INTERIM PROGRESS REPORT

WATER QUALITY ASPECTS OF THE CALOOSAHATCHEE RIVER SYSTEM, PHASE I

by

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PART I

INTRODUCTION

Program Description: The Caloosahatchee River, one of the major outflows from Lake Okeechobee, is a very important leg of the Cross-State Okeechobee Waterway. The primary importance of the Caloosahatchee River is as a public water supply and in its ability for the control and stage maintenance of Lake Okeechobee. Secondarily, the spillways and their associated locks serve three ancillary functions; the maintenance of canal stages, salinity and general flushing control, and navigation. The operation of these structures, however, is modified by localized conditions within each basin; conditions which must be satisfied first.

Generally, the District's responsibility for the Caloosahatchee River resource lies in its ability to best manage the water flow to provide potable water at the intakes of Lee County Utilities and Fort Myers treatment plant, recognize the need for agricultural irrigation, and provide for flood control and adequate drainage.

Due to the lack of good background chemistry data on the Caloosahatchee River and tributaries and the importance of the system to the Lower West Coast-Water Use Plan (LWC-WUP), Program 8762 (CR) was begun during fiscal year 1977-78 with sample collection beginning in January 1978.

The purpose of the Caloosahatchee River Study was to initiate the development of a water quality data base of the river including its major tributaries. Also some direct emphasis was placed on determining possible causative mechanisms for the recurrent algal blooms upstream of the W.P. Franklin Lock and dam (S-79).

The original design of the Caloosahatchee River program established three main phases of the program with four main objectives. Monthly water quality samples were to be collected at six tributary and twelve main stream sites between January and December 1978. Prior to the commencement of monthly sampling, orientation and review of the study area and a sediment inventory was performed (October and Decmeber 1977). Intensive water quality sampling between April and June 1978 was performed to monitor the water quality characteristics during potential bloom periods. This included bimonthly grab samples at all stations and daily surface water quality monitoring at Alva bridge (CR-36.0) and the Lee County Water Treatment Plant (CR-40.3). Evaluation of the data and redesign of the study as necessary occurred between August and September 1978 as a result of the initial effort.

Due to the preliminary findings of the Caloosahatchee River program during 1978 calendar year, the current year program (1979 calendar year) purpose and goals were amended to include the continued development of a water quality data base, initiate the monitoring of the quality of water delivered to the Caloosahatchee River through S-77, and document the quality of major inflows within the East Caloosahatchee Basin.

THE RESULTS OF THE DATA FOUND WITHIN THIS DOCUMENT ARE BASED UPON THE STUDY YEAR 1978 AND ARE PRELIMINARY, SUBJECT TO CHANGE AS FUTURE INFORMATION MIGHT INDICATE.

Description and Hydrology of the Caloosahatchee River Study Area: The function of Lake Okeechobee in the drainage of South Florida is as a balancing reservoir, receiving runoff from the north, northwest, and south and within the limit of safe storage capacity retains a portion of the runoff for water supply.

The stage of Lake Okeechobee is controlled to provide flood protection and an available water supply to residents and property within the adjacent drainage basins. The same canal network and water control system regulating water releases from Lake Okeechobee to control stages, also serve for both irrigation and drainage of adjacent lands. Outflow from Lake Okeechobee is controlled, in part, to the Atlantic and Gulf Coasts by the St. Lucie and Caloosahatchee Canals, respectively. This forms the Cross-State Okeechobee Waterway of which the Caloosahatchee Canal is a very important leg.

The Caloosahatchee River originates in Moore Haven on the southwest shore of Lake Okeechobee. Water from Lake Okeechobee is released through a combination spillway and navigation lock (S-77) and flows southwest about 6 miles through a nearly level overflow basin, Lake Hicpochee. The River continues westerly to Ortona some 15 miles from Moore Haven where a second lock and spillway (S-78) aids in the control of water levels on adjacent lands upstream. Water level and salinity control in the remaining 26 mile reach of the Caloosahatchee River are maintained by the W.P. Franklin Lock and Dam (S-79).

The Caloosahatchee River has been straightened and channelized throughout most of its 65 mile length. Many of the bends found in the natural setting now remain only as oxbows on both sides of the channel in the lower pool. The drainage influence to the Caloosahatchee River extends, on an average, about 15 miles on either side of the river, sloping toward the river (U.S. Corps of Engineers, Jacksonville,). Ortona Lock (S-78) separates the Caloosahatchee River Study Area into two distinct hydrologic boundaries. The upper pool or East Caloosahatchee Basin (ECB) drains 338 square miles (216,133 acres) while the lower pool or West Caloosahatchee Basin (WCB) drains 497 square miles (318,253 acres). The hydrologic boundaries are shown in Figure 1. Table 1 presents the land use in each basin (SFWMD, 1978 Land Cover Inventory).

