TEXAS WATER DEVELOPMENT BOARD

REPORT 130

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE COASTAL BASINS OF TEXAS

By

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ABSTRACT

The eight coastal basins in Texas have a combined drainage area of more than 19,000 square miles and include all of the 370 miles of the coast except for a few miles across the mouths of the major rivers. Most of the coastal region is a smooth, featureless, depositional plain with altitudes generally less than 200 feet above mean sea level.

An abundance of water for municipal supply, industrial use, irrigation, and transportation has resulted in a diversified and expanding economy in the coastal basins. In addition to the local ground-water and surface-water supplies, large volumes of surface water are imported to the coastal basins from adjacent river basins. Imported water is moved through a network of canals to irrigated fields and industrial sites. With oil production scattered throughout the region, oil-refining and petrochemical plants are a major part of the industrial activities. The major industrial centers and seaports of the coastal basins include Beaumont, Port Arthur, Galveston, Texas City, and Corpus Christi.

The activities of man are affecting the chemical quality of surface waters in the coastal basins. Low flows in many of the streams are being degraded to some degree by oil field and other industrial wastes and by irrigation-return flows. However, runoff from the generally abundant precipitation along the Texas coast dilutes or flushes out these wastes in most of the coastal streams.

Surface waters of the coastal basins are generally of good chemical quality, and in streams receiving little or no man-made wastes, the dissolved-solids concentrations are generally less than 250 milligrams per liter. Recent regulations of the Railroad Commission of Texas should reduce the amount of oil-field brines reaching surface-water courses.

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE COASTAL BASINS OF TEXAS

INTRODUCTION

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 Development Board and with federal and local agencies. However, this network has not been adequate to inventory completely the chemical quality of surface waters of the State. To supplement the information being obtained by the network, a cooperative statewide reconnaissance by the U.S. Geological Survey and the Texas Water Development Board was begun in September 1961. Samples for chemical analysis were collected periodically at numerous sites throughout Texas so that some water-quality information would be available for locations where water-development projects are likely to be built. These data aid in the delineation of areas having water-quality problems and in the identification of probable sources of pollution, thus indicating areas in which more detailed investigations are needed.

The State has been divided into 15 river and 8 coastal basins, with the name of each river basin being the name of the main river which the basin topographically encloses and the name of each coastal basin being the combined names of the two main rivers between which the coastal basin lies. Coastal basins are defined so as to include the areas of coastal plains, peninsulas, and islands that lie adjacent to and between the main river basins (Texas Board of Water Engineers, 1961, p. 29). The chemical quality of surface waters in each basin is being studied, and a series of reports summarizing the results of the study is being prepared by the U.S. Geological Survey in cooperation with the Texas Water Development Board. (See list of references for previous reports).

The purpose of this report is to present available data and interpretations on the quality of surface waters to aid in the proper development, management, and use of water resources of the Texas coastal basins. In this study, the following factors were considered: The nature and concentrations of mineral constituents in solution; the geologic, hydrologic, and cultural influences that determine the water quality; and the suitability of the water for municipal supply, industrial use, and irrigation.

GENERAL DESCRIPTION OF THE COASTAL BASINS

The eight coastal basins include an area of more than 19,000 square miles along the Texas Gulf Coast (Figure 1). Except for a few miles across the mouths of the major rivers, the 370 miles of Texas coast is within these basins. The drainage areas of some of the coastal basins extend inland more than a hundred miles.

All of the coastal basins are in the West Gulf Coastal Plain physiographic section of the Coastal Plain province. Topographically, the area is generally a smooth, featureless, depositional plain. The altitude of most of the region is less than 200 feet above mean sea level except along the interior boundary of the Nueces-Rio Grande coastal basin, where the altitude reaches 900 feet.

The geology of the Gulf Coast region of Texas has been described by Wood, Gabrysch, and Marvin (1963). Sedimentary deposits range in age from Miocene to Holocene (Figure 2). Holocene deposits form the coastline and successively older beds crop out toward the interior. Alluvium, beach sands, and terrace deposits of Holocene age and the Beaumont Clay and Lissie Formation of Pleistocene age dominate the surface geology of the coastal basins. Older formations ranging in age from Miocene to Pliocene(?) are exposed in small areas in the headwaters of the Brazos-Colorado and San Antonio-Nueces coastal basins and in the western part of the Nueces-Rio Grande coastal basin. Widespread eolian deposits cover a 2,800-square-mile area in the center of the Nueces-Rio Grande coastal basin.

The climate along the Texas Gulf Coast varies greatly from east to west. The average annual precipitation decreases from about 56 inches near the Texas-Louisiana line to less than 20 inches in the southwestern part of the Nueces-Rio Grande coastal basin (Figure 3). According to Thornthwaite's classification (1952, p. 32), the coastal area is divided into regions of moisture-surplus and moisture-deficiency by a line through the Lavaca-Guadalupe coastal basin. The climatic type and moisture deficiency-surplus index for the coastal basins are shown on Figure 3.

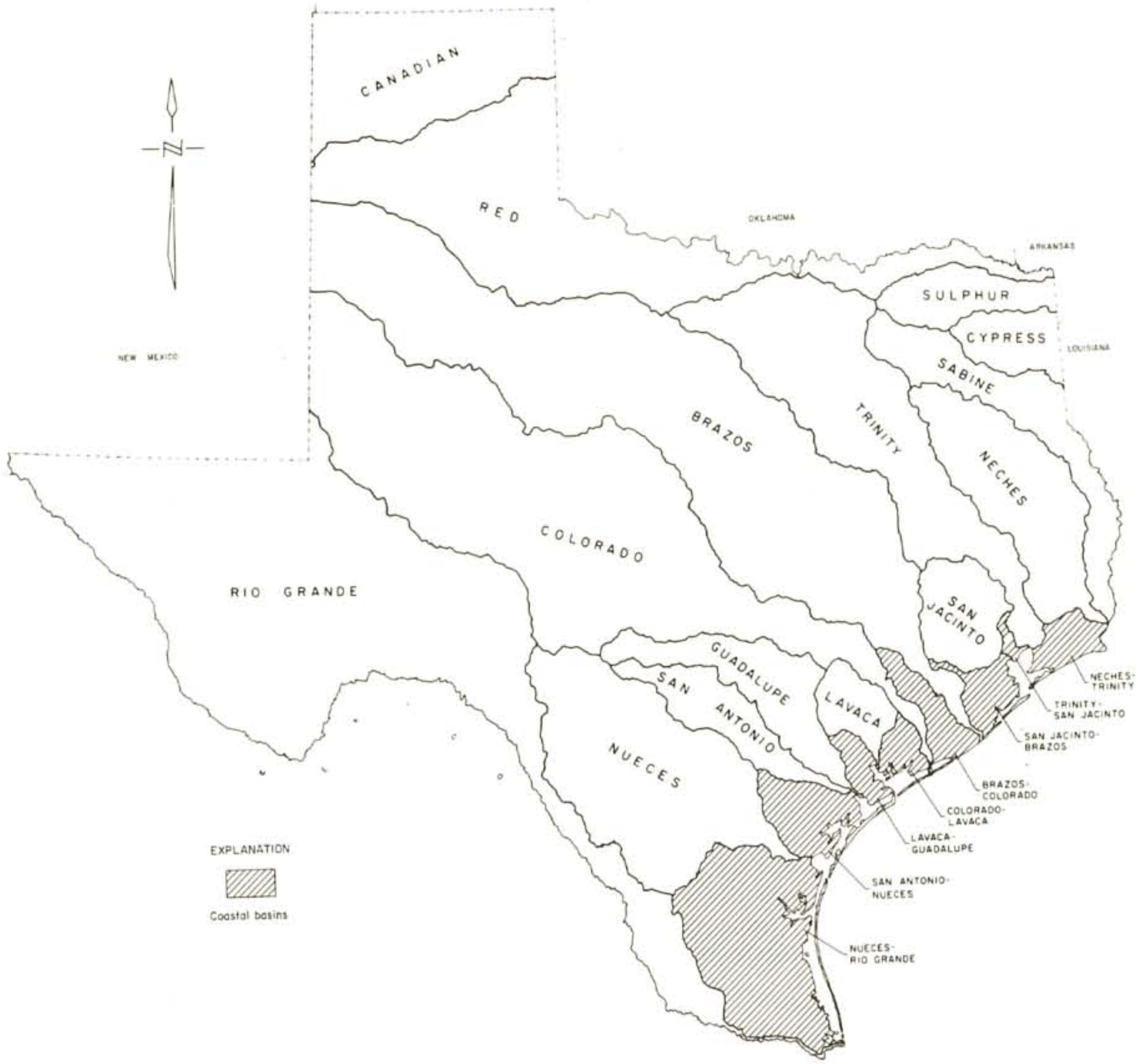

Figure 1.—Drainage Basins in Texas

The Texas Gulf Coast generally has mild winters and hot summers. Daily-minimum temperatures are seldom less than 32°F (0°C) during the winter; and during the summer, daily-maximum temperatures greater than 90°F (32°C) are common. Carr (1967, p. 19) reports average annual mean air temperatures (1931-60) from 69°F (20.5°C) along the Texas-Louisiana line to 74°F (23.3°C) in south Texas near the Rio Grande.

The general availability of water along the Texas Gulf Coast is the principal factor in the economic development of the coastal basins. Water for municipal supply, industrial use, irrigation, and transportation has resulted in a diversified and expanding economy. Sources of water supplies, quantity and quality of water, and principal products are discussed for each coastal basin in later sections of this report.

RELATION OF WATER QUALITY TO USE

The quality of water, as well as quantity of water, should be considered for any water use. All natural waters contain mineral constituents dissolved from rocks and minerals of the earth's crust. The commonly determined constituents and properties and their source and significance are given in Table 1.

To aid in determining the extent to which chemical quality limits the suitability of water for irrigation, the U.S. Salinity Laboratory Staff (1954, p. 69) has prepared a system for classifying irrigation waters in terms of salinity and sodium hazards. A diagram was formulated which uses sodium-adsorption ratio (SAR) and specific conductance in classifying

Table 1.—Source and Significance of Dissolved-Mineral Constituents and Properties of Water

CONSTITUENT OR PROPERTY	SOURCE OR CAUSE	SIGNIFICANCE
Silica (SiO_2)	Dissolved from practically all rocks and soils, commonly less than 30 mg/l. High concentrations, as much as 100 mg/l, 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 mg/l of iron in surface waters generally indicates 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 mg/l stains laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. U.S. Public Health Service (1962) drinking-water standards state that iron should not exceed 0.3 mg/l. 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_3) and carbonate (CO_3)	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_4)	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. U.S. Public Health Service (1962) drinking-water standards recommend that the sulfate content should not exceed 250 mg/l.
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. U.S. Public Health Service (1962) drinking-water standards recommend that the chloride content should not exceed 250 mg/l.
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 susceptbility of the individual. (Maier, 1950)
Nitrate (NO_3)	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average may suggest pollution. U.S. Public Health Service (1962) drinking-water standards suggest a limit of 45 mg/l. 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.	U.S. Public Health Service (1962) drinking-water standards recommend that waters containing more than 500 mg/l dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 mg/l dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$	In most waters nearly all the hardness is due to calcium and magnesium. All 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 as much as 60 ppm are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, 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.

irrigation waters. SAR expresses 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 concentrations of the ions are in milliequivalents per liter. The U.S. Salinity Laboratory Staff stated that this classification should be used only for general guidance, because other factors such as soil type, climate, types of crops, and toxic elements in water also affect the suitability of water for irrigation.

The diagram is reproduced in modified form as Figure 4. The observed ranges in SAR and specific conductance for six sites in the coastal basins are plotted on the diagram. The chemical quality of surface waters at these sites is affected to some degree by irrigation-return flows and other activities of man, but sites on streams highly degraded by industrial wastes were not included because these waters could not be used for irrigation.

FACTORS AFFECTING CHEMICAL QUALITY OF WATER

All waters from natural sources contain dissolved minerals, but the chemical character and concentrations of dissolved constituents in surface waters may fluctuate widely in response to differences in environment. The most important factors that affect the chemical quality of surface waters are geology, patterns and characteristics of streamflow, and the activities of man.

In streams unaffected by man's activities, the geologic environment determines to a large extent the kinds and amounts of dissolved constituents. All rocks and soils contain soluble materials, but the amount of minerals available for solution is decreased by leaching. Therefore, rocks and soils in areas of high rainfall usually are well leached and yield water of low mineralization; whereas rocks and soils in arid regions are poorly leached and often yield large quantities of minerals to circulating waters.

The mean annual precipitation exceeds 25 inches along the Texas Gulf Coast, except in the western half of the Nueces-Rio Grande coastal basin; consequently, many of the more soluble minerals have been leached from the surface rocks and soils. The western half of the Nueces-Rio Grande coastal basin has a poorly defined drainage network that has little or no sustained dry-weather flows. Runoff during periods of heavy precipitation is rapidly lost by infiltration and evaporation. Because of the short time in contact with surface rocks and soils, the surface water in this area is generally low in dissolved solids, but the limited and undependable quantities are of little significance as a water supply.

The patterns and characteristics of streamflow usually affect the chemical character of water in streams. In most streams where the flow is not regulated by upstream impoundments the concentration of dissolved constituents varies inversely with the water discharge. The concentration usually is minimum during floods when most of the water is surface runoff that has been in contact with the rocks and soils for a short time. Conversely, the concentration is maximum during low-flow periods when the flow is sustained by ground-water effluent that has been in contact with the rocks and soils for a sufficient time to dissolve more of their soluble minerals. This general relationship is true for coastal streams.

Activities of man have generally degraded the chemical quality of surface water in the coastal basins. Depletion of flow by diversion and consumptive use, irrigation-return flows that include ground water and water that has been imported from other surface-water sources, and municipal and industrial wastes contribute to the degradation of chemical quality of coastal streams. As shown on Figure 5, there are heavily irrigated areas in all the coastal basins. Irrigation supplies include ground water and both local and imported surface water. Surface-water supplies are moved across the basins in numerous canals. Thus, irrigation-return flows reaching a stream may be derived from three different sources.

Oil is produced in all the coastal basins (Figure 6), and many of the coastal streams are affected to some degree by oil-field brines. The Railroad Commission of Texas, Oil and Gas Division, Order Number 20-56,841 states, in part, that effective January 1, 1969, use of salt-water disposal pits for storage and evaporation of oil-field brines and discharge of oil-field brines into surface-drainage water courses is prohibited. Before January 1, 1969, some coastal streams were used for conveyance of oil-field brines to the bays. For example, in the San Antonio-Nueces coastal basin, the dissolved-solids concentration of the Mission River at Refugio has exceeded 70,000 mg/l (milligrams per liter).

Much of the industrial and municipal wastes enters the coastal streams in the lower reaches along the coast—principal areas include Beaumont-Port Arthur, Baytown, Galveston-Texas City, and Corpus Christi. However, numerous small towns and industrial operations are scattered throughout the coastal basins and their wastes are altering the quality of water in many streams and reaches of streams.

Data on the chemical quality of surface water and related data on hydrology are presented and discussed for each coastal basin in the following sections of this report.

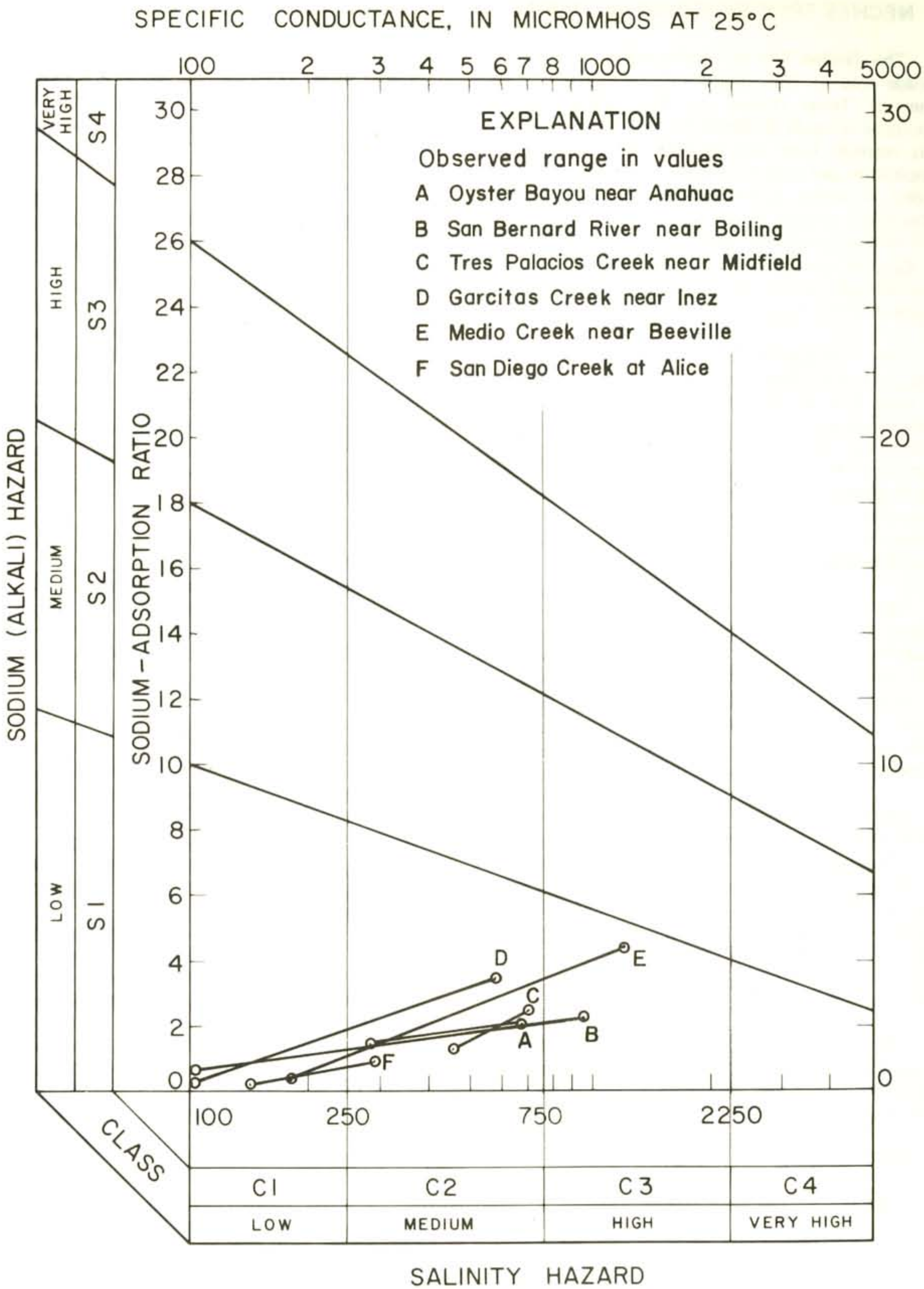

Figure 4
Classification of Irrigation Waters

NECHES-TRINITY COASTAL BASIN

The Neches-Trinity coastal basin, which has a drainage area of 769 square miles is in the southeast corner of Texas (Figure 1). This nearly flat area (maximum altitude is about 50 feet above mean sea level) receives, from east to west, 55 to 44 inches of precipitation per year on the average and is frequently flooded. As shown by the average monthly precipitation at Beaumont (Figure 3), the precipitation in the basin is fairly well distributed throughout the year, with March and October generally having the minimum monthly accumulations. The maximum annual precipitation at Beaumont (1931-68) was 87 inches in 1949.

