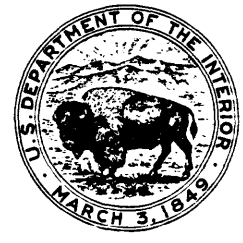
STATISTICAL AND GRAPHICAL SUMMARIES OF SELECTED WATER-QUALITY AND STREAMFLOW DATA FROM THE TRINITY RIVER NEAR CROCKETT, TEXAS, 1964-85

By Richard L. Goss

U.S. GEOLOGICAL SURVEY

Open-File Report 87-393



Prepared in cooperation with the

TRINITY RIVER AUTHORITY

Austin, Texas

1987

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
649 Federal Bldg.
300 E. Eighth St.
Austin, TX 78701

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center, Bldg. 41
Box 25425
Denver, CO 80225

CONTENTS

ILLUSTRATIONS

TABLES

METRIC CONVERSIONS

Factors for converting inch-pound units to metric (International System) units are given in the following table:

Multiply inch-pound unit	By	To obtain metric unit
acre	0.4047	hectare
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch (in.)	25.40	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
ton per day (ton/d)	0.9072	megagram per day

Temperature data in this report are in degrees Celsius (°C) and may be converted to degrees Fahrenheit (°F) by the following formula:

$$°F = 1.8(°C) + 32.$$

STATISTICAL AND GRAPHICAL SUMMARIES OF SELECTED WATER-QUALITY AND STREAMFLOW DATA FROM THE TRINITY RIVER NEAR CROCKETT, TEXAS, 1964-85

By
Richard L. Goss

ABSTRACT

Statistical and graphical summaries of selected water-quality and streamflow data collected between 1964 and 1985 at the Trinity River near Crockett are presented to document the baseline water quality of the Trinity River at this location. Dissolved oxygen exceeded 7.0 milligrams per liter in more than 50 percent of the samples analyzed. The mean value of pH was 7.4 units; the mean values of specific conductance and temperature were 619 microseimens per centimeter at 25 degrees Celsius and 20.5 degrees Celsius, respectively.

As part of the statistical summaries, trend tests were conducted. Several small uptrends were detected for total nitrogen, total organic nitrogen, total ammonia nitrogen, total nitrite nitrogen, total nitrate nitrogen, total organic plus ammonia nitrogen, total nitrite plus nitrate nitrogen, and total phosphorus. Small downtrends were detected for biochemical oxygen demand and dissolved magnesium.

INTRODUCTION

The Trinity River in north-central Texas flows through the Dallas-Fort Worth metroplex in a southeasterly direction toward the Gulf of Mexico (fig. 1). Drainage area of the Trinity River near Crockett is 13,911 mi^2. Water in the Trinity River downstream of the Dallas-Fort Worth metroplex is adversely affected by the municipalities, and the stretch of the river from the metroplex to Livingston Reservoir is considered to be one of the most polluted reaches in the basin. During low-flow conditions, the main stem of the Trinity River is composed almost entirely of treated effluents from wastewater treatment plants (Texas Department of Water Resources, 1984). Water-quality problems that have been attributed to runoff from the metropolitan areas of Dallas-Fort Worth occasionally occur in the Trinity River near Crockett. That urban runoff, combined with existing seasonal water-quality conditions of the river, has resulted in serious environmental problems (Texas Water Commission, written commun., 1987).

The purpose of this report is to present statistical and graphical summaries of selected water-quality and related streamflow data collected at the gaging station on the Trinity River near Crockett. The summaries include a statistical test for trends. Determining the causes of any trends is beyond the scope of this report. Statistical and trend analyses performed on periodic water-quality and streamflow data from 1964 to 1985 are presented in tables. Continuous streamflow, water-temperature, dissolved oxygen, pH, and specific-conductance data for the 1975-84 water years are presented graphically in illustrations.

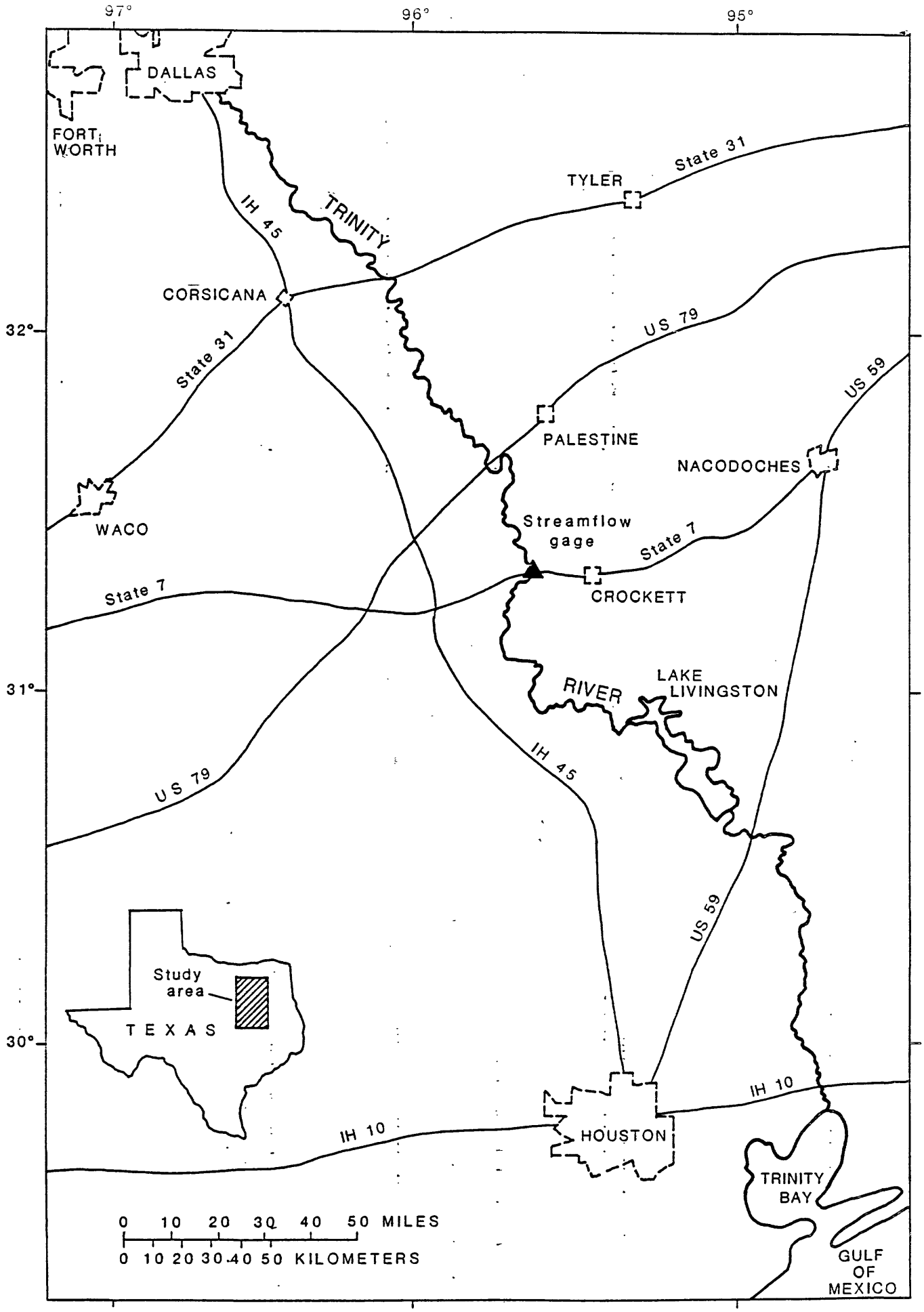


Figure 1.--Generalized map of the Trinity River near Crockett, Texas.

Statistical analyses of water-quality and related streamflow data were performed using the Statistical Analysis System (SAS)[1] programs developed by the SAS Institute of Cary, North Carolina (SAS Institute, Inc., 1982a,b). The SAS computer programs provide data-analysis and data-management functions such as sorting, merging, copying, and condensing sets of data.

The SAS procedure used for the statistical summary of water-quality data included in this report is the univariate procedure. This procedure produces simple descriptive statistics of numeric variables and provides detailed information on the distribution of their values. Some of the statistical features obtained with the univariate procedure and tabulated in this report include sample size (the number of observations) on which statistical calcutions were based and the maximum, minimum, and mean values. Other statistical features obtained for constituents with five or more observations include the 95th, 75th, 50th (median), 25th, and 5th percentile values.

A non-parametric SAS procedure (SEASKEN), developed by the Systems Analysis Group of the U.S. Geological Survey (Crawford, Slack, and Hirsch, 1983), was used to test for trends in water-quality data. A brief description of this procedure is presented in the "Trend Analysis" section of this report.

