

# RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE SABINE RIVER BASIN TEXAS AND LOUISIANA



## TEXAS WATER COMMISSION BULLETIN 6405

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TEXAS WATER COMMISSION

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BULLETIN 6405

RECONNAISSANCE OF THE CHEMICAL QUALITY OF  
SURFACE WATERS OF THE SABINE RIVER BASIN  
TEXAS AND LOUISIANA

By

L. S. Hughes and D. K. Leifeste

Prepared by the U. S. Geological Survey  
in cooperation with the  
Texas Water Commission

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RECONNAISSANCE OF THE CHEMICAL  
QUALITY OF SURFACE WATERS OF  
THE SABINE RIVER BASIN  
TEXAS AND LOUISIANA

ABSTRACT

Surface water of the Sabine River Basin is generally of excellent chemical quality, and meets U. S. Public Health Service drinking-water standards. The concentration of dissolved solids in the water in most streams is less than 250 ppm (parts per million). Runoff from the outcrop areas of the older geologic formations in the upper part of the basin generally has concentrations ranging from 100 to 200 ppm, and water from the outcrops of younger formations in the lower basin has concentrations less than 100 ppm.

The water from much of the basin is soft, having less than 60 ppm hardness, but water from drainage areas where the Cretaceous rocks crop out is moderately hard (60 to 120 ppm).

The chloride concentration is less than 20 ppm in surface water from about two-thirds of the Sabine River Basin. Concentrations greater than 100 ppm are found only where pollution is occurring.

The principal existing reservoirs all contain water of excellent quality, and water to be stored in proposed reservoirs should also be excellent, although further evaluation of pollution in Lake Fork Creek should be made before finalizing plans for a reservoir on this stream.

Municipal use of water has caused only local changes in the chemical quality of surface water in the Sabine River Basin, and flow in streams is usually adequate to dilute municipal wastes. Oil-field brines, however, are polluting streams in Lake Fork Creek sub-basin, and probably in Socagee Creek.

Natural pollution of surface water is occurring at Grand Saline, in Van Zandt County, where a small amount of highly saline ground water enters Grand Saline Creek.

The Sabine River Basin has an abundant supply of surface water of excellent quality, but uneven distribution of runoff makes storage projects necessary in order to provide dependable supplies.



Average annual rainfall in the basin ranges from 40 inches in the northwest to more than 56 inches in the southeast, and annual runoff from the basin has averaged 13 inches. However, runoff rates vary widely with time. The yearly mean discharge of the Sabine River near Ruliff has ranged from 1,760 cfs (cubic feet per second) to 17,210 cfs, and instantaneous flows have varied from a low of 270 cfs to a high of 121,000 cfs.

Until recent years, water-development projects had been comparatively small ones, built by cities and private businesses for municipal and industrial use. One large reservoir, Lake Tawakoni, was completed in 1960, and another, Toledo Bend, is under construction (1963). In 1959, 42,060 acre-feet of surface water was used consumptively in the Sabine River Basin. Requirements for surface water for municipal and industrial use in the basin in 1980 are estimated by the Texas Water Commission to be 298,000 acre-feet, plus 114,200 acre-feet to be exported to the Trinity River Basin and 4,400 acre-feet to the Neches River Basin. Additional reservoirs are included in the Sabine River Authority's Master Plan to meet the water needs of the basin in the year 2010.

The kinds and quantities of minerals dissolved in surface water are the result of a number of environmental factors, including geology, patterns and characteristics of streamflow, and cultural influences. Rainfall has a great influence on the chemical quality of waters in the Sabine River Basin and much of the soluble materials has been leached from the surface rocks and soils. Consequently, the water in streams is usually low in concentration of dissolved minerals.

RECONNAISSANCE OF THE CHEMICAL  
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INTRODUCTION

Knowledge of the quality of the water that will be available is essential in planning for any water-use project, because the suitability of a water for household or domestic purposes, for agricultural purposes, or for industrial processes, depends upon its chemical quality. For a public supply, a water that meets the requirements of all three main types of utilization is needed. If a raw water is not satisfactory for a specific use, chemical analyses are necessary to determine the type and cost of treatment needed to make it satisfactory.

In addition to the determination of the suitability of water for specific purposes, chemical-quality data are needed for: (1) the inventory of the water resources, (2) the detection and control of man-made pollution of water supplies, (3) the study of salt-water encroachment into coastal streams and aquifers, (4) planning for reuse of water, and (5) demineralization of water.

A network of daily chemical quality stations on principal streams in Texas is operated by the U. S. Geological Survey in cooperation with the Texas Water Commission (prior to 1962, Texas Board of Water Engineers) and with Federal and local agencies. However, the network never has been adequate to inventory completely the chemical quality of the surface waters of the State.

To supplement the information being obtained by the network, a statewide reconnaissance study was begun in September 1961 cooperatively by the U. S. Geological Survey and the Texas Water Commission. The study includes the analysis of water samples collected periodically at numerous sites throughout the State; it will insure that some quality-of-water information is available at most locations where water-development projects are likely to be built. The study will also aid in the delineation of water-quality problem areas and the identification of probable sources of pollution, thus indicating areas where more detailed investigations are needed.

Water-quality data were collected for the principal streams in each basin and at the sites of a large number of proposed reservoirs. Included were all the reservoirs proposed in the Texas Water Commission's plan for meeting 1980 water requirements (Board of Water Engineers, 1961), as well as a number of other reservoirs which are listed in master-plan reports of various river authorities. Data were collected also for many existing reservoirs.

Data were collected over a wide range of water-discharge rates. At low flows, concentrations of dissolved minerals are likely to be highest, and the analyses of low-flow samples indicate where pollution and salinity problems exist. Data representative of medium and high flows indicate the probable quality of the water that will be stored in reservoirs. Sampling sites were selected at streamflow stations wherever possible, in order that chemical analyses could be considered in relation to water discharge. At sites other than streamflow stations, the water discharge was usually measured when the samples were collected.

A report presenting the results of the reconnaissance study and summarizing all available chemical-quality data is planned for each major river basin in Texas. This report on the Sabine River Basin is the first of the planned series.

Chemical analyses of streams in the Sabine River Basin in Louisiana, made by the U. S. Geological Survey in cooperation with the Louisiana Department of Public Works, are also included in this report, and the surface-water resources of the Louisiana portion of the basin are discussed in a general way. However, the report is concerned principally with the Texas portion of the Sabine River Basin.

Agencies that have cooperated in the collection of chemical-quality and streamflow data in the Sabine River Basin include the Sabine River Authority of Texas, Sabine River Compact Administration, U. S. Army Corps of Engineers, Panola County (Texas) Fresh Water Supply District No. 1, Wood County, Texas, Louisiana Department of Public Works, and Louisiana Department of Highways.

The Texas State Department of Health has made available the water-quality data collected in the Sabine River Basin by its Water Pollution Control Division.

## SABINE RIVER DRAINAGE BASIN

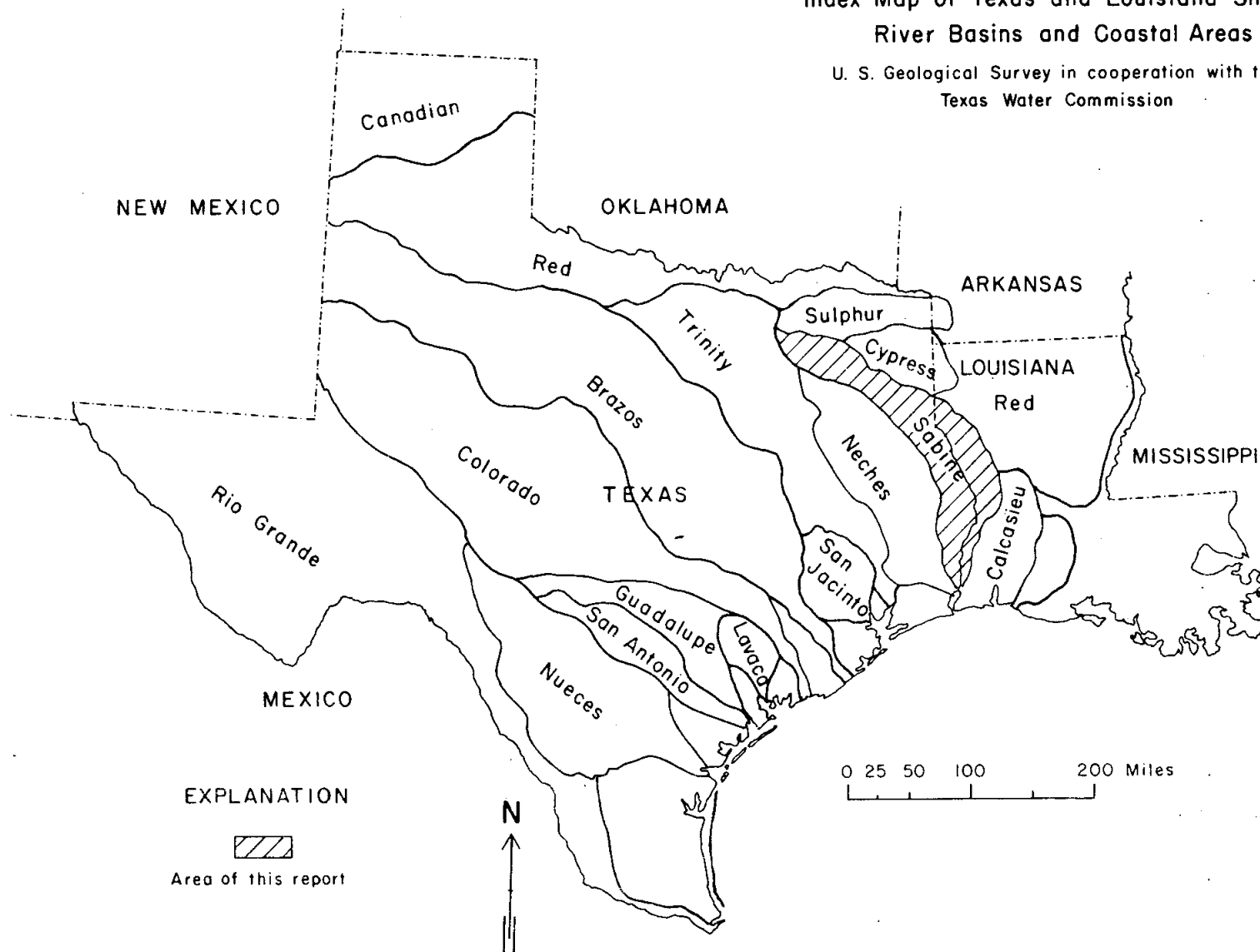
### Location and Extent

The Sabine River drains an area of about 7,400 square miles in eastern Texas and 2,300 square miles in western Louisiana (Figure 1). The drainage basin is crescent-shaped and is about 300 miles long and averages about 30 miles wide, and includes all or part of 20 counties in Texas and 6 parishes in Louisiana. From its source in northern Hunt County, Texas, the Sabine River flows southeastward to the Texas-Louisiana border near Logansport, then forms the boundary between the two States as it flows southward to its mouth on Sabine Lake, an arm of the Gulf of Mexico.

Low divides separate the drainage basin of the Sabine River from the drainage basins of the Trinity River on the west, the Neches River on the south and west, Cypress Creek and the Sulphur River on the north, the Red River on the east, and the Calcasieu River on the southeast (Figure 1).

Figure 1  
 Index Map of Texas and Louisiana Showing  
 River Basins and Coastal Areas

U. S. Geological Survey in cooperation with the  
 Texas Water Commission



EXPLANATION



Area of this report

## Topography, Soils, and Vegetation

The Sabine River slopes from an altitude of about 750 feet to sea level. In the northwest one-fourth of the basin are rolling plains, extending into eastern Smith and Wood Counties. Southward to northern Orange County are low hills and stream divides, with flat flood plains along the Sabine River and its major tributaries. Central and southern Orange County has relatively open prairie and poorly drained flatlands.

Except for the black waxy soils in the extreme northwest, soils are mostly light-colored fine sandy loams, with subsoils that range from loamy sand to plastic clay in texture and from yellow to red in color. These soils are low in necessary plant nutrients, but are very responsive if properly fertilized and managed.

The abundant rainfall provides moisture for lush vegetation, and water-demanding trees flourish. Various varieties of oak, elm, magnolia, black gum, and sweet gum are abundant, but pine is the principal timber and the most important commercially. A large part of Texas' commercial timber is grown in the Sabine River Basin. Extensive areas of forest have been cleared and used for cropland, but as timber has become more important commercially, much of this cropland has been allowed to return to forest.

## Geology

The rocks exposed in the Sabine River Basin are a thick series of sedimentary strata that range in age from Cretaceous to Recent. Figure 2 is a generalized map of the geology of the basin. The oldest rocks are exposed in the upper, northwest part of the basin and dip toward the southeast. In general, successively younger rocks crop out toward the Gulf Coast, but this stratigraphic sequence is interrupted in the central part of the basin by the Sabine uplift, a large dome-shaped structural high centered in Panola County. From the northwest flank of the uplift, the formations dip to the northwest, and from the southern flank they dip to the south towards the Gulf of Mexico, being overlain by successively younger rocks. Much of the area of the Sabine uplift is covered by an outcrop of the Wilcox Group of Tertiary age. The stratigraphic succession of formations in the Texas part of the Sabine River Basin, with brief descriptions of the rock units, is given in Table 1.

## Drainage

The Sabine River Basin is about 300 miles long, averages 30 miles wide, and is only about 45 miles across at the widest point (Plate 1). The river has many tributaries, all of them small when compared to the Sabine River. Most of the streams are less than 30 miles long and drain less than 200 square miles. Lake Fork Creek in Texas and Bayou Anacoco in Louisiana drain 685 and 431 square miles, respectively, and none of the other tributaries drain more than 400 square miles.

## Precipitation and Runoff

The climate of the Sabine River Basin ranges from moist subhumid to humid (Thornthwaite, 1952, p. 32). The average annual precipitation is about 48

Figure 2  
Geologic Map of the  
Sabine River Basin

U. S. Geological Survey in cooperation with  
the Texas Water Commission

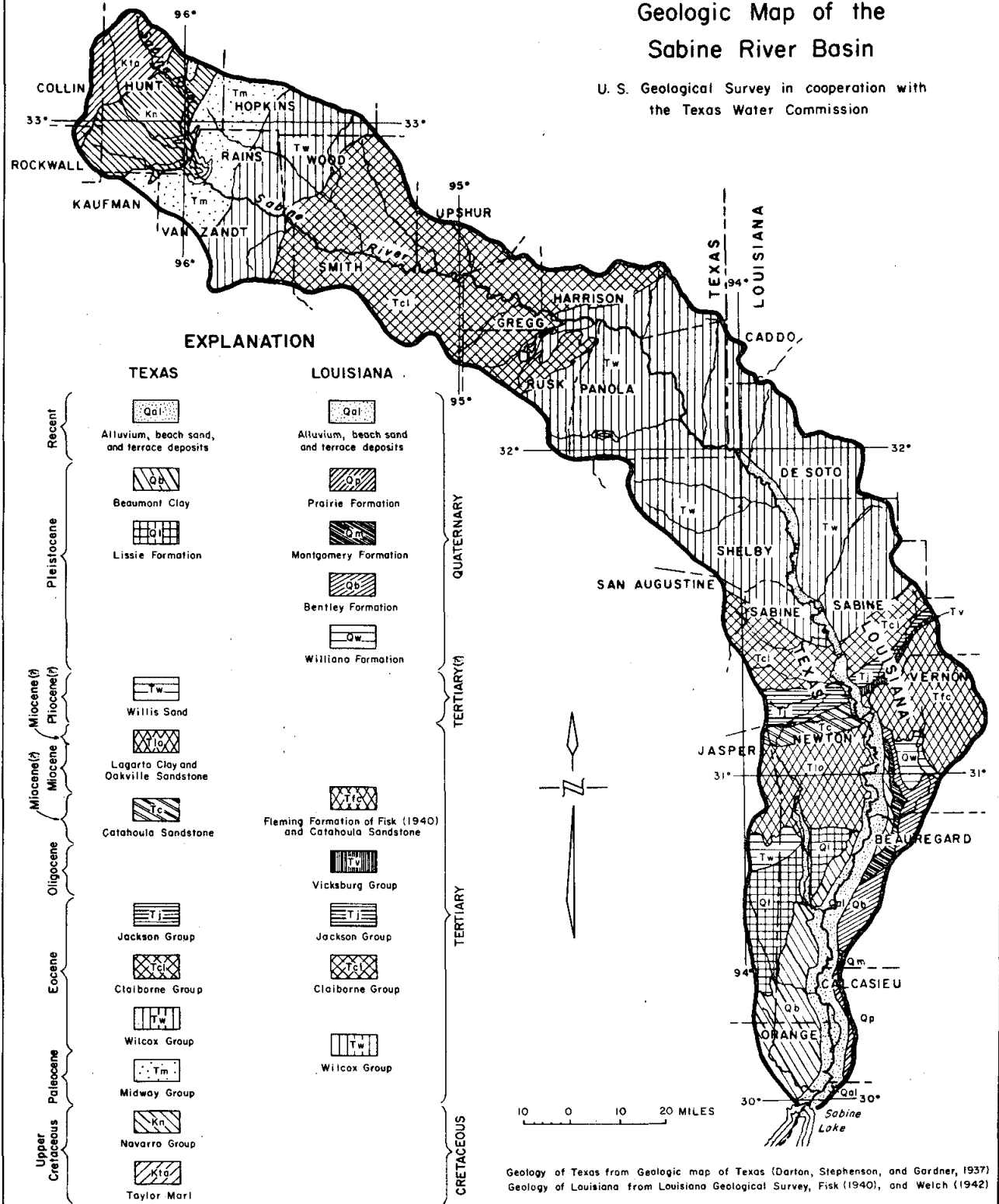


Table 1.--Stratigraphic units in the Sabine River Basin, Texas

System	Series	Group	Stratigraphic unit	Character of rocks	
Quaternary	Recent		Alluvium, beach sand, and terrace deposits.	Unconsolidated gravel, sand, silt, and clay.	
	Pleistocene		Beaumont Clay	Calcareous clay, silt, sand, and gravel.	
			Lissie Formation	Beds of sand, gravel, silt, and clay.	
Tertiary (?)	Pliocene (?)		Willis Sand	Gravel, calcareous sand, silt, and clay.	
Tertiary	Miocene (?) and Miocene		Lagarto Clay and Oakville Sandstone undifferentiated	Gravel, calcareous sand, silt, and clay.	
			Catahoula Sandstone	Sand and clay; some volcanic ash and fuller's earth.	
	Eocene	Jackson	Undifferentiated	Sand, sandy clay, clay, and volcanic ash.	
		Claiborne	Yegua Formation	Sand, sandy shale, clay, and lignite.	
			Cook Mountain Formation	Clay and shale containing small amounts of sand, silt, limestone, glauconite, and selenite.	
			Sparta Sand	Sand interbedded with shale and clay.	
			Mount Selman Formation	Weches Greensand Member	Glauconitic sandstone and shale.
				Queen City Sand Member	Medium to fine sand, silt, and clay.
				Reklaw Member	Shale, with thin sand layers.
		Carrizo Sand	Medium to fine sand, with thin interbedded shales.		
	Wilcox	Undifferentiated	Silt, clay, fine to medium grained sandstone, sandy shale and clay, and thin beds of lignite.		
Paleocene	Midway	Undifferentiated	Shale, clay, and silt.		
Cretaceous	Upper Cretaceous	Navarro	Kemp Clay	Clay and sandy clay.	
			Nacatoch Sand	Sand and sandy clay.	
			Neylandville Marl	Shaly marl and clay.	
			Taylor Marl	Marl, chalk, and limestone, with some clay, sand, and sandy clay.	

inches, which exceeds the average for the State of Texas by about 60 percent. Within the basin, the average annual precipitation ranges from about 40 inches in the northwest to more than 56 inches in the southeast. At Bon Weir in Newton County, annual rainfall for the period 1931-60 averaged 56.82 inches, the highest for any weather station in Texas. Mean annual precipitation in the basin, normal (average) monthly precipitation at four U. S. Weather Bureau stations, and annual precipitation for 1889-1962 at one station are shown in Figure 3.

"Runoff" is defined as that part of the precipitation that appears in surface streams (Langbein and Iseri, 1960, p. 17). It is the same as streamflow unaffected by artificial diversion, storage, or other works of man in or on stream channels. Locally in the Sabine River Basin "runoff" and "streamflow" may not be synonymous, but runoff from the basin as a whole has been affected only slightly by diversions or storage.

Many factors other than the total quantity of precipitation affect the amount of runoff from a drainage basin. These include temperature, seasonal distribution of rainfall, storm intensity, infiltration rates, and types and density of vegetation.

Because of the topography and vegetal cover the rate of runoff from the Sabine River Basin is much slower than from most river basins in Texas. The long narrow shape of the basin and the lack of large tributary streams prevent the rapid accumulation of floodwaters. Streambed gradients are very low--for much of its length the Sabine River has a slope of less than 0.8 foot per mile. The river meanders through its flood plain with numerous sloughs, overflow channels, and marshes. The heavy forest cover of pines and hardwoods slows the runoff even from the rolling hills, and the dense underbrush and timber growing on the flood plains further retard movement of the water.

