fig. 2). At a few places within the Red River flood plain, resistant masses of the older rocks have defied the erosive action of streams and stand as prominent hills.

The terraces, mounting like steps away from the flood plains, are remnants of former flood plains and were formed by deposition, uplifting, and downcutting. The three terraces in Red River Parish are separated from one another by 20- to 75-foot differences in altitude. Along the flood plains the terraces are relatively narrow; however, near the southern end of the parish one terrace reaches a width of 5 miles.

FIGURE 2.—Typical ranch-land topography in Red River Parish.

The rolling surface of the upland underlain by Tertiary rocks contrasts strongly with the broad, flat valleys of the major streams.

RELIEF

The maximum relief in Red River Parish is about 240 feet, the altitude ranging from 90 feet in the Black Lake Bayou flood plain in the southern part of the parish to about 330 feet in the area of exposed Tertiary rock. Local relief is greatest in the dissected Pleistocene terrace deposits that form the eastern wall of the Red River Valley. Here the relief is as much as 80 feet.

Within the area of the Red River flood plain the altitude ranges from 120 feet in the south to 145 feet in the north. The Pleistocene terrace surfaces, like the flood plains, slope toward the south, and within the parish they lie between the altitudes of 140 and 240 feet. In the upland the altitude ranges from 160 feet in the valleys to more than 300 feet on the highest hills.

DRAINAGE

The water-covered area of Red River Parish totals 13 square miles under normal conditions. During times of flood the water area ranges from 2 to 3 times that amount.

There are no large lakes in Red River Parish. The largest of the approximately dozen and a half small lakes is Cannisnia Lake, which straddles the Caddo-Red River Parish boundary. It has an area of approximately half a square mile, of which only about half lies within Red River Parish. The remainder of the lakes, generally having an area of 0.2 square mile or less, have a total area of approximately 1 square mile. These smaller lakes are principally in the Red River bottoms and were, for the most part, formed in old land scars left as the river changed its course numerous times down through the centuries. Swamps or marshes cover a total area of about 10 square miles, the largest single area being approximately 7 square miles in the vicinity of Cannisnia Lake. Small swampy areas in the vicinity of Thorn, Prudhomme, and Turners Lakes, the Cutoff, Robinson, Moss, Lee, and Ida Lakes, and Horseshoe Bayou compose a total of about 3 square miles.

Except for the small hilly upland section bordering Loggy Bayou, and a narrow strip 3 to 5 miles wide consisting of bottom land and a narrow fringe of upland between the east bank of the Red River and U.S. Highway 71, very little of Red River Parish drains directly into Red River, although upstream from Coushatta the river carries the runoff from an area of about 63,400 square miles. Practically all the area west of Red River drains directly into Bayou Pierre, which empties into the Red River about 17 miles downstream from the extreme south end of the parish. Numerous small bayous that once had direct connections to Red River on the west bank have long since been dammed off by construction of flood levees and ditches or have been dredged to divert their flow into Bayou Pierre. The central and major part of the upland area is drained by Grand Bayou, which empties into Black Lake at the southeast corner of the parish. The principal tributary to Grand Bayou is Bayou Chicot, which drains most of the western part of the upland area. The eastern part of the upland area drains directly into Black Lake Bayou, which forms the eastern boundary of the parish. Principal tributaries emptying into Black Lake Bayou are Brushy Creek, Stanley Branch, and Madden Branch via Mill Creek. Plate 1 shows the general drainage pattern.

Bayou Pierre flows along the western boundary of the parish and falls about 32 feet in the 43-mile reach. About 26 feet of this fall is in the 20-mile reach between La Coupe Bridge and Evelyn Bridge (pl. 1). In the 17-mile reach from Evelyn Bridge to the mouth of Bayou Lumbra, where Bayou Pierre leaves Red River Parish, the fall is only about 3 feet when the Red River at the mouth of Bayou Pierre is at average pool stage.

The Red River, which takes a meandering course approximately parallel to Bayou Pierre, falls about 22.5 feet in the 45-mile reach across the parish, the slope being approximately uniform.

Grand Bayou follows a crooked course southward across the central upland area and then veers eastward toward Black Lake near the southern boundary of the parish. It falls about 105 feet in its approximately 32 miles of length in the parish.

Black Lake Bayou falls approximately 37 feet in its crooked 26-mile course along the eastern boundary of the parish. Most of the fall in the stream occurs in the upper two-thirds of its reach—the lower 6 or 8 miles before it enters Black Lake is relatively flat.

The major streams are hydraulically connected with the groundwater reservoirs of the alluvial valleys and thus function as drains of the aquifers. Low-flow discharges of many tributaries such as Loggy Bayou, Grand Bayou, and Brushy Creek consist primarily of groundwater discharge from the rocks of the upland areas.

CLIMATE

Red River Parish lies within the humid zone of the United States. The average annual temperature in the parish is 65 °F, summer temperatures averaging about 80 °F. The mild spring and fall weather is sufficiently warm to afford long growing seasons. Winters are short and mild, the average temperature being 49 °F. Temperatures seldom go below freezing and the average frost-free period is about 230 days. The region has more rainy weather than intense cold. The average annual precipitation during the standard 30-year period, 1921–50, computed by the Theissen polygon method from records for five Weather Bureau stations surrounding the area, is about 52 inches.

As there are no continuous records of temperature and precipitation for stations within the parish, values shown in figures 3, 4, and 6

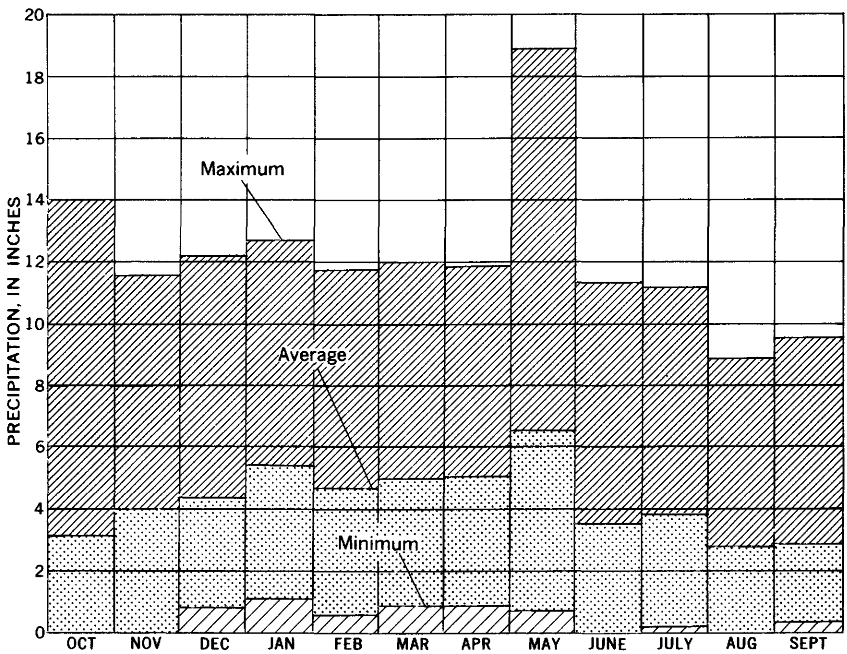

FIGURE 3.—Monthly precipitation in the vicinity of Red River Parish, 1941–55.

were obtained by averaging data for the five nearest stations in neighboring parishes.

Precipitation since 1941 shows a monthly variation, being at a maximum in May and a minimum in August as shown in figure 3, and a year-to-year variation as shown in figure 4. The variation in annual precipitation at Shreveport since 1872, shown in figure 5, indicates that in only 3 years was the precipitation greater and in only 5 years was it less than that recorded since 1941 when rainfall records were started for the five nearest stations in surrounding parishes. At the Shreveport weather station the average annual precipitation for the standard 30-year period, 1921–50, was 45.1 inches.

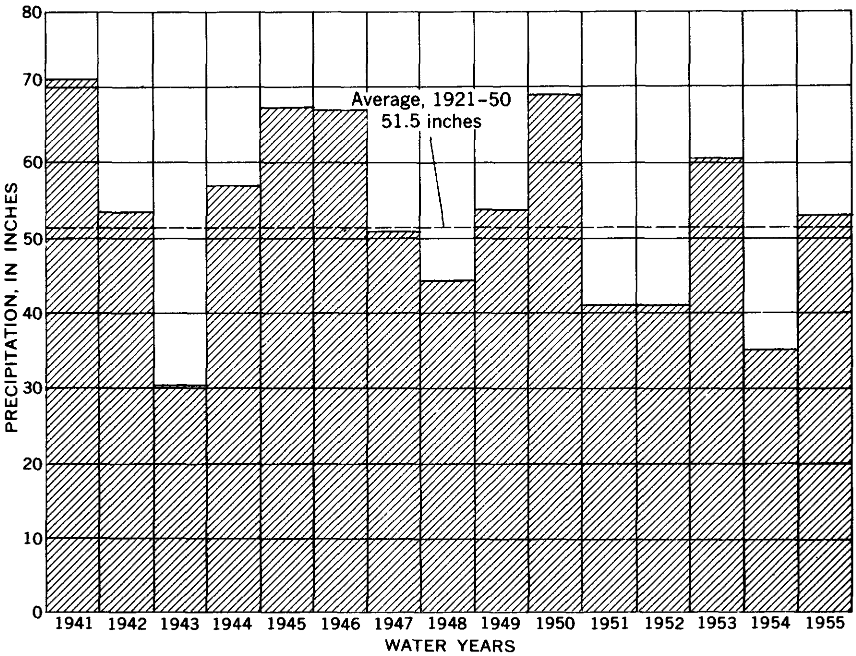

FIGURE 4.—Annual (water-year) precipitation in the vicinity of Red River Parish, 1941–55.

During the 5-year period 1951–55 the annual precipitation in Red River Parish ranged from about 30 to about 60 inches. Such great variation in rainfall has a pronounced effect on water levels in the aquifers of Red River Parish and on the flow in surface streams. During periods of below-normal rainfall the quantity of water available from shallow dug wells is severely reduced, particularly in the upland areas.

Maximum, minimum, and average monthly air temperatures plotted on figure 6 show that the highest average monthly air temperature generally occurs in August and the lowest in December or January. The maximum range in monthly temperature throughout the year is nearly 50° F.

VEGETATION

The humid climate and long growing season favor the luxuriant growth of many types of vegetation. The alluvial soils of the Red River Valley support a rapid and heavy growth of pasture grasses and row crops, and a nearly constant problem is the clearing of drainage ditches of choking weed growth. There are some swampy areas in the parish, but not as many as in the parishes farther south. In the lowlands there is an abundant forest growth of cypress and hardwood trees.

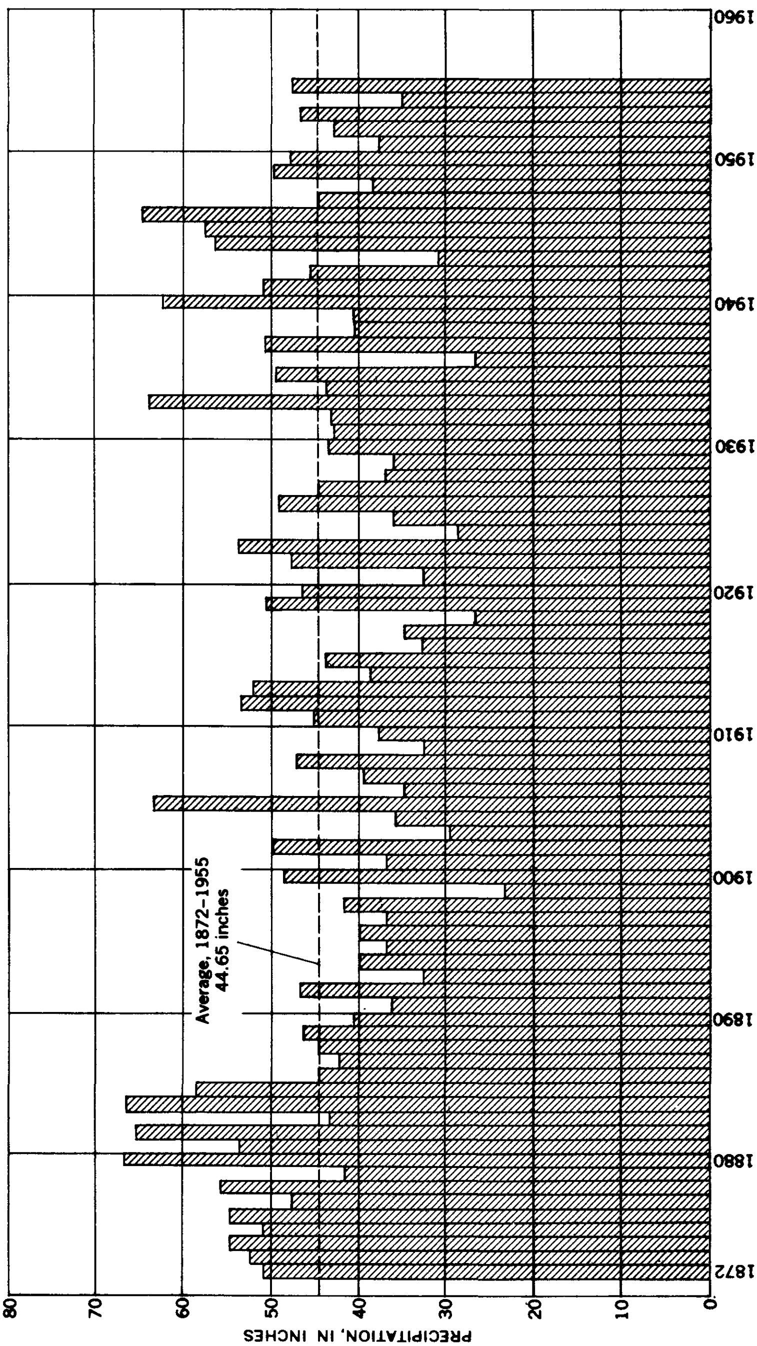

FIGURE 5.—Annual precipitation at Shreveport, La., 1872–1955.

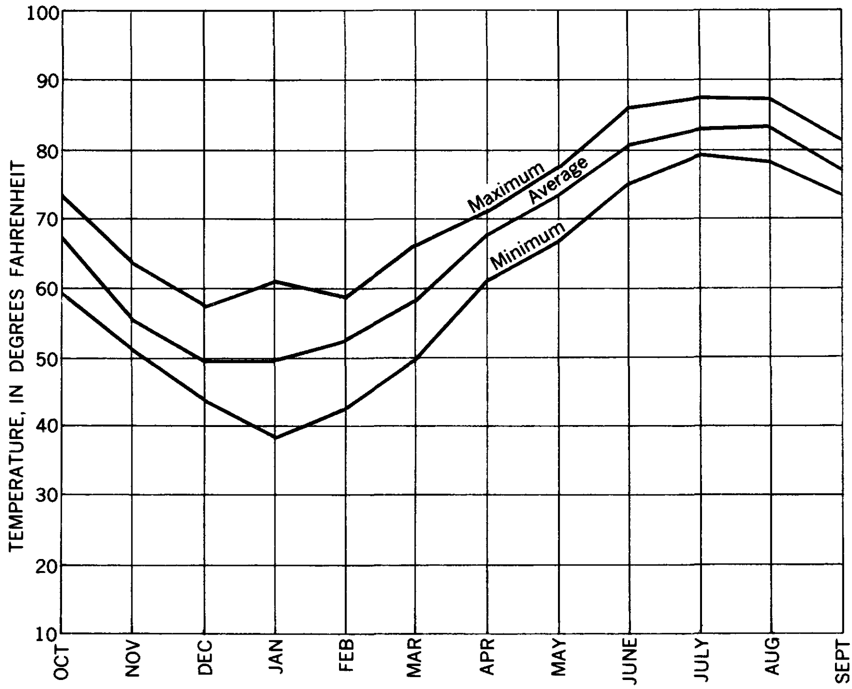

FIGURE 6.—Summary of monthly air temperature in Red River Parish, 1941–55.

The hilly three-fifths of the parish has thin sandy and clayey soils and is not suitable for intensive agricultural development. However, the upland supports large tracts of pine and scrub oak, the pine being an important resource.

OCCURRENCE AND GENERAL PROPERTIES OF WATER

HYDROLOGIC CYCLE

Precipitation is the source of practically all fresh-water supply. Precipitation is condensed moisture from the atmosphere falling on the earth in the form of rain, snow, hail, or sleet. In the never-ending cycle of water circulating from the clouds to earth and back again, part of the precipitation returns directly to the atmosphere through evaporation and transpiration, commonly considered together as "evapotranspiration," part runs directly off the land into natural waterways on their way to the sea, and the remainder seeps into the ground and becomes stored in the interstices of soil and rock formations. The ground water later is discharged by seepage or spring flow into bodies of surface water, by evapotranspiration, and by withdrawal from wells. The hydrologic cycle is extremely complicated and is affected and controlled by precipitation, temperature,

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type of soil, topography, vegetal cover, and geology. Figure 7 is a pictorial representation of this cycle.

Of Red River Parish's long-term average annual precipitation of approximately 52 inches, about 16 inches runs off in small streams and bayous that flow into the Red River. The remainder evaporates or is transpired by vegetation.

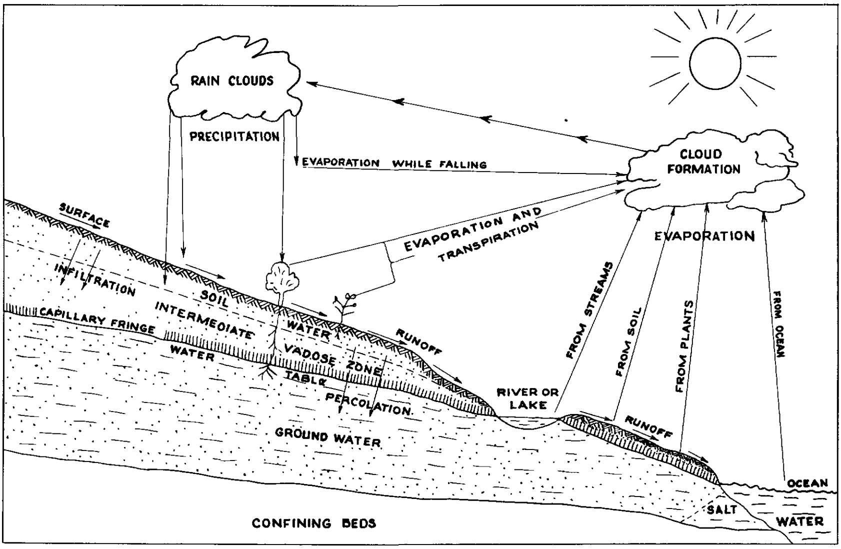

FIGURE 7.—Pictorial representation of hydrologic cycle.

SIGNIFICANCE OF CHEMICAL AND PHYSICAL CHARACTERISTICS

It is generally impossible to evolve a single standard that would meet all chemical, physical, or sanitary requirements for the varied uses of water. Water that meets the requirements of one user may be unsatisfactory for another. It is convenient in this report to divide potential use into three broad classes—agricultural, domestic, and industrial. The total concentration of soluble salts and the type and characteristics of the constituents are essential considerations in water that is used for irrigation, which is an important agricultural use. The domestic consumer is concerned primarily with bacterial and sanitary characteristics and hardness, as well as with iron, manganese, fluoride, sulfate, and nitrate content. The total mineral content, hardness, alkalinity, hydrogen-ion concentration, organic and inorganic impurities, color, corrosiveness, and temperature are primary factors in determining the value of water for industrial use.

Four major characteristics determine quality of water for irrigation: the total concentration of soluble salts; the concentration of sodium and the sodium-adsorption-ratio; the concentration of bicarbonate; and the occurrence of minor elements, such as boron, in amounts that are toxic. Slightly saline water can be used for irrigation if leaching and drainage are provided to remove dissolved salts that would otherwise accumulate in the root zone or in the subsoil immediately below.

The sodium-adsorption-ratio (SAR) is related to the adsorption of sodium by the soil. The ratio is used for soil extracts and irrigation waters to express the relative activity of sodium ions in exchange reactions with soil. The SAR provides an estimate of the sodium or alkali hazard and reportedly is more significant for interpreting water quality than the percent sodium (proportion of sodium to principal cations—calcium, magnesium, sodium, and potassium).

The chemical constituents of water are reported in analyses in terms that state their concentration in the water. These terms are "parts per million" and "equivalents per million" and are defined as follows:

One part per million (ppm) is a unit weight of a constituent present in a million unit weights of water. (Some laboratories report constituents in grains per gallon, but this practice is gradually being superseded by the more convenient expression of parts per million. Results expressed in parts per million can be converted to grains per gallon by multiplying by 0.0584; conversely, grains per gallon can be converted to parts per million by multiplying by 17.1.)

Equivalents per million (epm) expresses concentration in terms of chemical equivalents and is the number of unit equivalent weights of an ion in 1 million unit weights of the water. An equivalent weight of a substance is the weight that is exactly equivalent to one atomic weight (1.0080 grams) of hydrogen. The equivalents per million for each constituent are calculated by dividing its concentration in parts per million by its equivalent weight. For example, 100.16 ppm of calcium divided by its equivalent weight (20.04) amounts to 5 epm of calcium. Equivalents per million are useful in expressing chemical combinations as well as in expressing analyses graphically because one equivalent of an anion, such as chloride, combines with one equivalent of a cation, such as sodium, to form one equivalent weight of the compound sodium chloride, or common salt.

Maximum acceptable concentration limits for some of the chemical constituents commonly found in water have been established by the U.S. Public Health Service (1946). These standards, which apply to drinking water used in interstate traffic and where Federal quarantine regulations apply, are expressed in parts per million by weight as follows:

	Parts per million
Iron and manganese (Fe+Mn)	0.3
Magnesium (Mg)	125
Sulfate (SO_4)	250
Chloride (Cl)	250
Nitrate (NO_3)	[1] 44
Fluoride	1.5
Dissolved solids	[2] 500

[1] National Research Council, 1950; not a part of the U.S. Public Health Service 1946 Drinking Water Standards.

[2] 1,000 ppm permissible when water of better quality is not available.

Iron and manganese in concentrations of more than a few tenths of a part per million are objectionable for domestic purposes because they stain fixtures, utensils, and fabrics. Although iron seldom occurs in solution in surface water in sufficient quantity to be objectionable, it is commonly present in solution in ground water and precipitates as a rust-colored deposit as it rapidly oxidizes on contact with air. Calcium and magnesium are the principal constituents causing hardness of water. Water containing large quantities of magnesium in conjunction with sulfate (epsom salt) has saline cathartic properties. Drinking water containing more than about 500 ppm of chloride has a perceptible salty taste to most persons.

High fluoride concentration in water used regularly by children is associated with mottled dental enamel. However, the consumption of water that contains small quantities of fluoride during the period of calcification or formation of the teeth is known to lessen the incidence of tooth decay (Dean, 1936). The American Dental Association, the U.S. Public Health Service, and many State and local health agencies recommend about 1.0 ppm fluoride in drinking water. The maximum concentration permissible is 1.5 ppm.

Hardness does not necessarily make water unusable but it may be troublesome. It is the property of water generally recognized by the increased quantity of soap required to produce a lather or by the deposit of insoluble salts formed when the water is heated or evaporated. Hard water is objectionable in the home because it leaves deposits on utensils in which it is used and increases soap consumption. The use of hard water also causes objectionable scale in boilers, water heaters, radiators, and pipes, and results in reduction in flow and heat transfer; it may cause boiler failure. There is an advantage in having a small amount of calcium bicarbonate in water, however, because it tends to form a protective coating on pipes and other equipment. It is generally agreed that water having a hardness of more than 200 ppm is very hard.

Carbonate (temporary) hardness is caused by the calcium and magnesium equivalent to the bicarbonate and carbonate in a water; the remainder of the hardness is noncarbonate (permanent) hardness. Carbonate hardness is removed by boiling, whereby the calcium is precipitated as calcium carbonate.

Industry is often more concerned with quality of water than with quantity, for it may cost more to treat the water than to develop the original supply. Uniformity in quality of the water is usually as necessary as special chemical characteristics. General requirements of water quality for various types of industry are given in table 1.

Turbidity of water due to suspended material such as silt, clay, finely divided organic material, microscopic organisms, and other matter is objectionable in many ways. Besides the obvious objections to it, suspended solids are abrasive to pumps, turbine blades, and valves.

Iron and manganese are objectionable in water for several reasons. Oxidized iron and manganese are very slightly soluble in alkaline solutions; consequently, precipitation of these oxides may interfere with a process by producing turbidity. Iron and manganese also form colored complexes with several organic and inorganic substances. Aluminum, iron, and certain other metals are objectionable in process and wash waters used for the manufacture of photographic film.

The dissolved-solids content, or residue on evaporation, indicates the total mineralization of the water. High dissolved-solids concentration may be closely associated with the corrosive property of water, particularly if chloride is present in appreciable quantities. Water having high concentrations of magnesium chloride may be very corrosive to some metals because the hydrolysis of this salt yields hydrochloric acid.

Specific conductance is a measure of the capacity of water to conduct an electrical current. Conductance increases with the quantities of dissolved mineral constituents and the degree of ionization of these constituents, as well as with the temperature of the water. It is useful as a general indication of the degree of concentration of mineral matter in water.

Hydrogen-ion concentration, expressed as pH, denotes the acidic or alkaline properties of a water. Ordinarily, water having a pH of 7.0 is regarded as neutral; a pH value of less than 7.0 indicates acidic properties, and a pH greater than 7.0 indicates alkaline properties.

Water used for boiler feed must meet exacting quality requirements. The characteristics of water desired for boiler operation are given in table 2. High-pressure steam boilers demand water from which almost all organic and inorganic solids have been removed. Even traces of silica are objectionable.

TABLE 1.—*Suggested water-quality tolerances in industry*

[After Moore (1940, p. 271). Color in units on standard cobalt-platinum scale; odor (taste) in terms of degree, that is, high, medium, low; other tolerance factors in parts per million]

Industry or use	Turbidity	Color	Hardness as $CaCO_3$	Iron as Fe	Manganese as Mn	Iron and manganese	Total solids	Aklalinity as $CaCO_3$	Odor (taste)	Hydrogen sulfide	Other requirements
Air conditioning				0.5	0.5	0.5			Low	1	No corrosiveness, slime formation.
Baking	10	10		.2	.2	.2			Low	.2	Potable water.[1]
Brewing:											
Light beer	10			.1	.1	.1	500	75	Low	.2	Potable water.[1] NaCl less than 527 ppm (pH 6.5–7.0).
Dark beer	10			.1	.1	.1	1,000	150	Low	.2	Potable water.[1] NaCl less than 275 ppm (pH 7.0 or more).
Canning:											
Legumes	10		25–75	.2	.2	.2			Low	1	Potable water.[1]
General	10			.2	.2	.2			Low	1	Potable water.[1]
Carbonated beverages	2	10	250	.2	.2	.4	850	50–100	Low	.2	Potable water.[1] Organic color plus oxygen consumed less than 10 ppm.
Confectionery				.2	.2	.2	100		Low	.2	Potable water.[1] pH above 7.0 for hard candy.
Cooling	50		50	.5	.5	.5				5	No corrosiveness, slime formation.
Food, general	10			.2	.2	.2			Low		Potable water.[1]
Ice	5	5		.2	.2	.2			Low		Potable water.[1] SiO_2 less than 10 ppm.
Laundering			50	.2	.2	.2					Potable water.[1]
Plastics, clear uncolored	2	2		.02	.02	.02	200				
Paper and pulp:											
Groundwood	50	20	180	1.0	.5	1.0					No grit, corrosiveness.
Kraft pulp	25	15	100	.2	.1	.2	300				
Soda and sulfite	15	10	100	.1	.05	.1	200				
High-grade light papers	5	5	50	.1	.05	.1	200				
Rayon (viscose), pulp production	5	5	8	.05	.03	.05	100	Total 50; hydroxide 8.			Al_2O_3 less than 8 ppm, SiO_2 less than 24 ppm, Cu less than 5 ppm.
Manufacture	.3		55	.0	.0						pH 7.8 to 8.3.
Tanning	20	10–100	50–135	.2	.2	.2		Total 135; hydroxide 8.			
Textiles:											
General dyeing	5	5–20		.25	.25	.25	200				Constant composition. Residual alumina less than 0.5 ppm.
Wool scouring		70		1.0	1.0	1.0					
Cotton bandage	5	5		.2	.2	.2			Low		

[1] Conforming to U.S. Public Health Service standards.

TABLE 2.—*Characteristics of water desired for boiler operation*
[After Moore, 1940]

Characteristic or constituent	Allowable limits (parts per million)			
Pressure lbs per sq in	0–150	150–250	250–400	Over 400
Turbidity (silica scale)	20	10	5	1
Color cobalt platinum scale units	80	40	5	2
Oxygen consumed	15	10	4	3
Dissolved oxygen [1]	1.4	.14	.0	.0
Hydrogen sulfide (H_2S) [2]	5	3	0	0
Total hardness as $CaCO_3$	80	40	10	2
Sulfate-carbonate ratio (A.S.M.E.) (Na_2SO_4: Na_2CO_3).	1:1	2:1	3:1	3:1
Aluminum oxide (Al_2O_3)	5	.5	.5	.1
Silica (SiO_2)	40	20	5	1
Bicarbonate (HCO_3) [1]	50	30	5	0
Carbonate (CO_3)	200	100	40	20
Hydroxide (OH)	50	40	30	15
Total solids [3]	3,000–500	2,500–500	1,500–100	50
pH value (minimum)	8.0	8.0	9.0	9.6

[1] Limits applicable only to feedwater entering boiler, not to original water supply.
[2] Except when odor in live steam would be objectionable.
[3] Depends on design of boiler.

GEOLOGY

By ROY NEWCOME, JR.

The rocks exposed in Red River Parish consist of clay, sand, and some gravel; they range in age from early Tertiary to Recent. The Tertiary (Paleocene and Eocene) strata have been cut by deep valleys which were subsequently filled with Quaternary alluvium. At the present time the streams are flowing in valleys entrenched in the clay and sand of their own deposition.

SUMMARY OF STRATIGRAPHY

TERTIARY ROCKS

PREVIOUS CLASSIFICATIONS

The Tertiary rocks exposed in the east-central part of the parish and covered elsewhere by Quaternary alluvium have long been considered as belonging to the Wilcox group of Eocene age, which comprises the sedimentary rocks between the Claiborne group of Eocene age above (not present in Red River Parish) and the Midway group of Paleocene age below (table 3).

Murray (1948, p. 83) referred to the discovery of Midway fossils in strata formerly classed as Wilcox. On the basis of that evidence, the contact between the Midway and Wilcox groups was placed about 800 feet higher than previously. Murray divided the redefined Midway group into five formations which, in order of deposition, were named the Kincaid, Porters Creek, Naborton, Logansport, and Hall Summit. The Kincaid and Porters Creek, of calcareous lignitic clay, were already included in the Midway group. According to Murray each of the Naborton, Logansport, and Hall Summit formations

TABLE 3.—*Classifications of sedimentary*

Early classification			Proposed by Murray (1948)					Proposed by	
System	Series	Formation	Series	Group	Formation	Member	Average thickness (feet)	Series	Stage (age)
Quaternary			Recent	Recent	Recent	Alluvium			
	Pleistocene	Terrace deposits	Pleistocene		Prairie				
					Montgomery				
					Bentley				
Tertiary	Eocene	Wilcox	Eocene	Wilcox	Marthaville	Not named	100	Eocene	Sabine
							50		
							100		
			Paleocene	Midway	Hall Summit	Bistineau	100	Paleocene	Midway
						Grand Bayou	50		
						Loggy Bayou	50		
					Logansport	Lime Hill	200		
						Cow Bayou	90		
						Dolet Hills	50		
					Naborton		200		
	Paleocene	Midway			Porters Creek		600		
					Kincaid		30		
Cretaceous	Gulf	Navarro	Gulf	Navarro	Arkadelphia		50		

represents a depositional cycle that includes a basal sand phase, a middle lignitic shale phase, and an upper calcareous silt and shale phase. The overlying Wilcox group was subdivided by Murray into the Marthaville, Pendleton, and Sabinetown formations, of which only part of the lower unit, the Marthaville, was mapped in Red River Parish.

Only a part of the total thickness of the Naborton formation is exposed in the Sabine uplift. The exposed part of the formation was described by Murray but not divided into named members.

In the overlying Logansport formation Murray observed three well-defined members to which he gave the names Dolet Hills (1948, p. 105–110), Cow Bayou (p. 110–115), and Lime Hill (p. 117–122), in *rocks in Red River Parish*

Murray (1955)		Classification used in this report				
Group	Formation	Series	Group	Formation	Thickness (feet)	Water-bearing characteristics
		Recent		Alluvium	0–40	Mostly red silt and clay. Little water available.
		Pleistocene		Valley alluvium, terrace deposits	40–100	Large supplies of hard, iron-bearing water available to wells less than 100 ft deep in Red River Valley. Yields of 1,000 gpm or more from large-diameter wells. Moderate supplies of soft, slightly acidic water containing iron available to wells less than 100 ft deep. Yields may be as high as 500 gpm from large-diameter wells.
Wilcox	Marthaville	Eocene	Wilcox	Marthaville (of Murray, 1948)	500 (Maximum)	Small to moderate supplies of soft water available to a depth of 150 ft. Probable maximum yield 100 gpm from 4-in. wells. Marthaville formation (of Murray, 1948) yields may be higher, but water is high in iron. These sediments contain most of the fresh water in Tertiary rocks in Red River Parish.
	Hall Summit			Undifferentiated		
	Logansport			Dolet Hills	50–125	
	Naborton	Paleocene		Naborton	150–200	Small supplies of soft water available generally to a depth of 200 ft in valley. Probable maximum yield 50 gpm from 4-in. well. Water high in chloride in valley area.
Not named	Porters Creek		Midway	Porters Creek, Clayton	700–900	No water available to wells.
	Clayton					
				Arkadelphia Marl	0–60	No fresh water indicated on electrical logs.

the order of deposition. According to Murray each member is a part of a depositional cycle, the Dolet Hills being the basal sand, the Cow Bayou a lignitic shale phase, and the Lime Hill a calcareous silt and shale phase marking the end of the cycle.

The Hall Summit formation of Murray (1948), next above the Logansport, also contains three members, to which he gave the names Loggy Bayou (p. 129–130), Grand Bayou (p. 130–131), and Bistineau (p. 132–134), again following the order outlined for the depositional cycle.

The Marthaville formation of Wilcox age also seems to represent a depositional cycle, but Murray did not divide the formation into members. The generalized geologic map (pl. 2) shows the approximate distribution of Tertiary and younger rocks. Plate 3 is a map showing the general distribution of Tertiary rocks prior to Quaternary deposition.

In 1955 Murray proposed the terms Midway and Sabine stages (ages) as provincial time-rock and time units, and applied the term Wilcox group to the lignitic clay and sand deposits of his Sabine stage and the upper part of his Midway stage; he thus returned the lower boundary of the Wilcox to its original position at the top of the Porters Creek clay. At this time he also substituted the name "Clayton" for his 1948 use of "Kincaid" for the oldest formation of the Midway group (table 3).

CLASSIFICATION USED IN THIS REPORT

Some controversy has arisen regarding the location of the contacts between the Paleocene and Eocene time units and the Midway and Wilcox rock units. As subsurface evidence obtained in this study and the findings of Durham and Smith (1958) conform more reasonably with the earlier rock classification than with those proposed by Murray (1948; 1955), the contact between the two rock groups is placed at the top of the Porters Creek clay. The Paleocene-Eocene boundary, however, is placed within the Wilcox group on the basis of reported fossils.

Practically all correlations used in this report were made on the basis of studies of electrical logs, there having been insufficient time to make a detailed surface study of the rocks. The electrical logs were supplemented by samples from two geologic test holes and three oil-test holes and by the drillers' logs of several water wells. In electrical logs of oil-test holes in the region the most easily correlated point is the contact between the thick clay interval representing the Clayton and Porters Creek formations and the underlying predominantly calcareous and sandy beds of Cretaceous age. As the Porters Creek clay contains no significant sand beds, the sandy sequence easily discernible above the 700- to 900-foot clay interval marks a change in deposition at the contact with the overlying Naborton formation. This contact is easily traceable throughout the parish on electrical logs.

Plate 4 is a contour map showing the altitude of the top of the Porters Creek. The top of the Porters Creek is the youngest formational contact that can be traced throughout the subsurface of the parish, because it has been cut by erosion only in a small area underlying the Red River flood plain. It is also the lower limit at which fresh ground-water supplies may be obtained in the parish.

The relative positions and thicknesses of the formations are shown on a geologic cross section (pl. 5) that extends northeastward across the center of the parish. Electrical logs indicate an average thickness of 750 feet for the Clayton and Porters Creek. This is somewhat more than the thickness stated by Murray (table 3).

The units designated the Naborton formation and Dolet Hills member of the Logansport formation by Murray are easily recognized and traceable in the subsurface in Red River Parish. By definition, the sands directly overlying the Porters Creek clay form the lower part of the Naborton formation, and the first massive sand above the clayey upper part of the Naborton is the Dolet Hills. However, the other members of Murray's Logansport and Hall Summit formations cannot be distinguished sufficiently well in the subsurface to conform with the descriptions, geologic map, and cross sections of Murray's report. Accordingly, the Naborton formation, averaging 180 feet in thickness, is used in this report as defined by Murray, but because the name Logansport is preempted and because of the doubtful validity of some of Murray's nomenclature, the Dolet Hills sand of Murray, 50 to 125 feet in thickness, has been assigned formational status, and is so used in this report. The above-described assignment of the Naborton and Dolet Hills units was made with the concurrence of the Louisiana Geological Survey.

Sediments younger than those already mentioned are incompletely represented on electrical logs because they lie at shallower depths than are generally recorded by the logs. The maximum thickness of these rocks in Red River Parish is 500 feet. They are undifferentiated in this report, although further detailed investigation may corroborate the presence near the eastern margin of the parish of Murray's Marthaville formation, the base of which is considered to mark the Paleocene-Eocene time boundary.

QUATERNARY ROCKS

PLEISTOCENE TERRACE DEPOSITS

Clay, sand, and gravel deposits of controversial origin and mode of deposition flank the flood plains of the Red River and Black Lake Bayou in the form of terraces and underlie the alluvium of the present valleys. The surface of each terrace deposit is a remnant of a former flood plain, the streams having dissected each in turn as uplift forced them to deepen their channels. Three such surfaces remain in this parish. Successive terrace surfaces are 20 to 75 feet apart vertically and dip toward the Gulf of Mexico at 0.75 to 2.5 feet per mile (Murray, 1948, p. 25). The terrace deposits have generally been considered to be of Pleistocene age, although some workers believe that at least part of the material is of Pliocene age.

The mechanics of entrenchment and later filling of the Red River Valley are considered analogous to those in the Mississippi Valley and underlying alluvium; therefore, the controversies that have arisen apply to both examples. Some points in question are (a) the time of entrenchment of the valleys (whether during the Pleistocene epoch or before); (b) the time and conditions of valley filling; (c) the mechanics of deposition; and (d) the extent to which sediments once present have been removed from the trenches. The different theories on these questions were presented by Fisk (1938) and Trowbridge (1954) and are not repeated here.

The terrace deposits in southern Louisiana have proved to be an important source of ground-water supply, and large supplies have been developed in some areas, particularly for rice irrigation. There has been little such development in Red River Parish, where the deposits are thinner and more highly dissected by streams; however, here the terrace deposits are important as a source of sand and gravel for construction purposes. Louisiana Geological Survey Bulletin 19 contains a discussion of the terrace sands and gravels, together with descriptions and production figures of many commercial deposits.

VALLEY ALLUVIUM

The present-day Red River flows in a channel entrenched in alluvial material. The original valley of the river was cut into the Tertiary rocks now exposed only in the east-central part of the parish and in neighboring parishes. During subsequent elevations of sea level the old valley was flooded and filled with sediments. After a lowering of sea level the river's bed was many feet above the original valley floor. Further uplifts of the land or subsidences of sea level caused the river to deepen its valley, each time leaving the preceding flood plain as a terraced surface flanking the new valley. Each time the gradient decreased the river began to meander, and thus to widen its valley by cutting back the flanking terrace deposits.

At the present time the entrenched valley in Red River Parish contains an average of 80 feet of alluvial material grading from gravel or coarse sand at its base up through progressively finer sand and silt into clay. The changes in texture are so gradational that it is difficult to delineate them; however, a general line can be drawn between the clay and silt above and the sand and gravel below.

