A LIMNOLOGICAL STUDY OF THE NEW BRAUNFELS-GONZALES STRETCH OF THE GUADALUPE RIVER

THESIS

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By

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CHAPTER I

INTRODUCTION

The purpose of this study was to estimate, through the use of certain limnological parameters, the relative quality of water passing along a 153-km stretch of the Guadalupe River between New Braunfels and Gonzales, Texas. Limnological parameters such as dissolved oxygen, pH, alkalinity, turbidity, and chlorophyll *a* were used to determine the effect of cultural eutrophication and main-stream impoundment upon water quality.

The dissolved-oxygen content of a body of water is an important index of its quality.[1,2] A decrease in dissolved-oxygen content of a stream below a waste effluent is one of the first indications of organic pollution.[3] Organic-rich effluents entering a stream may alter the dissolved oxygen balance in two ways. The first and most obvious way is by increasing the oxygen demand directly by requiring large amounts of oxygen for decomposition of the incoming organic waste. The second effect of organic enrichment upon the dissolved oxygen balance of a stream results from decay of

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[1]Morlais Owens, "Some Factors Involved in the Use of Dissolved Oxygen Distributions in Streams to Determine Productivity," pp. 209-224.

[2]Louis Klein, *River Polution*, *Vol. I*, *Chemical Analysis*, p. 108.

[3]*Ibid*.

aquatic vegetation produced as a result of nutrients in the effluent.[4] Edwards and Owens[5] found that, in unpolluted or mildly polluted streams, photosynthetic production of organic material and its subsequent decomposition are of comparable importance to organic wastes from sewage effluents. Diel dissolved-oxygen sampling is often necessary to get a true picture of the oxygen balance in a body of water receiving organic enrichment because daytime grab samples may not show the effect of increased organic decomposition upon normal nighttime dissolved-oxygen minimums.

The reaeration potential of an impoundment is influenced by its size, shape, and depth. Small, narrow, main-stream impoundments such as those located on the Guadalupe River lose the advantage of flowing stream turbulence as a reaeration source and, because of their small size, fail to gain the asset of wind-caused turbulent reaeration. Environmental factors such as light intensity, wind, boat traffic, and rainfall must be taken into consideration when dissolved oxygen levels and reaeration rates of a body of water are examined. Increased turbulence caused by wind or boat traffic may result in increased chlorophyll concentrations per community area because with more turbulence larger plant cells can be suspended in the

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[4]Morlais Owens and Gavin Wood, "Some Aspects of Eutrophication of Water," pp. 151-159.

[5]R.W. Edwards and Morlais Owens, "The Oxygen Balance of Streams," pp. 149-172.

water.[6] Photosynthetic oxygen production is recognized as an important reaeration mechanism in both lentic and lotic waters.[7,8,9,10] A relationship between dissolved oxygen levels and chlorophyll may be used to estimate the proportion of reaeration being contributed by photosynthetic organisms. O'Connor[11] used chlorophyll a, b, and c concentrations to estimate the maximum photosynthetic rate in the Mohawk River barge canal. Lund[12] related increased chlorophyll concentrations in Lake Washington to increased domestic drainage into that impoundment.

Alkalinity levels can also be affected by increased organic enrichment. Eckenfelder and Wood[13] found that oxidation of sewage can cause a decrease in alkalinity. Reduction in bicarbonate alkalinity concentrations can also be caused by

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[6] H.T. Odum, William McConnell, and Walter Abbott, "The Chlorophyll A of Communities," pp. 65-96.

[7] F.S. Stay, Jr., W.R. Duffer, B.L. Deprater, and J.W. Keeley, The Components of Oxygenation in Flowing Streams, pp. 1-17.

[8] R.W. Edwards and Morlais Owens, "The Oxygen Balance of Streams," pp. 149-172.

[9] C.H.J. Hull, "Oxygenation of Baltimore Harbor by Planktonic Algae," p. 5.

[10] A.F. Bartsch and W.M. Ingram, "Stream Life and the Pollution Environment," pp. 119-127.

[11] D.J. O'Connor, Water Quality Analysis of the Mohawk River Barge Canal, p. 124.

[12] J.W. Lund, "Eutrophication," pp. 557-558.

[13] W.W. Eckenfelder and J.W. Wood, "Alkalinity Significance in Sewage Oxidation," pp. 189-193.

utilization of bicarbonates by algae as a source of carbon dioxide for photosynthesis.[14,15]

The determination of pH is another important parameter to be considered in stream studies. Ellis[16] recommended that in pollution work a hydrogen ion concentration outside the range of pH 6.7 to 8.6 be viewed with suspicion until it is definitely shown to be a result of natural causes. Photosynthesis by algae on clear days was shown by Sawyer[17] and Klein[18] to frequently result in pH levels above 9.0 in both lentic and lotic situations.

Specific conductance has been used to indicate changes in levels of ionizable salts in river waters. Discharges of oil-field waste water or industrial wastes containing salts or strong acids are easily detected by changes in specific conductance levels. In all types of streams except those draining highly alkaline substrates Ellis[19] recommended a search for specific pollutant action if the specific conductance of the

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[14]R.O. Megard, Planktonic Photosynthesis and the Environment of Calcium Carbonate Deposition in Lakes, p. 4.

[15]Willem Rudolfs and H. Heukelekian, "Effect of Sunlight and Green Organisms on Re-aeration of Streams," pp. 52-56.

[16]M.M. Ellis, "Detection and Measurement of Stream Pollution," pp. 129-185.

[17]C.N. Sawyer, "Factors Involved in Disposal of Sewage Effluent to Lakes," pp. 317-328.

[18]Louis Klein, River Pollution, Vol. I, Chemical Analysis, p. 13.

[19]M.M. Ellis, "Detection and Measurement of Stream Pollution," pp. 129-185.

water exceeded 1,000 µmhos at 25° C.

A waste discharge causing increased water temperature, turbidity, or coloration has been classified as physical pollution.[20] Natural increases in turbidity and siltation as a result of increased discharge were reported in the upper Mississippi River by Dorris and Copeland[21] and in the Guadalupe River by Kuehne.[22] Although most of the Guadalupe River below the Edwards Plateau is turbid much of the time, Kuehne[23] reported that the larger lakes on the lower Guadalupe appear to act as sediment traps and thereby cause a reduction in turbidity in the lakes. Reduced turbidity has been listed as a beneficial effect of impoundment of streams that were once free-flowing.[24,25]

The role of flow-reducing dams in possibly enhancing both natural and cultural eutrophication processes by causing increased primary production was examined in the present study

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[20] H.A. Hawkes, The Ecology of Waste Water Treatment, p. 106.

[21] T.C. Dorris and B.J. Copeland, "Limnology of the Upper Mississippi River, IV, Physical and Chemical Limnology of River and Chute," pp. 79-88.

[22] R.A. Kuehne, Stream Surveys of the Guadalupe and San Antonio Rivers, p. 3.

[23] Ibid.

[24] J.M. Symons, W.H. Irwin, Jack DeMarco, and G.C. Robeck, Effects of Impoundments on Water Quality--A Review of Literature and Statement of Research Needs, pp. 28-36.

[25] S.K. Love, "Relationship of Impoundments to Water Quality," pp. 559-568.

by analysis of limnological data from stations located above and below those man-made structures. A nutrient study was conducted in conjunction with this study.[26] Results from that study were used as deemed necessary for complete analysis of this data.

Impounded waters are more adversely affected by domestic enrichment than are flowing waters because of nutrient accumulations that may develop as flow decreases.[27] Tarzwell and Palmer[28] and Tarzwell and Gaufin[29] have shown that dams may act as nutrient traps when organic wastes entering a turbid impoundment are reduced to useable nutrient forms which cannot be utilized by the plant populations present because of insufficient light penetration of the water. Resulting accumulations of nutrients in the impoundment may be periodically released downstream, where, as the water clears sufficiently for photosynthesis to occur, undesirable blooms of aquatic vegetation may be produced far from the original source of enrichment. The major problem involving nutrient accumulation in the impounded sections of the Guadalupe River appeared to

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[26]Howard Woerner, "A Nutrient Study of the New Braunfels-Gonzales Stretch of the Guadalupe River," Master's Thesis, in progress.

[27]A.D. Hasler, "Cultural Eutrophication is Reversible," pp. 425-431.

[28]C.M. Tarzwell and C.M. Palmer, "Ecology of Significant Organisms in Surface Water Supplies," pp. 568-578.

[29]C.M. Tarzwell and A.R. Gaufin, "Some Important Biological Effects of Pollution Often Disregarded in Stream Surveys," pp. 21-31.

be continued recycling and buildup in the lakes rather than in downstream release. Downstream nutrient releases were inhibited by top-draining construction of all the dams on the Guadalupe River except Canyon Dam which was located approximately 50.7 km upstream from Station 1.

Cultural eutrophication of natural waters often results in the esthetic deterioration of the entire water course as evidenced by algal scum discoloring the water and by excessive growths of large aquatic plants.[30] Boating and swimming may become uninviting and fish populations may suffer due to decreased dissolved-oxygen levels. River and lake-front property values will naturally decline under such conditions and the economy of an entire area may suffer.

The use of this study as a water quality baseline in future years should aid in avoiding the degree of over-eutrophication described above. The main objective of this study was to determine the relative quality of the water passing along the New Braunfels-Gonzales stretch of the Guadalupe River. This objective required analysis and discussion of individual parameters and relationships between different parameters with emphasis upon the following factors: (1) the effect of domestic and industrial effluents, (2) limnological changes across dams, (3) differences between flowing and standing river stretches, (4) diel variations, (5) surface and bottom differences,

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[30]A.D. Hasler, "Eutrophication of Lakes by Domestic Drainage," pp. 383-395.

(6) seasonal changes, (7) fluctuations in water discharge levels, and (8) agricultural run-off.

CHAPTER II

DESCRIPTION OF STUDY AREA

General Description

From its source in the Edwards Plateau region of south-central Texas the Guadalupe River flows southeastward from an elevation of almost 610 m to sea level at its mouth in San Antonio Bay. The Guadalupe River transects five of the natural geological subdivisions of Texas in its 644 km course. The subdivisions are, from source to mouth: Cretaceous, Eocene, Miocene, Pliocene, and Quaternary.

The swift, shallow, and relatively clear Guadalupe River of the Edwards Plateau changes abruptly in nature soon after entering the study area just below New Braunfels, Texas. This change is due to entry of the stream into the Blackland Prairie region. From east of New Braunfels to the coast the Guadalupe River is characterized by a meandering pattern within broad, flat river valleys.[1]

Although the study area section of the Guadalupe River receives a large and fairly constant water supply from the spring-fed Comal River at New Braunfels and the Guadalupe River downstream from Canyon Reservoir, only small areas of shallow, flowing water remain within the Blackland Prairie section due

[1] R.A. Kuehne, Stream Surveys of the Guadalupe and San Antonio Rivers, p. 9.

to construction of three hydroelectric dams between New Braunfels and Seguin (Figure 1). The three dams, Dunlap, McQueeney, and Placid, have converted the swift-flowing Guadalupe River of the Edwards Plateau into a series of long, narrow riverine impoundments characterized by moderate depths, mud bottoms, and persistent murkiness.

East of Seguin, Texas, the Guadalupe River enters the Sandy Post Oak Belt.[2] Long pools separated by occasional gravel riffles are common to the river in this area. Lake Gonzales and Lake Wood have converted lengthy stretches of this section of the river into standing water characterized by murkiness, silted mud bottoms, and an over-abundance of water lilies and water hyacinths.

Descriptions of Stations

The sixteen stations included in this study were located along 153-river km of the Guadalupe River between New Braunfels and Gonzales, Texas. Station 1 was located in Comal County, Stations 2 through 10 in Guadalupe County, and Stations 11 through 15 in Gonzales County. See Figure 1 for approximate locations of stations, impoundments, and effluents. Station locations in river miles and kilometers from the mouth of the Guadalupe River are shown in Table LIV in the appendix. Water depth and velocity at each station are shown in Tables XXXXVII

[2] Ibid.

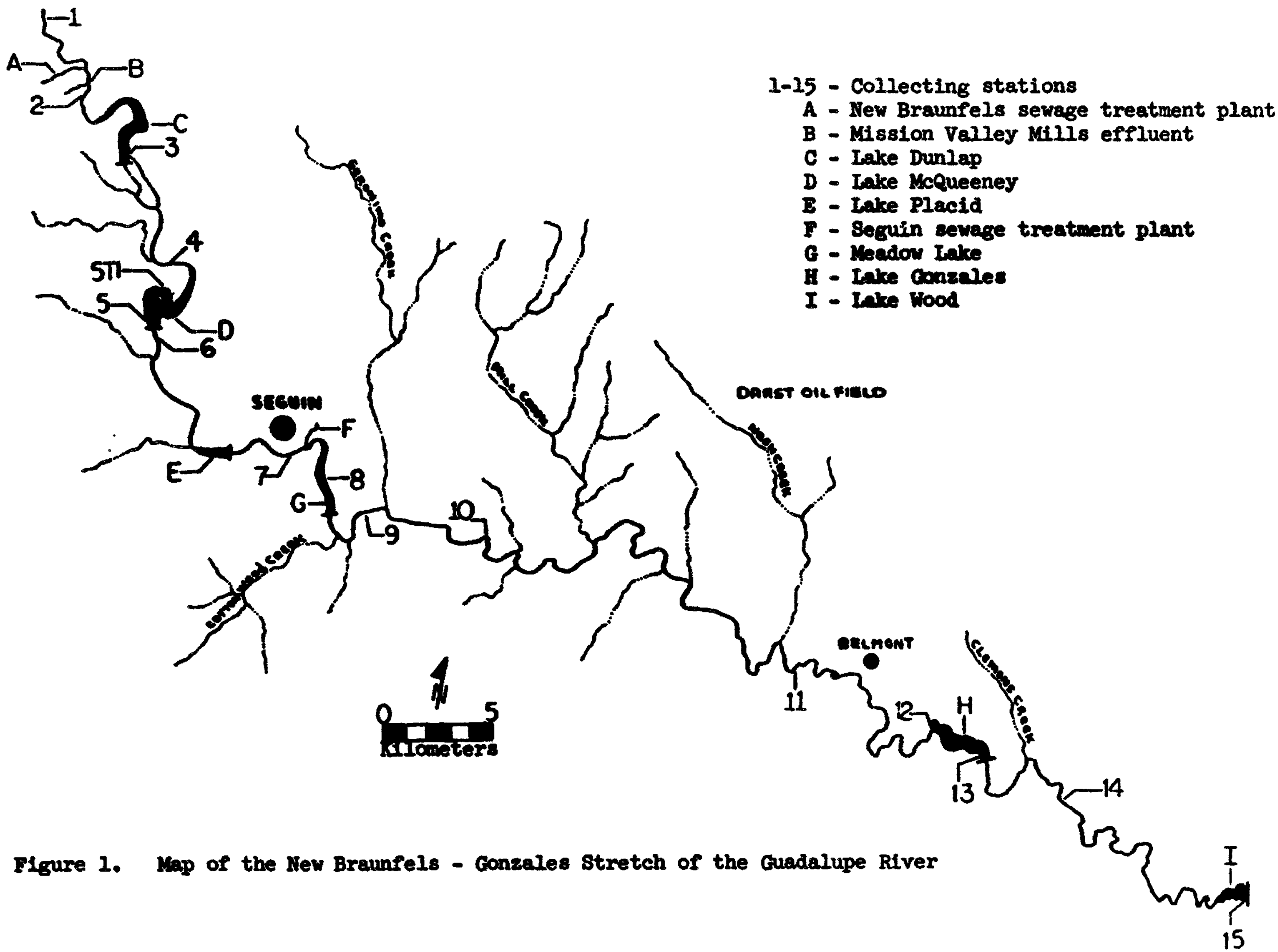

Figure 1. Map of the New Braunfels - Gonzales Stretch of the Guadalupe River

and XXXXVIII, respectively. Unless indicated otherwise, samples were taken from a boat in the center of flow of the river or lake channel.

Station 1 was located beneath the Interstate 35 highway bridge approximately 1.6 km downstream from the confluence of the Comal and Guadalupe Rivers. Midstream water depth at the sampling point ranged from 2.3 to 2.9 m during the study period. Relatively constant flow of moderate velocity and low turbidity were observed at Station 1. Large masses of cropped macrophytic aquatic vegetation from Comal Springs were observed floating past Station 1 on several occasions. The bottom at Station 1 was rock with scattered pockwts of mud supporting sparse growths of *Ludwigia* sp.

Station 2 was located at Leibsch's farm approximately 4.2 km downstream from Station 1. Effluents from the New Braunfels sewage treatment plant and the Mission Valley textile mill entered the river approximately 1.6 and 0.6 km, respectively, above Station 2. Water depth at Station 2 ranged from 3.0 to 3.5 m during the study period. The substrate at Station 2 was composed of brown mud with some benthic vegetation (*Ludwigia* sp.) present. Dense mats of cropped aquatic macrophytes were frequently observed floating past Station 2. The source of this vegetation was the Comal River above Station 1.

Station 3 was located 0.1 km above Lake Dunlap Dam at a point where depth ranged from 7.3 to 7.8 m during the study period. The sampling area was approximately 7.4 km downstream from Station 2. No measureable water velocity was observed at Station 3. The substrate was composed of brown mud similar to that found at Station 2. No aquatic vegetation was present on the substrate at Station 3.

Station 4 was located approximately 6.8 km below Lake Dunlap Dam at Elm Grove Camp. Water depth ranged from 4.0 to 4.3 m over a substrate composed of rock. Mud bottom supporting growths of algae (Oscillatoria sp.) and water lilies (Nuphar sp.) was present along each river bank. Measureable water velocity was observed at Station 4 only when the Lake Dunlap hydroelectric power station was in operation.

Station 5 was located 25 m above Lake McQueeney Dam and approximately 5.3 km below Station 4. Depth ranged from 6.7 to 7.5 m over a substrate of mud. No measureable water velocity was observed at Station 5.

Station 5TI, located behind Treasure Island on the north side of Lake McQueeney, was established as a sampling station on June 14, 1969. Water depth at Station 5TI ranged from 3.6 to 4.3 m over a substrate of deep mud covered with fine layers of organic detritus. The island and entire lake front area of Lake McQueeney is crowded with private residences and boat concessions. Septic tanks furnish the only known means of domestic sewage disposal from this heavily populated area. Extensive growths of water lilies and filamentous algae were observed at both stations in Lake McQueeney. A heavy phytoplankton bloom was observed monthly from February through June behind Treasure Island. Negligible flow was present through the section of Lake McQueeney behind the island.

Samples from Station 6, located 0.4 km below Lake McQueeney Dam at McQueeney, Texas, were taken from the end of a boat ramp extending some 2.5 m out into the river channel. Water depth ranged from 1.0 to 2.7 m. Fluctuations in depth were due to intermittent discharge from the Lake McQueeney power station. The substrate at Station 6 was composed of a mixture of gravel, mud, and rock. No macrophytic aquatic vegetation was observed at Station 6.

Station 7 was located in Seguin's Starke Park downstream from State Highway 123 bridge, approximately 0.6 km upstream from the Seguin sewage treatment plant outfall, and 12.6 km downstream from Station 6. Due to steep banks along the river in that area, samples were taken from an overhanging tree approximately 1.2 m out from the bank. The bottom at that point was composed of dark mud and organic detritus. Water depth at Station 7 ranged from 1.8 to 2.5 m during the study period. Moderate flow was observed during each sampling period. The only macrophytic aquatic vegetation present at Station 7 was water hyacinths (*Eichornia* sp.) trapped in low-hanging branches and vines along the bank.

Station 8 was located in Meadow Lake approximately 5.1 km below the Seguin sewage treatment plant outfall and 1.6 km above Nolte Dam. Depth ranged from 5.9 to 6.2 m over a substrate of light-colored mud. No measureable water velocity was observed at Station 8 during the study period. Scattered patches of water hyacinths and water lilies were the only aquatic macrophytes observed at Station 8.

Station 9 was located beneath the Ranch Road 466 bridge approximately 0.4 km downstream from the Nolte hydroelectric power station and 4.1 km downstream from Station 8. Water velocity and depth fluctuated at Station 9 due to opening and closing of the Nolte turbines. Water depth ranged from 0.8 to 1.4 m during the study period while water velocity varied from 0.43 to 0.60 m per second. The substrate at Station 9 was composed of rock perforated by crevices and holes.

Station 10 was located on Hugo Pape's Pecan Valley Ranch, approximately 8.0 km below Station 9, in a rapidly flowing, shallow stretch of the river characterized by a gravel substrate and no macrophytic vegetation. Water depth ranged from 0.7 to 1.3 m during the study period. Samples were taken at Station 10 by wading out to near midstream.

Station 11 was located approximately 35.5 km below Station 10 in a shallow, gravel-bottom section of the river on J.E. Hopwood's Lazy Day Ranch. Water velocity fluctuated at Station 11 due to changes in discharge levels through the Nolte power station. Water depth at Station 11 ranged from 0.4 to 1.1 m. Aquatic vegetation was limited to free-floating plankton and benthic algae along the banks. Nash Creek, which drains a portion of the Darst Oil Field, enters the river 2.2 km above Station 11. Samples were taken at Station 11 by wading out to near midstream.

Station 12 was located in the river channel entrance into Lake Gonzales approximately 22.7 km downstream from Station 11. Water depth ranged from 4.3 to 5.5 m. Water velocity ranged from 0.1 to 0.3 m/sec during the study period. The substrate at Station 12 was composed of mud and organic detritus. Heavy growths of water lilies and elephant ears (Philodendron sp.) bordered the river channel at Station 12.

Station 13 was located in the lower end of Lake Gonzales approximately 50 m upstream from the dam. Mud substrate and low water velocity characterized Station 13. Water depth ranged from 3.0 to 7.3 m during the study period. This wide variation in depth during different monthly sampling periods was attributed to samples being taken at different loci along the sloping, inundated banks of the old river channel. A similar situation was found to exist at Station 15 in Lake Wood. Scattered patches of water lilies and water hyacinths were observed near Station 13.

Station 14 was located in a rapidly flowing stretch of the Guadalupe River approximately 11.1 km below the Lake Gonzales dam, 1.6 km south of Oak Forest, Texas, and 1.0 km downstream from Wade Dam. Samples were taken by lowering a sampler from a bridge on an unnumbered farm road which links Alternate U.S. Highway 90 and Ranch Road 466. Water depth at Station 14 was 3.1 m. The substrate was composed of a mixture of gravel and mud. No rooted aquatic vegetation was observed at Station 14.