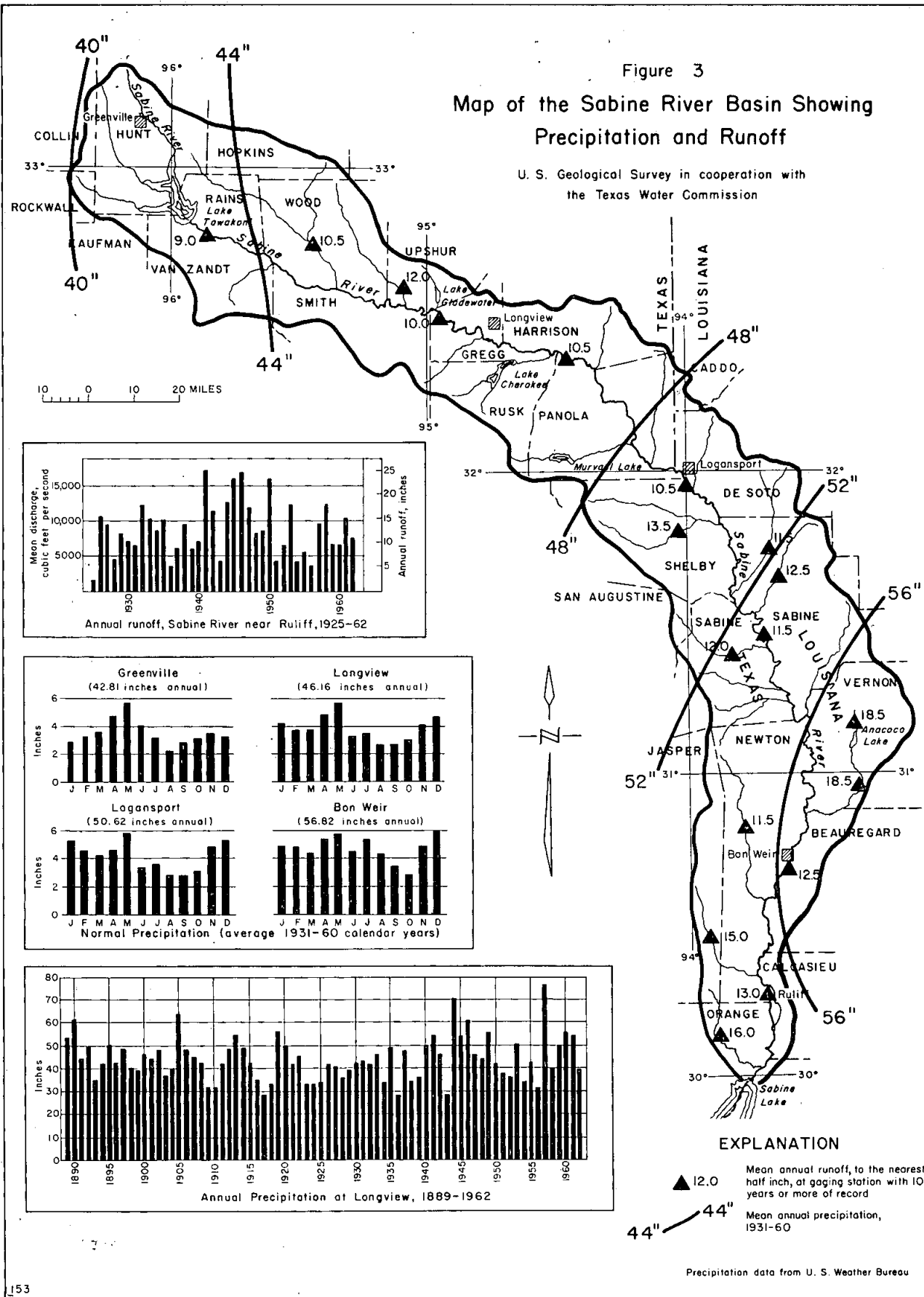
About 25 percent of the precipitation in the Sabine River Basin appears in the streams as runoff. Runoff data plotted on the map in Figure 3 show that average runoff from sub-basins has ranged from 9.0 inches annually in the upper part of the basin to 18.5 inches in a Louisiana sub-basin in the lower part. Runoff from the entire basin, as measured at the lowermost gaging station, Sabine River near Ruliff, averaged 13.0 inches annually for the period 1925-62. Annual runoff at the Ruliff station, expressed as mean discharge in cubic feet per second and as inches per year, is shown for the period of record in a graph on Figure 3.

Precipitation and runoff in the Sabine River Basin are subject to much greater variations than are indicated by the annual and monthly averages. The yearly mean discharge of the Sabine River near Ruliff has ranged from 1,760 cfs (cubic feet per second) to 17,210 cfs (Figure 3), but instantaneous flows have varied much more widely, from a low of 270 cfs to a high of 121,000 cfs. Similarly, normal monthly rainfall at Longview ranges from 2.56 inches for August to 5.72 inches for May (Figure 3); but in 1962 the monthly totals ranged from only 0.30 inches in August to 6.28 inches in April. Thus, in spite of relatively high averages, precipitation so unevenly distributed in time does not sustain streamflow, and storage projects are required to make surface water available in dependable quantities for municipal or industrial use.



Figure 3  
Map of the Sabine River Basin Showing  
Precipitation and Runoff

U. S. Geological Survey in cooperation with  
the Texas Water Commission



## Population and Municipalities

The population of the Texas part of the Sabine River Basin was slightly more than 300,000 in 1960, which is about 3.2 percent of the total population of the State. The basin has no large cities; only two, Longview and Orange, had populations over 25,000 in 1960. Several cities have more than 5,000 inhabitants, and all have grown rapidly since 1940. Many of the people living in the cities have come from farms. In 1940 the great majority of the people in the Sabine River Basin lived on farms, but by 1960 more than half the inhabitants lived in cities and towns. Although the cities and towns have grown, the population of most of the counties has decreased slowly since 1940. Smith, Gregg, and Orange Counties are the only counties that have increased in population.

The principal cities of the Sabine River Basin in Texas and their populations are given below:

City	Population, 1960	City	Population, 1960
Longview	40,050	Gladewater	5,742
Orange	25,605	Carthage	5,262
Greenville	19,087	Center	4,510
Kilgore	10,092		

Marshall, Tyler, Henderson, and San Augustine are on stream divides, and are only partly within the Sabine River Basin. Marshall, on the divide between the Sabine River and Cypress Creek, had a population of 23,846 in 1960. Tyler, Henderson, and San Augustine, on the divide between the Sabine and Neches Rivers, had populations of 51,230, 9,666, and 2,584, respectively.

The principal cities in the Louisiana part of the Sabine River Basin are Mansfield, with a population of 5,839; Leesville, population 4,689; and Many, population 3,164.

## Agricultural and Industrial Development

Agriculture is important to the economy of the Sabine River Basin. The number of farms has decreased in the past 30 years, but the remaining farms are generally larger.

Corn, cotton, sorghums, rice, fruit, and truck-farm products are the principal crops. Corn, cotton, and sorghums are grown chiefly in the northern portion, but rice is grown only in the south. Fruit and truck-farm products are grown over the whole basin.

Beef cattle are raised throughout the basin, and dairy farming has increased as farm-to-market roads have been built and electric service has become available.

Many farms once engaged in diversified farming are now specializing in poultry raising. Center, in Shelby County, is in the heart of a large poultry-raising area, and has become a major poultry processing and shipping point. Hatcheries and feed mills are related industries.

The lumbering industry is another important segment of the economy of the Sabine River Basin. The central and southern portions of the basin are in the great tree-growing section of Texas, and at many places forest products are the major source of income. Many large and small sawmills are operated, and southern yellow pine and hardwood lumber are produced in large quantities. Forested acreage has increased as cropland has been allowed to grow over or has been planted with trees.

The production of oil has been of utmost importance to the economy of the basin. The development of the East Texas oil field began in 1930 with a discovery of oil west of Henderson. The field was soon extended to Kilgore, Longview, and Gladewater, and became the most productive field in the nation. Many other oil fields are in the basin, as shown in Figure 4. Kilgore, Longview, and Gladewater experienced rapid economic growth, as well as growth in population, as the result of oil activities. In addition to oil-field maintenance and production equipment businesses in these cities, the steel mills, manufacturing plants, fertilizer plants, feed and flour mills, and textile factories help form a broad economic base.

Natural gas production is also important in the Sabine River Basin. Carthage is in the center of the largest gas-producing area, which includes most of Panola County.

At Grand Saline, in Van Zandt County, one of the largest salt mines in the world is operated. Salt is removed from a salt dome by conventional shaft-and-tunnel methods. Large deposits of clay, lignite, and iron are found in the northern and north-central part of the basin, but these minerals have not been extensively developed.

Orange, the second largest city in the basin, is an industrial center near the mouth of the Sabine River, and is a port on the Sabine-Neches Waterway. In addition to shipping activities, Orange has chemical plants, rice mills, and other industries.

#### Surface-Water Resources Development

The average runoff in the Sabine River Basin is about 13 inches per year, and the Texas part of the basin contributes about 13 percent of the total runoff for the State (Figure 5). As the basin has less than 3 percent of the State's total area and only 3.2 percent of the population, the quantity of surface water available for development is considerably above the average for the State. Until recent years, the only water-development projects were comparatively small ones, built by cities and private businesses to provide water supplies for municipal and industrial use. Table 2 lists the capacity, owner, location, and use of the reservoirs in Texas with capacity of 5,000 acre-feet or more which were existing or under construction in January 1963.

Lake Tawakoni, on the Sabine River in Rains, Hunt, and Van Zandt Counties, was completed in 1960 and is the largest of the existing reservoirs. It is owned and operated by the Sabine River Authority of Texas, and will supply water for the cities of Greenville and Point in the Sabine River Basin and Dallas and Terrell in the Trinity River Basin. In return for paying a large share of the development costs, the city of Dallas acquired the right to 80 percent of the water, and a pipeline to Dallas was completed in 1963.

Figure 4  
Generalized Map of Oil Fields  
in the Sabine River Basin

U. S. Geological Survey in cooperation with  
the Texas Water Commission



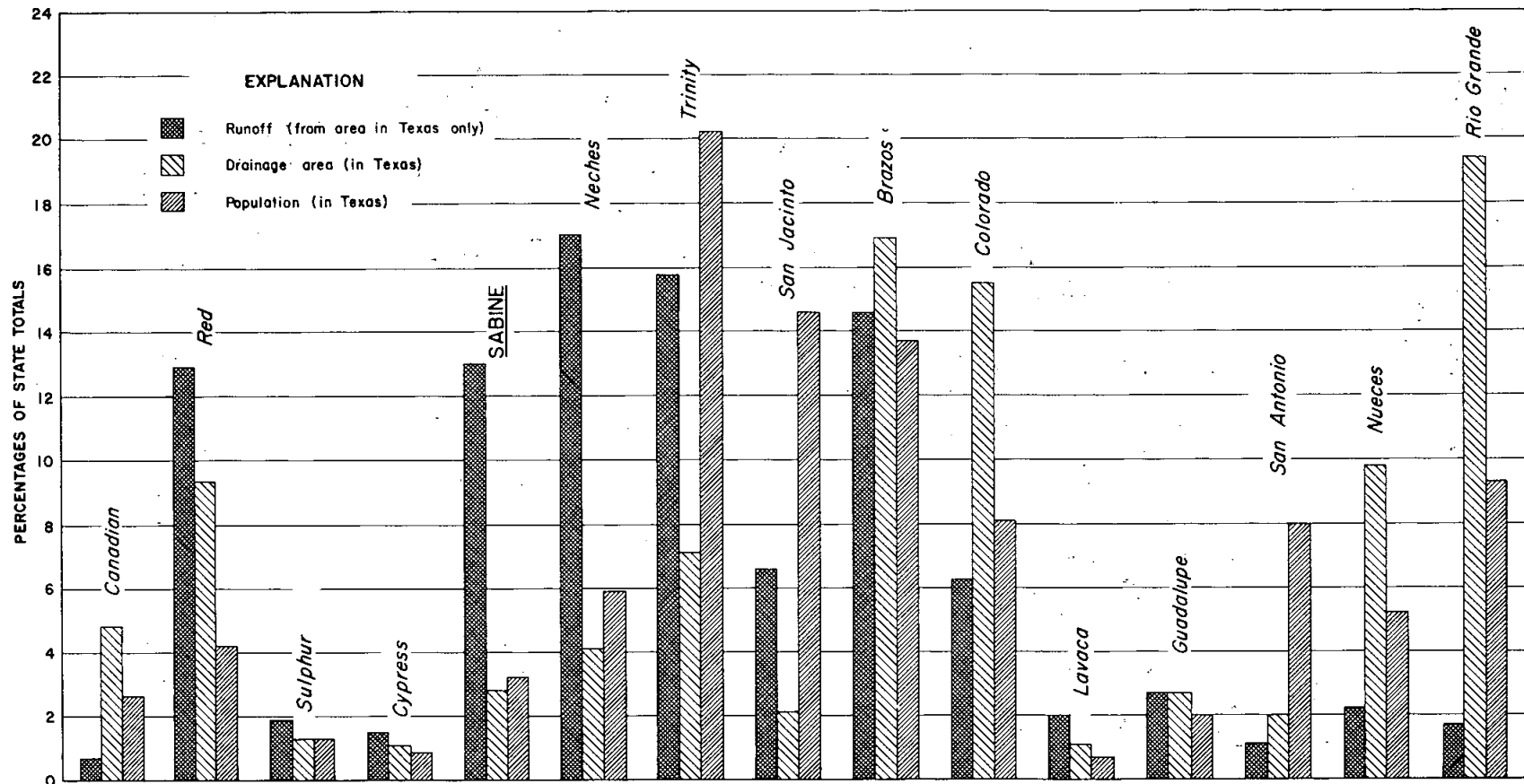


Figure 5  
Graph Showing Average Annual Runoff, Drainage Area, and 1960 Population of Major River Basins in Texas, as Percentages of State Totals

Adjacent coastal areas have been included in basin totals. (Data from Texas Water Commission.)

U. S. Geological Survey in cooperation with the Texas Water Commission

Table 2.--Reservoirs with capacity of 5,000 acre-feet or more in the Sabine River Basin in Texas completed or under construction on January 1, 1963

The purpose for which the impounded waters are used is indicated by the following symbols:  
M, municipal; I, industrial; Ir, irrigation; R, recreation; P, power.

Name of reservoir	Year operation began	Stream	Total storage capacity (acre-feet)	Owner	County	Use
Lake Tawakoni	1960	Sabine River	936,200	Sabine River Authority	Hunt, Rains, Van Zandt	M,I, Ir
Lake Holbrook	1962	Keys Creek	7,990	Wood County	Wood	R
Lake Quitman	1962	Dry Creek	7,440	do	do	R
Lake Hawkins	1962	Little Sandy Creek	10,340	do	do	R
Lake Winnsboro	1962	Big Sandy Creek	6,580	do	do	R
Lake Gladewater	1952	Glade Creek	6,950	City of Gladewater	Upshur	M
Lake Cherokee	1948	Cherokee Bayou	46,700	Cherokee Water Co. City of Longview	Gregg, Rusk	M,I, R
Murvaul Lake	1957	Murvaul Bayou	45,840	Panola County Fresh Water Supply District No. 1	Panola	M,I
Toledo Bend Reservoir	<sup>a/</sup>	Sabine River	<sup>b/</sup> 4,661,000	Sabine River Authority	Newton, Sabine, Shelby	M,I, Ir,P

<sup>a/</sup> Under construction.

<sup>b/</sup> Texas' share of total storage capacity is 2,330,500 acre-feet.

One of the oldest reservoirs in the Sabine River Basin is Greenville Reservoir No. 1. This reservoir was constructed on Cowleach Fork in 1888 to provide a water supply for the city of Greenville. Later Greenville built five additional reservoirs. Several more of the larger cities in the basin use impounded surface water for municipal supplies. Lake Cherokee in Gregg and Rusk Counties supplies part of the municipal water for Longview. Lake Gladewater (Figure 6) on Glade Creek in Upshur County supplies the city of Gladewater and Lake Center on Mill Creek in Shelby County supplies part of the municipal water for Center. Murvaul Lake will provide municipal and industrial water for Carthage and Panola County. The city of Marshall, which is partly in the Sabine and partly in the Cypress Basin, uses water from Caddo Lake on Cypress Creek. Several smaller towns that use surface-water reservoirs for public supplies include Grand Saline, Edgewood, Canton, Van, and Wills Point in Van Zandt County, and Caddo Mills in Hunt County.

In 1959, 74,770 acre-feet of water was used for municipal, industrial, and irrigation purposes in the Texas part of the Sabine River Basin. Of this total, 42,060 acre-feet was derived from surface-water sources. The 1980 municipal and industrial requirements are estimated by the Texas Water Commission (Texas Board of Water Engineers, 1961) to be 307,900 acre-feet, of which 298,000 acre-feet would be supplied from surface-water sources. Three new reservoirs were proposed in the Commission's plan to meet 1980 needs: Cherokee Reservoir No. 2 on Cherokee Bayou in Rusk County, Kilgore Reservoir on Wilds Creek in Smith County, and Toledo Bend Reservoir on the Sabine River in Shelby, Sabine, and Newton Counties. The Toledo Bend Reservoir, now under construction, is the largest water-development project planned in the basin. It is being built jointly by the States of Texas and Louisiana, and will supply water and hydroelectric power for both States. The dependable yield of Toledo Bend Reservoir is expected to exceed by a million acre-feet annually the estimated 1980 needs of the southern part of the basin.

Additional reservoirs have been considered in the Sabine River Authority's Master Plan to meet the water needs of the basin in the year 2010 (Sabine River Authority, 1960). In the northern part of the basin, Big Sandy Reservoir on Big Sandy Creek, Lake Fork Reservoir on Lake Fork Creek, and Rabbit Reservoir

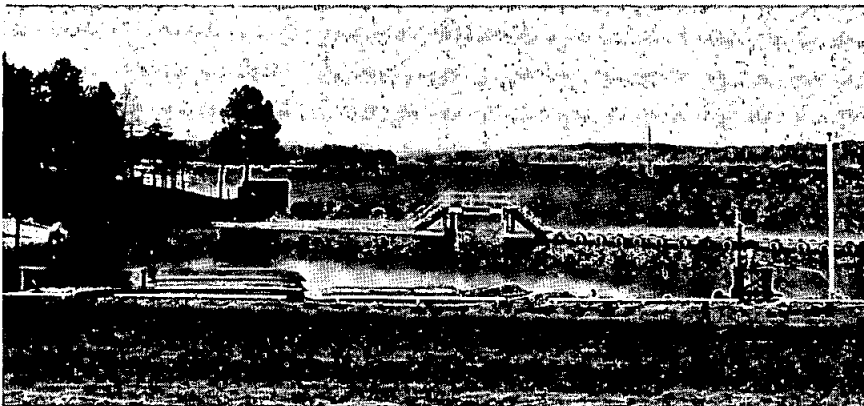


Figure 6.--View of Lake Gladewater,  
Upshur County, Texas

on Rabbit Creek would furnish the additional water needed. Carthage and State-line Reservoirs on the Sabine River in Panola County would supply the central part of the basin and Bon Weir Reservoir on the Sabine River in Newton County would supply the southern part of the basin.

Optimum development and use of the water resources of Texas may require the diversion of excess water from the Sabine River Basin to areas of water deficiency. The U. S. Bureau of Reclamation (1953) has a plan for the distribution of excess supplies by an aqueduct which would generally parallel the Gulf Coast. The aqueduct would be a part of an integrated system of inter-basin water exchange aimed at development of the full economic potential of water-deficient areas to the southwest along the Texas Gulf Coast. The Bureau's plan includes the construction of Tenaha Reservoir on Tenaha Bayou in Shelby County and Sabine Diversion Reservoir in Newton County (U. S. Bureau of Reclamation, written communication, 1963).

The capacities of all the proposed reservoirs are given in Table 3, and the locations are shown in Figure 7.

Boating, fishing, camping, and other water-related recreational activities have had phenomenal growth in Texas in recent years, and have been of great economic benefit to the areas surrounding reservoirs, especially where the reservoirs have been readily accessible to centers of population. Real estate development, the construction and operation of tourist facilities and fishing camps, boat sales and servicing, and general retail activities have grown rapidly as a result of reservoir construction. In the past, recreation was usually regarded as an incidental use for a reservoir that was built for other purposes. Now, however, it is considered a primary reason for water-resources development, and included in Table 2 are several reservoirs in the Sabine River Basin, built or under construction, for which recreation is cited as a principal use.

Anococo Lake, on Bayou Anacoco in Vernon Parish, is the only reservoir of significant size in the Sabine River Basin in Louisiana. It has a total capacity of 24,000 acre-feet, and was built for conservation and recreation purposes.

#### STREAMFLOW RECORDS

Streamflow records in the Sabine River Basin date from 1903, when the U. S. Weather Bureau installed a chain gage on the Sabine River at Logansport. The U. S. Geological Survey established a gaging station at Longview in 1904, and at Logansport in 1905. The two stations were operated through 1906, and re-established in 1923. For the periods 1903 to 1905 and 1907 to 1923 monthly records of discharge are available for Sabine River at Logansport, based on gage-height records obtained by the U. S. Weather Bureau. More than 20 years of continuous discharge records are available for several stations on the main stem of the Sabine River, and records for more than 10 years are available for many of the principal tributaries. In 1962 the U. S. Geological Survey in Texas operated 9 streamflow stations on the Sabine River and 10 stations on tributaries, 3 reservoir-content stations, and 26 low-flow partial-record stations. In addition, discharge measurements were made at other sites where samples were collected for chemical analysis.