The sections in plate 6 and the fence diagram in plate 7 show that the surface configuration of the Tertiary rock underlying the entrenched valley is very uneven in places, likely owing to the differential resistance to erosion of the rock and to the local structural anomalies. Couchanda Hill, the prominent monadnock west of Armistead, has had a pronounced effect on the depth of alluvium in its vicinity. Apparently at one time the Red River was deflected to the west by the hill, which is composed of relatively resistant materials.

This deflection forced the river to flow for a time in the narrow channel now occupied by Bayou Pierre. The increased velocity caused by this constriction resulted in the scouring of a deep depression in the underlying Tertiary rocks. Later deposition filled the valley with alluvium and the depression became a catchment basin for the coarser materials. Nearly 35 feet of gravel accumulated in the depression west of Couchanda Hill (pls. 6, 7).

The coarse sediments forming the lower part of the alluvial fill in the Red River Valley and the sand of the Pleistocene terrace deposits possibly all represent Pleistocene deposition. The tentative correlations of the terrace material with that in the entrenched valley as shown in the cross sections of plate 6 are based upon inconclusive data; however, the physical similarity of the materials and their present relative positions suggest that such a correlation may be logical.

The flood plain of Black Lake Bayou is underlain by about 40 feet of yellow and tan clay, silt, and sand which contrast with the red and gray sediments in the Red River Valley.

STRUCTURE

The most important structural feature in northwestern Louisiana is the Sabine uplift, a structural dome having its point of greatest uplift in Caddo Parish but having a subordinate crest in eastern De Soto Parish (fig. 8). Truncation of the dome by subsequent erosion left the oldest rocks exposed at the center and circled by outcrops of progressively younger rocks. The dip of the strata in Red River Parish is generally eastward at 20 to 125 feet per mile, as shown in plates 4 and 5. The reversal of dip at the eastern boundary of the parish is caused by a small structural dome centered in southern Bienville and northern Natchitoches Parishes.

The accumulation of petroleum in many oil fields of the region is associated with faulted structures (Murray, 1948); however, there is no definite evidence of faults in the near-surface formations.

GROUND-WATER RESOURCES

By Roy Newcome, Jr.

METHOD OF STUDY

Fieldwork in the ground-water investigation was started in June 1954 by D. T. Sperry and continued in January 1955 by the writer. Records of existing water wells were obtained as an aid in ascertaining the depths to water-bearing strata, the quantity and quality of the water, and the methods used in developing wells. In selected wells the water levels were measured periodically to determine the relation

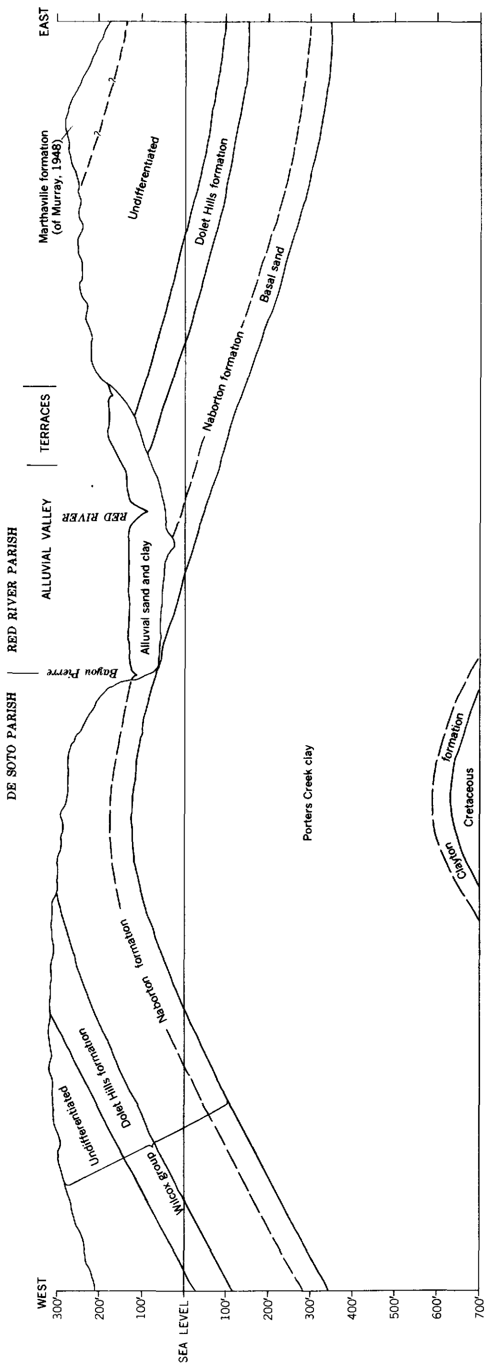

FIGURE 8.—Generalized section across the Sabine uplift in Red River and De Soto Parishes.

of ground-water levels to precipitation, streamflow, and other influences. To aid in these determinations an automatic water-stage recorder was installed in an unused well (RR–66) owned by the town of Coushatta.

Available data indicated that the sand and gravel underlying the flood plain of the Red River composes the most productive ground-water reservoir in Red River Parish. In order to obtain accurate data on this important aquifer, 18 test holes were augered into the flood plain. The test holes were put down to a maximum depth of 100 feet along four lines crossing the valley. In most places the alluvial clay, silt, sand, and gravel were completely penetrated and the holes bottomed in the underlying lignitic clay and silt of Tertiary age. Samples of the augered material were collected for microscopic examination and grain-size analysis. Plate 8 shows the location of the augered holes and of borings made by the Corps of Engineers, New Orleans District.

In addition to providing important geologic information, the augered holes, when fitted with small-diameter pipes and screens, served as observation wells for the periodic measurement of water levels. Because of the type of pump installation it generally was not possible to measure water levels in privately owned wells; thus, the water-level data obtained from the augered holes were of great value in determining the occurrence and movement of ground water in the flood-plain area.

Geologic data were obtained also from two holes, RR–160 and Na-269, augered through the flood-plain deposits of Black Lake Bayou near the eastern margin of the parish and from two privately contracted 300-foot holes (RR–110 and –111) drilled into the Tertiary bedrock east of the Red River Valley.

Samples of water were collected from selected wells in the various aquifers for analysis to ascertain the chemical quality of the ground water (table 11).

Pumping tests were made on a few large-diameter (greater than 4 inches) irrigation and municipal wells and on a few low-yield wells.

WELL-NUMBERING SYSTEM

The system of well designation used in this report involves, for each well, a symbol for the parish followed by a number; thus, for well RR–12 the symbol "RR" is the abbreviation for Red River Parish and "12" is the number assigned to the well in the files of the U.S. Geological Survey.

Some records of project borings made by the Corps of Engineers (Kolb, 1950) also are included in this report. Their numbers are the same as given in the cited report, but have been prefixed by an "E"—for example, RR–E–3.

Where wells are shown on maps and tables containing parish names and boundaries, the parish abbreviation is ordinarily omitted to avoid congestion. (See well-location map, pl. 8, and list of well records, table 13.)

SOURCE

Ground water in Red River Parish is of meteoric origin—that is, it is precipitation that has found its way into the aquifers.[1] Water enters the aquifers of the parish principally by (a) vertical seepage directly into the sands or through overlying clay and silt, and by (b) inflow from adjacent aquifers. Recharge from streams occurs intermittently at times of high water.

Salty water, possibly from deep bodies of connate water associated with salt domes or from deep artesian aquifers, occurs as a contaminant in the near-surface aquifers in some localities, generally near oil fields. The salty water may have reached the surface by traveling along faults; however, the scarity of evidence for faulting at shallow depths implies another means of entry. It is possible that incompletely plugged oil wells allow the salty water, which is under artesian pressure and in places gas pressure, to rise into the fresh-water-bearing sands or that the salty water percolates upward through the intervening Porters Creek clay. Lowering of the artesian head in fresh-water aquifers may permit the inflow of highly mineralized water from other aquifers or from points downdip in the same aquifer.

OCCURRENCE

Water that escapes surface runoff and evapotranspiration moves downward from the land surface into underlying rocks until it reaches the water table, which marks the upper limit of the zone of saturation—the zone in which all voids are filled with water under hydrostatic pressure. The water levels in shallow wells mark the position of the water table, and the ground water is said to occur under water-table conditions.

In places, relatively impermeable beds (called "confining beds") prevent or impede the downward seepage of water into more permeable rocks. These rocks may receive recharge in other areas where they crop out or are covered by permeable material. As water moves laterally through these rocks to points of discharge it becomes confined under pressure beneath the overlying less permeable material. The

[1] An "aquifer" is defined (Meinzer, 1923) as a "rock formation or stratum that will yield water in sufficient quantity to be of consequence as a source of supply."

water levels in wells drilled through the confining beds thus rise above the base of the confining bed. Such conditions of ground-water occurrence are termed "artesian." An imaginary surface that coincides with the static levels in an artesian aquifer is the artesian-pressure surface, or "piezometric surface" (fig. 9).

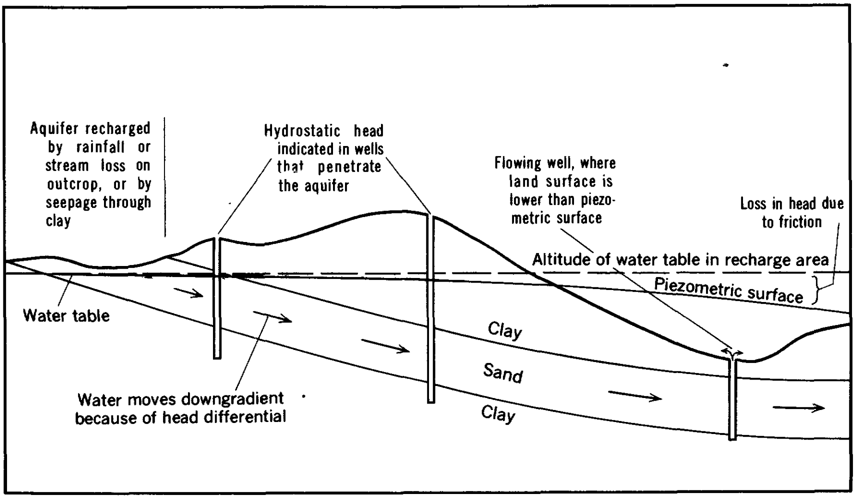

FIGURE 9.—Diagram illustrating the occurrence of ground water.

Ideal examples of water-table conditions are seldom found in nature, and in many places a combination of water-table and artesian conditions exists owing to the presence of a somewhat permeable, or "leaky," confining bed overlying the aquifer. The occurrence of water under such conditions may be termed "semiartesian," and the water level in wells is approximately the same as the upper surface of the zone of saturation. However, when water is pumped from the lower, more permeable material, the difference in the ability of the two materials to transmit water may be so great that the upper bed has the characteristics of a confining bed. With continued pumping the confining effect of the upper bed may become less and less, and the entire saturated part will function as a water-table aquifer.

An aquifer can receive water by leakage through an underlying confining bed as well as through an overlying one. Deeper aquifers may contain water under artesian pressure sufficient to percolate to higher aquifers, even through many feet of clay.

In Red River Parish, water-table conditions exist in the outcrop areas of sands of Tertiary age and locally in Pleistocene terrace sands where they are not overlain by clay. Artesian conditions occur in the Tertiary aquifers downdip from their areas of outcrop and in the alluvium of the Red River Valley. In the valley aquifer, initial

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pumping effects are typical of those in an artesian aquifer, but prolonged pumping induces drainage from overlying fine-grained material. During pumping tests that have been made in the alluvium, no conversion to full water-table conditions has been indicated, however.

RECHARGE

To transmit and yield water perennially an aquifer must have a source of replenishment. This replenishment is called "recharge," and the place where replenishment occurs is a "recharge area." Vertical seepage into the sands and infiltration from streams and from other aquifers serve as the means of recharge for the aquifers in Red River Parish. It is important to determine the type of recharge and the location of recharge areas as an aid in ascertaining the quantity of ground water available. For example, a sand recharged by a stream that goes dry in the summer might not support large yields when most needed. Likewise, a sand recharged by polluted water or water containing undesirable minerals in solution may not be a satisfactory source of water.

Recharge of an aquifer is greatly influenced by the geologic conditions. Folding and faulting may bring deeply buried sands to the surface where they may receive recharge from rainfall, streams, or the overlying younger aquifers. Overlying aquifers, however, may be recharged from below if the water in the lower aquifer is under sufficient artesian pressure. In Red River Parish this form of recharge is undesirable where the deeper zones contain salty water.

DISCHARGE

Ground water is discharged from aquifers in the parish through wells, springs, seepage into streams, and evapotranspiration. At the present time the withdrawal from wells is probably insignificant compared to the total quantity of ground water discharged. Two municipal wells at Coushatta, the largest capacity wells used throughout the year, are pumped alternately at not more than 200 gpm (gallons per minute). The only other large-capacity wells in the parish are two irrigation wells which usually are pumped only in dry weather. Only a few other wells in the parish are known to be pumped at rates approaching 50 gpm.

Springs, generally restricted to the hilly section of the parish, are not plentiful and do not constitute an important means of groundwater discharge. They occur as seeps at the base of sand or gravel beds where the underlying bed is clay or shale. A few springs occur where the excavation of sand or gravel has exposed the contact with the underlying rock.

The greatest amount of ground-water discharge in Red River Parish is that given up by the alluvial aquifer to the incised channels of the Red River and Bayou Pierre during periods of low and normal stream stage. Similarly, but in smaller quantities, water in sands of the Tertiary rock units and Pleistocene terrace deposits is discharged to streams flowing across their outcrops.

Evapotranspiration is the loss of water to the atmosphere by evaporation from the surface of both land and water and by transpiration from plants. In this region of heavy rainfall, dense vegetation, and large areas of poorly drained land, tremendous quantities of water are consumed by evapotranspiration. About two-thirds of the precipitation in the lower Mississippi River basin is returned to the atmosphere in this manner. Large quantities of ground water are discharged by evapotranspiration, but probably less than is discharged by effluent seepage into streams.

WATER-BEARING ROCK UNITS

The water-bearing strata of Red River Parish may be divided into three classes on the basis of age and lithology: (a) fine-grained lignitic sand of the Tertiary formations, (b) fine to coarse sand and gravel of the Pleistocene terrace deposits, and (c) the alluvial sand and gravel underlying the flood plain of the Red River.

TERTIARY ROCKS

Sands in the Tertiary strata are the chief aquifers in the part of Red River Parish outside the Red River alluvial valley. Most wells in the outcrop area of Tertiary rocks are dug, bored, or driven and range in depth from 15 to 45 feet. Yields are low because the dug wells and most bored wells only partially penetrate the aquifer and because the driven wells have small diameters. The yields of such wells are likely to decline in dry weather because the wells ordinarily tap only the shallowest sands, which are dependent on recharge from local precipitation and which may be partly drained by nearby streams or springs.

In the outcrop areas of Pleistocene terrace deposits, some drilled wells are developed in the deeper Tertiary sands because of the better quality of the water. These wells average about 125 feet in depth.

At least 15 wells have been drilled through the alluvium of the Red River Valley and into the Tertiary strata to obtain softer water. They range in depth from 100 to 400 feet, the average being about 200 feet. In that part of the parish there are many places where wells 200 feet deep or deeper have encountered salty or brackish water, possibly derived from unflushed connate water or salty water that has moved updip in the valley area as a result of the natural discharge into the valley from the Tertiary sands.

PALEOCENE SERIES, WILCOX GROUP

Naborton formation.—The basal sand of the Naborton formation underlies the entire parish except for a small area near Williams and a narrow strip across the Red River Valley at the community of Grand Bayou where the Naborton has been removed by erosion and Quaternary alluvium rests directly on the Porters Creek clay. Plate 4 shows the small areas in which the basal sand has been removed and the depth below sea level at which it is in contact with the underlying Porters Creek clay. The regional structure is rather irregular but, in general, the dip is to the north, east, and southeast from the vicinities of Williams and Grand Bayou. For example, southeast of Grand Bayou near the Natchitoches Parish border the base of the sand is at a depth of about 550 feet; north of Williams at the Caddo Parish border it is at a depth of 250 feet; and on the eastern margin of Red River Parish it may be traced to a depth of 800 feet below sea level. Most of the wells yielding water from the basal sand of the Naborton are in the Red River Valley. The logs of three wells at Armistead indicate the sand is between the depths of 210 and 250 feet. Three miles up the valley at Gahagan the top of the sand is at a depth of 180 feet. To the north at East Point the sand is again encountered between the depths of 100 and 150 feet.

The sand of the Naborton formation is very fine and appears to be in thin beds alternating with clay, lignite, and siltstone. Drillers' logs and electrical logs indicate thicknesses of 20 to 75 feet for the sandy zone, the average being about 40 feet. Some drillers' logs and sample descriptions in table 14 show the lithologic character of the Naborton formation. Figure 10 is a mechanical-analysis graph illustrating the texture of the basal sand of the Naborton.

Because of the very fine texture and thin bedding of the sand, the quantity of water that may be obtained from wells in this formation is very small compared to that from the aquifers of Quatenary age. Wells in the basal sand of the Naborton yield sufficient water for domestic supplies and probably adequate amounts for restaurant, service-station, or tourist-court supplies.

Drawdown tests were made on two wells yielding water from the Naborton formation. In RR–120, a 4-inch well near East Point, the water level declined 22 feet during 43 minutes of pumping at a rate of 15 gpm. This decline indicates a specific capacity [2] of 0.7 gpm per foot of drawdown. The drawdown and recovery of the water level in this well caused by pumping are shown graphically in figure 11. RR–89

[2] The specific capacity of a well, expressed in gallons a minute per foot of drawdown, is determined by dividing the discharge rate, in gallons a minute, by the decline of water level, in feet, after the well has been pumped a sufficient length of time for the water level to become reasonably stable.

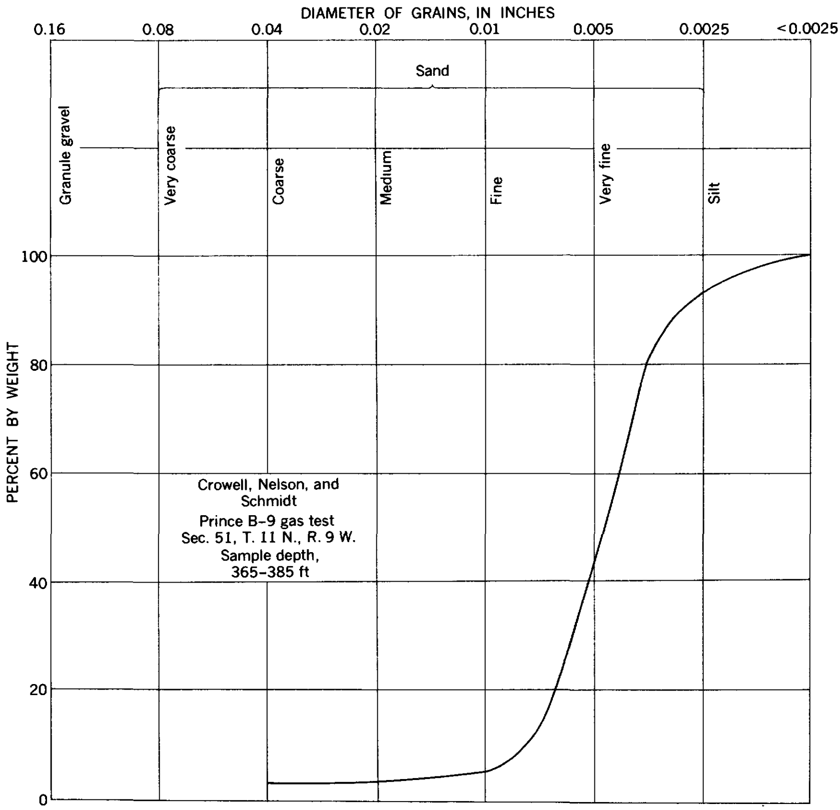

FIGURE 10.—Cumulative curve of mechanical composition of material from the basal sand of the Naborton formation.

(4 inches in diameter) near Carroll was pumped 20 minutes at a rate of 6 gpm and the water level was lowered 11 feet; thus, a specific capacity of 0.5 gpm per foot of drawdown was indicated. Other wells yielding from the Naborton formation have similarly low specific capacities.

Static water levels in wells tapping the Naborton formation underlying the alluvium are about the same as those in the alluvium. The static level is about 130 feet above sea level in the small area of the hills where fresh water is available in the Naborton.

Dolet hills formation.—The Dolet Hills formation underlies the part of Red River Parish east of a general north-south line running through the Coushatta-Armistead area. The beveled edge of the formation is covered by Pleistocene terrace deposits that flank the Red River Valley in the west-central part of the parish. From there the Dolet Hills dips to 450 feet below the surface at the eastern boundary of the parish.

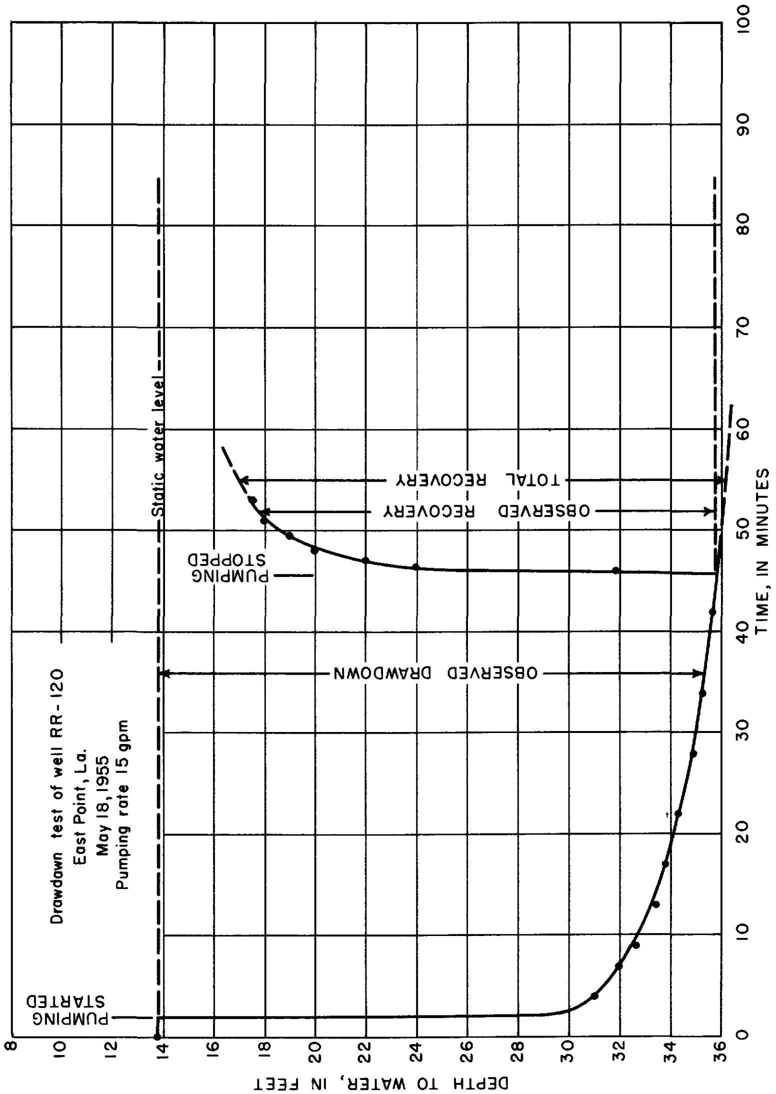

FIGURE 11.—Graph illustrating drawdown and recovery of the water level in a pumped well tapping sands of the Naborton formation. Solid circle indicates observed water level.

The sand is coarser than that of the basal part of the Naborton formation, and the bedding is more massive. It contains relatively few beds of clay and lignite, but substantial amounts of granular lignite. The thickness averages 75 feet and ranges from 50 to 125 feet. The top of the sand is best defined on electrical logs of wells in the central part of the parish; to the east the sand appears to interfinger with overlying undifferentiated clays and to lose its massive character.

Test holes drilled in sec. 9, T. 13 N., R. 9 W., and sec. 22, T. 12 N., R. 9 W., reached the top of the Dolet Hills at 220 feet and 190 feet, respectively. The formation is 60 feet thick in the northern well and 70 feet thick in the southern. Drillers' logs of water wells that tap the Dolet Hills and the description of sample cuttings from test holes penetrating the member are given in table 14. The graphs of mechanical analyses (fig. 12) show the sand to be fine to medium grained.

Although the yields of wells in the Dolet Hills formation are low, they appear to be higher than those from the Naborton formation. A drawdown test of well RR–40 in the Dolet Hills indicated a specific capacity of 1 gpm per foot of drawdown. Like the sand of the Naborton, the Dolet Hills can be relied on to furnish small supplies for domestic and moderate commercial uses, but not sizable industrial supplies. The Coushatta Sawmill has a well tapping the Dolet Hills that is equipped with a pump yielding 15 gpm; however, the pump cannot be operated continually at this rate because of the large drawdown.

East of the Red River Valley, water levels in the Dolet Hills rise to 160 feet above sea level; in the valley, however, they stand at about the same elevation as water levels in the alluvial sand—less than 130 feet above sea level.

Undifferentiated beds of the Wilcox group.—Most of the Tertiary rocks exposed in Red River Parish are younger than the Dolet Hills formation. These rocks were assigned by Murray (1948) to the Cow Bayou and Lime Hill members of the Logansport formation and to the Hall Summit and Marthaville formations. As stated earlier, there is some question as to the validity of the nomenclature assigned by Murray to the rocks between the Dolet Hills sand member and the Marthaville formation. Therefore, the rocks occupying the interval are undifferentiated in this discussion.

Data from test wells and electrical logs of other wells indicate several thin sand beds in the undifferentiated interval. These beds dip to the east, and the base of the deepest sand is 350 feet below the land surface at the eastern boundary of the parish. The sands are mostly fine or very fine, and there are also many beds of silt. Figure 13 contains graphs illustrating the texture of these sand beds pene-

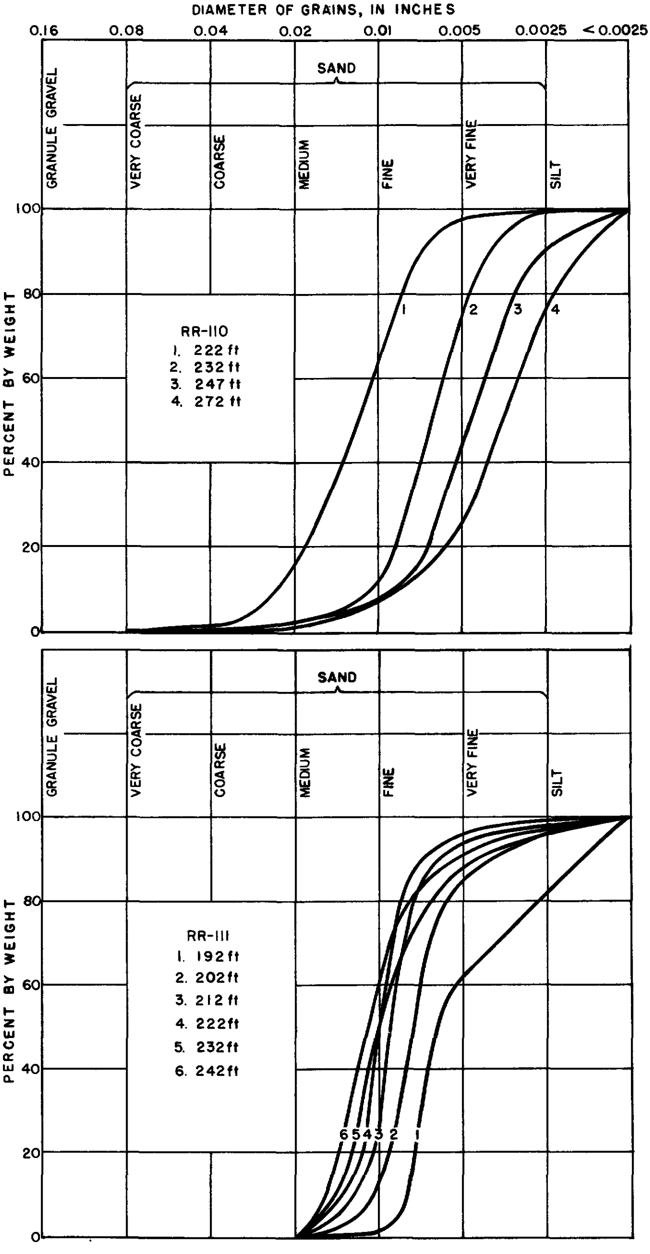

FIGURE 12.—Cumulative curves of mechanical composition of material from the Dolet Hills formation.

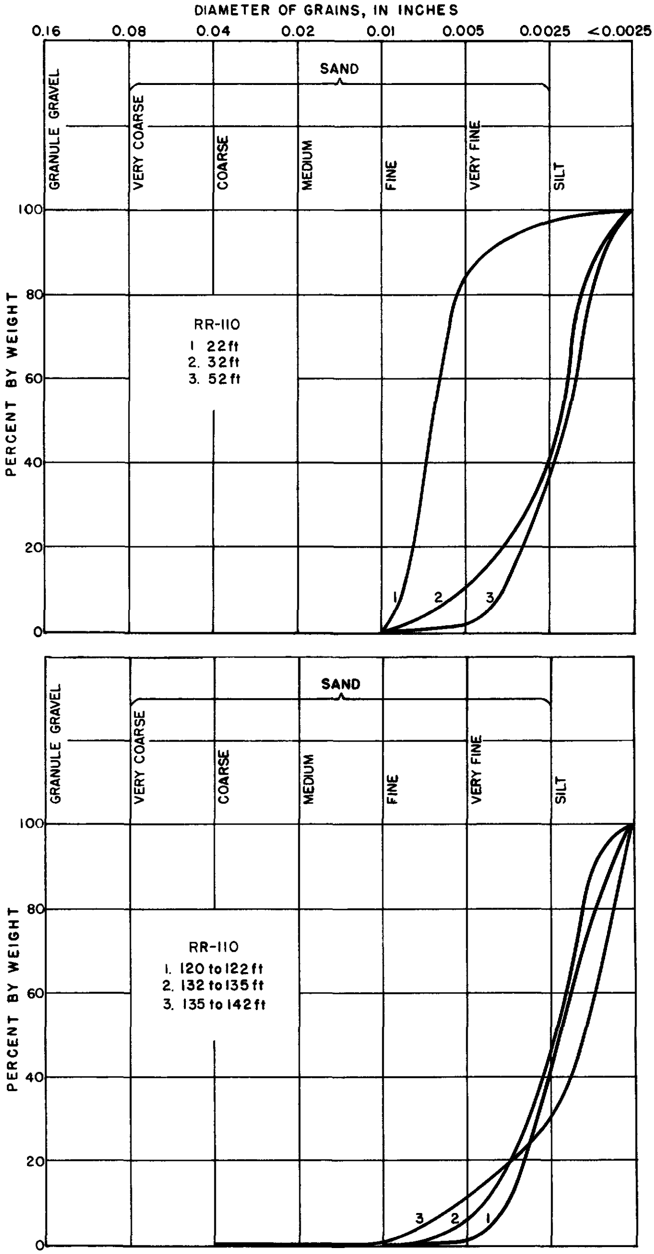

FIGURE 13.—Cumulative curves of mechanical composition of material from undifferentiated beds of the Wilcox group.

trated in a test hole. Descriptions of samples from test holes penetrating these unnamed sand beds are given in table 14.

As the undifferentiated beds occupy such a large proportion of the area of outcrop of Tertiary rocks, the unnamed sand beds are tapped for water supplies more extensively than any other formation. Shallow dug wells, rarely more than 45 feet deep, are common in the outcrop area and yield barely adequate domestic supplies. The few drilled wells that tap the sand beds at greater depth also have low yields. Reported specific capacities are less than 1 gpm per foot of drawdown. Such low yields are to be expected because of the very fine texture of the sand and its thin bedding.

Water levels in the shallow dug wells generally stand 10 to 20 feet below the land surface and fluctuate seasonally. Water-level data for drilled wells are too meager to justify a conclusive statement, but reported water levels are 20 to 40 feet below the land surface.

EOCENE SERIES, WILCOX GROUP

Marthaville formation (of Murray, 1948).—The Marthaville formation (of Murray, 1948) is confined to a strip 4 to 5 miles wide along the eastern margin of the parish, and even there it is almost entirely covered by Pleistocene terrace material and valley alluvium. Exposures are restricted to the valleys of streams dissecting the terraces.

Information on the stratigraphy of the beds named Marthaville by Murray is sparse in this area. As the formation is at a shallow depth it is rarely shown on electrical logs of oil-test wells; however, several drillers' logs of water wells (table 14) indicate that it contains a sizable percentage of sand in beds that are 10 to 30 feet thick and are separated from one another by clay beds 5 to 30 feet thick. The average thickness of the sand beds appears to be about 15 feet. The sand is dark colored, owing to the presence of granular lignite. Its texture is generally coarser than that of sands in the underlying formations.

It is difficult to evaluate the potential yield of wells tapping sands of the Marthaville formation because most of the wells are equipped with low-capacity pumps; however, the yields are apparently adequate for domestic use. A well at the Martin school provides a plentiful supply for 275 pupils and a food-canning center. Reported data on wells indicate that these sand beds are capable of supporting substantially higher yields than the older sand beds of the Wilcox group.

RECHARGE TO SANDS OF TERTIARY AGE

The sands of Tertiary age are recharged principally from rainfall. The major outcrops of the Naborton formation and Dolet Hills formation are in De Soto Parish and mark one of the high points of the Sabine uplift. Water from precipitation enters the sand in these outcrop areas and moves downdip in the beds where it becomes confined between clay beds and is under artesian conditions. The eastward movement is interrupted by the deeply cut, alluvium-filled Red River Valley, the western boundary of which is formed in large part by Bayou Pierre. All formations of the Wilcox group crop out beneath the valley alluvium. The water transmitted by the sands of these formations has at least 200 feet of head (the difference in altitude between the land surface in the outcrop area and the water level in the alluvial deposits at the valley's western margin); consequently it enters and recharges the alluvial sand. The loss of water from the sands of Tertiary age to the valley alluvium naturally causes a dissipation of the artesian head so that, in effect, the alluvial valley of the Red River serves as a gigantic artesian well discharging water from the sands of Tertiary age and causing a depression in the piezometric surface.

Water levels in the Tertiary rocks east and west of the Red River Valley are higher than those in the alluvium or in the Tertiary rocks beneath the valley. The beveled edges of the Tertiary strata flank the valley on the east and crop out beneath a mantle of terrace material from which they receive recharge. The static water level in the terrace deposits is higher than that in the valley alluvium, and it verifies the possibility of this means of recharge to the beveled edges of the Tertiary units flanking the east side of the valley. The large area of Tertiary strata exposed in east-central Red River Parish serves as a recharge area for the younger Tertiary sands, particularly those of the undifferentiated beds overlying the Dolet Hills formation.

QUATERNARY ROCKS

PLEISTOCENE TERRACE DEPOSITS

Sand and clay deposited during periods of valley flooding in the Pleistocene epoch, and subsequently sculptured into terraces by meandering streams, occur in the form of a nearly continuous narrow band around the east, west, and south sides of the outcropping Tertiary rocks in Red River Parish (pl. 2). The terrace deposits have been deeply cut by streams flowing from the highlands toward the major stream valleys on the eastern and western margins of the parish.

In some places the terrace deposits are so thin that dug wells ranging in depth from 15 to 45 feet reach the basal sand. Elsewhere, drilled wells penetrate as much as 100 feet of terrace material before entering the Tertiary rocks. In a typical section of these deposits the sand becomes coarser with depth and the basal beds commonly contain gravel. The wide range in grain size of the terrace material obtained from test hole RR-111 is presented graphically in figure 14. Table 14 contains logs of wells penetrating the terrace deposits.

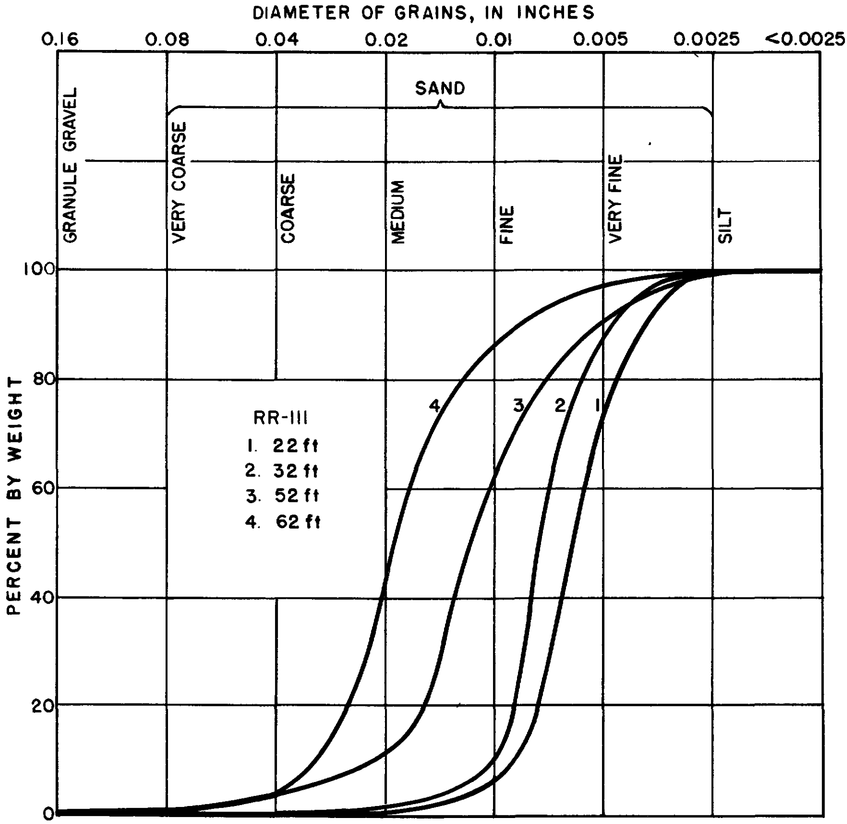

FIGURE 14.—Cumulative curves of mechanical composition of material from Pleistocene terrace deposits.

The sand and gravel in the lower part of the deposits are an important source of water. In addition to the many dug wells used for domestic supplies, there are several drilled wells yielding substantial quantities of water from the terrace material. The largest user is the town of Coushatta, whose two municipal wells (RR–61, RR–62) are pumped at an average of slightly more than 100,000 gallons per day. These wells, which are 60 and 65 feet deep and spaced 104 feet apart, are screened in a 17-foot bed of sand which is separated from a higher 20-foot sand bed by about 3 feet of clay. They are gravel walled below a depth of 10 feet in an effort to obtain water from both sands. A pumping test on these wells was made in March 1955 and is described in the section on ground-water hydraulics. RR–62 was pumped at the average rate of 90 gpm for 3½ hours and the water level was lowered 26 feet; thus the specific capacity was 3.5 gpm per foot of drawdown.

Water levels in the wells are 15 to 40 feet below the land surface and average about 25 feet. An automatic water-stage recorder was installed on RR–66 owned by the town of Coushatta. A year's record of water-level fluctuations in this well and the precipitation at Coushatta during part of 1955 are shown in figure 15. Although the net decline in the water level was only 0.75 foot, the trend generally followed the seasonal distribution of rainfall.

The terrace deposits are recharged by rainfall that enters the sand directly or seeps into it through the overlying finer grained material. Except in the southern part of the parish, there is no evidence of ground-water movement from the flanking terrace deposits directly to the valley sediments. Movement is restricted by the ridge of Tertiary clay that forms the east wall of the present valley. The cross sections in plate 6 illustrate this barrier between the terrace deposits and the valley alluvium. On the western margin of the alluvial valley, ground-water flow toward the valley is intercepted by the deeply cut channel of Bayou Pierre.

VALLEY ALLUVIUM

The sediments filling the deeply entrenched buried valley of the Red River constitute an important ground-water reservoir. The increasing use of the level flood plain for large-scale farming and grazing suggest that in the near future the underlying aquifer may be utilized for irrigation.

