GEOLOGICAL SURVEY CIRCULAR 374

WATER RESOURCES OF THE NEW ORLEANS AREA LOUISIANA

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WATER RESOURCES OF THE NEW ORLEANS AREA, LOUISIANA

By M. L. Eddards, L. R. Kister, and Glenn Scarcia

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PREFACE

This report is one of a series concerning water resources and present water use in selected industrial areas of national importance, which has been prepared at the request of and in consultation with the Water and Sewerage Industry and Utilities Division of the Business and Defense Administration of the U. S. Department of Commerce. This series is designed to serve the dual purpose of providing information for national defense planning and at the same time render a service to business and industry, as well as to municipalities, in their development of water resources for present and future use. This report was prepared with the assistance of the Water Utilization Section, Technical Coordination Branch. It was prepared under the direct supervision of F. N. Hansen, district engineer (Surface Water Branch); Rex R. Meyer, district geologist (Ground Water Branch); and Burdge Ireland, district chemist (Quality of Water Branch). E. L. Hendricks (Technical Coordination Branch) assisted in planning and writing it.

Many of the data summarized herein have been collected over a period of many years by the U. S. Geological Survey in cooperation with the Department of Conservation, Department of Public Works, Department of Highways, and Louisiana University, and Agricultural and Medical College. Data on the Mississippi River at New Orleans and chloride content of the water of Lake Pontchartrain were furnished by the Corps of Engineers, U. S. Army. Chemical-quality data on the Mississippi River at New Orleans were furnished by the Sewerage and Water Board of New Orleans. Bacterial analyses were furnished by the City Board of Health.

Additional information pertaining to the use of water was obtained from industries in the area and from the Sewerage and Water Board of New Orleans.

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WATER RESOURCES OF THE NEW ORLEANS AREA, LOUISIANA

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ABSTRACT

Industry, commerce, and public utilities in 1954 withdrew about 1,500 mgd from surface- and ground-water sources in the New Orleans area. Most of the withdrawal was made from the Mississippi River. However, some withdrawal of surface water was made from Lake Pontchartrain. A large part of the withdrawal from both ground- and surface-water sources is available for reuse. Ground-water withdrawal amounts to about 100 mgd and is primarily for industrial and commercial uses. The average flow of the Mississippi River for the 23-year period, 1931–54, amounted to 309,000 mgd, and the approximate average flow of all the tributaries to Lake Pontchartrain is about 4,000 mgd. The flow of the Pearl River, which adjoins the tributary drainage area of Lake Pontchartrain, averages about 8,000 mgd. Total withdrawal of ground and surface waters amounts to less than 3 percent of the recorded minimum flow of the Mississippi River or less than 1 percent of the average flow. Although large quantities of water are always available in the Mississippi River the quality of the water is not suitable for all uses.

Streams from the north that drain into Lakes Maurepas and Pontchartrain, and the aquifers in that area, offer one of the best sources of fresh water in the State. Industry, if located on the northern shores of Lake Maurepas or Lake Pontchartrain near the mouths of these tributaries, would be assured of an ample supply of either ground or surface water of excellent quality. All the tributaries north of Lake Pontchartrain have dry-weather flows which are dependable. The Pearl River above Bogalusa also is a good source of fresh water of excellent quality. At present it serves to dilute the tidal flow of salt water into Lake Pontchartrain through the Rigolets, the principal outlet of the lake.

In the area north of Lake Pontchartrain, wells 60 to 2,000 feet deep yield fresh water. There are no known wells tapping sands below 2,000 feet. However, electrical logs of oil-test wells show that fresh water is available to a maximum depth of 3,000 feet. In the area south of Lake Pontchartrain, there is no withdrawal of ground water for public water supplies because of the saline content of the water.

Three principal water-bearing sands, the "200-foot," "400-foot," and "700-foot" sands, are tapped in the New Orleans area south of Lake Pontchartrain for industrial and commercial use. In this area all deeper sands yield salt water.

In some areas the "200-foot" sand contains saline water of the sodium chloride type. Consequently, this sand is not developed extensively. Water from the "200-foot" sand is relatively fresh north of the Mississippi River and becomes increasingly saline to the south and west.

The "400-foot" sand is the second most highly developed aquifer in the New Orleans industrial district. The aquifer appears to be very prolific, but its full capabilities have not yet been determined. This aquifer yields a highly mineralized sodium chloride water in some areas; however, elsewhere it is a source of large quantities of fresh water.

The "700-foot" sand is the most continuous fresh-water bearing sand in the area and is the principal source of fresh ground water in the New Orleans industrial district. Most of the wells tapping this aquifer yield soft water of the bicarbonate type. In the southern and western parts of the industrial district the water in the "700-foot" sand is too mineralized to be suitable for human consumption.

INTRODUCTION

Purpose and Scope of Investigation

The purpose of this report is to summarize available data on the water resources of the greater New Orleans area and to evaluate these resources as to their present and potential use insofar as possible. Water use has been increasing constantly throughout the area owing to the rapid increase in industrial and municipal requirements, and this increase should be met by the most satisfactory and economical method possible.

This report does not solve all questions and problems which relate to water supplies in any specific area, as there are too many unknown factors which will call for future detailed investigations. However, it contains data useful to defense or nondefense industries and municipalities for the preliminary planning of new works or the expansion of existing facilities. It describes the quantity, quality, and physical characteristics of the surface waters in the area, and it outlines the water-bearing sands and describes their hydrologic properties.

Although large quantities of water are available from the Mississippi River, other sources of water supplies should be considered for supplementary development because the quality of the water is poor at times.

During periods of extreme low flow, salt water moves as a wedge along the bottom of the river and some mixing within the channel takes place. Infrequently, at low water, salinities at the surface exceed standards set for potable water and exceed desirable limits set for other uses. Continuous pumping in the area has caused ground-water levels to decline; however, not enough information has been gathered to determine the effects of present and future withdrawal. It is hoped that a more detailed study of the area will be made in the future to determine the availability of large quantities of ground water for specific uses.

Description of Area

Topography and Drainage

The New Orleans area is in the Gulf Coastal Plain and lies in two sections of the Coastal Plain province—the Mississippi Alluvial Plain to the south and the East Gulf Coastal Plain to the north (Fenneman, 1938, p. 65–87). As described in this report, the New Orleans area covers about 3,100 square miles, of which about 840 square miles is in bodies of water. The area includes all of St. Charles and Orleans

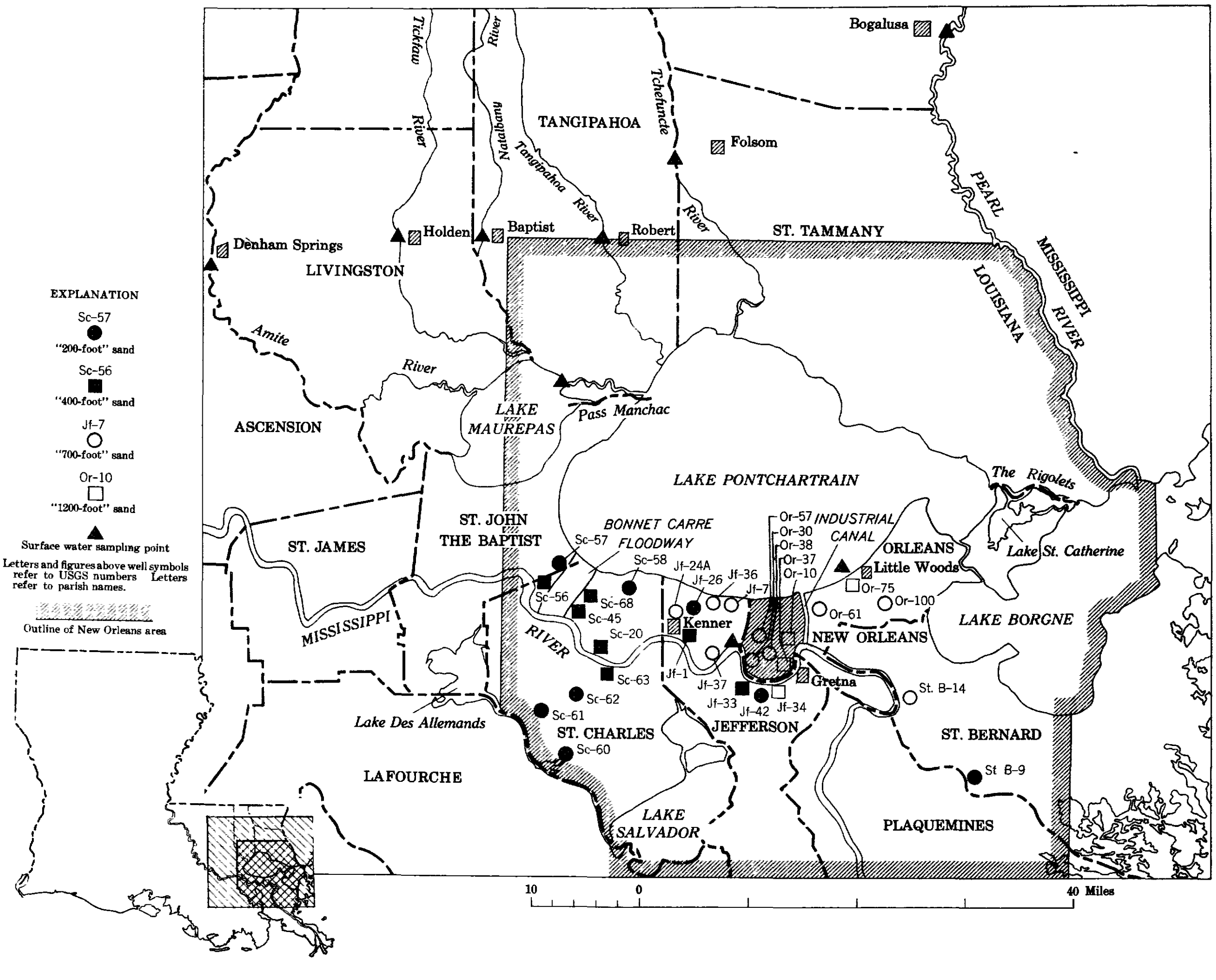

Figure 1.—Map of the New Orleans area showing location of streams, lakes, and wells sampled for chemical analysis. Insert map shows location of New Orleans area.

Parishes and parts of St. Bernard, Plaquemines, Jefferson, St. John the Baptist, Tangipahoa, and St. Tammany Parishes (fig. 1).

Topographically, the East Gulf Coastal Plain to the north of Lake Pontchartrain is of low relief, the altitude ranges from 5 to 45 feet. The land surface slopes toward the south and usually is covered by second- and third-growth pine trees. The principal streams flow southward into Lake Pontchartrain, draining an area of about 3,650 square miles. Runoff into Lake Pontchartrain from all directions is from an area of about 4,200 square miles. Although the principal streams draining into Lake Pontchartrain have an abundant supply of water of good quality, very little water is withdrawn at present from the streams for industrial use.

South of Lake Pontchartrain the Mississippi Alluvial Plain ranges in altitude from 5 feet below to about 10 feet above sea level; the crest of the artificial levees have a maximum altitude of about 25 feet. As described by Fisk (1944, p. 35), the Metairie Ridge extends from the Mississippi River near Kenner, La., eastward to New Orleans and is about 5–10 feet above sea level. This ridge marks the course of a former Mississippi River distributary which flowed eastward to the Rigolets.

The Mississippi Alluvial Plain, composed of marshy delta land, flat brush-covered plains, and large lakes, is dissected by the Mississippi River, bayous, drainage ditches, and canals. The Mississippi River flows southeastward through most of the New Orleans area, then makes a sharp turn southward in St. Bernard and Plaquemines Parishes. The river now occupies a position on the east side of the Mississippi Alluvial Plain, which was formed by its aggradation. This position is the result of regional eastward tilting.

The area south of Lake Pontchartrain and near the banks of the Mississippi River in northern St. Charles, Jefferson, Plaquemines, northern St. Bernard, and southwestern Orleans Parishes will be referred to in this report as the New Orleans industrial district. Most of the larger industrial plants, commercial establishments, and public water-supply systems are located along the river where they can gain access to its large flow of water and its means of transportation.

Climate

The area is characterized by a humid subtropical climate, and usually has long summers and short winters. The mean annual temperature based upon an 80-year period of record is 69.8°F and the mean monthly temperature ranges from 55°F in January to 83°F in July (fig. 2). The maximum temperature observed to date was 102°F in July 1901 and June 1915 and the minimum temperature was 7°F in February 1899. Temperatures of 100° are infrequent, and temperatures of 95°F or higher occur on an average of only 5 times a year. Only 23 times during the period of record has the temperature fallen as low as 24°F.

Precipitation is well distributed throughout the year, the mean annual precipitation being 60.53 inches for 1871–1953. The maximum annual precipitation was 85.73 inches in 1875, and the minimum was 31.07 inches in 1899. The mean monthly precipitation for the period of record is shown in figure 2. There are no definite rainy seasons; however, the highest normal monthly precipitation occurs in July and August and the lowest in October and November. No measurable snow has fallen on the city since January 22, 1935, when 0.1 inch was recorded.

Tornadoes are rare, and only 3 hurricanes have passed through the area in the past half century. The relative humidity is high throughout the year. There is sunshine about 59 percent of the time and the average annual wind velocity is about 8 miles per hour, the maximum of record being 98 in September 1915. These data were collected and furnished by the U. S. Weather Bureau.

Natural Resources

The primary natural resources of the greater New Orleans area are oil, gas, and water. Locally in southern St. Tammany Parish, clay, sand, and gravel are used mostly for concrete and ceramic products. Oil is produced in 20 localities and gas in 15; thus, the area is an important source of petroleum (La. Dept. Conserv., 1953). Water has always been an important natural resource; its principal uses are for public water supplies, industrial supplies, waste disposal, and navigation.

Population

The total population of the New Orleans area cannot be determined exactly because parts of several parishes are included, but a reliable estimate from the 1950 U. S. Census is 685,000. The city of New Orleans shows the greatest concentration with 570,445, which represents about 80 percent of the population of the area. The 1950 population of the principal cities (more than 5,000) follows:

New Orleans	570,445
Gretna	13,813
Westwego	8,328
Kenner	5,535
Covington	5,113

Transportation

The area is served by 8 trunk railroad lines which carried about 12,000,000 tons of cargo in 1953; 4 buslines; 9 airlines of which 8 are passenger and 1 is cargo; 75 trucklines of which 35 are common carriers and 40 are contract carriers; 80 steamship lines which carried about 17,000,000 net tons in 1953; 40 barge lines which carried about 23,000,000 net tons in 1953; and a network of Federal, State, and Parish highways. These data were obtained from publications of the New Orleans Chamber of Commerce.

One of the most important waterways of the nation is the Mississippi River, on which the port of New Orleans is located. The Inner Harbor-Navigation Canal (Industrial Canal) was built as a connecting link between Lake Pontchartrain and the Mississippi River and joins the Gulf Intra-Coastal Waterway, which extends from Brownsville, Tex., to Florida. Thus, these different modes of transportation provide direct and indirect passenger and freight service to principal cities throughout the world.

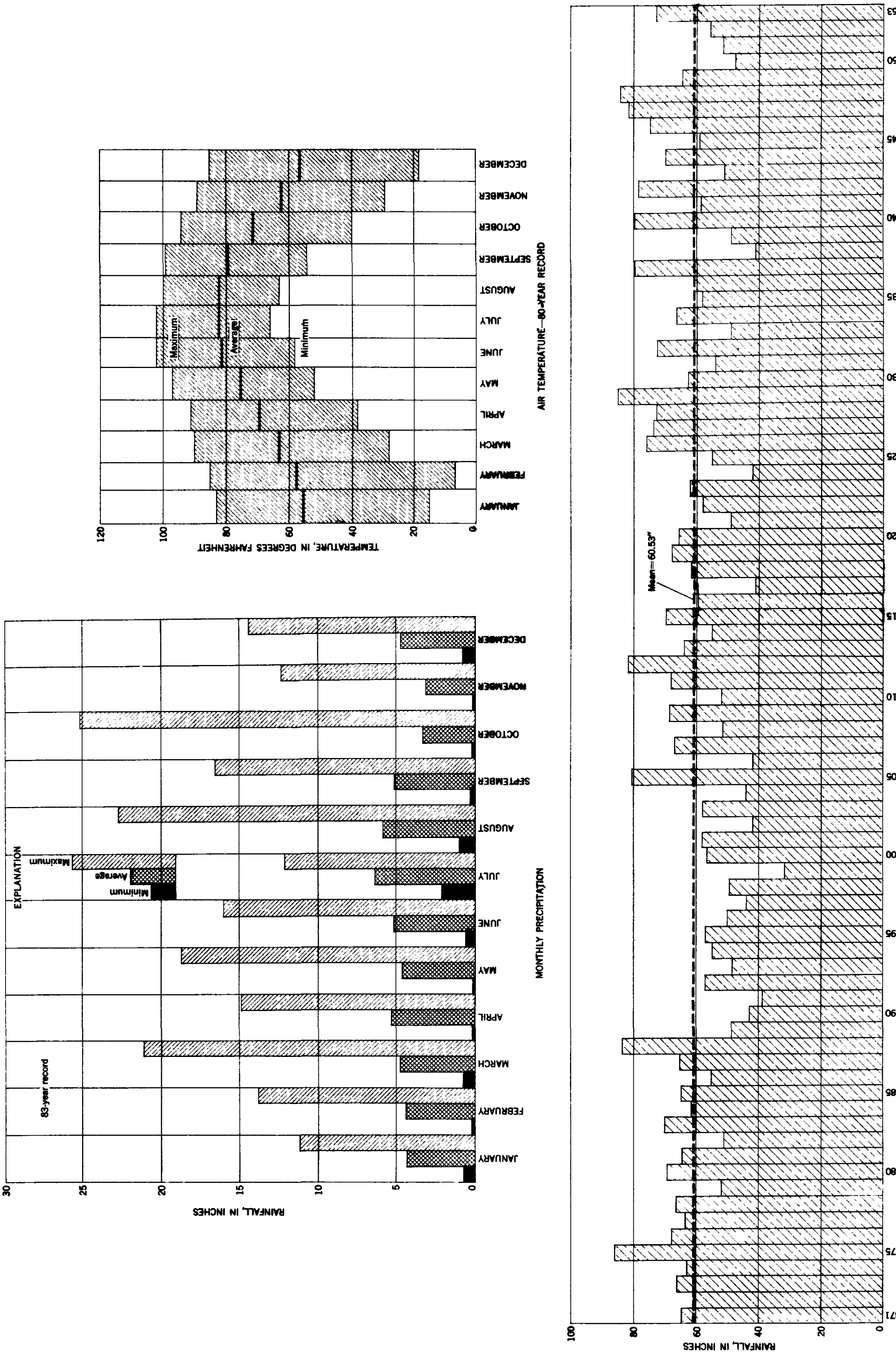

Figure 2.—Climatological data, New Orleans, La.

The Industrial Development

The industrial growth of the greater New Orleans area is primarily the result of its geographic location near the mouth of the Mississippi River. The port of New Orleans is now second in the United States in dollar value of foreign trade, handling more than a billion dollars of cargo annually. It is a general cargo port and leads the nation in the export of corn, wheat flour, and cotton, and in the importation of sugar, molasses, burlap and bagging, sisal, jute, and hemp. It is second in the importation of bananas and coffee. With the discovery of oil and natural gas and with an abundance of water, the area contains one of the largest refining potential capacities in the State. The area is within the chief region of the State for truck-crop production and on the fringe zone of the largest sugarcane belt in the United States.

It would be impracticable to mention in this report all the industries that have aided in the growth of the area; however, some of the important ones are: canning of food and kindred products, brewing, power-generating plants, transportation equipment including ship and boat building, defense plants, textile and textile products, chemical and allied products, fabricated metal products, and paper and milled products. It is a major U. S. Navy repair base and is the home of four universities.

DEFINITION OF TERMS

In this report the chemical concentrations are expressed either in parts per million or equivalents per million. A part per million (ppm) is a unit weight of a substance dissolved in 1 million unit weights of the solution. For example, 50 ppm of chloride means that there are 50 milligrams of chloride in 1,000,000 milligrams of the solution.

An equivalent per million (epm) is an expression of the reacting value of a substance. It is a unit equivalent weight of an ion contained in 1 million unit weights of the water. An equivalent weight is defined as the weight that is exactly equal in reacting capacity to one atomic weight of hydrogen (1.0080 g). The equivalent per million of a substance is calculated by dividing the concentration in parts per million by its equivalent weight.

A water that contains more than 1,000 ppm of dissolved solids is called saline. Water containing from 1,000–3,000 ppm is said to be slightly saline; water containing 3,000–10,000 ppm of dissolved solids is moderately saline.

Biochemical oxygen demand (B. O. D.) is the amount of oxygen used by micro-organisms in the biochemical oxidation of organic matter in a specified time at a specified temperature. The B. O. D., as determined by standard laboratory procedure for 5 days at 20°C, is usually expressed in parts per million.

Suspended sediment is that sediment which remains in suspension in water owing to the upward components of turbulent currents and as a colloid. Suspended sediment is usually expressed in parts per million.

Cubic foot per second (cfs) is the rate of discharge of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 cfs. Mgd is the abbreviation for million gallons per day and gpm is the abbreviation for gallons per minute 1 cfs = 0.646 mgd = 449 gpm. An acre-foot is the amount of water required to cover an area of 1 acre to a depth of 1 foot and is equivalent to 43,560 cubic feet, or 325,851 gallons.

Cubic feet per second per square mile is the average number of cubic feet of water flowing per second per square mile drained, on the assumption that the runoff is distributed uniformly in relation to time and area.

Specific capacity of a well is its rate of yield per unit of drawdown. It depends upon the hydraulic characteristics of the aquifer; rate and length of time of pumping, and effeciency of well construction. Thus if a well is pumped at a rate of 500 gpm and the drawdown is 50 feet, the specific capacity of the well is 10 gpm per foot.

PRINCIPLES OF OCCURRENCE OF WATER

Sources of Water

Precipitation is the source of fresh water, and reaches the earth in the form of rain, snow, hail, or sleet. It rarely occurs in the New Orleans area except as rain. In the endless cycle of water from the clouds to the earth and back again, a part returns to the atmosphere through evaporation and transpiration and a part runs off the land into natural waterways and returns to the seas. The remainder seeps into the ground; and a part is evaporated and transpired and the rest eventually reaches the ground-water zone, from which it is discharged by seepage or by evapotranspiration.

Precipitation on the city of New Orleans is about 60 inches annually, and excess precipitation must be pumped into Lake Pontchartrain to prevent flooding of the city, a great part of which is below mean sea level. Excess precipitation that falls on the city, and precipitation that falls on the marshlands and coastal lagoons such as Lakes Salvador, Des Allemands, Cataouatche, Maurepas, and Pontchartrain, is lost at present as a fresh-water source, because it soon becomes saline upon mixing with salt water from the Gulf of Mexico.

The principal sources of water of all kinds for the New Orleans area are the Mississippi River, Lakes Pontchartrain and Maurepas, and wells. The flow of the Mississippi River at New Orleans comes mostly from large land areas outside Louisiana. Lakes Pontchartrain and Maurepas (fig. 3) receive continual fresh-water inflows from local tributaries that drain eastern Louisiana and a part of the State of Mississippi. Water from wells in the New Orleans area comes largely from water-bearing sands that receive recharge north of the New Orleans area. Locally some of the sands probably receive their recharge from streams and precipitation in that region of the New Orleans area just north of Lake Pontchartrain.

