

INTENSIVE SURFACE WATER MONITORING SURVEY
FOR
SEGMENT NO. 0404
BIG CYPRESS CREEK - ABOVE LAKE O' THE PINES
TO FORT SHERMAN DAM

REPORT NO. IMS-51

PREPARED BY
STEVE R. TWIDWELL
SPECIAL STUDIES SECTION

FIELD OPERATIONS DIVISION
TEXAS WATER QUALITY BOARD
MAY, 1977

Authorization for use or reproduction of original material contained in this publication is freely granted. The Board would appreciate acknowledgement. Single copies available free of charge from: Texas Water Quality Board, P.O. Box 13246 Capitol Station, Austin, Texas 78711.

TABLE OF CONTENTS

| | <u>Page</u> |
|---|-------------|
| INTRODUCTION | 1 |
| DIRECTIVE | 1 |
| PURPOSE | 1 |
| SUMMARY | 2 |
| WATER QUALITY PROBLEMS | 5 |
| METHODS | 7 |
| DESCRIPTION OF SURVEY AREA | 8 |
| WASTE SOURCES IN SURVEY AREA | 11 |
| POINT SOURCES | 11 |
| NON-POINT SOURCES | 13 |
| PRESENTATION OF DATA | 14 |
| HYDROLOGICAL | 14 |
| FIELD MEASUREMENTS | 14 |
| WATER ANALYSES | 19 |
| SEDIMENT ANALYSES | 23 |
| <u>Chemical</u> | 23 |
| <u>Heavy Metals</u> | 23 |
| <u>Pesticides</u> | 24 |
| BIOLOGICAL | 26 |
| <u>Chlorophyll a</u> | 26 |
| <u>Phytoplankton</u> | 26 |
| <u>Zooplankton</u> | 29 |
| <u>Benthic Macroinvertebrates</u> | 30 |

TABLE OF CONTENTS (CONT.)

| | <u>Page</u> |
|---|-------------|
| <u>Bacteria</u> | 32 |
| RELATED TEXAS WATER QUALITY BOARD ACTIVITIES . . . | 33 |
| WASTE LOAD EVALUATIONS | 33 |
| TWQB PERMITS AND REGISTRATIONS; NPDES PERMITS | 33 |
| STREAM MONITORING | 33 |
| REFERENCES CITED | 34 |
| APPENDIX A: FIELD AND LABORATORY PROCEDURES | |
| APPENDIX B: DETECTION LEVELS OF HEAVY METAL AND PESTICIDE ANALYSES | |

LIST OF TABLES

| <u>Tables</u> | | <u>Page</u> |
|---------------|---|-------------|
| 1. | Big Cypress Creek Survey Sampling Stations | 9 |
| 2. | Wastewater Dischargers | 12 |
| 3. | Hydrological Data | 14 |
| 4. | Big Cypress Creek Field Measurements | 15 |
| 5. | Laboratory Water Analyses | 20 |
| 6. | Sediment Chemical Data | 23 |
| 7. | Sediment Heavy Metals Data | 24 |
| 8. | Sediment Pesticides Data | 25 |
| 9. | Chlorophyll <u>a</u> Data | 26 |
| 10. | Phytoplankton Data | 28 |
| 11. | Zooplankton Data | 29 |
| 12. | Benthic Macroinvertebrate Data | 31 |
| 13. | Fecal Coliform Data | 32 |

LIST OF FIGURES

| <u>Figure</u> | | <u>Page</u> |
|---------------|--|-------------|
| 1. | Map of Study Area | 10 |
| 2. | Dissolved Oxygen Data at Station 7 | 18 |

INTENSIVE SURFACE WATER MONITORING SURVEY
FOR
SEGMENT NO. 0404
BIG CYPRESS CREEK - ABOVE LAKE O' THE PINES
TO FORT SHERMAN DAM

INTRODUCTION

DIRECTIVE

This intensive survey was accomplished in accordance with the Texas Water Quality Act, Section 21.257, as amended in 1973. The report is to be used in developing and maintaining the State Water Quality Strategy required by regulations published in 40 CFR 130.40 pursuant to Section 303(e) of the Federal Water Pollution Control Act as amended on October 18, 1972.

PURPOSE

The purpose of this intensive survey was to provide the Texas Water Quality Board with a valid information source:

- 1) to determine quantitative cause and effect relationships of water quality;
- 2) to obtain data for updating water quality management plans, setting effluent limits, and, where appropriate, verifying the classifications of segments;
- 3) to set priorities for establishing or improving pollution controls; and
- 4) to determine any additional water quality management actions required.

SUMMARY

An intensive monitoring survey was conducted on Segment 0404 of Big Cypress Creek in September 1976. Segment 0404 of Big Cypress Creek begins at Fort Sherman Dam, which impounds Lake Bob Sandlin, and ends at the headwaters of Lake O' the Pines, a distance of approximately 12 miles. Big Cypress Creek drains all or parts of Franklin, Titus, Morris, and Camp Counties located in the northeastern portion of Texas. This survey included sampling stations in the main body of Big Cypress Creek, at selected locations on all significantly flowing tributaries, and at all wastewater dischargers located along the segment.

Municipal sewage treatment plants are the most common facilities from which wastewater is discharged to the segment. Of the four sewage treatment plants that were discharging during the survey, the City of Mount Pleasant's southwest plant was the largest. This plant discharged a treated effluent that contained an average of 239 lbs/day of BOD₅ and 316 lbs/day of nutrient compounds. The City of Mount Pleasant's northeast and southeast sewage treatment plants also discharged significant quantities of BOD₅ (74 and 181 lbs/day, respectively) and nutrient compounds (70 and 240 lbs/day respectively).

Big Cypress Creek and its tributaries contained little water at the time the survey was conducted. Discharge in the lower portion of Big Cypress Creek was only 10 cubic feet per second. Tankersley Creek, Hart Creek, and Dry Creek each contributed less than 5 cfs to the segment. Big Cypress Creek upstream from the Tankersley Creek confluence was dry. The creek in this area was blocked for construction work on Fort Sherman Dam and no water was being released downstream.

Temperature and pH values measured from Big Cypress Creek and its tributaries varied from station-to-station, but none were in violation of the Texas Water Quality Standards established for the segment. Most of the pH values from Big Cypress Creek were neutral to slightly acidic. Alkalinity was due totally to bicarbonates and levels for this parameter were generally low throughout the segment. The low bicarbonate levels reduce Big Cypress Creek's buffering capacity making it susceptible to low pH values.

The introduction of wastewaters from the five dischargers had noticeable effects on various field and chemical parameters in the receiving waters. These effluents contained abundant levels of chloride, sulfate, phosphorus, nitrogen, and BOD₅. The carbonaceous and nitrogenous oxygen demand of the American Petrofina and City of Mount Pleasant southwest sewage treatment plant effluents caused depression of dissolved oxygen in Tankersley Creek to levels below 2 mg/l. These effluents also caused chronically low dissolved oxygen levels farther downstream in Big Cypress Creek. The treated effluents from the City of Mount Pleasant's northeast and southeast plants did not cause serious depression of dissolved oxygen levels in Hart Creek. Dissolved oxygen levels ranged between 4.6 and 5.1 mg/l in this creek throughout the study period. The carbonaceous and nitrogenous oxygen demand of the treated wastewater discharged from the City of Pittsburg's Sparks Branch Plant was responsible for the observed low dissolved oxygen levels (less than 2 mg/l) in Dry Creek.

The sediments from Segment 0404 were not strongly influenced by the introduction of wastewater effluents. The maximum concentrations of copper, lead, manganese, nickel, and zinc in sediments sampled from the segment were found to be excessive when compared with state-wide sediment data. The highest concentrations of lead and zinc occurred in the sediment collected from Dry Creek downstream from the City of Pittsburg's treated sewage discharge. The maximum concentrations of copper, nickel, and manganese occurred at the control station on Tankersley Creek upstream from the influence of all known wastewater dischargers. Polychlorinated biphenyls were found in sediments from all stations sampled. The PCB levels observed at Stations 1 (390 mg/kg) and 2 (130 mg/kg) on Tankersley Creek were high; however, no source for these contaminants was identified during this survey.

The biological communities of most of the stations sampled (phytoplankton, zooplankton, and benthic macroinvertebrates) were characterized by low numbers of different taxa and large numbers of total individuals, indicating some form of environmental stress. The benthic macroinvertebrate and phytoplankton communities from Tankersley Creek and Big Cypress Creek downstream from the American Petrofina and the City of Mount Pleasant's southwest sewage treatment plant discharges were composed of pollution tolerant organisms. Similar assemblages were observed in Dry Creek

downstream from the City of Pittsburg's Sparks Branch Treatment plant. The American Petrofina discharge from its oxidation pond contained large quantities of pollution tolerant blue-green algae. The decay and decomposition of this large algal biomass in Tankersley Creek and Big Cypress Creek may partially account for the low dissolved oxygen levels observed in the creeks downstream from American Petrofina's discharge.

Samples from stations on Tankersley Creek, Hart Creek, and Dry Creek immediately downstream from the City of Mount Pleasant's southwest sewage treatment plant, City of Mount Pleasant's northeast and southeast sewage treatment plants, and the City of Pittsburg's Sparks Branch sewage treatment plant, respectively contained high levels of fecal coliform bacteria. These high bacteria densities were apparently influenced by the treated municipal sewage effluents.

WATER QUALITY PROBLEMS

Chemical and biological parameters evaluated during this survey indicate that Big Cypress Creek is a naturally sensitive body of water, particularly during low flow conditions. During periods of low flow, low stream discharge rates and occasionally near stagnant velocity are contributing natural factors to low dissolved oxygen levels in the segment. These naturally low dissolved oxygen levels are further aggravated by the introduction of the prevailing point source pollutant loads.

