IS 88-01

Intensive Survey of Buffalo Bayou and South Mayde Creek Upstream of Buffalo Bayou – Segment 1014

April 7-10, 1987

Texas Water Commission

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INTENSIVE SURVEY OF BUFFALO BAYOU AND SOUTH MAYDE CREEK UPSTREAM OF BUFFALO BAYOU - SEGMENT 1014

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Hydrology, Field Measurements,
Water Chemistry

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ABSTRACT

An intensive survey of Buffalo Bayou and South Mayde Creek upstream of Buffalo Bayou Segment 1014 was conducted April 7-10, 1987, by the Texas Water Commission (TWC). The 264 square mile watershed of Buffalo Bayou headwaters is experiencing intense suburban development as the Houston metropolitan area expands to the west. Field, chemical and hydrological data were collected from 15 stream stations located on Buffalo Bayou, Mason Creek, South Mayde Creek, Turkey Creek, Bear Creek, Langham Creek, Dinner Creek, Horsepen Creek, and from 11 major wastewater discharges. There are presently 108 existing and planned facilities in the study area that are permitted to discharge 118 MGD (182.5 ft^3/s) of treated wastewater. TWC self-reporting data, however, show that there are only 29 existing facilities that currently discharge 8.68 MGD (13.4 ft^3/s) of treated wastewater in the study area.

No major water quality problems were encountered during this survey. Field data indicated no critically low dissolved oxygen levels, although most stations exhibited wide diurnal fluctuations. Water chemistry indicated that organic constituents and nutrients (nitrogen and phosphorus) were elevated at most stations, due to the impact of treated wastewater discharges. Chemical data of the wastewater discharges showed high quality treatment levels were being attained. In order to more accurately address the potential for water quality problems, these data will be utilized by the TWC, through mathematical modeling processes, to evaluate effluent limitations for specific discharges in the Buffalo Bayou watershed and to refine a waste load evaluation for the bayou.

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INTRODUCTION

DIRECTIVE

This intensive survey was accomplished in accordance with the Texas Water Code, Section 26.127, as amended in 1985. The report is an integral part of the State Water Quality Management Program and is utilized for the purposes listed below.

PURPOSE

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

1. determine quantitative cause and effect relationships of water quality;

2. obtain data for updating water quality management plans, setting effluent limits, and where appropriate, verifying the classifications of segments;

3. set priorities for establishing or improving pollution controls; and

4. determine any additional water quality management actions required.

METHODS

Field and laboratory procedures used during this survey are described in Appendix A. The survey was conducted April 7 through 10, 1987, by TWC personnel from the Water Quality Monitoring Unit (Jeff Kirkpatrick, Don Ottmers, David Petrick and Dave Buzan), Water Quality Evaluation Unit (Phil Trowbridge and Ed Peacock) and Southeast Region-Houston Office (Randy Flowers and Kirk Smith). Laboratory analyses of water samples were conducted by the Texas Department of Health, Chemistry Laboratory, in Austin. Parametric coverages, sampling frequencies, and spatial relationships of sampling stations are consistent with the objectives of the survey and with known or suspected forms and variability of pollutants entering the streams and tributaries.

SITE DESCRIPTION

Buffalo Bayou upstream of Segment 1014 and South Mayde Creek are located in the western portion of Harris County and the northern portion of Fort Bend County, west of Houston, in southeast Texas (Figure 1). Total drainage area of Buffalo Bayou upstream of South Mayde Creek is 141.1 square miles. Buffalo Bayou originates at the confluence of Willow Fork and Cane Island Branch in northern Fort Bend County, about one mile south of Katy, and flows eastward 17.0 mi to SH 6 (the upstream boundary of Segment 1014). South Mayde Creek joins Buffalo Bayou 1.4 mi downstream of SH 6. Barker Dam, a flood control project operated by the U. S. Army Corps of Engineers, is located 330 yards upstream of SH 6.

Total drainage area of the South Mayde Creek watershed is 123.1 square miles. South Mayde Creek originates at FM 529 in western Harris County and flows southeast for 18.3 miles to Buffalo Bayou. The major tributary is Bear Creek (15.1 miles in length with a 74.9 square mile watershed). The principle tributary to Bear Creek is Langham Creek (10.0 miles in length with a 45.2 square mile watershed). The major tributary to Langham Creek is Horsepen Creek (5.0 miles in length with a 16.7 square mile watershed). Addicks Dam, another flood control project operated by the U. S. Army Corps of Engineers, is located across South Mayde Creek 700 yards upstream of IH 10.

Mean annual total rainfall in the area is about 48 inches, which is usually relatively evenly distributed throughout the year (TDWR, 1984a). The two flood control projects are necessary to prevent downstream flooding of the Houston metropolitan area. Barker Dam and Addicks Dam detain and impound floodwaters. Under normal operating conditions, no impoundment of the streams occurs during low flow conditions.

Barker Reservoir encompasses the 9.4 mile portion of Buffalo Bayou upstream of Barker Dam. Addicks Reservoir encompasses 6.4 miles of South Mayde Creek, 5.8 miles of Bear Creek, 4.8 miles of Langham Creek and 0.4 miles of Horsepen Creek upstream of Addicks Dam. The areas contained in Barker and Addicks Reservoirs are owned by the U. S. Government. With the exception of project-associated construction and maintenance, and certain areas leased for parks and grazing rights, the land remains in a relatively undisturbed state. The area of Buffalo Bayou upstream of Barker Reservoir and the South Mayde Creek watershed upstream of Addicks Dam was historically used for agricultural activities (rice production and cattle grazing). However, due to the expansion of the Houston metropolitan area, much of the land has been recently converted to suburban use.

WATER QUALITY STANDARDS

Specific water quality standards specifying desired water uses and numerical criteria to protect these uses have not been developed for Buffalo Bayou upstream of Segment 1014 or for the South Mayde Creek watershed, since these streams are not classified segments. For streams, or portions of streams, that are not designated by the Texas Water Commission (TWC) as classified segments, the general criteria of the Texas Surface Water Quality

Standards are applicable (TDWR, 1984b). The goals of the Commission are to maintain a minimum of 3 mg/L dissolved oxygen (D.O) and a 2,000/100 mL fecal coliform density (30-day geometric mean) to protect minimum aquatic life and recreational uses for these streams.

WATER QUALITY MONITORING STATIONS

One active stream monitoring network (SMN) station is located in the study area. Buffalo Bayou at Barker Dam (Station 1000.2915) is sampled quarterly for field data, chemical parameters, bacteriological densities and metals in water. Data from 1983 to 1987 show adequate dissolved oxygen concentrations, but frequently elevated concentrations of BOD_5, inorganic nitrogen and total phosphorus. Fecal coliform densities are occasionally elevated.

PREVIOUS INTENSIVE SURVEYS

There have been no previous intensive surveys conducted on upper Buffalo Bayou or South Mayde Creek. However, two intensive surveys have been conducted on Segment 1014 of Buffalo Bayou. One survey was conducted during September and October 1980 (TDWR, 1982), and the other during July 1985 and May 1986 (TWC, 1987). Additionally, a use attainability analysis was conducted in September 1986 for Segments 1014 and 1013 of Buffalo Bayou (TWC, 1986).

WASTEWATER DISCHARGES

Due to the westward expansion of the Houston metropolitan area during the past several years, there are numerous TWC permitted facilities in the upper Buffalo Bayou and South Mayde Creek watersheds. Most of these facilities are small domestic wastewater treatment plants since the suburban expansion occurred in the outlying areas where no services had previously existed. Table 2 shows the numbers of existing and projected permitted facilities (excluding no discharge permits and internal outfalls) and the flow and loadings of each category. There are presently 108 facilities (101 domestic and 7 industrial) in the study area that are permitted to discharge 118.3 MGD (117.7 MGD from domestic sources and 0.6 MGD from industrial sources) with a combined BOD_5 loading of 9889.2 lb/d (9814.3 lb/d from domestic sources and 74.8 lb/d from industrial sources), a combined ammonia nitrogen (NH_3-N) loading of 9988.3 lb/d (9982.0 lb/d from domestic sources and 6.3 lb/d from industrial sources) and a combined ultimate oxygen demand (UOD) of 66,609.9 lb/d (66,410.5 lb/d from domestic sources and 199.4 lb/d from industrial sources).

The total number of TWC permitted facilities in the study area is 119, most of which are located on Buffalo Bayou (21), Mason Creek (10), South Mayde Creek (20), Bear Creek (12), Langham Creek (14) and Horsepen Creek (19) (Table 3). Only 29 of these facilities are presently discharging, however. Most of the present wastewater discharges are to Buffalo Bayou (3), Mason Creek (4), South Mayde Creek (4), Langham Creek (6) and Horsepen Creek (5). TWC self-reporting data from these 29 facilities show an average annual combined flow of 8.68 MGD and relatively good quality of effluent, as indicated by generally low concentrations of BOD_5 and TSS (Table 4).

RESULTS

Data collection during this survey consisted of diurnal field measurements, diurnally composited water samples for chemical analyses, flow measurements at selected stream stations and all wastewater discharges sampled, stream cross-section measurements and stream velocity measurements. Fifteen stream stations and eleven major wastewater discharges were sampled. Table 1 provides descriptions of the sampling stations and Figure 1 shows their locations on an area map.

FIELD MEASUREMENTS

Field data consisted of diurnal measurements of temperature, conductivity, dissolved oxygen and pH at each mainstream station and wastewater discharge (Table 5). Additionally, residual chlorine was measured at each wastewater discharge.