Station 15 was located in Lake Wood approximately 20 m above the dam and 22.5 km downstream from Station 14. The only section of open water in the lake was located in the area just above the sampling station. Water depth ranged from 3.0 to 7.2 m over a substrate of mud. Prolific growths of water lilies occurred in the littoral zone of the lake. No measureable water velocity was observed at Station 15 during the study period.

CHAPTER III

METHODS AND MATERIALS

Collection of Samples

Collections of monthly water samples were made from February 22, 1969, through July 12, 1969, at fifteen stations on the Guadalupe River between New Braunfels and Gonzales, Texas. Diel samples were collected at 4-hr intervals in February and May. All fifteen stations could not be sampled every 4 hr in a given 24-hr period; therefore, in February and May, Stations 1 through 9 were sampled one week and Stations 10 through 15 were sampled the following week. March, April, June, and July samples were collected once during the day and once during the night at all fifteen stations. Daytime sampling was begun at 1200 hr and nighttime sampling at 2400 hr.

Surface samples were taken at all stations during each sampling period. On February 22 and March 1, bottom water samples were collected at Stations 3, 4, 5, and 8. From March 29 through July 12, bottom water samples were collected at Stations 3, 4, 5, 8, 12, 13, and 15. In June and July, surface and bottom water samples were taken at Station 5TI located behind Treasure Island in Lake McQueeney. All samples were taken with 2-liter Kemmerer water samplers.

Physicochemical Determinations

Duplicate dissolved oxygen samples were collected at each station in 140-ml bottles. Dissolved oxygen was analyzed by the Alsterburg-Azide modification of the Winkler method.[1] All dissolved oxygen samples were fixed immediately upon collection and titrated within 4 to 6 hr after fixing. Oxygen saturation values were calculated from a nomograph.[2] Duplicate alkalinity determinations were made from each sample using water stored on ice in 32-oz polyethylene bottles. Both phenolphthalein and methyl orange alkalinity were measured by titration with 0.02 N sulfuric acid.[3] All alkalinity titrations were completed within 4 to 6 hr after collection of the samples.

In February and May, 1969, samples for pH and specific conductance measurements were either analyzed in the field immediately after sampling or at a rendezvous point within 2 or 3 hr after collection. In March, April, June, and July, pH and specific conductance samples were transported back to the laboratory for analysis. All samples were transported in tightly-sealed quart jars. All pH readings from February through July were made with either a Beckman Model M meter or with an IL Model 175 meter. With the exception of samples taken at Stations 5 through 9 on February 22-23, all conductance readings were made with a temperature compensated Beckman RB3 Solu

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[1]American Public Health Association, Standard Methods for Examination of Water and Wastewater, pp. 406-410.

[2]G.K. Reid, Ecology of Inland Waters and Estuaries, p. 147.

[3]American Public Health Association, Standard Methods for Examination of Water and Wastewater, pp. 49-51.

Bridge. The non-temperature calibrated conductance readings taken in February were corrected to 25.0 C.[4] Carbon dioxide concentrations were estimated from a pH-bicarbonate alkalinity nomograph.[5]

Temperature readings at Stations 1 through 4 during the February 22-23 diel sampling period were made using a YSI Model 51 temperature meter. Except for the use of an FT3 Marine Hydrographic Thermometer in checking for thermoclines at Stations 3 and 15 in July, all other temperature measurements were made with a standard centigrade mercury thermometer. Bottom temperature measurements were made by placing the thermometer immediately into water collected with a Kemmerer sampler.

Estimates of wind velocities were made using a Dwyer wind meter. Measurements of solar radiation were taken with a Tri-Lux foot-candle meter. The time required for a cork to float 5 ft was measured with the sweep-second hand of a watch to estimate surface water velocity. Light penetration of the water was determined with a standard 20-cm Secchi disk. Weighted brass chains marked at 2-ft intervals were used to measure depth.

Chlorophyll _a_ and turbidity analyses were made on water samples transported to the laboratory in tightly-sealed quart

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[4]H.L. Golterman, editor, _Methods for Chemical Analysis of of Fresh Waters_, p. 20.

[5]E.W. Moore, "Graphic Determination of CO_2 and Three Forms of Alkalinity," pp. 51-66.

jars. Two 100-ml aliquots from each sample were filtered through 0.45 mμ Millipore filters for use in the chlorophyll a determination. Chlorophyll was extracted in 10 ml of 90 per cent acetone for 24 hr at 5 C. After centrifugation, optical density of the chlorophyll extract was determined at 665 mμ with a Bausch and Lomb Spectronic 20 Colorimeter. Chlorophyll a was calculated by use of the equation of Odum, McConnel, and Abbott.[6] Turbidity was measured with a Bausch and Lomb Spectronic 20 and converted to Jackson turbidity units.[7]

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[6]H.T. Odum, William McConnell, and Walter Abbott, "The Chlorophyll A of Communities," pp. 65-96.

[7]Hach Procedures for Water and Sewage Analysis Using the Bausch and Lomb Spectronic 20 Colorimeter, pp. 114-115.

CHAPTER IV

RESULTS AND DISCUSSION

Meteorological Conditions

Wind velocity and solar illumination were measured periodically throughout each diel sampling period (Tables L-LIII in the appendix). Maximum and minimum wind velocities during any one diel period were 16 and 0 km/hr, respectively. Illumination varied from an early morning low of 10 ft-c on March 1 to a noon high of 9000 ft-c on April 19. Prevailing wind was generally from the north and east in February through April and from the south and west in May through July. Measureable wind velocity was observed consistently in the forenoon and early afternoons of each sampling period. Consistent nighttime wind was observed only on May 17-18, June 14-15, and July 12-13. Wind action undoubtedly aided in keeping the waters of the lakes well-mixed.

Measureable rainfall was not observed during sampling periods. Heavy rainfall in the study area during the second week in May was reflected in high turbidity at Stations 10-15 during the May 17-18 sampling period (Tables XXXIII-XXXVIII in the appendix).

The minimum air temperature during the study period was 6.5 C at Station 7 on February 22 (Table VII in the appendix). The maximum air temperature was 39.0 C at Station 10 on June 14

(Table XXXXI in the appendix). Mean air temperatures for each diel sampling period increased from February through July. The effect of cloud cover upon minimum nighttime air temperature levels was noted at Stations 10-15 during the 2400 hr sampling run of the March 1-2 sampling period. Sudden clearing of cloud cover during the March 1 midnight sampling run correlated exactly with decreases of 1.7 to 5.5 C in air temperatures (Tables X-XV in the appendix). The return of cloud cover during the 0400 hr sampling run resulted in temperature increases at four of the six stations involved.

Limnological Conditions

Results of all limnological analyses are summarized in Tables I through XXXXIX in the appendix.

Surface water temperatures ranged from a minimum of 13.0 C at Station 9 in February (Table IX) to a maximum of 32.0 C at Station 5 in July (Table XXXXIV). The similarity of surface and bottom water temperature ranges and means for the six-month study period showed the general trend of thorough thermal mixing at nearly all stations (Figure 2).

Comparison of the minimum temperature ranges for Stations 1 through 9 and 10 through 15 is deceiving because the initial sampling effort at the lower stations was conducted a week later than at the upper nine stations. Water temperatures ranged from 1.0 to 4.0 C higher at Stations 10 through 15 on March 1-2 than at Stations 1 through 9 on February 22-23. The

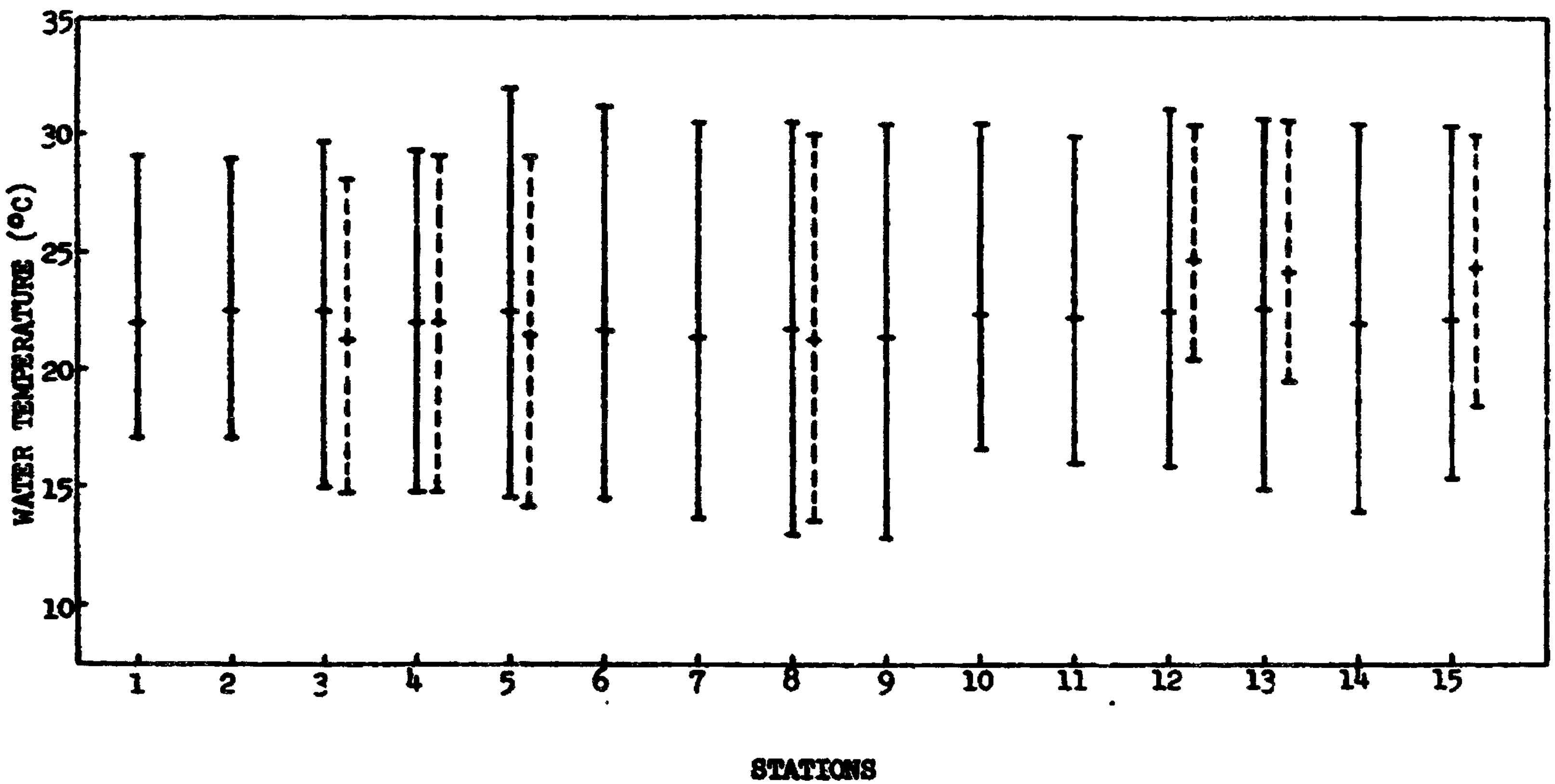

FIGURE 2. SURFACE AND BOTTOM WATER TEMPERATURE RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SOLID VERTICAL LINES INDICATE SURFACE TEMPERATURE RANGES AND DASHED VERTICAL LINES INDICATE BOTTOM TEMPERATURE RANGES. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETHIC MEANS FOR EACH STATION. SEE TABLES XXXX AND XXXXIV IN THE APPENDIX FOR STATION 5TI WATER TEMPERATURE DATA.

bottom temperature ranges for Stations 12, 13, and 15 were narrower than the surface temperature ranges because bottom water sampling was not initiated at those stations until March 29.

Six-month surface water temperature means for the fifteen stations ranged from 21.0 to 22.5 C (Figure 2). This range showed only slight temperature variations between upstream-downstream and flowing-standing stretches of the river. The regular movement of water through the impoundments for hydroelectric power production was the main reason for the lack of water temperature differences between standing and flowing stretches of the river.

The thermal stabilizing effect of the inflow of the relatively constant temperature Comal River water into the Guadalupe River above Station 1 was noticeable in February. Water temperatures at Stations 1 and 2 ranged from 1.0 to 2.0 C higher than at any of the other upper nine stations sampled in February (Tables I and II). Such temperature differences were not evident as water temperatures increased at all stations in sampling periods after February; however, the overall six-month temperature ranges for Stations 1 and 2 were noticeably less than any of the other stations (Figure 2).

The only appreciable temperature changes across a dam were observed above and below Lake McQueeney Dam at Stations 5 and 6. In June and July, daytime water temperatures at Station 6 ranged from 1.5 to 2.6 C lower than those recorded above the dam during the same sampling period (Tables XXXX and XXXXIV). The decrease across the dam resulted from heat from radiant energy accumulating in the standing water above the dam and then being lost during turbulent passage of the water through the hydroelectric power station turbines.

Only slight diel variations in water temperatures were recorded during the study period. The maximum variation during a diel period was 5.0 C at Station 6 on February 22-23 (Table VI). Most stations showed diel variations of less than 2.0 C. variation in water temperature was more pronounced during February than in May because of the greater differential between mean air and water temperatures in February. Diel variations in water temperature were no greater in the flowing stretches of the river than in the impoundments. Large warm streams like the Guadalupe River show considerably less diel temperature variation than small, colder streams.[1]

The only surface-bottom temperature differences greater than 2.0 C occurred at Stations 3 and 5 in June and July (Tables XXXIX, XXXX, XXXXIII, and XXXXIV) and at Station 13 in June (Table XXXXIV). The maximum surface-bottom temperature difference of 5.5 C was recorded at Station 3 in Lake Dunlap after midnight on June 15. The Dunlap power station was not in operation at that time. The surface water temperature was 28.5 C while the bottom temperature was 23.5 C at a depth of

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[1]G.K. Reid, Ecology of Inland Waters and Estuaries, p. 123.

7.8 m. Small, gradual temperature gradients of 5 to 10 C from surface to bottom are common in shallow, main-stream impoundments.[2]

During the study period, surface dissolved oxygen ranged from a low of 4.9 mg/l at Station 7 on July 12 (Table XXXXIV) to a maximum of 15.9 mg/l at Station 3 on June 14 (Table XXXX). Surface oxygen saturation ranged from 64 per cent at Station 4 on April 19 (Table XX) and at Station 7 on July 12 (Table XXXXIV) to above 150 per cent at Stations 3 and 5 in June and July (Tables XXXIX, XXXX, XXXXIII, and XXXXIV). Except for sporadic periods of high oxygen concentration due to photosynthesis, as estimated by chlorophyll a, dissolved oxygen and per cent saturation at all stations generally decreased from February through July (Figures 3-8). Oxygen exceeded 100 per cent saturation only when photosynthetic oxygen production was high.

Mean diel surface dissolved oxygen concentrations at Stations 1, 2, 3, 4, 6, and 7 ranged between 6.0 and 8.0 mg/l during the March 29 sampling period (Tables XVI-XIX). At Station 5 and Stations 8 through 15 surface dissolved oxygen was above 8.0 mg/l as a result of planktonic photosynthesis (Figure 4). Surface oxygen saturation greater than 100 per cent occurred at all of the above mentioned stations except Station 14.

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[2]F.W. Kittrell, "Effects of Impoundments on Dissolved Oxygen Resources," pp. 1065-1081.

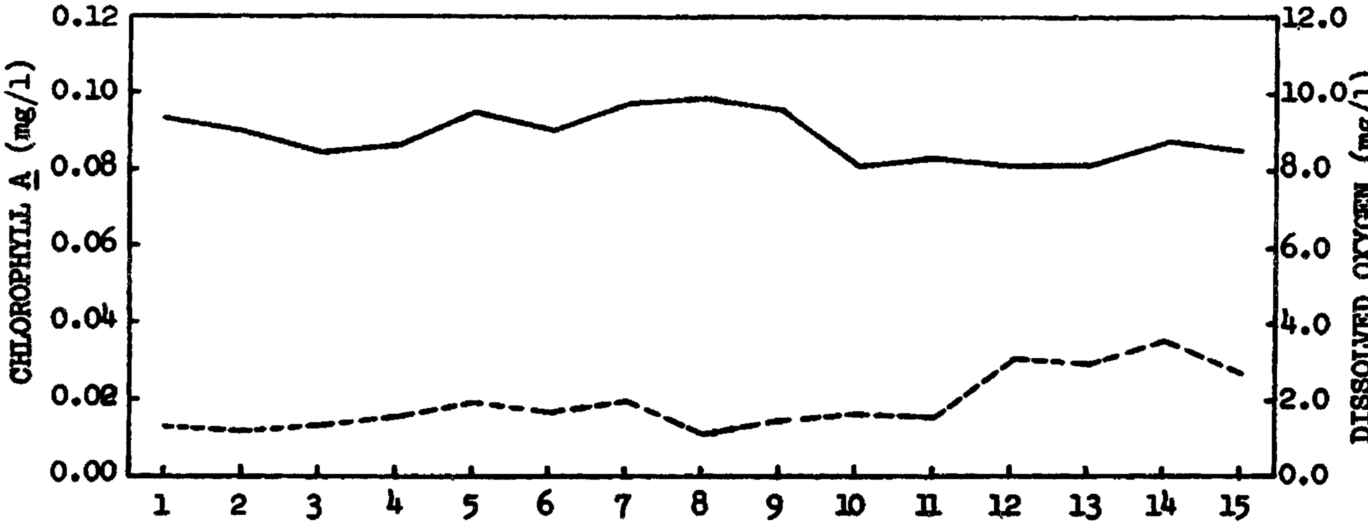

FIGURE 3. DISSOLVED OXYGEN AND CHLOROPHYLL A AT 15 STATIONS IN THE GUADALUPE RIVER, FEBRUARY 22-23 AND MARCH 1-2, 1969. —DISSOLVED OXYGEN, --- CHLOROPHYLL A

FIGURE 4 - DISSOLVED OXYGEN AND CHLOROPHYLL A AT 15 STATIONS IN THE GUADALUPE RIVER, MARCH 29, 1969. —DISSOLVED OXYGEN, ---CHLOROPHYLL A

In April and May, mean surface diel dissolved oxygen concentrations ranged between 6.0 and 8.0 mg/l at all stations except Station 5 (Figures 5 and 6). Photosynthesis was responsible for daytime surface dissolved oxygen concentrations greater than 9.0 mg/l occurring at Station 5 during both months. Mean diel chlorophyll a concentrations at Stations 8, 12, and 13 in April and at Stations 12, 13, and 15 in May were almost as high as those at Station 5 during the same sampling periods (Figures 5 and 6). Greater turbidity at Stations 8, 12, 13, and 15 than at Station 5 reduced light penetration of the water (Tables XXI, XXII, XXIII, XXVIII, XXXI, XXXV, XXXVI, XXXVIII). This curtailed any appreciable photosynthetic oxygen production at the downstream stations. The limiting effect of increased turbidity upon photosynthetic oxygen production in streams has been observed by O'Connell and Thomas,[3] Rudolfs and Heukelekian,[4] and Tarzwell and Gaufin.[5]

In June and July, surface dissolved oxygen ranged between 6.0 and 7.0 mg/l at Stations 1 and 2 and between 8.0 and 15.0 mg/l at Stations 3, 4, 5, 5TI, and 6 (Figures 7 and 8). Surface oxygen saturation ranged from 95 to 150 per cent at Stations 3

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[3]R.L. O'Connell and N.A. Thomas, "Effect of Benthic Algae on Stream Dissolved Oxygen," pp. 1-16.

[4]Willem Rudolfs and H. Heukelekian, "Effect of Sunlight and Green Organisms on Reaeration of Streams," pp. 52-56.

[5]C.M. Tarzwell and A.R. Gaufin, "Some Important Biological Effects of Pollution Often Disregarded in Stream Surveys," pp. 21-31.