Large quantities of water which require much chemical treatment for public water supplies are available

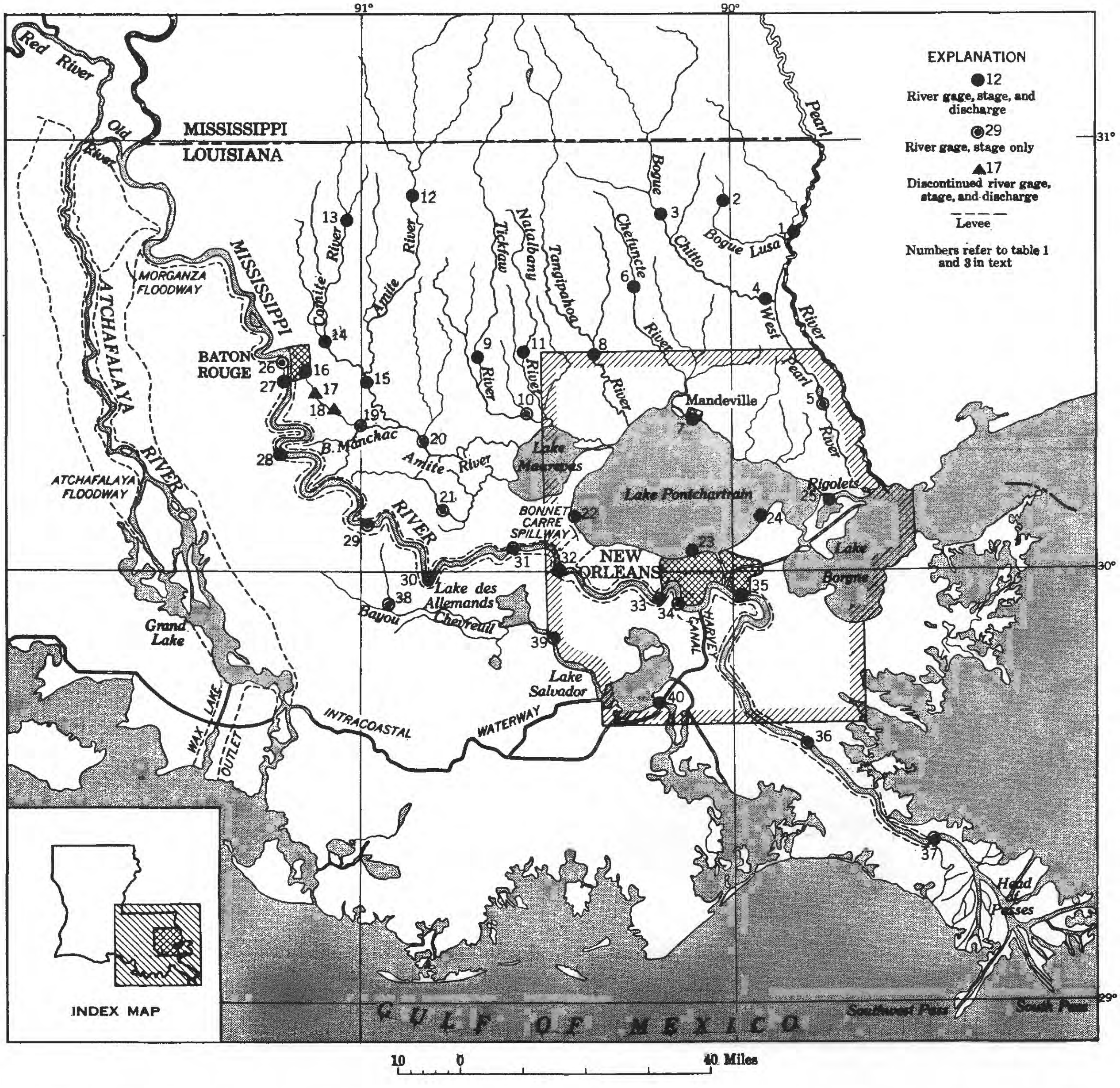

Figure 3.—Map of the New Orleans area and vicinity showing river systems, lakes, and gaging stations.

in the Mississippi River. During low-flow periods, salt water has extended in the Mississippi River as far as and beyond the city of New Orleans.

Most of the water in the Industrial Canal used by industries comes from Lake Pontchartrain. It is too saline, however, to be suitable to all users and is especially unsuitable as a source of potable water. Lake Pontchartrain receives saline water by tidal inflow from the Gulf of Mexico through Lake Borgne and the Rigolets and other smaller outlets. However, water entering through the Rigolets has been diluted by Pearl River inflow into Lake Borgne. After entering Lake Pontchartrain this water is further diluted by large volumes of water from those tributaries emptying along its northern shore. The saline content probably is not constant throughout the lake because of the variable inflow of fresh and saline water. The waters of the lake are probably fresher along the northern shore where the major tributaries enter. The principal tributary streams are the Amite and Tickfaw Rivers, which empty into Lake Maurepas, and the Tangipahoa and Chefuncte Rivers. All these streams are among the best sources of water in the State of Louisiana because they have dependable flows of excellent quality. The salinity of Lake Maurepas is probably lower than that of Lake Pontchartrain because it is less likely to be affected by salt-water encroachment from the Gulf of Mexico and is more affected by dilution from the Amite and Tickfaw Rivers.

Ground water south of Lake Pontchartrain is not used as a source for public water supplies. Ground water is withdrawn for industrial uses from three principal water-bearing sands, the "200-foot," "400-foot," and "700-foot" sands. Although water from a "1,200-foot" sand is used to some extent, it is not considered a principal source of ground water because of the poor quality of its water. The "700-foot" sand is the most important water-bearing sand because it is the most extensive and generally contains water of the best quality.

North of Lake Pontchartrain, wells 60–2,000 feet deep yield fresh water used mostly for public and private water supplies. There are no known water-supply wells deeper than 2,000 feet in the New Orleans area; however, fresh-water-bearing sands are present to a maximum depth of about 3,000 feet north of Lake Pontchartrain.

Significance of the Quality of Water

Water probably has more different uses than any other single natural resource. The quality of water is a very important factor, sometimes more important than the quantity. Because of its wide variety of uses, no single set of standards can be established. Treatment costs are often higher in converting a water supply of poor quality to one of good quality than the cost of a new supply.

The quality of the water comprises its chemical, physical, and sanitary characteristics.

The chemical quality of the water refers to the total amount and the interrelationship of the dissolved mineral constituents in the water, which determine its suitability for a great number of uses. Physical quality refers to such properties as turbidity, color, temperature, and odor, which also are important factors in evaluating the suitability of the water for industrial, municipal, and domestic uses.

The sanitary quality of the water shows the degree of pollution of surface and ground water. The term pollution implies the fouling of an otherwise inoffensive water by sewage or other liquids or suspensions, thus rendering it offensive to sight and smell and unsatisfactory for potable, culinary, or industrial uses (Am. Water Works Assoc., 1950, p. 29). Natural pollution occurs where the drainage from unpreventable sources caused the fouling of clean water. Some of the results of the pollution of a stream, such as color, turbidity, odor, and taste, are easily seen or detected. The effects of acid and oil wastes, oxygen depletion, and toxicity are not as easily recognized by the casual observer, although studies of the stream fauna may reveal the presence of a serious pollution problem.

The water in a stream free from pollution generally has a high dissolved-oxygen content, and no significant B.O.D., taste, or odor. However, in the zone of recent pollution the amount of dissolved oxygen in the water is decreased, and the B.O.D. and turbidity are increased. The septic zone is characterized also by noxious odors. Temperature is an important physical characteristic of water for industrial and domestic uses. Uniformity of temperature is important to operators of industrial plants, especially for the water used for cooling. In municipal water-treatment plants, the amount of coagulant to be added to water to form a floc in a specified time is dependent on the water temperature; the lower the temperature, the longer it takes to form a floc with a given amount of coagulant.

Hardness is a measure of the soap-consuming property of water and is generally considered troublesome in concentrations greater than 150 ppm because more soap is required to form a lather. The use of excessively hard water also results in the formation of scale in water pipes (especially in hot-water pipes), thus reducing the carrying capacity of the pipes. A certain amount of hardness is desirable in prevention of rust by the deposition of a thin protective coating of calcium carbonate on the inner surface of water pipes. Hardness in water is caused primarily by the presence in solution of calcium and magnesium salts. Iron, aluminum, barium, zinc, some other metals, and free mineral acid also may cause hardness, but the amount of these ions normally found in a natural water is small and therefore they do not appreciably affect the hardness. Carbonate ("temporary") hardness is that part of hardness caused by the combination of calcium and magnesium ions chemically equivalent to the bicarbonate ion. This type of hardness can be removed by heating, thus precipitating as calcium and magnesium carbonate. The remaining hardness is noncarbonate ("permanent") hardness and is more difficult to remove.

The residue on evaporation (dissolved solids) is a measure of the weight of dissolved mineral salts and is also a measure of the usability of the water. Water used for certain industrial purposes not only must meet specific requirements for allowable concentrations of individual ions but also must conform to allowable concentrations of dissolved solids.

Staining of porcelain plumbing fixtures and laundry may result from the use of water containing excess iron and maganese. Generally accepted drinking-water standards limit the combined iron and manganese concentration to 0.3 ppm (U. S. Public Health Service, 1946). When soluble iron compounds are oxidized they become insoluble and form precipitates which may impart color and turbidity to the water. Crenothrix, an organism associated with waters containing iron and manganese, may cause clogging of pipes and well screens by forming in clumps or as slime attached to the wells or pipes or other submerged surfaces.

Excessive quantity of fluoride in water is associated with dental fluorosis (mottled enamel) whereas about 1 ppm reduces the incidence of dental caries (tooth decay) in children's teeth. The U. S. Public Health Service Drinking Water Standards (1946) states that the presence of fluoride in excess of 1.5 ppm in water supplies used by common carriers subject to Federal quarantine regulations shall constitute grounds for rejection of the supply. Water containing fluoride in concentrations greater than 1.5 ppm may cause mottling and discoloration of teeth if used during the period of calcification. Investigations, however, have disclosed that children with mottled enamel caused by an excess of fluoride in the drinking water experienced fewer dental caries than children whose drinking water contained no fluoride or only trace quantities (Am. Water

Works Assoc., 1950, p. 57). Many health agencies recommend that about 1 ppm fluoride be present in potable water supplies.

Turbidity in water is caused by suspended sediment or organic material. In water-treatment plants where the water is processed through zeolite material, the raw turbid water, unless previously clarified, will deposit suspended material on the surface of the resin grains and eventually will interfere with the passage of water and cause difficulty in the flushing process. Turbidity in the water also causes soiling of paper, linen, and other textile products.

SURFACE WATER

Records Available

Records of stage and of discharge in the New Orleans area are available in the Water-Supply Papers of the U. S. Geological Survey, publications of the Mississippi River Commission, the Corps of Engineers, and the U. S. Weather Bureau. Continuous records of stage on the Mississippi River at New Orleans (Carrollton gage) and at Baton Rouge began in 1872. Continuous records of discharge at Baton Rouge have been available since 1939. Discharge records between 1931 and 1939 were computed on the basis of the stations closest to Baton Rouge. Records of discharge and (or) stage are available at several other sites on the Mississippi River and on other streams, lakes or canals in the vicinity of the New Orleans area for shorter periods since 1872.

The location and duration of selected gaging-station records in the vicinity of New Orleans area is given in table 1. Data collection sites are shown on figure 3. Numbered points refer to table 1. Records of flood-crest stages and miscellaneous discharge measurements at 17 sites, not indicated in table 1, are available in the Baton Rouge office of the Surface Water Branch of the U. S. Geological Survey. Some stage records not indicated in table 1, but collected by the Corps of Engineers, are available in the district office in New Orleans. These stage records are principally on the Intracoastal Waterway, Industrial Canal, and the Mississippi River.

Mississippi River

The Mississippi River, one of the great rivers of the world, has been important in the establishment and growth of the New Orleans area, as well as in the development of the United States. Below Baton Rouge, the river has built a great fan-shaped delta on which the city of New Orleans is located.

About 200 miles upstream from New Orleans, the Mississippi River divides into the distributary system of the lower Mississippi River valley. At this point Old River connects the Mississippi River with the Atchafalaya River, the main distributary channel to the Gulf of Mexico. The head of the Atchafalaya River is at the juncture of Red and Old Rivers. A part of the flow of the Mississippi River moves west through Old River for 6.2 miles and thence down the Atchafalaya River to the gulf.

Distribution of the flow in the channels between the Mississippi and Atchafalaya Rivers vitally affects the volume of flow past New Orleans in the main stem of the Mississippi River. When the Red River is high some of its waters flow through Old River into the Mississippi River. Not since 1942, and then for only 9 days, has water from the Red River flowed into the Mississippi River. The distance to the Gulf of Mexico via Old and Atchafalaya Rivers is 142 miles whereas it is 315 miles by way of the Mississippi River. As a result, slopes are steeper and velocities are higher through the shorter route in the Atchafalaya River channel (Mississippi River Comm., 1950).

Below New Orleans, near the Head of Passes, the Mississippi River divides into several distributary channels through the recent delta fan (fig. 3).

In its history, the Mississippi River has passed through several channels in its course to the Gulf of Mexico. In the last 200 years, meandering in the lower Mississippi River has been halted by man-made improvements for navigation, flood control, and channel stabilization. The Corps of Engineers, through the Mississippi River Commission, which was organized in 1879 has made studies and recommendations for the control and development of the Mississippi River, its tributaries and distributaries.

Floods and Flood Protection

Since the early days of settlement of the lower Mississippi River valley, settlers have been plagued with floods. Efforts to control these floods have produced a progressive decrease in flood hazards to the valley. Not since 1849 has the city of New Orleans suffered serious flooding.

Stages of the Mississippi River in New Orleans, at the Carrollton gage operated by the Corps of Engineers, have been recorded intermittently between 1828 and 1871, and continuously since 1872. Maximum yearly elevations of the Mississippi River as recorded at the Carrollton gage for the period 1872–1953 are shown in figure 4. An increase in the height of flood crest between 1872 and 1927 was the result of confining the channel between levees. Levee crevasses generally prevented floods from reaching a stage of 20 feet at the Carrollton gage. However, the great floods of 1912, 1922, and 1927 did crest higher than 20 feet. Bonnet Carre spillway, essentially complete in 1931, prevented crests of the great floods of 1937, 1945, and 1950 from exceeding 20 feet at Carrollton.

The number of occurrences, by months, of the maximum annual stages of the Mississippi River at New Orleans from 1872 to 1953 is shown in figure 5. During the 82 years of record, the maximum annual stages occurred more than 90 percent of the time in the 5 months, February through June, and more than 50 percent of the time in April and May. Water-surface profiles of the Mississippi River at New Orleans and vicinity during the floods of 1927, 1945, and 1950 are shown in figure 6. The difference between mean low water and floods of extreme stages is about 33 feet at Donaldsonville, 19 feet at Carrollton, 17 feet at Chalmette and about 10 feet at West Pointe a la Hache.

Table 1.—Location and duration of selected gaging-station records in the vicinity of New Orleans, La.

[USGS, U. S. Geological Survey; CE, Corps of Engineers, Department of Army; USWB, U. S. Weather Bureau]

Index no. (fig. 3)	Station	Location	Records available	Collection agency
	Pearl River basin			
1	Pearl River near Bogalusa	Bridge on State Highway 35	Gage heights and daily discharge, October 1938 to date	USGS
2	Bogue Lusa near Franklinton	do	Oct. 1948 to date	USGS
3	Bogue Chitto at Franklinton	do	Gage heights and daily discharge, Aug. 1928 to Sept. 1931 and Oct. 1938 to date. Gage heights since Feb. 1922.	USGS and USWB
4	Bogue Chitto near Bush	Bridge on State Highway 7	USGS, October 1937 to date, CE, gage heights since May 1936 (unpublished).	USGS and CE
5	Pearl River at Pearl River	Bridge on U. S. Highway 11	Gage heights, since October 1899 to date (unpublished before 1906).	USWB
	Lake Pontchartrain basin			
6	Lake Pontchartrain at Mandeville	On lake side at end of Lott's Pier	Gage heights, Sept. 26, 1931 to date	CE
7	Chefuncte River near Folsom	Bridge on State Highway 189	Gage heights, and daily discharge, January 1944 to date	USGS
8	Tangipahoa River at Robert	Bridge on U. S. Highway 190	Gage heights and daily discharge, October 1938 to date	USGS
9	Tickfaw River at Holden	do	Gage heights and daily discharge, October 1940 to date	USGS
10	Tickfaw River near Springfield	Bridge on State Highway 160	Gage heights, May 1947 to date	CE
11	Natalbany River at Baptist	Bridge on U. S. Highway 190	Gage heights and daily discharge, August 1943 to date	USGS
12	Amite River near Darlington	Bridge on State Highway 35	Crest stages, March 1949 to November 1950, daily discharge, October 1950 to date.	USGS
13	Comite River near Olive Branch	Bridge on State Highway 36	Gage heights and daily discharge, August 1942 to date	USGS
14	Comite River near Comite	Bridge on State Highway 877	Gage heights and daily discharge, March 1944 to date	USGS
15	Amite River near Denham Springs	Bridge on U. S. Highway 190	Gage heights and daily discharge, September 1938 to date	USGS
16	Ward Creek at Government St., Baton Rouge	U. S. Highway 61 (Government Street) in Baton Rouge	Gage heights and daily discharge, March 29, 1954 to date	USGS
17	Bayou Duplantier at City Park Lake, at Baton Rouge	Lower end of City Park Lake	Gage heights and daily discharge, April 1933 to August 1938	USGS
18	Ward Creek at Siegen Lane near Baton Rouge	Bridge on Siegen Lane	Gage heights and daily discharge, December 1946 to March 1954	USGS
19	Bayou Manchac at Hope Villa	Bridge on U. S. Highway 61 at Hope Villa	Gage heights, February 1945 to date (unpublished)	USGS
20	Amite River at Port Vincent	Bridge on State Highway 46 at Port Vincent	Gage heights, August 1945 to date (unpublished)	USGS
21	Petite Amite River near Sorrento	Junction with New River Canal near Sorrento	Gage heights, intermittently Mar. 10, 1950 to Oct 31, 1950	CE
22	Lake Pontchartrain at Frenier	Frenier on structure 400 feet east of shoreline	Gage heights, Sept. 25, 1931, to date	CE
23	Lake Pontchartrain at West End	Attached to west end of Municipal Yacht Building in west end Harbor in New Orleans.	Gage heights, Sept. 25, 1931 to November 30, 1946; and March 9, 1949 to date.	CE
24	Lake Pontchartrain at Little Woods	Right side of Carlson's wharf	Gage heights, Sept. 28, 1931 to date	CE
25	Rigolets near Lake Pontchartrain	Southwest end of U. S. Highway 90 bridge across Rigolets near extreme east end of Lake Pontchartrain.	Gage heights, Sept. 28, 1931 to date	CE
	Mississippi River main stem			
26	Mississippi River near Baton Rouge	Bridge on U. S. Highway 190	Gage heights, June 1940 to date	USGS
27	do	Yazoo and Mississippi Valley railroad station	Gage heights, January 1872 to date, occasional discharge measurements 1929 and June 1938 to date, daily discharge 1931–45 and 1947 to date.	CE and USWB
28	Mississippi River at Plaquemine	Plaquemine lock	Jan. 1880 to May 1885, Dec. 1888 to date	CE
29	Mississippi River at Donaldsonville	Donaldsonville City waterworks plant	Gage heights, June 1890 to date	CE and USWB
30	Mississippi River at College Point	Left bank 300 feet downstream from new College Point Pharmacy.	Gage heights, December 1879 to September 1885 and December 1888 to date.	CE
31	Mississippi River at Reserve	Wharf of Godchaux Sugars, Inc.	Gage heights, March 1929 to date	CE and USWB
32	Mississippi River at Bonnet Carre	Spillway structure near Norco	Gage heights, March 1930 to date	CE
33	Mississippi River at New Orleans	Huey P. Long bridge on U. S. Highway 90	Gage heights, November 1934 to date	USGS
34	Mississippi River at Carrollton (New Orleans)	Near intersection of St. Charles Avenue and Levee	Gage heights, January 1872 to date, occasional discharge measurements 1851, 1852 and 1879–1927; daily discharge, 1928–36 and 1938–44.	CE and USWB
35	Mississippi River at Chalmette	Between berths B and C of Southern Railway slip no. 1	Gage heights, October 1923 to date	CE
36	Mississippi River at West Pointe a la Hache	Right bank at ferry landing	Gage heights, February 1926 to date	CE
37	Mississippi River at Fort Jackson	Wharf 1 mile downstream from Fort Jackson	Gage heights, February 1891 to date	CE
	Sites at or near Lake Des Allemands and Lake Salvador			
38	Bayou Chevreuil near Chegby	Bridge on State Highway 83 near Chegby	Gage heights, July 11, 1951 to date	CE
39	Bayou Des Allemands at Allemands	U. S. Highway 90 at Allemands	Gage heights, Jan. 18, 1950 to date	CE
40	Bayou Barataria at Barataria	Wharf near junction with Bayou Villars	Gage heights, Jan. 6, 1950 to Sept 26, 1950; Nov. 2, 1951 to date	CE

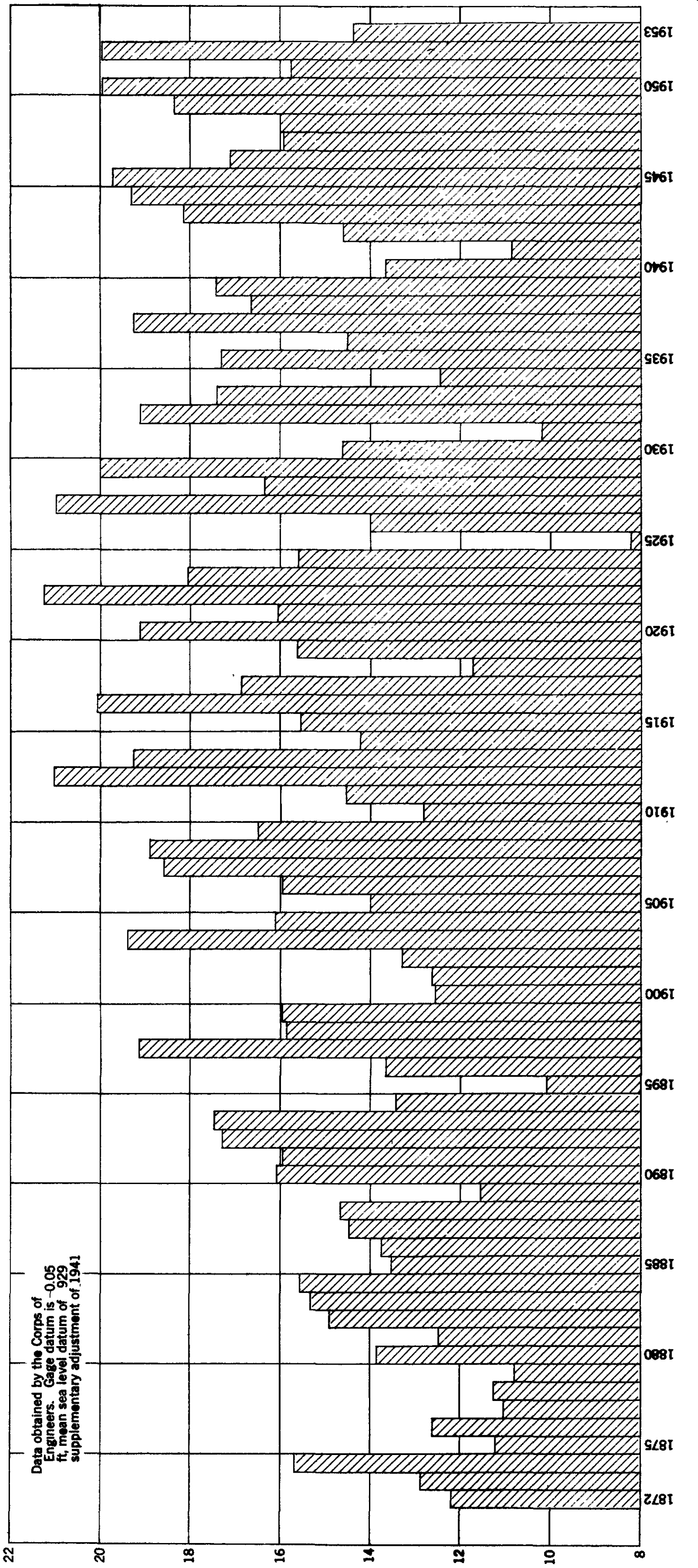

Figure 4.—Maximum annual stages of the Mississippi River at New Orleans (Carrollton gage), 1872–1953.