The oxygen demand of the effluents discharged from the City of Mount Pleasant's southwest sewage treatment plant and American Petrofina caused depression in dissolved oxygen to critically low levels (less than 2 mg/l) in Tankersley Creek. The City of Mount Pleasant's southwest plant was by far the largest contributor of oxygen demanding materials to Tankersley Creek. The effluent from this plant accounted for approximately 96 percent of the total oxygen demand (ammonia nitrogen and BOD₅) of waste loads discharged to Tankersley Creek. During this intensive survey no water was being released from Fort Sherman Dam to Big Cypress Creek upstream from the Tankersley Creek confluence. Without inflow from Big Cypress Creek to provide dilution of the oxygen demanding waters from Tankersley Creek, critically low dissolved oxygen levels also developed in Big Cypress downstream from the Tankersley Creek confluence.

The treated sewage effluent from the City of Pittsburg's Sparks Branch plant caused extremely low dissolved oxygen levels in Dry Creek downstream from the discharge point and may have caused similar problems in Big Cypress Creek. The impact of the Dry Creek discharge on Big Cypress Creek could not be ascertained because Big Cypress Creek was not accessible immediately downstream from the Dry Creek confluence.

A waste load evaluation for Segment 0404 of Big Cypress Creek was conducted by the Texas Water Quality Board's Modeling Section in May 1974. This evaluation was written when plans specified the location of Lake Bob Sandlin downstream from Tankersley Creek and Hart Creek. The change in location of the lake has altered the hydraulic regime of the segment. The waste load evaluation should be reassessed based on the data collected during this intensive monitoring survey.

Fecal coliform levels of samples collected within Segment 0404 were high at stream stations located on Tankersley Creek, Hart Creek, and Dry Creek immediately downstream from the City of Mount Pleasant's southwest sewage treatment plant, the City of Mount Pleasant's northeast and southeast sewage treatment plants, and the City of Pittsburg's Sparks Branch sewage treatment plant, respectively. Fecal coliform sampling of effluents from these four plants and of the receiving waters should be conducted by Texas Water Quality Board District 5 personnel during compliance monitoring inspections of the plants to determine if these are recurrent problems.

METHODS

Field and laboratory procedures in this survey are described in Appendix A. The data were collected in September, 1976 by the Special Studies Section, assisted by Texas Water Quality Board District 5. Laboratory analyses of water and sediment samples were conducted by the Texas Department of Health Resources Chemistry Laboratory in Austin, Texas. Parametric coverage, sampling frequencies, and spatial relationships of sampling stations are consistent with the particular objectives of this survey and with known or suspected forms and variability of pollution occurring in the area.

DESCRIPTION OF SURVEY AREA

Segment 0404 of Big Cypress Creek begins at Fort Sherman Dam and ends at the headwaters of Lake O' the Pines, a distance of approximately 12.3 miles (1). Construction of Fort Sherman Dam, which will impound Big Cypress Creek to form Lake Bob Sandlin, was underway during the time this study was conducted. The dam is located approximately 2 miles upstream from the Tankersley Creek confluence, 6 miles southwest of Mount Pleasant. Lake Bob Sandlin was financed principally by the City of Mount Pleasant and the Texas Utilities Generating Company. The City of Mount Pleasant will utilize water from Lake Bob Sandlin for water supply, while the Texas Utilities Generating Company will pump water from the lake to its small reservoir on Blundell Creek for condensor cooling purposes. Big Cypress Creek and its tributaries within Segment 0404 drain all or portions of Franklin, Titus, Morris, and Camp Counties located in the northeastern portion of Texas. Inflow to Big Cypress Creek in Segment 0404 is supplied principally by Tankersley Creek, Hart Creek, and Dry Creek, the three largest tributary streams.

The land along the segment is utilized primarily as rangeland and is characterized by irregular rolling and hilly uplands and flat flood plains. Agricultural activities dominate the economy.

This survey included sampling stations in the main body of Big Cypress Creek throughout the segment, on three tributaries, and at the major wastewater dischargers. Table 1 provides descriptions of each sampling location and Figure 1 is a map of the survey area which shows the locations of the various sampling stations.

Table 1
Big Cypress Creek Survey Sampling Stations

| Station Number | Station Location |
|----------------|---|
| 1 | Tankersley Creek at FM 899 |
| 2 | Tankersley Creek at county road 4 miles southwest of Mount Pleasant |
| 3 | Tankersley Creek on private property 1/2 mile upstream from Big Cypress Creek |
| 4 | Big Cypress Creek at US 271 |
| 5 | Hart Creek at US 67 |
| 6 | Hart Creek at county road 4 miles southeast of Mount Pleasant |
| 7 | Big Cypress Creek at SH 11 |
| 8 | Dry Creek at county road 3 miles east of Pittsburg |

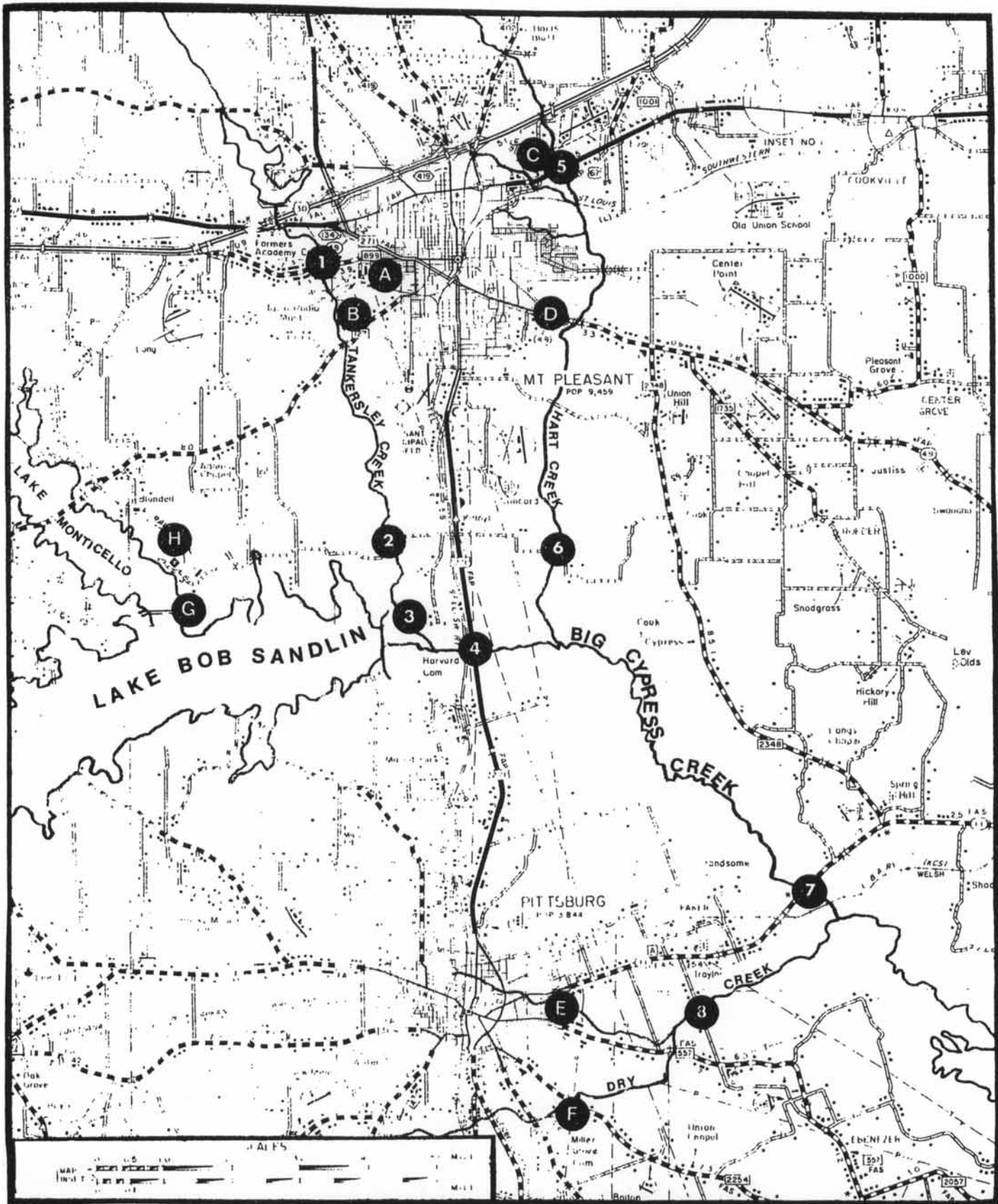


Figure 1. Map of Study Area

WASTE SOURCES IN SURVEY AREA

POINT SOURCES

Table 2 contains a summary of all Texas Water Quality Board permitted wastewater dischargers in the survey area (see Figure 1 for locations). The values in Table 2 represent estimates of average quantities discharged and were obtained from Texas Water Quality Board self reports (2) and return flow data (3).

Sewage treatment plants are the most common facilities from which wastewater is discharged to the segment. Of the five sewage treatment plants that discharge, the City of Mount Pleasant's southwest plant is the largest. Mount Pleasant's southwest plant discharged treated sewage effluent containing an average of 239 lbs/day of BOD₅ and 316 lbs/day of nutrients (ammonia + Nitrite + nitrate nitrogen and ortho-phosphate).

