TEXAS WATER DEVELOPMENT BOARD

REPORT 67

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE TRINITY RIVER BASIN, TEXAS

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TABLE OF CONTENTS

	Page
ABSTRACT	1
INTRODUCTION	3
TRINITY RIVER DRAINAGE BASIN	4
General Description	4
Population and Municipalities	6
Economic Development	6
Development of Surface-Water Resources	6
CHEMICAL QUALITY OF THE WATER	13
Chemical-Quality Records	13
Streamflow Records	15
Environmental Factors and Their Effects on the Chemical Quality of the Water	15
Geology	16
Streamflow	17
Activities of Man	17
Relation of Quality of Water to Use	24
Domestic Purposes	24
Industrial Use	26
Irrigation	28
Geographic Variations in Water Quality	30
Dissolved Solids	30
Hardness	31
Chloride	31

TABLE OF CONTENTS (Cont'd.)

	Page
Other Constituents	31
Water Quality in Reservoirs	32
Bridgeport Reservoir	32
Lake Amon G. Carter	32
Eagle Mountain Reservoir	32
Lake Worth	32
Benbrook Reservoir	32
Lake Arlington	32
Mountain Creek Lake	33
Garza-Little Elm Reservoir	33
Grapevine Reservoir	33
White Rock Lake	33
Lavon Reservoir	33
Lake Ray Hubbard	33
Terrell Reservoir	33
Cedar Creek Reservoir	33
Navarro Mills Reservoir	33
Lake Waxahachie	33
Bardwell Reservoir	33
Livingston Reservoir	33
Water Quality at Potential Reservoir Sites	34
Bridgeport Enlargement	34
Boyd	34
Big Fossil Creek	34
Lakeview	34
Aubrey	34

TABLE OF CONTENTS (Cont'd.)

	Page
Roanoke	34
Lavon Enlargement	34
Italy	34
Richland Creek	34
Tehuacana Creek	34
Tennessee Colony	34
Upper Keechi Creek	35
Big Elkhart Creek	35
Houston County Lake	35
Hurricane Bayou	35
Lower Keechi Creek	35
Bedias Creek	35
Nelsons Creek and Harmons Creek	35
Mustang Creek	35
Gail Creek	35
Caney Creek	35
Long King Creek	35
Wallisville	35
Problems Needing Additional Investigation	36
REFERENCES	37

TABLES

1. Reservoirs in the Trinity River basin with capacities of 5,000 acre-feet or more as of December 31, 1965 10

2. Source and significance of dissolved mineral constituents and properties of water 25

3. Water-quality tolerances for industrial applications 27

Page

4. Index of surface-water records in the Trinity River basin........... 41

5. Summary of chemical analyses at daily stations on streams in the Trinity River basin.. 47

6. Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations..................... 56

FIGURES

1. Index Map of Texas Showing River Basins and Coastal Areas........... 5

2. Map and Graphs Showing Precipitation and Runoff..................... 7

3. Graph Showing Average Annual Runoff, Drainage Area, and 1960 Population of Major River Basins................................. 9

4. Map Showing Major Reservoirs and Potential Reservoir Sites.......... 11

5. Graph Showing Relation of Dissolved Solids to Water Discharge in Three Tributaries of the Trinity River........................ 18

6. Duration Curves for Dissolved Solids and Water Discharge, Trinity River at Romayor, Water Years 1958-65............................ 19

7. Generalized Map of Oil and Gas Fields............................... 21

8. Diagram for Classification of Irrigation Waters..................... 29

9. Geologic Map Showing Location of Streamflow and Chemical-Quality Data-Collection Sites.. 67

10. Map Showing Dissolved-Solids Concentrations of Surface Water........ 69

11. Map Showing Hardness of Surface Water.............................. 71

12. Map Showing Chloride Concentrations of Surface Water................ 73

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE TRINITY RIVER BASIN, TEXAS

ABSTRACT

The natural runoff in the Trinity River basin is of good chemical quality and is suitable for most municipal, industrial, and agricultural purposes.

The kinds and quantities of minerals dissolved in surface water of the basin are related to the geology of the runoff area and to rainfall and streamflow characteristics; but the quality of the water in many parts of the basin has been degraded by municipal and industrial wastes.

The rocks exposed in the Trinity River basin are sedimentary deposits that range in age from Pennsylvanian to Quaternary. The rocks of Pennsylvanian age crop out in the northwestern part of the basin and dip to the northwest. The successively younger rocks crop out toward the coast and dip to the southeast.

Water from the outcrop areas of Pennsylvanian and Cretaceous rocks generally has dissolved-solids concentrations ranging from 100 to 250 ppm (parts per million); water draining the rocks of Tertiary and Quaternary age generally contains less than 100 ppm dissolved solids. Higher concentrations are found in several areas where municipal or industrial wastes are discharged into the streams.

In the northwestern part of the basin, water from rocks of Pennsylvanian age is moderately hard; in the northern part of the basin, water from rocks of Cretaceous age is hard; and in the central and southern parts of the basin, water from the younger formations is generally soft.

The chloride concentration in surface water of much of the basin is less that 50 ppm. Higher concentrations are found in the Elm Fork Trinity River, Richland Creek, Tehuacana Creek, and Menard Creek subbasins where oil-field brines are reaching the streams. The Trinity River downstream from Dallas contains higher concentrations because of the municipal wastes that are discharged into the river in the Dallas-Fort Worth area.

All the water-supply reservoirs in the basin contain water of good quality. The dissolved-solids concentration is usually less than 350 ppm. Water available for storage at potential reservoir sites is also of good quality with the exception of Richland and Tehuacana Creeks where reservoirs would store water of doubtful quality because of oil-field brine pollution.

The disposal of municipal and industrial wastes poses serious water-quality problems that must be resolved before the water resources of the Trinity River basin can be effectively developed.

RECONNAISSANCE OF THE CHEMICAL QUALITY OF SURFACE WATERS OF THE TRINITY RIVER BASIN, TEXAS

INTRODUCTION

The investigation of the chemical quality of the surface waters of the Trinity River basin, Texas, is part of a statewide reconnaissance. This report is the fifth in a series presenting the results of the study and summaries of available chemical-quality data. Reports on the Sabine, Neches, San Jacinto, and Brazos River basins have been prepared, and future reports are planned for each major river basin in Texas.

Knowledge of the quality of water that will be available is essential in planning any water-use project, because the chemical character of the water determines its suitability for domestic, irrigation, or industrial purposes. If raw water is not satisfactory for a specific use, then chemical analyses are necessary to determine the type and extent of treatment needed.

In addition to determining the suitability of water for specific uses, chemical-quality data are needed for the (1) inventory of water resources, (2) detection and control of pollution of water supplies, including the setting of water-quality control standards, (3) study of techniques for preventing salt-water encroachment into coastal streams and aquifers, (4) planning for reuse of water, and (5) demineralization of water.

A network of daily chemical-quality stations on principal streams in Texas is operated by the U.S. Geological Survey in cooperation with the Texas Water Development Board and with Federal and local agencies. However, this network has not been adequate to inventory completely the chemical quality of the surface waters of the State. To supplement the information being obtained by the network, a cooperative statewide reconnaissance was undertaken by the U.S. Geological Survey and the Texas Water Development Board. In this study, samples for chemical analyses have been collected periodically at numerous sites throughout Texas so that some quality-of-water information would be available for locations where water-development projects are contemplated. 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.

During the period September 1961 to September 1965, water-quality data were collected for the principal streams, the major reservoirs, a number of potential reservoir sites, and many tributaries in the Trinity River basin.

Agencies that have cooperated in the collection of chemical-quality and streamflow data include the U.S. Army Corps of Engineers, the Tarrant County Water Control and Improvement District No. 1, the Chambers-Liberty Counties Navigation District, the Trinity River Authority, and the cities of Dallas, Fort Worth, and Houston.

TRINITY RIVER DRAINAGE BASIN

General Description

The Trinity River heads in north-central Texas and flows in a general southeasterly direction to the Gulf of Mexico. The drainage basin is bounded on the north by the Red River basin, on the east by the Sulphur, Sabine, and Neches River basins, and on the west by the Brazos and San Jacinto River basins (Figure 1). The drainage basin, which includes all or part of 37 counties, has an area of approximately 18,000 square miles.

The headwater stream in the Trinity River basin, the West Fork Trinity River, rises in southeastern Archer County, and is joined by the Clear Fork at Fort Worth, the Elm Fork at Dallas, and the East Fork in Kaufman County. These four forks and Denton Creek, a major tributary to the Elm Fork, are the major streams that form the Trinity River. Downstream from Kaufman County, the major tributaries are Cedar and Richland Creeks.

The basin slopes from an altitude of about 1,200 feet in the headwaters to sea level. The northern part of the basin is characterized by a series north-trending linear belts of alternating, smooth to slightly rolling, treeless prairies and rolling timbered hills. The central part of the basin is a gently rolling area, most of which is heavily timbered. The southern part of the basin is a relatively flat coastal prairie.

The average annual precipitation ranges from about 27 inches in the northwestern part of the basin to over 52 inches in the southern part. The maximum rainfall usually occurs during April and May, except in the lower part of the basin where rainfall is fairly evenly distributed throughout the year. Mean annual precipitation in the basin, average monthly precipitation at three U.S. Weather Bureau stations, and annual precipitation for the period 1930-65 at one station are shown in Figure 2.

Runoff is defined as that part of the precipitation appearing in surface streams, and is the same as streamflow unaffected by artificial diversions or storage (Langbein and Iseri, 1960, p. 17). The natural runoff pattern in the upper part of the basin has been greatly affected by the construction of reservoirs in the Dallas-Fort Worth area and by numerous small floodwater-retarding structures.

About 15 percent of the precipitation appears in the streams as runoff. Runoff data plotted on the map in Figure 2 show that runoff from subbasins varies from 2.0 inches in the upper part of the basin to 7.0 inches in the central part. These runoff values were computed from streamflow records that were adjusted slightly to include water in storage in the upper basin at the close of the period of record. At Romayor, the lowermost streamflow station where daily discharge is computed, annual runoff averages 5.6 inches. Annual runoff

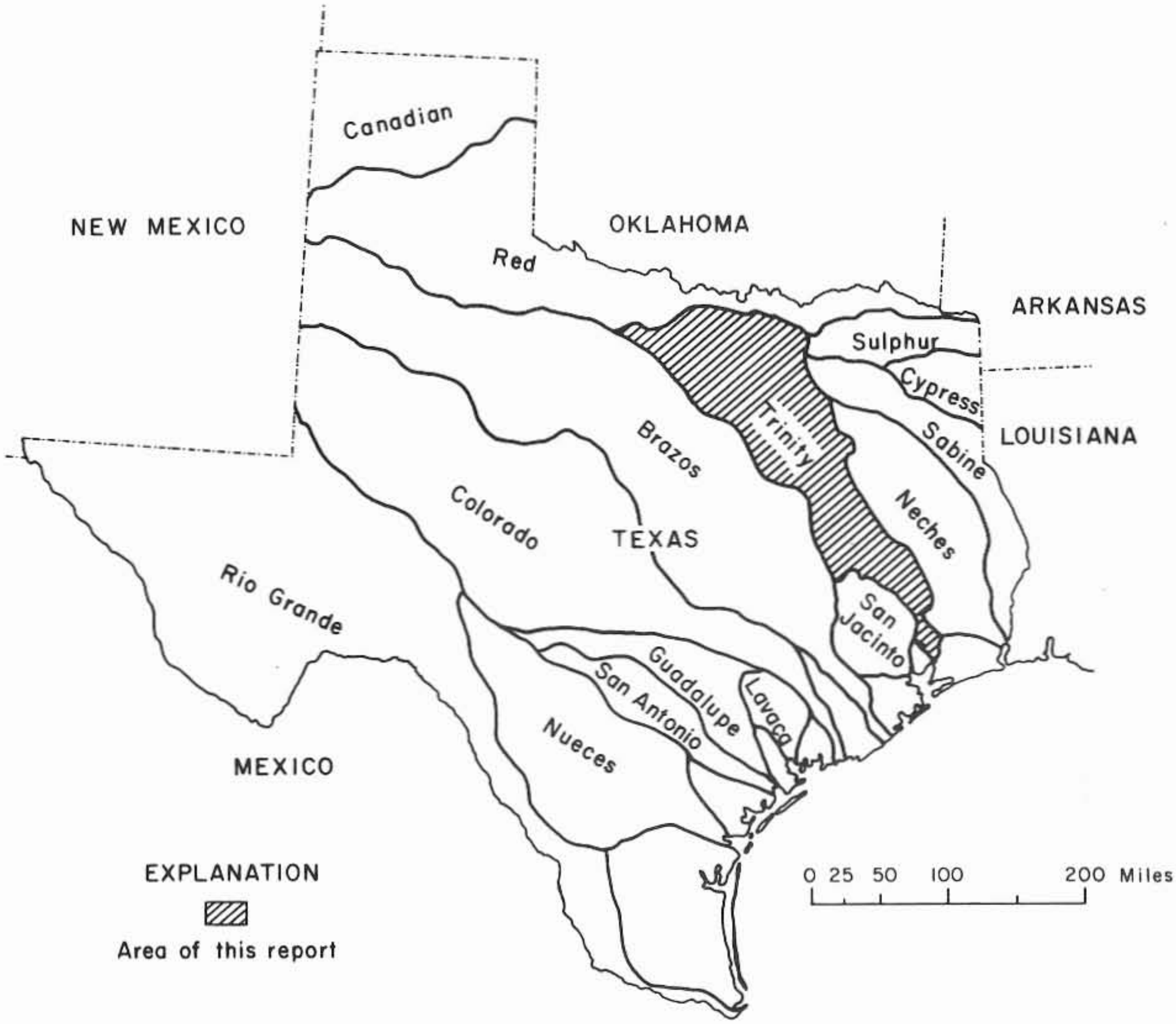

Figure 1

Index Map of Texas Showing River Basins and Coastal Areas

U. S. Geological Survey in cooperation with the Texas Water Development Board

at Romayor computed from historical streamflow records (1925-65) averages 5.6 inches showing that storage in the upper basin has not significantly affected average yearly runoff in the lower basin. Runoff at Romayor, expressed as inches per year and as mean discharge in cubic feet per second, is shown for the period 1925-65 in Figure 2.

Precipitation and runoff are subject to much greater variations than are indicated by the annual and monthly averages. The yearly mean discharge of the Trinity River at Romayor has ranged from 913 to 16,930 cfs (cubic feet per second), but instantaneous flows have ranged from 102 to 111,000 cfs. Thus in spite of relatively high averages, streamflow is unevenly distributed in time, and storage projects are necessary to make surface water available in dependable quantities. Seasonal distribution of rainfall is the major factor; but storm intensity, temperature, types and density of vegetation, surface slope, soils, and permeability of aquifers also affect the amount and distribution of runoff from a drainage basin.

Population and Municipalities

The population of the Trinity River basin was almost 2.5 million in 1965. About 1.9 million people live in the Dallas-Fort Worth area and almost 400,000 more live in the peripheral cities of Garland, Grand Prairie, Irving, Mesquite, Denton, Waxahachie, Arlington, Hurst, Ennis, Gainesville, and McKinney. Other cities and towns in the central and southern parts of the basin and the estimated 1965 populations (Texas Almanac, 1966) are: Corsicana, 21,500; Terrell, 14,855; Weatherford, 13,500; Crockett, 5,200; and Liberty, 6,970. Palestine, Athens, and Huntsville, only partly in the basin, had estimated populations in 1965 of 14,000, 10,619, and 13,522, respectively. About 84 percent of the population is classified as urban; the remainder is fairly evenly distributed in the rural areas of the basin.

Economic Development

The economy of the basin ranges from varying types of industry in the population centers to diversified forms of agriculture in the rural areas. Dallas, Fort Worth, and the cities nearby are leading centers of finance, insurance, meat packing, aerospace research, aircraft manufacturing, and petroleum-related activities. Farther south, the economy is dependent upon agriculture and the production of oil and gas. In the northern half of the basin, general farming produces cotton, grain, livestock, and dairy products. Near the coast, rice is the most important crop.

Development of Surface-Water Resources

The Trinity River basin covers 7 percent of the State's total area, contributes almost 16 percent of the State's total runoff, and has over 20 percent of the State's population (Figure 3). Many general-purpose water-development projects have been necessary to make water available to the population centers of the basin. Table 1 lists the capacities, owners, and uses of the reservoirs having capacities of 5,000 acre-feet or more. Locations of the reservoirs are shown in Figure 4.

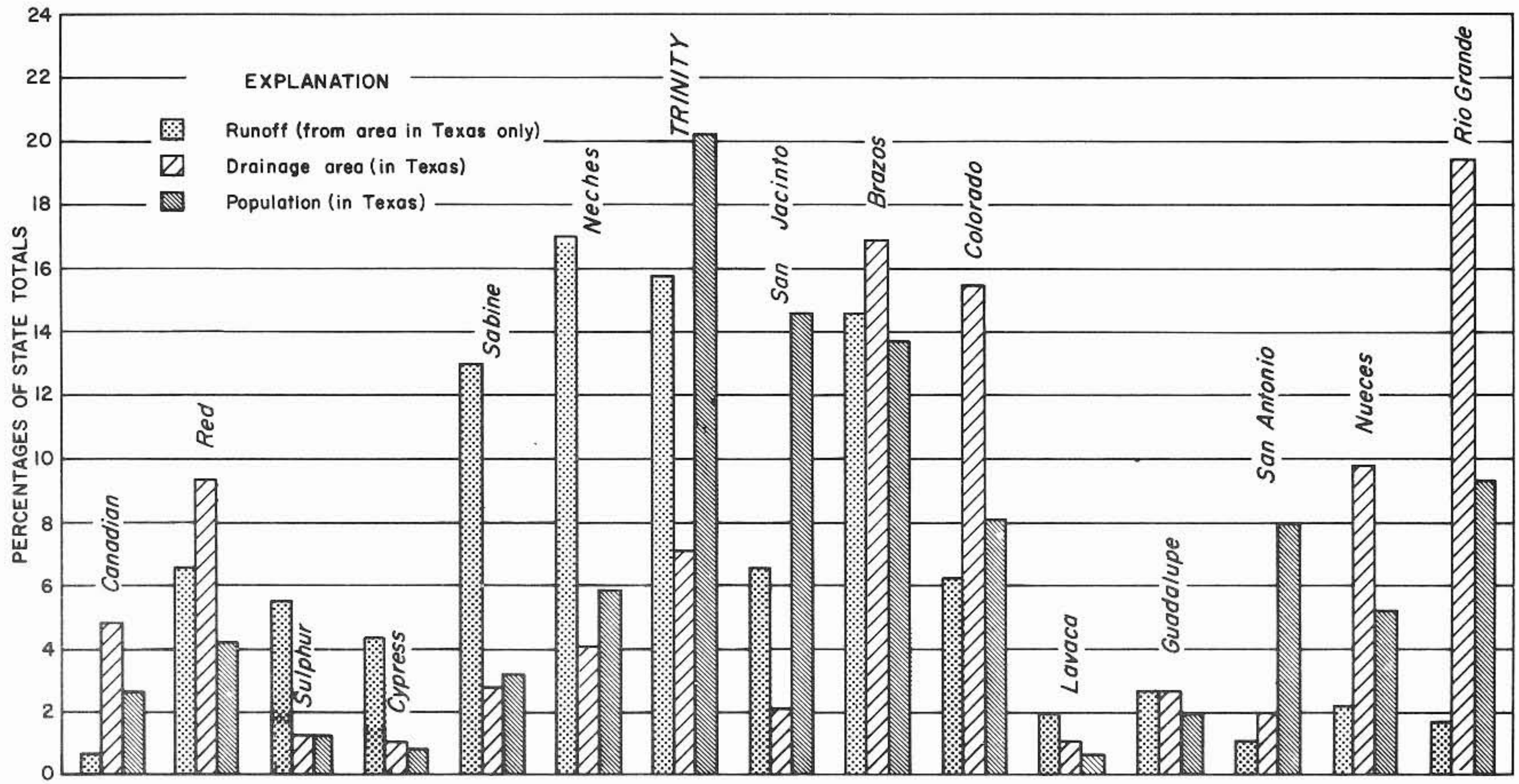

Figure 3

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

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

U. S. Geological Survey in cooperation with the Texas Water Development Board

Table 1.--Reservoirs in the Trinity River basin with capacities of 5,000 acre-feet or more as of December 31, 1965

The purpose for which the impounded waters are used is indicated by the following symbols: D, domestic; FC, flood control; I, industrial; Ir, irrigation; M, municipal; Mi, Mining; Nav, navigation; R, recreation.

Name of reservoir	Year operation began		a/ Total storage capacity (acre-feet)	Owner or operator	County	Use
Bridgeport	1932	West Fork Trinity River	270,900	Tarrant County Water Control and Improvement District No. 1	Wise, Jack	M, I, Ir, R
Lake Amon G. Carter	1956	Big Sandy Crk.	20,050	City of Bowie	Montague	M, I
Eagle Mountain	1934	West Fork Trinity River	182,700	Tarrant County Water Control and Improvement District No. 1	Tarrant	M, I, Ir, R
Lake Worth	1914	West Fork Trinity River	33,660	City of Fort Worth	do	M
Lake Weatherford	1957	Clear Fork Trinity River	19,600	City of Weatherford	Parker	M, I
Benbrook	1952	Clear Fork Trinity River	164,800	U. S. Army Corps of Engineers	Tarrant	FC, Nav, M
Lake Arlington	1957	West Fork Trinity River	45,710	City of Arlington	do	M, I
Mountain Creek Lake	1937	Mountain Creek	25,720	Dallas Power & Light Co.	Dallas	I
Garza-Little Elm	1954	Elm Fork Trinity River	989,700	U. S. Army Corps of Engineers	Denton	FC, M, I
Grapevine	1952	Denton Creek	435,500	do	Tarrant, Denton	FC, M, I, R
North Lake	1957	South Fork Grapevine Creek	17,000	Dallas Power & Light Co.	Dallas	I
White Rock Lake	1911	White Rock Creek	12,300	City of Dallas	do	M, I, R
Lavon	1953	East Fork Trinity River	423,400	U. S. Army Corps of Engineers	Collin	FC, M, D, I
Lake Ray Hubbard	b/	East Fork Trinity River	540,000	City of Dallas	Dallas, Kaufman, Rockwall	M
Trinidad Lake	1925	Unnamed slough	7,800	Texas Power & Light Co.	Henderson	I
Terrell	1955	Muddy Cedar Creek	8,300	City of Terrell	Kaufman	M, R
Cedar Creek	1965	Cedar Creek	679,200	Tarrant County Water Control and Improvement District No. 1	Henderson, Kaufman	M
Navarro Mills	1963	Richland Creek	212,200	U. S. Army Corps of Engineers	Navarro, Hill	FC, M
Lake Waxahachie	1956	South Prong Waxahachie Creek	13,500	Ellis County Water Improvement District No. 1	Ellis	M, I
Bardwell	1965	Waxahachie Creek	140,000	U. S. Army Corps of Engineers	do	FC, M
Lake Halbert	1921	Elm Creek	7,420	City of Corsicana	Navarro	M, I, R
Livingston	b/	Trinity River	2,060,000	Trinity River Authority	Polk, San Jacinto, Trinity	M, I
Anahuac Lake	1954	Turtle Bay	35,300	Chambers-Liberty Counties Navigation District	Chambers	I, Ir, Mi

a/ Total capacity is that capacity below the lowest uncontrolled outlet or spillway (in some cases top of gates) and is based on the most recent reservoir survey available.

b/ Under construction as of December 31, 1965.

