TEXAS WATER DEVELOPMENT BOARD

REPORT 112

# QUANTITY AND CHEMICAL QUALITY OF LOW FLOW IN CIBOLO CREEK, TEXAS, MARCH 4-8, 1968

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## ABSTRACT

This report defines the changes in quantity and inorganic chemical quality of base flow of Cibolo Creek within a reach that extends from the stream-gaging station Cibolo Creek at Selma, mile 89.6, downstream to a point 2.5 miles upstream from the mouth. The investigation was made during a period (March 4-8, 1968) when evapotranspiration was at a minimum. Discharge increased in a downstream direction, from no flow at about mile 88 to 67.4 cfs (cubic feet per second) at mile 2.5, as compared to an increase from no flow to 18.6 cfs during a similar investigation in March 1963. Dissolved-solids concentrations also increased in a downstream direction throughout the reach. The chemical-quality patterns of the 1963 and 1968 investigations are similar.

# QUANTITY AND CHEMICAL QUALITY OF LOW FLOW IN CIBOLO CREEK, TEXAS, MARCH 4-8, 1968

## PURPOSE AND SCOPE OF THE INVESTIGATION

The purposes of this investigation were to define the changes in quantity and inorganic chemical quality of base flow in Cibolo Creek from the gaging station Cibolo Creek at Selma to the mouth of Cibolo Creek, and to compare the results of this investigation with the investigation made in March 1963 by Holland and Welborn (1965).

The fieldwork for this investigation was done during March 4-8, 1968, when evapotranspiration was at a minimum. Discharge measurements were made and water samples were collected at 25 sites on Cibolo Creek and at 18 sites on tributaries to Cibolo Creek. No-flow observations were made at two sites on Cibolo Creek and at 11 sites on tributaries (Table 1).

## DESCRIPTION OF THE BASIN

Cibolo Creek rises northwest of the study area, and flows southeasterly to form the Bexar-Guadalupe county line, then flows through Wilson County and into Karnes County, where it enters the San Antonio River about two miles east of Panna Maria (Figure 3). The study area for this investigation begins at the gaging station Cibolo Creek at Selma, at mile 89.6 (distance in river miles measured upstream from the mouth), and extends to a point 2.5 miles upstream from the mouth.

The drainage area of the study area is 581 square miles. The topography is steep hill country from mile 89.6 to about mile 40. Downstream from about mile 40, the topography gradually changes to low rolling hills. The mean slope of the creek channel from mile 89.6 to mile 0 is 5.6 feet per mile.

The rock units exposed in the study area range in age from Cretaceous (Austin Chalk, Taylor Marl, Navarro Group) to Holocene. These rocks dip southeastward toward the Gulf of Mexico at a rate slightly greater than the dip of the land surface, and the outcrops formed by the dissected edges of the strata trend generally northeastward. The younger units crop out nearest the Gulf and the older beds crop out successively farther inland (Figure 3). Alluvial deposits of Pleistocene and Holocene age occur at the surface in much of the area; these deposits are not shown on Figure 3.

## CONDITIONS OF FLOW

During this investigation, the flow in Cibolo Creek was sustained by ground-water effluent, sewage effluent, and return flow from bank storage. Evapotranspiration was at a minimum.

The discharge at the gaging station Cibolo Creek near Falls City (site 52) increased 2 cfs (cubic feet per second), 3 percent, on March 6 due to light, fairly uniform rain on the study area on the night of March 5. The gaging station Cibolo Creek at Selma (site 1) had no flow throughout the investigation. Site 23, where the last discharge measurement made on March 5, was remeasured on March 6 to determine the increase in discharge due to the light rain. The increase was 1.4 cfs, 4 percent, and was considered not enough to justify repeating the investigation. This increased flow due to runoff probably affected the chemical quality of the base flow; however, it was not possible to determine whether the chemical quality was improved or deteriorated by this runoff.

Universal City, Randolph Air Force Base, Schertz, Converse, and Stockdale discharge sewage effluent into Cibolo Creek in the study area. The Converse wastewater treatment plant treats sewage from Live Oak Village (a rapidly growing residential area northwest of Universal City) as well as from the town of Converse. The sewage effluent discharged is measured at all treatment plants except the Stockdale plant. The average daily discharges for the period of this investigation are as follows (data furnished by the sewage treatment plant operators):

| PLANT | AVERAGE SEWAGE EFFLUENT (GALLONS PER DAY) | (CFS) |
|---|---|---|
| Universal City | 370,000 | 0.57 |
| Randolph Air Force Base | 1,028,000 | 1.59 |
| Schertz | 350,000 | .54 |
| Converse | 400,000 | .62 |
| Stockdale | Not known | -- |

## GAINS AND LOSSES IN FLOW

The study area was subdivided into three subreaches (Table 2) on the basis of significant changes in quantity and quality of water. The subreaches were also picked to coincide, as nearly as possible, with those used in the March 1963 investigation (Holland and Welborn, 1965).

There was a net gain in flow throughout each subreach (Table 2). These gains are attributed to sewage effluent, tributary inflow, ground-water effluent, and return flow from bank storage. Losses in streamflow (Table 1) probably occurred due to underflow at some of the discharge measurement sites. Losses of streamflow can also be attributed to loss of water to the creekbed alluvium; however, because of the high base-flow condition, these losses were probably at a minimum. No diversion from Cibolo Creek or its tributaries was observed during the investigation.

Ground-water effluent and return flow from bank storage during this investigation should not necessarily be considered average, because supporting data concerning the altitude of the water table and the amount of water in bank storage are not available.

## CHEMICAL QUALITY OF THE WATER

Chemical quality of the water in Cibolo Creek (Table 3) generally deteriorated in the first subreach. Dissolved-solids concentration increased from 387 mg/l (milligrams per liter) at site 4 to 511 mg/l at site 16 (Figure 1 and 2). Inflow from several unnamed tributaries (sustained by sewage effluent) and Santa Clara Creek, all of which contained water with high concentrations of sodium and chloride, was responsible for the deterioration of chemical quality in the first subreach. Chemical quality of the water in Cibolo Creek improved where no tributary inflow was found.