Water temperature and conductivity data did not indicate any thermal load or brine sources of any magnitude being discharged in the study area. All dissolved oxygen (D.O.) measurements appreciably exceeded the 3.0 mg/L goal for unclassified segments. Diurnal D.O. ranges, however, were appreciable at Station 5 on Bear Creek, Station 8 on Langham Creek, Station 10 on Dinner Creek, Station 11 on Horsepen Creek, Stations 12, 13 and 14 on Buffalo Bayou and Station 15 on Mason Creek. These stations exhibited supersaturated D.O. levels in excess of 130%, and most of them were accompanied by elevated pH measurements during the time of high D.O. content. The elevated pH and D.O. content at these stations were caused by algal and/or macrophyte production. Horsepen Creek at Station 11 exhibited the widest diurnal D.O. fluctuation (4.9 to 16.4 mg/L). Field measurements of the wastewater discharges did not indicate any problem areas.

Chlorine residuals of all wastewater discharges were adequate for proper disinfection. Spencer Road PUD (Station I), however, discharged an excessive amount of chlorine, averaging 14.7 mg/L and ranging from 11.3 to 19.2 mg/L.

WATER CHEMISTRY

Water chemistry of South Mayde Creek at Station 1 (headwaters) indicated excellent water quality. All other stream stations exhibited elevated concentrations of organic constituents and/or nutrients, which are indicative of the influence of treated sewage. Langham Creek at FM 529 (Station 7), which is near the headwaters, exhibited the poorest water quality of all stream stations. Highest concentrations of $CBOD_5$ (8.5 mg/L), filtered $CBOD_5$ (7.5 mg/L), $CBOD_{20}$ (24.0 mg/L), filtered $CBOD_{20}$ (22.0 mg/L), filtered total organic carbon (TOC)(17 mg/L), orthophosphorus (O-P) (8.91 mg/L), total phosphorus (T-P) (9.89 mg/L), total dissolved solids (TDS) (656 mg/L) and conductivity (1,112 μmhos/cm) were observed at this station. Concentrations of organic nitrogen (3.15 mg/L) and nitrate-nitrogen (NO_3-N) (15.49 mg/L) were also high at Station 7. The upstream area of Horsepen Creek, at SH 6 (Station 11), also exhibited poor water quality as exemplified by the highest concentrations of total Kjeldahl nitrogen (TKN)

(3.6 mg/L), ammonia nitrogen (NH_3-N) (2.16 mg/L) and chlorophyll a (58 μg/L). Concentrations of $CBOD_5$ (7.5 mg/L), filtered $CBOD_5$ (5.5 mg/L), $CBOD_{20}$ (20.0 mg/L), filtered $CBOD_{20}$ (13.0 mg/L), filtered TOC (11 mg/L), nitrite nitrogen (NO_2-N) (0.23 mg/L) and NO_3-N (1.17 mg/L) were also high. Buffalo Bayou near the headwaters, at Katy-Flewellen Road (Station 12), also exhibited poor water quality, as indicated by the highest concentration of NO_2-N (0.61 mg/L), and elevated levels of $CBOD_5$ (4.0 mg/L), filtered $CBOD_5$ (3.0 mg/L), $CBOD_{20}$ (8.5 mg/L), filtered $CBOD_{20}$ (6.5 mg/L), TKN (2.00 mg/L), NH_3-N (1.93 mg/L), NO_3-N (1.05 mg/L), O-P (4.62 mg/L) and T-P (4.82 mg/L).

Chemical analyses of the wastewater discharges, all of which were domestic wastewater treatment plants (WWTP's), indicated generally well-treated effluent being discharged in the study area. Organic constituents and oxygen-consuming NH_3-N concentrations were generally low. The City of Katy WWTP (Station J) discharged the highest levels of $CBOD_5$ (4.0 mg/L), filtered $CBOD_5$ (3.5 mg/L), filtered $CBOD_{20}$ (6.5 mg/L) and NO_2-N (0.20 mg/L). Highest concentrations of $CBOD_{20}$ (9.0 mg/L), filtered $CBOD_{20}$ (6.5 mg/L) and NH_3-N (7.65 mg/L) were discharged by Harris County MUD #149 (Station E). The effluent of Spencer Road PUD (Station I) contained 9.24 mg/L NH_3-N but was being used for irrigation during the study period. Westlake MUD #1 (Station B) discharged the highest total suspended solids (TSS) level (59 mg/L).

FLOW MEASUREMENTS

Stream discharge measurements (Table 7) show that the major source of base flow in the study area is treated wastewater discharges. Stream flow of Buffalo Bayou at Barker Dam was 9.86 ft^3/s on April 8 and receded to 8.01 ft^3/s on April 10. Combined wastewater inflow into Buffalo Bayou upstream of Barker Dam from only those three major facilities sampled during this survey was 5.14 ft^3/s. Stream discharge of South Mayde Creek at Addicks Dam was 17.20 ft^3/s on April 7 and 9.53 ft^3/s on April 9. Combined wastewater inflow into South Mayde Creek upstream of Addicks Dam from only those eight major facilities sampled during this survey was 6.67 ft^3/s. The combined discharge of Buffalo Bayou and South Mayde Creek was 17.535 ft^3/s on April 9 and 10, 1987. Total measured wastewater inflow from the eleven major facilities sampled during this survey was 11.81 ft^3/s. Much of the difference can undoubtedly be attributed to smaller wastewater discharges not sampled during this study.

Jackrabbit Road PUD (Station C) discharged the greatest volume of wastewater (3.036 ft^3/s), followed by West Memorial MUD (Station K) (2.556 ft^3/s), Harris County MUD #208 (Station H) (1.712 ft^3/s), City of Katy (Station J) (1.328 ft^3/s) and Memorial MUD (Station L) (1.253 ft^3/s). The remaining discharges flowed less than 0.5 ft^3/s. No inflow originated from Spencer Road PUD (Station I) because the effluent was used for irrigation during the study period.

CROSS-SECTION MEASUREMENTS

Except for certain channelized reaches of the streams, cross-sectional area varied considerably (Table 8). Average width of Buffalo Bayou from Katy-Flewellen Road (Station 12) to Barker Dam (Station 14) was 26.4 ft, and individual observations ranged from 11.5 to 48.6 ft. South Mayde Creek from Clay Road to Memorial Drive averaged 23.8 ft in width, ranging from 3.3 ft to 62.3 ft.

TIME-OF-TRAVEL DATA

Stream velocity measurements were made in various reaches of Buffalo Bayou, Horsepen Creek, Langham Creek, Dinner Creek, Bear Creek and South Mayde Creek (Table 9). Velocities were slow due to the small slope of the streambeds. Highest velocity was observed in Buffalo Bayou from Clodine Road to Barker Dam (0.294 ft/s), while the lowest velocity (0.01 ft/s) was observed in South Mayde Creek below Clay Road. Most stream velocities ranged from 0.10 ft/s to 0.22 ft/s.

CONCLUSIONS

Since the majority of base flow in upper Buffalo Bayou and South Mayde Creek originates from wastewater discharges, the streams have a high potential for the development of water quality problems. Data from this survey show that the existing major facilities are discharging high quality effluent with low concentrations of oxygen demanding substances. However, the streams are quite productive, as indicated by wide diurnal dissolved oxygen fluctuations in most areas. Stream productivity (from algal and/or macrophyte metabolism) is enhanced by nutrients (mainly nitrogen and phosphorus) from the wastewater discharges and by the sluggish and shallow nature of the receiving streams.

No major water quality problems were encountered during this intensive survey. However, since additional development in the area is presently underway, and more is in the planning stages, future water quality problems could occur. In order to more accurately address the potential for water quality problems, these data will be utilized by the TWC, through mathematical modeling processes, to evaluate effluent limitations for specific discharges in the Buffalo Bayou watershed and to refine a waste load evaluation for the bayou.

PRESENTATION OF DATA

TABLE 1

Station Descriptions

Station	SMN Number	Buffalo Bayou Stream Km*	Description
1	1000.5373	90.3 (19.6)	South Mayde Creek at Clay Road
2	1000.5368	90.3 (4.8)	South Mayde Creek at SH 6
3	1000.5365	90.3 (0.8)	South Mayde Creek at Memorial Drive
4	1000.5366	90.3 (2.2)(0.6)	Turkey Creek at Addicks-Fairbanks Road
5	1000.5380	90.3 (3.6)(17.0)	Bear Creek at Fry Road
6	1000.5370	90.3 (3.6)(3.1)	Bear Creek at Patterson Road
7	1000.5330	90.3 (3.6)(1.8)(16.1)	Langham Creek at FM 529
8	1000.5320	90.3 (3.6)(1.8)(8.3)	Langham Creek 0.2 Km downstream of Addicks-Satsuma Road
9	1000.5310	90.3 (3.6)(1.8)(1.2)	Langham Creek at Patterson Road
10	1000.5335	90.3 (3.6)(1.8)(14.5)(0.3)	Dinner Creek at Barker-Cypress Road
11	1000.5340	90.3 (3.6)(1.8)(6.9)(6.5)	Horsepen Creek at SH 6
12	1000.2930	119.0	Buffalo Bayou at Katy-Flewellen Road
13	1000.2919	101.7	Buffalo Bayou 1.16 Km upstream of Mason Creek
14	1000.2915	92.9	Buffalo Bayou at Barker Dam
15	1000.2917	100.5 (8.2)	Mason Creek at Mason Road
B	1000.9113	90.3 (12.3)	Westlake MUD #1 (11284.001)
C	1000.9114	90.3 (3.6)(6.8)(0.9)	Jackrabbit PUD (11290.001)
D	1000.9115	90.3 (3.6)(1.8)(13.9)	Langham Creek UD (11682.001)
E	1000.9116	90.3 (3.6)(1.8)(11.9)(1.5)	Harris County MUD #149 (11836.001)
F	1000.9117	90.3 (3.6)(1.8)(10.1)	Harris County MUD #102 (11523.001)
G	1000.9118	90.3 (3.6)(1.8)(14.5)(3.6)	Harris County MUD #157 (11906.001)
H	1000.9119	90.3 (3.6)(1.8)(7.0)(6.2)	Harris County MUD #208 (11947.001)
I	1000.9120	90.3 (3.6)(1.8)(7.0)(4.2)	Spencer Road PUD (11472.001)
J	1000.9121	120.0 (0.9)	City of Katy (10706.001)
K	1000.9122	100.5 (5.2)(2.0)	West Memorial MUD (11152.001)
L	1000.9123	102.1 (2.3)	Memorial MUD (11893.001)