The principal streams in the basin are Taylor Bayou, East Bay Bayou, Oyster Bayou, and East Fork and West Fork Double Bayous (Figure 7). Numerous small tributaries, many of them unnamed, feed the principal streams. The Neches-Trinity coastal basin has no major water-supply reservoirs. J. D. Murphree Area Impoundments, a 32,000 acre-foot group of shallow impoundments on Big Hill Bayou, is owned and operated by the Texas Parks and Wildlife Department for wildlife management purposes.

The natural drainage network has been altered by a maze of canals used to distribute irrigation waters imported from the Neches and Trinity River basins. In 1964, about 260,000 acre-feet of surface water was imported to irrigate 104,000 acres of rice (Gillett and Janca, 1965, p. 36). In addition to rice production, cattle ranching, dairying, poultry, and truck crops contribute to the agricultural economy.

Oil is produced in many areas of the basin (Figure 6), and the eastern part of the basin in the Beaumont-Port Arthur area is a highly developed industrial complex that includes several large refineries and petrochemical plants. Most of the water for municipal and industrial uses is imported from the Neches River. However, ground water is used by the petroleum industry as a source of supply for secondary oil-recovery operations in the western part of the basin.

Chemical-quality data collected in the Neches-Trinity coastal basin are given in Table 2, and the seven data-collection sites are shown on Figure 7. Dissolved-solids concentrations were generally low in all streams at the times of sampling. Taylor Bayou near LaBelle (site 2) and Hillebrandt Bayou near Lovell Lake (site 3) were sampled during a period of high runoff, and the dissolved-solids concentrations were 113 and 94 mg/l, respectively. Concentrations of dissolved constituents in these streams probably increase during low-flow periods.

East Bay Bayou at Farm Road 1941 near Stowell (site 4), sampled during periods of low to medium flows, had a range in dissolved-solids concentrations from 115 to 841 mg/l. The variation in dissolved-solids, chloride, and nitrate concentrations indicates that agricultural and industrial wastes are sometimes reaching the stream.

Samples collected from Oyster Bayou near Anahuac (site 5), East Fork Double Bayou near Anahuac (site 6), and West Fork Double Bayou near Anahuac (site 7) show less variation in dissolved constituents than samples from East Bay Bayou, but all these streams are probably being degraded to some degree by man's activities.

Limited sampling at the seven sites indicates that the surface waters of the Neches-Trinity coastal basin are generally low in dissolved solids and are of good to excellent chemical quality. However, streams and reaches of streams are being affected by man's activities, and by occasional sea-water flooding of coastal areas at high tides. The greatest degradation of water quality is probably occurring in the industrialized eastern part of of the basin. The abundant precipitation in this humid area has leached out most of the naturally occurring soluble minerals from the rocks and soils, and to a considerable degree, has diluted and flushed out the wastes from man's activities.

TRINITY-SAN JACINTO COASTAL BASIN

The Trinity-San Jacinto coastal basin, which has a drainage area of 247 square miles, is the smallest of the eight coastal basins (Figure 1). The maximum altitude is about 100 feet above mean sea level; some areas are frequently flooded. Average annual precipitation exceeds 48 inches. The annual and average monthly precipitation data (1931-68) for the city of Houston, adjacent to the Trinity-San Jacinto coastal basin on the east, are representative of the precipitation patterns of the basin (Figure 3). Precipitation is distributed fairly well throughout the year, with the monthly maximum usually occurring in July and the minimum in March. The maximum annual precipitation (1931-68) for Houston was 69 inches in 1946.

The Cedar Bayou watershed includes 204 of the 247 square miles in the Trinity-San Jacinto coastal basin (Figure 8). As in the Neches-Trinity coastal basin, numerous canals are used to distribute water imported from the adjacent major streams. Highlands Reservoir, a 5,580 acre-foot impoundment, is the only major surface-water development in the basin. This off-channel reservoir is maintained by importing water from the San Jacinto River. Water stored temporarily in the reservoir is released into the canal system for irrigation, municipal supply, and industrial use.

In 1964, about 31,000 acre-feet of water was used to irrigate about 13,000 acres of rice and pasture—18,000 acre-feet was imported from the Trinity and San Jacinto River basins and 13,000 acre-feet was from local ground-water supplies (Gillett and Janca, 1965, p. 37). Irrigated areas are shown on Figure 5. In addition to rice production, beef cattle, dairying, poultry, and truck crops contribute to the agricultural economy.

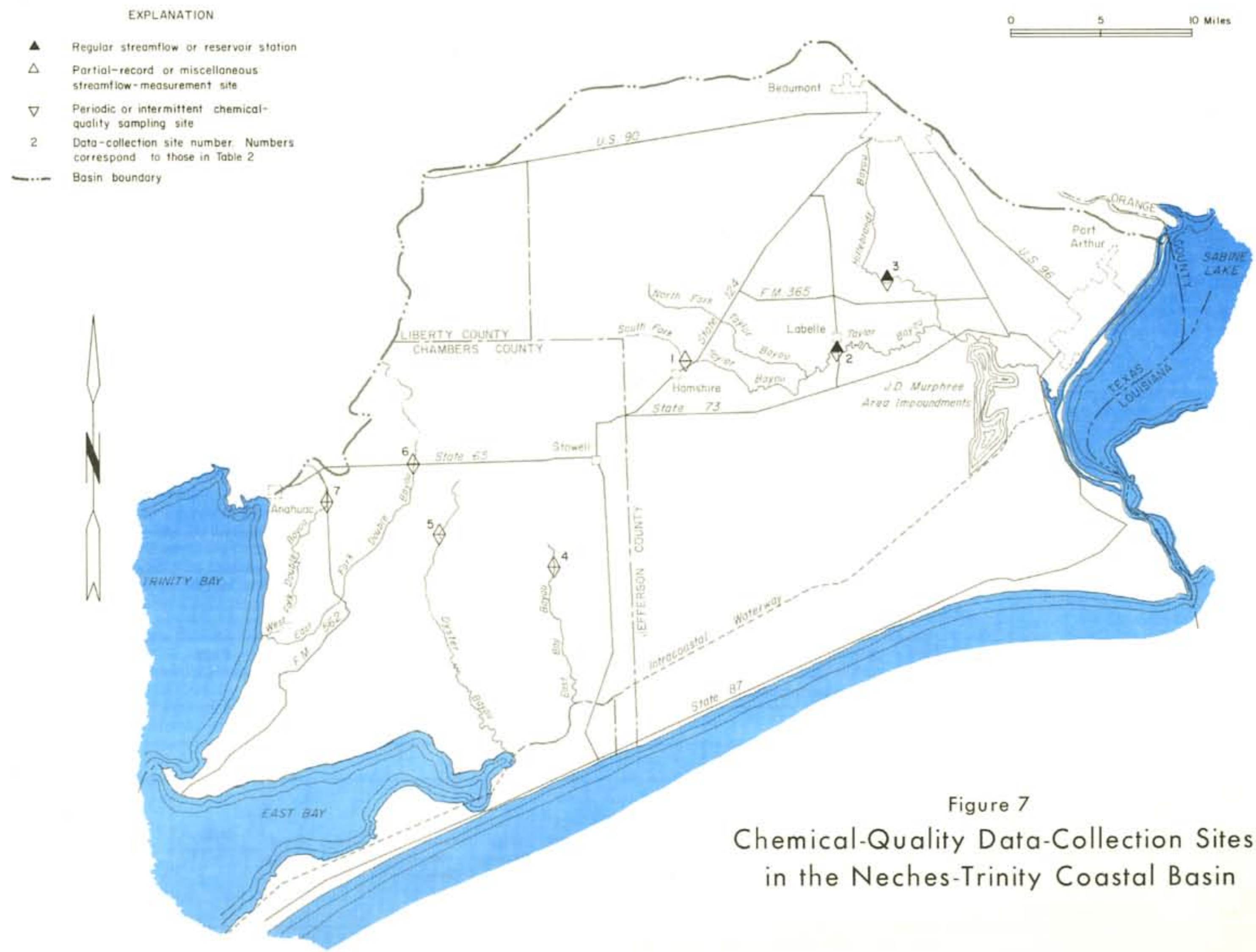

Figure 7
Chemical-Quality Data-Collection Sites in the Neches-Trinity Coastal Basin

Table 2.--Chemical analyses of streams in the Neches-Trinity coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. SOUTH FORK TAYLOR BAYOU AT INTERSTATE HIGHWAY 10 NEAR HAMSHIRE																						
Mar. 11, 1969	3.26										60		2.8								549	
2. TAYLOR BAYOU NEAR LaBELLE																						
Apr. 9, 1968	5210	0.2		14	2.7	23		18	3	27	33	0.2	0.6		113			46	26	1.5	217	8.6
3. HILLEBRANDT BAYOU NEAR LOVELL LAKE																						
Apr. 9, 1968	7780	0.1		11	2.1	21		14	6	16	29	0.3	1.3		94			36	15	1.5	192	9.1
4. EAST BAY BAYOU AT FARM ROAD 1941 NEAR STOWELL																						
Dec. 15, 1967	0.73	5.7		59	15	144		113	0	128	210	0.4	0.2		618			208	116	4.3	1100	7.7
Mar. 25, 1968	.60	4.4		81	14	213		172	0	121	322	.3	.4		841			260	118	5.8	1490	7.6
May 10	3.29	5.2		50	6.6	45		131	0	57	52	.1	11		291			152	44	1.6	512	7.4
June 13	4.01	4.0		52	7.2	33		157	9	35	36	.5	.0		254			159	16	1.1	445	8.4
Aug. 20	2.59	12		46	7.0	52		114	0	54	70	.5	8.6		306			144	50	1.9	543	7.4
Sept. 17	61.2	12		16	2.7	18		38	0	24	22	.6	1.0		115			51	20	1.1	199	6.6
5. OYSTER BAYOU NEAR ANAHUAC																						
Dec. 15, 1967	4.56	9.4		61	7.5	66		120	0	94	86	0.7	7.3		391			183	84	2.1	672	7.5
Mar. 25, 1968	4.53	10		63	10	46		144	0	68	77	.3	.8		346			198	80	1.4	595	7.5
May 14	46.8	10		33	4.2	30		78	0	38	41	.3	2.2		197			100	36	1.3	338	7.2
June 13	11.6	10		49	5.4	33		131	0	10	46	.4	1.1		249			144	37	1.2	440	7.1
Aug. 20	11.1	28		55	7.0	54		148	0	51	75	.6	2.2		346			166	44	1.8	589	7.6
Sept. 17	62.4	13		22	3.1	27		65	0	18	37	.4	.8		153			68	14	1.4	271	6.8
6. EAST FORK DOUBLE BAYOU NEAR ANAHUAC																						
Dec. 15, 1967	13.1	13		50	7.4	61		56	0	105	90	0.3	6.0		361			156	110	2.1	620	6.9
Mar. 25, 1968	5.51	7.5		40	6.0	50		91	0	53	72	.2	2.6		276			124	50	2.0	494	6.9
May 14	115	8.7		30	4.0	30		60	0	47	38	.3	5.0		193			91	42	1.4	336	6.6
June 13	5.56	10		47	5.8	31		100	0	63	38	.4	7.6		252			141	59	1.1	430	7.1
Aug. 20	17.5	14		55	7.4	43		188	0	26	56	.5	.5		294			168	14	1.4	525	7.1
Sept. 17	60.7	32		42	5.8	53		136	0	34	68	.4	.8		303			129	17	2.0	486	6.9
7. WEST FORK DOUBLE BAYOU NEAR ANAHUAC																						
Dec. 15, 1967	1.80	7.8		63	12	100		83	0	124	160	0.2	1.3		509			206	138	3.0	908	7.2
Mar. 25, 1968	1.72	4.1		46	7.6	65		100	0	74	89	.3	2.0		337			146	64	2.3	612	7.0
May 13	75.0	.1		20	3.9	39		26	4	39	57	.3	1.6		178			66	38	2.1	243	8.7
June 13	39.7	5.8		34	6.2	46		135	0	24	51	.4	1.7		235			110	0	1.9	421	7.7
Aug. 20	3.15	19		53	8.8	72		171	0	37	102	.6	.8		377			168	28	2.4	667	7.7
Sept. 17	26.9	14		28	5.6	50		70	0	34	76	.4	1.6		244			93	36	2.3	414	6.6

Oil is produced in many areas in the basin (Figure 6), and oil and related petroleum products represent a major part of the industrial activities. The Baytown area, located on the Houston Ship Channel and Galveston Bay, is the urban and industrial center of the basin.

Chemical analyses of samples from Cedar Bayou near Mont Belvieu (site 1) show water of good quality at this station (Table 3). However, during lowflow periods, irrigation-return flows and industrial wastes are probably degrading the quality of surface waters in some areas. Municipal and industrial discharges from the Baytown area enter the Galveston Bay system. The natural dissolved-solids concentration of runoff in the basin is probably less than 250 mg/l.

SAN JACINTO-BRAZOS COASTAL BASIN

The San Jacinto-Brazos coastal basin, which drains an area of 1,440 square miles, is bounded on the east by Galveston Bay, on the west by the Brazos River basin, and on the north by the San Jacinto River basin (Figure 1). Some areas are frequently flooded because the maximum altitude in the basin is about 100 feet and much of the basin is less than 50 feet above mean sea level. In addition to flooding throughout the basin from local storm runoff, lowlands along the coast and in the Galveston Bay area are inundated by high tides. The western side of the basin is subjected to flooding by overflow waters from the Brazos River. Precipitation in the basin averages 44-48 inches per year—monthly, seasonal, and yearly precipitation patterns are shown by records for the city of Houston (Figure 3).

The principal streams in the basin are Clear Creek, Oyster Creek, and Dickinson, Halls, Mustang, Chocolate, and Bastrop Bayous (Figure 9). Clear Creek drains much of the northern part of the basin and discharges into Galveston Bay near Seabrook. The watersheds of the five major bayous include most of the central and southeastern drainage areas of the basin. Dickinson Bayou flows into Galveston Bay north of Texas City, and the other four bayous flow into the West Bay system. Oyster Creek drains a 247-square-mile strip that parallels the Brazos River along the western edge of the basin. Oyster Creek discharges into Oyster Bay.

William Harris Reservoir, a 12,000 acre-foot impoundment, is located immediately adjacent to the basin, between the Brazos River and Oyster Creek. This off-channel reservoir serves for temproary storage of water diverted from the Brazos River. Water from the reservoir is released to Oyster Creek and then to a canal system for distribution to various industrial plants.

More than 150,000 acre-feet of surface water, mostly imported from the Brazos River, and about 14,000 acre-feet of ground water was used to irrigate 70,000 acres of rice and pasture in 1964 (Gillett and Janca, 1965, p. 37). Irrigated areas are shown on Figure 5.

Oil is produced in many areas of the basin (Figure 6), and oil and related petroleum products represent a large part of the industrial economy. The eastern part of the basin along Galveston Bay is a populous, highly industrialized area and shipping center.

Chemical analyses of streams in the San Jacinto-Brazos coastal basin are shown on Table 4. Water-quality data collected at nine sites in the basin (Figure 9) in 1967-68 show waters of generally good to excellent chemical quality. The dissolved-solids concentration did not exceed 1,000 mg/l in any of the samples collected. However, irrigation-return flows and municipal and industrial wastes probably have some effect on the water quality in all streams. Nitrate concentrations exceeded 10 mg/l at five sites during low flow. The maximum concentration of 77 mg/l was observed in Flores Bayou near Danbury (site 8).

All sampling sites are far enough upstream to be above normal tide effects. The ranges in water discharge at the time of sampling provide water-quality data that are generally representative of the range in concentrations of dissolved constituents at these sites. The lower reaches of the principal drainage systems are affected by tides, and tidal action compounds the effects of municipal and industrial wastes and irrigation-return flows on water quality, particularly in the urban areas along Galveston Bay.

BRAZOS-COLORADO COASTAL BASIN

The Brazos-Colorado coastal basin, which has a drainage area of 1,850 square miles, lies between the Brazos and Colorado River basins as a long narrow band extending about 100 miles inland from the coast (Figure 1). Although the maximum altitude exceeds 400 feet above mean sea level in the headwaters of the basin, altitudes in much of the lower part of the basin are less than 50 feet. The lower basin is subjected to overflows from the Brazos River on the east and the Colorado River on the west, and the coastal areas are occasionally inundated by high tides.

Precipitation in the basin averages 40-44 inches per year. Monthly, seasonal, and yearly precipitation patterns are approximated by records for the city of Houston (Figure 3).

The San Bernard River (Figure 10), which has a drainage area of about 1,000 square miles, is the only large stream in the basin. The Brazos-Colorado coastal basin has no major reservoirs. Some off-channel storage has been developed together with a canal system for distribution of water imported from the Colorado River.

In 1964, about 50,000 acres of rice and pasture was irrigated in the basin with 130,000 acre-feet of surface water, mostly from the Colorado River, and 32,000 acre-feet of ground water (Gillett and Janca, 1965, p. 38). Irrigated areas are shown on Figure 5.