STATISTICAL SUMMARY OF WATER-QUALITY DATA

Descriptive

Statistical summaries of selected water-quality and streamflow data collected at periodic intervals from the Trinity River near Crockett are presented in table 1. Although a detailed analysis of the data is beyond the scope of this report, several water-quality features are noted to exemplify the utility of the data summaries. Dissolved-oxygen concentrations exceeded 7.0 mg/L (milligrams per liter) in more than 50 percent of the samples analyzed, while concentrations less than or equal to 3.3 mg/L occurred 5 percent of the time. Measurements of pH had a mean value of 7.4 units and ranged between 5.5 and 8.9 units. The pH values were above 6.9 pH units 95 percent of the time, but equaled or exceeded 8.0 units only 5 percent of the time. The maximum specific conductance was 2,100 µS/cm (microsiemens per centimeter at 25 °C), the mean was 619 µS/cm, and the minimum was 172 µS/cm. Temperature ranged from a maximum of 34.5 °C to a minimum of 4.0 °C, with a mean of 20.5 °C.

Trend Analysis

Trends, for the purpose of this report, are defined as a monotonic change with time, occurring either as an abrupt or gradual change in a water-quality constituent or property. Trends in water quality often are not readily apparent. Concentrations of elements or compounds in water often change by only a few percent annually. Trends are often masked by fluctuations in streamflow, seasonal variations, and sampling and analytical variability. Changes in constituent concentration caused by variations in discharge are particularly

[1] Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 1.--Statistical summary of selected water-quality and streamflow data in the Trinity River near Crockett, Texas

[mg/L, milligrams per liter; µg/L, micrograms per liter; cols/100 mL, colonies per 100 milliliters; ton/d, ton per day; µS/cm, microsiemens per centimeter at 25 degrees Celsius; ft^3/s, cubic feet per second; °C, degrees Celsius; NTU, nephelometric turbidity units]

Note: Data collected at periodic intervals from February 1964 to August 1985

Property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown				
	Sample size	Maximum	Minimum	Mean	95	75	50 (median)	25	5
Alkalinity, field (mg/L as CaCO3)	353	181.00	25.00	114.90	157.00	130.00	117.00	100.00	74.10
Arsenic, dissolved (µg/L as As)	50	17.00	0.00	5.10	12.90	7.50	4.00	2.75	0.00
Arsenic, total (µg/L as As)	12	12.00	3.00	6.50	12.00	8.50	6.00	4.00	3.00
Barium, dissolved (µg/L as Ba)	25	700.00	0.00	62.12	520.00	57.00	40.00	0.00	0.00
Barium, total recoverable (µg/L as Ba)	1	0.00	0.00	--	--	--	--	--	--
Bromide, dissolved (mg/L as Br)	3	0.73	0.25	--	--	--	--	--	--
Cadmium, dissolved (µg/L as Cd)	49	3.00	0.00	0.14	2.00	0.00	0.00	0.00	0.00
Cadmium, total recoverable (µg/L as Cd)	11	2.00	0.00	0.18	2.00	0.00	0.00	0.00	0.00
Calcium, dissolved (mg/L as Ca)	405	74.00	20.00	48.75	62.00	54.00	49.00	45.00	33.30
Carbon, organic, total (mg/L as C)	116	160.00	0.00	12.22	21.30	13.00	10.00	7.65	4.66
Carbonate, fet-fld (mg/L as CO3)	375	33.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Chloride, dissolved (mg/L as Cl)	408	550.00	8.00	75.07	195.75	91.00	62.00	31.00	17.00
Chromium, dissolved (µg/L As Cr)	50	30.00	0.00	1.24	10.00	0.00	0.00	0.00	0.00
Chromium, total recoverable (µg/L as Cr)	13	30.00	0.00	7.69	30.00	20.00	0.00	0.00	0.00
Cobalt, dissolved (µg/L as Co)	28	2.00	0.00	0.14	2.00	0.00	0.00	0.00	0.00
Cobalt, total recoverable (µg/L as Co)	11	8.00	0.00	1.45	8.00	3.00	0.00	0.00	0.00
Coliform, total, immed. (cols./100 mL)	35	20,999.96	105.00	6,088.13	17,799.95	7,299.98	4,599.99	2,800.00	373.00
Coliform, fecal, 0.7 um-mf (cols./100 mL)	12	800.00	48.00	205.17	800.00	230.00	155.00	71.50	48.00
Color (platinum-cobalt units)	128	560.00	0.00	53.55	200.00	50.00	30.00	20.00	10.00
Copper, dissolved (µg/L as Cu)	49	38.00	0.00	4.57	12.00	5.00	4.00	2.50	0.00
Copper, total recoverable (µg/L as Cu)	11	58.00	0.00	9.36	58.00	11.00	4.00	0.00	0.00
Fluoride, dissolved (mg/L as F)	313	3.20	0.00	0.61	1.20	0.80	0.50	0.30	0.20
Hardness (mg/L as CaCO3)	408	210.00	55.00	143.84	180.00	160.00	150.00	130.00	97.90
Hardness, noncarbonate (mg/L as CaCO3)	408	74.00	0.00	28.50	54.00	39.00	27.00	19.00	6.45
Iron, dissolved (µg/L as Fe)	50	4,700.00	0.00	184.56	992.00	65.00	21.00	12.25	0.00
Iron, total recoverable (µg/L as Fe)	11	10,000.00	710.00	3,309.09	10,000.00	5,000.00	2,600.00	810.00	710.00
Lead, dissolved (µg/L as Pb)	48	100.00	0.00	5.50	49.40	2.00	0.00	0.00	0.00

Table 1.--Statistical summary of selected water-quality and streamflow data in the Trinity River near Crockett, Texas--Continued

Property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown				
	Sample size	Maximum	Minimum	Mean	95	75	50 (median)	25	5
Lead, total recoverable (µg/L as Pb)	11	700.00	0.00	78.73	700.00	36.00	10.00	0.00	0.00
Lithium, dissolved (µg/L as Li)	25	20.00	0.00	4.40	20.00	10.00	0.00	0.00	0.00
Magnesium, dissolved (mg/L as Mg)	405	12.00	1.20	5.38	8.97	6.40	5.30	4.00	2.80
Manganese, total recoverable (µg/L as Mn)	11	210.00	60.00	130.91	210.00	190.00	150.00	60.00	60.00
Manganese, dissolved (µg/L as Mn)	50	350.00	0.00	26.66	165.00	22.25	1.00	0.00	0.00
Mercury, dissolved (µg/L as Hg)	46	0.80	0.00	0.06	0.26	0.10	0.00	0.00	0.00
Mercury, total recoverable (µg/L as Hg)	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methylene blue active substance (mg/L)	163	1.00	0.00	0.16	0.66	0.20	0.10	0.04	0.00
Nickel, dissolved (µg/L as Ni)	24	25.00	0.00	9.04	24.75	13.75	8.00	2.50	0.00
Nitrogen, total (mg/L as N)	91	9.40	0.75	4.46	9.14	6.50	4.00	2.20	1.30
Nitrogen, organic, total (mg/L as N)	127	3.60	0.05	1.13	2.50	1.50	0.98	0.68	0.24
Nitrogen, ammonia, total (mg/L as N)	132	6.30	0.00	0.61	2.91	0.57	0.13	0.05	0.00
Nitrogen, nitrite, dissolved (mg/L as N)	1	0.13	0.13	--	--	--	--	--	--
Nitrogen, nitrite, total (mg/L as N)	134	1.60	0.00	0.14	0.58	0.14	0.06	0.02	0.00
Nitrogen, nitrate, dissolved (mg/L as N)	2	3.80	2.20	--	--	--	--	--	--
Nitrogen, nitrate, total (mg/L as N)	198	12.00	0.00	3.09	7.21	4.53	2.40	1.17	0.38
Nitrogen, NO2+NO3, total (mg/L as N)	90	7.60	0.00	2.62	6.64	4.23	2.05	0.91	0.26
Nitrogen, ammonia + organic, total (mg/L as N)	97	8.50	0.57	1.85	4.41	2.30	1.40	1.00	0.72
Oxygen demand, biochemical, 5 day (mg/L)	146	33.00	0.40	5.62	19.00	6.50	3.40	1.90	1.20
Oxygen demand, chemical (low level) (mg/L)	12	110.00	16.00	41.92	110.00	53.00	35.00	25.50	16.00
Oxygen, dissolved (mg/L)	148	13.40	0.40	6.96	10.30	8.50	7.05	5.80	3.30
Oxygen, dissolved (percent saturation)	144	179.00	5.10	76.02	113.75	88.00	78.00	64.25	35.25
pH (units)	424	8.90	5.50	7.43	8.00	7.70	7.40	7.10	6.90
Phenols (µg/L)	100	33.00	0.00	2.23	7.90	3.00	1.00	0.00	0.00
Phosphorus, total (mg/L as P)	134	7.10	0.08	1.47	3.97	2.20	0.85	0.51	0.24
Potassium, dissolved (mg/L as K)	208	13.00	2.30	6.54	10.55	7.98	6.00	5.00	3.90
Sediment, suspended, sieve diameter percent finer than 0.062 millimeter	49	100.00	18.00	84.14	99.00	95.00	91.00	80.50	
Sediment, suspended (mg/L)	55	946.00	14.00	223.73	616.40	339.00	194.00	75.00	16.60
Sediment, discharge, suspended (ton/d)	50	23,700.00	29.00	6,340.26	22,064.99	10,592.50	2,565.00	356.50	35.10
Selenium, dissolved (µg/L as Se)	32	1.00	0.00	0.03	0.35	0.00	0.00	0.00	0.00
Selenium, suspended, total (µg/L as Se)	1	0.00	0.00	--	--	--	--	--	--