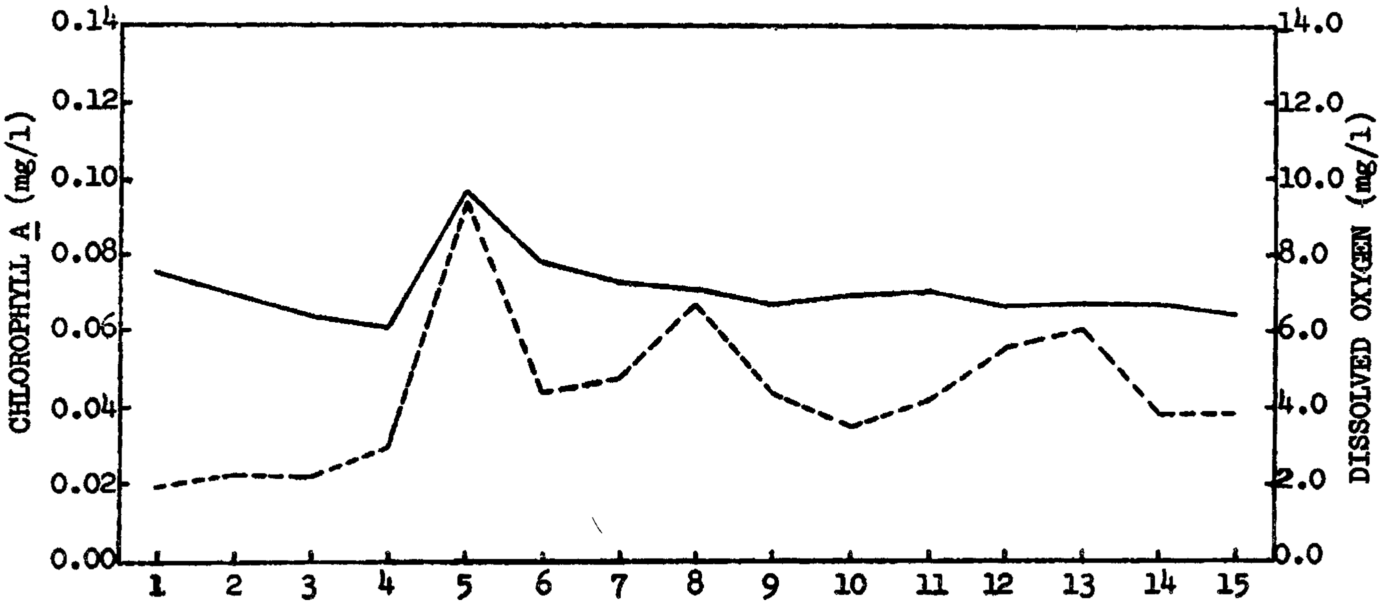

FIGURE 5 - DISSOLVED OXYGEN AND CHLOROPHYLL A AT 15 STATIONS IN THE GUADALUPE RIVER, APRIL 19-20, 1969. —DISSOLVED OXYGEN, ---CHLOROPHYLL A

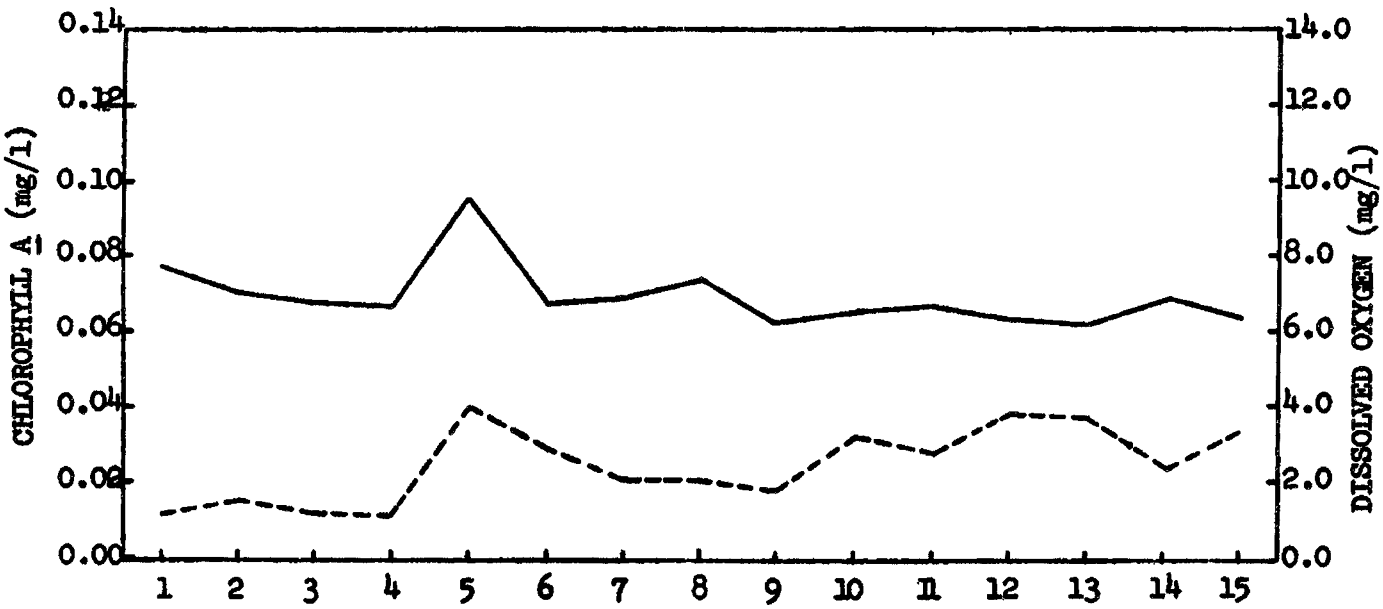

FIGURE 6 - DISSOLVED OXYGEN AND CHLOROPHYLL A AT 15 STATIONS IN THE GUADALUPE RIVER, MAY 10-11 AND MAY 17-18, 1969. — DISSOLVED OXYGEN, ---- CHLOROPHYLL A

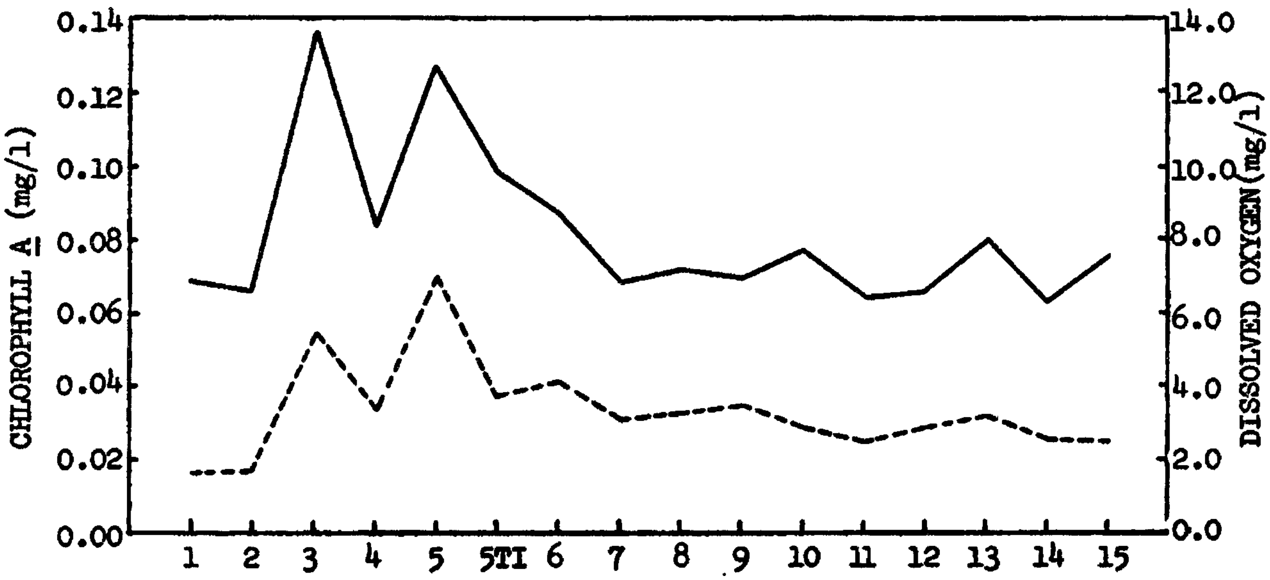

FIGURE 7. DISSOLVED OXYGEN AND CHLOROPHYLL A AT 16 STATIONS IN THE GUADALUPE RIVER, JUNE 14-15, 1969. —DISSOLVED OXYGEN, --- CHLOROPHYLL A

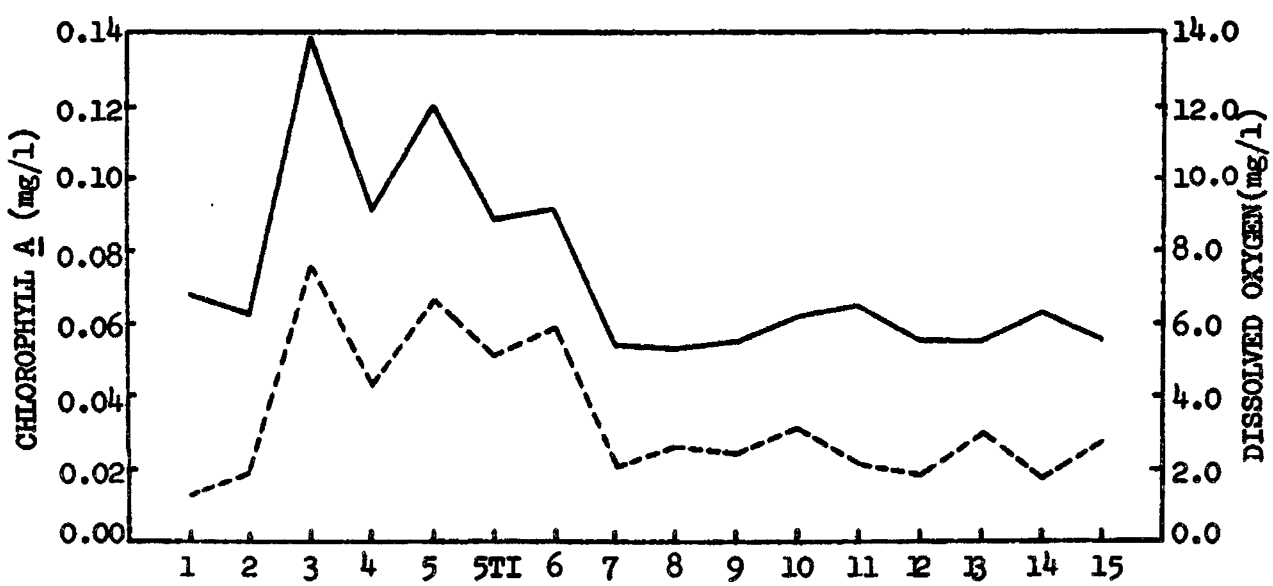

FIGURE 8. DISSOLVED OXYGEN AND CHLOROPHYLL A AT 16 STATIONS IN THE GUADALUPE RIVER, JULY 12-13, 1969. — DISSOLVED OXYGEN, --- CHLOROPHYLL A

through 6 in both June and July (Tables XXXIX, XXXX, XXXXIII, and XXXXIV). The high oxygen saturation and dissolved oxygen at these stations was attributed to an increase in the phytoplankton community. Oxygen rarely exceeds 100 per cent saturation when photosynthetic organisms are absent or inactive.[6] Studies by Camp in the Merrimack River showed that planktonic photosynthesis furnished approximately two-thirds of the dissolved oxygen held by the waters of that stream.[7] During the summer, planktonic photosynthesis contributed more to the total oxygen content of Baltimore Harbor than did atmospheric reaeration.[8]

Surface and bottom dissolved oxygen at Stations 7 through 15 ranged between 6.0 and 8.0 mg/l in June and between 5.0 and 7.0 mg/l in July (Tables XXXX-XXXXII and XXXXIV-XXXXVI). Surface and bottom oxygen saturation at these stations ranged from 67 to 97 per cent in June and from 58 to 92 per cent in July. The low oxygen concentrations at Stations 7 through 15 in June and July were a natural result of high water temperatures, low discharge, and a decrease in the phytoplankton community (Tables XXXX-XXXXII and XXXXIV-XXXXVI).

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[6] J.K. Neel, H.P. Nicholson, and A. Hirsch, Main Stem Reservoir Effects on Water Quality in the Central Missouri River, 1952-1957, p. 53.

[7] T.R. Camp, "Field Estimates of Oxygen Balance Parameters," pp. 255-261.

[8] C.H.J. Hull, "Oxygenation of Baltimore Harbor by Planktonic Algae," p. 5.

Bottom dissolved oxygen and per cent saturation ranged from 3.7 mg/l and 44 per cent at Station 3 on April 19 to 10.2 mg/l and 109 per cent at Station 15 on March 29 (Tables XX and XIX). Bottom oxygen concentrations generally showed less diel fluctuations than surface concentrations. Minimum dissolved oxygen levels occurred on the bottom at Station 3 during every month of the study period (Tables III, XVI, XX, XXVI, XXXIX, and XXXXIII). This undoubtedly resulted from the Station 3 area having the deepest longitudinal profile of any impoundment in the study area and also a narrow channel which restricted wind-caused turbulence. It is also possible that organic matter in the form of effluent from the New Braunfels sewage treatment plant and cropped vegetation from Comal Springs could be settling out in the area of reduced flow above Lake Dunlap Dam. The accumulation of organic matter would cause an increased oxygen demand on and near the bottom.

The only appreciable and consistent differences between surface and bottom dissolved oxygen levels occurred at Station 3 on June 14 and July 12 (Tables XXXIX and XXXXIII), at Station 5 on March 29, April 19, May 10, June 14, and July 12 (Tables XVII, XXI, XXVIII, XXXX, XXXXIV), at Station 5TI on June 14 and July 12 (Tables XXXX and XXXXIV), and at Station 12 on March 29 (Table XVIII). In all of these instances, comparison of chlorophyll <u>a</u> and dissolved oxygen concentrations showed that higher surface dissolved oxygen concentrations resulted from photosynthesis occurring in the euphotic zone (Figures 3-8).

Complete stratification with anoxic bottom conditions was not found in any of the impoundments during the study period.

Nighttime surface dissolved oxygen was 1.0 mg/l higher than daytime levels for only five samples during the study. These occurrences were observed at Stations 3 and 13 on June 14 (Tables XXXIX and XXXXII) and at Station 15 on March 29 and June 14 (Tables XIX and XXXXII). Dissolved oxygen levels ranged from 1.1 to 4.5 mg/l higher between 0400 and 044 hours than during the daytime. No relationship between these nighttime dissolved oxygen increases and changes in power station discharge levels could be established. Gunnerson[9] observed that nighttime increases in dissolved oxygen occurred as much as half the time in the Sacramento River. These increases were attributed to variations in respiration.

Diel fluctuations in surface dissolved oxygen were small during February and May (Tables I-XV and XXIV-XXXXIX). Of the fifteen stations sampled at 4-hr intervals for 24 hr during both months, only Station 5 in February showed a diel fluctuation greater than 2 mg/l (Table V). Limitation of photosynthesis in May by increased turbidity from local rainfall runoff undoubtedly reduced the amount of diel variation in surface dissolved oxygen concentrations during the two May sampling periods. Diel variation in February was limited by low photosynthesis as estimated by chlorophyll a.

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[9]C.G. Gunnerson, "Diurnal and Random Variation of Dissolved Oxygen in Surface Waters," pp. 307-321.

The classic high midday and low early morning pattern of diel oxygen variation occurred frequently during the study period, but departures from it were numerous. Examples of both normal and abnormal diel oxygen variations are shown in Figures 9, 10, and 11. The choice of stations used in the figures adequately represents diel oxygen dynamics in both flowing and standing stretches of the study area during two different seasons of the year.

Departures from the usual diel variation pattern were often associated with changes in discharge levels through the reservoir power stations. For example, the gradually increasing dissolved oxygen and per cent saturation levels recorded at Station 3 on May 10-11 probably resulted from water release through the Lake Dunlap power station pulling slightly higher oxygenated upstream water past Station 3 (Figure 9).

Surface dissolved oxygen concentrations were consistently higher above the Lake McQueeney dam at Station 5 than below the dam at Station 6 (Figure 10). The loss of oxygen across the dam was due to turbulent passage of the water through the power station turbines. This loss was most pronounced when the water above the dam was more than 100 per cent saturated with oxygen due to photosynthetic oxygen production by phyto-plankton.

Oxygen concentrations at Stations 11 and 12 on March 1-2 and May 17-18 showed minor diel variations (Figure 11). This was characteristic of flowing stretches of the Guadalupe River

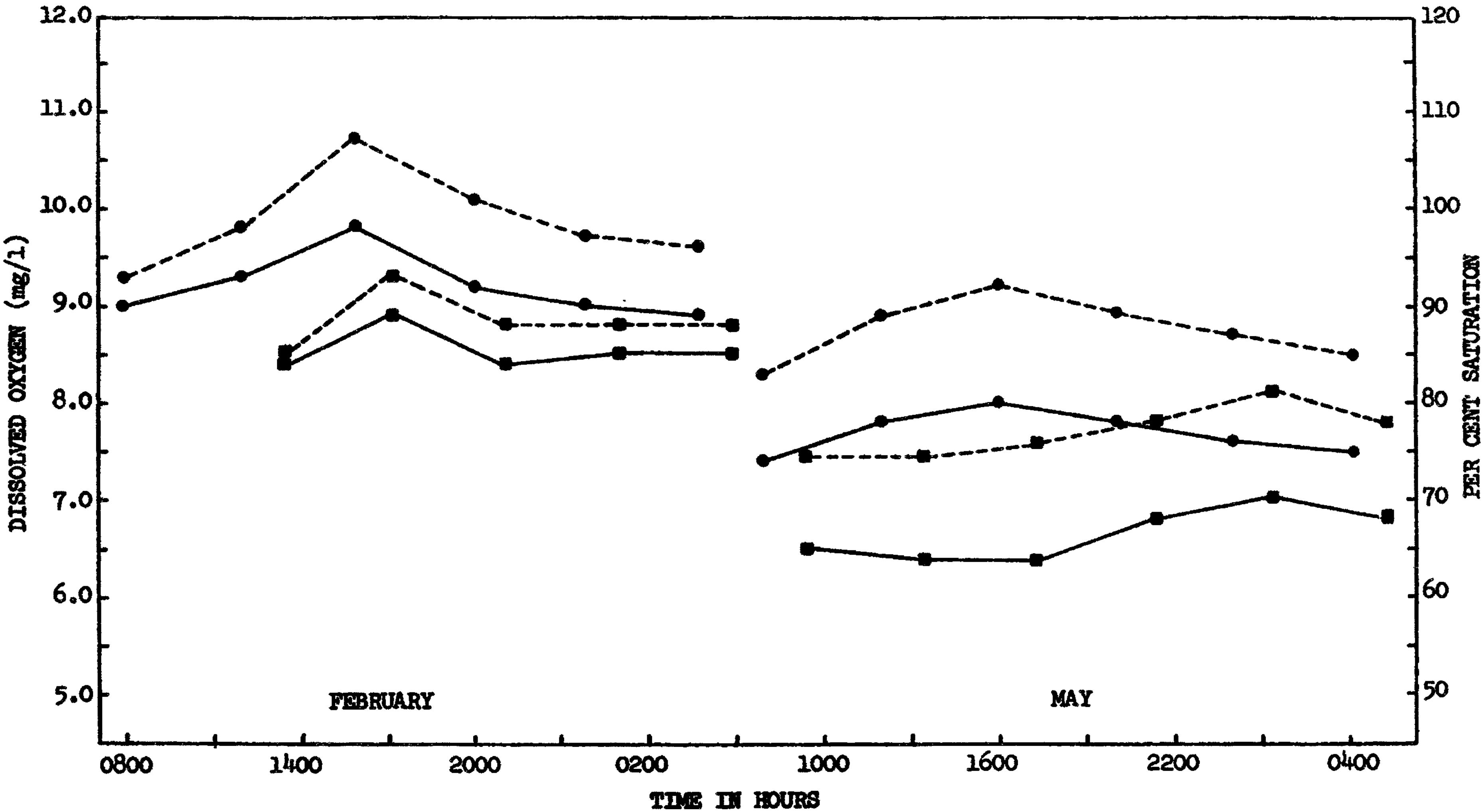

FIGURE 9 - DIEL CHANGES IN DISSOLVED OXYGEN AND PER CENT SATURATION AT STATIONS 1 AND 3 IN FEBRUARY AND MAY, 1969. ● STATION 1, ■ STATION 3, ——DISSOLVED OXYGEN, ---PER CENT SATURATION

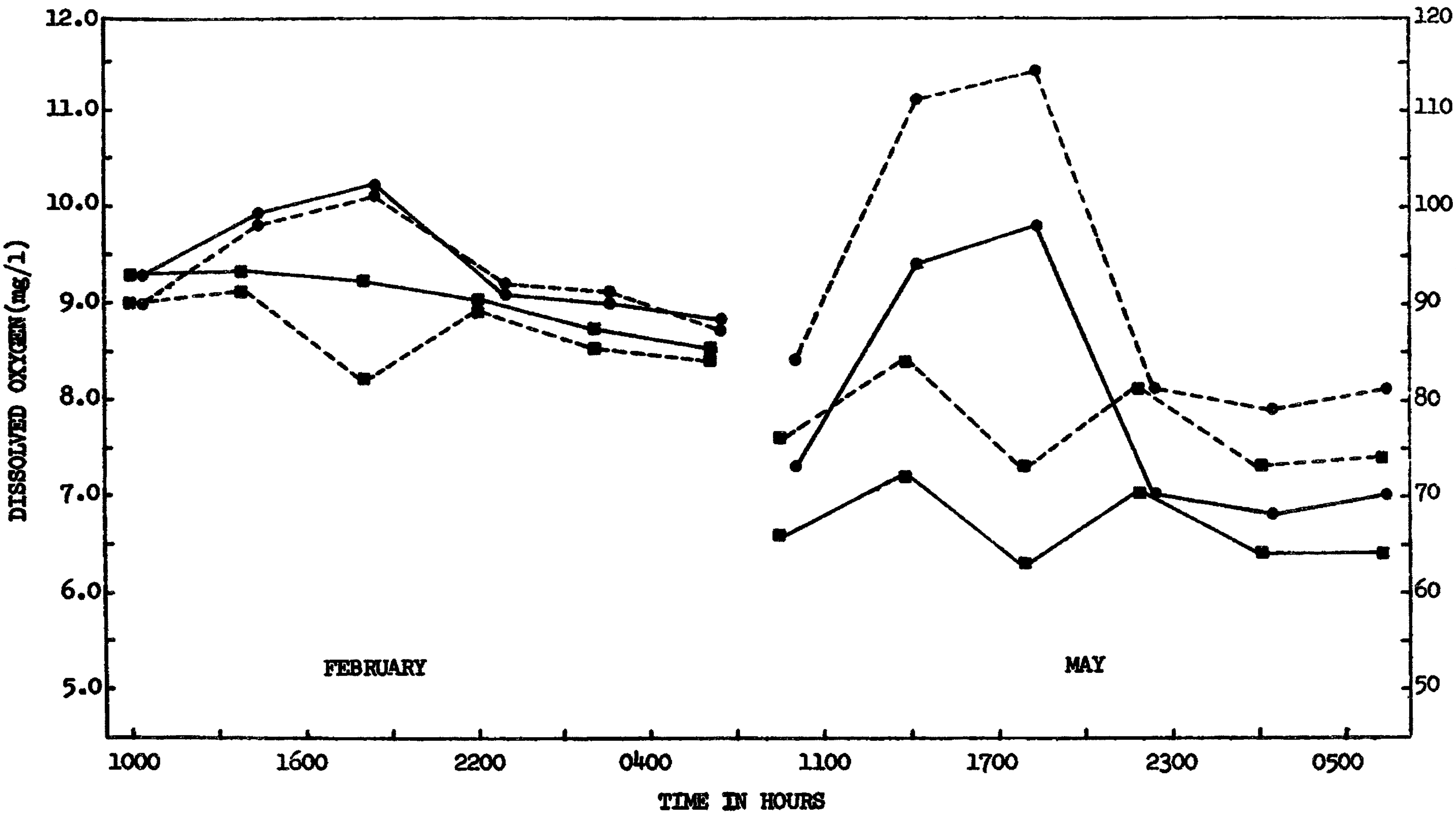

FIGURE 10 - DIEL CHANGES IN DISSOLVED OXYGEN AND PER CENT SATURATION AT STATIONS 5 AND 6 IN FEBRUARY AND MAY, 1969. ● STATION 5, ■ STATION 6, —— DISSOLVED OXYGEN, --- PER CENT SATURATION