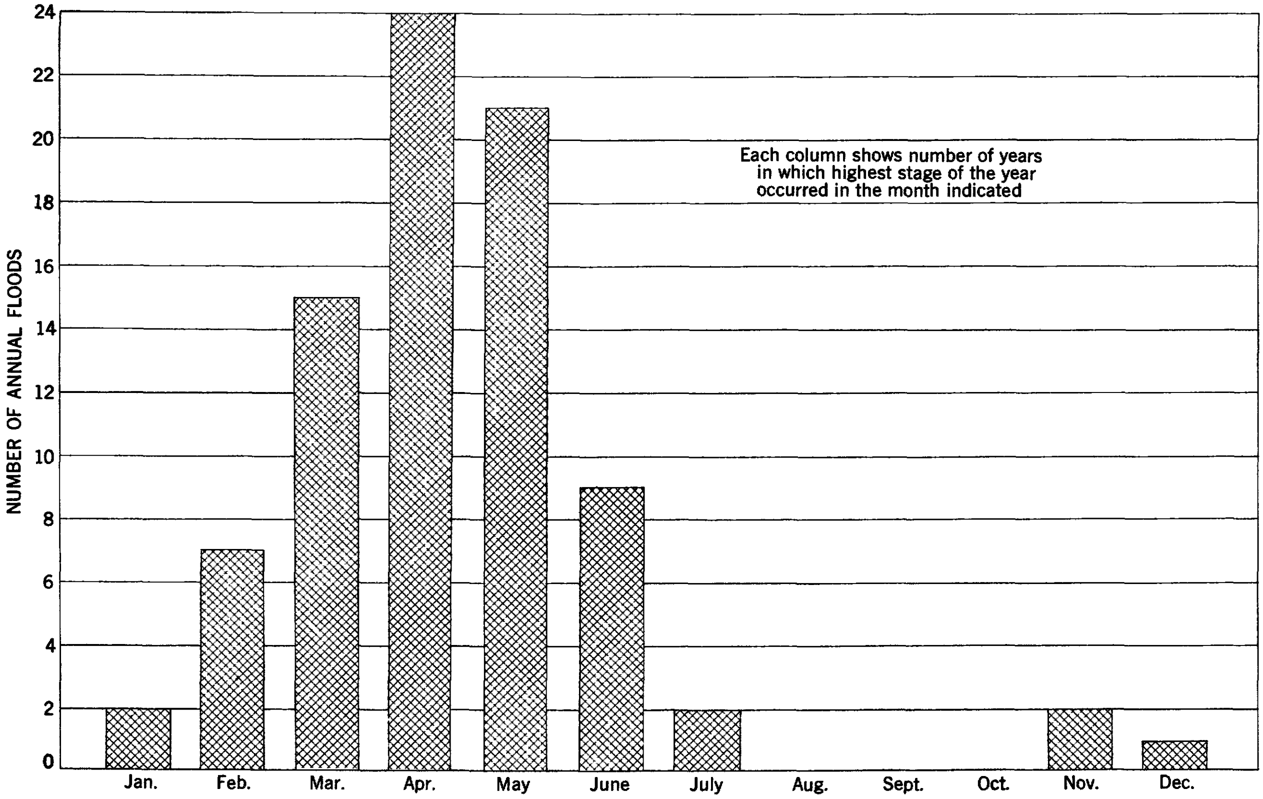

Figure 5.—Distribution graph showing frequency of annual floods by months, Mississippi River at New Orleans, 1872–1953.

The 1927 flood in the lower Mississippi River valley was one of the great national disasters. The valley was largely submerged, scores of lives were lost, and property damage was high. Crevasses above Angola and below New Orleans saved the city from being flooded.

The devastation wrought by the 1927 flood spurred Congress to pass the Flood Control Act of May 15, 1928 which committed the Federal government to a definite program of flood control that through the years has been modified and enlarged by subsequent Flood Control Acts. The flood control plan adopted for the Mississippi River provides for protection against a project flood, the greatest hypothetical flood that meteorologists consider possible. Below the mouth of the Arkansas River the project flood is 17–27 percent greater than the greatest flood of record, that of 1927 (Mississippi River Commission, Feb. 1950).

In the vicinity of Old River, the project flood is estimated to be about 3,000,000 cfs. The Atchafalaya River system will carry about half, or 1,500,000 cfs, and the main stem of the Mississippi River below Old River will carry half, of which 250,000 cfs will be diverted through the Bonnet Carre spillway, with the remainder, or 1,250,000 cfs, flowing in the main stem of the Mississippi River past New Orleans.

Since the passing of the Flood Control Act of 1928, floods in 1929, 1937, 1945, and 1950 in the lower Mississippi River valley have proved the effectiveness of the flood-control measures which have been undertaken. Work has been continuous and is so extensive that it is impossible here to completely describe the different phases.

To safely pass the project flood below Old River, several floodways, levees, and control structures have been built and some structures remain to be built. Flow of the Mississippi River through Old River into the Atchafalaya River is uncontrolled. West Atchafalaya Floodway, practically completed by 1938, the Atchafalaya River, and Morganza Floodway and Control Structure, recently completed, are designed to carry about 1,500,000 cfs of the project flood. Bonnet Carre spillway, built specifically to prevent flooding of New Orleans, was essentially complete in 1931. Bonnet Carre spillway will probably be used about once in 5 years, for periods ranging from 1 to 3 months. The spillway is used when necessary to prevent stages exceeding 20 feet on the Carrollton gage, a stage 5 feet below levee grade. This stage was selected to prevent disturbance, of waterborne and railroad traffic, removal of goods from wharves and river-front storehouses, and acute apprehension and fear among the general populace and business interests.

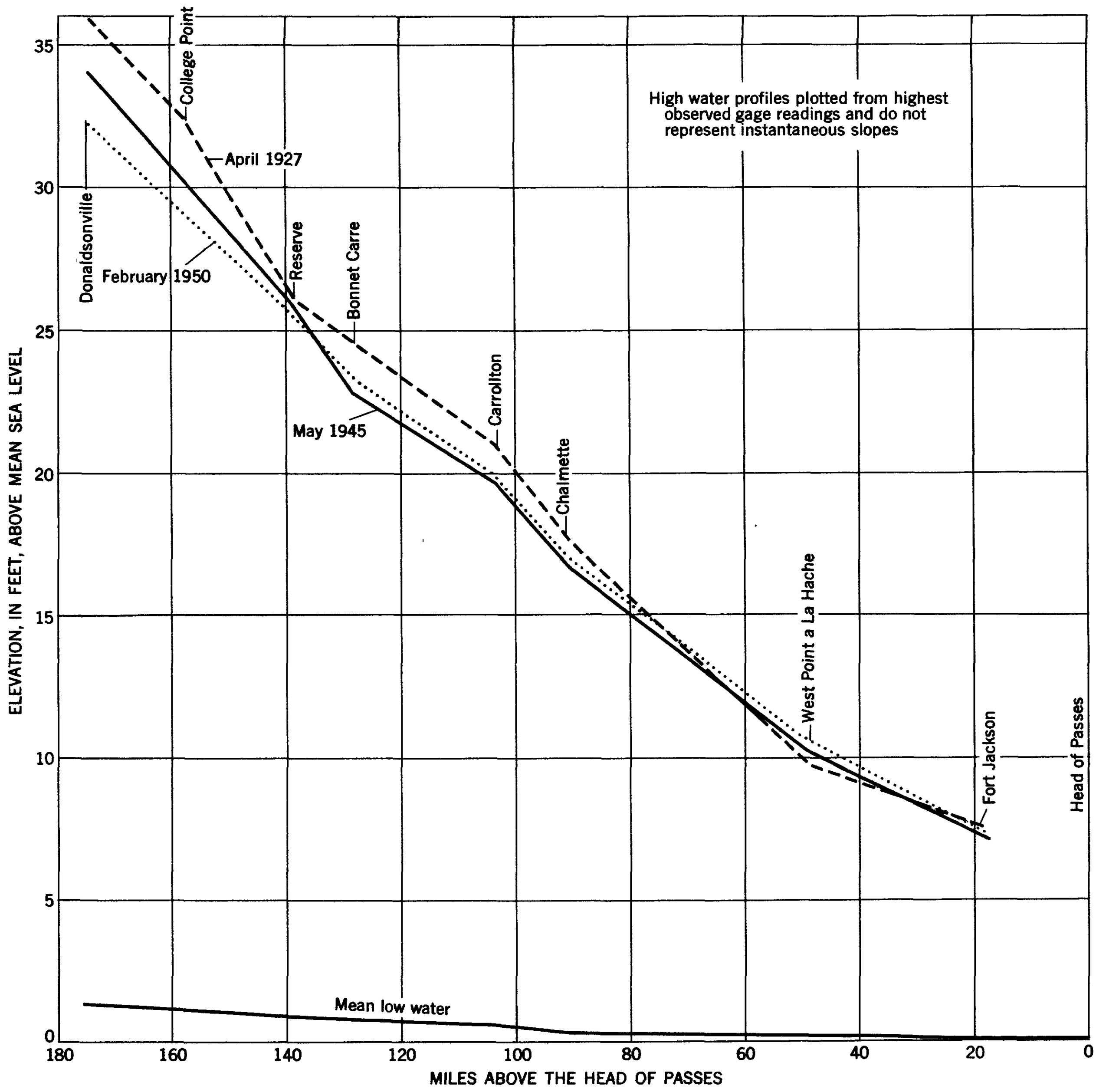

Figure 6.—Water-surface profiles for selected floods on the Mississippi River, New Orleans and vicinity.

A careful watch of stages and discharges along the Mississippi River above New Orleans is maintained when floods are in progress and daily instructions are issued for operation of the bays of the spillway to prevent stages from rising higher than 20 feet at the Carrollton gage. By opening or closing any or all of 350 bays, the stage at New Orleans can be regulated within close limits.

The gates have been operated three times since the Bonnet Carre spillway was completed. The spillway was used from January 30 to March 16, 1937, from March 20 to May 17, 1945, and from February 10 to March 19, 1950. The effectiveness of the operation of Bonnet Carre spillway in maintaining elevations in the vicinity of New Orleans below 20 feet on the Carrollton gage during the time the spillway was opened February 10 to March 19, 1950 may be observed in the graph shown in figure 7.

Discharge

The farthest point downstream on the Mississippi River at which discharge records are collected on a systematic basis is at Baton Rouge, about 130 miles from New Orleans. The inflow between Baton Rouge and New Orleans is negligible, so that the flow

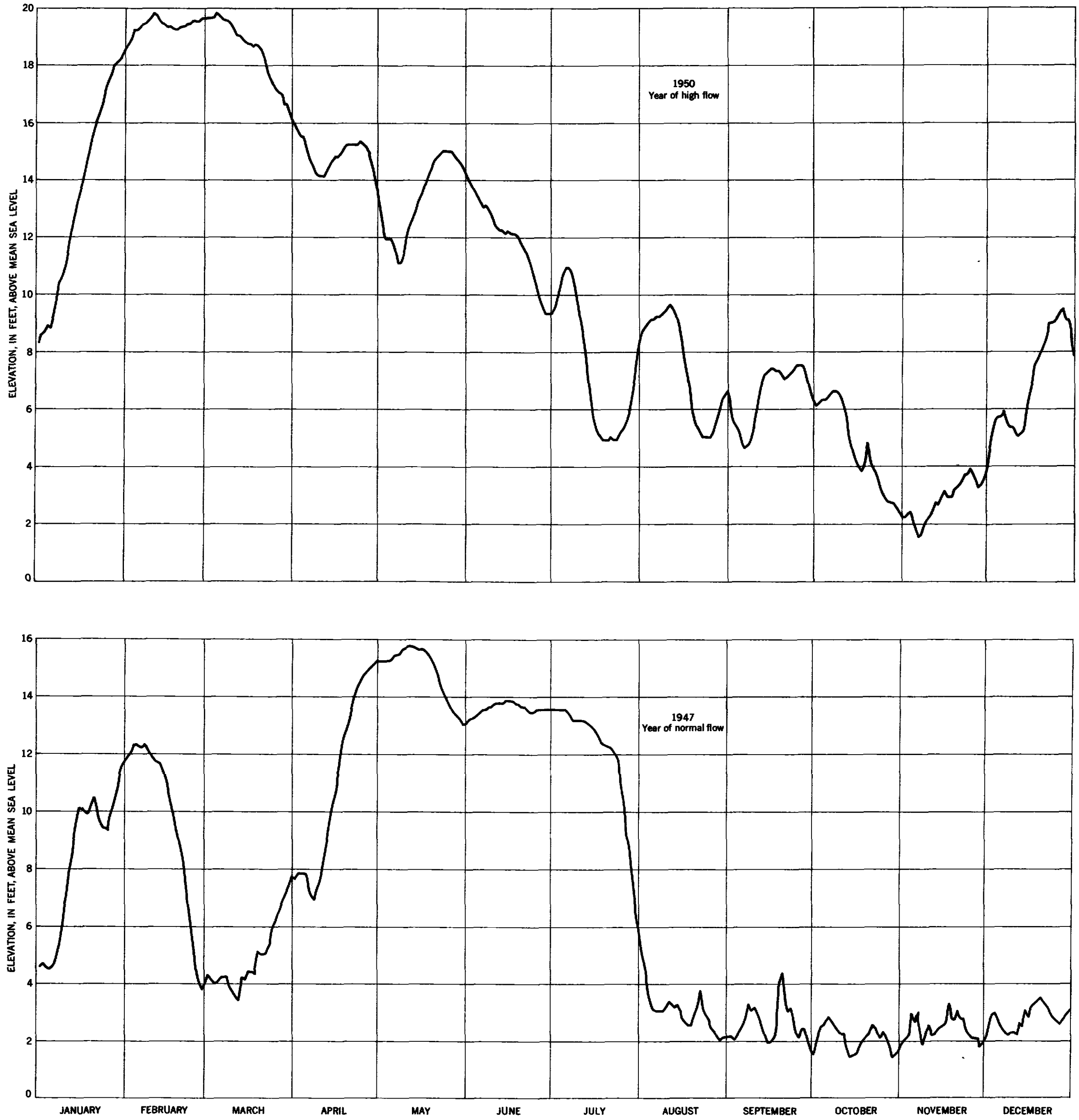

Figure 7.—Stage hydrographs of the Mississippi River near New Orleans (Huey P. Long Bridge).

observed at Baton Rouge is essentially the same as that in the vicinity of New Orleans. Hence, discharges for that station will be considered applicable at New Orleans.

The mean flow for the 24-year period, 1931–54, is 309,000 mgd, according to the Corps of Engineers. Maximum discharge recorded during that period was 952,000 mgd on April 16, 1945, and the minimum discharge recorded was 47,600 mgd on October 19, 1939.

The maximum, average, and minimum of the mean monthly discharges are shown on figure 8. This diagram shows that in most years the maximum of the average discharges occur during March, April, and May and that the season of low runoff extends usually

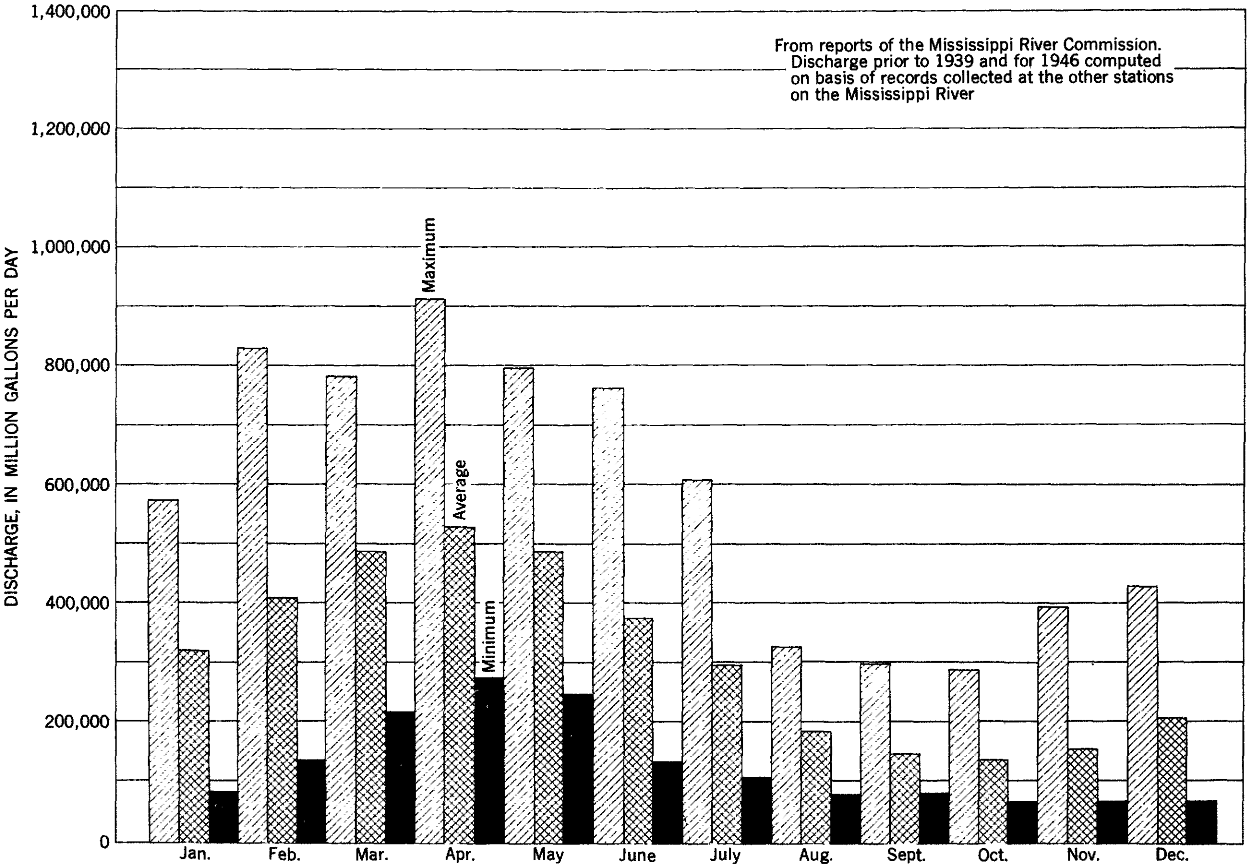

Figure 8.—Maximum, minimum, and average mean monthly discharge of the Mississippi River at Baton Rouge, 1931–53.

from August through November. Although there is a considerable range in discharge between the typically high and low season of a year, generally the flow changes relatively slowly and uniformly between these periods. Mississippi River elevations at the Carrollton gage in New Orleans for 1947, a year of near medium flow, are shown in figure 7.

Port Facilities and Navigation

The normal width of the navigable channel within the limits of the port of New Orleans ranges from 1,600 to 2,400 feet. Provisions have been made to maintain a minimum channel depth of 35 feet and minimum width of 1,500 feet.

The harbor has an average depth of 150 feet at midstream and along the wharves the depth ranges from 30 to 60 feet. The range in tides averages about 10 inches during low stages and becomes negligible during high stages of the river.

From the lower limits of the port of New Orleans south on the Mississippi River to Head of Passes, a channel 40 feet deep by 1,000 feet wide and 86.7 miles long is available for navigation by ocean-going vessels. Southwest Pass has a channel depth of 35 feet, width between 600 and 800 feet, and length of 21.2 miles; South Pass has a channel depth of 30 feet, width of 450 feet, and length of 14.2 miles. These passes provide for passage from the Head of Passes to the Gulf of Mexico.

The Gulf Intracoastal Waterways, an inland navigation channel generally parallel to the coast of the Gulf of Mexico is available for barge traffic from New Orleans. This channel, 12 feet deep and 125 feet wide, extends eastward from New Orleans to Carrabelle, Fla., and westward to Brownsville, Tex. A navigable channel 35 feet deep and 500 feet wide, extends 128.6 miles from New Orleans to Baton Rouge and accommodates ocean-going vessels to that point.

The Mississippi River Inland Waterways system developed for barge traffic connects New Orleans by navigable channels with the Great Lakes, Sioux City on the Missouri River, Minneapolis on the Mississippi River, Chicago on the Illinois River, Pittsburgh on the Ohio River, and Knoxville on the Tennessee River. Above Baton Rouge, it is at least 9 feet in depth and of variable widths.

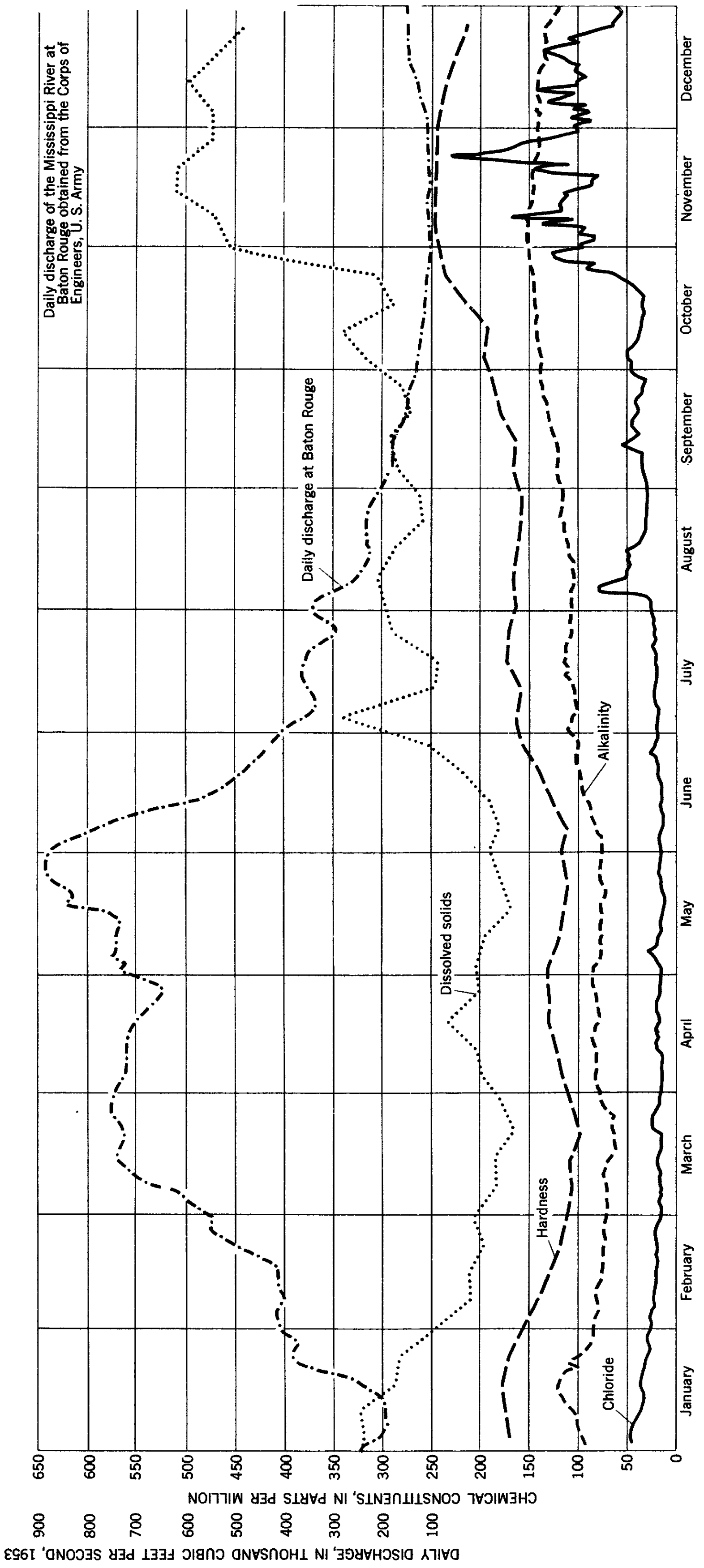

Figure 9.—Relationship between streamflow and chemical composition of Mississippi River water at Carrollton treatment plant, New Orleans, 1953.

Quality of the Water

The concentration of the mineral constituents of the Mississippi River water at New Orleans varies throughout the year, although the chemical elements, expressed as a percentage of the total mineral content, remains uniform except during periods of saline-water encroachment. Daily determinations of chloride, alkalinity, and sanitary quality are made at Carrollton. Total and noncarbonate hardness, calcium, magnesium, sulfate, and dissolved solids are determined weekly.