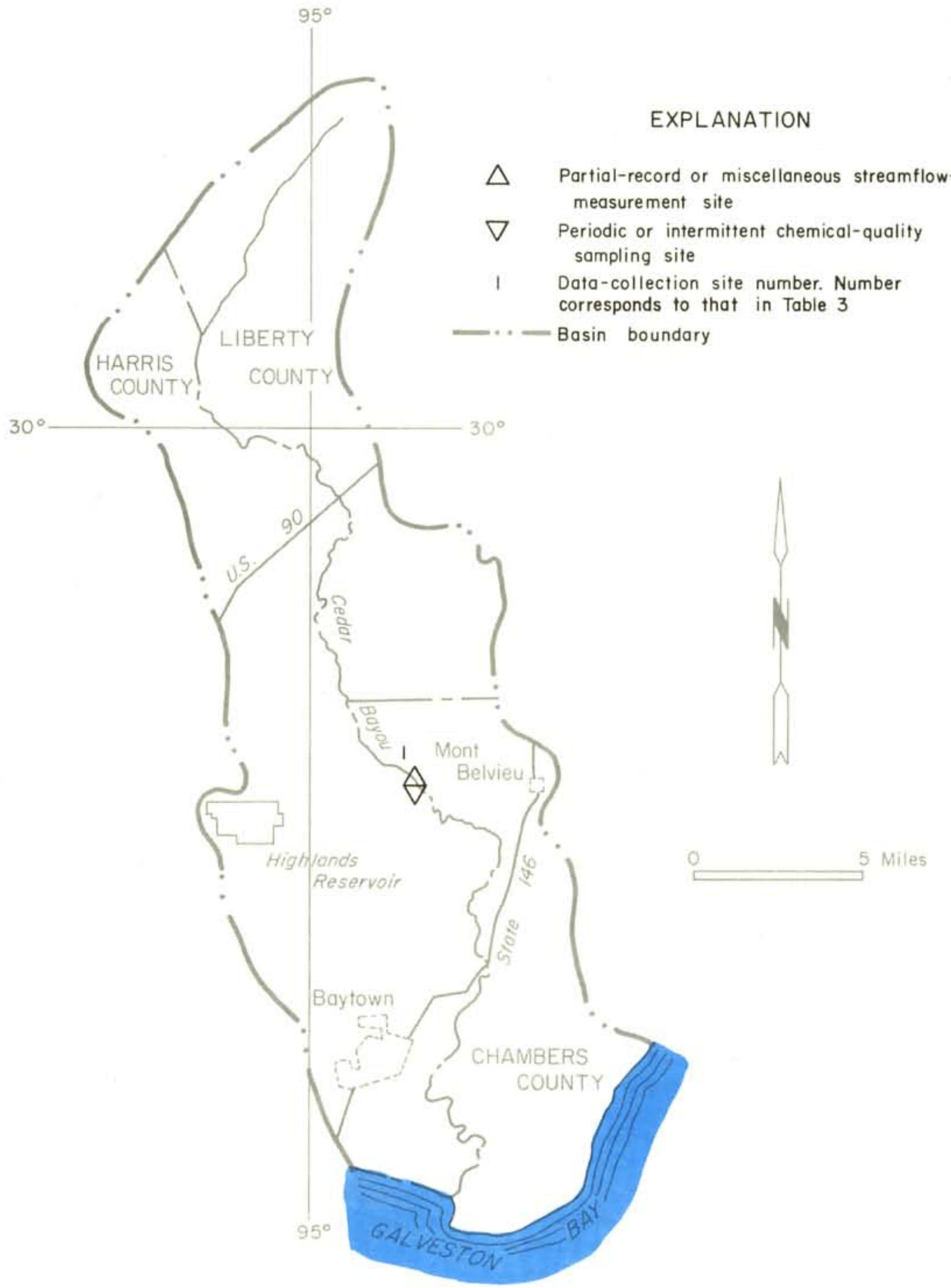

Figure 8

Chemical-Quality Data-Collection Site in the Trinity-San Jacinto Coastal Basin

Table 3.--Chemical analyses of stream in the Trinity-San Jacinto coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. CEDAR BAYOU NEAR MONT BELVIEU																						
Dec. 15, 1967.....	34.4	4.4		39	4.8	94		81	6	39	144	0.4	0.3		372			117	40	3.8	692	8.3
Mar. 25, 1968.....	53.8	.0		29	3.1	47		70	10	20	65	.4	.2		209			85	11	2.2	384	8.7
May 13............	1300	12		24	2.9	64		60	0	15	101	.4	2.6		252			72	23	3.3	468	6.8

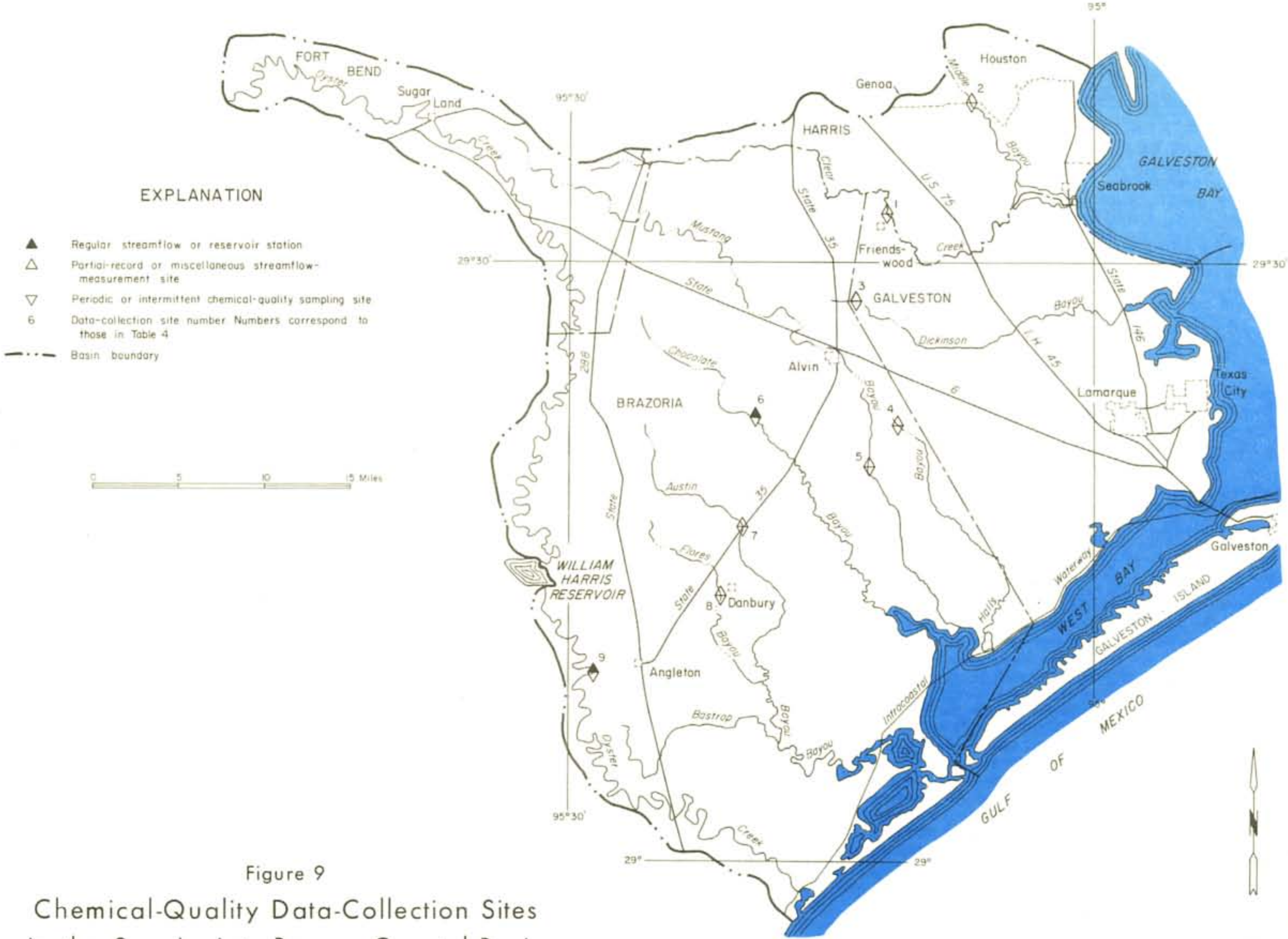

Figure 9

Chemical-Quality Data-Collection Sites in the San Jacinto-Brazos Coastal Basin

Table 4.--Chemical analyses of streams in the San Jacinto-Brazos coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. CLEAR CREEK NEAR FRIENDSWOOD																						
Nov. 30, 1967	1.25	6.2		26	17	151		201	0	38	170	1.6	18		527			135	0	5.6	969	7.7
Jan. 23, 1968	843	9.8		19	4.9	19		40	0	20	32	.5	11		136			68	35	1.0	243	6.7
Mar. 28	4.89	--		--	--	--		--	--	45	104	--	--		--			--	--	--	772	--
May 16	22.5	14		29	6.4	35		91	0	18	51	.4	10		209			99	24	1.5	383	7.0
Aug. 9	13.5	12		44	12	54		177	0	28	71	.8	2.0		311			160	14	1.9	540	7.4
2. MIDDLE BAYOU NEAR GENOA																						
Dec. 6, 1967	1.27	13		10	3.0	202		233	60	31	98	3.6	6.7		542			38	0	14	930	9.1
Jan. 23, 1968	41.8	11		24	5.8	19		100	0	14	17	.2	4.6		145			84	2	.9	256	7.6
Mar. 28	3.79	.8		57	18	111		272	47	30	82	1.2	9.2		490			216	0	3.3	818	8.9
May 21	2.65	14		59	18	106		360	0	27	76	2.1	20		499			221	0	3.1	847	7.8
Aug. 13	1.68	19		38	15	173		404	0	27	96	4.4	34		605			156	0	6.0	1000	7.4
3. DICKINSON BAYOU NEAR ALVIN																						
Dec. 6, 1967	0.18	9.1		66	25	90		224	0	74	143	0.7	0.3		518			268	84	2.4	936	7.4
Jan. 22, 1968	280	8.7		12	3.4	10		40	0	15	11	.1	1.9		82			44	11	.7	149	7.0
Mar. 28	2.84	.1		61	18	79		236	0	66	95	.4	.0		436			226	32	2.3	766	8.0
May 16	12.4	14		41	11	56		132	0	53	72	.8	2.4		315			148	40	2.0	543	7.5
4. HALLS BAYOU NEAR ALVIN																						
Jan. 22, 1968	22.7	14		16	4.8	7.8		66	0	8.0	8.6	0.4	1.2		93			60	6	0.4	154	7.0
Mar. 27	.3	6.4		48	11	31		209	0	16	30	.6	1.8		248			165	0	1.0	433	7.8
May 16	.84	14		28	5.9	11		119	0	.6	12	.4	1.4		132			94	0	.5	232	7.2
5. MUSTANG BAYOU NEAR ALVIN																						
Dec. 12, 1967	3.52	15		58	11	192		252	0	70	222	1.8	13		707			190	0	6.0	1250	7.6
Jan. 27, 1968	393	8.5		17	3.5	26		52	0	7.6	42	.6	2.4		134			57	14	1.5	254	7.0
Mar. 27	11.9	4.6		73	11	219		158	8	20	382	.4	.3		796			227	84	6.3	1500	8.3
May 16	71.9	12		30	5.0	44		91	0	10	73	.4	2.0		221			95	21	2.0	406	7.7
Aug. 13	6.36	13		88	14	147		274	0	27	242	.5	1.6		668			277	52	3.8	1220	7.5
6. CHOCOLATE BAYOU NEAR ALVIN																						
Feb. 7, 1968	18	16		52	8.5	56		115	0	26	111	0.2	11		338			164	70	1.9	625	7.4
July 23	85.0	12		46	11	35		179	0	28	42	.4	.8		263			160	13	1.2	472	7.1
July 25	114	20		50	9.3	89		121	0	9.6	174	.2	1.4		414			164	64	3.0	779	7.2
Aug. 13	52.1	14		57	14	59		187	0	54	83	.4	.8		374			200	46	1.8	663	7.3
Sept. 4	67.1	21		58	16	72		192	0	62	101	.5	.4		428			210	53	2.2	706	7.4
7. AUSTIN BAYOU NEAR DANBURY																						
Dec. 5, 1967	0.32	6.4		74	28	152		283	0	42	250	0.7	0.7		693			300	68	3.8	1300	7.6
Jan. 22, 1968	741	8.9		11	2.6	13		38	0	16	11	.5	1.8		84			38	7	.9	141	7.0
Mar. 27	8.98	2.8		59	14	78		151	0	75	120	.4	2.1		425			204	81	2.4	766	7.3
May 16	41.4	15		36	8.2	37		117	0	37	46	.6	2.8		241			124	28	1.1	421	7.1
Aug. 13	5.18	16		60	14	50		174	0	52	83	.4	2.6		364			207	64	1.5	633	7.4

Table 4.--Chemical analyses of streams in the San Jacinto-Brazos coastal basin--continued

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)			Hardness as $CaCO_3$		Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
															Milligrams per liter (mg/l)	Tons per acre-foot	Tons per day	Calcium, Magnesium	Non-carbonate			
8. FLORES BAYOU NEAR DANBURY																						
Nov. 28, 1967	0.14	16		31	16	314		534	0	30	188	12	77		947			144	0	11	1570	8.1
Jan. 22, 1968	589	7.0		9.5	2.6	8.0		35	0	9.2	8.4	.0	2.2		64			34	6	.6	113	6.9
Apr. 17	6.33	9.6		50	12	54		165	0	52	69	.6	3.8		332			174	40	1.8	594	7.2
May 24	1.22	8.5		56	14	87		232	0	44	96	1.3	14		435			197	7	2.7	768	7.6
June 26	870	9.8		12	2.5	6.6		49	0	4.6	5.5	.4	.9		66			40	0	.5	115	7.1
Aug. 7	10.4	12		54	13	46		185	0	31	73	.4	.8		321			188	36	1.5	567	7.5
9. OYSTER CREEK NEAR ANGLETON																						
Nov. 28, 1967	140	6.0		52	8.0	54		138	0	60	72	0.5	1.2		322			162	50	1.8	576	7.2
Jan. 23, 1968	1090	8.5		26	4.5	16		88	0	14	19	.2	4.2		135			83	11	.8	240	7.3
Mar. 13	117	4.7		65	10	59		181	0	61	83	.3	2.6		375			203	54	1.8	667	7.6

Although oil is produced in many parts of the basin, the major oil fields are in the lower half of the basin (Figure 6). The production of oil and related products, rice processing, and meat packing are the principal industries. Bay City is the major industrial and commercial center, but various small industries are scattered throughout the basin.

Chemical analyses of streams indicate that runoff throughout the basin is generally of good to excellent quality (Table 5). Limited data from five sites (Figure 10) on the San Bernard River indicate that high to moderate flows usually contain less than 250 mg/l dissolved solids, and that high flows in the upper part of the river often contain less than 100 mg/l dissolved solids. However, irrigation-return flows and oil-field brines are probably degrading the chemical quality of the river throughout its reach.

Samples collected over a wide range in water discharge at San Bernard River near Boling (site 4) ranged in dissolved-solids concentrations from 51 to 552 mg/l. Concentrations of dissolved constituents, especially sodium and chloride, increase between Boling and the next downstream site near Newgulf (site 5). Samples collected near Boling on November 29 and near Newgulf on November 30, 1967, show dissolved-solids concentrations of 429 and 1,170 mg/l, respectively.

Small streams in the lower part of the basin contain water low in dissolved solids during high flows, but low flows in some of the streams show the effects of oil-field brines. A sample collected during low flow in Cedar Lake Creek near Cedar Lane (site 7) contained 3,170 mg/l dissolved solids. Cottonwood Creek near Bay City (site 10) receives municipal and industrial wastes from Bay City and probably has high organic and nutrient concentrations at low flow. A sample collected on November 29, 1967, had a nitrate concentration of 66 mg/l. Other small streams and reaches of streams in the basin are probably being affected locally by irrigation-return flows and municipal and industrial wastes. Nondegraded surface waters in the basin probably contain less than 250 mg/l dissolved solids.

COLORADO-LAVACA COASTAL BASIN

The Colorado-Lavaca coastal basin, which has a drainage area of about 940 square miles, is located near the center of the Texas Gulf Coast (Figure 1). The maximum altitude is about 100 feet above mean sea level. Annual precipitation varies from about 41 inches in the east to about 38 inches in the west (Figure 3). Precipitation in the basin is fairly well distributed throughout the year, with May and September generally having the maximum monthly accumulations (Figure 3). The maximum annual precipitation at Edna for the period 1931-68 was 59.95 inches in 1941.

The principal streams in the basin are Tres Palacios and Carancahua Creeks (Figure 11). There are no major reservoirs in the basin. Drainage is poor, and flooding occurs during periods of heavy rainfall. Lowlands near the coast are frequently inundated by high tides.

Much of the industrial economy is based on petroleum and related products. Oil fields are located in many parts of the basin (Figure 6).

In 1964, about 176,000 acre-feet of water was used to irrigate about 47,000 acres of rice and pasture (Gillett and Janca, 1965, p. 39). More than half of this water was surface water, most of which was imported from the Colorado River basin. Principal irrigated areas are shown on Figure 5.

Chemical-quality data collected in the Colorado-Lavaca coastal basin are given in Table 6, and the data-collection sites are shown on Figure 11. The dissolved-solids concentrations were less than 500 mg/l in all streams at the times of sampling, indicating that surface waters of the Colorado-Lavaca coastal basin are generally of good to excellent quality. However, some streams or reaches of streams in the basin may be affected locally by industrial and municipal wastes and irrigation-return flows.

LAVACA-GUADALUPE COASTAL BASIN

The Lavaca-Guadalupe coastal basin is located in the central part of the Texas coastal area (Figure 1). The basin, which heads about 60 miles inland at an altitude of about 200 feet, contains an area of about 998 square miles. Precipitation, which averages from 36 to 38 inches per year, decreases from east to west (Figure 3). Precipitation is fairly well distributed throughout the year with May and September generally having the maximum monthly accumulations (Figure 3). The minimum monthly precipitation at Edna was 0.00 inches during several months, and the maximum was 14.38 inches in June 1960.

The principal streams in the basin are Arenosa, Garcitas, and Placedo Creeks (Figure 12). There are no major reservoirs in the basin; however, Garcitas Reservoir has been proposed (Figure 12).

The economy in the Lavaca-Guadalupe coastal basin is supported by agriculture, oil production, recreation, and seafood processing. In 1964, about 18,000 acres (Figure 5) was irrigated with about 53,000 acre-feet of surface and ground water (Gillett and Janca, 1965, p.39). Most of the surface water is imported from the Guadalupe River basin. Smaller amounts are supplied by Garcitas Creek or imported from the Lavaca River basin.

