TEXAS WATER DEVELOPMENT BOARD

REPORT 105

RECONNAISSANCE OF WATER TEMPERATURE OF SELECTED STREAMS IN SOUTHEASTERN TEXAS

By

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ABSTRACT

During this study, 258 temperature-profile measurements were made at 61 cross sections of seven major streams in Texas. No cross-sectional variations of temperature were observed during 147 measurements. Only 34 measurements showed a temperature difference of more than 0.5°C within a cross section; the maximum difference encountered was 1.5°C. Therefore, point-temperature records reported by the U.S. Geological Survey in Texas are usually representative of the average temperature of water within the stream cross section.

A comparison of stream-temperature records for 10 sites on seven major streams with air-temperature records for nearby U.S. Weather Bureau stations indicates that air temperature is a reasonable index of the temperature of the major streams in the State—provided that temperature is not affected by such artificial influences as addition of treated wastes or presence of impoundments. At eight sites where artificial influence was not significant, the mean monthly water temperatures, as computed from once-daily observations, seldom differed from corresponding mean monthly air temperatures by more than 2°C and often differed by no more than 1°C.

Temperature records for nine once-daily measurement sites and one thermograph site indicate the temperature of Texas streams has varied widely from month to month. The spread between observed monthly maximum and minimum temperatures at these sites averaged at least 3°C. At most sites the spread was smallest during the summer when air temperature was high and solar radiation was maximum. During the other seasons, the spread between observed monthly maximum and minimum temperatures usually averaged more than 6°C.

RECONNAISSANCE OF WATER TEMPERATURE OF SELECTED STREAMS IN SOUTHEASTERN TEXAS

INTRODUCTION

Many physical, chemical, and biological properties of water are closely related to water temperature. Temperature affects the palatability of water, the treatment processes, the value of water for many industrial uses, and the suitability of water as a habitat for aquatic life. Therefore, temperature is an important parameter in determining water quality.

Before 1948, little data on water temperatures in Texas were available. Since 1948, the U.S. Geological Survey has collected stream-temperature data at many sites. Continuous records have been obtained at a few sites by means of thermographs, but most records consist of once-daily observations at daily chemical-quality or sediment stations and periodic observations at stream-gaging stations and miscellaneous sites. Neither the once-daily nor periodic temperature records are adequate substitutes for comprehensive thermograph records, but both have value in developing a reconnaissance description of stream temperature.

Because of the widespread and growing interest in water temperature, all significant stream-temperature data collected in the State by the Geological Survey before October 1966 were compiled by Goines (1967). This compilation included point data and data for depth-integrated water samples collected near the center of flow in the stream cross sections. An analytical study was considered essential to appraise the records and to ensure that these temperature data were representative of the average for the stream. Therefore, in January 1967 the Geological Survey in cooperation with the Texas Water Development Board began a reconnaissance of water temperature for selected sites on most of the principal streams in Texas.

METHODS OF COLLECTING AND REPORTING STREAM-TEMPERATURE DATA

Stream-temperature data have been obtained at thermograph, chemical-quality, sediment, and stream-gaging stations. When most of these stations were established, care was exercised to locate them far enough downstream from tributaries to ensure that water in the main stream was well mixed. Temperatures obtained were in flowing water or of samples collected from near the center of flow. Temperature data at thermograph stations were obtained by means of a sensing element set in flowing water at an elevation of approximately 2 feet below the lowest anticipated water surface. At daily chemical-quality and sediment stations, samples of flowing water were collected and temperatures were measured with a hand thermometer. Temperatures at the stream-gaging stations were also obtained with a hand thermometer.

Before October 1, 1967, the Geological Survey usually reported temperature data to the nearest degree Fahrenheit (°F). Since that time, most of the data have been reported to the nearest degree Celsius (°C). [1] The relation between the Fahrenheit and Celsius scales is shown in Table 1.

Fahrenheit thermometers used by the Geological Survey are graduated in 1° intervals from 30° to 110°F and are rated by the manufacturer as accurate within 0.5°F. These thermometers are gradually being replaced by Celsius thermometers, which are graduated in 1° intervals from -10° to 60°C and are rated accurate within 0.5°C. Thermometers used by the Geological Survey in Texas are tested for accuracy by comparing them with a laboratory-rated thermometer. Usually, both the Fahrenheit and Celsius thermometers are accurate to within one-half the smallest graduation (0.5°F or 0.5°C, respectively).

Thermographs used by the Geological Survey are rated by the manufacturer as accurate within 2°F. Experience in Texas has shown that thermograph and hand-thermometer observations usually agree within 2°F and often agree within 1°F.

[1] The Ninth General Conference on Weights and Measures, October 1948, approved the term "Celsius" for the temperature also known as "Centigrade".

Table 1.—Temperature-Conversion Data

°F	°C	°F	°C	°F	°C	°F	°C
32	0	55	13	78	26	101	38
33	1	56	13	79	26	102	39
34	1	57	14	80	27	103	39
35	2	58	14	81	27	104	40
36	2	59	15	82	28	105	41
37	3	60	16	83	28	106	41
38	3	61	16	84	29	107	42
39	4	62	17	85	29	108	42
40	4	63	17	86	30	109	43
41	5	64	18	87	31	110	43
42	6	65	18	88	31	111	44
43	6	66	19	89	32	112	44
44	7	67	19	90	32	113	45
45	7	68	20	91	33	114	46
46	8	69	21	92	33	115	46
47	8	70	21	93	34	116	47
48	9	71	22	94	34	117	47
49	9	72	22	95	35	118	48
50	10	73	23	96	36	119	48
51	11	74	23	97	36	120	49
52	11	75	24	98	37	121	49
53	12	76	24	99	37	122	50
54	12	77	25	100	38		

Before this stream-temperature study began, two telethermometers were purchased so that water temperature could be measured at any desired depth. Temperature is read directly from the dial of a small console while the probe is stationed at a desired depth. The range of the telethermometer is 30° to 120°F, and accuracy is within 1 percent of the range, or 0.9°F (0.5°C).

All temperature data used in this report have been converted to the Celsius scale. Even though much of the data collected by the telethermometers is not accurate to 0.1°C, temperature differences of 0.1°C can be detected by the instruments. Therefore, all data obtained by use of the telethermometers during this study were reported to the nearest 0.1°C.