The chemical composition of the Mississippi River water at the Carrollton treatment plant in relation to streamflow for the year 1953 is shown in figure 9. During the period of low flow, from October through December, the chloride increased from 33 ppm on October 19 to 230 ppm on November 23; likewise, the dissolved solids increased from 290 ppm to 480 ppm on these dates. When the discharge of the river decreases below 170,000 cfs the danger of saline-water encroachment increases. The increase of the chloride content of the river water indicates that there is insufficient flow to hold back the wedge of saline water that gradually moves upstream along the bottom of the river channel as the flow of the river decreases. This explanation of the increase in the chloride content of the water at the Carrollton plant is substantiated by the fact that the chloride content in the river water at the Algiers plant downstream from Carrollton is consistently higher. According to the Corps of Engineers, New Orleans District, the normal chloride content of the Mississippi River at and below New Orleans is about 30 ppm. An increase in the surface salinity substantially greater than this amount is generally indicative of movement of the salt wedge up to and beyond

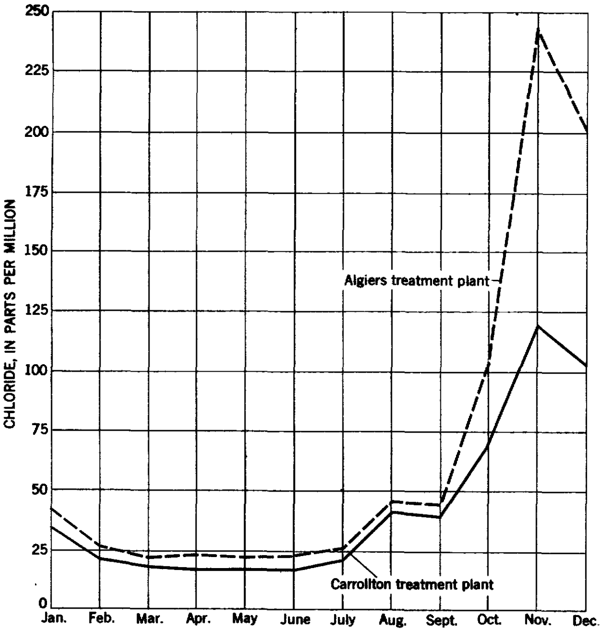

Figure 10.—Monthly average chloride content of Mississippi River water at Algiers and Carrollton treatment plants, New Orleans, 1953.

the point of observation. A comparison of the chloride concentrations at both plants is shown in figure 10. The Corps of Engineers also states that "*** brine wedge extended up the Mississippi River at practically full strength to Norco, La., at a depth of 120 feet on October 2, 1936. It was accompanied by a peak salinity condition at the surface of the river at the following places to the indicated extent:"

	Parts per million	Date
Port Sulphur	2,195	October 8
Chalmette	825	7
Algiers	620	7
Celotex	430	7
Carrollton	383	9
Reserve	120	11
Baton Rouge	130	13

The results of the analyses of the raw water at the Carrollton treatment plant for the year 1953 are shown in table 2. The water is of the calcium bicarbonate type, ranging in concentration of dissolved solids from about 100 to more than 500 ppm.

Temperature

The mean monthly air and Mississippi River water temperatures at New Orleans for a period of 30 years is shown in figure 11. The mean monthly air temperature exceeds the water temperature by about 8°–10°F

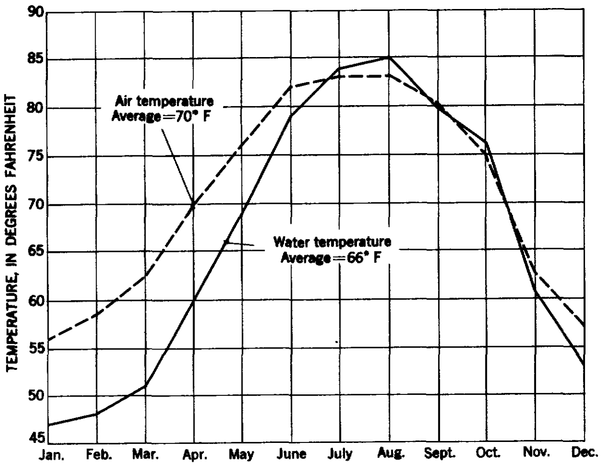

Figure 11.—Mean monthly air and Mississippi River water temperatures at New Orleans, 1921–50.

from January to April. The temperature difference then gradually decreases through May and June; during July and August the water temperature exceeds the air temperature by about 1°–3°.

During the 1953 calendar year the temperature of the Mississippi River at New Orleans equaled or exceeded 65°F on 51 percent of the days. It exceeded 85°F on 15 percent of the days and was less than 50°F on about 18 percent of the days (fig. 12).

Table 2.—Concentrations of several constituents in the raw Mississippi River water at the Carrollton treatment plant, New Orleans, La., 1953

[Analyzed by New Orleans Sewerage and Water Board]

Date of collection	Calcium (Ca)	Magnesium (Mg)	Alkalinity (as $CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids	Hardness as $CaCO_3$	
							Calcium, magnesium	Non-carbonate
Jan. 3	46.4	13.1	97	66.5	47	317	170	74
10	46.7	13.1	104	69.1	36	320	173	70
17	46.9	14.6	119	62.0	36	285	177	57
24	44.0	14.6	98	53.0	30	281	170	60
Feb. 7	35.2	12.9	81	39.0	24	209	141	59
14	34.8	9.7	76	36.8	21	211	127	46
21	33.2	8.5	74	38.8	20	195	118	41
28	30.0	8.8	72	33.5	16	206	111	36
Mar. 7	29.6	7.8	70	30.4	16	184	106	34
14	30.4	7.8	70	30.8	19	184	108	33
21	26.8	7.8	63	29	15	165	99	35
28	29.5	7.5	74	30.0	17	175	105	29
Apr. 4	32	8.5	82	....	15	198	115	33
11	33	14.1	83	37.6	20	204	121	38
18	35	10.0	79	44.6	17	233	129	44
25	35	9.7	82	41.1	17	201	128	44
May 2	35.2	12.6	84	40.7	15	204	130	55
9	33.2	8.7	77	35.3	20	194	119	40
16	29.6	10.2	76	32.9	14	170	116	42
23	29.6	8.7	75	....	17	175	110	33
30	31.2	9.2	75	25.9	14	192	116	38
June 6	32.4	7.5	82	35.3	14	180	112	29
13	33.2	10.4	91	35.6	14	191	126	35
20	37.6	10.9	98	42.3	18	216	139	42
27	39.6	13.9	100	57.1	22	255	156	52
July 4	40.4	14.8	106	57.5	19	341	162	54
11	42.8	12.2	103	52.2	23	248	157	54
18	46.4	13.6	115	75.4	21	242	172	56
25	45.6	13.9	106	74.6	23	286	171	57
Aug. 1	44.0	13.1	107	53.4	24	271	164	54
8	46.4	12.4	105	....	52	304	167	59
15	45.6	11.9	109	....	50	287	163	51
22	42.8	12.4	112	48.1	31	261	158	40
29	42.4	12.6	114	45.2	31	260	158	43
Sept. 5	45.2	12.9	122	54.5	35	283	166	46
12	44.0	13.1	123	....	48	287	164	48
19	46.0	15.6	129	38.8	39	273	179	56
26	46.4	16.8	136	48.3	33	278	185	50
Oct. 3	50.0	17.0	137	78.3	52	315	195	55
10	52.0	14.8	142	56.5	37	339	191	52
17	52.0	13.1	145	70.3	....	288	....	47
24	53.2	18.4	145	....	59	304	236	64
31	58.0	22.1	151	81.0	96	454	....	89
Nov. 7	58.8	24.1	152	104.8	106	469	246	94
14	56.8	24.8	147	104.8	115	510	244	97
21	57.6	14.5	147	81.4	111	507	245	114
28	58.4	24.1	140	80.8	116	474	245	105
Dec. 5	58.0	23.1	143	81	106	474	240	92
12	54.8	23.3	142	68.6	101	497	283	87
19	54.0	21.4	135	66.6	127	....	223	83
26	53.2	19.4	130	....	65	444	213	78

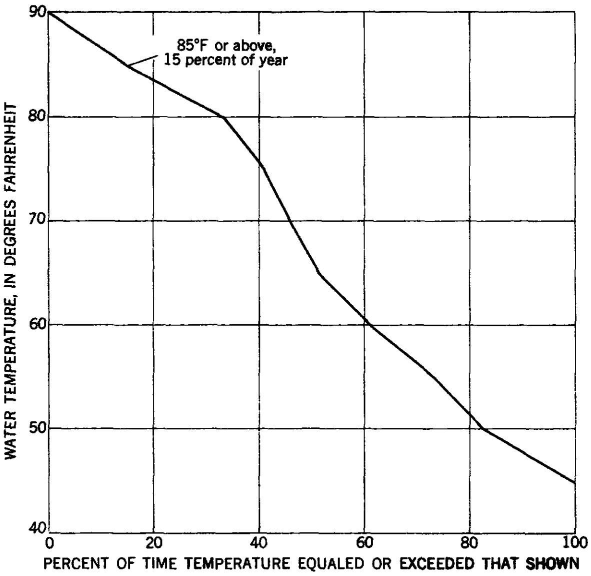

Figure 12.—Cumulative frequency graph of water temperature of Mississippi River at New Orleans.

Sediment

The Mississippi River Delta has been built up by the deposition of sediments transported by the River. The deposition of this waterborne material is a continuous process.

At the present time sediment measurements are not being made in the reach of the Mississippi River at New Orleans; however, the Corp of Engineers, U. S. Army, measures sediment at Baton Rouge which probably represents the sediment concentrations and loads of the river at New Orleans. Figure 13, taken from data furnished by the New Orleans District, shows the sediment concentration for the 1953 water year. These concentrations were obtained from complete analyses of samples taken on dates indicated on the figure.

The cumulative monthly sediment load of the Mississippi River at Baton Rouge is shown in figure 14. The total sediment load for the year was about 213 million tons. The heaviest monthly sediment loads occurred during March, April, and May. The river carried about 53 million tons or 25 percent of the total 1953 sedimentload in May. The sediment concentration of the River equaled or exceeded 250 ppm during 60 percent of the 1953 water year (fig. 15).

Pollution and its Control

The Federal Government is authorized by the Water Pollution and Control Act of 1950 to appropriate one million dollars annually to the states for research and studies to prevent and control pollution of the water by industries. Money is also available to the states for studies preliminary to the construction of approved sewage treatment works and other projects.

The danger of stream pollution is ever present in Louisiana because of the location of diversified industrial plants. The raw or partly treated wastes from sugar refineries, paper mills, fertilizer plants, meatpacking houses, canneries, oil refineries, cement plants, wood creosote treating plants, oilfield operations, and other processing plants are discharged into Louisiana streams. In addition to the aforementioned possible sources of pollution, some communities release untreated sewage to the streams.

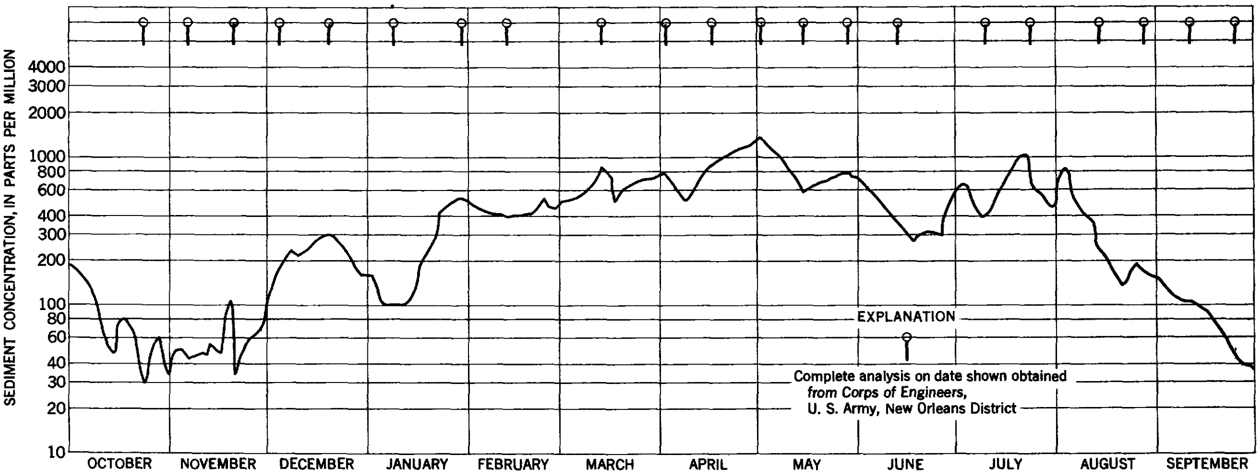

Figure 13.—Sediment concentration of the Mississippi River at Baton Rouge, water year 1953.

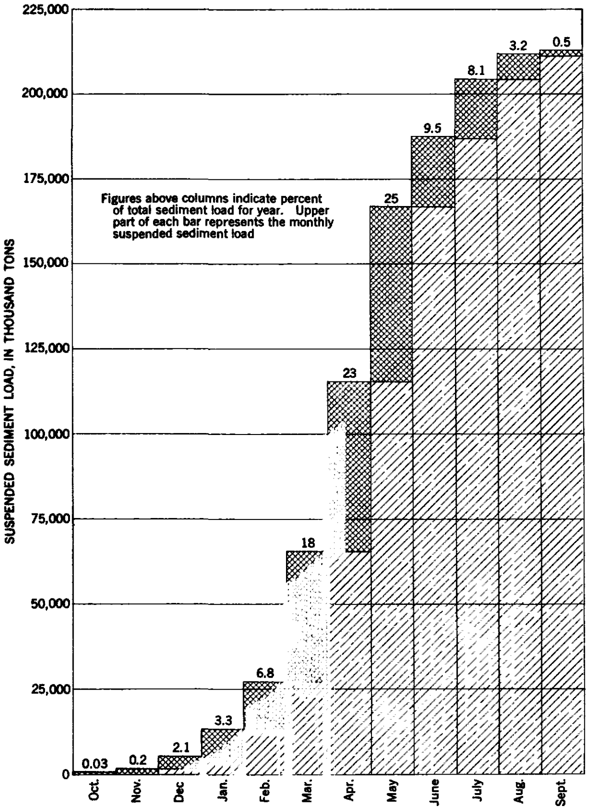

Figure 14.—Cumulative monthly suspended sediment load of Mississippi River at Baton Rouge, water year 1953.

Lake Pontchartrain Drainage Basin

Lake Pontchartrain

Lake Pontchartrain is the largest of several shallow coastal lagoons in the Mississippi River Delta. New Orleans is on its southern shore.

The average elevation of Lake Pontchartrain is about 0.8 foot above mean sea level. At mean sea level its volume is about 4,600,000 acre-feet; the average depth is about 12 feet; the surface area is about 610 square miles; and the normal tide range is about 1 foot.

Stages in Lake Pontchartrain are dependent on inflow from the tributaries to the north of the lake, tides in the Gulf of Mexico, and the effect of winds. Winds cause higher stages than tides do. The maximum stage recorded on the lake was about 6 feet above mean sea level and was the result of a hurricane on September 19, 1947. The minimum stage of record occurred on January 26, 1938, and was about 2 feet below mean sea level.

Large volumes of fresh water flow into Lake Pontchartrain from the tributary areas bordering the lake. These areas lie principally to the north of the lake, and extend into the southern parts of the State of Mississippi.

Saline water can enter Lake Pontchartrain from the Gulf of Mexico through Lake Borgne and the Rigolets, the principal connecting channel. Gulf waters that reach Lake Pontchartrain are reduced in salinity, however, owing to the fresh water from East Pearl River and other streams that discharge into Lake Borgne, and by West Pearl River which empties into the Rigolets.

Levees on the east bank of the Mississippi River prevent the natural discharge of Mississippi flood waters into Lake Pontchartrain. Since the construction of the Bonnet Carre spillway, water has been diverted from the Mississippi River three times through Lake Pontchartrain, with little effect on the elevation of the lake. A levee on the southern shore of the lake protects New Orleans from flooding. Because parts of New Orleans are as much as 3 feet below mean tide level and the greater part is below the high-water level of Lake Pontchartrain and the Mississippi River, it is necessary during heavy storms for pumps with a combined capacity of 16,500 mgd to pump water into Lake Pontchartrain. Along its northern shores, breakwater walls prevent beach erosion.

Lake Pontchartrain has ample facilities for recreational activities, which at present include bathing beaches on both the northern and southern shores, and boating and fishing. One large State park and several smaller parks are located on its northern shores. It is open to navigation by barge traffic from the Gulf of Mexico, Mississippi River, and Lake Maurepas.

The Greater New Orleans Causeway, 23 miles long across the middle of the lake extending from near Mandeville on the northern shore to New Orleans on the southern shore, is under construction. This causeway is expected to become a major link between New Orleans and regions north of Lake Pontchartrain.

Tributaries to Lake Pontchartrain

Lake Pontchartrain is fed by several streams that head in the hills of southern Mississippi and drain the area between the Mississippi River and the Pearl River basin.

Lake Pontchartrain drains about 4,200 square miles of land area. Lakes Pontchartrain and Maurepas have a combined surface area of 705 square miles. Of the 4,200 square miles of drainage area, 2,433 square miles is gaged. The gaged tributaries to Lake Pontchartrain, principally the Amite, Tangipahoa, Tickfaw, and Chefuncte Rivers, drain a region abundant in water resources. The waters are of excellent quality and are not being utilized at present. Tributaries south of Lake Pontchartrain are probably poor as a source of water supply.

Discharge

The gaged inflow to Lake Pontchartrain is summarized in table 3. Runoff into Lake Pontchartrain from the gaged area of 2,433 square miles averages about 2,520 mgd (2,826,000 acre-feet per year) or from the total drainage area of about 4,200 square miles runoff is estimated to average about 4,000 mgd (4,480,000 acre-feet per year). Although it is beyond the scope of

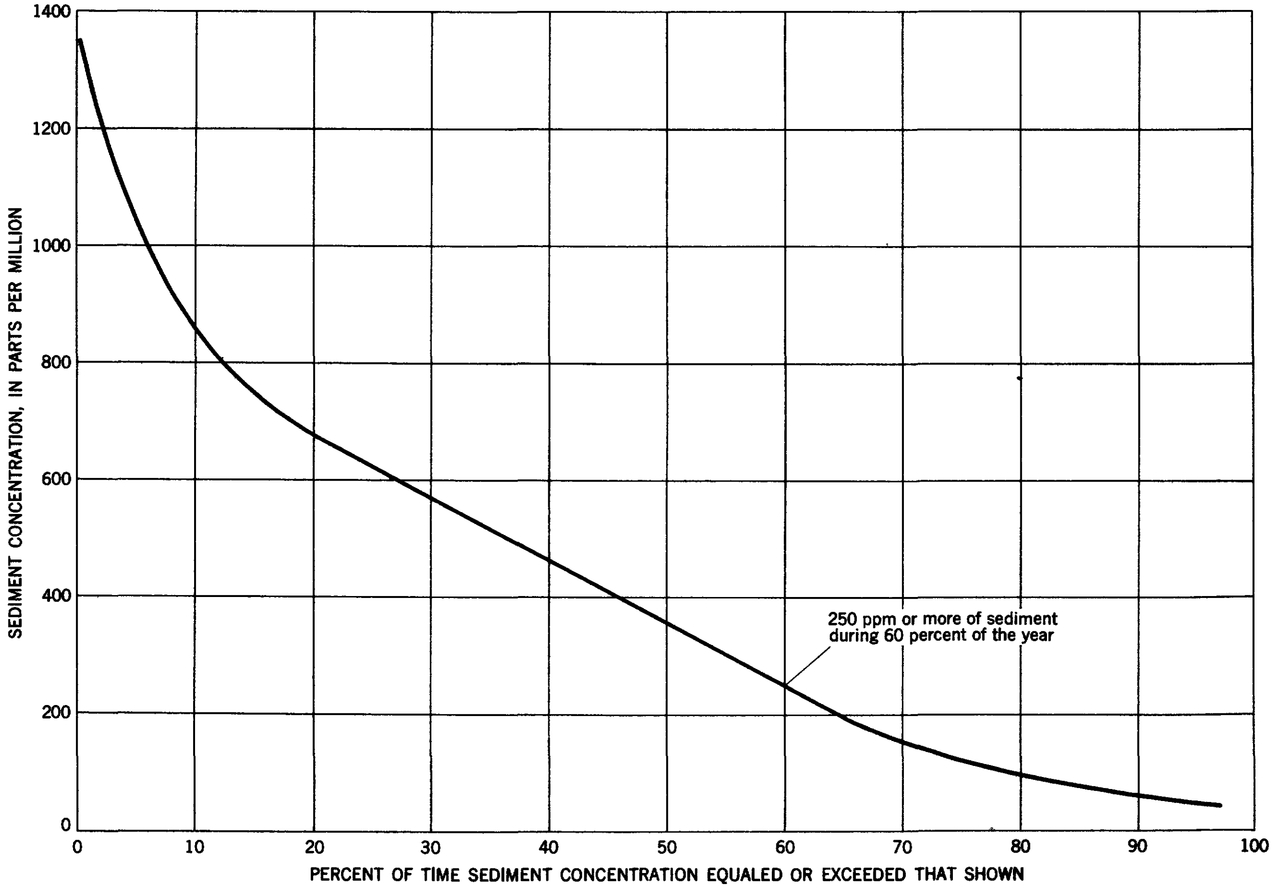

Figure 15.—Cumulative frequency graph of sediment concentration, Mississippi River at Baton Rouge, water year 1953.

Table 3.—Summary of streamflow data for streams tributary to Lake Pontchartrain, Louisiana

Index no. (fig. 3)	Stream and location	Drainage area (square miles)	Years of record	Discharge: Average (mgd)	Discharge: Maximum: Rate (mgd)	Discharge: Maximum: Date	Discharge: Momentary minimum: Rate (mgd)	Discharge: Momentary minimum: Date
15	Amite River near Denham Springs.	1,330	Sept. 1938 to Sept. 1953	1,320	43,300	May 20, 1953	180	November 1938.
9	Tickfaw River at Holden.	242	Nov. 1940 to Sept. 1953	253	6,260	Mar. 22, 1943	50	Oct. 20 to Nov. 2, and Nov. 5, 1952.
11	Natalbany River at Baptist.	79.5	Aug. 1943 to Sept. 1953	82.7	6,170	May 3, 1953	1.55	Oct. 22, 1952.
8	Tangipahoa River at Robert.	646	Oct. 1938 to Sept. 1953	742	32,600	May 3, 1953	171	Several days in Oct. 1939.
6	Chefuncte River near Folsom.	95.5	Jan. 1944 to Sept. 1953	125	11,800	May 3, 1955	23.3	Several days in Oct. 1952.