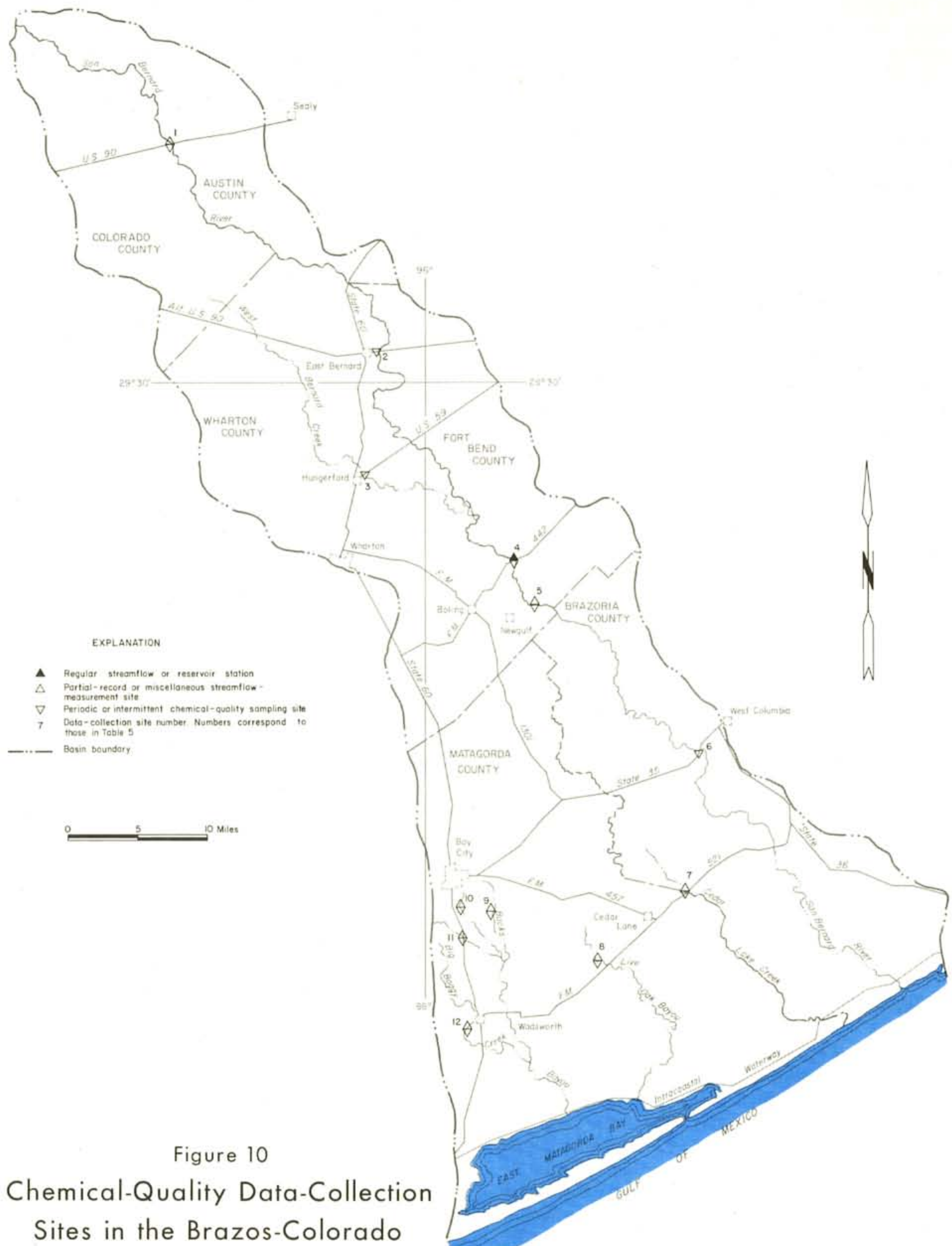

Figure 10

Chemical-Quality Data-Collection Sites in the Brazos-Colorado Coastal Basin

Table 5.--Chemical analyses of streams in the Brazos-Colorado coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. SAN BERNARD RIVER NEAR SEALY																						
Mar. 17, ,959	a5	15		9.0	2.4	26		25	0	7.0	43	0.1	1.0		116			32	12	2.0	209	7.2
2. SAN BERNARD RIVER AT EAST BERNARD																						
Apr. 25, 1959		11		11	2.8	9.8	0.5	41	0	5.4	14	0.2	1.2		76			39	5	0.7	135	6.4
3. WEST BERNARD CREEK AT HUNGERFORD																						
Apr. 25, 1959		14		20	4.3	23		107	0	4.4	17	0.2	0.2		136			68	0	1.2	244	6.3
4. SAN BERNARD RIVER NEAR BOLING																						
Jan. 14, 1949	--	16		94	24	67		349	0	22	120	--	0.0		b552			333	47	1.6	966	--
Sept. 14, 1961	11500	8.0		11	2.0	6.1	4.5	40	0	9.8	6.0	0.3	.2		68			36	3	.4	93	6.2
Nov. 29, 1967	7.2	16		71	14	71		249	0	14	121	.4	.0		429			234	30	2.0	773	8.1
Jan. 24, 1968	6100	7.2		8.2	2.2	5.4		27	0	6.4	4.5	1.0	4.2		52			30	7	.4	86	7.1
Jan. 26	4760	7.7		6.0	2.3	7.2		30	0	5.6	5.2	.2	2.2		51			24	0	.6	85	6.7
Feb. 13	62	10		34	6.8	35		117	0	13	54	.8	1.8		213			113	17	1.4	396	7.5
Mar. 13	170	8.6		24	5.0	19		80	0	12	27	.9	2.7		138			80	15	.9	253	7.3
Aug. 9	260	17		41	10	32		152	0	16	48	.9	1.2		241			143	19	1.2	432	7.2
Sept. 11	550	30		30	7.2	23		115	0	9.2	34	1.0	1.0		192			104	10	1.0	323	7.1
5. SAN BERNARD RIVER NEAR NEWGULF																						
Jan. 14, 1949	--	16		102	26	155		354	0	30	268	--	0.0		b825			362	72	3.5	1460	--
Nov. 30, 1967	10.8	13		110	23	300		236	0	76	530	0.4	.0		1170			369	176	6.8	2140	7.7
Aug. 9, 1968	274	16		40	11	39		149	0	19	61	.4	.7		260			145	23	1.4	460	7.7
Sept. 11	540	30		32	7.2	31		116	0	12	47	1.0	.8		218			109	14	1.3	372	7.1
6. SAN BERNARD RIVER NEAR WEST COLUMBIA																						
Jan. 14, 1949		14		80	27	95		384	0	8.0	138		0.0		b583			310	0	2.3	1070	
July 17, 1952		15		66	14			80	0	21	99							180				7.7
7. CEDAR LAKE CREEK NEAR CEDAR LANE																						
Nov. 28, 1967	0.21	8.9		272	48	877		328	0	84	1720	--	0.4		3170			876	607	13	5680	7.6
Apr. 17, 1968	6.77	3.6		48	7.8	23		133	17	9.2	37	0.7	.2		212			152	14	.8	382	8.7
May 17	135	10		33	4.3	11		115	0	4.8	15	1.0	1.5		138			100	6	.5	249	7.3
June 26	5.51	8.2		22	3.0	2.8		79	0	.4	3.6	.8	1.2		81			67	2	.1	146	7.2
Aug. 7	1.00	12		173	29	168		225	0	268	318	1.1	2.2		1080			551	366	3.1	1780	7.7
Sept. 4	13.6	6.4		28	4.2	29		65	0	23	49	.9	1.4		174			87	34	1.4	324	7.4
8. LIVE OAK BAYOU NEAR CEDAR LANE																						
May 17, 1968	15.5	13		22	4.7	9.0		80	0	7.6	11	1.1	2.5		110			74	9	0.5	189	7.1
June 26	30.0	13		20	4.1	6.3		76	0	3.6	8.1	.9	.8		94			67	4	.3	161	7.2
Aug. 7	9.46	11		50	14	32		196	0	22	46	.9	.4		272			182	22	1.0	494	7.9
Sept. 4	22.4	40		50	13	38		193	0	20	56	1.1	.7		314			178	20	1.2	527	7.3

See footnotes at end of table.

Table 5.--Chemical analyses of streams in the Brazos-Colorado coastal basin--continued

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
9. BUCKS BAYOU NEAR BAY CITY																						
Nov. 29, 1967.....	2.60	22		64	26	166		334	0	96	178	0.7	0.0		717			266	0	4.4	1230	7.6
Apr. 16, 1968.....	1.01	--		--	--	--		--	--	153	222	--	--		--			--	--	--	1480	--
May 16............	24.0	17		26	6.0	15		84	0	20	17	1.0	7.5		150			90	21	.7	248	7.4
June 27...........	138	18		22	5.2	14		88	0	11	14	1.0	2.0		130			76	4	.7	216	7.0
Aug. 7............	15.4	17		60	17	52		232	0	35	74	1.0	.2		370			220	30	1.5	649	7.5
10. COTTONWOOD CREEK NEAR BAY CITY																						
Nov. 29, 1967.....	2.29	22		63	15	152		284	0	20	161	5.8	66		645			218	0	4.5	1110	6.7
Jan. 22, 1968.....	81.2	13		19	3.9	12		70	0	8.4	14	.1	5.0		109			63	6	.7	185	7.3
Apr. 16...........	4.01	--		--	--	--		--	--	28	146	--	--		--			--	--	--	1110	--
May 16............	21.5	18		28	6.0	35		121	0	13	31	1.9	12		205			95	0	1.6	355	7.5
June 27...........	62.7	20		24	4.7	11		87	0	8.8	14	.9	1.8		128			79	8	.5	209	7.5
Aug. 7............	8.63	16		54	14	78		234	0	23	86	2.2	22		410			192	0	2.4	713	7.6
11. LIVE OAK SLOUGH NEAR BAY CITY																						
Jan. 22, 1968.....	78.3	12		19	3.6	6.5		69	0	5.2	9.4	0.1	1.2		91			62	6	0.4	157	7.3
Apr. 16...........	1.73	--		--	--	--		--	--	26	46	--	--		--			--	--	--	482	--
May 16............	8.24	2.4		44	8.0	20		126	9	26	26	.9	2.2		200			143	24	.7	358	8.5
June 26...........	124	14		32	5.2	11		113	0	11	12	.9	1.2		143			101	9	.5	245	7.3
Aug. 7............	8.29	10		48	14	34		187	0	25	50	.4	.2		274			178	24	1.1	485	7.9
12. BIG BOGGY CREEK NEAR WADSWORTH																						
Jan. 16, 1968.....	1.52	7.0		11	3.8	9.1		38	0	10	14	0.1	1.6		76			43	12	0.6	142	7.0
Jan. 22...........	211	7.3		6.5	2.1	6.9		30	0	5.0	5.5	.4	1.4		50			25	0	.6	87	6.9
Apr. 17...........	.37	--		--	--	--		--	--	15	20	--	--		--			--	--	--	240	--
May 17............	10.8	16		18	4.6	10		70	0	7.0	12	1.1	2.0		105			64	6	.5	179	6.9
June 26...........	135	16		16	3.9	6.2		58	0	4.6	10	.9	.8		87			56	8	.4	145	7.3
Aug. 7............	20.6	10		46	14	28		170	0	22	49	.9	.2		254			172	33	.9	465	7.3
Mar. 13, 1969.....	.58	--		--	--	--		--	--	--	31	--	2.4		--			--	--	--	286	--

a Estimated.
b Residue on evaporation at 180° C.

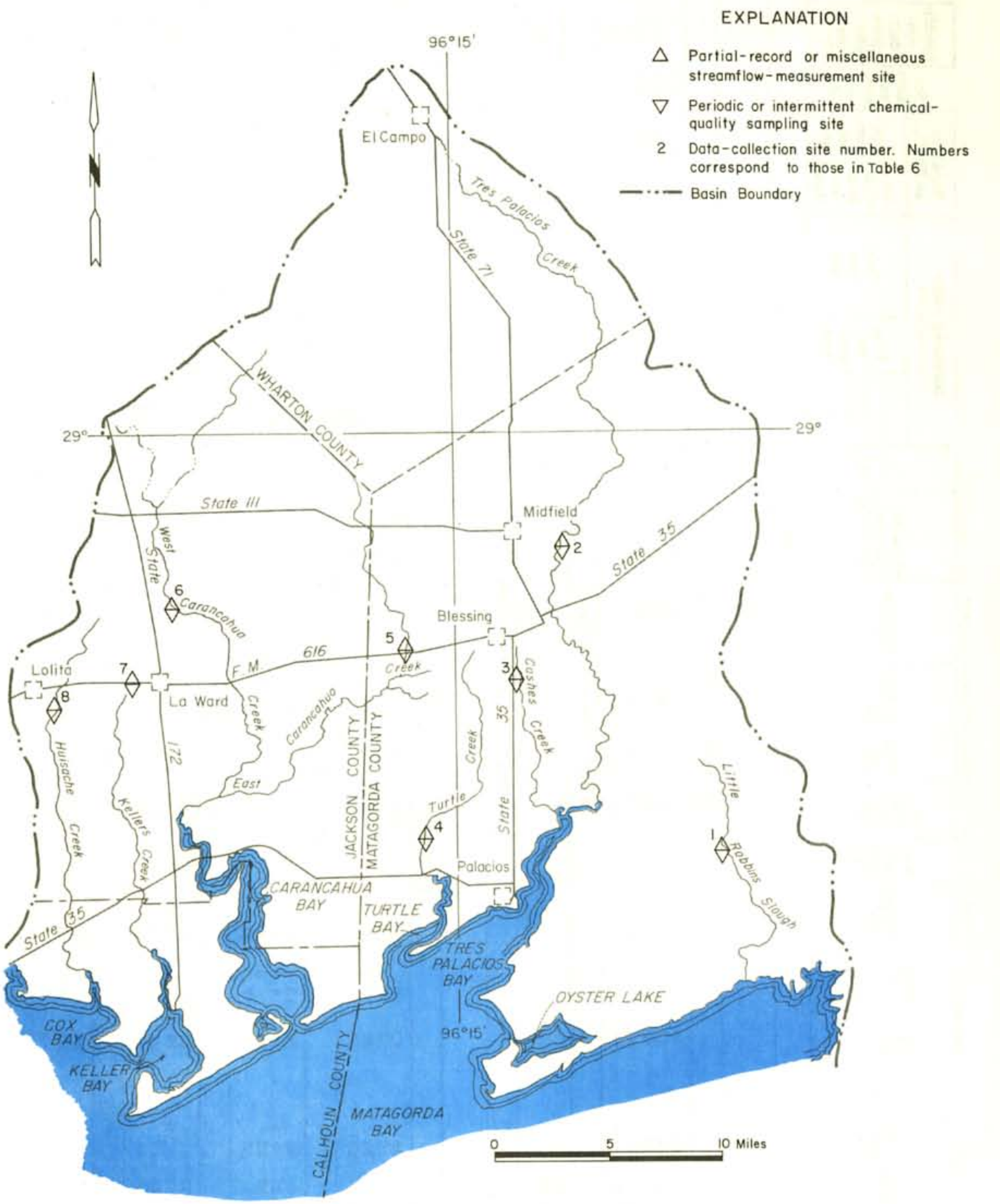

Figure 11

Chemical-Quality Data-Collection Sites in the Colorado-Lavaca Coastal Basin

Table 6.--Chemical analyses of streams in the Colorado-Lavaca coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)			Hardness as $CaCO_3$		Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
															Milligrams per liter (mg/l)	Tons per acre-foot	Tons per day	Calcium, Magnesium	Non-carbonate			
1. LITTLE ROBBINS SLOUGH NEAR MATAGORDA																						
Mar. 13, 1969....	0.69										202		1.8								1040	
July 22..........	a20										70		.4								512	
2. TRES PALACIOS CREEK NEAR MIDFIELD																						
Sept. 12, 1967...	38.1	40		48	15	60	5.0	247	0	12	72	0.6	0.8		374			182	0	1.9	615	7.7
Feb. 6, 1968.....	28.3	12		47	12	80		185	0	16	119	.6	3.0		381			167	16	2.7	701	7.8
May 2............	50.9	16		42	11	35		167	0	15	50	.5	1.4		253			150	13	1.2	453	7.4
July 24..........	101	19		44	12	40		182	0	15	56	.4	.4		276			159	10	1.4	493	7.3
Mar. 13, 1969....	24.2	--		--	--	--		--	--	--	96	--	4.6		--			--	--	--	644	--
3. CASHES CREEK NEAR BLESSING																						
Mar. 13, 1969....	1.21										144		1.8								897	
July 22..........	4.68										104		.4								745	
4. TURTLE CREEK NEAR PALACIOS																						
Mar. 12, 1969....	0.57										81		0.0								506	
July 22..........	a15										99		.3								659	
5. EAST CARANCAHUA CREEK NEAR BLESSING																						
Sept. 12, 1967...	12.0	46		43	19	101	5.0	285	0	12	115	0.8	0.5		482			186	0	3.2	800	7.6
Feb. 6, 1968.....	11.7	10		32	12	39		143	0	17	54	.4	1.3		236			129	12	1.5	425	7.7
May 21...........	36.2	20		28	8.6	38		133	0	11	46	.4	.8		218			105	0	1.6	389	7.5
July 24..........	73.8	20		30	10	36		145	0	9.6	45	.4	.4		222			116	0	1.5	387	7.9
6. WEST CARANCAHUA CREEK NEAR LaWARD																						
Sept. 12, 1967...	11.0	50		70	19	67	7.4	284	0	13	113	0.5	0.8		481			252	20	1.8	798	7.6
Feb. 6, 1968.....	1.87	9.6		31	6.8	38		121	0	11	53	.4	1.2		211			105	6	1.6	388	7.4
May 21...........	7.97	23		32	6.8	20		137	0	6.6	21	.6	1.0		178			108	0	.8	296	7.6
July 24..........	61.1	20		30	7.0	21		115	0	6.2	34	.3	.3		176			104	9	.9	306	7.3
7. KELLERS CREEK NEAR LaWARD																						
Sept. 13, 1967...	0.32	67		40	13	43	6.4	223	0	5.2	43	0.5	0.5		329			154	0	1.5	480	7.7
Feb. 6, 1968.....	.17	.6		18	4.0	9.5		70	3	4.4	10	.3	.2		84			61	0	.5	165	8.4
May 21...........	.25	12		27	6.2	18		125	0	4.0	16	.4	1.8		146			93	0	.8	266	7.1
July 24..........	.60	13		21	4.6	21		98	0	2.4	24	.4	.4		135			71	0	1.1	244	7.5
8. HUISACHE CREEK NEAR LOLITA																						
Sept. 13, 1967...	0.05	15		34	7.6	124	6.5	211	0	21	135	1.3	6.2		455			116	0	5.0	835	7.6
May 21, 1968.....	.86	16		16	3.8	13		80	0	1.0	9.7	.6	1.4		100			56	0	.8	172	7.5
July 24..........	1.33	15		16	4.2	12		78	0	2.6	10	.9	.8		100			57	0	.7	170	7.0

a Estimated

Chemical-quality data collected in the Lavaca-Guadalupe coastal basin are given in Table 7, and the data-collection sites are shown on Figure 12. Dissolved-solids concentrations in Garcitas Creek near Inez (site 1) ranged from 37 to 342 mg/l, and concentrations in Arenosa Creek near Inez (site 2) ranged from 26 to 553 mg/l. If the flows of Garcitas and Arenosa Creeks are impounded in the proposed Garcitas Reservoir, the water should be of excellent quality, with dissolved-solids concentrations less than 250 mg/l.