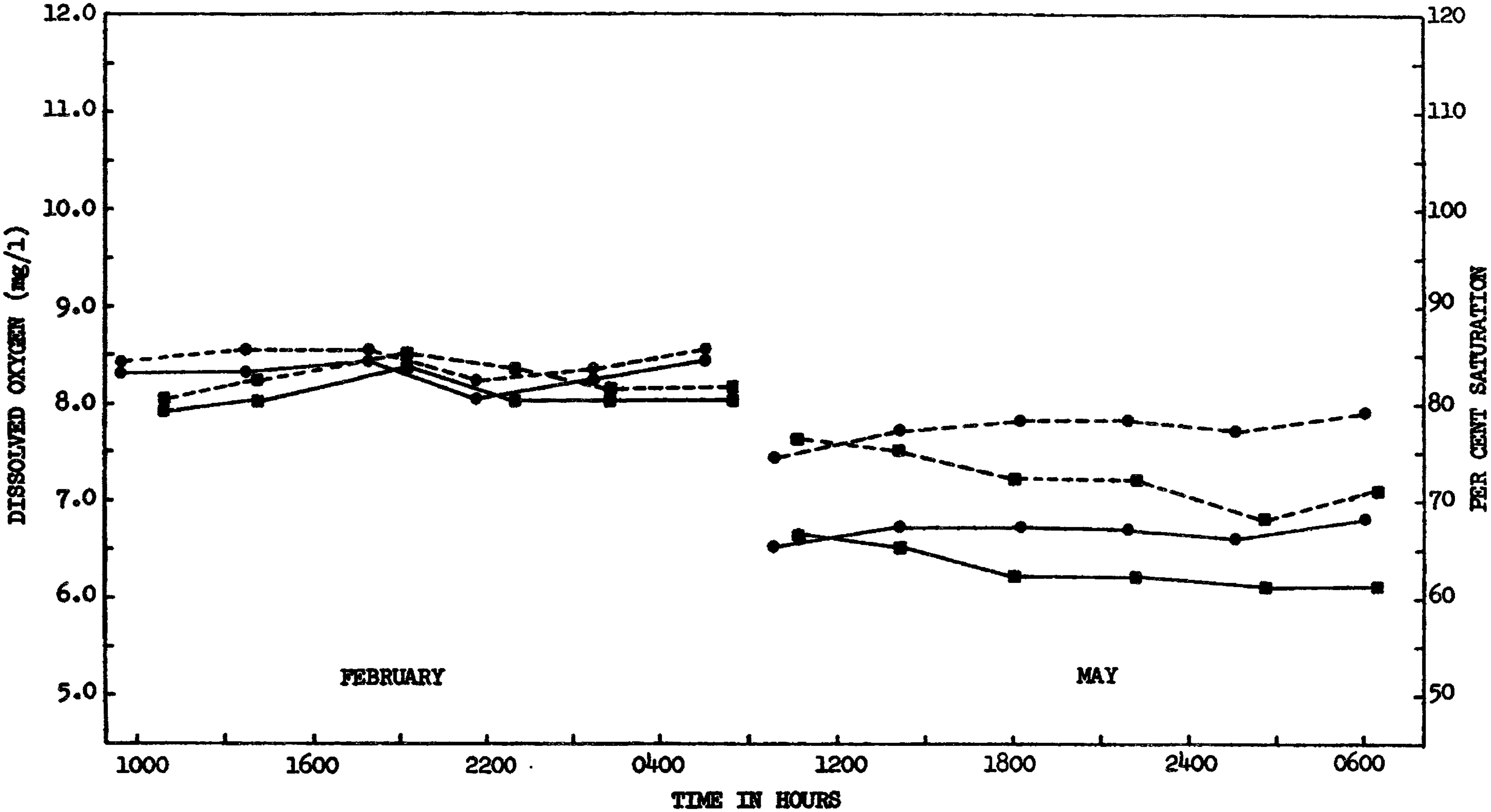

FIGURE 11 - DIEL CHANGES IN DISSOLVED OXYGEN AND PER CENT SATURATION AT STATIONS 11 AND 12 IN FEBRUARY AND MAY, 1969. ● STATION 11, ■ STATION 12, —— DISSOLVED OXYGEN, --- PER CENT SATURATION

located considerable distances from dams. Stations located immediately downstream from dams showed greater diel oxygen variations.

No consistent changes in dissolved oxygen were observed below any waste outfall. Dissolved oxygen sampling downstream from the point of discharge of effluents from the Mission Valley textile mill and the New Braunfels sewage treatment plant revealed no oxygen sag zone.

Chlorophyll a concentrations during the study period ranged from a daytime low of 0.009 mg/l at Station 3 on May 10 (Table XXVI) to a daytime high of 0.260 mg/l at Station 12 on March 29 (Table XVIII). Unless indicated otherwise, all chlorophyll a concentrations mentioned in the discussion and shown in figures are an average of one daytime surface sample and one nighttime surface sample.

Chlorophyll a concentrations at Stations 1 and 2 were consistently low, less than 0.025 mg/l, throughout the study period (Tables I, II, XVI, XX, XXIV, XXV, XXXIX, and XXXXIII). This was due, not to a lack of nitrate or inorganic phosphate, but rather to moderate water velocity and to the absence of upstream, top-draining impoundments which could have contributed large phytoplankton populations.

In the February 22-23 and March 1-2 sampling periods, chlorophyll a concentrations were less than 0.020 mg/l at all stations except 12, 13, 14, and 15 (Figure 3). During the March 29-30 sampling period, spring phytoplankton pulses were evident at Station 5 and at Stations 8 through 12 (Figure 4). Chlorophyll a concentrations at these stations ranged from 0.062 mg/l at Station 5 to 0.152 mg/l at Station 12. Chlorophyll a levels at Stations 1 through 4 remained less than 0.030 mg/l during the March 29-30 sampling period (Table XVI). In April, chlorophyll a concentrations ranged from 0.020 to 0.030 mg/l at Stations 1 through 4 and from 0.040 to 0.060 mg/l at Stations 6 through 15. Station 5 had a diel average of 0.094 mg/l.

Peak chlorophyll a concentrations were observed at Stations 5, 12, 13, and 15 in May (Figure 6). Chlorophyll a concentrations ranged downward from 0.039 mg/l at Station 5 to 0.033 mg/l at Station 15. The overall lower chlorophyll a levels in May, as compared to all other months except February, can be attributed to the limiting effect of increased turbid discharge from rainfall runoff upon phytoplankton concentrations. High stream discharge has a destructive effect upon plankton populations.[10] Chlorophyll a and dissolved oxygen concentrations generally decreased when turbidity increased but no consistent correlation could be made between the three parameters because of fluctuations in other environmental factors such as flow and illumination.

In June and July, chlorophyll a concentrations peaked at

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[10]L.G. Williams, "Possible Relationships Between Plankton-Diatom Species Numbers and Water-Quality Estimates," pp. 809-823.

Stations 3 and 5 (Figures 7 and 8). In both months, chlorophyll _a_ concentrations at Stations 1 and 2 and 7 through 15 ranged between 0.015 and 0.032 mg/l. Chlorophyll _a_ levels at Stations 3, 5, 5TI, and 6 were all above 0.040 mg/l in both June and July (Figures 7 and 8). There was a definite correlation between surface chlorophyll _a_ and dissolved oxygen levels at Stations 3 through 6 in June and July (Figures 7 and 8). O'Connor[11] observed a similar relationship between chlorophyll concentrations and dissolved oxygen levels in the Mohawk River barge canal.

Bottom water samples were analyzed for chlorophyll _a_ on March 29-30, April 19-20, and May 17-18 (Tables XVI-XXIII and XXXV, XXXVI, and XXXVIII). Out of thirty-four water samples analyzed, only four had chlorophyll _a_ concentrations greater than surface samples collected at the same time. The majority of samples showed bottom and surface chlorophyll _a_ levels to be similar.

Of ninety-two pairs of daytime-nighttime surface samples analyzed for chlorophyll _a_, 55 per cent showed less than 0.01 mg/l difference between daytime and nighttime concentrations. Thirty-two per cent of the samples had daytime chlorophyll _a_ concentrations more than 0.01 mg/l greater than nighttime levels. Only 13 per cent of the samples had nighttime chlorophyll _a_ concentrations more than 0.01 mg/l greater than daytime

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[11]D.J. O'Connor, _Water Quality Analysis of the Mohawk River Barge Canal_, p. 124.

levels. The seventeen pairs of daytime-nighttime bottom water samples analyzed showed 47 per cent of the pairs to have less than 0.01 mg/l difference between daytime and nighttime chlorophyll *a* concentrations. Twelve per cent had higher daytime levels, and 41 per cent had higher nighttime concentrations. The above percentages showed that approximately 50 per cent of the time higher daytime chlorophyll *a* concentrations occurred near the surface while higher nighttime levels occurred near the bottom. This distribution may have resulted from the tendency of the photosynthetic organisms to concentrate in the euphotic zone during the daylight hours and then to settle downward during the night.

In February and early March, chlorophyll *a* concentrations were higher at Stations 12 through 15 than at Stations 1 through 11 (Figure 3). Chlorophyll *a* concentrations increased at Stations 1 through 15 in late March (Figure 4). In general, chlorophyll *a* decreased at Stations 6 through 15 in April and at all stations in May. By the June 14 sampling period, high chlorophyll *a* concentrations were established at Station 3 in Lake Dunlap and at Station 5 in Lake McQueeney. Observations in February, March, and April in the area of Lake McQueeney behind Treasure Island revealed that a heavy phytoplankton bloom was in progress there as early as the second week in February. Appreciable remnants of that early spring phytoplankton bloom were observed in June when Station 5TI was established behind Treasure Island. The larger standing water areas of Lake Dunlap and Lake McQueeney supported more substantial phytoplankton populations than any of the other impoundments in the study area.

The fact that stream impoundment often results in increases in phytoplankton populations has been shown in numerous river studies.[12,13] The highest and most consistent chlorophyll a levels in this study were generally found either in, immediately above, or just below impounded stretches of the Guadalupe River. The high chlorophyll a concentrations at Stations 10 and 11 on March 29-30 were the principal exceptions (Table XVIII). Both noon and midnight samples from the rapidly flowing stretches of river at Stations 10 and 11 had chlorophyll a levels above 0.10 mg/l. It is probable that phytoplankton was being washed downstream from Station 8 in Meadow Lake. Several studies have shown that upstream plankton populations may be carried considerable distances downstream.[14,15] It is possible, however, that there were areas above Stations 10 and 11 where flow was sufficiently reduced to allow local

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[12] C.E. Cushing, Jr., "Plankton and Water Chemistry in the Montreal River Lake-Stream System, Saskatchewan," pp. 306-313.

[13] A.J. Brook and J. Rzoska, "The Influence of the Gebel Aulyia Dam on the Development of Nile Plankton," pp. 101-114.

[14] R.T. Hartman, "Composition and Distribution of Phytoplankton Communities in the Upper Ohio River," pp. 45-65.

[15] Samuel Eddy, "The Plankton of the Sangamon River in the Summer of 1929," pp. 57-69.

development of phytoplankton populations. Eddy[16] concluded from his study of plankton in the Sangamon River that when the current becomes very slow plankton development becomes local and is controlled by local conditions.

Increased chlorophyll a concentrations below several of the impoundments on the Guadalupe River occurred after chlorophyll a increased within the impoundments (Tables XXX and XXXXIV). The fact that chlorophyll a increased below the dams and yet higher chlorophyll a concentrations were consistently found in the standing water areas above the dams showed that the environmental requirements of the phytoplankters were evidently being met more effectively in the impoundments than in the flowing stretches of the river.

The nutrient study conducted in conjunction with this study revealed that phytoplankton populations utilized nitrate and inorganic phosphate more extensively in the impoundments than in the flowing stretches of the river. A direct correlation between high chlorophyll a and decreased surface nitrate and inorganic phosphate concentrations was observed at Stations 3, 5, 5TI, and 6 in June and July.[17] A similar relationship between high chlorophyll a and nitrate levels was observed at Stations 5, 8, 9, 10, and 11 on March 29-30. Quantities of

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[16] Ibid.

[17] Howard Woerner, "A Nutrient Study of New Braunfels-Gonzales Stretch of the Guadalupe River," Master's Thesis, in progress.

nitrate and inorganic phosphate above the concentrations known to limit algal growth were present during the entire study period in both flowing and impounded sections of the Guadalupe River.[18] Seilheimer[19] found that consistently high nutrient concentrations in the Ohio River played an important role in sustaining large potamoplankton populations when physical conditions were favorable. He concluded, however, that it was unlikely that nutrients, in themselves, controlled the cyclic abundance of plankton in the Louisville, Kentucky, section of the Ohio River. Observations on nutrient concentrations in the Guadalupe River, coupled with an absence of consistent correlations between variations in chlorophyll a levels and physicochemical factors such as water temperature, carbon dioxide, and pH led to the conclusion that reduced water velocity due to impoundment was the main factor influencing chlorophyll a concentrations in the study area.

Limestone and shale geological formations of the upper Guadalupe River watershed were responsible for the high fixed carbon dioxide levels encountered in this study. The high fixed carbon dioxide levels provided buffering protection against both acid and alkali pollutants and were also conducive to substantial

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[18] C.N. Sawyer, "Fertilization of Lakes by Agricultural and Urban Drainage," pp. 109-127.

[19] J.A. Seilheimer, "The Dynamics of Potamoplankton Populations in the Ohio River at Louisville, Kentucky, 1959-1962," pp. 1-17.

production of crustacea and aquatic insects. Unless indicated otherwise, the term alkalinity used in this discussion refers only to the bicarbonate (methyl orange) form.

Mean alkalinity levels at individual stations for six months showed a small but generally consistent downstream decrease from 207 mg/l at Station 1 to 178 mg/l at Station 15 (Figure 12). The main reason for this trend was the increasing downstream dilution of the bicarbonate-rich water entering the study area from Comal Springs and the upstream limestone-bottomed stretch of the river between Canyon Dam and Station 1. Since bicarbonate alkalinity is usually produced by the action of carbonic acid upon limestone, it appears logical that alkalinity levels should decrease downstream as the Guadalupe River flowed out of the Edwards Plateau into the Blackland Prairie and then into the Sandy Post Oak Belt. Some downstream reduction in alkalinity concentrations, especially in the lakes, also resulted from the precipitation of calcium carbonate due to utilization of bicarbonate as a carbon dioxide source for planktonic photosynthesis.

Alkalinity concentrations generally increased at all stations from February through April (Tables I-XXIII). Alkalinity levels at Stations 1 through 9 were about the same during the May 10-11 sampling period as in April (Tables XXIV-XXXII); however, there was a marked decrease in the fixed carbon dioxide levels at Stations 10 through 15 on May 17 and 18 (Tables XXXIII-XXXVIII). In June and July, alkalinity levels

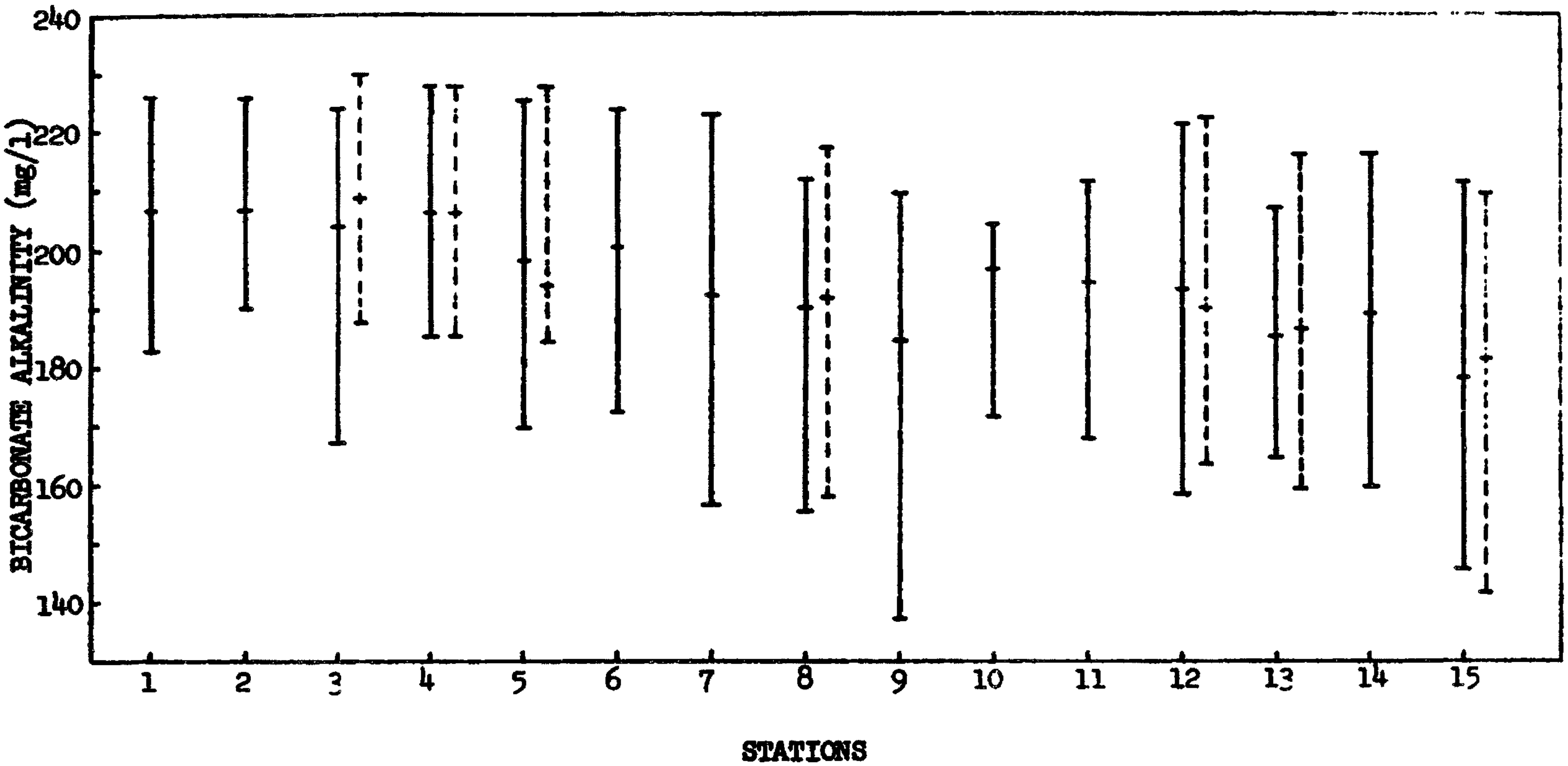

FIGURE 12. SURFACE AND BOTTOM BICARBONATE ALKALINITY RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SOLID VERTICAL LINES INDICATE SURFACE BICARBONATE ALKALINITY RANGES AND DASHED VERTICAL LINES INDICATE BOTTOM BICARBONATE ALKALINITY RANGES. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETIC MEANS FOR EACH STATION.. SEE TABLES XXXX AND XXXXIV IN THE APPENDIX FOR STATION 5TI BICARBONATE ALKALINITY DATA.

at Stations 1 through 9 were from 10 to 30 mg/l lower than the May range of 195 to 225 mg/l (Tables XXXIV-XXXXI and XXXXIII-XXXXV). Alkalinity at Stations 10 through 15 increased from low concentrations of 145 to 190 mg/l in May (Tables XXXIII-XXXVIII) to a range of 180 to 200 mg/l in both June and July (Tables XXXXI-XXXXII and XXXXV-XXXXVI).

The most noticeable variation in the alkalinity concentrations during the six-month study period was the marked decrease at Stations 10 through 15 on May 17-18 (Tables XXXIII-XXXVIII). This decrease was apparently caused by the dilution effect of increased stream discharge from local rainfall runoff. A similar inverse relationship between alkalinity concentrations and stream discharge levels was noted by Woods[20] in the upper Ohio River and by Neel, Nicholson, and Hirsch[21] in the Central Missouri River.

In June and July, slightly lower surface alkalinity concentrations were observed at Stations 3, 5, and 5TI than at adjacent stations (Tables XXXIX, XXXX, XXXXIII, and XXXXIV). Even though free carbon dioxide was present at the three stations, a correlation between the reduced surface bicarbonate alkalinity levels and significantly high chlorophyll a concentrations was noted. A reduction of bicarbonate concentration

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[20] William Woods, "Physical and Chemical Limnology of the Upper Ohio River," pp. 4-39.

[21] J.K. Neel, H.P. Nicholson, and A. Hirsch, Main Stem Reservoir Effects on Water Quality in the Central Missouri River, 1952-1957, p. 40.

due to calcium carbonate precipitation resulting from utilization of the bicarbonate as a carbon dioxide source for planktonic photosynthesis was observed by Cushing[22] in the impounded sections of the Montreal River. Reid,[23] Megard,[24] and Rudolfs and Heukelekian[25] have confirmed the fact that in the absence of free carbon dioxide certain species of algae and aquatic macrophytes may utilize bicarbonate as a source of carbon dioxide for photosynthesis. In this study, it appeared that certain species of phytoplankton may have made limited use of the bound carbon dioxide present in soluble bicarbonate along with, or in preference to, available free carbon dioxide.

The only carbonate (phenolphthalein) alkalinity detected during this study occurred in samples from Stations 8, 10, 11, 12, and 13 during the March 29-30 sampling period (Tables XVII, XVIII, and XIX). With the exception of Station 13, the stations showing phenolphthalein alkalinity all had pH levels of 8.1 or above and chlorophyll _a_ concentrations above 0.10 mg/l. These chlorophyll _a_ levels were the highest recorded

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[22] C.E. Cushing, Jr., "Plankton and Water Chemistry in the Montreal River Lake-Stream System, Saskatchewan," pp. 306-313.

[23] G.K. Reid, _Ecology of Inland Waters and Estuaries_, p. 181.

[24] R.O. Megard, _Planktonic Photosynthesis and the Environment of Calcium Carbonate Deposition in Lakes_, p. 4.

[25] Willem Rudolfs and H. Heukelekian, "Effect of Sunlight and Green Organisms on Reaeration of Streams," pp. 52-56.

during the study period. The phenomenon of carbonate production from bicarbonate during phytoplankton photosynthesis has been observed and it appears that such production was the only source of carbonate alkalinity in the present study.[26]

The absence of significant alkalinity increases or decreases across the dams located in the study area was matched by similar lack of variation in carbon dioxide and pH levels. It was also found that no significant variations in alkalinity, carbon dioxide, or pH occurred below any of the waste outfalls entering the study area. Except at times when high pH levels resulted from photosynthetic reduction of free carbon dioxide concentrations, alkalinity generally varied directly with pH. No significant diel variations in alkalinity were observed during the February and May sampling periods.

The only appreciable differences in surface and bottom alkalinity levels were observed at Station 3 in June (Table XXXIX) and at Stations 3 and 5 in July (Tables XXXXIII and XXXXIV). The significantly higher bottom alkalinity concentrations at these stations appeared to result from reductions in surface alkalinity levels due to planktonic photosynthesis. Out of the 124 pairs of surface and bottom alkalinity determinations made during the study period, 57 per cent had higher bottom alkalinity concentrations than surface concentrations,

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[26] J.K. Neel, H.P. Nicholson, and A. Hirsch, Main Stem Reservoir Effects on Water Quality in the Central Missouri River, 1952-1957, p. 36.