Table 1.--Statistical summary of selected water-quality and streamflow data in the Trinity River near Crockett, Texas--Continued

Property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown				
	Sample size	Maximum	Minimum	Mean	95	75	50 (median)	25	5
Selenium, total (µg/L as Se)	11	1.00	0.00	0.09	1.00	0.00	0.00	0.00	0.00
Silica, dissolved (mg/L as SiO2)	406	18.00	0.60	9.67	15.00	12.00	9.50	7.50	5.34
Silver, dissolved (µg/L as Ag)	25	1.00	0.00	0.08	1.00	0.00	0.00	0.00	0.00
Silver, total recoverable (µg/L as Ag)	1	0.00	0.00	--	--	--	--	--	--
Sodium adsorption ratio	406	11.00	0.20	2.55	6.00	3.32	2.00	1.00	0.70
Sodium, dissolved (mg/L as Na)	313	353.00	9.80	72.05	173.50	97.00	60.00	28.50	17.00
Solids, residue at 105 °C, suspended (mg/L)	129	4,039.99	0.00	228.05	764.00	247.00	113.00	44.50	21.00
Solids, residue at 180 °C, dissolved (mg/L)	38	728.00	140.00	302.76	537.05	386.50	266.00	199.75	145.70
Solids, sum of constituents, dissolved (mg/L)	349	1,100.00	53.00	332.35	555.00	410.00	320.00	233.50	167.50
Solids, volatile, suspended (mg/L)	122	1,040.00	0.00	43.11	140.40	46.00	20.50	10.00	1.00
Specific conductance (µS/cm)	424	2,100.00	172.00	618.67	1105.00	758.00	580.50	421.00	294.50
Streamflow, instantaneous (ft^3/s)	144	41,299.92	401.00	6,718.06	23,449.95	10,174.99	2,320.00	1,265.00	647.25
Streptococci, fecal, kf agar (cols./100 mL)	12	700.00	13.00	344.08	700.00	512.50	350.00	133.50	13.00
Strontium, dissolved (µg/L as Sr)	24	630.00	200.00	431.25	617.50	480.00	450.00	365.00	210.00
Sulfate, dissolved (mg/L as SO4)	409	134.00	12.00	61.98	100.00	81.00	62.00	41.00	26.00
Temperature (°C)	182	34.50	4.00	20.50	31.00	28.00	21.00	14.00	7.07
Turbidity (NTU)	48	510.00	0.70	99.59	431.00	137.50	60.00	20.25	9.08
Zinc, dissolved (µg/L as Zn)	49	60.00	0.00	15.88	50.00	30.00	10.00	0.00	0.00
Zinc, total recoverable (µg/L as Zn)	11	80.00	0.00	29.09	80.00	40.00	20.00	20.00	0.00

troublesome in trend-detection efforts. As discharge increases, the concentrations of many water-quality constituents such as dissolved solids decreases. Concentrations of suspended sediment and constituents related to suspended sediment, such as bacteria, nutrients, trace metals, and many organic compounds, generally increase with increasing streamflow.

Trend tests conducted in this study were performed using the Seasonal Kendall trend procedure outlined by Smith, Hirsch, and Slack (1982) and Crawford, Slack, and Hirsch (1983). The Seasonal Kendall procedure was designed for analysis of time trends in seasonally varying water-quality data from fixed, regularly sampled monitoring sites. This statistical procedure also provides an estimate of the median rate of change of quality over the sampling period (trend slope) and a method for flow-adjusting the data to correct for effects of changing streamflow on trends in the water-quality data.

Results of trend tests for the Trinity River near Crockett are presented in table 2. Tests for biochemical oxygen demand (BOD) and dissolved magnesium indicate that a small downtrend has occurred at this site. Uptrends occurred in total nitrogen, total organic nitrogen, total ammonia nitrogen, total nitrite nitrogen, total nitrate nitrogen, total organic plus ammonia nitrogen, total nitrite plus nitrate nitrogen, total phosphorus, dissolved solids, dissolved sulfate, and dissolved sodium. No trends were detected for dissolved chloride, dissolved calcium, hardness, or field alkalinity.

GRAPHICAL SUMMARY

Graphs were prepared showing the data collected from 1975 to 1984 by the U.S. Geological Survey flow-through water-quality monitor. Graphs of water-quality and streamflow data (figs. 2-11) include: (1) Mean daily discharge, (2) mean daily specific conductance, (3) daily maximum and minimum pH values, (4) daily maximum and minimum dissolved oxygen, and (5) mean daily water temperature. Additional graphs (fig. 12) show the phenomenon of rapid decrease in dissolved oxygen when discharge is rapidly increased for several time periods.

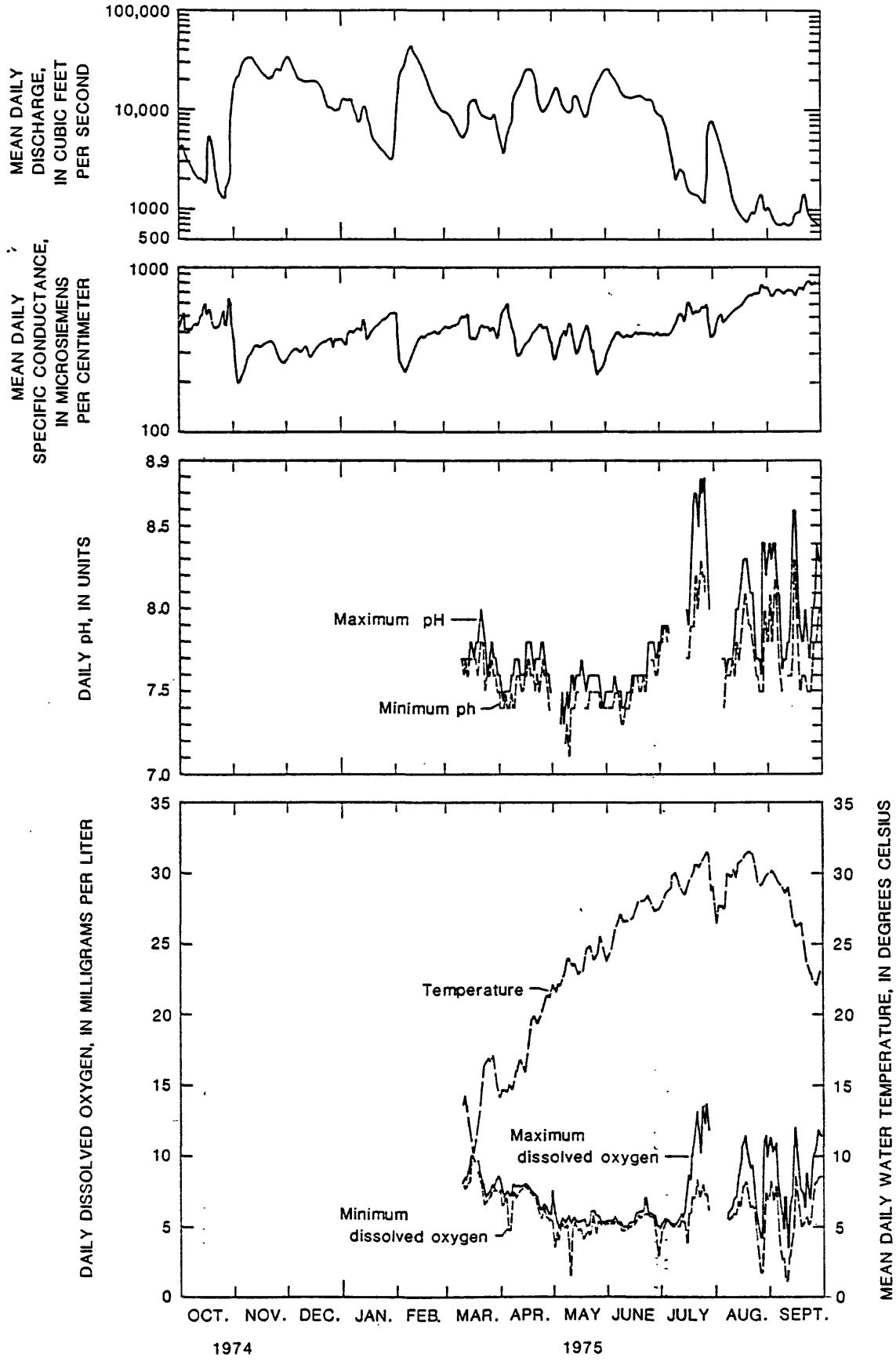


Figure 2.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1975 water year.