The Texas Water Development Board (1966, p. 31) reported that 402,000 acre-feet of water was used by cities and industries in the Trinity River basin in 1960 and that irrigation usage in 1964 was about 62,000 acre-feet. More than two-thirds of the water used in the basin was from surface-water sources. Principal users of surface water are the cities of the Dallas-Fort Worth area.

The city of Dallas obtains its water supply principally from Garza-Little Elm and Grapevine Reservoirs, supplemented by Lavon Reservoir and Lake Tawakoni (in the Sabine River basin). White Rock Lake is available as an emergency supply.

Several other cities in the Dallas area, including Denton, Garland, McKinney, and Mesquite, also obtain water from these sources.

Fort Worth obtains most of its water supply from a chain of three reservoirs--Bridgeport Reservoir, Eagle Mountain Reservoir, and Lake Worth--on the West Fork Trinity River, and furnishes part of the supply for several adjoining cities. Benbrook and Navarro Mills Reservoirs are available as additional supplies for Fort Worth. Cedar Creek Reservoir was recently completed as a supply for Fort Worth and vicinity.

Other municipalities obtaining water supplies from reservoirs include Bowie (Lake Amon G. Carter), Arlington (Lake Arlington), Corsicana (Lake Halbert), Waxahachie (Lake Waxahachie), Weatherford (Lake Weatherford), and Terrell (Terrell Reservoir); Bardwell Reservoir will supply the city of Ennis.

Projects under construction in the Trinity River basin include Lake Ray Hubbard for additional municipal supply for the city of Dallas, and Livingston Reservoir which will be the largest reservoir in the Trinity River basin and will furnish municipal, industrial, and irrigation water for Houston and vicinity.

The Soil Conservation Service of the U.S. Department of Agriculture was authorized by the Flood Control Act of 1936 to investigate and prescribe measures for runoff and water flow retardation and soil erosion prevention. As of September 30, 1965, 499 Soil Conservation Service floodwater retarding structures had been built in the Trinity River basin. These structures partly control flow from 1,139 square miles.

CHEMICAL QUALITY OF THE WATER

Chemical-Quality Records

The U.S. Geological Survey has collected chemical-quality records in the Trinity River basin since 1945 when a sampling station was established on the Trinity River at Romayor. This station was discontinued for several months during 1949, but was reactivated and records are currently (1965) being collected at this site. In addition to the Romayor station, the U.S. Geological Survey in 1965 was operating five other daily chemical-quality stations. Numerous samples for chemical analyses have been collected at miscellaneous sites throughout the basin since 1952.

Collection of chemical-quality data for this reconnaissance study began in 1961. Samples were collected periodically from the principal tributary streams and from 13 reservoirs.

Data were collected over a wide range of discharge rates. At low flows, concentrations of dissolved solids are likely to be highest; and the data commonly indicate where pollution or salinity problems exist. Data collected during medium and high flows indicate the probable quality of the water that would be stored in reservoirs. Stream-gaging stations were selected as sampling sites whenever possible so that chemical content could be considered in relation to water discharge. At sites other than stream-gaging stations, water discharge was usually measured when the samples were collected.

The periods of record at all data-collection sites are given in Table 4, and the locations are shown in Figure 9. The chemical-quality data for the daily stations are summarized in Table 5, and the complete records are published in an annual series of U.S. Geological Survey Water-Supply Papers and in reports of the Texas Water Development Board. (See tables at end of References.) Results of all the periodic and miscellaneous analyses are given in Table 6.

The Texas State Department of Health makes available to the Geological Survey the data collected in its statewide stream-sampling program, which includes the periodic determination of pH, biochemical oxygen demand, total solids, dissolved oxygen, chlorine demand, and sulfate at 33 locations in the Trinity River basin. The data-collection sites of the Texas State Department of Health are listed in the following table. Some of them are at U.S. Geological Survey stream-gaging stations. The numbers refer to sites shown in Figure 9.

Reference no.	Texas State Department of Health data-collection sites
2	West Fork Trinity River near Jacksboro
--	West Fork Trinity River at White Settlement Road in Fort Worth
--	Clear Fork Trinity River at Henderson Street in Fort Worth
--	West Fork Trinity River at North Main Street in Fort Worth
--	West Fork Trinity River at NE 12th Street in Fort Worth
--	West Fork Trinity River at E. First Street in Fort Worth
--	West Fork Trinity River at Randall Mill-Hurst Road in Fort Worth
--	West Fork Trinity River at Elderville Road in Fort Worth
--	West Fork Trinity River at bridge on Farm Road 157 in Fort Worth
20	West Fork Trinity River at Grand Prairie
--	West Fork Trinity River at Old Singleton Road in Dallas
29	Elm Fork Trinity River near Sanger
--	Elm Fork Trinity River at Gravwyler Road in Dallas
--	Trinity River at Westmoreland bridge in Dallas
--	Trinity River at Forrest Avenue bridge in Dallas

(Continued on next page)

Reference no.	Texas State Department of Health data-collection sites
--	Trinity River at South Central Expressway in Dallas
--	Trinity River at SE Loop 12 in Dallas
--	Trinity River at Dowdy Ferry Road in Dallas
61	East Fork Trinity River near Lavon
64	East Fork Trinity River near Crandall
65	Trinity River near Rosser
66	Trinity River at Trinidad
--	Trinity River near Cayuga
77	Richland Creek near Richland
--	Chambers Creek near Italy
84	Chambers Creek near Corsicana
90	Trinity River near Oakwood
95	Trinity River near Crockett
97	Trinity River near Midway
102	Trinity River at Riverside
--	Trinity River near Point Blank
109	Trinity River at Romayor
110	Trinity River at Liberty

Streamflow Records

Streamflow records in the Trinity River basin begin in 1903 when the U.S. Geological Survey established a streamflow measuring station on the Trinity River at Dallas. More than 25 years of discharge records are available for 12 stations in the Trinity River basin and over 10 years of record are available at several other sites in the basin.

In 1965 the U.S. Geological Survey operated 57 streamflow stations, 4 reservoir content stations, and 12 partial record stations. The U.S. Army Corps of Engineers operated reservoir content stations on five other reservoirs in the basin. The periods of record for all the streamflow and reservoir stations are given in Table 4, and the locations are shown in Figure 9.

Records of discharge, stage of streams, and contents and stages of reservoirs from 1903 to 1960 have been published in the annual series of U.S. Geological Survey Water-Supply Papers. (See tables at end of References.) Beginning with the 1961 water year, streamflow records have been released by the U.S. Geological Survey in annual reports for each state (U.S. Geological Survey, 1961, 1962, 1963, 1964b, 1964c). Summaries of discharge records have been published giving monthly and annual totals (U.S. Geological Survey, 1960, 1964a; Texas Board of Water Engineers, 1958).

Environmental Factors and Their Effects on the Chemical Quality of the Water

All water from natural sources contains mineral constituents dissolved from the rocks and minerals of the earth's crust. The kind and quantities of dissolved minerals in surface water depend upon a number of environmental factors, some of the most important of which are geology, patterns and characteristics of streamflow, and the activities of man.

Geology

In areas where municipal and industrial influences are small, the amounts and kinds of minerals dissolved in surface waters depend principally on the chemical composition and physical structure of the rocks and soils traversed by the water.

The availability of the minerals in rocks and soils is decreased by leaching. In arid or semiarid regions most soils and the rocks from which they originated are incompletely leached and still contain large quantities of readily soluble material. In some areas of high rainfall, rocks that originally contained large quantities of readily soluble minerals have been leached by circulating water until the mantle rock and residual soils contain relatively small amounts of readily soluble minerals. In the Trinity River basin where the average annual precipitation varies from less than 30 inches in the northwestern part of the basin to over 50 inches in the southern part, the amount of leaching that has occurred varies geographically. Consequently, the dissolved-solids content of surface runoff and ground-water inflow to streams is greater in the northwestern part of the basin and decreases toward the coast.

The geology of the Trinity River basin reflects the various depositional phases and environments during Pennsylvanian, Cretaceous, Tertiary, and Quaternary geologic times (Peckham and others, 1963, p. 16). (See Figure 9).

During Pennsylvanian time, deposition of sediments in a large sea produced a sequence of marine sand, shale, and limestone. Rocks of Pennsylvanian age crop out in the northwestern part of the Trinity River basin and dip regionally to the northwest.

Sedimentary rocks of Cretaceous age are exposed in the northern part of the basin and dip in a general eastward direction. These sediments are characterized by typical nearshore sand, shale, and limestone.

Water from outcrop areas of rocks of Pennsylvanian and Cretaceous age generally have dissolved-solids concentrations ranging from 100 to 250 ppm (parts per million). The water is of the mixed type with calcium and bicarbonate the predominant ions.

During the Tertiary and Quaternary Periods, an alternating sequence of marine and continental deposits was formed as a result of repeated transgressions and regressions of the sea. The sediments are composed of clay, shale, marl, and minor amounts of sand. Rocks of Tertiary and Quaternary age crop out in the central and southern parts of the basin and dip in a general southeastward direction.

Water draining the rocks of Tertiary and Quaternary age generally contains less than 100 ppm dissolved solids. The water is of the mixed type with no predominant ions.

Streamflow

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 reservoirs, the concentration of dissolved-mineral constituents varies inversely with the flow of the stream. The base flow, or sustained low flow, of a stream is predominantly water that has entered the stream as groundwater discharge. Usually this water has been in contact with rocks and soils for a sufficient time to dissolve part of their soluble minerals. Conversely, at high stages most of the flow of a stream consists of surface-water runoff that has been in contact with rocks and soils for only a short time. Therefore, the dissolved-solids concentration of a stream is usually lowest during periods of high flow.

In the Trinity River basin most of the total flow in streams consists of surface runoff, but streamflow records show that the low flow of many streams is maintained by ground water.

The relation of dissolved-solids concentration to water discharge in three tributary streams is shown in Figure 5. The East Fork Trinity River and Bear Creek drain metropolitan areas in the northern part of the basin. The dissolved-solids concentration of these streams is influenced by municipal and industrial wastes. During periods of high flow, the effects of the waste discharged in the streams are minimized as surface runoff of low concentration dilutes the waste. Catfish Creek has dissolved-solids concentrations near 100 ppm even at lowest rates of discharge. The ground water reaching this stream is low in dissolved material, because rainfall has already leached the soluble materials from the rocks and soils. Therefore the dissolved-solids concentration varies only slightly with water discharge.

The relation of dissolved-solids concentration to water discharge for the Trinity River at Romayor is shown by the duration curves in Figure 6. The curves show the inverse relationship of rates of water discharge to the concentration of dissolved solids in the stream during water years 1958-65.

Activities of Man

The activities of man often have a deteriorative effect on the chemical quality of water. Depleting streamflow by diversion for municipal and industrial use, disposing of oil-field brines and municipal and industrial wastes, and altering streamflow by storing water all produce changes in quality.

Oil is produced in many areas in the Trinity River basin (Figure 7). Brine is produced in nearly all oil fields; and it may, if improperly handled, eventually reach the streams. The composition of oil-field brine varies, but the prinicipal chemical constituents in order of magnitude are chloride, sodium, calcium, and sulfate. Some brines are reaching the surface water in the Elm Fork Trinity River subbasin and causing local deterioration of water quality, but the effect on the quality of water stored downstream in Garza-Little Elm Reservoir has been minor. Brines have been reaching the surface waters in the Richland and Tehuacana Creek subbasins. Osborne and Shamburger (1960) reported on the effects of oil-field brine on the surface and ground water in the lower watershed of Chambers and Richland Creeks. Among other findings, their report concluded that approximately 83,700 barrels of the total daily brine yield

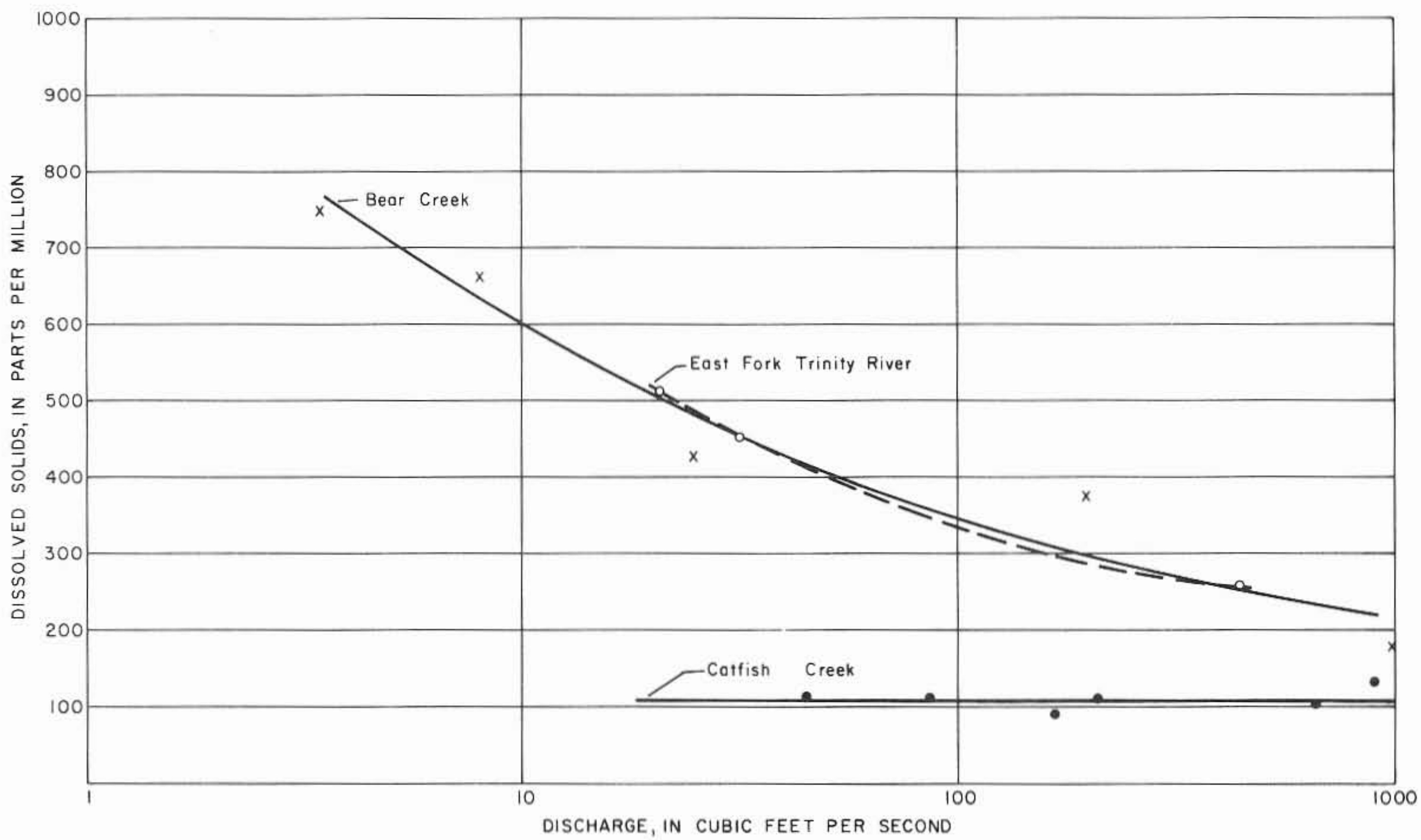

Figure 5

Relation of Dissolved Solids to Water Discharge in Three Tributaries of the Trinity River

U. S. Geological Survey in cooperation with the Texas Water Development Board

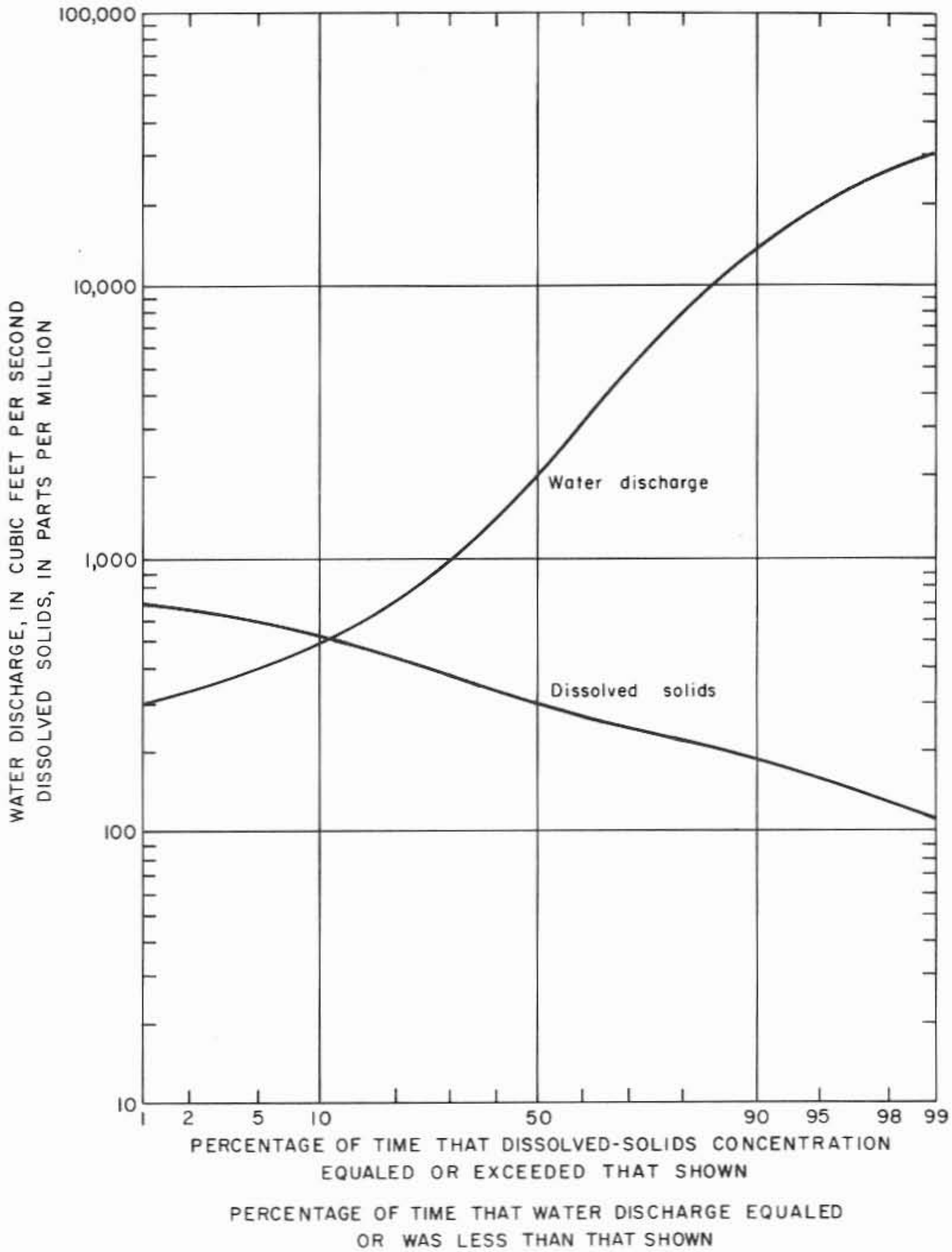

Figure 6

Duration Curves for Dissolved Solids and Water Discharge, Trinity River at Romayor, Water Years 1958-65

U. S. Geological Survey in cooperation with the Texas Water Development Board

(95,300 barrels) was being disposed of on the surface, and that approximately 61,500 barrels per day (4.0 cfs) of the brine drained directly to tributaries which flow into Chambers and Richland Creeks. Chemical-quality records collected at the daily sampling station Richland Creek near Fairfield (Table 5, site 86) show that the amount of brine reaching the streams is sufficient to greatly impair the usefulness of the water. Chloride concentrations usually are greater than 1,000 ppm, and at times have exceeded 7,000 ppm. Tehuacana Creek, which enters Trinity River a short distance downstream from the mouth of Richland Creek, is also degraded by the discharge of oil-field brine (Table 6, site 87). The annual loads of salt contributed by these streams cannot be estimated with accuracy because streamflow data are not available. The short period of concurrent chemical quality record at the Trinity River stations near Rosser and near Crockett (February to September, 1964) gives some indication of the effect of the Richland Creek inflow on the chloride concentration of the Trinity. During this period the weighted-average concentration of chloride was 35 ppm at the Rosser station but increased to 115 ppm at the station near Crockett. Streamflow in the Trinity River during 1964 was less than the long term average, and the effect of saline inflow on water quality would be not so pronounced during years of normal flow. Some brines appear to be reaching the surface water in the Menard Creek subbasin, but the effect on the main stem of the Trinity has not been noticeable.

Municipal use of water tends to increase the concentration of dissolved solids in a stream system. The depletion of flow by diversion and consumptive use, the loss of water because of increased evaporation, and the disposal of municipal wastes into a stream result in higher average concentrations of dissolved solids in the remaining water. In the upper Trinity River basin, the storage and diversion of water for municipal use and the disposal of municipal and industrial wastes have caused serious water quality problems. A sewage and industrial wastes survey made by the Texas State Department of Health in 1958-60 concluded in part that:

> The evaluation of water quality data of the upper Trinity River indicates the Trinity River and some tributaries to contain water of generally poor organic quality. This survey has disclosed that this poor organic quality is a result of inadequate collection and treatment of sewage and industrial wastes, coincident with restricted flow characteristics of the Trinity River. The ability of the Trinity River to accomplish self-stabilization is retarded by low flows and the discharge effluent from industries and the sewage treatment plants of the cities through which it flows. The trends for population increase and water usage, and the establishment of additional industries in the Fort Worth-Dallas metropolitan area will undoubtedly increase the need for better and improved waste treatment facilities.