Table 3.--Reservoirs proposed for construction in the Sabine River Basin, Texas

Name of reservoir	Stream	Total capacity (acre-feet)	County
-------------------	--------	----------------------------	--------

To Meet 1980 Requirements

Kilgore	Wilds Creek	16,270	Rusk
Cherokee No. 2	Cherokee Bayou	112,320	do
Toledo Bend <sup>a/</sup>	Sabine River	4,661,000	Newton, Sabine, Shelby
Sabine Diversion	do	35,000	Newton

To Meet 2010 Requirements

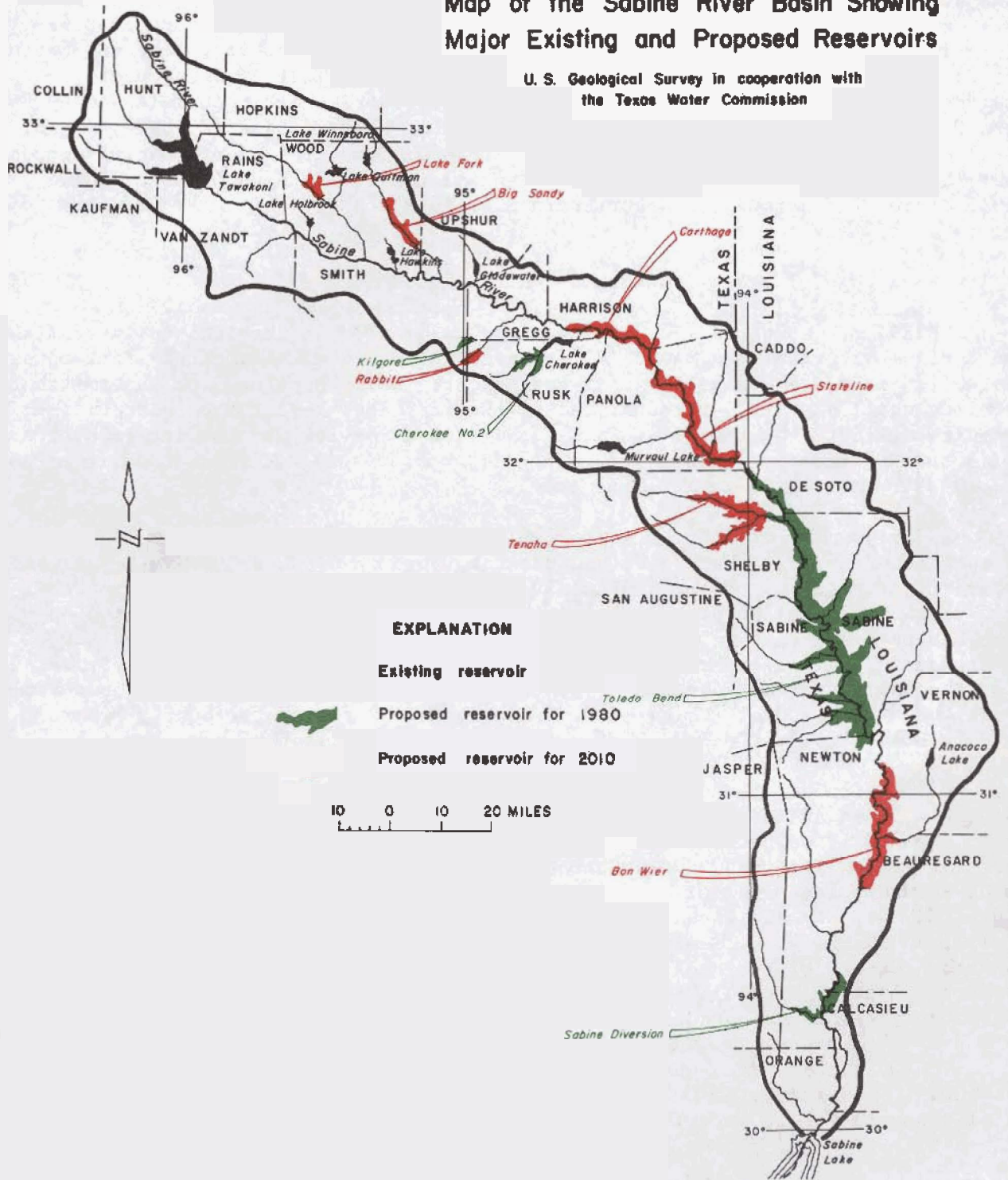
Lake Fork	Lake Fork Creek	526,000	Wood
Big Sandy	Big Sandy Creek	174,000	do
Rabbit	Rabbit Creek	18,000	Rusk
Carthage	Sabine River	652,000	Panola
Stateline	do	268,000	do
Bon Weir	do	354,000	Newton
Tenaha	Tenaha Bayou	900,000	Shelby

<sup>a/</sup> Under construction, 1963.

Figure 7

# Map of the Sabine River Basin Showing Major Existing and Proposed Reservoirs

U. S. Geological Survey in cooperation with the Texas Water Commission



In Louisiana, 12 streamflow stations and many low-flow and crest-stage partial-record stations are operated.

The periods of record for all the streamflow stations in Texas and Louisiana are given in Table 6, and the locations are shown in Plate 1. Records of discharge and stage of streams and contents and stage of lakes or reservoirs from 1903 to 1907 and from 1924 to 1960 have been published in the annual series of U. S. Geological Survey Water-Supply Papers. (See list of references.) Beginning with the 1961 water year, streamflow records have been released by the U. S. Geological Survey in annual reports on a State-boundary basis (U. S. Geological Survey, 1961a, 1961b, 1962a, 1962b). Summaries of discharge records have been published giving monthly and annual totals (U. S. Geological Survey, 1939, 1960; Texas Board of Water Engineers, 1958).

#### CHEMICAL-QUALITY RECORDS

The U. S. Geological Survey began the collection of chemical-quality data on surface waters of the Sabine River Basin in 1939 when a sampling station was established on the Sabine River at Logansport. Data, obtained for intermittent periods until August 1945, consisted of chemical analyses of the filtrate from samples collected by the U. S. Soil Conservation Service for the determination of suspended matter. Usually only specific conductance and chloride determinations were made on these filtered samples.

A daily sampling station was established near Ruliff in October 1945, was discontinued in September 1946, and reestablished in October 1947. The station near Ruliff, and one on the Sabine River near Tatum, established in February 1952, are still in operation. Daily sampling stations were also operated on the Sabine River near Emory from July 1952 to September 1954 and on Cow Bayou near Mauriceville from March 1952 to December 1955. The chemical-quality data for the daily stations are summarized in Table 7, and the complete records are published in an annual series of U. S. Geological Survey Water-Supply Papers and in Bulletins of the Texas Water Commission. (See list of references.)

Collection of chemical-quality data for the Sabine River Basin reconnaissance study began in 1961. Two to twelve samples were collected and analyzed from each of 17 tributary streams and 5 reservoirs. Most of the sampling sites were at gaging stations, and at other sites discharge measurements were usually made when samples were collected. Single samples were also collected during the study at many additional sites. Numerous miscellaneous samples have been collected by the U. S. Geological Survey in the Sabine River Basin since 1940, and the results of the analyses of these samples have been included in this report. Analyses for all the periodic and miscellaneous samples collected from streams in the Texas part of the basin are given in Table 8.

In Louisiana, water-quality data have been collected for the principal tributaries by the U. S. Geological Survey in cooperation with the Louisiana Department of Public Works. The analyses of streams in Louisiana are given in Table 9.

The locations of all the sampling sites for which analyses are given are shown in Plate 1.

The Water Pollution Control Division of the Texas State Department of Health since 1957 has had a statewide stream-sampling program, which has

included the collection of data at 15 sites in the Sabine River Basin--12 on the main stem and 3 on tributaries. The analyses have included the determination of pH, biochemical oxygen demand, total solids, dissolved oxygen, chloride, chlorine demand, and sulfate. Data from this program were made available to the U. S. Geological Survey and have been studied during the preparation of this report. The State Department of Health data-collection sites are listed below. Most of them are at U. S. Geological Survey gaging stations, and the numbers below refer to locations shown in Plate 1.

Reference no.	Data-collection site
6	Sabine River near Emory
12	Sabine River near Mineola
20	Lake Fork Creek near Quitman
--	Sabine River near Big Sandy
21	Big Sandy Creek near Big Sandy
22	Sabine River near Gladewater
24	Sabine River near Longview
31	Sabine River near Tatum
42	Sabine River at Logansport
68	Sabine River near Milam
83	Sabine River below Toledo Bend near Burkeville
99	Sabine River near Bon Weir
121	Sabine River near Ruliff
--	Sabine River at Orange
122	Cow Bayou near Mauriceville

#### RELATION OF QUALITY OF WATER TO USE

Quality-of-water studies usually are concerned with the suitability of the water for a proposed use, judged by the chemical, physical, and sanitary characteristics of the water. In the Sabine River Basin, surface water is being used, and developments are planned, primarily for municipal and industrial use. Water of suitable quality for public supply will be satisfactory also for irrigation and recreation purposes.

This report considers principally the chemical character of the water and its relation to the principal types of utilization. Other water-quality considerations, including color, turbidity, taste, and presence of microorganisms and organic substances, are not considered in this report.

Most mineral matter dissolved in water is in the form of ions. An ion is an atom or group of atoms having an electrical charge. Principal cations (positive charge) found in natural waters are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and iron (Fe). The principal anions (negative charge) are carbonate (CO<sub>3</sub>), bicarbonate (HCO<sub>3</sub>), sulfate (SO<sub>4</sub>), chloride (Cl), fluoride (F), and nitrate (NO<sub>3</sub>). Other constituents and properties are often determined to aid in the definition of the chemical and physical quality of water. Table 4 lists constituents and properties determined by the U. S. Geological Survey, and includes a resume of their sources and significance.

Table 4.--Source and significance of dissolved mineral constituents and properties of water

Constituent or property	Source or cause	Significance
Silica (SiO <sub>2</sub> )	Dissolved from practically all rocks and soils, commonly less than 30 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 ppm of iron in surface waters generally indicate acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 ppm stain laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. USPHS (1962) drinking-water standards state that iron should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and Magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (See hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and Potassium (K)	Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium content may limit the use of water for irrigation.
Bicarbonate (HCO <sub>3</sub> ) and Carbonate (CO <sub>3</sub> )	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon-dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.
Sulfate (SO <sub>4</sub> )	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. USPHS (1962) drinking-water standards recommend that the sulfate content should not exceed 250 ppm.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. USPHS (1962) drinking-water standards recommend that the chloride content should not exceed 250 ppm.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual. (Maier, F. J., 1950, Fluoridation of public water supplies, Jour. Am. Water Works Assoc., vol. 42, part 1, p. 1120-1132.)
Nitrate (NO <sub>3</sub> )	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution, USPHS (1962) drinking-water standards suggest a limit of 45 ppm. Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing inter-crystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes some water of crystallization.	USPHS (1962) drinking-water standards recommend that waters containing more than 500 ppm dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 ppm dissolved solids are unsuitable for many purposes.
Hardness as CaCO <sub>3</sub>	In most waters nearly all the hardness is due to calcium and magnesium. All of the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness up to 60 ppm are considered soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; more than 180 ppm, very hard.
Specific conductance (micromhos at 25° C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
Hydrogen ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

## Domestic Purposes

The safe limits for the mineral components usually found in water vary with individuals, with different amounts of water used, and with other factors. The limits usually quoted in the United States for drinking water are based on the United States Public Health Service drinking-water standards. These standards were established first in 1914 to control the quality of water used on interstate carriers for drinking and for culinary purposes. They have been revised several times; the latest revision was in 1962 (U. S. Public Health Service, 1962). These standards have been endorsed by the American Water Works Association as minimum standards for all public water supplies.

The limits specified by the drinking-water standards for the various constituents are included in the statements under "significance" in Table 4. The concentration of fluoride, in ppm (parts per million), should not average more than the appropriate upper limit in the following table:

Annual average of maximum daily air temperatures (°F) <sup>1/</sup>	Recommended control limits (Fluoride concentrations in ppm)		
	Lower	Optimum	Upper
50.0 - 53.7	0.9	1.2	1.7
53.8 - 58.3	.8	1.1	1.5
58.4 - 63.8	.8	1.0	1.3
63.9 - 70.6	.7	.9	1.2
70.7 - 79.2	.7	.8	1.0
79.3 - 90.5	.6	.7	.8

<sup>1/</sup> Based on temperature data obtained for a minimum of 5 years.

## Irrigation

The chemical composition of a water supply is an important factor in evaluating its usefulness for irrigation. The extent to which chemical quality limits the suitability of a water depends on a number of factors. These include the nature and composition of the soil and subsoil, the topography of the land, the amounts of water used and methods of applying it, the kind of crops grown, and the climate of the region, including the amounts and distribution of rainfall.

The characteristics of an irrigation water that are most important in determining its quality, according to the U. S. Salinity Laboratory Staff (1954, p. 69) are: (1) total concentration of soluble salts, (2) relative proportion of sodium to other cations, (3) concentration of boron or other elements that may be toxic, and (4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium.

The U. S. Salinity Laboratory Staff introduced the term "sodium adsorption ratio" (SAR) to express the relative activity of sodium ions in exchange reactions with the soil. This ratio is expressed by the equation:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}},$$

where the concentrations of the ions are expressed in equivalents per million.

The U. S. Salinity Laboratory Staff has prepared a system for classifying irrigation waters in terms of salinity and sodium hazards. Empirical equations were used in developing a diagram which uses SAR and specific conductance in evaluating irrigation water. The diagram is reproduced in modified form as Figure 8. Although the classification embodies both research and field observations, it is tentative and should be used for general guidance only.

With respect to salinity hazard, waters are divided into four classes: low salinity, medium salinity, high salinity, and very high salinity; the dividing points between classes are 250, 750, and 2,250 micromhos per centimeter. They range from water that can be used for irrigation of most crops on most soils to that which is not usually suitable for irrigation.

Waters are divided into four classes with respect to sodium or alkali hazard: low, medium, high, and very high, depending on the SAR value and the specific conductance. The classification covers waters that range from those which can be used for irrigation on almost all soils to those which are generally unsatisfactory for irrigation.

Representative data from analyses of water from three reservoirs and the Sabine River at the chemical-quality stations near Tatum and near Ruliff are plotted on Figure 8. For the river stations the percentage of time that the specific conductance exceeded the indicated value during the period 1953 to 1962 is shown. The data show that the water of the Sabine River Basin generally is low with respect to salinity and sodium hazards.

The principal use of surface water for irrigation in the Sabine River Basin in Texas is for growing rice in the lower part of the basin. The concentration of chemical constituents tolerated by rice varies with the stage of growth, but investigators generally agree that water containing less than 600 ppm of sodium chloride (350 ppm of chloride) is not harmful to rice at any stage of growth (Ireland, 1956, p. 330). Water of the Sabine River Basin, except at a few points where gross pollution occurs, meets all quality requirements for rice irrigation.

Surface water is also used for supplemental irrigation of field crops and truck gardens, principally in the upper half of the basin. For supplemental irrigation in humid and subhumid areas, water-quality requirements are not rigid; water of the Sabine River and its tributaries would generally be classified as excellent for irrigation.

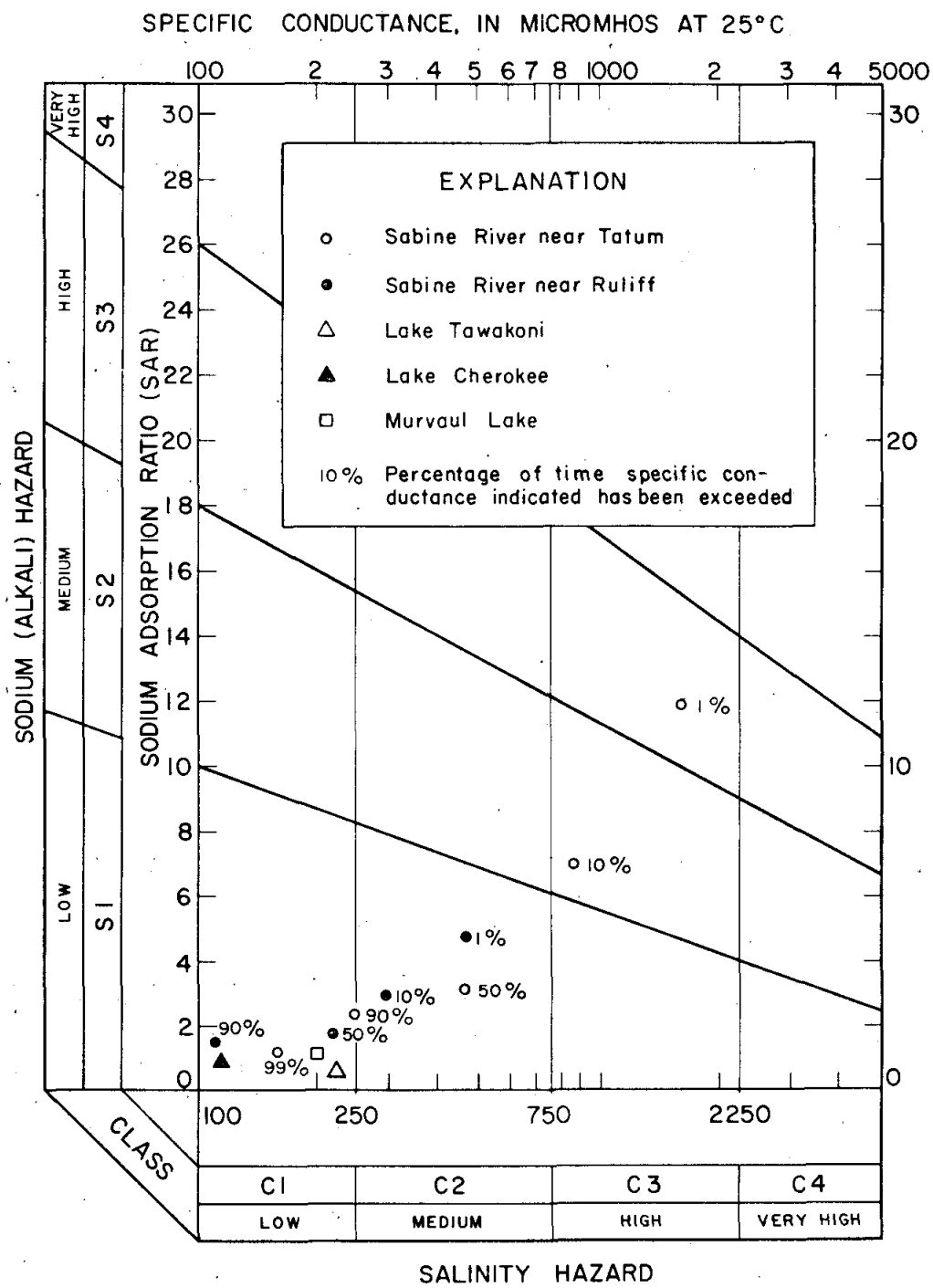


Figure 8  
**Diagram for Classification of Irrigation Waters, Sabine River Basin**  
 (Adapted from U. S. Salinity Laboratory Staff, 1954, p.80)

U. S. Geological Survey in cooperation with the  
 Texas Water Commission



## Industrial Use

Industry is one of the major water users in the Sabine River Basin; the economic feasibility of a water-development project may depend on the acceptability of the water for industrial use.

The quality requirements for industrial water vary widely from industry to industry. For some purposes, such as cooling, water of almost any quality can be used, while in some manufacturing processes and in high-pressure steam boilers water approaching the quality of distilled water may be required. The requirements of water quality for many types of industry and processes are given in Table 5.

Hardness is a property which receives great attention in industrial water supplies. It is objectionable because of the formation of scale in boilers, pipes, water heaters, and radiators, with the resultant loss in heat transfer, boiler failure, and loss of flow. However, calcium carbonate sometimes forms protective coatings on pipe and other equipment, thus reducing corrosion. A certain amount of calcium salts is desirable in water used by the brewing industry.

High dissolved-solids concentration may be closely associated with the corrosive property of a water, particularly if chloride is present in appreciable quantities. Water containing high concentrations of magnesium chloride may be very corrosive because the hydrolysis of this unstable salt yields hydrochloric acid.

## Recreation

The use of waters for recreation, including swimming, boating, and fishing, is an increasingly valuable bonus associated with the development of surface-water resources for municipal and industrial supplies.

Waters used for swimming and bathing should be reasonably free from pathogenic organisms and should be esthetically enjoyable, being free from objectionable floating or suspended substances and free of foul tastes and odors. They should contain no substance which is toxic on ingestion or is irritating to the skin. Water used for boating and associated water sports should meet these same requirements, because the users are subjected to sprays and other contact with the water.

Probably the greatest recreational use of water is for fishing. Although there is considerable published material on the effect of water quality on fish life, limits have not been established for a multitude of elements and compounds which may be toxic to fish. Recent research indicates that fish are extremely sensitive to certain insecticides and commercial poisons.

## FACTORS AFFECTING CHEMICAL QUALITY OF WATER

The kinds and quantities of minerals dissolved in surface water are the result of a number of environmental factors, including geology, patterns and characteristics of streamflow, and cultural influences.

Table 5.--Water-quality tolerances for industrial applications<sup>1/</sup>

(Allowable limits in parts per million except as indicated)

Industry	Turbidity	Color	Color + O <sub>2</sub> consumed	D.C. (ml/l)	Odor	Hardness	Alkalinity (as CaCO <sub>3</sub> )	pH	Total solids	Ca	Fe	Mn	Fe + Mn	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Cu	F	CO <sub>3</sub>	HCO <sub>3</sub>	OH	CaSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub> to Na <sub>2</sub> SO <sub>3</sub> ratio	General <sup>2/</sup>
Air conditioning <sup>3/</sup>	--	--	--	--	--	--	--	--	--	--	0.5	0.5	0.5	--	--	--	--	--	--	--	--	--	A, B
Baking-----	10	10	--	--	--	(4)	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	C
Boiler feed:																							
0-150 psi-----	20	80	100	2	--	75	--	8.0+	3,000-1,000	--	--	--	--	5	40	--	200	50	50	--	--	1 to 1	--
150-250 psi-----	10	40	50	.2	--	40	--	8.5+	2,500-500	--	--	--	--	.5	20	--	100	30	40	--	--	2 to 1	--
250 psi and up-----	5	5	10	0	--	8	--	9.0+	1,500-100	--	--	--	--	.05	5	--	40	5	30	--	--	3 to 1	--
Brewing: <sup>5/</sup>																							
Light-----	10	--	--	--	Low	--	75	6.5-7.0	500	100-200	.1	.1	.1	--	--	--	1	--	--	--	100-200	--	C, D
Dark-----	10	--	--	--	Low	--	150	7.0 →	1,000	200-500	.1	.1	.1	--	--	--	1	--	--	--	200-500	--	C, D
Canning:																							
Legumes-----	10	--	--	--	Low	25-75	--	--	--	--	.2	.2	.2	--	--	--	1	--	--	--	--	--	C
General-----	10	--	--	--	Low	--	--	--	--	--	.2	.2	.2	--	--	--	1	--	--	--	--	--	C
Carbonated beverages <sup>6/</sup>	2	10	10	--	0	250	50	--	850	--	.2	.2	.3	--	--	--	.2	--	--	--	--	--	C
Confectionary-----	--	--	--	--	Low	--	--	(7)	100	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	A, B
Cooling <sup>8/</sup>	50	--	--	--	--	50	--	--	--	--	.5	.5	.5	--	--	--	--	--	--	--	--	--	C
Food, general-----	10	--	--	--	Low	--	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	C
Ice (raw water) <sup>9/</sup>	1-5	5	--	--	--	--	30-50	--	300	--	.2	.2	.2	--	10	--	--	--	--	--	--	--	C
Laundering-----	--	--	--	--	--	50	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--
Plastics, clear, undercolored-----	2	2	--	--	--	--	--	--	200	--	.02	.02	.02	--	--	--	--	--	--	--	--	--	--
Paper and pulp: <sup>10/</sup>																							
Groundwood-----	50	20	--	--	--	180	--	--	--	--	1.0	.5	1.0	--	--	--	--	--	--	--	--	--	A
Kraft pulp-----	25	15	--	--	--	100	--	--	300	--	.2	.1	.2	--	--	--	--	--	--	--	--	--	--
Soda and sulfite-----	15	10	--	--	--	100	--	--	200	--	.1	.05	.1	--	--	--	--	--	--	--	--	--	--
Light paper, HL-Grade-----	5	5	--	--	--	50	--	--	200	--	.1	.05	.1	--	--	--	--	--	--	--	--	--	B
Rayon (viscose) pulp:																							
Production-----	5	5	--	--	--	8	50	--	100	--	.05	.03	.05	<8.0	<25	<5	--	--	--	--	--	--	--
Manufacture-----	5	--	--	--	--	55	--	7.8-8.3	--	--	.0	.0	.0	--	--	--	--	--	--	--	--	--	--
Tanning <sup>11/</sup>	20	10-100	--	--	--	50-135	135	8.0	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--
Textiles:																							
General-----	5	20	--	--	--	20	--	--	--	--	.25	.25	--	--	--	--	--	--	--	--	--	--	--
Dyeing <sup>12/</sup>	5	5-20	--	--	--	20	--	--	--	--	.25	.25	.25	--	--	--	--	--	--	--	--	--	--
Wool scouring <sup>13/</sup>	--	70	--	--	--	20	--	--	--	--	1.0	1.0	1.0	--	--	--	--	--	--	--	--	--	--
Cotton bandage <sup>13/</sup>	5	5	--	--	Low	20	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--

1 American Water Works Association, 1950.

2 A--No corrosiveness; B--No slime formation; C--Conformance to Federal drinking water standards necessary; D--NaCl, 275 ppm.