Chemical quality of the water in Cibolo Creek remained essentially the same in the second subreach. Dissolved solids, however, decreased from 511 mg/l at site 16 to 489 mg/l at site 33. The increment of good quality water from ground-water effluent was probably the reason for the constancy of the quality of water in this subreach. Inflow from Martinez Creek (partially sustained by sewage effluent from the Converse sewage treatment plant) at site 21 and from Elm Creek (1,680 mg/l dissolved solids and 0.20 cfs discharge) at site 24 caused the dissolved-solids concentration to increase to 520 mg/l at site 25. Highly mineralized Elm Creek, which drains one of the largest oil fields in the study area, may be polluted by oil-field wastes, as indicated by Holland and Welborn (1965, p. 6). Downstream from site 28, ground-water effluent and tributary inflow caused a slight improvement in the chemical quality of water at site 33.

Streamflow within the third subreach exhibited a progressive increase in all dissolved constituents except fluoride and nitrate. Dissolved solids increased from 489 mg/l at site 33 to 774 mg/l at site 56 (2.5 miles upstream from mouth). Inflow from two unnamed tributaries, Alum Creek, Clifton Branch, and Casiano Creek was responsible for only a slight deterioration in chemical quality of water in Cibolo Creek. Anders (1957 and 1960) reports that almost all the geologic formations traversed by Cibolo Creek in this subreach yield water of poor chemical quality to wells. Therefore, the deterioration in chemical quality is probably due primarily to saline ground-water effluent in the subreach. The exact source of the highly mineralized water in Casiano Creek (9,930 mg/l dissolved solids, 15,400 micromhos specific conductance, and 0.06 cfs discharge) at site 51 was not determined during this investigation. However, a study of the county maps of the drainage area of Casiano Creek shows a concentration of oil-field activities. Casiano Creek may therefore be contaminated by oil-field wastes.

## COMPARISON OF MARCH 1963 AND MARCH 1968 INVESTIGATIONS

The antecedent conditions of the March 1963 investigation were quite different from those of the March 1968 investigation. Rainfall on the study area prior to the 1963 investigation was about normal, whereas, prior to the 1968 investigation, the rainfall on the study area was above normal. For instance, the rainfall at San Antonio in January and February 1968 was 10.1 inches, and the rainfall in the same two months in 1963 was 3.86 inches. The normal (1931-60 average) rainfall for these two months totals 3.39 inches.

Water-bearing rocks in the study area were producing more base flow than during the 1963 investigation because of the antecedent rainfall conditions. However, the areas of gains and losses along Cibolo Creek as identified during the 1963 base-flow investigation were generally confirmed by this investigation (Figure 1).

Changes in water quality along Cibolo Creek were similar in the 1963 and 1968 investigations (Figures 1 and 2). During each investigation the water changed

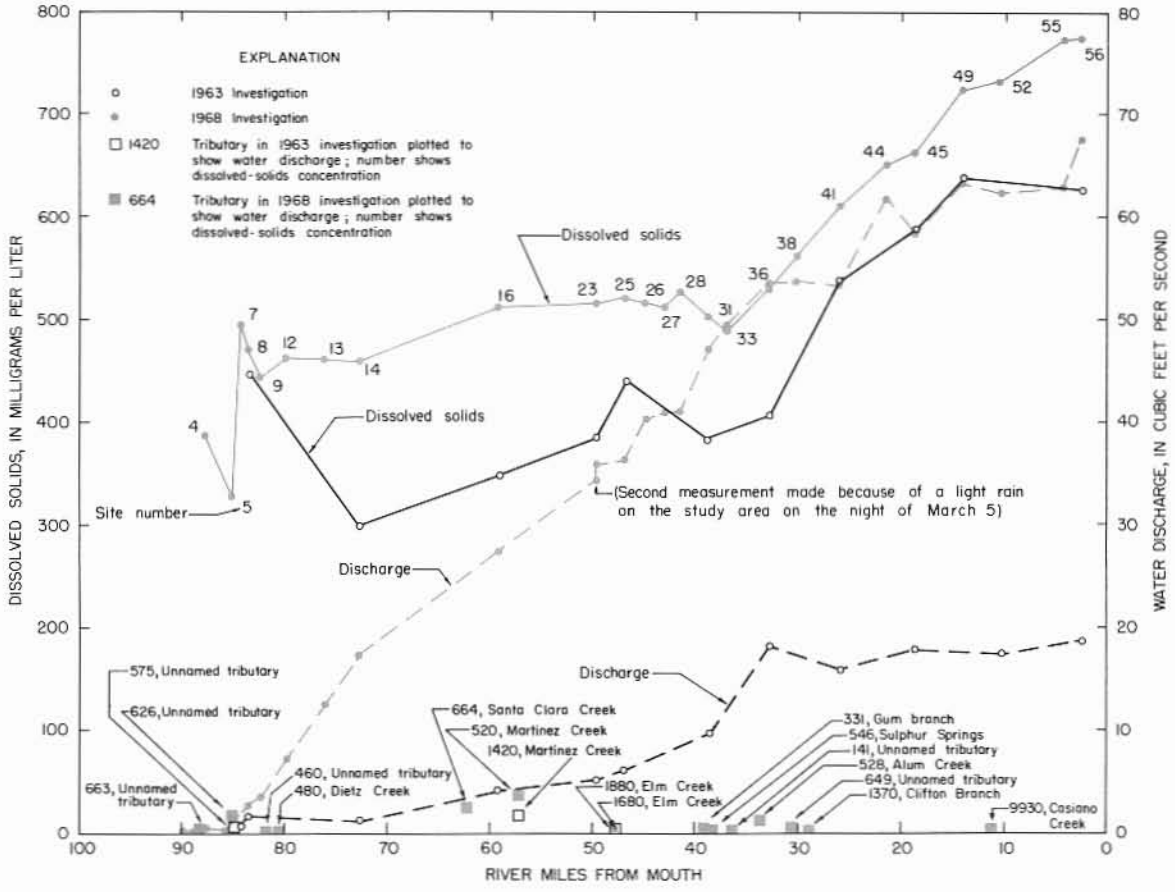


Figure 1.--Dissolved-Solids Concentration and Discharge for Cibolo Creek, March 5-7, 1963, and March 4-8, 1968

from a calcium bicarbonate type in the upper part of the study area to a mixed type at the mouth, and the relative proportions of chemical constituents were very similar at most sites during the two studies. However, the water in the 1968 investigation contained higher dissolved solids at the mouth than in the 1963 investigation. The effects of sewage effluent were again noted in the upper part of the Cibolo Creek study area. A chemical quality sample obtained from Elm Creek again indicated continued oil-field contamination.