...At the confluence of Marine Creek, beginning with the West Fork Trinity River, in Fort Worth, and extending downstream to Rosser, in Kaufman County, the Trinity River is devoid of oxygen and is unable to accomplish self-stabilization. Oxidation of organic matter is retarded and septic conditions and offensive odors are usually present. The water is turbid and discolored. Sludge banks may be observed at numerous locations. There is insufficient oxygen for fish life to propagate.

Downstream from Rosser the municipal, industrial, and agricultural use of water from the Trinity River has not caused any significant changes in water quality, but effects of the municipal and industrial wastes from the Fort Worth-Dallas area continue to be noticeable throughout the reach of the river.

The waste load carried by the upper Trinity River can also have significant effects on the water impounded in downstream reservoirs. Connell (1964) was especially concerned about the increasing phosphates in Texas reservoirs and the potential phosphate loading of many of the projected reservoirs. He lists the prinicipal source of phosphate as municipal and industrial wastewater, but also says surface runoff may contribute significantly to phosphate content of streams and reservoirs, from leaching and erosion of mineral phosphate from soil, decay of vegetation and animal wastes, and use of phosphate fertilizers and phosphorus-containing insecticides. Connell lists the following serious quality threats caused by phosphate loading of projected reservoirs:

First, production of excessive biological activity and associated odors and tastes rendering the water difficult and expensive to purify for domestic use.

Second, promotion of heavy algal bloom and subsequent oxygen-consuming decay of organic matter sufficient to kill fish and to render water undesirable for recreation activities.

Third, production of sufficient organic matter--slimy soupy growth--to render water difficult and expensive to process, distribute and use for industrial purposes.

Fourth, very objectionable calcium phosphate scaling in cooling and boiler water uses.

A principal and relatively new source of phosphate is the household and laundry use of detergents. The two principal active ingredients of detergents are alkyl benzene sulfonates (ABS), the "suds and foam" producing components, and polyphosphates (hydrolyzable phosphates), the principal "builders" component. The previously used non-biodegradable suds and foam producing components have been replaced by biodegradable forms, but there is no available information that affords promise of elimination of phosphates in detergents within the foreseeable future.

In "pre-detergent" days, Connell says raw sewage was observed to contain from 5 to 12 ppm PO_4, and secondary effluents from 0.3 to 2.5 ppm. Assay of raw and effluent sewage in 1964 showed wide variations at much higher levels:

20 to 70 ppm and 5 to 60 ppm, respectively. Algal blooms may be promoted by as small amounts as 0.05 to 0.1 ppm of inorganic phosphate, or 0.2 to 0.6 ppm of inorganic plus organic phosphate (phosphate expressed in equivalent PO_4). Other factors favoring development of algal bloom are presence of essential nutrients, quiescence, clear water, and abundant sunlight. These conditions will frequently be attained in many reservoirs.

The U.S. Geological Survey has been making determinations of phosphate at three sites on the Trinity since 1964. The Trinity River at Rosser frequently contains over 10 ppm phosphate (expressed in equivalent PO_4), and the weighted average for the 1964 water year was 2.4 ppm. At the Crockett station for the period February to September 1964, the weighted-average concentration was 2.2 ppm.

Relation of Quality of Water to Use

Quality-of-water studies usually are concerned with determining the suitability of water--judged by the chemical, physical, and biological characteristics--for its proposed use. In the Trinity River basin, surface water is used primarily for municipal and industrial supplies and for irrigation. This report considers only the chemical character of the water and its relation to the principal uses.

All natural water contains dissolved-mineral matter. Most of this mineral matter in water is dissociated into charged particles, or ions. Principal cations (positive charged) in natural water are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and iron (Fe). The principal anions (negative charged) are carbonate (CO_3), bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), fluoride (F), and nitrate (NO_3). Other constituents and properties are often determined to help define the chemical and physical quality of water. Table 2 lists the constituents and properties commonly determined by the U.S. Geological Survey, and includes a résumé of their sources and significance.

Surface water of the Trinity River basin is generally of acceptable chemical quality. With a minimum of treatment, the water is suitable for domestic, industrial, and irrigation use.

Domestic Purposes

The use of water for domestic purposes generally is its most essential use. Because of differences in individuals, varying amounts of water used, and other factors, it is difficult to define the safe limits for the mineral constituents usually found in water. The limits usually accepted in the United States for drinking water are the drinking-water standards established by the United States Public Health Service. Originally established in 1914 to control the quality of water used on interstate carriers for drinking and for culinary purposes, these standards have been revised several times. The latest revision was in 1962 (U.S. Public Health Service, 1962). These standards have been accepted by the American Water Works Association and by most of the state departments of public health as minimum standards for all public water supplies.

The maximum concentrations permitted by these standards are given for selected constituents in the table on the following page.

Table 2.--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 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high-pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 ppm of iron in surface waters generally indicate acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 ppm stain laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. U.S. Public Health Service (1962) drinking-water standards state that iron should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and Magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and 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 (NCO_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 ppm.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium, gives salty taste to drinking water. In large quantities, increases' the corrosiveness of water. U.S. Public Health Service (1962) drinking-water standards recommend that the chloride content should not exceed 250 ppm.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual. (Maier, F. J., 1950.)
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 ppm. Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undersirable 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 ppm dissolved solids not be used if other less mineralized supplies are available. Waters containing more than 1000 ppm dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$	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 noncarbonate hardness. Waters of hardness as much as 60 ppm are considered soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; more than 180 ppm, very hard.
Specific conductance (micromhos at 25° C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
Hydrogen ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

Constituent	Maximum concentration (ppm)
Sulfate	250
Chloride	250
Nitrate	45
Fluoride	[a] 1.0
Dissolved solids	500

[a] Based on temperature records for Corsicana.

In the Trinity River basin the concentrations of these constituents are generally lower than the maximum concentrations recommended by the U.S. Public Health Service.

Industrial Use

The quality requirements vary greatly for almost every industrial application, as is indicated by the water-quality tolerances given in Table 3. One requirement of most industries is that the concentrations of the various constituents of the water remain relatively constant. When concentrations of undesirable substances in water vary, constant monitoring is required and operating expenses are increased.

Hardness is one of the more important properties of water that affects its utility for industrial purposes. Excessive hardness is objectionable because it contributes to the formation of scale in steam boilers, pipes, water heaters, radiators, and various other equipment where water is heated, evaporated, or treated with alkaline materials. The accumulation of scale increases costs for fuel, labor, repairs, and replacement, and lowers the quality of many wet-processed products. However, some calcium hardness may be desirable because calcium carbonate sometimes forms protective coatings on pipes and other equipment and reduces corrosion.

The corrosive property of a water receives considerable attention in industrial water supplies. A high concentration of dissolved solids in a water may be closely associated with the corrosive property of the water, particularly if chloride is present in appreciable quantities. Water that contains a large concentration of magnesium chloride may be highly corrosive because the hydrolysis of this salt yields hydrochloric acid.

Because the surface water of the Trinity River basin is hard and only moderately low in dissolved solids, treatment is necessary to make it suitable for use by most industries.

Table 3.--Water-quality tolerances for industrial applications[1]

[Allowable limits in parts per million except as indicated]

Industry	Turbidity	Color	Color + O_2 consumed	Dissolved oxygen (ml/1)	Odor	Hardness	Alkalinity (as $CaCO_3$)	pH	Total solids	Ca	Fe	Mn	Fe + Mn	Al_2O_3	SiO_2	Cu	F	CO_3	HCO_3	OH	$CaSO_4$	Na_2SO_4 to Na_2SO_3 ratio	General [2]
Air conditioning [3]	--	--	--	--	--	--	--	--	--	--	0.5	0.5	0.5	--	--	--	--	--	--	--	--	--	A,B
Baking	10	10	--	--	--	(4)	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	C
Boiler feed:																							
0-150 psi	20	80	100	2	--	75	--	8.0+	3,000-1,000	--	--	--	--	5	40	--	--	200	50	50	--	1 to 1	--
150-250 psi	10	40	50	.2	--	40	--	8.5+	2,500- 500	--	--	--	--	.5	20	--	--	100	30	40	--	2 to 1	--
250 psi and up	5	5	10	0	--	8	--	9.0+	1,500- 100	--	--	--	--	.05	5	--	--	40	5	30	--	3 to 1	--
Brewing: [5]																							
Light	10	--	--	--	Low	--	75	6.5-7.0	500	100-200	.1	.1	.1	--	--	--	1	--	--	--	100-200	--	C,D
Dark	10	--	--	--	Low	--	150	7.0-	1,000	200-500	.1	.1	.1	--	--	--	1	--	--	--	200-500	--	C,D
Canning:																							
Legumes	10	--	--	--	Low	25- 75	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	C
General	10	--	--	--	Low	--	--	--	--	--	.2	.2	.2	--	--	--	1	--	--	--	--	--	C
Carbonated beverages [6]	2	10	10	--	0	250	50	--	850	--	.2	.2	.3	--	--	--	.2	--	--	--	--	--	C
Confectionary	--	--	--	--	Low	--	--	[7]	100	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--
Cooling [8]	50	--	--	--	--	50	--	--	--	--	.5	.5	.5	--	--	--	--	--	--	--	--	--	A,B
Food, general	10	--	--	--	Low	--	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	C
Ice (raw water) [9]	1-5	5	--	--	--	--	30-50	--	300	--	.2	.2	.2	--	10	--	--	--	--	--	--	--	C
Laundering	--	--	--	--	--	50	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--
Plastics, clear, undercolored	2	2	--	--	--	--	--	--	200	--	.02	.02	.02	--	--	--	--	--	--	--	--	--	--
Paper and pulp: [10]																							
Groundwood	50	20	--	--	--	180	--	--	--	--	1.0	.5	1.0	--	--	--	--	--	--	--	--	--	A
Kraft pulp	25	15	--	--	--	100	--	--	300	--	.2	.1	.2	--	--	--	--	--	--	--	--	--	--
Soda and sulfite	15	10	--	--	--	100	--	--	200	--	.1	.05	.1	--	--	--	--	--	--	--	--	--	--
Light paper, HL-Grade	5	5	--	--	--	50	--	--	200	--	.1	.05	.1	--	--	--	--	--	--	--	--	--	B
Rayon (viscose) pulp:																							
Production	5	5	--	--	--	8	50	--	100	--	.05	.03	.05	<8.0	<25	<5	--	--	--	--	--	--	--
Manufacture	.3	--	--	--	--	55	--	7.8-8.3	--	--	.0	.0	.0	--	--	--	--	--	--	--	--	--	--
Tanning [11]	20	10-100	--	--	--	50-135	135	8.0	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--
Textiles:																							
General	5	20	--	--	--	20	--	--	--	--	.25	.25	--	--	--	--	--	--	--	--	--	--	--
Dyeing [12]	5	5- 20	--	--	--	20	--	--	--	--	.25	.25	.25	--	--	--	--	--	--	--	--	--	--
Wool scouring [13]	--	70	--	--	--	20	--	--	--	--	1.0	1.0	1.0	--	--	--	--	--	--	--	--	--	--
Cotton bandage [13]	5	5	--	--	Low	20	--	--	--	--	.2	.2	.2	--	--	--	--	--	--	--	--	--	--

[1] American Water Works Association, 1950.
[2] A--No corrosiveness; B--No slime formation; C--Conformance to Federal drinking-water standards necessary; D--NaCl, 275 ppm.
[3] Waters with algae and hydrogen sulfide odors are most unsuitable for air conditioning.
[4] Some hardness desirable.
[5] Water for distilling must meet the same general requirements as for brewing (gin and spirits mashing water of light-beer quality; whiskey mashing water of dark-beer quality).
[6] Clear, odorless, sterile water for syrup and carbonization. Water consistent in character. Most high quality filtered municipal water not satisfactory for beverages.
[7] Hard candy requires pH of 7.0 or greater, as low value favors inversion of sucrose, causing sticky product.
[8] Control of corrosiveness is necessary as is also control of organisms, such as sulfur and iron bacteria, which tend to form slimes.
[9] $Ca(HCO_3)_2$ particularly troublesome. $Mg(HCO_3)_2$ tends to greenish color. CO_2 assists to prevent cracking. Sulfates and chlorides of Ca, Mg, Na should each be less than 300 ppm (white butts).
[10] Uniformity of composition and temperature desirable. Iron objectionable as cellulose adsorbs iron from dilute solutions. Manganese very objectionable, clogs pipelines and is oxidized to permanganates by chlorine, causing reddish color.
[11] Excessive iron, manganese, or turbidity creates spots and discoloration in tanning of hides and leather goods.
[12] Constant composition; residual alumina 0.5 ppm.
[13] Calcium, magnesium, iron, manganese, suspended matter, and soluble organic matter may be objectionable.

Irrigation

The chemical composition of a water is an important factor in determining its usefulness for irrigation, because the quality of the water should not adversely affect the productivity of the land irrigated. The extent to which chemical quality limits the suitability of a water for irrigation depends on many factors, such as: the nature, composition, and drainage of the soil and subsoil; the amounts of water used and the methods of applying it; the kind of crops grown; and the climate of the region, including the amounts and distribution of rainfall. Because these factors are highly variable, every method of classifying waters for irrigation is somewhat arbitrary.

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

High concentrations of dissolved salts in irrigation water may cause a buildup of salts in the soil solution, and may make the soil saline. The increased salinity of the soil may drastically reduce crop yields by decreasing the ability of the plants to take up water and essential plant nutrients from the soil solution. The tendency of irrigation water to cause a high buildup of salts in the soil is called the salinity hazard of the water. The specific conductance of the water is used as an index of the salinity hazard.

High concentrations of sodium (Na) relative to the concentrations of calcium and magnesium in irrigation water can adversely affect soil structure, Cations in the soil solution become fixed on the surface of the soil particles; calcium (Ca) and magnesium (Mg) tend to flocculate the particles, whereas sodium tends to deflocculate them. This adverse effect on soil structure caused by high sodium concentrations in an irrigation water is called the sodium hazard of the water. An index used for predicting the sodium hazard is the sodium-adsorption ratio (SAR), which is defined by the equation:

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

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

The U.S. Salinity Laboratory Staff has prepared a classification for irrigation waters in terms of salinity and sodium hazard. Empirical equations were used in developing a diagram, reproduced in modified form as Figure 8, which uses SAR and specific conductance in classifying irrigation waters. This classification, although embodying both research and field observations, should be used only for general guidance because many additional factors (such as availability of water for leaching, ratio of applied water to precipitation, and crops grown) also affect the suitability of water for irrigation. With respect to salinity and sodium hazards, waters are divided into four classes: low, medium, high, and very high. The classification range encompasses those waters which can be used for irrigation of most crops on most soils as well as those waters which are usally unsuitable for irrigation.

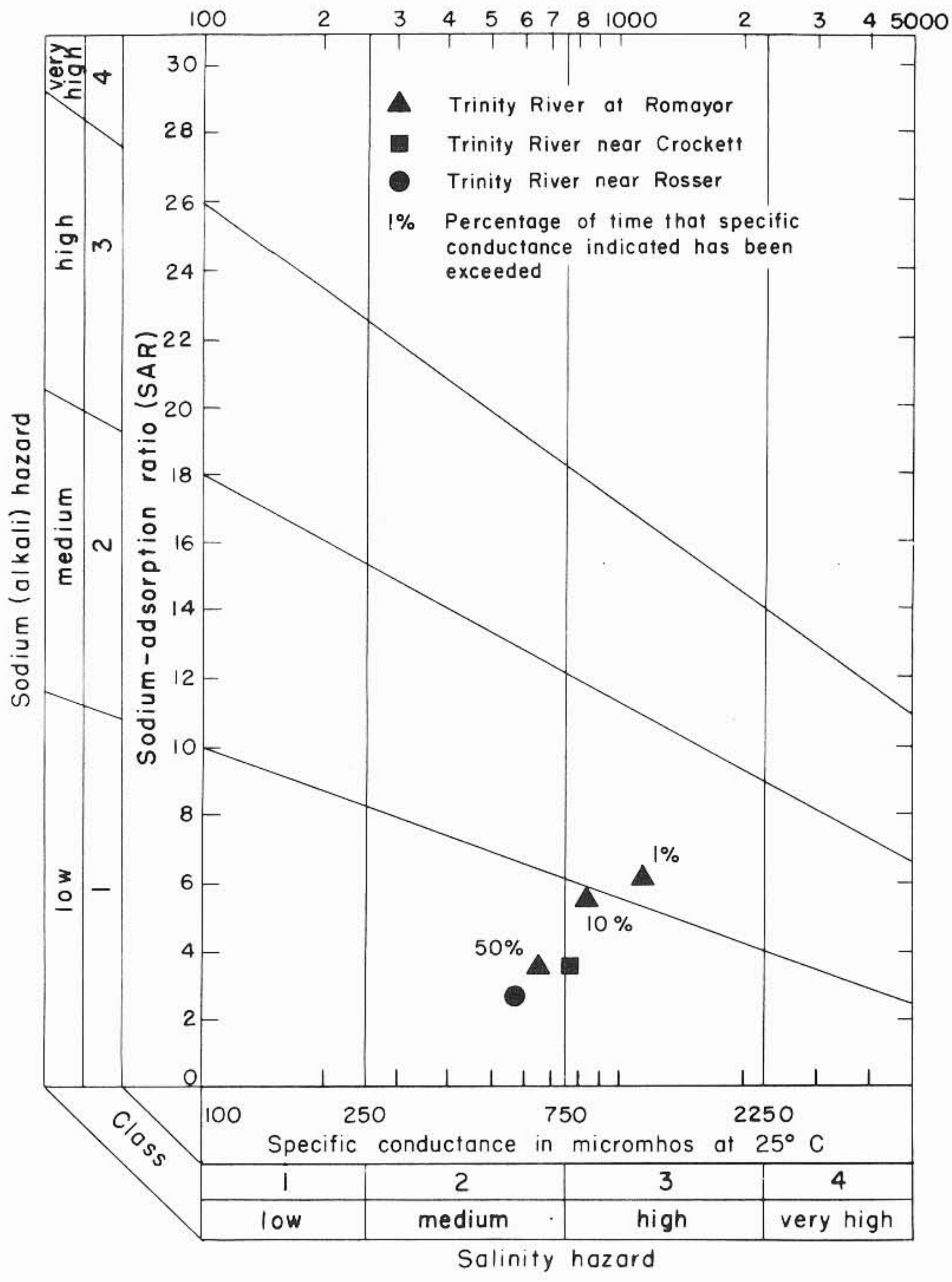

Figure 8

Classification of Irrigation Waters

U. S. Geological Survey in cooperation with the Texas Water Development Board

Representative data from analyses of water from the Trinity River are plotted in Figure 8. Also plotted, for the Trinity River at Romayor, is the percentage of time that certain values of specific conductance were exceeded. The data show that the sodium hazard for water of the Trinity River basin is low and that the salinity hazard generally ranges from medium to high.

A few determinations of boron in waters of the Trinity River basin have been made by the U.S. Geological Survey. These determinations indicate that boron is not present in sufficient quantity to be a problem in irrigation waters.

Surface water for irrigation in the Trinity River basin is used principally for rice growing. Although the concentrations of chemical constituents tolerated by rice varies with the stage of growth, investigators generally agree that water containing less than 600 ppm of sodium chloride (350 ppm of chloride) is not harmful to rice at any stage of growth (Irelan, 1956, p. 330). Surface water of the Trinity River basin generally meets the quality requirements for rice irrigation, but irrigators in the lower basin are at times unable to use water from the Trinity River because of salt water from Trinity Bay intruding up the river. Chemical quality records collected at the Devers and Lone Star pumping plants (Trinity River near Moss Bluff and at Anahuac) indicate that during the months of July, August, and September and sometimes in June and October, flow in the river is not sufficient to keep the salt water from being pushed up the river channel.

Geographic Variations in Water Quality

Variations of dissolved solids, hardness, and chloride in the streams in the Trinity River basin are shown in Figures 10, 11, and 12. These values are based on the discharge-weighted average concentrations, as calculated from chemical-quality data. The discharge-weighted average represents approximately the chemical character of the water if all the water passing a point in the stream during a period were impounded in a reservoir, and mixed, with on adjustments for evaporation, rainfall, or chemical changes that might occur during storage. No attempt was made to adjust for future storage and diversion features that might be constructed in the basin. For many of the streams chemical-quality data are limited, especially data on the chemical quality of flood flows; therefore, the divisions shown on the maps are general. All the streams will at times have concentrations exceeding those shown, but the averages shown on the maps at a potential reservoir site are indicative of the type of water that would be stored in a reservoir.

Dissolved Solids

The concentrations of dissolved solids in surface water of the Trinity River basin are shown on Figure 10. Water from the outcrop areas of rocks of Pennsylvanian and Cretaceous age in the northern part of the basin usually has dissolved-solids concentrations ranging from 100 to 250 ppm. Concentrations are higher in the Elm Fork Trinity River subbasin apparently because of oil-field brine pollution. Water from the outcrop areas of rocks of Tertiary and Quaternary age generally has concentrations near 100 ppm, except in the Tehuacana and Richland Creeks subbasins where concentrations are over 500 and 1,000 ppm, respectively, because of oil-field brine pollution. The main stem Trinity River contains concentrations ranging from 250 to 500 ppm throughout most of its reach. The higher concentrations in the Trinity River are the result of the municipal and industrial wastes that are discharged into the river in the Fort Worth-Dallas area.

The discharge-weighted average concentrations of dissolved solids of the Trinity River at Rosser and Romayor for the period 1958-64 were 296 and 238 ppm, respectively. The analyses showing annual maximum and minimum dissolved-solids concentrations and the weighted averages for the stations are shown in Table 5.

Time-weighted averages are usually higher that discharge-weighted averages. The duration curve for concentrations of dissolved solids for the Trinity River at Romayor (Figure 6) shows that 300 ppm dissolved solids has been equaled or exceeded 50 percent of the time.

Hardness

Surface water of the Trinity River basin varies considerably in hardness (Figure 11). In the northwestern part of the basin, water from the rocks of Pennsylvanian age is moderately hard (61 to 120 ppm) and in the northern part of the basin, water from the rocks of Cretaceous age is hard (121 to 180 ppm). In the central and southern parts of the basin, water from the younger formations is generally soft, having less than 60 ppm hardness.