* Numbers in parentheses are distances of tributaries (primary) (secondary) (tertiary) (quaternary) from Buffalo Bayou

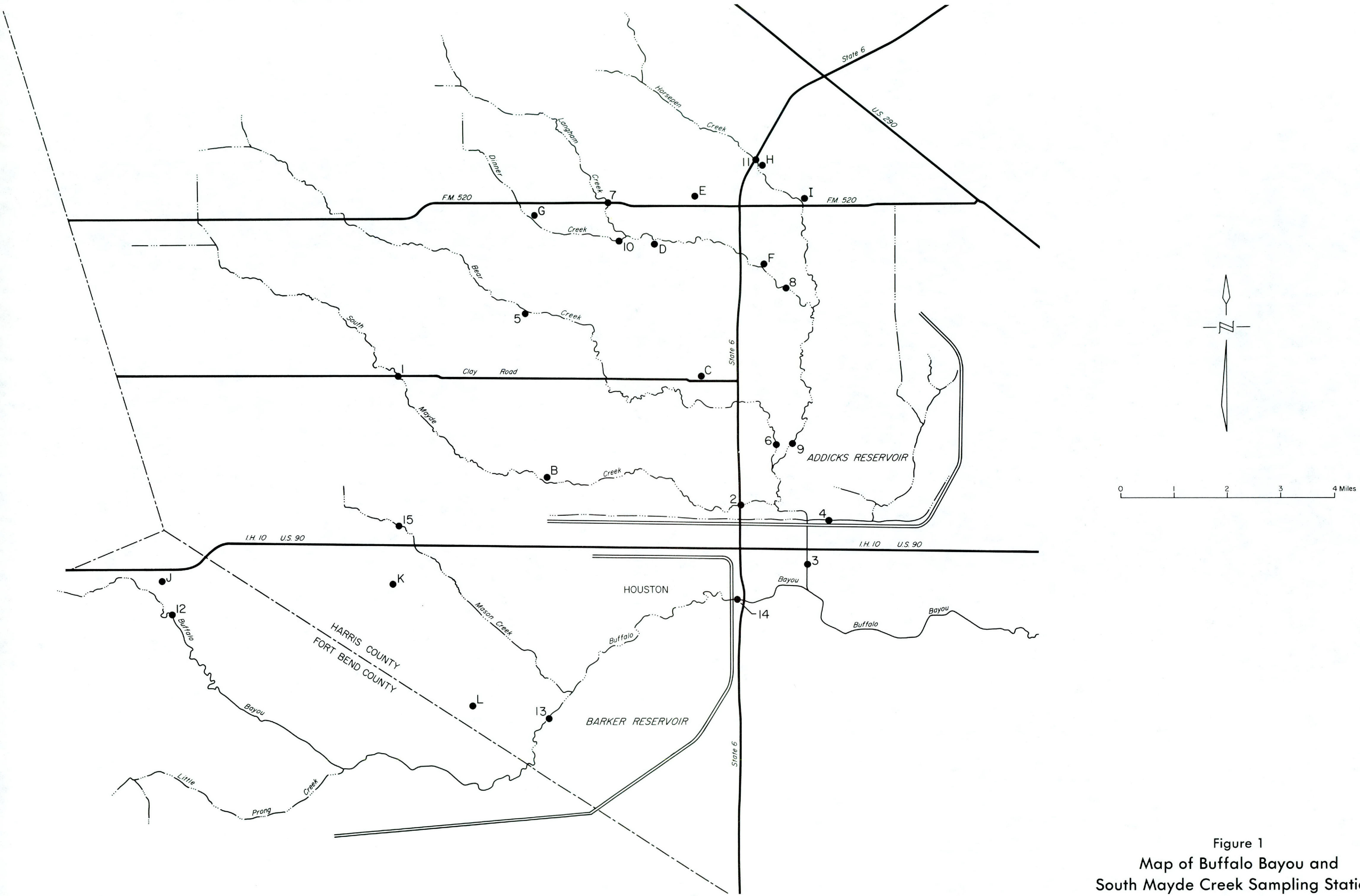

Figure 1
Map of Buffalo Bayou and
South Mayde Creek Sampling Stations

TABLE 2

Existing, Projected and Permitted Numbers and Loadings of Facilities Discharging to Upper Buffalo Bayou and South Mayde Creek

Type Facility	Status	Number	Flow MGD	BOD_5 lb/d	NH_3-N lb/d	UOD lb/d
Domestic	Existing (1986)	57	11.99	358.7	84.9	1192.7
	Projected (1990)	85	25.56	2130.7	3195.4	18736.7
	Permitted (Final)	101	117.70	9814.3	9982.0	65,795.0
	Pending Permits (New)	2	2.05	171.0	51.3	615.3
	Permitted (Ultimate)	103	119.75	9985.3	10033.3	66410.5
Industrial	Existing (1986)	6	1.01	21.1	0.1	48.8
	Projected (1990)	7	0.43	54.6	4.6	145.5
	Permitted (Final)	7	0.59	74.8	6.3	199.4
	Pending Permits (New)	0	0.00	0.0	0.0	0.0
	Permitted (Ultimate)	7	0.59	74.8	6.3	199.4
Domestic and Industrial	Existing (1986)	63	13.00	379.8	85.0	1241.5
	Projected (1990)	92	25.99	2185.3	3200.0	18882.1
	Permitted (Final)	108	118.30	9889.2	9988.3	65994.7
	Pending Permits (New)	2	2.05	171.0	51.3	615.3
	Permitted (Ultimate)	110	120.35	10060.2	10039.6	66,609.9

TABLE 3

Number of Permitted and Presently Discharging Facilities Located in the Upper Buffalo Bayou and South Mayde Creek Watersheds

Watershed	Stream/ Tributary	Number of Facilities: Permitted	Number of Facilities: Presently Discharging
Buffalo Bayou upstream of South Mayde Creek	Buffalo Bayou	21	3
	Willow Fork	4	2
	Cane Island Branch	1	1
	Little Prong Creek	2	0
	Mason Creek	10	4
	Wolf Creek	2	0
	Long Point Slough	9	1
	Total	49	11

Watershed	Stream/ Tributary	Number of Facilities: Permitted	Number of Facilities: Presently Discharging
South Mayde Creek	South Mayde Creek	20	4
	Bear Creek	12	2
	Langham Creek	14	6
	Horsepen Creek	19	5
	Turkey Creek	5	1
	Total	70	18

TABLE 4

Existing Wastewater Discharges Into Upper Buffalo Bayou and South Mayde Creek

Permit No.	Name	Flow MGD	BOD_5 mg/L	TSS mg/L	Receiving Stream
01402.001	Cameron Iron Works, Cypress	3.546	5.7	142.7	Horsepen Creek
02229.101	Igloo Corp., Katy Plant	0.002	18.1	22.0	Willow Fork
02229.201	Igloo Corp., Katy Plant	0.001	----	2.7	Willow Fork
10706.001	Katy, City of	0.552	2.0	5.0	Cane Island Branch
10932.001	Harris County, Bear Creek Park	0.004	8.0	22.0	Langham Creek
11152.001	West Memorial MUD	1.164	11.5	23.8	Mason Creek
11284.001	Westlake MUD #1	0.092	7.8	17.7	South Mayde Creek
11290.001	Jackrabbit Road PUD	1.433	3.0	6.7	Bear Creek
11414.001	Realty Investors IV, Inc.	0.008	12.0	13.0	Horsepen Creek
11455.001	Park 10 MUD	0.192	6.0	7.0	Buffalo Bayou
11472.001	Spencer Road PUD	0.340	4.0	7.0	Horsepen Creek
11486.001	Harris County MUD #070	0.031	9.4	6.8	Langham Creek
11523.001	Harris County MUD #102	0.102	2.9	16.7	Langham Creek
11598.001	Harris County MUD #061	0.285	3.8	5.5	Mason Creek
11619.001	Harris County MUD #107	0.256	30.4	47.6	Buffalo Creek
11632.001	Weston MUD	0.049	3.4	5.0	Mason Creek
11682.001	Langham Creek UD	0.175	7.0	22.0	Langham Creek
11696.001	Addicks UD	0.051	3.9	9.5	South Mayde Creek
11758.001	N L Industries, Inc.	0.022	5.0	10.0	Turkey Creek
11792.001	Harris County MUD #105	0.049	10.9	14.8	Bear Creek
11836.001	Harris County MUD #149	0.058	6.0	33.0	Langham Creek
11883.001	Castlewood MUD	0.022	1.9	3.2	Mason Creek
11893.001	Memorial MUD	0.097	1.9	2.1	Buffalo Bayou
11903.001	Toshiba International Corp.	0.014	10.0	15.0	Horsepen Creek
11935.001	Northwest Harris County MUD #16	0.020	10.0	22.0	Langham Creek
11947.001	Harris County MUD #208	0.070	6.0	15.0	Horsepen Creek
11969.001	Mayde Creek MUD	0.001	2.0	4.0	South Mayde Creek
11989.001	Fry Road MUD	0.048	3.7	6.6	South Mayde Creek
12005.001	Texas Industries Inc.	0.0003	4.0	4.0	Long Point Slough
Total	29	8.684			