Character, distribution, and thickness.—The general character, distribution, and thickness of the valley alluvium are shown in plates 6 and 7 and indicated by the logs in table 15. The material consists of clay, sand, and gravel having characteristics that are locally variable but reasonably consistent for areal correlation within the valley. The silt and clay generally are deep red or orange, the underlying sand brown or gray. In texture the alluvium is gradational from sticky clay at the top through sand to gravel at the base. Analyses of sand-size material from the test holes are shown by graphs in figures 16, 17, and 18. The total thickness of alluvium under the present flood plain ranges from 50 to 105 feet and averages about 80 feet. The sand and gravel composing the aquifer are as much as 75 feet thick in places, but are pinched out by the walls bounding the entrenched valley. The average thickness of sand and gravel is 40 feet. The proportion of coarse to fine sediments varies throughout the valley; it depends in part on the configuration of the surface upon which the sediments were deposited, a greater thickness of coarse material being present in the depressions. In the part of the valley directly underlain by the Porters Creek clay, the sand averages only 30 feet in

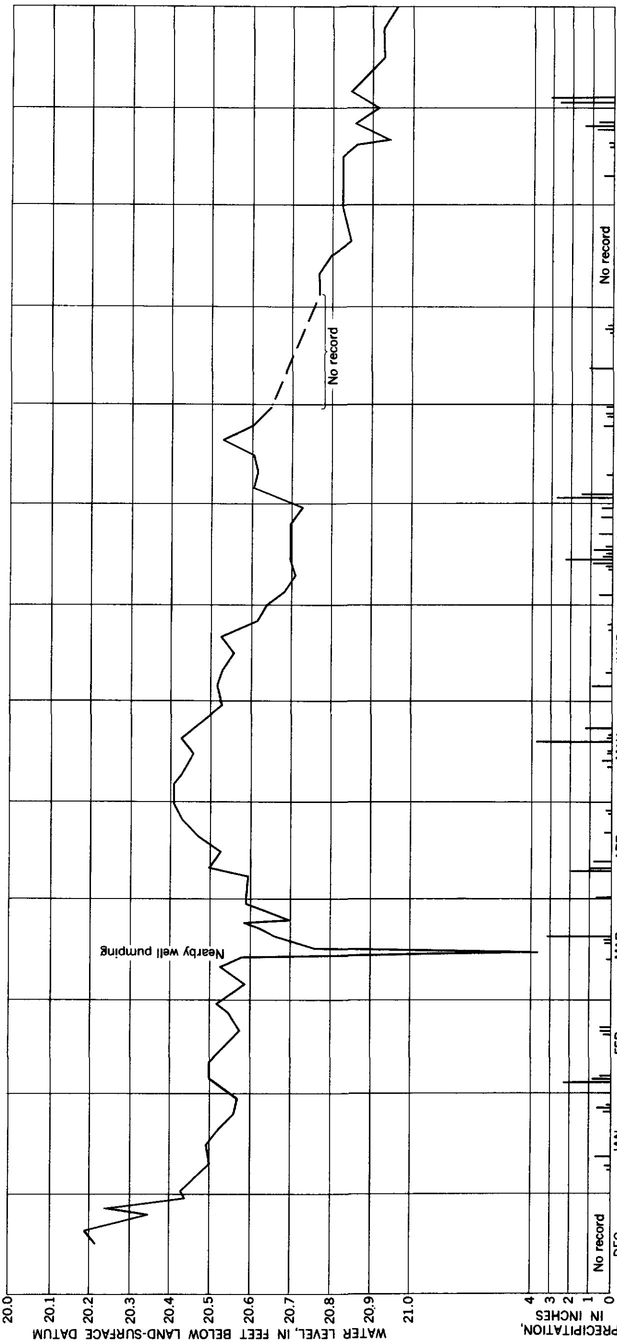

FIGURE 15.—Hydrograph of water levels in well RR-66 and precipitation at Coushatta, 1955.

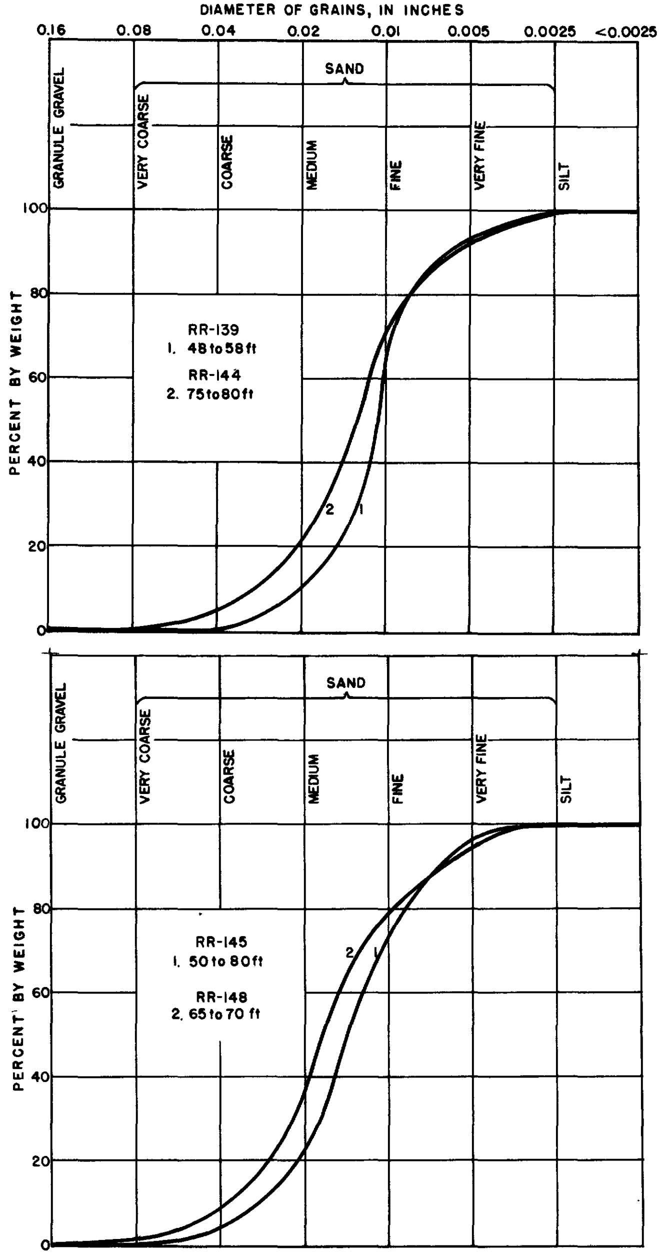

FIGURE 16.—Cumulative curves of mechanical composition of material from the valley alluvium, RR–139, –144, –145, –148.

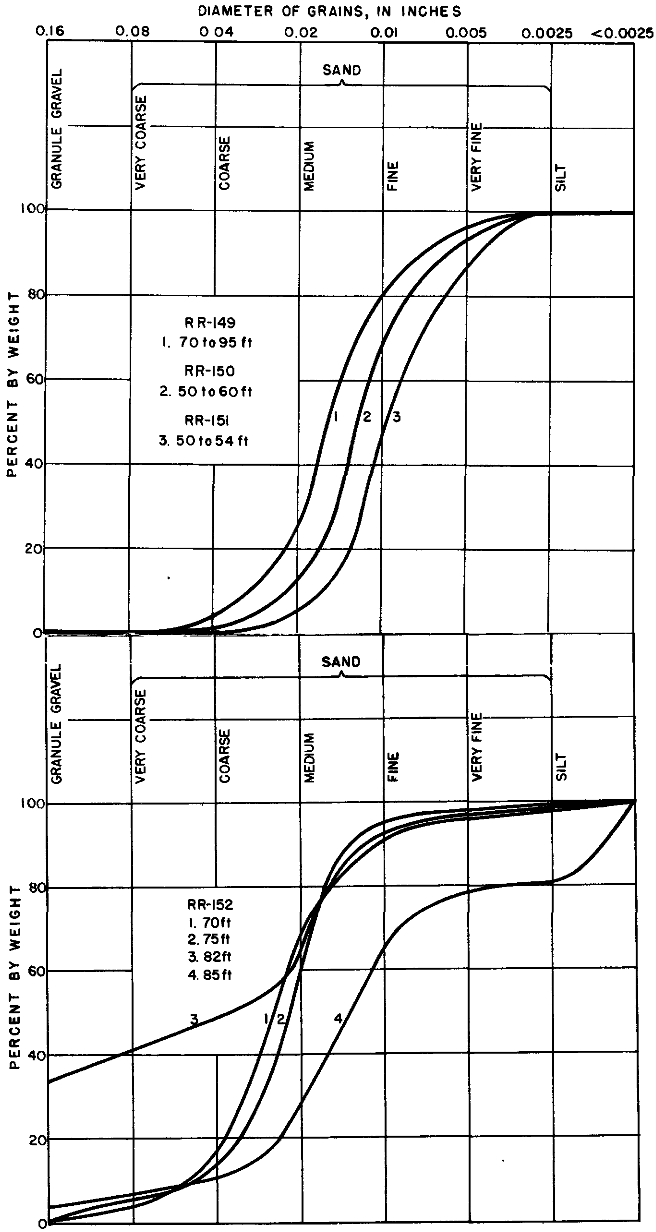

FIGURE 17.—Cumulative curves of mechanical composition of material from the valley alluvium, RR–149 to –152.

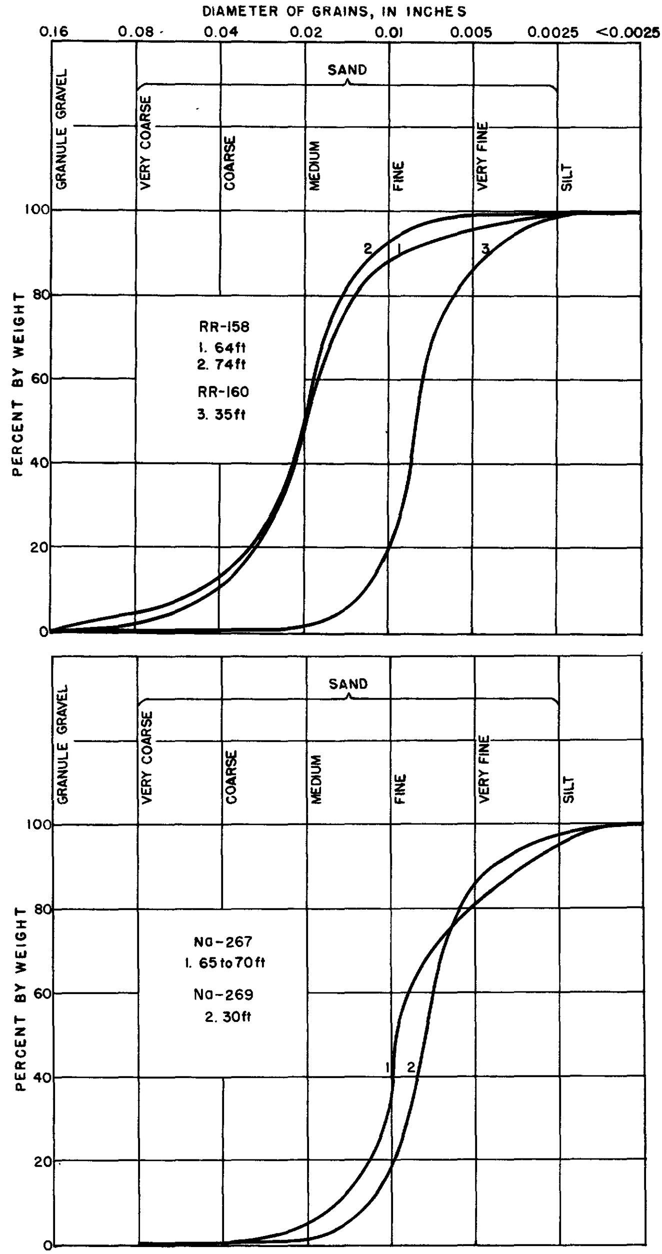

FIGURE 18.—Cumulative curves of mechanical composition of material from the valley alluvium, RR–158, –160, NA–267, –269.

thickness, or about 40 percent of the total thickness of valley fill, compared to an average of 40 feet, or 55 percent, elsewhere in the valley. This thinning is due to a high in the valley floor caused by the resistance to erosion of the Porters Creek clay (pl. 3).

Water levels and recharge.—The water levels indicated on hydrographs in figure 19 for RR–138, –150, and –71, which are near Red River, show much greater fluctuations than those for RR–141, –144, –148, and –154. Changes in river stage affect the water levels in nearby wells, the magnitude of effect depending upon the distance from the river and the degree of connection between the aquifer and the stream. RR–150, about 200 yards from the river on the bluff side of the stream, proved to be particularly sensitive to river-stage fluctuations. Near this well ground water usually may be observed seeping from the bluff into the river. Generally, a more continuous flow from the aquifer to the stream exists on the outside, or bluff side, of the stream meanders because the bluff is being continually cut away and thus exposes the sand to the stream. On the inside of the meanders a clay mantle commonly restricts the transfer of water between the sand and the stream.

Water-level maps showing the configuration of the piezometric surface at times of three different relationships between water levels

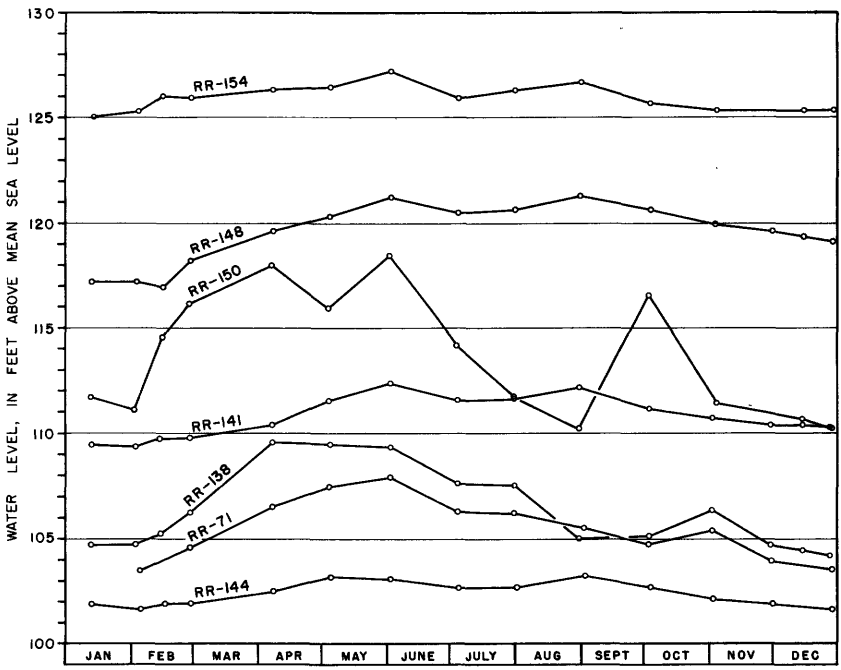

FIGURE 19.—Hydrographs of wells in the alluvium of the Red River Valley, 1955.

in the alluvium and surface streams are presented in plates 9, 10, and 11. Plate 9 is based on measurements made in early February when ground-water levels and stream levels were at or near their lowest for the year. Plate 10 shows the water levels in early June when both surface-water and ground-water levels were at their highest. Plate 11 shows that early September ground-water levels were equal to the high levels in June, but surface-water levels were at or near their lowest. These maps show that the water levels are highest in the interstream area and slope down to the Red River on the east and Bayou Pierre on the west, and also down the valley.

The alluvium is recharged principally by rainfall. Although clay overlies the sand of the alluvium nearly everywhere, it is thin and silty in places and permits water to pass downward into the sand. Even in places where the clay mantle is many feet thick it can transmit significant quantities of water by downward seepage. The extreme hardness and high iron content of water in the sand may be attributed in part to its downward seepage through the iron-bearing calcareous clay and silt overlying the sand. The alluvium is recharged in part from the underlying Tertiary strata (p. 37).

In the Grand Bayou area some highly mineralized water may rise through the Porters Creek clay into the overlying alluvium. This possible recharge from deep sources may explain the poor quality of ground water in this part of the parish. The high chloride content of water from well RR–149, 1.8 miles west of Grand Bayou, is indicated in table 12.

As the recharge from the Tertiary rocks cannot be computed directly, it is not possible with present data to determine accurately the amount of recharge derived from precipitation. However, an approximation can be made by a comparison with results obtained in a study made in Evangeline Parish, La. (Fader and Harder, 1953), where recharge from precipitation through Quaternary sediments was determined to be 2.7 percent of the annual precipitation. As there is a relatively rapid response of water levels in wells to local rainfall in the Red River Valley, the clay and silt overlying the sand apparently are more permeable than the tough Pleistocene clay overlying the aquifer in Evangeline Parish. Therefore, recharge from precipitation in the Red River Valley is probably considerably greater and is estimated to be not less than 5 percent of the precipitation, or an average of 10 to 11 mgd (million gallons per day) in the area between the Red River and Bayou Pierre in Red River Parish.

Discharge.—Ground water in the Red River Valley is discharged eastward into the Red River, westward into Bayou Pierre, and southward down the valley into other parishes.

Because of the relatively poor quality of the water, the development of wells large enough to test the water-yielding ability of the alluvium has been delayed. Until 1954 the largest wells in this aquifer were those drilled to supply water for oil-well drilling operations. They were commonly 4- or 6-inch wells pumped by airlift. There are practically no quantitative data on these wells, although some are still in existence but unused. It is doubtful that they were ever called upon to furnish more than 50 gpm.

In 1954 and 1955, four irrigation wells (RR–39, –50, –85, and –127) were drilled in the alluvium in the northwestern part of the parish. Pumping tests were made at RR–50 at the Lawrence Ranch near Westdale and at RR–85 at the Lucky H Ranch near Williams. RR–50 is a gravel-walled well completed with 64 feet of 16-inch casing and 20 feet of screen having 0.030-inch openings. RR–85 is gravel walled and contains 78 feet of 10¾-inch casing, the bottom 20 feet of which is slotted. RR–50 was pumped at 1,160 gpm for 5 hours, during which time the water level in the well was lowered 48.5 feet. Thus the specific capacity was 24 gpm per foot of drawdown. RR–85 was pumped at 242 gpm for 3 hours and had a drawdown of 32.7 feet; the specific capacity thus was 7.4 gpm per foot of drawdown. Drawdown data obtained from nearby observation wells in both tests indicate little difference in the water-yielding ability of the aquifer in the two places; therefore, the poorer performance of RR–85 may result from the well's construction and development or possibly from incrustation of the slotted casing.

Well RR–127, tested a year after its construction, yielded 175 to 200 gpm with a drawdown of 60 feet. This well is gravel walled and contains 88 feet of 12¾-inch casing and 20 feet of screen. Well RR–39, drilled late in 1955 and located 0.6 mile from RR–127, was reported to yield 1,000 gpm. It contains 83 feet of 12-inch casing and 20 feet of screen having 0.030-inch openings and is gravel walled. No other wells in Red River Parish approach these wells in size or yield. An irrigation well (Na–116) on the Green Acres Farm, at Powhatan, Natchitoches Parish, 4 miles southwest of the Red River Parish boundary, has a measured yield of 260 gpm with a drawdown of 31 feet; the specific capacity is 8.4 gpm per foot of drawdown. This well is gravel walled and contains 56 feet of 8-inch casing and 20 feet of 6-inch screen. In addition to differences in well construction, the capacities of the pumps differ considerably among the wells described.

The variation in observed yields and specific capacities of wells may be attributed in part to aquifer thickness and permeability. For example, the cross sections in plate 6 show that the high places on the Tertiary surface are covered with a thinner section of water-bearing material which generally lacks the coarse sand and gravel phase. Other important factors are well diameter, screen length and size of openings, well development, and the capacity and depth setting of the pump.

QUALITY OF THE WATER

RELATION TO WATER-BEARING UNITS

Ground water in Red River Parish is of three general types which can be correlated with the three types of aquifers present in the parish. Plate 12, a series of bar graphs in which the ionic constituents, termed "cations" and "anions," are plotted, illustrates the chemical composition of water from each type of aquifer. For this type of graph the concentrations are expressed in equivalents per million. The greater height of the graphs on the left side of the illustration representing the composition of water from the Naborton formation, Dolet Hills formation, and Marthaville formation (of Murray, 1948) as compared to those in the middle series of graphs representing water from Pleistocene deposits, indicates a much greater dissolved-solids content. Water from the valley alluvium, shown in the right-hand graphs, is distinguished from both of the foregoing types by its extreme hardness as indicated by the high calcium and magnesium content, which is nearly equivalent to the bicarbonate. In addition, although it does not appear on the graphs, a very high iron content is characteristic of the water in the Quaternary alluvium and is common in the water from Pleistocene deposits, whereas the iron content of water in the Tertiary rocks is generally low (table 11).

TERTIARY ROCKS

Water from the Tertiary rocks is of the best quality obtainable in Red River Parish. It is typically soft and low in iron and other objectionable minerals. However, salty water in certain areas and at depth limits the use of the water from these sands. The water tends to be neutral or slightly alkaline as indicated by the pH, which is generally 7.0 or higher.

Plate 13 is a contour map showing the altitude of the base of fresh water as determined from electrical logs of oil-test holes. In the Red River Valley there is evidence of fresh water beneath the alluvium in only a few places. Throughout the rest of the parish the maximum depth of sand bearing fresh water ranges from nearly 200 feet above sea level to 300 feet below sea level. As the rocks dip to the east, the maximum depth of fresh water remains in this range, but the base of fresh water occurs in progressively younger formations so that on the eastern margin of the parish the deepest fresh water is in the sand beds of the Marthaville formation (of Murray, 1948). Somewhat higher iron concentrations have been observed in water from the Marthaville than is typical for water from the older Tertiary rocks. It is probable that the iron is derived from recharge through the iron-bearing Pleistocene terrace deposits which mantle the Marthaville nearly everywhere in Red River Parish.

QUATERNARY ROCKS

Pleistocene terrace deposits.—Water from the terrace deposits is soft and, the pH being less than 7.0, tends to be acidic. Although a low dissolved-solids content is typical, some analyses show a high concentration of aluminum. The source of the aluminum is not definitely known. In many places water from the terrace sands contains excessive amounts of iron and is generally unpopular for domestic use.

Valley alluvium.—The extremely hard iron-bearing water from the alluvium of the Red River Valley has a distinctive chemical composition. It contains an unusually high percentage of bicarbonate for a water of the calcium-magnesium type. The dissolved-solids content also is high and the water generally is not considered potable. As indicated by the analyses in table 11, the hardness averages about 500 ppm and the iron content about 6 ppm. The water tends to be alkaline because the pH is above 7.0. The hardness and high iron content may be attributed to passage of the water through the iron-bearing calcareous sediments of the valley, particularly the fine-grained red materials overlying the aquifer. The prevailing temperature of the water is about 68° F.

The chloride concentration in water of the Red River and other streams traversing the alluvial valley has no noticeable effect on the chloride content of water in the alluvial sand. As shown by water-level contour maps (pls. 9, 11), water moves from the aquifer to the surface streams under normal conditions of streamflow; thus, no additional mineralization is introduced by the streams. The low chloride content of the ground water substantiates this explanation. Table 12 contains field determinations, made during February and December 1955, of the chloride content of water from wells throughout the alluvial valley. In order to determine the qualitative effects that changes in stream stage have on ground water, samples of water from the streams were analyzed for chloride content at various times and places. In December 1955 the Red River was at a low stage. Samples collected from it at Coushatta and two other points in Red River Parish contained about 300 ppm of chloride (table 9). At the same time a sample of water from well RR–138, a hundred yards from the river, contained 36 ppm of chloride. When the river was at mean stage in February 1955 the chloride content of its water was about 50 ppm, whereas the water in RR–138 contained only 16 ppm of chloride. As the river stage rises, the chloride concentration of the river water becomes less, so that at times of high stream stage, such as in June 1955, the chloride concentration is probably much less than the 50 ppm noted at mean stage. Therefore, it is unlikely that the quality of ground water in the alluvium is adversely affected by inflow from the surface streams at times of high stream stage.

The chloride content of ground water in the alluvium may rise where a well very near the river is pumped at a high rate; the ground-water level is thus lowered, so that water from the river would be induced to flow toward the well at low river stages when the chloride content of the river water is highest. The 300 ppm of chloride in the Red River at low flow is near the maximum toleration limit reported for some crops under conditions of prolonged application and low soil permeability. Therefore, irrigation wells located very near the river might pump water of undesirably high chloride content if a period of drought and low stream levels coincided with the part of the growing season requiring the heaviest irrigation.

GROUND-WATER HYDRAULICS

PUMPING TESTS AND THEIR INTERPRETATION

Pumping tests are made primarily to determine the capacity of aquifers to store and transmit water. This information can be used to estimate the effect of withdrawals on wells in the aquifers tested. The principal prerequisites for a pumping test are (a) a well that can be pumped at controlled rates, and (b) one or more observation wells penetrating the same aquifer as the pumped well, in which measurements of the water level can be made to determine effects of pumping (see fig. 20.) The rate at which water levels in the observation wells rise or decline in response to starting and stopping the pump in the discharging well is determined by the coefficients of transmissibility and storage, which are defined as follows (Theis, 1935): *coefficient of transmissibility:* the rate of flow of water, in gallons per day, through a vertical strip of the aquifer 1 foot wide extending the height of the aquifer under a hydraulic gradient of 1 foot per foot, at the prevailing temperature of the water; *coefficient of storage:* the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

The coefficient of transmissibility may be divided by the thickness of the aquifer, in feet, to obtain the field coefficient of permeability, defined as the rate of flow of water, in gallons per day, through a cross-sectional area of 1 square foot of an aquifer under a hydraulic gradient of 1 foot per foot, at the prevailing temperature of the water.

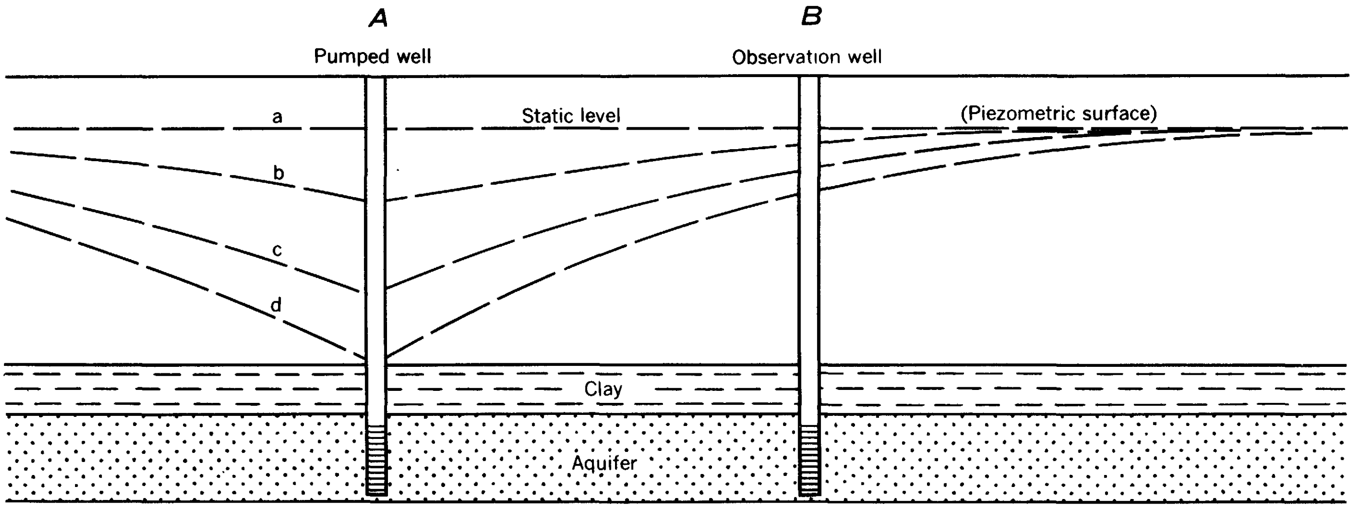

FIGURE 20.—Diagram of pumping effects in an artesian aquifer. Prior to pumping well *A*, the water level stands at *a* in both wells. When the pump in *A* is started, water is withdrawn and a cone of depression in the piezometric surface forms around the pumped well. As pumping continues, the depression increases in size and the influence of pumping becomes more widespread. When the cone of depression reaches well *B*, the water level in that well also is lowered. With continued pumping, the cone reaches out farther in all directions, and water levels within its area of influence continue to be lowered until an adequate source of recharge is intersected (positions *b*, *c*, and *d*). The rate of growth and size of the cone of depression depend upon the coefficients of transmissibility and storage of the aquifer.

In short, the coefficient of permeability of an aquifer is a measure of the aquifer's ability to transmit water. This property may be determined by field or laboratory methods; however, field methods generally give results that are more representative of average conditions in an aquifer because they are not affected by inadequacies in sampling or by disturbance of the samples.

The test made at the Lawrence Ranch on wells RR–50, –156, and –157, which are screened in the valley alluvium, serves as an example of the procedure used and the analysis of data obtained in a pumping test. In figure 21 the depth to water level in observation wells RR–156 and –157 is plotted against time for a period on February 9, 1955, during which RR–50 was pumped for 5 hours and the recovery of the water level was observed for 2 hours after pumping. Measurements of the rate of discharge were made during pumping.

In analyzing the data obtained in pumping tests it is commonly necessary to apply corrections to offset the effects of rising or falling

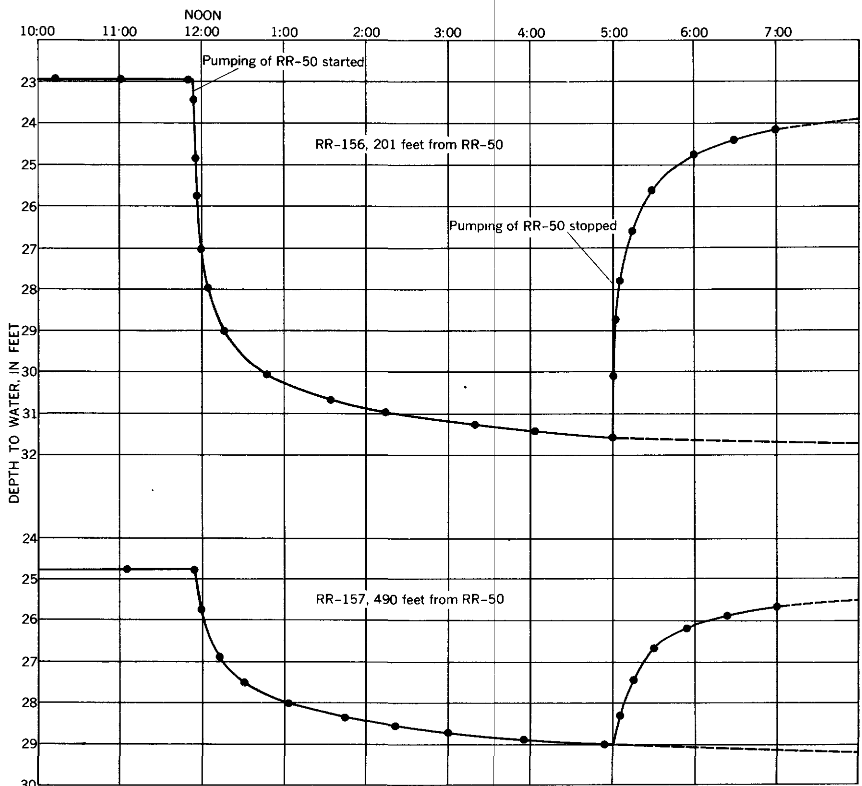

FIGURE 21.—Graphs showing drawdown and recovery in observation wells during and after pumping of well RR–50. Solid circle indicates observed water level.

water-level trends and changes in barometric pressure. The dashed curve in figure 21 shows the extrapolated trend of the water level if pumping had continued. The drawdown or recovery actually measured is the "observed" drawdown or recovery. The "total" drawdown or recovery at any time is the observed drawdown plus or minus a correction for prior trend. In this test the trend correction was the only correction made to the observed data; the minor changes in barometric pressure did not warrant a correction factor.

In order to determine the coefficients of transmissibility and storage from the field data, use was made of the Theis (1935) nonequilibrium formula.

$$s=\frac{114.6Q}{T}\int_{\frac{1.87r^2S}{Tt}}^{\infty}\frac{e^{-u}}{u}du \tag{1}$$

in which $u=\frac{1.87r^2S}{Tt}$ (2)

and in which s=drawdown, in feet, at any distance r, in feet, from a discharging well

Q=discharge, in gallons per minute

T=coefficient of transmissibility, in gallons per day per foot

S=coefficient of storage expressed as a decimal fraction

t=time since discharging began or, for recovery, the time since discharging stopped, in days

Equation (1) may be written

$$T=\frac{114.6Q}{s}W(u) \tag{3}$$

and S may be determined from equation (2) written in the form

$$S=\frac{utT}{1.87r^2} \tag{4}$$

Equation (1) and its components cannot be solved directly, inasmuch as T appears in two places; however, T and S may be conveniently determined by graphical methods described by Wenzel (1942, p. 88, 89) and Stallman (1952). Values of $W(u)$ are plotted against corresponding values of $\frac{1}{u}$ on logarithmic paper to form a type curve. The corrected water levels are then plotted against time on the same type of paper, as shown in figures 22 and 23. These curves were then compared with the type of curve by superimposing the test plot on the type curve as shown in the inset in figure 22. By keeping the axes

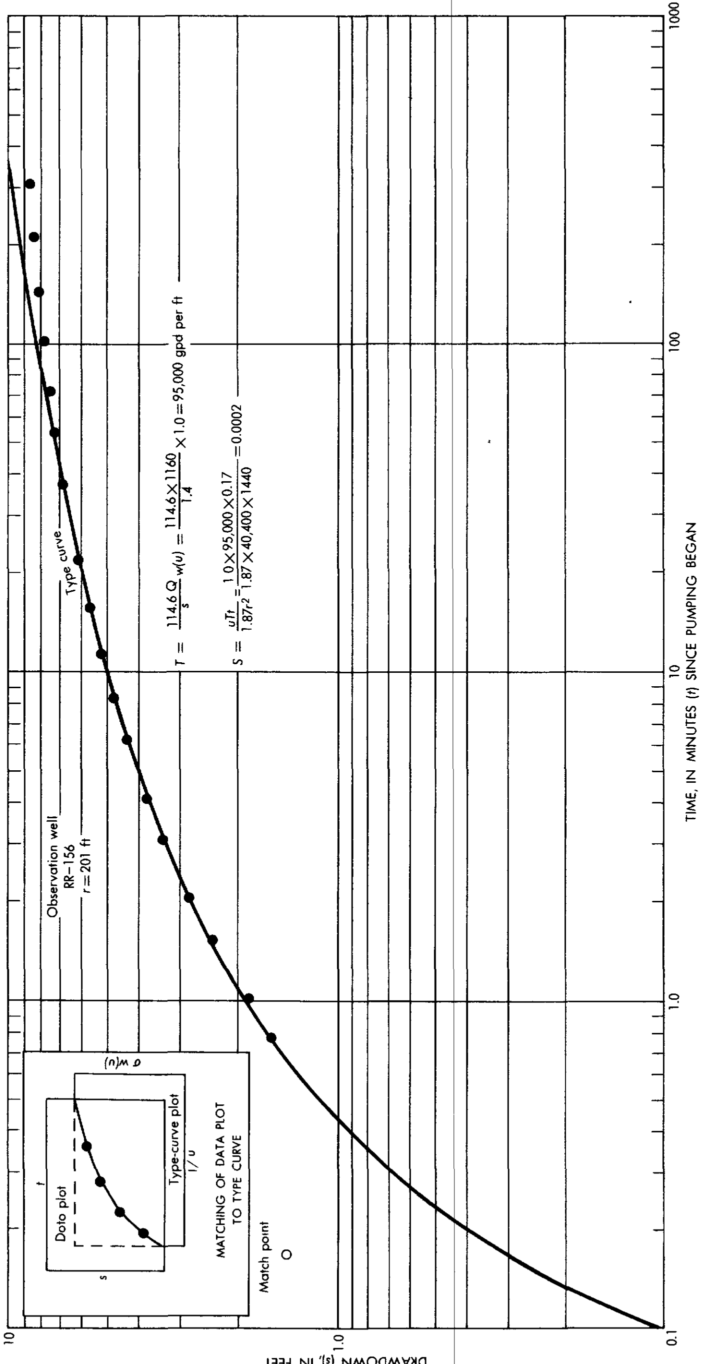

FIGURE 22.—Logarithmic plot of drawdown in observation well RR-156 during pumping of RR-50. Solid circle indicates corrected observed drawdown.

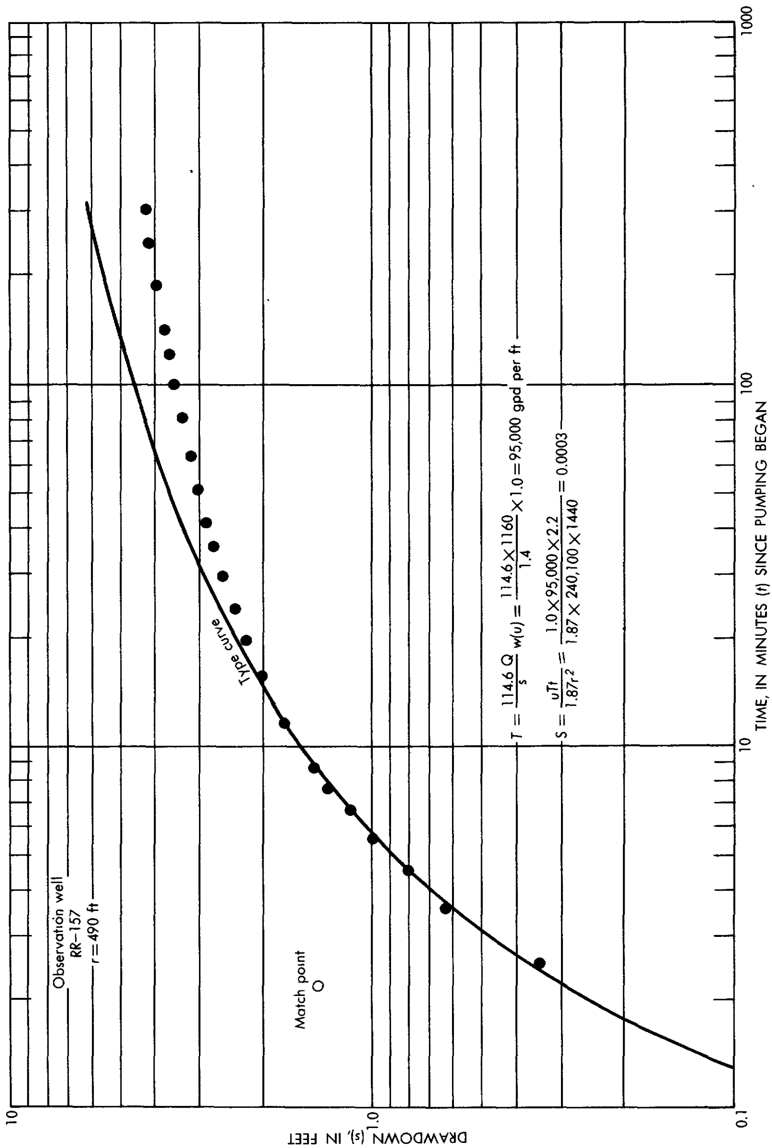

FIGURE 23.—Logarithmic plot of drawdown in observation well RR-157 during pumping of RR-50. Solid circle indicates corrected observed drawdown.

parallel and moving the test plot until the curves most nearly coincide, an arbitrary match point is selected whose coordinates on both curves may be used to solve equations (3) and (4), in the order listed.

The nonequilibrium formula assumes that (a) the aquifer is homogeneous, isotropic, and infinite in areal extent; (b) the pumped well penetrates the entire thickness of the aquifer; (c) the coefficient of transmissibility is constant; (d) water taken from storage by the decline in water level is discharged instantaneously with the decline in head; and (e) the flow is laminar. Although there probably are few aquifers in which all the above-listed requirements can be satisfied closely, pumping tests are of value if discretion is used in their interpretation and if the prevailing geologic conditions are reasonably understood.

The principal objective of a pumping test usually is to provide a basis for predicting the effects of pumping. The coefficients of transmissibility and storage can be used in computing the drawdown within the cone of depression in an ideal aquifer at any time and any distance from a well whose rate of discharge is known.