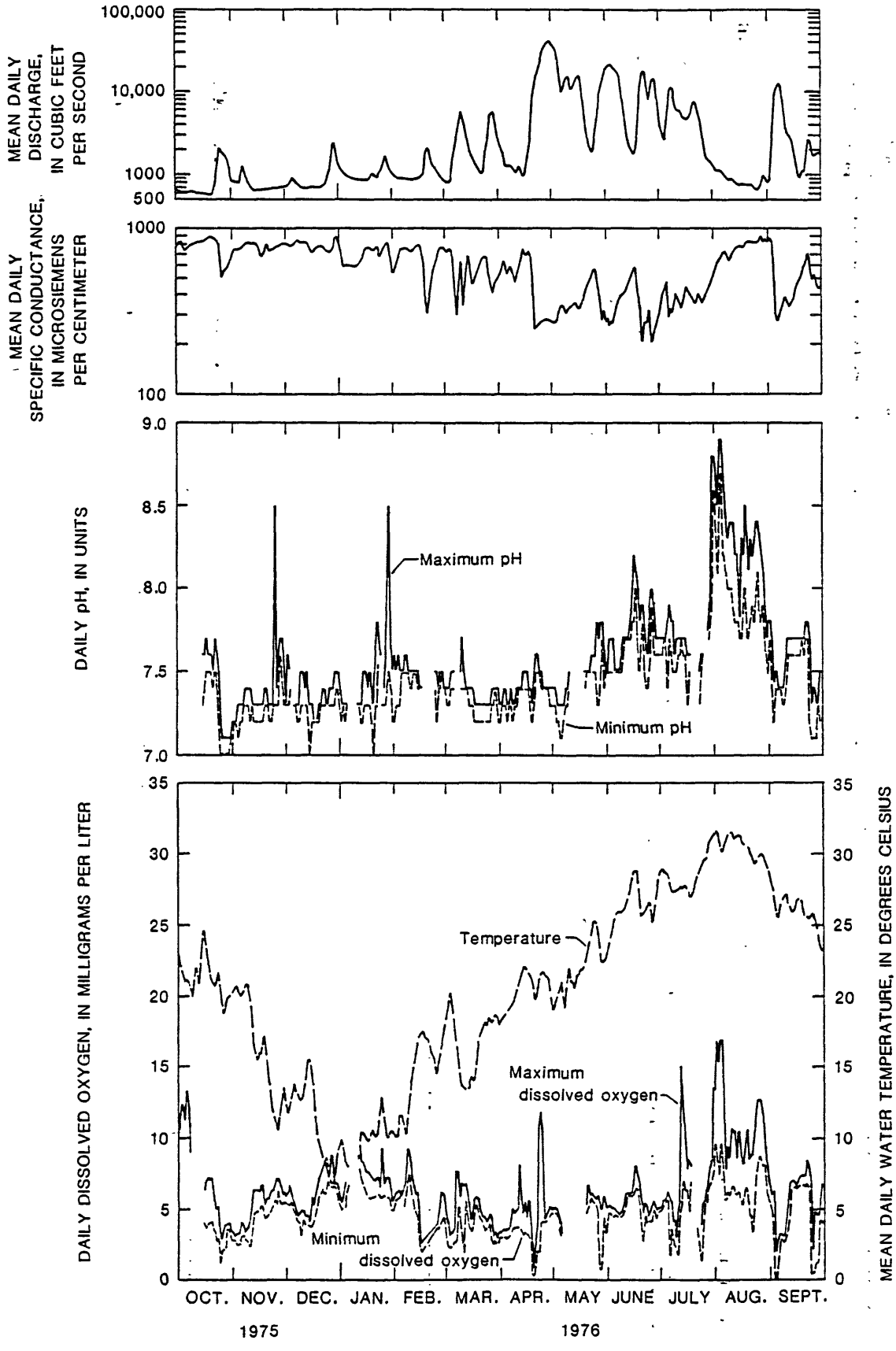


Figure 3.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1976 water year.

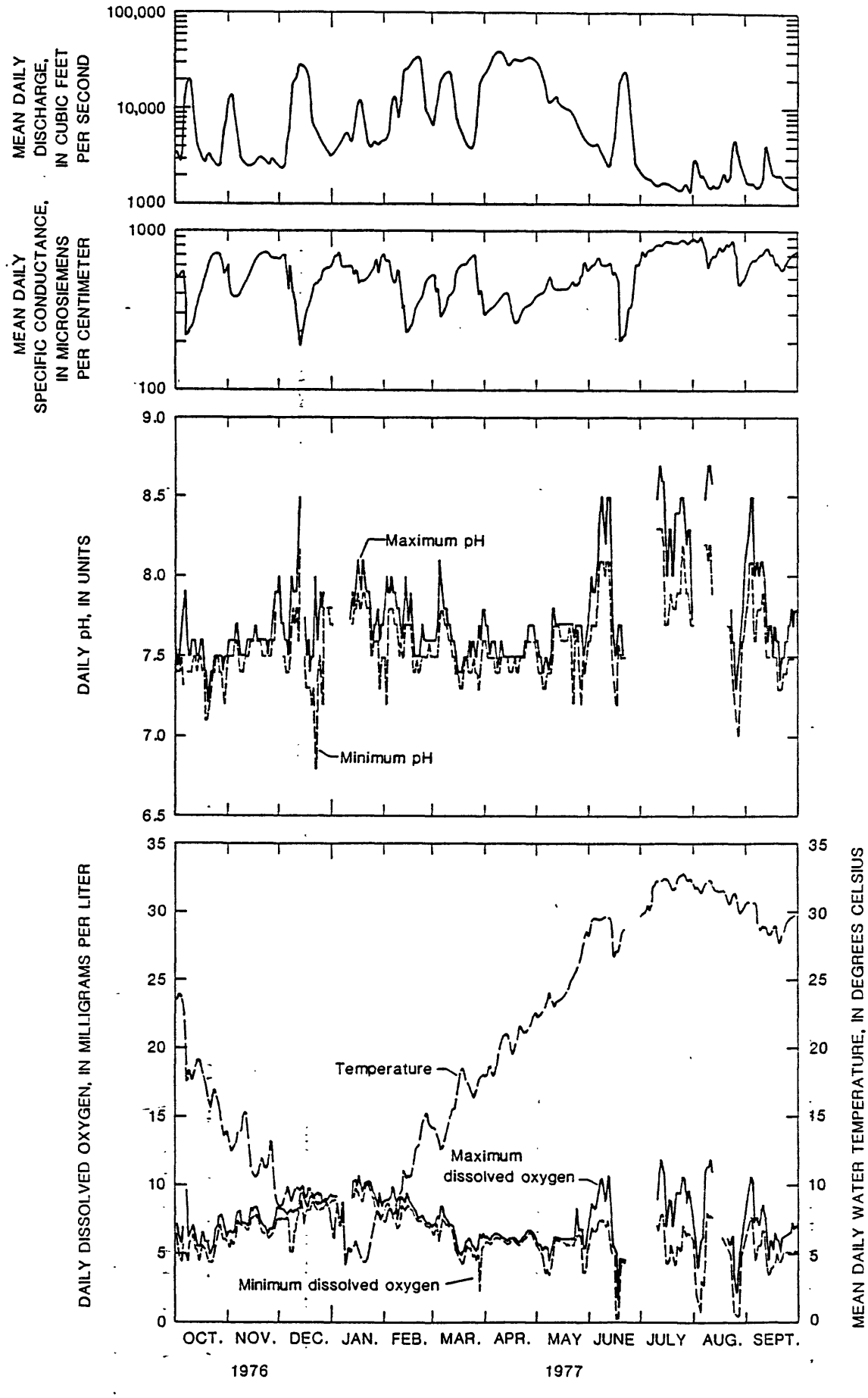


Figure 4.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1977 water year.