TABLE 5

Field Measurements

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
1 1000.5373	04/07/87	1805	1.0	17.4	440	9.5	99.4	7.8
	04/08/87	0722	1.0	12.9	444	7.9	75.0	7.3
	04/08/87	1109	1.0	17.3	440	8.0	83.5	7.5
	04/08/87	1353	1.0	19.6	439	9.7	106.2	7.6
		DIEL MEAN		16.1	441	8.8	89.5	7.6
2 1000.5368	04/07/87	1700	1.0	16.1	593	8.3	84.5	8.1
	04/08/87	0740	1.0	13.7	532	7.9	76.3	7.7
	04/08/87	1039	1.0	14.2	524	7.6	74.3	8.0
	04/08/87	1412	1.0	15.8	508	8.5	86.0	8.2
		DIEL MEAN		14.9	550	8.1	80.3	8.0
3 1000.5365	04/07/87	1614	1.0	17.6	506	8.9	93.5	7.6
	04/08/87	0710	1.0	14.8	508	7.6	75.2	---
	04/08/87	1004	1.0	15.4	520	8.4	84.2	7.8
	04/08/87	1335	1.0	16.4	518	8.9	91.2	7.7
		DIEL MEAN		16.1	510	8.4	85.2	7.7
4 1000.5366	04/07/87	1746	1.0	21.1	406	9.2	103.8	7.7
	04/08/87	0824	1.0	11.6	533	5.6	51.6	7.9
	04/08/87	1127	1.0	15.4	529	7.8	78.2	7.7
	04/08/87	1446	1.0	19.5	545	10.2	111.4	7.8
		DIEL MEAN		16.6	487	7.8	82.2	7.8
5 1000.5380	04/07/87	1828	1.0	20.0	713	12.1	133.5	8.7
	04/08/87	0733	1.0	11.9	706	7.8	72.4	---
	04/08/87	1119	1.0	17.8	687	10.5	110.8	8.5
	04/08/87	1411	1.0	20.6	672	9.4	105.0	8.8
		DIEL MEAN		16.9	701	10.0	104.7	8.6

TABLE 5 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
6 1000.5370	04/07/87	1732	1.0	18.9	601	9.9	106.9	8.0
	04/08/87	0810	1.0	15.1	646	6.6	65.8	7.8
	04/08/87	1112	1.0	16.6	644	9.2	94.7	8.0
	04/08/87	1433	1.0	19.1	653	11.4	123.5	8.2
		DIEL MEAN		17.2	630	8.8	92.3	8.0
7 1000.5330	04/07/87	1856	1.0	20.9	1073	10.4	116.8	7.3
	04/08/87	0747	1.0	13.3	1037	7.8	74.7	7.6
	04/08/87	1133	1.0	18.4	1037	9.0	96.2	7.7
	04/08/87	1424	1.0	21.6	1040	8.8	100.2	7.8
		DIEL MEAN		18.0	1050	9.1	96.8	7.5
8 1000.5320	04/07/87	2032	1.0	22.0	551	13.3	152.7	8.5
	04/08/87	0658	1.0	15.6	608	7.9	79.6	7.9
	04/08/87	1002	1.0	16.2	621	8.3	84.7	7.9
	04/08/87	1347	1.0	21.2	599	12.1	136.7	8.3
		DIEL MEAN		19.2	587	10.8	119.0	8.2
9 1000.5310	04/07/87	1735	1.0	17.9	443	6.0	63.4	8.0
	04/08/87	0814	1.0	14.1	498	5.6	54.6	7.9
	04/08/87	1118	1.0	15.4	503	5.9	59.2	8.0
	04/08/87	1438	1.0	17.7	513	6.8	71.6	7.9
		DIEL MEAN		16.1	480	5.9	60.7	7.9
10 1000.5335	04/07/87	1918	1.0	21.1	571	13.6	153.4	9.2
	04/08/87	0801	1.0	12.7	613	7.2	68.0	8.3
	04/08/87	1145	1.0	15.4	588	10.8	108.3	8.5
	04/08/87	1435	1.0	19.9	577	9.6	105.7	8.9
		DIEL MEAN		17.3	589	10.4	110.5	8.7

TABLE 5 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
11 1000.5340	04/07/87	1655	1.0	23.4	361	16.4	193.3	9.0
	04/08/87	0732	1.0	13.3	390	4.9	46.9	8.1
	04/08/87	1138	1.0	17.0	394	10.5	109.0	8.2
	04/08/87	1429	1.0	21.6	385	14.1	160.6	8.6
		DIEL MEAN		18.3	380	10.8	120.4	8.5
12 1000.2930	04/07/87	1700	1.0	22.6	876	15.8	183.5	8.0
	04/08/87	0658	1.0	14.5	884	5.6	55.1	7.3
	04/08/87	1050	1.0	17.1	843	9.7	100.9	7.8
	04/08/87	1412	1.0	21.5	814	14.2	161.4	7.7
		DIEL MEAN		18.6	866	10.9	120.5	7.7
13 1000.2919	04/07/87	1932	1.0	19.4	863	12.4	135.2	8.4
	04/08/87	0845	1.0	15.9	839	8.3	84.1	7.7
	04/08/87	1223	1.0	19.2	832	10.1	109.7	8.2
	04/08/87	1525	1.0	20.1	838	11.6	128.3	8.2
		DIEL MEAN		18.2	847	10.5	112.7	8.1
14 1000.2915	04/07/87	1645	1.0	18.3	787	10.0	106.6	8.2
	04/08/87	0725	1.0	14.0	828	8.5	82.7	8.0
	04/08/87	1025	1.0	15.3	827	10.8	108.1	8.2
	04/08/87	1402	1.0	18.5	821	11.9	127.4	8.3
		DIEL MEAN		16.3	812	9.8	100.7	8.1
15 1000.2917	04/07/87	1720	1.0	24.1	662	15.3	182.8	9.0
	04/08/87	0745	1.0	10.5	782	9.7	87.1	7.5
	04/08/87	1127	1.0	18.0	734	14.0	148.3	8.0
	04/08/87	1428	1.0	23.8	648	16.3	193.6	8.5
		DIEL MEAN		18.1	716	13.1	143.2	8.2

TABLE 5 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
B 1000.9113	04/07/87	1723	1.0	21.0	---	10.6	119.3	8.1
	04/08/87	0702	1.0	14.9	793	8.8	87.3	7.8
	04/08/87	1034	1.0	17.5	764	11.2	117.4	8.3
	04/08/87	1331	1.0	21.5	788	12.7	144.4	8.4
		DIEL MEAN		18.4	787	10.3	111.2	8.1
C 1000.9114	04/07/87	1715	1.0	21.7	713	8.4	95.8	7.7
	04/08/87	0755	1.0	20.4	710	9.0	100.1	7.7
	04/08/87	1100	1.0	21.0	696	8.8	99.0	7.7
	04/08/87	1422	1.0	21.6	710	8.8	100.2	7.8
		DIEL MEAN		21.1	709	8.7	98.4	7.7
D 1000.9115	04/07/87	1900	1.0	20.7	714	8.6	96.2	7.8
	04/08/87	0823	1.0	19.7	705	8.7	95.4	7.7
	04/08/87	1236	1.0	20.2	701	8.7	96.4	7.2
	04/08/87	1535	1.0	20.9	700	8.6	96.6	7.8
		DIEL MEAN		20.3	707	8.7	96.0	7.7
E 1000.9116	04/07/87	1826	1.0	21.6	740	7.3	83.1	7.3
	04/08/87	0803	1.0	21.1	738	6.0	67.7	7.0
	04/08/87	1210	1.0	21.5	739	6.3	71.6	7.2
	04/08/87	1508	1.0	21.8	739	6.5	74.3	7.3
		DIEL MEAN		21.4	739	6.6	74.6	7.2
F 1000.9117	04/07/87	1937	1.0	22.3	697	6.9	79.7	7.2
	04/08/87	0714	1.0	19.2	687	7.3	79.3	7.6
	04/08/87	1027	1.0	21.7	713	7.3	83.3	7.1
	04/08/87	1401	1.0	22.1	665	7.4	85.1	7.3
		DIEL MEAN		21.2	690	7.2	81.1	7.3