Storm runoff from the runways and other areas at Randolph Air Force Base continues to empty into Cibolo Creek at mile 83.9 as reported by Holland and Welborn (1965, p. 3). No flow in the storm system was observed during this investigation. Waste water from vehicle and airplane maintenance is no longer discharged into Cibolo Creek via a large open pit in the creek gravel near the stream, as reported by Holland and Welborn (1965, p. 3). At the time the fieldwork was being done on this investigation, Randolph Air Force Base was beginning to dispose of waste water in the following manner, according to Mr. Pete Armstrong, Director of Sanitation at the base. Waste water from the base kitchens and vehicle and airplane maintenance flows into two septic tanks located on the base. The greases are separated from the water in the tanks and hauled to Randolph Air Force Base sanitary fill, which is a few miles southeast of Schertz, where they are buried. The grease-free water is moved by means of French drains (rubble drain used to dispose of liquids underground) to the golf course for irrigation.

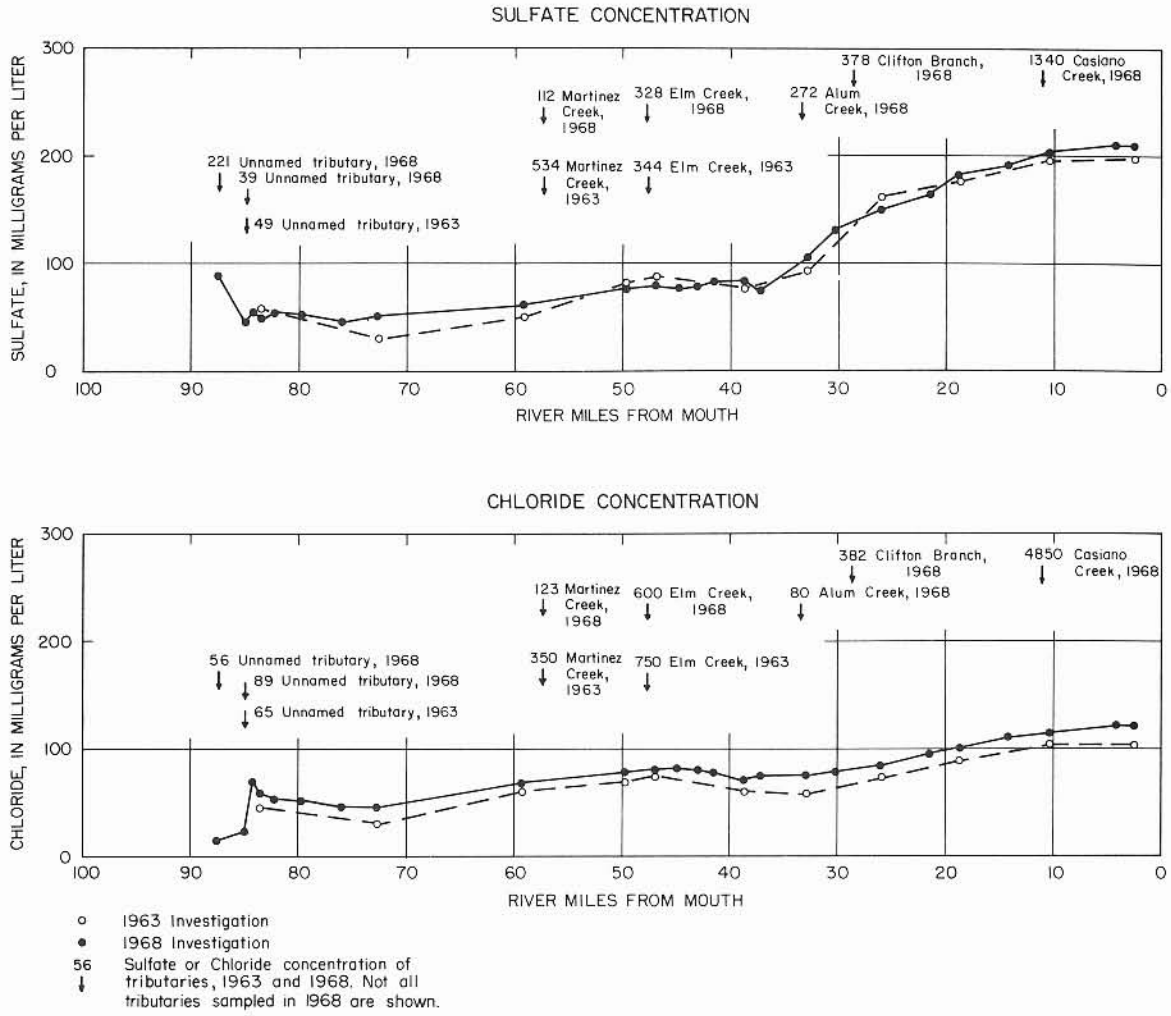


Figure 2.--Chloride and Sulfate Concentrations for Cibolo Creek, March 5-7, 1963, and March 4-8, 1968

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Holland, P. H., and Welborn, C. T., 1965, Base-flow studies, Cibolo Creek, Texas, quantity and quality, March 5-7, 1963: Texas Water Comm. Bull. 6511, 13 p., 3 figs., 1 pl.