Limited data show that dissolved-solids concentrations have ranged from 457 to 1,570 mg/l in Placedo Creek near Placedo (site 3), and low flows in East Coloma Creek near Port Lavaca (site 5) and West Coloma Creek near Seadrift (site 6) contained dissolved-solids concentrations of 4,700 mg/l and 3,920 mg/l, respectively. High concentration of dissolved solids and chloride indicate that these three streams are being degraded by oil-field wastes. Two low-flow samples from Chocolate Bayou near Port Lavaca (site 4) had dissolved-solids concentrations of 200 and 117 mg/l, showing that water in this stream is of excellent quality.

Available data for streams in the Lavaca-Guadalupe coastal basin indicate that streams in the upper part of the basin contain water of very good quality. Some streams and reaches of streams in the lower part are being degraded by man's activities.

SAN ANTONIO-NUECES COASTAL BASIN

The San Antonio-Nueces coastal basin, which has a drainage area of 2,650 square miles, lies between the San Antonio and Nueces River basins (Figure 1). The maximum altitude of the basin is about 500 feet above mean sea level, but much of the area is at altitudes less than 100 feet. Annual precipitation ranges from about 36 inches in the east to 28 inches in the west (Figure 3). The precipitation is fairly well distributed throughout the year, with May and September generally having the maximum monthly accumulations (Figure 3). Precipitation at Beeville has ranged from a low of 0.00 inches during several months to a high of 22.62 inches in September 1967.

The principal streams in the San Antonio-Nueces coastal basin are the Mission River and its tributaries, Blanco and Medio Creeks, the Aransas River, and Chiltipin Creek (Figure 13). There are no major reservoirs in the basin. Natural drainage is poor, and occasional heavy rains flood large areas near the coast.

Agriculture, oil production, commercial fishing, and recreation support the local economy. Fewer acres are irrigated in this basin than in any of the other coastal basins. In 1964, 16,000 acres was irrigated with about 7,600 acre-feet of ground water (Gillett and Janca, 1965, p. 40). Irrigated areas are shown on Figure 5. Oil is produced in many areas, but the large oil fields are in the lower part of the basin (Figure 6).

Chemical-quality data collected in the San Antonio-Nueces coastal basin are given in Tables 8 and 9, and the data-collection sites are shown on Figure 13. Dissolved-solids concentrations were less than 200 mg/l in Salt Creek near Refugio (site 2), in Copano Creek near Refugio (site 3), and in Melon Creek near Refugio (site 9) at all times of sampling. Artesian Creek near Tivoli (site 1) had dissolved-solids concentrations ranging from 131 to 261 mg/l. Water-quality data collected over a wide range in discharge show that the water in these streams is of excellent quality.

Blanco Creek near Refugio (site 4), Medio Creek near Beeville (site 5), and Medio Creek near Refugio (site 6) contained water varying from excellent to marginal in chemical quality. However, even during periods of very low flow, the water of these streams usually has dissolved-solids concentrations less than 500 mg/l.

The quality of water in the Aransas River watershed is being degraded by drainage from oil fields, and low flows frequently contain dissolved solids in excess of 1,000 mg/l. However, moderate to high flows in the Aransas River near Skidmore (site 10) usually contain less than 500 mg/l dissolved solids. Dissolved-solids concentrations in Chiltipin Creek, which is highly degraded by oil-field brines, have exceeded 60,000 mg/l.

Dissolved-solids concentrations in the Mission River at Refugio for the period 1962-68 have ranged from a minimum of 80 mg/l during May 5-7, 1966, to a maximum of 70,100 mg/l during August 1-10, 13-30, 1963 (Table 8). Weighted-average dissolved-solids concentration for this 7-year period was 984 mg/l. The Mission River and Chiltipin Creek have been used for the conveyance of oil-field brines to Copano Bay. Although the Railroad Commission prohibited this practice beginning January 1, 1969, the effects of residual brines may appear for many years.

The chemical quality of water in the San Antonio-Nueces coastal basin varies from excellent to extremely poor. Tributary streams to the Mission and Aransas Rivers contain water of excellent chemical quality. However, man's activities have frequently degraded the Mission and Aransas Rivers and Chiltipin Creek to the extent that the quality of water in these streams ranges from good to extremely poor, depending on the amount and source of streamflow.

NUECES-RIO GRANDE COASTAL BASIN

The Nueces-Rio Grande coastal basin, the largest of the coastal basins, has an area of more than 10,400 square miles in the southernmost section of the Texas coastal region (Figure 1). Annual precipitation in this semiarid basin ranges from about 30 inches in the northeast to about 20 inches in the southwest (Figure 3). Rainfall is fairly well distributed throughout the year, with May and September generally having the maximum monthly accumulations (see average monthly

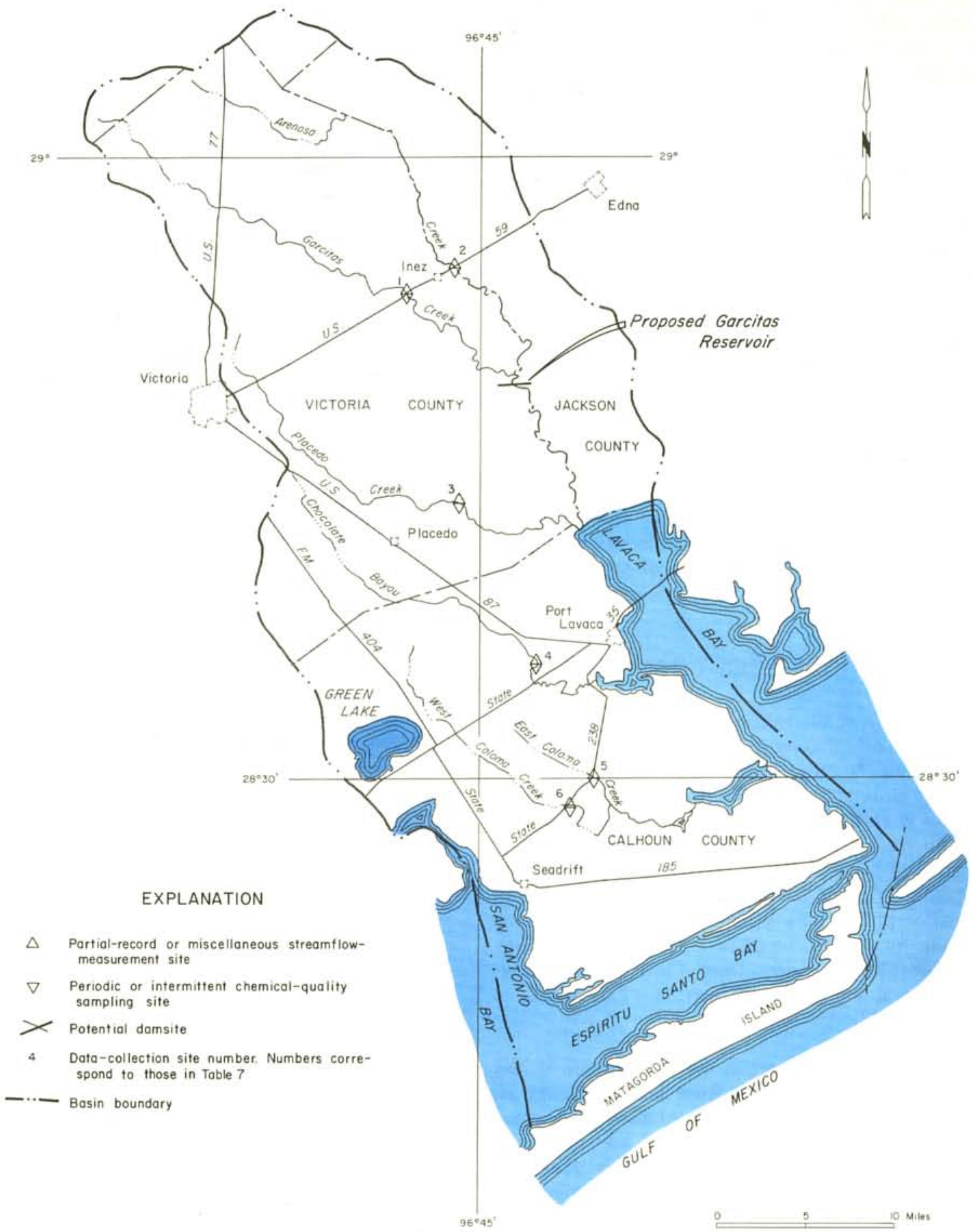

Figure 12
Chemical-Quality Data-Collection Sites in the Lavaca-Guadalupe Coastal Basin

Table 7.--Chemical analyses of streams in the Lavaca-Guadalupe coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. GARCITAS CREEK NEAR INEZ																						
Apr. 20, 1965....	1.10	5.2		32	7.8	72	--	154	0	23	83	0.5	0.2		300			112	0	3.0	549	7.3
May 21...........	43.3	14		15	2.3	15	--	66	0	4.2	14	.2	.5		97			47	0	1.0	157	7.0
Nov. 15...........	7.65	17		21	3.8	15	--	87	0	5.6	15	.4	1.5		122			68	0	.8	206	6.4
Jan. 26, 1966.....	38.4	8.6		7.2	1.8	8.6	2.5	32	0	6.2	9.2	.2	.2		60			25	0	.7	97	6.3
May 11............	37.2	--		--	--	--	--	90	0	11	--	--	--		--			77	3	--	204	6.9
June 17...........	.25	23		64	8.3	36	2.1	220	0	32	44	.4	.2		318			194	13	1.1	536	7.5
Oct. 25, 1967.....	6.79	23		54	5.5	24	2.4	164	0	32	29	.3	.8		252			157	23	.8	410	7.5
Nov. 21...........	1.81	17		49	4.8	26	--	152	0	23	35	.3	.3		230			142	17	.9	397	7.3
Dec. 28...........	.31	19		58	8.0	35	--	171	0	47	45	.3	.1		296			178	38	1.1	501	7.9
Jan. 31, 1968.....	14.8	--		42	4.8	--	--	135	0	--	27	--	--		--			125	14	--	368	7.5
Apr. 9...........	3.83	16		66	8.2	47	--	206	0	43	60	.3	.4		342			198	29	1.5	579	7.3
May 13............	9.71	6.8		7.8	1.5	1.9	--	29	0	.6	2.9	.1	1.3		37			26	2	.2	67	6.7
June 21...........	1.51	10		14	2.5	8.7	--	54	0	4.8	9.6	.2	1.0		78			45	1	.6	134	6.6
July 24...........	5.70	26		64	6.6	25	--	206	0	30	29	.3	.4		282			187	18	.8	465	7.3
2. ARENOSA CREEK NEAR INEZ																						
Oct. 27, 1960.....	--	5.3		3.2	1.3	2.3	1.7	16	0	0.2	4.0	0.1	0.2		26			13	0	0.3	40	6.2
Sept. 13, 1961....	--	7.9		6.1	1.4	6.7	3.4	30	0	2.4	8.2	.1	.0		51			21	0	.6	78	6.1
Apr. 21, 1965....	40.1	13		27	7.0	52	--	127	0	22	57	.5	1.8		242			96	0	2.3	436	6.7
June 29...........	4.24	24		34	9.0	60	--	168	0	11	73	.4	.8		295			122	0	2.4	524	6.6
Nov. 15...........	12.4	96		16	5.4	20	--	88	0	7.2	18	.3	.5		120			62	0	1.1	220	6.3
Jan. 26, 1966.....	40.0	7.0		7.7	2.9	9.9	3.5	39	0	8.6	10	.2	.8		70			31	0	.8	116	6.3
Mar. 9............	.82	15		46	9.0	47	4.6	200	0	3.8	64	.3	.2		288			152	0	1.7	523	7.2
May 11............	91.7	16		13	2.5	10	3.5	58	0	3.6	11	.2	1.0		90			43	0	.7	141	6.7
Dec. 7............	.01	38		84	18	95	4.1	438	0	14	84	.4	.2		553			284	0	2.5	925	7.5
Oct. 25, 1967.....	12.6	26		28	6.4	40	4.0	138	0	5.6	49	.2	1.8		229			96	0	1.8	385	7.5
Nov. 21...........	.93	21		47	9.9	62	--	210	0	5.2	81	.4	.7		330			158	0	2.1	588	7.5
Dec. 28...........	.13	29		72	15	96	--	322	0	4.0	128	.4	.7		503			241	0	2.7	887	7.7
Jan. 1, 1968......	--	--		22	4.7	--	--	98	0	--	29	--	--		--			74	0	--	305	7.6
Apr. 1...........	8.75	17		58	14	113	--	294	0	31	121	.4	3.5		503			202	0	3.5	895	7.5
May 13............	2860	4.6		5.0	1.5	3.5	--	24	0	.4	3.7	.1	1.0		32			19	0	.3	60	6.4
June 21...........	3.06	12		13	3.8	23	--	68	0	7.0	23	.2	1.3		116			48	0	1.4	203	6.7
July 24...........	18.5	25		39	9.8	67	--	196	0	11	78	.3	.7		327			138	0	2.5	577	7.2
Mar. 12, 1969.....	6.30	--		--	--	--	--	--	--	--	64	--	1.7		--			--	--	--	482	--
July 22...........	3.2	--		--	--	--	--	--	--	--	146	--	.6		--			--	--	--	932	--
3. PLACEDO CREEK NEAR PLACEDO																						
Sept. 13, 1967....	0.56	27		71	11	226	6.8	198	0	12	385	0.7	2.8		839			222	60	6.6	1530	7.3
Feb. 6, 1968......	1.11	18		150	22	271		229	0	36	585	.3	3.3		1200			464	277	5.5	2270	7.5
May 21............	8.89	15		61	8.7	97		129	0	13	197	.2	2.0		457			188	82	3.1	876	7.3
July 25...........	1.59	26		194	28	360		273	0	26	800	.4	2.2		1570			599	376	6.4	2900	7.5
4. CHOCOLATE BAYOU NEAR PORT LAVACA																						
Sept. 13, 1967....	1.97	34		30	4.5	25	7.2	113	0	0.4	41	0.6	1.5		200			94	1	1.1	321	7.3
May 22, 1968......	8.00	24		20	3.3	12		72	0	1.2	19	.2	2.3		117			63	4	.7	198	6.8
5. EAST COLOMA CREEK NEAR PORT LAVACA																						
Mar. 12, 1969.....	0.26										2500		0.2		a4700						8640	
July 23...........	a20										92		.4								714	
6. WEST COLOMA CREEK NEAR SEADRIFT																						
Mar. 12, 1969.....	0.35										2050		1.6		a3920						7210	
July 23...........	a20										102		.2								771	

a Estimated.

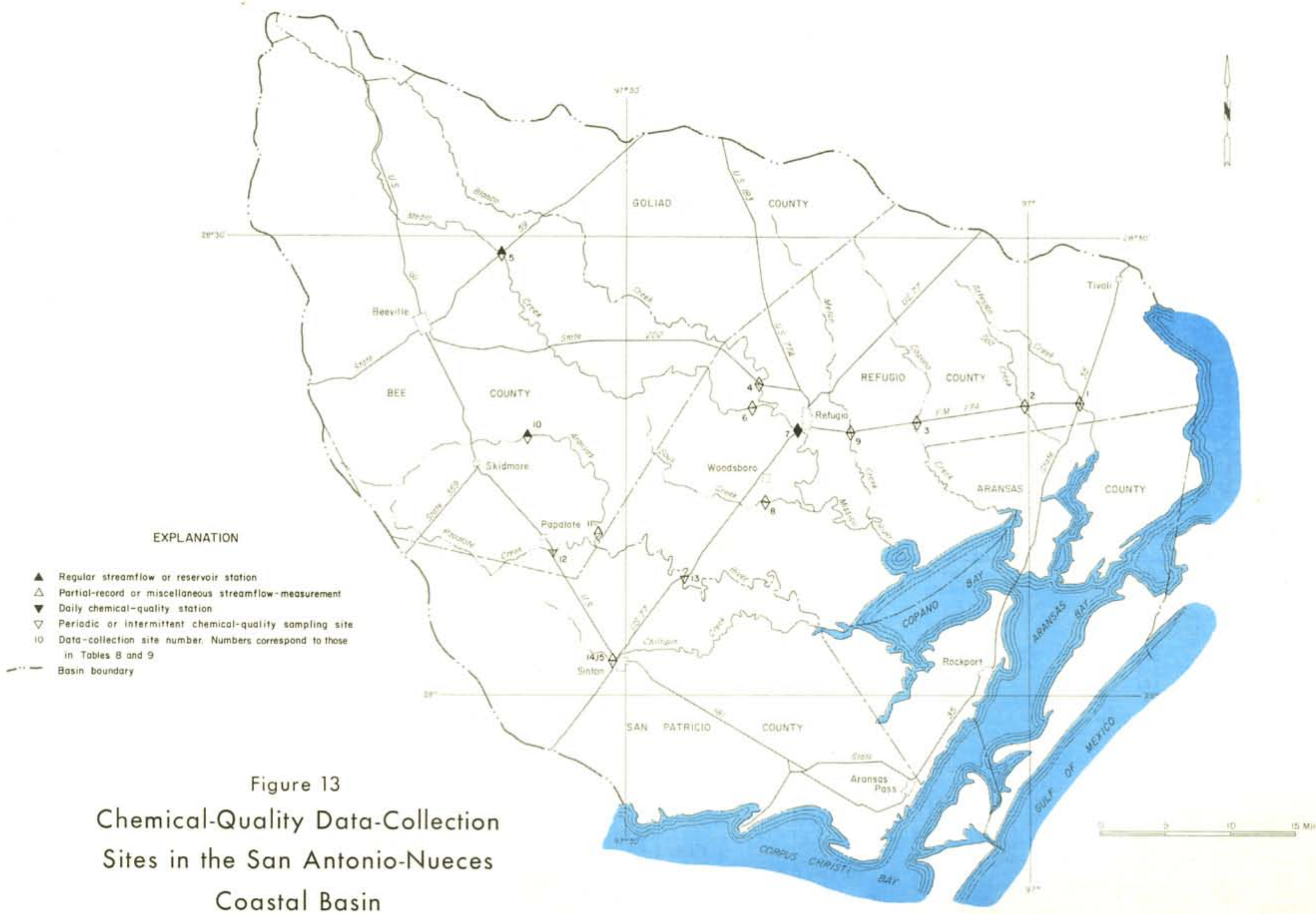

Figure 13
Chemical-Quality Data-Collection Sites in the San Antonio-Nueces Coastal Basin