Two industrial facilities are also permitted by the Texas Water Quality Board to discharge wastewater to the segment. American Petrofina, an oil refinery, made the only industrial discharge to the segment during the study. This discharge, which enters Tankersley Creek, contained an average BOD₅ of 76.2 lbs/day. No discharge of wastewater was made from the Texas Utilities Generating Company's power plant or solid waste site during the study.

Table 2
Wastewater Dischargers

| Map Code | Discharger | BOD ₅ lbs/day | Ortho- Phosphate lbs/day | Ammonia + nitrite + Nitrate nitrogen lbs/day |
|----------|---|-----------------------------|--------------------------------|--|
| A | American Petrofina, Oil refinery | 76.2 | * | * |
| B | City of Mount Pleasant, Southwest STP | 239.2 | 52.4 | 263.8 |
| C | City of Mount Pleasant, Northeast STP | 73.9 | 39.4 | 31.4 |
| D | City of Mount Pleasant, Southeast STP | 180.7 | 33.6 | 206.4 |
| E | City of Pittsburg, Sparks Branch STP | 1.4 | 1.3 | 1.3 |
| F | City of Pittsburg, Dry Creek STP | ND | | |
| G | Texas Utilities Generating Co., Power Plant | ND | | |
| H | Texas Utilities Generating Co., Solid Waste Site | ND | | |

ND - No discharge made during study period

* - Nutrient data not available to TWQB

NON-POINT SOURCES

There exists the possibility that varying amounts of wastewater may be generated and sporadically discharged to the segment from non-point agricultural runoff, since some of the land along the segment is utilized for cultivation of crops. Several oil fields are located close to Big Cypress Creek and runoff from these areas could contribute contaminants to the segment. Runoff from forested areas may also contribute non-point source wastes to the creek.

PRESENTATION OF DATA

The raw hydrological, physico-chemical, and biological data are available in the Texas Water Quality Board Central Office files.

HYDROLOGICAL

Hydrological data shown in Table 3 represent discharge measurements of Big Cypress Creek and tributary streams which were flowing at the time of the survey. The data in Table 3 indicate that the study was conducted during low flow conditions. Discharge in the lower portion of the creek (Station 7) was only 10 cubic feet per second. Tankersley Creek and Hart Creek, the two largest tributaries contributed 4.6 and 4.0 cfs, respectively to the segment. Big Cypress Creek upstream from the Tankersley Creek confluence was dry. The creek in this area was blocked for construction work on Fort Sherman Dam and no water was being released downstream.

Table 3
Hydrological Data

| Station Number | | Method | Time | Date | Discharge cfs |
|----------------|-------------------|--------|------|---------|---------------|
| 1 | Tankersley Creek | PM | 1315 | 9/28/76 | 0.1 |
| 2 | Tankersley Creek | PM | 0830 | 9/29/76 | 4.6 |
| 5 | Hart Creek | PM | 1500 | 9/28/76 | 0.1 |
| 6 | Hart Creek | PM | 1015 | 9/29/76 | 4.0 |
| 7 | Big Cypress Creek | USGS | 1040 | 9/29/76 | 10.0 |
| 8 | Dry Creek | PM | 1600 | 9/29/76 | 3.0 |

PM - Pygmy Current Meter

FIELD MEASUREMENTS

Table 4 contains a summary of diurnal field measurements made at the appropriate Big Cypress Creek stations and wastewater dischargers on September 29, 1976. Station 1 on Tankersley Creek, and Station 4 on Hart Creek were sampled once.

Table 4
Big Cypress Creek
Field Measurements

| Parameter | Station Number | | | | | | | | | | | | |
|---------------------------------------|-------------------------------|----------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|--------------------|-------------------------------|-------------------------------|--------------------|------------------------------|----------------------------------|-------------------|
| | Tanker- sley Creek 1 | American Petrofina A | Mount Pleasant STP B | Tanker- sley Creek 2 | Tanker- sley Creek 3 | Big Cypress Creek 4 | Hart Creek 5 | Mount Pleasant STP D | Mount Pleasant STP C | Hart Creek 6 | Big Cypress Creek 7 | City of Pittsburg STP E | Dry Creek 8 |
| Temperature °C | \bar{x} | 24 | 27 | 20.1 | 19.7 | 20.3 | 20.5 | 22.8 | 24.2 | 19.5 | 20.7 | 23.5 | 20.5 |
| | Range | 22.5- 25.5 | 25.5- 28 | 19.5- 21.0 | 19- 20.5 | 19- 21.5 | * | 22.5- 23 | 23- 25.5 | 19- 20 | 20- 21.5 | 22.5- 24.5 | 19.5- 21 |
| pH | \bar{x} | 7.7 | 6.9 | 7.2 | 7.1 | 6.9 | 6.7 | 6.8 | 6.6 | 7 | 6.9 | 7.0 | 7.35 |
| | Range | 6.9- 8.5 | 6.5- 7.1 | 7.2- 7.2 | 7.1- 7.1 | 6.7- 7.1 | 6.7- 7.1 | 6.5- 7.0 | 6.5- 6.8 | 6.7- 7.1 | 6.8- 7.0 | 6.8- 7.2 | 7.3- 7.4 |
| Conductivity µmhos/cm | \bar{x} | 640 | 166 | 276 | 199 | 433 | 230 | 437 | 520 | 305 | 471 | 933 | 790 |
| | Range | 410- 905 | 105- 220 | 160- 505 | 100- 315 | 330- 470 | * | 410- 460 | 400- 600 | 290- 310 | 405- 520 | 890- 980 | 770- 800 |
| Dissolved Oxygen mg/l | \bar{x} | 7.6 | 0.4 | 0.7 | 1.4 | 0.8 | 2.2 | 2.4 | 5.2 | 4.9 | 2.8 | 4.4 | 1.3 |
| | Range | 3.3- 10.7 | 0.0- 1.1 | 0.3- 1.0 | 1.0- 1.8 | 0.0- 1.5 | * | 0.7- 3.8 | 4.9- 5.4 | 4.6- 5.1 | 2.5- 3.1 | 4.0- 5.0 | 0.8- 2.0 |
| Dissolved Oxygen & Sat. mg/l | \bar{x} | 89.4 | 4.9 | 7.6 | 15.1 | 8.7 | 24.2 | 27.6 | 61.3 | 52.6 | 31.1 | 51.2 | 14.2 |
| | Range | 37.7- 129 | 0- 13.9 | 3.2- 11.1 | 10.6- 19.7 | 0- 16.8 | * | 8- 43.6 | 56.3- 65.1 | 48.9- 55.4 | 27.2- 34.8 | 45.7- 59.2 | 8.6- 22.2 |
| P-Alkalinity mg/l | \bar{x} | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Range | * | * | * | * | * | * | * | * | * | * | * | * |
| Total Alkalinity mg/l | \bar{x} | 3.9 | 6.9 | 5.9 | 3.5 | 70 | 88 | 118 | 64 | 55.5 | 68 | 281 | 261 |
| | Range | 1.8- 1.9 | 5.9- 7.6 | 5.5- 6.1 | 3.3- 4.0 | 64- 76 | * | 98- 136 | 54- 72 | 52- 60 | 66- 70 | 264- 288 | 230- 272 |

Temperature and pH values shown in Table 4 indicate some station-to-station variation within Big Cypress Creek, but none were in violation of the respective Texas Water Quality Standards of 90°F and 6.0-8.0 (4). Most of the pH values from Big Cypress Creek were neutral to slightly acidic. Alkalinity was due totally to bicarbonates and levels for this parameter were generally low throughout the segment. The naturally low bicarbonate levels reduce the bayou's buffering capacity making it susceptible to low pH values (5). Such acidic pH values and low bicarbonate alkalinity content are common in the sandy, forested areas of East Texas where the streams flow sluggishly and are well shaded (6). The alkaline pH values observed at Tankersley Creek Stations 2 and 3, Hart Creek Station 5, and Dry Creek Station 7, and the elevated alkalinity values at Dry Creek Station 7 were apparently influenced by the wastewater dischargers located upstream from these stations.

Dissolved oxygen levels throughout the segment were generally low. This survey was conducted during low flow conditions. During these periods, low stream discharge rates (see Table 3) and occasionally near stagnant velocity are contributing natural factors to the low dissolved oxygen resources in the segment. For instance, very low dissolved oxygen levels occurred in Tankersley Creek (Station 1) and Hart Creek (Station 5) at locations upstream from all known wastewater discharges.

The introduction of the treated sewage effluent from the City of Mount Pleasant's southwest plant and American Petrofina's wastewater discharge downstream from Station 1 caused a depression in dissolved oxygen levels. The carbonaceous and nitrogenous oxygen demand of these combined wastewaters reduced the oxygen content in Tankersley Creek at Stations 2 and 3 and Big Cypress Creek at Station 4 to levels below 2 mg/l throughout the diurnal study period. Extremely low dissolved oxygen levels occurred at Stations 2 (0.3 mg/l), 3 (1.0 mg/l), and 4 (0.0 mg/l) during the early morning hours of the survey.

A recent water quality study of Tankersley Creek conducted in June, 1976 by Texas Water Quality Board District 5 personnel indicated the stream was stressed from the American Petrofina's and City of Mount Pleasant's wastewater discharge (7). During their study, the creek had low dissolved oxygen levels, high BOD₅ levels, and was enriched with excessive nutrient compounds. Although Tankersley Creek had recovered somewhat from the two wastewater dischargers in the lower portion, its discharge caused degradation of Big Cypress Creek.

The introduction of the treated sewage effluents from the City of Mount Pleasant's northeast and southeast plants downstream from Hart Creek Station 5 did not cause serious dissolved oxygen depressions in Hart Creek at Station 6. Dissolved oxygen levels at this station were near the 5 mg/l segment standard throughout the study period, but none were in excess of 60 percent saturation. The impact of the Hart Creek discharge on Big Cypress Creek could not be ascertained because Big Cypress Creek was inaccessible between Stations 4 and 7.