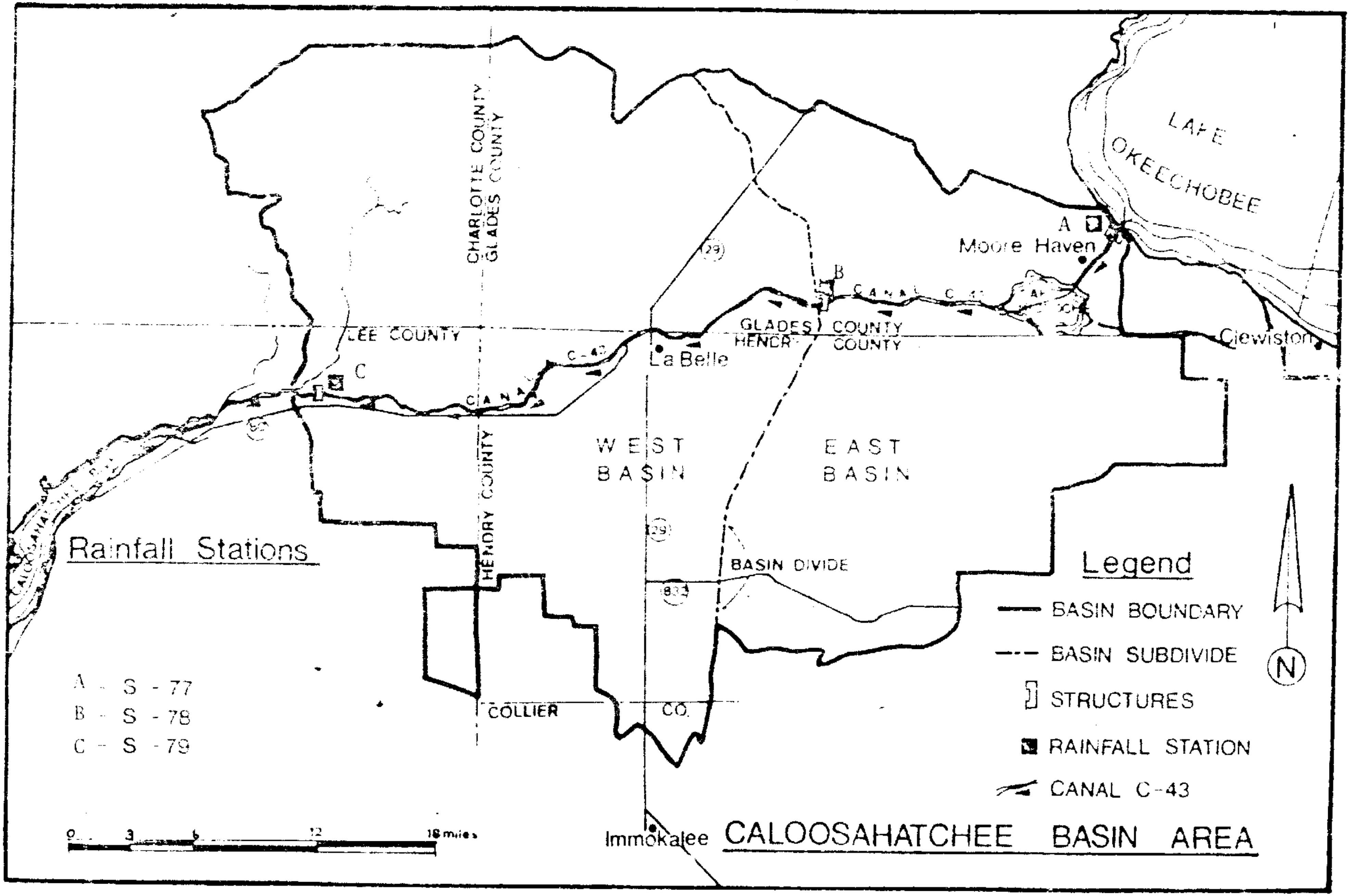

LAKE OKEECHOBEE
A
Moore Haven
Clewiston
B
CANAL C-43
GLADES COUNTY
HENDRY COUNTY
CHARLOTTE COUNTY
GLADES COUNTY
LEE COUNTY
C
C-43
CANAL
La Belle
29
WEST BASIN
EAST BASIN
BASIN DIVIDE
832
HENDRY COUNTY
COLLIER CO.
Immokalee
Rainfall Stations
A - S - 77
B - S - 78
C - S - 79
0 3 6 12 18 miles
Legend
BASIN BOUNDARY
BASIN SUBDIVIDE
STRUCTURES
RAINFALL STATION
CANAL C-43
N
CALOOSAHATCHEE BASIN AREA

FIGURE 1

TABLE 1 LAND COVER INVENTORY*

Land Use	East Caloosahatchee Basin (Acres)	West Caloosahatchee Basin (Acres)
Urban and built-up land	1,530	18,993
Agriculture	116,029	182,952
Rangeland	6,214	12,902
Forested uplands	14,078	64,898
Wetlands	76,451	35,299
Water	1,177	1,572
Barren Land	654	1,637
Total	216,133	318,253

*SFWMD Unpublished Records, January, 1979; From Level 3 Analyses

Stages in the Eastern Basin from S-77 to S-78 (upper pool) are maintained at approximately 11 feet M.S.L. while the Western Basin from S-78 to S-79 (lower pool) stages are maintained at approximately 3 ft. M.S.L.

Based upon field experience during 1978, most of the tributaries adjoining the Caloosahatchee River exhibited continuous flow to the River during the wet season, May through October inclusive. During the dry season, some of the tributaries were utilized for drainage, flowing to the river, while other tributaries were utilized for irrigation purposes withdrawing water from the Caloosahatchee River. Still other tributaries exhibited no flow during the dry season.

Figure 2 represents the discharge occurrence versus date. Water releases at S-77 during 1978 were essentially nonexistent with the exception of a few weeks during the year. S-77 discharged continuous during the latter part of March into early April to maintain canal stages in the upper and lower pool and again in August to maintain the regulation stage of Lake Okeechobee. The remainder of the year exhibited intermittent releases lasting nc more than a few days at a time. S-77 at Moore Haven, when releases are not being made, completely isolates Lake Okeechobee from the system, with the minor exception of lockages. Therefore, Lake Okeechobee was not a factor affecting the water quality in the river during most of the year. S-78 and S-79 discharges were substantially different from that of S-77 in that water releases occurred continuously during 1978 interspersed with gate closure lasting a few days to a couple of weeks at a time.

Table 2 represents the actual monthly discharge during 1978 and the average discharge for the period of record.