Chloride

The concentration of chloride in surface waters of much of the Trinity River basin is less than 50 ppm (Figure 12). Chloride concentrations over 50 ppm are found only where the activities of man have influenced the quality of the surface water. In the Elm Fork Trinity River, where oil-field brine is reaching the surface streams, chloride concentrations over 300 ppm have been observed even during relatively high flows. In the Richland Creek subbasin chloride concentrations of 1,000 ppm or more are common, because of oil-field brine disposal practices, and chloride concentrations over 50 ppm have been observed in Menard Creek, apparently because of oil-field brine. The main stem of the Trinity River usually has chloride concentrations over 50 ppm because of the municipal wastes from the Dallas-Fort Worth area and because of the more concentrated inflow from Richland Creek.

Other Constituents

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

Most of the streams in the Trinity River basin contain from 10 to 20 ppm silica, and the annual weighted-average concentration in the Trinity River has usually been between 10 and 15 ppm. However, some of the streams in the south-central part of the basin that drain outcrops of rocks of Tertiary age often contain more than 20 ppm silica.

Sodium concentrations are generally less than 50 ppm in most of the streams. In those waters having high chloride concentrations, sodium occurs in quantities approximately equivalent to the chloride. It is therefore present in highest concentrations in the Elm Fork Trinity River, Richland Creek, and Tehuacana Creek subbasins. The annual weighted-average sodium concentration of the Trinity River at Rosser and Romayor is usually less than 50 ppm.

Bicarbonate is the principal anion in water draining from rocks of Cretaceous age. In the lower part of the basin, water draining the younger formations contains much smaller concentrations, usually less than 50 ppm. The weighted-average concentration of bicarbonate for the 10-year period 1955-64 for the daily sampling stations at Rosser and Romayor was 149 ppm and 109 ppm, respectively.

Sulfate concentrations are generally less than 50 ppm in most of the tributary streams in the basin, although higher concentrations are found in the polluted streams. The weighted-average concentration for the Trinity River near Rosser has ranged from 33 to 151 ppm and at Romayor from 24 to 60 ppm. Fluoride concentrations seldom exceed 0.7 ppm and generally range from 0.2 to 0.5 ppm.

The concentration of nitrate in surface water of the Trinity River basin is subject to wide fluctuations. Runoff not polluted by municipal wastes usually contains less than 1.0 ppm of nitrate. Most of the streams in the southern part of the basin contain less than 1.0 ppm nitrate. In the northern part of the basin where some of the streams receive municipal wastes, nitrate concentrations of 40 ppm are not uncommon. The weighted-average concentration for the Trinity River near Rosser has ranged from 5.6 to 49 ppm and near Romayor from 1.8 to 5.3 ppm.

Water Quality in Reservoirs

The principal reservoirs in the Trinity River basin were sampled during the reconnaissance and the chemical analyses are given in Table 6. Analyses are also available for many of the small reservoirs used for public supply (Sundstrom and others, 1948).

Bridgeport Reservoir.--The water in Bridgeport Reservoir is calcium bicarbonate in type and is moderately hard. Dissolved-solids concentrations have ranged from 140 to 180 ppm.

Lake Amon G. Carter.--Lake Amon G. Carter contains water that is moderately hard. An analysis in 1959 and another in 1964 showed dissolved-solids concentrations of 111 and 123 ppm, respectively.

Eagle Mountain Reservoir.--The water in Eagle Mountain Reservoir is of the mixed type with bicarbonate the principal anion. The water is hard and usually contains about 190 ppm of dissolved solids.

Lake Worth.--Lake Worth is just downstream from Eagle Mountain Reservoir; therefore the water is of very similar quality.

Benbrook Reservoir.--The water in Benbrook Reservoir is calcium bicarbonate in type and is hard. The dissolved-solids concentration is usually between 130 and 140 ppm.

Lake Arlington.--The analysis of one sample collected in January 1964 showed that the water was hard and contained 237 ppm dissolved solids.

Mountain Creek Lake.--Mountain Creek Lake has shown variable quality during the period for which analyses are available (January 1964 to July 1965): dissolved-solids concentration has ranged from 229 to 380 ppm and the sulfate content from 68 to 131 ppm. The analysis of a sample collected on April 2, 1965, showed a nitrate content of 4.8 ppm, an indication that organic pollution may be occurring.

Garza-Little Elm Reservoir.--The water in Garza-Little Elm Reservoir is hard. Dissolved-solids concentrations have ranged from 220 to 291 ppm.

Grapevine Reservoir.--Grapevine Reservoir impounds water that is calcium bicarbonate in type and is hard. The dissolved-solids concentrations of the two samples collected in 1964 were 185 and 196 ppm.

White Rock Lake.--Outflow samples were collected at the spillway near the dam. These samples indicate that the water in White Rock Lake is hard, with a dissolved-solids concentration of about 225 ppm.

Lavon Reservoir.--The water in Lavon Reservoir is calcium bicarbonate in type and is hard. Dissolved-solids concentration has usually been about 200 ppm.

Lake Ray Hubbard.--Lake Ray Hubbard is under construction and was not impounding water during this study. When the reservoir is completed it should impound water similar to that in Lavon Reservoir. The water will be calcium bicarbonate in type, will be hard, and will contain about 250 ppm dissolved solids.

Terrell Reservoir.--The most recent analysis of the water in Terrell Reservoir was made in 1952. At that time the water was moderately hard (69 ppm) and contained 125 ppm dissolved solids.

Cedar Creek Reservoir.--This reservoir was filling for the first time during the course of this investigation. Past chemical-quality records for Cedar Creek indicate that the water stored in Cedar Creek Reservoir should be moderately hard and contain about 100 ppm dissolved solids.

Navarro Mills Reservoir.--The water in Navarro Mills Reservoir is hard and in the summer of 1965 contained 198 ppm dissolved solids.

Lake Waxahachie.--Hard water, containing about 150 ppm dissolved solids, is stored in Lake Waxahachie. The principal dissolved constituents are calcium and bicarbonate.

Bardwell Reservoir.--Bardwell Reservoir was near completion in 1965 and began impounding water November 20, 1965. Analyses of miscellaneous samples collected from Waxahachie Creek during 1961-64 indicate that the water impounded will be hard and contain about 300 ppm dissolved solids.

Livingston Reservoir.--Livingston Reservoir was in the preliminary stages of construction during this study. The quality of the water that will be stored should be similar to that of the Trinity River at the daily chemical quality station at Romayor. The discharge weighted-average of dissolved solids of the Trinity River at Romayor for the period 1958-64 was 238 ppm.

Water Quality at Potential Reservoir Sites

One of the principal purposes of the reconnaissance was to appraise the quality of the water which will be available for storage in potential reservoirs. Many reservoir sites proposed by various Federal, State, and local agencies are shown on Figure 4.

Bridgeport Enlargement.--The enlargement of Bridgeport Reservoir should not cause any change in the quality of the water stored. The water should still be moderately hard and contain less than 200 ppm dissolved solids.

Boyd.--The water available for storage at the Boyd site is calcium bicarbonate in type and is moderately hard; the dissolved-solids concentration is usually about 200 ppm.

Big Fossil Creek.--Water stored at the Big Fossil Creek site would be hard and contain about 250 to 300 ppm dissolved solids.

Lakeview.--A reservoir at the Lakeview site would impound water similar in quality to that stored in Mountain Creek Lake. The quality of the water would probably be slightly better than that now stored in Mountain Creek Lake because the increased storage could retain more flood flow to dilute the more concentrated low flows.

Aubrey.--The Aubrey site is just upstream from Garza-Little Elm Reservoir on the Elm Fork Trinity River. Water impounded at this site will be hard, with dissolved solids ranging from 250 to 300 ppm.

Roanoke.--A reservoir at the Roanoke site would be just upstream from Grapevine Reservoir and would impound water very similar in quality. The water would be hard and contain about 200 ppm dissolved solids.

Lavon Enlargement.--The enlargement of Lavon Reservoir should not have any effect on the quality of the water in storage.

Italy.--The quality of the water at the Italy site can be inferred from the analyses for Chambers Creek near Corsicana. The water at Italy should be of slightly better quality than it is at Corsicana. The water stored would be hard but contain less than 300 ppm dissolved solids.

Richland Creek.--Salt water produced with oil in Navarro County is entering surface streams in the Richland Creek drainage area. Water that would be stored at the Richland Creek damsite would be of doubtful quality or unfit for municipal use unless an alternate method for disposal of the salt water is adopted. The natural runoff from the area is of acceptable quality, but will not at all times be adequate to dilute the oil-field wastes.

Tehuacana Creek.--Salt water from oil fields is also reaching the streams in the Tehuacana Creek watershed. Alternate disposal methods should be adopted to insure that water will be of acceptable quality at this site.

Tennessee Colony.--A reservoir on the Trinity River at the Tennessee Colony site will store water containing less than 300 ppm dissolved solids. The Tennessee Colony site is between the chemical-quality stations Trinity River near Rosser and Trinity River at Romayor where, for the period 1958-65, the weighted-average dissolved-solids concentration has been 296 and 238 ppm, respectively.

Upper Keechi Creek.--Chemical analyses of Upper Keechi Creek near Oakwood indicate that a reservoir would impound water that is moderately hard and contain about 150 ppm dissolved solids.

Big Elkhart Creek.--A reservoir on Big Elkhart Creek would impound water containing about 150 ppm dissolved solids. The water would be low in all dissolved constituents and would be soft.

Houston County Lake.--Houston County Lake is being built on Little Elkhart Creek. Miscellaneous analyses collected from Little Elkhart Creek near Grapeland indicate that the water impounded will be low in all dissolved constituents and contain less than 100 ppm dissolved solids.

Hurricane Bayou.--Very limited data is available on the quality of the water in Hurricane Bayou, but the quality can be inferred from analyses for nearby Little Elkhart Creek. The reservoir should store soft water having a dissolved-solids content of near 100 ppm.

Lower Keechi Creek.--Chemical analyses of Lower Keechi Creek near Centerville indicate that a reservoir on Lower Keechi Creek would store water containing about 200 ppm dissolved solids.

Bedias Creek.--According to periodic chemical-quality data for Bedias and Caney Creeks near Madisonville, water impounded in a reservoir on Bedias Creek would be soft and contain less than 100 ppm dissolved solids.

Nelsons Creek and Harmons Creek.--Very little water-quality data has been collected on Nelsons and Harmons Creeks. Analyses of nearby Caney Creek indicate that reservoirs on Nelsons and Harmons Creeks would store water containing about 100 ppm dissolved solids.

Mustang Creek.--Analyses for White Rock Creek near Trinity indicate that a reservoir upstream on Mustang Creek would store water containing about 100 ppm dissolved solids.

Gail Creek.--A reservoir on Gail Creek would impound soft water containing about 100 ppm dissolved solids.

Caney Creek.--The quality of water in Caney Creek can be inferred from analyses for nearby Kickapoo Creek. A reservoir on Caney Creek would store water containing less than 200 ppm dissolved solids.

Long King Creek.--The water in Long King Creek is usually of good quality. A reservoir would store water containing less than 150 ppm dissolved solids.

Wallisville.--A dam on the Trinity River at the Wallisville site would store water for use in the coastal region and also would prevent salt-water encroachment into the lower river. Water available at this site would be very similar in quality to the water sampled at the daily quality station at Romayor where the weighted-average dissolved-solids concentration has ranged from 178 to 405 ppm. Additional inflow will be received from Big Creek which is very low in dissolved solids, and from Menard Creek which is low in dissolved solids.

Problems Needing Additional Investigation

This reconnaissance of the chemical quality of the Trinity River basin has shown that the natural runoff of the basin is of good chemical quality. However, the disposal of industrial and municipal wastes has created water-quality problems in some areas.

The lower reaches of Richland, Chambers, and Tehuacana Creeks are polluted with salt water produced with oil or gas, and Elm Fork Trinity River subbasin and Menard Creek at times contain high chloride concentrations, apparently because of oil-field pollution.

Oil is produced in many areas in the Trinity River basin and brine is produced in nearly all oil fields. In 1961, approximately 94 million barrels (12,140 acre-feet) of brine was produced in the Trinity River basin (Texas Water Commission and Texas Water Pollution Control Board, 1963). Approximately 64.5 percent of the brine produced was reinjected into wells. The remaining salt water was either placed in unlined surface pits or discharged directly into surface watercourses.

The upper Trinity River generally contains water of poor organic quality because of inadequate collection and treatment of sewage and industrial wastes coincident with depleted flow in the Trinity River. Continued municipal and industrial growth in the upper basin will cause an increase in the waste-disposal burdens of the stream system. Additional impoundment of water in reservoirs upstream will cause a further reduction in streamflow now utilized for the assimilation of municipal wastes. Consequently, continued municipal and industrial growth will require that wastes be consistently treated to the maximum extent if gross pollution of streams is to be avoided in the future.

Encroachment of sea water from the Gulf of Mexico through Trinity Bay at times makes the water of the lower reach of the Trinity River unsuitable for irrigation or for municipal or industrial use. Further depletion of sustained flow as a result of increased consumptive use and upstream storage will aggravate the encroachment problem until the proposed salt-water barrier is built. The effect of the decreased flow on the marine life in bays and estuaries should be anticipated and studied.

Impoundment of water will result in changes of water quality. Beneficial effects will include: the reduction in turbidity, silica, color, and coliform bacteria; lessened variations in chemical quality; the entrapment of sediment; and a reduction in temperature. On the other hand, detrimental effects of impoundment will include: an increase in the growth of algae; the reduction of dissolved oxygen; and an increase of dissolved solids and hardness as a result of evaporation. The continued extensive development of the water resources in the Trinity River basin will necessitate detailed studies of the changes in water quality.

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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.
1940-45	--	*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	1951	Rept. 7
1954	1352	* 1954			

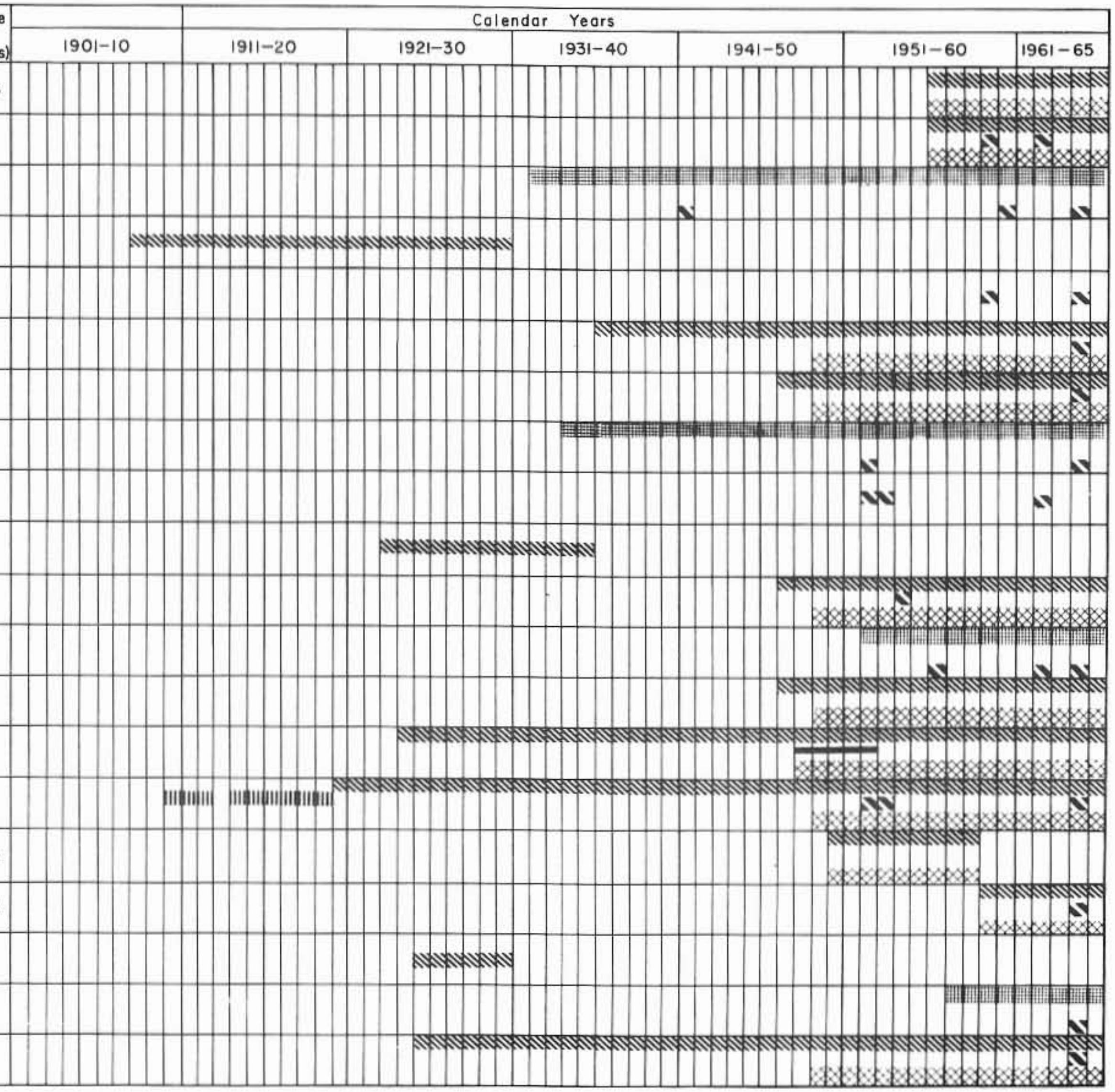
* "Chemical Composition of Texas Surface Waters" was designated only by water year from 1938 through 1955.

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

Year	Water-Supply Paper No.	Year	Water-Supply Paper No.	Year	Water-Supply Paper No.
1903	99	1924	588	1943	978
1904	132	1925	608	1944	1008
1905	174	1926	628	1945	1038
1906	210	1927	648	1946	1058
1907-08	248	1928	668	1947	1088
1909	268	1929	688	1948	1118
1910	288	1930	703	1949	1148
1911	308	1931	718	1950	1178
1912	328	1932	733	1951	1212
1913	358	1933	748	1952	1242
1914	388	1934	763	1953	1282
1915	408	1935	788	1954	1342
1916	438	1936	808	1955	1392
1917	458	1937	828	1956	1442
1918	478	1938	858	1957	1512
1919-20	508	1939	878	1958	1562
1921	528	1940	898	1959	1632
1922	548	1941	928	1960	1712
1923	568	1942	958		

Table 4.--Index of surface-water records in the Trinity River basin

Reference no.	Stream and Location	Drainage Area (sq. miles)
1	North Creek near Jacksboro	21.6
2	West Fork Trinity River near Jacksboro	683
3	Bridgeport Reservoir above Bridgeport	1,111
4	West Fork Trinity River at Bridgeport	1,143
5	Lake Amon G. Carter near Bowie	100
6	Big Sandy Creek near Bridgeport	333
7	West Fork Trinity River near Boyd	1,725
8	Eagle Mountain Reservoir above Fort Worth	1,970
9	Lake Worth at Fort Worth	2,064
10	West Fork Trinity River at Lake Worth Dam above Fort Worth	2,064
11	Clear Fork Trinity River near Aledo	251
12	Benbrook Reservoir near Benbrook	429
13	Clear Fork Trinity River near Benbrook	431
14	Clear Fork Trinity River at Fort Worth	518
15	West Fork Trinity River at Fort Worth	2,615
16	Marine Creek at Fort Worth	17.4
17	Big Fossil Creek at Haltom City	52.8
18	Village Creek near Handley	130
19	Lake Arlington at Arlington	143
20	West Fork Trinity River at Grand Prairie	3,065

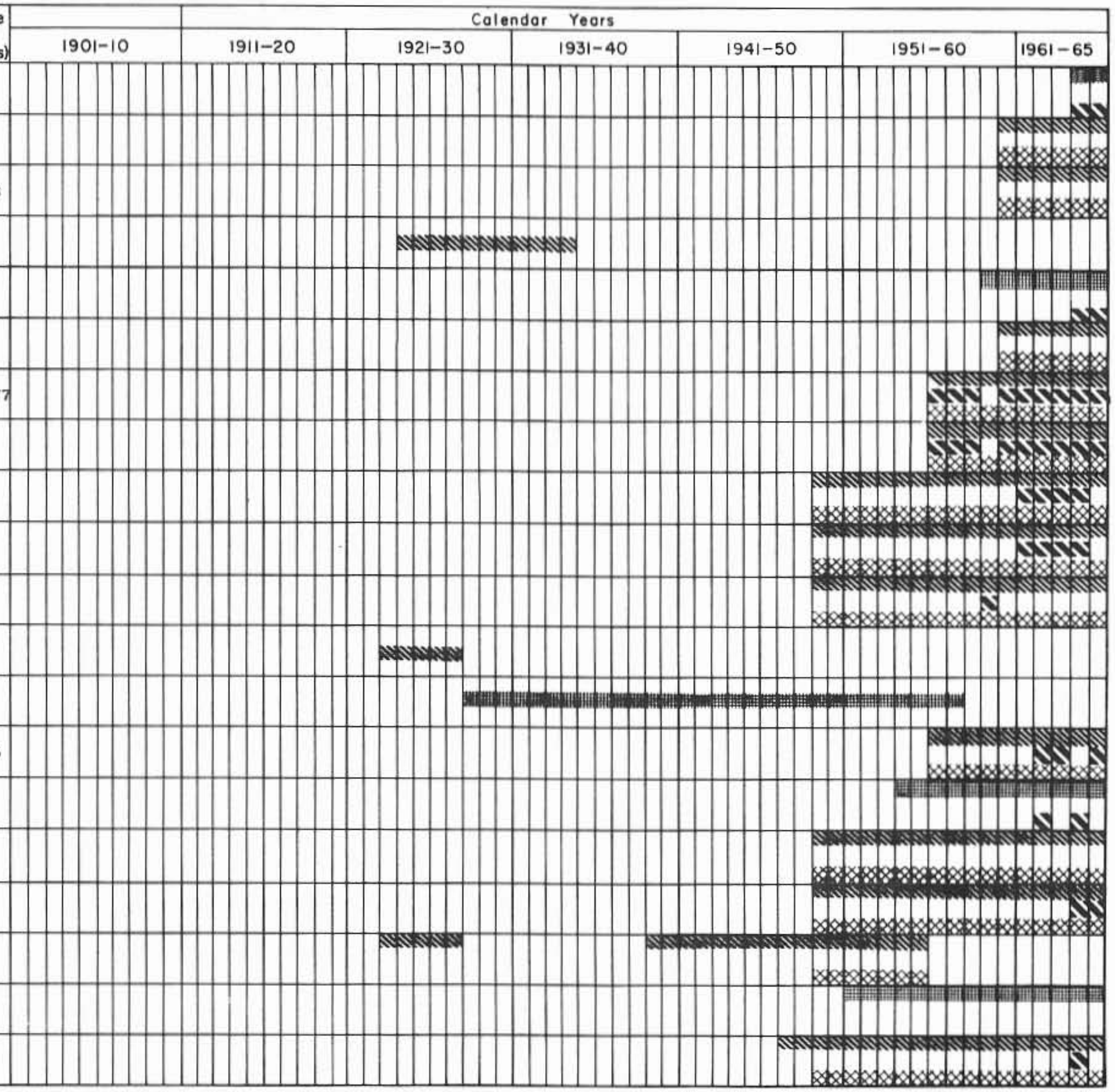


Discharge Gage heights only Gage heights and discharge measurements Reservoir contents