In matching the logarithmic curve of plotted values with the type curve it is not uncommon to find that, although the early data of the plotted curve coincide with some part of the type curve, the later points fall either above or below the type curve and indicate an increase or decrease in the rate at which the water level is declining. Such a change takes place when the cone of depression, which is spreading out in all directions from the pumped well, intersects an impermeable barrier or a source of recharge, or a part of the aquifer which, because of changes in hydraulic properties, gives the same effect. The term "boundary" is applied to the cause of the anomaly in the water-level curve; it may be a "discharging" or a "recharging boundary." Examples of changes giving the effect of discharging boundaries are thinning of the aquifer, decrease in permeability of the aquifer, and truncation of the aquifer by valley walls or by faults. Examples of recharging boundaries are streams and lakes and thickening or increase in permeability of the aquifer.

Where semipermeable material overlies the aquifer, as in the alluvium of the Red River Valley, water-level data obtained during the early part of pumping tests indicate artesian conditions. As typified by the graphs of figures 22 and 23, the plot of the data obtained during the latter part of the tests made in the alluvial aquifer departs from the type curve in a manner similar to that caused by a recharging boundary. However, the geologic setting in the valley suggests that this departure is caused by the slow drainage of water from the saturated silt and clay overlying the aquifer. Where hydrologic boundaries are present, the effect of drainage may be masked or accentuated and impossible to delineate.

Table 4 gives the hydraulic characteristics determined from four pumping tests made in this investigation. Well RR–85 at the Lucky H Ranch is screened in the valley alluvium. The test at this site was very similar to the one at the Lawrence Ranch, and the results were nearly identical. In the test made at the Green Acres Farm (p. 46), a considerably lower value was obtained for the coefficient of permeability. At Coushatta the town-supply wells are screened in a sand of the Pleistocene terrace deposits. As table 4 shows, the permeability is about the same as the lower value obtained for the alluvial aquifer at The Green Acres Farm.

The results of the pumping tests may be used in predicting, in a general way, aquifer performance in the alluvial valley. The average thickness of the water-bearing sand in the Red River Valley is about 40 feet. Using a coefficient of permeability of 1,900 gpd (gallons per day) per square foot, a coefficient of storage of 0.0002, and an arbitrary pumping rate and distance, substitution may be made in the Theis nonequilibrium formula to obtain the theoretical effects of pumping shown in figure 24. As the graph is made on the assumption that the aquifer is infinite and homogeneous, it does not take into account the presence of hydrologic boundaries or drainage effects, conditions encountered commonly in the valley.

The practical effect of hydrologic boundaries is apparent. A recharging boundary would have the effect of increasing the overall yield of an aquifer by permitting closer well spacing or heavier pumping than otherwise would be feasible. A discharging boundary

TABLE 4.—*Hydraulic characteristics determined from pumping tests*

Aquifer	Location of test	Well pumped	Observation wells	Thickness of aquifer (feet)	Coefficient of transmissibility (gpd per ft)	Coefficient of storage	Field coefficient of permeability (gpd per ft²)	Specific capacity (gpm per ft)	Length of test (hours)
Valley alluvium.	Lawrence Ranch, Sec. 29, T. 14 N., R. 11 W.	RR–50	RR–156, 157	50	95,000	0.0002	1,900	24	5
	Lucky H Ranch, sec. 7, T. 14 N., R. 11 W.	RR–85	RR–158, 159	[1] 60	115,000	.0002	1,900	7.4	3
	Green Acres Farm, sec. 22, T. 10 N., R. 8 W.	Na–116	Na–309, 310, 311, 312.	[1] 30	31,000	.0005	1,000	8.3	168
Terrace deposits.	Town of Coushatta, sec. 19, T. 12 N., R. 9 W.	RR–62	RR–61	17	18,000	.0006	1,100	3.5	3.6

[1] Estimated.

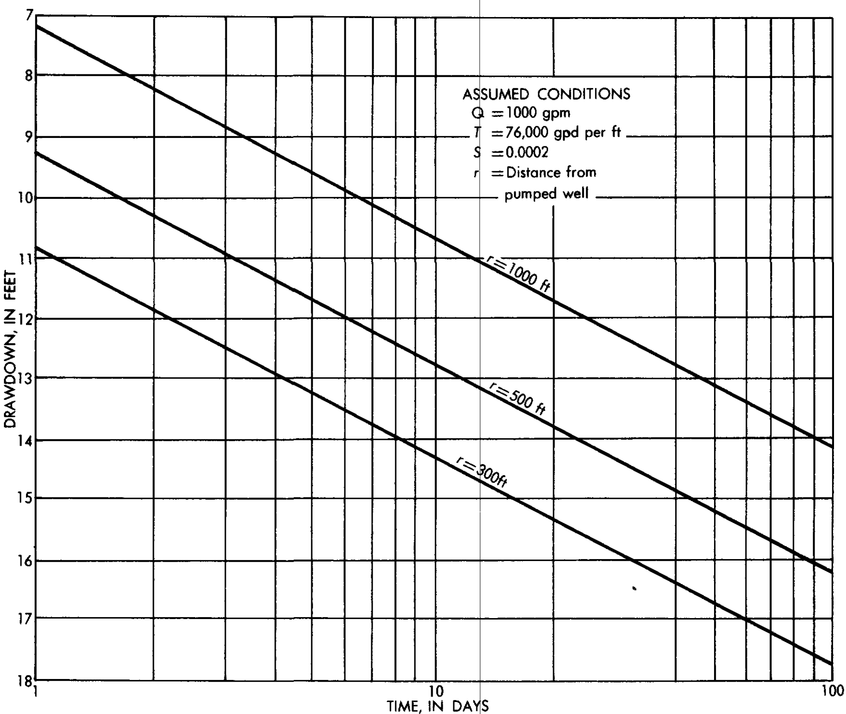

FIGURE 24.—Theoretical time-drawdown relation for an aquifer having the hydraulic characteristics determined for the valley alluvium.

is probably of more concern, for although a well near such a boundary might function satisfactorily for a considerable period, the yield may decline rapidly when the expanding cone of depression reaches the discharging boundary.

GROUND-WATER MOVEMENT IN THE ALLUVIAL VALLEY

The amount of water moving through the aquifer underlying the flood plain of the Red River, the amount in storage, and the quantities received by the aquifer from the major sources of recharge—rainfall and inflow from the Tertiary rocks—may be estimated from data obtained during the investigation and from certain assumptions. From the logs of test borings and of wells, the average thickness of the aquifer is estimated to be 40 feet. The area of the flood plain in Red River Parish is 160 square miles. If the aquifer is considered to have an average porosity of 25 percent, the total amount of water it contains in storage can be estimated at 330 billion gallons.

As the lines of flow are at right angles to the water-level contours, the piezometric maps (pls. 9–11) indicate the direction of ground-water movement as well as the head differences causing the movement. These maps, constructed from water-level data obtained during February, June, and September, 1955, show that the magnitude of the east and west components of ground-water movement in the valley varies with the levels of Red River and Bayou Pierre. When the stages of the streams are low the piezometric surface slopes toward the streams; conversely, when the streams are high the gradient is more gradual and less water moves from the aquifer to the streams. At times the hydraulic gradient adjacent to the streams is reversed and water moves from the stream into the aquifer. However, this movement of surface water is limited to a few hundred yards from the stream, for when stream levels are higher than ground-water levels the discharge of ground water is effectively blocked, and rising ground-water levels limit further movement of surface water into the aquifer.

With a transmissibility coefficient of 76,000 gpd per foot (computed from a 40-foot aquifer thickness and a permeability coefficient of 1,900 gpd per square foot) and the hydraulic gradient determined from the piezometric map, the amount of ground-water movement may be computed from the modified Darcy formula:

$$Q=TIL \qquad (9)$$

in which

Q = rate of movement, in gallons per day

T = coefficient of transmissibility, in gallons per day per foot

I = hydraulic gradient, in feet per mile

L = length of section across which movement is computed, in miles

From this equation the quantity of water discharged from the alluvium in the 122-square-mile area between the Red River and Bayou Pierre was computed to be about 32 mgd in September 1955, when the hydraulic gradient was near its maximum for the year (pl. 11). Of this amount about 17 mgd moved toward Bayou Pierre and 14 mgd toward the Red River. These figures may be broken down further to show a discharge into the Red River of 0.7 cfs (cubic feet per second) per mile of valley, and a discharge into Bayou Pierre of 0.8 cfs per mile of valley. There was an outflow of about 0.3 mgd into Natchitoches Parish.

The bulk of the water required to replace the above amounts leaving the parish has three sources—inflow from the part of the aquifer in Caddo Parish, rainfall, and underlying sands of Tertiary age. The September piezometric map indicates an inflow from Caddo Parish of about 3 mgd. It is estimated that about 5 percent of the annual precipitation enters the ground-water reservoir. About 13 percent (6.5 inches) of the annual rainfall (52 inches) is ordinarily received during the July-August period; thus the amount of rainfall recharging the aquifer is computed to be about 12 mgd. The remaining approximately 20 mgd is credited to recharge from the Tertiary sands, inasmuch as there was no significant net change in storage in the aquifer during this period. The foregoing computations are based on a period of maximum ground-water flow from the Quaternary alluvium to the streams of the flood-plain area. The conditions represented exist for short periods of time—in 1955, late August and early September.

The early February 1955 period represents a time when both ground-water and surface-water levels were low and the rate of ground-water outflow was at a minimum (pl. 9). The total discharge was computed to be about 21 mgd, of which 8 mgd flowed into the Red River, an average of 0.4 cfs per mile of valley, and 13 mgd flowed into Bayou Pierre, an average of 0.6 cfs per mile of valley. Outflow into Natchitoches Parish was about 0.3 mgd. In computing the recharge for this period, allowance is made for the fact that the rainfall in December and January ordinarily makes up about 18 percent (9.5 inches) of the year's total. If 5 percent of this amount enters the ground-water reservoir, it constitutes about 17 mgd of the total recharge. The remainder is attributed largely to recharge from the Tertiary sands, though about 0.4 mgd flows into the parish from Caddo Parish. During this period there was no significant net change in storage in the aquifer.

River and ground-water levels were both high in June 1955 (pl. 10). At that time the river level was higher than adjacent ground-water levels and the river recharged the aquifer. The map shows that during this period water moved also toward the river and created a temporary ground-water divide in the immediate vicinity of the river. However, the river did not remain high long enough to shift the position of the ground-water divide in the middle of the valley.

Present data are insufficient to permit a reasonable estimate of the quantity of water moving through the part of the valley east of the Red River and west of the highlands, an area of about 40 square miles. The available data indicate that the ground water moves westward except when the river is at high stages.

WELL CONSTRUCTION AND METHODS OF LIFT

Domestic and stock wells in Red River Parish are dug, bored, driven, or drilled. The dug wells generally are constructed with tile casing ranging in diameter from 8 to 36 inches. Bored wells commonly contain wooden casing constructed of unfinished cypress planks.

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Wells of these types are equipped with bailer buckets, pitcher, or electrically operated jet pumps. Generally the driven wells are constructed with 1¼-inch pipe and a drive point fitted with screen having 60 meshes to the inch.

Small-capacity drilled wells in the flood plain are installed by the hydraulic-rotary method and are constructed with 2- to 4-inch casing and 5 to 10 feet of stainless-steel screen. The wells are equipped with one- or two-pipe jet jumps generally operated by a ¼-horsepower motor. The one-pipe jet jump utilizes the well casing as a discharge pipe and pumps into a pressure tank. Two-pipe jet pumps operated by ¼- to 1-horsepower motors usually are installed in wells having casings 3 inches or more in diameter. The few irrigation and municipal wells have casings and screens that range in diameter from 6 to 16 inches. These wells generally contain 20 feet of screen and are gravel walled—that is, the space between the wall of the hole and the casing and screen is packed with pea gravel to increase the effective diameter of the well. The wells are equipped with deep-well turbine pumps having capacities ranging from 100 to more than 1,000 gpm. The pumps are driven by electric motors or internal-combustion engines ranging from 10 to 65 horsepower. Figure 25 is a photograph of well RR–50 at the Lawrence Ranch at Westdale. The pump, driven by a 35-horsepower electric motor on a horizontal shaft, is discharging 1,160 gpm into a collection basin from which the water is pumped into the irrigation lines.

FIGURE 25.—Irrigation well in Red River Parish.

Drilled wells in the highlands generally are more than 100 feet deep. Some are equipped with screens, but many are of the "open-hole" type, that is, casing is set to a depth just above the water-bearing sand and cemented in place, and the hole is left open below the casing. This procedure saves the cost of well screens, but it relies upon the semiconsolidated nature of the fine sand to prevent its collapse into the well. Two-pipe jet pumps are generally installed in the wells. This type of construction is followed in the flood-plain area in wells that are drilled through the alluvium to obtain soft water from underlying sands of Tertiary age.

CONCLUSIONS

Red River Parish is underlain by sand and clay beds of Tertiary (Paleocene and Eocene) age. Erosion has sculptured these rocks to form a rolling upland in the east-central part of the parish. The western half of the parish and the eastern margin have been leveled by stream action and subsequent valley filling. The flood plains of the Red River and Black Lake Bayou occupy the lowlands, which are flanked by terraces consisting of dissected remnants of higher and wider flood plains. The terrace deposits and the clay and sand underlying the flood plains are of Quaternary age.

In Red River Parish ground water occurs under conditions ranging from artesian to water-table. Except in their outcrop areas the fine-grained lignitic sands of Tertiary age contain water under artesian conditions. Water in the terrace sands and in the valley alluvium of Quaternary age is confined by an overlying semipermeable blanket of clay and silt that imparts to the aquifers characteristics that are imperfectly artesian. In some places the terrace sands are not covered by an overlying clay bed, and water occurs under water-table conditions.

Water in the Tertiary sands is derived principally from rainfall in the highland areas of De Soto and Red River Parishes where the formations crop out or are thinly covered by younger sand deposits. The water is soft and of the bicarbonate type, potable in near-surface sands but generally salty below a depth of 300 feet. The salty water may be derived from the updip migration of mineralized water in sands that have undergone artesian head loss through drainage into the alluvium of the Red River Valley, or it may be connate water that was never flushed completely from the sands. Although water in the sands of Tertiary age is of better quality than that from other aquifers in the parish, the low permeability and the thinness of the sands limit the yields of wells. As a result, the sands are developed principally for domestic, school, and small-business uses.

Dissected terrace deposits of Pleistocene age contain water-bearing sand and gravel of varying thickness and extent. Their principal source of recharge is infiltration from rainfall. The water is acidic, generally soft, and commonly high in iron, the amount of iron varying greatly. Little quantitative information is available concerning the water supply of these deposits, but their composition suggests that where they are not too highly dissected they may yield moderate quantities of water adequate for limited irrigation, small industries, and communities. Treatment to remove iron very likely would be required for the latter two uses.

The most productive reservoir of ground water in the parish, and the one for which the most data are available, is the extensive sand aquifer underlying the flood plain of the Red River. The water-bearing sand averages 40 feet in thickness and has an areal extent of 160 square miles. It is covered by clay and silt having an average thickness of 40 feet. In texture the material ranges from very fine grained sand to gravel. The water obtained from this sand is very hard and of the calcium magnesium bicarbonate type. It has a high concentration of iron. The hardness and iron are presumably derived from the calcareous red silt and clay through which some of the water passes.

The aquifer has two principal sources of recharge—the downward seepage of rainfall through overlying clay, and the upward seepage of water from underlying Tertiary sands. Water-level (piezometric) maps for this aquifer show the movement of water to be mainly to the east and west from a divide in the middle of the valley. At times of high ground-water levels and low surface-water levels more than 30 mgd of ground water is discharged into the Red River and Bayou Pierre, which are hydraulically connected with the aquifer. In addition, a small amount moves south into Natchitoches Parish. At times of low ground-water levels and high surface-water levels the flow is reversed, the water moving from the streams into the aquifer. This movement, however, generally is restricted to near-stream areas, as surface-water levels rarely remain above the ground-water levels long enough for the gradient to be reversed more than a few hundred yards from the streams.

Results of pumping tests indicate that the permeability of the aquifer ranges from about 1,000 to about 1,900 gpd per square foot. The observed storage coefficients average about 0.0003. The effect of hydrologic boundaries must be considered in assessing the ground-water resources in most places. Boundary conditions result from changes in aquifer thickness and permeability and from the influence of surface streams. In addition, large withdrawals from closely spaced wells might cause water levels in an area to decline below the clay and silt blanket overlying the aquifer. Such a decline would result in a change in ground-water occurrence from artesian to water-table conditions, which has the effect of increasing the amount of water derived from storage for each unit decline in head. This phenomenon would result in a lower rate of water-level decline than would be predicted on the basis of artesian conditions.

On the basis of data obtained in this investigation, it appears that properly constructed and developed wells in the alluvial sand will yield 500 to 1,500 gpm. Because of its relatively poor quality the most obvious use for the water at present is irrigation. However, treatment to reduce hardness and remove iron would make the quality satisfactory for other uses.

SURFACE-WATER RESOURCES

By Leland V. Page

QUANTITATIVE DATA AND ANALYTICAL STUDIES

The basic surface-water data used in this report have been collected by the Geological Survey in cooperation iwth the Louisiana Department of Public Works, the Louisiana Department of Highways, and the Corps of Engineers, New Orleans District. Other data and information have been taken directly from technical reports of the Corps of Engineers, U.S. Weather Bureau, Louisiana Department of Public Works, and Arkansas-White-Red River Basins Inter-Agency Committee. These sources of data are generally indicated through bibliographical references.

Streamflow records of several streams which flow in or near the parish and which are potential sources of water supply for the parish are compiled and analyzed in this report. These records are from gaging stations on the Red River, Black Lake Bayou, and Loggy Bayou, and from gaging stations on two streams tributary to Bayou Pierre, namely, Boggy Bayou and Cypress Bayou (fig. 26). A brief description of each stream-gaging station, accompanied by tables of monthly discharge, monthly runoff, and yearly discharge is given on pages 99–107.

If streams in the area are to be used as the source of large additional supplies, water must be held in storage for several months or even several years. The amount of storage required can be computed from the tabulations of monthly discharge. These monthly discharges summarize the daily discharge published annually in the U.S. Geological Survey water-supply papers as part 7 of the series "Surface Water Supply of the United States." A similar summary through

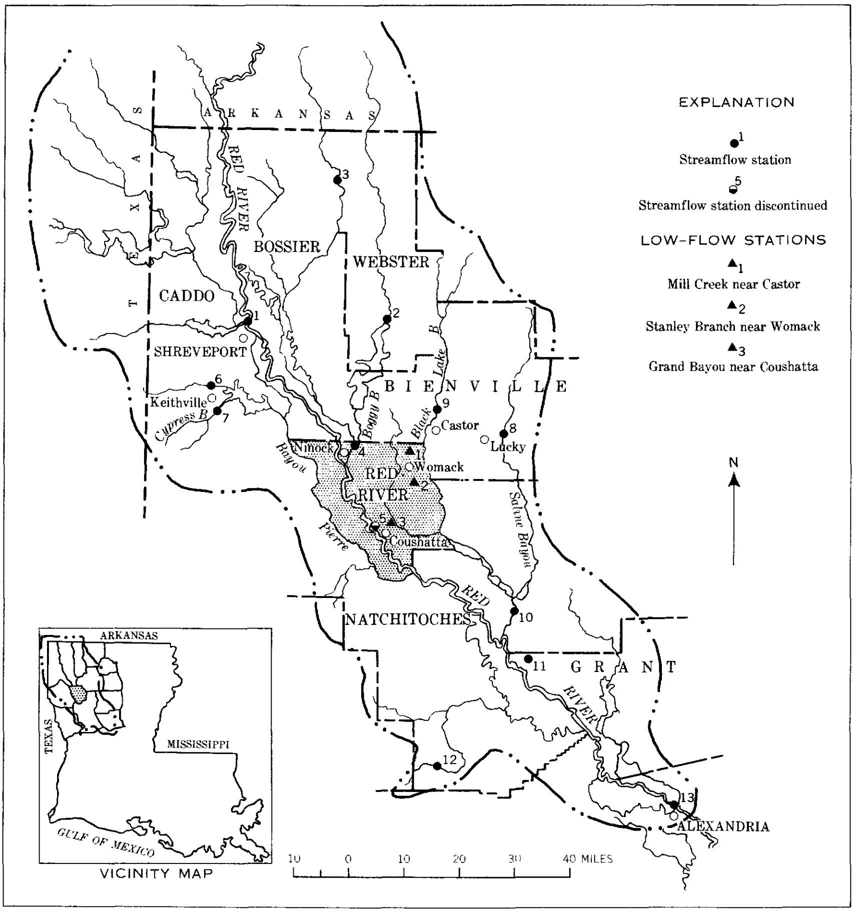

Figure 26.—Map showing principal towns, streams, gaging stations in or near Red River Parish.

the water year 1950 is published in U.S.G.S. Water-Supply Paper 1311 and a summary for the water years 1951–60 is planned.

Records of daily stage and occasional discharge measurements at selected points on Bayou Pierre in the vicinities of Gayle, Grand Bayou, Hanna, and Lake End are available in reports of the Corps of Engineers, New Orleans District, for the periods indicated below:

Location	*Period*
Gayle	Apr. 1938 to Dec. 1939; Mar. 1942 to Nov. 1954
Grand Bayou	Oct. 1946 to Nov. 1954
Hanna	Sept. 1938 to June 1945; Aug. 1945 to Oct. 1952
Lake End	May 1939 to Dec. 1951; July 1952 to Nov. 1954

As indicated in figure 27, no streamflow records were collected in the report area prior to the 1939 water year. Although the period

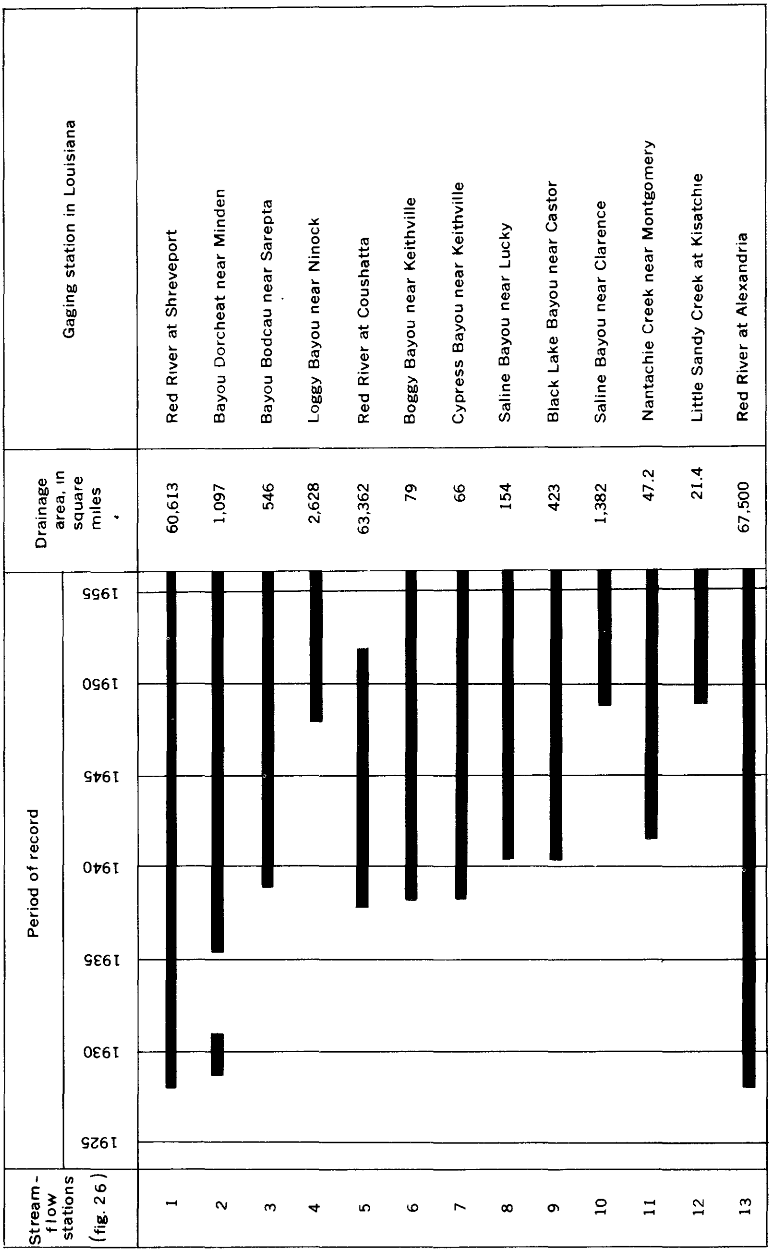

FIGURE 27.—Bar graph showing length of gaging-station records in region.

1939 to 1955 is relatively short, it probably is a fairly representative period of streamflow inasmuch as it is one in which monthly and annual mean discharges, as well as momentary extremes, varied greatly.

EXPLANATION OF HYDROLOGIC TERMS

Quantities of water, as presented in records shown in this report, are in units of cubic feet per second (flow rate), inches (runoff), and acre-feet (volume). "Second-feet" was formerly used in U.S. Geological Survey reports as a shorter form of "cubic feet per second."

A *cubic-foot per second* is the rate of discharge equivalent to that of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second.

Cubic feet per second per square mile is the average number of cubic feet of water flowing per second from each square mile of area drained, the runoff being assumed to be distributed uniformly in time and area.

Runoff, in inches, is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface.

An *acre-foot* is equivalent to 43,560 cubic feet and is the quantity required to cover an acre to the depth of 1 foot.

1 cfs=449 gpm

1 cfs=646,300 gpd=0.646 mgd

1 acre-foot per day=0.504 cfs, or 1 acre-foot=0.504 cfs-day

0.504 cfs for 24 hr or 1 day=1 acre-foot

STREAMFLOW CHARACTERISTICS

The effect of topography and geology on the runoff characteristics within a drainage basin is reflected in the behavior of the streamflow, the most sensitive characteristic being its timing—that is, the time that a basin requires to discharge the runoff from a storm.

Some basins have a permeable soil mantle and have underlying rocks with a large capacity for penetration and storage of ground water that is released to the streams at a relatively steady rate. Consequently, streamflow in these basins may be well substained during fair-weather periods. On the other hand, in basins with a shallow soil mantle covering impermeable rocks or poorly drained subsoils, the streamflow between storms may recede rapidly from sharply concentrated flood peaks to low flow, or even to no flow. Ground-water storage and timing factors, however, generally have only a slight influence on the total volume of runoff.

The hydrographs of three streams are compared in figure 28 to show the effect on runoff of differences in topography and in under-

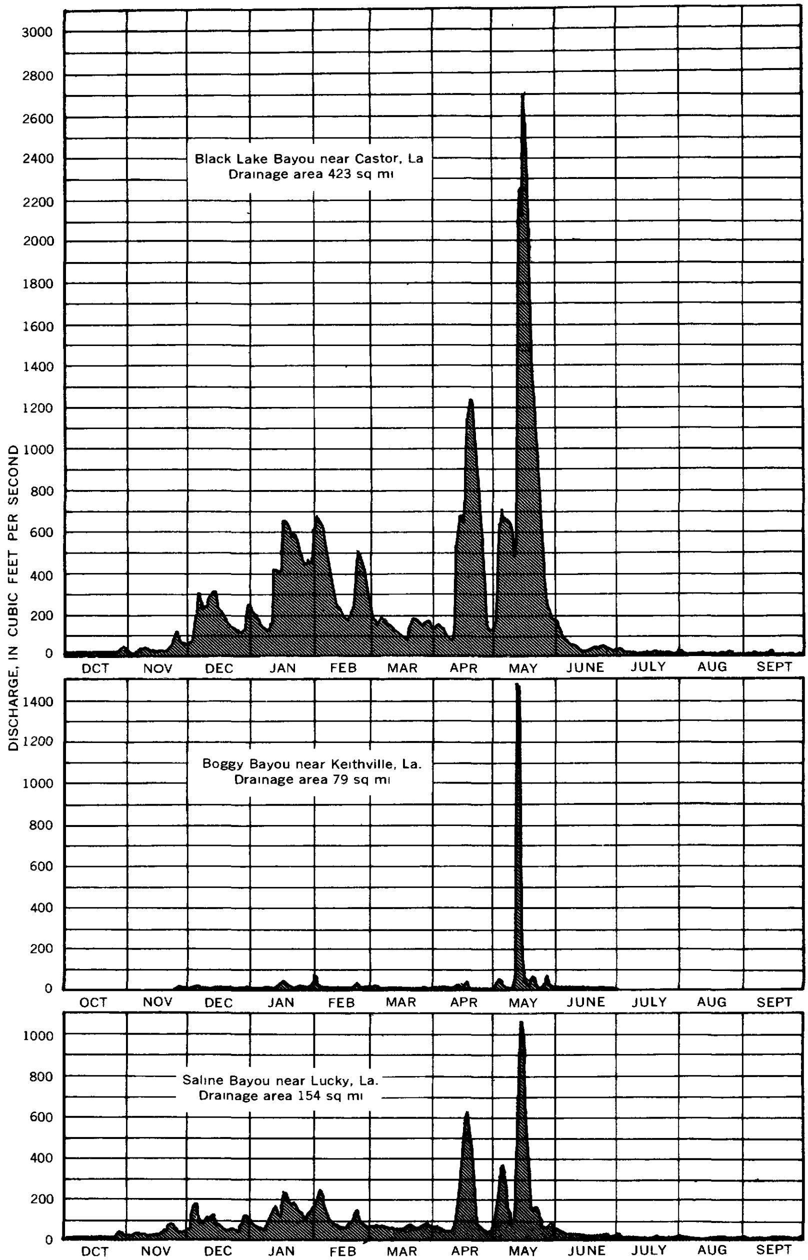

FIGURE 28.—Hydrographs of three streams for 1954 showing variation in runoff characteristics.

ground storage capacity. The Black Lake Bayou drainage basin, which consists largely of rolling terrain with friable, well-drained subsoils and a relatively flat stream gradient, is more capable of absorbing, storing, and releasing water uniformly than is the basin drained by Boggy Bayou, which consists of rolling land with a relatively steep stream gradient and impermeable, poorly drained subsoils. The contrast of the hydrograph for Boggy Bayou with that for Saline Bayou in neighboring Bienville Parish is even more pronounced because the Saline Bayou drainage basin, which has friable, well-drained subsoils throughout, is even more capable of absorbing, storing, and releasing water uniformly than is the Black Lake Bayou drainage basin. This contrast is the more remarkable inasmuch as the drainage area of Boggy Bayou is more nearly comparable in size to that of Saline Bayou than it is to that of Black Lake Bayou.

To evaluate and compare streamflow characteristics of various streams in or near the report area, records of daily discharge are analyzed and presented in several different ways. Flow-duration curves (fig. 29) are shown for three streams that are not affected by regulation—Black Lake, Boggy, and Cypress Bayous. For Black Lake and Cypress Bayous, curves of maximum period of deficient discharge (fig. 30), storage requirement curves (fig. 31), and graphs of low-flow frequency curves (figs. 32 and 33) are shown also.

A flow-duration curve shows the frequency distribution of different rates of flow. It indicates the percentage of time during the period studied that any given rate of flow was equaled or exceeded. The longer the period of record from which the flow-duration curve is computed, the more representative of average conditions will be the results.

The slope of the flow-duration curve is a good index of the storage within a basin, including ground-water storage; the flatter the general slope of the curve, the greater the storage. A comparison of flow-duration curves for several streams shows which streams have the highest dry-weather flow and are thus the best sources for a run-of-the-river water supply.

Flow-duration data in this report are shown in cubic feet per second and in millions of gallons per day. Assuming equal yield from all parts of the drainage area, these data may be used to estimate flow characteristics at any place on the stream. For example, if information is desired on Black Lake Bayou at a place where the drainage area is 500 square miles, the flow-duration data can be estimated from data on Black Lake Bayou near Castor, which has a drainage area of 423 square miles (fig. 29). By allowing for difference in drainage area, a daily flow of 7.3 mgd (6.2 mgd $\times$ (500 $\div$ 423)) may be expected

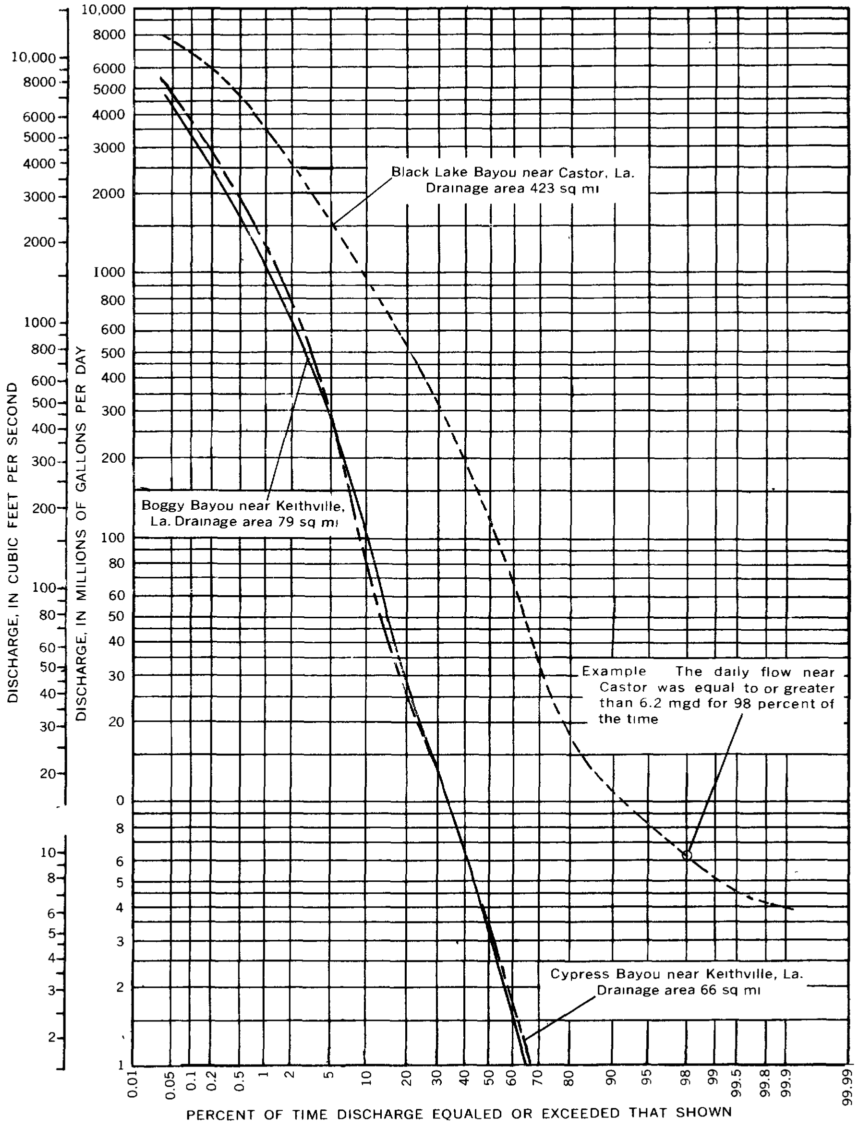

FIGURE 29.—Duration curves of daily flow in and adjacent to Red River Parish, 1939–54.

to be equaled or exceeded 98 percent of the time, and daily flow of 142 mgd (120 mgd × (500 ÷ 423)) may be expected to be equaled or exceeded 50 percent of the time. Care should be exercised in using this method, because not all parts of a drainage basin may have equal yields or the same runoff characteristics. In general, the possibility of error increases with an increase in the distance upstream or downstream from the gaging station.

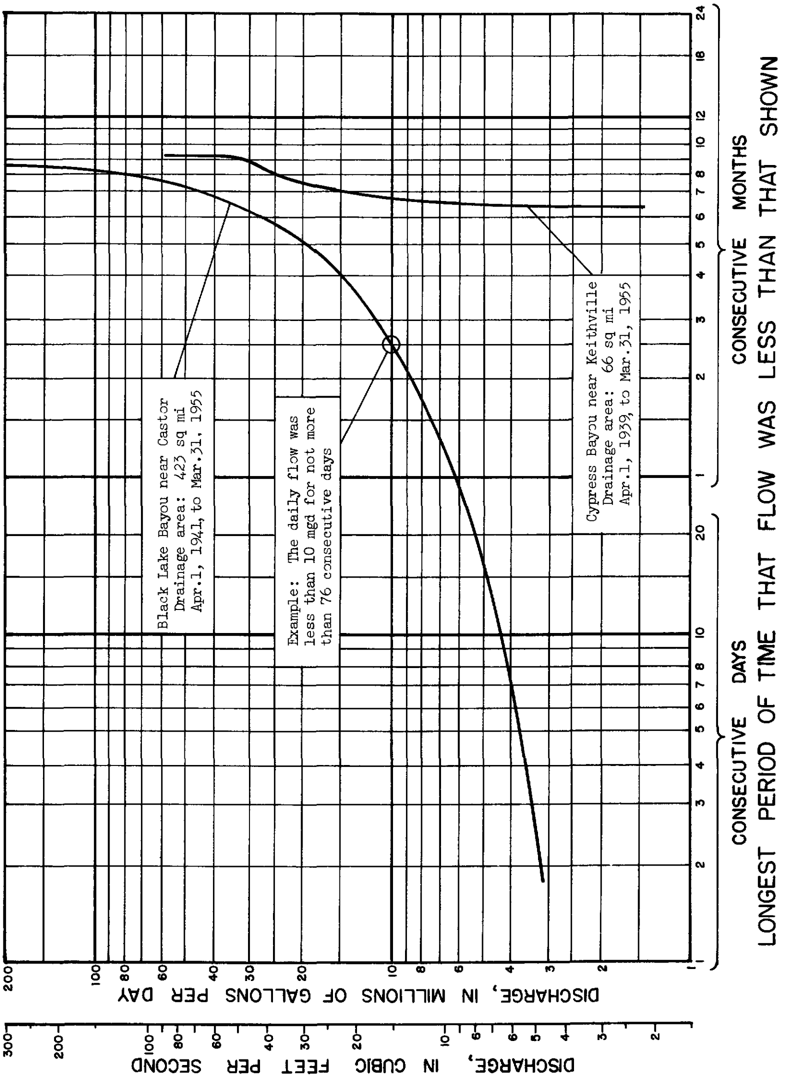

FIGURE 30.—Maximum period of deficient discharge for Black Lake Bayou near Castor and Cypress Bayou near Keithville.

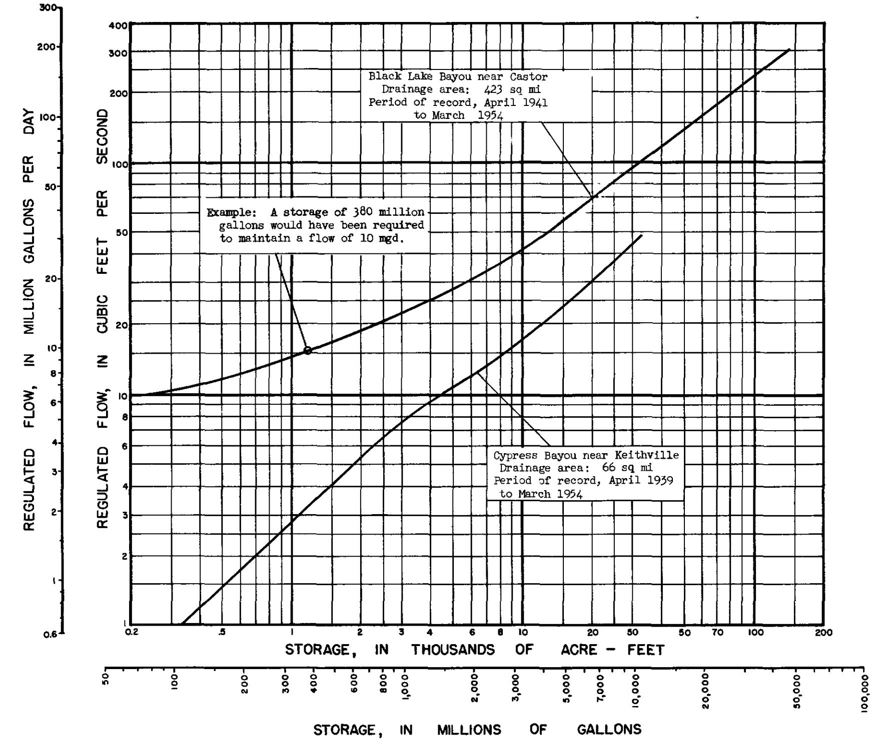

FIGURE 31.—Storage requirements, Black Lake Bayou near Castor and Cypress Bayou near Keithville.