Table 1.--Discharge Measurements, Cibolo Creek and Tributaries

| SITE | DATE (MAR. 1968) | STREAM | LOCATION | RIVER MILE 1/ | WATER TEMP. °C | WATER TEMP. °F | DISCHARGE IN CFS MAIN STREAM | DISCHARGE IN CFS TRIBUTARY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | Cibolo Creek | Lat 29°35'35", long 98°18'40", at gaging station (8-1850.0) at Selma. | 89.6 | -- | -- | 0 | -- | Streambed material is gravel and rock. |
| 2 | 4 | do | Lat 29°35'04", long 98°18'14", at Interstate Highway 35. | 88.7 | -- | -- | 0 | -- | Do. |
| 3 | 4 | Unnamed tributary | Lat 29°34'13", long 98°18'10", 300 ft upstream from mouth. " | 87.5 2/ | 10 | 50 | -- | 0.15 3/ | Streambed material is rock and sand. |
| 4 | 4 | Cibolo Creek | Lat 29°34'09", long 98°18'08", 30 ft downstream from unnamed tributary (right bank). | 87.5 | 14 | 57 | .43 | -- | Streambed material is gravel. |
| 5 | 4 | do | Lat 29°33'03", long 98°16'30", 500 ft upstream from Universal City sewage effluent. | 85.0 | 14 | 58 | .15 | -- | Do. |
| 6 | 4 | Unnamed tributary | Lat 29°32'54", long 98°16'44", 0.4 mi upstream from mouth, Universal City sewage effluent. | 84.9 2/ | 19 | 67 | -- | 1.17 | Streambed material is rock. Flow is Universal City sewage. |
| 6 | 8 | do | Lat 29°32'54", long 98°16'44", 0.4 mi upstream from mouth, Universal City sewage effluent. | 84.9 2/ | 20 | 68 | -- | 1.2 3/ | Do. |
| 7 | 4 | Cibolo Creek | Lat 29°32'35", long 98°15'57", 15 ft downstream from first crossing upstream from Randolph AFB sewage plant. | 84.2 | 13 | 55 | .90 | -- | Streambed material is gravel. |
| 8 | 4 | do | Lat 29°32'23", long 98°15'20", 80 ft downstream from crossing of road to Lone Star gravel plant. | 83.5 | 14 | 58 | 2.66 | -- | Do. |
| 9 | 5 | do | Lat 29°33'09", long 98°15'34", measured in large meander. | 82.3 | 13 | 55 | 3.45 | -- | Streambed material is gravel and sand. |
| 10 | 8 | Unnamed tributary | Lat 29°32'58", long 98°15'06", at Schertz sewage release, 0.05 mi upstream from mouth, 100 ft downstream from plant. | 81.5 2/ | 18 | 64 | -- | .05 3/ | Streambed material is sandy loam. Flow is Schertz sewage. |

See footnotes at end of table.

Table 1.--Discharge Measurements, Cibolo Creek and Tributaries --Continued

| SITE | DATE (MAR. 1968) | STREAM | LOCATION | RIVER MILE [1] | WATER TEMP. °C | WATER TEMP. °F | DISCHARGE IN CFS MAIN STREAM | DISCHARGE IN CFS TRIBUTARY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 4 | Dietz Creek | Lat 29°33'33", long 98°14'50", 0.25 mi upstream from mouth, at Farm Road 78. | 80.9[2] | 12 | 54 | -- | .04[3] | Streambed material is gravel. |
| 12 | 5 | Cibolo Creek | Lat 29°33'03", long 98°13'50", 10 ft upstream from county road. | 79.7 | 13 | 56 | 7.12 | -- | Do. |
| 13 | 4 | do | Lat 29°31'26", long 98°12'59", 5 ft upstream from Farm Road 2538. | 76.0 | 15 | 59 | 12.5 | -- | Streambed material is gravel and sand |
| 14 | 5 | do | Lat 29°30'11", long 98°11'13", 1,000 ft upstream from U.S. Highway 90. | 72.6 | 14 | 57 | 17.3 | -- | Streambed material is sand and silt. |
| 15 | 5 | Santa Clara Creek | Lat 29°29'16", long 98°07'10", 1.2 mi upstream from mouth, 200 ft downstream from county road. | 62.2[2] | 12 | 53 | -- | 2.67 | Streambed material is gravel. |
| 16 | 5 | Cibolo Creek | Lat 29°27'10", long 98°07'26", 50 ft upstream from Farm Road 2538. | 59.2 | 13 | 55 | 27.4 | -- | Streambed material is gravel and sand. |
| 17 | 8 | Woman Hollering Creek | Lat 29°30'58", long 98°16'31", 100 ft downstream from Randolph Field Golf Course Lake, 10.8 mi upstream from Martinez Creek. | 57.3[2] | 18 | 64 | -- | .60[3] | Streambed material is sand. |
| 18 | 5 | do | Lat 29°28'57", long 98°11'52", 50 ft upstream from county road, 4.1 mi upstream from Martinez Creek, which is 4.8 mi upstream from Cibolo Creek. | 57.3[2] | 11 | 52 | -- | 2.81 | Streambed material is sand and gravel. |
| 19 | 5 | Salitrillo Creek | Lat 29°26'40", long 98°13'20", 15 ft upstream from Farm Road 1518, 0.05 mi upstream from Martinez Creek, which is 7.5 mi upstream from Cibolo Creek. | 57.3[2] | 11 | 52 | -- | 0.43 | Streambed material is silt. |
| 20 | 5 | Martinez Creek | Lat 29°26'38", long 98°13'22", 7.5 mi upstream from mouth and 50 ft downstream from Farm Road 1518. | 57.3 | 12 | 53 | -- | .22[3] | Streambed material is silt and gravel. |

See footnotes at end of table.