Periodic discharge measurements Daily chemical quality Periodic chemical quality Water temperature

Table 4.--Index of surface-water records in the Trinity River basin--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)
21	Bear Creek at State Highway 183 near Euless	--
22	Mountain Creek near Cedar Hill	119
23	Walnut Creek near Mansfield	62.8
24	Mountain Creek near Grand Prairie	267
25	Mountain Creek Lake near Grand Prairie	295
26	Mountain Creek at Grand Prairie	298
27	Elm Fork Trinity River subwatershed No. 6-0 near Muenster	.77
28	Elm Fork Trinity River near Muenster	46
29	Elm Fork Trinity River near Sanger	381
30	Isle du Bois Creek near Pilot Point	266
31	Clear Creek near Sanger	295
32	Elm Fork Trinity River near Denton	1,084
33	Lake Dallas near Lake Dallas	1,168
34	Little Elm Creek near Aubrey	75.5
35	Garza-Little Elm Reservoir near Lewisville	1,660
36	Elm Fork Trinity River near Lewisville	1,673
37	Denton Creek near Justin	400
38	Denton Creek near Roanoke	616
39	Grapevine Reservoir near Grapevine	695
40	Denton Creek near Grapevine	705



Discharge / Gage heights only / Gage heights and discharge measurements / Reservoir contents

Periodic discharge measurements / Daily chemical quality / Periodic chemical quality / Water temperature

Table 4.--Index of surface-water records in the Trinity River basin--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–65
41	Elm Fork Trinity River near Carrollton	2,536							
42	Joes Creek at Dallas	7.51							
43	Bachman Branch at Dallas	10.0							
44	Turtle Creek at Dallas	7.98							
45	Trinity River at Dallas	6,106							
46	White Rock Creek at Keller Springs Road at Dallas	29.4							
47	Cottonwood Creek at Forest Lane at Dallas	8.50							
48	Floyd Branch at Forest Lane at Dallas	4.17							
49	White Rock Creek at Greenville Avenue at Dallas	66.4							
50	White Rock Creek at White Rock Lake at Dallas	100							
51	Ash Creek at Highland Road at Dallas	6.92							
52	Forney Creek at Lawnview Avenue at Dallas	1.84							
53	White Rock Creek at Scyene Road at Dallas	125							
54	Trinity River below Dallas	6,278							
55	Honey Creek subwatershed No. 11 near McKinney	2.14							
56	Honey Creek subwatershed No. 12 near McKinney	1.26							
57	Honey Creek near McKinney	39.0							
58	East Fork Trinity River near McKinney	190							
59	Sister Grove Creek near Princeton	113							
60	Lavon Reservoir near Lavon	770							

Discharge · Gage heights only · Gage heights and discharge measurements · Reservoir contents

Periodic discharge measurements · Daily chemical quality · Periodic chemical quality · Water temperature

Table 4.--Index of surface-water records in the Trinity River basin--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901–10	1911–20	1921–30	1931–40	1941–50	1951–60	1961–65
61	East Fork Trinity River near Lavon	773							
62	East Fork Trinity River near Rockwall	839							
63	Duck Creek near Garland	31.6							
64	East Fork Trinity River near Crandall	1,256							
65	Trinity River near Rosser	8,146							
66	Trinity River at Trinidad	8,537							
67	Terrell Reservoir								
68	Cedar Creek near Kemp	189							
69	King Creek near Kaufman	233							
70	Cedar Creek near Mabank	733							
71	Cedar Creek Reservoir near Trinidad	1,007							
72	Cedar Creek at Trinidad	1,011							
73	Navarro Mills Reservoir near Dawson	320							
74	Richland Creek near Dawson	333							
75	Pin Oak Creek subwatershed No. 1 near Hubbard	2.66							
76	Pin Oak Creek near Hubbard	17.6							
77	Richland Creek near Richland	734							
78	Richland Creek above mouth of Chambers Creek near Winkler								
79	Mill Creek at Milford								
80	South Prong Creek near Waxahachie								

Discharge — Gage heights only — Gage heights and discharge measurements — Reservoir contents

Periodic discharge measurements — Daily chemical quality — Periodic chemical quality — Water temperature

Table 4.--Index of surface-water records in the Trinity River basin--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-65
81	Lake Waxahachie near Waxahachie								
82	Waxahachie Creek near Bardwell	178							
83	Chambers Creek near Emhouse	803							
84	Chambers Creek near Corsicana	963							
85	Chambers Creek at mouth near Eureka	1,070							
86	Richland Creek near Fairfield	--							
87	Tehuacana Creek near Fairfield	--							
88	Cottonwood Creek near Fairfield	--							
89	Catfish Creek near Tennessee Colony	207							
90	Trinity River near Oakwood	12,833							
91	Upper Keechi Creek near Oakwood	150							
92	Big Elkhart Creek near Grapeland								
93	Little Elkhart Creek near Crockett								
94	Hurricane Bayou near Crockett								
95	Trinity River near Crockett	13,911							
96	Lower Keechi Creek near Centerville								
97	Trinity River near Midway	14,150							
98	Bedias Creek near Madisonville								
99	Caney Creek near Madisonville	112							
100	Nelsons Creek near Riverside								

Discharge; Gage heights only; Gage heights and discharge measurements; Reservoir contents

Periodic discharge measurements; Daily chemical quality; Periodic chemical quality; Water temperature

Table 4.--Index of surface-water records in the Trinity River basin--Continued

Reference no.	Stream and Location	Drainage Area (sq. miles)	Calendar Years 1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-65
101	Harmons Creek near Riverside								
102	Trinity River at Riverside	15,589							
103	Gail Creek near Lovelady								
104	White Rock Creek near Trinity								
105	Kickapoo Creek near Onalaska								
106	Long King Creek at Livingston	141							
107	Menard Creek near Rye								
108	Big Creek near Shepherd								
109	Trinity River at Romayor	17,186							
110	Trinity River at Liberty	17,468							
111	Trinity River near Moss Bluff								
112	Old River near Cove								
113	Trinity River at Anahuac								
114	Trinity Bay at mouth of Trinity River near Anahuac								

Discharge · Gage heights only · Gage heights and discharge measurements · Reservoir contents

Periodic discharge measurements · Daily chemical quality · Periodic chemical quality · Water temperature

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River 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 parts per million 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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: 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
14. CLEAR FORK TRINITY RIVER AT FORT WORTH																						
Water year 1949																						
Maximum, Jan. 11-31, 1949	16.0	15		42	6.3	174		284		114	112	--	0.0		621	0.84	27	131	0	6.6	1,020	--
Minimum, May 17	42,500	13		22	3.1	12		98		6.9	3.0	--	2.2		124	.17	14,200	68	0	.6	180	7.7
Weighted average	289	13		40	4.5	15		142		17	10	--	2.8		184	.25	144	118	2	.6	291	--
Water year 1950																						
Maximum, Dec. 1-10, 1949	23.2	11		94	12	46		320		58	44	0.3	.0		415	.56	26	284	22	1.2	713	8.1
Minimum, Oct. 25-29	403	6.5		33	3.9	6.5		114		11	6.5	.2	1.2		132	.18	144	98	5	.3	230	8.0
Weighted average	215	13		57	6.6	19		191		26	19	.3	2.1		244	.33	142	169	13	.6	400	--
Water year 1951																						
Maximum, Dec. 1-10, 1950	25.2	17		98	19	28		310		56	50	--	.5		458	.62	31	322	68	.7	747	8.2
Minimum, June 14-15, 17-18, 1951	235	11		36	5.5	15		130		15	14	.4	1.8		163	.22	103	112	6	.6	282	8.0
Weighted average	41.4	14		59	12	29		210		36	32	.3	1.4		291	.40	33	196	24	.9	489	--
Water year 1952																						
Maximum, Dec. 21-31, 1951	4.2	13		67	8.2	54		232		53	50	.3	.5		366	.50	4.2	200	10	1.6	584	7.7
Minimum, Aug. 11-20, 1952	.0	10		36	4.6	27		133		21	24	.4	1.2		191	.26	.0	109	0	1.1	346	7.5
Weighted average	20.1	11		51	6.8	24		165		35	23	.3	2.9		245	.33	13.3	155	20	.8	399	--
65. TRINITY RIVER NEAR ROSSER																						
Water year, 1955																						
Maximum, Dec. 11-20, 1954	159	26		58	8.8	273		132		254	218	--	118		1,020	1.39	438	180	72	8.8	1,660	7.2
Minimum, Apr. 13-15, 1955	1,755	12		52	2.7	55		144		69	37	--	21		320	.44	1,520	140	22	2.0	535	7.8
Weighted average	312	16		57	5.5	143		150		145	113	--	49		625	.85	526	164	42	4.8	999	--
Water year, 1956																						
Maximum, Aug. 21-31, 1956	119	29		88	15	522		229		512	455	--	67		1,800	2.45	578	281	94	14	2,470	7.5
Minimum, May 1-10	3,637	13		57	3.3	36		161		57	26	--	7.7		279	.38	2,740	156	24	1.3	470	8.0
Weighted average	280	18		59	6.0	168		179		151	142	--	42		678	.92	513	172	25	5.6	1,120	--
Water year, 1957																						
Maximum, Oct. 1-10, 1956	118	28		94	18	496		213		353	555	--	78		1,730	2.35	551	308	134	12	2,740	8.0
Minimum, June 21-30, 1957	10,020	11		42	3.4	21		130		21	24	--	3.5		190	.26	5,140	119	12	.8	333	7.7
Weighted average	5,805	12		47	3.4	26		136		33	27	--	5.6		231	.31	3,620	131	20	1.0	378	--
Water year, 1958																						
Maximum, Oct. 9-13, 1957	276	17		64	4.9	159		195		151	124	--	42		684	.93	510	180	20	5.2	1,080	7.5
Minimum, Nov. 6	6,465	13		33	1.6	12		101		23	2	--	4.8		139	.19	2,430	88	5	.5	224	7.8
Weighted average	4,257	8.9		53	3.4	30		151		43	28	--	5.9		260	.35	2,990	146	22	1.1	420	--
Water year, 1959																						
Maximum, Dec. 21-31, 1958	284	14		66	6.6	190		288		178	105	--	43		745	1.01	571	192	0	6.0	1,180	7.2
Minimum, Apr. 19, 1959	6,510	10		40	1.1	18		110		34	8.0	--	9.1		174	.24	3,060	104	14	.8	287	8.0
Weighted average	664	12		56	4.6	80		168		97	54	--	22		425	.58	762	158	21	2.8	678	--

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

Date of collection	Mean discharge (cfs)	Silica (SiO_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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
65. TRINITY RIVER NEAR ROSSER--Continued																						
Water year, 1960																						
Maximum, Aug. 16-20, 1960	370	18		51	6.0	162		192		156	114	--	29		653	0.89	652	152	0	5.7	1,020	7.2
Minimum, Oct. 5, 1959	14,900	--		--	--	--		78		--	11	--	--		133	.18	5,350	86	22	--	220	7.6
Weighted average	2,150	9.7		54	4.4	39		157		54	32	--	7.8		286	.39	1,660	153	24	1.4	472	--
Water year, 1961																						
Maximum, Nov. 1-10, 1960-	231	17		52	6.5	178		202		167	120	--	44		684	.95	437	156	0	6.2	1,120	7.2
Minimum, June 27-30, 1961	7,958	11		46	3.4	27		135		42	20	--	4.9		233	.32	5,010	129	18	1.0	362	7.2
Weighted average	1,582	9.7		56	4.3	49		159		69	38	--	9.0		328	.45	1,400	157	26	1.7	534	--
Water year, 1962																						
Maximum, Oct. 16-31, 1961	285	14		58	6.2	150		211		142	110	--	26		658	.89	506	170	0	5.0	1,050	6.8
Minimum, July 28-31, 1962	16,000	7.0		21	2.7	18		74		25	12	--	0.0		122	.17	5,270	64	3	1.0	210	8.2
Weighted average	1,903	11		50	4.5	42		148		55	35	--	8.4		287	.39	1,470	142	21	1.5	474	7.3
Water year, 1963																						
Maximum, Apr. 1-23, 1963-	422	14		61	6.0	126		194		126	89	1.1	40		604	.82	688	176	18	4.1	918	7.2
Minimum, Oct. 1-19, 1962-	6,747	9.9		45	4.5	28		133		32	33	0.4	3.0		225	.31	4,100	131	22	1.1	385	7.3
Weighted average	1,752	11		53	4.7	44		157		54	37		9.4		297	.40	1,410	151	23	2.0	491	7.1
Water year, 1964																						
Maximum, Aug. 1, 1964	666	18		56	8.4	253		93		424	100	--	58		975	1.33	1,750	174	98	8.3	1,470	7.5
Minimum, Sep. 22-30	12,870	8.9		47	3.1	17		137		32	12	--	4.1		192	.26	6,670	130	18	.6	334	7.2
Weighted average	848	12		50	5.0	66		144		79	47	--	22		357	.49	817	144	27	2.3	594	7.0
70. CEDAR CREEK NEAR MABANK																						
Water year, 1957																						
Maximum, Jan. 14-21, 1957	1.30	9.6		26	7.1	142		65		23	230	0.5	1.2		471	0.64	1.65	95	42	6.4	891	7.2
Minimum, Feb. 24-25	72.1	5.8		3.3	2.1	8.4	3.4	18		7.8	8.2	.8	2.0		51	.07	9.93	17	2	.9	79	6.7
Weighted average	911	9.2		11	2.5	12		42		8.7	9.4	.5	2.6		76	.10	187	38	3	.8	127	--
84. CHAMBERS CREEK NEAR CORSICANA																						
Water year, 1962																						
Maximum, Apr. 13, 1962	52.0	--		--	--	--		248		143	91	--	--		570	0.78	80	210	8	--	938	7.3
Minimum, June 30	1,070	--		--	--	--		86		8.0	12	--	--		114	.16	329	66	0	--	194	7.2
Weighted average	215	11		58	3.4	28		148		60	23	--	3.3		268	.36		157	38	.9	429	7.3
Water year, 1963																						
Maximum, July 1-4, 28-29, 1963	6.9	7.8		80	5.0	123	4.5	288		126	88	1.1	.2		578	.79	10.8	220	0	3.6	930	7.4
Minimum, May 30-31	436	12		--	--	19		119		30	9.0	--	5.0		174	.24	205	104	6	.8	274	7.5
Weighted average	114	13		64	3.6	33		156		77	24	--	3.5		299	.41	120	175	47	1.1	472	7.4
Water year, 1964																						
Maximum, Feb. 1, 1964	7.5	16		58	6.7	504		a728		352	212	--	8.1		1,510	2.05	30.6	172	0	17	2,350	8.6
Minimum, June 1-18	29.8	11		54	3.2	21		162		37	12	0.5	4.2		223	.30	17.9	148	15	.7	367	7.1
Weighted average	20.3	11		65	3.7	43		175		83	25	--	4.1		323	.44	37	176	38	1.9	525	7.7

a Includes the equivalent of 55 ppm carbonate (CO_3).

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

86. RICHLAND CREEK NEAR FAIRFIELD

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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
Water year, 1957																						
Maximum, Oct. 11-17, 1956		--	--	--	--	--		b615		--	7,110	--	--		12,200	--		296	0	--	19,500	8.6
Minimum, Apr. 21-30, 1957		9.6	0.27	29	2.5	14		99		14	10	0.8	2.0		131	0.18		83	2	0.7	217	7.9
Water year, 1958																						
Maximum, Aug. 11-16, 1958		11	.02	81	22	2,620		222		70	4,000	.6	--		6,960	9.47		292	28	67	12,000	8.0
Minimum, Aug. 18-20, 24-27		12	.08	35	2.4	24		101		35	18	.6	3.0		180	.24		97	14	1.0	313	7.6
Water year, 1959																						
Maximum, Feb. 4, 1959----		--		--	--	--		c384		--	2,350	--	--		4,260	5.79		300	0	--	7,480	8.6
Minimum, June 24-27------		11	.09	34	2.1	12		102		21	8.0	.5	1.5		140	.19		94	10	.5	239	7.5
Water year, 1960																						
Maximum, Aug. 22, 1960---		--	--	--	--	--		438		--	3,760	--	--		6,500	8.87		284	0	--	11,200	8.0
Minimum, Jan. 10, 14-17--		14	--	38	2.8	20		123		24	16	.3	2.0		178	.24		106	6	--	297	7.8
Water year, 1961																						
Maximum, Oct. 1, 1960----		--	--	--	--	--		404		--	4,460	--	--		7,900	10.8		254	0	--	13,100	7.6
Minimum, Jan. 19, 1961---		--	--	--	--	--		76		--	8.5	--	--		102	.14		60	0	--	175	7.2
Water year, 1962																						
Maximum, Sept. 1-7, 1962-		--	--	--	--	--		352		67	4,290	--	--		7,450	--		314	26	--	12,600	7.3
Minimum, Nov. 23-27, 1961		11	--	36	2.7	19		115		24	14	.4	2.2		180	.24		101	7	.8	282	7.6
Water year, 1963																						
Maximum, Sept. 1-30, 1963		.8	--	62	34	3,880		476		59	5,870	--	--		10,100	13.8		294	0	99	16,100	7.6
Minimum, May 25----------		16	--	32	2.7	22		98		32	15	--	5.0		173	.24		91	11	1.0	271	7.4
Water year, 1964																						
Maximum, Aug. 1-31, 1964-		0.5	--	44	40	4,740		548		40	7,150	--	--		12,300	16.9		274	0	--	19,700	7.6
Minimum, Apr. 24-25------		16	--	66	3.8	46		175		73	40	.7	3.5		335	.46		180	36	1.5	549	8.0

90. TRINITY RIVER NEAR OAKWOOD

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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
Water year, 1948																						
Maximum, Aug. 29-31, 1948	612	11		72	11	385		160		97	572		29		1,260	1.71	2,080	224	94	11	2,290	--
Minimum, May 13-20--------	30,290	9.0		32	3.1	21		104		24	19		2.8		179	.24	14,600	93	7	.9	273	--
Weighted average---------	4,612	--		47	4.6	41		134		46	46		4.2		282	.38	3,510	136	26	1.5	458	--
Water year, 1949																						
Maximum, Dec. 12-14, 19-20, 1948------------	531	13		64	11	359		141		126	495		50		1,190	1.62	1,710	204	89	11	2,150	--
Minimum, May 21-31, 1949-	17,120	15		44	3.6	20		130		28	21		2.2		204	.28	9,430	125	18	.8	339	8.0
Weighted average---------	3,867	12		47	4.6	40		131		45	45		4.8		277	.38	2,890	136	29	1.5	458	--

b Includes the equivalent of 41 ppm carbonate (CO_3).
c Includes the equivalent of 27 ppm carbonate (CO_3).

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

Date of collection	Mean discharge (cfs)	Silica (SiO_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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: 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
90. TRINITY RIVER NEAR OAKWOOD--Continued																						
Water year 1950																						
Maximum, Oct. 2-3, 7-8, 1949	585	11		66	12		389	159		86	588		13		1,290	1.75	2,040	214	84	12	2,230	7.9
Minimum, Feb. 11-19, 1950	47,330	11		35	4.2		12	103		27	12		2.0		165	.22	21,100	105	20	.5	269	7.5
Weighted average	6,694	13		45	5.0		32	132		38	37		4.2		250	.34	4,520	133	25	1.2	413	--
Water year 1951																						
Maximum, Sept. 7-11, 1951	347	15		80	12		432	161		98	660		30		1,410	1.92	1,320	249	117	12	2,550	7.6
Minimum, June 11-20	12,880	15		44	3.8		35	134		35	38		3.0		247	.34	8,590	125	16	1.4	416	7.4
Weighted average	1,863	15		50	6.0		75	149		55	89		9.6		384	.52	1,930	150	28	2.7	655	--
Water year 1952																						
Maximum, Sept. 1-9, 1952	181	28		71	10		454	255		117	612		13		1,430	1.94	699	218	9	13	2,640	8.2
Minimum, Apr. 22-30	14,520	18		45	4.5		30	135		38	30		3.9		234	.32	9,170	131	20	1.1	391	8.1
Weighted average	1,663	16		50	5.6		93	140		57	119		9.1		434	.59	1,949	148	34	3.3	738	--
Water year 1953																						
Maximum, Sept. 7, 1953	1,880	23		115	19		1,610	d326		128	2,450		--		4,500	6.12	22,840	365	98	37	7,820	8.6
Minimum, May 15-23	38,340	13		29	3.1		16	91		20	16		3.5		170	.23	17,600	85	11	.8	252	8.0
Weighted average	3,164	14		41	4.4		52	117		42	62		7.0		303	.41	2,590	120	24	2.1	487	--
Water year 1954																						
Maximum, Sept. 11, 1954	140	18		87	14		697	e263		187	975		6.5		2,110	2.87	798	274	58	18	3,700	8.3
Minimum, May 12, 15-22	7,526	17		40	2.8		34	121		36	31		7.0		236	.32	4,800	111	12	1.4	388	7.9
Weighted average	871	16		47	6.3		137	149		75	165		12		547	.74	1,290	144	22	5.0	944	--
95. TRINITY RIVER NEAR CROCKETT																						
* Water year 1964																						
Maximum, Sept. 20-22, 1964	1,229	12		62	8.1		319	184		134	400		15		1,050	1.43	3,480	188	37	10	1,860	7.2
Minimum, Sept. 26-30	7,502	8.8		52	3.0		25	154		34	22		4.8		226	0.31	4,580	142	16	0.9	401	7.2
Weighted average	1,194	10		52	6.0		101	147		75	115		8.8		443	.60	1,430	153	33	3.5	[illegible]	[illegible]
109. TRINITY RIVER AT ROMAYOR																						
Water year 1946																						
Maximum, Aug. 11-20, 1946	910			55	6.8		94	170		44	130	--	0.8		451	.61	1,110	166	26	3.2	762	--
Minimum, Feb. 10-15	40,450			23	3.5		14	79		14	16	--	1.5		144	.20	15,700	72	7	.7	202	--
Weighted average	11,590			37	4.6		27	110		29	34	--	2.7		223	.30	6,980	111	21	1.1	345	--
Water year 1947																						
Maximum, Oct. 13, 15-16, 1946	1,039			51	7.0		146	158		38	215	--	3.0		585	.80	1,640	156	27	5.2	1,100	--
Minimum, May 14-19, 1947	13,190			16	2.7		19	66		9.5	18	--	3.0		101	.14	3,600	51	0	1.2	182	--
Weighted average	9,681			36	4.6		31	108		32	37	--	2.7		235	.32	6,140	109	20	1.3	351	--
Water year 1948																						
Maximum, Nov. 1-4, 8-13, 1947	940			50	8.2		78	176		61	238	--	4.6		642	.87	1,630	158	14	2.7	1,150	--
Minimum, Dec. 5-9	5,268			19	3.8		40	83		31	33	--	4.0		207	.28	2,940	63	0	2.2	293	--
Weighted average	6,167			42	5.0		51	136		45	55	--	4.4		303	.41	5,050	126	14	2.0	493	--

d Includes the equivalent of 19 ppm carbonate (CO_3).
e Includes the equivalent of 5 ppm carbonate (CO_3).
* Includes only February through September.