The flow-duration curves (fig. 29), curves showing maximum periods of deficient discharge (fig. 30), curves showing storage requirements (fig. 31), and low-flow frequency graphs (figs. 32 and 33) can be very useful in the solution of many water-supply design problems. For example, suppose a flow of 10 mgd (15.5 cfs) is required for a water supply. If flow conditions in the future are comparable to those experienced during the period of record 1939–55, 10 mgd would be available from Black Lake Bayou near Castor for 92 percent of the time (fig. 29). During unusually dry years, the daily flow at Castor would be expected to be less than 10 mgd for not more than 76 consecutive days (fig. 30). During a 14-year period in which the pattern of flow was similar to that in 1941–54, a storage of 3.8 million gallons would be required to maintain a flow of 10 mgd (fig. 31). To this must be added the amount of dead storage below the reservoir-outlet and an allowance for evaporation and leakage from the reservoir. Without storage, the daily flow would be as low as 10 mgd at average intervals of 2 years and the average flow for 30 days would be as low as 10 mgd at average intervals of 2½ years (fig. 32).

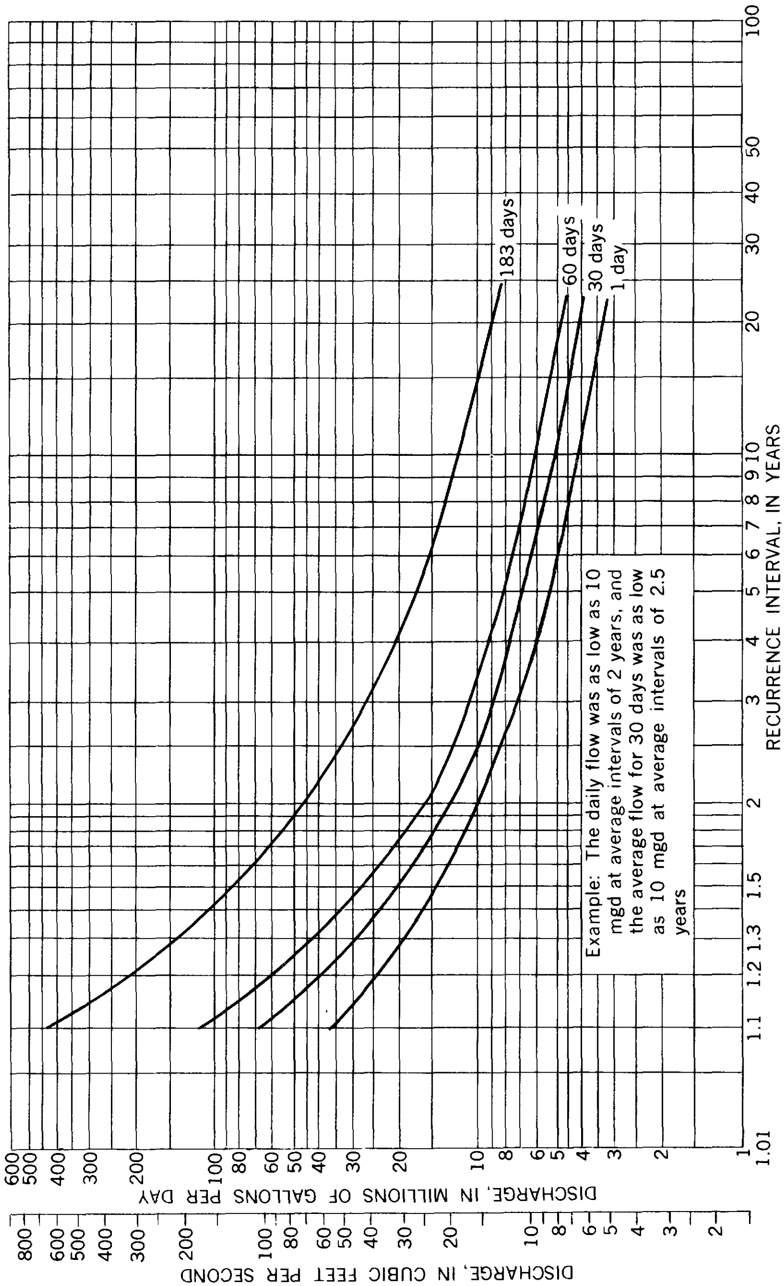

FIGURE 32.—Frequency of annual low flow for Black Lake Bayou near Castor, 1940–54.

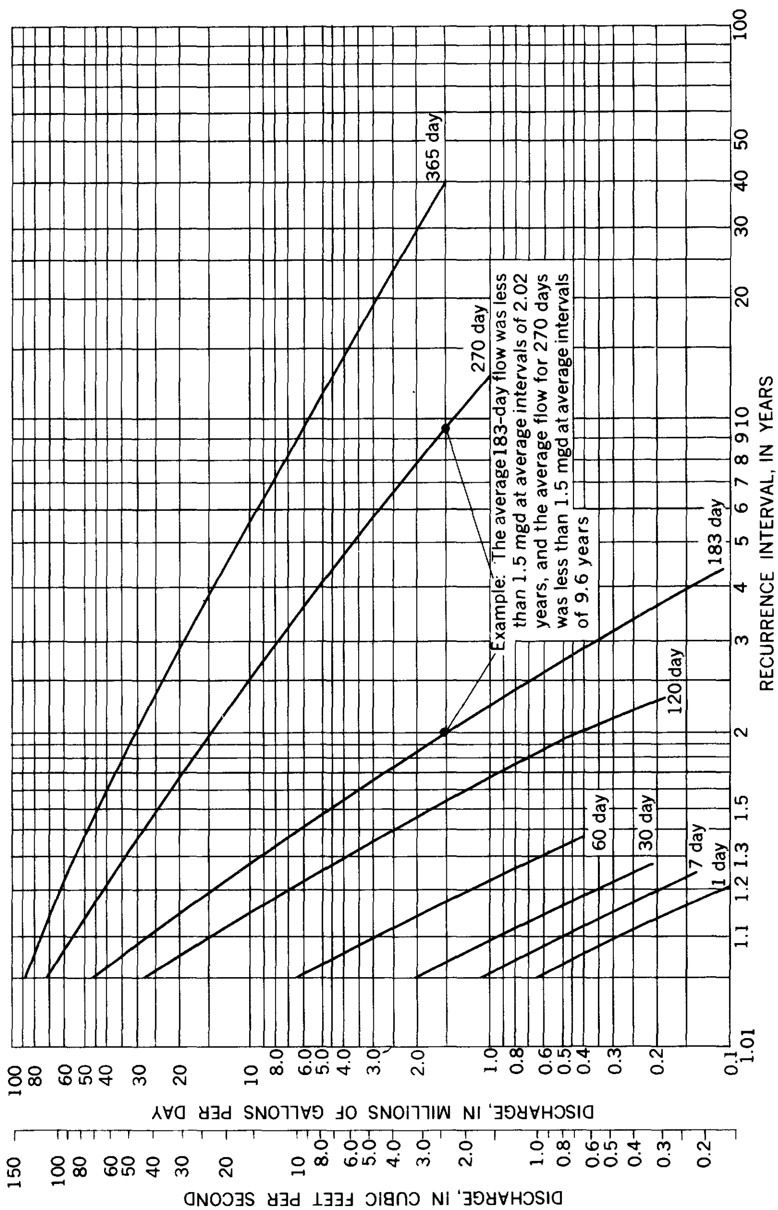

FIGURE 33.—Frequency of annual low flow for Cypress Bayou near Keithville, 1939–54.

This means not that a daily flow of as low as 10 mgd would occur at regular intervals of 2 years, but that over a long period of time the minimum daily flow during the year would be expected to be as low as 10 mgd about 50 times in 100 years.

DROUGHT FLOWS

The most severe droughts experienced in Red River Parish in recent years were in the 1943 and 1954 water years. The rainfall over the parish in these years averaged about 30 and 35 inches, respectively, as compared to the 30-year average of 52 inches.

A deficiency of water results in drought conditions, the seriousness of which depends upon such factors as the supply of water available and the control exercised over the supply. If the supply is appreciably controlled by impounding, a critical drought may not develop until there has been a rainfall deficiency for many months or even several years.

Thornthwaite and Mather (1955) stated: "Drought does not begin when rain ceases but rather only when plant roots can no longer obtain moisture in needed amounts. To farmers everywhere drought is a serious matter. Drought is hard to measure because we are not yet able to determine the water needs of plants very accurately. We do not know when to expect droughts or how intense they may be. Therefore, we cannot be sure which moisture-conservation measures may be best at a given time and place. Droughts deserve study. Not until we have conquered drought by scientific irrigation will we achieve the maximum production from the soil."

A very useful tool in the design of any water-supply system, whether it be for a municipality or an irrigation works, is the low-flow frequency graph. Low-flow frequency graphs based on annual flows for Black Lake Bayou near Castor and Cypress Bayou near Keithville are shown in figures 32 and 33. The curves for Black Lake Bayou show the recurrence interval, or probable return period, for low flows having a duration of 1 day, 1 month, 2 months, and 6 months. A curve for minimum 7-day flow is not shown because it nearly coincides with the 30-day curve. The Black Lake Bayou station represents an area of better sustained flow than does Cypress Bayou. The curves for Cypress Bayou are fairly representative of those for Boggy Bayou. As shown in figure 29, the Cypress and Boggy Bayou stations are in areas of no sustained flow. The low-flow frequency curves for Cypress Bayou (fig. 33) show the recurrence interval for low flows lasting 1 month, 2 months, 4 months, 6 months, 9 months, and 1-year. It is apparent that most years can be expected to produce flows as low as 1 cfs for periods of a month or more. Because of the probable great variation in flow characteristics from stream to stream, these curves cannot be used indiscriminately to determine the probable frequency of drought flows on other streams in the parish.

The combined flows from Boggy Bayou and Cypress Bayou, which flow into Wallace Lake, are a fair indication of the flows available in Bayou Pierre as it flows past Red River Parish. However, low flows in Bayou Pierre are sustained somewhat by Wallace Lake reservoir, whereas Boggy and Cypress Bayous go dry nearly every year during periods in the summer and fall.

In order to appraise the low-flow characteristics of other streams in the parish, special low-flow measurements were made during 1954 and 1955 on the small ungaged streams listed in table 5. These data are too meager for reliable correlation with records for regular gaging stations; however, these measurements exemplify the well-known fact that most streams that originate in the upland areas of the parish have no flow for at least several successive weeks every year. The length of no-flow periods depends on the size of drainage area and the type of soil mantle, on whether there is any sustained base flow from a ground-water source, and on the length of time without rainfall. It is planned to continue the low-flow observations with the expectation that sufficient data eventually will be available for reliable correlation with records at regular gaging stations.

TABLE 5.—*Special low-flow determinations*

[Discharges in cubic feet per second. Station numbers shown in fig. 26]

Date of measurement	Measured discharge at low-flow station	Concurrent gaging-station discharge	
		6. Boggy Bayou at Keithville, La. (drainage area, 79 sq mi)	9. Black Lake Bayou near Castor, La. (drainage area, 423 sq mi)
1. Mill Creek near Castor, La. (drainage area, 21.5 sq mi)			
July 7, 1955	2.93	1.1	117
Aug. 15	5.73	10	171
2. Grand Bayou near Coushatta, La. (drainage area, 93.9 sq mi)			
Aug. 30, 1954	No flow	No flow	9.1
Sept. 23	No flow	No flow	6.8
Oct. 22	[1].02	No flow	10
Nov. 22	[1].02	.5	18
Dec. 6	[1].02	No flow	20
Jan. 17, 1955	[1].02	8.8	83
Aug. 23	1.5	2.3	48
Dec. 12	1.81	.7	64.7
3. Stanley Branch near Womack, La. (drainage area, 4.7 sq mi)			
July 7, 1955	.062	1.1	117

[1] Estimated.

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FLOODS

The flood of April 1945 was the most notable flood of recent times in Red River Parish and was the maximum known on the lower Red River. Red River reached an elevation of 135.68 feet above mean sea level at Coushatta and parts of the town were inundated. Maximum stages known on the lower reaches of Loggy Bayou and Bayou Pierre also occurred during the 1945 flood. The higher stages on lower reaches of Loggy Bayou were due to backwater from Red River and those on Bayou Pierre were due largely to overflow from Red River through levee crevasses upstream in the vicinities of Hanna, Armistead, and East Point. The stage of Loggy Bayou near Ninock was 150.46 feet above mean sea level on April 8, 1945.

Excessively high stages on Bayou Pierre occurred in early August 1933 following heavy rains in the headwaters in late July. This storm produced the maximum stages known in the upper reaches of Bayou Pierre. The following tabulation shows a comparison of the 1933 and 1945 high water at various locations along Bayou Pierre:

Location	*Elevation in feet above mean sea level*	
	August 1933	*April 1945*
Bayou Pierre:		
South of Gayle	155.1	146.4
West of Grand Bayou	136.5	——
West of Hanna	129.8	131.0
Jim Island Bridge near Lake End	129.0	130.4

As indicated in the following tabulation, in relation to discharge the flood of June 1908 on Red River ranks second and the flood of April 1927 ranks third in magnitude during the periods of record at Shreveport, which date from 1873. At Alexandria, where the record dates from 1872, the flood of June 1908 ranks second and the more recent flood of May 1955 ranks third in order of magnitude, discharge-wise. The April 1927 flood ranks sixth in discharge at Alexandria but third with respect to stage. It is interesting to note that

Notable floods on Red River

Rank	Shreveport				Alexandria			
	Maximum stage		Maximum discharge		Maximum stage		Maximum discharge	
	Gage height (feet)	Year	Cubic feet per second	Year	Gage height (feet)	Year	Cubic feet per second	Year
1	45.9	1849	303,000	1945	45.23	1945	233,000	1945
2	45.6	1892	256,000	1908	43.77	1932	205,000	1908
3	45.1	1908	248,000	1927	42.35	1927	193,000	1953
4	44.7	1890	243,000	1930	42.05	1953	190,000	1932
5	44.4	1894	242,000	1892	41.84	1908	175,000	1892
6	44.1	1902	221,000	1890	41.27	1935	173,000	1927
7	43.6	1905	215,000	1894	41.25	1930	157,000	1950

the highest stage known on Red River at Shreveport was 45.9 feet (gage datum) in 1849, whereas the stage for the corresponding flood at Alexandria was only 35.36 feet (gage datum) which was exceeded by twenty or more floods during the period of record. The relatively high stages at Shreveport during the earlier years are attributed to backwater from log rafts formed in the river downstream (see discussion of the "Great Raft," p. 96).

Figure 34 shows water-surface profiles for the floods of May 1930, April 1945, and May 1953 for the Red River between Shreveport and Colfax. There is insufficient data available to draw a profile of the flood of April 1927. Most of the data for the profiles in figure 46 were furnished by the Corps of Engineers, New Orleans District. Although the floods of April 1927 and May 1930 greatly exceeded the flood of May 1953 in rate of discharge, the stage at Grand Ecore was slightly higher in 1953.

A list of annual peak stages of record for Red River at Coushatta appears in table 6. Table 7 shows peak stages and discharges for each water year for period of record at Shreveport.

Based on the record for Red River at Shreveport (1873–1954), which also represents dates of occurrence of high water for points on Red River in Red River Parish, the highest stage during the year occurred one or more times in every month except August, September, and October. The highest stage in the year has occurred in either April or May in 50 percent of the years. Figure 35 shows the

TABLE 6.—*Annual peak stages of Red River at Coushatta, La.*

Water year	Date	Gage height (feet)	Water-surface elevation (feet above mean sea level)
1889	Feb. 12, 13, 1889	[1] 26.5	122.3
1890	May 15, 16, 1890	[1] 38.1	133.9
1891	Feb. 15–17, 1891	22.5	118.3
1892	June 5, 1892	39.2	135.0
1893	Jan. 4, 5, 1893	27.4	123.2
1894	Apr. 7–9, 1894	31.9	127.7
1938	Mar. 2, 3, 1938	34.3	130.08
1939	Mar. 3, 1939	24.10	119.88
1940	July 9, 1940	23.36	119.14
1941	May 13, 1941	31.18	126.96
1942	May 7, 1942	35.25	131.03
1943	May 19, 1943	23.05	118.83
1944	May 11, 1944	31.2	127.0
1945	Apr. 7, 1945	39.9	135.7
1946	June 5, 1946	28.9	124.7
1947	Nov. 13, 14, 1946	26.75	122.53
1948	Mar. 6, 1948	23.85	119.63
1949	Feb. 3, 4, 1949	30.75	126.53
1950	Feb. 20, 1950	31.75	127.53
1951	Feb. 25, 1951	24.73	120.51
1952	Apr. 28, 1952	29.00	124.78
1953	May 21, 1953	[1] 34.36	130.14

[1] Data from Corps of Engineers.

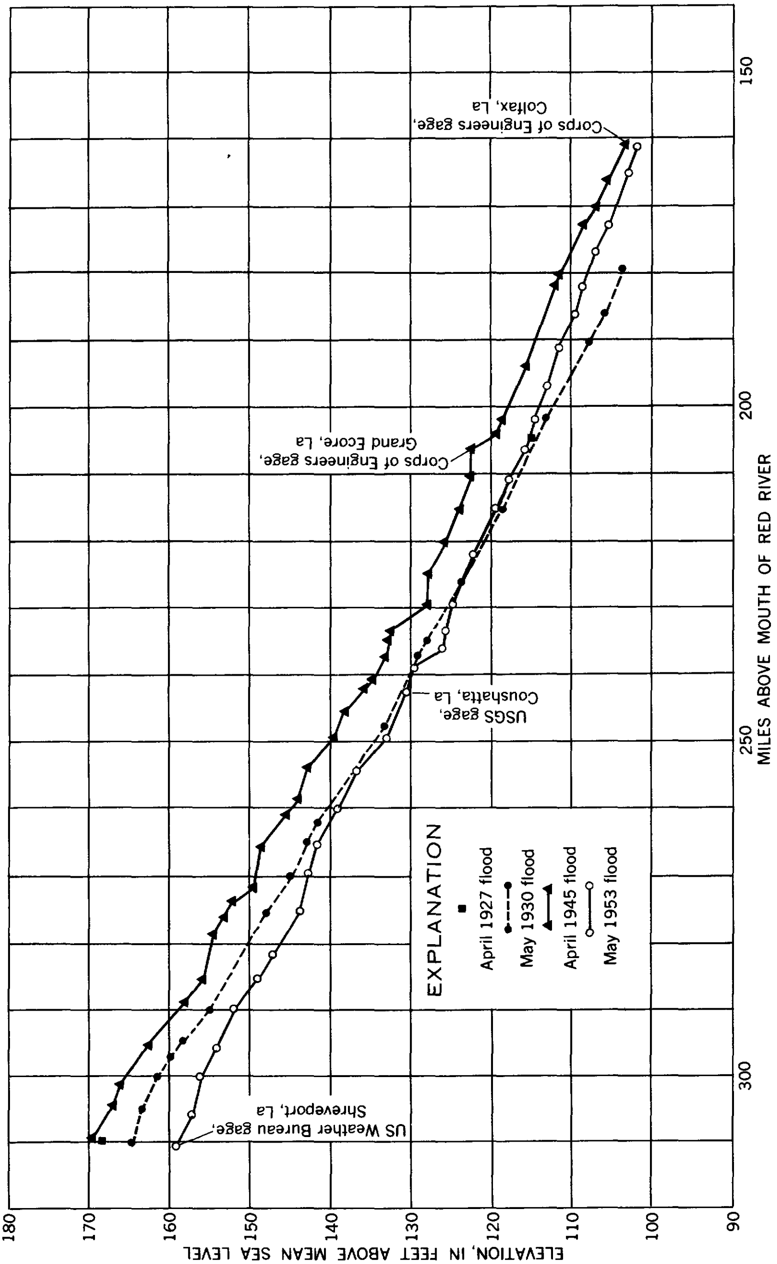

FIGURE 34.—Water-surface profiles for selected floods on Red River, Shreveport to Colfax.

TABLE 7.—*Annual peak stages and discharges of Red River at Shreveport, La.*

Water year	Date	Gage height (feet)	Water-surface elevation (feet above mean sea level)	Discharge (cfs)
1849	Aug. 1849	[1] 45.9	177.4	
1873	June 8, 1873	35.5	167.0	57,000
1874	Apr. 29, 1874	37.9	169.4	88,000
1875	Apr. 22, 1875	35.8	167.3	61,000
1876	July 28, 1876	41.9	173.4	160,000
1877	May 11, 12, 1877	39.8	171.3	120,000
1878	Jan. 31, 1878	38.4	169.9	97,000
1879	May 16, 1879	34.9	166.4	53,000
1880	Apr. 4, 1880	33.2	164.7	42,000
1881	Mar. 7, 1881	37.3	168.8	80,000
1882	Feb. 21, 1882	41.4	172.9	150,000
1883	Mar. 11, 12, 1883	35.3	166.8	57,000
1884	May 14, 1884	42.7	174.2	177,000
1885	May 11, 12, 1885	40.5	172.0	132,000
1886	Apr. 29, 1886	28.3	159.8	31,000
1887	Mar. 19, 1887	28.4	159.9	33,000
1888	May 19, 1888	40.3	171.8	129,000
1889	Feb. 3, 1889	41.9	173.4	160,000
1890	May 8, 1890	44.7	176.2	221,000
1891	Feb. 12, 1891	35.2	166.7	59,000
1892	May 28, 1892	45.6	177.1	242,000
1893	Jan. 1, 2, 1893	39.1	170.6	108,000
1894	Apr. 2, 1894	44.4	175.9	215,000
1895	July 29, 30, 1895	40.3	171.8	129,000
1896	Feb. 25, 26, 1896	27.5	159.0	35,000
1897	Apr. 11-13, 1897	34.10	165.58	53,000
1898	May 21, 1898	25.00	156.48	30,000
1899	Jan. 24, 1899	25.60	157.08	31,000
1900	May 8, 1900	25.00	156.48	30,000
1901	June 7, 1901	26.4	157.9	33,000
1902	June 14, 1902	27.6	159.1	35,000
1903	Dec. 15, 16, 1902	44.10	175.58	208,000
1904	June 24, 25, 1904	38.5	170.0	98,000
1905	June 9, 1905	43.6	175.1	197,000
1906	Jan. 2, 3, 1906	32.6	164.1	54,000
1907	June 13, 1907	36.9	168.4	90,000
1908	June 15, 1908	45.1	176.6	256,000
1909	Dec. 7, 1908	22.0	153.5	33,000
1910	Apr. 21, 1910	23.86	155.34	40,000
1911	Apr. 25, 27, 1911	23.42	154.90	41,000
1912	Apr. 14, 1912	29.3	160.8	68,000
1913	May 28, 1913	22.2	153.7	41,000
1914	Apr. 10, 1914	32.93	164.41	102,000
1915	May, 9, 1915	39.0	170.5	185,000
1916	Feb. 10, 1916	35.5	167.0	140,000
1917	May 4, 1917	20.4	151.9	41,000
1918	Apr. 25, 26, 1918	26.9	158.4	77,000
1919	Dec. 29, 1918	23.8	155.3	62,000
1920	May 26, 1920	36.2	167.7	178,000
1921	May 3, 1921	28.4	159.9	99,000
1922	May 5, 6, 1922	31.3	162.8	132,000
1923	Feb. 8, 1923	24.3	155.8	75,000
1924	Dec. 26, 27, 1923	30.4	161.9	133,000
1925	May 3, 1925	21.8	153.3	63,000
1926	July 30, 31, 1926	23.2	154.7	75,000
1927	Apr. 29, 30, 1927	37.4	158.9	248,000
1928	Apr. 28, 1928	25.1	156.6	95,000
1929	May 26, 27, 1929	27.48	158.96	121,000
1930	May 26-28, 1930	35.91	167.39	243,000
1931	Dec. 11, 1930	22.74	154.22	62,600
1932	Feb. 3, 1932	31.79	163.27	171,000
1933	May 31, 1933	22.82	154.30	75,600
1934	Apr. 11, 1934	21.78	153.26	71,400
1935	May 29, 1935	32.65	164.13	[2] 181,000
1936	Dec. 12, 1935	22.32	153.80	86,400
1937	Jan. 29, 1937	23.15	154.63	93,600
1938	Mar. 1, 1938	33.50	164.98	211,000
1939	Apr. 21, 1939	22.47	153.95	88,500
1940	July 8, 1940	22.04	153.52	95,600
1941	May 12, 1941	27.93	159.41	143,000
1942	May 5, 1942	31.47	162.95	183,000
1943	May 18, 1943	21.86	153.34	93,300
1944	May 9, 1944	28.25	159.73	163,000
1945	Apr. 7, 1945	38.4	169.9	303,000
1946	June 5, 1946	24.0	155.5	123,000

See footnotes at end of table.

TABLE 7.—*Annual peak stages and discharges of Red River at Shreveport, La.*—Continued

Water year	Date	Gage height (feet)	Water-surface elevation (feet above mean sea level)	Discharge (cfs)
1947	Nov. 11, 1946	22.6	154.1	131,000
1948	Mar. 6, 1948	20.3	151.8	99,500
1949	Feb. 2, 1949	25.8	157 3	171,000
1950	Feb. 18, 1950	26.2	157.7	163,000
1951	June 20, 1951	22.15	153.63	111,000
1952	Apr. 28, 1952	25.45	156.93	154,000
1953	May 20, 1953	27.32	158.80	173,000
1954	May 16, 1954	20.53	152.01	94,700

[1] Data from Corps of Engineers.
[2] Occurred May 15; gage height 32.13 ft.

frequency distribution of the annual floods with respect to the months in the year.

The following miscellaneous high-water discharge measurements of Loggy Bayou were made at the bridge on U.S. Highway 71 prior to the establishment of the gaging station:

Date	*Discharge, in cubic feet per second*	*Date*	*Discharge, in cubic feet per second*
Mar. 9, 1944	10,900	Apr. 1, 1946	9,790
Mar. 14, 1944	9,480	May 11, 1946	4,170
May 13, 1944	14,900	Jan. 23, 1947	7,120
Feb. 26, 1945	6,690	Feb. 14, 1948	10,200
Mar. 7, 1945	15,000		

The probable frequency of floods is an important factor in any project involving flood control and protection or in the proper design and location of structures placed in, across, or adjacent to streams. Levees, dams, or like structures that may cause loss of life in the event of failure should be designed to withstand the maximum probable flood. Works of lesser importance, however, where failure would not usually cause a loss of life or would not cause an exceedingly great financial loss can be designed for much lesser floods, usually at considerable savings. Consequently, the more economical approach in such cases is to design for a flood of some particular recurrence interval rather than for the maximum probable flood. The estimated damage resulting from the occurrence of the design flood, coupled with the probable useful life of the structure, can be weighed against the additional costs of designing the structure to prevent such damage.

To aid in the design of waterway openings, the Louisiana Department of Highways has published a cooperative report (Cragwall, 1952, p. 229–273) prepared by U.S. Geological Survey engineers that contains considerable data on Louisiana streams and includes a section on frequency of floods. Figures 36 and 37 were developed from

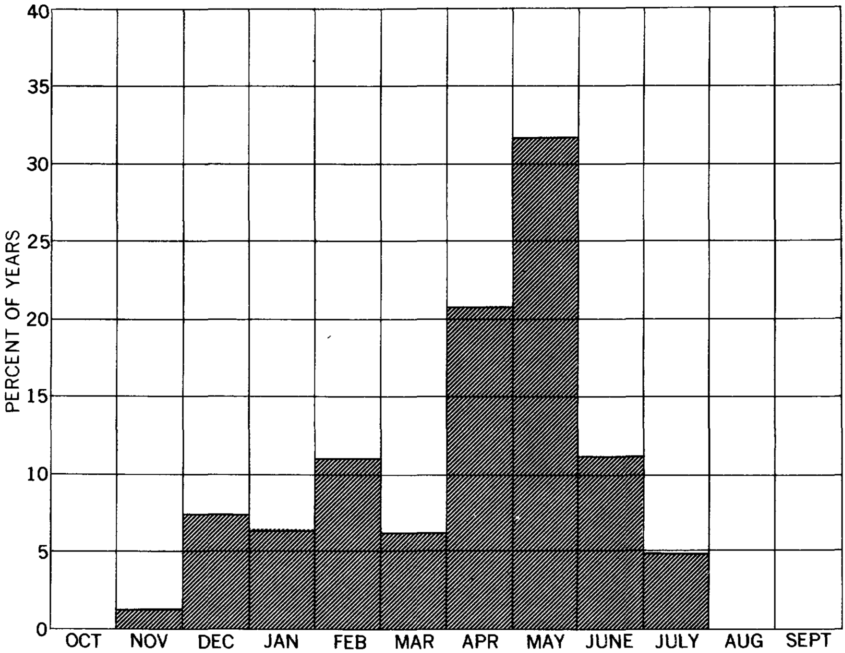

FIGURE 35.—Month of occurrence of annual floods on Red River at Shreveport, 1873–1954.

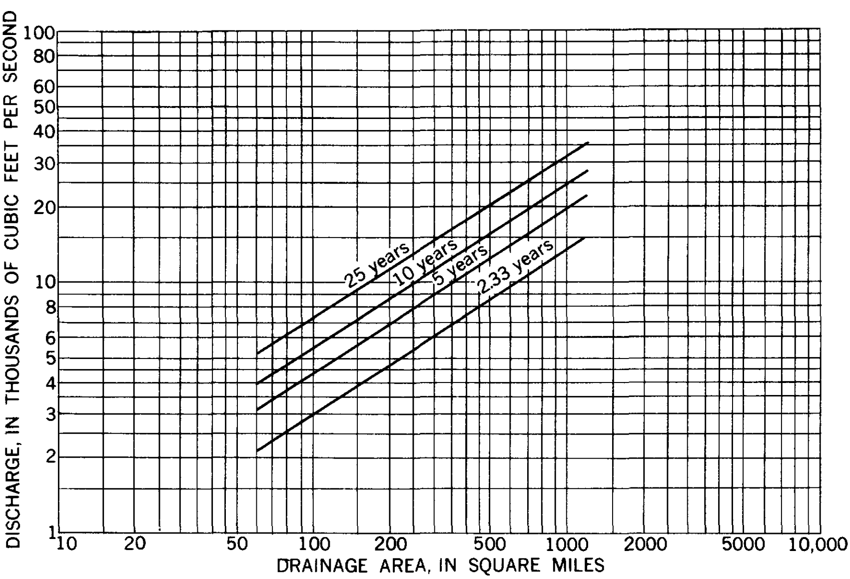

FIGURE 36.—Relation of peak discharge to drainage area, Red River Parish area, except Red River and Cypress and Boggy Bayous.

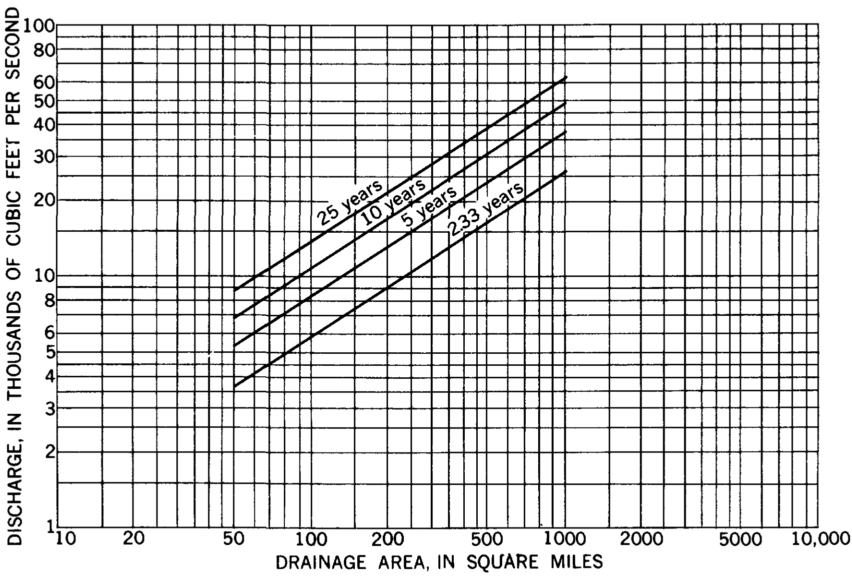

FIGURE 37.—Relation of peak discharge to drainage area, Cypress and Boggy Bayous.

Cragwall's curves for northwestern Louisiana and figure 38 shows a frequency curve for Red River at Coushatta, La., taken from Cragwall's report. Figure 36 may be used to estimate the probable magnitude of floods having a recurrence interval of 2.33 (mean annual), 5, 10, and 25 years on most streams in Red River Parish. Figure 37 may be used in like manner for Cypress and Boggy Bayous, which have characteristics somewhat different from those for streams within Red River Parish. For example, a peak discharge of 7,200 cfs may be expected to occur on the average of once in 25 years on any stream in Red River Parish where the drainage area is 100 square miles (fig. 36), but a discharge of about 13,000 cfs may be expected to occur on the average of once in 25 years on Cypress and Boggy Bayous where the drainage area is 100 square miles (fig. 37). It should be recognized, however, that the recurrence interval does not imply any regularity of occurrence but is the probable average interval between floods of a given magnitude in a long period of time. Two 25-year interval floods could conceivable occur in consecutive years or even in the same year.

CHEMICAL AND PHYSICAL CHARACTERISTICS

CHEMICAL QUALITY

As all natural water comes in contact with soils or rocks, or at least with air containing solid or gaseous impurities, it contains dissolved mineral matter. The quantity of dissolved mineral matter depends

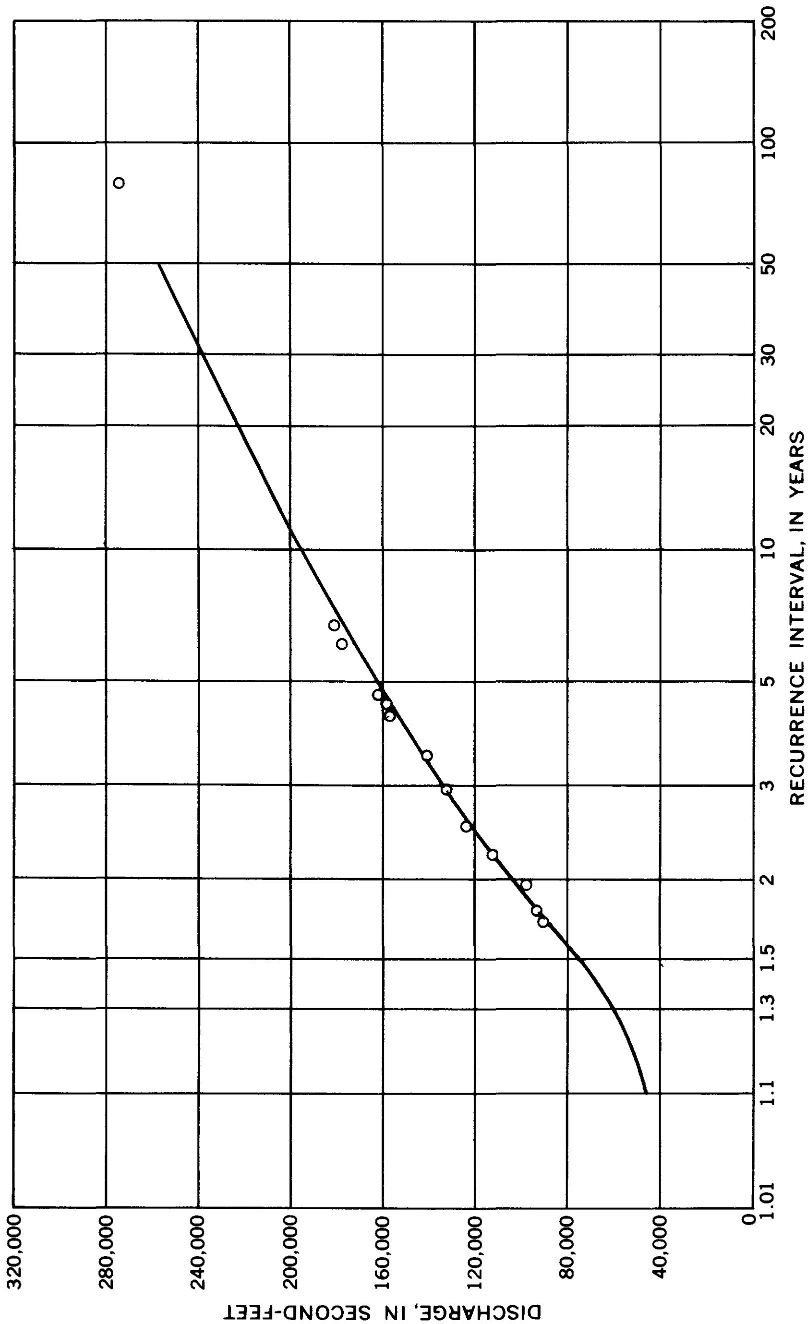

FIGURE 38.—Flood frequency curve for Red River at Coushatta, period 1872–1950.

largely on the type of rock or soil over or through which the water flows, and the length of time they have been in contact. Drainage from mines or inflow of municipal or industrial wastes often increases the concentration of mineral matter in a river.

In contrast to ground water, surface water may change in chemical quality from day to day; therefore it is desirable to have daily records of chemical analyses at strategically located points within each large river system. Unfortunately, this information is not available for Red River Parish; however, daily samples of Red River at Alexandria, La., have been taken since October 1952. Analyses of several samples collected at selected sites in or near Red River Parish during the 15-month period November 1954-January 1956 give an indication of the quality of the water. The mineral constituents and physical properties of the surface waters in or near Red River Parish that have a practical bearing on the uses of surface water for most purposes are given in table 8. Field chloride analyses of these waters are shown in table 9.

It will be noted that analyses of waters in Red River tributaries listed in table 8 with the exception of those for Loggy Bayou and Black Lake Bayou taken during low flows, are low in dissolved solids and in chloride and sulfate. These waters would be suitable for public water supply without softening, but treatment would be necessary to remove color and suspended material, inasmuch as water having a color of more than 20 units on the standard cobalt-platinum scale, is not generally acceptable for public use. If these analyses are representative, a storage of several hundred acre-feet of water on any of the small streams probably would provide a good surface supply for a small city in the parish.

Analyses of Red River water collected during September to December 1955 at Dennison, Shreveport, and Alexandria appear in table 10. This comparative analysis clearly shows that the limiting quality of the water that could be pumped from the Red River at any point in Red River Parish would be that of water released from Dennison reservoir. Water released from Dennison reservoir is, of course, a mixture of the inflow of flood and low flows of the semiarid region of Oklahoma and Texas and is rather highly mineralized. As chloride concentrations greater than 250 ppm are not recommended for public water supplies and as dissolved solids should preferably be not greater than 500 ppm, the Red River water would not be generally suitable for municipal and most industrial uses. It might be used, however, where large quantities of cooling or processing waters are needed for once-through processes.