Chronically low dissolved oxygen levels (range of 2.5 to 3.1 mg/l) were also observed in the extreme lower portion of Big Cypress Creek at Station 7. These low dissolved oxygen levels were apparently caused by the introduced waste loads upstream. The waste load evaluation for Segment 0404 indicates that dissolved oxygen violations of the 5 mg/l dissolved oxygen standard at this station result principally from the Tankersley Creek discharge. (1)

Historical dissolved oxygen data collected by Texas Water Quality Board District 5 personnel at Station 7 indicate that levels often fall below the 5 mg/l segment standard (8) (Figure 2). Most of these violations occur in the dry summer and fall months when water temperature is elevated and flows in Big Cypress Creek retard dilution of oxygen demanding material. Such low dissolved oxygen levels have been observed in other northeast Texas streams (9, 10, 11).

Extremely low dissolved oxygen levels were observed in Dry Creek downstream from the City of Pittsburg's Sparks Branch sewage treatment plant. The carbonaceous and nitrogenous oxygen demand of the effluent from this plant was apparently responsible for the observed low dissolved oxygen levels (range of 0.8 to 2 mg/l) in Dry Creek.

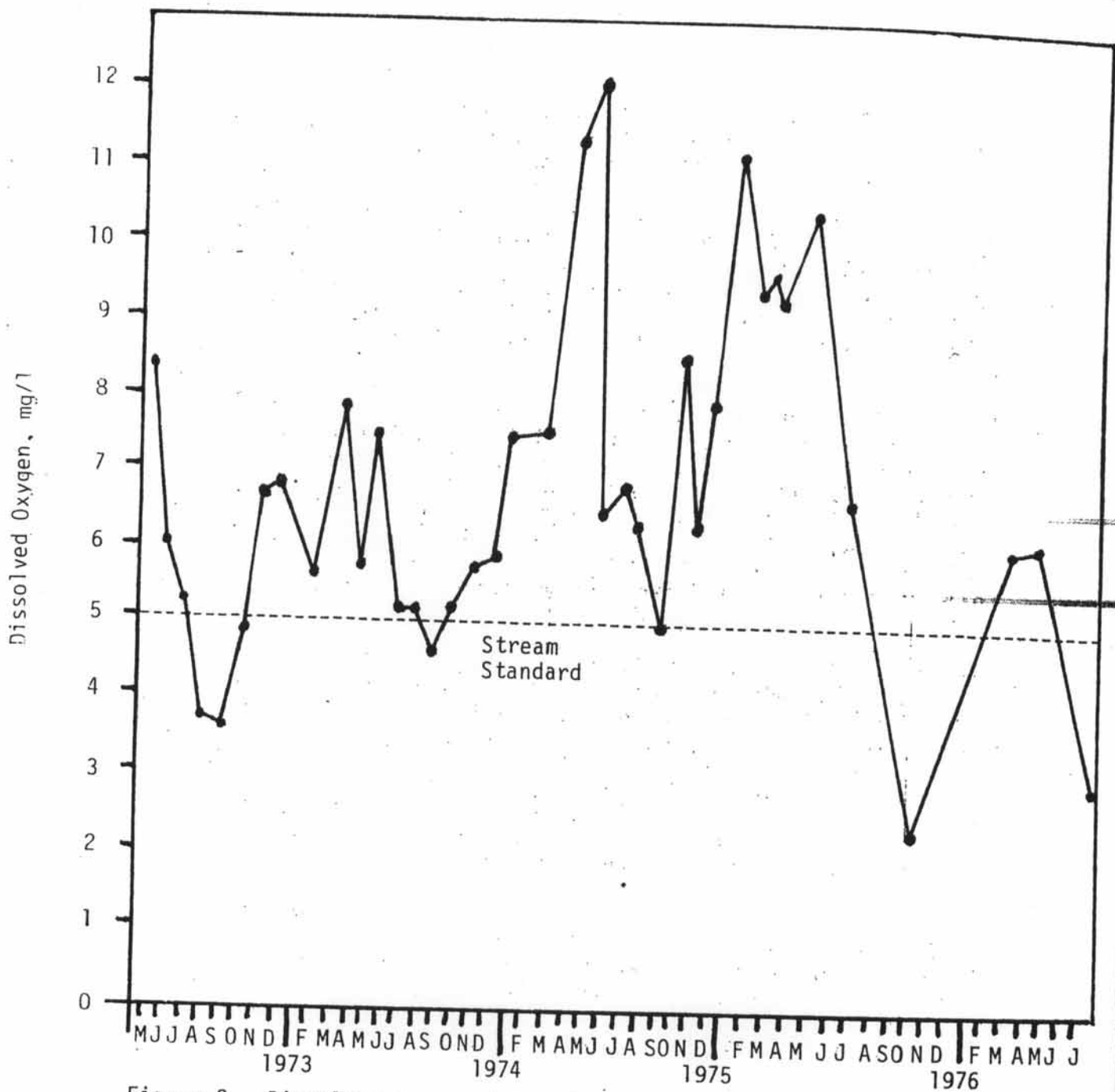


Figure 2. Dissolved oxygen data collected at Station 7 on Big Cypress Creek May, 1972 through August, 1976.

WATER ANALYSES

Laboratory analyses of diurnally composited water samples collected at the Big Cypress Creek stations and from all wastewater dischargers are shown in Table 5. Grab water samples were collected for analyses from Station 1 on Tankersley Creek, and Station 5 on Hart Creek.

Chloride and sulfate levels were generally low at all the Big Cypress Creek, Tankersley Creek, and Hart Creek stations and were below the segment standard of 100 mg/l for both parameters (annual averages) (4). The American Petrofina (Station A) discharge was the only wastewater effluent which contained high levels of chloride and sulfate. This discharge was responsible for the increase in levels for these two parameters observed in Tankersley Creek at Station 2.

Ortho-phosphorus was low in concentration (0.03 mg/l) at Station 1 on Tankersley Creek upstream from the influence of American Petrofina's and City of Mount Pleasant's southwest sewage treatment plant discharges. The City of Mount Pleasant's southwest treatment plant effluent (Station B) contained high levels of ortho (3.5 mg/l) and total (5.7 mg/l) phosphorus. Levels for both phosphorus parameters remained high throughout Tankersley Creek and at Station 4 on Big Cypress Creek downstream from the treated sewage discharge. This provides evidence that phosphorus was not rapidly assimilated in the stream. Similar phosphorus increases in Hart Creek were caused by the treated sewage effluents discharged from the City of Mount Pleasant's northeast (Station D) and southeast (Station C) plants. The City of Pittsburg's Sparks Branch Plant treated sewage effluent (Station E) contained high levels of ortho (9.8 mg/l) and total (10.9 mg/l) phosphorus. This discharge contributed to the high levels for both parameters in Dry Creek (Station 8). The phosphorus levels observed at Stations 2, 3, 4, 6, 7, and 8 were considerably above the 0.1 mg/l level considered by Connell to cause excessive biogrowth and decay in Texas streams (12).

The same general areas that had high nutrient phosphorus loads attributable to discharges of treated sewage effluent also had high nitrogen levels. Since ammonia is a constituent of most treated municipal sewage effluents, its occurrence in the segment correlated well with areas that receive such effluents. Ammonia nitrogen was highest at Tankersley Creek Station 2 (20.3 mg/l); however, Station 3 on Tankersley Creek and Station 4 on Big Cypress Creek farther downstream also had high levels (10.9 and

Table 5
Laboratory Water Analyses

| Parameter mg/l | Station Number | | | | | | | | | | | | | | | |
|------------------------------|-------------------------------|----------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|--------------------|-------------------------------|-------------------------------|--------------------|------------------------------|----------------------------------|-------------------|--|--|--|
| | Tanker- sley Creek 1 | American Petrofina A | Mount Pleasant STP B | Tanker- sley Creek 2 | Tanker- sley Creek 3 | Big Cypress Creek 4 | Hart Creek 5 | Mount Pleasant STP C | Mount Pleasant STP D | Hart Creek 6 | Big Cypress Creek 7 | City of Pittsburg STP E | Dry Creek 8 | | | |
| Chloride | 49 | 248 | 80 | 92 | 83 | 59 | 30 | 78 | 55 | 34 | 70 | 68 | 45 | | | |
| Sulfate | 45 | 183 | 56 | 61 | 64 | 50 | 12 | 66 | 50 | 34 | 50 | 83 | 70 | | | |
| Calcium | 0.03 | 0.6 | 3.5 | 0.74 | 0.39 | 0.51 | 0.07 | 7.7 | 1.3 | 1.2 | 1.1 | 9.8 | 6.1 | | | |
| Total Dissolved Solids | 0.06 | 1.2 | 5.7 | 1.4 | 1.0 | 1.2 | 0.13 | 9.0 | 3.2 | 1.4 | 1.4 | 10.9 | 7.4 | | | |
| Ammonia Nitrogen | 0.1 | 15.6 | 28.6 | 20.3 | 10.9 | 9.9 | <0.1 | 6.6 | 8.9 | 0.1 | 5.7 | 22.4 | * | | | |
| Nitrite Nitrogen | 0.02 | <0.02 | 0.08 | <0.02 | 0.03 | 0.02 | <0.02 | 0.23 | 0.06 | 0.03 | 0.19 | 0.09 | <0.02 | | | |
| Nitrate Nitrogen | 0.12 | 0.03 | <0.02 | 0.04 | 0.03 | 0.05 | 0.09 | 9.6 | 0.07 | 1.7 | 2.0 | 1.38 | 0.04 | | | |
| Nitrogen Nitrogen | 0.5 | 23.1 | 50.4 | 22.2 | 13.8 | 11.8 | 0.9 | 29.1 | 12.2 | 0.9 | 6.9 | 27.3 | * | | | |
| Total Or- ganic Carbon | 14 | 68 | 148 | 59 | 30 | 24 | 10 | 42 | 53 | 15 | 20 | 45 | 22 | | | |
| Phosphate | <0.5 | 13 | 60 | 25 | 5 | 7 | 5 | 13 | 15 | 2.1 | 6 | 40 | 7 | | | |
| Fluoride | 11 | 54 | 175 | 37 | 29 | 48 | <10 | 28 | 82 | 37 | 34 | 37 | <10 | | | |
| TSS | 2 | 1 | 12 | 8 | 15 | 26 | <10 | 4 | 26 | 24 | 21 | 6 | <10 | | | |
| VSS | 9 | 53 | 163 | 29 | 14 | 22 | <10 | 24 | 56 | 13 | 13 | 31 | <10 | | | |