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

109. TRINITY RIVER AT ROMAYOR--Continued

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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
Water year 1949																						
Maximum, Dec. 11-20, 1948	548	14		56	8.5	193		135		64	288	--	15		720	.98	1,070	175	64	6.3	1,280	--
Minimum, Feb. 26-28, 1949	23,070	12		21	3.8	29		68		34	27	--	1.5		162	.22	10,100	68	12	1.5	264	7.2
Weighted average---------	5,566	12		45	5.7	45		140		41	52	--	4.2		296	.40	4,450	136	21	1.7	499	--
Water year 1950																						
Maximum, Apr. 11-21, 1950	8,134	9.5		57	11	91		162		74	119	--	9.9		452	.61	9,930	187	54	2.9	761	7.7
Minimum, Oct. 21-26, 1949	10,940	9.2		19	4.5	4.1		51		10	15	--	1.8		98	.13	2,890	66	24	.2	161	7.0
Weighted average---------	11,220	10		39	4.9	34		119		33	41	--	5.3		241	.33	7,300	117	20	1.4	399	--
Water year 1953																						
Maximum, Sept. 28-30, 1953	267	11		79	11	446		240		87	655	--	1.5		1,410	1.92	1,020	242	46	12	2,510	7.8
Minimum, Apr. 30, May 2-3, 14-22---------	39,780	9.6		18	2.7	10		57		13	12	--	2.0		95	.13	10,200	56	10	.6	168	7.4
Weighted average---------	f7,220	13		31	3.7	24		95		25	28	--	2.6		178	.24	3,470	92	14	1.1	309	--
Water year 1954																						
Maximum, Nov. 7, 1953----	1,250	28		70	13	628		216		136	892	--	22		1,900	2.58	6,410	228	51	18	3,170	8.2
Minimum, July 31, 1954---	4,400	6.4		--	--	--		41		--	21	--	2.8		82	.11	974	36	2	--	154	7.6
Weighted average---------	1,694	15		34	4.7	75		105		40	95	--	4.0		342	.47	1,560	104	18	3.2	568	--
Water year 1955																						
Maximum, Oct. 17-19, 1954	310	15		84	11	534		239		183	728	--	2.5		1,680	2.28	1,410	254	58	15	2,790	8.1
Minimum, Apr. 11-14, 1955	31,600	9.0		12	1.2	13		36		15	12	--	2.5		83	.11	7,080	36	6	.9	130	7.5
Weighted average---------	2,935	14		29	3.4	64		81		36	83	--	4.9		296	.40	2,350	86	20	3.0	487	--
Water year 1956																						
Maximum, Sept. 11-21, 1956	157	16		54	9.7	378		207		119	498	--	1.5		1,180	1.60	500	175	6	12	2,120	8.2
Minimum, Apr. 13-16------	2,750	11		18	2.9	31		48		23	41	--	3.8		155	.21	1,150	58	18	1.7	280	7.2
Weighted average---------	1,211	16		41	4.8	98		119		49	129	--	5.0		405	.55	1,320	122	24	3.9	720	--
Water year 1957																						
Maximum, Oct. 21-31, 1956	224	18		82	13	554		248		165	770	--	1.2		1,730	2.35	1,050	258	55	15	2,930	8.0
Minimum, Apr. 18-19, 26-27, 29-30, 1957-----	3,357	11		17	1.6	16		54		13	18	--	1.5		105	.14	952	49	4	1.0	164	7.3
Weighted average---------	12,690	19		33	2.6	30		103		24	33	--	1.7		201	.27	6,890	93	8	1.3	325	--
Water year 1958																						
Maximum, Oct. 2, 4-5, 1957	1,370	9.6		44	6.1	290		128		37	440	--	1.5		911	1.24	3,370	135	30	11	1,590	8.1
Minimum, Oct. 17-20------	44,000	7.2		15	1.5	13		52		8.4	14	--	.8		86	.12	10,220	44	1	.8	144	7.9
Weighted average---------	11,690	12		40	3.2	31		113		31	37	--	2.6		215	.29	6,790	113	20	1.3	366	--
Water year 1959																						
Maximum, Sept. 7-8, 10-16, 1959------------	752	11		62	7.9	171		187		75	232	--	1.8		666	.91	1,350	187	34	5.4	1,180	7.6
Minimum, Apr. 12-22------	23,990	12		22	2.8	19		64		20	23	--	2.0		132	.18	8,550	66	14	1.0	235	7.3
Weighted average---------	4,909	14		38	4.1	42		107		37	51	--	3.4		249	.34	3,300	112	24	1.7	425	--
Water year 1960																						
Maximum, Oct. 1-7, 1959--	1,097	14		59	7.3	186	7.5	181		88	252	--	3.2		719	.98	2,130	177	28	6.1	1,280	7.3
Minimum, June 27, 1960---	27,300	8.6		19	2.0	10		59		14	9.0	--	2.0		94	.13	6,930	55	6	.6	160	6.9
Weighted average---------	6,621	13		41	4.3	40		113		40	51	--	2.5		259	.35	4,630	120	28	1.6	434	--

f Represents 66% of runoff for water year Oct. 1952 through Sept. 1953.

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

Date of collection	Mean discharge (cfs)	Silica (SiO_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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
109. TRINITY RIVER AT ROMAYOR--Continued																						
Water year 1961																						
Maximum, Sept. 1-11, 1961	809	15		62	7.2	168		188		59	235	--	3.2		665	.90	1,450	184	30	5.4	1,150	7.6
Minimum, Nov. 24-26, 1960	27,770	9.4		12	2.1	13		39		12	15	--	.8		83	.11	6,220	38	6	.9	143	6.7
Weighted average	10,440	12		30	3.2	29		87		29	34	--	1.8		185	.25	5,210	88	16	1.3	315	--
Water year 1962																						
Maximum, June 11-12, 1962	1,650	19		61	7.2	162		170		64	230	--	3.5		631	.86	2,810	182	42	5.2	1,130	7.6
Minimum, Dec. 19-23, 1961	16,860	11		23	1.9	22		58		25	26	--	3.0		141	.19	6,420	66	18	1.2	246	6.8
Weighted average	4,469	14		42	4.8	53		116		45	66	--	3.6		295	.40		126	30	2.0	503	7.2
Water year 1963																						
Maximum, May 1-3, 1963	2,767	22	0.3	62	8.4	148		186		88	185	0.3	7.1		612	.83	4,570	189	36	4.7	1,040	7.7
Minimum, Apr. 8-10	11,210	8.5		17	2.8	25		47		27	28	--	2.2		134	.18	4,060	54	16	1.5	224	6.6
Weighted average	3,495	12		45	4.3	51		128		41	64	--	3.2		287	.39	2,710	129	25	1.9	496	7.2
Water year 1964																						
Maximum, Sept. 25-28, 1964	2,210	10		54	6.2	207		169		108	245	--	8.6		727	.99	4,340	160	22	7.1	1,290	7.2
Minimum, Mar. 2-4	10,370	5.8		22	2.2	18		g72		15	20	0.2	.2		119	.16	3,330	64	4	1.0	211	8.8
Weighted average	1,750	12		40	4.6	80		119		60	92	--	5.3		351	.48	1,600	119	21	3.0	622	7.2
111. TRINITY RIVER AT MOSS BLUFF																						
Water year 1950																						
Maximum, Oct. 1-3, 1949		7.0		32	6.4	163		104		84	203	--	2.2		557	.76		106	22	6.9	997	7.7
Minimum, Oct. 4-10		6.2		17	2.3	13		59		7.8	16	--	1.8		110	.15		52	4	.8	168	7.2
Water year 1951																						
Maximum, Sept. 25-27, 1951		15		59	7.0	274		128		65	418	--	13		915	1.24		176	71	9.0	1,650	7.4
Minimum, June 21-30, 1951		18		47	4.3	30		140		36	32	--	3.5		253	.34		135	20	1.1	411	7.4
Water year 1952																						
Maximum, Aug. 26-27, 1952		17		114	121	1,090		201		295	1,900	--	2.5		3,640	4.95		782	618	17	6,550	7.5
Minimum, Feb. 4-6, 1952		8.0		18	2.3	37		59		17	45	--	7.2		198	.27		54	6	2.2	292	6.9
Water year 1953																						
Maximum, Nov. 1-10, 1952		21		82	11	280		251		109	382	--	1.8		1,010	1.37		250	44	7.7	1,770	8.2
Minimum, May 11-13, 15-20, 1953		9.6		25	2.5	17		82		16	18	--	1.8		130	.18		73	6	.9	225	7.9
Water year 1954																						
Maximum, Aug. 21-31, 1954		15		78	54	535		200		166	880	--	2.8		1,830	2.49		416	252	11	3,310	7.6
Minimum, Nov. 13-14, 1953		10		--	--	25		44		16	29	--	1.5		157	.21		41	5	1.7	203	7.3
Water year 1955																						
Maximum, Dec. 23-27, 1954		17		50	8.3	254		96		61	398	--	9.3		883	1.2		159	80	8.7	1,590	7.6
Minimum, Apr. 9-13, 1955		9.6		15	.6	15		39		9.0	20	--	3.8		144	.20		40	8	1.0	159	6.5

g Includes the equivalent of 9 ppm carbonate (CO_3).

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

Date of collection	Mean discharge (cfs)	Silica (SiO_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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
111. TRINITY RIVER AT MOSS BLUFF--Continued																						
Water year 1956																						
Maximum, Aug. 26, 28-31, 1956		16		124	117		1,200	192		303	2,080	--	--		3,930	5.34		790	632	19	6,900	7.7
Minimum, Apr. 14-16		9.0		16	1.8		26	48		20	30	--	2.1		129	.18		48	9	1.6	243	7.0
Water year 1957																						
Maximum, Nov. 1-12, 1956		15		91	12		524	264		162	730	--	1.8		1,670	2.27		276	60	14	2,940	7.9
Minimum, Apr. 16-30, 1957		9.6		16	2.2		20	48		17	24	--	1.5		114	.16		48	9	1.3	206	6.5
Water year 1958																						
Maximum, Oct. 6-14, 1957		8.2		53	5.2		144	178		29	205	--	.5		544	.74		154	8	5.0	985	7.1
Minimum, Feb. 17-28, 1958		7.8		19	2.4		25	48		25	32	--	2.5		138	.19		57	18	1.5	239	7.1
Water year 1959																						
Maximum, Dec. 5-8, 1958		17		61	8.0		173	172		62	252	--	.5		693	.94		185	44	5.5	1,210	7.0
Minimum, Apr. 12-20, 1959		9.0		24	2.2		23	67		20	30	--	1.8		143	.19		69	14	1.2	255	7.0
Water year 1960																						
Maximum, Oct. 1-12, 1959		14	0.5	58	7.2	148	7.1	189		64	199	0.5	2.0		604	.82		174	19	4.9	1,060	7.1
Minimum, June 26-30, 1960		10		22	1.9		19	73		15	20	--	1.2		125	.17		63	3	1.0	217	6.8
Water year 1961																						
Maximum, Sept. 3-9, 1961		12		58	6.0		124	180		50	169	--	.8		528	.72		169	22	4.1	924	7.5
Minimum, Jan. 24		--		--	--		--	47		--	13	--	--		86	.12		46	8		151	6.8
Water year 1962																						
Maximum, Oct. 11-16, 1961		15		62	6.9		178	189		77	235	--	4.2		719	.98		183	28	5.7	1,200	7.6
Minimum, Jan. 25-31, 1962		11		25	2.7		34	56		38	41	--	3.8		184	.25		74	28	1.7	310	6.6
Water year 1963																						
Maximum, Sept. 1-15, 1963		9.9	0.6	66	6.7		155	232		75	184	0.6	.8		612	.83		192	2	4.9	1,110	6.9
Minimum, Dec. 25-31, 1962		8.8		22	2.0		17	62		16	22	--	1.8		120	.16		63	12	.9	212	6.7
Water year 1964																						
Maximum, Aug. 31, 1964		21		46	7.5		191	188		133	188	--	4.8		683	.93		146	0	6.9	1,190	8.1
Minimum, Apr. 3-11		8.2		23	3.3	28	4.1	h65		34	35	--	.0		168	.23		71	17	1.4	349	9.4
112. OLD RIVER AT COVE																						
Water year 1950																						
Maximum, Oct. 1-10, 1949		9.2		60	34		318	101		88	570		2.8		1,130	1.54		290	206	8.1	2,150	7.6
Minimum, Mar. 11-20, 1950		9.5		32	5.6		22	116		9.9	30		3.2		179	.24		103	8	.9	307	7.7
Water year 1951																						
Maximum, Aug. 21, 23-31, 1951		12		102	68		676	135		218	1,180		1.0		2,320	3.16		534	424	13	4,260	7.4
Minimum, Feb. 1-10		1.4		36	5.8		39	98		48	48		1.8		242	.33		114	33	1.6	420	7.7

h Includes the equivalent of 28 ppm carbonate (CO_3).

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

Date of collection	Mean discharge (cfs)	Silica (SiO_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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
112. OLD RIVER AT COVE--Continued																						
Water year 1952																						
Maximum, Aug. 18-19, 22, 1952		15		103	108	1,040		122		281	1,820		4.0		3,430	4.66		701	601	17	6,130	8.2
Minimum, Jan. 26-31		13		16	4.2	27		48		24	36		2.2		156	.21		57	18	1.6	257	7.1
Water year 1953																						
Maximum, Oct. 11-22, 31, 1952		14		82	29	340		212		105	550		4.5		1,230	1.67		324	150	8.2	2,500	7.9
Minimum, June 22-30, 1953		13		32	4.5	26		101		23	32		4.0		199	.27		98	16	1.1	332	7.5
Water year 1954																						
Maximum, Aug. 31, 1954		12		164	334	2,830		122		707	5,030		--		9,140	12.43		1,780	1,680	29	14,900	7.8
Minimum, Dec. 19-26, 30-31, 1953		13		20	3.1	28		66		13	38		1.5		184	.25		63	9	1.5	267	7.2
Water year 1955																						
Maximum, Oct. 8, 14, 1954		22		221	187	1,660		176		426	3,080		--		5,680	7.7		1,320	1,180	20	9,510	8.0
Minimum, Jan. 15-26, 1955		13		16	3.4	36		62		17	45		.5		183	.25		55	4	2.1	290	7.2
Water year 1956																						
Maximum, Sept. 21-30, 1956		18		214	261	2,390		185		588	4,290		--		7,850	10.7		1,610	1,460	26	12,900	8.0
Minimum, Feb. 1-14		15		28	5.1	52		83		33	72		1.0		271	.37		91	23	2.4	446	7.6
Water year 1957																						
Maximum, Oct. 14-29, 1956		14		354	384	3,400		174		868	6,240		--		11,300	15.37		2,460	2,320	30	17,900	7.8
Minimum, Apr. 29, May 1-2, 1957		11		11	1.7	12		44		5.4	12		1.5		77	.10		34	0	.9	131	6.8
Water year 1958																						
Maximum, Sept. 1-6, 1958		14		56	5.8	107		186		46	138		2.0		460	.63		164	11	3.6	816	8.2
Minimum, Jan. 22-31		7.0		18	2.4	20		68		7.8	24		1.0		113	.15		55	0	1.2	205	7.5
Water year 1959																						
Maximum, Jan. 15-28, 1959		4.2		60	8.0	139		161		59	206		.1		585	.80		182	50	4.5	1,020	8.0
Minimum, Feb. 6, 15-16		9.8		17	1.8	17		61		11	17		1.0		105	.14		50	0	1.0	187	7.2
Water year 1960																						
Maximum, June 1-6, 1960		14		70	16	192		159		83	312		1.8		822	1.12		240	110	5.4	1,380	7.3
Minimum, June 26-29		16		18	3.1	27		62		18	32		1.2		145	.20		58	7	1.5	238	7.2
Water year 1961																						
Maximum, June 8-13, 1961		5.8		63	18	220		142		88	355		1.0		887	1.21		231	114	6.3	1,510	7.2
Minimum, Dec. 14-18, 1960		11		16	1.8	17		51		9.0	23		.8		104	.14		47	6	1.1	185	7.2
Water year 1962																						
Maximum, Aug. 1-4, 1962		19	0.5	61	22	234		137		83	390	0.5	1.5		878	1.19		242	130	6.5	1,630	7.5
Minimum, Nov. 3-18, 1961		13		17	2.4	22		50		18	28		.8		134	.18		52	11	1.3	213	6.8

Table 5.--Summary of chemical analyses at daily stations on streams in the Trinity River basin--Continued

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

Date of collection	Mean discharge (cfs)	Silica (SiO_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: Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: 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
112. OLD RIVER AT COVE--Continued																						
Water year 1963																						
Maximum, July 15-20, 1963		8.0		73	38	384		162		118	650		0.8		1,350	1.84		338	206	9.1	2,450	7.5
Minimum, Dec. 26-31, 1962		11		18	2.7	17		50		15	26		.5		115	.16		56	15	1.0	205	6.4
Water year 1964																						
Maximum, Oct. 27-31, 1963		14		107	54	528		202		166	920		1.2		1,890	2.57		489	324	10	3,410	7.4
Minimum, Feb. 5-8, 1964--		9.8		20	2.7	23		67		16	28		.5		133	.18		61	6	1.3	245	6.9
113. TRINITY RIVER AT ANAHUAC																						
Water year 1950																						
Maximum, Oct. 3, 1949----		17		153	347	2,750		153		716	4,900		--		8,960	12.19		1,810	1,680	28	14,300	7.5
Minimum, Mar. 1-10, 1950-		7.8		17	5.2	34		70		18	42		1.8		184	.25		64	6	1.8	286	7.4
Water year 1951																						
Maximum, May 1, 1951-----		14		191	381	3,020		129		803	5,430		--		9,900	13.5		2,040	1,960	29	16,500	7.9
Minimum, June 21-30------		16		44	5.9	30		130		39	34		4.0		247	.34		134	28	1.1	407	7.4
Water year 1952																						
Maximum, Sept. 21-30, 1952		15		258	450	3,860		114		998	6,910		--		12,500	17.0		2,490	2,400	34	20,200	7.7
Minimum, June 4-6, 8-12, 14---------------		19		38	4.0	30		124		28	30		3.2		226	.31		111	10	1.2	359	7.8
Water year 1953																						
Maximum, Oct. 21-31, 1952		13		263	704	4,860		126		1,290	8,990		--		16,200	22.0		3,550	3,450	35	25,600	7.7
Minimum, Apr. 30, May 1-12, 15-16, 1953--		9.8		28	3.5	22		86		21	27		2.5		193	.26		84	14	1.0	280	7.7
Water year 1954																						
Maximum, Sept. 11-20, 1954		13		271	673	5,620		138		1,380	10,000		--		18,000	24.5		3,440	3,330	42	27,400	7.6
Minimum, Aug. 1, 3, 1954-		12		16	3.7	32		50		13	49		1.2		167	.23		55	14	1.9	265	7.6
Water year 1955																						
Maximum, Oct. 3-6, 1954--		13		283	669	5,520		166		1,380	9,850		--		17,800	24.2		3,460	3,320	41	26,700	7.7
Minimum, Apr. 12-19, 1955		13		16	1.3	30		46		17	37		2.5		140	.19		45	8	1.9	248	7.1
Water year 1956																						
Maximum, Aug. 1-31, 1956-		11		275	665	5,780		136		1,430	10,200		--		18,400	25.02		3,420	3,310	43	27,800	7.4
Minimum, May 7-23--------		17		41	4.2	79		122		42	103		3.8		375	.51		120	20	3.1	625	7.7