3 Waters with algae and hydrogen sulfide odors are most unsuitable for air conditioning.

4 Some hardness desirable.

5 Water for distilling must meet the same general requirements as for brewing (gin and spirits mashing water of light-beer quality; whiskey mashing water of dark-beer quality).

6 Clear, odorless, sterile water for syrup and carbonization. Water consistent in character. Most high quality filtered municipal water not satisfactory for beverages.

7 Hard candy requires pH of 7.0 or greater, as low value favors inversion of sucrose, causing sticky product.

8 Control of corrosiveness is necessary as is also control of organisms, such as sulfur and iron bacteria, which tend to form slimes.

9 Ca(HCO<sub>3</sub>)<sub>2</sub> particularly troublesome. Mg(HCO<sub>3</sub>)<sub>2</sub> tends to greenish color. CO<sub>2</sub> assists to prevent cracking. Sulfates and chlorides of Ca, Mg, Na should each be less than 300 ppm (white butts).

10 Uniformity of composition and temperature desirable. Iron objectionable as cellulose adsorbs iron from dilute solutions. Manganese very objectionable, clogs pipelines and is oxidized to permanganates by chlorine, causing reddish color.

11 Excessive iron, manganese or turbidity creates spots and discoloration in tanning of hides and leather goods.

12 Constant composition; residual alumina 0.5 ppm.

13 Calcium, magnesium, iron, manganese, suspended matter, and soluble organic matter may be objectionable.

## Geology

In areas where cultural influences are small the amount of dissolved solids carried by streams depends principally on the types of rocks and soils in the drainage basin. The physical and chemical properties of the rocks and soils depend not only on the environment in which the rocks were formed but also on the post-depositional environment. In some areas of high rainfall, rocks that originally contained large quantities of easily soluble minerals have been leached by circulating water until the mantle rock and residual soil contain relatively small amounts of readily soluble minerals. Conversely, in arid or semiarid regions the rocks and soils may contain large amounts of soluble material. Surface rocks and soils of the Sabine River Basin have been leached as a result of high rainfall, and over much of the basin the dissolved-mineral content of surface runoff and ground-water inflow is exceptionally low.

The relation of the geology to the concentration of the various dissolved constituents in the water of the Sabine River Basin is discussed later in the section "Chemical quality of the water."

## Streamflow

The patterns and characteristics of streamflow usually affect the chemical character of the water in streams. Water discharge of any stream not regulated by upstream reservoirs varies from day to day and even from hour to hour. The variation may be large, such as for streams that flow mostly in response to storms, or small, if the flow is mostly from ground water. Usually the dissolved-solids concentration of the water is highest during periods of low flow, when the flow is mostly from ground water that has been in contact with rock and soil particles for a sufficient time to dissolve part of the soluble minerals, and lowest when the flow is from flood runoff. The effect of rates of streamflow on the dissolved-solids concentration of streams is usually greatest in streams whose low-flow waters have high concentrations of dissolved solids.

In the Sabine River Basin the water in streams is derived mostly from surface runoff, but review of streamflow records shows that the base flow of many streams is maintained by ground-water inflow. In much of the basin the ground water reaching the streams is low in dissolved material because heavy rainfall has already leached the soluble minerals from the exposed rocks and soils. Therefore, in many of the streams the dissolved-solids concentration varies only slightly with changes in water discharge. Figure 9 shows the relation of the concentration of dissolved solids to water discharge in three tributary streams. Palo Gaucho Bayou and Martin Creek have dissolved-solids concentrations less than 100 ppm even at lowest rates of discharge, and at floodflows have only slightly lower concentrations. Lake Fork Creek shows evidence of pollution. During periods of low flow, dissolved-solids concentrations have ranged widely indicating that pollution occurs intermittently. During periods of high flow, the effects of pollution are minimized as surface runoff of low concentration dilutes the small quantities of more saline waters. Samples of low flow, collected soon after high flow has subsided, have also contained low concentrations of dissolved solids.

Figure 10 shows the relation of the annual weighted-average concentration of dissolved solids to the annual mean discharge of the Sabine River near Tatum and near Ruliff. The plots for both stations show decreases in dissolved solids

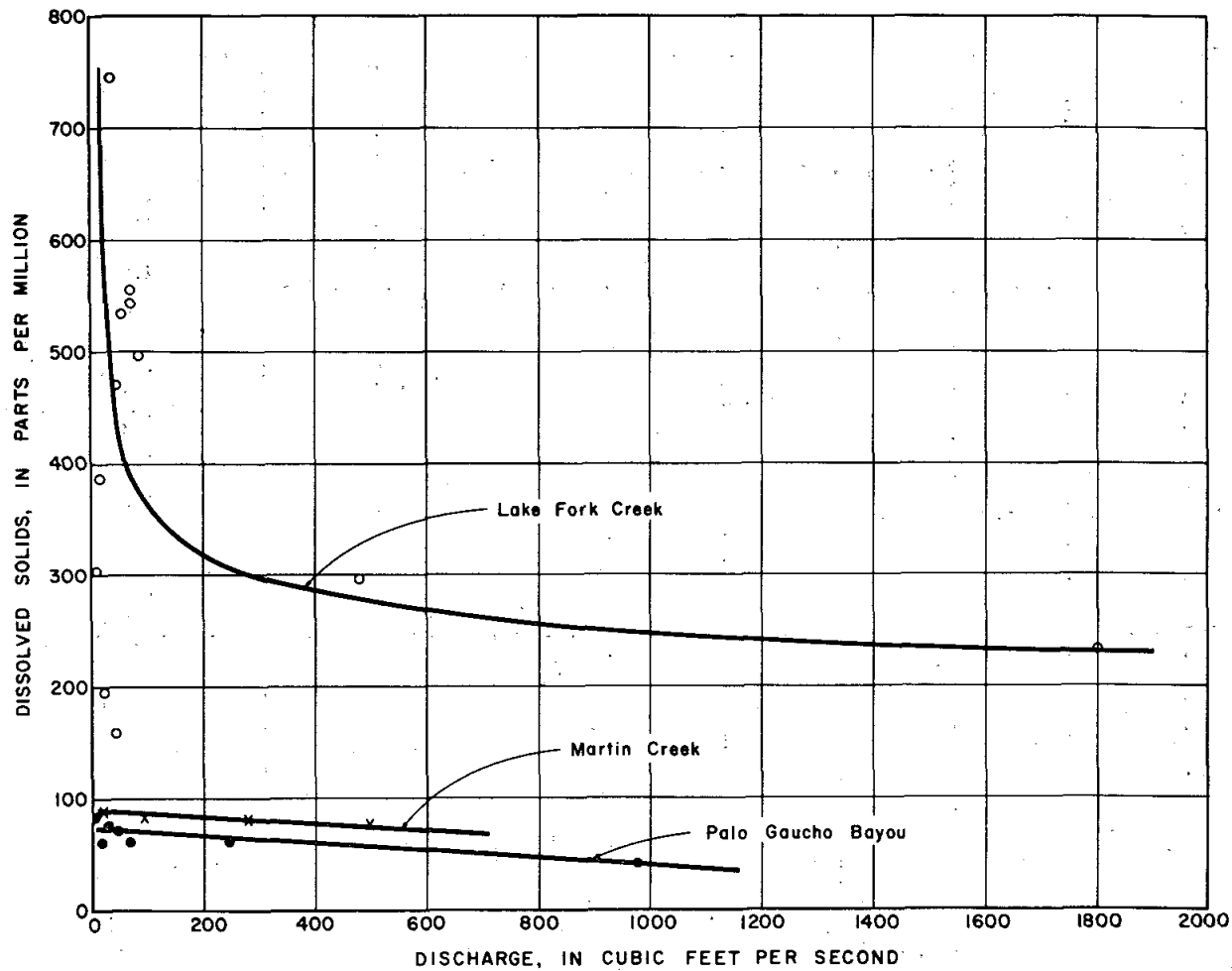


Figure 9  
Graph Showing Relation of Concentration of Dissolved Solids to Water Discharge  
in Three Tributaries of the Sabine River

U. S. Geological Survey in cooperation with the  
Texas Water Commission

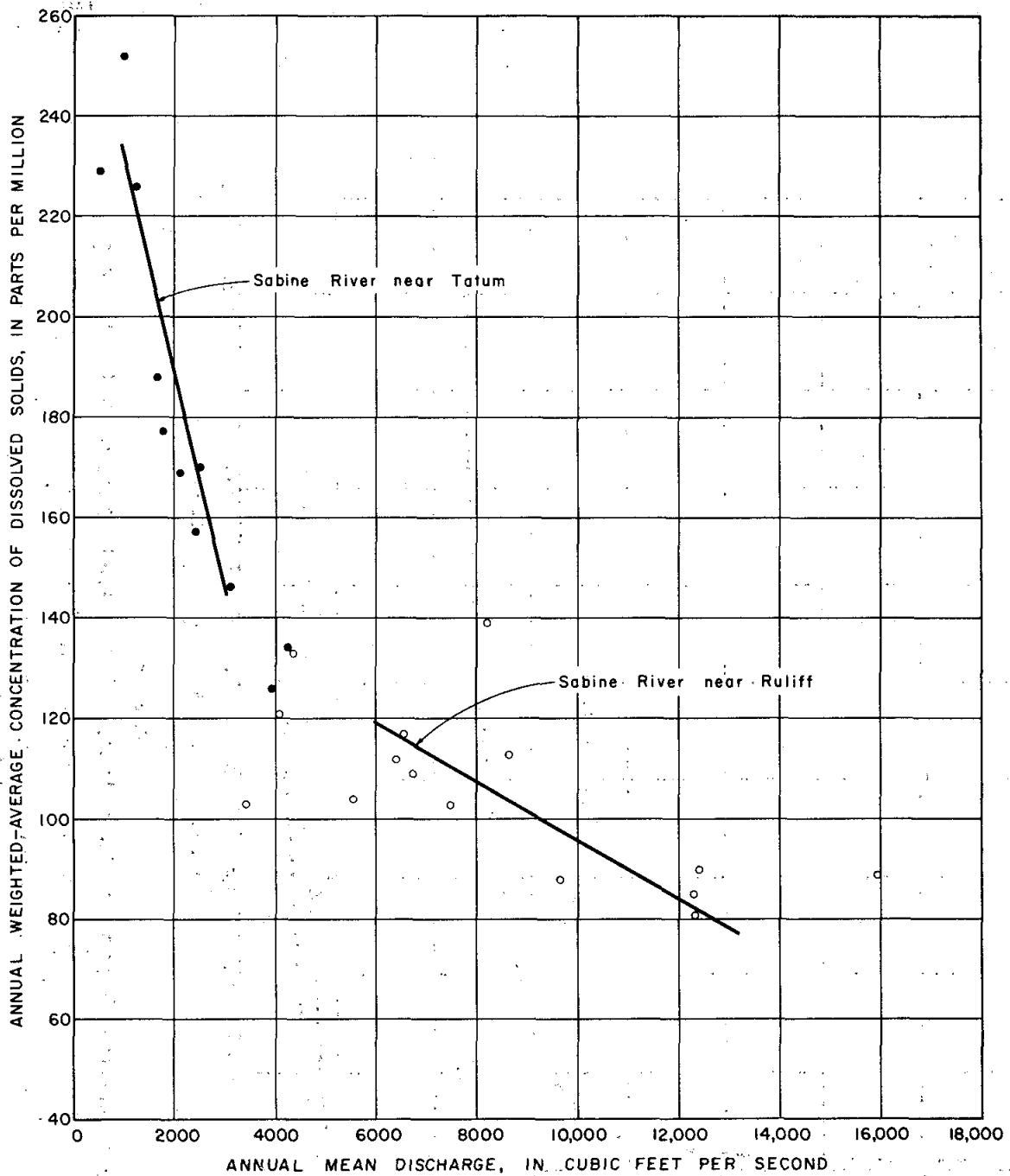


Figure 10  
 Graph Showing Relation of Annual Weighted-Average Concentration of  
 Dissolved Solids to Annual Water Discharge, Sabine  
 River near Tatum and near Ruliff, Texas

U. S. Geological Survey in cooperation with the Texas Water Commission

with increases in discharge, but the effect is much greater at Tatum. That part of the basin above Tatum has the lowest rainfall, and the dissolved-solids concentrations of the water vary over a wide range. The quality of water at the Ruliff station shows the effect of inflow from the high-rainfall area where dissolved solids are always low and subject to only slight variations.

### Cultural Influences

The activities of man often have a significant effect on the chemical quality of surface water. The disposition of oil-field brines and municipal and industrial wastes and the depletion of streamflow by diversion for municipal and industrial uses all produce changes in water quality.

Brine is produced in nearly all oil fields, and if improperly handled, eventually reaches the streams. The composition of oil-field brines varies, but the principal chemical constituents, in order of magnitude of their concentrations (in ppm), are generally chloride, sodium, calcium, and sulfate. Pollution of the surface streams by oil-field brines can be a major problem in areas where oil production is extensive. Although oil is produced in many areas in the Sabine River Basin (Figure 4), most of the brine is reinjected into wells, and so the pollution of surface water has been kept at a low level. Some brines appear to be reaching the surface waters in the Lake Fork Creek and Socagee Creek sub-basins and causing deterioration of water quality in these streams. The effect on the main stem of the Sabine River has been minor.

Injected brine may sometimes move upward along fault zones or as a result of leakage into other wells, thus polluting fresh ground water, and even eventually reaching the surface. Pollution of fresh ground water in city wells at Hawkins, in Wood County, has been reported (Burnitt, 1963).

Municipal use of water tends to increase the concentration of dissolved solids in a stream system. The depletion of flow by diversion and consumptive use, the loss of water because of increased evaporation, and the disposal of municipal wastes into a stream result in higher average concentrations of dissolved solids in the remaining water. The municipal use of water from the Sabine River has caused only local changes in water quality. There are no large diversions downstream from Lake Tawakoni and the flow is adequate to dilute the municipal wastes that are introduced.

The diversion of the water of Lake Tawakoni from the Sabine River Basin will have little effect on the average quality of the main stem of the Sabine River. The quantity of water diverted is small in comparison to the total flow of the Sabine, and the dissolved-solids content of the water to be diverted is near the average for the basin as a whole.

### CHEMICAL QUALITY OF THE WATER

Surface water of the Sabine River Basin generally is of good chemical quality, meeting U. S. Public Health Service drinking-water standards. Variations in concentrations of dissolved constituents are influenced principally by the geology of the runoff area and by cultural influences, but also by rainfall and streamflow characteristics.

The geographic variations of dissolved solids, hardness, and chloride are shown in the maps on Plate 2. These maps are based on the discharge-weighted-average concentrations, as estimated from all available chemical-quality records. All the streams will at times have concentrations exceeding those shown for their respective areas, but the averages shown on the maps are indicative of the type of water that would be stored in reservoirs. For many of the streams the data were limited, particularly on the chemical quality of flood-flows, and the boundaries of the areas are necessarily generalized. Comparison of these maps with the geologic map (Figure 2) shows that the quality of the water contributed by the different sections of the basin is related to the surface geology.

### Dissolved Solids

The concentration of dissolved solids in surface water of the Sabine River Basin is generally less than 250 ppm (Plate 2). Water from the outcrop areas of the Taylor Marl and the Navarro Group, the Midway and Wilcox Groups, and the older formations of the Claiborne Group, generally has dissolved-solids concentrations ranging from 100 to 250 ppm. Water from the outcrops of younger formations has concentrations less than 100 ppm. Exceptions to these general relationships were observed in two areas (Lake Fork and Socagee Creek sub-basins) where dissolved-solids concentrations are higher than 250 ppm, apparently because of oil-field pollution.

One area where natural pollution of surface water is occurring is at Grand Saline, in Van Zandt County. Here a salt dome lying close beneath the surface is overlain by a salt flat, or "saline" (Figure 11). A small flow of highly saline ground water emerges here and flows from the flat into Grand Saline Creek. A sample of the brine in one of the small streams draining the flat contained 39,200 ppm chloride and 66,200 ppm dissolved solids. Comparison of the chloride content of Grand Saline Creek at sites above and below the salt flat indicates that in February 1963 the brine effluent was contributing about 25 tons of chloride per day to the creek and thence to the Sabine River. (See analyses for sites 8, 9, and 10 in Table 8.)



Figure 11.--View of Salt Flat at Grand Saline,  
Van Zandt County, Texas

The discharge-weighted average concentration of dissolved solids in the main stem of the Sabine River falls within the 101-250 ppm range throughout most of the river's length. For the 10-year period from October 1952 to September 1962, for which concurrent records are available, the weighted-average concentrations at Tatum and Ruliff were 161 and 96 ppm, respectively. The analyses showing annual maximum and minimum dissolved-solids concentrations and the annual weighted averages for the daily sampling stations are given in Table 7.

Time-weighted averages are much higher than discharge-weighted averages. Duration curves for concentrations of dissolved solids for the Tatum and Ruliff stations, given in Figure 12, show that at Tatum 260 ppm dissolved solids has been equaled or exceeded 50 percent of the time, and at Ruliff 120 ppm has been equaled or exceeded 50 percent of the time. After Toledo Bend Reservoir is completed and in operation, the water at Ruliff will be more uniform in quality, and will seldom exceed 150 ppm in dissolved-solids concentration.

### Hardness

Surface water of much of the Sabine River Basin is soft, having less than 60 ppm hardness (Plate 2). In the southern one-third of the basin the water is very soft, with less than 30 ppm hardness.

Water draining from the northwest end of the basin, where limestone, chalk, and marl of Cretaceous age crop out, is moderately hard (61 to 120 ppm). The principal dissolved constituents in the water from this area are calcium and bicarbonate, as shown by the analyses for Greenville Reservoir and Lake Tawakoni (sites 1 and 5 in Table 8).

Hard water is typical of the Grand Saline and Lake Fork Creek sub-basins where natural and man-made pollution is occurring.

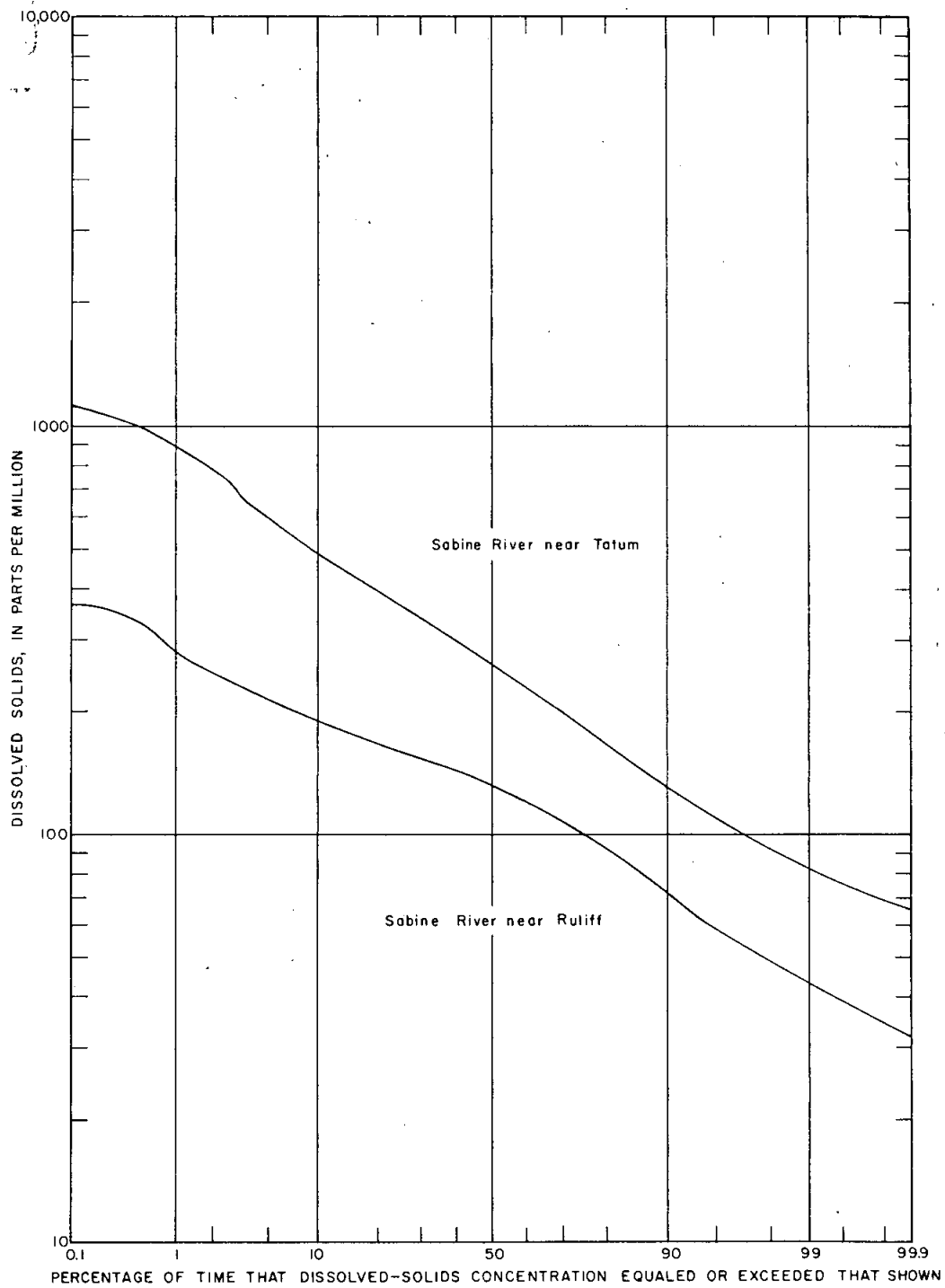
Water of the upper one-third of the length of the main stem of the Sabine River is moderately hard. Inflow of softer water in the lower part of the basin decreases the hardness to less than 30 ppm (very soft) at the Ruliff station.