TABLE 8.—*Chemical analyses of surface waters in or near Red River Parish, La.*

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids (p.p.m.)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH	Color (cobalt-platinum scale, units)
Black Lake Bayou near Castor, La.																		
9-14-55	17.0	14	0.41	3.9	1.3	82		10	3.7	129	0.2	240	15	7	92	458	6.6	45
10-25-55	16.5	15	.14	5.4	1.6	128		6	3.6	206	.2	364	20	15	93	710	6.1	25
11-22-55	45.4	18	.21	2.0	1.0	18		16	1.3	24	.5	73	9	0	81	109	6.5	70
12-12-55	64.7	17	.23	2.8	.7	46		6	5.5	70	.2	161	10	5	91	258	6.0	60
1-3-56	50.4	15	.49	2.4	.5	12		12	2.3	15	.2	54	8	0	76	77.3	6.3	70
Boggy Bayou near Keithville, La.																		
11-19-54	1.83	15	.28	7.6	3.7	18		21	25	22	0.2	102	34	17	54	181	6.3	90
1-14-55	3.14	33	.60	12	6.7	31		59	10	46	.2	168	57	9	54	269	7.1	55
2-7-55	588	8.0	.21	3.4	2.1	5.8	2.4	14	8.9	8.2	1.0	47	17	6	38	78.5	6.7	90
4-13-55	2,650	4.8	.28	2.5	1.4	4.2	2.8	16	4.2	4.8	.5	33	12	0	37	58.1	6.0	100
5-17-55	1.53	20	1.1	18	8.2	34		94	11	45	.8	184	78	1	49	324	7.3	90
6-7-55	328	7.4	.26	4.3	2.6	7.3	3.6	22	6.6	10	.8	54	21	3	38	91.7	6.5	100
7-19-55	2	14	.42	13	6.4	29		75	10	35	.8	146	59	0	52	263	7.4	55
8-16-55	6.22	16	.74	11	5.1	18		48	12	25	.8	136	48	9	45	198	6.8	65
9-22-55	.2	12	.32	16	7.6	37		104	4.8	44	1.0	174	72	0	53	316	7.3	45
Cypress Bayou near Keithville, La.																		
1-14-55	1.82	27	.41	16	8.0	33		93	15	38	0.2	184	74	0	49	302	7.3	60
2-7-55	686	8.8	.17	4.0	2.5	6.6	1.9	18	9.8	8.5	.8	52	20	6	39	84.9	6.5	80
4-12-55	1,290	4.1	.20	2.3	1.5	3.9	2.2	14	4.3	5.2	.8	32	12	1	36	56.0	6.1	80
5-17-55	1.00	13	.14	32	17	67		170	29	89	.5	349	150	10	49	618	7.5	70
6-7-55	25.6	14	.27	11	6.1	21		53	17	26	.8	122	53	9	47	210	6.9	80
7-14-55	5	5.0	.12	3.7	2.0	5.0	2.3	20	3.7	6.5	1.0	39	17	1	35	67.5	6.3	45
8-16-55	1.2	18	.34	21	10	33		95	24	44	.2	212	94	16	43	348	7.2	40

TABLE 8.—*Chemical analyses of surface waters in or near Red River Parish, La.*—Continued

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids (p.p.m.)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH	Color (cobalt-platinum scale, units)
Loggy Bayou near Ninock, La.																		
11-4-54	(1)	6.2	0.00	55	33	144		260	67	215	0.5	650	272	66	53	1,200	7.6	5
11-22-54	13.7	4.0	.05	72	35	176		249	109	275	.2	817	324	120	54	1,460	7.9	10
12-6-54	18.4	9.4	.05	65	34	158		225	98	255	.0	753	302	118	53	1,340	7.7	25
1-17-55	109	11	.38	32	11	64		107	47	90	.5	309	125	38	53	560	7.0	80
2-9-55	1,300	7.8	.25	15	5.5	76		50	12	123	.5	265	61	20	73	514	7.6	90
4-11-55	3,270	6.0	.36	12	3.4	61		44	12	90	.2	207	43	7	76	394	6.9	180
5-19-55	1,280	6.4	.86	12	2.9	16		43	2.7	28	.8	91	43	8	45	171	7.3	120
6-6-55	4,960	6.2	.31	8.9	3.2	23		27	3.5	42	.8	101	35	13	59	201	6.6	90
7-18-55	1,880	8.6	.17	12	3.5	33		34	4.2	59	.8	138	44	16	62	275	6.8	45
8-15-55	500	11	.57	18	6.6	33		69	11	54	.8	169	72	16	50	311	7.0	90
9-14-55	26.9	14	.02	70	31	133		302	68	193	.2	658	301	54	49	1,170	7.9	15
10-25-55	(1)	11	.00	65	29	132		279	58	198	.2	630	281	52	51	1,140	7.8	10
11-7-55	79.2	10	.04	80	37	170		345	72	258	.2	797	352	69	51	1,420	8.0	15
12-12-55	44.3	12	.29	42	17	62		160	54	87	.5	380	176	45	43	623	7.6	30
1-3-56	74.6	11	1.1	40	14	138		138	34	218	.5	525	158	44	65	983	7.2	220
Bayou Pierre west of Westdale, La.																		
2-9-55	----------	7.0	0.19	9.7	4.1	16		36	18	18	1.8	93	41	12	45	1,178	6.8	50
Grand Bayou near Coushatta, La.																		
8-23-55	1.5	16	0.81	7.0	2.6	10		34	2.8	14	0.5	71	28	0	45	118	6.5	100
12-12-55	1.70	18	.35	4.4	1.2	8.2	3.2	15	4.5	14	.2	61	16	4	47	84.3	6.2	90
Mill Creek near Castor, La.																		
8-15-55	5.71	25	0.73	5.6	2.0	11		34	1.0	11	1.0	89	22	0	51	96.8	6.8	45

Brushy Bayou near Frierson, La.																	
8-16-55	2.21	18	0.59	18	9.5	39	75	36	50	0.5	222	84	22	51	364	7.1	50
Wallace Lake Dam near Shreveport, La.																	
9-22-55	----------	4.1	0.11	12	6.3	18	58	20	17	3.0	121	55	7	42	206	6.9	30

[1] Backwater from Red River severe.

TABLE 9.—*Field analyses of chloride content of surface waters in or near Red River Parish, La.*

Stream and location	Date of sampling	Chloride (Cl)
Loggy Bayou north of East Point, La	2-15-55	140
Loggy Bayou north of East Point, La	12-15-55	168
Bayou Pierre west of Westdale, La	2- 9-55	18
Bayou Pierre west of Grand Bayou, La	12-15-55	72
Bayou Pierre west of Armstead, La	12-15-55	144
Bayou Pierre west of Armstead, La	12-28-55	112
Bayou Pierre west of Armstead, La	2-14-55	24
Bayou Pierre west of Lake End, La	12-15-55	96
Bayou Pierre west of Westdale, La	12-15-55	64
Bayou Pierre west of Williams, La	12-15-55	64
Red River at Coushatta, La	2-14-55	48
Red River at Coushatta, La	12-15-55	280
Red River at Coushatta, La	12-28-55	292
Red River at sec. 30, T. 13, N., R. 10 W	12-15-55	272
Red River at sec. 1, T. 14 N., R. 11 W	12-15-55	308

A considerable variation in the chemical character of Red River water during the year is indicated by the results of specific-conductance determinations in figure 39. This figure shows also the relation of hardness, dissolved solids, and specific conductance of the Red River at Alexandria to the streamflow at that point during the water year October 1953 to September 1954. Figure 40 shows shows the relation of chloride concentration of Red River at Alexandria to specific conductance for the same period. It is apparent from this graph that the relation of conductivity to chloride content is nearly linear except for the very high and very low concentrations of chloride. Fortunately, the specific conductance shown in figure 39 and its relation to chloride shown in figure 40 indicate the chloride concentration is usually highest at times other than the irrigating season.

TEMPERATURE

The temperature of surface water varies with air temperature; it usually reaches a maximum in July and August and a minimum in December and January. During winter and spring when streamflow is above average and the water temperature is not altered appreciably by pollution, the monthly average surface-water temperature is nearly the same as the monthly average air temperature. During the low-flow months from June to November the monthly average surface-water temperature is several degrees higher than the monthly average air temperature. Figure 41 shows the maximum average and minimum monthly water temperatures of Red River at Alexandria based on 3 years (1953–55) of daily records. Shown also on this figure for comparative purposes is a graph of average monthly air temperature at Alexandria for the same period. Figure 42 shows a graph of daily water temperature for Red River at Alexandria, La., for the year October 1953 to September 1954. Water

TABLE 10.—*Comparative analyses of water from Red River*

[Chemical constituents in parts per million]

Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids		Hardness as $CaCO_3$		Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25° C)	pH
													Parts per million	Tons per acre-foot	Calcium, magnesium	Noncarbonate				
At Denison Dam near Denison, Tex.																				
9/1-30/55	11	------	106	21	212	6.0	122	240	342	0.4	1.2	0.14	1,000	1.36	351	251	56	4.9	1,720	7.8
10/1-31/55	11	------	106	24	230	6.5	117	252	358	.5	1.0	.19	1,050	1.43	364	268	57	5.2	1,750	7.8
11/1-30/55	10	------	103	22	210	6.2	117	236	328	.4	1.8	.15	976	1.33	348	252	56	4.9	1,640	7.6
12/1-31/55	9.8	------	98	21	198	6.0	118	228	302	.3	1.2	.08	970	1.32	331	234	56	4.7	1,590	7.9
At Shreveport, La.																				
10/7-11/55	10	0.11	35	5.4	46		80	47	65	0.3	1.5	------	263	0.36	109	43	48	1.9	439	7.6
10/12-20/55	10	.03	100	20	184		114	216	292	.3	1.7	------	935	1.27	332	238	55	4.4	1,520	7.8
10/21-26, 28-31/55	8.8	.01	96	20	205		111	225	312	.3	.9	------	974	1.32	322	230	58	5.0	1,580	7.7
11/1-10/55	12	.00	96	20	190		131	207	290	.3	1.0	------	931	1.27	322	214	56	4.6	1,510	7.5
11/11-20/55	12	.00	101	21	191		147	207	295	.6	1.0	------	962	1.31	338	218	55	4.5	1,560	7.9
11/21-30/55	12	.02	99	21	190		140	210	292	.5	1.2	------	946	1.29	334	219	55	4.5	1,540	8.0
12/1-10/55	11	------	88	19	172		125	188	262	.4	2.2	------	856	1.16	298	195	56	4.3	1,410	7.5
12/11-20/55	10	------	88	20	162		133	180	252	.3	1.7	------	830	1.13	302	192	54	4.1	1,370	7.5
12/12-31/55	10	------	92	20	169		143	188	258	.4	1.6	------	854	1.16	312	194	54	4.2	1,400	7.5
At Alexandria, La.																				
10/1-14/55	9.4	0.08	32	5.4	39		92	33	54	------	1.5	------	222	.30	103	28	45	1.7	359	7.7
10/15-20/55	9.4	.01	98	18	172		114	212	268	------	1.2	------	928	1.26	318	225	54	4.2	1,510	7.8
10/21-31/55	9.0	.01	96	20	197		115	216	305	------	.9	------	957	1.30	322	222	57	4.8	1,560	7.8
11/1-10/55	11	.00	94	19	192		124	202	295	------	1.5	------	939	1.28	312	211	57	4.7	1,510	7.8
1/11-20/55	14	.00	98	21	180		162	192	275	------	1.5	------	916	1.25	331	198	54	4.3	1,480	7.9
11/21-29/55	13	.02	97	21	177		164	190	270	------	1.0	------	903	1.23	328	194	54	4.2	1,450	8.0
12/1-10/55	9.6	------	91	20	184		131	194	282	------	2.1	------	85	1.20	309	202	56	4.5	1,460	7.5
12/11-20/55	9.6	------	83	20	170		139	162	265	------	1.8	------	825	1.12	289	175	56	4.3	1,370	7.5
12/21-31/55	9.6	------	87	20	157		152	169	240	------	1.8	------	814	1.11	299	174	53	3.9	1,330	7.5

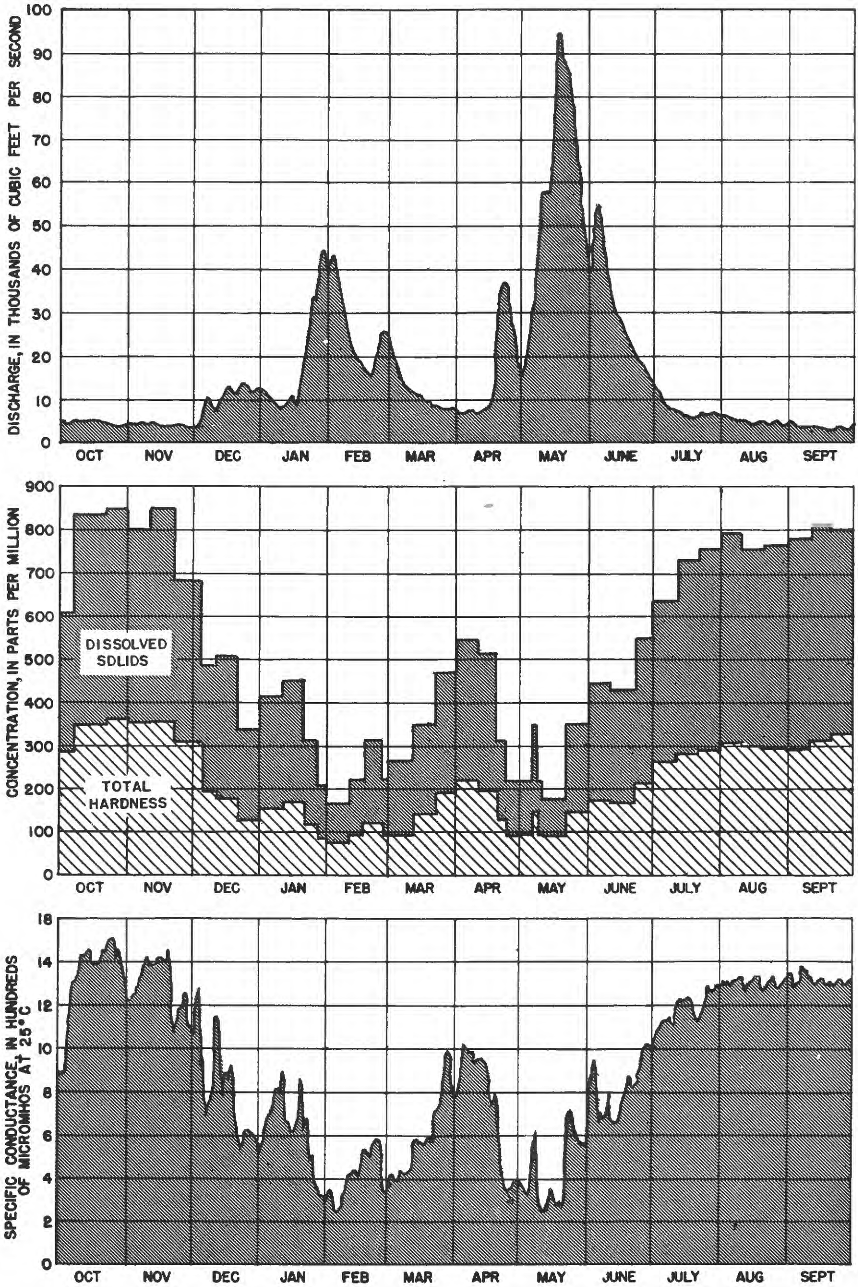

FIGURE 39.—Relation of hardness, dissolved solids, and specific conductance to streamflow, Red River at Alexandria, water year October 1953 to September 1954.

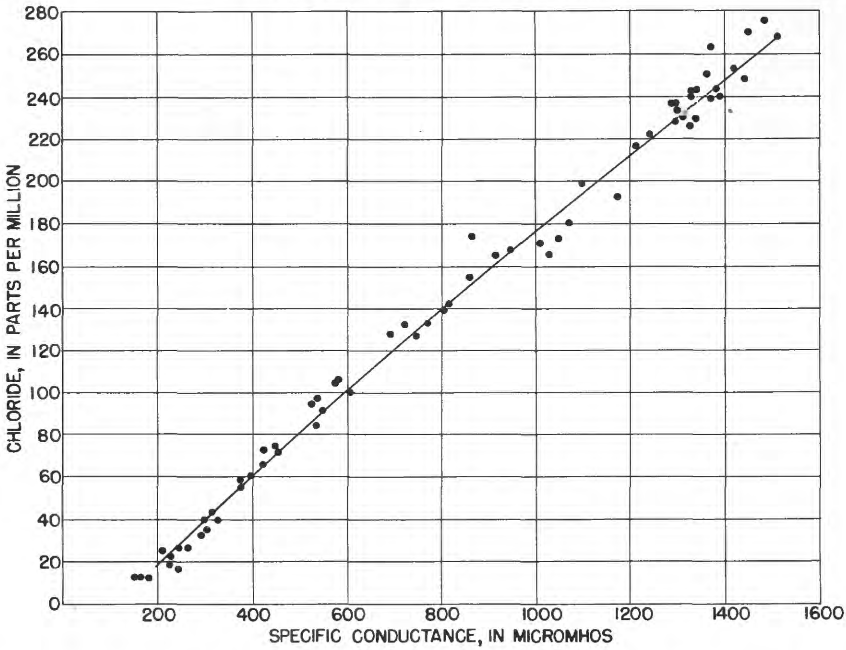

FIGURE 40.—Relation of chloride concentration to specific conductance, Red River at Alexandria, water year October 1953 to September 1954.

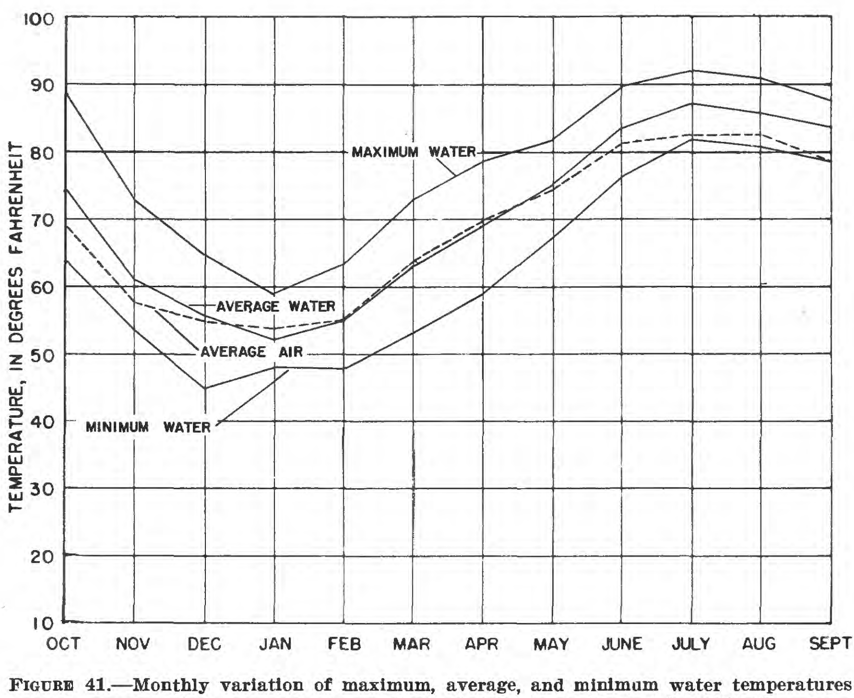

FIGURE 41.—Monthly variation of maximum, average, and minimum water temperatures compared to average air temperature, Red River at Alexandria, 1953–55.

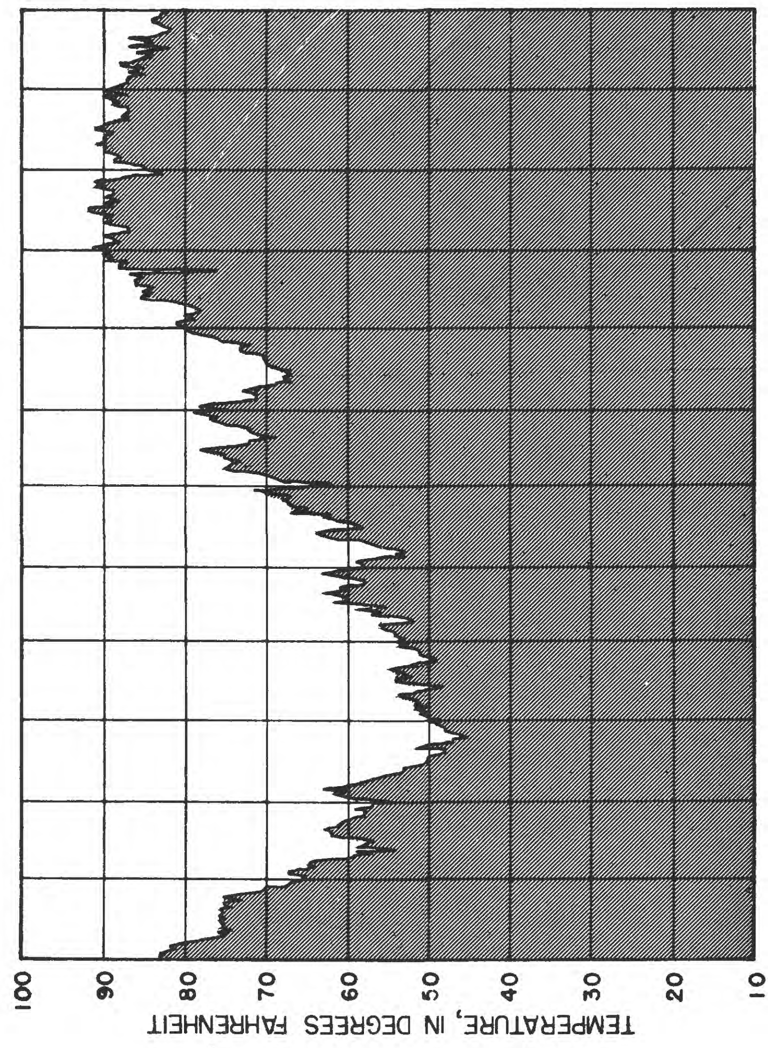

FIGURE 42.—Daily water temperature, Red River at Alexandria, water year October 1953 to September 1954.

temperatures were observed at about 4 p.m. each day at the time samples were taken for chemical analysis.

Daily water temperature records for the period October 7, 1955, to January 31, 1956, indicate that the water temperature of Red River at Shreveport is several degrees lower than that at Alexandria. Temperature observations at the two points were made practically simultaneously at about 4 p.m. each day. Comparisons of several water-temperature observations for Black Lake Bayou near Castor and Loggy Bayou near Ninock with those of Red River during the above-mentioned 4-month period indicate that during the fall months water temperature of Loggy Bayou corresponds to that of Red River at Shreveport, but that the water temperature of Black Lake Bayou during periods of low flow averages several degrees lower than that of Red River at Shreveport. Accordingly it would appear that, of the three streams, Black Lake Bayou could be depended upon for the coolest water during low-flow periods in the fall and winter months. Although no temperature observations were made during the hot summer months, the fact that during dry weather the flow of Black Lake Bayou is largely sustained by ground water indicates that the water in this stream may be cooler than that in Red River at Shreveport.

Periodic observations have been made of water temperature of Black Lake Bayou near Castor since June 1944 and of Loggy Bayou near Ninock since December 1949. Results of these observations are:

Loggy Bayou near Ninock, La.

Date	Water temperature (°F)	Date	Water temperature (°F)
Dec. 29, 1948	49	Sept. 4	90
Feb. 14, 1949	56	Oct. 4	82
Mar. 2	55	Dec. 4	54
May 19	78	May 17, 1952	48
June 3	86	July 23	83
Aug. 1	83	Aug. 15	88
Aug. 9	84	Aug. 29	80
Aug. 18	87	Sept. 30	78
Oct. 17	71	Oct. 15	64
Nov. 23	66	Nov. 20	54
Jan. 26, 1950	60	Dec. 15	48
Feb. 17	58	Jan. 12, 1953	58
May 19	79	Feb. 17	48
July 24	90	Mar. 23	58
Aug. 25	88	Apr. 20	64
Aug. 29	82	May 4	64
June 27, 1951	86	May 11	72
July 24	82	May 19	68
Aug. 2	92	June 15	78
Aug. 8	88	July 20	80
Aug. 24	85	Aug. 18	76

Loggy Bayou near Ninock, La.—Continued

Date	Water temperature (°F)	Date	Water temperature (°F)
Sept. 28, 1953	72	Mar. 14	56
Nov. 17	56	Apr. 11	63
Jan. 21, 1954	54	May 19	76
Feb. 15	50	June 1	76
Mar. 15	57	June 6	78
May 24	49	June 28	83
Aug. 20	86	July 7	89
Aug. 30	80	July 18	84
Sept. 23	76	Aug. 5	82
Nov. 4	54	Sept. 14	81
Nov. 22	56	Nov. 7	59
Dec. 6	54	Dec. 12	44
Jan. 17, 1955	50	Jan. 3, 1956	56
Feb. 9	49	Feb. 13	50

Black Lake Bayou near Castor, La.

Date	Water temperature (°F)	Date	Water temperature (°F)
June 23, 1944	85	Mar. 1	52
July 29	85	Mar. 18	68
Sept. 18	74	Apr. 20	59
Oct. 19	71	May 19	75
Oct. 23	58	Aug. 18	82
Dec. 11	42	Nov. 4	52
Jan. 15, 1945	48	Nov. 23	58
Apr. 3	64	Feb. 8, 1950	52
Jan. 23, 1946	43	Apr. 6	54
Feb. 28	56	July 24	80
Apr. 5	70	Mar. 13, 1951	52
May 17	72	June 27	80
Sept. 13	76	July 24	80
Oct. 17	60	Aug. 17	83
Jan. 2, 1947	34	Oct. 19	65
Apr. 23	65	Nov. 5	50
May 27	68	Apr. 9, 1952	56
June 18	76	Apr. 22	64
July 17	82	July 28	85
Aug. 25	81	Aug. 15	82
Sept. 18	79	Sept. 30	70
Oct. 28	65	Oct. 15	58
Dec. 18	40	Nov. 20	56
Feb. 16, 1948	47	Dec. 15	42
May 3	73	Jan. 12, 1953	58
June 3	70	Feb. 17	48
June 24	83	Mar. 20	68
Aug. 23	81	May 18	67
Sept. 15	73	June 15	70
Dec. 29	49	July 20	78
Feb. 14, 1949	60	Aug. 18	81

Black Lake Bayou near Castor, La.—Continued

Date	Water temperature (°F)	Date	Water temperature (°F)
Sept. 28, 1953	74	Feb. 11	43
Nov. 17	48	Mar. 14	56
Feb. 15, 1954	48	Apr. 11	61
Mar. 15	57	May 19	76
June 17	69	June 6	82
July 13	82	Aug. 15	78
Aug. 20	80	Sept. 14	81
Sept. 23	76	Oct. 25	61
Oct. 22	62	Nov. 22	54
Nov. 22	52	Dec. 12	43
Dec. 6	50	Jan. 3, 1956	53
Jan. 17, 1955	47		

USES OF SURFACE WATER

Little use is made of surface water for domestic or industrial supplies in Red River Parish. The town of Coushatta, which is the only municipality in the parish having a public water-supply system, obtains its water from wells. The Red River may represent a feasible and economic alternate supply if satisfactory water quality is maintained by continued improvements upstream such as impoundments and the control of pollution.

In dry seasons more and more use is being made of surface waters in the parish for irrigation. Even though the parish is situated in the humid zone where the normal precipitation during the growing season is usually adequate for most agricultural pursuits, comparatively short periods of drought that adversely affect crops are not uncommon. Several private irrigation systems have been installed along Bayou Pierre and Red River in the past few years. A large installation near Sample Ferry in the vicinity of Watson Bayou pumps water directly from Bayou Pierre and from a well close to the river bank. Another installation near Grand Bayou pumps water directly from Bayou Pierre into temporary storage in Grand Bayou, which has been dammed off from the river, and from there the water is lifted into the distribution system. A third, smaller installation near Magnolia utilizes water pumped directly from Bayou Pierre. There are two installations on the Red River, one near Emmett, which draws water directly from Red River into the system, and another in the vicinity of Redoak Lake, which takes water from the Red River and temporarily stores it in Redoak Lake and Nicholas Bayou, whence it is drawn into the system at a number of points remote from the river.

The town of Coushatta relies on the Red River for disposal of its wastes. Untreated sewage is emptied directly into the river.

Streams in Red River Parish do not play an important role in navigation at the present time, owing to their inability to carry large modern craft. Red River, Bayou Pierre, and Loggy Bayou have played important roles in earlier times when they were extensively used by smaller craft. The approved project for the Overton-Red River lateral canal will provide for 9-foot-draft navigation from the Mississippi River to Shreveport. The proposed waterway is expected to provide low-cost transportation to move local agricultural products, raw materials, and manufactured products to markets. Inbound traffic serving commercial activities and consumer-goods requirements of the area is also expected to use the waterway. A fringe benefit resulting from the construction of the canal would be the drainage of wet lands adjacent to the waterway.

HISTORY OF NAVIGATION

Earlier navigation on the Red River played a colorful role in the history and development of Red River Parish. During the period of early French exploration and French and Spanish occupancy of Louisiana, the river was the main highway to the northwest; Natchitoches, the seat of neighboring Natchitoches Parish, was the largest settlement on the upper river. After Louisiana was purchased by the United States, the supplies for Fort Towson in the Indian Territory were shipped up the Red River from New Orleans, and as soon as Shreveport was established there was considerable traffic from there to Natchitoches. As the country became well known, people began to settle along the banks of the river in what is now known as Red River Parish. Until the early 1830's Natchitoches was the head of navigation on the Red River because the "Great Raft" impeded the progress of boats. During this period Bayou Pierre served as a bypass and played an important part in the early history of the region as the only means of navigation northwestward from Natchitoches. Although not capable of accommodating large craft, Bayou Pierre was used extensively by fur traders and pioneers bound for Texas in dugouts and flatboats.

The "Great Raft" was a collection of trees and debris that had been collecting for many years; it extended up the river from Coushatta Bayou for nearly 180 miles. In 1831 Congress appropriated money for removal of the raft and improvement of navigation of the Red River. The work of removing the raft, or of making new channels where the raft was too solid to be removed, progressed, and by 1840 the river was cleared and was navigable for more than 1,000 miles. The work was hardly completed before the river started building anew, and within 2 years 8 miles of raft was formed between

Hurricane and Carolina Bluffs upstream from Shreveport. Successive attempts to keep the river clear upstream from Red River Parish failed and the raft was left for years; by 1872 there was 12 miles of solid obstruction. Another appropriation was made, and, by the use of powerful explosives, the channel was cleared within a year. The islands had become so large by this time that there were willow trees from 10 to 12 inches in diameter growing on them. In 1882 the work was continued, and in 1890 a raft said to be at least 300 years old was removed at Youngs Point about 9 miles upstream from Red River Parish. A channel 600 feet wide and 5 miles long was cut, and a clear channel now exists all the way to Shreveport.

Loggy Bayou also was an important waterway in steamboating days. Boats entered it from the Red River and passed through Lake Bistineau and upstream in Bayou Dorcheat during high water to avoid the swifter water in the Red River.

Several lakes in the Red River Valley, of which Black Lake is typical, were formed as a result of the damming of Red River by the "Great Raft." The level of the lakes depends largely on that of Red River, which during high water floods them by backwater. The fact that local people tell of being able to see the remains of boilers and engines of old steamboats during low-water periods on Black Lake indicates that steamboats once plied these waters, probably during the period of the "Great Raft."

WATER PROBLEMS

The principal surface-water problems in the parish pertain to flood control, drainage, irrigation, and navigation. Other problems are pollution and salt contamination.

Flood flows on the Red River are partially controlled by operation of Denison Dam (Lake Texoma) near Denison, Tex. Channel improvement and completion of Wallace Lake Reservoir on Bayou Pierre, the completion of Bodcau Reservoir on Bayou Bodcau, and the completion of levees on the Red River have alleviated the flood problem considerably.

Wet lands along the Red River are very fertile and productive when properly drained and protected from floods. Because of the large percentage of clay in their structure, the soils in these areas are wet natured, and the flat topography and heavy rainfall of the area add to the degree of wetness. Considerable work has been done by the Louisiana Department of Public Works and the Corps of Engineers in clearing and enlarging old bayous and constructing new ditches and levees. Additional flood protection would be required, however, to permit drainage of some areas.

Many current or potential problems arise in connection with irrigation, such as occasional pumping dry of Bayou Pierre by those using the water for irrigation. The Red River provides ample water for irrigation, and its quality is suitable for irrigating areas or crops of low salt tolerance in spite of its comparatively high salinity during periods of low flow, for these periods do not usually coincide with the irrigation season. The main problem in the use of water from the Red River is one of distribution to make water available to the more remote areas.

The Red River has navigable depths only during high stages, but even then swift currents, flood debris, and shifting channels make navigation impracticable.

No serious pollution problems originate within the parish. Since the construction of Dennison Dam the sediment load in the lower Red River, including that part flowing through Red River Parish, has decreased, and hardness and chlorides content are less variable. The city of Shreveport in neighboring Caddo Parish once used the Red River for its domestic water supply but later abandoned it because of salt contamination. Considerable brine from the Pine Island oil field in Caddo Parish enters the Red River above Shreveport to add to the natural salt content of Red River.

FUTURE NEEDS

The population of Red River Parish is comparatively static or slightly declining, with a shift from rural farm to rural nonfarm, and no appreciable increase in demand for surface-water for domestic or industial use is anticipated in the foreseeable future. The present sources appear to be adequate to provide the quantities that might be required for these purposes.

The demand for suitable water for irrigation is increasing at a rapid rate. Present sources of water of better quality in the smaller streams are already overtaxed in dry years. Additional surface-water supplies, particularly in the area now served by Bayou Pierre water, will have to come from the Red River. The chemical analyses indicate that water suitable for irrigation can be obtained from the Red River druing the irrigating season. The course that the river traverses across the parish makes its water potentially accessible to the entire western part of the parish, where most areas now being irrigated are located. Water from the Red River could be distributed to a large part of this area by pumping over the levees at various points and by utilizing existing bayous and other natural water-courses through the construction of relatively simple control dams or regulatory structures.

GAGING STATION RECORDS

Loggy Bayou near Ninock, La.

Location: Lat 32°14′10″, long 93°25′35″, in SE¼SE¼ sec. 31, T. 15 N., R. 10 W., on line between Bossier and Bienville Parishes, at bridge on U.S. Highway 71, a quarter of a mile downstream from Flat River, 2 miles southeast of Ninock, and 6 miles downstream from Lake Bistineau Dam.

Drainage area: 2,628 sq mi.

Gage: Water-stage recorder. Datum of gage is 100.26 ft above mean sea level, datum of 1929, supplementary adjustment of 1941 (levels by Corps of Engineers). Prior to Mar. 29, 1949, and June 30 to Sept. 24, 1951, staff gage at same site and datum. Auxiliary wire-weight gage read twice daily, 6 miles downstream.

Average discharge: 7 years (1948–55), 2,228 cfs (1,613,000 acre-ft per year).

Extremes: 1948–55: Maximum daily discharge, 20,000 cfs May 21, 22, 1953; maximum gage height 43.95 ft May 21, 1953; no flow at times.

Remarks: Some regulation by Lake Bistineau. A list of miscellaneous discharge measurements made prior to establishment of gaging station is given on page 80.

Monthly and yearly mean discharge, in cubic feet per second

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1949	42.6	156	772	3,698	9,903	4,304	5,298	1,706	631	354	262	118	2,216
1950	2,447	1,086	1,247	9,089	9,294	7,645	4,449	7,452	3,351	879	569	728	3,994
1951	1,861	571	199	1,497	6,064	4,647	3,252	1,836	455	698	121	45.7	1,743
1952	31.6	30.7	2,270	2,519	8,174	6,331	5,271	3,126	952	70.0	32.3	21.7	2,380
1953	17	36.8	435	974	3,661	5,677	3,833	16,830	3,772	981	671	385	3,114
1954	21.8	22.5	103	444	2,002	969	834	2,831	885	37.4	6.8	4.17	672
1955	2.0	10.0	40.3	369	1,482	3,187	4,257	3,493	3,101	813	967	35.0	1,476

Monthly and yearly runoff, in acre-feet

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1949	2,620	9,310	47,450	227,400	550,000	264,600	315,300	104,900	37,550	21,750	16,120	7,020	1,604,000
1950	150,400	64,620	76,700	558,800	516,200	470,100	264,800	458,200	199,400	54,020	34,980	43,340	2,892,000
1951	114,400	33,990	12,230	92,040	336,800	285,800	193,500	112,900	27,070	42,920	7,460	2,720	1,262,000
1952	1,940	1,820	139,600	154,900	470,200	389,300	313,600	192,200	56,670	4,300	1,980	1,290	1,728,000
1953	1,050	2,190	26,780	59,900	203,300	349,100	228,100	1,035,000	224,400	60,310	41,240	22,890	2,254,000
1954	1,340	1,340	6,330	27,300	111,200	59,590	49,640	174,000	52,640	2,300	419	248	486,300
1955	123	595	2,480	22,700	82,330	196,000	253,300	214,800	184,500	49,970	59,450	2,080	1,068,000

Loggy Bayou near Ninock, La.—Continued

Yearly discharge, in cubic feet per second

Water year	Water-supply paper	Water year ending Sept. 30							Calendar year		
		Momentary maximum		Minimum day	Mean	Per Square mile	Runoff		Mean	Runoff	
		Discharge	Date				Inches	Acre-feet		Inches	Acre-feet
1949	1147	14,300	Feb. 7, 1949	10	2,216	0.843	11.45	1,604,000	2,536	13.10	1,836.000
1950	1177	14,000	Jan. 23, 1950	0	3,994	1.52	20.03	2,892,000	3,813	19.70	2,760,000
1951	1211	7,250	Feb. 21, 1951	0	1,743	.663	9.01	1,262,000	1,719	8.88	1,245,000
1952	1241	10,100	Feb. 14, 1952	0	2,380	.906	12.32	1,728,000	2,224	11.52	1,614,000
1953	1281	20,000	May 21, 22, 1953		3,114	1.18	16.08	2,254,000	3,085	15.93	2,233,000
1954	1341	5,850	May 12, 1954		672	.256	3.48	486,300	664		480,500
1955	1391	9,700	May 27, 1955		1,476			1,068,000			

Black Lake Bayou near Castor, La.

Location: Lat 32°15′40″, long 93°12′50″, in NW¼ sec. 29, T. 15 N., R. 8 W., in Bienville Parish, at bridge on State Route 417, 2.8 miles downstream from Fourmile Bayou, 2.8 miles northwest of Castor, and 6.0 miles southeast of Ringgold.

Drainage area: 423 sq mi.

Gage: Water-stage recorder. Altitude of gage is 135 ft (from topographic map). Prior to Sept. 19, 1946, wire-weight gage; Apr. 5 to May 13, 1952, staff gage at same site and datum.

Average discharge: 15 years (1940–55), 565 cfs (409,000 acre-ft per year).

Extremes: 1940–55: Maximum discharge, 14,100 cfs Apr. 3, 1945 (gage height, 13.2 ft, from floodmark); minimum, 5.6 cfs Aug. 29 to Sept. 1, 1943 (gage height, 1.78 ft).