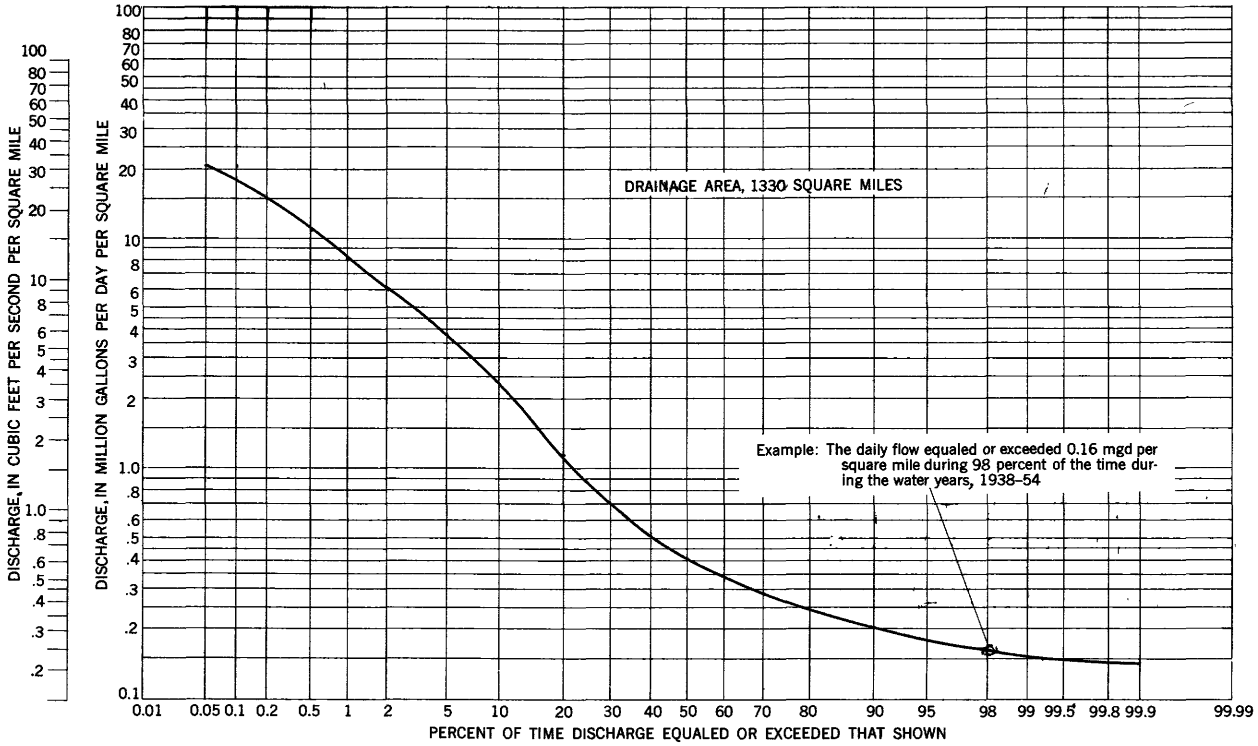

Figure 16.—Duration curve of daily flows, Amite River near Denham Springs, water years 1939–54.

this report to present in detail all the flow records for the tributary area north of Lake Pontchartrain, flow characteristics for the Amite River, the largest of the gaged rivers, is given as an example.

Records for the gaging station on Amite River near Denham Springs are summarized in a duration curve, which is shown in figure 16. A duration curve indicates the percent of time, within the period of record, during which any given rate of flow was equaled or exceeded. The slope of the curve is a good indication of the storage within a basin, including ground-water storage; that is, the flatter the general slope of the curve, the lower the flood peaks and the higher the sustained dry-weather flow. A comparison of flow-duration curves for several streams in an area may be used to show which ones have the highest dry-weather flow and are, therefore, the most dependable source of water.

The slope of the duration curve for Amite River (fig. 16) is almost flat indicating high sustained dry-weather flow. As an example of its use, this curve shows that the flow of Amite River near Denham Springs equaled or exceeded 0.16 mgd per square mile, or a total of 213 mgd, for 98 percent of the time during the water years, 1939–54.

Although the above example indicates that during the period of record the flow of Amite River near Denham Springs was below 0.16 mgd per square mile (213 mgd) for only 2 percent of the time, further analysis of the records is required to determine the maximum number of consecutive days during which the flow was below that rate. Such an analysis, for a range in rates of flow, is summarized in the curve shown in figure 17. This curve shows that the flow near Denham Springs was below 0.16 mgd per square mile (213 mgd) for a maximum of 40 consecutive days.

The Amite River drains about 1,800 square miles above its mouth at Lake Maurepas. If the flow from the ungaged area in the Amite River basin could be assumed to be proportional to the flow from the gaged area above the Denham Springs gaging station, then the above example may be extended to estimate the flow into Lake Maurepas during the water years 1939–54. Preliminary studies, however, indicate that low flows are somewhat less per square mile in the southernmost parts of the areas tributary to Lake Pontchartrain than in the northernmost parts of those areas.

The flow of the Amite River combined with that of the Tickfaw River averages about 2,500 mgd (2,800,000 acre-feet per year). This inflow represents most of the runoff into Lake Maurepas. The volume of water in Lake Maurepas at about 0.5 foot above mean sea level is about 570,000 acre-feet.

Low-flow yields of the streams tributary to Lake Pontchartrain appear to depend on the location of the drainage area. Streams draining the Recent alluvium of the Mississippi River south of the lake yield less water than streams incising the geologically older sands to the north (fig. 1). The principal tributaries all have highly sustained low flows, and an industry located on the northern shore of Lake Pontchartrain near the mouth of any of these streams would have dependable

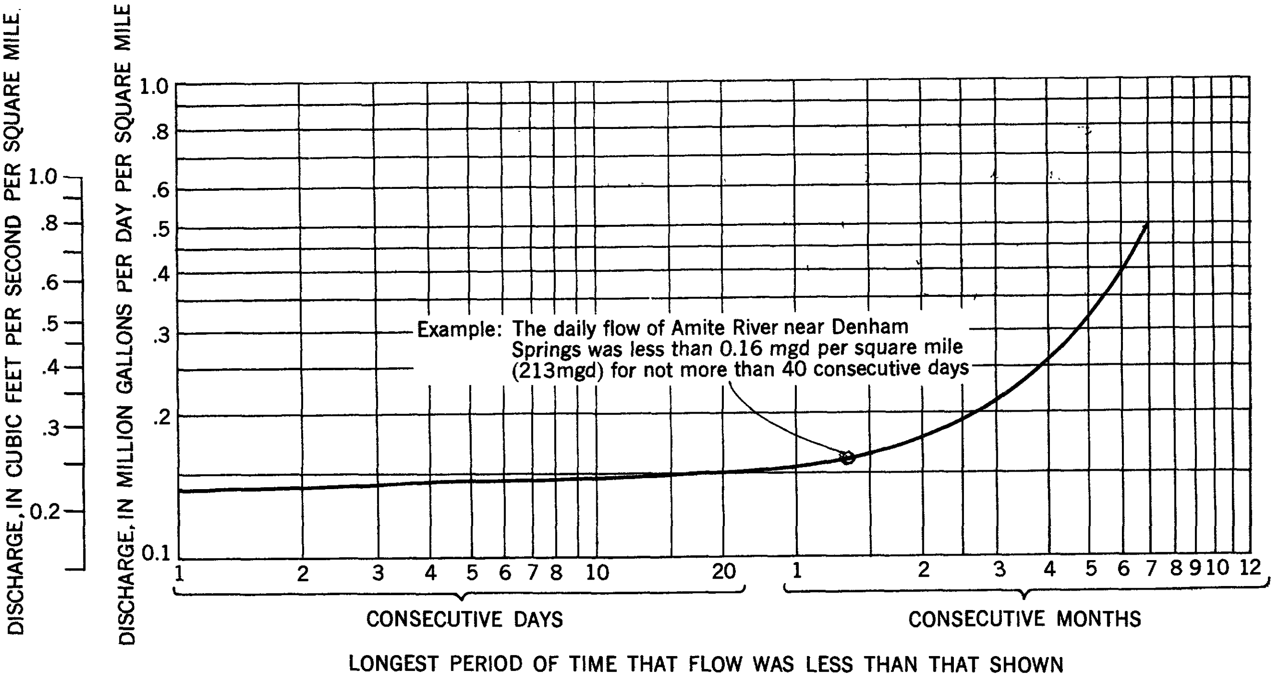

Figure 17.—Maximum period of deficient discharge, Amite River near Denham Springs, water years 1939–52.

fresh water supplies commensurate with the drainage area of the stream. The low-flow yield per square mile of the Tangipahoa River is the highest of the tributaries discussed here. Low-flow yields per square mile of the Chefuncte, Tickfaw, Amite, and Natalbany Rivers are lower than that of the Tangipahoa River, in the order given.

The characteristic seasonal fluctuation of daily flows is shown in figure 18, which is a discharge hydrograph

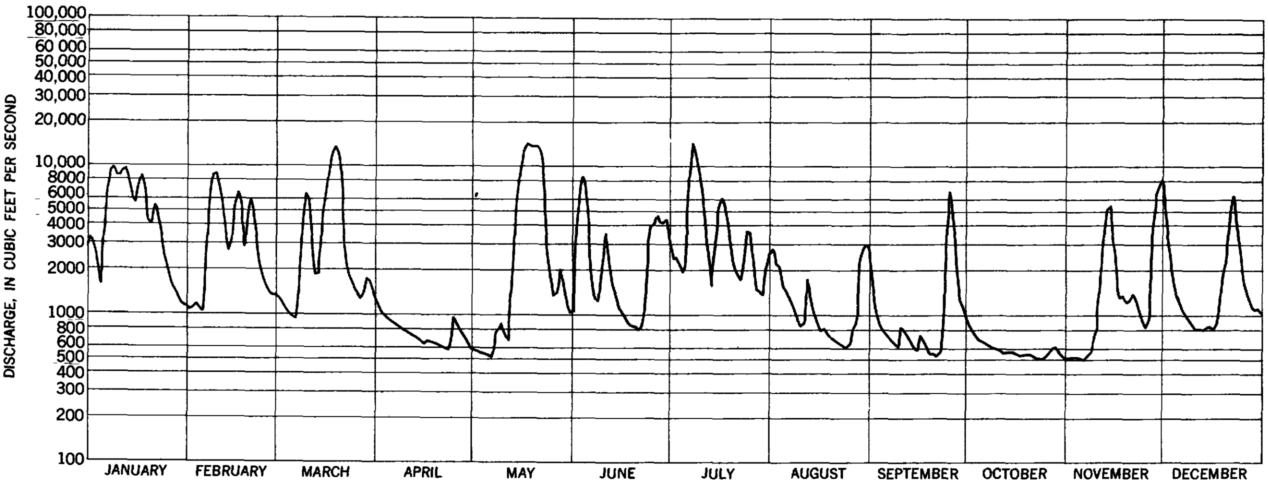

Figure 18.—Mean daily discharge of the Amite River near Denham Springs, 1946.

Table 4.—Mineral analyses and related physical measurements of surface water in the Lake Pontchartrain drainage basin and the Pearl River at Bogalusa

[Analyses in parts per million, except as indicated]

Date of collection	Discharge (cfs)	Temperature (°F)	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 $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Color
Chefuncte River near Folsom																					
Oct. 7, 1943	42	...	...	...	...	...	...	...	15	...	4.0	...	...	...	...	[a] 20	...	...	36.0	...	...
Feb. 7, 1944	118	59	...	...	...	...	...	...	10	...	5.0	...	...	...	...	[a] 16	...	...	33.0	...	...
Apr. 26	214	66	7.5	0.07	1.6	1.1	2.0	1.3	8	1.0	4.0	0.3	0.5	...	23	8	2	30	30.0	6.1	50
Aug. 20, 1954	43	78	12	.09	1.0	.7	4.1	.5	10	.6	4.0	.1	.5	0.05	29	5	0	60	27.0	6.4	10
Tangipahoa River at Robert																					
Oct. 6, 1943	453	71	...	...	...	...	...	...	15	...	4.0	...	...	...	...	[a] 39	...	...	47.0	...	...
Feb. 9, 1944	909	60	...	...	...	...	...	...	19	...	5.0	...	...	...	...	[a] 36	...	...	50.0	...	...
Apr. 27	1,480	66	10	0.46	2.3	0.9	3.2	1.9	13	2.2	3.0	0.3	1.0	...	32	9	0	37	37.0	6.0	80
Aug. 20, 1954	328	79	14	.10	1.7	.9	4.6	1.0	16	1.5	4.2	.0	.2	0.04	38	8	0	52	42.9	6.9	10
Oct. 26	341	71	15	.10	1.6	.8	6.6	1.0	19	1.6	4.0	...	.2	...	40	7	0	63	48.6	6.8	10
Natalbany River at Baptist																					
Oct. 6, 1943	11.0	70	...	...	...	...	...	...	24	...	8.0	...	...	...	...	[a] 32	...	...	82.0	...	...
Feb. 10, 1944	122	59	...	...	...	...	...	...	11	...	5.0	...	...	...	...	[a] 18	...	...	42.0	...	...
Apr. 27	78.4	72	10	0.18	2.4	1.0	4.7	1.9	12	3.9	5.0	0.3	1.2	...	36	10	0	45	52.0	5.9	70
Aug. 20, 1954	6.4	80	19	.25	4.0	1.7	10	1.5	25	5.8	9.2	.1	.5	0.01	64	17	0	54	86.6	6.5	40
Tickfaw River at Holden																					
Oct. 6, 1943	117	70	...	...	...	...	...	...	14	...	4.0	...	...	...	...	[a] 26	...	...	40.0	...	...
Feb. 10, 1944	305	60	...	...	...	...	...	...	26	...	5.0	...	...	...	...	[a] 21	...	...	53.0	...	...
Aug. 20, 1954	84	81	12	0.18	1.4	0.9	4.2	0.5	12	0.5	4.0	0.1	0.5	0.03	32	7	0	54	32.1	6.6	15
Amite River near Denham Springs																					
Oct. 8, 1943	460	70	...	...	2.9	1.6	5.5		19	[b] 3	5.0	...	0.0	...	27	14	0	46	56.0	...	...
May 4, 1944	1,190	72	15	0.43	2.8	1.1	4.1	1.6	15	1.9	5.0	0.1	1.0	...	40	12	0	40	54.0	6.4	130
Sept. 2, 1952	365	85	13	.10	1.2	1.5	5.2	3.2	14	1.9	7.5	.1	2.0	...	49	9	0	46	60.5	6.3	10
Sept. 15	380	81	13	.26	1.6	1.6	5.3	.0	15	1.3	6.5	.3	1.0	0.03	39	11	0	52	47.3	6.5	20
Oct. 10	291	59	11	.45	1.6	1.0	4.9	1.0	15	.5	5.2	.0	.2	...	40	81	0	53	45.3	7.0	5
Nov. 26	402	58	13	.47	1.8	1.7	5.9	...	16	1.0	7.2	...	.5	...	40	12	0	53	47.4	6.7	40
Jan. 9, 1953	703	58	13	.66	2.1	1.1	5.4	...	12	2.2	6.2	...	.5	...	37	10	0	55	49.7	6.6	60
Feb. 12	1,330	...	9.6	.48	2.0	1.1	3.0	...	11	1.6	4.2	...	.8	...	28	10	0	41	38.1	6.1	50
Mar. 17	11,500	69	7.0	.40	1.7	1.1	2.6	...	10	2.5	2.5	...	1.0	...	24	9	1	39	32.6	5.9	70
June 26	635	82	13	.21	2.1	1.1	5.8	...	14	1.4	6.0	.0	1.5	...	38	10	0	56	51.5	6.4	10
July 3	1,130	82	9.9	.53	1.6	1.3	3.0	1.9	12	1.9	3.5	...	1.5	...	31	10	0	34	38.0	6.6	70
Sept. 14	...	...	12	.25	1.9	1.2	6.3	1.3	18	.8	6.0	...	.8	...	40	10	0	55	48.0	6.8	20
Aug. 20, 1954	340	80	13	.14	2.0	1.1	5.4	1.0	14	1.2	6.2	.1	.5	.05	38	10	0	52	49.5	6.5	35
Pearl River near Bogalusa																					
Aug. 26, 1952	1,675	84	12	0.03	2.3	1.8	6.6	3.6	9	9.0	8.5	0.1	1.0	...	61	13	6	45	84.3	5.9	20
Sept. 10	1,220	...	13	.01	2.6	1.5	7.8	.4	12	8.6	8.2	.5	.5	0.06	49	13	3	56	72.1	6.4	10
Oct. 7	...	...	13	.06	2.2	1.4	8.0	...	12	5.2	9.5	...	.4	...	46	11	1	61	62.6	6.4	10
Nov. 25	1,420	57	11	.17	2.2	1.2	7.2	...	14	2.7	8.5	...	.4	...	40	10	0	60	58.0	6.6	20
Jan. 6, 1953	3,170	50	12	.63	2.7	1.1	6.5	...	12	4.2	8.0	...	.8	...	42	11	1	56	58.7	6.5	60
Feb. 10	11,370	...	8.0	.45	2.4	1.2	3.3	...	7	6.3	3.8	...	1.0	...	29	11	5	40	43.1	5.8	45
Mar. 10	24,500	59	7.8	.28	3.2	1.6	3.1	...	4	14	2.8	...	.2	...	35	15	11	32	54.8	5.3	40
Apr. 21	6,490	...	11	.63	3.4	1.3	4.3	1.6	14	6.1	6.0	...	1.5	...	43	15	4	35	60.3	6.5	60
June 24	3,070	85	14	.05	4.2	1.5	5.2	1.1	16	7.7	6.2	.1	1.0	...	49	17	4	38	67.7	6.3	10
July 21	3,150	...	12	.12	3.2	1.2	5.4	1.3	14	5.8	7.2	...	.5	...	44	13	2	44	66.2	7.0	10

[a] By soap method.
[b] By turbidity.

of Amite River near Denham Springs for a typical calendar year. Other principal tributaries follow this same general pattern.

Quality of water

The waters from tributary streams north of Lake Pontchartrain are of good quality and generally would require a minimum amount of treatment for most uses (table 4.) However, the pH values indicate that some of these stream waters probably would be corrosive to water pipes or other metal surfaces; color and silica would be objectionable for some uses of the water. The waters are soft and contain only small amounts of dissolved solids, of which silica constitutes about one-third.

Daily determinations of chloride in the water of Lake Pontchartrain at Little Woods are made by the Corps of Engineers. The approximate monthly maximum, minimum, and average chloride content of the lake water at Little Woods from 1947 to 1954 are given in table 5. The data in this table indicate that the chloride concentration is generally higher from August through December than during the remainder of the year. The chloride content of the water is not constant for any given point on the lake. The tributaries to Lake Pontchartrain contribute water very low in dissolved solids. Undoubtedly the chloride concentration near the mouths of the tributary streams is considerably less than was found at Little Woods. Lake Pontchartrain is unsuitable as a source of potable water because of the inflow of saline water from the gulf.

The salinity of Lake Maurepas is probably less than that of Lake Pontchartrain because it is less likely to be affected by salt water from the gulf, and it is affected more by dilution from streams entering from the north and west.

An analysis of a single sample of the water of Lake Maurepas at Pass Manchac at the railroad bridge, collected on November 5, 1953, is shown below:

Constituent	Parts per million (except pH, color, and turbidity)
Iron (total)	0.7
Chloride (Cl)	1,130
Dissolved solids	2,240
Ignition loss	426
Hardness (as $CaCO_3$)	405
Alkalinity (as $CaCO_3$)	20
pH	6.2
Color	30
Turbidity	16
Free carbon dioxide (CO_2)	9.3

Table 5.—Approximate maximum, minimum, and average chloride concentration in water from Lake Pontchartrain, Little Woods, La.

[Analyses made by Corps of Engineers; results in parts per million]

Year	Concentration	January	February	March	April	May	June	July	August	September	October	November	December
1947	Maximum	1,050	650	650	350	....	....	....	2,900	3,650	4,250	5,250	3,100
	Minimum	400	400	350	200	....	....	....	250	1,000	3,000	2,000	1,500
	Average	648	532	390	280	....	....	....	660	1,590	3,550	2,700	2,200
1948	Maximum	2,200	2,100	950	750	700	700	2,200	1,450	3,100	2,000	1,700	1,400
	Minimum	1,000	750	500	500	500	600	850	900	1,000	1,400	950	800
	Average	1,760	1,140	634	651	583	634	1,280	1,200	1,770	1,560	1,450	1,180
1949	Maximum	1,000	750	500	500	400	450	300	300	2,300	2,300	1,500	3,000
	Minimum	500	400	400	200	150	200	150	150	250	1,050	1,050	1,200
	Average	729	493	485	375	290	281	242	216	1,150	1,610	1,340	1,640
1950	Maximum	1,900	1,200	700	200	150	250	500	1,750	3,700	6,000	3,500	2,650
	Minimum	1,200	700	50	50	50	50	150	350	1,750	1,500	2,500	2,250
	Average	1,500	1,100	158	95	100	110	221	573	2,830	3,230	2,570	2,490
1951	Maximum	2,500	1,750	2,000	1,750	1,000	1,250	1,250	2,000	3,600	3,600	2,750	2,700
	Minimum	1,750	1,500	1,250	1,000	750	850	750	1,000	1,400	2,650	2,150	2,000
	Average	2,080	1,580	1,620	1,310	865	975	1,080	1,360	2,160	2,840	2,440	2,390
1952	Maximum	2,450	2,400	2,000	2,100	1,800	1,800	2,800	6,000	5,950	5,200	4,750	5,500
	Minimum	2,000	1,750	1,500	1,500	1,500	1,500	1,500	2,800	3,700	3,900	4,250	3,750
	Average	2,170	2,120	1,910	1,850	1,690	1,620	2,180	3,210	4,240	4,240	4,610	4,600
1953	Maximum	4,000	3,750	3,250	2,500	2,500	1,300	1,600	1,500	3,000	2,600	3,700	2,000
	Minimum	2,750	2,550	2,250	1,700	1,300	1,200	1,000	1,100	1,400	1,900	1,600	1,200
	Average	3,580	3,440	2,780	2,220	2,140	1,280	1,410	1,330	1,820	2,140	2,090	1,630
1954	Maximum	1,000	800	1,000	1,000	1,300	1,600	2,000	7,500	....	....	....	....
	Minimum	700	600	700	900	1,000	1,000	1,000	1,800	....	....	....	....
	Average	781	757	865	957	1,150	1,440	1,640	....	....	....	....	....

Pearl River and Lakes

Pearl River

Pearl River rises in the east-central part of Mississippi and flows southward for 485 miles to its mouths. The lower 116 miles is the boundary between Mississippi and Louisiana, and the basin adjoins the tributary drainage area of Lake Pontchartrain. About 50 miles above its mouths, Pearl River divides into East Pearl River, which flows into Lake Borgne, and West Pearl River, which flows into the Rigolets, the principal outlet of Lake Pontchartrain.

The Pearl River, at its mouths, drains an area of about 8,700 square miles, of which 7,840 square miles is gaged. Records of daily stage and discharge are available since October 1938 for Pearl River at Bogalusa (6,630 square miles). The average daily flow for 15 years at Bogalusa is 6,060 mgd. The highest daily and momentary flow was 38,800 mgd on January 25–26, 1947. The lowest daily and momentary flow was 737 mgd from October 22 to November 2, 1952.

Analyses of water samples collected monthly from the Pearl River near Bogalusa show the water to be low in dissolved solids. (See table 4.) The principal constituents in the water are sodium chloride and calcium bicarbonate. The observed dissolved solids for the period of sampling ranged from 29 to 61 ppm. The pH values ranged from 5.3 to 7.0 thus indicating that the water would be somewhat corrosive to metal surfaces.

Lakes

Lakes Des Allemands and Salvador are two interconnected coastal lagoons existing as arms of the sea, in the swamps of the lower Mississippi River Delta.

Lake Des Allemands contains about 79,000 acre-feet and Lake Salvador contains about 294,000 acre-feet of water at about mean sea level. Although no specific information is available as to salinity in these two lakes, the water is probably moderately saline, and Lake Des Allemands is probably less saline than Lake Salvador.

GROUND WATER

Geology

The New Orleans area lies within the Gulf Coastal Plain and is immediately underlain by unconsolidated river alluvium of Recent and Pleistocene (Quaternary) age. The Recent river alluvium lies at the surface in the greatest part of the area. These deposits, which immediately overlie the Pleistocene deposits, range in thickness from about 30 to 120 feet and were laid down in a fresh-water or brackish-water environment (Fisk, 1947, p. 59–63). At the top are clay and silt beds that are high in organic content; these grade downward into alternating marine beach sand and clay containing scattered shell beds and sand and silt lenses. The deposits of Pleistocene age are exposed at the surface north of Lake Pontchartrain. These deposits consist mostly of oxidized clay, silt, and sand and some local gravel beds. North of Lake Pontchartrain, where the deposits of late Pleistocene age dip southward beneath the alluvium of the Mississippi Alluvial Plain, they form a low southwestward-facing scarp which trends southeastward (fig. 1).

South of the scarp the Pleistocene sediments were deposited as part of a great deltaic mass in a fresh- to marine-water environment. The sediments that form the upper part of the Pleistocene in this area consist of lenticular beds of clay, silt, and sand and many scattered shell beds. The upper part of the Pleistocene deposits is well oxidized and more indurated than the overlying Recent alluvium (Fisk, 1947, p. 59–63). The lower sand beds in the Pleistocene deposits are more continuous and areally extensive. The southerly dip of the beds is irregular, but successively deeper beds appear to have greater dips. North of Lake Pontchartrain, sediments of Miocene age lie beneath the Pleistocene deposits, at a depth of about 2,000 feet below sea level (Fisk, 1944, fig. 69). The Miocene deposits are the oldest in this area that contain fresh water. In the industrial district these deposits contain saline water.