Table 1.--Discharge Measurements, Cibolo Creek and Tributaries --Continued

| SITE | DATE (MAR. 1968) | STREAM | LOCATION | RIVER MILE 1/ | WATER TEMP. °C | WATER TEMP. °F | DISCHARGE IN CFS MAIN STREAM | DISCHARGE IN CFS TRIBUTARY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 21 | 5 | do | Lat 29°26'21", long 98°08'16", 1,000 ft upstream from mouth. | 57.3 2/ | 11 | 52 | -- | 3.54 | Streambed material is sandstone and gravel. |
| 22 | 5 | Dry Hollow Creek | Lat 29°21'46", long 98°06'58", at road 0.4 mi upstream from mouth. | 50.0 2/ | -- | -- | -- | 0 | Streambed material is silt. |
| 23 | 5 | Cibolo Creek | Lat 29°21'33", long 98°06'25", 100 ft downstream from Farm Road 775. | 49.6 | 13 | 55 | 34.4 | -- | Streambed material is sand and gravel. |
| 23 | 6 | do | Lat 29°21'33", long 98°06'25", 100 ft downstream from Farm Road 775. | 49.6 | 13 | 55 | 35.8 | -- | Do. |
| 24 | 6 | Elm Creek | Lat 29°21'50", long 98°05'06", 50 ft downstream from Farm Road 2772 and 0.7 mi upstream from mouth. | 47.6 2/ | 11 | 52 | -- | .20 3/ | Streambed material is gravel and rock. |
| 25 | 6 | Cibolo Creek | Lat 29°21'04", long 98°04'27", 150 ft downstream from first county road crossing downstream from LaVernia. | 46.8 | 12 | 54 | 36.3 | -- | Streambed material is sand and gravel. |
| 26 | 6 | do | Lat 29°20'00", long 98°04'32", at upstream edge of Carrizo Sand outcrop. | 44.9 | 12 | 54 | 40.3 | -- | Do. |
| 27 | 6 | do | Lat 29°19'00", long 98°04'22", at Carrizo Sand outcrop. | 43.0 | 10 | 50 | 40.9 | -- | Do. |
| 28 | 6 | Cibolo Creek | Lat 29°18'12", long 98°03'39", at abandoned railroad crossing - Carrizo Sand outcrop. | 41.5 | 14 | 58 | 40.9 | -- | Streambed material is sand and gravel. |
| 29 | 6 | Gum Branch | Lat 29°16'56", long 98°03'50", 0.1 mi downstream from U.S. Highway 87 and 0.4 mi downstream from mouth. | 38.7 2/ | -- | -- | -- | 0 | Streambed material is sandy loam. |
| 30 | 6 | do | Lat 29°17'05", long 98°03'37", 10 ft upstream from mouth. | 38.7 2/ | 16 | 61 | -- | 0.18 3/ | Streambed material is sand and silt. |

See footnotes at end of table.

Table 1.--Discharge Measurements, Cibolo Creek and Tributaries --Continued

| SITE | DATE (MAR. 1968) | STREAM | LOCATION | RIVER MILE [1] | WATER TEMP. °C | WATER TEMP. °F | DISCHARGE IN CFS MAIN STREAM | DISCHARGE IN CFS TRIBUTARY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 31 | 6 | Cibolo Creek | Lat 29°17'06", long 98°03'36", 50 ft downstream from mouth of Gum Branch-Carrizo Sand outcrop. | 38.7 | 14 | 58 | 47.0 | -- | Streambed material is sand and gravel. |
| 32 | 6 | Sulphur Springs | Lat 29°16'50", long 98°03'21", at springs, 0.1 mi upstream from Cibolo Creek. | 37.8[2] | 23 | 74 | -- | .15[3] | Streambed material is silt. |
| 33 | 6 | Cibolo Creek | Lat 29°16'39", long 98°02'55", at downstream edge of Carrizo Sand outcrop. | 37.2 | 15 | 59 | 49.1 | -- | Streambed material is sand and gravel. |
| 34 | 6 | Unnamed tributary | Lat 29°16'34", long 98°01'55", "Spring Flow", at county road 0.3 mi upstream from Cibolo Creek. | 36.2[2] | 18 | 65 | -- | .11[3] | Streambed material is sand. |
| 35 | 6 | Alum Creek | Lat 29°15'32", long 98°01'18", at county road, 0.8 mi upstream from mouth. | 33.4[2] | 20 | 68 | -- | 1.42 | Do. |
| 36 | 6 | Cibolo Creek | Lat 29°14'48", long 98°01'22", 10 ft downstream from U.S. Highway 87. | 32.8 | 16 | 60 | 53.1 | -- | Streambed material is sand and gravel. |
| 37 | 7 | Unnamed tributary | Lat 29°13'11", long 98°00'33", upstream from county road on right bank, 20 ft upstream from mouth. | 30.3[2] | 13 | 55 | -- | .63[3] | Streambed material is sand. |
| 38 | 7 | Cibolo Creek | Lat 29°13'09", long 98°00'32", 500 ft downstream from county road crossing. | 30.2 | 14 | 58 | 53.5 | -- | Streambed material is sand and gravel. |
| 39 | 7 | Clifton Branch | Lat 29°14'18", long 97°59'00", at U.S. Highway 87, at Stockdale, 3.5 mi upstream from mouth. | 28.7[2] | -- | -- | -- | 0 | Streambed material is sandy loam. |
| 40 | 7 | do | Lat 29°13'45", long 97°59'30", at county road, 2.6 mi upstream from mouth, downstream from Stockdale sewer plant. | 28.7[2] | 12 | 54 | -- | .22[3] | Streambed material is sand. Flow is Stockdale sewage. |

See footnotes at end of table.