Nearly all the hardness of the water of the basin is due to calcium and magnesium. In the moderately hard water draining from the area where Cretaceous rocks crop out, calcium is present in a ratio of about 8 parts to one of magnesium, whereas in the softer waters the ratio may be less than 2 to 1.

### Chloride

The chloride concentration is less than 20 ppm in surface water from about two-thirds of the Sabine River Basin (Plate 2). Low-chloride water is in streams draining areas where rocks of the Taylor Marl, Navarro Group, and Midway Group crop out at the upper end of the basin, areas where rocks of the Claiborne Group crop out in the north-central part, and the entire southern half of the basin, which is underlain by Quaternary and upper Tertiary rocks. Water containing 21 to 100 ppm chloride is typical of streams draining areas underlain by rocks of the Wilcox Group and the older formations of the Claiborne Group. Chloride concentrations exceeding 100 ppm occur in water of Lake Fork and Socagee Creeks which drain oil fields. The relation of oil fields to the chloride concentration in the water of Socagee Creek was not determined in this





**Figure 12**  
**Duration Curves for Dissolved Solids for Sabine River near**  
**Tatum and near Ruliff, Texas, Water Years 1953-62**

U. S. Geological Survey in cooperation with the  
 Texas Water Commission

study, but in the Lake Fork Creek sub-basin, streams draining the Quitman oil field were found to have chloride concentrations as high as 1,020 ppm (sites 18 and 19 in Table 8). Water draining from the salt flat at Grand Saline contained 39,200 ppm chloride on February 26, 1963; this inflow of high-chloride water raised the chloride concentration of base flow of Grand Saline Creek downstream from the salt flat to 1,350 and 1,200 ppm on February 26 and 27, respectively. Upstream from the salt-flat inflow, Grand Saline Creek contained only 100 ppm of chloride. (See sites 8 to 10 in Table 8.)

### Other Constituents

Other constituents of importance in the evaluation of the quality of a water include silica, iron, sodium, bicarbonate, sulfate, fluoride, and nitrate.

Many streams in the Sabine River Basin contain from 10 to 30 ppm silica, and the weighted-average concentration in the Sabine River near Ruliff is about 12 ppm. In some streams having low dissolved-solids concentrations, silica may constitute up to 40 percent of the dissolved material present. Water draining rocks of Cretaceous age is very low in silica, containing only about 3 ppm.

The occurrence of iron in surface waters was not studied during this reconnaissance, but data on iron concentrations are available for the Sabine River near Ruliff and for the sampling points in Louisiana. In surface waters, the sediment normally present often includes some iron oxides that are carried in colloidal suspension or as very fine sediment particles. High values for "dissolved" iron frequently are the result of the presence of these finely divided particles in suspension. Usual public water-supply treatment and filtration practices effectively remove both dissolved and suspended iron from surface waters.

Sodium is the principal cation in the waters of the Sabine River Basin, except that calcium predominates in the area where Cretaceous rocks crop out. In those waters having high chloride concentrations, sodium occurs in quantities approximately equivalent to the chloride. It is therefore present in highest concentrations in Grand Saline, Lake Fork, and Socagee Creeks. In unpolluted streams, the sodium concentration seldom exceeds 50 ppm.

In water draining from rocks of Cretaceous age, bicarbonate is the principal anion, and occurs in quantities approximately equivalent to the calcium and magnesium. In the remainder of the Sabine River Basin, it is present in smaller concentrations.

Sulfate concentrations are generally less than 30 ppm in most streams of the basin. The weighted-average concentration for the Sabine River near Tatum ranged from 13 to 28 ppm, and near Ruliff from 9.5 to 19 ppm. Higher concentrations are found in the polluted streams. Concentrations of fluoride and nitrate are low in all surface waters in the Sabine River Basin. Fluoride concentrations range generally from 0.1 to 0.5 ppm, and nitrate from 0.0 to 2 ppm.

### Water Quality in Reservoirs

The principal reservoirs in the Sabine River Basin in Texas were sampled during the reconnaissance study, and the chemical analyses are given in Table 8.

Analyses are also available for many of the small reservoirs used for public supply (Sundstrom and others, 1948; Texas State Department of Health, 1960). The water in all the reservoirs is satisfactory for public supply, except that softening the water of Greenville Reservoir and Lake Tawakoni might be desirable.

#### Greenville Reservoir

The water in the Greenville Reservoir is calcium bicarbonate in type and is moderately hard. Dissolved-solids concentrations have ranged from 154 to 205 ppm. Analyses have shown maximum chloride and sulfate concentrations of 13 and 32 ppm, respectively.

#### Lake Tawakoni

This new reservoir was filling for the first time during the course of the investigation. The water of Lake Tawakoni is also calcium bicarbonate in type and moderately hard, but the concentrations of most constituents are less than in Greenville Reservoir. Although dissolved-solids concentrations ranged from 118 to 134 ppm during the 8-month period from December 1961 to July 1962, the chemical composition of stored water remained remarkably uniform.

#### Lake Gladewater

Very soft water, containing only 60 to 70 ppm dissolved solids, is stored in Lake Gladewater. The principal dissolved constituents are silica, 16 ppm, and chloride, 15 to 20 ppm.

#### Lake Cherokee

Water in Lake Cherokee, similar to that in Lake Gladewater, is very soft and low in all dissolved constituents.

#### Murvaul Lake

The water of Murvaul Lake is soft, and in the winter of 1961-62, contained only 108 ppm dissolved solids.

### Water Quality at Proposed Reservoir Sites

One of the principal purposes of the Sabine River Basin reconnaissance study was to appraise the quality of the water which will be available for storage in proposed reservoirs. Streams were sampled periodically at or near all the reservoir sites except those on the main stem, where quality can be inferred from the daily-station records. An evaluation of water quality follows for each of the reservoirs proposed in the Texas Water Commission's Plan for 1980 (Texas Board of Water Engineers, 1961) and in the Sabine River Authority's Master Plan (Sabine River Authority, 1960) to meet requirements for 2010. These evaluations are based on present conditions; cultural influences in the basin may cause significant changes in water quality before some of the reservoirs are built.

### Kilgore Reservoir

Only low-flow samples were collected from Wilds Creek, but the highest dissolved-solids concentration observed was 77 ppm. All constituents were present in very low concentrations, except silica, which ranged from 26 to 30 ppm. Higher flows would probably have a lower silica content, and the dissolved-solids content of water to be stored in Kilgore Reservoir should not exceed 70 ppm.

### Cherokee Reservoir No. 2

Analyses of samples from Cherokee Bayou near Oak Hill, above Lake Cherokee, indicate that the upstream reservoir might contain water having slightly higher concentrations of dissolved constituents, principally sodium and chloride, than does the existing reservoir. However, dissolved-solids concentrations in the upstream reservoir should not exceed 150 ppm.

### Toledo Bend Reservoir

Although this main-stem reservoir is under construction in the lower one-third of the basin, much of the area of highest rainfall and lowest dissolved-solids content of the water is below the dam site. The concentration of dissolved constituents in water which will be stored in Toledo Bend Reservoir will probably be about midway between that measured at the Tatum and Ruliff stations. Thus, if the reservoir fills during a period of average rainfall and runoff, the stored water would contain approximately 150 ppm dissolved solids and would be soft.

### Lake Fork Reservoir

The pollution of Lake Fork Creek by oil-field brines has been mentioned. In February 1963 the effects of this pollution were greatest in the lower part of the Dry Creek sub-basin, but chloride concentrations were also high in other streams (Table 8). The Lake Fork dam site is above the mouth of Dry Creek, whereas the gaging station on Lake Fork Creek near Quitman, where the periodic sampling was done, is below Dry Creek. Thus, the chemical-quality records obtained are not strictly applicable to the dam site. This area should be given additional study before a reservoir is built.

### Big Sandy Reservoir

The chemical analyses in Table 8 indicate that oil-field activities may influence slightly the quality of the water of Big Sandy Creek near Big Sandy, but even so the maximum chloride concentration observed during March 1961 to February 1963 was 70 ppm and the maximum dissolved solids was 184 ppm. Water stored in a reservoir on Big Sandy Creek would be of excellent quality, would be soft, and would have a dissolved-solids concentration probably not exceeding 150 ppm.

### Rabbit Reservoir

The quality of water in Rabbit Creek at the reservoir site can be inferred from the analyses for nearby Wilds Creek (see Site 25, Table 8). If oil-field pollution is prevented the reservoir should store soft water having a dissolved-solids content less than 100 ppm.

### Carthage and Stateline Reservoirs

The quality of the water at the sites of these two main-stem reservoirs probably is similar to that determined for Sabine River near Tatum (see Table 7). Stateline Reservoir would receive additional inflow from several tributaries carrying water having low concentrations of dissolved solids, but would also receive water from Socagee Creek, whose water quality appears to be affected by oil fields. (See data for Site 40, Table 8.) Dissolved-solids concentrations of the water in the two reservoirs will probably range between 150 and 200 ppm.

### Tenaha Reservoir

Floodwater of Tenaha Creek is very low in concentrations of dissolved constituents, and the water which will be stored in Tenaha Reservoir should contain less than 100 ppm dissolved solids.

### Bon Weir and Sabine Diversion Reservoirs

Water available for storage in Bon Weir and Sabine Diversion Reservoirs will consist of inflow from a number of tributaries below Toledo Bend Dam, and releases from Toledo Bend Reservoir. The tributaries yield water containing only about 50 ppm dissolved solids, and the releases from Toledo Bend will probably contain about 150 ppm.

### Problems Needing Additional Investigation

The Sabine River Basin has an abundance of water of good quality, and is remarkably free of water-quality problems. However, three areas were noted during this reconnaissance where further study should be made, and the widespread practices of water-flooding in oil fields and the reinjection of oil-field brines should be watched carefully.

Lake Fork Creek sub-basin is an area where oil-field brine pollution is occurring. Further study will be needed to determine whether the brine is reaching the streams by seepage from disposal pits or is leaking back to the surface after being injected into wells.

Oil fields in the Socagee Creek sub-basin may be contributing brine to surface waters as the high chloride concentrations (88 to 252 ppm) observed at the sampling site near Carthage indicate.

The brine discharge from the salt flat at Grand Saline may have an increasing effect on the quality of the water of the Sabine River. In February 1963

the effluent from the salt flat was contributing about 25 tons of chloride per day to Grand Saline Creek and thence to the river. If the additional dams being built in the upper basin tend to decrease the base flow of the Sabine, such a saline inflow may become significant.

Large quantities of oil-field brines are reinjected into wells in the Sabine River Basin. If geologic conditions are suitable, if the wells are properly constructed, if excessive pressures are not used, and if nearby oil wells are properly cased and abandoned wells properly plugged, this method of disposing of brine poses little danger of polluting fresh ground-water and surface-water supplies. That oil-field operation can be a hazard to water quality is evident in other areas of Texas. Conselman, Jenke, and Tice, Consultants, (written communication, 1962) report that pollution in the Hubbard Creek drainage area in the Brazos River Basin is partly due to leakage from waterflood injection wells and salt-water disposal wells. They state:

Industrial brines have reached the watershed from (1) surface leakage of salt water pits, producing wells, water injection wells, lease lines, tanks, heaters, treaters and abandoned dry holes; (2) leaching of salt-impregnated areas by run-off; (3) seepage of salt-water pits into the shallow subsurface; (4) subsurface seepage from salt water disposal wells pumping brine into the annulus, with pressures and volumes in excess of the capacity of subsurface reservoirs; (5) waterflood injection wells which unintentionally inject brine into reservoirs other than those to be re-pressured; (6) abandoned shot-holes and core-holes which receive lateral salt water migration from other sources...

Similar pollution of surface waters may occur in the Sabine River Basin as a result of salt-water disposal wells and waterflooding activities and, if so, could cause deterioration of water quality.

Continued municipal and industrial growth in the Sabine River Basin will increase the waste-disposal burdens of the stream system, and will require continuous effort by water-pollution control agencies to keep deterioration of water quality at a minimum.

The encroachment of sea water from the Gulf of Mexico through Sabine Lake may make the water of the lower reach of the river unsuitable for use. Depletion of flow as a result of increased consumptive use and upstream storage will permit a wedge of salt water to travel increased distances up the river. A study of the water-quality characteristics of the tidal reach of the river should be made before diversions from potentially affected reaches are planned.

The quality of water may be improved or degraded by impoundment. Beneficial effects include the reduction of turbidity, silica, color, and coliform bacteria, the evening-out of sharp variations in chemical quality, the entrapment of sediment, and reductions in temperature. Detrimental effects of impoundment include increased growth of algae, reduction of dissolved oxygen, and increases in dissolved solids and hardness as a result of evaporation. The significance of these changes in water quality and their relations to the intended uses of the water are subjects on which further study is needed.

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\_\_\_\_\_ 1961b, Surface water records of Louisiana, 1961, basic data release.

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Quality-of-water records for the Sabine River Basin are published in the following U. S. Geological Survey Water-Supply Papers and Texas Water Commission (prior to January 1962, Texas Board of Water Engineers) Bulletins:

Water Year	Water-Supply Paper No.	TWC Bull. No.	Water Year	Water-Supply Paper No.	TWC Bull. No.
1940-45	--	*1938-45	1954	1352	*1954
1946	1050	*1946	1955	1402	*1955
1947	1102	*1947	1956	1452	5905
1948	1133	*1948	1957	1522	5915
1949	1163	*1949	1958	1573	6104
1950	1188	*1950	1959	--	6205
1951	1199	*1951	1960	--	6215
1952	1252	*1952	1961	--	6304
1953	1292	*1953			

\* "Chemical Composition of Texas Surface Waters" was designated only by water year from 1938 through 1955.



The following U. S. Geological Survey Water-Supply Papers contain results of stream measurements in the Sabine River Basin, 1903-60:

Year	Water-Supply Paper No.	Year	Water-Supply Paper No.	Year	Water-Supply Paper No.
1903	99	1934	763	1948	1118
1904	132	1935	788	1949	1148
1905	174	1936	808	1950	1178
1906	210	1937	828	1951	1212
1924	588	1938	858	1952	1242
1925	608	1939	878	1953	1282
1926	628	1940	898	1954	1342
1927	648	1941	928	1955	1392
1928	668	1942	958	1956	1442
1929	688	1943	978	1957	1512
1930	703	1944	1008	1958	1562
1931	718	1945	1038	1959	1632
1932	733	1946	1058	1960	1712
1933	748	1947	1088		

Table 6.--Index of surface-water records in the Sabine River Basin

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years								
			1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-63		
1	Greenville Reservoir at Greenville, Tex.									■	■
2	Sabine River at Greenville, Tex.	77.7									■
3	Sabine River near Lone Oak, Tex.										■
4	South Fork Sabine River near Quinlan, Tex.	78.7									■
5	Lake Tawakoni near Wills Point, Tex.	756									■
6	Sabine River near Emory, Tex.	888								■	■
7	Mill Creek near Edgewood, Tex.										■
8	Grand Saline Creek at FM Road 857 near Grand Saline, Tex.										■
9	Salt Flat at Grand Saline, Tex.										■
10	Grand Saline Creek at U. S. Highway 80 near Grand Saline, Tex.										■
11	Sabine River near Colden, Tex.	1,123			■						■
12	Sabine River near Mineola, Tex.	1,357								■	■
13	Duck Creek near Lindale, Tex.									■	■
14	Lake Fork Creek near Point, Tex.										■
15	Caney Creek near Quitman, Tex.										■
16	Lake Fork Creek near Alba, Tex.										■
17	Dry Creek at FM Road 69 near Quitman, Tex.										■
18	Unnamed creek at Myrtle Springs, Tex.										■
19	Dry Creek near Quitman, Tex.										■
20	Lake Fork Creek near Quitman, Tex.	585									■

Discharge ██████████ Gage heights only ██████████ Gage heights and discharge measurements ██████████ Reservoir contents ██████████  
 Periodic discharge measurements ██████████ Daily chemical quality ██████████ Periodic chemical quality ██████████ Water temperature ██████████

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Table 6.--Index of surface-water records in the Sabine River Basin--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years															
			1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-63									
101	Caney Creek near Bon Weir, Tex.	46.2									///	////	////	////	////	////	////	////
102	Davis Creek near Bon Weir, Tex.	27.1											///	////	////	////	////	////
103	Dempsey Creek near Bon Weir, Tex.												///	////	////	////	////	////
104	Donahoe Creek near Bon Weir, Tex.												///	////	////	////	////	////
105	Hoosier Creek near Merryville, La.	13.1													////	////	////	////
106	Cypress Creek near Bivens, La.	15.4													////	////	////	////
107	Big Cow Creek at Farrsville, Tex.	19.9								///	///				////	////	////	////
108	Hunters Creek near Farrsville, Tex.	12.9								///	///				////	////	////	////
109	Melhomes Creek near Jasper, Tex.	15.8								///	///				////	////	////	////
110	Bishop Creek near Jasper, Tex.	3.0								///	///				////	////	////	////
111	Big Cow Creek at Dam Site near Newton, Tex.	122													////	////	////	////
112	Big Cow Creek near Newton, Tex.	128								///	///			///	////	////	////	////
113	Big Cow Creek near Bleakwood, Tex.														///	///	///	///
114	Big Cow Creek near Call, Tex.													///	///	///	///	///
115	Big Cow Creek near Belgrade, Tex.	342													////	////	////	////
116	Brushy Creek at Bancroft, La.	25.9													////	////	////	////
117	Trout Creek near Call, Tex.														///	///	///	///
118	Nichols Creek near Buna, Tex.	54.4													////	////	////	////
119	Cypress Creek near Buna, Tex.	69.2												///	////	////	////	////
120	Cypress Creek near Deweyville, Tex.	146													////	////	////	////

Discharge //////////////// Gage heights only //////////////// Gage heights and discharge measurements //////////////// Reservoir contents ////////////////  
 Periodic discharge measurements //////////////// Daily chemical quality //////////////// Periodic chemical quality //////////////// Water temperature ////////////////





Table 7.--Summary of chemical analyses at daily stations on streams in the Sabine River Basin in Texas

(Analyses listed as maximum and minimum were classified on the basis of the values for dissolved solids only; values of other constituents may not be extremes. Results in parts per million except as indicated)

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
													Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
6. SABINE RIVER NEAR EMORY, TEX.																					
Water year 1953																					
Maximum, June 11-21, 1953--	0.25	12	49	6.6		25	180	30	16		2.0		230	0.31	0.16	149	2	26	0.9	397	8.0
Minimum, April 24, 29-30----	13,340	5.0	6.6	1.3	4.4	2.9	28	6.9	4.0		1.5		47	.06	1,690	27	4	27	.4	70	6.9
Weighted average-----	575	8.9	17	2.6		9.7	63	11	5.1		2.5		88	.12	137	53	2	28	.6	145	--
Water year 1954																					
Maximum, July 2-7, 1954----	0.01	14	48	6.4		21	187	21	11		2.2		236	0.32	0.01	146	0	24	0.8	373	7.8
Minimum, Jan. 11-12, 14-19--	3,256	8.8	11	2.1	6.5	3.1	44	10	4.2		3.0		71	.10	624	36	0	26	.5	114	7.7
Weighted average-----	248	11	21	2.8		14	78	15	7.5		3.6		134	.18	89.7	64	0	32	.8	191	--
31. SABINE RIVER NEAR TATUM, TEX.																					
Water year 1952																					
Maximum, July 14-17, 19, 21-26, 1952-----	173	18	22	8.0		147	59	22	238		1.5		532	0.72	248	88	40	78	6.8	942	6.7
Minimum, May 1-6, 8, 27-29--	9,575	12	9.6	3.6		21	30	18	27		2.4		115	.16	2,970	39	14	54	1.4	175	6.4
Weighted average-----	2,134	14	13	4.8		34	31	24	51		2.1		169	.23	974	52	27	59	2.0	277	--
Water year 1953																					
Maximum, July 5-6, 8-9, 1953	152	23	22	8.7		186	37	22	312		1.8		667	0.91	274	91	60	82	8.5	1,160	7.3
Minimum, May 10-20-----	16,550	7.8	10	3.3		13	34	11	18		1.5		82	.11	3,660	38	11	42	0.9	148	7.1
Weighted average-----	2,420	11	12	4.2		31	31	19	48		1.6		157	.21	1,030	48	22	59	2.0	260	--
Water year 1954																					
Maximum, Dec. 7-10, 13, 1953	1,956	18	20	4.9		207	18	38	330		0.8		682	0.93	3,600	70	56	87	11	1,200	6.6
Minimum, Jan. 22-31, 1954--	4,639	17	11	3.2		28	26	21	40		1.5		178	.24	2,230	41	19	60	1.9	225	7.2
Weighted average-----	1,004	19	15	4.6		55	32	27	85		1.9		252	.34	683	56	30	68	3.2	398	--
Water year 1955																					
Maximum, Oct. 16-25, 1954--	80.0	7.8	24	8.4		262	69	20	415		1.0		823	1.12	178	94	38	86	12	1,510	7.8
Minimum, Oct. 31, Nov. 1-8, 12-15-----	3,200	11	13	2.1		25	37	15	33		2.0		119	.16	1,030	40	10	57	1.7	211	7.2
Weighted average-----	1,291	14	14	4.1		51	29	26	79		1.6		226	0.31	788	52	28	68	3.1	370	--
Water year 1956																					
Maximum, Aug. 21-31, 1956--	14.2	8.8	26	10		315	120	19	475		1.1		936	1.27	35.9	105	6	87	13	1,750	7.8
Minimum, May 1-7, 10-16----	4,697	11	11	2.7		28	33	15	40		1.8		126	0.17	1,600	39	12	61	2.0	230	7.2
Weighted average-----	516	14	13	4.4		60	30	23	95		1.4		229	.31	319	50	26	72	3.7	420	--
Water year 1957																					
Maximum, Oct. 21-31, 1956--	32.5	4.4	24	9.0		273	148	26	385		0.0		805	1.09	70.6	98	0	86	12	1,480	7.3
Minimum, April 24-30, 1957--	18,580	8.2	4.7	2.5		16	14	12	23		.8		74	0.10	3,710	22	11	61	1.5	133	5.8
Weighted average-----	3,968	11	13	3.2		25	41	13	37		1.4		126	.17	1,350	46	12	54	1.6	226	--
Water year 1958																					
Maximum, Sept. 1-15, 1958--	165	17	18	5.5		131	42	18	212		1.5		424	0.58	189	68	33	81	6.9	815	7.4
Minimum, May 1-13-----	38,130	7.8	9.0	1.9		16	30	12	19		.8		82	.11	8,440	30	6	53	1.3	139	6.5
Weighted average-----	4,291	10	12	3.1		30	31	19	43		.8		134	.18	1,550	43	17	60	2.0	241	--
Water year 1959																					
Maximum, Oct. 20, 1958-----	472						39		485				883	1.20	1,130	121	89			1,680	7.4
Minimum, May 1-6, 1959-----	14,200	8.0	9.0	2.5		19	23	14	28		1.0		92	.13	3,530	33	14	56	1.4	172	7.0
Weighted average-----	1,683	13	13	4.1		46	25	24	73		1.0		188	.26	854	49	29	67	2.9	343	--