26 per cent had greater surface levels than bottom levels, and 17 per cent showed less than a one mg/l difference between surface and bottom levels. Out of the total of 124 pairs of alkalinity determinations made, only ten instances were recorded in which differences between surface and bottom alkalinity concentrations exceeded 10 mg/l (Tables IV, V, XVIII, XX, XXII, XXXV, XXXVI, XXXIX, XXXXIII, and XXXXIV).

Hydrogen ion concentrations in natural waters are normally determined by the relative quantities of carbon dioxide, bicarbonate, and carbonate present. Chemical buffering by systems such as the carbon dioxide-bicarbonate-carbonate complex helps maintain near neutral conditions in natural waters. Under general conditions, pH values above 8.0 usually denote the presence of carbonate, a pH of 8.0 usually indicates bicarbonate alone, and values below 8.0 show the occurrence of free carbon dioxide.[27,28] Carbon dioxide production by decomposition and respiration thus tends to reduce the pH, whereas photosynthesis tends to raise the pH.

Surface pH during this study ranged from a low of 7.1 at Station 9 in May (Table XXXII) to a high of 8.7 at Station 11 in March (Table XI). Bottom pH ranged from 7.4 at Station 3 in April (Table XX) to 8.2 at Stations 3 and 5 in February

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[27] G.K. Reid, Ecology of Inland Waters and Estuaries, p. 158.

[28] J.K. Neel, H.P. Nicholson, and A. Hirsch, Main Stem Reservoir Effects on Water Quality in the Central Missouri River, 1952-1957, p. 33.

(Tables III and V), Station 13 on March 29 (Table XIX) and Station 15 in April (Table XXIII). Mean pH for six months at individual stations ranged from 7.7 to 8.0 (Figure 13). Eleven of the sixteen stations had surface pH means of 7.8. Of the eight stations at which bottom samples were taken, six had bottom pH means of 7.8. The constancy of pH levels in the Guadalupe River was expected because of the buffering potential of the high fixed carbonate levels present. Data from a physiochemical survey of the Guadalupe River in 1955 showed all but one recorded pH value to be above 7.0.[29] Most unpolluted major streams have been found to have relatively uniform pH levels on the alkaline side of neutrality.[30]

Hydrogen ion concentrations during the May sampling periods were consistently below 8.0. These slightly reduced pH levels correlated precisely with decreases in alkalinity and increases in carbon dioxide. Lower pH levels in May resulted from the buildup of carbon dioxide that resulted from the restriction of photosynthesis by increased turbid discharge.

The majority of the higher pH values observed during this study occurred at stations which had high chlorophyll a and high dissolved oxygen concentrations (Tables XVI-XIX and

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[29] R.A. Kuehne, Stream Surveys of the Guadalupe and San Antonio Rivers, p. 18.

[30] G.K. Reid, Ecology of Inland Waters and Estuaries, p. 171.

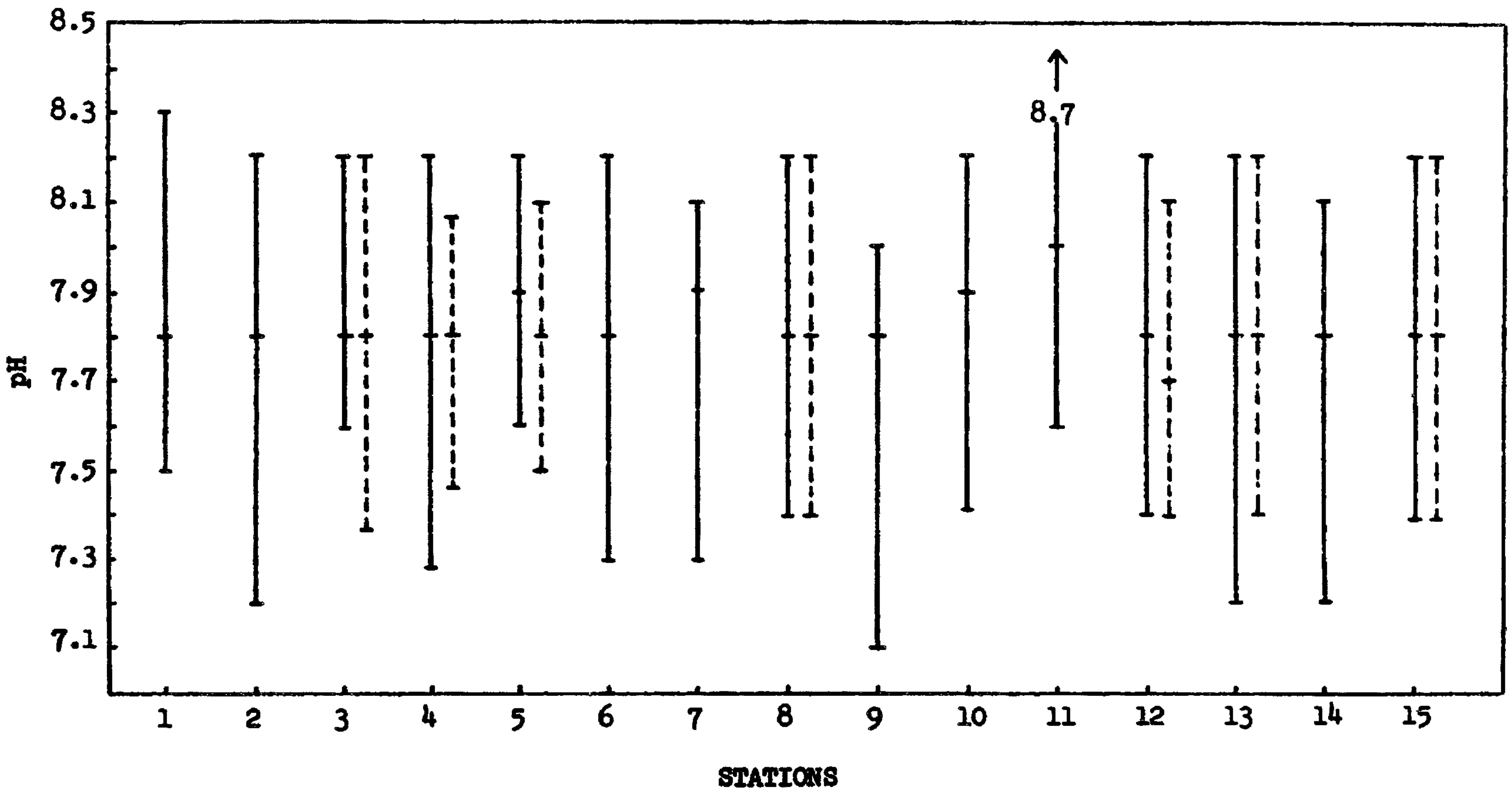

FIGURE 13. SURFACE AND BOTTOM pH RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SOLID VERTICAL LINES INDICATE SURFACE pH RANGES AND DASHED VERTICAL LINES INDICATE BOTTOM pH RANGES. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETHIC MEANS FOR EACH STATION. SEE TABLES XXXX AND XXXXIV IN THE APPENDIX FOR STATION 5TI pH DATA.

XXXIX-XXXX). A surface pH of 9.2 was recorded on June 27 at the Mission Valley textile mill outfall into the Guadalupe River. The area of high pH near the mouth of the outfall was confined to a surface film covering approximately one-half the width of the river. Some 15 meters below the outfall, surface pH levels were within the usual range of 7.8 to 8.0. Maintenance of pH near 8.0 during the entire six-month study period indicated an absence of high levels of organic decomposition in the river.

Only slight diel variations in pH levels were observed in either February or May. The largest fluctuation in pH at any station during a given diel period was less than one pH unit. A similar lack of variation was observed between surface and bottom pH. The largest surface-bottom difference was 0.7 pH unit at Station 12 on March 29 (Table XVIII) and at Station 3 on June 14 (Table XXXIX). Both Station 12 in March and Station 3 in June had surface pH above 8.0 due to photosynthetic activity by phytoplankton. Photosynthesis by algae on clear days has been shown to result in increased pH in both lotic and lentic situations.[31,32] Photosynthetic activity appeared to be the main factor causing appreciable variations in pH in the Guadalupe River during this study.

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[31]C.N. Sawyer, "Factors Involved in Disposal of Sewage Effluent to Lakes," pp. 317-328.

[32]Louis Klein, River Pollution, Vol. I, Chemical Analysis, p. 13.

Carbon dioxide in stream waters is derived primarily from organic decomposition, plant and animal respiration, and ground water. High carbon dioxide concentrations are not usually observed in streams draining limestone areas because any excess carbon dioxide reacts with water to form carbonic acid which reacts with lime in the substrate to give a carbonate. Thus, the behavior of carbon dioxide in streams is generally similar to that of oxygen, but with inverse properties.[33]

Surface carbon dioxide means during this study ranged from 4 mg/l at Station 11 to 8 mg/l at Station 9 (Figure 14). Bottom carbon dioxide means ranged from 6 mg/l at Station 13 to 8 mg/l at Station 3. Minimum and maximum surface carbon dioxide for the six-month period ranged from 0 mg/l at numerous stations to 35 mg/l at Station 9 on May 10. Minimum and maximum bottom carbon dioxide concentrations ranged from a low of 1.5 mg/l at Station 8 on February 22 to 18.5 mg/l at Station 3 on April 19.

Natural waters other than ground water normally contain less than 10 mg/l of free carbon dioxide.[34] Waters supporting good fish fauna have been found to generally have carbon

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[33] G.K. Reid, Ecology of Inland Waters and Estuaries, p. 170.

[34] American Public Health Association, Standard Methods for Examination of Water and Wastewater, p. 77.

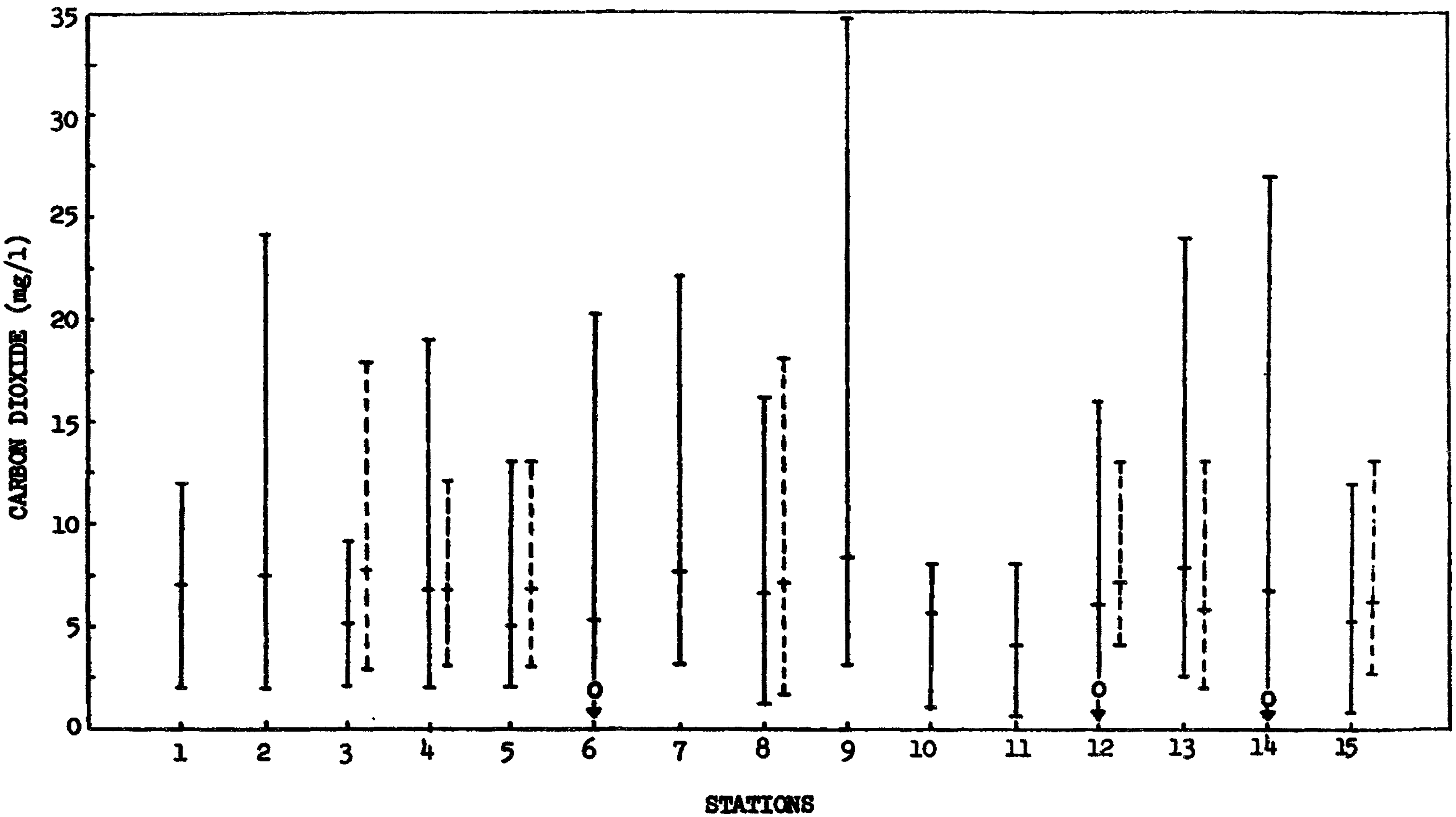

FIGURE 14. SURFACE AND BOTTOM CARBON DIOXIDE RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SOLID VERTICAL LINES INDICATE SURFACE CARBON DIOXIDE RANGES AND DASHED VERTICAL LINES INDICATE BOTTOM CARBON DIOXIDE RANGES. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETHIC MEANS FOR EACH STATION. SEE TABLES XXXX AND XXXXIV IN THE APPENDIX FOR STATION 5TI CARBON DIOXIDE DATA.

dioxide levels below 5 mg/l.[35,36] In this study, 88 per cent of the observed carbon dioxide values were below 10 mg/l; however, only 42 per cent were 5 mg/l or less.

Less than 50 per cent of the seventy carbon dioxide values of 10 mg/l and over came from bottom water samples. Higher carbon dioxide levels at the surface than at the bottom were the rule rather than the exception when planktonic photosynthesis was reduced. The limiting effect of high turbidity upon photosynthesis appeared to be a major reason for the high carbon dioxide levels recorded at many stations in May. Some increase in carbon dioxide levels during the May sampling periods probably resulted from decomposition of quantities of organic material washed into the river by rainfall runoff.

Changes in carbon dioxide concentrations across dams, above and below waste outfalls, and in flowing stretches of the river as opposed to standing stretches were too variable to show any definite trends. It was apparent, however, that surface carbon dioxide in the impoundments ranged consistently lower during periods of substantial planktonic photosynthesis.

Diel fluctuations in carbon dioxide concentrations at most stations were rather limited; however, sporadic diel variations of more than 10 mg/l were observed. The classic

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[35]M.M. Ellis, "Detection and Measurement of Stream Pollution, pp. 129-185.

[36]California State Water Pollution Control Board, Water Quality Criteria, pp. 205-206.

low midday and high early morning pattern of diel carbon dioxide variation was observed very infrequently during the study period (Tables I-IV).

An inverse relationship between pH levels and carbon dioxide concentrations was evident throughout the study because carbon dioxide values were estimated from a pH-bicarbonate alkalinity nomograph. There appeared to be a direct relationship between changes in discharge and carbon dioxide concentrations. The majority of high carbon dioxide levels recorded in this study were observed during the period of high discharge in May. The lowest carbon dioxide levels were recorded during the low flow periods in June and July.

Specific conductance values during this study showed rather limited variations. Surface conductance ranges for the six-month study period ranged from a minimum of 360 µmhos at Station 15 on May 17 to a maximum of 558 µmhos at Station 12 on May 17. Surface and bottom six-month conductance means at all stations except 5TI and 15 ranged between 480 and 500 µmhos (Figure 15). Surface and bottom conductance means at Station 5TI were 415 and 435 µmhos, respectively. Conductance values for six months at Station 15 averaged 460 µmhos at both sampling levels. The overall narrow range of conductance levels encountered in this study was shown by the fact that 65 per cent of all recorded conductance values ranged between 475 and 525 µmhos.

Conductance levels recorded at Station 5TI in June and

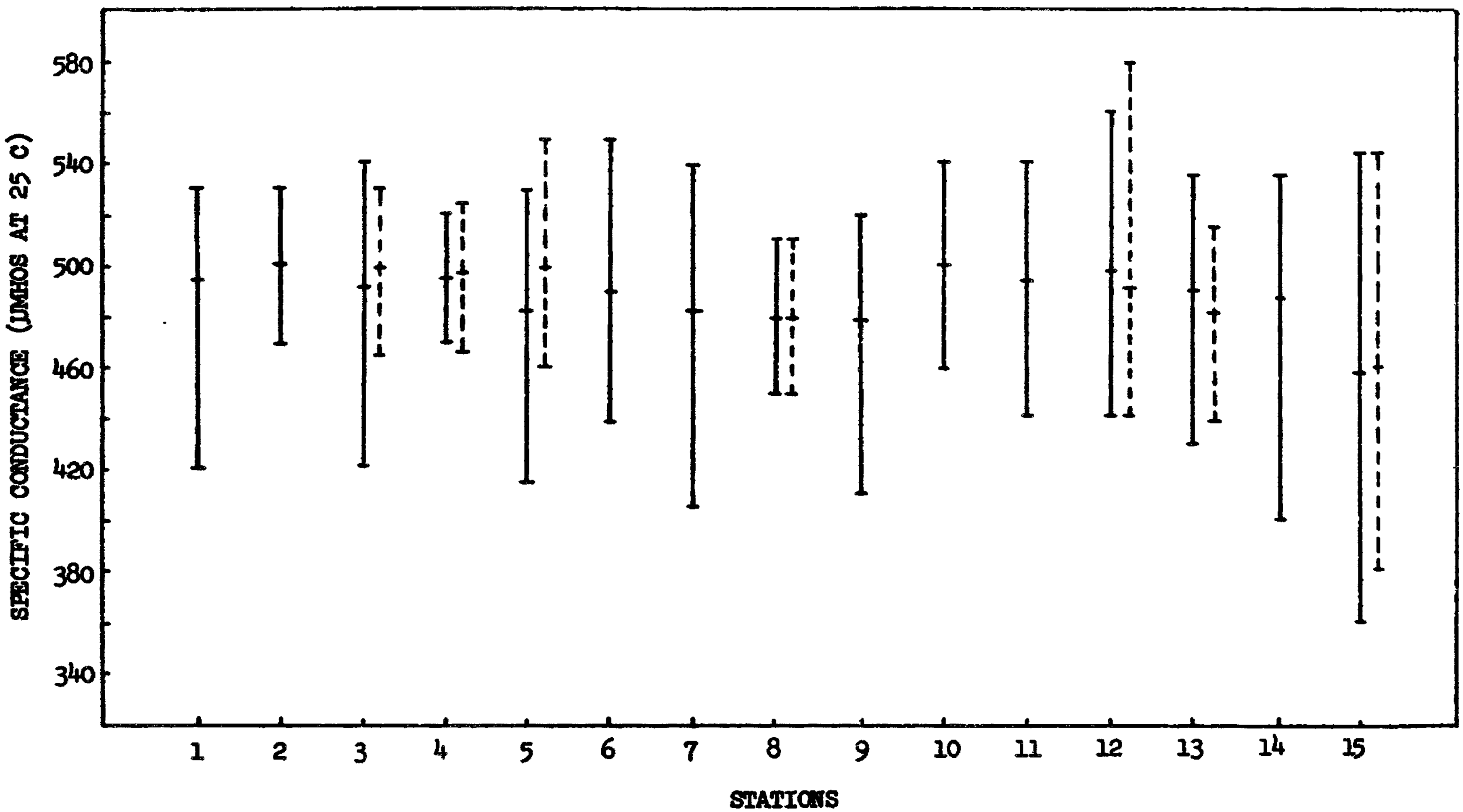

FIGURE 15. SURFACE AND BOTTOM SPECIFIC CONDUCTANCE RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SOLID VERTICAL LINES INDICATE SURFACE CONDUCTANCE RANGES AND DASHED VERTICAL LINES INDICATE BOTTOM CONDUCTANCE RANGES. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETIC MEANS FOR EACH STATION. SEE TABLES XXXX AND XXXXIV IN THE APPENDIX FOR STATION 5TI CONDUCTANCE DATA.

July were conspicuously low (Tables XXXX and XXXXIV). A correlation between low conductance and reduced alkalinity and nutrient concentrations was noted at Station 5TI. A direct correlation between conductance and alkalinity levels was generally observed throughout the study period. The six-month mean conductance of 460 µmhos at Station 15 resulted from several values less than 400 µmhos being recorded at that station during the May 17-18 sampling period (Table XXXVIII). Reduced alkalinity and pH levels were detected at Station 15 during that sampling period. Conductance values below 400 µmhos were also recorded at Station 15 during the March 29 sampling period.

No significant fluctuations in specific conductance levels were observed between stations above and below waste outfalls. Conductance measurements taken in or just below points where effluents entered the river showed some deviation from the conductance levels being recorded at stations further above or below the outfalls. Conductance values up to 2600 µmhos were recorded at the point of entrance of the Mission Valley textile mill effluent into the Guadalupe River. A conductance of 825 µmhos was recorded at the mouth of the New Braunfels sewage treatment plant outfall on June 27. Specific conductance in Nash Creek at Alternate U.S. Highway 90 on May 17 was 855 µmhos. Dilution of these waste waters was obviously accomplished quite rapidly upon its entrance into the river, since conductance was not affected over long stretches.

The greatest diel variation in conductance at a single station during one diel period was 185 µmhos at Station 15 on March 29-30 (Table XIX). Diel variations of from 40 to 60 µmhos were observed frequently during this study but no consistent pattern of variation could be ascertained. No relationship between the magnitude of diel conductance variations at individual stations and water velocity and depth at these stations could be established. No seasonal effect was observed in either diel conductance variation or in overall ranges.

The greatest surface-bottom differences in conductance values were observed at Stations 3 and 5 in June and July (Tables XXXIX, XXXX, XXXXIII, and XXXXIV). These differences varied from 40 to 75 µmhos with the greater conductance values found consistently on the bottom. The low surface conductance levels, which were responsible for the appreciable surface-bottom differences, were related to similar reductions in surface bicarbonate alkalinity which were apparently the result of planktonic photosynthesis.