The Mississippi Alluvial Plain is a valley that was formed during the final cycle of the world-wide glaciation. About 100,000 years ago, during the last glacial stage, sea level was several hundred feet lower than at present and the Mississippi River valley became deeply incised within the sediments of the Gulf Coastal Plain (Fisk, 1944, fig. 75). With the subsequent rise in sea level the river meandered throughout the valley, filling it with sand, silt, and clay and forming the present surface.

Geologic structures, associated chiefly with the Gulf Coast geosyncline, are important in the accumulation of oil and gas and have an effect on the occurrence of fresh ground water in the area. The exact location of most of the structures is unknown; however, in the latitude of Lake Pontchartrain they are believed to have caused a sharp decrease in the depth of occurrence of fresh ground water within short distances. Further investigation would be necessary to determine their detailed relationship to the occurrence of fresh water in the area.

As described by Russell (1936, p. 6–9), the migration of the mouth of the river along the coast concentrated sediments in a belt parallel to the coast and along the axis of the Gulf Coast geosyncline. The weight of these deposits probably caused the subsidence of the coastal area and an uplift of the land to the north. The subsidence is evident by the drowning of depressions in the area which are typified by Mississippi Sound and Lakes Borgne, Maurepas, and Pontchartrain. The subsidence of the area is still active. For example, an Indian village has subsided to 14 feet below sea level at the north end of Lake Pontchartrain. Moreover, Fisk (1944, p. 34) reports the active subsidence of benchmarks, buildings, cemeteries and engineering works in the New Orleans area.

The principal water-bearing sands in the New Orleans area crop out or are near the surface north of Lake Pontchartrain where they receive recharge primarily from local precipitation. In these areas the sands are incised by streams and may either supply water to the streams during periods of low flow or be recharged when the stream level is above the water table. In these areas, where there are no impervious layers overlying the sand, the ground water is under water-table conditions. As the water moves southward toward the city of New Orleans it passes beneath impervious layers of clay and becomes confined under artesian pressure. Thus, the water in all the principal water-bearing sands in the New Orleans industrial area occurs under artesian conditions.

Any rock stratum that yields sufficient quantities of water to make it a usable source of supply is called an aquifer or a water-bearing unit. The amount of water that may be obtained from an aquifer is dependent principally on its ability to transmit and store water. The capacity of an aquifer to transmit water is a function of its permeability and thickness. Thus, the yield of wells is potentially greater in areas of maximum sand thickness and permeability.

The movement of ground water from areas of recharge to areas of discharge generally is unlike surface-water flow, in that it is not confined to definite channels. The movement of water through an areally extensive bed of sand is retarded by the small size of the pore spaces between the sand grains. Consequently, the natural rate of ground-water movement is measured in feet or fractions of a foot per day, much less than the ordinary velocity of streams.

Water-Bearing Units

General Features

As shown by geologic cross sections (pl. 1), the deltaic sediments underlying the New Orleans area include sand beds which, in the northern part of the area, contain fresh water to a maximum depth of about 3,000 feet below the land surface. The generalized geologic cross section D-D' (pl. 1) shows the depth to the fresh-water—salt-water interface from the northern part of Lake Pontchartrain southward through the industrial district. Between the northern and southern shores of Lake Pontchartrain the interface rises abruptly from a maximum depth of 3,000 to 900 feet. The abrupt change in depth may be caused by structures such as faults which inhibit the flushing of the saline water from the deeper sand beds.

Additional data on the aquifers are needed, as most of the sands are similar in appearance, and, owing to their mode of origin, may lens out abruptly. However, the available information indicates that the correlations shown on the sections in plate 1 are approximately correct.

In general, fresh water from the principal sands is of the soft sodium bicarbonate type. As shown in figure 19 the quality of the water varies greatly within the same sand aquifer, depending upon the location of the supply well. The cause of this variation in mineralization with location is not the result of any known surface contamination, but is probably the result of saline-water movement within the aquifer, in part in response to pumping. Southward from the city of New Orleans the mineralization of the water increases, and it is likely that pumping for a long period may cause migration of saline water northward toward areas of heavy withdrawals. Water from most wells just south of Lake Pontchartrain has a low chloride content, whereas southward in the vicinity of Gretna the water generally has a high chloride content. The deeper sands come to the surface to the north, probably in the State of Mississippi, where they receive their recharge. The dip or slope of these sands is gulfward at a rate of 30–50 feet per mile (La. Dept. Public Works 1954) South of Lake Pontchartrain, beneath the New Orleans industrial district, are four principal water-bearing sands above a depth of about 1,200 feet (pl. 1, A-A'). Each sand dips or slopes gulfward, and the depth to the top of each sand becomes greater in that direction. The areal extent of each principal aquifer within the New Orleans industrial district and its correlation from well to well were determined by a study of driller' logs, electrical logs, and hydrologic data. For convenience, the different sands are discussed in this report according to their depth of occurrence in the New Orleans industrial district.

Ground water for industrial and commercial uses in the New Orleans industrial area is obtained primarily from the "200-," "400-," and "700-foot" sands. The principal fresh-water bearing sand is the "700-foot" sand; however, the "400-foot" sand supplies most of the ground water used for industrial purposes in northern St. Charles Parish, where the "700-foot" sand contains highly mineralized water. The quality of ground water in each sand varies throughout the report area.

The temperature of water within a given sand is comparatively uniform from place to place and through out the year, generally fluctuating only a few degrees. That of water at a depth of a few tens of feet is about the same as the mean annual air temperature. At greater depths the temperature increases in the New Orleans area at a rate of 1°F for about each 90 feet of increased depth. Thus the observed temperature of the water from about 200 wells in the New Orleans area ranged from 69° at 20 feet to 91° at about 2,500 feet. These ranges occurred in the Florida Parishes north of Lake Pontchartrain.

North of Lake Pontchartrain, in St. Tammany Parish, wells screened in sands between 60 and 2,000 feet below the land surface yield fresh water. The wells screened in the deeper sands generally are under sufficient artesian pressure to flow. The recorded artesian flows range from 1 to 450 gpm depending chiefly on the diameter of the well and the artesian pressure.

"200-Foot" Sand

The "200-foot" sand is the shallowest of the important water-bearing sands that yield water to wells within the industrial district. It is of late Pleistocene age. As shown in plate 1, the "200-foot" sand is irregular in areal extent, as it thickens and thins and pinches out abruptly. However, the sand generally ranges from about 30 to 150 feet in thickness. It has a slight southerly regional dip of about 8 to 10 feet per mile and generally increases in thickness from north to south. In the western part of the industrial district in St. Charles Parish the "200-foot" sand is relatively continuous, as shown in cross section C-C', and is separated from the "400-foot" sand by a clay bed which pinches out west of Norco (section B-B'). Thus, the "200-foot" and the "400-foot" sands in that area become

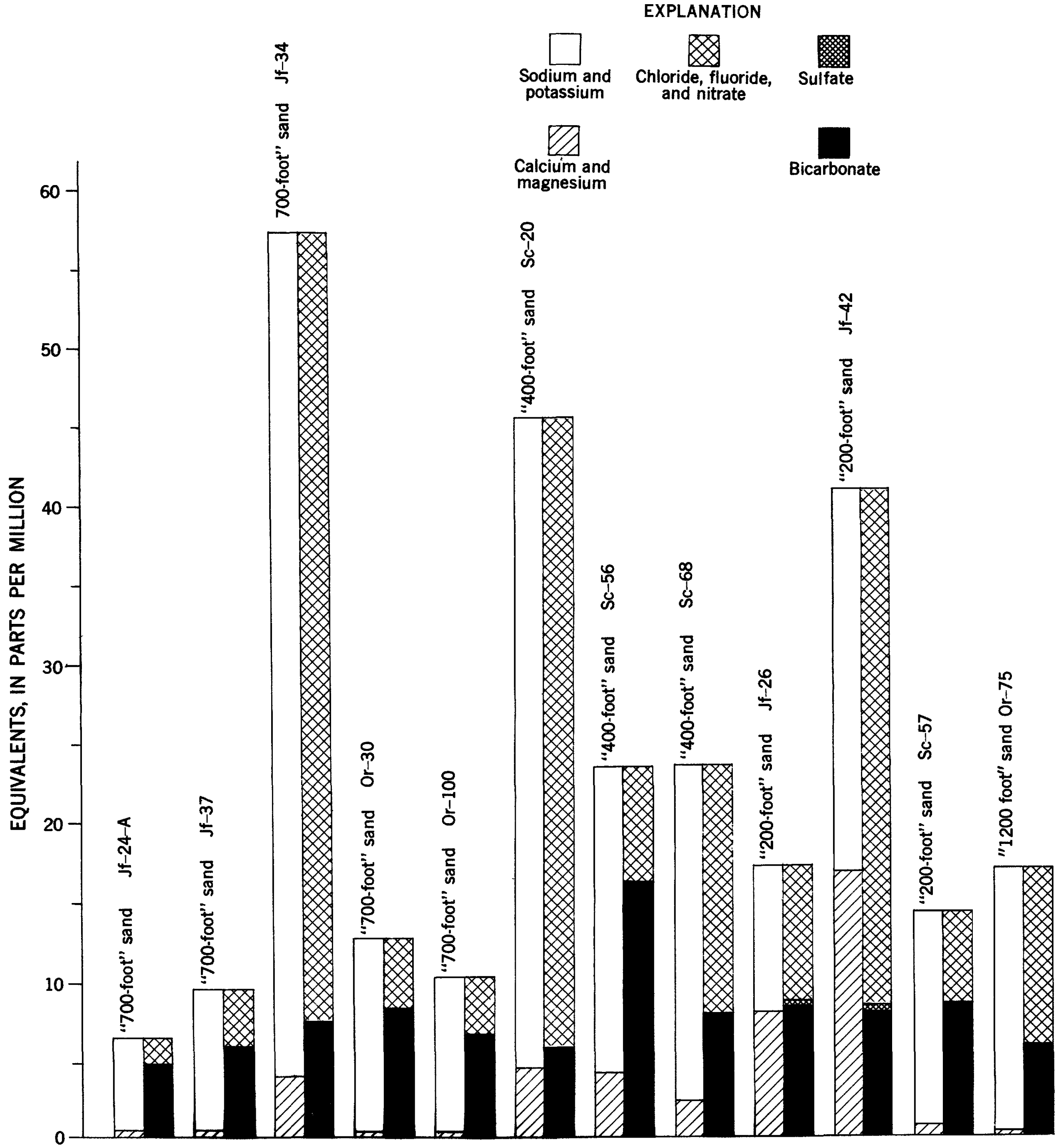

Figure 19.—Graph showing chemical characteristics of water from wells in the New Orleans area.

one hydrologic unit. East of well 4 in section A-A' and north of well 37 in section E-E', the "200-foot" sand appears to pinch out completely. The electrical logs directly east of well 5 begin at depths greater than the "200-foot" sand, and additional information would be necessary to show a definite pinch out. However, there are no water wells in this area screened at depths that would indicate the presence of the "200-foot' sand. Logs of wells in the southern part of Lake Pontchartrain show that the "200-foot" sand pinches out south of the lake and does not crop out in the bed of the lake.

The "200-foot" sand is medium to very fine grained, and there is only a small percentage of coarse grains and silt. In some areas drillers' logs indicate the presence of some coarser material including streaks of lignite, shell beds, and cypress stumps. The sand

Table 6.—Summary of ground-water pumpage, in million gallons a day, from each sand in the New Orleans industrial area, 1953

Parish	Aquifers				Total
	"200-foot"	"400-foot"	"700-foot"	"1,200-foot"	
Jefferson	0.40	0.50	10.00	....	10.90
Orleans	.40	.05	23.00	0.05	23.50
Plaquemines	....	....	....	....	....
St. Bernard	....	....	2.00	....	2.00
St. Charles	....	19.60	6.00	....	25.60
Total	0.80	20.15	41.00	0.05	62.00

grains range from angular to subangular. The color is generally grayish-orange to pink.

Yield of wells

Records show only 4 industrial wells tapping the "200-foot" sand in the New Orleans area. The yield of these wells, which have diameters of 6 to 10 inches, ranges from 175 to 350 gpm and averages about 275 gpm. About 15 domestic and stock wells are screened in this sand and are used mostly for laundering, washing, and emergency supplies. Further data will be necessary to determine the possibility of obtaining greater quantities of water from the "200-foot" sand; however, this sand has not been developed extensively to date.

Water-level fluctuations

A water well screened in the "200-foot" sand in southwestern New Orleans flowed saline water 1 foot above the land surface at a rate of 12 gpm in 1904 (Harris, 1905, p. 43). At the present time some wells in this sand still flow; however, in a few areas the water level has declined to about 20 feet below the land surface. Unless withdrawal from this sand is increased, future decline of water levels probably will be small.

Withdrawal

The average daily withdrawal from the "200-foot" sand in the industrial area is 0.8 mgd (table 6), or about 292 million gallons annually. The greatest concentration of pumping occurs in the north-central and southwestern parts of Jefferson and Orleans Parishes, respectively. Most of the water is used for industrial and cooling purposes, and the pumpage is about the same in winter and summer.

Quality of water

Chemical analyses of water from 9 wells screened in the "200-foot" sand are given in table 8, together with analyses of water from the other sands. These samples were selected to show the range in constituents and general type of water available from each sand. Partial and complete chemical analyses of samples taken from 19 wells indicate that the "200-foot" sand yields a highly mineralized sodium bicarbonate chloride water having a hardness ranging from 42 to about 840 ppm. In general as the chloride content increases the hardness also increases. The chloride content of the samples ranged from 165 to 2,180 ppm. The silica content ranges from 26 to 42 ppm, and treatment may be required before the water can be used by some industries. Most of the samples were high in dissolved solids, ranging from 839 to 4,230 ppm. The pH of all samples collected from wells screened in the "200-foot" sand ranged from 7.4 to 7.8. The observed total-iron content is as much as 1.9 ppm. The temperature of the ground water is about 71°F and generally fluctuates only a few degrees during the year. Owing to the moderate salinity of the water in this sand in some areas, the water is not suitable for some industrial and domestic uses. In general, the water is relatively fresh north of the Mississippi River and becomes increasingly saline southeastward, as indicated by the chloride content of water from well StB-9 near the village of St. Bernard (see table 7, wells Sc-57 and Sc-61).

"400-Foot" Sand

Within the New Orleans industrial district, the "400-foot" sand is more continuous in areal extent and more uniform in thickness than the "200-foot" sand. The thickness ranges from a maximum of about 250 feet in western St. Charles Parish to a minimum of about 40 feet northward in the vicinity of Lake Pontchartrain. The average thickness of this sand is about 140 feet. Plate 1 indicates that the "400-foot" sand pinches out near the southern shoreline and does not crop out in the lake. Toward the southern part of the area, the "400-foot" sand breaks up into thin stringers and loses its identity. The sand is usually separated from the "200-foot" and "700-foot" sands by shale and clay beds containing interbedded sand stringers. The regional dip or slope is gulfward at about 5 feet per mile, as shown by the geologic cross section C-C'.

The sand is medium to fine grained and the material is less uniform in grain size than that from the "200-foot" and "700-foot" sands. It consists largely of yellowish quartz grains and has a yellowish-gray color, and the grains range from angular to subrounded. Thin beds of shells and of coarser sand and gravel are present at some places.

Table 7.—Chemical analyses and related physical measurements of ground water in the New Orleans area

[Analyses in parts per million except as indicated]

USGS well no.	Depth of well (in feet)	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	Color	pH
"200-foot" sand																				
Or-38	300	May 19, 1942	38	0.61	25	21	616	8.9	......	688	1.4	660	0.4	0.4	1,730	149	89	....	90	.....
Jf-26	185	May 20, 1950	26	.90	77	50	190	22	0	476	13	318	.0	.2	927	398	49	1,730	20	7.7
Jf-42	288	Jan. 14, 1955	38	.73	198	84	530	19	0	452	21	1,170	.1	.0	2,280	840	57	4,080	20	7.5
StB-9	384	Aug. 29, 1949	40	1.1	50	58	1,550		0	790	2.9	2,180	....	1.0	4,230	364	90	7,620	.....	7.6
Sc-57	200	Sept. 14, 1948	40	.00	8.6	5	308		0	500	2.5	210	....	3.0	839	42	94	1,420	.....	7.7
Sc-58	200	.........do.......	33	1.9	30	20	472		0	372	1.6	620	.6	.0	1,360	157	87	2,570	.....	7.6
Sc-60	258	Sept. 15, 1948	42	.00	149	80	630		0	444	.4	1,210	.0	.2	2,330	701	66	4,400	.....	7.4
Sc-61	298	.........do.......	34	.10	40	19	259		0	616	1.6	165	.4	.0	847	178	76	1,470	.....	7.8
Sc-62	273	.........do.......	32	.10	59	33	498		0	532	7.8	652	.6	.5	1,550	282	79	2,890	.....	7.6
"400-foot" sand																				
Jf-1	460	Aug. 2, 1940	......	....	....	....	....	....	......	344	1.0	468	....	....	....	[a]104	......	....	.....	....
Jf-33	422	Sept. 18, 1950	32	....	679	434	3,400		0	429	253	7,270	....	....	12,300	3,480	68	19,100	.....	7.0
Sc-20	492	Jan. 14, 1955	38	0.64	46	25	920	9.6	0	341	1.6	1,410	0.5	0.0	2,620	219	90	4,630	15	7.7
Sc-45	400	July 15, 1949	40	....	16	12	374		....	[b]402	.0	362	....	6.5	1,050	90	90	1,920	50	8.8
Sc-56	375	Sept. 14, 1948	38	.00	28	33	442		....	976	2.9	245	.6	19	1,290	206	82	2,190	.....	8.0
Sc-63	475	Sept. 15, 1948	34	.10	90	50	733		0	334	1.0	1,240	.2	.2	2,310	430	79	4,390	.....	7.4
Sc-68	463	Sept. 8, 1950	29	.46	21	14	473	8.0	0	462	.5	560	.5	.0	1,330	110	90	2,470	80	7.4
"700-foot" sand																				
StB-14	719	Jan. 13, 1955	36	0.58	48	22	1,390	11	0	254	1.1	2,160	.7	0.0	3,800	210	93	6,840	60	7.7
Or-30	815	.........do.......	36	.32	3.8	2.6	272	3.4	0	494	1.2	156	.8	.0	728	20	96	1,180	200	8.0

Table 7—Chemical analyses and related physical measurements of ground water in the New Orleans area—Continued

USGS Well no.	Depth of well (in feet)	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	Color	pH
"700-foot" sand—Continued																				
Or-37	790	Oct. 12, 1951	26	0.19	35	20	706	2.0	0	478	12	940	0.7	1.0	1,980	170	90	3,600	150	7.6
Or-57	802	Apr. 1, 1950	29	....	4.0	1.9		235	....	[c]500	5.0	80	....	.2	626	18	97	983	320	8.6
Or-100	580	Jan. 13, 1955	36	.25	2.0	1.7	220	2.2	0	385	.1	131	.4	.00	590	12	97	963	160	8.0
Or-61	670	Oct. 12, 1951	29	.08	5.6	3.8	233	.8	0	478	.5	96	1.0	3.0	608	30	94	1,040	140	7.7
Jf-7	700	May 19, 1942	28	.03	2.7	1.1	139	1.2	....	277	1.2	64	.6	1.0	382	11	96	....	85	.....
Jf-24-A	708	May 30, 1950	36	.30	3.2	1.4	132	7.6	0	275	1.4	60	.3	1.8	384	14	92	606	45	7.8
Jf-34	807	Jan. 14, 1955	32	.45	42	20	1,220	13	0	442	.2	1,770	.7	.0	3,320	188	93	5,800	50	7.7
Jf-36	454	Oct. 12, 1951	41	.08	5.2	4.3	208	.8	0	456	.2	76	1.2	.5	572	30	93	914	120	7.9
Jf-37	688	Jan. 14, 1955	36	.16	3.2	1.4	205	2.2	0	350	.3	128	.7	.00	549	14	96	888	120	8.0
"1,200-foot" sand																				
Or-10	1,248	Sept. 11, 1941	....	....	....	....	....	....	....	322	1.0	12,200	....	....	....	[a]2,520	....	....	....	....
Or-75	760	Jan. 13, 1955	38	0.10	3.2	1.4	378	1.5	0	350	.2	396	0.5	0.0	976	14	98	1,710	30	8.1

a Soap hardness.
b Includes equivalent of 35 ppm of carbonate (CO_3).
c Includes equivalent of 14 ppm of carbonate (CO_3).

Yield of wells

About 20 industrial wells tap this aquifer, yielding 250 to 2,400 gpm. The average discharge is about 700 gpm to wells that are 8–12 inches in diameter and are completed with about 80–90 feet of screen. The reported specific capacities of 11 wells screened in the "400-foot" sand range from 6.1 to 71 gpm per foot and average about 30. The information on yields and the relatively slight decline in artesian head for long periods indicates that the "400-foot" sand is very prolific, but the available hydrologic data to determine the full capabilities of the aquifer are meager.

Water-level fluctuations

The extent to which the water level in the "400-foot" sand has declined varies greatly in the New Orleans industrial district, depending upon the local rate of pumping. Records show that a well ending in this sand flowed at a rate of 6 gpm in 1903 (Harris, 1905, p. 43), and, in areas where there is very little pumping, wells tapping this aquifer will still flow small quantities of water.

The upper line on figure 20 shows the general decline in artesian head of the "400-foot" sand in northern St. Charles Parish, which has averaged about 1 foot per year since 1903. It should be noted that there was a gradual drop between 1903 and 1943 and then a sharp decline between 1943 and 1949. In those 6 years the average decline was about 5.3 feet per year, and the artesian head declined to about 74 feet below the land surface. Since 1949, pumping from the "400-foot" sand has decreased slightly, and the artesian head recovered about 8 feet, to about 66 feet below the land surface by 1953, at which time the well in which observations were being made was destroyed. Figure 21 shows the relationship of pumping to water levels in wells screened in the "400-foot" sand in northern St. Charles Parish between 1943 and 1953. This graph shows that the water levels declined from 1943 to 1950 in response to increasing rates of withdrawal and from 1950 to 1953 recovered as withdrawals decreased. To the east, in Jefferson and Orleans Parishes, the water levels in the "400-foot" sand are probably much nearer the land surface, as few wells are screened in this aquifer there.

Withdrawal

Pumping from the "400-foot" sand is approximately uniform throughout the year. As shown by table 6, the average withdrawal from the "400-foot" sand is about 20 mgd, which amounts to about 7,300 million gallons annually. About 98 percent of the total pumpage occurs in the northern part of St. Charles Parish, where the water is used chiefly for industrial cooling.

Data in table 6 indicate that there is very little pumping from the sand outside St. Charles Parish. Figure 21 shows an increase in pumping of about 6.2 mgd occurred in the "400-foot" sand between 1943 and 1953.