Table 7.--Summary of chemical analyses at daily stations on streams in the Sabine River Basin in Texas--Continued

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
													Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
31. SABINE RIVER NEAR TATUM, TEX.--Continued																					
<u>Water year 1960</u>																					
Maximum, Aug. 17, 19-21, 1960----	124	17	23	7.0	159	67	20	251			2.8		513	0.70	172	86	32	80	7.5	957	7.2
Minimum, Oct. 12-21, 1959----	4,298	14	10	2.9	17	46	10	18			1.2		96	.13	1,110	37	0	51	1.2	160	6.8
Weighted average-----	2,527	13	13	4.1	39	32	25	57			.7		170	.23	1,160	49	23	63	2.4	303	--
<u>Water year 1961</u>																					
Maximum, Oct. 21-31, 1960----	441	15	16	5.8	87	40	19	142			0.8		334	0.45	398	64	31	75	4.7	585	6.6
Minimum, Dec. 8-25-----	14,200	7.4	6.5	2.5	20	12	13	32			.8		88	.12	3,370	26	17	62	1.7	163	5.6
Weighted average-----	3,104	11	10	4.0	34	19	23	53			.6		146	.20	1,220	41	26	64	2.3	266	--
<u>Water year 1962</u>																					
Maximum, July 16-26, 1962----	168	16	16	6.7	120	46	24	188			1.2		395	0.54	179	68	30	79	6.3	735	6.3
Minimum, Nov. 23, 1961----	4,970	--	--	--	--	12	8.4	18			--		65	.09	872	15	5	--	--	104	6.4
Weighted average-----	1,802	14	11	4.9	41	19	28	66			.8		177	.24	861	48	32	65	2.6	320	--
121. SABINE RIVER NEAR RULIFF, TEX.																					
<u>Water year 1948</u>																					
Maximum, Oct. 1, 7-10, 1947----	1,104		13	5.4	106	44	16	164			0.8		364	0.50	1,090	54	2	81	6.3	647	--
Minimum, Feb. 11-20, 1948----	22,910	12	6.9	2.9	17	15	19	24			.5		100	.14	6,190	29	17	56	1.4	141	--
Weighted average-----	8,193		8.0	3.7	23	24	17	34			.2		139	.19	3,070	35	16	59	1.7	191	--
<u>Water year 1949</u>																					
Maximum, Dec. 26-27, 1948----	2,620	18	14	2.0	122	20	32	183			0.5		411	0.56	2,910	43	27	86	8.1	695	--
Minimum, Nov. 21-25, 29-30, Dec. 1-----	11,380	6.2	3.4	1.4	15	9	7.1	22			.2		67	.09	2,060	14	7	69	1.7	102	--
Weighted average-----	8,636	11	6.0	3.1	18	21	12	27			.9		113	.15	2,630	28	10	59	1.5	147	--
<u>Water year 1950</u>																					
Maximum, Oct. 2, 12, 21-24, 1949-----	7,687	13	8.8	3.2	52	36	16	72			1.2		184	0.25	3,820	35	6	76	3.8	311	7.6
Minimum, June 5-11, 1950----	74,760	4.7	2.6	1.5	5.8	10	7	5.2			3.0		35	.05	7,060	13	4	50	0.1	48	6.5
Weighted Average-----	15,940	12	6.0	2.9	15	19	11	21			1.4		89	.12	3,830	27	11	55	1.3	117	--
<u>Water year 1951</u>																					
Maximum, May 21-31, 1951----	2,924	18	14	5.5	48	41	29	68			1.5		204	0.28	1,610	58	24	64	2.7	360	7.4
Minimum, Jan. 4-10-----	13,030	7.5	2.5	2.2	12	10	9.0	17			0.8		56	.08	1,970	15	7	64	1.3	94	6.7
Weighted average-----	4,374	14	8.4	3.8	29	26	19	40			1.1		133	.18	1,570	37	15	64	2.1	216	--
<u>Water year 1952</u>																					
Maximum, Nov. 1-15, 21-25, 1951-----	980	16	12	4.4	75	43	15	114			0.5		258	0.35	683	48	13	77	4.8	472	6.8
Minimum, April 22-30, 1952----	34,780	6.4	3.1	1.9	10	10	11	12			1.8		59	.08	5,540	16	7	59	1.1	82	6.2
Weighted average-----	6,415	12	6.9	3.2	23	21	16	32			1.8		112	.15	1,940	30	13	62	1.8	178	--
<u>Water year 1953</u>																					
Maximum, Feb. 3-5, 1953----	5,427	15		1.4	8.3	55	15	36	85		1.2		232	0.32	3,400	52	40	70	3.3	396	6.7
Minimum, Mar. 1-2, 14-26----	25,660	7.8	3.1		2.2	10	10	11			1.0		50	.07	3,460	14	6	51	1.0	82	6.5
Weighted average-----	12,340	8.7	5.3	2.1	13	18	9.5	18			1.3		81	.11	2,700	22	7	57	1.2	119	--

Table 7.--Summary of chemical analyses at daily stations on streams in the Sabine River Basin in Texas--Continued

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
													Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
121. SABINE RIVER NEAR RULIFF, TEX.--Continued																					
<b>Water year 1954</b>																					
Maximum, Dec. 16-22, 1953---	4,977	14	13	4.9	86	11	18	25	141		1.0		326	0.44	4,380	52	38	78	5.2	543	6.6
Minimum, May 4-10, 15, 1954---	20,380	9.6	3.8	1.7	11	12	12	6.4	16		2.5		57	.08	3,140	16	6	60	1.2	84	6.4
Weighted average-----	4,097	14	8.3	2.9	26	22	22	14	38		1.6		121	.16	1,340	32	14	63	2.0	202	--
<b>Water year 1955</b>																					
Maximum, Dec. 21-22, 1954---	2,940	19	19	4.0	80	32	30	128			1.0		318	.43	2,520	65	39	73	4.3	534	7.4
Minimum, Aug. 5-13, 1955---	22,280	6.2	3.2	0.7	5.7	10	10	3.2	10		1.0		37	.05	2,230	11	3	48	0.8	57	6.5
Weighted average-----	5,574	11	6.9	2.3	22	19	13	32			1.4		104	0.14	1,570	26	11	64	1.9	174	--
<b>Water year 1956</b>																					
Maximum, July 11-20, 1956---	607	22	11	3.6	50	51	8.3	70			1.0		193	0.26	316	42	0	72	3.3	332	7.3
Minimum, Feb. 6-16-----	19,400	8.8	4.0	1.4	14	8	9.9	20			0.5		63	.09	3,300	16	10	65	1.5	110	6.3
Weighted average-----	3,421	13	6.8	2.4	23	21	12	33			.9		103	.14	951	27	10	65	1.9	176	--
<b>Water year 1957</b>																					
Maximum, Dec. 1-12, 1956---	561	15	10	4.0	76	56	12	105			0.5		250	0.34	379	42	0	80	5.1	472	7.6
Minimum, Dec. 22-26, 28-----	10,520	7.8	3.2	1.0	10	11	6.8	13			.2		47	.06	1,330	12	3	65	1.3	72	6.3
Weighted average-----	9,645	11	8.0	2.5	17	27	10	24			1.2		88	.12	2,280	30	8	55	1.3	151	--
<b>Water year 1958</b>																					
Maximum, Oct. 7-15, 1957---	2,108	13	12	2.7	74	40	14	109			0.5		261	0.35	1,490	41	8	80	5.0	457	7.4
Minimum, Sept. 23-26, 28-30, 1958-----	34,700	4.6	2.2	.8	5.3	10	3.4	7.5			.8		32	.04	3,000	9	1	50	.8	52	6.8
Weighted average-----	12,290	9.7	7.2	2.1	18	21	13	24			.7		85	.12	2,820	26	10	60	1.5	146	--
<b>Water year 1959</b>																					
Maximum, Sept. 9, 16-24, 1959--	1,271	15	14	4.9	55	56	12	82			0.8		212	0.29	728	55	9	68	3.2	377	7.0
Minimum, Jan. 31, 1959-----	9,730	5.8	7.4	1.1	4.4	6	5.8	15			.5		43	.06	1,130	23	18	29	0.4	76	6.7
Weighted average-----	6,723	12	7.6	2.7	24	21	15	35			.7		109	.15	1,980	30	13	63	1.9	192	--
<b>Water year 1960</b>																					
Maximum, May 13-24, 1960----	2,838	13	15	5.8	50	44	32	71			1.0		217	.30	1,660	62	26	64	2.8	380	6.3
Minimum, Dec. 16-31, 1959----	12,860	7.8	7.5	2.1	14	23	9.0	20			0.8		72	.10	2,500	27	8	53	1.2	126	6.9
Weighted average-----	6,545	11	9.0	3.3	25	23	19	36			1.3		117	.16	2,070	36	17	60	1.8	202	--
<b>Water year 1961</b>																					
Maximum, Oct. 2-3, 5, 1960--	2,540	12	10	3.9	63	35	16	94			0.2		216	.29	1,480	41	12	77	4.3	402	6.8
Minimum, Sept. 15-18, 1961--	23,850	8.1	3.0	0.5	6.4	12	3.8	9.0			.8		40	.05	2,580	10	0	54	0.9	59	5.5
Weighted average-----	12,410	16	6.3	2.4	18	21	12	24			.6		90	.12	3,020	26	8	60	1.5	144	--
<b>Water year 1962</b>																					
Maximum, July 11-16, 1962---	2,228	14	14	5.9	63	34	23	103			0.2		261	.35	1,570	60	32	70	3.5	422	6.1
Minimum, Dec. 11-23, 1961---	25,040	11	3.5	1.2	9.4	8	8.0	13			.5		51	.07	3,450	14	7	60	1.1	75	5.7
Weighted average-----	7,500	12	7.1	2.9	22	20	15	32			.9		103	.14	2,090	30	13	62	1.7	175	--

Table 7.--Summary of chemical analyses at daily stations on streams in the Sabine River Basin in Texas--Continued

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
													Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
123. COW BAYOU NEAR MAURICEVILLE, TEX.																					
<u>Water year 1952</u>																					
Maximum, Sept. 21-30, 1952---	0.01	27	36	20		173	109	23	308		0.8		692	0.94	0.02	172	82	69	5.7	1,210	7.9
Minimum, April 23-30-----	1,541	3.5	1.8	1.3		3.6	7	5	4.2		1.0		23	.03	95.7	10	4	44	.5	28	6.0
Weighted average-----	112	5.0	2.2	1.7		6.2	7	6.4	8.4		1.1		37	.05	11.2	12	7	52	.8	46	--
<u>Water year 1953</u>																					
Maximum, July 29-31, 1953---	2.63	8.3	43	17	325	5.3	8	5.4	620		1.0		1,030	1.40	7.31	178	171	79	11	2,110	6.4
Minimum, Dec. 4-5, 19-23, 30-31, 1952-----	27.7	4.6	1.8	1.1	4.0		8	4.7	6.0		1.0		27	0.04	2.02	9	2	49	0.6	46	6.5
Weighted average-----	78.6	4.8	2.6	1.3		10	8	3.5	15		1.3		43	.06	.91	12	5	65	1.3	78	--
<u>Water year 1954</u>																					
Maximum, Oct. 14-25, 1953---	0.09	30	36	18		163	108	21	288		1.0		639	0.87	0.16	164	76	68	5.5	1,120	7.5
Minimum, May 14-22, 25-29, 1954-----	181	5.4	2.0	0.9		5.7	8	2.2	7.8		1.5		30	.04	14.7	9	2	59	0.8	46	6.5
Weighted average-----	32.5	7.1	3.0	1.3		11	8	3.6	18		1.3		49	.07	4.3	13	6	65	1.3	83	--
<u>Water year 1955</u>																					
Maximum, Nov. 18-22, 1954---	1.06	6.4	33	12		304	9	4.7	552		1.0		917	1.25	2.62	132	124	83	11	1,780	6.3
Minimum, Feb. 8-19, 1955---	385	5.6	2.2	1.2	4.7	0.7	7	3.6	8.0		0.8		30	.04	31.2	10	5	47	.6	59	6.3
Weighted average-----	66.0	7.0	2.7	1.5		9.2	8	4.1	15		1.3		50	.07	8.91	13	6	61	1.1	76	--

Table 8.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Texas, for locations other than daily stations

(Results in parts per million except as indicated)

Date of collection	Dis-charge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Cal-cium (Ca)	Mag-ne-sium (Mg)	So-dium (Na)	Po-tas-sium (K)	Bicar-bonate (HCO <sub>3</sub> )	Sul-fate (SO <sub>4</sub> )	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO <sub>3</sub> )	Bo-ron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Per-cent so-dium	So-dium adsorp-tion ratio	Specific conductance (micro-mhos at 25° C)	pH	
														Parts per million	Tons per acre-foot	Tons per day	Cal-cium, magne-sium	Non-carbon-ate					
1. GREENVILLE RESERVOIR AT GREENVILLE																							
Mar. 25, 1952-----		2.4	0.01	38	6.5	21	0.8	142	32	13	0.3	0.0		a205	0.28		122	5	27	0.6	347	7.9	
Nov. 28, 1961-----		3.9		38	3.7			138	19	12	.5	.0		a175	.24		110	0	27	.8	295	7.2	
Feb. 5, 1962-----		2.9		35	3.7			128	21	9.6	.4	.0		154	.21		102	0	27	.8	265	7.1	
2. SABINE RIVER AT GREENVILLE																							
Feb. 27, 1963-----	0.8							180		49							160	12			306	7.1	
3. SABINE RIVER NEAR LONE OAK																							
Feb. 26, 1963-----	b5							186		43							171	18			575	6.4	
5. LAKE TAWAKONI NEAR WILLS POINT																							
Dec. 5, 1961-----		2.9		29	3.7			108	12	6.0	0.3	0.2		118	0.16		88	0	21	0.5	220	7.0	
Jan. 12, 1962-----		2.4		28	3.6	9.3	4.5	108	12	6.0	.3	.5		120	.16		85	0	18	.4	219	7.0	
Jan. 17-----		2.1		28	4.1			106	12	9.0	.3	.0		120	.16		87	0	23	.6	218	7.0	
Apr. 16-----		1.2		29	3.7			114	12	7.0	.3	.8		a134	.18		88	0	25	.6	229	7.2	
July 12-----		.6		30	3.9			110	12	7.2	.3	.0		a128	.17		91	1	20	.5	224	7.1	
6. SABINE RIVER NEAR EMORY																							
Sept. 26, 1958-----		12		34	3.1			113	28	8.0		3.5		a176	0.24		98	5	28	0.8	271	7.6	
Mar. 1, 1961-----		8.2		19	4.0			68	25	12	0.2	.2		118	.16		64	8	36	.9	210	6.7	
7. MILL CREEK NEAR EDGEWOOD																							
Feb. 26, 1963-----	b3	22		45	21		65	48	133	115	0.2	0.2		a464	0.63		199	160	42	2.0	737	6.5	
8. GRAND SALINE CREEK AT FM ROAD 857 NEAR GRAND SALINE																							
Feb. 26, 1963-----		20		50	23		70	20	201	100	0.1	0.2		474	0.64		220	203	42	2.1	792	6.3	
9. SALT FLAT AT GRAND SALINE																							
Feb. 26, 1963-----	b0.1	9.2		315	51		25,500	99	1,100	39,200				66,200	94.3		996	915	98	352	71,100	7.0	
10. GRAND SALINE CREEK AT U. S. HIGHWAY 80 NEAR GRAND SALINE																							
Feb. 26, 1963-----	b7			64	29		786	38	40	251	1,350			2,370	3.22		287	256			4,630	6.2	
Feb. 27-----	6.8	17						40			1,200		.2	1.0			279	246	86	20	4,160	6.7	
13. DUCK CREEK NEAR LINDALE																							
Apr. 2, 1953-----		21	0.42	5.5	3.5	6.8	2.1	14	18	11	0.3	0.2		76	0.10		29	17	32	.6	105	6.4	
14. LAKE FORK CREEK NEAR POINT																							
Feb. 27, 1963-----	b0.2							316		42							284	25				779	7.1

a Residue on evaporation at 180°C.

b Field estimate.

Table 8.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Texas, for locations other than daily stations--Continued

Date of collection	Discharge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
15. CANEY CREEK NEAR QUITMAN																						
Feb. 26, 1963-----	b5	17		39	19	92		52	102	160	0.2	0.0		a475	0.65		176	133	53	3.0	823	6.8
16. LAKE FORK CREEK NEAR ALBA																						
Feb. 27, 1963-----	b15							54		155							231	186			948	6.8
17. DRY CREEK AT FM ROAD 69 NEAR QUITMAN																						
Feb. 26, 1963-----	b3	27		25	8.8	96		0	71	175	0.2	0.2		413	0.56		98	98	65	4.2	766	e3.8
18. UNNAMED CREEK AT MYRTLE SPRINGS																						
Feb. 26, 1963-----	b0.05	43		114	41	505		0	172	1,020	0.7	1.0		1,900	2.58		453	453	68	10	3,470	e3.8
19. DRY CREEK NEAR QUITMAN																						
Feb. 26, 1963-----	3.8	31		82	29	340		0	158	650	0.4	0.5		1,290	1.75		324	324	68	8.2	2,350	d4.3
20. LAKE FORK CREEK NEAR QUITMAN																						
Dec. 5, 1961-----	43.2	20		31	13	101		20	78	179	0.2	0.0		a471	0.64		131	114	63	3.8	787	6.1
Jan. 11, 1962-----	85	20		37	18	103		19	127	172	.2	.2		a495	.67		166	151	57	3.5	842	6.1
Jan. 17-----	480	13		25	11	60		18	80	99	.2	.2		297	.60		108	93	55	2.5	534	6.0
Feb. 11-----	69.7	21		43	20	115		24	133	200	.2	.0		544	.74		190	170	57	3.6	952	6.3
Mar. 13-----	1,800	10		19	7.5	52		13	46	94	.2	.0		235	.32		78	68	59	2.6	442	6.2
Apr. 17-----	52.1	14		42	19	119		50	121	194	.3	.0		534	.73		183	142	59	3.8	950	7.4
May 22-----	16.8	14		32	14	84		63	74	135	.3	.1		384	.52		138	86	57	3.1	679	7.5
July 11-----	8.04	14		26	10	58		54	44	101	.2	.0		a302	.41		106	62	55	2.4	527	6.0
Aug. 3-----	47.3	11		15	5.9	31		44	23	49	.3	.2		157	.21		62	26	53	1.7	283	6.1
Sept. 20-----	23.0	11		19	6.5	38		49	29	60	.2	.2		a194	.26		74	34	52	1.9	336	6.8
Jan. 20, 1963-----	69.4	20		43	19	109		36	130	182	.2	.2		a558	.76		186	156	56	3.5	881	6.6
Feb. 24-----	32.6	19		58	27	148		42	183	248	.2	1.5		a745	1.01		256	221	56	4.0	1,210	6.5
Feb. 26-----	b30	--		--	--	--		40	--	235	--	--		--	--		250	217	--	--	1,190	6.6
21. BIG SANDY CREEK NEAR BIG SANDY																						
Mar. 1, 1961-----	--	14		8.5	3.7	23		6	33	33	0.1	0.5		119	0.16		36	32	58	1.7	207	6.0
Dec. 4-----	131	16		9.0	4.3	31		7	27	52	.2	.2		143	.19		40	34	63	2.1	252	6.1
Jan. 11, 1962-----	194	18		12	5.4	35		5	45	54	.1	.2		172	.23		52	48	59	2.1	296	5.8
Jan. 17-----	200	18		10	5.2	43		4	35	70	.1	.2		184	.25		46	43	67	2.6	330	5.5
Feb. 10-----	142	17		10	5.3	36		5	35	59	.1	.0		164	.22		47	43	62	2.3	291	5.4
Mar. 13-----	458	12		8.0	3.7	30		7	26	47	.1	.0		130	.18		35	29	65	2.2	231	5.6
Apr. 17-----	114	15		9.5	4.6	34		18	27	51	.2	.1		a162	.22		43	28	63	2.3	250	6.9
July 11-----	36.0	15		6.2	2.8	21		15	8.4	36	.1	.2		97	.13		27	15	63	1.8	165	5.9
Aug. 3-----	40.8	16		5.0	2.4	18		14	8.8	28	.1	.1		85	.12		22	11	63	1.7	133	6.1
Sept. 20-----	29.0	15		6.2	2.6	19		8	16	30	.1	.8		94	.13		26	20	61	1.6	150	6.1
Jan. 19, 1963-----	83.5	17		8.3	3.9	26		5	24	46	.1	.2		128	.17		37	33	61	1.9	227	5.8
Feb. 23-----	71.6	--		--	--	--		6	--	52	--	--		--	--		36	31	--	--	237	5.7

a Residue on evaporation at 180°C.  
b Field estimate.  
c Contains 1.4 ppm total acidity as H<sup>+</sup>.  
d Contains 0.4 ppm total acidity as H<sup>+</sup>.  
e Contains 0.3 ppm total acidity as H<sup>+</sup>.