C-2. DISCHARGE PERIOD FOR S-77 S-78 AND S-79 DURING 1978

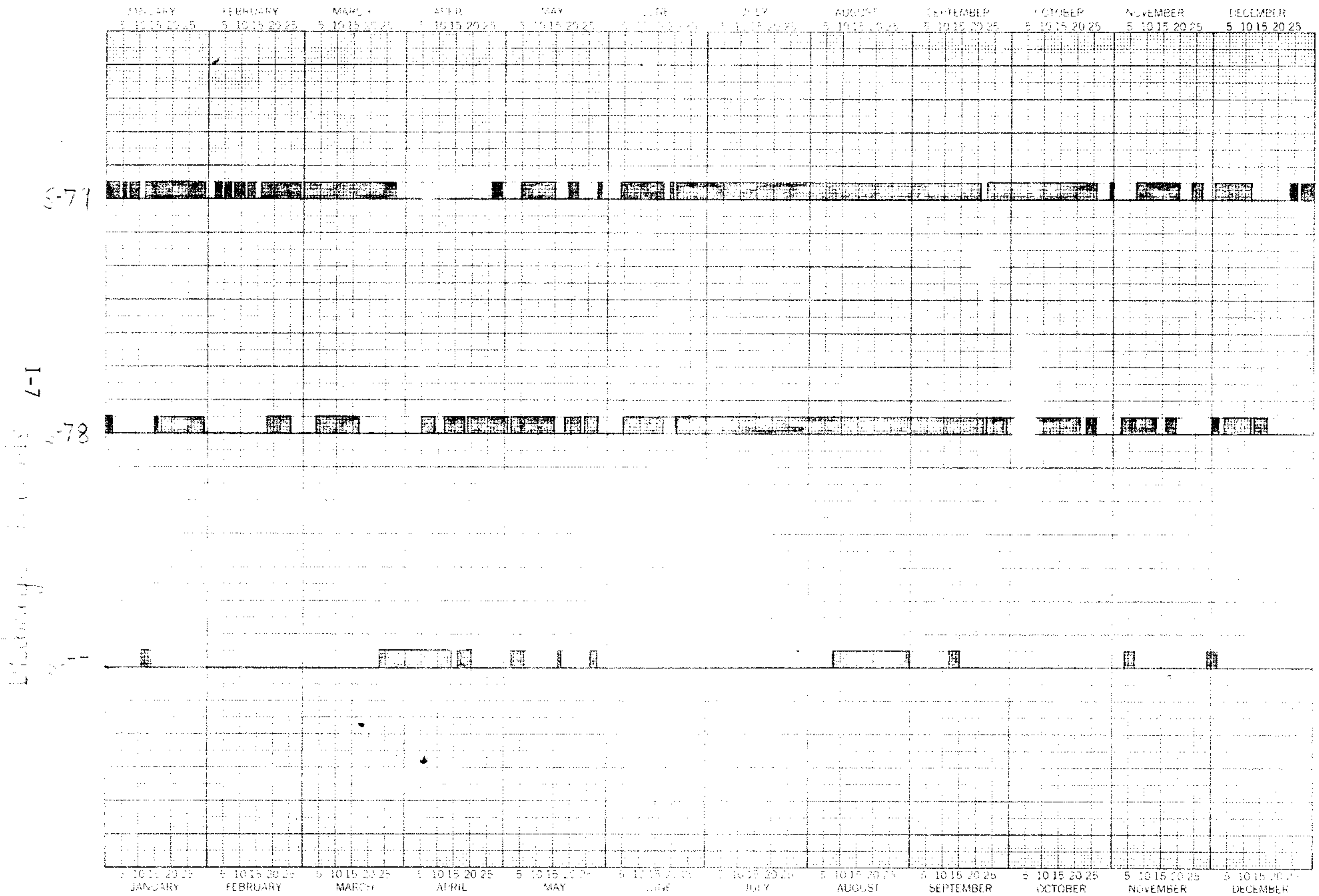


TABLE 2. DISCHARGE* COMPARISON ON THE CALOOSAHATCHEE RIVER 1978

	S-77		S-78		S-79	
	**Average	1978	Average	1978	Average	1978
January	32,035	879	34,542	9,092	47,327	21,757
February	23,102	758	25,992	2,182	35,883	14,327
March	48,605	3,443	60,044	11,363	86,973	42,707
April	80,439	15,043	77,203	7,113	79,080	2,801
May	35,550	3,352	41,094	23,805	45,006	27,096
June	49,898	298	97,019	24,469	141,963	45,094
July	57,870	300	118,947	45,501	183,983	99,673
August	87,684	182,474	147,176	266,791	183,089	308,359
September	15,393	25,091	55,071	68,868	113,189	103,088
October	32,988	307	55,365	18,876	93,996	43,786
November	35,305	1,632	39,943	6,018	51,095	15,583
December	25,052	543	23,378	10,332	32,108	27,780
Annual Total	523,921	264,320	775,774	494,410	1,093,690	752,051

*Discharge in Acre-feet; S-78 data based upon instantaneous flow, C.O.E. logs. S-77 data taken from the Lake Okeechobee Water Budget Reports supplied by the USGS and S-79 data taken from unpublished USGS miscellaneous data.

**Average data from the U.S.G.S. Water Resources data between 1966 and 1977, inclusive. Average includes the extreme discharges during the dry season, 1969, 1970 due to unseasonable rainfall.

Rainfall: The Caloosahatchee River Study Area lies within the region covered by the Florida Climatological Report, Division 5, entitled, "The Everglades and Southwest Coast" (U. S. Department of Commerce, NOAA, 1978). The locations of rainfall stations mentioned in this section -Moore Haven (S-77), Ortona (S-78), and the W. P. Franklin Lock and Dam (S-79) are shown in Figure 1 .

Figure 3 compares the rainfall in the East Caloosahatchee Basin (ECB), the average of S-77 and S-78, and the West Caloosahatchee Basin (WCB), the average of S-78 and S-79. Included in the graph is the respective historic average (based upon the period of record at S-77, S-78, and S-79 from the National Weather Bureau). Total rainfall in the WCB (52.88 inches) and in the ECB (50.54 inches) during 1978 was quite similar to the historic average in the ECB (50.54 inches) during 1978 was quite similar to the historic average in the ECB (47.71 inches) and WCB (45.91 inches); an approximate difference of 10% (Table 3).

The rainfall data demonstrated a well defined seasonal pattern with approximately 71% of the rainfall in the study area falling during the six month wet season which extends from May through October. Although the wet season appeared to be normal and the dry season appeared to be wetter tha normal, the general conditions and patterns in the Caloosahatchee River Study area indicate that the nominal differences in rainfall during 1978 could be considered normal.