TABLE 5 CONTINUED

Map Code and Station Number	Date	Time	Depth (ft)	Water Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	pH
G 1000.9118	04/07/87	1246	1.0	18.4	685	9.8	104.7	7.2
		DIEL MEAN		18.4	685	9.8	104.7	7.2
H 1000.9119	04/07/87	1723	1.0	22.6	739	8.2	95.2	7.5
	04/08/87	0741	1.0	21.4	738	8.3	94.2	7.2
	04/08/87	1148	1.0	22.2	771	8.3	95.6	7.4
	04/08/87	1442	1.0	22.7	767	8.2	95.4	7.4
		DIEL MEAN		22.1	747	8.3	94.9	7.4
I 1000.9120	04/07/87	1755	1.0	21.9	835	7.6	87.1	7.0
	04/08/87	0851	1.0	21.1	845	6.4	72.2	---
	04/08/87	1255	1.0	21.8	746	7.5	85.7	---
	04/08/87	1552	1.0	22.0	---	7.6	87.2	7.2
		DIEL MEAN		21.6	822	7.1	81.0	7.1
J 1000.9121	04/07/87	1638	1.0	21.2	665	6.6	74.6	6.8
	04/08/87	0725	1.0	19.3	689	5.2	56.6	6.9
	04/08/87	1108	1.0	20.4	674	6.3	70.1	7.1
	04/08/87	1354	1.0	21.4	672	6.8	77.1	7.3
		DIEL MEAN		20.4	676	6.0	67.3	6.9
K 1000.9122	04/07/87	1745	1.0	20.5	824	8.9	99.2	7.3
	04/08/87	0758	1.0	19.4	825	9.2	100.3	7.1
	04/08/87	1141	1.0	20.0	827	9.1	100.4	7.7
	04/08/87	1438	1.0	20.7	822	8.8	98.5	7.9
		DIEL MEAN		20.0	825	9.0	99.7	7.4
L 1000.9123	04/07/87	1845	1.0	20.0	826	9.8	108.1	7.5
	04/08/87	0825	1.0	19.2	837	8.7	94.5	7.3
	04/08/87	1205	1.0	20.2	826	8.5	94.2	7.6
	04/08/87	1511	1.0	20.7	822	8.9	99.6	7.4
		DIEL MEAN		19.8	829	9.1	100.0	7.4

TABLE 6

Water Chemistry

Map Code and Station Number	Date	Time	Depth ft	5day CBOD mg/L	Filt. 5day CBOD mg/L	20day CBOD mg/L	Filt. 20day CBOD mg/L	Filt. TOC mg/L	TKN mg/L	NH_3-N mg/L	NO_2-N mg/L	NO_3-N mg/L	Ortho P mg/L	Total P mg/L	Chl. a µg/L	Pheo. a µg/L	Cl^- mg/L	$SO_4^=$ mg/L	TSS mg/L	VSS mg/L	TDS mg/L	Total Alk. mg/L	Cond. µmhos/cm	pH
1 1000.5373	04/08/87	COMP	1.0	1.0	1.0	4.0	3.5	3	0.50	0.06	<0.01	0.10	0.02	0.05	2	6	40	7	18	2	264	155	456	8.1
2 1000.5368	04/08/87	COMP	1.0	4.0	2.5	11.0	3.0	9	1.20	0.10	0.14	6.22	4.38	4.64	8	7	59	30	36	6	334	122	580	7.8
3 1000.5365	04/08/87	COMP	1.0	3.5	1.5	14.0	6.0	7	1.10	0.18	0.16	3.63	2.11	4.17	7	10	59	24	63	10	322	130	560	7.7
4 1000.5366	04/08/87	COMP	1.0	2.0	1.0	6.0	5.0	9	1.10	0.03	0.01	0.04	0.56	0.77	4	13	50	7	81	13	316	187	556	7.8
5 1000.5380	04/08/87	COMP	1.0	3.5	2.5	7.0	4.5	7	1.30	0.07	0.27	15.52	3.95	4.00	8	8	86	36	41	6	410	102	735	8.7
6 1000.5370	04/08/87	COMP	1.0	2.0	1.5	5.0	4.5	5	1.10	0.12	0.03	0.89	5.50	5.73	4	2	75	31	17	2	380	173	695	8.1
7 1000.5330	04/08/87	COMP	1.0	8.5	7.5	24.0	22.0	17	3.30	0.15	0.11	15.49	8.91	9.89	3	<2	118	27	11	5	658	246	1112	8.1
8 1000.5320	04/08/87	COMP	1.0	4.0	4.0	8.5	8.5	6	1.50	0.53	0.28	7.53	5.61	5.90	4	3	69	27	34	5	382	140	652	7.9
9 1000.5310	04/08/87	COMP	1.0	4.5	4.0	6.5	6.5	9	1.10	0.56	0.31	3.81	4.38	4.68	8	2	56	22	53	7	310	121	528	7.9
10 1000.5335	04/08/87	COMP	1.0	3.0	1.5	6.5	5.5	5	1.10	0.04	0.31	11.61	2.97	3.38	16	4	76	28	48	6	362	88	620	8.9
11 1000.5340	04/08/87	COMP	1.0	7.5	5.5	20.0	13.0	11	3.60	2.16	0.23	1.17	0.22	0.42	58	12	34	32	42	11	248	110	426	7.9
12 1000.2930	04/08/87	COMP	1.0	4.0	3.0	8.5	6.5	7	2.00	1.93	0.61	1.05	4.62	4.82	19	5	115	107	15	4	568	163	1022	8.2
13 1000.2919	04/08/87	COMP	1.0	3.0	2.0	7.0	4.5	5	0.90	0.08	0.05	0.88	1.35	1.56	8	12	129	52	57	8	526	206	1001	8.7
14 1000.2915	04/08/87	COMP	1.0	3.5	2.0	7.0	5.5	6	1.10	0.05	0.06	2.42	2.23	2.44	6	4	114	45	59	8	482	191	917	8.5
15 1000.2917	04/08/87	COMP	1.0	4.0	2.0	9.0	4.5	4	1.40	0.03	0.12	16.40	1.72	5.31	23	5	96	31	66	9	462	122	814	9.0
B 1000.9113	04/08/87	COMP	1.0	2.5	2.5	7.0	5.5	7	1.40	0.11	0.13	12.53	5.81	6.13	---	---	90	36	59	7	490	----	798	8.5
C 1000.9114	04/08/87	COMP	1.0	1.5	1.0	4.5	3.5	4	1.00	<0.02	<0.01	0.92	6.49	6.80	---	---	86	35	17	6	430	----	781	8.0
D 1000.9115	04/08/87	COMP	1.0	1.5	1.0	4.0	3.0	4	1.10	<0.02	<0.01	16.46	9.08	9.45	---	---	81	37	<5	<5	468	126	787	7.7
E 1000.9116	04/08/87	COMP	1.0	3.0	1.5	9.0	6.5	6	8.70	7.65	0.03	6.04	7.04	7.46	---	---	86	36	<5	<5	432	184	816	7.5
F 1000.9117	04/08/87	COMP	1.0	1.5	1.0	3.5	3.5	5	1.50	0.28	0.01	15.99	8.47	8.99	---	---	76	37	10	2	452	135	781	7.4
G 1000.9118	04/07/87	1246	1.0	<0.5	<0.5	2.5	1.0	3	0.40	<0.02	<0.01	18.14	7.06	7.35	---	---	84	29	7	3	414	----	730	7.5
H 1000.9119	04/08/87	COMP	1.0	1.0	<1.0	7.0	3.5	9	5.10	3.85	0.10	12.45	7.29	8.02	---	---	99	26	7	4	474	150	828	7.7
I 1000.9120	04/08/87	COMP	1.0	2.5	1.5	8.5	5.0	6	9.70	9.24	0.04	2.12	4.86	5.04	---	---	107	30	9	7	486	237	938	7.5
J 1000.9121	04/08/87	COMP	1.0	4.0	3.5	8.5	6.5	4	3.70	3.43	0.20	1.10	7.79	8.04	---	---	80	41	7	4	434	196	785	7.8
K 1000.9122	04/08/87	COMP	1.0	2.0	2.0	7.0	6.0	5	1.00	0.03	<0.01	15.48	8.78	9.24	---	---	110	42	<5	<5	530	159	959	7.9
L 1000.9123	04/08/87	COMP	1.0	1.0	1.0	3.5	3.5	3	0.60	<0.02	<0.01	6.13	8.94	9.39	---	---	112	39	<5	<5	532	210	966	8.0

TABLE 7

Flow Measurements

Station	Location	Date	Time	Flow ft^3/s	Method*
12	Buffalo Bayou at Katy-Flewellen Road	04/07/87	1540	0.6118	FM
----	Buffalo Bayou at Green-Busch Road	04/10/87	1025	1.6086	FM
----	Buffalo Bayou at Fry Road	04/09/87	1920	10.1125	FC
----	Buffalo Bayou at Clodine Road	04/09/87	1440	7.7540	FM
----	North Barker Dam Borrow Ditch 50 feet upstream of Buffalo Bayou	04/08/87	1210	0.4903	FM
14	Buffalo Bayou at 100 yards downstream Barker Dam	04/08/87	1155	9.8604	FM
14	Buffalo Bayou at 100 yards downstream Barker Dam	04/10/87	0900	8.0070	FM
11	Horsepen Creek 150 feet downstream of SH 6	04/07/87	1510	0.1563	FM
----	Horsepen Creek at West Little York Road	04/08/87	1055	2.1431	FC
----	Dinner Creek 20 yards downstream of Station G discharge	04/08/87	1835	0.2553	FM
----	Dinner Creek 20 yards downstream of Station G discharge	04/09/87	1635	0.3278	FM
----	Dinner Creek upstream of Barker-Cypress Road	04/10/87	0850	0.4418	FC
10	Dinner Creek at Barker-Cypress Road	04/07/87	1910	0.1070	FM
----	Langham Creek at Barker-Cypress Road	04/07/87	1540	0.3246	FM
----	Langham Creek at Queenston Blvd.	04/09/87	1038	0.7041	FM
5	Bear Creek at Fry Road (Main Channel)	04/07/87	1825	0.1043	FM
5	Bear Creek at Fry Road (South Channel)	04/07/87	1437	0.0278	FM
5	Bear Creek 100 m downstream of Fry Road	04/08/87	1856	0.1217	FM
1	South Mayde Creek at Clay Road	04/07/87	1631	0.0597	FM
----	South Mayde Creek 550 yards downstream of Clay Road	04/08/87	1927	0.0537	FM