ANALYSIS OF CROSS-SECTIONAL TEMPERATURE PROFILES

Water-temperature profiles were obtained at 61 sites on seven major streams during this reconnaissance. Locations of these sites are shown on Figure 4. At the beginning of the study, selected reaches of the Guadalupe and Colorado Rivers were traversed by boat, and cross-sectional temperature profiles were obtained at many sites to determine the effects of pools and riffles on stream temperature. During these initial surveys, no significant variation of stream temperature at pools or riffles was noted. Therefore, temperature surveys of the Colorado River from Austin to Wadsworth and the Guadalupe River from Gonzales to Tivoli could be limited to selected road crossings. Data-collection sites on most other streams were at chemical-quality or stream-gaging stations; one site was a thermograph station. Repeated surveys were made at each of these stations to determine if there were significant temperature variations within a cross section during different seasons and at different rates of flow.

At each of the data-collection sites, water temperature was measured near the surface and bottom in each of three verticals evenly spaced across the stream cross section. When vertical or transversal variations of water temperature were noted, temperature was measured at a number of intermediate points to define the stream-temperature profile. One such profile obtained for the Brazos River at Richmond (site 7) on May 29, 1968, is shown on Figure 1.

The results of 258 temperature-profile measurements are summarized in Table 2. The detailed data upon which the table is based are in the files of the U.S. Geological Survey at Austin. The average temperatures shown in Table 2 are arithmetic averages of the observations. Temperature differences within a cross section were so small that weighting by discharge would not significantly change the average.

Data in Table 2 show that no cross-sectional variation of temperature was detected in 147 of the 258 temperature-profile measurements. Only 34 of the measurements showed a temperature variation of more than 0.5°C, and no measurement showed a temperature variation of more than 1.5°C. Also, data in Table 2 show that temperature differences of more than 0.5°C in a cross section were not restricted to any season but were fairly evenly distributed throughout the year. Moreover, temperature variations during low-flow periods were not significantly different from those during high-flow periods.

In summary, the temperature-profile study indicates that point-temperature data reported by the Geological Survey usually are representative of the average temperature.

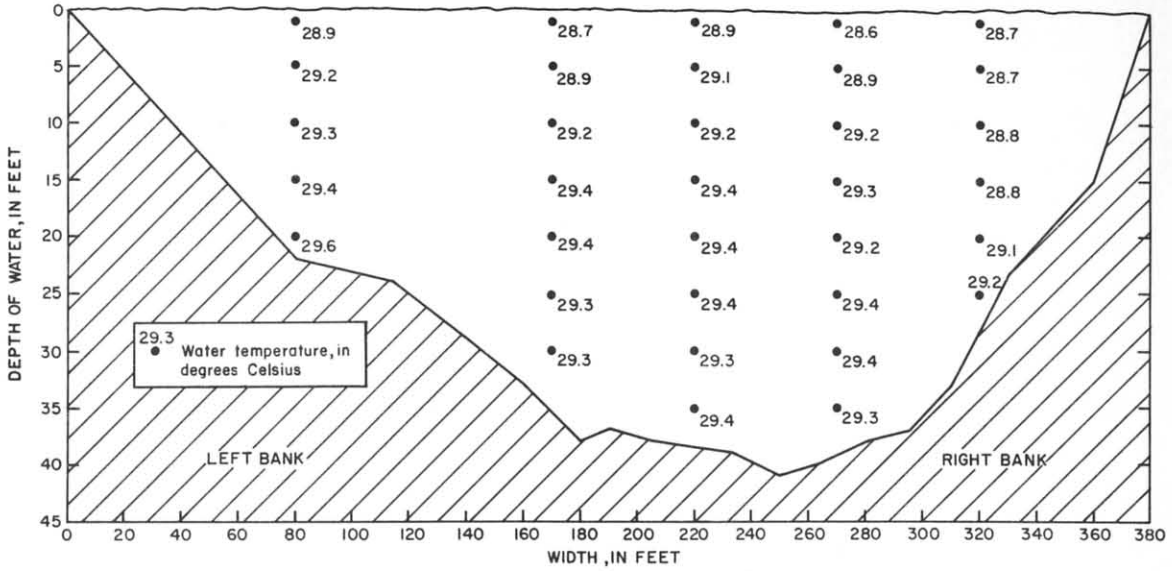

Figure 1.—Temperature Profile for Brazos River at Richmond, May 29, 1968

CORRELATION OF STREAM TEMPERATURE AND AIR TEMPERATURE

Because solar radiation is one of the principal factors affecting both air and stream temperatures, and because air temperature affects stream temperature, air temperature should be a reasonable index of the temperature of streams in many areas where man-made influences are not present. Several investigators have found a close correlation between air and stream temperatures. In 1925, Collins (1925, p. 101) reported that the mean monthly temperature of surface water at any place is generally within a few degrees (°F) of the mean monthly air temperature when the air temperature is above the freezing point. In 1966, Blakey (1966, p. 8) reported that although the air-water temperature relationship for many streams has been upset by natural conditions, such as ground-water inflows with temperatures differing from air temperatures, and by man's activities, Collins' conclusions are still valid for many streams.

A comparison of mean monthly water temperatures for nine daily chemical-quality or sediment stations and one thermograph station with mean monthly air temperatures at nearby U.S. Weather Bureau stations is shown in Figure 2. The mean monthly water temperatures for most of these stations seldom differed from corresponding air temperatures by more than 2°C and often differed by no more than 1°C. Exceptions to this general relationship were noted for the stations Trinity River near Rosser (site 3) and Brazos River near Whitney (site 6). Mean January and February water temperatures for Trinity River near Rosser were 3°C higher than corresponding air temperatures, and water temperature was consistently higher than air temperature during the months from October through April.

Because air temperature in Texas generally decreases with distance inland and distance to the north, winters at the station near Rosser are colder and air temperature is below the freezing point more frequently and for longer periods than at most of the other stations. Colder winters and the frequency that air temperature is below freezing probably account for part of the greater than average spread between air and water temperatures for the station near Rosser. However, according to Leifeste and Hughes (1967, p. 20), the disposal of municipal and industrial wastes has caused serious water-quality problems upstream from Rosser. The disposal of heated effluents supplemented by heat produced by the oxidation of organic wastes probably has resulted in a significant increase in water temperature and accounts for part of the spread between air and water temperature of Trinity River near Rosser—especially during winter when air temperature is low.

Records for the continuous thermograph station, Brazos River near Whitney, show that the mean monthly water and air temperatures usually differed by more than 2°C (Figure 2). The mean monthly water temperature for this station was higher than corresponding air temperature during winter but was lower than air temperature during summer. This station is 3.4 miles downstream from Whitney Reservoir. According to Sylvester (1963, p. 15-17), large and deep impoundments generally will decrease downstream water temperatures in the summer and increase them in the winter if withdrawals are from lower depths in the reservoir. Thus, the natural air-water temperature relation for Brazos River near Whitney apparently has been altered by the operation of Whitney Reservoir.