Table 1.--Discharge Measurements, Cibolo Creek and Tributaries --Continued

| SITE | DATE (MAR. 1968) | STREAM | LOCATION | RIVER MILE 1/ | WATER TEMP. °C | WATER TEMP. °F | DISCHARGE IN CFS MAIN STREAM | DISCHARGE IN CFS TRIBUTARY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 41 | 7 | Cibolo Creek | Lat 29°10'12", long 97°59'41", 100 ft upstream from Farm Road 537. | 26.0 | 14 | 58 | 53.0 | -- | Streambed material is sand. |
| 42 | 7 | Unnamed tributary | Lat 29°10'04", long 97°59'48", 200 ft upstream from mouth. | 25.8 2/ | -- | -- | -- | 0 | Do. |
| 43 | 7 | Wallace Branch | Lat 29°10'21", long 97°58'12", at county road, 2.5 mi upstream from mouth. | 23.1 2/ | -- | -- | -- | 0 | Streambed material is red sand. |
| 44 | 7 | Cibolo Creek | Lat 29°07'34", long 97°58'10", 10 ft downstream from Plummer Crossing. | 21.5 | 14 | 58 | 61.5 | -- | Streambed material is gravel. |
| 45 | 7 | do | Lat 29°05'34", long 97°58'08", at downstream side of low-water crossing on Farm Road 541. | 18.7 | 14 | 57 | 58.1 | -- | Streambed material is sand. |
| 46 | 7 | Pulaski Creek | Lat 29°04'16", long 97°58'12", 2.5 mi upstream from mouth. | 16.7 2/ | -- | -- | -- | 0 | Do. |
| 47 | 7 | Dry Creek | Lat 29°04'02", long 97°56'10", at State Highway 123, 1.2 mi upstream from mouth. | 15.1 2/ | -- | -- | -- | 0 | Do. |
| 48 | 7 | Biala Creek | Lat 29°02'52", long 97°57'14", at county road, 0.7 mi upstream from mouth. | 14.4 2/ | -- | -- | -- | 0 | Streambed material is sand. |
| 49 | 7 | Cibolo Creek | Lat 29°02'44", long 97°56'52", 100 ft downstream from Farm Road 887. | 14.1 | 15 | 59 | 63.0 | -- | Streambed material is rock. |
| 50 | 7 | Unnamed tributary | Lat 29°02'24", long 97°55'56", at State Highway 123, 0.9 mi south of Pawelekville, 1.6 mi upstream from mouth. | 12.1 2/ | -- | -- | -- | 0 | Streambed material is silt. |

See footnotes at end of table.

Table 1.--Discharge Measurements, Cibolo Creek and Tributaries --Continued

| SITE | DATE (MAR. 1968) | STREAM | LOCATION | RIVER MILE 1/ | WATER TEMP. °C | WATER TEMP. °F | DISCHARGE IN CFS MAIN STREAM | DISCHARGE IN CFS TRIBUTARY | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 51 | 7 | Casiano Creek | Lat 29°00'54", long 97°56'32", at county road, 0.1 mi upstream from mouth. | 11.1 2/ | 19 | 66 | -- | .06 3/ | Do. |
| 52 | 7 | Cibolo Creek | Lat 29°00'50", long 97°55'48", at gaging station (8-1860) near Falls City. | 10.4 | 17 | 62 | 62.1 | -- | Streambed material is sand and gravel. |
| 53 | 7 | Jacobs Creek | Lat 28°59'30", long 97°55'31", at State Highway 123, 0.4 mi upstream from mouth. | 7.0 2/ | -- | -- | -- | 0 | Streambed material is sandy loam. |
| 54 | 7 | Mulifest Creek | Lat 29°00'31", long 97°53'52", at county road, 1.9 mi upstream from mouth. | 4.7 2/ | -- | -- | -- | 0 | Streambed material is sand. |
| 55 | 7 | Cibolo Creek | Lat 28°59'24", long 97°53'01", 20 ft upstream from Farm Road 2724. | 4.2 | 16 | 61 | 62.7 | -- | Do. |
| 56 | 7 | do | Lat 28°58'18", long 97°52'30", 25 ft upstream from Farm Road 81. | 2.5 | 17 | 62 | 67.4 | -- | Do. |

1/ River miles determined from topographic maps with mouth = to mile 0.
2/ River mile on Cibolo Creek at mouth of tributary.
3/ Discharge estimated.

Table 2.--Streamflow Gains in Three Subreaches of Cibolo Creek

| SUBREACH | RIVER MILES | CHANGE IN DISCHARGE | NUMBER OF MILES IN SUBREACH | REMARKS |
|---|---|---|---|---|
| Site 1 to site 16 | 89.6 to 59.2 | 27.4 cfs gain | 30.4 | Flow increased in this subreach from 0 to 27.4 cfs from mile 88 to mile 59.2. Dissolved-solids concentration increased from 387 to 511 mg/l. Fifteen discharge measurements were made, and 15 chemical-quality samples were obtained. Chemical quality of water generally deteriorated. Two observations of no flow were made on Cibolo Creek. |
| Site 16 to site 33 | 59.2 to 37.2 | 21.7 cfs gain | 22.0 | This subreach contributed the greatest rate of inflow per unit length of stream. Chemical quality of water remained essentially the same in this subreach. Sixteen discharge measurements were made, and 16 chemical-quality samples were obtained. Two observations of no flow were made on tributaries to Cibolo Creek. |
| Site 33 to site 56 | 37.2 to 2.5 | 18.3 cfs gain | 34.7 | This subreach had a gain of 18.3 cfs; however, small losses occurred between 3 sites. Concentrations of all chemical constituents, except fluoride and nitrate, steadily increased. Fourteen discharge measurements were made, and 14 chemical-quality samples were obtained. Nine observations of no flow were made on tributaries to Cibolo Creek. |

Table 5.--Chemical Analyses of Water From Cibolo Creek and Tributaries, March 7-8, 1968

(Results in milligrams per liter except as indicated)