TABLE 7 CONTINUED

Flow Measurements

Station	Location	Date	Time	Flow ft^3/s	Method*
----	South Mayde Creek at Greenhouse Road	04/08/87	1745	1.2160	FM
----	South Mayde Creek at Dulaney Street	04/09/87	1215	1.7890	FM
2	South Mayde Creek at SH 6	04/08/87	0900	1.6369	FM
----	South Mayde Creek at Addicks Dam	04/07/87	1505	17.2047	FM
----	South Mayde Creek at Addicks Dam	04/09/87	1107	9.5280	FM
----	South Mayde Creek at IH 10	04/07/87	2007	15.7986	FM
B	Westlake MUD #1	04/08/87	Comp	0.3095	MM
C	Jackrabbit Road PUD	04/08/87	Comp	3.0358	C
D	Langham Creek UD	04/07-08/87	Comp	0.3490	MM
E	Harris County MUD #149	04/07-08/87	Comp	0.4976	MM
F	Harris County MUD #102	04/07-08/87	Comp	0.3528	MM
G	Harris County MUD #157	04/07-08/87	Comp	0.4178	FT
H	Harris County MUD #208	04/07-08/87	Comp	1.7122	MM
I	Spencer Road PUD	04/07-08/87	Comp	0.0	I
J	City of Katy	04/07-08/87	Comp	1.3278	FT
K	West Memorial MUD	04/07-08/87	Comp	2.5562	FT
L	Memorial MUD	04/07-08/87	Comp	1.2533	FT

* FM = Flow Meter
FC = Floating Chip Method
MM = Manual Measurement of Flow Measuring Device
C = Calculated from Pumpage Volumes
FT = Flow Totalizer
I = Effluent used for Irrigation

TABLE 8

Cross-Section Measurements

Stream	Reach	Date	Width Average,M	Width Range, M	Width #Obvs.	Depth Average, M	Depth Range, M	Depth #Obvs.
Buffalo Bayou	Katy-Flewellen Road (Station 12)	04/10/87	7.1	4.5 - 11.0	10	0.30	0.06 - 0.61	8
Buffalo Bayou	Green-Busch Road	04/10/87	6.0	3.5 - 9.4	14	0.23	0.06 - 0.46	11
Buffalo Bayou	Mason Road	04/09/87	4.8	3.8 - 5.7	4			
Buffalo Bayou	Greenhouse Road	04/09/87	5.3	4.8 - 5.7	2			
Buffalo Bayou	Station 13	04/09/87	14.4		1			
Buffalo Bayou	Barker-Clodine Road	04/09/87	8.9	7.6 - 11.2	8			
Buffalo Bayou	Powerline Crossing downstream of Barker-Clodine Road	04/10/87	7.7	6.8 - 8.8	4			
Buffalo Bayou	Upstream of Barker Dam	04/10/87	10.2	6.5 - 14.8	8			
Horsepen Creek	SH 6 (Station 11) to Trailside Dr.	04/07/87	3.9	1.5 - 8.6	12	0.26	0.09 - 0.40	12
Dinner Creek	Station G Outfall to Station 10	04/09/87	5.9	0.8 - 20.0	22	0.28	0.06 - 0.76	18
Dinner Creek	Station 10 to Langham Creek	04/09/87	1.7	1.0 - 2.9	6	0.18	0.06 - 0.30	2
Langham Creek	FM 529 to Barker-Cypress Road	04/09/87	3.6	0.6 - 12.0	24	0.28	0.06 - 0.85	20
Langham Creek	Barker-Cypress Road to Queenston Blvd.		4.5	0.8 - 7.1	24	0.22	0.03 - 0.30	17
Langham Creek	150 - 260 M downstream of Hwy. 6	04/08/87	15.0	2.5 - 35.0	5	0.30		1
Langham Creek	Clay Road		6.3		13	0.55	0.30 - 0.76	8
Bear Creek	Fry Road	04/09/87	2.2	0.5 - 3.6	19	0.27	0.06 - 0.76	16
South Mayde Creek	Clay Road	04/09/87	5.4	1.0 - 12.0	21	0.22	0.06 - 0.46	18
South Mayde Creek	Greenhouse Road to Dulaney Road	04/09/87	3.9	2.8 - 5.0	15	0.26	0.12 - 0.46	5
South Mayde Creek	Dulaney Road to 320 M downstream	04/09/87	9.6	4.0 - 14.0	13	0.88	0.03 - 1.37	12
South Mayde Creek	Addicks Dam to 1350 M upstream	04/08/87	5.8	5.0 - 7.1	20			
South Mayde Creek	Addicks Dam to 1200 M downstream	04/07/87	11.4	4.9 - 19.0	27			
South Mayde Creek	Memorial Drive to Buffalo Bayou	04/08/87	7.4	7.0 - 9.5	17			

TABLE 9

Time-of-Travel Data

Injection Point	Date/Time	Monitoring Point	Date/Time	Distance, M	Travel Time, hrs:min	Velocity, M/S
Buffalo Bayou Station 12	04-07/1525	Green-Busch Road	04-08/<0800	3900	<16:35	>0.0653
Buffalo Bayou at Clodine Road	04-09/1412	Barker Dam	04-10/0715	5500	17:03	0.0896
Horsepen Creek 50 m downstream from SH 6	04-07/1520	West Little York Road	04-08/1117	4500	19:57	0.0627
Langham Creek at Barker-Cypress Road	04-07/1545	West Little York Road	04-09/0530	4200	37:45	0.0309
Dinner Creek Station G	04-09/1634	60 M upstream of Wooden bridge downstream of Station G	04-10/0820	940	15:46	0.0166
Bear Creek at Fry Road	04-07/1440	1.0 km downstream	04-08/1855	1000	28:15	0.0098
South Mayde Creek at Clay Road	04-07/1635	900 M downstream	04-08/1928	900	26:53	0.0093
South Mayde Creek 900 M below Clay Road	04-08/1928	200 M downstream	04-09/1400	200	18:32	0.0030
South Mayde Creek at Greenhouse Road	04-08/1750	Dulaney Road	04-09/0100	600	7:10	0.0232
South Mayde Creek 50 M upstream of Addicks Dam	04-07/1515	IH 10	04-07/1850	700	3:35	0.0543
South Mayde Creek at SH 6	04-08/0850	Addicks Dam	04-08/2000	2750	11:10	0.0684

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APPENDIX A

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 unless otherwise noted.

WATER ANALYSES

Field Measurements

Parameter	Unit of Measure	Method
Temperature	°C	Hand mercury thermometer, Hydrolab Model 60 Surveyor, or Hydrolab 4041.
Dissolved Oxygen (DO)	mg/l	Azide modification of Winkler titration method, Hydrolab Model 60 Surveyor, or Hydrolab 4041.
pH	Standard Units	Hydrolab Model 60 Surveyor, Hydrolab 4041 or Sargent-Welch portable pH meter.
Conductivity	µmhos/cm	Hydrolab Model 60 Surveyor, Hydrolab 4041, or Hydrolab TC-2 conductivity meter
Phenolphthalein Alkalinity (P-Alk)	mg/l as $CaCO_3$	Titration with sulfuric acid using phenolphthalein indicator(1).
Total Alkalinity (T-Alk)	mg/l as $CaCO_3$	Titration with sulfuric acid acid using phenolphthalein and methyl red/bromcresol green indicators(1).
Chlorine Residual	mg/l	N,N-diethyl-p-phenylene-diamine (DPD) Ferrous Tetrimetric method(1).
Transparency	m or cm	Secchi disc

Laboratory Analyses

Parameter	Unit of Measure	Method
Five Day, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_5, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using 2-chloro-6-(trichloromethyl)-pyridine (TCMP) method(2).
Five Day, Filtered, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_5, Filt., N-Supp.)	mg/l	Samples filtered with glass fiber filter. Analysis conducted on filtrate. Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Twenty Day, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_{20}, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Twenty Day, Filtered, Nitrogen Suppressed, Biochemical Oxygen Demand (BOD_{20}, Filt., (N-Supp.)	mg/l	Samples filtered with glass fiber filter. Analyses conducted on filtrate. Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
One through Seven Day, Nitrogen-Suppressed, Biochemical Oxygen Demand (BOD_{1-7}, N-Supp.)	mg/l	Membrane electrode method(1). Nitrogen Suppression using TCMP method(2).
Total Suspended Solids (TSS)	mg/l	Gooch crucibles and glass fiber disc(1).
Volatile Suspended Solids (VSS)	mg/l	Gooch crucibles and glass fiber disc(1).
Kjeldahl Nitrogen (Kjel-N)	mg/l as N	Micro-Kjeldahl digestion and automated colorimetric phenate method(3).
Ammonia Nitrogen (NH_3-N)	mg/l as N	Distillation and automated colorimetric phenate method(3).
Nitrite Nitrogen (NO_2-N)	mg/l as N	Colorimetric method(1).
Nitrate Nitrogen (NO_3-N)	mg/l as N	Automated cadmium reduction method(3).