Table 8.--Summary of chemical analyses at daily station on stream in San Antonio-Nueces coastal basin

(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 milligrams per liter except as indicated.)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
7. MISSION RIVER AT REFUGIO																						
Water year 1962																						
Maximum, Aug. 11-31, 1962...	1.9	35		1480	205	17100	--	187	0	22	29500	--	--		48600	66.0	241	4520	4370	109	60700	6.6
Minimum, June 2-4...........	2213	26		26	2.0	32	--	94	0	3.6	42	--	3.2		181	.25	1080	73	0	1.6	280	7.7
Weighted average............	41.9	27		139	18	1010	--	118	0	7.9	1940	--	--		3330	4.53	377	418	324	17	7070	7.6
Water year 1963																						
Maximum, Aug. 1-10, 13-30, 1963...............	1.0	45		1970	331	24900	--	141	0	4.9	42800	--	--		70100	95.3	181	6280	6160	134	80500	6.4
Minimum, Nov. 27-28, 1962...	395	--		--	--	--	--	52	0	2.8	151	--	--		324	.44	346	60	18	--	724	7.2
Weighted average............	10.6	25		312	49	3410	--	120	0	9.6	5810	--	--		9690	13.1	277	979	882	45	13300	7.1
Water year 1964																						
Maximum, Nov. 1-7, 1963.....	3.3	27		1780	256	21600	--	176	0	9.3	37000	--	--		60700	82.6	541	5500	5360	124	72500	7.0
Minimum, July 20, 1964......	769	12		18	2.7	72	--	60	0	.0	114	0.2	1.8		251	.34	521	56	7	4.2	482	7.2
Weighted average............	13.9	16		246	41	2730	--	107	0	7.8	4700	--	--		7800	10.6	299	783	695	29	11300	7.2
Water year 1965																						
Maximum, Dec. 1-7, 1964.....	1.7	29		1780	377	22300	--	235	0	13	38500	--	--		63100	85.8	290	6000	5810	12	72900	6.9
Minimum, Feb. 17-18, 1965...	2435	13		30	2.5	28	--	102	0	4.2	41	--	.8		170	.23	1120	85	1	1.3	323	8.0
Weighted average............	45.7	13		91	16	772	--	113	0	6.5	1320	--	--		2270	3.09	286	281	189	7.0	3480	7.4
Water year 1966																						
Maximum, Oct. 1-17, 19, 1965	2.0	21		1330	206	15800	100	160	0	11	27000	--	--		44600	60.6	241	4150	4020	20	66700	6.3
Minimum, May 5-7, 1966......	5743	8.2		15	1.4	8.5	3.8	56	0	.2	12	.1	2.5		80	.11	1240	43	0	.6	145	7.2
Weighted average............	126	11		57	7.6	379	--	91	0	5.2	658	--	--		1170	1.60	399	174	101	6.3	2050	7.4
Water year 1967																						
Maximum, July 1-20, 1967....	1.3	34		1540	221	17100	100	132	0	15	30300	--	--		49300	67.0	173	4770	4660	106	73100	6.9
Minimum, May 21.............	1730	5.5		17	1.8	49	4.8	51	0	5.4	82	0.1	1.8		192	.26	897	50	8	3.0	360	7.7
Weighted average............	647	20		52	5.0	90	5.6	158	0	6.9	153	--	--		409	.56	721	150	21	2.2	693	7.7
Water year 1968																						
Maximum, Apr. 1-30, 1968....	15.4	34		255	48	2600	16	84	0	39	4600	--	--		7630	10.4	317	834	764	--	13500	7.7
Minimum, May 12-13..........	8420	9.1		22	2.0	6.4	--	61	0	.8	10	--	15		95	.13	2160	63	13	.4	167	7.0
Weighted average............	203	17		71	9.6	278	--	133	0	12	547	--	5.6		1010	1.37	554	216	108	6.0	1880	7.7

Table 9.--Chemical analyses of streams in the San Antonio-Nueces coastal basin for locations other than daily station

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)			Hardness as $CaCO_3$		Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
															Milligrams per liter (mg/l)	Tons per acre-foot	Tons per day	Calcium, Magnesium	Non-carbonate			
1. ARTESIAN CREEK NEAR TIVOLI																						
Sept. 14, 1967	12.0	46		39	3.9	18	7.4	148	0	19	9.8	0.5	3.0		220			113	0	0.7	305	7.3
Feb. 7, 1968	.80	12		36	4.5	53		148	0	37	43	.4	2.4		261			108	0	2.2	449	7.8
May 22	34.7	30		30	2.6	6.6		108	0	.6	6.4	.1	1.8		131			86	0	.3	204	7.2
July 25	.69	18		34	3.4	24		124	0	23	15	.3	3.7		182			99	0	1.0	293	7.1
2. SALT CREEK NEAR REFUGIO																						
Sept. 14, 1967	8.41	49		24	4.2	10	6.2	106	0	0.4	8.2	0.4	1.5		156			77	0	0.5	198	7.1
Feb. 7, 1968	.11	3.2		35	5.4	23		130	0	5.4	32	.1	2.8		171			110	3	1.0	328	7.3
May 22	18.1	--		--	--	--		72	0	12	--	--	--		--			56	0	--	164	6.8
July 25	5.89	23		16	3.3	7.2		68	0	.8	7.9	.1	1.5		93			53	0	.4	140	7.1
3. COPANO CREEK NEAR REFUGIO																						
Sept. 14, 1967	20.9	35		12	2.6	21	6.1	66	0	5.2	23	0.5	1.8		139			41	0	1.4	204	7.0
Feb. 7, 1968	3.28	8.2		16	3.8	43		73	0	24	43	.2	2.6		177			56	0	2.5	314	6.7
May 22	132	--		--	--	--		40	0	--	41	--	--		--			34	1	--	215	6.5
July 26	15.0	17		12	2.7	18		51	0	6.6	21	.1	2.0		104			41	0	1.2	172	6.7
4. BLANCO CREEK NEAR REFUGIO																						
Oct. 24, 1961	0.99	35		78	16	84	--	291	0	32	121	0.5	0.0		510			260	22	2.3	857	7.5
Jan. 3, 1962	1.09	36		97	18	106	--	324	0	45	166	.4	.0		a661			316	50	2.6	1090	7.2
Jan. 30	1.62	38		95	21	127	--	326	0	55	194	.4	.0		a700			324	56	3.1	1180	7.3
Apr. 5	1.50	34		66	20	129	--	240	0	51	197	.4	.0		a637			247	50	3.6	1060	7.5
June 13	5.71	27		60	8.6	50	--	214	0	18	70	.4	.0		a347			185	10	1.6	592	6.8
Oct. 31	13.2	27		52	13	79	--	184	0	30	122	.4	.0		a422			183	32	2.5	722	7.4
Jan. 9, 1963	1.25	18		59	9.4	54	--	212	0	20	76	.4	.0		341			186	12	1.7	606	7.4
Mar. 21	.36	29		64	21	131	--	240	0	50	200	.4	.0		a631			246	50	3.6	1070	7.4
Dec. 18	.34	8.1		38	6.4	33	--	143	0	12	45	.2	.2		213			121	4	1.3	402	7.1
Feb. 26, 1964	39.4	5.7		18	1.7	12	--	60	0	5.4	15	.4	.5		89			52	3	.7	171	6.4
May 6	.10	13		64	11	80	--	242	0	21	111	.3	.0		419			204	6	2.4	758	7.2
July 20	50.8	21		45	11	82	--	186	0	30	107	.4	.0		387			158	5	2.8	688	7.0
Feb. 8, 1965	19.5	8.1		21	2.1	13	--	78	0	3.6	14	.2	1.0		101			61	0	.7	180	7.1
Mar. 23	1.38	21		84	17	98	--	308	0	34	145	.4	.2		551			280	27	2.5	956	8.0
July 2	.64	26		68	10	56	--	260	0	17	72	.3	.2		378			210	0	1.7	650	7.2
Jan. 26, 1966	27.4	7.6		13	1.8	7.9	3.1	47	0	5.2	9.0	.2	.5		71			40	2	.5	123	6.0
Mar. 8	1.96	9.9		40	4.9	26	2.9	144	0	12	34	.3	.2		201			120	2	1.0	366	7.4
May 6	6840	7.9		14	1.1	3.0	3.6	57	0	.2	2.5	.1	.2		61			39	0	.2	100	7.1
May 9	266	23		40	2.8	5.6	8.6	146	0	.2	5.9	.2	2.0		160			111	0	.2	261	7.0
May 13	61.4	27		74	9.2	40	3.6	258	0	18	60	.2	.2		359			222	11	1.2	622	7.8
Nov. 21	1.37	39		104	16	87	2.8	354	0	36	135	.2	.2		594			326	36	2.1	1010	7.5
Mar. 10, 1967	.92	32		93	19	104	2.2	309	0	44	167	.1	.0		613			310	57	2.6	1070	7.4
May 17	0.08	28		51	13	102	3.2	218	0	38	138	.6	.2		481			180	2	3.3	837	7.4
July 26	1.47	36		70	18	124	4.2	240	0	44	198	1.0	.2		613			248	52	3.4	1060	7.9
Aug. 30	3.62	16		40	3.3	12	3.8	143	0	3.4	15	.2	1.0		165			113	0	.5	271	7.6
Oct. 6	60.7	34		89	11	47	3.6	281	0	23	76	.2	.1		422			267	36	1.3	720	7.3
Jan. 16, 1968	9.40	32		34	13	67	--	125	0	34	103	.3	.0		344			138	36	2.5	600	7.7
Mar. 28	8.04	32		92	16	98	--	274	0	39	172	.3	.4		585			296	71	2.5	1020	7.5
July 11	38.9	--		--	--	--	--	229	0	--	77	--	--		--			213	26	--	647	7.5

See footnotes at end of table.

Table 9.--Chemical analyses of streams in the San Antonio-Nueces coastal basin for locations other than daily station--continued

(Results in milligrams per liter except as indicated)

Date of collection	Mean Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
5. MEDIO CREEK NEAR BEEVILLE																						
May 3, 1959	--	3.4		72	17	154	--	250	0	24	250	0.4	0.0		644			250	44	4.2	1220	7.7
June 2, 1962	2650	7.0		42	1.5	5.8	5.2	142	0	3.4	5.5	.1	.5		a144			111	0	.2	256	6.6
June 5	9.74	12		30	2.9	47	--	124	0	20	43	.3	6.9		a233			87	0	2.2	398	7.0
Nov. 1	.10	9.5		23	2.4	11	--	89	0	4.6	7.8	.4	1.8		104			67	0	.6	188	7.0
Jan. 22, 1965	448	13		52	3.7	42	--	188	0	8.4	52	.2	.0		263			145	0	1.5	472	7.3
Jan. 22	640	11		42	2.7	41	--	150	0	13	46	.3	3.5		234			116	0	1.7	404	7.8
Feb. 8	2.68	9.8		26	2.0	24	--	94	0	7.0	27	.3	1.8		144			73	0	1.2	248	7.4
Feb. 19	21.5	14		41	3.8	27	--	160	0	8.2	25	.2	.8		199			118	0	1.1	348	7.4
Feb. 15, 1966	.22	5.7		28	2.7	36	6.6	93	0	29	42	.1	.2		196			81	5	1.7	360	6.9
Aug. 24, 1967	163	14		30	1.2	4.9	7.3	107	0	3.6	3.6	.2	2.0		120			80	0	.2	180	7.6
Sept. 25	79.2	22		68	5.4	47	7.5	205	0	14	84	.3	1.8		351			192	24	1.5	597	8.1
Sept. 26	55.4	27		82	6.4	37	7.6	265	0	19	55	.4	2.2		367			231	14	1.1	611	7.5
Oct. 5	23.8	32		122	11	76	7.4	339	0	56	130	.2	1.5		603			350	72	1.8	1010	7.8
Oct. 19	10.6	24		87	9.4	82	6.7	215	0	50	148	.2	1.2		514			256	80	2.2	887	7.6
Nov. 7	5.22	33		66	17	118	--	118	0	94	209	.3	.4		596			234	138	3.4	1030	7.7
Dec. 13	2.23	34		75	21	146	--	107	0	120	268	.3	.3		718			274	186	3.8	1250	7.8
Jan. 25, 1968	4.74	--		54	6.0	--	--	160	0	--	101	--	--		--			159	28	--	664	7.8
Feb. 23	1.32	18		88	17	130	--	179	0	98	228	.3	1.8		669			290	143	3.3	1160	7.2
Mar. 28	.64	--		--	--	--	--	101	0	--	258	--	--		--			252	169	--	1170	7.2
June 6	11.4	13		38	3.5	45	--	123	0	24	56	.2	2.2		242			109	8	1.9	439	6.8
July 11	2.14	--		--	--	--	--	222	0	--	230	--	--		--			273	--	--	1160	7.2
6. MEDIO CREEK NEAR REFUGIO																						
Sept. 14, 1961	--	9.7		22	2.6	10	--	81	0	0.6	14	0.2	0.5		100			66	0	0.5	184	6.4
Jan. 30, 1962	b1	33		92	23	152	--	323	0	51	238	.4	.5		a766			324	60	3.7	1320	7.3
Apr. 5	.99	32		65	23	152	--	231	0	48	245	.4	1.0		a719			256	67	4.1	1200	7.5
Oct. 31	1.01	29		68	16	91	--	239	0	25	148	.5	.0		a505			236	40	2.6	869	7.3
Jan. 9, 1963	1.12	19		61	12	75	--	232	0	25	105	.3	.0		411			202	12	2.3	728	6.9
Mar. 21	.61	25		84	24	142	--	288	0	46	235	.5	.2		a741			308	72	3.5	1240	7.0
May 29	.05	26		58	16	125	--	237	0	34	178	.5	.0		554			210	16	3.8	957	7.0
Oct. 9	.02	17		50	10	54	--	194	0	13	78	.3	.2		318			166	7	1.8	587	6.7
Dec. 18	.92	16		56	9.6	58	--	200	0	20	84	.3	.2		342			179	15	1.9	622	7.1
Feb. 26, 1964	19.4	7.4		19	2.1	9.2	4.3	71	0	3.6	10	.4	.5		92			56	0	.5	162	6.5
May 6	b.20	26		73	20	153	--	274	0	38	235	.4	.2		681			264	40	4.1	1210	7.4
July 20	242	6.4		12	1.0	2.6	3.8	48	0	.6	2.2	.1	.2		53			34	0	.2	90	6.6
Sept. 24	b.4	13		38	13	120	--	205	0	29	148	.7	.2		463			148	0	4.3	833	7.8
Jan. 8, 1965	.23	19		55	20	137	--	246	0	38	195	.4	.0		585			220	18	4.0	1020	7.8
Feb. 8	7.26	9.8		29	2.8	22	--	107	0	4.4	27	.1	.5		149			84	0	1.0	269	6.9
Mar. 23	.96	23		87	19	104	--	310	0	26	169	.3	.2		580			295	41	2.6	1030	7.4
July 1	.31	28		65	14	83	--	270	0	21	110	.4	.2		455			220	0	2.4	803	6.8
Jan. 26, 1966	6.43	62		14	2.2	8.3	5.0	52	0	6.0	9.1	.2	1.8		79			44	1	.5	132	6.4
Mar. 8	.85	14		66	11	68	4.1	241	0	23	103	.3	.2		409			210	12	2.0	753	7.6
May 7	1740	10		12	1.2	3.4	4.3	52	0	.2	2.3	.1	.8		60			35	0	.2	93	6.8
May 9	--	12		23	2.7	7.3	5.0	94	0	.4	8.3	.3	.8		106			68	0	.4	187	7.4
May 13	248	17		53	7.2	32	5.0	194	0	11	46	.2	.5		267			162	3	1.1	475	7.8
Nov. 21	.43	37		85	20	132	4.4	330	0	42	198	.3	.2		681			294	24	3.4	1190	7.4
Mar. 10, 1967	.50	30		85	24	145	2.6	295	0	49	244	.2	.0		725			310	68	3.6	1300	7.5
May 17	.12	19		54	11	70	5.3	196	0	20	112	.5	.5		388			180	19	2.3	695	7.2
July 26	b.06	20		40	8.4	70	4.9	154	0	21	101	.5	.5		342			134	8	2.6	602	7.5
Oct. 6	147	29		70	7.2	38	5.8	206	0	27	61	.1	1.5		341			204	35	1.2	578	7.2
Jan. 16, 1968	--	--		87	18	--	--	228	0	--	188	--	--		--			291	104	--	1060	7.8
July 11	11.7	--		--	--	--	--	312	0	--	125	--	--		--			288	32	--	916	7.4

See footnotes at end of table.