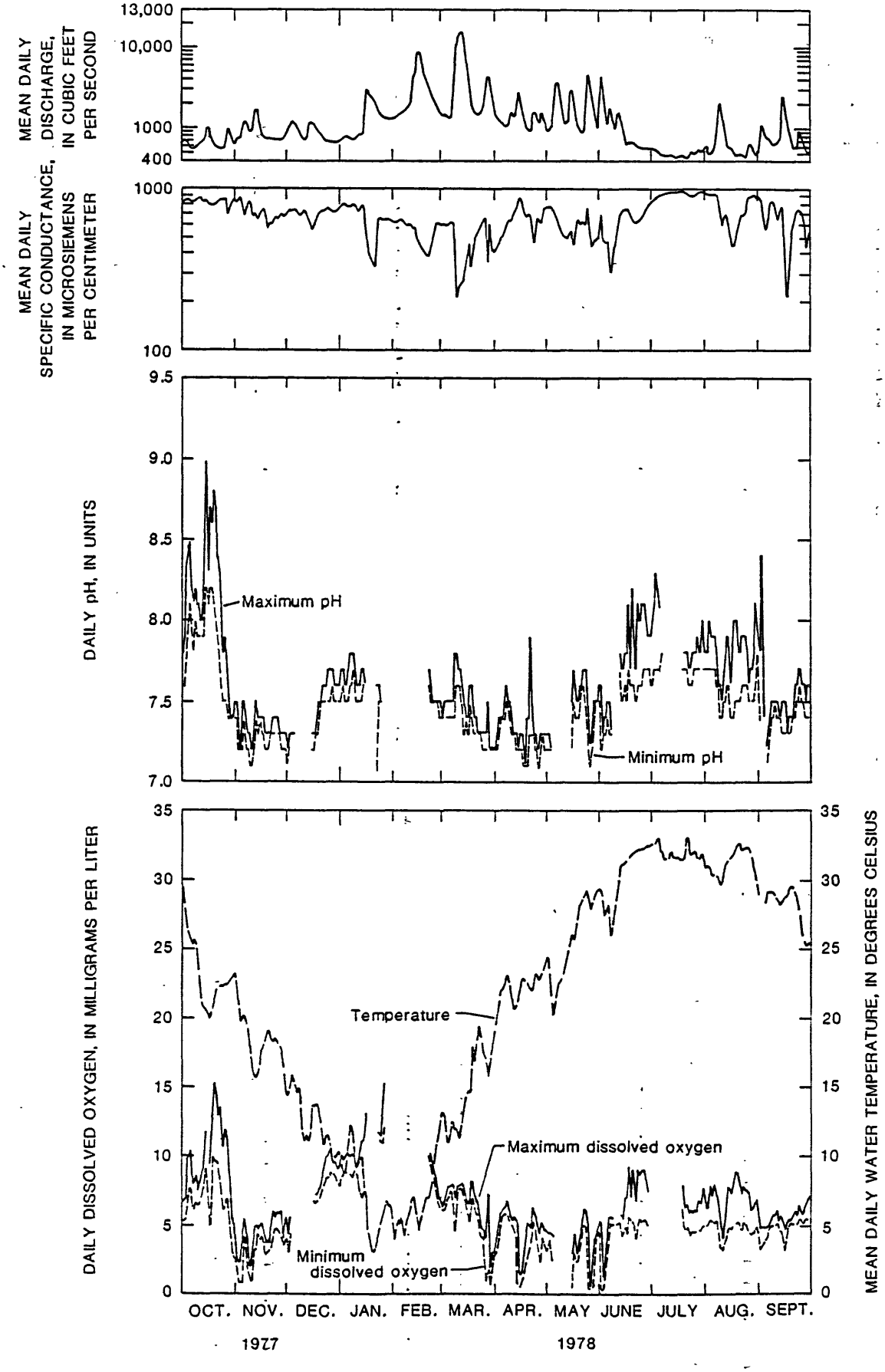


Figure 5.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1978 water year.

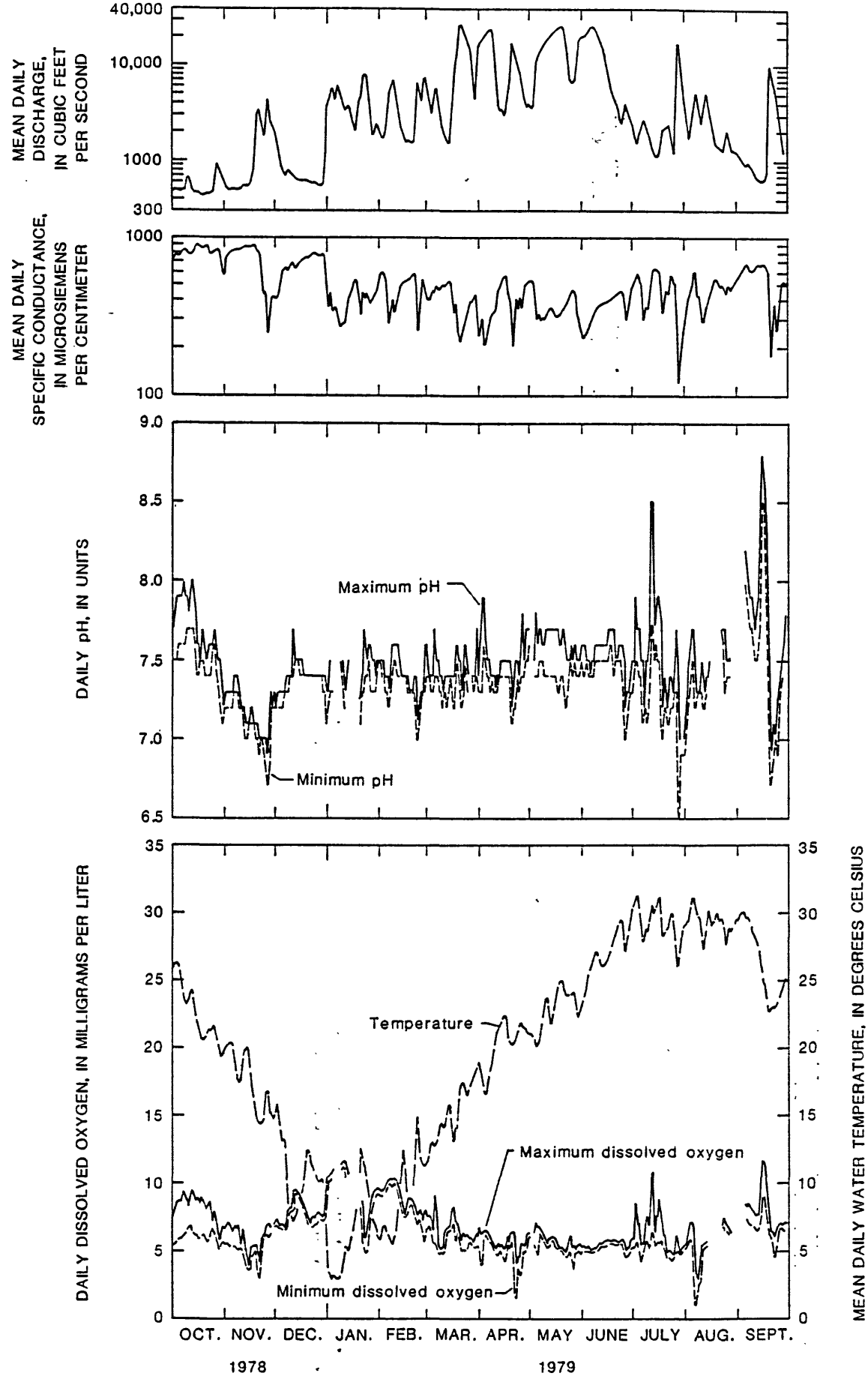


Figure 6.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1979 water year.

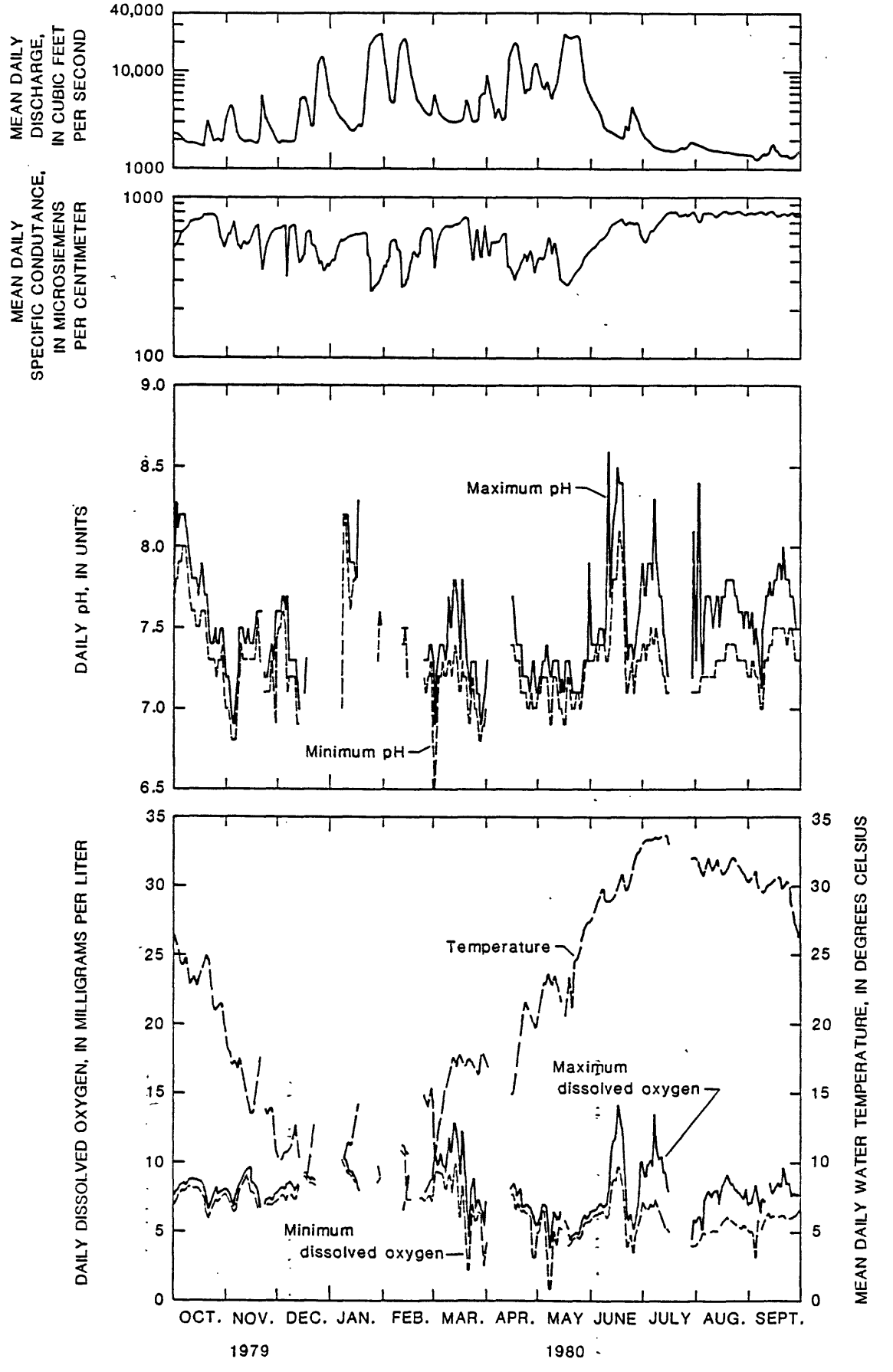


Figure 7.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1980 water year.