Laboratory Analyses - Continued

Parameter	Unit of Measure	Method
Total Phosphorus (T-P)	mg/l as P	Persulfate digestion followed by ascorbic acid method(1).
Orthophosphorus (O-P)	mg/l as P	Ascorbic acid method(1).
Sulfate (SO_4)	mg/l	Turbidimetric method(1).
Chloride (Cl)	mg/l	Automated thiocyanate method(3).
Total Dissolved Solids (TDS)	mg/l	Evaporation at 180°C(3).
Total Organic Carbon (TOC)	mg/l	Beckman TOC analyzer
Conductivity	µmhos/cm	Wheatstone bridge utilizing 0.01 cell constant(1).
Chlorophyll a	µg/l	Trichromatic method(1).
Pheophytin a	µg/l	Pheophytin correction method(1).

SEDIMENT ANALYSES

Field Measurements

Sediment Oxygen Demand

A benthic respirometer, constructed of clear plexiglass, is utilized on intensive surveys to measure benthal oxygen demand(14). A dissolved oxygen probe, paddle, solenoid valve and air diffuser are mounted inside the test chamber. The paddle issued to simulate stream velocity and produce circulation over the probe. The solenoid valve allows air to escape from the test chamber during aeration. The air diffuser is connected by plastic tubing to a 12-volt air compressor which is used to pump air into the test chamber if required.

The paddle, solenoid valve, and air compressor are actuated by switches on a control panel which is housed in an aluminum box. The control box also contains two 12-volt batteries, the air compressor, a stripchart recorder (for automatic recordings of dissolved oxygen meter readings), a battery charger, and a battery test meter.

Selection of a specific test site must be made in the field by the investigator with the depth, velocity, and benthic substrate taken into consideration. At the test site the dissolved oxygen meter, and strip-chart recorder are calibrated, the respirometer is dry tested by opening and closing switches and testing batteries; a stream velocity measurement is taken (for paddle calibration), and a water sample is collected just above the stream bottom near the sampling site. Portions of this water sample are poured into separate BOD bottles, one of which is opaque. The opaque bottle is placed on the respirometer and left for the remainder of the test. The initial dissolved oxygen value in the other bottle is measured when the test begins, while the dissolved oxygen in the opaque bottle is measured at the end of the benthic uptake test. The difference in the two dissolved oxygen values represents the oxygen demand of the water column.

The respirometer can be lowered from a boat or bridge, or can be placed by hand in shallow streams. Care is taken to insure that the sediment at the test location is not disturbed and that a good seal between the base of the instrument and bottom of the stream is made. After the respirometer has been placed in the stream, the dissolved oxygen is recorded. In shallow, clear streams the instrument is covered to prevent photosynthesis from occurring within the chamber. The test chamber is then closed and the paddle frequency adjusted. Recordings of dissolved oxygen are made until oxygen is depleted within the chamber or 6 hours has elapsed.

Paddle Frequency

$$f = 36\ v$$

where: f = Paddle frequency in revolutions per minute

v = Velocity to be simulated in m/s (measureed with current meter)

Benthic Oxygen Uptake

$$B^T DO_1\text{-}DO_2 = 196\ \frac{(DO_1\text{-}DO_2) - BOD_t}{\Delta t}$$

where: $B^T DO_1\text{-}DO_2$ = Oxygen uptake rate in $g/m^2/d$ corresponding to the sample temperature, T

DO_1 = Initial DO reading in mg/l

DO_2 = Final DO reading in mg/l

Δt = Time interval between DO_1 and DO_2

T = Temperature of sample in °C

BOD_t = Measured difference in DO between the two BOD bottles

Laboratory Analyses

Parameter	Unit of Measure	Method
Arsenic (As)	mg/kg	Silver diethylidithcocarbonate method(3).
Mercury (Hg)	mg/kg	Potassium permanganate digestion followed by atomic absorption(3,4).
All other metals	mg/kg	Atomic absorption(3,4).
Volatile Solids	mg/kg	Ignition in a muffle furnace(3).
Chemical Oxygen Demand (COD)	mg/kg	Dichromate reflux method(3).
Kjeldahl Nitrogen (Kjel-N)	mg/kg	Micro-Kjeldahl digestion and automated colorimetric method(3).
Total Phosphorus (T-P)	mg/kg as P	Ammonium molybdate(3).
Pesticides	µg/kg	Gas chromatographic method(4,5).
Oil and Grease	mg/kg	Soxhlet extraction method(3).

BACTERIOLOGICAL

Bacteriological samples are collected in sterilized bottles to which 0.5 ml of sodium thiosulfate is added to dechlorinate the sample. Following collection, the samples are stored on ice until delivery to a 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.

Parameter	Unit of Measure	Method
Total Coliform	Number/100 ml	Membrane filter method(1)
Fecal Coliform	Number/100 ml	Membrane filter method(1)
Fecal Streptococci	Number/100 ml	Membrane filter method(1)

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are collected with a Surber sampler (0.09 m^2) in riffles and an Ekman dredge (0.02 m^2) in pools. Samples are preserved in 5 percent formalin, stained with Rose Bengal, and sorted, identified, and enumerated in the laboratory.

Diversity ($\bar{d}$) is calculated according to Wilhm's(6) equation:

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

where n is the total number of individuals in the sample, n_i is the number of individuals per taxon, and s is the number of taxa in the sample.

Redundancy ($\bar{r}$) is calculated according to the equations derived by Young et al.(7)

(1) $\bar{d}\ max = \log_2 s$

(2) $\bar{d}\ min = - \frac{s-1}{n} \log_2 \frac{1}{n} - \frac{n-(s-1)}{n} \log_2 \frac{n-(s-1)}{n}$

(3) $\bar{r} = \frac{\bar{d}\ max - \bar{d}}{\bar{d}\ max - \bar{d}\ min}$

where s is the number of taxa in the sample and n is the total number of individuals in the sample.

Equitability is (e) is calculated according to Pielow's(8) equation:

$$e = \frac{\bar{d}}{\log_2 s}$$

where $\bar{d}$ is the calculated diversity value and s is the number of taxa in the sample.

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

PERIPHYTON

Periphyton are collected from streams and reservoirs from natural substrates or from artificial substrates placed in the water. Standard size, frosted microscope slides are commonly used as artificial substrates and are held in place a few centimeters beneath the water surface at the sampling sites in floating periphytometers. Following a 25 to 30 day incubation period the accrued materials are analyzed for chlorophyll a, pheophytin a, and for identification and enumeration of the attached organisms.

In the field, following retrieval of the periphytometer, two slides are placed in a brown glass container containing 100 ml of 90 percent aqueous acetone. The material from these two slides is used for pigment measurements. Two slides are placed in another brown glass container containing 100 ml of 5 percent buffered formalin. The material from these two slides is used for biomass measurements. The remaining slides are also placed in buffered formalin and utilized for identification and enumeration of organisms according to procedures discussed for the phytoplankton. The brown glass jars containing the material for laboratory analyses (pigment and biomass measurements) are placed in a deep freeze and kept frozen prior to analysis.

The autotrophic index is calculated according to the equation given by Weber and McFarland(9).

$$\text{Autotrophic Index} = \frac{\text{Biomass (g/m2)}}{\text{Chlorophyll } \underline{a} \text{ (g/m}^2\text{)}}$$

Periphyton samples may also be collected from natural substrates by scraping areas from each type of substrate available at each sampling location. Scrapings are made from a range of depths from subsurface to the stream bottom, from bank to bank, and at points spanning the range in stream velocity. The scrapings from each sampling location are composited into a container, preserved with Lugols solution and returned to the laboratory for identification and enumeration following procedures discussed in the phytoplankton section. Diversity, redundancy, and equitability statistics are calculated as described previously.

PLANKTON

Phytoplankton

Stream phytoplankton are collected immediately beneath the water surface with a Van Dorn sampler or by immersing a sampling container. Phytoplankton samples are collected with a Van Dorn water sampler at depths evenly spaced throughout the water column of reservoirs.

Samples are stored in quart cubitainers on ice and transferred to the laboratory where aliquots of each sample are analyzed live to aid in taxonomic identification. Samples (950 ml) are then preserved with 50 ml of 95 percent buffered formalin or 9.5 ml of Lugols solution and stored in the dark until examination is completed. The phytoplankton are concentrated in sedimentation chambers, and identification and enumeration are conducted with an inverted microscope utilizing standard techniques. If diatoms are abundant in the samples, slide preparations are made using Hyrax mounting medium(10). The diatoms are identified at high magnification under oil until a minimum of 250 cells are tallied. Diversity, redundancy, and equitability statistics are calculated as described previously.

Zooplankton

Zooplankton are concentrated at the site by either filtering a known volumne of water through a number 20 mesh standard Wisconsin plankton net or vertically towing the net a known distance or time. Concentrated samples are preserved with Lugols solution or in a final concentration of 5 percent buffered formalin. The organisms are identified to the lowest taxonomic level possible, and counts are made utilizing a Sedgwick-Rafter cell. Diversity, redundancy, and equitability statistics are calculated as described previously.

NEKTON

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

Common-sense minnow seine	- 6 m x 1.8 m with 0.6 cm mesh
Otter trawl	- 3 m with 3 cm outer mesh and 1.3 cm stretch mesh liner
Chemical fishing	- rotenone
Experimental gill nets	- 38.1 m x 2.4 m (five 7.6 m sections ranging in mesh size from 1.9 to 6.4 cm).
Electrofishing	- backpack and boat units (both equipped with AC or DC selection). Boat unit is equipped with variable voltage pulsator.