Monthly and yearly mean discharge, in cubic feet per second

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1940									855	612	576	73.1	
1941	19.6	881	2,219	1,585	956	1,008	483	1,317	368	357	261	70.8	796
1942	148	1,156	519	413	404	692	1,031	2,054	309	67.6	198	135	595
1943	30.9	40.2	95.8	168	314	365	401	49.2	33.9	26.4	8.17	11.8	127
1944	17.1	26.7	56.9	495	1,660	1,653	1,224	1,993	172	16.2	17.8	99.6	616
1945	21.6	150	633	3,096	1,161	2,225	2,332	385	249	553	181	89.1	923
1946	900	271	460	3,366	1,868	1,546	922	1,843	1,619	573	261	132	1,145
1947	97.6	984	608	2,167	729	1,328	729	180	83.3	28.5	22.1	29.4	582
1948	26.6	132	448	502	1,941	959	586	296	60.4	26.2	15.6	14.4	411
1949	18.3	79.6	192	1,323	1,290	738	564	160	61.7	43.9	54.7	33.6	375
1950	426	258	686	2,252	1,737	844	499	800	1,372	296	115	368	799
1951	401	243	234	1,111	1,237	705	682	251	150	41.6	17.5	39.1	421
1952	45.1	54.0	582	513	1,514	1,026	934	209	64.4	32.9	19.2	14.8	411
1953	11.8	29.7	59.3	172	1,018	1,597	818	3,879	73.5	42.0	21.2	20.4	647
1954	15.5	40.6	199	399	375	154	469	945	46.1	14.5	8.70	7.49	222
1955	12.7	20.7	29.1	96.3	310	690	723	1,065	717	760	285	31.7	396

Monthly and yearly runoff, in acre-feet

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1940									50,900	37,610	35,390	4,350	
1941	1,200	52,450	136,500	97,430	53,120	61,990	28,730	80,980	21,900	21,950	16,040	4,210	576,500
1942	9,130	68,780	31,920	25,380	22,440	42,550	61,340	126,300	18,360	4,160	12,140	8,060	430,600
1943	1,900	2,390	5,890	10,360	17,430	22,430	23,860	3,020	2,020	1,620	502	705	92,130
1944	1,050	1,590	3,500	30,430	95,500	101,600	72,830	122,500	10,250	996	1,090	5,920	447,300
1945	1,330	8,900	38,920	190,400	64,480	136,800	138,700	23,660	14,810	34,030	11,150	5,300	668,500
1946	55,350	16,120	28,290	207,000	103,700	95,050	54,880	113,300	96,340	35,250	16,020	7,860	829,200
1947	6,000	58,560	37,410	133,300	40,510	81,650	43,400	11,100	4,960	1,750	1,360	1,750	421,800
1948	1,640	7,860	27,560	30,860	111,600	58,980	34,860	18,200	3,500	1,610	960	859	299,600
1949	1,120	4,740	11,830	81,340	71,670	45,370	33,590	9,860	3,670	2,700	3,360	2,000	271,300
1950	26,210	15,330	42,170	138,400	96,440	51,870	29,710	49,200	81,660	18,200	7,090	21,920	578,200
1951	24,660	14,480	14,390	68,310	68,730	43,350	40,570	15,430	8,900	2,560	1,080	2,320	304,800
1952	1,550	3,210	35,770	31,510	87,090	63,090	55,570	12,870	3,830	2,030	1,180	882	298,600
1953	726	1,770	3,650	10,580	56,560	98,200	48,660	238,500	4,380	2,580	1,300	1,210	468,100
1954	956	2,410	12,260	24,510	20,840	9,460	27,900	58,080	2,740	890	535	446	161,000
1955	784	1,230	1,790	5,920	17,200	42,400	43,030	65,490	42,640	46,750	17,550	1,890	286,700

Yearly discharge, in cubic feet per second

Water year	Water-supply paper	Water year ending Sept. 30							Calendar year		
		Momentary maximum		Minimum day	Mean	Per Square mile	Runoff		Mean	Runoff	
		Discharge	Date				Inches	Acre-feet		Inches	Acre-feet
1940	897, 957										
1941	927, 957	9,480	May 8, 1941	18	796	1.88	22.54	576,500	685	21.98	496,200
1942	957	11,000	May 20, 1942	19	595	1.41	19.08	430,600	457	14.66	330,900
1943	977	1,370	Apr. 1, 1943	5.6	127	.300	4.07	92,130	122	3.90	88,090
1944	1007	11,000	Mar. 31, 1944	11	616	1.46	19.83	447,300	675	21.72	490,300
1945	1037	14,100	Apr. 3, 1945	18	923	2.18	29.63	668,500	993	31.87	719,100
1946	1211, 1337	9,270	Jan. 9, 1946	52	1,145	2.71	36.73	829,200	1,148	36.86	831,400
1947	1087	3,400	Mar. 17, 1947	18	582	1.38	18.71	421,800	493	15.81	356,800
1948	1117	4,710	Feb. 16, 1948	12	411	.972	13.24	299,600	385	12.38	279,200
1949	1147	3,070	Jan. 31, 1949	13	375	.887	12.03	271,200	466	14.96	227,300
1950	1177	5,490	June 5, 1950	15	799	1.89	25.63	578,200	757	24.29	548,000
1951	1211	2,010	Apr. 2, 1951	12	421	.995	13.50	304,800	403	12.93	291,800
1952	1241	3,990	Feb. 16, 1952	9.7	411	.972	13.24	298,600	364	11.71	264,200
1953	1281	11,500	May 1, 1953	8.4	647	1.53	20.74	468,100	660	21.16	477,600
1954	1341	2,780	May 16, 1954	5.7	222	.525	7.13	161,000	206	6.60	149,200
1955	1391	5,000	May 27, 1955	8.1	396	.936	12.69	286,700			

Boggy Bayou near Keithville, La.

Location: Lat 32°22′35″, long 93°49′20″, in NW¼SE¼ sec. 17, T. 16 N., R. 14 W., in Caddo Parish, at bridge on U.S. Highway 171, 0.4 mile downstream from Gilmer Bayou, 3 miles north of Keithville, and 5 miles upstream from mouth.
Drainage area: 79 sq mi.
Gage: Water-stage recorder. Datum of gage is 145.13 ft above mean sea level, datum of 1929 (levels by Corps of Engineers). Prior to Aug. 31, 1949, wire-weight gage; Jan. 19 to Apr. 7, 1954 staff gage at same site and datum.
Average discharge: 16 years (1939–55), 90.4 cfs (65,450 acre-ft per year).
Extremes: 1938–55: Maximum discharge, 14,800 cfs Jan. 5, 1946 (gage height, 20.2 ft, from graph based on gage readings), from rating curve extended above 5,200 cfs by velocity-area studies; no flow during long periods in most years.
Maximum stage known, 26.7 ft, from floodmark, in 1933.

Monthly and yearly mean discharge, in cubic feet per second

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1939	--------	--------	20.5	397	684	51.0	6.32	48.0	2.50	0.56	0.57	0	--------
1940	0	1.60	173	49.1	252	62.4	204	30.2	17.4	8.19	21.5	2.51	67.6
1941	.19	423	729	212	334	154	22.1	259	212	20.8	1.47	3.09	197
1942	53.5	314	126	51.1	65.0	191	252	321	26.0	.93	39.6	8.93	121
1943	.38	.96	7.64	10.7	9.34	45.1	17.8	2.38	4.11	.52	0	0	8.26
1944	0	.31	36.4	229	365	261	112	411	36.2	.11	.04	1.80	121
1945	0	3.61	148	476	199	578	246	72.3	2.15	87.1	4.87	.36	152
1946	297	47.3	215	900	459	335	58.3	393	153	4.89	1.80	1.08	239
1947	3.98	32.3	49.9	197	138	232	163	8.70	2.43	.19	0	.01	68.6
1948	0	1.47	10.5	104	288	85.1	26.5	72.3	1.22	1.23	0	0	48.3
1949	0	2.18	5.57	179	118	42.0	61.3	6.34	1.31	1.33	.62	4.54	34.7
1950	326	7.08	35.8	497	243	53.4	66.0	181	55.7	32.5	1.86	4.50	125
1951	3.98	5.71	4.72	35.7	189	85.3	29.9	5.23	8.39	.57	.05	.60	29.6
1952	.15	1.12	67.5	145	378	123	156	49.8	3.87	.43	.42	0	75.9
1953	0	.27	7.29	22.2	68.6	126	271	393	.75	.47	.12	0	74.3
1954	0	1.14	4.55	12.7	10.1	3.99	6.66	136	1.29	.08	0	0	14.9
1955	0	.98	4.55	19.3	85.8	75.1	160	203	23.7	6.17	243	.89	68.7

Monthly and yearly runoff, in acre-feet

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1939	--------	--------	1,260	24,430	37,990	3,130	376	2,950	149	34	35	0	--------
1940	0	95	10,610	3,020	14,500	3,840	12,120	1,860	1,040	503	1,320	149	49,070
1941	12	25,160	44,830	13,050	18,580	9,470	1,320	15,930	12,610	1,280	90	184	142,500
1942	3,290	18,710	7,720	3,140	3,610	11,730	14,980	19,720	1,550	57	2,430	531	87,470
1943	23	57	470	660	519	2,770	1,060	146	245	32	0	0	5,980
1944	0	18	2,240	14,080	21,000	16,030	6,680	25,250	2,150	6.9	2.2	107	87,560

1945	0	215	9,090	29,250	11,040	35,560	14,660	4,450	128	5,350	300	22	110,100
1946	18,280	2,820	13,190	55,340	25,480	20,600	3,470	24,170	9,080	301	111	64	172,900
1947	245	1,920	3,070	12,140	7,650	14,250	9,690	535	144	12	0	.8	49,660
1948	0	87	645	6,390	16,550	5,230	1,580	4,450	73	75	0	0	35,080
1949	0	130	343	11,030	6,530	2,580	3,650	390	78	82	38	270	25,120
1950	20,070	421	2,200	30,540	13,470	3,280	3,920	11,120	3,310	2,000	114	268	90,710
1951	245	340	290	2,200	10,480	5,240	1,780	321	499	35	3.0	36	21,470
1952	9.3	66	4,150	8,890	21,770	7,560	9,290	3,060	230	26	26	0	55,080
1953	0	16	448	1,370	3,810	7,760	16,120	24,160	45	29	7.1	0	53,770
1954	0	68	280	783	560	245	396	8,350	77	4.8	0	0	10,760
1955	0	58	280	1,190	4,770	4,620	9,550	12,470	1,410	379	14,960	53	49,740

Yearly discharge, in cubic feet per second

Water year	Water-supply paper	Water year ending Sept. 30							Calendar year		
		Momentary maximum		Minimum day	Mean	Per square mile	Runoff		Mean	Runoff	
		Discharge	Date				Inches	Acre-feet		Inches	Acre-feet
1939	877								110	18.95	79,800
1940	1211, 897	3,360	Dec. 23, 1934	0	67.6	0.856	11.65	49,070	149	25.72	108,400
1941	1211, 927	8,380	Dec. 27, 1940	0	197	2.47	33.81	142,500	141	24.25	102,200
1942	1211, 957	8,370	May 18, 1942	0	121	1.53	20.77	87,470	80.5	13.85	58,300
1943	1211, 977	435	Mar. 26, 1943	0	8.26	.105	1.41	5,980	10.6	1.82	7,690
1944	1211, 1007	5,670	May 2, 1944	0	121	1.53	20.78	87,560	130	22.45	94,610
1945	1211, 1037	7,430	Mar. 4, 1945	0	152	1.92	26.12	110,100	189	29.45	136,800
1946	1057	14,800	Jan. 5, 1946	0.3	239	3.03	41.05	172,900	199	34.16	143,900
1947	1087	4,030	Apr. 8, 1947	0	68.6	.868	11.79	49,660	62.4	10.71	45,150
1948	1117	1,610	Feb. 9, 1948	0	48.3	.611	8.33	35,080	48.0	8.27	34,820
1949	1147	1,610	Jan. 27, 1949	0	34.7	.439	5.96	25,120	65.4	11.23	47,340
1950	1177	5,100	Oct. 5, 1949	0.1	125	1.58	21.53	90,710	95.2	16.36	68,900
1951	1211	845	Mar. 29, 1951	0	29.6	.375	5.10	21,470	34.3	5.90	24,820
1952	1241	6,930	Feb. 12, 1952	0	75.9	.961	13.08	55,080	70.7	12.19	51,320
1953	1281	7,320	Apr. 29, 1953	0	74.3	.941	12.75	53,770	74.1	12.73	53,650
1954	1341	2,780	May 12, 1954	0	14.9	.189	2.56	10,760	14.9	2.55	10,750
1955	1391	6,840	Aug. 4, 1955	0	68.7	.870	11.80	49,740			

Cypress Bayou near Keithville, La.

Location: Lat 32°18'00'', long 93°49'40'', in SW¼ sec. 8, T. 15 N., R. 14 W., in Caddo Parish, at bridge on U.S. Highway 171, immediately downstream from Texas and Pacific Railroad bridge, 2 miles south of Keithville, and 6 miles upstream from mouth of Boggy Bayou.

Drainage area: 66 sq mi.

Gage: Water-stage recorder. Datum of gage is 162.13 ft above mean sea level, datum of 1929, supplementary adjustment of 1941 (levels by Corps of Engineers). Prior to Dec. 28, 1929, staff gage at same site and datum.

Average discharge: 16 years (1939–55), 78.6 cfs (56,900 acre-ft per year).

Extremes: 1938–55: Maximum discharge, 23,700 cfs Aug. 3, 1955 (gage height, 13.62 ft), from rating curve extended above 8,000 cfs by logarithmic plotting and velocity-area studies; no flow during long periods.

Maximum stage known, 18.0 ft, from floodmark, in 1933.

Monthly and yearly mean discharge, in cubic feet per second

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1939	------	------	7.87	99.7	394	38.1	10.1	31.9	2.53	1.13	0.161	0	------
1940	0	0	142	36.0	255	31.0	197	45.9	77.2	10.4	32.7	.6	68.0
1941	.061	437	534	154	186	145	25.9	208	293	34.5	4.18	.897	168
1942	125	269	97.9	72.2	40.9	144	155	147	23.4	.787	.671	.600	89.8
1943	.03	.32	3.78	5.01	5.72	15.5	5.20	5.13	2.36	.12	0	0	3.60
1944	0	0	13.3	213	292	203	166	472	6.23	.60	.62	1.97	114
1945	0	2.87	115	286	119	325	119	58.8	2.54	96.9	1.66	.02	94.4
1946	100	24.2	72.4	649	346	277	45.0	210	107	2.39	.26	.58	152
1947	1.49	21.3	23.8	242	208	233	61.3	9.39	2.01	.23	.10	.02	66.2
1948	0	.93	29.0	144	278	73.4	24.5	96.4	.58	4.55	0	0	53.6
1949	0	3.64	24.7	209	94.4	62.6	48.2	7.21	26.2	9.45	2.06	5.46	40.9
1950	370	6.88	72.1	281	223	29.2	35.3	167	63.2	57.9	3.33	2.87	109
1951	5.04	5.84	4.46	34.6	150	111	21.7	5.48	1.97	.72	.05	1.33	27.7
1952	.20	1.81	126	65.5	223	124	112	62.7	2.41	.98	2.66	0	59.6
1953	0	.39	12.0	36.0	157	234	292	517	.53	.45	.07	0	104
1954	0	.10	4.67	47.6	15.9	5.06	53.0	196	.72	0	0	0	27.1
1955	0	.02	2.60	15.6	78.9	81.6	162	140	3.56	17.1	454	.18	80.0

Monthly and yearly runoff, in acre-feet

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1939	------	------	484	6,130	21,910	2,340	599	1,960	151	69.4	9.92	0	------
1940	0	0	8,750	2,220	14,670	1,910	11,750	2,820	4,590	639	2,010	34	49,390
1941	3.8	25,980	32,800	9,500	10,360	8,930	1,540	12,800	17,410	2,120	257	53	121,800
1942	7,660	15,990	6,020	4,440	2,270	8,830	9,220	9,050	11,390	48	41	36	65,000
1943	1.8	19	233	308	318	951	309	316	140	7.5	0	0	2,600
1944	0	0	819	13,080	16,820	12,460	9,860	29,000	371	37	38	117	82,600

1945	0	171	7,090	17,590	6,620	19,990	7,090	3,620	151	5,960	102	1.2	68,390
1946	6,180	1,450	4,450	39,880	19,210	17,030	2,680	12,920	6,350	147	16	35	110,300
1947	91	1,270	1,460	14,860	11,570	14,320	3,650	578	120	14	6.1	1.2	47,940
1948	0	55	1,780	8,870	15,990	4,510	1,460	5,930	35	280	0	0	38,910
1949	0	217	1,520	12,880	5,240	3,850	2,870	443	1,560	581	127	325	29,610
1950	22,750	410	4,430	17,300	12,360	1,800	2,100	10,270	3,760	3,560	205	171	79,120
1951	310	348	274	2,130	8,330	6,820	1,290	337	117	44	28	79	20,080
1952	12	108	7,770	4,030	12,820	7,620	6,660	3,860	143	60	164	0	43,250
1953	0	23	735	2,220	8,700	14,370	17,380	31,780	31	27	4.6	0	75,270
1954	0	6.1	287	2,930	882	311	3,150	12,040	43	0	0	0	19,650
1955	0	1.4	160	958	4,380	5,020	9,620	8,580	212	1,050	27,900	11	57,890

Yearly discharge, in cubic feet per second

Water year	Water-supply paper	Water year ending Sept. 30							Calendar year		
		Momentary maximum		Minimum day	Mean	Per square mile	Runoff		Mean	Runoff	
		Discharge	Date				Inches	Acre-feet		Inches	Acre-feet
1939	877	7,720	Feb. 3, 1939	0					57.9	11.90	41,920
1940	897	5,170	Dec. 23, 1939	0	68.0	1.03	14.04	49,390	137	28.25	99,430
1941	927	8,050	Dec. 27, 1940	0	168	2.55	34.58	121,800	128	26.31	92,640
1942	957	6,970	Oct. 31, 1941	0	89.8	1.36	18.47	65,000	49.2	10.12	35,580
1943	977	220	May 31, 1943	0	3.60	.055	.75	2,600	4.38	.90	3,170
1944	1007	8,250	Apr. 30, 1944	0	114	1.73	23.47	82,600	123	25.30	89,040
1945	1037	7,050	Mar. 4, 1945	0	94.4	1.43	19.42	68,390	101	20.78	73,200
1946	1057	14,700	Jan. 5, 1946	0	152	2.30	31.34	110,300	140	28.72	101,100
1947	1087	4,840	Mar. 13, 1947	0	66.2	1.00	13.63	47,940	64.9	13.35	46,950
1948	1117	3,200	May 12, 1948	0	53.6	.812	11.05	38,910	53.5	11.01	38,810
1949	1147	3,200	Jan. 28, 1949	0	40.9	.620	8.41	29,610	76.6	15.76	55,470
1959	1177	8,010	Oct. 5, 1949	0.4	109	1.65	22.49	73,180	72.5	14.92	52,460
1951	1211	1,130	Mar. 28, 1951	0	27.7	.420	5.71	20,080	37.4	7.68	27,040
1952	1241	3,700	Feb. 12, 1952	0	59.6	.903	12.29	43,250	49.7	10.27	36,120
1953	1281	13,900	Apr. 29, 1953	0	104	1.58	21.38	75,270	103	21.25	74,800
1954	1341	7,450	May 12, 1954	0	27.1	.411	5.58	19,650	27.0	5.55	19,520
1955	1391	23,700	Aug. 3, 1955	0	80.0	1.21	16.45	57,890			

Red River at Coushatta, La.

Location: Lat 32°00'45", long 93°21'10", in lot 23, T. 12 N., R. 10 W., in Red River Parish, at bridge on U.S. Highway 84 at Coushatta, 11 miles downstream from Coushatta Bayou and 242.4 miles upstream from mouth.

Drainage area: 63,362 sq mi, of which 5,936 sq mi above Denison Dam is noncontributing.

Supplemental records available: Discharge observations, August and November 1893, in reports of Mississippi River Commission. Gage heights, August 1890 to June 1894, and gage heights and discharge observations since April 1937 in reports of Corps of Engineers.

Gage: Wire-weight gage. Datum of gage is 95.78 ft above mean sea level, datum of 1929, supplementary adjustment of 1941 (levels by Corps of Engineers).

Average discharge: 14 years (1938–52), 13,140 cfs.

Extremes: 1937–52: Maximum discharge, 275,000 cfs (including overflow through Bayou Pierre) Apr. 7, 1945, computed on basis of records for station at Shreveport and two discharge measurements at Grand Ecore; maximum gage height, 39.9 ft (affected by levee crevasse upstream) Apr. 7, 1945; minimum discharge, 880 cfs Nov. 10, 11, 1939 (gage height, 1.25 ft).

Flood of June 5, 1892, reached a stage of 39.2 ft.

Remarks: Some regulation of flow by Lake Texoma. Station discontinued September 1952.

Monthly and yearly mean discharge, in cubic feet per second

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1939	1,739	3,249	2,655	13,720	40,070	52,370	64,690	20,230	8,467	8,174	3,000	1,998	18,170
1940	1,087	1,240	1,987	2,609	5,902	5,295	29,580	39,550	46,870	52,720	14,500	5,590	17,290
1941	2,306	19,850	49,340	48,740	37,340	43,530	50,550	99,760	81,610	29,050	9,312	8,362	39,510
1942	34,210	46,070	23,470	21,000	16,810	28,550	94,150	116,400	41,800	16,240	8,606	16,380	38,700
1943	9,555	17,110	9,234	25,010	10,510	17,790	39,190	45,120	35,920	6,720	2,343	1,907	18,380
1944	2,282	3,103	4,466	13,640	34,490	69,560	54,380	86,190	36,680	3,917	1,927	2,774	26,090
1945	1,890	3,929	19,650	48,600	40,500	150,500	162,700	64,250	74,320	50,920	17,970	7,621	53,580
1946	57,480	19,180	13,830	67,210	94,970	53,040	44,830	72,250	73,570	12,790	5,032	7,036	43,090
1947	4,808	68,060	64,210	33,720	20,110	35,610	47,870	80,020	46,410	10,640	4,203	9,146	35,440
1948	4,235	10,060	34,220	38,090	48,430	68,850	26,800	49,710	22,480	21,030	4,751	3,067	27,660
1949	2,556	3,827	5,716	32,720	83,350	49,350	37,370	35,720	38,360	10,020	5,836	4,690	25,370
1950	15,680	17,970	13,870	76,630	110,500	39,710	17,560	92,880	29,810	25,030	53,180	61,120	45,790
1951	30,970	8,008	6,110	17,840	50,120	38,280	21,740	24,370	63,010	45,070	6,573	5,499	26,290
1952	4,041	11,890	14,630	19,690	23,970	32,460	71,360	43,100	14,530	4,600	4,515	3,346	20,610

Monthly and yearly runoff, in thousands of acre-feet

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1939	106.9	193.3	163.3	843.7	2,225	3,220	3,849	1,244	503.8	502.6	184.4	118.9	13,150
1940	66.82	73.80	122.2	160.4	339.5	325.6	1,760	2,432	2,789	3,242	891.4	354.0	12,560
1941	141.8	824.0	3,034	2,997	2,074	2,676	3,008	6,134	4,856	1,786	572.6	497.6	28,600
1942	2,103	2,741	1,443	1,291	933.8	1,755	5,602	7,159	2,487	998.4	529.2	974.7	28,020

1943	587.5	1,018	567.8	1,538	583.5	1,094	2,332	2,774	2,137	413.2	144.1	113.5	13,300
1944	140.3	184.6	274.5	838.9	1,984	4,277	3,236	5,299	2,183	240.9	118.5	165.1	18,940
1945	116.2	233.8	1,208	2,988	2,249	9,255	9,680	3,951	4,422	3,131	1,105	453.5	38,790
1946	3,535	1,141	850.3	4,133	5,274	3,261	2,667	4,443	4,378	786.5	309.4	418.7	31,200
1947	295.7	4,050	3,948	2,074	1,117	2,190	2,848	4,920	2,762	654.2	258.4	544.2	25,660
1948	260.4	598.4	2,104	2,342	2,786	4,234	1,595	3,056	1,337	1,293	292.1	182.5	20,080
1949	157.2	227.7	351.5	2,012	4,629	3,035	2,223	2,196	2,283	616.2	358.8	279.1	18,370
1950	964.0	1,069	852.7	4,712	6,138	2,442	1,045	5,711	1,774	1,539	3,270	3,637	33,150
1951	1,904	476.5	375.7	1,907	2,784	2,354	1,294	1,498	3,750	2,771	404.2	327.2	19,040
1952	248.5	707.4	899.5	1,211	1,379	1,996	4,246	2,650	864.5	282.9	277.6	199.1	14,960

Yearly discharge, in cubic feet per second

Water year	Water-Supply Paper	Water year ending Sept. 30							Calendar year		
		Momentary maximum		Minimum day	Mean	Per Square mile	Runoff		Mean	Runoff	
		Discharge	Date				Inches	Acre-feet		Inches	Acre-feet
1939	877	99,000	Mar. 3, 1939	1,210	18,170			13,150,000	17,890		12,950,000
1940	897	92,700	July 9, 1940	880	17,290			12,560,000	22,440		16,290,000
1941	927	158,000	May 11, 1941	1,690	39,510			28,600,000	42,670		30,890,000
1942	957	178,000	May 6, 1942	3,000	38,700			28,020,000	33,020		23,900,000
1943	977	91,800	May 19, 1943	1,820	18,380			13,300,000	16,200		11,730,000
1944	1007	141,000	May 9-11, 1944	1,600	26,090			18,940,000	27,410		19,900,000
1945	1037	275,000	Apr. 7, 1945	1,270	53,580			38,790,000	59,070		42,760,000
1946	1057	132,000	June 5, 1946	3,760	43,090			31,200,000	46,910		33,960,000
1947	1087	124,000	Nov. 12, 13, 1946	3,130	35,440			25,660,000	28,080		20,330,000
1948	1117	113,000	Mar. 6, 1948	2,400	27,660			20,080,000	24,590		17,850,000
1949	1147	157,000	Feb. 2, 1949	1,920	25,370			18,370,000	28,340		20,520,000
1950	1177	162,000	Feb. 19, 1950	5,310	45,790			33,150,000	45,610		33,020,000
1951	1211	112,000	Feb. 25, 1951	3,980	26,290			19,040,000	25,050		18,130,000
1952	1241	149,000	Apr. 28, 1952	2,770	20,610			14,960,000			

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BASIC DATA

TABLE 11.—*Chemical analyses of water from wells in Red River Parish*

Stratigraphic unit: N, Naborton formation; DH, Dolet Hills formation; U, undifferentiated beds of Wilcox group; M, Marthaville formation (of Murray, 1948); TD, terrace deposits; Al, valley alluvium.

USGS well No.	Depth (feet)	Stratigraphic unit	Date of collection	Chemical constituents, in parts per million																			Specific conductance (micromhos at 25 °C)	Color	pH	Percent sodium
				Silica (SiO_2)	Aluminum (Al)	Total iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Phosphate (PO_4)	Boron (B)	Carbon dioxide (CO_2)				
RR-6	91	Al	2- 3-54	21	----	6.7	0.20	104	64	129	1.8	640	0	64	143	0.6	1.2	844	522	0.30	0.16	10	1,480	10	8.0	35
RR-7	65	Al	2- 3-54	24	----	4.6	.17	85	68	62	1.9	580	0	84	38	.6	3.2	652	492	.33	.02	23	1,060	10	7.6	21
RR-26	165	U	7- 5-56	38	2.0	1.8	.20	29	8.8	45	2.6	158	0	17	53	.2	1.5	271	120	.00	.06	16	448	5	7.2	44
RR-50	105	Al	2- 9-55	26	----	4.4	----	102	55	56	1.6	545	0	73	62	.3	3.0	657	480	.01	.00	----	1,080	0	7.2	20
RR-62	65	TD	11-3-54	38	----	.06	.02	16	5.8	24	1.1	29	0	13	46	.1	15	189	64	----	.06	46	282	0	6.0	44
RR-74	45	U	7- 5-56	53	----	.22	.0	16	2.2	16	1.3	62	0	13	10	.2	6.8	168	49	.06	.05	9.9	180	15	7.0	41
RR-83	400	N	2- 3-55	13	----	.05	.02	5.2	1.9	428	4.2	548	0	.2	370	1.1	.2	1,090	21	.53	2.5	----	1,920	5	8.1	97
RR-85	78	Al	5- 5-55	25	----	5.9	.07	111	54	34	1.4	617	0	21	39	.3	2.0	591	499	.2	.16	----	1,030	0	7.3	13
RR-90	140	M,TD	2-24-55	50	----	2.1	.02	1.6	.5	15	1.0	36	0	5.0	4.5	.1	2.0	101	6	.24	.00	14	91.1	35	6.6	81
RR-94	45	TD	6-17-55	48	4.2	.34	.05	1.1	.1	9.0	.4	35	0	.6	7.5	.0	2.5	101	26	.00	.00	----	88.1	5	6.6	42
RR-97	60	TD	6-16-55	22	4.8	1.0	.01	.8	.3	3.2	1.5	42	0	.6	4.2	.0	1.0	60	30	.00	.02	----	87.5	0	6.8	18
RR-109	84	TD	7- 5-56	34	.3	.33	.02	1.1	.8	5.4	.8	15	0	2.1	2.8	.1	2.2	59	8	.00	.04	7.5	44.6	5	6.5	58
RR-120	147	N	5-18-55	18	----	1.4	.00	39	14	526	4.7	605	0	3.8	588	1.1	.2	1,550	155	.09	3.1	----	2,750	5	7.4	88
RR-125 [1]	115	DH	1-19-56	----	----	.2	----	17	14	21		104	0	9.6	38	----	----	----	100	----	----	44	----	----	6.8	----
RR-134	150	M	1-19-56	49	----	3.3	.20	26	3.6	14	1.6	130	0	1.3	2.5	.1	.5	166	79	.3	.03	6.5	208	110	7.5	27
Na-116 [2]	76	Al	4- 6-55	21	----	7.4	.29	126	79	79	1.2	674	0	138	85	.2	1.5	886	640	.09	.21	----	1,430	0	7.2	21
DS-112 [3]	185	N	4-27-55	22	----	.04	.02	5.8	2.4	301	3.1	525	0	106	90	.1	2.8	795	24	.4	.60	8.3	1,280	10	8.0	96

[1] Analysis by City of Alexandria, La.
[2] Located in sec. 23, T. 10 N., R. 8 W.
[3] Located in sec. 22, T. 13 N., R. 12 W.

TABLE 12.—*Field analyses of chloride content of water from wells in the valley alluvium*

USGS well No.	Location	Date of collection	Chloride (parts per million)
RR-138	Sec. 37, T. 12 N., R. 10 W	2-14-55	16
		12-28-55	36
RR-139	Sec. 37, T. 12 N., R. 10 W	2-14-55	16
		12 28-55	20
RR-140	Sec. 27, T. 12 N., R. 10 W	2-14-55	24
RR-141	Sec. 22, T. 12 N., R. 10 W	2-14-55	28
		12-28-55	24
RR-143	Sec. 30, T. 12 N., R. 10 W	2-14-55	8
		12-28-55	8
RR-144	Sec. 50, T. 11 N., R. 9 W	2-16-55	24
RR-145	Sec. 29, T. 10 N., R. 9 W	2-16-55	92
RR-146	Sec. 31, T. 11 N., R. 9 W	2-16-55	36
RR-148	Sec. 26, T. 13 N., R. 11 W	2-15-55	90
RR-149	Sec. 28, T. 13 N., R. 11 W	2-15-55	364
RR-150	Sec. 30, T. 13 N., R. 10 W	2-15-55	68
RR-151	Sec. 20, T. 13 N., R. 10 W	2-15-55	88
RR-153	Sec. 18, T. 14 N., R. 11 W	2-15-55	18
RR-154	Sec. 17, T. 14 N., R. 12 W	2-15-55	164
RR-155	Sec. 13, T. 14 N., R. 11 W	2-15-55	144
DS-189	Sec. 25, T. 12 N., R. 11 W	2-14-55	148
DS-190	Sec. 27, T. 12 N., R. 11 W	2-14-55	36
		12-28-55	32

TABLE 13.—*Records of water*

Stratigraphic unit: N, Naborton formation; DH, Dolet Hills formation; U, undifferentiated beds of Wilcox group; M, Marthaville formation (of Murray, 1948); TD, terrace deposits; Al, valley alluvium.
Water level: r, reported water level.

Well (pl. 8)	Location Sec.	T.	R.	Owner	Driller	Year completed	Altitude (feet)	Depth (feet)	Casing diameter (inches)
1	13	12 N.	10 W.	Gulf Public Service Utilities.		1930	140	55	20–10
2	13	12 N.	10 W.	do	C. O. Bolt	1938	140	76	15–6
3	13	12 N.	10 W.	do	do	1936	144	55	10–6
4	38	12 N.	10 W.	O. J. Dykes	C. G. Vaught	1940	138	120	6
5	13	12 N.	10 W.	Gulf Public Service Utilities.			140	72	6
6	51	11 N.	9 W.	William Prince	L. E. Simmons	1949	125	91	4
7	31	14 N.	10 W.	East Point School			145	65	2
8	35	13 N.	10 W.	W. S. Posey		1954	160	165	4
9	37	12 N.	10 W.	E. F. Lester		1875	140	150+	1½–1
10	11	13 N.	11 W.	J. D. Sherwin			140	65	
11	33	13 N.	8 W.	Charley Pickett	H. B. Gorum	1954	200	143	2
12	10	13 N.	11 W.	J. D. Sherwin			130	72	2½
13	1	12 N.	11 W.	do	John Boskey	1955	140	70	1¼
14	25	12 N.	11 W.	M. P. Lelong	John Duco		125	60	4
15	36	11 N.	10 W.	Cleve Brown	John Boskey	1953	125	63	2
16	14	13 N.	11 W.	J. D. Sherwin			135	80	2¼
17	12	12 N.	11 W.	H. J. Hogan	Owner	1952	140	56	2
18	12	12 N.	11 W.	Cecil Blount	John Boskey		140	81	2
19	32	13 N.	8 W.	Webb Pickett	H. B. Gorum	1954	240	48	
20	18	14 N.	10 W.	Guy Saucier			147	170	1½
21	30	14 N.	10 W.	East Point Gin			142	77	5
22	16	13 N.	10 W.	Mrs. W. B. Butler	Mr. Katz	1951	190	62	8
23	7	13 N.	10 W.	B. B. Box	John Boskey		140	65	3
24	5	13 N.	10 W.	B. B. Box, Jr	John Boskey	1949	136	100	4
25	5	13 N.	10 W.	do	do		136	57	3
26	25	13 N.	9 W.	Clyde Loftin	H. B. Gorum	1955	206	165	2
27	31	11 N.	9 W.	J. F. Clinton	Owner	1944	128	65	1¼
28	28	12 N.	10 W.	M. P. Lelong		1951	160	96	4
29	4	14 N.	10 W.	Ralph Wilson		1954	220	44	3
30	28	12 N.	10 W.	E. C. Durham		1925	160	69	4
31	21	14 N.	10 W.	B. F. Madden			240	22	2¼
32	21	14 N.	10 W.	Z. E. Madden		1939	225	28	6
33	16	13 N.	10 W.	O. E. Moore			196	29	36*
34	35	13 N.	10 W.	George Posey		1925	180	27	24
35	36	13 N.	10 W.	G. L. Lofton	Owner	1939	188	25	48
36	30	12 N.	8 W.	R. L. Kibler	John Boskey	1955	180	53	2
37	29	12 N.	9 W.	Fred Carlisle		1954	160	23	30
38	18	13 N.	10 W.	C. H. Tuttle	A. Allen	1954	137	50	2
39	1	14 N.	12 W.	Marvin Yearwood	B. F. Edington	1955	148	105	12

*Square casing.

Wells in Red River Parish

Method of lift: A, airlift; B, bucket; C, centrifugal pump; H, hand pump; J, jet; P, piston; T, turbine.
Use: A, abandoned; D, domestic; I, industrial; Ir, irrigation; N, none; O, observation; P, public supply; S, stock.
Remarks: C, chemical analysis; L, see log.

Interval screened (feet)	Stratigraphic unit	Depth to water level below land surface (feet)	Date of measurement	Method of lift	Pump capacity (gpm)	Use	Remarks
30-55	TD			T	30	A	Gravel walled.
46-76	TD						Do.
21-55	TD	20r	1941	A	30	P	Hardness 50 ppm; drawdown 5-7 ft.
99-109	Al						Gravel walled.
	TD			A		P	
	Al			J	5	D	Gravel walled. C. Open-end casing at 91 ft.
59-65	Al			J	4	P	C.
105-?	N			J		D	L. Reported 30 ft drawdown at 10 gpm. Reported yield 4-8 gpm.
?-150+	DH	20r		J		D	Water reported soft.
	Al					S	Water reported hard and to contain iron and sulfur. 18 feet of sand and gravel.
	M			J		D	L. Maximum yield reported to be 10-15 gpm. Perforated casing 130-143 ft.
50-72	Al			J		S	Water reported hard and to contain iron and sulfur. 22 ft of sand and gravel.
68-70	Al	12r	1955	P	6	S	Water reported hard. Supplies 160 head of cattle. 20 ft of sand.
44-60	Al	21r		J		D	Gravel-walled. Equipped with softener.
59-63	Al	31r		J	5	D	Water reported hard and to contain iron.
	Al			J		D	Water reported hard and to contain iron and sulfur. 28 ft of sand and gravel.
	Al			J		D	Driven well. 18 in. of sand. Reported hard water.
	Al			J		S	Coppery color reported.
	TD			J		D	Reported yield 20 gpm. Perforated casing 39-48 ft.
	N			J		D	
	Al	14.9	Sept. 1955	J		I	Water reported very hard.
	TD	38.0	Feb. 1955	B		D	Water level 25 ft when drilled.
60-65	Al			J		D	Water reported hard.
90-100	Al	16 r	1953	J		D	28 ft coarse white sand reported.
	Al	14.5	July 1955	J		D	
155-165	U	19 r	May 1955	J		D	C. Reported yield 15 gpm with 80 ft of drawdown. Water reported high in iron.
62-65	Al			H		D	Driven well. Water reported hard.
	DH, N	35 r		J	5	D	Reported 50 ft drawdown at 5 gpm. Water reported soft. Pump set at 94 ft. Well is on Couchanda Hill. Open hole below 55 ft.
	TD	15.0	Apr. 1955			A	
	DH	46.0	Nov. 1955	J		D	Water reported soft. Well is on Couchanda Hill.
	TD			P		A	Water reported soft.
	TD	25.0	Aug. 1954	B		D	Do.
	TD	27.0	Aug. 1954			D	Do.
	TD	25 r	1925	J		D	Do.
	TD	16.4	Feb. 1955	B		D	Dug well. Water reported soft.
48-52	TD	29 r	1955	J	2	D	L. Pump set at 46 ft.
	TD	18.5	June 1955	J		D	Dug well with two driven well points. Supply reported plentiful. Clay at 23 ft.
	Al			J		D	Water reported hard. Four other similar wells in same well field.
83-103	Al	19.0	July 1955	T	1,000	Ir	Pump set at 72 ft. Gravel walled. Reported drawdown 70 ft at 650 gpm.