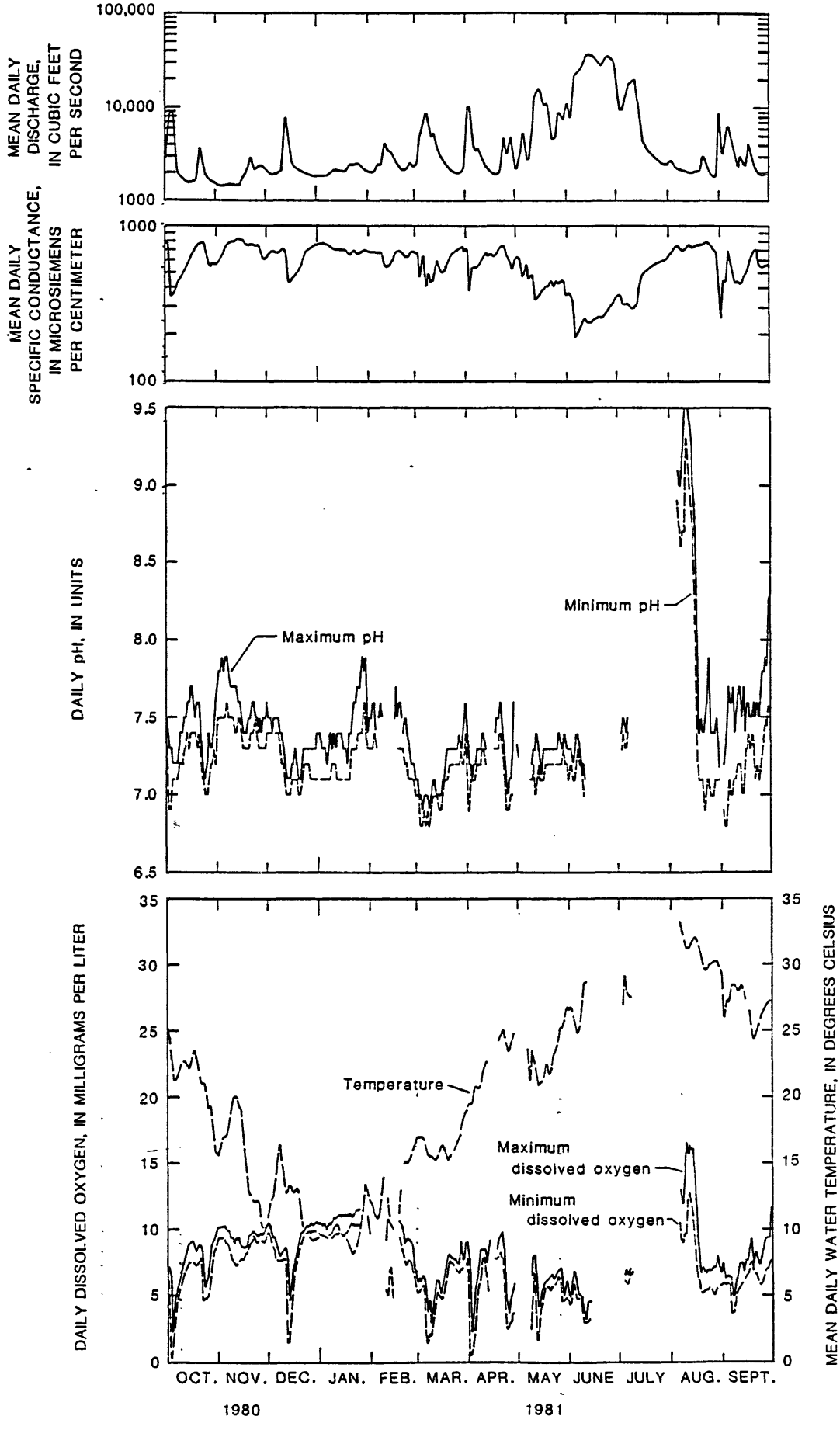


Figure 8.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1981 water year.

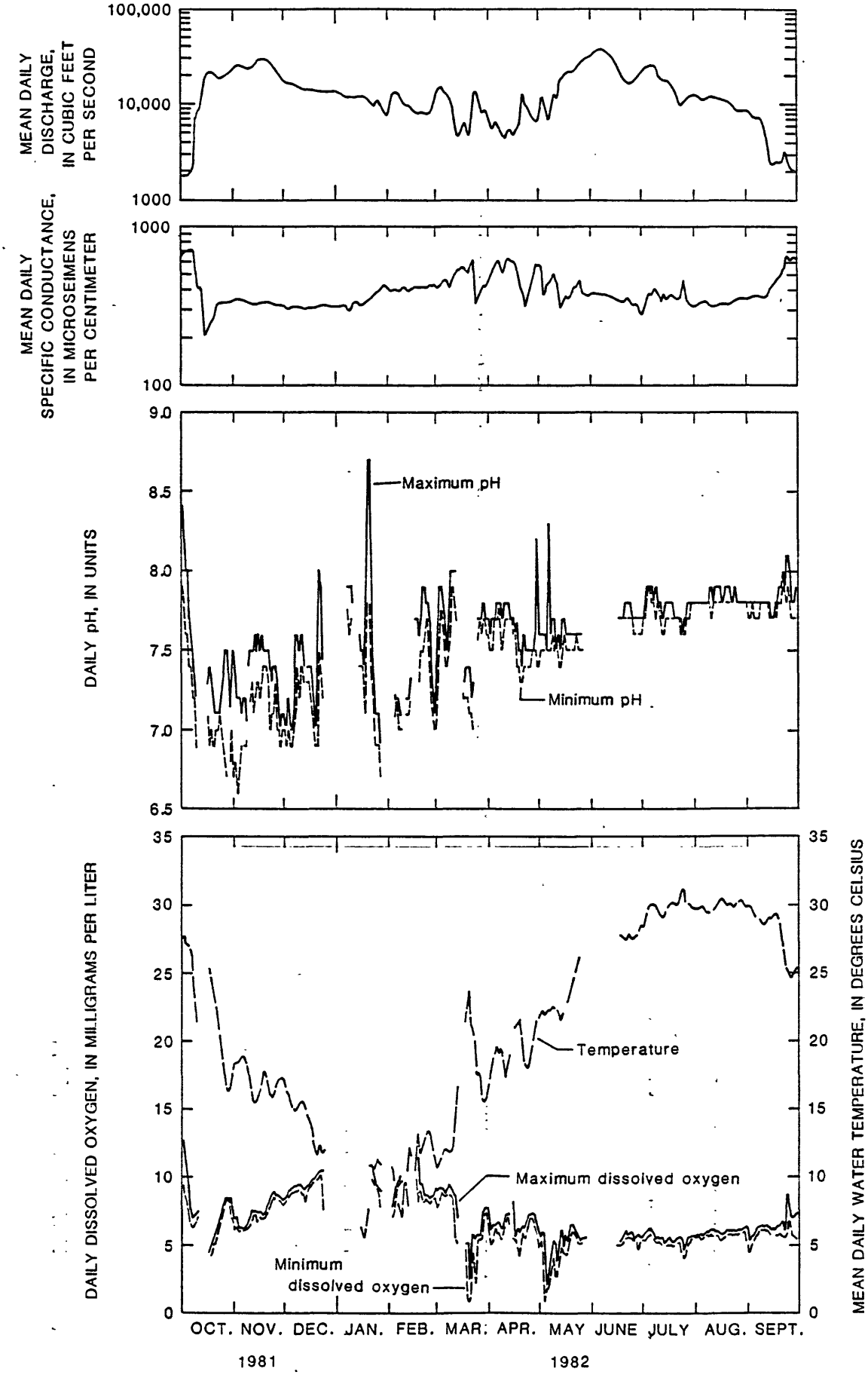


Figure 9.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1982 water year.