Nekton are collected to determine: (1) species present, (2) relative and absolute abundance of each species, (3) species diversity (4) size distribution, (5) condition, (6) success of reproduction, (7) incidence of disease and parasitism, (8) palatability, and (9) 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 alumnium foil, placed in a waterproof plastic bag, and placed on ice.

As special instances dictate, specimens necessary for positive identification or parasite examination are preserved in 10 percent formalin containing 3 borax and 50 ml glycerin per liter. Specimens over 15 cm in length are slit at least one-third of the length of the body to enhance preservation of the internal organs. As conditions dictate, other specimens are weighed and measured before being returned to the reservoir or stream.

ALGAL ASSAYS

The "*Selenastrum capricornutum* Printz Algal Assay Bottle Test" procedure(11) is utilized in assaying nutrient limitation in freshwater situations, whereas the "Marine Algal Assay Procedure Bottle Test"(12) is utilized in marine and estuarine situations. *Selenastrum capricornutum* is the freshwater assay organism and *Dunaliella tertiolecta* is the marine assay alga.

PHOTOSYNTHESIS AND RESPIRATION

In areas where restricted flow produces natural or artifical ponding of sufficient depth, standard light bottle-dark bottle techniques are used. In flowing water the diurnal curve analysis 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. 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 rank, 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 4 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 O_2/hour,

$$R = \frac{DO_I - DO_{DB}}{\text{Hours incubated}}$$

where DO_I = initial dissolved oxygen concentration

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

(2) For plankton net photosynthesis (P_N), expressed as mg/l O_2/hour,

$$P_N = \frac{DO_{LB} - DO_I}{\text{Hours incubated}}$$

where DO_{LB} = average dissolved oxygen concentration of duplicate light bottles

(3) For plankton gross photosynthesis (P_G), expressed as mg/l O_2/hour,

$$P_G = P_N + R$$

Conversion of respiration and phtotsynthesis volumetric values to an aerial basis 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 g/m^3. These products are added and the result is expressed in g O_2/m^2/d by multiplying by the photoperiod. Conversion from oxygen to carbon may be accomplished by multiplying grams O_2 by 0.32 [1 mole of O_2 (32 g) is released for each mole of carbon (12 g) fixed].

Diurnal Curve Analysis

In situations where the stream is flowing, relatively shallow, and may contain appreciable growths of macropytes or filamentous algae, the diurnal curve analysis is tuilized to determine productivity and respiration. The procedure is adopted from the United States Geological Survey(13). Both the dual station and single station analyses are utilized, depending upon the various controlling circumstances.

Dissolved oxygen and temperature data are collected utilizing the Hydrolab surface units, sondes, data scanners, and strip chart recorders. Diffusion rate constants are directly measured in those instances where atmospheric reaeration rate studies have been conducted. In situations where direct measurements are not made, either the diffusion dome method is utilized, or an appropriate alternative. These alternatives are: (1) calculations from raw data, (2) substitution into various published formulas for determination of K_2, and (3) arbitrary selection of a value from tables of measured diffusion rates for similar streams.

HYDROLOGICAL

Parameter	Unit of Measure	Method
Flow Measurement	m^3/s	Pygmy current meter (Weather Measure Corporation Model F583), Marsh-McBirney Model 201 electronic flow meter, Price current meter (Weather Measure Corporation Model F582), or gage height readings at USGS gaging stations.
Time-of-Travel	m/s	Tracing of Rhodamine WT dye using a Turner Model 110 or 111 fluorometer(15).
Stream Width	m	Measured with a range finder
Tidal Period	hours	Level recorder
Tidal Amplitude	m	Level recorder
Changes in Stream Surface Level	m	Level recorder

Stream Reaeration Measurements

The stream reaeration technique is utilized to measure the physical reaeration capacity of a desired stream segment(16). The method depends on the simultaneous release of three tracers in a single aqueous solution: a tracer for detecting dilution and dispersion (tritiated water molecules), a dissolved gaseous tracer for oxygen (krypton-85), and Rhodamine WT dye to indicate when to sample for the radiotracers in the field. The tracer release location is chosen to meet two requirements: (1) it must be upstream of the segment for which physical reaeration data are desired, and (2) it must be at least 0.6 m deep and where the most complete mixing takes place. Before the release, samples are collected at the release site and at designated sampling stations to determine background levels of radiation. The first samples are collected 15 to 60 m downstream from the release site in order to establish the initial ratio of drypton 85 to tritium. Sampling sites are located downstream to monitor the dye cloud every 4 to 6 hours over a total period of 35 to 40 hours. The Rhodamine WT dye is detected with Turner 111 flow-through fluorometers. Samples are collected in glass bottles (30 ml) equipped with polyseal caps which are sealed with black electrical tape. Samples are generally collected every 2 to 5 minutes during the passage of the dye cloud peak. The three samples collected nearest the peak are designated for analysis in the laboratory (three alternate samples collected near the peak are also designated). Extreme caution is exercised throughout the field and laboratory handling of samples to prevent entrainment of air.

Samples are transferred to the laboratory for analyses within 24 hours of the collection time. Triplicate counting vials are prepared from each primary sample. All counting vials are counted in a Tracor Analytic 6892 LSC Liquid Scintillation Counter which has been calibrated. For each vial, counting extends for a minimum of three 10-minute cycles. The data obtained are analyzed to determine the changes in the krypton-85 to tritium ratio as the tracers flow downstream.

The calculations utilized in determining the physical reaeration raes from a stream segment from the liquid scintillation counter data are included here. Krypton-85 transfer in a well-mixed water system is described by the expression:

$$\frac{dC_{kr}}{dt} = - K_{kr}(C_{kr},t) \qquad (1)$$

where: C_{kr},t = concentration of krypton-85 in the water at time(t)

K_{kr} = gas transfer rate coefficient for krypton-85

The concentration of krypton-85 present in the earth's atmosphere can be assumed zero for practical purposes. Therefore, any krypton-85 dissolved in water which is exposed to the atmosphere will be steadily lost from the water to the atmosphere according to equation 1.

The gas transfer rate coefficient for oxygen (K_{ox}) is related to K_{kr} by the equation:

$$\frac{K_{kr}}{K_{ox}} = 0.83 \pm 0.04 \qquad (2)$$

Equation 2 is the basis for using krypton-85 as a tracer for oxygen transfer in stream reaeration because the numerical constant (0.83) has been experimentally demonstrated to be independent of the degree of turbulent mixing, of the direction in which the two gases happen to be moving, and of temperature. The disperion or dilution tracer (tritiated water) is used simultaneously with the dissolved gas tracer (krypton-85) to correct for the effects of dispersion and dilution in the stream segment being studied.

A single homogeneous solution containing the dissolved krypton-85 gas, tritiated water, and dye is released at the upstream reach of the stream segment being studied. As the tracer mass moves downstream, multiple samples are collected as the peak concentration passes successive sampling stations. In the laboratory, peak concentration samples from each station are analyzed and the krypton-85/tritium concentration ratio (R) is established by the equation:

$$R = \frac{C_{kr}}{C_h} \qquad (3)$$

where: C_{kr} = concentration of krypton-85 in water at time of peak concentration

C_h = concentration of tritium in the water at time of peak concentration

Applying this ratio concept, equation 1 can be modified to:

$$\frac{dR}{dt} = - K_{kr} R \qquad (4)$$

with terms as previously defined

Equation 4 can be transformed to:

$$K_{kr} = \frac{n(R_d/R_u)}{- t_f} \qquad (5)$$

where: R_u and R_d = peak ratios of krypton-85 to tritium concentrations at an upstream and downstream station

t_f = travel time between the upstream and downstream station determined by dye peaks

The tracers are used to evaluate the actual krypton-85 transfer coefficient (K_{kr}), and the conversion to the oxygen transfer coefficient (K_{ox}) is from the established gas exchange ratio:

$$K_{ox} = \frac{K_{kr}}{0.83}$$

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APPENDIX B

ENGLISH-METRIC CONVERSION TABLE

miles	(mi)	x	1.609	=	kilometers	(km)
feet	(ft)	x	0.3048	=	meters	(m)
square miles	(mi^2)	x	2.59	=	square kilometers	(km^2)
acres	(ac)	x	4047	=	square meters	(m^2)
square feet	(ft^2)	x	0.0929	=	square meters	(m^2)
cubic feet	(ft^3)	x	0.02832	=	cubic meters	(m^3)
cubic feet per second	(ft^3/s)	x	0.02832	=	cubic meters per second	(m^3/s)
cubic feet per second	(ft^3/s)	x	0.646	=	millon gallons per day	(MGD)
million gallons per day	(MGD)	x	0.04382	=	cubic meters per second	(m^3/s)
million gallons per day	(MGD)	x	1.547	=	cubic feet per second	(ft^3/s)

kilometers	(km)	x	0.6214	=	miles	(mi)
meters	(m)	x	3.281	=	feet	(ft)
square kilometers	(km)	x	0.3861	=	square miles	(mi^2)
square meters	(m)	x	0.0002471	=	acres	(ac)
square meters	(m)	x	10.76	=	square feet	(ft^2)
cubic meters	(m^3)	x	35.31	=	cubic feet	(ft^3)
cubic meters per second	(m^3/s)	x	35.31	=	cubic feet per second	(ft^3/s)
cubic meters per second	(m^3/s)	x	22.821	=	million gallons per day	(MGD)