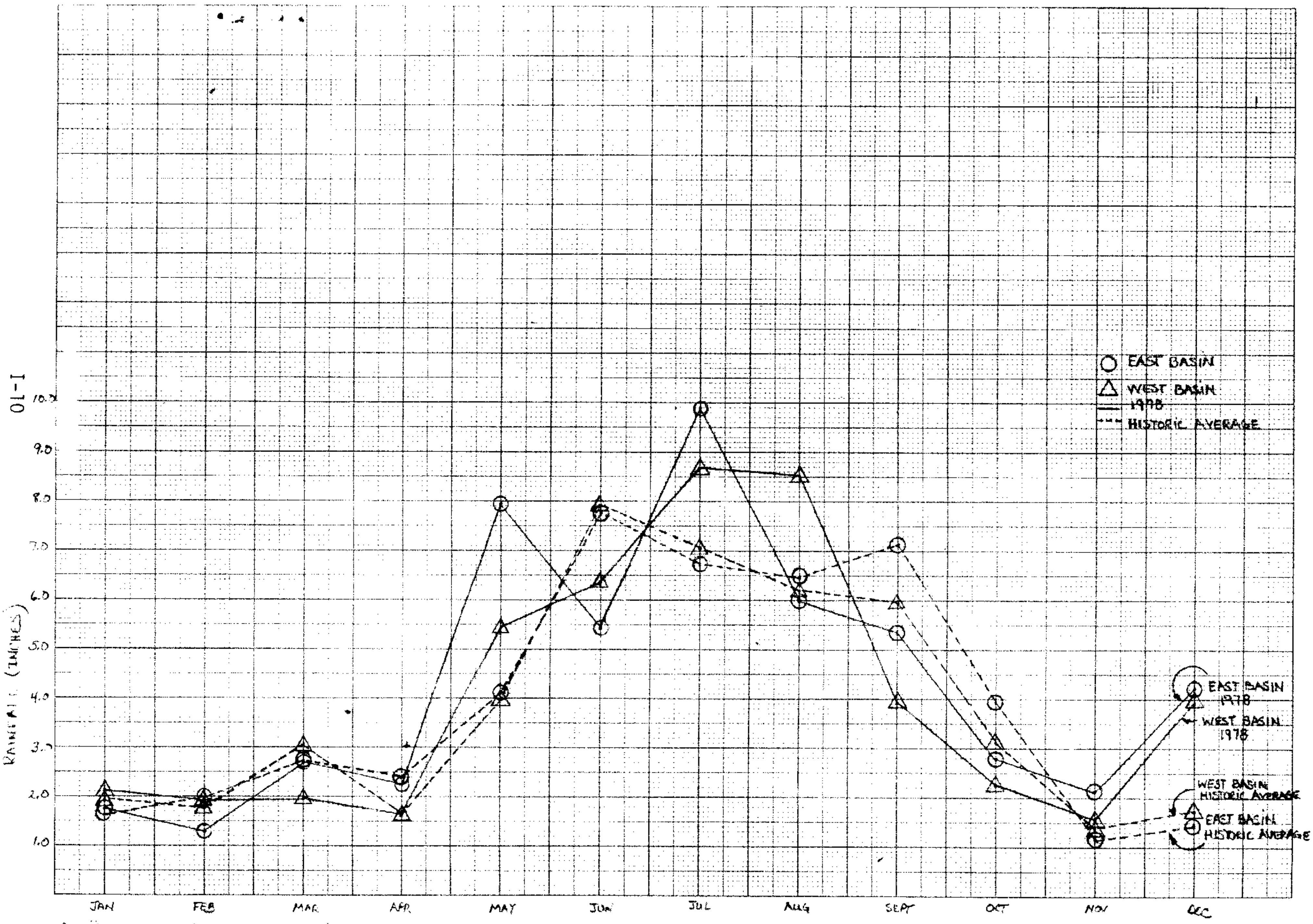


FIG 2 RAINFALL AND HISTORIC RAINFALL IN THE EAST AND WEST CALOOSAHATCHEE BASINS - 1978

TABLE 3 MONTHLY RAINFALL* DATA, CALOOSAHATCHEE RIVER STUDY AREA 1978

	Moore Haven S-77		Ortona S-78		W. P. Franklin Lock & Dam S-79		East Basin			West Basin		
	Normal	1978	Normal	1978	Normal	1978	Normal	1978	% of Normal	Normal	1978	% of Normal
January	1.75	1.78	1.53	1.74	2.44	2.52	1.64	1.76	107	1.98	2.13	107
February	2.06	1.39	1.94	1.22	1.65	2.66	2.00	1.30	65	1.80	1.94	108
March	2.88	2.84	2.61	2.57	3.56	3.37	2.74	2.70	98	3.08	2.97	96
April	2.67	2.06	2.20	2.47	1.05	0.82	2.44	2.26	93	1.62	1.64	101
May	4.43	8.38	3.88	7.59	4.17	3.32	4.16	7.98	192	4.02	5.46	136
June	8.65	5.43	7.53	5.46	8.27	7.31	7.79	5.44	70	7.90	6.38	81
July	7.16	9.32	6.28	10.49	7.87	6.87	6.72	9.90	147	7.08	8.68	122
August	6.57	2.67	6.40	9.41	6.00	7.64	6.48	6.04	93	6.20	8.52	137
September	7.49	6.40	6.83	4.37	5.15	3.51	7.16	5.38	75	5.99	3.94	66
October	4.48	2.23	3.40	3.36	2.89	1.16	3.94	2.80	71	3.14	2.26	72
November	1.14	2.13	1.18	2.04	1.57	1.11	1.16	2.08	179	1.38	1.58	114
December	1.53	4.39	1.43	6.10	2.02	3.98	1.48	5.24	354	1.72	5.04	293
Total	50.22	49.02	45.14	56.82	46.64	44.27	47.71	52.88		45.91	50.54	
Wet Season Total	38.18	34.43	34.32	40.68	34.35	29.81	36.25	37.55		34.33	35.24	

* Values are in inches

MATERIALS AND METHODS

Sampling Locations and Frequency: Twenty-four stations were sampled routinely in the Caloosahatchee River Study Area; eleven tributary sites and thirteen mainstream sites. Their codes and corresponding site descriptions are described in Table 4 .

Station identification numbers include a two letter prefix representing the study area (CR) and a 3-digit number corresponding to the mileage from a point of orientation located at the center of the Lake Okeechobee Rim Canal (adjacent to S-77 spillway in Moore Haven). An additional letter suffix (T) is included in the identification number only when the code refers to a tributary station. The mileage indication for all tributary stations refers to that point where the Caloosahatchee River and an associated tributary intersect.

The general locations of these sites are on Figures 4 and 5 . The general criteria used for the selection of these stations were:

1. The tributaries should appear to either release large volumes of water of unknown quality to C-43, or
2. Release poor quality water of unknown volumes to C-43.

To meet these general requirements, tributary sites were selected and continuous stage recorders were installed. As the program progressed, field experience indicated that some additional tributaries should be included in the study. Consequently, the LaBelle Canal (CR-25.0T), Crawford Canal (CR-26.2T), Jack's Branch (CR-30.3T), and Ft. Simmons Branch (CR-31.0T) were added.

The frequency of sample collection is shown in Table 5. Sediment and interstitial water samples were collected in November 1977 as outlined by the program objectives. Daily sampling occurred at only two stations. Alva bridge

TABLE 4 CALOOSAHATCHEE RIVER STUDY AREA STATION LOCATIONS

A. River

° 1.	CR-00.5, C-43	1/2 mile west of Moore Haven Lock (S-77)
2.	CR-03.0, C-43	3 miles west of Moore Haven Lock (S-77)
3.	CR-06.0, C-43	6 miles west of Moore Haven Lock (S-77)
4.	CR-11.0, C-43	11 miles west of Moore Haven Lock (S-77)
° 5.	CR-16.0, C-43	1.2 miles west of Ortona Lock (S-78)
6.	CR-22.5, C-43	1.0 mile east of LaBelle Bridge
° 7.	CR-26.0, C-43	2.5 miles west of LaBelle Bridge
8.	CR-30.4, C-43	1.6 miles west of Ft. Denaud Bridge
9.	CR-32.0, C-43	3.6 miles west of Ft. Denaud Bridge
*°10.	CR-36.0, C-43	5.0 miles east of Franklin Lock (S-79)
11.	CR-37.0, C-43	4.0 miles east of Franklin Lock (S-79)
12.	CR-39.0, C-43	2.0 miles east of Franklin Lock (S-79)
*°13.	CR-40.3, C-43	At Franklin Lock adjacent to Olga surface water intake at water plant