* Laboratory Error

9.9 mg/l, respectively). The ammonia nitrogen concentrations from these three stations were considerably above the 2.5 mg/l level considered toxic to many freshwater fish species (13). The effluents from the City of Mount Pleasant's southwest plant and American Petrofina contained high levels of ammonia (28.6 and 15.6 mg/l, respectively) and contributed to the high levels for this parameter observed in Tankersley Creek and Big Cypress Creek.

The City of Mount Pleasant's northeast and southeast sewage treatment plants discharged effluents high in ammonia nitrogen (8.9 and 6.6 mg/l, respectively) to Hart Creek. The low level of ammonia (0.1 mg/l) observed at Hart Creek Station 6 indicates that the ammonia discharged in the two treated domestic effluents had nearly been assimilated at this point. The City of Pittsburg's Sparks Branch Plant treated sewage discharge to Dry Creek contained high levels of ammonia nitrogen (22.4 mg/l). The amount of ammonia nitrogen in Dry Creek could not be ascertained because of a laboratory error.

The presence of ammonia and nitrite in most of the wastewater discharges and the reduced levels for both parameters in the various receiving waters provides evidence that nitrification was occurring. The oxidation of ammonia to nitrite and on to nitrate may partially account for the low dissolved oxygen levels observed at Stations 2, 3, 4, 6, 7, and 8, since nitrification is an oxygen consuming process.

Levels for BOD₅ throughout the segment were generally high. The introduction of the effluents from American Petrofina and the City of Mount Pleasant's southwest sewage treatment plant which enter Tankersley Creek between Stations 1 and 2 increased the BOD₅ levels in the stream from less than 0.5 mg/l at Station 1 to 25 mg/l at Station 2. Of the two wastewater discharges made to Tankersley Creek, the City of Mount Pleasant's treated sewage effluent was the largest contributor of oxygen demanding materials. This treated effluent accounted for 96 percent of the total oxygen demand (ammonia nitrogen plus BOD₅) of the waste loads discharged to the creek. The BOD₅ levels in Tankersley Creek at Station 3 (5 mg/l) and Big Cypress Creek at Station 4 (7 mg/l), although substantially reduced from Station 2, remained relatively high. These BOD₅ levels may partially account for the chronically low dissolved oxygen levels between Stations 2 and 4. The BOD₅ level (6 mg/l) observed farther downstream on Big Cypress Creek at Station 7 indicates the stream had not yet recovered from the waste loads discharged upstream.

The effluents from the City of Mount Pleasant's northeast and southeast sewage treatment plants which enter Hart Creek contained relatively low levels of BOD₅ (15 mg/l and 13 mg/l, respectively). These discharges did not cause a noticeable elevation in BOD₅ at Hart Creek Station 6. The City of Pittsburg's Sparks Branch sewage treatment plant discharged an effluent to Dry Creek that contained a high level (40 mg/l) of BOD₅ and obviously influenced the level (7 mg/l) for this parameter observed in the receiving stream. The oxygen demand of this wastewater may partially account for the chronically low dissolved oxygen levels observed in Dry Creek. The impact of Dry Creek on Big Cypress Creek could not be determined because Big Cypress Creek was inaccessible immediately downstream from the Dry Creek confluence.

SEDIMENT ANALYSES

Chemical

With the exception of Station 2, the highest values for the various chemical sediment parameters occurred at stations located downstream from wastewater discharges (Table 6). Sediments from Station 8, which was located on Dry Creek downstream from the City of Pittsburg's Sparks Branch Sewage Treatment Plant treated sewage discharge, had the highest total phosphorus, Kjeldahl nitrogen, and oil and grease levels. The sediment from Station 4 on Big Cypress Creek had the greatest oxygen demanding potential and was more organic than other sediments sampled.

Table 6
Sediment Chemical Data

| Parameter | Station Number | | | | |
|-------------------------|----------------|--------|--------|--------|--------|
| | 1 | 2 | 4 | 7 | 8 |
| COD, mg/kg | 12,800 | 15,300 | 38,900 | 17,600 | 28,900 |
| Total Phosphorus, mg/kg | 130 | 96 | 600 | 350 | 1,320 |
| Kjel-N, mg/kg | 380 | 150 | 670 | 350 | 710 |
| Volatile Solids, % | 3.6 | 1.1 | 4.1 | 2.4 | 3.5 |
| Oil and Grease, mg/kg | 300 | 540 | 810 | 620 | 1,240 |

Heavy Metals

The metals content of sediment collected was influenced somewhat by the wastewater effluents which enter the segment (Table 7). Sediment from Station 8 on Dry Creek had the highest concentrations of lead, mercury, and zinc. This station was located downstream from the City of Pittsburg's Sparks Branch plant discharge. The sediment from Station 4 on Big Cypress Creek had the highest arsenic and chromium levels. This station was located downstream from the City of Mount Pleasant's southwest sewage treatment plant and American Petrofina's discharges. However, the sediment sampled from Station 2

on Tankersley Creek, which was located immediately downstream from American Petrofina's and the City of Mount Pleasant's southwest plant discharges was relatively low in metals content. Station 1 on Tankersley Creek had the highest concentrations of copper, manganese, and nickel. This station was located upstream from all known wastewater discharges.

Comparison of the maximum levels for each metal from sediments collected in Segment 0404 with fresh water sediment heavy metals data collected throughout the State indicates that most are excessive. The highest arsenic level was exceeded by 42% of the statewide samples; copper by less than 1%, chromium by 44%, lead by 30%, manganese by 19%, nickel by 32%, and zinc by 18% (14).

Table 7
Sediment Heavy Metals Data

| Parameter mg/kg | Station Number | | | | |
|--------------------|----------------|-------|-------|------|-------|
| | 1 | 2 | 4 | 7 | 8 |
| Arsenic | 1.8 | 0.7 | 3.2 | 1.2 | 1.6 |
| Cadmium | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Copper | 56 | 2.3 | 8.8 | 5.6 | 9.8 |
| Chromium | 16 | 10 | 19 | 8.5 | 9.8 |
| Lead | 10 | 6.0 | 15 | 5.2 | 20 |
| Mercury | 0.018 | 0.028 | 0.043 | 0.06 | 0.138 |
| Manganese | 580 | 26 | 350 | 260 | 100 |
| Nickel | 20 | 4.5 | 12 | 6.7 | 6.2 |
| Zinc | 46 | 11 | 53 | 23 | 75 |

Pesticides

The results of the sediment pesticide analyses, summarized in Table 8, show that most of the common pesticides were not detected in samples collected within Segment 0404. A low level of dieldrin (5 ug/l) was detected in sediment sampled from Station 8 on Dry Creek. Polychlorinated biphenyls (PCB's), although not classified as pesticides, exhibit toxic properties similar to DDT. PCB's were

found in all the sediment samples collected, with the greatest concentration observed at Station 1. Because of their widespread usage, the origins of PCB's are difficult to trace.

Station 1 on Tankersley Creek was located upstream from all known wastewater discharges. This station had the highest sediment concentrations of PCB's, and the previously mentioned heavy metals. The benthic macroinvertebrate community sampled from the sediment at this station had the highest diversity of any within the segment (Table 12). The sediment contaminants apparently do not pose a serious problem for the aquatic organisms found in this portion of the creek.

Table 8
Sediment Pesticides Data

| Parameter ug/kg | Station Number | | | | |
|-----------------------|----------------|-----|----|----|----|
| | 1 | 2 | 4 | 7 | 8 |
| Silvex | * | * | * | * | * |
| Aldrin | * | * | * | * | * |
| Chlordane | * | * | * | * | * |
| DDD | * | * | * | * | * |
| DDE | * | * | * | * | * |
| DDT | * | * | * | * | * |
| Diazinon | * | * | * | * | * |
| Diieldrin | * | * | * | * | 5 |
| Endrin | * | * | * | * | * |
| Heptachlor | * | * | * | * | * |
| Heptachlor Epoxide | * | * | * | * | * |
| Lindane | * | * | * | * | * |
| Methoxychlor | * | * | * | * | * |
| Methyl Parathion | * | * | * | * | * |
| Parathion | * | * | * | * | * |
| Toxaphene | * | * | * | * | * |
| PCB | 390 | 130 | 54 | 88 | 75 |

* denotes less than detection limits (see Appendix B)

BIOLOGICAL

Chlorophyll a

Chlorophyll a analyses were utilized to provide an estimate of the relative amount of algal standing crop that was present at the stations sampled (Table 9). Chlorophyll a was not detected in the sample from Station 1 on Tankersley Creek upstream from the discharges of American Petrofina and the City of Mount Pleasant's southwest treatment plant. American Petrofina utilizes several ponds in its wastewater treatment system. The effluent from this pond system had a very high level of chlorophyll a (0.67 mg/l) and was responsible for the high levels for this parameter in Tankersley Creek at Stations 2 and 3 and farther downstream at Station 4 on Big Cypress Creek. Chlorophyll a levels at these stations were above the 0.05 mg/l level considered indicative of nuisance aquatic plant growths (15). Chlorophyll a levels in Hart Creek, Dry Creek, and the lower portion of Big Cypress Creek were relatively low, and below the 0.02 mg/l level considered characteristic of eutrophic waters (16).