TABLE 13.—*Records of water wells*

Well (pl. 8)	Location			Owner	Driller	Year completed	Altitude (feet)	Depth (feet)	Casing diameter (inches)
	Sec.	T.	R.						
40	36	11 N.	10 W.	U. S. Bullock	W. S. Boone	1952	128	210	4
41	2	12 N.	10 W.	Ory Baker	John Boskey	1954	160	40	3
42	28	13 N.	10 W.	R. E. Posey			140	18	5
43	7	12 N.	10 W.	Randolph Marston			132	100	4
44	1	12 N.	11 W.	Lee Porter		1952	140	78	2¼
45	4	14 N.	11 W.	Arthur Sample	Owner	1953	140	45	1¼
46	10	14 N.	11 W.	do	do	1954	140	49	2
47	11	14 N.	11 W.	do	John Boskey		140	104	2
48	3	14 N.	11 W.	do	Owner		140	44	2
49	30	12 N.	10 W.	Evelyn Gin	John Duco	1948	131	70	4
50	29	14 N.	11 W.	R. G. Lawrence	B. F. Edington	1954	141	105	16
51	16	13 N.	11 W.	H. M. Bundrick	Owner		140	42	1¼
52	16	13 N.	11 W.	do			140	150	10
53	31	13 N.	10 W.	Alvin Wilson	John Boskey	1953	135	65	2¼
54	4	13 N.	11 W.	A. P. Dill	Owner		140	42	1¼
55	17	12 N.	10 W.	George Posey	do	1954	135	65	1¼
56	19	12 N.	10 W.	Central Louisiana Electric Co.		1930	133	73	3
57	36	14 N.	10 W.	B. O. Wiggins	H. B. Gorum	1955	240	83	2
58	2	12 N.	11 W.	Presley Blount, Jr.	John Boskey	1954	134	84	5
59	4	13 N.	11 W.	P. E. Hinky	J. B. Dice	1949	139	75	1¼
60	7	12 N.	10 W.	Magnolia Oil Co.		1945	140	72	6
61	19	12 N.	9 W.	Town of Coushatta	B. M. Crooks	1949	140	60	6
62	19	12 N.	9 W.	do	do	1950	140	65	10
63	2	12 N.	11 W.	Clanton estate	Greyhound Drilling Co.	1952	120	105	10
64	13	13 N.	11 W.	J. D. Sherwin	Gulf Oil Co.	1934	143	76	6
65	3	12 N.	11 W.	Pat Curfman	Owner	1940	135	32	3
66	37	12 N.	10 W.	Town of Coushatta	C. O. Bolt	1920	144	80	4
67	19	14 N.	9 W.	C. W. Moland	Mr. Weems	1940	240	20	3
68	30	14 N.	9 W.	M. P. Waters		1943	240	26	8
69	28	13 N.	10 W.	C. H. Townsend	Owner		135	22	2½
70	28	13 N.	10 W.	do	do		135	50	1½
71	1	11 N.	10 W.	Hanna Gin	John Duco	1948	133	60	4
72	22	12 N.	10 W.	John Boskey	Owner	1950	129	43	3
73	51	11 N.	9 W.	Reece Youngblood	Rex Kuhlman		120	80	
74	34	14 N.	9 W.	W. M. Smith			220	45	36
75	32	13 N.	8 W.				240	50	36
76	35	13 N.	9 W.	Rake Henson			220	15	6
77	16	13 N.	9 W.	Desrie Lloyd			190	22	8
78	6	14 N.	9 W.				260	14	4
79	5	14 N.	9 W.	S. W. Harper	John Duco		260	165	2½
80	2	14 N.	9 W.	Estelle Knowlin			220	18	12*
81	24	14 N.	9 W.	L. Baldwin		1950	174	18	6
82	30	13 N.	9 W.	L. E. Smith			155	17	6
83	22	12 N.	10 W.	L. A. Drake	W. S. Boone	1955	131	400	6
84	27	12 N.	10 W.	C. H. Hankins	do	1954	131	230	4
85	7	14 N.	11 W.	L. P. Wall	W. C. Barnwell	1954	145	78	10¾
86	26	13 N.	11 W.	Texas and Pacific Railroad.	B. F. Edington	1943	137	261	
87	38	12 N.	10 W.	do	M. H. Simpson	1945	138	210	2½
88	1	11 N.	10 W.	do	B. F. Edington	1943	130	176	5
89	35	13 N.	10 W.	J. W. Roberson	Lewis Brooks	1954	180	184	4

*Square Casing.

in Red River Parish—Continued

Interval screened (feet)	Stratigraphic unit	Depth to water level below land surface (feet)	Date of measurement	Method of lift	Pump capacity (gpm)	Use	Remarks
----	DH	19.0	Nov. 1955	J	6	D	Water reported soft. Sand 200-210 ft. Pump set at 40 ft. Open hole below 130 feet.
----	TD	13 r	July 1954	J	7	S	Water reported soft.
----	Al	7.7	Feb. 1955	B	----	D	
80-100	N	12.4	Mar. 1955	A	----	A	Do.
----	Al	14 r	1952	P	----	S	
----	Al	22	Aug. 1954	H	----	D	Water reported hard.
44-49	Al	11 r	Aug. 1954	P	----	S	Driven well. Water reported hard.
----	Al	----	----	J	----	D	Water reported hard.
----	Al	----	----	J	----	D	Water reported hard and to contain iron. Driven well.
60-70	Al	29.0	Oct. 1955	J	----	I	Water reported hard. Perforated casing.
70-90	Al	19.5	Sept. 1955	T	1,160	Ir	Gravel walled. C. See pumping-test data.
----	Al	----	----	H	----	D, S	Driven well.
----	Al	15 r	1954	J	----	D, S	Water reported hard.
----	Al	----	----	J	----	D	Do.
37-42	Al	----	----	J	----	D	Do.
----	Al	17.3	Sept. 1954	H	----	S	Do.
----	Al	14?	----	----	----	A	
?-83	DH	35 r	----	J	----	D	Water reported soft. Pump set at 40 ft.
----	Al	16.3	Sept. 1955	----	----	N	Water reported hard. No pump on well.
----	Al	15 r	1949	----	----	D, S	Water reported hard.
----	Al	----	----	P	----	I	
40-60	TD	23.5	Mar. 1955	T	225	P	L. Gravel walled from 10 ft. Pump set at 50 ft.
40-60	TD	23.5	Mar. 1955	T	100	P	104 ft from well RR-61. C. Gravel walled from 10 ft. See pumping-test data.
100-?	Al	----	----	----	----	I	Water reported soft.
----	Al	----	----	----	----	A	
?-32	Al	17 r	1954	P	4-5	D	Driven well. Water reported soft.
----	TD	20.0	Oct. 1955	----	----	O	
----	U	10.7	Feb. 1955	J	----	D	Water reported soft.
----	U	10.5	Feb. 1955	B	----	S	Do.
----	Al	26.0	Dec. 1954	----	----	A	Driven well.
----	Al	26.5	1954	J	----	S	Do.
44-60	Al	28.0	Oct. 1955	----	----	O	
----	Al	14 r	1950	J	----	D	
----	Al	25 r	Aug. 1954	J	----	D	Water reported good.
----	U	29.2	Dec. 1954	B	----	D	C. Water reported soft.
----	M	37.2	Dec. 1954	B	----	D	
----	M or U	9.9	Dec. 1954	A	----	----	
----	U	11.9	Dec. 1954	B	----	D	Water reported medium hard.
----	U	8.3	Dec. 1954	----	----	A	Water reported poor.
155-165	DH	----	----	----	----	A	Water reported soft.
----	TD	----	----	B	----	D	Do.
----	M	8.2	Dec. 1954	B	----	----	Water reported good.
----	Al	9.4	Dec. 1954	B	----	D	
----	N	17 r	Jan. 1955	P	5	D	C. Open hole below 230 ft. Pump set at 147 ft. Reported drawdown 73 ft at 5 gpm.
----	N	19 r	Dec. 1954	----	----	D	Reported drawdown 16 ft at 5 gpm. Open hole below 210 ft.
----	Al	16.4	Oct. 1955	T	242	Ir	C. See pumping-test data. Slotted casing 58 to 78 ft.
----	Al	----	----	----	----	N	
200-210	N	----	----	----	----	N	L.
----	DH	----	----	----	----	N	L. Open casing at 176 ft.
----	N	50.7	Nov. 1955	J	8	D	Water reported soft. Pump set at 80 ft. Sand reported 60-80 ft and 140-184 ft. Open hole below 110 ft.

TABLE 13.—*Records of water wells*

Well (pl. 8)	Location			Owner	Driller	Year completed	Altitude (feet)	Depth (feet)	Casing diameter (inches)
	Sec.	T.	R.						
90	22	13 N.	8 W.	M. B. Hunter	L. E. Simmons	1954	180	140	6
91	32	13 N.	8 W.	do	H. G. Gorum	1955	220	84	3
92	32	13 N.	8 W.	C. J. Auer	do	1955	250	107	3
93	27	14 N.	10 W.	Erskine Biggs		1954	220	45	
94	27	14 N.	10 W.	Mrs. J. E. Woodward	Walter Davis	1930	210	45	8
95	24	14 N.	10 W.	L. C. Sanders	Johnson Drilling Co	1953	215	120	4
96	18	13 N.	8 W.	J. G. Kitchings	Owner	1955	219	25	
97	12	13 N.	9 W.	H. W. Ayers	H. B. Gorum	1954	240	60	2
98	15	14 N.	9 W.	I. B. Woodard	Owner	1952	250	42	28
99	1	13 N.	10 W.	A. T. Beauregard	B. F. Edington	1954	240	165	4
100	23	13 N.	10 W.	Dan Shaughnessy	do	1954	205	229	4
101	23	13 N.	10 W.	do	do	1955	205	96	4
102	1	11 N.	10 W.	John Duco	T. W. Cole	1954	130	208	4
103	35	12 N.	10 W.	Burnell Webb	John Duco	?	130	55	4
104	20	11 N.	9 W.	William Prince	John Boskey	1954	127	80	4
105	19	13 N.	8 W.	Martin School	John Duco	1950	200	120	4
106	7	12 N.	9 W.	Coushatta Sawmill	do	1950	180	130	4
107	19	13 N.	8 W.	R. C. Dupree	L. E. Simmons	1948	200	135	3
108	29	13 N.	8 W.	B. M. Sledge	Owner	1954	269	32	36
109	22	12 N.	9 W.	Gordon Nelson	H. B. Gorum	1954	185	84	3
110	9	13 N.	9 W.	G. H. Smith	B. F. Edington	1955	220	302	
111	22	12 N.	9 W.	Gordon Nelson	do	1955	185	302	
112	3	14 N.	9 W.	E. T. Collier	James Lesche	1953	260	112	2
113	19	12 N.	10 W.	Ira Campbell	John Duco		130	70	3
114	27	14 N.	11 W.	J. T. Bundrick	Lewis Brooks	1954	140	52	4
115	12	12 N.	10 W.	Gordon Foster	H. B. Gorum	1954	185	132	2
116	19	12 N.	8 W.	S. J. Maylock	do	1954	145	63	2
117	17	12 N.	8 W.	Jesse Scott	do	1954	220	72	2
118	38	11 N.	9 W.	A. N. Timon			130	90	6
119	1	11 N.	10 W.	Smith-Webb Plantation	John Duco	1952	130	65	4
120	29	14 N.	10 W.	Wm. McLelland, Jr	Mr. Martin	1955	143	147	4
121	20	12 N.	9 W.	Jewell Cloud	H. B. Gorum	1955	180	65	2
122	32	12 N.	8 W.	Baron Clinton	do	1954	200	74	2
123	30	12 N.	8 W.	R. L. Kibler	Owner	1951	180	100	4¾
124	29	14 N.	10 W.	Rex Woods			140	45	1¼
125	6	12 N.	9 W.	L. T. Waldrip	Houston Drilling Co	1953	185	115	4
126	30	14 N.	10 W.	East Point School	John Boskey	1953	145	70	2
127	1	14 N.	12 W.	Marvin Yearwood	L. E. Simmons	1954	140	108	12¾
128	1	11 N.	10 W.	Hanna School	John Boskey	1955	131	65	2
129	27	12 N.	10 W.	Nation brothers	Charles Hamlin	1955	135	250	2
130	33	12 N.	8 W.	S. M. Morgan		1953	180	45	2

in Red River Parish—Continued

Interval screened (feet)	Stratigraphic unit	Depth to water level below land surface (feet)	Date of measurement	Method of lift	Pump capacity (gpm)	Use	Remarks
127–138	M, TD	36r	1954	C	25	S	Gravel walled 30–148 ft. C. Pump set at 80 ft. Sand 60–75 ft and 120–140 ft. Reported drawdown 60–80 ft at 25 gpm.
64–84	M	35r	1955	J	8	D, S	Gravel walled. Water reported good.
87–107	M	44.9	Feb. 1955	----	------	D	Reported yield 10 gpm. L.
------------	TD	--------	------------	J	------	D, S	Water reported soft. Supply reported plentiful.
------------	TD	39.5	June 1955	J	------	D	Bored well. C. Open casing at 45 ft.
113–125	U, DH	6.0	Feb. 1955	A	------	N	Water reported soft. Sand 18–40, 50–80 and ?–125 ft. Reported yield 50 gpm. Gravel walled.
------------	TD	16r	Jan. 1955	J	------	D	Dug well. Water reported soft. Supply reported plentiful. Sand 15–25 ft; stopped in gravel.
55–60	TD	30r	Dec. 1954	J	7	D	Water reported soft.
------------	TD	39.7	Feb. 1955	J	------	D	L. Dug well. Water reported soft.
109–119	DH	--------	------------	J	10	D	L. Gravel walled. Reported drawdown 84 ft at 10 gpm. Pump set at 84 ft.
------------	DH	45.8	Feb. 1955	----	------	N	L. Water failed to clear. Open hole below 105 ft.
36–46	TD, DH	--------	------------	J	5	D	Gravel walled to 49 ft.
------------	DH	42.5r	Dec. 1954	J	------	D	Water reported soft but to contain salt and iron. Open hole below 95 ft.
45–55	Al	--------	------------	----	------	D	Water reported hard and iron bearing. 3-in. screen, gravel walled.
75–80	Al	--------	------------	C	------	D, I	------------------------------
100–120	M	--------	------------	J	8	P	Water reported to contain some iron. Supply reported plentiful for 275 pupils and canning center.
110–130	DH	30r	------------	J	15	I	Shale at 130 ft.
120–?	M	--------	------------	J	------	D	Much iron. Unfit for washing clothes.
------------	TD	28.1	Mar. 1955	J	------	D	Water reported soft.
76–82	TD	21r	Dec. 1954	J	8	D	C. Water reported soft. Gravel walled.
------------	U, DH	--------	------------	----	------	A	L. No fresh water below 24 ft. U.S.G.S. test hole.
------------	TD, DH	--------	------------	----	------	A	L. U.S.G.S. test hole.
------------	M	40r	Nov. 1953	J	7	D	Perforated casing 102–112 ft. Gravel walled 92–112 ft. Water reported soft. Reported drawdown 12 ft at 7 gpm.
------------	Al	--------	------------	J	------	S	Perforated casing interval 60–70 ft wrapped with screen and gravel walled.
------------	Al	--------	------------	J	------	D	Water reported hard. Gravel walled. Pump set at 20 ft. Perforated casing.
------------	DH	60r	1954	D	------	D	Perforated casing 125–132 ft.
58–63	M	16r	Nov. 1954	J	------	D	
67–72	TD	--------	------------	J	------	D	Sand and gravel 40–72+ ft.
(?)	Al	32.6	Feb. 1955	H	------	D	
55–65	Al	23r	1952	J	------	D	Gravel walled.
------------	N	13.1	May 1955	J	15	------	C., L. Drawdown 22 ft at 15 gpm. Pump set at 75 ft. Open hole below 84 ft.
58–65	TD	--------	------------	J	5	D	Some iron reported in water.
------------	TD	17r	1954	J	10	D	Water reported soft. Perforated casing 69–74 ft.
------------	TD, M	28.8	May 1955	----	------	N	L. Water reported soft. Open hole below 54 ft.
?–45	Al	11.0	May 1955	----	------	N	Driven well.
(?)	DH	30r	Jan. 1953	J	5	D	C.
65–70	Al	12r	1953	J	------	P	
88–108	Al	9.7	Sept. 1955	----	------	N	Drilled for irrigation. Reported drawdown 60 ft at 175–200 gpm after year's disuse.
60–65	Al	15r	May 1955	J	------	P	Water reported hard. Stopped in gravel.
(?)	N	--------	------------	J	------	S	Water reported soft and to contain some salt. Pump set at 150 ft.
?–45	TD	--------	------------	J	------	D	Water reported soft.

TABLE 13.—*Records of water wells*

Well (pl. 8)	Location			Owner	Driller	Year completed	Altitude (feet)	Depth (feet)	Casing diameter (inches)
	Sec.	T.	R.						
131	30	12 N.	8 W.	Brisker Bamburg	John Boskey	1955	160	60	2
132	27	13 N.	8 W.	Ezra Thomas	H B. Gorum	1954	120	72	2
133	7	13 N.	8 W.	D. W. Adcock	do	1954	240	95	4
134	36	14 N.	9 W.	M. B. Dupree	L. E. Simmons	1948	248	150	5
135	15	14 N.	9 W.	Social Springs Baptist parsonage.	Charles Hamlin	1953	230	156	2
136	14	14 N.	9 W.	Roy Martin	do	1953	240	120	2
137	7	12 N.	9 W.	Edna Pickett	Mr. Dickerson	1948	190	131	4
138	37	12 N.	10 W.	State of Louisiana		1954	128	48	1¼
139	37	12 N.	10 W.	do		1954	126	47	1¼
140	37	12 N.	10 W.	do		1954	134	53	1¼
141	22	12 N.	10 W.	State of Louisiana		1954	129	43	1¼
142	21	12 N.	10 W.	do		1954	130	51	1
143	30	12 N.	10 W.	do		1954	128	48	1
144	50	11 N.	9 W.	do		1954	134	67	1
145	29	10 N.	9 W.	do		1954	123	57	1
146	31	11 N.	9 W.	do		1954	128	52	1
147	30	11 N.	9 W.	do		1954	125		
148	26	13 N.	11 W.	do		1954	137	52	1½
149	28	13 N.	11 W.	do		1954	134	50	1
150	30	13 N.	10 W.	Alvin Wilson		1954	139	52	1
151	20	13 N.	10 W.	Mrs. W. B. Butler		1954	127	50	1
152	15	14 N.	11 W.	State of Louisiana		1954	138	58	1¼
153	18	14 N.	11 W.	do		1954	142	50	1
154	17	14 N.	12 W.	do		1954	141	53	1
155	13	14 N.	11 W.	do		1954	145	64	1
156	29	14 N.	11 W.	R. G. Lawrence		1955	145	77	1
157	29	14 N.	11 W.	do		1955	145	74	1
158	12	14 N.	12 W.	L. P. Wall		1955	145	66	1¼
159	12	14 N.	12 W.	do		1955	145	54	1¼
160	18	14 N.	8 W.	State of Louisiana		1955	140	39	
161	27	14 N.	11 W.	do		1955	140	49	

in Red River Parish—Continued

Interval screened (feet)	Stratigraphic unit	Depth to water level below land surface (feet)	Date of measurement	Method of lift	Pump capacity (gpm)	Use	Remarks
Well point	TD	25r	June 1955	J	------	D	Water reported soft. Well stopped in gravel.
61–72	M	7r	May 1954	J	5	D, S	Water reported soft and to contain some iron.
------------	M	--------	------------	J	8	D	Water reported soft and to contain much iron. Perforated casing 74–95 ft.
------------	M	35r	------------	----	------	D	Iron reported in water. Pump set at 60 ft. C.
------------	M	20r	Apr. 1953	J	------	D	Water reported soft and to contain much iron. Pump set at 40 ft. Open hole below 86 ft.
------------	M	30r	Apr. 1953	J	------	D	Water reported hard and to contain much iron. Pump set at 42 ft. Open hole below 97 ft.
------------	DH	46r	------------	J	------	D	Supply reported plentiful. Water reported good but hard.
Well point	Al	26.1	Dec. 1955	----	------	A	U.S.G.S. test hole. Total depth 68 ft. About 350 ft west of Red River.
do	Al	25.5	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 78 ft. 462 ft west of RR-138.
do	Al	30.1	Nov. 1955	----	------	A	U.S.G.S. test hole. Total depth 63 ft. 600 ft west of RR-139.
Well point	Al	19.9	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 43 ft.
do	DH	17.9	Dec. 1955	----	------	A	U.S.G.S. test hole. Total depth 63 ft.
do	Al	25.6	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 53 ft.
do	Al	33.5	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 98 ft.
do	Al	19.4	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 90 ft.
do	Al	27.4	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 83 ft.
------------	Al	--------	------------	----	------	A	U.S.G.S. test hole. Total depth 70 ft.
Well point	Al	18.4	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 75 ft.
do	Al	17.4	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 72 ft.
do	Al	31.5	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 75 ft.
do	Al	13.0	Dec. 1955	----	------	A	U.S.G.S. test hole. Total depth 75 ft.
do	Al	20.5	Feb. 1955	----	------	A	U.S.G.S. test hole. Total depth 87 ft.
do	Al	18.4	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 100 ft.
do	Al	17.4	Dec. 1955	----	------	A	U.S.G.S. test hole. Total depth 80 ft.
do	Al	25.8	Dec. 1955	----	------	O	U.S.G.S. test hole. Total depth 75 ft.
do	Al	20.6	Apr. 1955	----	------	A	U.S.G.S. test hole. Total depth 92 ft.
do	Al	24.6	Feb. 1955	----	------	A	U.S.G.S. test hole. Total depth 83 ft.
do	Al	17.7	May 1955	----	------	A	U.S.G.S. test hole. Total depth 80 ft.
do	Al	15.6	May 1955	----	------	A	U.S.G.S. test hole. Total depth 54 ft.
------------	Al	--------	------------	----	------	A	U.S.G.S. test hole. Total depth 39 ft.
------------	Al	--------	------------	----	------	A	U.S.G.S. test hole. Total depth 49 ft.

TABLE 14.—*Selected drillers' logs of wells*

RR–8

[Sec. 35, T. 13 N., R. 10 W. Altitude, 160 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Valley alluvium:			Naborton formation—Continued		
Clay, red	20	20	Shale	34	120
Sand	22	42	Sand	25	145
Naborton formation:			Porters Creek clay:		
Shale	38	80	Shale	20	165
Sand	6	86			

RR–11

[Sec. 33, T. 13 N., R. 8 W. Altitude, 200 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Terrace deposits:			Marthaville formation (of Murray, 1948):		
Sand and clay	45	45			
Sand	15	60	Clay	20	80
			Sand	10	90
			Clay	30	120
			Sand	23	143

RR–36

[Sec. 30, T. 12 N., R. 8 W. Altitude, 180 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Terrace deposits:			Marthaville formation (of Murray, 1948):		
Clay and sand, red	27	27			
Sand and clay	19	46	Clay	1	53
Sand	6	52			

RR–61

[Sec. 19, T. 12 N., R. 9 W. Altitude, 140 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
			Terrace deposits—Continued		
Valley alluvium:			Clay	3	43
Sand and clay	20	20	Sand	17	60
Terrace deposits:			Naborton formation:		
Sand	20	40	Clay	10	70

RR–87

[Sec. 38, T. 12 N., R. 10 W. Altitude, 138 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Valley alluvium:			Naborton formation:		
Gumbo	60	60	Gumbo and rock	55	180
Sand	65	125	Sand	30	210

RR–88

[Sec. 1, T. 11 N., R. 10 W. Altitude, 130 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Valley alluvium:			Dolet Hills formation—Continued	1	114
Clay, surface	10	10	Rock	31	145
Gumbo, red and yellow	30	40	Sand, gray	2	147
Sand, white	52	92	Rock	17	164
Dolet Hills formation:			Sand	1	165
Rock	1	93	Rock	11	176
Sand, gray	20	113	Sand		

TABLE 14.—*Selected drillers' logs of wells*—Continued

RR-92

[Sec. 32, T. 13 N., R. 8 W. Altitude, 250 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Terrace deposits:			Marthaville formation (of Murray, 1948):		
Sand and clay	65	65	Clay	4	89
Sand	20	85	Sand, black	18	107
			Clay	--------	--------

RR-98

[Sec. 15, T. 14 N., R. 9 W. Altitude, 145 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Terrace deposits:			Clay and gumbo, red and brown	12	37
Clay and gumbo, red and brown	22	22	Sand containing some gravel	3	40
Sand	3	25	Sand	2½	42½

RR-99

[Sec. 1, T. 13 N., R. 10 W. Altitude, 240 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Terrace deposits:			Dolet Hills formation:		
Surface	3	3	Sand	15	105
Clay, sandy	54	57	Sand and shale	15	120
Sand	21	78	Shale	18	138
Undifferentiated beds of Wilcox group:			Sand	24	162
Shale	12	90	Shale	3	165

RR-100

[Sec. 23, T. 13 N., R. 10 W. Altitude, 205 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Terrace deposits:			Dolet Hills formation:		
Topsoil	18	18	Sand	23	160
Sand, white	22	40	Shale, sandy	10	170
Undifferentiated beds of Wilcox group:			Sand	10	180
Shale	44	84	Shale	31	211
Sand	12	96	Sand	10	221
Shale, hard	39	135	Shale and sand	8	229
Rock	2	137			

RR-110

[Sec. 9, T. 13 N., R. 9 W. Altitude, 220 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Undifferentiated beds of Wilcox group:			Undifferentiated beds of Wilcox group—Continued		
Clay, silty, tan	12	12	containing lignite fragments	48	220
Sand, fine, well-rounded, grayish-tan	10	22	Dolet Hills formation:		
Silt, gray	10	32	Sand, fine to medium, colorless, rounded, containing grains of black chert and lignite (salt-and-pepper sand)	12	232
Clay, tough, light-gray	10	42	Clay, tough, gray, containing lignite fragments	10	242
Silt, gray	10	52	Sand, very fine to fine, gray, containing some lignite grains	5	247
Clay, tough, gray, containing lignite fragments	30	82	Clay, tough, gray	5	252
Lignite, bedded	11	93	Lignite and lignitic clay	10	262
Clay, tough, gray, containing lignite fragments	19	112	Sand, very fine, gray	10	272
Silt, light gray	33	145	Naborton formation:		
Clay, gray, containing lignite fragments	7	152	Clay, tough, gray	30	302
Silt, light gray	20	172			
Clay, tough, chocolate-brown,					

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TABLE 14.—*Selected drillers' logs of wells*—Continued

RR-111

[Sec. 22, T. 12 N., R. 9 W. Altitude, 185 ft.]

Description	Thickness (feet)	Depth (feet)
Terrace deposits:		
Clay, silty, orange and white	5	5
Silt, light-brown, iron-stained	7	12
Sand, very fine to fine, yellow	10	22
Sand, fine, yellow	10	32
Sand, fine to coarse, yellow, angular with rounded corners	10	42
Sand, fine to coarse, tan	10	52
Sand, medium to coarse	10	62
Undifferentiated beds of Wilcox group:		
Clay, silty, gray, containing chert and quartz gravel	10	72
Silt, gray, and sand, very fine	10	82
Clay, silty, gray	10	92
Clay, gray, and lignite	12	104
Sand, very fine, gray	6	110
Clay, gray, containing lignite fragments	2	112
Clay, dark-gray to chocolate	10	122
Silt, tan	10	132
Silt to very fine sand, grayish-tan, containing lignite fragments	10	142
Sand, very fine to fine, grayish-tan, containing lignite fragments	20	162
Undifferentiated beds of Wilcox group—Continued		
Silt to very fine sand, tan, containing some lignite fragments	10	172
Silt to very fine sand, tan	10	182
Sand, very fine to fine, brown, containing lignite grains	10	192
Dolet Hills formation:		
Sand, fine, brown	10	202
Sand, fine to medium, brown, containing large lignite fragments	10	212
Sand, fine to medium, colorless, containing lignite grains; very angular	30	242
Sand, very fine to fine, gray	8	250
Sand, fine to medium, containing lignite grains	10	260
Naborton formation:		
Lignite, large fragments	12	272
Clay, silty, gray	30	302

RR-120

[Sec. 29, T. 14 N., R. 10 W. Altitude, 145 ft.]

Description	Thickness (feet)	Depth (feet)
Valley alluvium:		
Sand, red (probably silt)	30	30
Sand, white	24	54
Naborton formation:		
Rock	½	54½
Gumbo and sand, white	5½	60
Lignite	½	60½
Gumbo	34½	95
Naborton formation—Con.		
Rock	¼	95¼
Lignite	4¾	100
Sand, fine, blue	22	122
Rock	1½	123½
Sand, fine, blue	20½	144
Gumbo and sand, blue	3	147

RR-123

[Sec. 30, T. 12 N., R. 8 W. Altitude, 180 ft.]

Description	Thickness (feet)	Depth (feet)
Terrace deposits:		
Clay, red	27	27
Sand, with clay partings	25	52
Marthaville formation (of Murray, 1948):		
Muck, blue	33	85
Sand, blue, and gravel	15	100
Rock	--------	--------

Oil-test well

[McAlester Fuel Company, Joe Price No. 2, Sec. 14, T. 13 N., R. 10 W. Altitude, 195 feet, depth, 1,200 feet. Samples to 600 feet]

Description	Thickness (feet)	Depth (feet)
Naborton formation:		
No samples	50	50
Clay, compact, gray	150	200
Sandstone, very fine to fine, containing lignitic grains; poorly cemented with lime	40	240
Naborton formation—Con.		
Sand, fine, angular, white, containing lignite grains	10	250
Sandstone, same as 200-240 interval	10	260
Porters Creek clay:		
Clay, compact, gray, lignitic	340	600

TABLE 15.—*Sample logs of test holes in the valley alluvium*

RR–138

[Sec. 37, T. 12 N., R. 10 W. Altitude, 128 ft]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, sandy, light-brown	7	7	Sand, medium to coarse, light grayish-brown, containing some pebbles	9	51
Sand, very fine, light reddish-brown	16	23	Clay, blue	4	55
Clay, silty, grayish-brown	1	24	Sand, very coarse, light grayish-brown	5	60
Sand, fine to medium, light-brown	4	28	Tertiary clay, silty, bluish-gray	8	68
Sand, fine-grained, light-brown	5	33			
Sand, medium-grained, light grayish-brown	9	42			

RR–139

[Sec. 37, T. 12 N., R. 10 W. Altitude, 126 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, sandy, light-brown	18	18	Sand, medium to coarse, gray	6	64
Sand, fine, light-brown	20	38	Clay, brown	1	65
Sand, fine to medium, light grayish-brown	10	48	Sand, medium to coarse, gray	6	71
Sand, medium to coarse, light grayish-brown	10	58	Tertiary clay, tough, bluish-gray	7	78

RR–140

[Sec. 37, T. 12 N., R. 10 W. Altitude, 134 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red	4	4	Sand, medium, light grayish-brown	8	55
Clay, stiff, red	1	5	Sand, coarse, grayish-brown	8	63
Sand, very fine, light-brown	42	47			

RR–141

[Sec. 22, T. 12 N., R. 10 W. Altitude, 129 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, dark reddish-brown	13	13	Sand, fine, white	2	23
Clay, silty, yellowish-brown	5	18	Sand, medium, grayish-brown	20	43
Sand, silty, yellow	3	21			

RR–142

[Sec. 21, T. 12 N., R. 10 W. Altitude, 130 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, light-brown	3	3	Silt, sandy, light-brown	19	43
Clay, stiff, light-brown	2	5	Tertiary silt, sandy, dark-gray	12	55
Clay, silty, light-brown	19	24	Silt, sandy, bluish-gray	8	63

RR–143

[Sec. 30, T. 12 N., R. 10 W. Altitude, 128 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red	5	5	Sand, fine to medium, light reddish brown	5	40
Clay, silty, dark-red	25	30	Sand, coarse, light-brown	13	53
Sand, fine, light reddish-brown	5	35			

RR–144

[Sec. 50, T. 11 N., R. 9 W. Altitude, 134 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red (levee)	5	5	Sand, fine, light-brown	10	50
Clay, silty, red	2	7	Sand, medium to coarse, light grayish-brown	30	80
Silt, red	6	13	Sand, coarse, and fine gravel	17	97
Sand, fine, and silt, light-red	15	28	Tertiary clay, tough, bluish-gray	1	98
Clay, silty, red	7	35			
Silt and fine sand, light reddish-brown	5	40			

TABLE 15.—*Sample logs of test holes in the valley alluvium*—Continued

RR-145

[Sec. 29, T. 10 N., R. 9 W. Altitude, 123 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, grayish-brown	1	1	Silt and fine sand	5	53
Clay, red	3	4	Sand, medium to coarse, grayish-brown	19	72
Silt, red	5	9	Gravel	6	78
Clay, stiff, red	21	30	Sand, coarse, gray	8	86
Silt, red	6	36	Tertiary clay, tough, blue	4	90
Clay, tough, blue	12	48			

RR-146

[Sec. 31, T. 11 N., R. 9 W. Altitude, 128 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, reddish-brown	5	5	Sand, medium, reddish-brown	15	45
Clay, silty, red	2	7	Sand, medium to coarse, grayish-brown	5	50
Silt and clay, red; alternating	9	16	Sand, coarse, gray	30	80
Silt and fine sand, light reddish-brown	9	25	Tertiary clay, blue	3	83
Sand, fine to medium, light reddish-brown	5	30			

RR-147

[Sec. 30, T. 11 N., R. 9 W. Altitude, 125 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red, containing some clay	5	5	Clay, stiff, red	5	55
Clay, silty, red	25	30	Sand, fine, light-brown	5	60
Clay, tough, red	5	35	Tertiary clay, tough, blue	5	65
Silt and very fine sand; brown	8	43	Clay, lignitic, containing fossil wood	5	70
Clay, red	1	44			
Sand, fine, light-brown	6	50			

RR-148

[Sec. 26, T. 13 N., R. 11 W. Altitude, 137 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt and sand, fine, reddish-brown	3	3	Sand, fine, light-brown	5	55
Clay, red	1	4	Sand, medium to coarse, grayish-brown	5	60
Clay, tough, blue	4	8	Sand, coarse, grayish-brown	10	70
Clay, tough, red	7	15	Sand, coarse, and fine gravel, gray	5	75
Clay, very tough, red and blue, containing partings of light-brown silt	30	45	Tertiary clay, tough, blue	--------	--------
Silt and fine sand, light-brown	5	50			

RR-149

[Sec. 28, T. 13 N., R. 11 W. Altitude, 134 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red	3	3	Sand, fine to medium, light-brown	5	55
Clay, silty, red	3	6	Sand, medium to coarse, grayish-brown	5	60
Clay, red	6	12	Gravel	2	62
Clay, silty	8	20	Sand, coarse, gray	8	70
Clay, very tough, blue and dark brown, containing lignite at 40± feet	30	50	Sandstone, silty, yellow	2	72

RR-150

[Sec. 30, T. 13 N., R. 10 W. Altitude, 139 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, brown	1	1	Sand, medium, grayish-brown	10	60
Clay, silty, dark-gray	2	3	Gravel	2	62
Silt, light red	2	5	Sand, medium to coarse, grayish-brown	11	73
Sand, very fine, light-red	8	13	Tertiary clay, tough, blue	2	75
Clay, tough, brown	2	15			
Clay, tough, blue	31	46			
Sand, fine to medium, grayish-brown	4	50			

TABLE 15.—*Sample logs of test holes in the valley alluvium*—Continued

RR-151

[Sec. 20, T. 13 N., R. 10 W. Altitude, 127 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, brown	3	3	Sand, medium to coarse, brownish-gray	32	58
Clay, tough, red	2	5	Gravel	1	59
Silt, brown	1	6	Tertiary sand, very fine, gray	16	75
Clay, silty, brown	3	9			
Clay, tough, blue and brown	9	18			
Sand, fine to medium, grayish-brown	8	26			

RR-152

[Sec. 15, T. 14 N., R. 11 W. Altitude, 138 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Soil	1	1	Sand, very coarse, gray	15	80
Clay, tough, red and blue alternating	22	23	Clay, tough, blue	2	82
Clay, red	37	60	Clay and gravel	1	83
Sand, coarse, brown	5	65	Tertiary clay, tough, black	4	87

RR-153

[Sec. 18, T. 14 N., R. 11 W. Altitude, 142 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red	3	3	Sand, medium to coarse, gray	8	63
Clay, red	6	9	Sand, coarse, gray	30	93
Silt, red	9	18	Sand, very coarse, and gravel	6	99
Sand, very fine to fine, red	30	48	Tertiary sand, very fine, bluish-gray	1	100
Sand, medium, reddish-brown	7	55			

RR-154

[Sec. 17, T. 14 N., R. 12 W. Altitude, 141 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay and silt, red	5	5	Sand, coarse, reddish-brown, and gravel	28	75
Clay, tough, red	28	33	Tertiary clay, silty, bluish-gray	5	80
Clay, very tough, gray	9	42			
Clay and sand	5	47			

RR-155

[Sec. 13, T. 14 N., R. 11 W. Altitude, 145 ft].

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, red	3	3	Clay, sandy, gray	1	55
Silt, red	3	6	Sand, fine to medium, brown	5	60
Clay, silty, red	8	14	Sand, medium to coarse, brown	10	70
Clay, tough, red	36	50	Tertiary clay, tough, dark-blue	5	75
Clay, tough, gray	4	54			

RR-156

[Sec. 29, T. 14 N., R. 11 W. Altitude, 145 ft].

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, silty, red	2	2	Sand, fine to medium, brown	40	70
Clay, red	10	12	Sand, coarse, brown, containing some gravel	21	91
Silt, clayey, red grading into brown	18	30	Tertiary silt, clayey, gray	1	92

RR-158

[Sec. 12, T. 14 N., R. 12 W. Altitude, 145 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, tough, red	6	6	Sand, medium to coarse, brown	10	59
Silt, clayey, red	13	19	Sand, coarse, and gravel, light-brown	19	78
Sand, very fine, red	10	29	Tertiary clay, silty, blue	2	80
Sand, fine, red	10	39			
Sand, medium, red	10	49			

TABLE 15.—*Sample logs of test holes in the valley alluvium*—Continued

RR–160

[Sec. 18, T. 14 N., R. 8 W. Altitude, 140 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Sand, fine, yellow	9	9	Tertiary clay, silty, gray	2	39
Sand, fine to medium, containing yellow clay parting at 30 feet	28	37			

DS–189

[Sec. 25, T. 12 N., R. 11 W. Altitude, 135 ft. This hole is in De Soto Parish, 1 mile west of Bayou Pierre on U.S. Highway 84]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red	4	4	Clay, red	1	28
Clay, silty, red	1	5	Silt and fine sand; reddish-brown	10	38
Sand, fine, red	7	12	Sand, fine to medium, reddish-brown	5	43
Clay, stiff, gray	15	27			

DS–190

[Sec. 27, T. 12 N., R. 11 W. Altitude, 135 ft. This hole is in De Soto Parish 1.3 miles northwest of DS–189]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, red	1	1	Sand, medium, reddish-brown	18	58
Clay and silt, red	29	30	Tertiary clay, tough	5	63
Sand, fine to medium, reddish-brown	10	40			

Na–267

[Sec. 23, T. 10 N., R. 8 W. Altitude, 127 ft. This hole is in Natchitoches Parish at Powhatan]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, red	19	19	Sand, fine, brown	20	70
Clay, sticky, blue	10	29	Sand, medium, and gravel	28	98
Silt, brown	21	50			

Na–269

[Sec. 23, T. 13 N., R. 8 W. Altitude, 110 ft. This hole is in Natchitoches Parish, on Louisiana Route 155, 0.7 mile west of Black Lake Bayou]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Silt, gray	4	4	Clay, silty, light-gray	2	14
Clay, silty, yellow	3	7	Clay, plastic, chocolate-brown	4	18
Sand, fine, yellow	1	8	Silt, tan, grading into tan fine sand	20	38
Clay, silty, yellow, containing gray clay balls	4	12	Clay containing pebbles	6	44

RR–E–1 [1]

[Sec. 13, T. 14 N., R. 11 W. Altitude, 142 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, firm, red	6	6	Sand, silty	22	69
Clay, stiff, red	36	42	Shale	3	72
Silt, sandy, red	5	47			

RR–E–2 [1]

[Sec. 22, T. 12 N., R. 10 W. Altitude, 130 ft. This hole is very near RR–141]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, firm, red with gray streaks	22	22	Sand, gray	10	61
Sand, silty, tan	26	48	Gravel	2	63
Sand, fine, tan	3	51	Silt, sandy	10	73

See footnote at end of table.

TABLE 15.—*Sample logs of test holes in the valley alluvium*—Continued

RR-E-3 [1]

[Sec. 21, T. 12 N., R. 10 W. Altitude, 128 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, brown, tan, gray	20	20	Sand, silty, gray	26	75
Sand, tan	10	30	Lignite	4	79
Sand, gray	16	46	Clay with lignite	8	87
Gravel	3	49			

RR-E-4 [1]

[Sec. 30, T. 12 N., R. 10 W. Altitude, 120 ft.]

Clay, red, calcareous	17	17	Sand, gray and brown	34	54
Clay, gray	3	20	Gravel	2	56

RR-E-5 [1]

[Sec. 36, T. 12 N., R. 11 W. Altitude, 130 ft.]

Clay, red	40	40	Sandstone	1	106
Sand, fine to coarse, silty, red	31	71	Clay, silty	4	110
Gravel, pea to coarse	34	105			

RR-E-6 [1]

[Sec. 26, T. 12 N., R. 11 W. Altitude, 135 ft.]

Silt, sandy, red	20	20	Gravel	2	57
Sand, silty, brown	35	55	Clay, silty	5	62

RR-E-7 [1]

[Sec. 26, T. 12 N., R. 11 W. Altitude, 135 ft.]

Silt, sandy, red	20	20	Sand, gray, lignitic	6	58
Clay, red and gray	7	27	Gravel	3	61
Sand, silty, red	25	52	Clay, silty	2	63

RR-E-8 [1]

[Sec. 28, T. 12 N., R. 10 W. Altitude, 120 ft.]

Clay, red	10	10	Sand, silty, brown	8	62
Sand	2	12	Shale, gray	2	64
Clay, red, calcareous	42	54			

RR-E-9 [1]

[Sec. 27, T. 14 N., R. 11 W. Altitude, 138 ft.]

Clay, red	5	5	Sand, grayish-brown, with pea gravel	24	74
Silt, sandy, red	10	15	Gravel	2	76
Sand, silty, red	11	26	Shale, hard, bluish-gray	4	80
Sand, red	24	50			

RR-E-10 [1]

[Sec. 29, T. 14 N., R. 11 W. Altitude, 140 ft.]

Clay, firm, gray	5	5	Sand, silty, red	76	101
Clay, stiff, red	20	25	Shale, lignitic, grayish-green	4	105

See footnote at end of table.

TABLE 15.—*Sample logs of test holes in the valley alluvium*—Continued

RR-E-11 [1]

[Sec. 28, T. 14 N., R. 11 W. Altitude, 137 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, red with calcareous concretions	6	6	Sand, brown	34	61
Sand, silty, red	8	14	Gravel	7	68
Clay, stiff, red and gray	13	27	Lignite	1	69

RR-E-12 [1]

[Sec. 22, T. 14 N., R. 11 W. Altitude, 140 ft.]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, brown	4	4	Sand	33	77
Sand, silty, red	14	18	Shale, hard, gray	3	80
Clay, stiff, grayish-brown	26	44			

RR-E-13 [1]

[Sec. 37, T. 12 N., R. 10 W. Altitude, 136 ft]

Description	Thickness (feet)	Depth (feet)	Description	Thickness (feet)	Depth (feet)
Clay, silty, red	4	4	Sand, fine, brown	23	52
Clay, sandy, red	2	6	Gravel	8	60
Clay, red with gray streaks	23	29	Clay	2	62

[1] Project boring put down by Corps of Engineers (Kolb, 1949).

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