B. Tributary

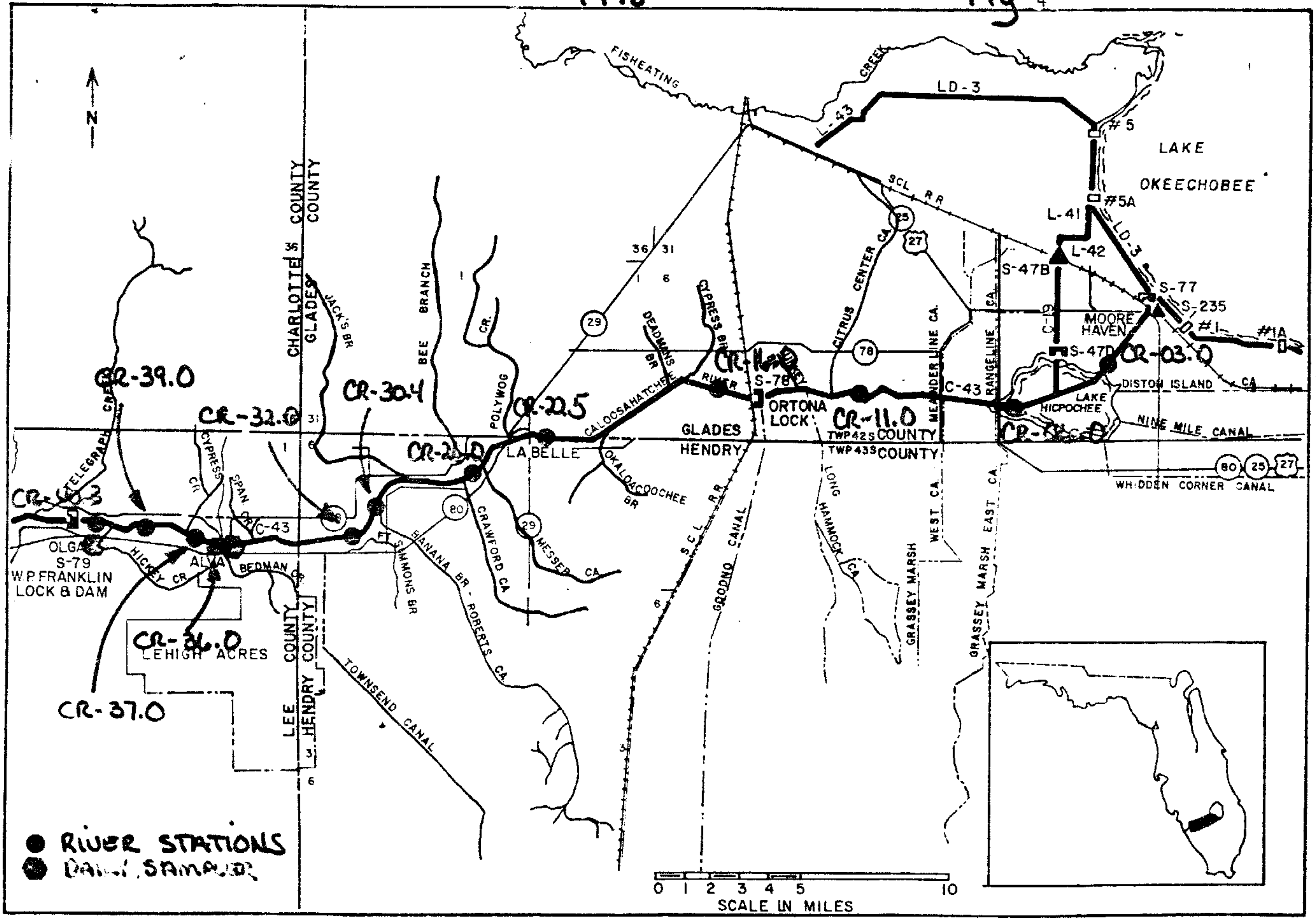
1.	CR-22.0T,	Okaloacoochee Branch at S.R. 80 west of Port LaBelle
2.	CR-25.0T,	Unnamed tributary (0700050) at mouth of tributary and river
3.	CR-26.2T	Crawford Canal at S.R. 80
4.	CR-29.3T,	Jack's Branch at S.R. 78
5.	CR-30.3T,	Jack's Branch at Norris Rd.
6.	CR-30.4T,	Banana Branch at Robert's Canal at C-78A
7.	CR-31.0T,	Ft. Simmons Branch at S-78A
8.	CR-33.5T,	Townsend Canal at S.R. 80
9.	CR-36.2T,	Bedmen's Creek at S.R. 80
10.	CR-38.2T,	Cypress Creek at S.R. 78
11.	CR-39.6T,	Hickey's Creek at S.R. 78

* Daily sample station

° Sediment station

CALOOSAHATCHEE RIVER STUDY AREA

1978 Fig 4



CALOOSAHATCHEE RIVER STUDY AREA

1978 Fig. 5

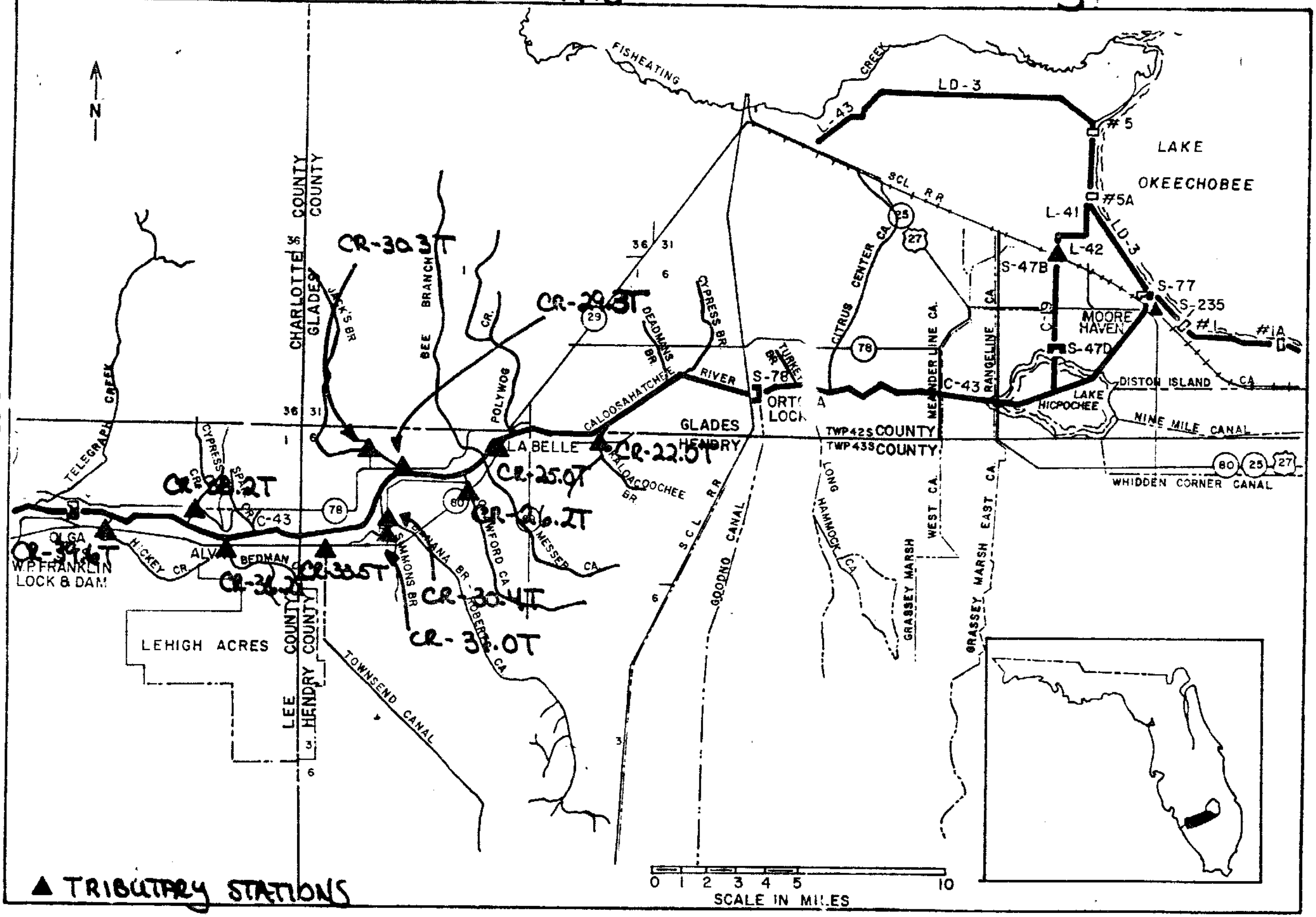


TABLE 5 . 1978 SAMPLE FREQUENCY*

JANUARY

SUN	MON	TUE	WED	THU	FRI	SAT
1						
8		M	M			
15						
22						
29						

FEBRUARY

SUN	MON	TUE	WED	THU	FRI	SAT
			1			
5		M	M			
12						
19						
26						

MARCH

SUN	MON	TUE	WED	THU	FRI	SAT
			1			
5		M	M			
12						
19						
26						

APRIL

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	D	DM	DM	D	D	D
D	D	D	D	D	D	D
D	D	DI	DI	D	D	D
D	D	D	D	D	D	D
D						