Photosynthetic utilization of ionizable material such as various nutrients and bicarbonate ions was one of the factors causing variations in the conductance levels during this study. Dilution caused by rainfall runoff caused slight reductions in conductance levels at Stations 10 through 15 on May 17-18.

Turbidity levels measured during this study generally increased downstream while Secchi disk transparency generally decreased (Figures 16 and 17). Surface turbidity levels for

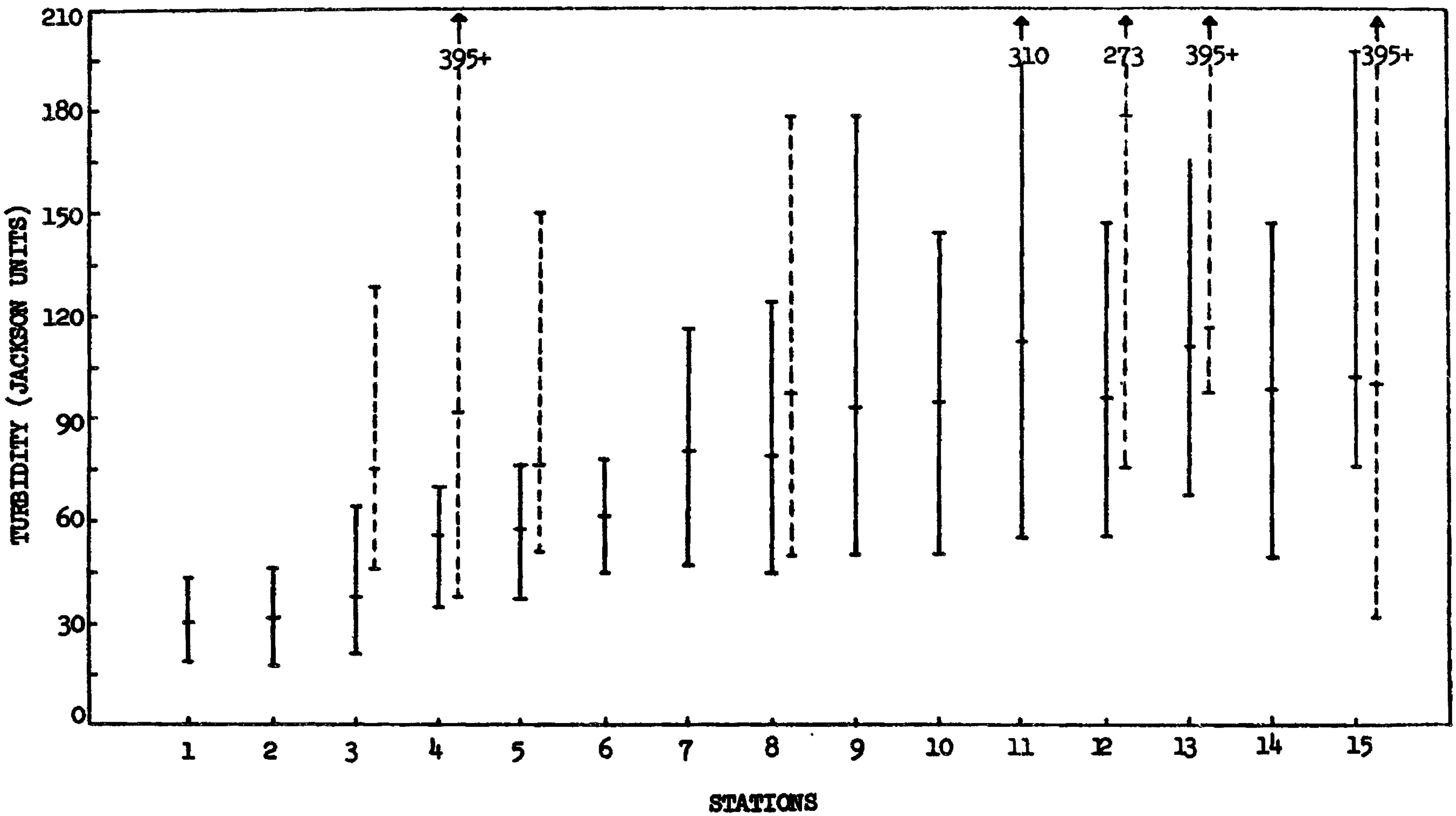

FIGURE 16. SURFACE AND BOTTOM TURBIDITY RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SOLID VERTICAL LINES INDICATE SURFACE TURBIDITY RANGES AND DASHED VERTICAL LINES INDICATE BOTTOM TURBIDITY RANGES. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETIC MEANS FOR EACH STATION. SEE TABLES XXXX AND XXXXIV IN THE APPENDIX FOR STATION 5TI TURBIDITY DATA.

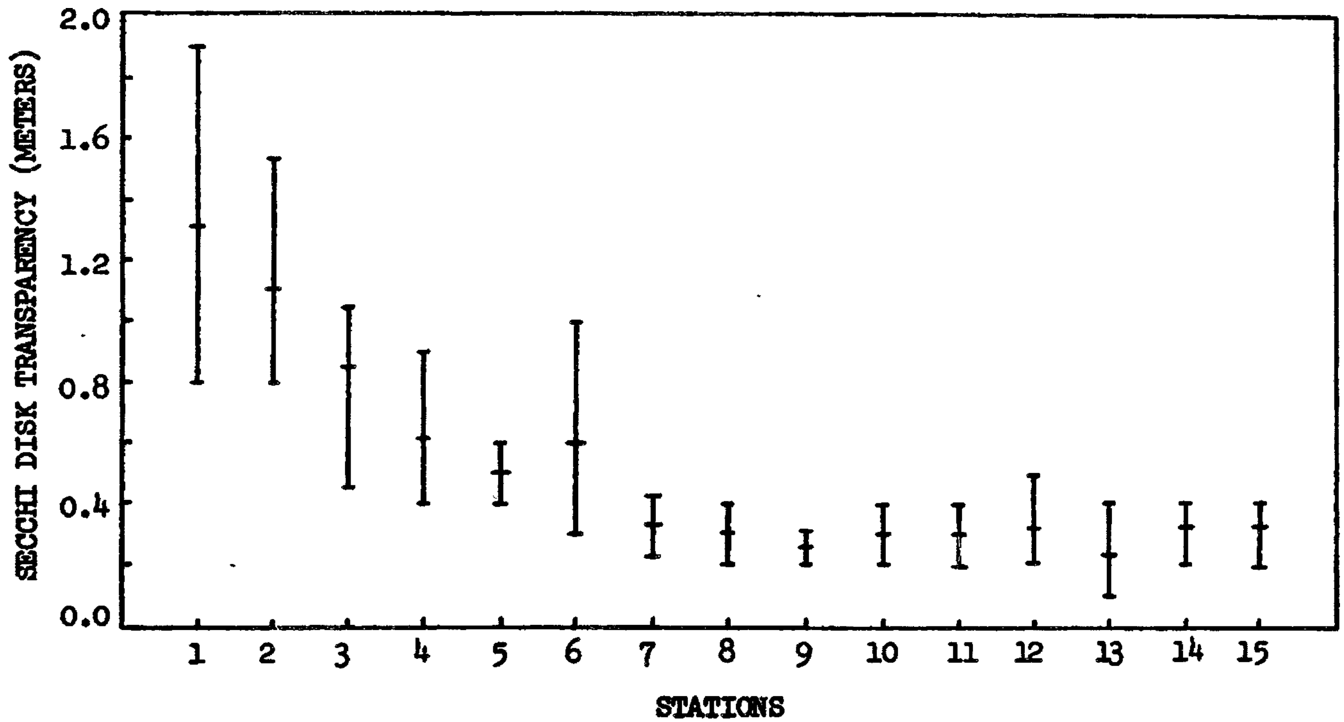

FIGURE 17. SECCHI DISK TRANSPARENCY RANGES AT 15 STATIONS IN THE GUADALUPE RIVER FROM FEBRUARY 22 THROUGH JULY 12, 1969. SEE TABLE XXXXIX IN THE APPENDIX FOR STATION 5TI SECCHI DISK TRANSPARENCY DATA. HORIZONTAL CROSS LINES ON THE VERTICAL RANGE LINES INDICATE SIX MONTH ARITHMETIC MEANS FOR EACH STATION.

the entire study period ranged from a minimum of 17 Jackson units at Station 2 on July 12 (Table XXXXIII) to a maximum of 197 Jackson units at Station 15 on May 17 (Table XXXVIII). Bottom turbidity ranged from a minimum of 32 Jackson units at Station 5TI on July 12 (Table XXXXIV) to a maximum of 395 Jackson units at Station 4 on February 22 (Table IV), Station 12 on April 19 (Table XXXVI), and Stations 13 and 15 on May 17 (Tables XXXVI and XXXVIII). Secchi disk transparency ranged from a minimum of 0.1 m at Station 13 on April 19 to a maximum of 1.9 m at Station 1 on March 29 and June 14 (Table XXXXIX).

The general downstream increase in turbidity and decrease in Secchi disk transparency occurred in spite of the flow reducing dams located within the study area. Stream flow reduction due to impoundment has been found to generally result in decreases in turbidity levels.[37,38,39] The sediment trap function of the riverine lakes on the Guadalupe River appeared to be inhibited by their small size, relatively shallow depths, and by the slug-flow movement of water through them. Heavy summertime boat traffic was another factor that acted to retard turbidity reduction in the impounded sections of the river.

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[37] S.K. Love, "Relationship of Impoundments to Water Quality," pp. 559-568.

[38] J.K. Neel, H.P. Nicholson, and A. Hirsch, Main Stem Reservoir Effects on Water Quality in the Central Missouri River, 1952-1957, p. 31.

[39] J.W. Symons, S.R. Wiebel, and G.C. Robeck, Influence of Impoundments on Water Quality, p. 13.

Large quantities of coarse suspended sediments carried by the river undoubtedly settled out in the areas of reduced flow above the dams; however, enough suspended matter remained during the study period to limit measureable light penetration to one meter or less in Lakes Dunlap and McQueeney and to less than one-half meter in Lakes Gonzales and Wood.

High turbidity and low Secchi disk transparency were generally observed at all stations from February through May due to increased discharge from spring rainfall runoff. The highest turbidity and lowest Secchi disk transparency observed during the study period occurred at Stations 10 through 15 on May 17 and 18. Secchi disk transparency increased and turbidity decreased during the low flow periods of June and July. A similar direct relationship between discharge levels and turbidity was also observed by Dorris and Copeland[40] in the upper Mississippi River, by Neel, Nicholson, and Hirsch[41] in the central Missouri River, and Kuehne[42] in the Guadalupe River.

Decreased chlorophyll a and dissolved oxygen during this study were generally associated with increased turbidity and decreased Secchi disk transparency; however, deviations from

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[40] T.C. Dorris and B.J. Copeland, "Limnology of the Upper Mississippi River. IV. Physical and Chemical Limnology of River and Chute," pp. 79-88.

[41] J.K. Neel, H.P. Nicholson, and A. Hirsch, Main Stem Reservoir Effects on Water Quality in the Central Missouri River, 1952-1957, p. 28.

[42] R.A. Kuehne, Stream Surveys of the Guadalupe and San Antonio Rivers, p. 3.

this relationship were observed. For example, lower turbidity levels were present at Station 3 on March 29-30 than at Station 5 and at Stations 8 through 12; however, much higher chlorophyll a and dissolved oxygen concentrations were recorded at these latter stations than at Station 3. It is known that turbidity is a limiting factor upon chlorophyll bearing plankton populations.[43,44] From this study it was evident that turbidity was only one of several interacting factors controlling planktonic photosynthesis in the Guadalupe River.

General downstream increases in turbidity overshadowed small variations recorded across dams and between flowing and standing stretches of the river. The lowest turbidity and highest Secchi disk transparency values were consistently observed at Stations 1 and 2. The entrance of the Guadalupe River into the Blackland Prairie Region between Stations 1 and 2 was perhaps the main factor that caused the beginning of consistent downstream increases in turbidity and decreases in Secchi disk transparency below Station 2.

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[43] C.M. Tarzwell and A.R. Gaufin, "Some Important Biological Effects of Pollution Often Disregarded in Stream Surveys," pp. 21-31.

[44] C.M. Tarzwell and C.M. Palmer, "Ecology of Significant Organisms in Surface Water Supplies," pp. 568-578.

CHAPTER V

SUMMARY

1. Water samples for limnological analysis were collected monthly at fifteen stations in the New Braunfels-Gonzales stretch of the Guadalupe River from February 22 through July 12, 1969. Results of analyses of these samples did not indicate pollution.

2. Reduction of water velocity due to impoundment was the main factor influencing variations in the limnological parameters measured.

3. Eutropic conditions, as indicated by heavy concentrations of water lilies, water hyacinths, and filamentous algae, were restricted to lower Lake Dunlap, the section of Lake McQueeney behind Treasure Island, and to the backwater areas of Lake Gonzales and Lake Wood.

4. Development of substantial plankton populations, as indicated by high chlorophyll *a* levels, was generally restricted to impounded sections of the study area.

5. A direct relationship between high chlorophyll *a* and increased surface dissolved oxygen and pH was observed during the study period. Except for sporadic periods of high oxygen concentrations due to photosynthesis, as estimated by chlorophyll *a*, dissolved oxygen and per cent saturation generally decreased at all stations from February through July. Oxygen exceeded 100 per cent saturation only when

photosynthetic oxygen production was high.

6. A direct correlation was generally observed between high chlorophyll a concentrations in the lakes and decreases in surface alkalinity, carbon dioxide, and specific conductance. On several occasions, a similar relationship between high chlorophyll a and surface nitrate and inorganic phosphate was observed.

7. Turbidity and alkalinity generally decreased downstream while Secchi disk transparency increased.

8. Rainfall runoff in May caused increased turbidity and carbon dioxide levels. Alkalinity, conductance, pH, and dissolved oxygen generally decreased during periods of increased turbid discharge.

APPENDIXES

TABLE I - LIMNOLOGICAL CONDITIONS AT STATION 1 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0752	S[c]	7.2	17.2	9.0	93	7.6	0	187	8	-	465	36
1200	S	18.0	17.8	9.3	98	8.3	0	195	2	0.014	525	29
1552	S	18.5	20.2	9.8	107	8.2	0	190	2	-	540	30
2000	S	13.8	20.0	9.2	101	7.9	0	194	8	-	490	43
2350	S	9.0	19.8	9.0	97	7.5	0	183	11	0.013	480	32
0345	S	8.2	19.2	8.9	96	7.5	0	186	12	-	460	26

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE II - LIMNOLOGICAL CONDITIONS AT STATION 2 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0845	S[c]	9.5	17.2	9.2	95	7.6	0	189	10	-	500	31
1246	S	17.2	18.5	9.1	96	8.2	0	190	2	0.013	500	32
1627	S	17.4	19.1	9.2	98	8.0	0	193	4	-	510	32
2028	S	12.5	19.2	9.2	98	7.7	0	191	8	-	500	31
0024	S	8.8	19.2	8.9	96	7.5	0	192	12	0.011	480	46
0420	S	7.8	19.0	8.7	93	7.8	0	196	6	-	470	39

[a]Mean of two samples

[b]P-phenolphthalein; MO-Methyl orange

[c]S-surface sample

TABLE III - LIMNOLOGICAL CONDITIONS AT STATION 3 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0925	S[c]	11.5	15.4	-	-	7.8	0	192	6	-	480	36
	B[d]		15.2	-	-	7.8	0	195	6	-	480	64
1324	S	17.8	17.0	8.4	85	8.1	0	195	4	0.015	530	36
	B		16.8	7.9	81	8.2	0	195	2	-	510	58
1713	S	14.8	18.0	8.9	93	8.0	0	192	4	-	510	32
	B		16.8	8.2	84	8.0	0	204	4	-	500	97
2105	S	9.8	18.0	8.4	88	7.8	0	190	6	-	490	39
	B		16.4	8.0	82	7.8	0	195	7	-	480	110
0107	S	8.6	17.6	8.5	88	7.8	0	192	6	0.012	490	40
	B		16.4	8.4	86	7.7	0	190	5	-	470	60
0503	S	7.0	17.4	8.5	88	7.7	0	188	8	-	495	64
	B		16.4	8.2	83	7.6	0	200	11	-	485	123

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE IV - LIMNOLOGICAL CONDITIONS AT STATION 4 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1011	S[c]	12.0	14.8	-	-	7.6	0	186	9	-	470	70
	B[d]		14.8	-	-	7.8	0	186	6	-	465	100
1410	S	14.0	16.8	8.8	89	8.2	0	194	2	0.018	520	60
	B		16.5	8.6	88	8.1	0	200	3	-	510	260
1806	S	13.8	16.8	8.8	90	7.8	0	195	6	-	500	-
	B		16.8	8.6	88	7.7	0	212	8	-	500	395+
2152	S	9.2	16.8	8.6	88	7.3	0	192	19	-	470	66
	B		16.8	8.6	88	7.5	0	196	12	-	480	120
0200	S	8.8	16.6	8.5	86	7.6	0	190	10	0.013	480	59
	B		16.8	8.4	85	7.5	0	196	12	-	490	58
0556	S	7.2	16.6	8.4	86	7.6	0	192	10	-	500	65
	B		16.6	8.5	86	7.6	0	192	10	-	490	73

[a] Mean of two samples

[b] P-phenolphthalein; MO-methyl orange

[c] S-surface sample

[d] B-bottom sample

TABLE V - LIMNOLOGICAL CONDITIONS AT STATION 5 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1035	S[c]	13.0	14.5	9.3	90	8.2	0	188	2	-	516	64
	B[d]		14.0	9.3	88	8.0	0	191	4	-	520	82
1425	S	20.5	15.5	9.9	98	8.1	0	186	3	0.020	530	63
	B		14.5	9.1	90	8.0	0	190	4	-	550	153
1825	S	13.5	16.0	10.1	101	7.9	0	178	5	-	510	70
	B		15.5	9.2	91	7.8	0	190	6	-	520	142
2230	S	10.5	15.8	9.1	92	8.0	0	178	4	-	460	74
	B		15.2	9.1	89	7.8	0	176	4	-	470	80
0230	S	8.8	16.0	9.0	90	8.1	0	184	3	0.018	470	68
	B		15.2	8.9	87	8.0	0	181	4	-	490	64
0635	S	8.0	14.8	8.8	87	8.0	0	180	4	-	480	59
	B		15.0	9.1	89	8.1	0	182	3	-	480	72

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE VI - LIMNOLOGICAL CONDITIONS AT STATION 6 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1006	S[c]	13.0	14.5	9.3	90	7.9	0	188	5	-	504	64
1353	S	15.0	14.5	9.3	91	7.9	0	188	5	0.020	540	70
1758	S	9.8	10.5	9.2	82	7.8	0	180	5	-	515	76
2200	S	10.5	15.5	9.0	89	7.8	0	181	5	-	490	74
0210	S	8.8	14.8	8.7	85	8.1	0	184	2	0.013	490	68
0610	S	7.8	15.0	8.5	84	8.2	0	179	2	-	490	70

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE VII - LIMNOLOGICAL CONDITIONS AT STATION 7 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0930	S[c]	13.5	13.2	10.1	96	7.9	0	157	4	-	455	116
1317	S	15.5	13.9	10.0	96	7.8	0	158	4	0.024	495	113
1725	S	13.5	14.2	10.0	98	7.7	0	163	6	-	495	98
2120	S	10.0	14.5	9.9	96	7.9	0	172	4	-	475	92
0130	S	8.5	14.5	9.3	91	8.0	0	180	3	0.015	485	94
0530	S	6.5	14.5	8.9	87	8.0	0	175	3	-	500	101

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE VIII - LIMNOLOGICAL CONDITIONS AT STATION 8 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0845	S[c]	10.9	13.2	9.8	94	7.9	0	172	4	-	481	95
	B[d]		13.6	10.0	97	7.8	0	169	5	-	478	158
1235	S	15.0	14.3	10.0	97	7.8	0	170	6	0.011	490	100
	B		13.7	9.6	92	7.7	0	170	7	-	500	126
1635	S	14.0	14.0	9.8	95	7.7	0	162	6	-	495	105
	B		14.0	9,5	92	7.7	0	167	6	-	490	178
2030	S	11.0	14.0	9.8	95	8.0	0	162	3	-	460	124
	B		14.0	10.0	96	7.9	0	158	4	-	460	113
0032	S	8.9	14.0	9.8	95	8.2	0	156	1	0.012	450	-
	B		14.0	9.6	92	8.2	0	164	2	-	450	-
0427	S	7.8	14.0	8.3	80	8.1	0	160	2	-	450	116
	B		13.5	9.4	88	8.0	0	162	3	-	465	97

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE IX - LIMNOLOGICAL CONDITIONS AT STATION 9 IN THE GUADALUPE RIVER, FEBRUARY 22, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chloro-phyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0805	S[c]	10.5	13.0	9.6	92	8.0	0	158	3	-	480	104
1205	S	12.5	13.5	9.6	91	8.0	0	160	3	0.014	465	109
1605	S	14.5	14.0	10.0	97	8.0	0	170	3	-	515	113
2005	S	11.0	14.0	9.8	94	8.0	0	166	3	-	470	128
0005	S	8.8	14.0	9.4	90	7.8	0	154	4	0.013	440	116
0405	S	8.1	14.0	8.4	81	7.9	0	138	6	-	410	178

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE X - LIMNOLOGICAL CONDITIONS AT STATION 10 IN THE GUADALUPE RIVER, MARCH 1, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0830	S[c]	12.7	16.9	7.4	77	8.0	0	216	4	-	500	73
1305	S	14.1	17.1	8.2	84	7.9	0	208	5	0.032	520	86
1715	S	14.4	17.2	8.5	88	8.0	0	208	4	-	520	87
2058	S	10.8	16.9	7.0	70	7.8	0	210	7	-	500	102
0052	S	9.1	16.9	7.8	80	8.2	0	206	2	0.020	485	96
0445	S	9.0	16.6	8.0	81	8.0	0	198	4	-	510	73

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XI - LIMNOLOGICAL CONDITIONS AT STATION 11 IN THE GUADALUPE RIVER, MARCH 1, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0930	S[c]	10.2	16.9	8.3	84	8.5	0	206	1	-	480	99
1350	S	14.8	16.9	8.3	85	8.7	0	210	0	0.030	505	96
1755	S	14.1	16.5	8.4	85	8.0	0	208	4	-	510	78
2140	S	12.0	16.7	8.0	82	7.9	0	214	6	-	520	85
0140	S	9.0	16.5	8.2	83	8.3	0	215	2	0.021	520	84
0530	S	9.0	16.1	8.4	84	8.1	0	202	3	-	540	88