Table 9
Chlorophyll a Data

| | Chlorophyll a, mg/l |
|----------------------|------------------------|
| 1 Tankersley Creek | <0.004 |
| A American Petrofina | 0.670 |
| B Mount Pleasant STP | 0.004 |
| 2 Tankersley Creek | 0.070 |
| 3 Tankersley Creek | 0.030 |
| 4 | 0.053 |
| 5 Hart Creek | <0.004 |
| C Mount Pleasant STP | 0.006 |
| D Mount Pleasant STP | 0.012 |
| 6 Hart Creek | 0.008 |
| 7 | 0.017 |
| E Pittsburg STP | 0.007 |
| 8 Dry Creek | <0.004 |

Phytoplankton

Phytoplankton assemblages were generally not diverse at the stations sampled within the segment (Table 10). The phytoplankton community at Station 1 on Tankersley Creek consisted of low numbers of only three taxa. Composition of the communities completely changed farther downstream. Phytoplankton dominance at Station 2 on Tankersley Creek and Station 4 on Big Cypress Creek was established by the blue-green alga, Anacystis sp. This organism is known to favor waters rich in organic matter and is commonly found in oxidation pond systems (17). Standing crop biomass, as estimated by numerical counts, was elevated at Stations 2 and 4 and indicated the presence of algal bloom conditions. The disproportionately large numbers of Anacystis sp. depressed diversity index values at Stations 2 and 4, indicating severe organic pollution (18). American Petrofina's oxidation pond effluent, which enters Tankersley Creek between Stations 1 and 2, had a very high algal standing crop (Table 9). This discharge was the apparent source for the large numbers of algae noted at Stations 2 and 4. The decay and decomposition of this large biomass apparently occurs in the lower portion of Tankersley Creek and the upper portion of Big Cypress Creek and may contribute to the low dissolved oxygen levels observed in this reach.

The phytoplankton community sampled at Station 7 in the lower portion of Big Cypress Creek was the most diverse of any sampled ($\bar{d} = 2.72$). Composition of this community consisted of green algae and diatoms. The sample from Dry Creek (Station 8) contained large numbers of Euglena, a pigmented flagellate commonly found in waste treatment systems, and pollution-tolerant blue-green algae. The discharge of treated sewage from the City of Pittsburg's Sparks Branch plant apparently was responsible for the occurrence of these organisms at Station 8.

Zooplankton

The results of zooplankton identifications and enumerations from samples collected at the appropriate stations are shown in Table 11. The zooplankton communities sampled were characterized by small numbers of different taxa and total numbers of individuals. The sample from Station 8 on Dry Creek was devoid of zooplankton.

Table 11
Zooplankton Data

| Station Number | 1 | 2 | 4 | 7 | 8 |
|--------------------------------------|------|------|------|------|---|
| Standing Crop as Total Ind./liter | 9 | 65 | 10 | 154 | 0 |
| Diversity Index (\bar{d}) | 0.99 | 0.50 | 0.72 | 1.18 | 0 |
| Organisms as Ind./liter | | | | | |
| ROTIFERA | | | | | |
| <u>Platytias</u> | 1 | 3 | | | |
| <u>Brachionus</u> | | 60 | 8 | 103 | |
| <u>Polyarthra</u> | | | | 7 | |
| <u>Filinia</u> | | | | 42 | |
| COPEPODA | | | | | |
| Immature copepods | 7 | 1 | 2 | 2 | |
| CLADOCERA | | | | | |
| <u>Alona costata</u> | 1 | 1 | | | |

Benthic Macroinvertebrates

The benthic macroinvertebrate assemblages were not diverse at any of the stations sampled (Table 12). A total of only 10 different benthic macroinvertebrate taxa was identified from samples collected during this study. The benthos at most of the stations was dominated by pollution tolerant oligochaete worms (Lumbriculus sp.) and blood worms (Tendipes tentans). (19) The benthic macroinvertebrate communities from the headwater station on Tankersley Creek (Station 1) and Station 7 on Big Cypress Creek were composed of relatively low numbers of five different taxa, and, as shown by diversity index values (\bar{d}), were the most diverse.

Station 2 on Tankersley Creek was influenced by American Petrofina and City of Mount Pleasant's southwest sewage treatment plant discharges; Station 4 on Big Cypress Creek was also influenced by these two discharges; and Station 8 on Dry Creek was influenced by the City of Pittsburg's Sparks Branch sewage treatment plant discharge. The benthic macroinvertebrate communities sampled from these stations were characterized by disproportionately large standing crops of only one and/or two of the pollution-tolerant taxa. Diversity index values from these stations were below the 1.0 level considered indicative of severe organic pollution (18).

Table 12
Benthic Macroinvertebrate Data

| Station Number | 1 | 2 | 4 | 7 | 8 |
|--|-----|-----|-----|-----|-----|
| Number of Taxa | 5 | 3 | 2 | 5 | 2 |
| Number of Individuals/ft. ² | 17 | 418 | 142 | 66 | 768 |
| Diversity Index (\bar{d}) | 2.1 | 0.9 | 0.4 | 1.2 | 0.2 |
| Organisms | | | | | |
| OLIGOCHAETA (Aquatic earthworms) | | | | | |
| <u>Oligochaeta</u> | 6 | | | | |
| <u>Lumbriculus</u> | | 293 | 13 | 21 | 736 |
| EPHEMEROPTERA (Mayflies) | | | | | |
| <u>Hexagenia</u> | | | | 1 | |
| DIPTERA (flies) | | | | | |
| <u>Pentaneura</u> | 5 | | | | |
| <u>Metriocnemus</u> | 3 | | | | |
| Ceratopogonidae | 2 | | | | |
| Tendipedidae | 1 | | | | |
| <u>Tendipes tentans</u> | | 119 | 129 | 42 | 32 |
| <u>Chaoborus</u> | | 6 | | 1 | |
| AMPHIPODA (Scuds) | | | | | |
| <u>Gammarus</u> | | | | 1 | |

Bacteria

A summary of analyses for fecal coliform bacteria is shown in Table 13. The Texas Water Quality Board's permissible and desirable fecal coliform levels are based on not less than five samples collected over not more than 30 days (4). Since the data collected during this survey are based on grab samples, direct comparison of these data cannot be made with the Texas Water Quality Standards.

Samples from Stations 2 and 8 contained the highest densities of fecal coliform bacteria. These two stations were located close to wastewater outfalls. The fecal coliform density (31,900/100 ml) from Station 2 on Tankersley Creek and (7,700/100 ml) from Station 8 on Dry Creek were the only ones in excess of the segment standard of 2000/100 ml.

Table 13
Fecal Coliform

| Station Number | Fecal Coliform #/100 ml |
|---------------------|----------------------------|
| 1 Tankersley Creek | 320 |
| 2 Tankersley Creek | 31,900 |
| 3 Tankersley Creek | 300 |
| 4 Big Cypress Creek | 1,120 |
| 5 Hart Creek | 300 |
| 6 Hart Creek | 800 |
| 7 Big Cypress Creek | 0 |
| 8 Dry Creek | 7,700 |

RELATED TEXAS WATER QUALITY BOARD ACTIVITIES

Several activities presently underway by the Texas Water Quality Board have direct influence on the protection of the water quality of Big Cypress Creek.

WASTE LOAD EVALUATIONS

A waste load evaluation was developed for Segment 0404 by the Modeling and Engineering Analysis Section of Texas Water Quality Board in May, 1974 to show the relationships among municipal loadings, stream assimilative capacity, and the effect on stream standards. This evaluation applies only to oxygen consuming substances being discharged and does not consider the effect of eutrophication caused by the introduction of nutrient compounds. The waste load evaluation recommended the City of Mount Pleasant's three plants and American Petrofina should be required to provide treatment processes with the effluent limits and monthly average BOD₅ of 20 mg/l and 30 mg/l, respectively.

This evaluation was based on estimated hydrological conditions. A reassessment of the waste load evaluation will be made based on data collected during this intensive monitoring survey.

TWQB WASTE PERMITS AND REGISTRATIONS; NPDES PERMITS

All wastewater dischargers and confined feeding operations are required to have a Permit from the Texas Water Quality Board, as well as an NPDES Permit (National Pollutant Discharge Elimination System) from the Environmental Protection Agency. These documents place restrictions on the quantity and quality of wastewater that can be released to the receiving stream.