MAY

SUN	MON	TUE	WED	THU	FRI	SAT
	1 D	DM	DM	D	D	D
D	D	D	D	D	D	D
D	D	DI	DI	D	D	D
D	D	D	D	D	D	D
D	D	D	D			

JUNE

SUN	MON	TUE	WED	THU	FRI	SAT
				1 D	D	D
D	D	DM	DM	DM	D	D
D	D					
18						
25						

JULY

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2						
9		M	M			
16						
23						
30						

AUGUST

SUN	MON	TUE	WED	THU	FRI	SAT
		1				
6		M	M			
13						
20						
27						

SEPTEMBER

SUN	MON	TUE	WED	THU	FRI	SAT
3						
10		M	M			
17						
24						

OCTOBER

SUN	MON	TUE	WED	THU	FRI	SAT
1						
8						
15		M	M	M		
22						
29						

NOVEMBER

SUN	MON	TUE	WED	THU	FRI	SAT
			1			
5		M	M	M		
12						
19						
26						

DECEMBER

SUN	MON	TUE	WED	THU	FRI	SAT
					1	
3						
10			M	M		
17						
24						
31						

* M= Monthly
D= Daily
I= Intensiv

(CR-36.0) and Lee County Water Treatment Plant (CR-40.3).

Sampling and Analytical Methods: Dissolved oxygen, temperature, specific conductivity, pH, and REDOX potential were measured at each station with a Hydrolab(R) Surveyor II. These measurements were made in profile at two meter intervals at the main river stations and at one meter intervals at the tributary sites. Daily water samples were collected 0.5 meters below the surface with an ISCO Automated Sampler Model 1392 and stored in refrigerated polyethylene bottles. Routine water samples were collected from the surface of the River and tributaries with a polyethylene bucket from which subsamples were then taken and prepared for analyses. Bottom samples (1 meter above the sediment) were also collected from the mainstream sites with a 5 liter PVC Niskin(R) Sampler and transferred to a polyethylene bucket from which subsamples were then taken and prepared for analyses. Unfiltered aliquots of samples were collected for total nutrient analysis. Samples for the analysis of dissolved constituents were filtered through a 0.45 micron Nuclepore(R) membrane filter. Dissolved metals were preserved with concentrated nitric acid (2 drops/100 mls). All water samples were stored on ice in polyethylene bottles until returned to the laboratory, at which time they were transferred to a refrigerator and held at 4^{o}C for subsequent analysis, usually 1 to 2 weeks.

The routine chemical analyses performed on each sample are listed in Table 6. Laboratory analyses performed were either recommended or approved by the Environmental Protection Agency or the American Public Health Association (Standard Methods for the Examination of Water and Wastewater).

TABLE 6. PARAMETER LIST, 1978

I. River and Tributary Sites

A. Grab Samples

1. Field Measurements (2 meter profiles)

a. Physical Parameters: Redox, Temp., Conductivity, D.O., pH, Depth, Secchi Disc.

2. Lab Measurements

a. Surface Samples

1) Physical Parameters: Turbidity, Color

2) Nutrients: NO_x, NO_2, TKN, NH_4, TPo_4, $TdPo_4$, OPO_4 SiO_2

3) Major Constituents: Cl, Alkalinity, SO_4

4) Metals: TFe, TdFe, Ca, Mg, Na, K, Mn, Cu, Zn

b. Bottom Samples

1) Nutrients: NO_x, NO_2, TKN, NH_4, TPo_4, $TdPo_4$, OPO_4

2) Major Constituents: Cl, Alkalinity

3) Metals: TFe, TdFe

B. Daily Intensive Composite Samples (River Only)

1. Lab Measurements

a. Surface Samples Only

1) Physical Parameters: Lab Conductivity

2) Nutrients: NO_x, NO_2, TKN, NH_4, TPO_4, $TdPO_4$, OPO_4

3) Major Constituents - Cl

C. Sediment Review Samples

1. Field Measurements

a. Physical Parameters: Redox, pH, Temp.

2. Lab Measurements

a. Physical Parameters: Lab pH, Texture, % Organic Matter

b. Nutrients: TKN, Toal Elemental P

c. Metals: TFe, Ca, Mg, K

RESULTS AND DISCUSSION

Nutrients

Nitrogen: Total nitrogen at S-77 indicated no significant seasonal pattern (Figure 6) with a wet season average of 1.95 mg/l and a dry season average of 2.12 mg/l (Table 7). The effects of the nominal water releases in April and the regulatory water releases in August from Lake Okeechobee upon the total nitrogen water quality immediately downstream of the structure was not appreciable. The average total nitrogen concentration during water releases at S-77 was 2.35 mg/l as opposed to the average concentration of 1.98 mg/l during no releases.

Total nitrogen demonstrated a slight decreasing trend (Figure 7) as the distance from Lake Okeechobee increased. The average total nitrogen value at each of the tributaries in the WCB demonstrated better quality than the average for the river. The apparent river water quality improvement downstream of S-78 is, at least, the partial result of the improved quality influence of the tributary drainage to the river.

Organic nitrogen was the major contributing component to the total nitrogen levels in the study area. The oxidized states of nitrogen contributed to a greater extent to the inorganic nitrogen component than did ammonia.

Phosphorus: Total phosphorus at S-77 demonstrated some seasonal variation during 1978 with slightly elevated values occurring during the wet season (Figure 8). Total phosphorus ranged from an average of 0.056 mg/l during the dry season to 0.082 mg/l during the wet season (Table 7). The average concentration of total phosphorus at S-77 during water releases (0.098 mg/l) was somewhat higher than the concentration during no releases (0.065 mg/l) during 1978. The highest concentration (0.152 mg/l) during August coincided with the occurrence of regulatory releases in August. However, two weeks after this value was measured, during the same regulatory release, an appreciable