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XII - LIMNOLOGICAL CONDITIONS AT STATION 12 IN THE GUADALUPE RIVER, MARCH 1, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1100	S[c]	15.0	16.5	7.9	80	7.5	0	209	16	-	520	80
1410	S	17.0	17.5	8.0	83	8.2	0	206	2	0.044	520	88
1915	S	14.0	17.0	8.3	84	8.1	0	209	3	-	525	99
2300	S	12.0	17.0	8.0	83	7.6	0	208	11	-	525	86
0215	S	7.5	17.0	8.0	81	8.0	0	212	4	0.017	520	80
0630	S	11.0	16.0	8.0	81	7.7	7.7	201	8	-	540	81

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XIII - LIMNOLOGICAL CONDITIONS AT STATION 13 IN THE GUADALUPE RIVER, MARCH 1, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
1020	S[c]	14.0	16.0	7.9	79	7.4	0	204	16	-	500	89
1330	S	14.0	17.0	8.0	82	8.2	0	208	2	0.032	510	97
1820	S	14.0	17.0	8.2	84	8.0	0	207	4	-	500	95
2215	S	12.0	17.0	8.0	83	7.9	0	205	4	-	520	91
0140	S	8.0	16.5	8.0	82	8.2	0	197	2	0.027	510	90
0525	S	10.0	15.0	8.0	78	7.8	0	199	6	-	510	86

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XIV - LIMNOLOGICAL CONDITIONS AT STATION 14 IN THE GUADALUPE RIVER, MARCH 1, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0920	S[c]	13.0	15.0	8.8	87	7.7	0	202	8	-	490	80
1250	S	15.0	16.5	8.8	88	8.0	0	201	4	0.042	500	82
1700	S	15.0	17.0	8.7	89	8.0	0	202	4	-	500	86
2040	S	12.0	16.5	8.6	88	7.2	0	198	27	-	520	90
0040	S	8.0	15.0	8.5	84	8.1	0	197	3	0.028	510	84
0445	S	10.0	15.0	8.4	83	7.6	0	198	8	-	525	90

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XV - LIMNOLOGICAL CONDITIONS AT STATION 15 IN THE GUADALUPE RIVER, MARCH 1, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0830	S[c]	13.5	16.0	8.2	83	7.6	0	169	7	-	430	93
1205	S	15.0	16.0	8.4	84	7.9	0	178	4	0.032	440	99
1605	S	16.0	16.0	8.3	83	7.9	0	179	4	-	455	88
2000	S	14.0	16.0	8.2	82	7.8	0	180	7	-	485	92
2400	S	8.5	15.5	8.3	82	8.0	0	172	3	0.020	475	88
0345	S	10.0	16.0	8.2	82	8.1	0	174	2	-	480	80

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XVI - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, MARCH 29, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 1					
1200	S[c]	24.0	22.0	7.5	85	7.6	0	214	8	0.013	501	22
2330	S	19.2	21.5	6.9	79	8.0	0	215	4	0.021	490	20
							STATION 2					
1220	S	23.0	21.9	7.3	82	7.7	0	217	8	0.011	510	31
0003	S	19.2	23.2	7.7	79	7.9	0	218	5	0.018	500	36
							STATION 3					
1305	S	24.4	20.9	7.6	85	7.8	0	218	7	0.029	500	39
	B[d]		20.9	5.6	62	7.8	0	216	8	0.011	500	70
0045	S	18.5	20.8	7.6	84	7.9	0	217	5	0.018	505	39
	B		20.7	5.6	62	8.0	0	217	4	0.016	510	95
							STATION 4					
1358	S	29.0	20.7	7.3	80	7.9	0	211	5	0.013	495	38
	B		20.8	6.8	74	7.8	0	216	7	0.020	500	46
0135	S	18.0	19.9	7.4	80	7.8	0	219	6	0.012	500	49
	B		20.0	7.4	81	7.9	0	214	5	0.015	505	47

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XVII - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, MARCH 29, 1969

Time	Level Sampled	Temperature Air (°C)	Water (°C)	Dissolved Oxygen[a] (mg/l)	(% Sat.)	pH	Alkalinity[a,b] P (mg/l)	MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
						STATION 5						
1453	S[c]	26.0	20.5	10.5	120	8.1	0	211	3	0.119	470	60
	B[d]		19.9	7.5	82	7.8	0	210	7	0.028	480	60
0220	S	19.5	19.5	8.3	90	8.0	0	211	4	0.025	500	61
	B		19.5	8.2	87	7.9	0	212	4	0.022	500	61
						STATION 6						
1543	S	25.0	19.4	7.5	81	7.9	0	218	5	0.029	465	58
0252	S	18.5	19.8	7.5	83	7.9	0	214	5	0.024	500	51
						STATION 7						
1130	S	23.2	19.0	7.7	82	8.0	0	213	4	0.047	470	80
2330	S	19.2	19.9	8.4	93	8.1	0	213	3	0.033	515	77
						STATION 8						
1210	S	24.0	20.2	10.5	114	8.2	8	210	3	0.156	485	84
	B		19.7	7.8	85	8.0	0	211	4	0.061	475	99
2400	S	20.8	20.0	8.9	97	8.2	0	213	2	0.062	510	73
	B		19.8	8.9	98	8.1	0	217	3	0.062	510	73

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XVIII - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, MARCH 29, 1969

Time	Level Sampled	Temperature Air (°C)	Water (°C)	Dissolved Oxygen[a] (mg/l)	(% Sat.)	pH	Alkalinity[a,b] P (mg/l)	MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 9					
1310	S[c]	24.0	19.7	9.6	105	8.1	0	211	3	0.081	465	89
0100	S	19.8	19.8	9.7	105	8.1	0	208	3	0.069	507	80
							STATION 10					
1350	S	25.2	20.5	9.8	108	8.2	9	203	1	0.100	470	85
0145	S	19.8	19.5	9.2	98	8.2	0	208	2	0.120	510	87
							STATION 11					
1440	S	27.0	20.4	9.4	102	8.3	10	199	1	0.105	470	81
0235	S	19.4	20.5	9.0	100	8.1	0	206	4	0.128	530	73
							STATION 12					
1430	S	32.0	22.0	12.1	138	8.1	24	195	4	0.260	435	86
	B[d]		20.5	-	-	7.9	0	223	6	0.024	440	198
0215	S	19.8	19.4	8.2	80	8.3	0	221	0	0.046	540	85
	B		20.8	8.3	92	7.6	0	217	10	0.047	555	99

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XIX - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, MARCH 29, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll *a*[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 13					
1350	S[c]	32.0	20.5	9.6	106	8.0	15	200	4	0.078	435	88
	B[d]		20.2	11.4	124	8.0	8	208	4	0.031	440	114
0135	S	19.7	20.5	10.9	120	8.2	0	208	1	0.053	535	109
	B		19.5	9.3	101	8.2	0	216	2	0.116	515	97
							STATION 14					
1250	S	24.5	20.0	8.8	97	7.9	0	215	4	0.052	365	116
0050	S	18.7	19.4	8.4	92	8.1	0	211	2	0.055	535	90
							STATION 15					
1205	S	24.0	19.0	8.3	90	8.0	0	190	3	0.062	360	82
	B		18.5	10.2	109	8.0	0	204	4	0.064	370	106
1150	S	19.0	19.0	9.6	103	8.2	0	204	.1	0.047	545	84
	B		18.7	9.0	96	8.0	0	203	4	0.046	545	93

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XX - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, APRIL 19, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 1					
1155	S[c]	28.0	22.8	7.7	88	7.6	0	226	12	0.024	485	22
2330	S	20.0	22.8	7.5	86	7.6	0	226	12	0.016	470	21
							STATION 2					
1210	S	28.2	23.0	6.7	77	7.2	0	225	24	0.016	485	28
2345	S	18.5	23.0	7.2	84	7.9	0	225	5	0.029	470	32
							STATION 3					
1312	S	27.0	23.5	6.0	71	7.7	0	222	9	0.021	482	43
	B[d]		23.0	3.7	44	7.7	0	226	8	0.018	492	60
0050	S	18.2	23.2	6.6	77	7.9	0	219	5	0.023	480	22
	B		22.2	5.0	57	7.4	0	232	19	0.033	470	75
							STATION 4					
1400	S	27.0	24.0	6.4	75	7.6	0	226	12	0.027	490	48
	B		23.9	6.4	75	7.7	0	226	8	0.034	487	51
0145	S	17.9	21.0	5.8	64	7.8	0	224	8	0.033	490	44
	B		22.0	5.8	65	7.6	0	225	10	0.033	480	49

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXI - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, APRIL 19, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 5					
1500	S[c]	26.0	24.6	12.0	136	8.2	0	226	3	0.125	458	59
	B[d]		23.4	7.5	87	8.0	0	227	4	0.041	460	86
0230	S	18.8	23.6	7.4	87	7.8	0	226	8	0.063	500	60
	B		23.0	6.5	75	7.8	0	230	8	0.049	500	75
							STATION 6					
1540	S	28.0	23.6	8.8	102	8.2	0	225	0	0.038	440	63
0305	S	18.0	23.6	7.1	81	7.3	0	214	20	0.047	500	54
							STATION 7					
1130	S	25.3	23.0	7.4	85	7.7	0	204	8	0.058	465	80
2330	S	21.5	23.0	7.4	85	7.8	0	223	7	0.040	485	97
							STATION 8					
1200	S	26.0	23.6	7.1	83	7.8	0	210	7	0.067	455	84
	B		23.0	6.4	72	7.8	0	203	6	0.038	455	109
2345	S	19.0	23.6	7.2	83	7.9	0	210	5	-	480	89
	B		23.0	7.0	81	7.9	0	212	5	0.046	480	91

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXII - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, APRIL 19, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 9					
1300	S[c]	28.0	23.2	6.7	77	7.8	0	202	6	0.031	460	104
0030	S	18.6	23.0	6.8	78	8.0	0	204	4	0.056	475	96
							STATION 10					
1330	S	28.0	23.9	7.0	82	7.9	0	202	5	0.034	460	105
0110	S	18.0	23.0	6.8	78	8.1	0	205	3	0.037	478	105
							STATION 11					
1425	S	29.5	23.1	6.9	79	8.1	0	204	2	0.044	460	106
0200	S	20.0	23.5	7.0	82	8.1	0	212	3	0.041	510	101
							STATION 12					
1400	S	29.0	25.0	6.8	81	8.1	0	190	4	0.067	455	92
	B[d]		24.1	5.5	65	7.8	0	218	6	0.041	455	240
0200	S	19.0	23.0	6.3	74	7.9	0	192	5	0.045	460	101
	B		23.0	6.5	75	7.8	0	195	6	0.050	455	395+

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXIII - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, APRIL 19, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 13					
1335	S[c]	29.0	24.5	7.0	84	8.2	0	194	0	0.075	455	120
	B[d]		23.0	5.6	65	7.9	0	204	5	0.026	495	231
0130	S	19.0	23.0	6.4	74	7.9	0	191	5	0.045	460	150
	B		23.0	6.5	75	-	0	194	-	0.052	445	157
							STATION 14					
1245	S	27.0	24.0	6.8	80	8.1	0	204	2	0.033	518	97
0100	S	18.0	23.0	6.8	78	7.7	0	199	7	0.043	470	106
							STATION 15					
1150	S	29.5	24.8	6.0	73	8.2	0	208	2	0.025	485	108
	B		24.0	7.2	87	8.2	0	211	2	0.068	485	85
2345	S	19.8	23.6	6.9	80	8.0	0	212	4	0.052	490	110
	B		23.0	6.4	74	8.0	0	209	4	0.049	490	108

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXIV - LIMNOLOGICAL CONDITIONS AT STATION 1 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chloro-phyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0800	S[c]	10.1	21.3	7.4	83	7.7	0	222	7	-	520	30
1205	S	26.1	21.5	7.8	89	7.7	0	218	7	0.013	500	20
1600	S	28.2	22.8	8.0	92	7.8	0	216	6	-	505	25
1959	S	22.0	22.2	7.8	89	7.8	0	222	6	-	505	28
2355	S	20.0	22.0	7.6	87	7.8	0	216	6	0.012	505	22
0405	S	18.5	21.9	7.5	85	7.8	0	209	5	-	505	22

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XXV - LIMNOLOGICAL CONDITIONS AT STATION 2 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0845	S[c]	16.0	21.2	7.0	78	7.8	0	222	6	-	525	31
1240	S	24.4	22.1	6.5	74	7.8	0	226	6	0.015	505	32
1635	S	26.4	22.6	7.6	88	7.6	0	218	10	-	500	32
2030	S	21.5	22.5	7.9	90	7.8	0	215	5	-	490	36
0030	S	18.4	22.2	7.4	85	7.8	0	222	6	0.016	535	32
0435	S	17.0	21.9	7.4	84	7.9	0	218	4	-	500	24

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XXVI - LIMNOLOGICAL CONDITIONS AT STATION 3 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0935	S[c]	20.5	23.0	6.5	75	7.8	0	224	6	-	540	31
	B[d]		22.5	5.8	66	7.7	0	219	7	-	530	45
1325	S	26.2	23.6	6.4	75	7.6	0	224	6	0.009	505	39
	B		23.2	5.5	65	7.7	0	222	8	-	510	52
1720	S	25.8	23.2	6.4	76	7.8	0	224	6	-	515	39
	B		22.8	6.3	72	7.7	0	220	7	-	515	51
2120	S	20.2	23.2	6.8	78	7.8	0	222	5	-	505	31
	B		22.1	6.5	74	7.7	0	226	5	-	505	84
0120	S	18.1	23.2	7.0	81	7.8	0	224	6	0.016	510	31
	B		22.0	6.4	72	7.8	0	227	6	-	520	61
0515	S	18.1	22.9	6.8	78	7.9	0	214	4	-	510	28
	B		22.0	6.4	72	7.7	0	226	7	-	520	61

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXVII - LIMNOLOGICAL CONDITIONS AT STATION 4 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1035	S[c]	22.0	22.5	6.2	71	7.8	0	226	6	-	510	42
	B[d]		22.2	6.0	68	7.8	0	229	6	-	520	54
1415	S	27.0	23.4	6.6	78	7.8	0	224	6	0.011	510	37
	B		23.5	6.6	77	7.8	0	226	6	-	510	62
1800	S	23.6	23.4	6.8	79	7.8	0	222	6	-	510	50
	B		23.2	6.7	77	7.8	0	222	6	-	510	69
2210	S	21.0	22.9	6.5	75	7.7	0	228	6	-	505	43
	B		22.5	6.5	74	7.8	0	226	6	-	505	57
0220	S	18.9	22.8	6.5	75	7.9	0	226	4	0.012	510	45
	B		22.4	6.5	75	7.7	0	224	7	-	522	69
0615	S	17.0	22.1	6.3	71	7.8	0	224	6	-	515	48
	B		22.0	6.3	72	7.8	0	224	6	-	525	54

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXVIII - LIMNOLOGICAL CONDITIONS AT STATION 5 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1005	S[c]	23.5	23.3	7.3	84	7.7	0	220	7	-	505	51
	B[d]		23.0	6.7	77	7.6	0	218	7	-	500	61
1415	S	25.2	24.0	9.4	111	7.9	0	214	4	0.059	502	59
	B		23.0	6.8	90	7.5	0	216	13	-	500	64
1820	S	23.0	23.5	9.8	114	8.0	0	218	4	-	505	55
	B		23.0	6.6	77	7.6	0	218	8	-	505	56
2225	S	20.5	23.6	7.2	81	7.6	0	222	13	-	500	57
	B		23.2	6.6	76	7.6	0	218	10	-	498	64
0230	S	19.9	23.1	6.8	79	7.7	0	218	7	0.019	490	56
	B		23.0	6.0	70	7.5	0	228	13	-	498	66
0630	S	18.0	23.0	7.0	81	7.7	0	217	6	-	500	55
	B		22.4	6.0	68	7.5	0	215	13	-	505	70

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXIX - LIMNOLOGICAL CONDITIONS AT STATION 6 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0930	S[c]	21.0	23.0	6.6	76	7.8	0	220	6	-	505	61
1350	S	24.0	23.3	7.2	84	7.8	0	216	6	0.029	500	61
1755	S	23.0	23.2	6.3	73	7.7	0	220	7	-	505	85
2200	S	19.8	23.2	7.0	81	7.7	0	224	7	-	495	56
0210	S	17.1	23.1	6.4	73	7.7	0	218	7	0.029	550	49
0615	S	16.2	22.9	6.4	74	7.6	0	222	10	-	500	48

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XXX - LIMNOLOGICAL CONDITIONS AT STATION 7 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0900	S[c]	16.2	23.0	6.8	78	7.3	0	205	22	-	465	74
1320	S	22.9	23.2	7.0	82	7.6	0	207	9	0.024	490	72
1525	S	20.6	23.3	7.1	81	7.4	0	211	15	-	492	84
2105	S	20.0	23.5	6.6	77	7.8	0	213	6	-	480	90
0120	S	18.9	23.1	6.6	75	7.6	0	211	10	0.016	540	82
0530	S	17.4	23.0	6.7	77	7.8	0	217	6	-	485	74

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XXXI - LIMNOLOGICAL CONDITIONS AT STATION 8 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0825	S[c]	17.0	23.0	6.6	76	7.4	0	199	16	-	458	88
	B[d]		23.0	6.2	70	7.4	0	200	18	-	460	90
1235	S	27.0	24.0	7.7	91	7.6	0	202	9	0.013	480	81
	B		23.0	6.3	73	7.6	0	200	9	-	480	91
1645	S	24.7	24.4	9.8	114	7.5	0	202	12	-	490	75
	B		23.0	6.4	75	7.4	0	202	15	-	490	110
2025	S	21.0	23.8	7.2	82	7.6	0	207	9	-	489	74
	B		23.2	7.2	82	7.7	0	207	7	-	490	73
0035	S	18.9	23.1	6.8	78	7.7	0	207	10	0.027	495	86
	B		23.0	6.7	77	7.6	0	213	10	-	495	85
0445	S	18.0	23.1	6.9	80	7.6	0	205	9	-	478	77
	B		23.0	6.8	79	7.6	0	205	9	-	480	77

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXII - LIMNOLOGICAL CONDITIONS AT STATION 9 IN THE GUADALUPE RIVER, MAY 10, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0750	S[c]	15.5	23.0	5.6	65	7.1	0	197	35	-	455	77
1150	S	26.7	23.5	6.0	69	7.2	0	196	28	0.016	490	100
1545	S	26.4	23.9	6.6	76	7.4	0	196	16	-	489	104
1945	S	22.4	23.9	6.5	77	7.7	0	203	7	-	480	89
2350	S	19.5	23.0	6.4	74	7.6	0	204	10	0.020	488	90
0400	S	18.0	22.2	6.5	74	7.6	0	207	11	-	500	72

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XXXIII - LIMNOLOGICAL CONDITIONS AT STATION 10 IN THE GUADALUPE RIVER, MAY 17, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0900	S[c]	21.8	23.0	6.5	74	7.4	0	173	14	-	495	144
1325	S	25.0	24.0	6.6	78	7.5	0	186	11	0.013	485	118
1725	S	26.2	24.8	6.5	77	7.7	0	187	6	-	480	112
2100	S	21.9	23.3	6.3	73	7.6	0	190	8	-	485	115
0100	S	17.1	23.0	6.4	74	7.6	0	187	8	0.052	540	138
0520	S	13.7	22.3	6.4	73	7.7	0	187	6	-	510	134

[a] Mean of two samples

[b] P-phenolphthalein; MO-methyl orange

[c] S-surface sample

TABLE XXXIV - LIMNOLOGICAL CONDITIONS AT STATION 11 IN THE GUADALUPE RIVER, MAY 17,1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0950	S[c]	22.2	22.5	6.5	74	7.6	0	165	8	-	440	310
1410	S	27.5	22.9	6.7	77	7.8	0	172	4	0.018	445	211
1815	S	24.8	23.7	6.7	78	7.8	0	176	4	-	455	180
2200	S	19.5	23.5	6.7	78	7.6	0	176	8	-	445	153
0145	S	17.9	23.7	6.6	77	7.7	0	182	6	0.037	460	111
0600	S	14.0	23.3	6.8	79	7.6	0	187	8	-	500	123

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

TABLE XXXV - LIMNOLOGICAL CONDITIONS AT STATION 12 IN THE GUADALUPE RIVER, MAY 17, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
1050	S[c]	20.0	23.1	6.6	76	7.8	0	182	4	-	515	113
	B[d]		23.1	6.4	73	7.8	0	184	4	-	518	155
1410	S	27.9	23.9	6.5	75	7.8	0	175	4	0.034	558	115
	B		23.1	6.2	72	7.6	0	182	8	0.027	575	206
1800	S	24.5	23.5	6.2	72	7.7	0	159	6	-	478	137
	B		23.1	6.2	70	7.7	0	171	5	-	480	198
2215	S	20.8	23.2	6.2	77	7.4	0	164	13	-	460	140
	B		23.0	6.2	70	7.4	0	166	13	-	460	273
0245	S	18.9	21.5	6.1	68	7.5	0	164	10	0.043	440	136
	B		22.0	6.2	70	7.4	0	167	13	0.064	440	172
0630	S	14.8	23.0	6.1	70	7.7	0	167	6	-	440	147
	B		22.1	6.2	69	7.8	0	163	10	-	440	164

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXVI - LIMNOLOGICAL CONDITIONS AT STATION 13 IN THE GUADALUPE RIVER, MAY 17, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
1015	S[c]	23.0	22.7	6.3	72	7.2	0	174	24	-	430	120
	B[d]		22.2	-	-	7.7	0	159	5	-	440	150
1340	S[c]	27.7	23.9	6.4	75	7.3	0	165	17	0.021	460	175
	B[d]		23.1	5.8	67	7.6	0	162	7	0.011	450	143
1730	S[c]	25.0	23.5	6.4	74	7.4	0	171	14	-	508	130
	B[d]		23.0	6.1	70	8.0	0	178	2	-	508	140
2130	S[c]	21.2	23.4	6.0	70	7.4	0	166	13	-	490	147
	B[d]		23.2	6.0	70	7.6	.0	184	8	-	495	395+
0200	S[c]	19.8	23.0	5.7	65	7.5	0	168	10	0.034	470	147
	B[d]		21.5	5.7	64	7.4	0	164	13	0.044	470	155
0600	S[c]	15.0	22.0	5.9	66	7.4	0	169	14	-	460	172
	B[d]		21.0	5.8	64	7.5	0	164	10	-	450	128