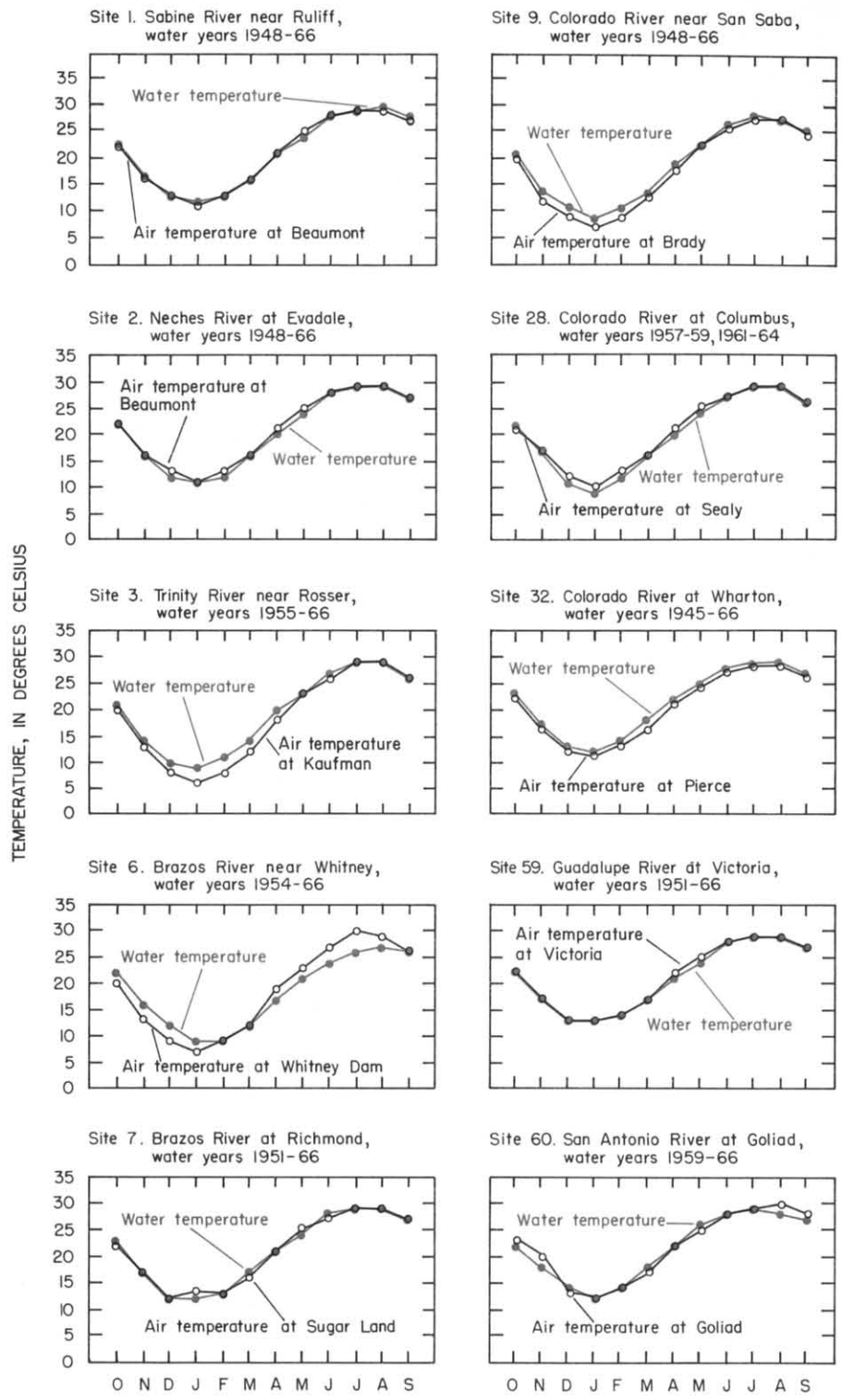

Figure 2

Comparison of Mean Monthly Water and Air Temperatures

COMPARISON OF MONTHLY MAXIMUM AND MINIMUM STREAM TEMPERATURES

Mean monthly water temperatures are significant data but give little indication of the wide variation in water temperature that may occur at a particular site. For that reason, the compilation report by Goines (1967) lists observed maximum and minimum water temperatures for each month of each year of record for thermograph, daily chemical-quality, and daily sediment stations. These data for one thermograph station and nine daily chemical-quality or sediment stations are summarized graphically in Figure 3.

Figure 3 shows generally that water temperature at each of the 10 stations varied considerably throughout the year; the spread between the mean maximum and mean minimum temperatures for any given month averaged at least 3°C. At most sites, the spread was smallest during the summer when solar radiation and air temperature were highest. During the other seasons, the spread between monthly mean maximum and mean minimum temperatures observed at most sites usually averaged more than 6°C.

CONCLUSIONS

Point stream-temperature data collected by the U.S. Geological Survey in Texas in cooperation with State, local, and other Federal agencies usually are representative of the average temperature of water within the stream cross section.

Mean monthly air temperature is a reasonable index of the mean monthly temperature of the principal streams in the State provided that temperature is not affected by such artificial influences as addition of treated wastes or presence of impoundments.

The temperature of streams in Texas varies considerably throughout the year. The spread between mean monthly maximum and minimum temperatures at most sites studied averaged at least 3°C during the summer and more than 6°C during the other seasons.