STREAM MONITORING

Personnel from the Texas Water Quality Board District 5 Office will continue to monitor water quality of Segment 0404 of Big Cypress Creek at Station 7 on a quarterly basis. This is Texas Water Quality Board stream monitoring station 0404.01

REFERENCES CITED

1. Texas Water Quality Board. 1974. Waste load evaluation for water quality segment no. 0404, Big Cypress Creek. Texas Water Quality Board Central Files, Austin, Texas.
2. Texas Water Quality Board. 1976. Self-reporting data. Texas Water Quality Board Central Files, Austin, Texas.
3. Texas Water Quality Board. 1976. Municipal and industrial return flow data. Texas Water Quality Board Central Files, Austin, Texas.
4. Texas Water Quality Board. 1976. Texas water quality standards. Texas Water Quality Board Central Files, Austin, Texas.
5. Hughes, L. S. and D. K. Leifeste. 1964. Reconnaissance of the chemical quality of surface waters of the Sabine River basin, Texas and Louisiana. Texas Water Commission, Bulletin 6405. 64 p.
6. Texas Water Quality Board. 1975. Segment report no 0505 of the Sabine River - WQS-12. Texas Water Quality Board Central Files, Austin, Texas.
7. Alford, J. 1976. Special investigation of Tankersley Creek. Texas Water Quality Board Central Office Files, Austin, Texas.
8. Texas Water Quality Board. 1976. Stream monitoring data. Texas Water Quality Board Central Files, Austin, Texas.
9. Texas Water Quality Board. 1975. Intensive surface water monitoring survey for segment 0505 of the Sabine River. IMS Report No. 31. Texas Water Quality Board Central Files, Austin, Texas.
10. Texas Water Quality Board. 1975. Intensive surface water monitoring survey for segment 0303 of the Sulphur River. IMS Report No. 18. Texas Water Quality Board Central Files, Austin, Texas.
11. Texas Water Quality Board. 1975. Intensive surface water monitoring survey for segment 0302 of the Sulphur River (Lake Wright Patman). Texas Water Quality Board Central Files, Austin, Texas.

REFERENCES (CONT.)

12. Connell, C. H. 1972. Phosphates in Texas rivers. Environmental Health Laboratory, University of Texas Medical Branch, Galveston, Texas.
13. Reid, G. K. 1961. Ecology of inland waters and estuaries. Reinhold Book Company, New York. 375 p.
14. Warshaw, S. 1976. Metals concentrations in water and sediment of Texas. Texas Water Quality Board Special Report No. 4. Texas Water Quality Board, Austin, Texas.
15. Texas Water Quality Board. 1974. Nutrient levels for Texas reservoirs. Interoffice memorandum. Texas Water Quality Board Central Files, Austin, Texas.
16. Weber, C.I. 1975. Biological monitoring in Model State Water Monitoring Program. U. S. Environmental Protection Agency. EPA Report No. 440/9-74-002.
17. Palmer, C.M. 1962. Algae in water supplies. U, S. Department of Health Service Publication No. 657.
18. Wilhm, J. L. and T. C. Dorris, 1968. Biological parameters for water quality criteria. Bioscience, 18(6):477-481.
19. Kemp, L. W., W. M. Ingram, and K. M. MacKenthum. 1966. The role of bottom-dwelling macrofauna in water pollution investigations. U. S. Public Health Service Publication No. 99-WP-38.

FIELD AND LABORATORY PROCEDURES

The following methods are utilized for field and laboratory determinations of specified physical and chemical parameters. Unless otherwise indicated composite water samples are collected at each sampling station and stored in polyethylene containers on ice until delivery to the laboratory. Sediment samples are collected with a dredge or coring device, decanted, mixed, placed in appropriate containers (glass for pesticides analyses and plastic for metals analyses), and stored on ice until delivery to the laboratory. Laboratory chemical analyses are conducted by the Water Chemistry Laboratory of the Texas Department of Health Resources unless otherwise noted.

WATER ANALYSES

Field Measurements

| <u>Parameter</u> | <u>Method</u> |
|------------------|---|
| Temperature | Hand mercury thermometer or temperature probe of Hydrolab Model 60 Surveyor. |
| Dissolved Oxygen | Azide modification of Winkler titration method or oxygen probe attachment of Hydrolab Model 60 Surveyor. |
| pH | Hydrolab Model 60 Surveyor or Sargent-Welch portable pH meter. |
| Conductivity | Hydrolab Model 60 Surveyor or Hydrolab TC-2 conductivity meter. |
| Alkalinity | Titration as described in "Standard Methods for the Examination of Water and Wastewater" 13th Ed., using phenolphthalein and methyl red/bromocresol green indicators. |

Laboratory Analyses

| <u>Parameter</u> | <u>Method</u> |
|----------------------|--|
| BOD ₅ | Membrane electrode method(1). |
| TSS | Gooch crucibles and glass fiber discs(1). |
| VSS | Gooch crucibles and glass fiber discs(1). |
| Kjel-N | Micro-Kjeldahl digestion and automated colorimetric phenate method(2). |
| NH ₃ -N | Distillation and automated colorimetric phenate method(2). |
| NO ₂ -N | Colorimetric method(1). |
| NO ₃ -N | Automated cadmium reduction method(2). |
| T-PO ₄ | Persulfate digestion followed by ascorbic acid method(1). |
| O-PO ₄ | Ascorbic acid method(1). |
| Sulfates | Turbidimetric method(1). |
| Chlorides | Automated thiocyanate method(2). |
| TDS | Evaporation at 180°C(2). |
| TOC | Beckman TOC analyzer. |
| Conductivity | Wheatstone bridge utilizing 0.01 cell constant(1). |
| BOD ₁₋₇ * | Membrane electrode method(1). |
| Chlorophyll <u>a</u> | Trichromatic method(1). |
| Pheophytin <u>a</u> | Pheophytin correction method(1). |

* For significant wastewater discharges only.

SEDIMENT ANALYSES

Field Measurements

Immediate Dissolved
Oxygen Demand (IDOD)

$$\text{mg/l IDOD} = \frac{D_0 P - D_1}{P}$$

where D_0 = D.O. of original
dilution water

$$P = \frac{\text{dilution water used (ml)}}{\text{volume of BOD bottle (ml)}}$$

$$P = \frac{\text{amount of sample used (ml)}}{\text{volume of BOD bottle (ml)}}$$

D_1 = D.O. of diluted sample
15 min. after prepara-
tion using membrane
electrode method

Laboratory Analyses

Parameter

Method

Arsenic

Colorimetric

Mercury

Potassium permanganate
digestion followed by atomic
absorption(3).

All other metals

Atomic absorption(3).

Volatile Solids

Ignition in a muffle furnace.

COD

Dichromate reflux method.

Kjel-N

Micro-Kjeldahl digestion and
automated colorimetric method(2).

T- PO_4

Ammonium molybdate(3).

Pesticides

Gas chromatographic method(4).

BACTERIOLOGICAL

Bacteriological samples are collected in sterilized glass bottles provided by the Texas Department of Health Resources and stored on ice until delivery to the laboratory or until cultures are set up by survey personnel (within 6 hours of collection). Bacteriological analyses are conducted by survey personnel or a suitable laboratory in the survey area.

| <u>Parameter</u> | <u>Method</u> |
|--------------------|---------------------------|
| Total Coliform | Membrane filter method(1) |
| Fecal Coliform | Membrane filter method(1) |
| Fecal Streptococci | Membrane filter method(1) |

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are collected with a Surber sampler (1.0 ft.²) in riffle areas and with an Ekman dredge (0.25 ft.²) in pool areas. Samples are preserved in 10% formalin in the field and stained with Rose Bengal. They are later sorted according to taxa and counted in the laboratory.

Analysis of diversity is accomplished with a computer program adopted from Wilhm(5) for use on the Univac 1106 computer operated by the Texas Water Development Board. The program computes the diversity index, d , for each sample using the following equation:

$$\bar{d} = - \sum_{l=1}^s (n_i/n) \log_2 (n_i/n)$$

where n = total number of organisms, n_i = number of individuals per taxon, s = number of taxa and \bar{d} = diversity.

The number of individuals per square foot is determined by dividing the total number of individuals by the area sampled.

PLANKTON

Phytoplankton

Phytoplankton samples in streams (which are usually vertically mixed) are collected beneath the water surface

in quart polyethylene containers. Sampling stations are generally located both upstream and downstream from pollution sources and care is taken to preclude confounding interferences such as contributions of plankton from reservoirs, from backwater areas, scouring of periphyton from the streambed, etc.

Phytoplankton samples from reservoirs are collected with a tube device in which sample collection is integrated from the surface to depth of the euphotic zone (3 times Secchi disc measurement). In cases where the euphotic zone depth is greater than the tube length, samples are collected with an appropriate water sampler at depths evenly spaced from the surface to the bottom of the euphotic zone. These samples are composited and stored in quart containers.

Phytoplankton samples collected during both stream and reservoir surveys are preserved in the field in a final concentration of 3 to 5 percent buffered formalin. The samples are returned to the laboratory and stored in the dark until microscopic examination is completed. Prior to examination, the samples are concentrated utilizing sedimentation chambers. Identification and enumeration of phytoplankton is conducted with an inverted microscope utilizing standard techniques. The diversity index (\bar{d}) is calculated as described previously.

Zooplankton

Zooplankton are concentrated at the site by either filtering a known volume of water through a No. 20 mesh standard Wisconsin plankton net or vertically towing the net a known distance. Concentrated samples are preserved in a final concentration of 5% formalin. The organisms are identified to the lowest taxonomic level possible and counts are made utilizing a Sedgwick-Rafter cell. Diversity is calculated as described previously.

NEKTON

Nekton samples are collected by the following methods(1):

- Common-sense minnow seine - 20' x 6' with 1/4" mesh
- Otter trawl - 12' with 1 3/16" outer mesh and 1/2" mesh liner
- Chemical fishing - rotenone

- Experimental gill nets - 125' x 8' (five 25' sections ranging in mesh size of 3/4" to 2 1/2")
- Electrofishing - backpack and boat units (both equipped with AC or DC selection). Boat unit is equipped with variable voltage pulsator.