| SITE | STREAM | DATE OF COLLECTION (MAR. 1968) | DISCHARGE (CFS) | SILICA ($SiO_2$) | CALCIUM (Ca) | MAGNESIUM (Mg) | SODIUM (Na) | POTASSIUM (K) | BICARBONATE ($HCO_3$) | SULFATE ($SO_4$) | CHLORIDE (Cl) | FLUORIDE (F) | NITRATE ($NO_3$) | BORON (B) | DISSOLVED SOLIDS[a] | HARDNESS as $CaCO_3$ CALCIUM, MAGNESIUM | HARDNESS as $CaCO_3$ NONCARBONATE | SODIUM-ADSORPTION RATIO | SPECIFIC CONDUCTANCE (MICROMHOS AT 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Unnamed tributary to Cibolo Creek | 4 | b 0.15 | 11 | 172 | 12 | 37 | 3.3 | 292 | 221 | 56 | 0.5 | 6.2 | -- | 633 | 478 | 239 | 0.7 | 1,010 | 7.4 |
| 4 | Cibolo Creek | 4 | .43 | 12 | 108 | 9.4 | 14 | 2.0 | 261 | 90 | 17 | .5 | 5.7 | -- | 387 | 308 | 94 | .3 | 624 | 7.5 |
| 5 | do | 4 | .15 | 5.2 | 92 | 10 | 13 | 1.9 | 246 | 47 | 24 | .2 | 13 | -- | 327 | 270 | 69 | .3 | 563 | 7.6 |
| 6 | Unnamed tributary to Cibolo Creek | 4 | 1.17 | 24 | c 95 | 16 | 90 | 10 | 466 | 39 | 89 | 10 | 3.0 | -- | d 626 | 298 | 0 | 2.3 | 1,070 | 7.3 |
| 6 | do | 8 | b 1.2 | 20 | 82 | 13 | 82 | 6.4 | 318 | 61 | 79 | 4.6 | .2 | -- | e 504 | 258 | 0 | 2.2 | 876 | 7.2 |
| 7 | Cibolo Creek | 4 | .90 | 10 | 93 | 13 | 68 | 5.5 | 332 | 55 | 70 | 4.1 | 13 | -- | e 495 | 286 | 14 | 1.7 | 848 | 8.0 |
| 8 | do | 4 | 2.66 | 14 | 92 | 14 | 53 | 6.1 | 286 | 51 | 58 | 4.2 | 38 | -- | 471 | 287 | 52 | 1.4 | 782 | 7.4 |
| 9 | do | 5 | 3.45 | -- | -- | -- | -- | -- | 298 | 55 | 54 | -- | -- | -- | f 445 | 292 | 48 | -- | 743 | 7.5 |
| 10 | Unnamed tributary to Cibolo Creek | 8 | b .05 | 20 | 58 | 19 | 68 | 11 | 276 | 67 | 64 | 7.0 | 9.9 | -- | 460 | 222 | 0 | 2.0 | 835 | 7.2 |
| 11 | Dietz Creek | 4 | b .04 | 9.3 | 125 | 7.6 | 37 | 6.0 | 336 | 54 | 54 | .2 | 22 | -- | 480 | 344 | 68 | .9 | 806 | 7.9 |
| 12 | Cibolo Creek | 5 | 7.12 | -- | -- | -- | -- | -- | 334 | 54 | 52 | -- | -- | -- | f 465 | 352 | 78 | -- | 787 | 7.8 |
| 13 | do | 4 | 12.5 | 10 | 103 | 15 | 44 | 3.4 | 342 | 48 | 47 | .9 | 23 | -- | 462 | 318 | 38 | 1.1 | 783 | 7.7 |
| 14 | do | 5 | 17.3 | -- | -- | -- | -- | -- | 336 | 53 | 46 | -- | -- | -- | f 460 | 332 | 56 | -- | 781 | 7.4 |
| 15 | Santa Clara Creek | 5 | 2.67 | 1.0 | 106 | 12 | 115 | 4.6 | 165 | 146 | 193 | .6 | 5.3 | -- | 664 | 314 | 179 | 2.8 | 1,170 | 7.2 |
| 16 | Cibolo Creek | 5 | 27.4 | 6.0 | 105 | 15 | 60 | 3.2 | 332 | 64 | 69 | .4 | 25 | -- | 511 | 324 | 52 | 1.5 | 864 | 7.9 |
| 17 | Woman Hollering Creek | 8 | b .60 | -- | -- | -- | -- | -- | 182 | 52 | 60 | -- | -- | -- | -- | 163 | 14 | -- | 565 | 7.4 |
| 18 | do | 5 | 2.81 | -- | -- | -- | -- | -- | 224 | 90 | 138 | -- | -- | -- | -- | 278 | 94 | -- | 1,010 | 7.4 |
| 19 | Salitrillo Creek | 5 | b .40 | -- | -- | -- | -- | -- | 194 | 203 | 97 | -- | -- | -- | -- | 258 | 99 | -- | 854 | 7.9 |
| 20 | Martinez Creek | 5 | b .22 | -- | -- | -- | -- | -- | 112 | 47 | 12 | -- | -- | -- | -- | 124 | 32 | -- | 305 | 7.1 |

See footnotes at end of table.

Table 3.--Chemical Analyses of Water From Cibolo Creek and Tributaries, March 5-8, 1968--Continued

(Results in milligrams per liter except as indicated)