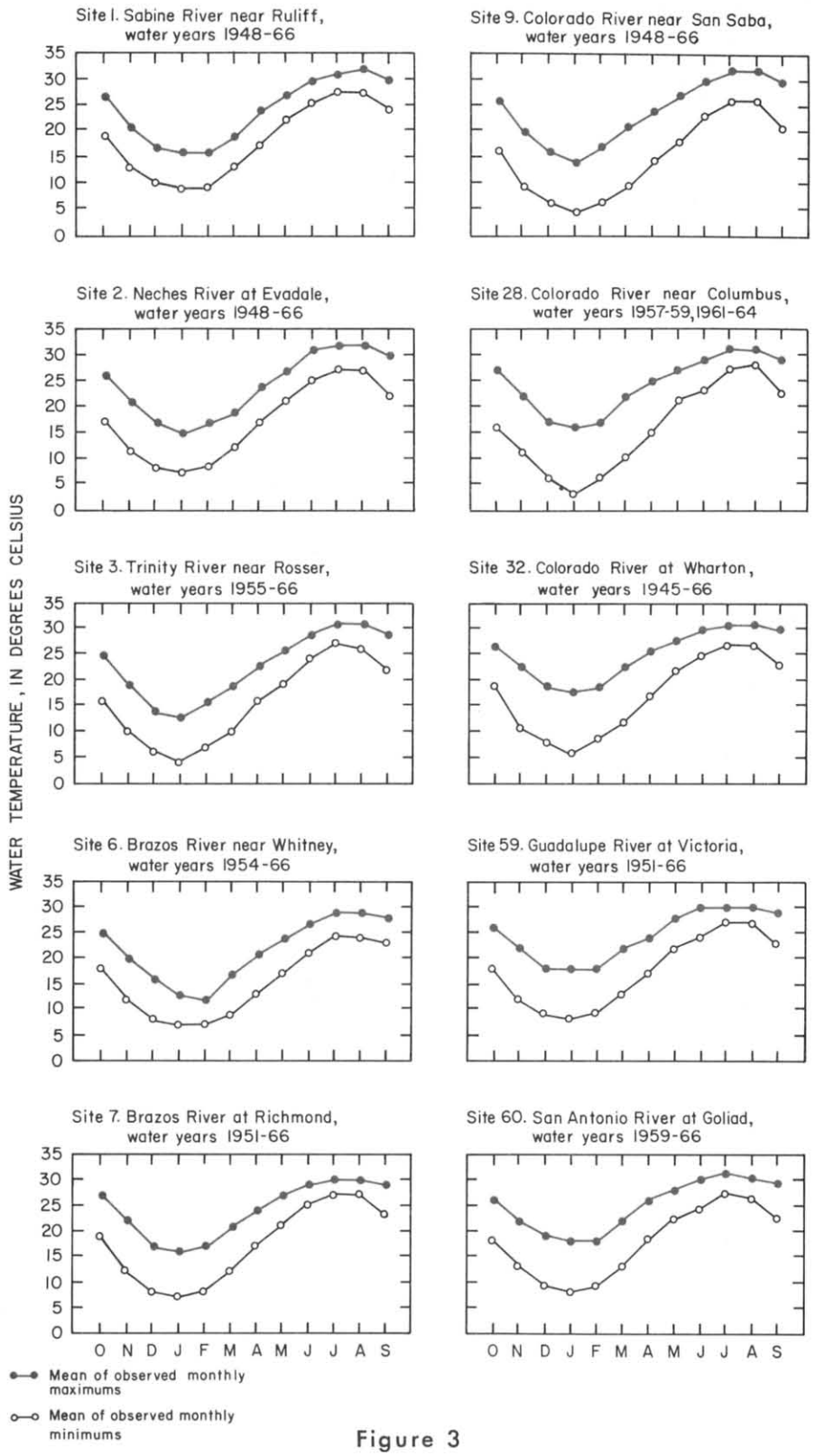

Figure 3

Comparison of Monthly Maximum and Minimum Water Temperatures

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Table 2.--Temperature Measurements at Selected Cross Sections of Streams in Texas