These organisms are collected to determine: (1) species present, (2) relative and absolute abundance of each species, (3) size distribution, (4) condition, (5) success of reproduction, (6) incidence of disease and/or parasitism, (7) palatability, and/or (8) presence or accumulations of toxins.

Nekton collected for palatability are iced or frozen immediately. Samples collected for heavy metals analyses are placed in leak-proof plastic bags and placed on ice. Samples collected for pesticides analyses are wrapped in aluminum foil, placed in a water proof plastic bag and placed on ice.

As special instances dictate, specimens necessary for positive identification, parasite examination, etc., are preserved in 10% formalin containing 3 grams borax and 50 ml glycerin per liter. Specimens over 7.5 cm in length are slit at least one-third of the length of the body to enhance preservation of the internal organs. Other specimens are weighed and measured before being returned to the reservoir or stream.

ALGAL ASSAYS

The algal assay procedure was adapted from the "Algal Assay Procedure Bottle Test". (6) The water samples used for the algal assay are composite samples collected from the euphotic zone. They are stored in polyethylene containers on ice for transport to the laboratory.

Upon delivery the samples are autoclaved (15 psi, 250°F, 10 min./l). After autoclaving and cooling, they are allowed to equilibrate by bubbling air to restore the carbon dioxide lost during autoclaving.

The water is then distributed in 60 ml aliquots in 125 ml Erlenmeyer flasks. Appropriate amounts of sodium nitrate and potassium phosphate dibasic solutions are added separately or in combination to the test flasks to arrive at final concentrations of 0.005, 0.015, 0.050 mg P/l for

the phosphorus spikes, 0.075, 0.225, 0.750 mg N/l for the nitrogen spikes and 0.005 mg P/l + 0.075 mg N/l, 0.015 mg P/l + 0.225 mg N/l, 0.050 mg P/l + 0.750 mg N/l for the combined spikes. No nutrients are added to the control flasks.

Finally, all the flasks are seeded with a 7 day old culture of Selenastrum capricornutum to give a final concentration of 5×10^3 cells/ml. The stock culture of Selenastrum capricornutum obtained from the National Eutrophication Research Program, Corvallis, Oregon is maintained in the laboratory.

The cultures are incubated for 14 days in a reach-in incubator (Hotpack Corporation). The temperature is maintained at $24 \pm 2^\circ\text{C}$, and continuous, 400 ft.-c illumination is provided by 40 watt cool-white fluorescent lights.

After 14 days, the biomass dry weight is obtained by filtering the algal suspension through a prewashed tared Reeve Angel glass filter (AH-934). The filters are dried for 16 to 21 hours at 110°C then cooled in a dessicator and weighed.

PRODUCTIVITY/RESPIRATION

Two methods are utilized to estimate productivity and respiration in the study area. In areas where restricted flow produces natural or artificial ponding of sufficient depth, standard light bottle-dark bottle techniques are used. In flowing water the diurnal curve analysis described by Odum(7) is utilized.

Light Bottle-Dark Bottle Analyses

The light and dark bottle technique is used to measure net production and respiration in the euphotic zone of a lentic environment. The depth of the euphotic zone is considered to be three times the Secchi disc transparency ($3 \times Z_{sp}$). This region is subdivided into three sections. Duplicate light bottles (300 ml BOD bottles) and dark bottles (300 ml BOD bottles covered with electrical tape, wrapped in aluminum foil and enclosed in a plastic bag) are filled with water collected from the mid-point of each of the three vertical sections, placed on a horizontal metal rack and suspended from a flotation

platform to the mid-point of each vertical section. The platform is oriented in a north-south direction to minimize shading of the bottles. An additional BOD bottle is filled at each depth for determining initial dissolved oxygen concentrations (modified Winkler method). The bottles are allowed to incubate for a varying time interval, depending on the expected productivity of the waters. A minimum of four hours incubation is considered necessary.

The following equations are used to calculate respiration and photosynthesis:

- (1) For plankton community respiration (R), expressed as mg/l O₂/hour

$$R = \frac{D0_I - D0_{DB}}{\text{Hours incubated}}$$

where D0_I = initial dissolved oxygen concentration.

and D0_{DB} = average dissolved oxygen concentration of the duplicate dark bottles.

- (2) For plankton net photosynthesis (P_N), expressed as mg/l O₂/hour

$$P_N = \frac{D0_{LB} - D0_I}{\text{Hours incubated}}$$

where D0_{LB} = average dissolved oxygen concentration of the duplicate light bottles.

- (3) For plankton gross photosynthesis (P_G), expressed as mg/l O₂/hour

$$P_G = P_N + R$$

Conversions of respiration and photosynthesis may be accomplished by multiplying the depth of each of the three vertical zones (expressed in meters) by the measured dissolved oxygen levels expressed in grams/m³. These products are added and the result is expressed as grams O₂/m²/day by multiplying by the photoperiod. Conversions from oxygen to carbon may be accomplished by multiplying grams O₂ by 12/32.

Diurnal Curve Analyses

In situations where the stream is flowing, relatively shallow, and/or contains extensive rooted macrophytes, the diurnal curve analysis adopted from Odum(7) is utilized to determine productivity and respiration. Values for productivity and respiration in grams of oxygen per square meter per day are calculated with the aid of a Univac 1106 computer operated by the Texas Water Development Board. The program includes options which provide several methods for determination of diffusion rate constants as indicated in the program listing which follows. These options are: (a) calculations from raw data as described by Odum(7), Odum and Hoskin(8), Odum and Wilson(9), and Blain and McDonnell(10), (b) substitution into various published formulas for determination of K_2 , and (c) arbitrary selection of a value from tables of measured diffusion rates for similar streams. (11)

HYDROLOGICAL

Parameter

Flow Measurement

(1) Pygmy current meter (Weather Measure Corp. Model F583) (2) gage height readings at USGS gaging stations.

Time of Travel

Tracing of Rhodamine WT dye using a Turner Model 110 fluorometer.

Stream Cross-sections

Measure average width and average depth at each main-stream station. At least 4 cross-section measurements are made in the vicinity of each mainstream station.

REFERENCES CITED

1. Standard methods for the examination of water and wastewater, 1971, APHA, AWWA, WPCF, 13 ed., 872 p.
2. Methods for chemical analysis of water and waste. Methods Development and Quality Assurance Research Laboratory, National Environmental Research Center, Cincinnati, Ohio 45268.
3. Chemistry laboratory manual, bottom sediments. Great Lakes Region Committee on Analytical Methods.
4. Manual of analytical methods. Pesticide Community Studies Laboratories, United States Environmental Protection Agency, Perrene, Florida.
5. Wilhm, Jerry L. 1970. Range of diversity index in benthic macroinvertebrate populations. J. Water Poll. Control Fed. 42:R221-224.
6. Environmental Protection Agency. 1971. Algal assay procedure - bottle test. Pacific Northwest Water Laboratory. Corvallis, Oregon. 82 p.
7. Odum, Howard T. 1956. Primary production in flowing waters. Limnol. and Oceanogr. 1:102-117.
8. Odum, Howard T. and Charles M. Hoskin. 1958. Comparative studies on the metabolism of marine waters. Publ. Inst. of Marine Sci. The University of Texas. 5:17-46.
9. Odum, Howard T. and Ronald R. Wilson. 1962. Further studies on reaeration and metabolism of Texas bays, 1958-1960. Publ. Inst. of Marine Sci. The University of Texas 8:23-55.
10. Blain, Wilbur A. and Archie J. McDonnell. 1966. Reaeration measurements in a eutrophic stream. Proc. 22nd Indiana Waste Conf. Purdue University. 1044-1057.
11. O'Connor, Donald J. 1958. The measurement and calculation of stream reaeration ratio. Robert A. Taft Sanitary Engineering Tech. Rept. W58-2. 35-46.

Detection Levels of Heavy Metal and Pesticide Analyses
(Sediment Analyses)

| Parameter | Code | Detection Level |
|---------------------------|-------|-----------------|
| Arsenic, mg/kg | 01003 | <1.0 |
| Cadmium, mg/kg | 01028 | <0.5 |
| Chromium, mg/kg | 01029 | <1.0 |
| Copper, mg/kg | 01043 | <1.0 |
| Lead, mg/kg | 01052 | <1.0 |
| Manganese, mg/kg | 01053 | <1.0 |
| Mercury, mg/kg | 71921 | <0.01 |
| Nickel, mg/kg | 01068 | <1.0 |
| Silver, mg/kg | 01078 | <0.5 |
| Zinc, mg/kg | 01093 | <1.0 |
| Silver, µg/kg | 39761 | <20.0 |
| Aldrin, µg/kg | 39333 | <1.0 |
| Chlordane, µg/kg | 39351 | <20.0 |
| DDD, µg/kg | 39363 | <3.0 |
| DDE, µg/kg | 39368 | <2.0 |
| DDT, µg/kg | 39373 | <5.0 |
| Diazinon, µg/kg | 39571 | <5.0 |
| Dieldrin, µg/kg | 39383 | <3.0 |
| Endrin, µg/kg | 39393 | <3.0 |
| Heptachlor, µg/kg | 39413 | <1.0 |
| Heptachlor Epoxide, µg/kg | 39423 | <1.0 |
| Lindane, µg/kg | 39783 | <1.0 |
| Methoxychlor, µg/kg | 39481 | <20.0 |
| Methyl Parathion, µg/kg | 39601 | <5.0 |
| Parathion, µg/kg | 39541 | <5.0 |
| Toxaphene, µg/kg | 39403 | <50.0 |
| PCB, µg/kg | 39519 | <20.0 |