| SITE | STREAM | DATE OF COLLECTION (MAR. 1968) | DISCHARGE (CFS) | SILICA ($SiO_2$) | CALCIUM (Ca) | MAGNESIUM (Mg) | SODIUM (NA) | POTASSIUM (K) | BICARBONATE ($HCO_3$) | SULFATE ($SO_4$) | CHLORIDE (Cl) | FLUORIDE (F) | NITRATE ($NO_3$) | BORON (B) | DISSOLVED SOLIDS[2] | HARDNESS as $CaCO_3$ CALCIUM, MAGNESIUM | HARDNESS as $CaCO_3$ NONCARBONATE | SODIUM ADSORPTION RATIO | SPECIFIC CONDUCTANCE (MICROMHOS AT 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | do | 5 | 3.54 | .8 | 79 | 10 | 92 | 4.6 | 168 | 112 | 123 | .6 | 15 | -- | 520 | 238 | 100 | 2.6 | 911 | 7.2 |
| 23 | Cibolo Creek | 5 | 34.4 | -- | -- | -- | -- | -- | 314 | 78 | 79 | -- | -- | -- | f 515 | 336 | 78 | -- | 881 | 7.8 |
| 23 | do | 6 | 35.8 | 1.9 | 102 | 15 | 66 | 3.3 | 320 | 73 | 76 | .4 | 19 | -- | 514 | 316 | 54 | 1.6 | 881 | 8.0 |
| 24 | Elm Creek | 6 | b .20 | 9.0 | 244 | 55 | 277 | 6.9 | 330 | 328 | 600 | .3 | 1.1 | -- | 1,680 | 835 | 564 | 4.2 | 2,770 | 7.3 |
| 25 | Cibolo Creek | 6 | 36.3 | -- | -- | -- | -- | -- | 302 | 81 | 81 | -- | -- | -- | f 520 | 344 | 96 | -- | 901 | 7.4 |
| 26 | do | 6 | 40.3 | 2.5 | 102 | 15 | 66 | 3.4 | 298 | 79 | 82 | .4 | 18 | -- | 515 | 316 | 72 | 1.6 | 892 | 7.4 |
| 27 | do | 6 | 40.9 | -- | -- | -- | -- | -- | 298 | 80 | 81 | -- | -- | -- | f 510 | 330 | 86 | -- | 885 | 7.3 |
| 28 | do | 6 | 40.9 | -- | -- | -- | -- | -- | 306 | 84 | 79 | -- | -- | -- | f 525 | 336 | 85 | -- | 876 | 7.7 |
| 30 | Gum Branch | 6 | b .18 | 26 | 68 | 5.6 | 31 | 9.0 | 178 | 66 | 37 | 0.2 | 0.0 | -- | 331 | 192 | 46 | 1.0 | 530 | 7.2 |
| 31 | Cibolo Creek | 6 | 47.0 | -- | -- | -- | -- | -- | 290 | 83 | 72 | -- | -- | -- | f 500 | 300 | 62 | -- | 831 | 7.8 |
| 32 | Sulphur Springs | 6 | b .15 | 16 | 14 | 2.1 | 200 | 4.1 | 468 | 33 | 46 | .9 | .2 | -- | 546 | 44 | 0 | 13 | 881 | 7.9 |
| 33 | Cibolo Creek | 6 | 49.1 | 6.3 | 93 | 14 | 63 | 4.1 | 288 | 77 | 75 | .4 | 14 | -- | 489 | 290 | 54 | 1.6 | 823 | 7.8 |
| 34 | Unnamed tributary to Cibolo Creek | 6 | b .11 | 10 | 30 | 4.2 | 9.6 | 5.0 | 76 | 27 | 18 | .4 | .1 | -- | 141 | 92 | 30 | .4 | 233 | 7.6 |
| 35 | Alum Creek | 6 | 1.42 | 20 | 70 | 22 | 55 | 7.5 | 2 | 272 | 80 | .4 | .0 | -- | 528 | 265 | 264 | 1.5 | 816 | 6.7 |
| 36 | Cibolo Creek | 6 | 53.1 | -- | -- | -- | -- | -- | 278 | 107 | 76 | -- | -- | -- | f 530 | 336 | 108 | -- | 885 | 7.3 |
| 37 | Unnamed tributary to Cibolo Creek | 7 | b .63 | 19 | 118 | 15 | 80 | 11 | 234 | 188 | 102 | .5 | .4 | -- | 649 | 356 | 114 | 1.8 | 1,050 | 7.2 |
| 38 | Cibolo Creek | 7 | 53.5 | -- | -- | -- | -- | -- | 284 | 131 | 78 | -- | -- | -- | 560 | 362 | 130 | -- | 929 | 7.4 |
| 40 | Clifton Branch | 7 | b .22 | 4.0 | 169 | 36 | 262 | 11 | 258 | 378 | 382 | .5 | 1.2 | -- | 1,370 | 496 | 284 | 5.1 | 2,250 | 7.4 |
| 41 | Cibolo Creek | 7 | 53.0 | 6.5 | 112 | 18 | 78 | 5.0 | 288 | 150 | 85 | .4 | 11 | -- | 608 | 354 | 118 | 1.8 | 994 | 7.6 |

See footnotes at end of table.

Table 3.--Chemical Analyses of Water From Cibolo Creek and Tributaries, March 4-8, 1968--Continued

(Results in milligrams per liter except as indicated)

| SITE | STREAM | DATE OF COLLECTION (MAR. 1968) | DISCHARGE (CFS) | SILICA ($SiO_2$) | CALCIUM (Ca) | MAGNESIUM (Mg) | SODIUM (Na) | POTASSIUM (K) | BICARBONATE ($HCO_3$) | SULFATE ($SO_4$) | CHLORIDE (Cl) | FLUORIDE (F) | NITRATE ($NO_3$) | BORON (B) | DISSOLVED SOLIDS[a] | HARDNESS as CaCO3 CALCIUM, MAGNESIUM | HARDNESS as CaCO3 NONCARBONATE | SODIUM ADSORPTION RATIO | SPECIFIC CONDUCTANCE (MICROMHOS AT 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 | do | 7 | 61.5 | 6.5 | 114 | 19 | 89 | 5.1 | 296 | 165 | 96 | .4 | 7.9 | -- | 649 | 362 | 120 | 2.0 | 1,070 | 7.5 |
| 45 | do | 7 | 58.1 | -- | -- | -- | -- | -- | 300 | 182 | 101 | -- | -- | -- | [e] 660 | 406 | 160 | -- | 1,100 | 7.5 |
| 49 | do | 7 | 63.0 | 8.8 | 126 | 21 | 100 | 5.0 | 312 | 191 | 111 | .3 | 7.2 | -- | 724 | 401 | 146 | 2.2 | 1,170 | 7.6 |
| 51 | Casiano Creek | 7 | [b] .06 | 22 | 1,650 | 150 | 1,750 | 42 | 262 | 1,340 | 4,850 | -- | -- | -- | 9,930 | 4,200 | 3,980 | -- | [g] 15,400 | 7.0 |
| 52 | Cibolo Creek | 7 | 62.1 | -- | -- | -- | -- | -- | 292 | 204 | 114 | -- | -- | -- | [f] 730 | 428 | 188 | -- | 1,170 | 7.4 |
| 55 | do | 7 | 62.7 | 12 | 128 | 22 | 113 | 5.5 | 312 | 210 | 122 | .5 | 6.2 | -- | 772 | 410 | 154 | 2.4 | 1,240 | 7.5 |
| 56 | do | 7 | 67.4 | 12 | 127 | 21 | 115 | 5.5 | 310 | 210 | 122 | .5 | 8.8 | 0.35 | [b] 774 | 404 | 150 | 2.5 | 1,240 | 7.6 |



a Calculated from determined constituents.
b Estimated.
c Calculated from ion difference.
d Includes 23 mg/l ammonia and 0.30 mg/l detergents (MBAS).
e Includes 0.25 mg/l detergents (MBAS).
f Calculated from dissolved solids-specific conductance relation.
g Density = 1.008.