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations

(Results in parts per million 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): Parts per million	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
2. WEST FORK TRINITY RIVER NEAR JACKSBORO																						
Apr. 21, 1959-----	34	9.0		38	9.4	90		74		12	181	0.3	1.2		377	0.51		134	73	3.4	738	6.9
June 13, 1962-----	1,840	11		13	2.9	12		47		5.8	18	.3	.2		86	.12		44	6	.8	148	6.2
3. BRIDGEPORT RESERVOIR ABOVE BRIDGEPORT																						
Sept. 27, 1941----		--		12	--	5		69		12	7.0	--	2.0		88	--		82	--	--	211	--
Mar. 22, 1960-----		5.0	0.20	32	4.9	10	4.3	109		11	18	0.2	.8	0.08	140	0.19		100	11	0.4	252	7.5
Jan. 21, 1964-----		4.6		41	5.8	19		142		14	25	.2	.0		180	.24		126	10	.7	338	7.5
July 8------------		4.7		38	5.9	18		135		13	24	.3	.0		170	.23		119	8	.7	316	7.2
5. LAKE AMON G. CARTER NEAR BOWIE																						
Apr. 21, 1959-----		1.0		24	4.9	8.0	5.4	90		8.8	14	0.0	0.5		111	0.15		80	6	0.4	220	6.9
Jan. 21, 1964-----		2.2		22	6.1	16		90		14	18	.3	.0		123	.17		80	6	.8	236	7.4
6. BIG SANDY CREEK NEAR BRIDGEPORT																						
Jan. 21, 1964-----	11.0	5.4		39	11	19		143		18	34	0.1	0.0		196	0.27		143	25	0.7	375	7.1
Feb. 3------------	18.7	7.0		34	7.8	19		118		19	28	.3	.8		174	.24		117	20	.8	321	7.2
Apr. 23-----------	8.18	5.3		48	11	28		176		17	44	.3	.0		241	.33		165	21	.9	455	6.9
May 15------------	13	7.3		40	7.8	20		149		15	26	.4	.8		190	.26		132	10	.8	354	6.7
7. WEST FORK TRINITY RIVER NEAR BOYD																						
Jan. 21, 1964-----	88.0	4.0		42	5.9	21		144		15	28	0.3	0.0		187	0.25		129	11	0.8	345	7.5
Feb. 3------------	34.0	7.6		33	5.8	19		113		19	24	.4	1.5		166	.23		106	14	.8	302	7.3
Apr. 23-----------	1,520	6.4		25	4.8	5.8	4.2	100		6.2	4.9	.3	2.8		109	.15		82	0	.3	197	6.5
May 15------------	17.6	21		33	6.2	21		112		22	26	.5	.5		185	.25		108	16	.9	314	7.3
July 8------------	500	5.5		39	6.2	17		138		13	23	.3	1.0		173	.24		123	10	.7	322	7.1
8. EAGLE MOUNTAIN RESERVOIR ABOVE FORT WORTH																						
Apr. 2, 1952------		5.6	0.01	40	7.3	17	1.2	151		15	21	0.3	0.5	0.10	182	0.32		130	6	--	335	7.7
Jan. 25, 1964-----		5.9		42	8.6	23		153		18	33	.1	.0		206	.28		140	15	0.8	385	7.6
July 8------------		4.7		38	7.8	22		141		17	29	.3	.5		188	.26		127	11	.8	353	7.3
9. LAKE WORTH AT FORT WORTH																						
Mar. 31, 1952-----		5.6	0.08	43	7.8	18	0.8	161		17	23	0.4	0.2	0.12	197	0.27		139	7		363	7.9
Dec. 16-----------		7.0	.20	38	8.1	21	3.7	153		18	25	.5	.2	.28	204	--		128	3		350	8.0
Jan. 12, 1953-----		5.5	.37	40	8.0	20	4.5	153		19	24	.3	.0	.11	201	--		133	7		353	7.5
Apr. 28-----------		7.2	.15	42	8.2	21	4.3	163		19	26	.4	.0	.09	212	.29		138	5		373	8.0
Feb. 27, 1962-----		5.8	.05	44	8.4	20	4.5	153		20	32	.3	.0	.08	228	.31		144	19	0.7	387	7.6
11. CLEAR FORK TRINITY RIVER NEAR ALEDO																						
May 21, 1954------		9.6	0.54	55	9.4	27		201		31	23	0.3	4.5		273	0.37		176	11		451	7.7
12. BENBROOK RESERVOIR NEAR BENBROOK																						
Nov. 16, 1956-----		3.7	0.14	43	5.3	11	8.2	157		13	14	0.3	1.0		177	0.24		129	0	0.4	315	7.8
Feb. 27, 1962-----		4.6		45	6.1	15	4.4	143		26	20	.4	.0	0.15	209	.28		137	20	.6	348	7.4
Feb. 3, 1964------		4.2		45	6.2	20		145		28	23	.3	.0		198	.27		138	19	.7	365	7.1

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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) Parts per million	Dissolved solids Tons per acre-foot	Dissolved solids Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
15. WEST FORK TRINITY RIVER AT FORT WORTH																						
Apr. 1, 1952------		5.4	0.10	49	9.5	23	2.8	184		22	27	0.4	1.5	0.12	a237	0.32		161	10	--	426	7.5
Jan. 19, 1953-----		5.0	.82	52	8.2	25	4.7	178		28	31	.4	1.5	.09	a252	--		163	18	--	421	7.3
May 25------------		11	1.3	70	6.8	31	5.1	211		45	34	.5	4.7	.18	312	.29		202	30	--	553	7.1
Jan. 23, 1964-----	14.9	4.6		60	7.4	31		200		31	36	.2	.0	--	269	.37		180	16	1.0	496	6.8
Feb. 7------------	21.3	4.8		48	3.0	20		139		34	19	.2	.0	--	197	.27		132	18	.8	359	6.5
July 23-----------	100	3.7		52	7.9	51		219		33	40	.1	2.8	--	298	.41		162	0	1.7	523	7.1
Aug. 20-----------	12.5	3.8		36	3.5	17		115		18	18	.3	2.0	--	156	.21		104	10	.7	288	6.9
17. BIG FOSSIL CREEK AT HALTOM CITY																						
Jan. 23, 1964-----	0.10	11		93	6.8	38		324		44	21	0.2	0.8		375	0.51		260	0	1.0	631	7.1
Feb. 7------------	.10	6.8		69	5.3	25		214		50	14	.4	.0		276	.38		194	19	.8	474	7.0
June 11-----------	.30	11		65	5.8	23		229		29	12	.3	.8		260	.35		186	0	.7	436	7.9
Aug. 20-----------	.48	8.9		51	4.1	19		176		29	6.9	.5	.0		206	.28		144	0	.7	350	7.0
19. LAKE ARLINGTON AT ARLINGTON																						
Jan. 22, 1964-----		2.4		38	7.1	41		153		41	32	0.3	0.0		237	0.32		124	0	1.6	429	7.6
20. WEST FORK TRINITY RIVER AT GRAND PRAIRIE																						
Jan. 22, 1964-----	94	8.0		43	11	113		196		115	64	0.7	18		478	0.65		152	0	4.0	805	7.8
Feb. 6------------	198	7.2		54	4.7	80		150		112	43	.4	22		407	.55		154	31	2.8	686	6.8
June 5------------	90	11		65	7.8	147		214		186	81	.7	34		638	.87		194	18	4.6	1,030	6.9
July 2------------	63	7.2		52	9.4	119		250		72	86	.9	29		498	.68		168	0	4.0	863	7.0
21. BEAR CREEK AT US HIGHWAY 183 NEAR EULESS																						
Dec. 8, 1964------	3.46	17		134	25	88		284		248	97	0.3	1.2		750	1.02		438	205	1.8	1,120	7.9
Apr. 2, 1965------	7.07	6.5		124	18	87		266		214	92	.4	.2		673	.92		384	166	1.9	1,090	7.4
May 10------------	198	8.8		86	6.2	34		172		125	29	.4	1.8		376	.51		240	99	1.0	628	6.7
Do.---------------	1,000	8.2		42	2.5	14		127		24	10	.3	2.2		165	.22		115	11	.6	293	6.6
May 19------------	25	17		89	12	43		230		111	42	.3	.8		428	.58		272	83	1.1	712	7.0
July 9------------	.02	12		117	16	44		296		150	38	.5	.2		524	.71		358	116	1.0	826	7.3
25. MOUNTAIN CREEK LAKE NEAR GRAND PRAIRIE																						
Jan. 22, 1964-----		1.1		46	6.1	82		166		131	31	0.7	0.2		380	0.52		140	4	3.0	629	7.3
Aug. 20-----------		2.5		46	4.4	60		144		111	20	.9	.0		316	.43		133	15	2.3	522	7.0
Apr. 2, 1965------		3.8		49	3.8	31		115		86	11	.5	4.8		247	.34		138	44	1.1	419	6.6
Apr. 29-----------		4.2		54	4.4	33		124		98	12	.5	3.5		271	.37		153	51	1.2	456	7.4
June 4------------		7.7		54	3.0	21		131		68	8.3	.4	2.8		229	.31		147	40	.8	382	7.1
July 9------------		.8		51	3.5	27		139		75	10	.5	.8		240	.33		149	35	1.0	408	7.2

a Residue at 180°C.

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): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
27. ELM FORK TRINITY RIVER SUBWATERSHED NO. 6-0 NEAR MUENSTER																						
Dec. 19, 1956		6.2		28	1.8	5.2	4.0	80		11	7.5	0.4	5.6		109	0.15		77	11	0.3	190	7.5
Mar. 20, 1957		1.8		185	12	285		80		39	702	.3	40		1,300	1.77		511	446	5.5	2,290	7.5
Mar. 12, 1958		3.2		88	4.1	59		191		43	111	.3	8.2		411	.56		236	80	1.7	749	7.7
Apr. 22, 1959		3.2		62	3.9	35		149		27	68	.1	1.2		273	.37		171	49	1.2	514	7.7
Oct. 28		7.3		38	2.3	17		110		10	28	.3	.8		169	.23		104	14	.7	287	7.7
June 14, 1961		9.1		76	5.4	58		167		47	104	.4	4.0		386	.52		212	74	1.7	697	7.7
Aug. 3, 1962		7.8		31	2.4	25		80		18	38	.4	4.0		166	.23		87	22	1.2	286	7.4
Mar. 21, 1963		1.0		71	4.4	35		182		44	53	.3	1.5		299	.41		195	46	1.1	536	7.0
Apr. 16, 1964		2.4		86	4.3	53		163		98	78	.3	1.8		404	.55		232	98	1.5	710	7.1
Sept. 25		7.6		34	2.0	18		94		22	21	.4	2.2		153	.21		93	16	.8	277	6.9
Feb. 19, 1965		4.8		62	2.6	26		164		34	34	.3	3.3		248	.34		165	30	.9	435	7.6
28. ELM FORK TRINITY RIVER NEAR MUENSTER																						
Dec. 19, 1956	--	8.6		201	15	250		44		9.2	750	0.5	3.8		1,260	1.71		564	528	4.6	2,520	7.5
Oct. 3, 1957	0.2	12		696	56	738		180		39	2,400	0.0	--		4,030	5.48		1,970	1,820	7.2	7,240	7.4
Dec. 27	12	6.8		130	6.0	63		252		38	170	.0	2.0		540	.73		349	142	1.5	986	7.8
Mar. 12, 1958	63	11		98	5.1	38		243		34	78	.3	2.5		416	.57		266	66	1.0	679	7.9
Jan. 15, 1959	.8	10		190	17	175		230		55	480	.2	.0		1,040	1.41		544	356	3.3	1,920	7.7
Apr. 22	.7	13		210	16	178		240		47	518	.2	.2		1,100	1.50		590	394	3.2	2,020	7.5
Mar. 2, 1961	--	4.0		100	6.5	42		231		32	102	.3	.0		430	.58		276	86	1.1	726	7.5
Aug. 30	--	8.7		402	37	507		130		33	1,500	.3	.5		2,550	3.47		1,160	1,050	6.5	4,720	7.0
Oct. 31	.45	7.5		368	31	432		226		34	1,250	.4	.0		2,230	3.03		1,050	860	5.8	4,170	7.0
June 13, 1962	23.9	9.8		88	5.1	39		199		19	100	.3	.0		a359	.49		240	78	1.1	675	7.0
Mar. 21, 1963	7.7	7.0		111	8.5	55		258		31	132	.3	.0		472	.64		312	100	1.4	853	7.0
June 12	3.52	7.4		126	10	103		212		22	270	.3	1.2		644	.88		356	182	2.4	1,190	7.2
Jan. 21, 1964	.02	10		775	65	957		190		61	2,880	--	--		4,840	6.58		2,200	2,050	8.9	8,450	7.3
Apr. 16	.6	8.9		298	30	303		234		62	900	--	.8		1,720	2.34		867	675	4.5	3,230	7.0
Sept. 25	100	8.9		37	2.1	16		112		12	22	.2	.2		153	.21		101	9	.7	275	6.8
Dec. 2	--	11		53	3.1	14		153		13	26	.1	.2		195	.27		145	20	.5	349	7.0
Feb. 19, 1965	--	8.0		106	5.7	42		257		31	96	.3	.0		415	.56		288	78	1.1	735	7.4
29. ELM FORK TRINITY RIVER NEAR SANGER																						
Oct. 31, 1961	2.9	5.5		59	5.5	68		212		31	77	0.5	0.8		a379	0.52		170	0	2.3	646	7.3
Nov. 3	2.29	3.5		62	6.2	81		253		32	80	.4	.5		400	.54		180	0	2.6	702	7.4
Dec. 14	28.7	8.0		90	7.7	88		194		32	179	.3	1.2		551	.75		256	97	2.4	925	7.8
Mar. 30, 1962	7.14	3.9		82	8.1	147		305		60	170	.4	3.8		640	.87		238	0	1.1	1,110	7.6
June 14	89.2	10		52	3.7	28		148		18	45	.3	1.2		a244	.33		145	24	1.0	420	7.0
July 17	19.9	8.3		73	5.8	85		203		30	136	.3	1.2		440	.60		206	40	2.6	811	6.8
Sept. 12	357	9.4		57	4.0	26		164		16	45	.3	.2		239	.33		159	24	.9	430	6.5
Oct. 30	53.2	9.1		72	6.3	67		212		42	94	.3	1.8		a434	.59		206	32	2.0	704	6.6
Dec. 4	382	11		70	4.9	38		194		29	61	.4	.8		310	.42		194	36	1.2	548	6.8
Dec. 13	64	12		103	6.8	55		277		42	92	.3	3.8		451	.61		285	58	1.4	799	6.9
Jan. 8, 1963	52.2	3.1		108	8.6	74		312		54	107	.3	2.2		510	.69		305	50	1.8	892	7.5
Feb. 14	29.8	1.2		108	9.2	100		320		59	140	.3	4.5		a601	.82		308	46	2.5	974	7.4

a Residue at 180°C.

Table 5.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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) Parts per million	Dissolved solids Tons per acre-foot	Dissolved solids Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
29. ELM FORK TRINITY RIVER NEAR SANGER--Continued																						
Mar. 26, 1963	17.2	4.5		103	9.4	85	2.9	322		61	105	0.3	1.5		a545	0.74		296	32	2.2	937	6.9
Apr. 26	9.07	15		102	8.9	91	3.7	326		55	115	.3	4.2		a559	.76		291	24	2.3	959	7.0
June 4	31.1	8.6		62	4.7	34		181		26	51	.3	.0		276	.38		171	26	1.1	506	6.6
Aug. 7	1.94	5.3		52	6.7	131		340		48	79	.4	.5		490	.67		157	0	4.5	860	6.7
Sept. 10	1.90	8.4		45	6.7	135		342		48	73	.4	.0		484	.66		140	0	5.0	825	6.9
Oct. 23	1.82	8.6		48	5.6	170		456		46	64	.4	.0		567	.77		143	0	6.2	936	7.4
Nov. 27	2.62	14		36	7.8	188		474		56	59	.5	.2		594	.81		122	0	7.4	975	8.1
Jan. 7, 1964	.49	6.8		54	7.2	159		423		53	65	.4	20		573	.78		164	0	5.4	959	8.1
Jan. 21	3.0	.4		58	7.7	138		420		53	53	.3	2.2		520	.71		176	0	4.5	887	7.5
Feb. 4	7.01	6.1		46	5.6	159		383		55	56	.4	41		557	.76		138	0	5.9	921	7.4
Apr. 23	32	7.3		44	2.5	20		148		17	15	.4	3.5		183	.25		120	0	.8	321	6.8
June 2	26	7.3		51	4.6	42		135		25	70	.3	2.2		268	.36		146	36	1.5	495	6.7
July 6	.35	2.4		64	7.4	114		264		37	124	.3	7.2		486	.66		190	0	3.6	880	7.1
30. ISLE DU BOIS CREEK NEAR PILOT POINT																						
Nov. 9, 1961	0.03	10		38	6.5	20		116		41	18	0.4	0.2		a208	0.28		122	26	0.8	329	7.0
Dec. 14	24.5	9.0		22	3.4	20		60		28	22	.4	3.5		138	.19		69	20	1.0	238	7.2
Apr. 26, 1962	195	14		27	4.2	21		76		32	21	.4	6.0		163	.22		85	22	1.0	274	6.9
June 14	53.2	8.7		15	2.9	9.7	3.4	45		16	13	.4	1.8		93	.13		94	12	.6	156	6.7
July 17	.43	9.9		68	13	72		213		65	96	.4	.0		430	.58		223	48	2.1	753	7.0
Sept. 11	105	11		35	6.0	26		83		37	43	.3	.0		a214	.29		112	11	1.1	317	6.9
Oct. 30	83.8	9.7		42	10	59		87		23	126	.4	.2		313	.43		146	74	2.1	601	6.4
Dec. 3	415	11		30	7.2	30		68		41	49	.3	.5		a214	.29		104	49	1.3	356	6.5
Dec. 13	14	16		91	20	91		209		92	169	.3	.0		a638	.87		310	138	2.2	1,020	6.8
Jan. 8, 1963	9.67	10		105	24	131		238		102	242	.4	2.5		a772	1.05		360	166	3.0	1,290	7.3
Mar. 26	3.90	6.0		113	26	139	3.8	252		107	268	.3	.5		788	1.07		389	182	3.1	1,400	6.9
Apr. 26	1.31	12		102	23	125	4.7	240		87	242	.4	2.5		717	.98		349	152	2.9	1,290	7.3
Feb. 1, 1964	.15	14		88	18	163		286		236	118	.4	1.0		779	1.06		294	59	4.1	1,230	8.0
Apr. 23	535	8.3		12	2.0	4.3	3.4	35		15	1.8	.4	3.2		67	.09		38	10	.3	109	6.0
May 12	6.6	11		30	4.7	18		96		32	14	.4	.5		158	.21		94	16	.8	277	6.3
31. CLEAR CREEK NEAR SANGER																						
Apr. 22, 1959	8.7	9.4		90	14	80		161		66	180	0.3	0.0		519	0.71		282	150	2.1	951	7.7

a Residue at 180°C.

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
34. LITTLE ELM CREEK NEAR AUBREY																						
June 14, 1962-----	12.8	11		56	4.0	14		120		74	7.0	0.4	0.8		226	0.31		156	58	0.5	374	7.1
Sept. 7-----------	1,200	9.5		46	2.9	11		112		50	3.5	.4	.2		a183	.25		127	35	.4	287	6.6
Sept. 8-----------	2,010	11		38	2.6	12		106		36	4.0	.2	.0		156	.21		106	19	.5	252	6.4
Sept. 11----------	26.2	12		66	4.3	14		152		76	6.2	.4	.2		254	.35		182	58	.5	4 03	6.8
Oct. 29-----------	39.0	7.8		53	4.0	22		90		102	8.5	.5	2.8		245	.33		149	75	.8	389	6.7
Dec. 3------------	83.0	11		70	6.2	25		140		118	10	.4	2.8		312	.42		200	86	.8	489	6.6
Jan. 7, 1963------	1.85	1.6		143	15	116		270		380	36	.6	1.2		a826	1.12		418	197	2.5	1,180	7.1
June 3------------	--	10		68	4.5	23		147		101	8.0	.5	.2		287	.39		188	68	.7	467	6.9
June 3, 1965------	1.2	8.3		67	5.3	30		133		126	9.4	.6	.2		312	.42		189	80	.9	509	7.0
35. GARZA-LITTLE ELM RESERVOIR NEAR LEWISVILLE																						
Mar. 22, 1962-----		2.1	0.32	53	6.2	39	4.4	139		44	64	0.4	0.5	0.06	a291	0.40		158	44	1.3	515	7.5
Jan. 22, 1964-----		1.6		50	6.1	33		137		36	51	.2	.0		245	.33		150	38	1.2	461	7.6
July 13-----------		2.7		43	5.0	32		122		35	42	.4	.0		220	.30		128	28	1.2	400	7.1
37. DENTON CREEK NEAR JUSTIN																						
Nov. 25, 1964-----	200	11		66	9.6	8.5	3.2	207		28	16	0.3	0.2		245	0.33		204	34	0.3	411	7.7
Feb. 19, 1965-----	127	9.1		98	1.6	25		254		53	28	.3	2.0		342	.47		251	43	.7	583	7.4
May 6-------------	15	8.9		98	14	44		292		88	46	.3	.0		443	.60		302	62	1.1	752	7.1
June 4------------	45	11		84	12	29		263		49	39	.3	.2		354	.48		259	44	.8	626	7.2
39. GRAPEVINE RESERVOIR NEAR GRAPEVINE																						
Jan. 22, 1964-----		4.1		47	5.0	19		147		30	19	0.4	0.0		196	0.27		138	17	0.7	357	7.6
July 22-----------		3.5		43	5.5	18		142		27	17	.3	.5		185	.25		130	14	.7	331	7.0
50. WHITE ROCK CREEK AT WHITE ROCK LAKE AT DALLAS																						
Jan. 22, 1964-----		0.3		48	2.7	23		112		55	22	0.4	0.2		207	0.28		131	39	0.9	371	7.2
Feb. 19-----------		.2		53	2.6	23		118		61	22	.3	.0		220	.30		143	46	.8	395	6.8
May 8-------------		1.6		58	2.5	20		130		59	20	.4	2.5		228	.31		155	48	.7	400	6.7
60. LAVON RESERVOIR NEAR LAVON																						
Oct. 24, 1961-----		4.7		46	3.9	17		128		43	12	0.5	0.8		a204	0.28		131	26	0.6	335	6.9
May 31, 1962------		.7		56	4.1	14		154		42	12	.4	.0		a218	.30		157	30	.5	374	6.6
Oct. 26-----------		6.2		48	3.2	14		142		33	8.8	.5	.0		184	.25		133	17	.5	316	6.8
Aug. 12, 1963-----		5.3		47	2.9	17		134		37	11	.5	.2		187	.25		129	19	.7	334	6.4
Jan. 22, 1964-----		4.8		51	2.9	17		149		38	8.8	.5	.0		196	.27		139	17	.6	343	8.0
Apr. 8------------		.5		48	4.7	17		145		40	9.6	.5	.2		192	.27		139	20	.6	346	7.6

a Residue at 180°C.