SITE	STREAM	LOCATION	DATE	TIME (24 HOUR)	DISCHARGE (CFS)	WATER TEMPERATURE IN CROSS SECTION (°C)		AIR TEMPERATURE (°C)
						AVERAGE	RANGE	
1	Sabine River	Lat 30°18'13", long 93°44'37", at daily chemical-quality and stream-gaging station Sabine River near Ruliff (8-0305).	Feb. 22, 1968	1545	1,290	9.8	9.8 - 9.8	0.6
			June 12, 1968	1645	20,300	23.3	23.2 - 23.5	29.6
			July 16, 1968	0755	1,730	27.8	27.7 - 27.9	26.3
			Aug. 21, 1968	1150	2,610	28.6	28.5 - 28.8	33.6
			Sept. 24, 1968	0800	10,900	22.8	22.6 - 23.2	21.9
			Oct. 22, 1968	0830	2,790	18.4	18.1 - 18.7	15.9
2	Neches River	Lat 30°21'22", long 94°05'36", at daily chemical-quality and stream-gaging station Neches River at Evadale (8-0410).	Feb. 19, 1968	1445	2,480	11.9	11.8 - 11.9	19.4
			June 11, 1968	1405	8,840	27.1	26.7 - 27.2	32.2
			July 12, 1968	1310	6,740	27.1	26.9 - 27.3	29.8
			Aug. 22, 1968	0920	4,300	29.6	29.1 - 29.9	29.6
			Sept. 25, 1968	1400	1,720	27.3	26.9 - 27.3	32.6
			Oct. 28, 1968	1600	2,370	21.0	20.7 - 21.3	25.6
3	Trinity River	Lat 32°25'35", long 96°27'45", at daily chemical-quality and stream-gaging station Trinity River near Rosser (8-0625).	Jan. 17, 1968	1620	996	6.5	6.4 - 6.6	18.3
			Feb. 15, 1968	1740	3,010	7.1	7.0 - 7.2	3.3
			Mar. 13, 1968	1440	14,300	10.3	10.3 - 10.3	15.6
			Apr. 25, 1968	1600	7,500	19.5	19.4 - 19.6	24.2
			May 28, 1968	1715	7,270	23.6	23.4 - 23.6	33.9
			July 5, 1968	1245	1,450	27.0	26.9 - 27.1	27.8
			Aug. 9, 1968	1335	1,320	29.5	29.4 - 29.7	33.1
			Oct. 22, 1968	1240	434	21.6	21.4 - 21.7	26.9
			Dec. 20, 1968	1735	780	11.1	10.9 - 11.2	17.2
4	Trinity River	Lat 32°08'05", long 96°06'20", at daily chemical-quality and stream-gaging station Trinity River at Trinidad (8-0627).	Jan. 11, 1968	1200	2,690	4.1	4.1 - 4.1	5.2
			Feb. 16, 1968	1235	4,750	7.6	7.5 - 7.6	6.7
			Mar. 26, 1968	1805	22,800	18.1	18.1 - 18.2	19.7
			May 1, 1968	1815	8,230	18.9	18.8 - 18.9	28.3
			May 27, 1968	1445	7,700	23.4	23.4 - 23.5	25.0
			July 2, 1968	1135	2,670	28.3	28.1 - 28.6	28.9
			Aug. 22, 1968	1050	628	29.4	29.3 - 29.4	35.0
			Oct. 28, 1968	1525	368	18.6	18.5 - 18.8	20.9
			Dec. 20, 1968	1645	560	11.2	11.1 - 11.2	18.3
5	Trinity River	Lat 30°25'30", long 94°51'02", at daily chemical-quality and stream-gaging station Trinity River at Romayor (8-0665).	Mar. 25, 1968	1615	21,800	14.3	14.1 - 14.7	19.4
			June 14, 1968	1110	11,120	27.0	29.9 - 30.1	35.0
			July 9, 1968	1520	5,260	29.1	28.7 - 29.3	31.9
			Aug. 23, 1968	0950	2,290	30.4	30.2 - 30.8	29.2
			Sept. 26, 1968	1305	1,190	26.3	26.1 - 26.4	26.9
			Oct. 28, 1968	1050	--	20.2	19.8 - 20.4	19.4
6	Brazos River	Lat 31°50'30", long 97°19'30", at stream-gaging station Brazos River near Whitney (8-0930).	Jan. 13, 1968	1145	297	4.4	4.1 - 4.7	4.2
			Feb. 7, 1968	1150	4,470	10.4	10.0 - 10.8	9.4
			Mar. 14, 1968	1405	4,700	10.3	9.9 - 10.7	20.3
			Apr. 22, 1968	1235	4,360	18.2	17.8 - 18.4	29.1
			May 20, 1968	1420	19,000	22.7	22.5 - 23.1	23.9
			June 20, 1968	1855	1,900	25.8	25.7 - 25.8	25.8
			July 10, 1968	1110	2,560	26.6	26.3 - 26.8	32.3
			Aug. 22, 1968	1920	1,900	27.8	27.3 - 28.3	--
			Sept. 11, 1968	1110	51.6	23.9	23.7 - 24.1	26.1
			Oct. 18, 1968	1130	138	19.2	18.7 - 19.4	21.7
			Dec. 27, 1968	1150	63.7	12.4	12.3 - 12.6	13.3
7	Brazos River	Lat 29°34'56", long 95°45'27", at daily chemical-quality and stream-gaging station Brazos River at Richmond (8-1140).	Jan. 17, 1968	1500	8,760	6.7	6.6 - 6.8	15.7
			Feb. 16, 1968	1210	11,800	10.5	10.2 - 10.8	7.0
			May 27, 1968	1435	32,000	26.6	26.1 - 27.4	19.1
			May 29, 1968	0930	15,700	29.1	28.6 - 29.6	31.1
			July 3, 1969	1215	20,600	29.8	29.5 - 30.2	31.7
			July 30, 1968	1805	6,250	30.1	29.9 - 30.3	33.3
			Sept. 10, 1968	1015	3,440	27.6	27.2 - 28.0	28.1
			Oct. 10, 1968	1030	3,720	23.2	22.9 - 23.4	23.6
8	Brazos River	Lat 29°20'58", long 95°34'56", at daily chemical-quality and stream-gaging station Brazos River near Rosharon (8-1166.5).	Jan. 11, 1968	1320	10,550	5.8	5.8 - 5.8	8.9
			Jan. 16, 1968	1435	9,910	5.5	5.3 - 5.6	16.6
			Jan. 26, 1968	1440	63,700	12.4	12.3 - 12.4	23.6
			May 31, 1968	1155	28,700	25.8	25.5 - 26.1	28.5
			July 5, 1968	1610	17,200	29.6	29.4 - 29.8	27.5
			Aug. 6, 1968	1125	4,280	30.6	30.5 - 30.7	35.6
			Sept. 6, 1968	1100	2,810	27.1	26.9 - 27.3	30.2
			Oct. 4, 1968	1135	1,830	26.3	26.1 - 26.7	24.7
9	Colorado River	Lat 31°13'05", long 98°33'50", at daily chemical-quality and stream-gaging station Colorado River near San Saba (8-1470).	Jan. 2, 1968	1235	130	7.4	7.0 - 7.8	11.3
			Feb. 16, 1968	0920	984	8.1	8.1 - 8.1	2.2
			Apr. 26, 1968	0845	1,320	20.0	20.0 - 20.0	23.9
			May 29, 1968	1145	1,240	25.0	25.0 - 25.0	28.1
			June 26, 1968	1215	710	26.9	26.9 - 26.9	24.6
			July 31, 1968	1045	155	28.3	28.3 - 28.3	26.7
			Aug. 26, 1968	1205	130	28.9	28.9 - 28.9	33.1
			Sept. 27, 1968	1210	155	22.8	22.8 - 22.8	25.0
			Oct. 25, 1968	1045	86	16.7	16.7 - 16.7	14.4
			Nov. 21, 1968	1147	135	11.9	11.9 - 11.9	20.0
			Dec. 19, 1968	1030	180	10.3	10.3 - 10.3	3.9

Table 2.--Temperature Measurements at Selected Cross Sections of Streams in Texas--Continued