Table 9.--Chemical analyses of streams in the San Antonio-Nueces coastal basin for locations other than daily station--continued

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
8. SOUS CREEK NEAR WOODSBORO																						
Sept. 15, 1967	1.26	2.1		25	3.8	14	6.8	89	0	5.8	25	0.4	1.2		147			78	5	0.7	239	7.0
Feb. 7, 1968	.12	17		200	70	553		250	0	179	1130	.2	4.3		2280			787	582	8.6	3440	7.2
May 22	16.4	17		28	4.7	24		95	0	10	36	.1	2.4		169			89	11	1.1	292	7.1
July 26	2.73	17		48	7.9	46		150	0	18	77	.2	1.5		290			152	30	1.6	518	7.2
9. MELON CREEK NEAR REFUGIO																						
Sept. 24, 1967	10.2	22		22	3.3	21	4.6	98	0	0.8	25	0.4	1.5		149			68	0	1.1	244	7.2
Feb. 7, 1968	4.94	10		25	4.2	33		107	0	9.6	36	.1	2.4		173			80	0	1.6	311	6.9
May 22	96.8	14		10	2.3	12		42	0	.8	17	.1	2.2		79			34	0	.9	144	6.7
July 26	34.8	--		--	--	--		60	0	--	17	--	--		--			46	0	--	163	6.7
10. ARANSAS RIVER NEAR SKIDMORE																						
Nov. 28, 1961	0.30	9.8		27	7.3	518	--	564	0	37	508	2.0	1.5		1390			98	0	23	2440	7.9
Jan. 3, 1962	.53	4.4		25	6.4	431	--	462	14	33	415	1.6	.2		1160			89	0	20	2090	8.3
Jan. 30	b.4	1.6		24	7.8	511	--	490	28	39	500	1.8	6.7		1360			92	0	23	2450	8.5
Sept. 26	1.56	16		49	6.6	191	--	344	0	15	188	.6	.5		a675			150	0	6.8	1110	7.2
Jan. 10, 1963	b.7	8.1		36	5.3	124	--	218	0	15	132	.5	1.2		429			112	0	5.1	792	7.0
Mar. 21	.45	3.6		22	7.7	440	--	490	0	30	430	1.4	1.8		1180			86	0	21	2100	8.0
Oct. 9	30	14		31	4.5	62	--	182	0	6.0	52	.3	1.8		261			96	0	2.8	482	6.6
Dec. 18	2.17	8.8		25	.6	64	--	148	0	5.8	52	.3	2.2		232			65	0	3.4	430	6.8
Feb. 26, 1964	3.75	6.1		16	8.0	354	9.7	393	0	28	355	1.2	3.0		986			73	0	18	1800	7.9
July 20	201	8.8		20	2.0	22	--	90	0	3.6	20	.2	.2		121			58	0	1.3	221	6.6
July 20	130	9.4		21	2.8	57	--	131	0	7.6	51	.2	.2		213			64	0	3.1	377	6.7
July 20	75.3	10		23	2.6	93	--	156	0	11	91	.3	1.5		309			68	0	4.9	565	6.7
July 21	20.8	12		19	4.0	109	--	172	0	9.4	104	.4	2.8		346			64	0	5.9	637	7.9
Nov. 24	b.08	.8		32	8.0	405	--	484	0	40	392	1.1	.5		1120			113	0	17	1950	7.7
Feb. 2, 1965	.3	11		13	7.7	245	--	301	0	22	230	.9	.5		678			64	0	13	1230	7.6
Apr. 13	5.11	16		30	5.3	115	--	236	0	7.8	102	.4	.2		393			97	0	5.1	723	7.0
May 11	451	6.4		34	2.0	16	--	129	0	5.4	10	.2	2.2		139			93	0	.7	255	7.0
May 13	15.8	2.6		23	3.0	102	--	170	0	13	96	.4	2.8		327			70	0	5.3	614	7.0
May 21	51.8	13		27	2.1	13	--	111	0	3.6	5.0	.1	2.5		121			76	0	.6	206	6.5
Jan. 11, 1966	.80	10		32	4.6	156	7.9	247	0	22	150	.4	12		516			99	0	6.8	939	7.2
Feb. 15	3.37	2.2		23	5.4	290	8.5	336	0	26	290	.7	13		824			80	0	14	1530	7.4
Apr. 21	3.03	6.2		30	7.7	567	13	604	0	34	558	1.4	1.8		1520			106	0	24	2700	7.4
Apr. 22	24.8	11		20	1.5	30	4.6	93	0	7.0	28	.3	1.5		150			56	0	1.7	269	6.5
Apr. 25	5430	19		22	1.5	14	4.4	89	0	4.0	12	.2	1.8		123			61	0	.8	202	6.7
Apr. 26	397	9.1		29	1.8	7.2	5.8	107	0	.6	4.6	.2	.5		112			80	0	.3	201	6.7
May 6	2020	8.9		20	1.1	3.8	4.4	78	0	.0	2.3	.1	.2		79			54	0	.2	135	7.0
May 7	259	11		24	1.7	8.0	5.2	96	0	2.8	5.3	.2	.2		105			67	0	.4	177	7.3
Feb. 3, 1967	.93	2.7		18	5.9	470	13	508	0	30	460	1.6	6.6		1260			70	0	24	2250	8.1
Mar. 8	.67	5.2		18	7.5	562	16	604	0	38	543	2.1	4.0		1490			76	0	28	2670	7.7
Apr. 12	.25	18		25	7.4	677	18	698	0	40	670	--	5.8		1800			93	0	31	3140	7.7
May 17	3.64	21		20	7.1	556	17	614	0	40	550	3.5	2.2		1520			79	0	27	2670	7.8
July 26	1.65	11		22	2.4	15	6.4	98	0	3.2	14	.3	.2		122			65	0	.8	207	7.4
Aug. 30	1.81	16		32	2.6	31	6.1	145	0	3.0	23	.4	1.8		187			91	0	1.4	307	7.7
Sept. 25	59.8	18		38	3.2	45	6.0	178	0	5.2	41	.5	1.8		247			108	0	1.9	420	7.4
Sept. 26	37.3	19		46	3.8	74	6.5	216	7	7.0	71	.7	1.5		342			130	0	2.8	577	8.3
Oct. 5	14.2	29		66	6.5	175	7.6	370	0	17	182	1.2	2.0		668			191	0	5.5	1150	7.9
Oct. 19	17.6	20		47	4.4	70	5.8	208	0	11	77	.5	2.2		340			136	0	2.6	588	8.0
Nov. 8	6.06	28		73	8.2	189	--	382	0	23	204	1.1	.2		714			216	0	5.6	1230	7.6
Jan. 16, 1968	1.89	--		57	9.6	--	--	534	0	--	455	--	--		--			182	0	--	2230	7.7
Jan. 25	3.21	--		--	--	--	--	264	0	--	215	--	--		--			128	0	--	1160	7.4
Mar. 28	1.44	--		--	--	--	--	432	0	--	382	--	--		--			151	0	--	1900	7.9
June 6	22.2	--		--	--	--	--	92	2	--	12	--	--		--			77	0	--	203	7.1
July 11	3.26	--		--	--	--	--	184	0	--	68	--	--		--			126	0	--	534	7.1

See footnotes at end of table.

Table 9.--Chemical analyses of streams in the San Antonio-Nueces coastal basin for locations other than daily station--continued

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
11. ARANSAS RIVER NEAR PAPALOTE																						
Nov. 28, 1961....	0.07	32		131	46	229		225	0	74	532	0.4	1.2		1160			516	332	4.4	2080	7.5
Jan. 3, 1962.....	.11	38		136	46	239		244	0	81	540	.5	.2		1200			528	328	4.5	2200	7.4
12. PAPALOTE CREEK NEAR SKIDMORE																						
May 3, 1959......		30		80	9.5	25		313	0	6.4	20	0.3	0.2		325			238	0	0.7	553	7.1
13. ARANSAS RIVER NEAR SINTON																						
May 1942.........				176	39	1570		186	0	42	2710		1.8		a4890			600	447	28	8320	
Mar. 14, 1959....		11		40	8.2	89		125	0	16	146	0.2	3.0		374			134	31	3.4	720	6.9
Sept. 14, 1961...		15		18	2.6	13		77	0	4.6	10	.4	2.0		104			56	0	.8	173	6.4
14. CHILTIPIN CREEK ABOVE SEWAGE RELEASE AT SINTON																						
Sept. 18, 1967...	3.67	18		2160	346	21400	92	104	0	264	38500				62800			6810	6730		88600	6.6
Feb. 7, 1968.....	3.15			2300	382			126	0		41500							7310	7210		79900	7.1
May 22...........	24.1			310	48			68	0		5080							971	916		14300	6.9
July 26..........	3.08			--	--			118	0		32200							6050	5950		58900	6.8
15. CHILTIPIN CREEK BELOW SEWAGE RELEASE AT SINTON																						
Sept. 14, 1961...	--	25		56	12	469		74	0	8.8	805	0.3	2.5		1410			189	128	15	2660	6.3
Sept. 18, 1967...	2.81	19		1530	238	15000	71	169	0	168	26400				43500			4730	4590		65100	6.6
Feb. 7, 1968.....	4.07	--		1080	174	--		190	0	--	18900				--			3110	3250		43900	7.4
May 22...........	25.0	--		325	52	--		70	0	--	5350				--			1020	968		14900	7.0
July 26..........	4.20	--		--	--	--		126	0	--	24000				--			4850	4750		47500	6.7
Oct. 1...........	4.61	--		1440	236	--		174	0	140	25200				--			4560	4420		65000	6.5
Oct. 3...........	4.41	19		1400	216	13200		170	0	176	23200				38300			4380	4240		60700	7.7
Nov. 26..........	4.24	22		1950	308	19500		188	0	185	34200				56300			6130	5980		84300	7.1
Dec. 31..........	3.02	21		1210	192	12300		230	0	142	21400				35400			3810	3620		56300	7.0
Feb. 7, 1969.....	3.43	--		1520	234	--		296	0	128	26400				--			4760	4510		67600	6.9

a Residue upon evaporation at 180°C.
b Estimated.

precipitation data for Falfurrias, Figure 3). During the 1931-68 period, precipitation at Falfurrias ranged from a low of 0.00 inches during several months to a high of 32.78 inches in September 1967, when Hurricane Beulah caused abnormally high rainfall.

Streamflow in the natural waterways is almost entirely dependent on the quantity and intensity of local rainfall. Therefore, flow in these streams is erratic and intermittent. The drainage network is generally poorly defined. The principal streams are Petronila, San Fernando, Santa Gertrudis, and Los Olmos Creeks in the northern part of the basin, which drains to Baffin Bay; and the Arroyo Colorado in the southern part of the basin (Figure 14).

Surface-storage reservoirs in the basin include Lake Alice, Delta Lake, and Tranquitas, Valley Acres, and Loma Alta Reservoirs. Lake Alice, on Chiltipin Creek, provides storage for municipal water supply for the city of Alice. Natural inflow to the reservoir is supplemented by water imported from Lake Corpus Christi in the adjacent Nueces River basin. Tranquitas Reservoir on Tranquitas Creek provides water supplies for the King Ranch. Valley Acres and Loma Alta Reservoirs and Delta Lake are off-channel reservoirs used for temporary storage of the irrigation water pumped from the Rio Grande.

The natural drainage network in the southern part of the basin has been altered by canals that distribute irrigation water imported from the Rio Grande. Some ground water is used to supplement the surface supply. In 1964, about 873,000 acre-feet of surface and ground water was used to irrigate 753,000 acres of cotton, vegetables, citrus, flax, and grain sorghums (Gillett and Janca, 1965, p. 37). Irrigated areas are shown on Figure 5.

The economy of the area is based on petroleum, agriculture, and food processing. Oil fields, oil refineries, and petrochemical plants are scattered throughout the basin, but the heaviest concentration is in the Corpus Christi area.

Chemical-quality data collected in the Nueces-Rio Grande coastal basin are given in Table 10, and the data-collection sites are shown on Figure 14.

Dissolved-solids concentrations were low in Petronila Creek near Driscoll (site 1), San Diego Creek at Alice (site 2), Lake Alice at Alice (site 3), and Los Olmos Creek near Falfurrias (site 8), at all times of sampling. However, data on Petronila and Los Olmos Creeks are very limited. San Diego Creek at Alice was sampled over a wide range of discharge, and dissolved solids ranged from a low of 84 mg/l to a high of 174 mg/l.

Dissolved-solids concentrations in San Fernando Creek at Alice (site 4) ranged from 100 to 1,600 mg/l. The higher concentrations occurred when the flow consisted principally of sewage effluent from the city of Alice; flood runoff contained less than 250 mg/l dissolved solids. Downstream at Kingsville (site 5) the salinity of low flows increased, but the quality of flood runoff remained excellent. The range of dissolved-solids concentrations was from 146 to 2,730 mg/l.

Santa Gertrudis Creek near Kingsville (site 6) was sampled only during low-flow periods, and dissolved-solids concentrations ranged from 1,740 to 28,400 mg/l. This salinity may be partly due to oil-field activities. However, shallow ground water in the area is reported to be very saline (Oral communication, E. T. Baker, 1970), and the salinity of the stream may be the result of the conditions which produce the saline ground water.

One analysis of water from the Arroyo Colorado near Mercedes (site 10) shows a dissolved-solids concentration of 3,800 mg/l. Four analyses of water from the Arroyo Colorado at Harlingen (site 11) show dissolved-solids concentrations less than 300 mg/l. However, samples for the latter were collected from the flood flows caused by Hurricane Beulah, and the analyses are not considered to be representative of the quality of water in the Arroyo Colorado during normal flow. Except for occasional flood flows, the flow of the Arroyo Colorado is due largely to municipal and industrial waste effluents and irrigation-return flows of water originally imported from the Rio Grande.

Available data indicate that the surface waters of the northern part of the basin are generally of good chemical quality. However, reaches of some streams are being degraded by man's activities. The flow regimen in the southern part of the basin is virtually man-made, and natural conditions do not exist.

SUMMARY OF CHEMICAL CHARACTERISTICS OF WATERS OF THE COASTAL BASINS

The chemical quality of surface waters of the coastal basins is generally good. Moderate to high rainfall and well-leached soils along much of the Gulf Coast provide runoff that is low in dissolved constituents. The variations in water quality of the coastal basins are shown in Figure 15. The minimums observed for dissolved solids, hardness, and chloride in each coastal basin show that runoff can be of excellent quality. The maximums observed for these three parameters in each coastal basin are an indication of the effects of man's activities on water quality.

The natural quality of streamflow is difficult to define in the coastal basins. Large volumes of water imported from adjacent river basins are moved across most of the coastal basins through a maze of canals to irrigated fields and industrial sites. Oil-field and other industrial wastes and irrigation-return flows have altered