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: 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
64. EAST FORK TRINITY RIVER NEAR CRANDALL																						
Jan. 22, 1964	21	8.9		43	7.4	141		206		75	138	0.6	0.5		515	0.70		138	0	5.2	963	6.9
Apr. 9	32.4	4.0		66	6.2	92		173		80	104	.5	22		460	.63		192	50	2.9	830	6.7
Apr. 24	415	12		80	2.8	14		234		34	8.8	.4	.5		268	.36		211	19	.4	450	6.8
67. TERRELL RESERVOIR NEAR TERRELL																						
July 30, 1943		13	0.78	16	3.9	4.0	3.6	63		10	4.0	0.4	0.8		92			56			132	8.4
Mar. 24, 1952		7.6	.83	19	5.2	13	.0	87		15	7.2	.4	.2		125	0.17		69	0		200	7.6
73. NAVARRO MILLS RESERVOIR NEAR DAWSON																						
Aug. 10, 1965		6.4		52	4.4	15		166		27	9.4	0.5	1.0		198	0.27		148	12	0.5	352	6.8
74. RICHLAND CREEK NEAR DAWSON																						
Jan. 23, 1964	0.2	8.4		126	13	84		307		144	105	0.3	0.5		632	0.86		368	116	1.9	1,060	7.0
Mar. 7	.02	3.6		70	6.7	38		200		64	37	.5	.0		318	.43		202	38	1.2	559	6.9
75. PIN OAK CREEK SUBWATERSHED NO. 1 NEAR HUBBARD																						
May 12, 1965		6.5		13	1.6	4.0	3.9	52		4.4	1.7	0.2	2.2		64	0.09		39	0	0.3	103	6.5
76. PIN OAK CREEK NEAR HUBBARD																						
Nov. 4,5, 1956	--	6.6	0.08	23	2.0	5.5	2.6	78		11	1.8	0.5	2.0		a101	0.14		65	1	0.3	159	7.6
Oct. 15-20, 1957	--	12		32	2.5	14		97		29	4.8	.6	2.2		a158	.21		90	11	.6	237	7.7
Aug. 24, 1958	1,140	7.8		22	1.4	4.8	3.0	73		8.6	1.5	.4	3.5		89	.12		61	8	.3	141	7.8
Aug. 26-30	0.1	17		58	6.8	77		220		96	40	.6	1.5		430	.58		172	0	2.5	641	8.2
Sept. 11-12, 17	.7	15		34	2.9	36		112		61	10	.7	3.5		218	.30		97	5	1.6	346	8.1
Apr. 14, 1965	0.45	3.8		48	3.5	18		156		34	6.1	.4	.5		191	.26		134	6	.7	338	7.0
May 11	149	8.6		34	2.2	11		112		19	3.5	.4	1.2		135	.18		94	2	.5	239	6.7
May 16	845	8.8		22	1.7	5.8	3.7	78		10	2.2	.3	.8		93	.13		62	0	.3	158	6.8
78. RICHLAND CREEK ABOVE MOUTH OF CHAMBERS CREEK NEAR WINKLER																						
Jan. 10, 1957		4.1		100	28	3,290		b526		38	4,990				8,710	11.9		365	0	75	14,500	8.4
79. MILL CREEK AT MILFORD																						
Apr. 22, 1959		10		80	1.0	6.1	1.0	216		20	8.0	0.1	7.7		240	0.33		204	27	0.2	431	7.5

a Residue at 180°C.
b Includes equivalent of 18 parts per million of carbonate (CO_3).

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
80. SOUTH PRONG CREEK NEAR WAXAHACHIE																						
Apr. 22, 1959		11		84	0.9	5.7	1.2	218		21	7.2	0.1	15		253	0.34		213	35	0.2	440	7.6
81. LAKE WAXAHACHIE NEAR WAXAHACHIE																						
Jan. 23, 1964		5.5		44	3.0	7.0	2.0	132		21	7.2	0.2	0.0		155	0.21		122	14	0.3	277	7.5
82. WAXAHACHIE CREEK NEAR BARDWELL																						
Oct. 30, 1961	6.34	10		72	2.7	27		226		29	20	0.6	5.2		a288	0.39		191	6	0.9	476	7.5
Oct. 31	7.45	9.3		67	2.6	27		212		28	20	.7	3.8		a278	.38		178	4	.9	452	7.2
Dec. 2	39.1	9.1		74	2.3	14		217		24	12	.5	5.0		a255	.35		194	16	.4	427	7.1
Jan. 17, 1962	36.1	6.0		85	2.3	16		241		29	15	.4	8.1		a282	.38		222	24	.5	485	7.2
Jan. 18	c30	5.6		89	2.7	18		255		29	18	.5	6.7		a302	.41		233	24	.5	502	7.2
Feb. 12	22.4	4.2		85	2.7	23		256		30	18	.5	4.2		a298	.41		223	13	.7	504	7.3
Mar. 16	19.7	6.3		92	2.9	24		264		34	24	.5	7.7		a336	.46		242	25	.7	552	6.9
May 3	48.7	8.2		64	2.6	14		187		27	12	.4	3.0		a232	.32		170	17	.5	367	7.4
June 1	9.61	8.9		58	22	18		172		21	18	.5	4.5		a231	.31		154	13	.6	388	6.5
July 17	4.53	9.0		67	3.0	17		195		26	18	.6	3.2		240	.33		180	20	.6	435	7.4
Aug. 14	.47	8.6		66	2.8	38		226		31	28	.8	.5		a300	.41		176	0	1.2	483	6.8
Sept. 26	7.52	11		72	2.8	34		234		32	24	.7	4.5		a314	.43		191	0	1.1	498	6.8
Nov. 27	96.3	11		66	3.5	25		173		59	15	.7	8.4		a290	.39		179	37	.8	462	6.7
Feb. 13, 1963	14.6	2.2		92	3.3	30		284		33	24	.6	7.5		333	.45		243	10	.8	577	7.3
July 18	.34	10		75	2.4	38		240		37	31	.7	.2		312	.42		197	0	1.2	548	7.0
Apr. 11, 1964	2.85	6.9		80	6.0	58		289		43	46	.7	1.8		384	.52		224	0	1.7	675	7.6
Apr. 24	54.4	8.7		63	2.1	19		167		36	15	.5	13		239	.33		166	29	.6	413	7.4
85. CHAMBERS CREEK AT MOUTH NEAR EUREKA																						
Jan. 10, 1957		1.4		136	30	2,550		d505		73	3,920				6,960	9.47		464	51	51	11,900	8.6
87. TEHUACANA CREEK NEAR FAIRFIELD																						
May 12, 1956	--	9.8		21	7.6	156		67		23	243	--	1.2		495	0.67		84	29	7.4	956	6.7
June 6	--	9.6		26	8.4	209		92		30	315	0.8	.9		645	.88		99	24	9.1	1,250	7.3
Nov. 5	--	5.4		33	11	450		44		24	738	.5	2.8		1,290	1.75		128	92	17	2,430	6.8
Jan. 10, 1957	--	.9		194	71	1,800		77		84	3,220	--	--		5,410	7.36		775	712	28	9,520	7.3
Feb. 22	--	4.0		22	9.8	356		87		20	550	.6	.8		1,010	1.37		96	24	16	1,910	7.2
Mar. 19	--	.9		41	16	576		90		58	910	.5	.8		1,650	2.24		168	94	19	3,090	7.8
Mar. 27	--	9.6		18	5.8	192		60		15	298	.6	1.2		570	.78		69	20	10	1,090	7.2
June 4	--	8.0		69	23	254		69		50	500	--	5.7		944	1.28		266	210	6.8	1,780	6.6
Oct. 3	--	3.9		62	20	511		79		46	875	.4	.2		1,560	2.12		236	172	15	2,990	7.8
Dec. 26	--	13		63	19	147		128		86	255	.3	.8		647	.88		235	130	4.2	1,190	7.7
Mar. 11, 1958	--	9.8		65	25	252		139		91	428	--	.8		940	1.28		265	151	6.7	1,750	7.2
Sept. 26	--	11		32	7.5	177		95		18	283	--	1.5		a626	.85		111	33	7.3	1,090	7.3
Oct. 23, 1962	--	6.1		26	10	313		63		28	500	.5	.0		a952	1.29		106	54	13	1,740	6.3
Nov. 28	296	7.3		28	10	402		44		10	665	.3	.0		1,140	1.55		111	75	17	2,250	5.8
Feb. 10, 1965	1,110	7.5		--	--	--		38		10	161	--	--		--	--		60	29	--	623	6.7

a Residue at 180°C.
c Field estimate.
d Includes equivalent of 31 parts per million of carbonate (CO_3).

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Non-carbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
88. COTTONWOOD CREEK NEAR FAIRFIELD																						
May 12, 1956	--	13		35	12	171		58		33	301	--	1.1		595	0.81		136	88	6.4	1,130	6.9
June 6	--	11		53	19	232		86		49	420	0.7	.4		827	1.12		211	190	7.0	1,590	7.4
Nov. 5	--	6.4		19	7.7	298		59		26	460	.4	3.0		850	1.16		79	30	15	1,590	6.9
Feb. 22, 1957	--	9.2		14	3.6	71		50		24	95	.8	2.8		245	.33		50	9	4.4	453	6.7
Mar. 19	--	9.0		19	5.5	97		64		34	133	.6	2.8		332	.45		69	16	5.1	611	7.5
Mar. 27	--	13		13	4.5	66		59		18	86	.6	5.7		236	.32		51	3	4.0	431	6.6
June 4	--	7.2		49	17	166		70		47	315	--	2.5		638	.87		192	135	5.2	1,220	7.5
Oct. 3	--	7.8		9.6	3.0	35		34		14	50	.0	.5		137	.19		36	8	2.5	254	7.1
Dec. 26	--	16		64	19	245		110		84	420	.4	.8		990	1.35		238	148	6.9	1,700	7.1
Mar. 11, 1958	--	14		73	22	279		98		102	490	.5	1.0		1,030	1.40		272	192	7.4	1,880	7.8
Sept. 26	--	12		14	4.8	58		44		15	91	--	1.0		218	.30		55	19	3.4	411	6.8
Oct. 23, 1962	c0.01	7.9		47	18	110		80		74	204	.4	.8		a543	.74		192	126	3.5	938	6.5
Nov. 28	31.9	9.8		8.5	2.6	32		40		19	34	.5	.2		127	.17		32	0	2.5	224	5.8
Mar. 12, 1963	11.4	16		36	13	116		58		62	200	.4	.5		473	.64		144	96	4.2	882	5.8
89. CATFISH CREEK NEAR TENNESSEE COLONY																						
Apr. 2, 1964	45:0	11		11	4.5	17		10		41	23	0.1	0.0		113	0.15		46	38	1.1	200	6.0
June 9	20.4	17		10	4.6	16		15		35	21	.1	.2		111	.15		44	32	1.0	183	6.2
July 14	6.52	13		7.0	3.3	15		17		25	16	.1	.2		88	.12		31	17	1.2	145	6.8
Feb. 17, 1965	209	17		10	4.4	18		5		44	22	.2	.5		118	.16		43	39	1.2	197	5.8
May 11	174	13		8.8	3.9	14		13		31	17	.2	.5		94	.13		38	27	1.0	157	5.9
May 19	925	19		16	7.6	8.6	3.3	0		86	12	.2	.2		153	.21		71	71	.4	264	e3.9
May 20	674	27		22	12	14	4.4	0		128	19	.3	.2		227	.31		104	104	.6	400	f3.5
June 2	85.4	16		12	3.9	16		23		33	19	.2	.5		112	.15		46	27	1.0	182	6.1
91. UPPER KEECHI CREEK NEAR OAKWOOD																						
June 4, 1962	16.4	19		21	9.1	28		21		67	44	0.2	0.8		199	0.27		90	73	1.3	343	6.8
July 13	2.26	17		20	9.4	28		38		53	44	.3	.0		191	.31		89	57	1.3	338	7.0
Nov. 27	16.5	22		15	7.1	24		3		65	34	.2	.0		168	.23		67	64	1.3	266	5.2
Jan. 2, 1963	6.59	28		19	10	34		0		92	47	.2	.2		a241	.33		89	89	1.6	366	4.5
Feb. 5	6.37	26	0.1	18	10	33		0		91	47	.2	.2		a236	.32		86	86	1.5	367	g4.2
Mar. 12	13.1	20		22	11	35		1		92	55	.2	1.0		236	.32		100	99	1.5	396	4.7
Apr. 17	3.22	18		24	11	40		16		89	61	.3	.5		252	.34		105	92	1.7	411	6.9
May 21	5.20	19		23	11	36		24		85	51	.3	.2		238	.32		103	83	1.5	388	5.8
July 2	.12	12		15	7.7	25		36		43	35	.2	.2		156	.21		69	40	1.3	282	6.5
Apr. 29, 1964	212	10		11	4.5	15		29		29	16	.2	.8		100	.14		46	22	1.0	173	6.1
Do.	165	11		12	5.4	15		27		35	18	.1	.5		110	.15		52	30	.9	193	6.2

a Residue at 180°C.
c Field estimate.
e Contains 0.30 ppm total acidity as H^{+1}.
f Contains 0.42 ppm total acidity as H^{+1}.
g Contains 0.1 ppm total acidity as H^{+1}.

Date of collection	Discharge (cfs)	Silica (SiO2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO3)	Carbonate (CO3)	Sulfate (SO4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO3)	Boron (B)	Dissolved solids (calculated) Parts per million	Dissolved solids Tons per acre-foot	Dissolved solids Tons per day	Hardness as CaCO3 Calcium, Magnesium	Hardness as CaCO3 Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
92. BIG ELKHART CREEK NEAR GRAPELAND																						
July 11, 1962	14.0	17		8.2	3.2	40		24		3.4	68	0.1	1.2		153	0.21		34	14	3.0	281	6.7
Oct. 26	14.3	14		11	4.5	66		19		4.6	119	.2	1.8		a242	.33		46	30	4.2	439	7.0
Jan. 5, 1963	36.9	17		11	4.4	40		21		8.8	74	.1	.8		166	.23		46	28	2.6	305	6.0
Feb. 8	24.0	15		10	4.3	40		21		7.2	74	.1	1.5		162	.22		43	25	2.7	297	5.9
Mar. 15	23.4	15		10	4.6	39		27		6.4	70	.1	1.2		a166	.23		44	22	2.6	294	6.2
May 20	18.6	17		10	3.7	44		20		7.4	79	.1	.8		172	.23		40	24	3.0	304	6.0
July 4	10.2	17		10	4.1	54		22		3.2	98	.1	.0		197	.27		42	24	3.6	407	6.6
Apr. 27, 1964	146	12		9.5	3.2	31		21		9.2	55	.1	.2		130	.18		37	20	2.2	252	6.0
93. LITTLE ELKHART CREEK NEAR CROCKETT																						
May 27, 1965	21.0	19		9.0	3.3	11		31		13	12	0.2	3.2		86	0.12		36	11	0.8	126	6.4
June 30	11.7	18		5.5	2.0	6.2	1.5	26		6.0	6.3	.1	.8		59	.08		22	1	.6	83	6.2
94. HURRICANE BAYOU NEAR CROCKETT																						
July 2, 1965	1.04	15		36	13	44		86		82	58	0.3	0.2		290	0.39		143	73	1.6	509	6.4
96. LOWER KEECHI CREEK NEAR CENTERVILLE																						
Oct. 23, 1962	0.45	17		26	8.2	31		26		86	38	0.2	0.0		a225	0.31		99	77	1.4	352	6.2
Nov. 26	5.10	25		20	6.6	30		18		71	38	.2	.0		a217	.30		77	62	1.5	315	5.9
Feb. 5, 1963	11.3	22		23	8.2	31		26		70	45	.2	.2		a226	.31		91	70	1.4	347	6.0
Mar. 11	15.2	20		30	10	34		33		82	54	.2	.0		246	.33		116	89	1.4	413	5.9
Apr. 17	7.43	20		29	9.4	38		56		71	52	.3	.2		248	.34		111	65	1.6	395	6.3
May 23	15.2	17		19	5.5	25		28		53	32	.2	.5		166	.23		70	47	1.3	265	6.0
98. BEDIAS CREEK NEAR MADISONVILLE																						
July 9, 1962	1.79	12		18	5.6	26		60		32	29	0.2	0.2		153	0.21		68	19	1.4	264	6.8
Oct. 22	.20	14		29	9.1	36		56		71	48	.2	.2		a254	.35		110	64	1.5	395	6.2
Nov. 30	129	7.6		6.2	1.6	6.7	5.2	20		12	9.2	.3	.2		59	.08		22	6	.6	95	5.7
Mar. 11, 1963	8.90	17		26	7.7	39		34		76	52	.2	.2		a258	.35		96	69	1.7	388	5.8
Apr. 27, 1964	740	9.5		8.5	1.9	7.6	4.9	27		12	9.0	.3	3.2		70	.10		29	7	.6	115	5.7
99. CANEY CREEK NEAR MADISONVILLE																						
Jan. 27, 1964	0.03	12		18	4.4	28		40		49	28	0.2	0.8		160	0.22		63	30	1.5	278	6.2
Jan. 31	11.4	9.1		7.2	1.7	5.6	3.9	26		8.8	5.6	.4	.5		56	.08		25	4	.5	84	5.9
Mar. 2	27.1	8.7		9.0	2.3	7.7	4.2	30		13	8.5	.3	.0		69	.09		32	7	.6	113	6.1
Apr. 2	.39	14		36	9.8	51		78		90	58	.2	.2		297	.40		130	66	1.9	501	7.3
Apr. 26	239	5.7		8.0	1.7	7.7	5.0	21		14	10	.2	2.0		64	.09		27	10	.6	110	6.0
Apr. 27	365	8.2		10	2.7	5.4	5.3	29		18	5.9	.3	1.2		71	.10		36	12	.4	118	6.1

a Residue at 180°C.

Table 6.--Chemical analyses of streams and reservoirs in the Trinity River basin for locations other than daily stations--Continued

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): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
100. NELSONS CREEK NEAR RIVERSIDE																						
Jan. 11, 1965-----	15.5	29		22	5.6	23		46		31	41	0.2	0.5		175	0.24		78	40	1.1	285	6.6
July 2------------	1.07	44		28	4.4	42		30		69	58	.2	.5		261	.35		88	63	1.9	404	5.9
101. HARMONS CREEK NEAR RIVERSIDE																						
Jan. 11, 1965-----	12.0	25		40	2.0	38		124		16	51	0.4	0.5		234	0.32		108	6	1.6	400	6.9
103. GAIL CREEK NEAR LOVELADY																						
July 13, 1962-----	0.31	12		28	9.0	48		59		64	67	0.2	0.2		257	0.35		107	58	2.0	450	6.9
Oct. 26-----------	.001	8.9		40	12	70		78		88	103	.2	.5		a368	.50		150	86	2.5	638	6.5
Nov. 30-----------	8.68	8.1		11	3.4	18		18		34	21	.3	.0		105	.14		41	27	1.2	183	5.5
Feb. 8, 1963------	2.52	22		47	16	95		32		176	128	.2	.0		a545	.74		184	158	3.0	824	5.9
Mar. 15-----------	3.37	17		43	15	83		42		144	117	.2	.2		a468	.64		169	134	2.8	751	6.0
May 20------------	.85	18		41	14	83		68		118	115	.2	.0		422	.57		160	104	2.9	724	6.4
July 4------------	16.4	6.6		12	4.6	22		37		30	24	.3	.5		118	.16		49	19	1.4	218	6.3
Apr. 27, 1964-----	631	7.4		7.0	2.6	12		28		17	8.7	.3	.8		70	.10		28	5	1.0	122	5.8
104. WHITE ROCK CREEK NEAR TRINITY																						
Dec. 1, 1963------	0.20	15		44	11	113		44		209	104	0.2	0.0		518	0.70		155	119	3.9	860	6.5
Dec. 30-----------	2.37	8.4		22	6.3	41		16		93	42	.2	.2		221	.30		81	68	2.0	378	6.2
May 18, 1964------	9.41	28		41	11	64		33		140	79	.2	2.5		382	.52		148	120	2.3	629	6.4
Apr. 23, 1965-----	1.40	26		34	12	65		59		93	92	.2	.2		351	.48		134	86	2.4	615	6.5
May 28------------	.35	16		30	10	62		62		88	76	.2	.2		312	.42		116	65	2.5	536	6.6
105. KICKAPOO CREEK NEAR ONALASKA																						
Dec. 4, 1963------	6.98	23		24	2.9	30		63		38	32	0.2	0.5		182	0.25		72	20	1.5	292	6.7
Jan. 3, 1964------	4.05	25		34	3.4	36		89		45	40	.2	.2		228	.31		99	26	1.6	369	6.8
June 17-----------	14.8	31		29	2.3	33		74		44	33	.2	.2		209	.28		82	21	1.6	325	7.5
107. MENARD CREEK NEAR RYE																						
Aug. 21, 1950-----	34.8	14		7.9	2.4	15		25		1.2	29	--	0		82	0.11		30	9	--	140	6.8
Sept. 19, 1963----	75.1	11		12	1.7	41		9		3.0	82	0.1	.2		155	.21		37	30	2.9	307	5.6
Feb. 20, 1964-----	44.8	14		14	2.7	49		10		3.0	99	.2	.2		187	.25		46	38	3.1	367	5.8
Mar. 4------------	476	5.9		4.0	1.0	7.7	1.9	6		3.6	15	.1	.0		42	.06		14	9	.9	82	5.4
Mar. 26-----------	87.2	11		10	2.0	29		12		3.6	58	.0	.2		120	.16		33	23	2.2	235	6.1
May 11------------	37.6	12		15	2.6	51		14		.2	104	.0	.2		192	.26		48	37	3.2	384	6.1
108. BIG CREEK NEAR SHEPHERD																						
Aug. 21, 1950-----	15.4	16		13	2.8	12		46		4.0	20	--	1.2		92	0.13		44	6	--	146	6.8
Sept. 19, 1963----	17.5	15		3.5	1.0	7.0	1.7	9		5.4	12	0.1	.2		50	.07		13	5	.8	74	5.4
Dec. 9------------	6.70	16		4.0	1.5	7.8	1.0	13		3.4	14	.1	.2		54	.07		16	6	.8	81	6.2
Feb. 17, 1964-----	16.1	15		4.5	1.2	7.5	1.0	12		4.8	13	.2	.2		53	.07		16	6	.8	80	6.2
Mar. 11-----------	73.3	12		3.8	1.1	5.5	1.4	9		7.2	8.5	.1	.0		44	.06		14	7	.6	66	5.7
Mar. 23-----------	24.3	13		1.0	1.2	7.7	.8	14		4.4	12	.1	.0		50	.07		15	4	.9	78	6.2

a Residue at 180°C.