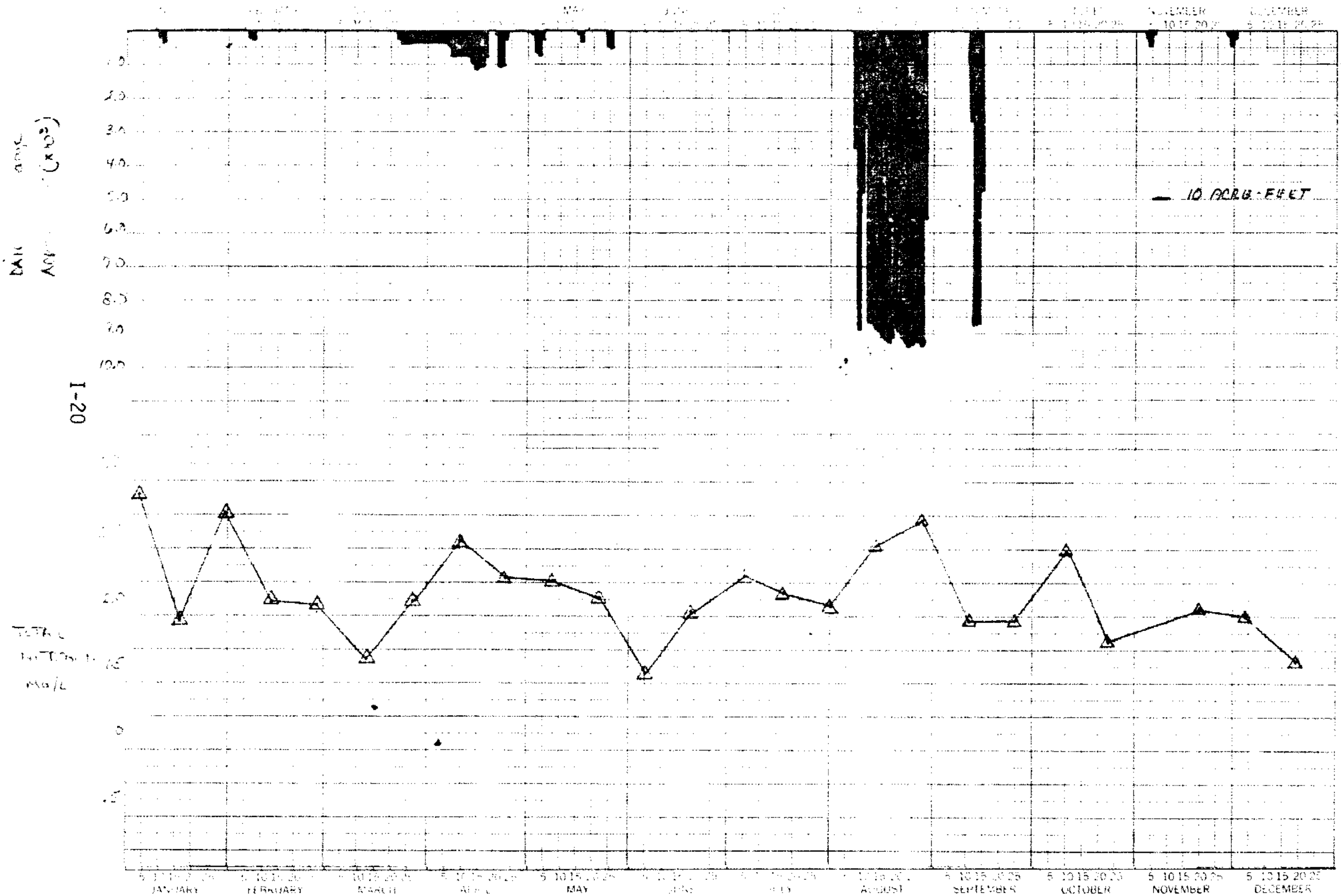


Fig. 6 DAILY Discharge VS. TOTAL NITROGEN AT S-77 1978

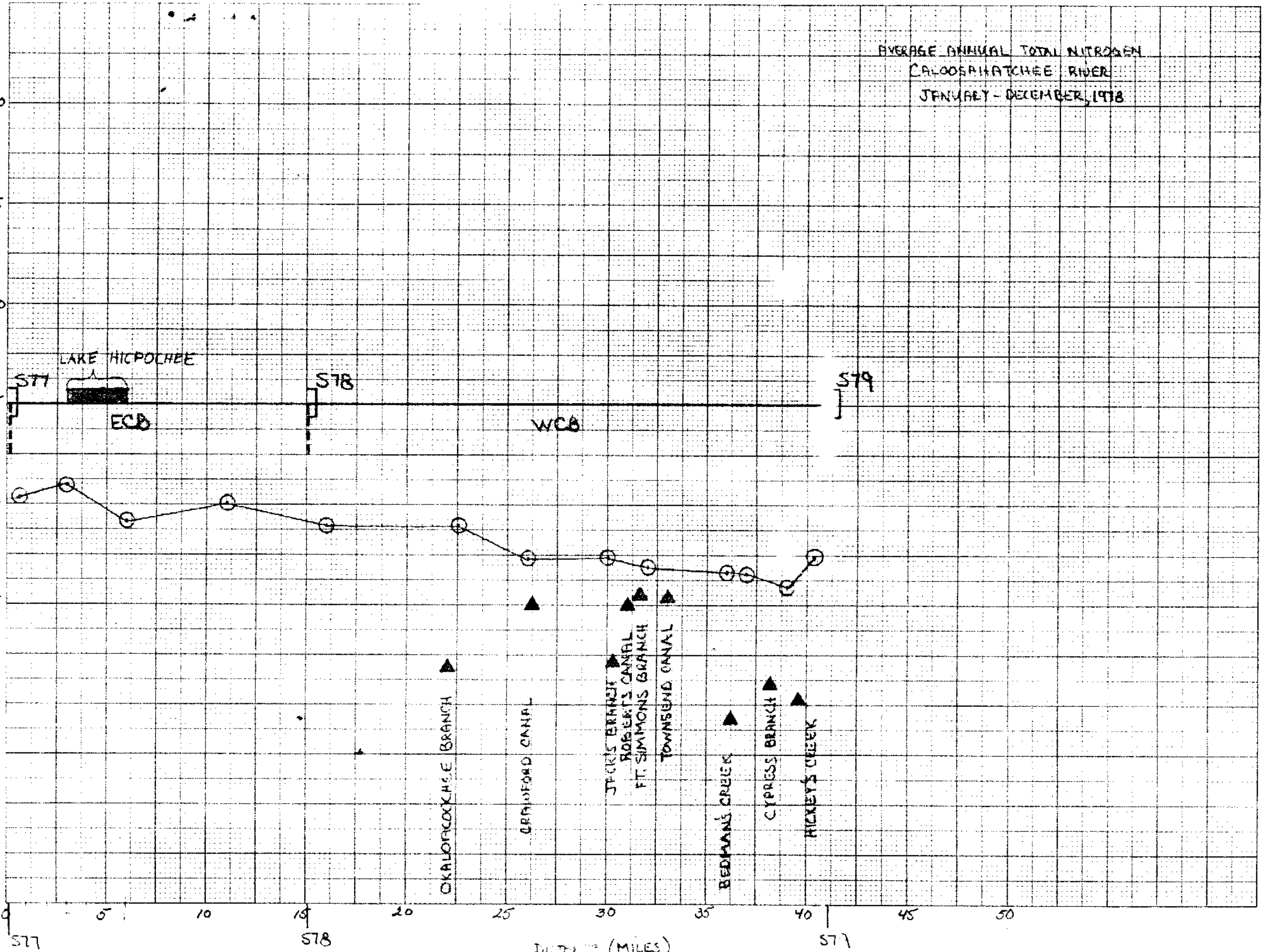
TABLE 7. AVERAGE CONSTITUENT CONCENTRATION* DURING THE WET AND DRY SEASON**

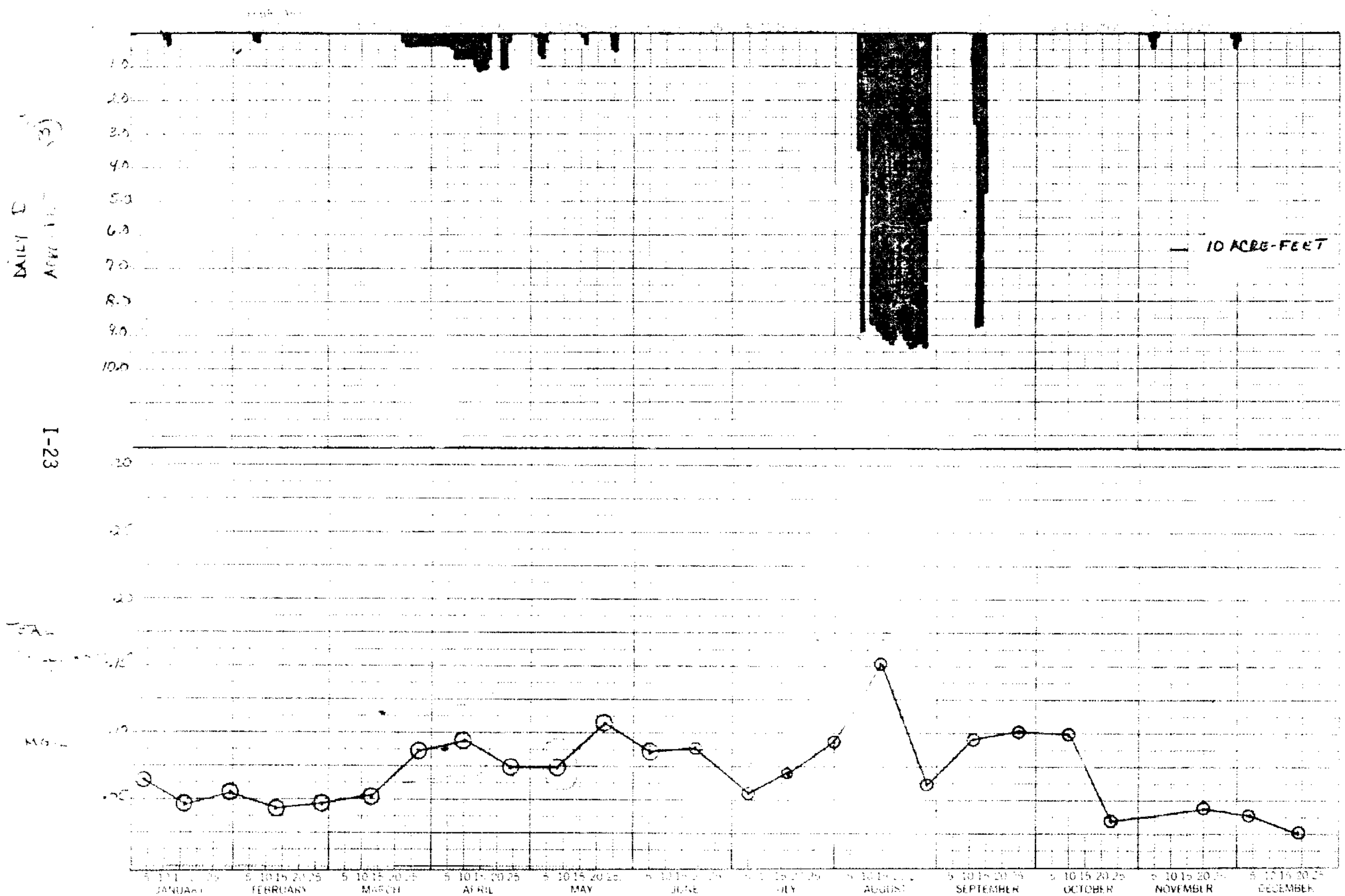
	TPO_4		T-N		Cl	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
S-77	.082	.056	1.95	2.12	64.6	103.2
S-78	.137	.098	2.06	1.73	51.2	67.3
S-79	.118	.082	1.92	1.54	73.1	74.8
Tributaries	.040	.030	1.34	1.21	75.5	87.4
ECB	.123	.076	2.16	1.63	60.1	89.8
WCB (excl. trib)	.131	.087	1.63	1.61	60.5	66.5

*Concentrations in mg/l

**Wet Season -- May to October
Dry Season -- November to April

Fig. 7


AVERAGE ANNUAL TOTAL NITROGEN
CALOOSAHATCHEE RIVER
JANUARY - DECEMBER, 1978
LAKE HICPOCHEE
S77
S78
S79
ECB
WCB
OKALOACOOCHEE BRANCH
CRAWFORD CANAL
JACKS BRANCH
ROBERTS CANAL
FT. SIMMONS BRANCH
TOWNSEND CANAL
BEDMANS CREEK
CYPRESS BRANCH
HICKEYS CREEK
TOTAL NITROGEN (MG/L)
(MILES)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
5
10
15
20
25
30
35
40
45
50



8. Daily Discharge VS. TOTAL Phosphorous AT S-77 1978

improvement in quality was also observed. The initial water quality and subsequent improved quality is probably due to the initial release of rim canal water to the Caloosahatchee River followed by the infiltration of Lake Okeechobee waters after continued releases through S-77.