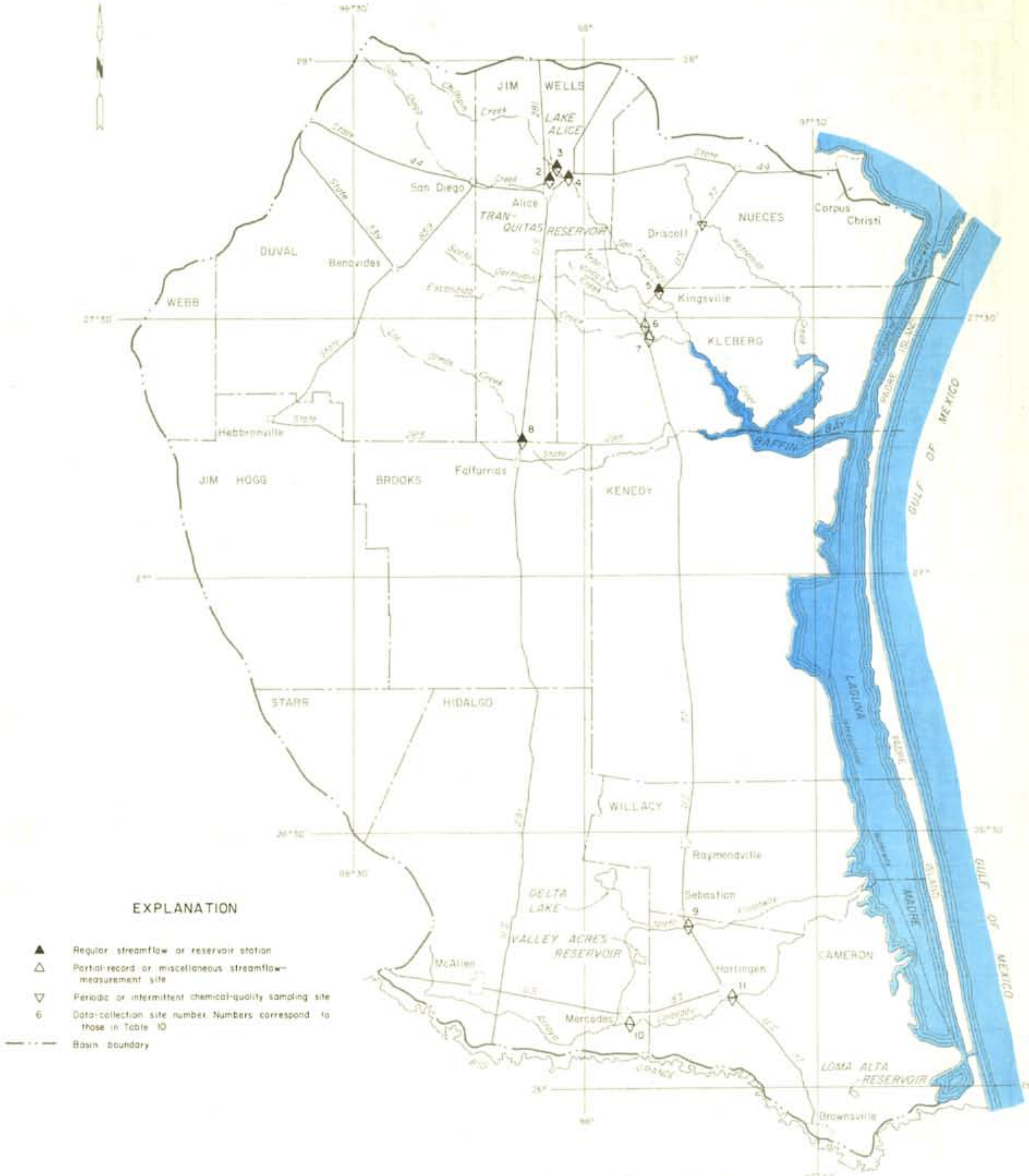

Figure 14

Chemical-Quality Data-Collection Sites in the Nueces-Rio Grande Coastal Basin

Table 10.--Chemical analyses of streams in the Nueces-Rio Grande coastal basin

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
1. PETRONILA CREEK NEAR DRISCOLL																						
Sept. 14, 1961....		17		49	4.2	66		181	0	9.2	88	0.3	0.2		323			140	0	2.4	580	6.7
2. SAN DIEGO CREEK AT ALICE																						
July 4, 1964.....	10.7	9.1		31	1.9	5.5	4.9	109	0	5.2	6.0	0.2	1.0		117			85	0	0.3	203	6.6
July 5...........	4.30	8.6		22	2.0	5.3	6.4	80	0	5.6	6.3	.2	.5		96			63	0	.3	163	6.6
July 14..........	38.7	8.6		21	1.6	3.8	8.6	83	0	4.0	3.6	.2	1.2		94			59	0	.2	163	6.6
Aug. 10..........	a.23	15		28	2.2	12	--	108	0	.8	10	.1	.8		122			79	0	.6	216	7.0
Aug. 25..........	346	11		45	2.1	12	--	165	0	.4	4.8	.2	5.4		162			121	0	.5	290	7.2
Aug. 25..........	346	--		--	--	--	--	166	0	--	4.5	--	--		--			115	0	--	272	7.7
Aug. 25..........	106	--		--	--	--	--	--	--	--	--	--	--		--			--	--	--	272	--
Aug. 25..........	54.5	--		--	--	--	--	150	0	--	4.8	--	--		--			115	0	--	264	6.9
Aug. 25..........	40.0	--		--	--	--	--	143	0	--	4.9	--	--		--			108	0	--	254	6.9
Aug. 25..........	30.1	--		--	--	--	--	138	0	--	5.0	--	--		--			102	0	--	246	7.2
Sept. 13.........	59.9	11		42	3.2	18	--	168	0	7.2	7.0	.2	2.0		174			118	0	.7	288	6.9
Mar. 30, 1965....	400	8.6		35	2.4	10	--	125	0	6.6	3.2	.4	5.0		132			97	0	.4	232	7.2
Mar. 31..........	83.9	6.5		24	1.5	3.1	5.8	88	0	4.8	2.1	.1	.2		91			66	0	.2	157	6.3
Mar. 31..........	31.5	8.8		22	2.2	2.8	6.1	82	0	4.8	2.5	.1	3.0		92			64	0	.2	154	6.8
Apr. 1...........	7.93	8.2		20	2.5	3.0	7.1	82	0	3.6	3.1	.2	.8		88			60	0	.2	149	6.4
May 2, 1966......	150	9.1		25	2.0	2.4	7.7	90	0	.4	3.4	.0	2.2		97			71	0	.1	227	6.4
May 2............	93.7	--		--	--	--	--	170	0	.4	4.1	--	--		--			133	0	--	302	7.0
Sept. 4, 1967....	29.0	8.8		28	1.8	4.5	4.8	102	0	2.0	1.6	.3	4.0		106			77	0	.2	177	7.6
Sept. 21.........	1280	6.1		38	2.0	3.4	6.1	129	0	.2	3.3	.2	2.2		125			103	0	.1	221	7.4
Sept. 21.........	2470	.6		28	1.4	2.0	5.5	100	0	.2	2.5	.2	.0		89			76	0	.1	168	7.7
Sept. 22.........	629	1.4		31	1.9	3.0	5.7	112	0	.4	2.9	.3	.0		102			85	0	.1	186	7.6
Sept. 29.........	93.8	8.3		32	2.3	5.4	8.1	112	0	5.4	8.5	.1	.5		126			89	0	.2	209	6.8
May 8, 1968......	11.2	5.6		23	1.6	5.3	--	80	0	5.0	1.2	.3	2.8		84			64	0	.3	154	7.4
3. LAKE ALICE AT ALICE																						
April 13, 1965...		10		44	3.5	18	--	161	0	10	14	0.3	0.2		179			124	0	0.7	323	6.8
June 21..........		8.2		38	4.2	11	--	151	0	5.4	4.3	.2	1.2		146			112	0	.5	265	6.7
May 3, 1966......		8.8		23	2.6	6.4	8.2	91	0	5.2	6.6	.1	1.8		108			68	0	.3	190	6.7
Aug. 16..........		11		55	6.1	1.7	16	210	0	3.6	7.6	.1	1.5		206			162	0	.1	366	7.5
Oct. 27..........		17		50	5.8	23	11	196	0	16	22	.4	1.0		242			149	0	.8	407	7.0
Jan. 3, 1967.....		18		58	5.4	35	9.1	216	0	26	33	.2	.2		291			166	0	1.2	489	7.1
4. SAN FERNANDO CREEK AT ALICE																						
Sept. 13, 1961...	--	25		38	16	454	--	488	0	162	408	0.7	1.8		1350			161	0	16	2330	7.2
Oct. 31..........	0.71	26		38	17	502	--	389	0	210	468	3.2	62		1520			165	0	17	2550	7.7
Dec. 4...........	.91	27		40	18	532	--	600	0	198	448	--	2.2		1560			174	0	18	2650	7.2
Jan. 10, 1962....	.95	25		38	18	554	--	628	0	197	460	1.8	.2		1600			169	0	19	2760	7.4
June 1...........	631	11		36	2.6	5.9	6.3	127	0	4.8	4.0	.2	3.8		b150			100	0	.3	237	6.5
June 1...........	332	16		57	3.7	20	--	205	0	11	12	.3	1.8		b238			157	0	.7	386	6.6
June 1...........	559	12		54	3.0	11	--	189	0	6.4	5.5	.3	1.0		b202			147	0	.4	329	6.5
June 2...........	265	15		43	2.7	6.8	6.7	147	0	6.4	5.5	.2	3.2		b170			118	0	.3	272	6.5
June 2...........	77.3	13		42	3.0	13	--	139	0	10	11	.3	5.3		166			117	0	.5	292	6.6
June 3...........	340	12		35	2.7	6.2	6.9	126	0	4.8	5.0	.2	2.0		b148			98	0	.3	238	6.5
Sept. 10.........	2130	7.4		26	1.7	3.9	7.1	94	0	.4	6.1	.2	.8		100			72	0	.2	167	6.7
Sept. 10.........	463	11		33	2.6	11	--	124	0	3.2	7.5	--	2.5		132			93	0	.5	234	6.8
Oct. 17..........	.56	41		42	17	518	--	570	0	147	478	2.4	.0		1530			175	0	17	2620	7.1
Nov. 20..........	.57	23		54	14	385	--	350	0	146	375	2.3	69		1240			192	0	12	2080	6.9
Dec. 27..........	1.01	23		37	12	356	--	300	0	110	335	2.7	95		1120			142	0	13	1930	7.0
May 23, 1965.....	1.22	13		35	6.5	34	--	116	0	29	32	.2	22		229			114	19	1.4	417	5.5

See footnotes at end of table.

Table 10.--Chemical analyses of streams in the Nueces-Rio Grande coastal basin--continued

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)			Hardness as $CaCO_3$		Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
															Milligrams per liter (mg/l)	Tons per acre-foot	Tons per day	Calcium, Magnesium	Non-carbonate			
5. SAN FERNANDO CREEK AT KINGSVILLE																						
Sept. 14, 1961	--	18		36	7.6	399	--	256	0	274	348	0.9	1.0		1210			122	0	16	2130	6.9
Nov. 1	4.23	17		80	34	748	--	362	0	596	740	1.1	.5		2390			340	43	18	3870	6.7
Nov. 7	a1	18		78	34	666	--	361	0	462	710	1.1	.2		2150			334	38	16	3520	6.8
Dec. 4	1.86	15		72	18	705	--	502	0	275	768	1.2	1.0		2100			254	0	19	3530	7.6
Jan. 10, 1962	.13	9.0		62	20	790	--	432	0	314	900	1.2	.5		2310			237	0	22	3850	7.4
Feb. 1	a.3	2.3		64	19	777	--	437	0	326	870	1.2	.0		2270			238	0	22	3900	7.6
Sept. 10	a.05	17		56	19	270	--	368	0	128	260	.1	2.0		934			218	0	7.9	1630	6.9
Sept. 11	1270	12		31	3.5	17	--	126	0	8.8	10	--	2.0		146			92	0	.8	261	7.2
July 21, 1964	170	14		30	3.7	62	--	147	0	31	50	.4	.2		263			90	0	2.8	461	6.6
July 21	170	14		31	4.5	52	--	146	0	28	42	.4	.2		244			96	0	2.3	427	6.4
Nov. 24	1.89	16		196	23	746	--	430	0	844	690	--	.5		2730			584	231	13	4010	7.2
Apr. 1, 1965	110	15		48	5.8	76	--	152	0	56	86	.3	4.0		366			144	20	2.8	650	7.1
Apr. 2	55.5	12		42	5.1	75	--	127	0	52	90	.3	2.2		341			126	22	2.9	606	6.8
May 2, 1966	1400	11		42	3.1	11	6.9	160	0	6.8	6.3	.1	3.0		169			118	0	.4	302	6.9
Sept. 6, 1967	164	16		30	3.1	63	7.0	218	0	15	22	.8	3.0		267			88	0	2.9	439	7.8
Oct. 4	65	14		66	14	138	12	190	0	110	195	.3	2.5		645			222	66	4.0	1110	7.4
Oct. 10	16.8	19		72	10	188	14	306	0	122	195	1.0	4.8		776			220	0	5.5	1290	8.2
Nov. 14	5.68	45		190	18	406	--	156	0	620	460	1.2	5.4		1820			548	420	7.6	2770	7.2
Dec. 20	3.13	39		143	17	679	--	266	0	576	770	--	.5		2360			427	209	14	3690	6.9
Feb. 1, 1968	3.73	--		66	6.2	--	--	652	0	--	482	--	--		--			190	0	--	2900	7.2
May 10	733	14		40	6.4	56	--	192	0	28	40	1.7	2.0		282			126	0	2.2	475	7.8
6. SANTA GERTRUDIS CREEK NEAR KINGSVILLE																						
Nov. 1, 1961	0.01	15		400	251	2790	--	257	0	1470	4500		--		9680			2030	1820	27	14300	7.6
Nov. 6	a.05	16		440	263	2900	--	314	0	1540	4700		--		10000			2180	1920	27	14700	7.0
Dec. 4	a.03	15		430	300	2880	--	296	0	1570	4750	0.6	--		10100			2310	2060	26	15200	6.8
Jan. 10, 1962	a.02	15		430	264	2970	--	273	0	1580	4780		--		10200			2160	1940	28	14800	6.9
Feb. 1	a.01	--		--	--	--	--	149	0	--	5620		--		--			2640	2520	--	17400	7.6
Sept. 10	a.1	24		128	50	778	--	252	0	678	925		0.2		2710			525	318	15	3740	7.0
July 21, 1964	a.05	15		640	424	3880	--	228	0	1850	6850		--		13800			3340	3150	--	19700	6.7
Apr. 1, 1965	a.007	24		1300	925	7960	--	400	0	3840	14200		--		28400			6920	6720	--	39600	7.0
Sept. 5, 1967	6.14	11		131	79	732	16	124	0	408	1250		3.0		2690			652	550	12	4590	7.1
Oct. 4	21.0	24		123	52	415	20	161	0	288	730		4.2		1740			521	389	7.9	3020	7.3
Oct. 10	1.95	17		345	216	1760	27	242	0	960	3150		--		6590			1750	1550	--	10800	7.7
Nov. 14	--	3.8		348	240	1990	--	274	0	1120	3400		--		7240			1860	1630	--	11700	7.6
Dec. 21	.47	3.5		462	344	3010	--	312	0	1670	5050		--		10700			2570	2310	--	16500	7.6
Feb. 1, 1968	.43	--		468	368	--	--	280	0	--	5400		--		--			2680	2450	--	16900	7.8
7. ESCONDIDO CREEK AT KINGSVILLE																						
Nov. 7, 1961	--	9.8		300	65	371	--	140	0	160	1090	0.4	4.5		2070			1020	902	5.0	3790	6.5
Feb. 2, 1962	--	.8		148	49	556	--	216	0	522	750	.4	.0		2130			571	394	10	3490	7.2
Oct. 4, 1967	83.5	15		26	5.5	33	12	102	0	31	41	.2	1.8		216			87	4	1.5	373	7.3
Oct 10	28.6	15		36	7.7	50	13	123	0	43	70	.3	2.2		297			121	21	2.0	513	7.6
Nov. 14	.03	4.9		238	68	467	--	252	0	286	980	2.7	2.7		2170			874	667	6.9	3780	7.7
Dec. 12	.32	5.4		328	121	839	--	215	0	516	1720	--	1.8		3640			1320	1140	10	6100	7.5
Feb. 1, 1968	.10	--		490	188	--	--	274	0	--	2560	--	--		--			2000	1770	--	8720	7.5
May 10	112	--		--	--	--	--	78	0	--	81	--	--		--			116	52	--	467	7.0

See footnotes at end of table.

Table 10.--Chemical analyses of streams in the Nueces-Rio Grande coastal basin--continued

(Results in milligrams per liter except as indicated)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated): Milligrams per liter (mg/l)	Dissolved solids (calculated): Tons per acre-foot	Dissolved solids (calculated): Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
8. LOS OLMOS CREEK NEAR FALFURRIAS																						
Sept. 24, 1967....	6030	6.0		11	1.4	2.0	5.3	46	0	0.8	2.3	0.1	1.0		53			33	0	0.2	87	6.9
Sept. 29..........	13.8	13		28	4.2	52	8.8	105	0	30	67	.2	1.9		256			87	1	2.4	447	7.0
9. NORTH FLOODWAY NEAR SEBASTIAN																						
Sept. 26, 1967....	59100	11		42	5.0	29	3.6	112	0	61	24	0.3	2.8		234			125	34	1.1	383	7.6
10. ARROYO COLORADO NEAR MERCEDES																						
Nov. 24, 1967.....		36		342	119	832		293	0	956	1350		17		3800			1340	1100	9.9	5740	7.5
Feb. 14, 1968.....										1120	1520										6580	
11. ARROYO COLORADO AT HARLINGEN																						
Sept. 26, 1967....	55200	9.7		43	5.7	33	3.4	115	0	69	26	0.3	2.8		250			131	36	1.3	414	7.7
Sept. 27..........	54800	9.4		46	6.0	31	3.4	120	0	68	25	.3	4.2		252			139	41	1.1	417	7.7
Sept. 28..........	50000	9.3		50	6.4	30	3.4	123	0	76	23	.3	6.8		265			151	50	1.1	436	7.9
Sept. 29..........	31000	10		52	6.7	30	3.6	129	0	78	25	.3	4.9		274			157	52	1.0	448	7.9

a Estimated.
b Residue on evaporation at 180°C.

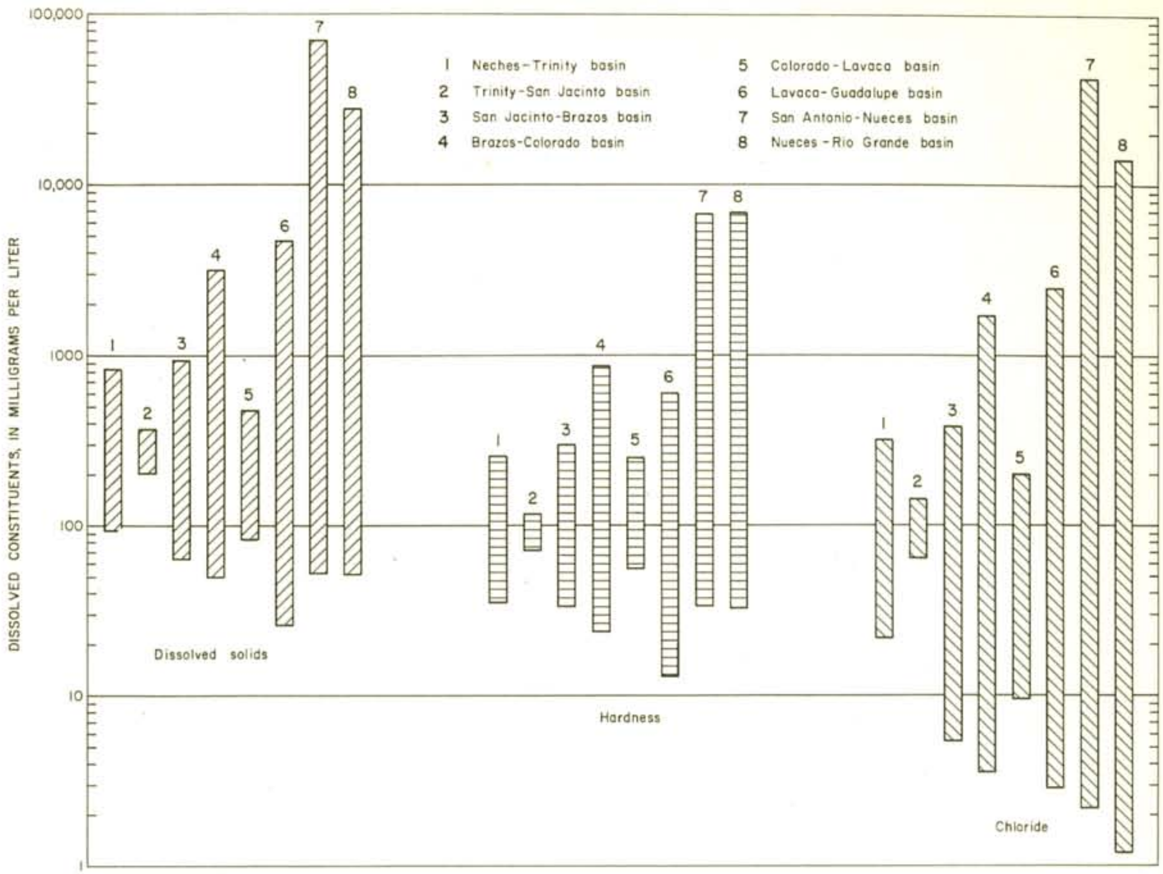

Figure 15.—Range Between Maximum and Minimum Values for Dissolved Solids, Hardness, and Chloride Observed in Surface Waters of the Coastal Basins

the natural quality of water of most of the streams. Municipal wastes are also degrading the quality of water of some streams. Therefore, the quality of low to moderate streamflows is probably more the result of man's activities than natural streamflow characteristics or geology.

Except for streams in the urban and industrial areas and streams receiving large amounts of oil-field wastes, the quality of runoff should meet requirements for municipal supply, irrigation, and most industrial uses most of the time. The minimum dissolved-solids and chloride concentrations in all the coastal basins are well below the recommended limits (500 mg/l dissolved solids and 250 mg/l chloride) of the U.S. Public Health Service (1962, p. 7) for municipal supply (Figure 15).

CONCLUSIONS

Water for municipal supply, industrial use, irrigation, and transportation has resulted in a diversified and expanding economy in the coastal basins. Water pollution will be a problem of increasing importance in areas of rapid urban and industrial development, especially along the coast where the tides act as a natural barrier to the movement and dilution of wastes. Because of the widespread use of agricultural chemicals, additional studies are needed to learn their effects on the quality of the water of the coastal streams.

Compliance with Order Number 20-56,841 of the Railroad Commission of Texas, which prohibits the use of salt-water disposal pits and the discharge of oil-field brines to surface-water drainage courses, as of January 1, 1969, should improve the quality of water in coastal streams that have been receiving oil-field wastes; but the effects of residual brines from past brine-disposal practices may remain for years.

Runoff from the generally abundant precipitation along the Gulf Coast will continue to flush out and dilute the wastes resulting from man's activities. Additional studies are needed, particularly in the drainage areas of the urban and industrial centers and in tidal reaches of the streams, to determine types and concentrations of wastes and their effects on Texas coastal waters.

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WATER YEAR	U.S.G.S. WATER-SUPPLY PAPER NO.	T.W.D.B. REPORT NO.	WATER YEAR	U.S.G.S. WATER-SUPPLY PAPER NO.	T.W.D.B. REPORT NO.
1942-45	—	* 1938-45	1955	1402	* 1955
1946	1050	* 1946	1956	1452	Bull. 5905
1947	1102	* 1947	1957	1522	Bull. 5915
1948	1133	* 1948	1958	1573	Bull. 6104
1949	1163	* 1949	1959	1644	Bull. 6205
1950	1188	* 1950	1960	1744	Bull. 6215
1951	1199	* 1951	1961	1884	Bull. 6304
1952	1252	* 1952	1962	1944	Bull. 6501
1953	1292	* 1953	1963	1950	Rept. 7
1954	1352	* 1954			

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