SITE	STREAM	LOCATION	DATE	TIME (24 HOUR)	DISCHARGE (CFS)	WATER TEMPERATURE IN CROSS SECTION (°C)		AIR TEMPERATURE (°C)
						AVERAGE	RANGE	
10	Colorado River	Lat 30°14'40", long 97°41'20", at U. S. Highway 183 at Austin.	Feb. 13, 1968	0736	--	11.4	11.4 - 11.4	11.7
			Apr. 24, 1968	0705	--	16.1	16.1 - 16.1	11.1
			June 12, 1968	0725	--	21.5	21.5 - 21.5	26.1
			Sept. 12, 1968	0712	--	23.8	23.8 - 23.9	15.6
			Dec. 19, 1968	1645	--	19.8	19.8 - 19.8	18.0
11	Colorado River	Lat 30°15'21", long 97°38'10".	Feb. 13, 1968	0816	--	11.4	11.4 - 11.4	9.7
12	Colorado River	Lat 30°13'38", long 97°39'29".	Feb. 13, 1968	0846	--	11.6	11.6 - 11.6	8.3
13	Colorado River	Lat 30°12'28", long 97°38'15", at Farm Road 973 near Austin.	Feb. 13, 1968	0909	--	11.6	11.6 - 11.6	8.3
			Apr. 24, 1968	0740	--	16.1	16.1 - 16.1	12.8
			June 12, 1968	0807	--	22.5	22.5 - 22.5	30.0
			Sept. 12, 1968	0745	--	24.6	24.5 - 24.6	18.3
			Dec. 19, 1968	1620	--	17.0	17.0 - 17.0	18.0
14	Colorado River	Lat 30°12'21", long 97°35'15".	Feb. 13, 1968	0949	--	11.7	11.7 - 11.7	8.3
15	Colorado River	Lat 30°13'33", long 97°32'29".	Feb. 13, 1968	1039	--	11.7	11.7 - 11.7	8.3
16	Colorado River	Lat 30°12'21", long 97°31'09".	Feb. 13, 1968	1149	--	11.7	11.7 - 11.7	8.3
17	Colorado River	Lat 30°12'42", long 97°29'35".	Feb. 13, 1968	1144	--	11.7	11.7 - 11.7	8.9
18	Colorado River	Lat 30°11'01", long 97°28'25".	Feb. 13, 1968	1209	--	11.7	11.7 - 11.7	8.9
19	Colorado River	Lat 30°11'21", long 97°25'33".	Feb. 13, 1968	1234	--	11.7	11.7 - 11.7	8.9
20	Colorado River	Lat 30°09'01", long 97°27'12".	Feb. 13, 1968	1327	--	11.8	11.8 - 11.8	9.4
21	Colorado River	Lat 30°10'00", long 97°24'12", at Farm Road 969 near Bastrop.	Feb. 13, 1968	1404	--	11.8	11.8 - 11.8	10.8
			Apr. 24, 1968	0825	--	16.1	16.1 - 16.1	18.9
			June 12, 1968	0900	--	23.5	23.5 - 23.5	28.6
			Sept. 12, 1968	0850	--	25.0	24.9 - 25.0	20.6
			Dec. 19, 1968	1540	--	15.0	15.0 - 15.0	18.0
22	Colorado River	Lat 30°10'54", long 97°22'40".	Feb. 13, 1968	1449	--	11.9	11.9 - 11.9	10.8
23	Colorado River	Lat 30°09'54", long 97°21'13".	Feb. 13, 1968	1514	--	11.9	11.9 - 11.9	11.1
24	Colorado River	Lat 30°07'48", long 97°21'40".	Feb. 13, 1968	1554	--	11.9	11.9 - 11.9	9.7
25	Colorado River	Lat 30°06'20", long 97°19'08", at stream-gaging station Colorado River at Bastrop (8-1592).	Feb. 13, 1968	1624	6,240	11.9	11.9 - 11.9	9.4
			Feb. 14, 1968	0815	6,240	10.6	10.6 - 10.6	3.1
			Apr. 24, 1968	0920	6,380	16.7	16.7 - 16.7	21.1
			June 12, 1968	0940	6,660	24.5	24.5 - 24.5	29.4
			Sept. 12, 1968	0915	1,080	25.5	25.4 - 25.5	22.2
			Dec. 19, 1968	1500	200	15.0	15.0 - 15.0	19.0
26	Colorado River	Lat 30°01', long 97°10', at stream-gaging station Colorado River at Smithville (8-1595).	Feb. 14, 1968	0945	6,920	10.6	10.6 - 10.6	3.9
			Apr. 24, 1968	1010	--	17.2	17.2 - 17.2	26.7
			June 12, 1968	1025	6,180	24.9	24.9 - 24.9	35.0
			Sept. 12, 1968	1015	1,230	25.8	25.7 - 25.8	25.0
			Dec. 19, 1968	1420	266	15.0	15.0 - 15.0	17.0
27	Colorado River	Lat 29°54',03", long 96°53'13", at State Highway 71 at La Grange.	Feb. 14, 1968	1115	--	10.6	10.6 - 10.6	4.4
			Apr. 24, 1968	1120	--	17.2	17.2 - 17.2	26.7
			June 12, 1968	1110	--	26.4	26.4 - 26.4	32.8
			Sept. 12, 1968	1100	--	26.3	26.3 - 26.4	27.2
			Dec. 19, 1968	1325	--	15.0	15.0 - 15.0	18.0
28	Colorado River	Lat 29°42'20", long 96°32'05", at daily sediment and stream-gaging station Colorado River at Columbus (8-1610).	Jan. 17, 1968	0945	1,180	8.4	8.2 - 8.6	13.2
			Feb. 14, 1968	1315	6,450	10.6	10.6 - 10.6	4.4
			Apr. 24, 1968	1416	6,980	18.3	18.3 - 18.3	25.0
			May 22, 1968	1605	14,400	20.9	20.1 - 21.6	30.0
			June 12, 1968	1210	6,530	27.2	27.2 - 27.2	35.6
			July 2, 1968	0820	6,720	27.4	27.2 - 27.6	27.2
			Aug. 2, 1968	1152	2,160	30.1	29.8 - 30.3	30.0
			Sept. 4, 1968	0840	2,010	27.8	27.5 - 28.1	28.7
			Sept. 12, 1968	1200	1,460	26.7	26.7 - 26.8	28.9
			Oct. 1, 1968	0900	1,060	26.0	25.7 - 26.2	23.3
			Dec. 19, 1968	1135	472	14.8	14.8 - 14.8	20.0
29	Colorado River	Lat 29°34'48", long 96°25'03", at U. S. Highway 90A near Altair.	Feb. 14, 1968	1415	--	10.3	10.3 - 10.3	3.9
			Apr. 24, 1968	1525	--	18.9	18.9 - 18.9	26.7
			June 12, 1968	1335	--	28.0	28.0 - 28.0	33.9
			Sept. 12, 1968	1310	--	27.2	27.2 - 27.3	30.0
			Dec. 19, 1968	1045	--	14.8	14.8 - 14.8	17.0

Table 2.--Temperature Measurements at Selected Cross Sections of Streams in Texas--Continued