Quality of water

A total of 30 partial and complete chemical analyses of water from wells indicate the "400-foot" sand generally yields a highly mineralized sodium chloride bicarbonate type of water. Chemical analyses of water from 7 wells screened in the "400-foot" sand in St. Charles and Jefferson Parishes are presented in table 7. The samples ranged in hardness from 90 to 3,480 ppm, depending upon the location of the well. A well (Jf-33) in Westwego, screened in the "400-foot sand, yielded water having a chloride content of 7 270 ppm and a hardness of 3,480 ppm. To the west, in northern Jefferson and St. Charles Parishes, the water from this sand is less saline, as indicated by the chloride content which ranges from 245 to 1,410 ppm. Most of the analyses indicate that the water is high in dissolved solids, ranging from 1,050 to 12,300 ppm. In all samples of water collected from the "400-foot" sand for which the pH has been determined, the pH ranged from 7.0 to 8.8. The silica content ranges from 29 to 40 ppm

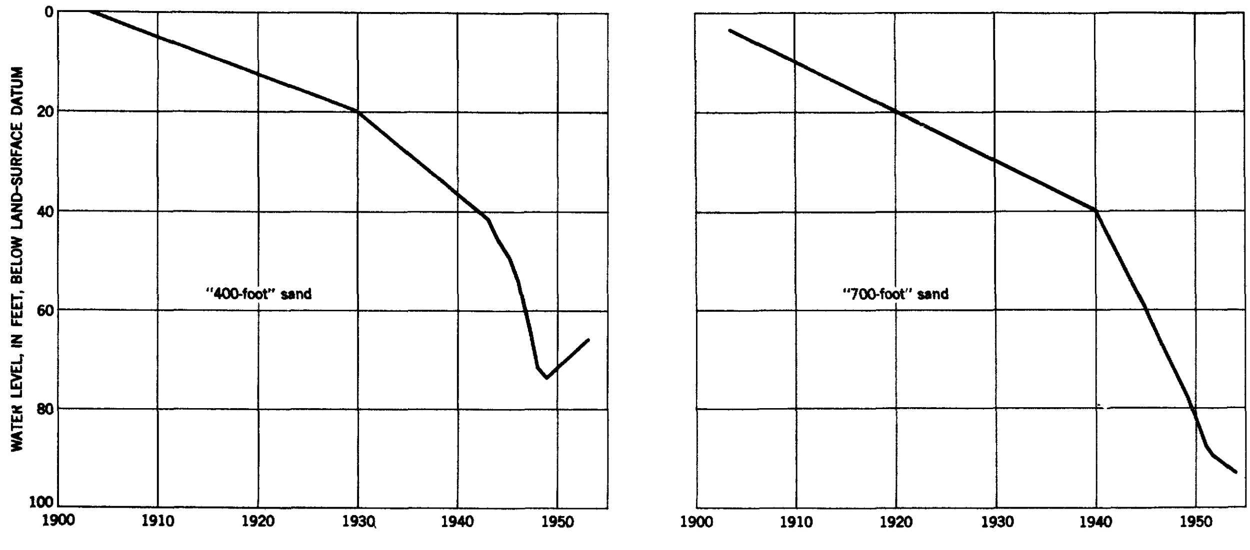

Figure 20.—Graph showing the general decline in artesian head, in feet, with reference to land-surface datum in the principal aquifers in the New Orleans area.

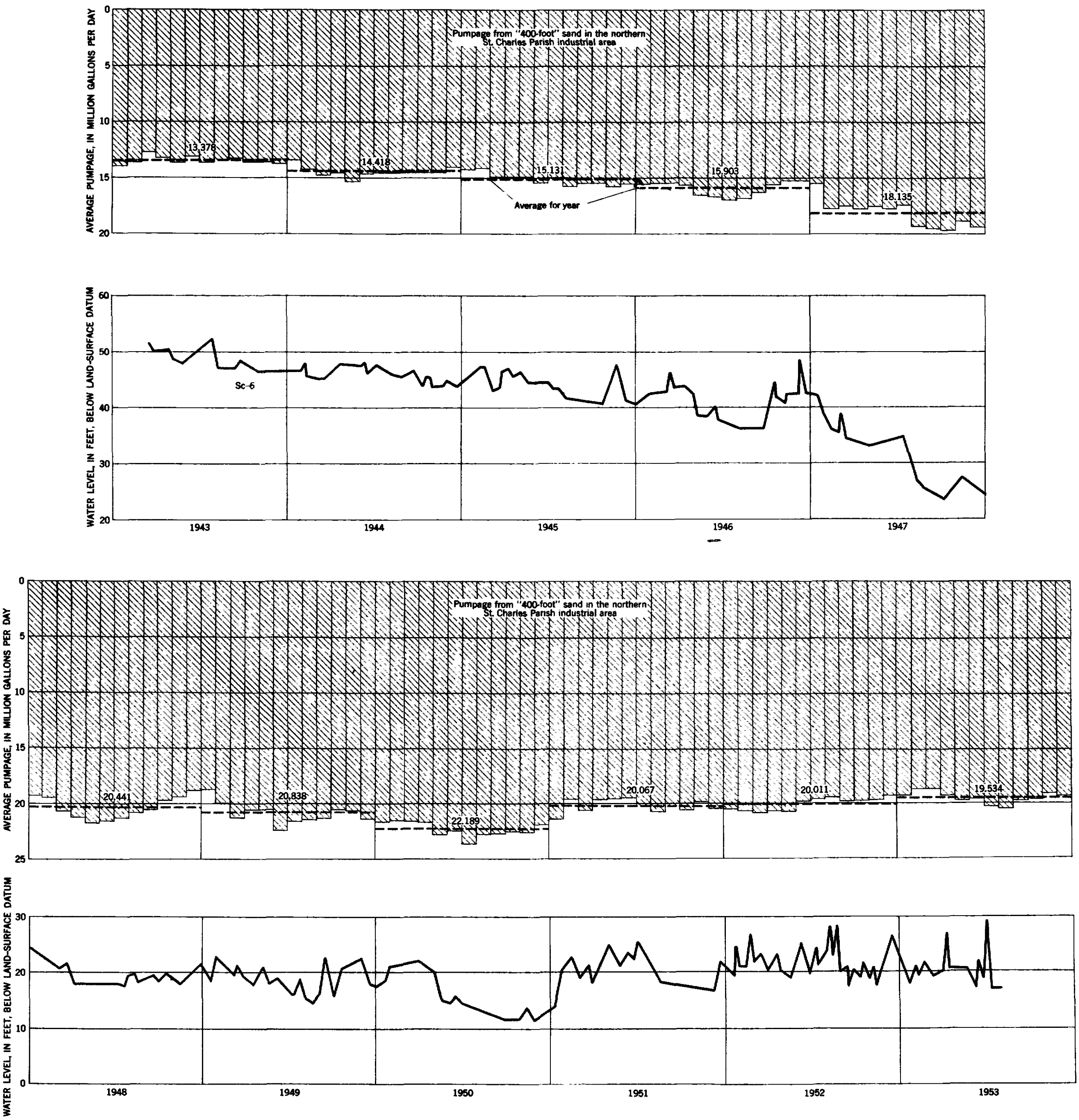

Figure 21.—Graph showing the relationship of pumping to water levels in wells screened in the "400-foot" sand in northern St. Charles Parish.

and the total-iron content usually ranges from 0 to 0.64 ppm. The average temperature of water from this sand is about 73°F.

The water is used mostly for cooling and is not palatable in some areas.

"700-Foot" Sand

The "700-foot" sand is the most important aquifer within the New Orleans industrial district. As is shown by the geologic cross sections in plate 1, this aquifer is continuous throughout the New Orleans area. One of the outstanding markers used in selecting the top of the "700-foot" sand, in differentiating it from the sand stringers overlying it, is a thin clay layer ranging from 10 to 70 feet in thickness and averaging about 10 to 20 feet throughout most of the area. There are usually one or more sand stringers, ranging from about 30 to 100 feet in thickness, between the "400-foot" and "700-foot" sands. The base of the "700-foot" sand also is separated from underlying sand beds by a clay of variable thickness. This aquifer is considered to be of Pleistocene age, because, according to structure maps by Lowman (1949, p. 1190) and Morgan (1953), it is above the basal deposits of Pleistocene age.

The "700-foot" sand appears to be relatively uniform in thickness (pl. 1). The average thickness of this sand is about 200 feet; however, locally it may range from 90 to 320 feet. As shown on cross sections A-A' and B-B', the thickness is more uniform along an east-west line roughly parallel to the Mississippi River than from north to south through the industrial district. The sand has a regional southerly dip of about 10 feet per mile. The sand crops out north of Lake Pontchartrain, where it receives its recharge primarily from rainfall. Present geologic information and quality-of-water data indicate that this sand is not hydraulically connected with Lake Pontchartrain. It is separated from the lake by several clay layers.

The material of the "700-foot" sand is fine grained and very uniform in texture. The sand is usually light olive gray; however, some of the grains have yellowish stains. This sand is composed of angular to subrounded quartz grains and contains thin layers of shell beds in some local areas.

Yield of wells

The "700-foot" sand is the principal aquifer, owing to its large yield to wells and the relatively low chloride content of the water in most of the industrial district. At present, about 55 large-diameter industrial wells tap this sand, yielding 250 to 2,000 gpm and averaging about 500 gpm.

The specific capacity of wells tapping this sand ranges from 8 to 67 gpm per foot and averages 30. Most of the wells are equipped with deep-well turbine pumps. Pump bowls are set between depths of 100 and 250 feet below the land surface, depending on the water level, yield, and specific capacity of the well.

Water-level fluctuations

A general decline in artesian head averaging 1.8 feet per year has occurred in the "700-foot" sand in New Orleans since 1903 (fig. 20). The artesian head in the "700-foot" sand in 1903 was about 3 feet below the land surface (Harris, 1905, p. 43) and declined to 94 below land surface by 1954. A gradual decline in artesian head occurred at a rate of 1 foot per year between 1903 and 1940. After 1940, a sharp decline in artesian head occurred at a rate of about 4 feet per year. Since 1945 water levels in the "700-foot" sand in southwest Orleans Parish have declined almost continuously, as shown by figure 22. The water-level graph presented in figure 22 shows a general decline in water levels due to increased pumping during the summer and a recovery of the artesian head during the winter. The recovery of water levels during the winter is generally less than the decline in the summer, resulting in a general decline for a long period. The lowest water level on record in southwestern Orleans Parish occurred during the period of heavy pumping in 1953, when it was 103 feet below the land surface.

The relationship of pumping to water-level decline in northern St. Charles Parish from the "700-foot" sand is shown in figure 23. Because fewer wells are screened

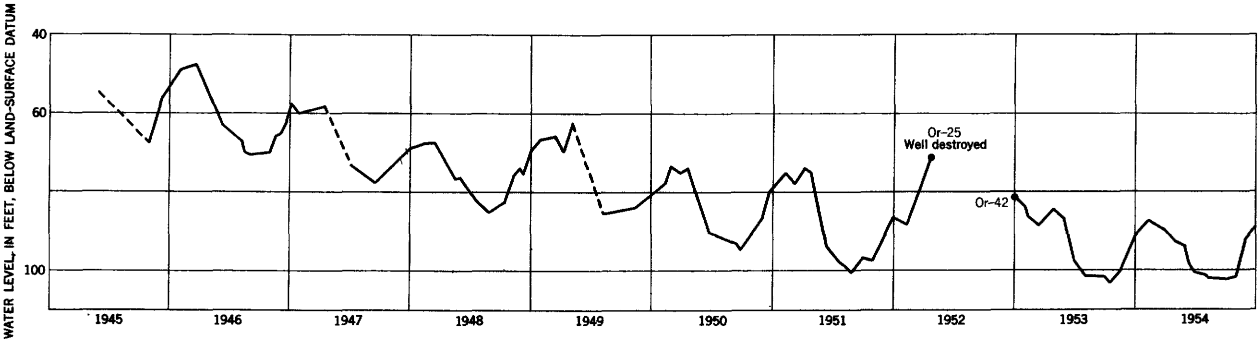

Figure 22.—Graph showing water-level fluctuations in wells screened in the "700-foot" sand in New Orleans area.

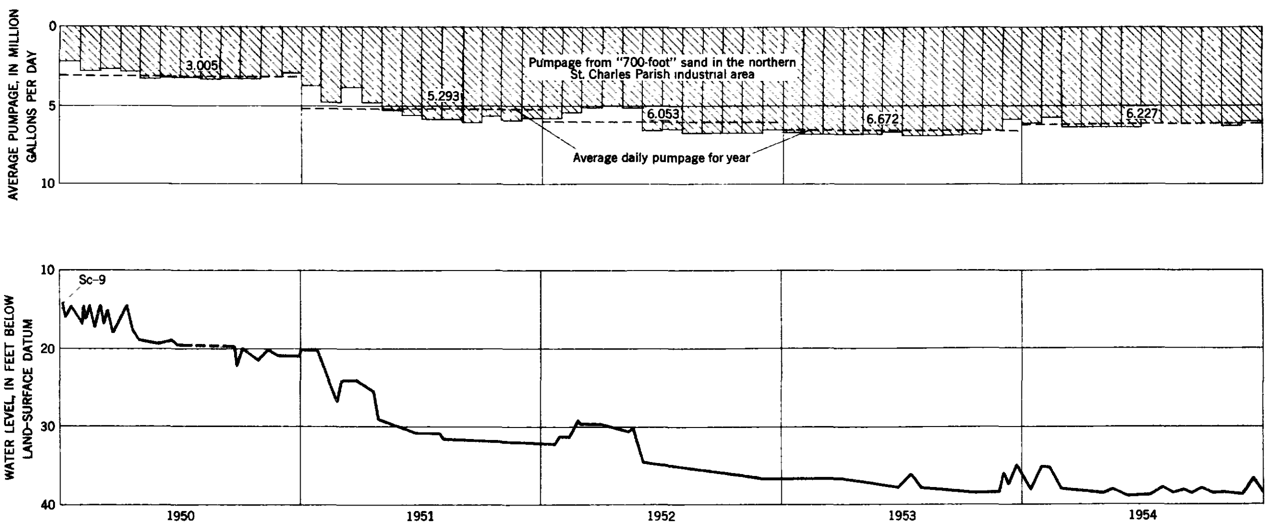

Figure 23.—Graph showing the relationship of pumping to water levels in wells screened in the "700-foot" sand in northern St. Charles Parish.

in the sand in that area, the aquifer is not pumped as heavily there as it is in the eastern part of the industrial district. Water-level declines in the past 5 years have been at a rate of about 5 feet per year, reaching a low level of 38 feet below the land surface.

Withdrawal

The average ground-water withdrawal from the "700-foot" sand in the New Orleans industrial district is about 41 mgd, or about 14,900 million gallons annually. The average daily summer pumpage is about 1.2 times greater than the average daily winter pumpage. About 56 percent of the withdrawal is in the western part of Orleans Parish, 24 percent in Jefferson Parish, 15 percent in St. Charles Parish, and 5 percent in St. Bernard Parish.

Quality of water

The "700-foot" sand yields fresh water to wells in most of the northern part of the New Orleans industrial district and in eastern Orleans Parish. Generally, in the southern and western parts of the industrial district the water from the "700-foot" sand is too highly mineralized to be suitable for human consumption. The geologic cross sections show the fresh-water—salt-water interface in the "700-foot" sand.

An isochloride map (fig. 24) of the "700-foot" sand in New Orleans and vicinity shows the distribution of chloride by means of lines of equal chloride content. This map is based upon 40 field tests of water collected from wells within a 1-month period. The general shape of the isochloride lines on this map indicates that concentrated pumping in this area has lowered the water levels sufficiently to cause salt water to move updip from the south. In comparing this recent isochloride map with similar data obtained in 1942, there appears to have been a slight movement of salt water updip to the north in the Algiers area. However, there has been a decrease in chloride content in the Gretna area, owing to the abandonment of some industrial wells. In the future, as in the past, the movement of water and variations in chloride content probably will change with rates of pumping. There is a high chloride concentration in the Norco area, ranging from about 1,000 to 2,200 ppm. As few data are available on the "700-foot" sand in that area, movement of high-chloride water on a regional basis is difficult to determine. However, a sampling program should be maintained to determine movement of saline water there.

The quality of water in the "700-foot" sand varies considerably, as shown by 11 complete chemical analyses in table 7, and 62 supplementary partial and complete analyses (not given in this report). Water from wells tapping this aquifer is a soft sodium bicarbonate type except in areas of high chloride concentration, where the water is extremely hard. The results of analyses show the concentration of dissolved solids generally is less than 1,000 ppm. The pH generally ranged from 7.6 to 8.6.

A small amount of hydrogen sulfide has been reported in the water from some wells, and locally the water is high in color. The color ranges from light to dark amber and is probably due to the organic material present in the sand. Color greater than 20 units makes the water undesirable for public supply and for some industrial uses.

"1,200-Foot" Sand

The deepest water-bearing sand tapped by wells in the New Orleans industrial district is the "1,200-foot" sand, which usually yields salt water. The top of this sand lies at about 1,150 feet below sea level in downtown New Orleans, and ranges in thickness from about 40 to 180 feet. In some places the sand is lenticular and contains interbedded clay and shale. A driller's log (Harris, 1905, p. 42) shows the sand is overlain

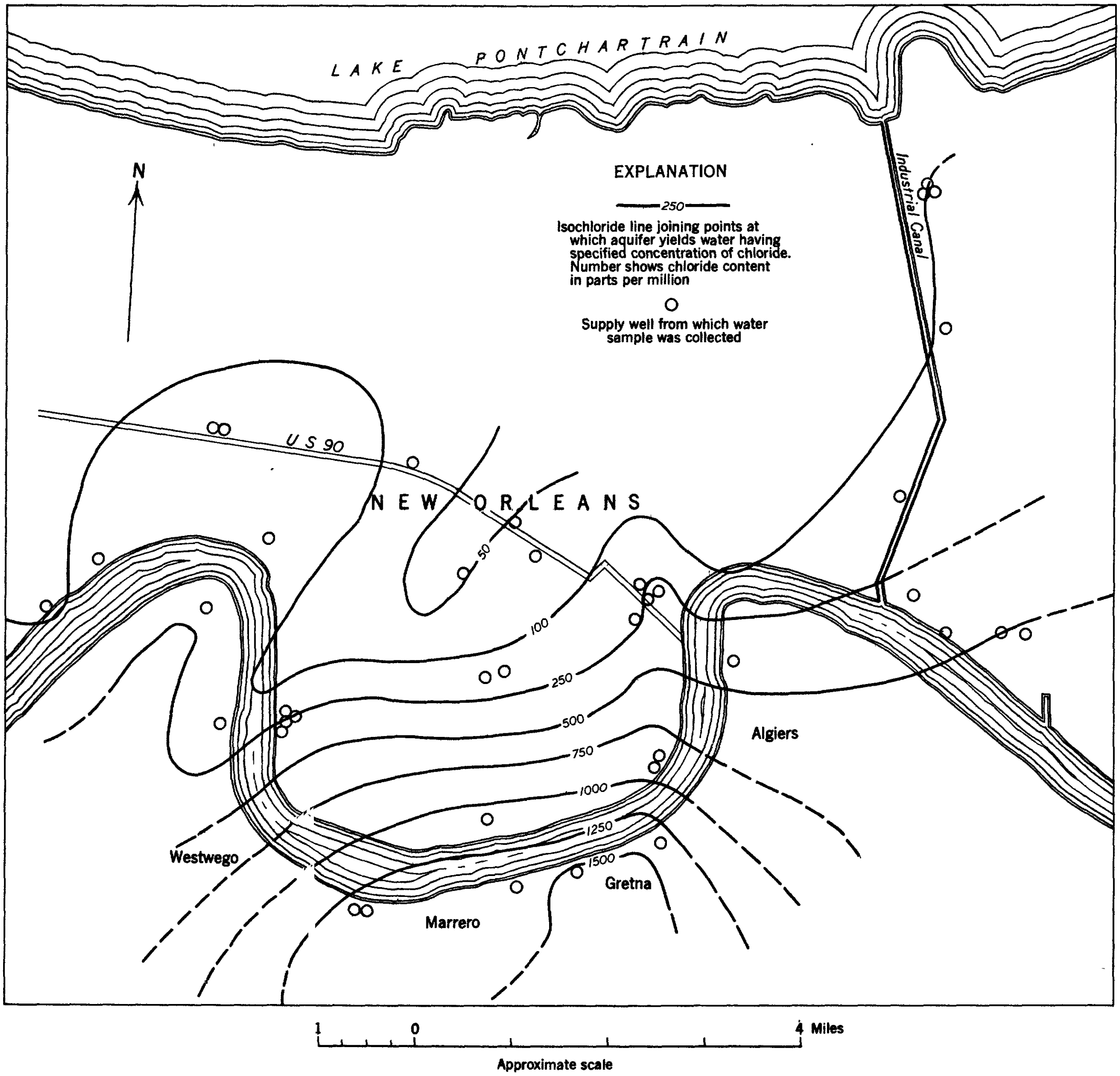

Figure 24.—Isochloride map of the "700-foot" sand in New Orleans.

by 6 feet of fine shells in downtown New Orleans, and the material is reported to consist of fine clean sand. Well 22, at the New Orleans Athletic Club (section B-B'), is screened in this sand between the depths of 1,148 and 1,181 feet, and 1,214 and 1,248 feet and yields water having a chloride content of 12,200 ppm. The "1,200-foot" sand is separated from the "700-foot" sand by a continuous bed of clay. The sand contains several lenses of clay; however, it is believed to be a continuous hydrologic unit. The electrical log of well 4 indicates fresh water, grading laterally and with depth into salt water. The depth of about 900 feet at well 4 is the greatest known depth to which fresh water occurs in the New Orleans industrial district.

The sand dips to the south at a rate of about 15 feet per mile. It probably crops out north of the report area in Louisiana or perhaps in the State of Mississippi.

Yield of wells

Harris (1905) reports that a well tapping the "1,200-foot" sand flowed about 55 gpm in 1904. Only a few wells are screened in this sand and the two highest yields reported are 115 and 200 gpm from 6-inch diameter wells. No data are available on the specific capacity of wells in this sand.

Water-level fluctuations

The artesian head was about 12 feet above the land surface in 1904 (Harris, 1905) and is reported to have remained at that level until 1937. No recent data are available, but, because only small quantities of water are withdrawn from this sand, the artesian head is probably near the same level at the present time (1955).

Withdrawal

The daily withdrawal from the "1,200-foot" sand is about 50,000 gallons, or about 18 million gallons per year.

Quality of water

A well drilled into the 1,200-foot" sand at the New Orleans Athletic Club at the turn of the century flowed 40 gpm of salt water and 830 cubic feet of gas a day in 1904 (Harris, 1905). Another well drilled in 1937 for the swimming pool at the New Orleans Athletic Club flowed salt water having a chloride content of 12,200 ppm, and a reported temperature of 82°F. (See table 7 for a partial chemical analysis of water from the "1,200-foot" sand.) In the northeastern part of Orleans Parish the water from the "1,200-foot" sand is relatively fresh, as shown by the chemical analysis of water from well Or-75.

Depth to Salt Water

Plate 1 section D-D', shows the general maximum depth of the fresh-water—salt-water interface from the northern shore of Lake Pontchartrain to the southern boundary of the report area. The decrease in the depth to the interface between wells 29 and 4 is about 2,000 feet, and its upward slope is about 120 feet per mile. Southward from well 4 the upward slope becomes more gentle. In the New Orleans industrial district the depth to salt water decreases southward. The variations in depth to the interface are due both to geologic structure and to concentrated pumping within the district. There are many factors which may affect the movement of salt water into a sand originally containing fresh water.

Over a long period of time, it is possible for salt water to migrate upward through a relatively impervious bed, such as clay, into sands containing fresh water, as a result of a pressure-head differential caused by pumping from wells screened in the fresh-water sands. The magnitude of such movement can be determined only if there is detailed information on the thickness and permeability of the clay, differences in head and changes in quality of the water.

The movement of saline connate water (salt water deposited or entrapped concurrently with the deposition of sediments) from downdip within the aquifer may occur when the normal hydraulic gradient is reversed because of pumping. It appears that this type of movement has occurred in the "700-foot" and "400-foot" sands in some areas (pl. 1, well 25, section C-C', and wells 16 and 17, section B-B'); however, further information would be necessary to determine accurately the updip rate of movement of the salt water. In many areas the upper part of a sand contains fresh water, which grades into salt water with depth. The interface between the fresh water and the salt water is not stationary but moves, at a rate depending upon the amount of pumping and the drawdown within the aquifer. If the pressure head in the fresh-water zone is reduced by pumping, the salt-water interface rises and moves northward in response to the density head of the salt water; but, if the equilibrium level of the interface is below the bottom of the wells tapping the fresh-water zone, then fresh water is "skimmed off." Nevertheless, the presence of salt water beneath a pumped well poses a constant threat of movement, as pointed out by Jones, Turcan, and Skibitzke (1954, p. 225) in their report on southwestern Louisiana.

Structural discontinuities (principally faults) may act as conduits allowing salt water to migrate from sands containing it into fresh-water sands.