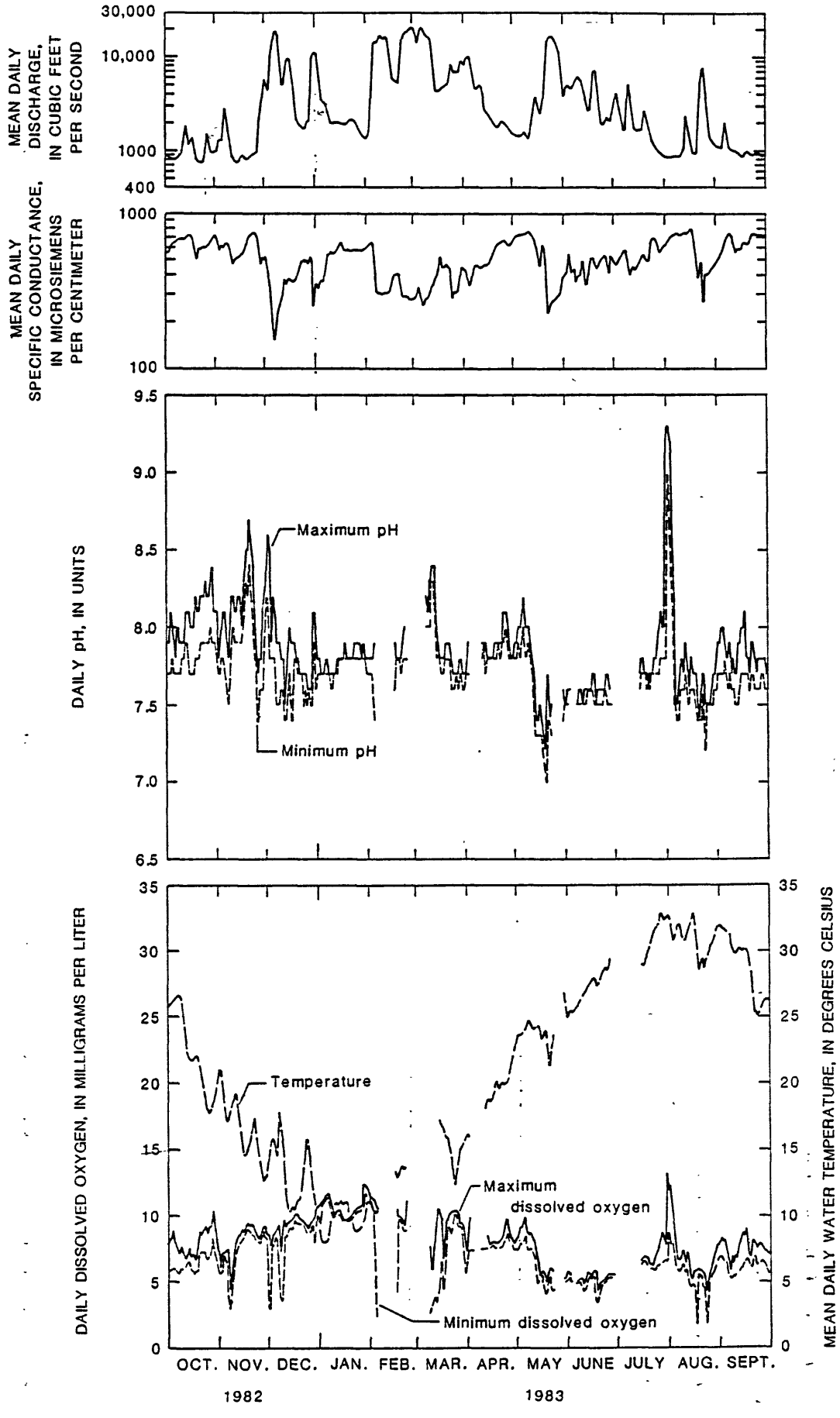


Figure 10.--Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1983 water year.

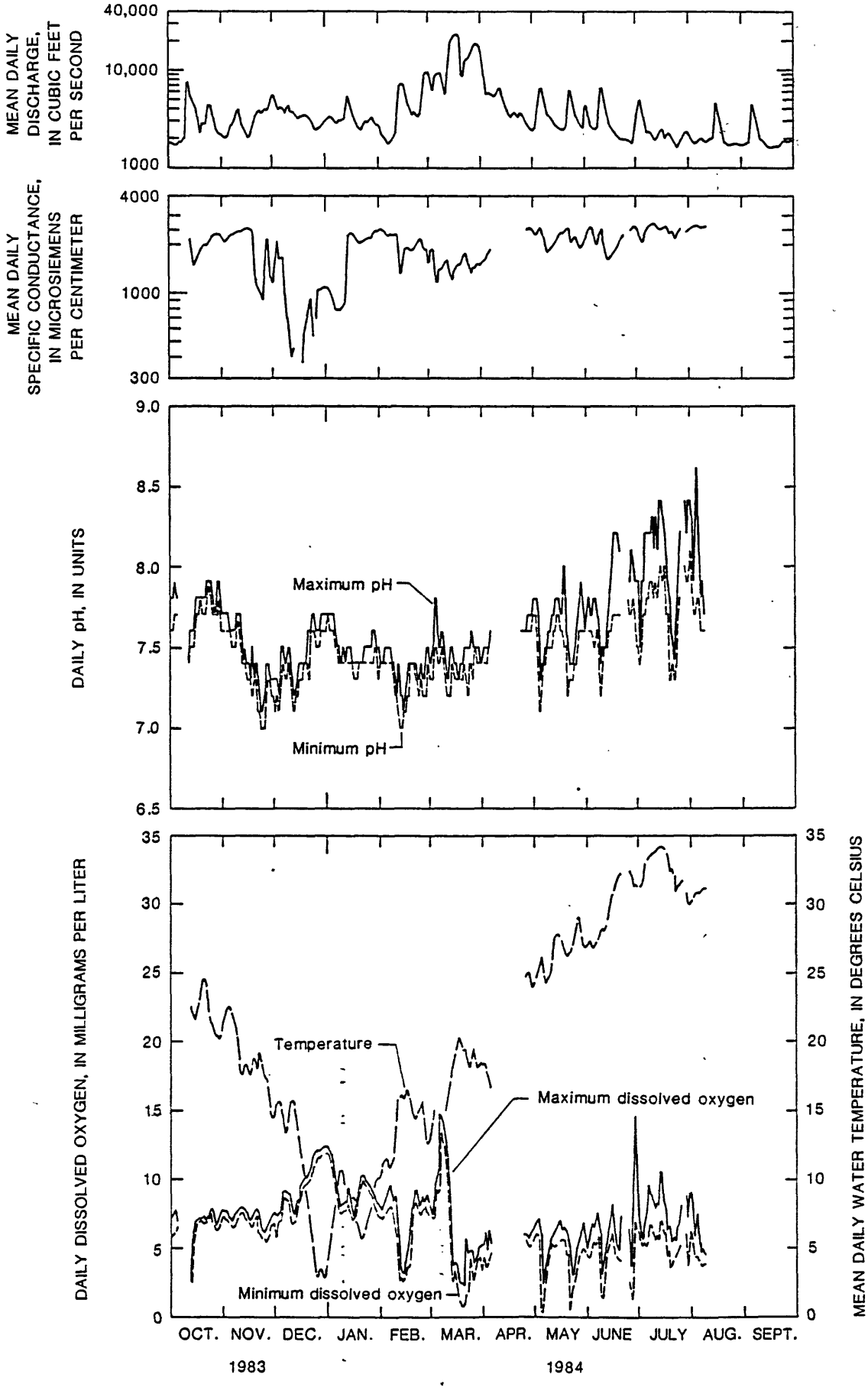


Figure 11.—Discharge, specific conductance, pH, dissolved oxygen concentrations, and water temperature of the Trinity River near Crockett, Texas, for 1984 water year.