SITE	STREAM	LOCATION	DATE	TIME (24 HOUR)	DISCHARGE (CFS)	WATER TEMPERATURE IN CROSS SECTION (°C)		AIR TEMPERATURE (°C)
						AVERAGE	RANGE	
30	Colorado River	Lat 29°27'13", long 96°23'48", at Farm Road 950 near Garwood.	Feb. 14, 1968	1520	--	10.3	10.3 - 10.3	3.9
			Apr. 24, 1968	1358	--	19.2	19.2 - 19.2	27.8
			June 12, 1968	1420	--	28.2	28.2 - 28.2	35.6
			Sept. 12, 1968	1353	--	27.8	27.8 - 27.9	31.7
			Dec. 19, 1968	1010	--	14.0	14.0 - 14.0	16.0
31	Colorado River	Lat 29°20'08", long 96°11'52", at Farm Road 940 at Glen Flora.	Feb 14, 1968	1600	--	10.2	10.2 - 10.2	3.9
			Apr. 24, 1968	1720	--	19.4	19.4 - 19.4	25.6
			June 12, 1968	1520	--	29.0	29.0 - 29.0	36.7
			Sept. 12, 1968	1435	--	27.8	27.8 - 27.9	28.9
			Dec. 19, 1968	0925	--	14.0	14.0 - 14.0	12.0
32	Colorado River	Lat 29°18'30", long 96°06'15", at daily chemical-quality and stream-gaging station Colorado River at Wharton (8-1620).	Jan. 17, 1968	1300	1,200	9.4	9.1 - 9.6	16.3
			Feb. 14, 1968	0840	6,470	10.4	10.4 - 10.4	5.9
			Feb. 14, 1968	1640	--	10.1	10.1 - 10.1	3.9
			Apr. 24, 1968	1814	8,480	19.4	19.4 - 19.4	22.8
			May 23, 1968	1000	13,400	21.6	21.3 - 21.8	30.3
			June 12, 1968	1605	2,480	29.0	29.0 - 29.0	37.8
			July 2, 1968	1450	6,700	29.3	29.2 - 29.4	34.2
			Aug. 8, 1968	1600	1,550	29.7	29.6 - 29.8	36.2
			Sept. 4, 1968	1540	1,440	27.7	27.4 - 27.9	30.6
			Sept. 12, 1968	1520	1,020	27.8	27.8 - 27.9	28.9
			Oct. 1, 1968	1440	588	26.7	26.4 - 26.7	31.7
			Dec. 19, 1968	0825	--	14.1	14.1 - 14.1	9.5
33	Colorado River	Lat 28°59'01", long 95°59'58", at State Highway 35 near Bay City.	Feb. 15, 1968	0730	--	10.0	10.0 - 10.0	4.4
			Apr. 24, 1968	1912	--	20.0	20.0 - 20.0	17.2
			June 12, 1968	1710	--	29.7	29.7 - 29.7	37.8
			Sept. 12, 1968	1645	--	27.8	27.8 - 27.9	29.4
			Dec. 18, 1968	1625	--	16.2	16.2 - 16.2	25.5
			Dec. 19, 1968	0735	--	15.2	15.2 - 15.2	7.0
34	Colorado River	Lat 28°47'24", long 95°59'48", at Farm Road 521 near Wadsworth.	Feb. 15, 1968	0840	--	10.0	10.0 - 10.0	4.4
			Apr. 25, 1968	0750	--	19.2	19.2 - 19.2	22.2
			June 13, 1968	0750	--	28.8	28.8 - 28.8	28.9
			Sept. 13, 1968	0745	--	26.1	26.1 - 26.1	20.6
			Dec. 18, 1968	1520	--	15.3	15.3 - 15.3	24.5
35	Guadalupe River	Lat 29°29'04", long 97°26'50", at U. S. Highway 183 near Gonzales.	Nov. 15, 1967	1200	--	17.6	17.6 - 17.6	20.8
			Feb. 15, 1968	1720	--	12.2	12.2 - 12.2	7.2
			Apr. 25, 1968	1550	--	22.2	22.2 - 22.2	29.4
			June 13, 1968	1535	--	29.0	29.0 - 29.0	34.4
			Sept. 13, 1968	1500	--	26.4	26.4 - 26.4	28.9
			Dec. 18, 1968	0706	--	15.0	15.0 - 15.0	20.0
36	Guadalupe River	Lat 29°29'19", long 97°26'05".	Nov. 15, 1967	1219	--	17.6	17.6 - 17.6	20.8
37	Guadalupe River	Lat 29°29'22", long 97°24'57".	Nov. 15, 1967	1244	--	17.6	17.6 - 17.6	20.8
38	Guadalupe River	Lat 29°27'30", long 97°24'03".	Nov. 15, 1967	1322	--	18.0	18.0 - 18.0	24.2
39	Guadalupe River	Lat 29°26'59", long 97°23'14".	Nov. 15, 1967	1352	--	18.0	18.0 - 18.0	21.1
40	Guadalupe River	Lat 29°25'41", long 97°21'36".	Nov. 15, 1967	1420	--	17.9	17.9 - 17.9	21.1
41	Guadalupe River	Lat 29°24'22", long 97°19'20".	Nov. 15, 1967	1510	--	17.9	17.9 - 17.9	22.8
42	Guadalupe River	Lat 29°21'11", long 97°17'37".	Nov. 15, 1967	1610	--	17.8	17.8 - 17.8	21.1
43	Guadalupe River	Lat 29°18'52", long 97°18'11", at U.S. Highway 183 near Hochheim.	Nov. 15, 1967	1700	--	17.7	17.7 - 17.7	19.2
			Nov. 16, 1967	0755	--	17.7	17.7 - 17.7	16.7
			Feb. 15, 1968	1640	--	12.2	12.2 - 12.2	7.2
			Apr. 25, 1968	1506	--	22.2	22.2 - 22.2	27.8
			June 13, 1968	1505	--	29.0	29.0 - 29.0	33.3
			Sept. 13, 1968	1425	--	26.4	26.4 - 26.4	27.8
			Dec. 18, 1968	0740	--	15.0	15.0 - 15.0	20.0
44	Guadalupe River	Lat 29°17'29", long 97°20'04".	Nov. 16, 1967	0825	--	17.7	17.7 - 17.7	16.7
45	Guadalupe River	Lat 29°15'19", long 97°20'04".	Nov. 16, 1967	0904	--	17.7	17.7 - 17.7	17.1
46	Guadalupe River	Lat 29°12'26", long 97°18'33".	Nov. 16, 1967	0944	--	17.7	17.7 - 17.7	17.1
47	Guadalupe River	Lat 29°08'48", long 97°19'02", at Farm Road 766 near Cuero.	Nov. 16, 1967	1034	--	17.8	17.8 - 17.8	17.8
			Feb. 15, 1968	1555	--	12.2	12.2 - 12.2	8.3
			Apr. 25, 1968	1425	--	22.2	22.2 - 22.2	27.8
			June 13, 1968	1400	--	29.0	29.0 - 29.0	32.3
			Sept. 13, 1968	1330	--	26.4	26.4 - 26.4	31.7
			Dec. 18, 1968	0835	--	15.0	15.0 - 15.0	21.0

Table 2.--Temperature Measurements at Selected Cross Sections of Streams in Texas--Continued