Table 8.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Texas, for locations other than daily stations--Continued

Date of collection	Dis-charge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Cal-cium (Ca)	Mag-ne-sium (Mg)	So-dium (Na)	Po-tas-sium (K)	Bicar-bonate (HCO <sub>3</sub> )	Sul-fate (SO <sub>4</sub> )	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO <sub>3</sub> )	Bo-ron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Per-cent so-dium	So-dium adsorp-tion ratio	Specific conduct-ance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Cal-cium, magne-sium	Non-carbon-ate				
23. LAKE GLADEWATER NEAR GLADEWATER																						
Dec. 4, 1961-----		16		4.8	2.4	12		14	7.4	20	0.1	0.2		70	0.10		22	10	34	1.1	113	6.0
Feb. 10, 1962-----		16		3.0	2.1	9.6	1.6	6	9.6	15	.1	.2		60	.08		16	11	53	1.0	93	5.5
25. WILDS CREEK NEAR LAIRD HILL																						
Dec. 3, 1961-----	7.2	30		5.0	3.0	6.8	1.8	20	12	8.5	0.1	0.2		77	0.10		25	8	35	0.6	94	6.1
Jan. 17, 1962-----	15.2	26		4.8	2.8	6.3	1.2	15	13	10	.1	.0		71	.10		24	11	35	.6	83	6.3
Feb. 10-----	9.75	28		4.8	2.5	6.4	1.5	16	11	7.2	.1	.2		70	.10		22	9	36	.6	82	6.0
Apr. 18-----	7.28	29		4.5	2.4	6.6	1.7	15	11	10	.1	.1		72	.10		21	9	38	.6	78	7.7
26. CHEROKEE BAYOU NEAR OAK HILL																						
Dec. 3, 1961-----	22.3	19		16	4.4		50	8	7.2	108	0.2	0.2		209	0.28		58	51	65	2.9	392	6.0
Jan. 17, 1962-----	57	17		10	3.7		30	7	13	60	.1	.2		137	.19		40	34	62	2.1	252	5.7
Feb. 9-----	38.6	17		14	3.7		38	7	8.8	83	.2	.2		168	.23		50	44	62	2.3	315	5.9
Apr. 18-----	24.4	17		17	4.1		47	13	7.2	102	.1	.1		200	.27		59	49	64	2.7	365	6.4
28. LAKE CHEROKEE NEAR LONGVIEW																						
Feb. 27, 1952-----		7.8	0.70	3.5	2.3		8.7	14	13	7.8	0.2	0.5		52	0.07		18	7	51	0.9	81	6.6
Dec. 3, 1961-----		11		4.5	3.0		14	14	9.6	23	.2	.2		72	.10		24	12	57	1.2	122	6.1
Jan. 8, 1962-----		12		5.2	2.4		13	8	13	22	.1	.2		72	.10		23	16	56	1.2	120	6.1
Jan. 17-----		13		5.0	2.5		12	8	12	21	.1	.2		70	.10		23	16	54	1.1	115	5.7
29. CHEROKEE BAYOU NEAR LONGVIEW																						
July 18, 1946-----		25		8.0	4.0		10	43	8.0	11	0.4			90	0.12		36	1	34	0.7		7.7
30. CHEROKEE BAYOU NEAR TATUM																						
Mar. 1, 1961-----		10		5.0	2.2		10	6	16	15	0.2	0.1		62	0.08		22	17	50	0.9	106	5.3
33. EIGHT MILE CREEK NEAR TATUM																						
Nov. 28, 1961-----	49.5	17		9.0	4.6		19	23	22	28	0.2	1.8		113	0.15		41	22	50	1.3	183	6.0
Jan. 17, 1962-----		8.9		4.5	2.6		8.9   2.3	12	12	15	.1	.8		61	.08		22	12	44	.8	100	5.6
May 29-----	7.91	18		13	5.3		33	48	23	38	.5	11		166	.23		54	15	57	2.0	282	6.8
July 4-----	6.76	19		12	4.0		24	42	18	26	.4	8.4		133	.18		46	12	52	1.5	223	6.1
34. MARTIN CREEK NEAR BECKVILLE																						
Nov. 28, 1961-----	278	11		5.2	4.1		13	16	20	17	0.2	0.1		79	0.11		30	17	49	1.0	131	5.8
Jan. 17, 1962-----	b500	8.1		4.5	3.5		13	11	21	16	.2	.8		72	.10		26	17	53	1.1	126	5.8
May 29-----	24.6	16		6.0	4.5		14	30	13	18	.2	.2		87	.12		33	9	48	1.1	136	6.4
July 4-----	92.3	12		6.2	4.6		12	16	23	16	.2	.0		82	.11		34	21	43	.9	147	5.7

a Residue on evaporation at 180°C.

b Field estimate.

Table 8.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Texas, for locations other than daily stations--Continued

Date of collection	Discharge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
36. SIX MILE CREEK NEAR CARTHAGE																						
Nov. 28, 1961-----	7.41	15		20	8.8	69		44	37	114	0.3	0.2		286	0.39		86	50	64	3.2	522	6.3
37. MURVAUL LAKE NEAR GARY																						
Dec. 3, 1961-----		5.1		7.8	6.5	21		37	22	27	0.2	0.5		108	0.15		46	16	50	1.3	196	6.3
Feb. 9, 1962-----		6.7		8.8	5.9	19		22	28	28	.2	.8		108	.15		46	28	47	1.2	197	6.4
40. SOCAGEE CREEK NEAR CARTHAGE																						
May 29, 1962-----	1.41	16		22	9.0	104		42	8.4	195	0.2	0.8		376	0.51		92	58	71	4.7	755	6.8
July 4-----	3.40	11		16	5.0	52		32	6.4	99	.2	.0		206	.28		60	34	65	2.9	405	6.9
Oct. 16-----	.03	9.0		18	6.5	51		38	22	90	.2	.2		216	.29		72	40	61	2.6	404	5.8
Nov. 20-----	.23	15		14	5.2	49		38	6.0	88	.3	.2		197	.27		56	25	65	2.8	370	5.7
Dec. 18-----	.14	19		25	8.6	131		18	12	252	.2	.2		457	.62		98	83	74	5.8	883	5.9
Jan. 29, 1963-----	3.23	19		21	8.6	95		26	18	180	.2	.0		355	.48		88	66	70	4.4	675	6.0
Feb. 20-----	85.8	12		18	8.1	89		26	21	162	.2	.8		324	.44		78	57	71	4.4	610	6.1
Mar. 5-----	21.6	9.9		16	6.8	64		28	23	113	.2	.8		248	.34		68	45	67	3.4	464	6.1
49. FLAT FORK CREEK NEAR CENTER																						
Nov. 29, 1961-----	54.8	14		12	8.8	36		39	46	46	0.2	0.2		182	0.25		66	34	55	1.9	317	6.4
Dec. 10-----	6,100	4.0		2.5	1.6	5.8	2.4	10	8.4	7.5	.2	.2		38	.05		13	5	44	.7	64	6.3
Dec. 12-----	1,400	7.4		3.5	2.0	7.2	2.1	11	11	9.5	.2	.5		48	.07		17	8	44	.8	79	6.1
Jan. 16, 1962-----	51,200	6.3		6.0	3.3	18		16	25	20	.2	.5		87	.12		28	15	58	1.5	152	5.8
Oct. 16-----	.21	9.4		14	8.2	53		131	23	36	.3	.2		208	.28		69	0	62	2.8	365	6.3
50. TENAHA CREEK NEAR SHELBYVILLE																						
June 12, 1952-----	9.20	19		--	--	24		53	26	18	--	--		a139	0.19		44	1	54	1.6	198	7.9
Jan. 21, 1953-----	35.4	16		9.0	7.9	29		29	49	30	--	1.2		156	.24		55	31	53	1.7	273	6.7
June 11-----	24.4	16		--	--	19		46	16	16	--	2.0		a132	.18		38	0	52	1.3	164	7.1
Nov. 29, 1961-----	25.3	16		8.5	6.9	24		25	40	27	0.2	.1		135	.18		50	29	51	1.5	217	6.2
Dec. 10-----	4,480	3.6		1.8	1.3	3.4	2.6	8	7.0	4.0	.2	.2		28	.04		10	3	36	.5	44	6.2
Dec. 11-----	1,110	4.7		2.5	1.8	4.3	2.4	10	9.6	5.0	.2	.2		36	.05		14	5	36	.5	58	5.8
Dec. 12-----	1,800	7.0		3.0	2.1	5.7	2.4	10	13	6.5	.2	.2		45	.06		16	8	39	.6	71	6.3
Jan. 16, 1962-----	320	9.4		4.5	3.7	15		10	28	15	.2	.8		82	.11		26	18	56	1.3	137	5.6
July 4-----	7.95	12		5.5	3.7	10		26	15	9.2	.1	1.2		70	.10		29	8	43	.8	118	5.8
Aug. 7-----	.74	12		9.2	6.0	23		54	26	18	.2	.2		122	.17		48	3	51	1.4	201	6.5
Oct. 15-----	4.05	12		6.5	5.4	10		34	16	11	.2	.0		78	.11		38	11	37	.7	133	5.9
53. BAYOU SIEP NEAR PATROON																						
Oct. 13, 1952-----	0.4	40				20		65	3.9	22		0.2		a141	0.19		47	0	49	1.3	191	7.2
Jan. 21, 1953-----	2.88	34		7.0	5.4	17		48	11	18		.2		117	.16		40	0	48	1.2	165	6.9
June 11-----	3.55	30				17		57	6.5	15		1.5		a132	.18		38	0	50	1.2	133	7.1

a Residue on evaporation at 180°C.  
b Field estimate.



Table 8.--Chemical analyses of streams and reservoirs in the Sabine River in Texas, for locations other than daily stations--Continued

Date of collection	Dis-charge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Cal-cium (Ca)	Mag-ne-sium (Mg)	So-dium (Na)	Po-tas-sium (K)	Bicar-bonate (HCO <sub>3</sub> )	Sul-fate (SO <sub>4</sub> )	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO <sub>3</sub> )	Bo-ron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Per-cent so-dium	So-dium adsorp-tion ratio	Specific conductance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Cal-cium, magne-sium	Non-carbonate				
67. PATROON BAYOU NEAR MILAM																						
June 12, 1952-----	18.7	17		--	--	22		53	31	18	--	--		a135	0.18		54	11	47	1.3	217	7.0
Jan. 21, 1953-----	10.5	18		11	8.5	18		42	40	18	--	0.2		a133	.18		62	39	1.0	226	7.2	
June 11-----	17.3	18		--	--	14		44	18	11	--	.5		a110	.15		40	4	43	1.0	132	7.6
Nov. 29, 1961-----	23.1	16		10	7.3	20		30	42	21	0.2	.0		132	.18		55	30	44	1.2	207	6.2
May 30, 1962-----	42.0	9.6		5.2	3.5	10		20	19	9.5	.2	.0		67	.09		27	11	45	.8	108	6.3
Oct. 17-----	1.67	13		11	7.4	21		66	23	18	.2	.0		126	.17		58	4	44	1.2	210	6.2
69. PALO GAUCHO BAYOU NEAR HEMPHILL																						
May 15, 1952-----	25.6	19		--	--	7.5		28	8.0	7.8	--	--		a75	0.10		26	3	38	0.6	89	6.8
Nov. 29, 1961-----	43.6	17		7.8	3.7	5.3	1.9	28	12	9.0	0.1	0.0		71	.10		35	12	24	.4	99	6.2
Dec. 11-----	975	9.1		3.5	2.1	2.8	2.8	12	10	4.5	.1	.5		41	.06		17	8	23	.3	55	6.6
Jan. 16, 1962-----	242	14		6.0	3.0	5.1	1.8	14	15	9.0	.2	.8		62	.08		27	16	27	.4	89	3.8
May 30-----	67.4	14		6.5	2.9	5.3	1.9	23	9.2	7.8	.1	.8		60	.08		28	8	27	.4	89	6.0
July 6-----	15.7	16		6.5	2.9	4.6	1.5	25	8.8	6.7	.1	.0		59	.08		28	8	25	.4	84	6.0
Aug. 8-----	.69	16		10	4.5	10		52	8.0	10	.1	.2		85	.12		43	1	34	.7	128	6.5
Oct. 17-----	3.59	15		8.0	3.9	5.7	2.3	30	14	8.2	.2	.2		72	.10		36	11	24	.4	110	5.8
71. PALO GAUCHO BAYOU NEAR MILAM																						
May 16, 1952-----	39.9	18				10		31	11	8	--	--		a79	0.11		26	1	46	0.9	91	7.0
Oct. 14-----	.2	13				20		80	6.3	8.0		0.8		a105	.14		41	0	51	1.3	171	7.7
Apr. 17, 1953-----	64.4	18				5.5	1.4	26	10	6.5		.5		a79	.11		26	5	30	.5	88	7.5
73. HOUSEN BAYOU NEAR YELLOWPINE																						
June 13, 1952-----	7.87	29		--	--	19		36	22	17	--	--		a135	0.18		34	4	55	1.5	172	7.1
Apr. 17, 1953-----	11.0	25		--	--	20		33	27	16	--	0.2		a137	.19		35	8	55	1.4	175	7.5
Nov. 30, 1961-----	4.77	22		7.2	4.4	26		36	30	21	0.3	.5		129	.18		36	7	61	1.9	199	6.2
Jan. 16, 1962-----	b400	16		4.8	2.3	13		7	25	12	.3	.8		77	.10		21	16	57	1.2	116	5.5
May 31-----	14.9	25		8.0	3.7	23		43	20	20	.2	.5		121	.16		35	0	59	1.7	184	6.0
Aug. 8-----	.04	13		8.0	3.9	31		67	10	26	.3	.5		126	.17		36	0	65	2.2	206	6.4
74. SANDY CREEK NEAR YELLOWPINE																						
June 13, 1952-----	24.7	23		--	--	7.7		16	6.2	7.2	--	--		a64	0.09		13	0	56	0.9	60	6.6
Oct. 14-----	1.2	21		--	--	6.0		15	3.9	5.0	--	0.8		a54	.07		11	0	54	.8	57	6.3
Apr. 17, 1953-----	36.6	20		--	--			15	--	6.0	--	.2		a63	.09		15	3	--	--	60	7.0
Nov. 30, 1961-----	30.8	22		2.5	1.2	4.6	1.3	8	4.4	8.0	0.1	.1		48	.07		11	5	44	.6	49	5.8
Jan. 16, 1962-----	246	15		3.0	1.0	5.8	1.4	4	12	7.0	.2	.2		48	.07		12	8	48	.7	63	5.3
May 31-----	33.5	13		2.0	1.1	4.5	1.4	8	5.6	5.6	.1	.5		38	.05		10	3	46	.6	48	5.5
Aug. 8-----	1.90	17		4.0	1.5	5.3	1.8	21	3.8	6.0	.0	.5		50	.07		16	0	38	.6	61	6.3
75. MILL CREEK NEAR YELLOWPINE																						
June 13, 1952-----	13.1	20				5.7		12	2.6	5.5		--		a44	0.06		18	0	60	0.9	41	6.7
Oct. 14-----	4.85	18				5.0		10	2.6	4.0		0.5		a36	.05		6	0	65	.9	38	6.6
Apr. 17, 1953-----	17.1	20				3.2	1.0	10	2.9	4.5		.2		a47	.06		8	0	43	.5	41	6.6

a Residue on evaporation at 180°C.  
b Field estimate.

Table 8.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Texas, for locations other than daily stations--Continued

Date of collection	Dis-charge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Cal-cium (Ca)	Mag-ne-sium (Mg)	So-dium (Na)	Po-tas-sium (K)	Bicar-bonate (HCO <sub>3</sub> )	Sul-fate (SO <sub>4</sub> )	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO <sub>3</sub> )	Bo-ron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Per-cent so-dium	So-dium adsorp-tion ratio	Specific conductance (micro-mhos at 25° C.)	pH
														Parts per mil-lion	Tons per acre-foot	Tons per day	Cal-cium, magne-sium	Non-carbon-ate				
76. BUCK CREEK NEAR BURKEVILLE																						
Oct. 14, 1952-----	4.21	22				6.1		7	3.7	4.5		0.5		a35	0.05		3	0	62	1.5	26	6.5
77. INDIAN CREEK NEAR BURKEVILLE																						
Oct. 14, 1952-----	4.04	30				5.7		12	3.6	4.0		0.2		a53	0.07		7	0	64	0.9	44	6.6
84. HICKMAN CREEK NEAR BURKEVILLE																						
Oct. 16, 1952-----	4.30	23				3.9		9	0.7	3.5		0.5		a37	0.05		5	0	63	0.8	30	6.5
88. LITTLE COW CREEK BELOW McCRAW CREEK NEAR BURKEVILLE																						
Feb. 13, 1952-----	b30	12		--	--	--		9	--	9	--	0.2		--	--		21	--	--	--	60	7.7
Oct. 16-----	46.2	19		--	--	4.6		12	2.6	4.5	--	.2		a40	0.05		9	0	53	0.7	43	6.7
Sep. 14, 1954-----	43.3	19		1.9	0.8	6.2		14	2.5	5.2	--	.2		43	.06		8	0	63	1.0	46	6.6
Nov. 30, 1961-----	91.5	15		4.0	1.2	3.1	1.3	17	1.6	5.5	0.1	.2		40	.05		15	1	29	.3	57	5.9
Jan. 16, 1962-----	158	13		6.0	.7	3.1	1.2	18	3.0	5.2	.1	.5		42	.06		18	3	26	.3	58	6.0
May 31-----	73	14		3.0	.8	2.9	1.6	11	2.8	4.9	.1	.1		35	.05		11	3	33	.4	43	5.6
July 6-----	54.6	17		3.5	1.0	2.9	1.5	13	2.0	5.6	.1	.0		40	.05		13	2	30	.3	44	6.1
101. CANEY CREEK NEAR BON WIER																						
May 13, 1952-----	19.5	16				6.0		21	1.6	7.2		--		a53	0.07		16	0	45	0.7	62	6.5
Oct. 17-----	4.66	18				5.8		17	1.8	6.0		0.5		a45	0.06		12	0	51	.7	58	6.6
Apr. 16, 1953-----	15.0	17				4.1	1.6	22	2.0	6.5		.5		a58	.08		17	0	32	.4	65	7.3
102. DAVIS CREEK NEAR BON WIER																						
Oct. 17, 1952-----	0.50	13				3.9		8	2.6	4.2		2.8		a33	0.04		9	2	48	0.6	41	6.4
103. DEMPSEY CREEK NEAR BON WIER																						
June 20, 1952-----	5.11	28		1.9	0.8	5.9		18	1	6.2	0.3	0.5		54	0.07		8	0	61	0.9	52	6.5
Oct. 17-----	.81	30				7.9		18	1.5	6.0		.5		a58	.08		8	0	68	1.2	52	6.9
104. DONAHOE CREEK NEAR BON WIER																						
June 20, 1952-----	6.52	24		3.2	1.3	6.4		14	2	7.2		1.0		52	0.07		13	2	51	0.8	58	6.3
107. BIG COW CREEK AT FARRSVILLE																						
Oct. 5, 1940-----	b14							10	2	5.0		0.0					9					
Apr. 10, 1941-----		9.4	0.48	2.0	0.8	2.8		7	2.5	4.2		.2		26	0.04		8	3	43	0.4		5.8

a Residue on evaporation at 180°C.

b Field estimate.