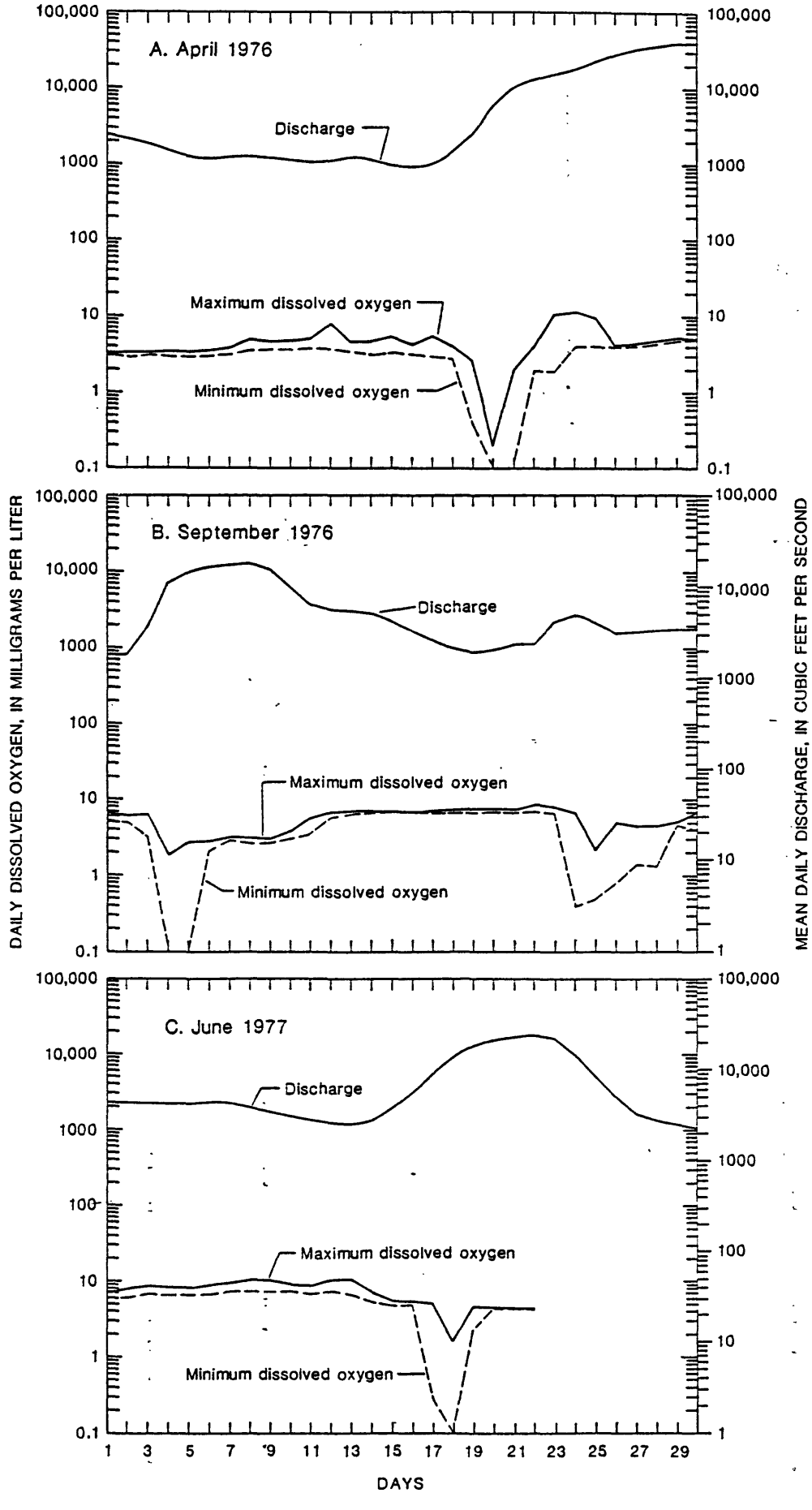


Figure 12.--Dissolved oxygen concentrations and discharge of the Trinity River near Crockett, Texas, during periods of high flow.

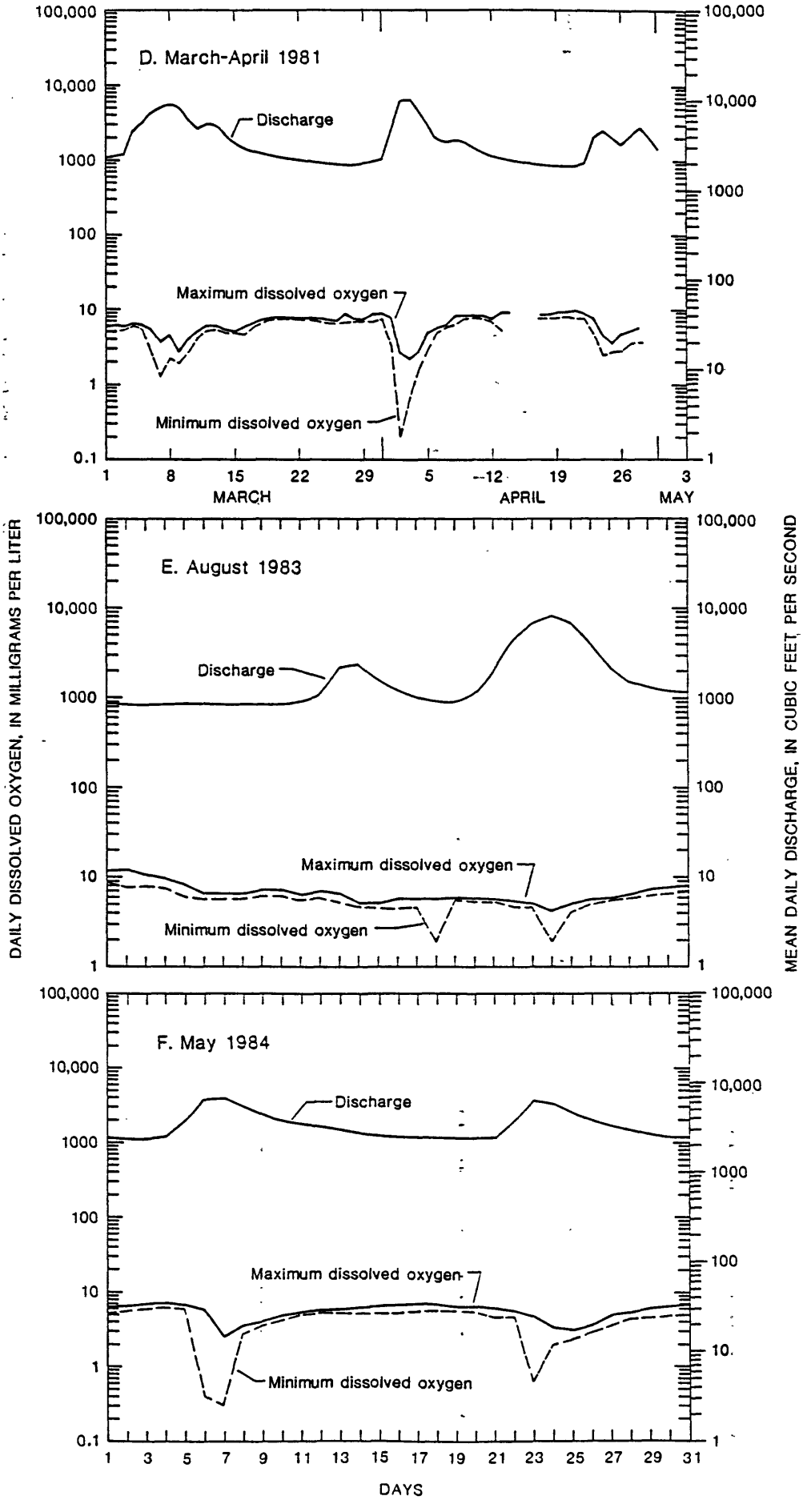

D. March-April 1981
Discharge
Maximum dissolved oxygen
Minimum dissolved oxygen
MARCH
APRIL
MAY
E. August 1983
Discharge
Maximum dissolved oxygen
Minimum dissolved oxygen
F. May 1984
Discharge
Maximum dissolved oxygen
Minimum dissolved oxygen
DAYS
DAILY DISSOLVED OXYGEN, IN MILLIGRAMS PER LITER
MEAN DAILY DISCHARGE, IN CUBIC FEET PER SECOND
100,000
10,000
1000
100
10
1
0.1

Table 2.--Trend test results for water-quality constituents and properties in the Trinity River near Crockett, Texas, February 1964 to August 1985

[+, uptrend; -, downtrend; --, no trend; mg/L, milligrams per liter]

Water-quality constituent	Concentration unit	Change	
		Median rate of change (units per year)	Percent per year
Total nitrogen	mg/L	+0.22	+4.89
Total organic nitrogen	mg/L	+0.11	+9.52
Total ammonia nitrogen	mg/L	+0.01	+2.07
Total nitrite nitrogen	mg/L	+0.01	+9.11
Total nitrate nitrogen	mg/L	+0.20	+6.51
Total organic plus ammonia nitrogen	mg/L	+0.03	+1.73
Total nitrite plus nitrate nitrogen	mg/L	+0.20	+7.76
Total phosphorus	mg/L	+0.02	+1.62
Biochemical oxygen demand	mg/L	-0.13	-2.38
Dissolved solids	mg/L	+3.02	+0.91
Dissolved oxygen	mg/L	--	--
Hardness	mg/L	--	--
Dissolved chloride	mg/L	--	--
Dissolved sulfate	mg/L	+1.49	+2.41
Dissolved sodium	mg/L	+1.14	+1.59
Dissolved calcium	mg/L	--	--
Dissolved magnesium	mg/L	-0.05	-0.87
Field alkalinity	mg/L	--	--

REFERENCES CITED

Crawford, C.G., Slack, J.R., and Hirsch, R.M., 1983, Nonparametric test for trends in water-quality data using the Statistical Analysis System: U.S. Geological Survey Open-File Report 83-550, 102p.

SAS Institute, Inc., 1982a, SAS user's guide: Basics, 1982 edition: Cary, North Carolina, SAS Institute, Inc., 923 p.

------ 1982b, SAS user's guide: Statistics, 1982 edition: Cary, North Carolina, SAS Institute, Inc., 584 p.

Smith, R.A., Hirsch, R.M., and Slack, J.R., 1982, A study of trends in total phosphorus measurements at NASQAN stations: U.S. Geological Survey Water-Supply Paper 2190, 34 p.

Texas Department of Water Resources, 1984, Water for Texas, Technical Appendix, Volume 2: Texas Department of Water Resources Report GP-4-1.