PUBLIC WATER-SUPPLY SYSTEMS

New Orleans

The present Sewerage and Water Board of New Orleans was created in 1899 by an act of the Louisiana Legislature and is responsible for the design, construction, operation and maintenance of the waterworks, sewerage and drainage systems. By the end of 1908 a modern water plant was put into operation in New Orleans.

The water supply for the city of New Orleans is obtained from the Mississippi River through two pumping plants, the Carrollton and the Algiers plants. The treatment of the water at the Carrollton plant consists of plain sedimentation, softening with lime, intermittent addition of activated carbon for taste and odor control, coagulation with ferrous sulfate, sedimentation, ammoniation, stabilization with polyphosphates, chlorination, rapid sand filtration, and postchlorination.

The treatment of the water at the Algiers plant is essentially the same as at the Carrollton plant. It includes prechlorination, coagulation, softening, sedimentation, ammoniation, filtration and postchlorination. Activated carbon is used for taste and odor control if necessary.

The rated capacities of the Carrollton and Algiers plants in 1954 were 112 mgd and 7 mgd, respectively. The storage capacity for the finished water at Carrollton is 15,000,000 gallons and at Algiers, 7,000,000 gallons.

The water consumption as reported by the Sewerage and Water Board of New Orleans (1952) is as follows: 41,000 million gallons of water was pumped during 1952. Fifty-three percent of this amount was sold. Unmetered free uses such as fire fighting. street cleaning, sewer flushing, leaks, and uses of water at the water plant accounted for 38 percent. The remaining 9 percent consisted of free-metered water to the city departments and charitable institutions that are entitled, by law, to free water.

Table 8.—Maximum, minimum, and average concentrations of several constituents in the raw and finished water at Carrollton treatment plant

[Chemical analyses by New Orleans Sewerage and Water Board; bacterial analyses by City Board of Health; in parts per million, except as indicated]

Year	Concentration	Alkalinity		Hardness		Noncarbonate hardness		Turbidity		Bacteria per cubic centimeter 37°C Agar	
		Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered
1945	Maximum	140	47	174	88	47	49	1,500	1.4	110,000	65
	Minimum	55	27	84	58	14	24	120	0	28	0
	Average	94	35	126	71	32	36	555	.03	42,800	3
1946	Maximum	135	48	200	109	75	77	1,770	1.2	200,000	200
	Minimum	61	29	88	54	20	19	55	0	100	0
	Average	95	35	133	75	38	39	540	.09	41,004	7
1947	Maximum	147	70	205	103	63	64	1,365	1.2	200,000	200
	Minimum	64	26	107	66	30	33	25	0	16	0
	Average	105	36	151	83	46	47	425	.05	78,068	9
1948	Maximum	146	44	194	98	59	59	1,765	1.1	200,000	200
	Minimum	57	25	85	53	26	27	36	0	400	0
	Average	98	33	141	79	44	45	560	.04	123,595	10
1949	Maximum	134	42	192	91	63	62	1,450	1.9	1,000,000	200
	Minimum	61	24	90	52	26	26	47	0	20,500	0
	Average	90	31	130	74	43	43	533	.26	150,055	6
1950	Maximum	130	45	182	82	72	62	1,570	4.0	....	....
	Minimum	58	24	85	54	23	26	163	0	....	....
	Average	85	31	121	67	37	36	667	.35	....	....
1951	Maximum	139	50	171	87	63	53	1,500	3.3	....	....
	Minimum	56	23	88	57	25	29	155	0	....	....
	Average	97	30	135	72	39	41	610	.76	....	....
1952	Maximum	157	58	255	129	80	81	750	3.3	....	....
	Minimum	65	27	99	71	33	33	11	0	....	....
	Average	109	40	145	87	47	47	317	.66	....	....

The finished water supplied to New Orleans is consistently of good quality. The average hardness as $CaCO_3$ for 1948–52 was 76 ppm. The maximum, minimum, and average concentrations of several constituents in the raw and finished water at the Carrollton treatment plant is shown in table 8.

Other Public Water Supplies

East Jefferson Parish Waterworks District 1 supplies Harahan, Kenner, Metaire, Shrewsbury, Southport, and other communities. The treatment plant at Shrewsbury has a daily capacity rated at 10 mgd. The finished-water storage at Jefferson Parish plant is 3,500,000 gallons. The raw Mississippi River water is treated by plain sedimentation, lime softening, coagulation with lime and iron salts, ammoniation, sedimentation, rapid sand filtration and chlorination.

The chemical quality of the raw and finished water is similar to the raw and finished water of New Orleans. (See table 9.)

The town of Gretna in Jefferson Parish also obtains its water supply from the Mississippi River. The treatment given the raw water is essentially the same as at East Jefferson Parish water plant. The treatment consists of sedimentation, softening, coagulation, filtration, and chlorination. The finished-water storage at Gretna is 1,250,000 gallons. Analysis of the raw and finished water at Gretna is shown in table 9.

The municipal water supplies in the New Orleans area serve about 650,000 people. This information is based on the 1950 census.

USE OF WATER

About 1,500 mgd of water from ground and surface sources was used in 1954. Of this volume, about 1,250 mgd from surface sources was used for industrial and commercial purposes and about 150 mgd was used by public utilities. About 100 mgd from ground-water sources was used primarily for industrial and commercial purposes. There is no withdrawal of ground

Table 9.—Mineral constituents and related physical measurements of the raw and finished water of the public supplies in the New Orleans area

	Treatment plant at							
	Carrollton		Algiers		East Jefferson		Gretna	
	Raw	Finished	Raw	Finished	Raw	Finished	Raw	Finished
Silica (SiO_2)	10	12	10	10	10	12	8.4	9.8
Iron (Fe)	.36	.08	.17	.03	.02	.03	.06	.05
Manganese (Mn)	.00	.00	.00	.00	....	.00	.00	.00
Calcium (Ca)	47	16	48	20	41	21	35	21
Magnesium (Mg)	14	8.1	14	8.3	13	5.5	9.7	3.0
Sodium (Na)	21	21	21	20	21	21	13	13
Potassium (K)	.8	.8	.8	.8	....	2.0	....	4.4
Carbonate (CO_3)	0	0	0	6	0	5	0	15
Bicarbonate (HCO_3)	161	37	162	24	144	23	114	6
Sulfate (SO_4)	51	52	51	58	41	56	38	42
Chloride (Cl)	24	26	24	27	26	27	14	15
Fluoride (F)	.3	.2	.3	.3	.3	.2	.2	.3
Nitrate (NO_3)	2.5	2.0	2.0	2.0	3.0	2.0	3.0	2.5
Dissolved solids	262	158	266	166	234	163	193	133
Hardness as $CaCO_3$:								
Total	175	73	177	84	156	75	127	65
Noncarbonate	43	43	45	54	38	48	34	35
pH	7.5	7.1	7.5	8.8	7.7	8.9	7.3	9.8
Specific conductance (micromhos at 25°C)	438	270	439	285	400	279	317	237
Date of collection (1951)	Aug. 31	Aug. 31	Aug. 31	Aug. 31	Oct. 12	Oct. 12	May 14	May 14

water for public-supply use in the area south of Lake Pontchartrain.

The total daily recorded usage from pumped public-supply wells at Covington, Slidell, and Mandeville is 450,000 gallons. The average artesian flow from public-supply wells screened in sands between the depths of 600 and 1,750 feet at Covington, Slidell, Abita Springs, Mandeville, Lacombe, Goodbee, and Pearl River is about 250 gpm (360,000 gpd).

Public Supplies

The use of surface water in the New Orleans area far exceeds the use of ground water. The Mississippi River is the principal source of water for municipal supplies in the area.

The average daily pumpage of treated Mississippi River water from the Carrollton treatment plant is shown in figure 25. The pumpage from this plant has increased about fivefold since 1909.

Surface Water

Seventeen large private industrial water supply systems in the New Orleans industrial district pump on the average about 1,000 mgd from surface-water sources. Twelve plants are on the west bank of the Mississippi River opposite New Orleans, four are on the east bank in or near Chalmette, and one is on the Industrial Canal. Most withdrawal for private, industrial and commercial supplies in the New Orleans area is made by this group of privately developed water-supply systems.

Of the 1,000 mgd total, about 855 mgd is pumped for cooling in the generation of electricity by steam power and is immediately returned to the river or canal at a slightly higher temperature. The Kaiser Aluminum and Chemical Corp. is the largest single user of surface water which is used mostly for cooling in the production of electricity. The cooling process involves circulation of 515 mgd through heat exchangers, condensers, and boiler feed water systems and then a return directly to the Mississippi River.

Except for the American Sugar Refinery, which uses 22 mgd for cooling, and the Celotex Corp., which uses 24 mgd for washing and cooling, most of the private systems pump less than 5 mgd. Most of the water is used for cooling, chemical processing, washing, and air conditioning and after passing through the process is returned to the surface-water source, essentially undiminished in quantity but generally with an increased temperature. Some surface water below New Orleans is used in the mining of sulfur and is not returned to the Mississippi River.

Several of the private, industrial and commercial systems pump continuously throughout the year, whereas a few pump on a seasonal basis for periods ranging from 4 to 8 months.

Ground Water

A summary of the average daily pumpage from 84 industrial wells within the industrial district is shown in table 6. An average of about 62 mgd of ground water was used for private, industrial, and commercial uses in the New Orleans industrial district during 1953.

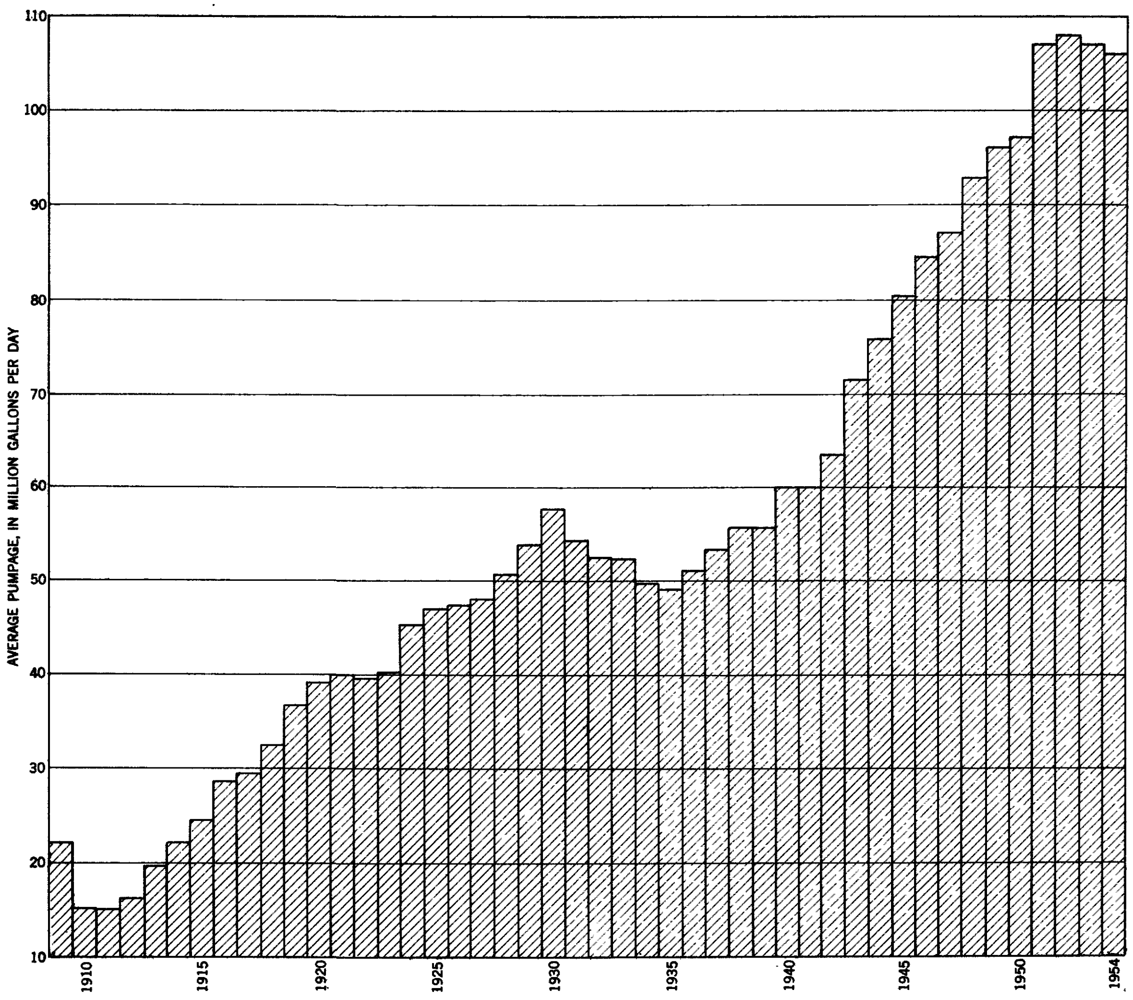

Figure 25.—Average daily pumpage of treated Mississippi River water from the Carrollton treatment plant at New Orleans, 1909–54.

The two major areas of concentrated pumping of ground water are in northern St. Charles Parish along the Mississippi River, and in western Orleans Parish and northeastern Jefferson Parish, where the water is used primarily for cooling in industrial plants and commercial buildings. Past records of pumping from ground-water reservoirs are not available, but the steady decline in artesian head in most of the sands indicates that more water is being withdrawn today than in the past. Although 65 industrial wells have been abandoned in recent years, most of them have been replaced by new installations at existing or new plants.

POTENTIAL WATER RESOURCES

Surface Water

Less than about 3 percent of the minimum flow or less than about 1 percent of the average flow of Mississippi River water is now being used. Most of the water that is withdrawn is for cooling and is returned to the river, although at a slightly higher temperature, and is available for reuse. Public water-supply system withdrawal is in great part returned below New Orleans by way of the city's sewerage system and is diluted by the Mississippi River. Although a large volume of water is available, the quality is undesirable for many uses.

Lake Des Allemands, storage volume about 79,000 acre-feet, and Lake Salvador, storage volume about 294,000 acre-feet at mean sea level are near New Orleans. The suitability of these lakes as a source of supply was not determined for this report.

The streams that drain into Lakes Maurepas and Pontchartrain are important sources of fresh water of good quality. These lakes serve only as temporary storage basins. The Amite and Tickfaw Rivers together discharge an average of about 2,500 mgd (2,800,000 acre-feet per year) into Lake Maurepas, which has a storage volume of about 570,000 acre-feet at 0.5 foot above mean sea level. The Tangipahoa and Chefuncte Rivers discharge an average of about 1,300 mgd (1,460,000 acre-feet per year) into Lake Pontchartrain directly. Water from all these streams is soft and generally would require a minimum amount of treatment. The Pearl River has an average flow of about 8,000 mgd, which serves to dilute salt water that enters Lake Pontchartrain from the Gulf of Mexico. The quality of this water is good above Bogalusa.

Ground Water

North of Lake Pontchartrain, large supplies of fresh ground water are available from water-bearing sand and gravel deposits of Pleistocene and possible Pliocene age and deeper sands of Miocene age. Wells tapping these sands generally have a flow of 1–450 gpm and yield larger quantities by pumping. No known wells tap sands below 2,000 feet, and consequently the potential yield of these deep sands has not been determined. However, electrical logs of oil-test wells show that fresh water is present in sands to a maximum depth of 3,000 feet. The many hydrologic and geologic factors that are necessary to determine the full capabilities of the sands are not available. Nevertheless, as the small quantities of water withdrawn from the many fresh-water sands have caused only slight local decline in water levels, the area north of Lake Pontchartrain appears to be favorable for large supplies of ground water.

South of Lake Pontchartrain in the industrial district the three principal water-bearing sands, the "200-foot," "400-foot," and "700-foot," supply about 62 mgd of ground water, principally for industrial purposes. This relatively large local withdrawal has resulted in declines in water levels to as much as 100 feet below the land surface in the immediate vicinity of areas of heavy pumping. This decline does not necessarily indicate an overdevelopment of the water-bearing sands, as the water-level decline has not been excessive.

One of the primary factors limiting the potential ground-water supply from these sands is the quality of water. For example, at Gretna the chloride content of the water from the "700-foot" sand is more than 1,500 ppm; whereas, to the north along the southern shore of Lake Pontchartrain, wells screened in this sand yield water having a chloride content of less than 100 ppm. Although the movement of salt water within the aquifer has been negligible since 1942, a continual increase in withdrawal in the northern part of the industrial district may eventually cause salt-water contamination to become more widespread.

In most areas the "200-foot" sand contains unpalatable water and consequently is not considered a principal source of fresh ground water. The "400-foot" sand contains highly mineralized water in some areas; however, elsewhere it is uncontaminated and is a large source of fresh water. Reported yields from individual wells tapping this sand are as high as 2,400 gpm. There has been no serious decline in water levels in the "400-foot" sand in the industrial district as a result of the present rate of pumping. The "700-foot" sand is the most continuous and has the greatest areal extent of the fresh-water-bearing sands in the report area. This sand yields as much as 2,000 gpm to large-diameter wells. Since 1940 the water level in the "700-foot" sand has declined about 54 feet in wells near the center of the pumping area; however, the decline has been much less in wells away from this area. Thus, in the northern part of the industrial district, where the aquifer contains fresh water, the "700-foot" sand provides a potential source for large ground-water supplies.

Owing to the poor quality of the water in the "1,200-foot" sand, it is not considered a principal source of fresh ground water.

Other promising sources of additional fresh ground water probably could be developed in Lake Pontchartrain north of the industrial district, where the depth of salt water is greater than it is south of the lake. However, the development of ground water in this area should be preceded by a detailed investigation that would include a test-drilling program.

WATER LAWS

Federal Law

The Federal Government controls interstate navigable streams, keep them free from trash and any other potential obstruction, and designs and constructs structures for flood control and power development. In 1913 the United States Supreme Court recognized a relationship of flood control to the "plenary power of the United States to legislate for the benefit of navigation" (President's Water Resources Policy Commission, 1950, p. 18) and upheld the right of the Federal Government to dispose of waterpower developed using a Federal multiple-purpose navigation dam.

Louisiana Law

In addition to Federal laws controlling the use of water, most of the states have enacted water laws in an effort to conserve water resources, to safeguard public health, and to provide for enforcement of rules and regulations deemed to be in the best interest of the people of the state.

Louisiana applies the riparian-rights doctrine to water. Unlike other states, Louisiana adopted the riparian-rights doctrine direct from the Code Napoleon and not from the English common law. However, the State of Louisiana does not have organized control of its water resources. Only one watershed—the Sabine River—is supervised and the use of water from it controlled. The Sabine River is regulated by the Sabine River Authority, composed of Federal and State officials.

It is the responsibility of the Stream Control Commission, Department of Wild Life and Fisheries, to control pollution of streams in Louisiana.

A 1938 legislative act granted to parish police juries the right to establish irrigation districts if petitioned to do so by property owners of the district. However, this act did not provide the right to regulate the use of water and may not include incorporated towns and cities. The irrigation district is authorized to "... conserve the fresh water supply..... provide water for irrigation ..... The governing authority may do and perform all acts necessary to construct, lease, acquire in any manner, maintain, and operate dikes, dams, reservoirs, storage basins, locks, levees, flumes, conduits, and acquire or lease any private canals and other bodies of water which may be within or without the irrigation district and necessary or suitable to the operation of the district." (Louisiana Legislative Council, 1955).

Act 113 of the 1955 Louisiana Legislature constitutes enabling legislation providing for a water district in southwestern Louisiana comprising the parishes of Acadia, Allen, Beauregard, Calcasieu, Cameron, Evangeline, Iberia, Jefferson Davis, Lafayette, St. Landry, St. Martin, St. Mary, and Vermilion.

The State Department of Health is authorized to prescribe sewage treatment and treatment of other wastes that are discharged into streams and to prepare a sanitary code which provides rules and regulations for the maintenance of the general sanitary conditions in the State.

The State of Louisiana does not have laws to control the use of ground water. The Louisiana Department of Health supervises the construction of wells used for public supply and usually requires the sealing of abandoned wells. In order to prevent the pollution of fresh-water sands, the Commissioner of Conservation designates the minimum amount of surface casing to be set in oilfield wells and salt-water injection wells.

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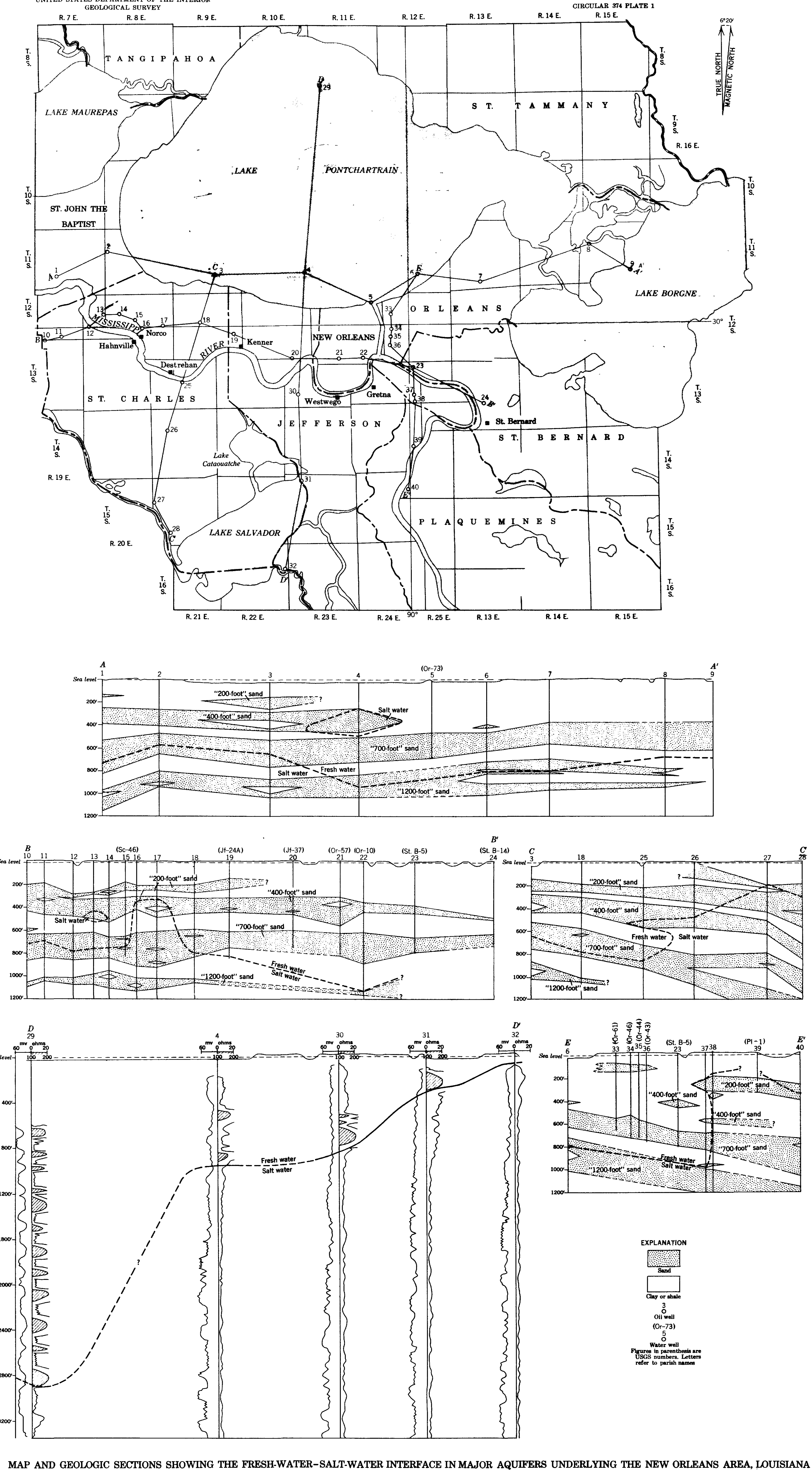

MAP AND GEOLOGIC SECTIONS SHOWING THE FRESH-WATER–SALT-WATER INTERFACE IN MAJOR AQUIFERS UNDERLYING THE NEW ORLEANS AREA, LOUISIANA

5 0 20 Miles

Datum is mean sea level