Table 8.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Texas, for locations other than daily stations--Continued

Date of collection	Dis-charge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Cal-cium (Ca)	Mag-nesium (Mg)	So-dium (Na)	Po-tas-sium (K)	Bicar-bonate (HCO <sub>3</sub> )	Sul-fate (SO <sub>4</sub> )	Chlo-ride (Cl)	Fluo-ride (F)	Ni-trate (NO <sub>3</sub> )	Bo-ron (B)	Dis-solved solids (calculated)			Hardness as CaCO <sub>3</sub>		Per-cent so-dium	So-dium adsorp-tion ratio	Specific conductance (micro-mhos at 25° C)	pH	
														Parts per million	Tons per acre-foot	Tons per day	Cal-cium, magne-sium	Non-carbon-ate					
108. HUNTERS CREEK NEAR FARRSVILLE																							
Oct. 5, 1940-----	b5							9	2	5.0		0.2			25	0.03		9	3	43	0.4		6.0
Apr. 10, 1941-----		8.8	0.50	2.0	0.8		2.8	7	2.1	4.4		.3						8					
109. MELHOMES CREEK NEAR JASPER																							
Oct. 5, 1940-----	b9							10	1.5	4.5		0.0			25	0.03		8	0	48	0.5		5.9
Apr. 10, 1941-----		8.8	0.62	1.6	0.8		3.1	7	2.5	3.9		.2						7					
110. BISHOP CREEK NEAR JASPER																							
Oct. 5, 1940-----								13	2	5.0		0.2						10					
Apr. 10, 1941-----		8.3	2.0	1.9	0.9		3.2	9	2.5	3.8		.2			27	0.04		8	1	46	0.5		6.0
112. BIG COW CREEK NEAR NEWTON																							
Oct. 17, 1940-----	--	--		--	--			12	2	4.0	--	0.1		--	--			10	--	--	--	--	6.5
May 9, 1952-----	53.8	13		--	--		5.8	14	1.6	6.0	--	--		a38	0.05			9	0	58	0.8	41	6.5
Nov. 30, 1961-----	84.0	12		1.5	1.2	3.2	1.0	10	.2	6.2	0.2	.2		31	.04			9	0	41	.5	42	5.9
Jan. 16, 1962-----	204	11		4.0	.7	3.5	.8	9	2.8	7.2	.1	.5		35	.05			13	6	35	.4	52	5.6
July 11-----	41.9	13		2.2	.7	2.9	.8	8	.4	6.0	.1	.0		30	.04			8	2	40	.4	36	5.6
Aug. 9-----	31.7	12		2.2	.6	3.1	1.0	8	.8	5.5	.1	.8		30	.04			8	1	42	.5	34	5.9
Oct. 18-----	36.5	13		1.5	.8	2.9	.7	8	.0	5.5	.1	.2		25	.03			7	0	44	.5	32	5.6
Nov. 21-----	168	12		2.2	1.2	3.5	1.7	4	4.6	8.0	.2	.5		36	.05			10	7	38	.5	43	5.5
113. BIG COW CREEK NEAR BLFAKWOOD																							
Mar. 19, 1959-----	b140	12		3.0	0.9	3.9	0.7	12	1.4	6.8	0.0	0.0		35	0.05			11	1	41	0.5	47	6.8
114. BIG COW CREEK NEAR CALL																							
Oct. 17, 1952-----	38.6	20						12	1.4	5.2		0.2		46	0.07			8	0	57	0.8	48	6.5
Feb. 28, 1961-----		11		2.2	0.8	3.6	0.5	7	1.4	6.5	0.1	.5		30	.04			9	3	45	.5	40	5.3
117. TROUT CREEK NEAR CALL																							
Mar. 19, 1959-----	b20	24		2.8	1.1	8.0	1.0	18	1.8	9.8	0.1	0.2		58	0.08			12	0	58	1.0	67	6.1
118. NICHOLS CREEK NEAR BUNA																							
Nov. 29, 1961-----	35.5	7.2		0.5	1.6		15	1	0.4	28	0.2	0.5		54	0.07			9	8	79	2.2	103	4.7
Jan. 15, 1962-----	70.3	8.0		1.5	1.1		16	1	3.0	28	.1	.5		58	.08			8	7	81	2.5	112	4.7
119. CYPRESS CREEK NEAR BUNA																							
June 4, 1952-----	5.15	7.9		--	--		6.0	10	1.3	8.8	--	--		a56	0.08			9	0	59	0.9	58	6.8
Mar. 19, 1959-----	4.0	8.4		1.5	1.2	7.2	0.5	10	1.8	9.8	0.2	0.2		36	.05			9	0	63	1.1	56	6.0
Nov. 29, 1961-----	19.9	6.1		.5	1.3	5.9	.7	3	3.0	10	.1	.5		29	.04			7	4	63	1.0	52	5.0
Jan. 15, 1962-----	180	5.7		1.5	1.0	5.9	.8	1	4.6	11	.1	.5		31	.04			8	7	59	.9	55	4.8
Jan. 16-----	133	4.6		1.5	1.0	5.6	.5	2	4.6	9.8	.1	.2		29	.04			8	6	59	.9	55	5.0
July 9-----	.24	9.6		2.5	1.5	8.0	.4	12	2.0	12	.1	.8		43	.06			12	3	57	1.0	69	5.5

a Residue on evaporation at 180°C.  
b Field estimate.

Table 9.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Louisiana

(Results in parts per million except as indicated)

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
42. SABINE RIVER AT LOGANSPORT																						
Oct. 21-28, 1941-----	1,450			22	6.6	124		43	14	214				402	0.55		82	47	77	6.0	820	
Oct. 30-31-----	2,310			6.4	3.0	13		20	4.0	26				62	.08		28	12	51	1.1	126	
Nov. 1-4-----	10,100			10	4.4	27		26	11	49				115	.16		42	22	58	1.8	236	
Nov. 5-9-----	7,900			22	6.5	109		44	19	186				365	.50		82	46	74	5.2	740	
Nov. 12-18-----	1,000			24	7.0	130		52	21	218				426	.58		89	46	76	6.0	856	
Dec. 21-24, 26-31-----	5,640			20	4.9	88		45	26	139				301	.41		70	33	73	4.6	592	
Jan. 1-10, 1942-----	4,880			20	8.4	107		42	34	176				366	.50		84	50	73	5.1	749	
Jan. 21-31-----	1,430	20	0.21	26	9.1	179		37	41	295	0.5			590	.80		102	72	79	7.7	1,120	
Mar. 1-10-----	6,540			16	6.4	73		32	25	122				259	.35		66	40	71	3.9	525	
Mar. 11-20-----	5,800			21	7.9	118		44	40	186		1.2		396	.54		85	49	75	5.6	775	
Apr. 7-----	1,270			19	9.2	142		40	28	235		.5		453	.62		86	52	78	6.7	915	
July 21-31-----	330			34	9.3	281		75	17	465		.2		843	1.15		123	62	83	11	1,630	
Sept. 11-12, 14-20-----	3,480			20	5.7	136		42	20	222		2.0		426	.58		74	39	80	6.9	836	
Sept. 21-25, 30-----	1,070			26	7.2	166		50	21	275		4.5		524	.71		94	54	79	7.4	1,040	
Jan. 1-5, 1944-----	2,900			21	7.5	120		30	50	189		1.5		404	.55		84	59	76	5.7	752	
Jan. 11-12, 14-20-----	8,410			13	4.5	43		48	21	58		.5		164	.22		51	12	64	2.6	325	
Jan. 21-31-----	7,300			17	6.5	69		25	42	109		.8		257	.35		69	49	68	3.6	484	
Feb. 1-10-----	3,570			22	7.7	95		27	34	165		2.2		339	.46		86	64	70	4.5	705	
43. BAYOU CASTOR NEAR LONGSTREET																						
Oct. 17, 1955-----	a0.16	32	0.73	7.5	2.5	16		46	2.0	16		1.0		101	0.14		29	0	54	1.3	141	6.9
Dec. 9-----	a .31	24	.70	8.6	3.3	17		57	1.5	16		.5		100	.14		35	0	51	1.2	154	7.0
Apr. 4, 1956-----	a2.98	20	.58	16	8.5	43		60	30	62		.6		211	.29		75	26	56	2.2	359	7.0
44. BUSHNECK BAYOU AT LONGSTREET																						
Oct. 17, 1955-----	a0.045	14	0.19	23	8.3	39		122	3.7	51		0.8		b202	0.27		92	0	48	1.8	364	7.2
Dec. 9-----	a .06	22	.33	28	11	39		136	2.3	62		.2		b246	.33		116	5	42	1.6	414	7.2
46. BAYOU GRAND CANE NEAR LOGANSPORT																						
Apr. 3, 1956-----	a6.24	10	0.32	18	11	54		49	57	76		0.5		251	0.34		90	50	56	2.5	450	7.3
56. BAYOU SAN PATRICIO NEAR NOBLE																						
Apr. 19, 1957-----	66	15	0.87	6.0	3.2	21		19	18	28		0.8		102	0.14		28	13	62	1.8	172	6.5
May 15-----	62	16	.89	7.3	3.5	30		28	9.4	45		1.5		128	.17		33	10	67	2.3	223	6.2
June 14-----	29	16	2.1	7.3	2.8	31		24	10	46		2.2		129	.18		30	10	69	2.5	229	5.9
July 8-----	5.8	18	3.0	9.5	4.1	38		40	11	55		2.2		161	.22		41	8	67	2.6	280	6.2
Sept. 3-----	.5	5.4	.20	13	6.4	29		77	.4	41		1.0		134	.18		59	0	52	1.6	295	7.2
59. BAYOU SAN MIGUEL NEAR ZWOLLE																						
June 20, 1956-----	0.0	7.0	0.06	11	6.1	21		78	3.8	21		1.2		109	0.15		53	0	46	1.2	205	7.4
Jan. 31, 1957-----	268	64	.50	1.8	1.5	4.0	2.9	6	7.6	5.5	0.7	.8		35	.05		11	6	38	.5	49	5.4
Mar. 1-----	24	15	.81	5.5	3.0	15		14	24	16		.5		87	.12		26	15	56	1.3	140	6.3

a Discharge at time of sampling  
b Residue on evaporation at 160°C.

Table 9.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Louisiana--Continued

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
65. HURRICANE CREEK TRIBUTARY AT LORING LAKE NEAR ZWOLLE																						
Apr. 11, 1958-----		2.0	0.14	2.4	0.7	3.2	1.6	11	1.2	4.2	0.6	0.3		21	0.03		9	0	39	0.5	44	6.3
66. BAYOU LA NANA NEAR ZWOLLE																						
Oct. 29, 1959-----	1.1	12	0.77	10	6.1	21	3.4	63	25	16	0.4	1.1		127	0.17		50	0	46	1.3	183	5.6
Nov. 11-----	1.2	14	.16	13	5.7	24	3.4	84	16	18	.3	.6		136	.18		56	0	46	1.4	219	5.7
Dec. 9-----	2.5	16	.31	16	6.6	31	4.3	102	14	30	.3	.3		169	.23		67	0	48	1.7	286	7.2
Feb. 3, 1960-----	80	13	.45	13	5.7	33	2.5	32	46	40	.2	.5		170	.23		56	30	35	1.9	293	6.6
Mar. 1-----	122	14	.42	8.4	3.7	18	1.7	18	32	20	.1	.5		108	.15		36	21	31	1.3	175	6.0
Apr. 6-----	20	12	.22	14	8.6	39	1.8	58	48	44	.3	.2		197	.27		70	22	34	2.0	340	7.1
May 3-----	8.9	13	2.7	17	8.2	54	2.4	114	1.0	70	.3	.7		225	.31		76	0	60	2.7	431	4.6
June 2-----	2.2	13	.32	20	6.1	48	2.1	95	23	56	.3	.0		216	.29		75	0	37	2.4	404	6.5
July 5-----	5.9	15	.43	8.8	4.9	20	2.3	44	15	25	.2	.9		115	.16		42	6	49	1.3	193	6.1
Aug. 3-----	1.8	11	.28	9.6	4.4	23	2.6	58	11	24	.3	.9		116	.16		42	0	52	1.5	208	6.2
Sept. 7-----	1.7	14	.39	15	4.5	32	2.0	93	12	28	.2	.3		154	.21		56	0	54	1.9	263	6.7
79. BAYOU TORO NEAR TORO																						
Sept. 10, 1958-----	52	17	0.62	3	0.5	3.9	1.5	9	4.2	4.6	0.4	0.7		40	0.05		10	2	43	0.6	42	6.2
Nov. 6, 1959-----	10	23	.24	3.7	1.2	5.3	.8	16	5.0	5.2	.1	.4		53	.07		14	1	43	.6	64	6.3
Dec. 10-----	9.0	25	.15	3.8	.6	7.4	2.3	17	8.6	6.0	.2	.1		62	.08		12	0	32	.9	67	6.2
Feb. 4, 1960-----	650	13	.37	4.5	.9	6.7	2.2	6	14	8.3	.1	1.0		54	.07		15	10	45	.7	82	3.3
Mar. 1-----	150	17	.37	4.4	1.7	6.4	1.4	8	15	8.0	.2	.5		59	.08		18	12	41	.7	74	6.6
Apr. 6-----	45	19	.35	5.1	1.8	8.7	1.8	19	12	9.2	.1	.3		67	.09		20	4	46	.8	82	6.6
May 3-----	24	21	.40	5.9	1.3	8.0	1.7	19	10	9.4	.2	.4		67	.09		20	4	44	.8	82	5.7
May 31-----	7.2	22	.83	5.4	1.1	8.5	1.9	25	7.6	7.2	.1	.0		67	.09		18	0	47	.9	84	6.6
July 6-----	26	20	.40	7.0	1.6	5.1	2.4	19	7.8	9.4	.1	.5		63	.08		24	8	29	.4	81	5.7
Aug. 3-----	7.0	18	.47	7.6	1.2	4.8	1.2	18	7.8	9.0	.1	.6		60	.08		24	9	29	.4	87	6.1
Sept. 6-----	5.0	20	.14	5.6	.5	4.6	.8	17	5.0	5.5	.0	.4		50	.07		16	2	37	.5	64	5.9
91. EAST ANACOCO CREEK NEAR ANACOCO																						
Sept. 10, 1958-----		22	0.16	2.4	0.2	3.9	0.9	9	0.6	5.8	0.2	0.4		41	0.06		7	0	51	0.6	35	5.9
Dec. 10, 1959-----	45.2	21	.07	2.1	.2	3.7	1.4	10	.6	4.9	.1	.1		39	.05		6	0	51	.7	38	6.0
May 18, 1960-----	44.5	20	.17	3.0	.4	3.7	1.1	9	4.6	4.0	.1	.3		42	.06		9	2	43	.5	42	6.1
May 11, 1961-----	413.4	15	.14	.9	.7	3.0	.8	8	.2	4.0	.0	.4		29	.04		5	0	52	.6	36	6.0
Sept. 6-----	46.21	16	.02	2.3	.3	2.8	.9	10	.0	4.0	.1	.2		32	.04		7	0	42	.5	34	5.4
95. ANACOCO LAKE NEAR LEESVILLE																						
Sept. 10, 1958-----		7.4	0.06	2.8	1.0	1.7	1.8	12	0	3	0.8	0.8		25	0.03		11	1	22	0.2	35	6.1
Nov. 6, 1959-----		6.6	.01	4.7	.8	2.8	1.0	18	.0	3.6	.2	1.3		30	.04		15	0	27	.3	35	6.2
May 18, 1960-----		6.5	.08	5.0	.9	2.8	.9	13	6.0	4.3	.1	.2		33	.04		16	5	26	.3	49	5.7
Nov. 2-----		6.9	.02	5.4	1.4	2.3	1.4	17	1.2	7.0	.1	.4		34	.05		19	5	19	.2	51	6.2
May 11, 1961-----		7.1	.12	3.0	.6	1.6	.9	10	1.2	3.0	.1	.7		23	.03		10	2	24	.2	40	5.6
Aug. 15-----		3.9	.00	2.2	.8	2.3	1.0	12	1.4	2.8	.1	.6		21	.03		9	0	32	.3	29	6.5

a Discharge at time of sampling.

Table 9.--Chemical analyses of streams and reservoirs in the Sabine River Basin in Louisiana--Continued

Date of collection	Mean discharge (cfs)	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids (calculated)			Hardness as CaCO <sub>3</sub>		Percent sodium	Sodium adsorption ratio	Specific conductance (micro-mhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Tons per day	Calcium, magnesium	Non-carbonate				
96. BAYOU ANACOCO NEAR ROSEFINE																						
Aug. 22, 1952-----	28	16	0.08	4.9	1.8	5.5	2.8	26	2.4	7.0	0.1	0.2		54	0.07		20	0	34	0.5	80	6.4
Sept. 24-----	53	20	.12	2.2	1.0	4.1	1.6	14	2.3	5.5	.4	.5	0.02	b45	.06		10	0	43	.6	42	6.6
Oct. 29-----	27	11	.44	5.2	1.2	4.5	2.0	24	1.2	5.7	.2	.5		44	.06		18	0	32	.5	63	6.6
Dec. 17-----	145	9.8	.40	4.2	1.0	4.5	--	20	1.7	4.2	--	1.2		37	.05		15	0	40	.5	53	6.3
Mar. 5, 1953-----	561	20	.44	2.2	1.0	4.3	--	9	3.7	4.8	--	.8		41	.06		10	2	49	.6	43	6.0
Apr. 8-----	227	9.0	.33	3.9	1.2	3.3	--	16	2.6	3.8	--	1.0		33	.04		15	2	33	.4	48	6.3
July 9-----	86	8.8	.23	4.0	.9	2.7	1.4	19	1.8	3.5	--	.5		33	.04		14	0	27	.3	47	6.5
Aug. 5-----	244	9.5	.35	3.4	.8	2.6	1.2	17	1.4	3.5	--	.5		31	.04		12	0	29	.3	43	6.5
Sept. 8-----	96	12	.18	3.9	1.2	4.0	1.3	20	1.1	4.5	--	1.2		39	.05		15	0	35	.5	47	7.1
Nov. 14, 1959-----	24	13	.06	5.4	.9	3.7	1.4	10	1.4	9.9	.1	3.5		44	.06		17	9	30	.4	65	6.4
Jan. 4, 1960-----	670	8.6	.19	2.8	.2	2.3	.7	6	1.8	4.2	.1	.5		24	.03		8	3	36	.4	36	6.0
Mar. 14-----	300	11	.19	4.1	.4	4.8	1.7	12	3.4	7.0	.1	1.6		40	.05		12	2	43	.6	54	6.1
May 3-----	91	13	.17	3.6	.7	4.6	1.7	9	2.2	9.0	.1	2.0		41	.06		12	5	41	.6	55	5.2
July 6-----	68.5	13	.01	6.0	.3	2.1	1.1	18	1.0	4.2	.1	.0		37	.05		16	1	21	.2	53	6.3
97. BAYOU ANACOCO NEAR KNIGHT																						
Sept. 21, 1959-----	a61.7	15	0.11	4.3	1.0	3.0	0.9	20	0	4.0	0.1	0.3		39	0.05		15	0	29	0.3	53	6.6
May 18, 1960-----	a87.5	13	.08	5.5	.6	3.9	1.0	16	4.8	5.0	.1	.2		42	.06		16	3	33	.4	55	5.7
Apr. 24, 1961-----	a243	8.8	.1	4.7	.1	3.9	1.2	14	.8	5.7	.0	1.2		34	.05		12	1	39	.5	51	5.9
Aug. 28-----	a258	11	.01	4.0	.5	2.8	.9	14	.6	4.0	.1	.2		31	.04		12	1	31	.3	42	5.9

a Discharge at time of sampling.

b Contains 0.02 ppm boron (B).

Map Showing Location of Streamflow and Chemical Quality Data-Collection Sites on Streams in the Sabine River Basin in Texas and Louisiana

U. S. Geological Survey in cooperation with the Texas Water Commission



EXPLANATION

- ▲ Regular streamflow or reservoir station
- △ Partial-record or miscellaneous streamflow measurement site
- ▼ Daily chemical quality station
- ▽ Periodic or intermittent chemical quality sampling site
- ◆ Daily chemical quality at regular streamflow station
- ◇ Periodic chemical-quality sampling at regular streamflow station
- ◇ Periodic chemical-quality sampling and streamflow measurement site
- 5 Data-collection site number; numbers correspond to those in tables of analyses and in index of surface water records

0 10 20 MILES

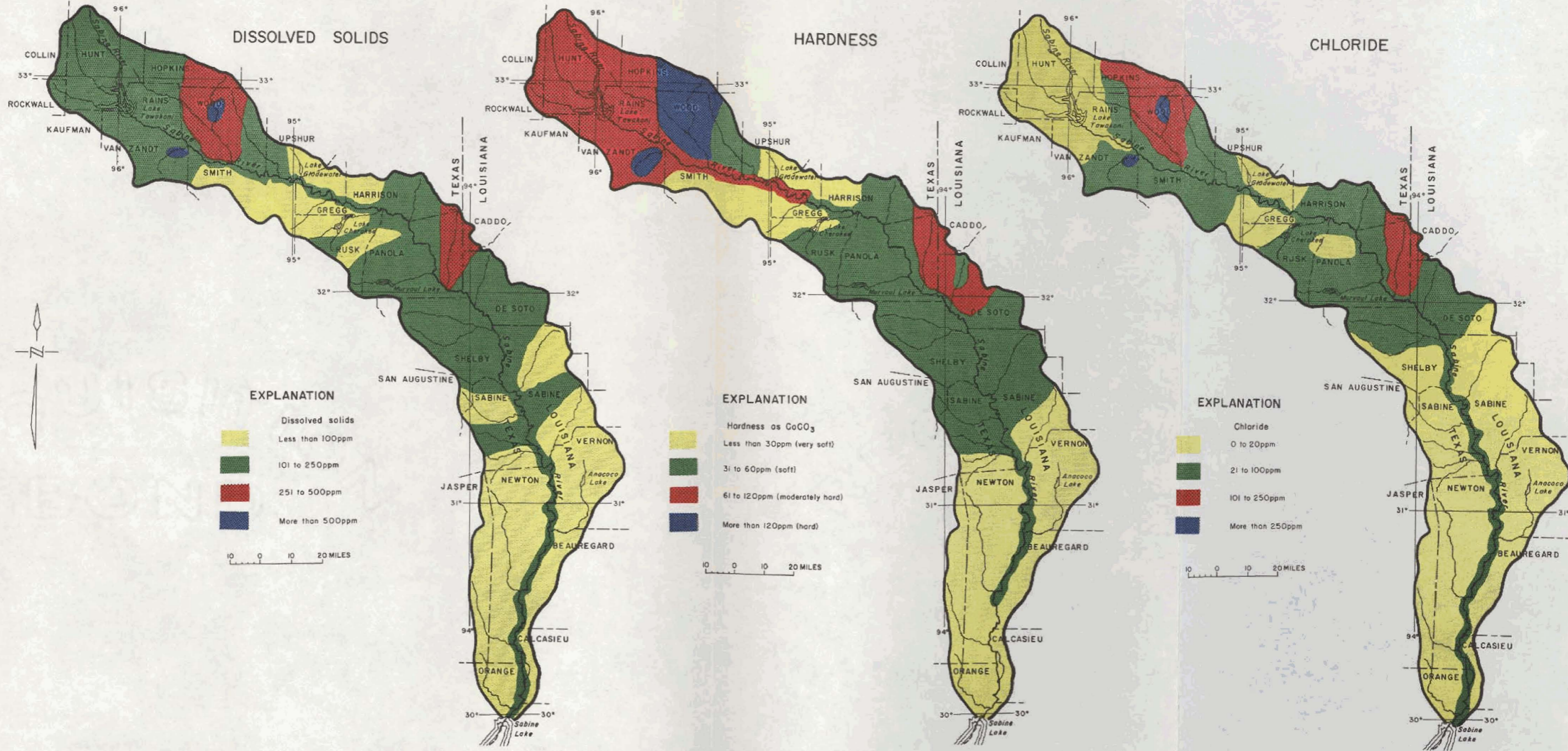


Plate 2  
 Maps of the Sabine River Basin Showing Chemical Quality of Surface Water  
 U. S. Geological Survey in cooperation with the Texas Water Commission