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXVII - LIMNOLOGICAL CONDITIONS AT STATION 14 IN THE GUADALUPE RIVER, MAY 17, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (μmhos/cm)	Turbidity[a] (Jackson Units)
0925	S[c]	22.9	22.5	7.3	84	7.9	0	166	3	-	438	120
1310	S	30.5	23.0	7.2	83	7.8	0	162	4	0.013	450	130
1645	S	26.0	22.5	7.4	84	7.4	0	160	13	-	440	147
2040	S	22.0	23.0	7.2	84	8.0	0	173	2	-	460	130
0100	S	19.0	23.8	6.5	74	7.5	0	175	10	0.013	500	115
0500	S	16.5	22.5	7.2	82	7.6	0	174	8	-	500	128

[a] Mean of two samples

[b] P-phenolphthalein; MO-methyl orange

[c] S-surface sample

TABLE XXXVIII - LIMNOLOGICAL CONDITIONS AT STATION 15 IN THE GUADALUPE RIVER, MAY 17, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
0815	S[c]	23.4	23.5	6.0	70	7.8	0	168	4	-	456	114
	B[d]		23.0	5.8	69	7.5	0	166	10	-	458	180
1210	S	26.1	23.7	6.1	72	7.6	0	162	7	0.016	450	125
	B		23.2	5.9	70	7.7	0	159	5	0.016	440	137
1600	S	27.9	24.9	6.3	74	7.4	0	152	12	-	390	184
	B		23.3	6.0	70	7.5	0	145	8	-	380	273
2000	S	23.8	23.8	6.0	70	7.4	0	147	12	-	360	197
	B		22.8	5.8	67	7.5	0	142	8	-	390	395+
0005	S	18.5	24.8	6.6	77	7.6	0	164	7	0.051	420	134
	B		23.5	6.4	74	7.4	0	162	13	0.052	410	143
0355	S	18.0	23.0	6.6	76	7.7	0	171	6	-	440	112
	B		23.0	6.4	75	7.8	0	172	4	-	443	114

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXIX - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JUNE 14, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 1					
1135	S[c]	28.2	25.0	7.0	84	7.6	0	198	9	0.015	420	18
2340	S	27.6	25.0	6.8	81	7.9	0	204	5	0.019	500	32
							STATION 2					
1200	S	32.0	25.1	6.2	75	7.7	-	-	-	0.014	505	18
0020	S	27.4	26.2	6.9	75	8.0	0	183	4	0.023	480	32
							STATION 3					
1300	S	31.5	27.9	11.4	144	8.2	0	182	2	0.040	460	21
	B[d]		23.8	3.9	45	7.6	0	185	12	-	485	58
0110	S	24.1	28.5	15.9	150	8.2	0	169	2	0.068	420	36
	B		23.0	5.5	63	7.5	0	194	12	-	465	95
							STATION 4					
1350	S	29.5	26.3	8.8	108	8.0	0	191	4	0.040	470	34
	B		26.2	8.5	104	8.0	0	192	4	-	475	37
0200	S	25.9	25.9	7.8	95	8.0	0	188	4	0.026	475	49
	B		25.9	7.8	95	7.9	0	196	5	-	475	42

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXX - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JUNE 14, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 5TI					
1450	S[c]	31.5	29.9	10.6	140	8.2	0	164	1	0.029	400	30
	B[d]		28.0	5.1	65	7.9	-	-	-	-	430	-
0330	S	26.5	22.7	9.3	106	8.0	0	162	3	0.036	405	36
	B	-	-	-	-	-	-	-	-	-	-	-
							STATION 5					
1510	S	32.0	29.2	14.0	150+	8.2	0	173	2	0.095	415	36
	B		26.1	6.7	82	7.9	0	188	5	-	480	50
0255	S	24.9	27.0	10.4	130	7.9	0	180	5	0.047	435	42
	B		25.9	6.6	78	7.7	0	186	7	-	470	61
							STATION 6					
1545	S	29.5	26.6	9.4	115	8.1	0	192	2	0.044	455	49
0345	S	26.2	25.8	8.0	97	7.9	0	188	5	0.038	440	44
							STATION 7					
1135	S	28.0	25.5	6.9	83	7.4	0	186	14	0.025	505	48
2330	S	25.5	26.5	-	-	7.8	0	186	6	0.034	480	59

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXI - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JUNE 14, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
						STATION 8						
1205	S[c]	29.0	27.0	7.1	89	7.9	0	186	5	0.024	500	47
	B[d]		26.0	6.6	80	7.8	0	199	6	-	495	54
2400	S	26.5	26.9	-	-	7.8	0	176	6	0.039	480	56
	B		26.5	-	-	7.8	0	186	6	-	480	51
						STATION 9						
1255	S	32.5	26.5	7.0	86	7.8	0	188	6	0.042	505	58
0050	S	26.9	26.0	-	-	7.8	0	179	6	0.026	480	59
						STATION 10						
1330	S	39.0	27.5	7.7	97	8.0	0	183	3	0.024	510	54
0130	S	26.5	26.2	-	-	7.9	0	184	5	0.031	495	65
						STATION 11						
1415	S	34.0	27.2	6.4	81	7.7	0	185	7	0.021	540	68
0215	S	24.0	27.9	-	-	8.0	0	184	0	0.029	510	92

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXII - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JUNE 14, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
						STATION 12						
1410	S[c]	33.0	30.1	6.9	92	8.0	0	186	3	0.040	485	55
	B[d]		28.1	5.8	74	7.9	0	190	4	-	480	82
0220	S	25.4	27.3	6.1	77	8.0	0	196	4	0.017	500	73
	B		26.8	6.0	77	8.0	0	190	4	-	500	84
						STATION 13						
1350	S	32.9	30.0	7.0	92	8.0	0	186	4	0.034	498	67
	B		28.0	5.2	67	7.8	0	179	3	-	490	134
0145	S	27.1	30.0	9.0	118	8.0	0	177	6	0.032	460	71
	B		27.4	6.2	78	8.0	0	186	4	-	495	101
						STATION 14						
1300	S	32.0	28.5	6.4	82	7.8	0	184	6	0.017	482	48
0100	S	24.4	27.5	6.4	80	7.9	0	187	5	0.034	500	81
						STATION 15						
1200	S	32.0	29.0	7.1	92	8.0	0	183	3	0.024	482	51
	B		28.0	6.0	76	7.8	0	183	6	-	495	74
2350	S	25.3	29.0	8.2	105	8.0	0	177	3	0.021	480	61
	B		27.5	5.8	72	7.8	0	185	6	-	490	84

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXIII - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JULY 12, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 1					
1130	S[c]	32.2	28.0	7.0	90	7.8	0	208	7	0.016	535	18
2325	S	28.0	29.0	6.7	87	7.8	0	200	6	0.011	505	20
							STATION 2					
1200	S	31.0	28.2	5.8	73	7.8	0	206	7	0.019	535	17
0010	S	28.5	29.0	6.6	85	7.8	0	199	6	0.018	515	20
							STATION 3					
1300	S	32.5	29.8	14.9	150+	8.1	0	197	2	0.075	455	41
	B[d]		27.5	3.8	47	7.6	0	199	8	-	505	56
0100	S	28.0	29.2	13.3	150+	8.0	0	172	3	0.074	445	32
	B		28.2	5.5	69	7.7	0	206	8	-	495	128
							STATION 4					
1400	S	32.5	29.2	10.0	130	7.9	0	195	5	0.048	495	57
	B		29.2	8.0	104	7.8	0	195	6	-	495	90
0135	S	26.8	29.5	8.2	107	7.8	0	186	6	0.037	481	56
	B		28.8	8.2	105	7.8	0	186	6	-	480	59

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXIV - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JULY 12, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 5TI					
1500	S[c]	34.5	31.5	9.4	127	7.8	0	166	4	0.060	435	32
	B[d]		30.9	5.0	67	7.7	0	158	4	-	450	38
0205	S	27.0	31.6	8.1	110	7.8	0	170	6	0.042	420	32
	B		31.0	8.0	106	7.9	0	170	6	-	425	32
							STATION 5					
1530	S	34.2	32.0	13.4	150+	7.6	0	170	6	0.096	435	46
	B		29.9	5.8	76	7.6	0	189	8	-	475	61
0230	S	26.0	29.9	10.6	138	7.9	0	170	4	0.036	445	49
	B		29.2	8.1	106	7.8	0	187	5	-	465	77
							STATION 6					
1615	S	34.9	30.5	9.2	124	7.8	0	178	5	0.066	445	99
0300	S	25.2	29.7	8.8	114	7.8	0	173	5	0.050	445	47
							STATION 7					
1135	S	31.5	30.0	4.9	64	7.6	0	192	7	0.017	480	56
2340	S	27.5	30.0	5.8	75	7.7	0	182	7	0.025	480	71

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXV - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JULY 12, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 8					
1205	S[c]	31.4	30.5	5.1	66	7.7	0	195	8	0.034	495	44
	B[d]		29.8	4.3	56	7.6	0	198	8	-	500	88
0010	S	29.0	30.2	5.4	74	7.7	0	187	7	0.016	490	61
	B		30.0	5.2	67	7.7	0	188	8	-	481	64
							STATION 9					
1300	S	32.5	30.2	5.1	70	7.7	0	196	7	0.027	495	51
0050	S	28.0	29.5	5.8	75	7.8	0	193	4	0.019	500	51
							STATION 10					
1330	S	32.5	30.5	6.9	92	7.8	0	197	6	0.030	505	51
0140	S	27.0	29.5	5.3	69	7.8	0	192	6	0.032	501	64
							STATION 11					
1415	S	32.0	29.8	6.3	82	7.8	0	198	6	0.025	520	54
0230	S	26.0	29.5	6.6	86	8.0	0	196	3	0.017	515	59

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXVI - LIMNOLOGICAL CONDITIONS AT STATIONS IN THE GUADALUPE RIVER, JULY 12, 1969

Time	Level Sampled	Temperature Air (°C)	Temperature Water (°C)	Dissolved Oxygen[a] (mg/l)	Dissolved Oxygen[a] (% Sat.)	pH	Alkalinity[a,b] P (mg/l)	Alkalinity[a,b] MO (mg/l)	Carbon Dioxide (mg/l)	Chlorophyll a[a] (mg/l)	Specific Conductance (µmhos/cm)	Turbidity[a] (Jackson Units)
							STATION 12					
1430	S[c]	32.8	31.0	5.8	79	7.8	0	195	6	0.029	505	54
	B[d]		30.6	5.3	71	7.8	0	196	6	-	510	76
0210	S	27.8	30.3	5.3	70	7.9	0	193	5	0.016	525	64
	B		29.9	5.3	69	7.9	0	196	5	-	525	172
							STATION 13					
1400	S	31.9	30.5	5.6	75	7.9	0	196	5	0.034	515	87
	B		30.0	5.4	70	7.8	0	198	6	-	505	188
0140	S	27.9	30.5	5.4	72	7.9	0	191	5	0.024	515	97
	B		29.9	4.4	58	7.9	0	200	5	-	500	147
							STATION 14					
1315	S	31.2	30.3	6.2	82	7.8	0	192	6	0.019	505	61
0040	S	27.8	30.0	6.2	81	7.9	0	188	6	0.015	505	71
							STATION 15					
1155	S	29.9	30.5	5.6	76	7.7	0	190	7	0.025	505	67
	B		30.3	5.2	69	7.8	0	196	7	-	495	123
2355	S	27.5	30.4	5.7	75	7.8	0	186	6	0.027	505	65
	B		30.0	5.8	77	7.8	0	185	6	-	510	90

[a]Mean of two samples

[b]P-phenolphthalein; MO-methyl orange

[c]S-surface sample

[d]B-bottom sample

TABLE XXXXVII - DEPTHS IN METERS AT 16 STATIONS IN THE GUADALUPE RIVER,1969

Station Numbers	Dates of Diel Sampling Periods[a]							
	Feb.22	Mar.1	Mar.29	April 19	May 10	May 17	June 14	July 12
1	3.2	-	2.8	2.1	2.9	-	2.2	2.0
2	3.0	-	3.5	3.3	3.4	-	3.0	3.4
3	7.7	-	7.5	7.3	7.6	-	7.8	7.5
4	4.0	-	4.3	4.0	4.2	-	4.0	4.0
5	7.3	-	8.0	7.5	6.7	-	7.4	7.6
5TI[b]	-	-	-	-	-	-	3.6	4.3
6	2.7	-	1.0	1.5	1.5	-	1.9	1.1
7	2.4	-	2.4	2.4	2.5	-	1.8	1.2
8	6.1	-	5.9	6.1	6.2	-	6.0	5.9
9	1.4	-	1.1	1.2	1.3	-	1.1	0.8
10	-	1.3	1.2	1.2	-	0.9	0.7	0.6
11	-	0.9	0.9	1.1	-	0.6	0.5	0.4
12	-	4.3	5.5	5.1	-	5.5	4.8	4.6
13	-	3.0	4.3	7.0	-	5.0	7.3	7.0
14	-	3.1	3.1	3.1	-	3.1	3.1	3.1
15	-	3.0	4.6	7.0	-	7.7	7.2	7.5

[a] See Chapter III, p.16, for explanation of sampling schedules.

[b] Station 5TI was added on June 14, 1969.

TABLE XXXXVIII - SURFACE WATER VELOCITIES IN METERS/SECOND AT 16 STATIONS ON THE GUADALUPE RIVER, 1969

Station Numbers	Dates of Diel Sampling Periods[a]					
	Feb.22	Mar.29	April 19	May 10[b]	June 14	July 12
1	0.38	0.27	-	0.34	-	0.22
2	0.15	0.00	-	0.25	-	UMV[c]
3	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	UMV	0.00	0.12
5	0.00	0.00	0.00	0.00	0.00	0.00
5TI[d]	-	-	-	-	0.00	0.00
6[e]	-	-	-	-	-	-
7	-	0.43	0.38	0.44	0.23	0.25
8	-	0.00	0.00	0.00	0.00	0.00
9	-	0.43	0.43	0.60	0.60	0.43
10	-	0.60	0.76	0.68	0.60	0.60
11	-	0.60	0.60	0.95	0.60	0.43
12	-	0.34	0.14	0.23	0.06	0.06
13	-	0.00	0.00	0.00	0.00	0.00
14[e]	-	-	-	-	-	-
15	-	0.00	0.00	0.00	0.00	0.00

[a]See p. 16, Chapter III, for explanation of sampling schedules

[b]Measurements were taken at Stations 10-15 on May 17, 1969

[c]UMV - Unable to measure surface velocity due to uncontrollable environmental factors

[d]Station 5TI added in June, 1969

[e]Unable to take measurement from bank

TABLE XXXXIX - SECCHI DISK TRANSPARENCY IN METERS AT 16 STATIONS ON THE GUADALUPE RIVER, 1969

Station Numbers	Dates of Diel Sampling Periods[a] Feb.22[b]	Mar.1[b]	Mar.29[c]	April 19[c]	May 10[b]	May 17[b]	June 14[c]	July 12[c]
1	1.1	-	1.9	0.8	0.9	-	1.9	1.2
2	0.9	-	1.2	0.9	0.9	-	1.5	1.3
3	0.8	-	0.9	0.5	1.0	-	1.1	0.8
4	0.4	-	0.9	0.6	0.6	-	0.8	0.4
5	0.5	-	0.5	0.4	0.4	-	0.6	0.6
5TI[d]	-	-	-	-	-	-	1.0	0.8
6	0.4	-	0.6	0.4	0.3	-	0.6	1.0
7	0.3	-	0.2	0.3	0.3	-	0.4	0.3
8	0.3	-	0.2	0.3	0.3	-	0.4	0.3
9	0.3	-	0.2	0.2	0.3	-	0.3	0.3
10	-	0.3	0.2	0.2	-	0.2	0.4	0.3
11	-	0.3	0.3	0.2	-	0.2	0.4	0.3
12	-	0.4	0.3	0.2	-	0.2	0.5	0.5
13	-	0.4	0.2	0.1	-	0.2	0.3	0.4
14[e]	-	-	-	-	-	-	-	-
15	-	0.3	0.3	0.3	-	0.2	0.4	0.4

[a]See p. 16, Chapter III, for explanation of sampling schedules

[b]Average of two to four measurements

[c]One measurement taken between 1200 and 1600 hrs.

[d]Station 5TI added in June, 1969

[e]Unable to take measurement from bank

TABLE L - ILLUMINATION AND WIND VELOCITY VALUES FOR FEBRUARY 22 AND MARCH 1, 1969, DIEL SAMPLING PERIODS

	February 22			March 1 [c]	
Time	Ft-c [a]	Km/hr [b]	Time	Ft-c	Km/hr
0750	420.0 [c]	0-0	0830	880.0	4-8
0845	2400.0 [c]	3-8	0920	1010.0	8-16
0925	1800.0 [c]	3-8	1020	1600.0	4-8
1010	1200.0 [c]	0-4	1100	2800.0	3-4
1200	7000.0	0-0	1205	3600.0	4-8
1245	6200.0	0-4	1250	2200.0	3-8
1325	5600.0	3-8	1330	3800.0	4-8
1410	6200.0	0-4	1410	2400.0	4-8
1550	2400.0	4-9	1605	4000.0	3-4
1630	2600.0	0-4	1700	100.0	2-3
1715	820.0	0-8	1800	420.0	0-0
1805	120.0	0-0	1915	240.0	0-0
2000	0.0	0-4	2000	0.0	0-0
2030	0.0	0-0	2040	0.0	0-0
2105	0.0	0-8	2215	0.0	0-0
2150	0.0	0-0	2300	0.0	0-0
2350	0.0	0-4	2400	0.0	0-0
0025	0.0	0-3	0040	0.0	0-0
0110	0.0	0-4	0140	0.0	0-0
0200	0.0	0-0	0215	0.0	0-0
0345	0.0	0-4	0345	0.0	0-0
0420	0.0	0-0	0445	0.0	0-0
0500	0.0	0-0	0525	0.0	0-0
0555	0.0	0-0	0630	10.0	4-8

[a] Ft-c - foot candles

[b] Km/hr - kilometers per hour

[c] cloud cover present

TABLE LI - ILLUMINATION AND WIND VELOCITY VALUES FOR MARCH 29 AND APRIL 19, 1969, DIEL SAMPLING PERIODS

	March 29			April 19	
Time	Ft-c[a]	Km/hr[b]	Time	Ft-c	Km/hr
1200	3200.0[c]	0-6	1155	9000.0	0-10
1220	2800.0[c]	8-14	1210	8800.0	0-11
1305	6400.0	4-14	1310	8600.0	8-16
1400	7200.0	0-3	1400	8000.0	0-0
1455	6400.0	6-12	1400	7000.0	0-16
1545	2000.0[c]	0-0	1540	6000.0	0-4
2330	0.0	0-0	2330	0.0	0-0
0005	0.0	0-0	2345	0.0	0-0
0045	0.0	0-0	0050	0.0	-
0135	0.0	0-0	0145	0.0	-
0220	0.0	0-0	0230	0.0	0-8
0250	0.0	0-0	0305	0.0	0-4

[a]Ft-c - foot candles

[b]Km/hr - kilometers per hour

[c]cloud cover present

TABLE LII - ILLUMINATION AND WIND VELOCITY VALUES FOR MAY 10 AND MAY 17, 1969, DIEL SAMPLING PERIODS

	May 10			May 17	
Time	Ft-c[a]	Km/hr[b]	Time	Ft-c	Km/hr
0800	1400.0	0-0	0815	1400.0[c]	3-4
0845	4400.0	0-0	0925	2360.0[c]	2-3
0935	5000.0	4-8	1015	2440.0[c]	9-12
1035	5400.0	0-4	1050	5800.0	2-4
1205	5000.0	0-0	1210	3700.0[c]	4-9
1240	6600.0	0-8	1310	2900.0[c]	2-3
1325	7000.0	0-12	1340	8200.0	2-3
1415	3200.0	0-4	1410	8000.0	2-3
1600	5800.0	0-4	1600	6200.0	4-9
1635	4800.0	0-16	1645	4600.0	0-0
1720	1800.0	0-16	1730	2400.0	0-0
1800	600.0	0-0	1800	2000.0	2-3
1950	680.0	0-0	2000	1200.0	0-4
2030	0.0	0-0	2040	0.0	0-0
2120	0.0	0-0	2130	0.0	0-0
2210	0.0	0-0	2215	0.0	0-4
2355	0.0	0-0	0005	0.0	2-8
0030	0.0	0-0	0100	0.0	2-3
0120	0.0	0-0	0200	0.0	2-8
0220	0.0	0-0	0245	0.0	2-4
0405	0.0	0-0	0355	0.0	2-8
0435	0.0	0-0	0500	0.0	2-3
0515	0.0	0-0	0600	0.0	2-8
0615	0.0	0-0	0630	1200.0	2-4

[a]Ft-c - foot candles

[b]Km/hr - kilometers per hour

[c]cloud cover present

TABLE LIII - ILLUMINATION AND WIND VELOCITY VALUES FOR JUNE 14 AND JULY 12, 1969, DIEL SAMPLING PERIODS

	June 14			July 12	
Time	Ft-c[a]	Km/hr[b]	Time	Ft-c	Km/hr
1135	7000.0	0-0	1130	2400.0[c]	0-3
1200	7200.0	0-6	1200	2400.0[c]	4-6
1300	7200.0	0-11	1300	3300.0[c]	11-14
1350	7200.0	0-3	1400	4400.0[c]	0-0
1450	6700.0	0-4	1500	6200.0	0-0
1510	6400.0	0-0	1530	6400.0	0-2
1545	1600.0[c]	0-0	1615	6800.0	0-3
2340	0.0	0-0	2325	0.0	0-3
0020	0.0	9-16	0010	0.0	4-8
0110	0.0	0-16	0100	0.0	3-4
0200	0.0	0-8	0135	0.0	0-4
0255	0.0	0-11	0205	0.0	0-11
0330	0.0	0-8	0230	0.0	0-11
0345	0.0	0-8	0300	0.0	0-0

[a]Ft-c - foot candles

[b]Km/hr - kilometers per hour

[c]cloud cover present

TABLE LIV - STATION LOCATIONS IN MILES AND KILOMETERS FROM THE MOUTH OF THE GUADALUPE RIVER

Station Number	River Miles	River Kilometers
1	279.0	449.5
2	276.6	445.3
3	272.0	437.9
4	267.8	431.1
5TI	265.5	427.4
5	264.5	425.8
6	264.2	425.4
7	256.4	412.8
8	252.7	406.8
9	250.1	402.7
10	245.1	394.6
11	223.1	359.1
12	209.0	336.4
13	206.1	331.8
14	199.2	320.7
15	184.0	296.2

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