SITE	STREAM	LOCATION	DATE	TIME (24 HOUR)	DISCHARGE (CFS)	WATER TEMPERATURE IN CROSS SECTION (°C)		AIR TEMPERATURE (°C)
						AVERAGE	RANGE	
48	Guadalupe River	Lat 29°03'57", long 97°19'16", at stream-gaging station Guadalupe River at Cuero (8-1758).	Nov. 16, 1967	1257	1,980	18.4	18.4 - 18.4	25.0
			Feb. 15, 1968	1520	1,700	12.2	12.2 - 12.2	8.9
			Apr. 25, 1968	1320	2,850	22.2	22.2 - 22.2	27.2
			June 13, 1968	1320	2,040	29.0	29.0 - 29.0	34.4
			Sept. 13, 1968	1250	795	26.1	26.1 - 26.2	28.9
			Dec. 18, 1968	0910	877	15.0	15.0 - 15.0	22.0
49	Guadalupe River	Lat 29°03'05", long 97°15'52", at Farm Road 236 near Cuero.	Nov. 16, 1967	1384	--	18.6	18.6 - 18.6	25.0
			Feb. 15, 1968	1440	--	12.2	12.2 - 12.2	9.4
			Apr. 25, 1968	1241	--	22.2	22.2 - 22.2	28.3
			June 13, 1968	1240	--	29.0	29.0 - 29.0	32.2
			Sept. 13, 1968	1215	--	26.1	26.1 - 26.2	27.2
			Dec. 18, 1968	0955	--	15.0	15.0 - 15.0	22.0
50	Guadalupe River	Lat 29°03'52", long 97°13'41".	Nov. 16, 1967	1404	--	18.8	18.8 - 18.8	25.6
51	Guadalupe River	Lat 29°02'05", long 97°11'43".	Nov. 16, 1967	1441	--	18.9	18.9 - 18.9	27.2
52	Guadalupe River	Lat 29°00'01", long 97°12'37".	Nov. 16, 1967	1524	--	18.9	18.9 - 18.9	23.9
53	Guadalupe River	Lat 28°58'28", long 97°11'16".	Nov. 16, 1967	1544	--	18.6	18.6 - 18.6	22.7
54	Guadalupe River	Lat 28°56'10", long 97°09'28".	Nov. 16, 1967	1634	--	18.5	18.5 - 18.5	21.7
55	Guadalupe River	Lat 28°53'50", long 97°08'16", at Farm Road 447 near Victoria.	Nov. 16, 1967	1701	--	18.5	18.5 - 18.5	21.6
			Nov. 17, 1967	0804	--	17.9	17.9 - 17.9	16.7
			Feb. 15, 1968	1355	--	12.2	12.2 - 12.2	10.0
			Apr. 25, 1968	1155		21.7	21.7 - 21.7	30.0
			June 13, 1968	1200	--	29.0	29.0 - 29.0	36.1
			Sept. 13, 1968	1135	--	26.1	26.1 - 26.1	24.4
			Dec. 18, 1968	1055	--	15.0	15.0 - 15.0	23.0
56	Guadalupe River	Lat 28°52'25", long 97°05'16".	Nov. 17, 1967	0839	--	17.9	17.9 - 17.9	16.7
57	Guadalupe River	Lat 28°50'00", long 97°03'54".	Nov. 17, 1967	0924	--	18.1	18.1 - 18.1	22.8
58	Guadalupe River	Lat 28°49'43", long 97°01'07".	Nov. 17, 1967	0956	--	18.3	18.3 - 18.3	21.0
59	Guadalupe River	Lat 28°47'35", long 97°00'45", at daily chemical-quality and stream-gaging station Guadalupe River at Victoria (8-1765).	Nov. 17, 1967	1056	2,150	18.6	18.6 - 18.6	26.7
			Jan. 26, 1968	1358	30,200	13.9	13.5 - 14.8	19.9
			Jan. 29, 1968	1825	4,620	15.9	15.9 - 15.9	19.7
			Feb. 2, 1968	0859	3,290	17.4	17.2 - 17.5	12.0
			Feb. 15, 1968	1300	2,090	12.2	12.2 - 12.2	10.0
			Mar. 6, 1968	1310	1,730	14.3	14.3 - 14.3	16.2
			Apr. 8, 1968	1747	1,850	22.2	21.4 - 22.2	22.6
			Apr. 25, 1968	1110	3,220	21.7	21.7 - 21.7	29.4
			May 14, 1968	1045	12,400	23.7	23.6 - 24.0	28.6
			June 13, 1968	1120	2,510	29.0	29.0 - 29.0	36.1
			June 17, 1968	1715	2,510	29.1	29.1 - 29.2	26.6
			July 24, 1968	0957	1,210	30.3	30.2 - 30.4	29.1
			Aug. 26, 1968	1734	828	30.1	30.0 - 30.1	33.2
			Sept. 13, 1968	1050	933	26.1	26.1 - 26.2	24.4
			Oct. 1, 1968	1750	840	26.7	26.1 - 27.6	29.7
			Nov. 5, 1968	1400	751	21.8	21.7 - 22.1	28.3
			Dec. 10, 1968	0949	1,270	11.9	11.9 - 12.0	15.6
			Dec. 18, 1968	1135	1,020	15.8	15.8 - 15.8	24.5
60	San Antonio River	Lat 28°38'58", long 96°23'04", at daily chemical-quality and stream-gaging station San Antonio River at Goliad (8-1885).	Jan. 25, 1968	1435	21,300	12.7	12.6 - 12.8	24.2
			Jan. 27, 1968	1431	12,200	14.5	14.4 - 14.5	20.6
			Jan. 29, 1968	1510	2,230	16.6	16.1 - 16.8	20.3
			Feb. 2, 1968	1126	1,390	18.4	17.8 - 18.6	22.5
			Mar. 6, 1968	1030	632	14.2	14.1 - 14.2	13.4
			Apr. 8, 1968	1242	518	21.0	20.6 - 21.6	24.4
			May 13, 1968	1542	7,710	22.2	21.9 - 22.4	27.8
			June 17, 1968	1319	397	29.3	29.3 - 29.4	28.5
			July 23, 1968	1418	415	29.7	29.6 - 29.7	35.2
			Aug. 27, 1968	1455	273	28.2	27.8 - 28.2	37.2
			Oct. 1, 1968	1218	358	23.9	23.1 - 24.4	30.2
			Nov. 5, 1968	0940	265	18.5	17.9 - 19.3	28.6
			Dec. 9, 1968	1505	415	11.6	10.7 - 12.1	17.2
61	Guadalupe River	Lat 28°30'20", long 96°53'04", at daily chemical-quality and stream-gaging station Guadalupe River near Tivoli (8-1888).	Feb. 15, 1968	1020	--	12.2	12.2 - 12.2	6.7
			Apr. 25, 1968	0954	--	21.1	21.1 - 21.1	26.1
			June 13, 1968	1005	--	29.5	29.5 - 29.5	30.6
			Sept. 13, 1968	0950	--	26.1	26.1 - 26.1	23.1
			Dec. 18, 1968	1335	--	16.2	16.2 - 16.2	26.5