Dickson, et al., 1978, reported an average total phosphorus of 0.089 mg/l at Moore Haven during backpumping events (April 1976 to August 1977) in the south end of Lake Okeechobee and an average of 0.050 mg/l during no backpumping. Since backpumping normally occurs during the wet season, the higher levels of total phosphorus would contribute to a somewhat higher wet season mean at S-77. The values reported compare closely to that data found during this study in 1978 at S-77. In the same study, the highest total phosphorus concentrations measured in the rim canal were in the vicinity of S-4. Although statistical comparison found that station location and backpumping were significant factors influencing the total phosphorus levels, no significant interaction between the two factors were found. Further testing indicated that the lack of apparent westward limit to the effects of backpumping is probably the result of moderately high phosphorus levels being released by Fisheating Creek.

Total phosphorus at S-78 and S-79 also demonstrated seasonal variation, however, the values and trends were much more pronounced than what was identified at S-77 (Figures 9 and 10). The average total phosphorus ranged from a low during the dry season at S-78 (0.098 mg/l) and S-79 (0.082 mg/l) to a high during the wet season (0.137 mg/l) and (0.118 mg/l), respectively. The peak concentrations during May and June at S-78 and S-79 are probably the result of the "first flush" of the wet season as they coincide with the onset of the rainy season. The "first flush" is a result of the drainage of adjacent lands, not from water releases from Lake Okeechobee.

46 2890

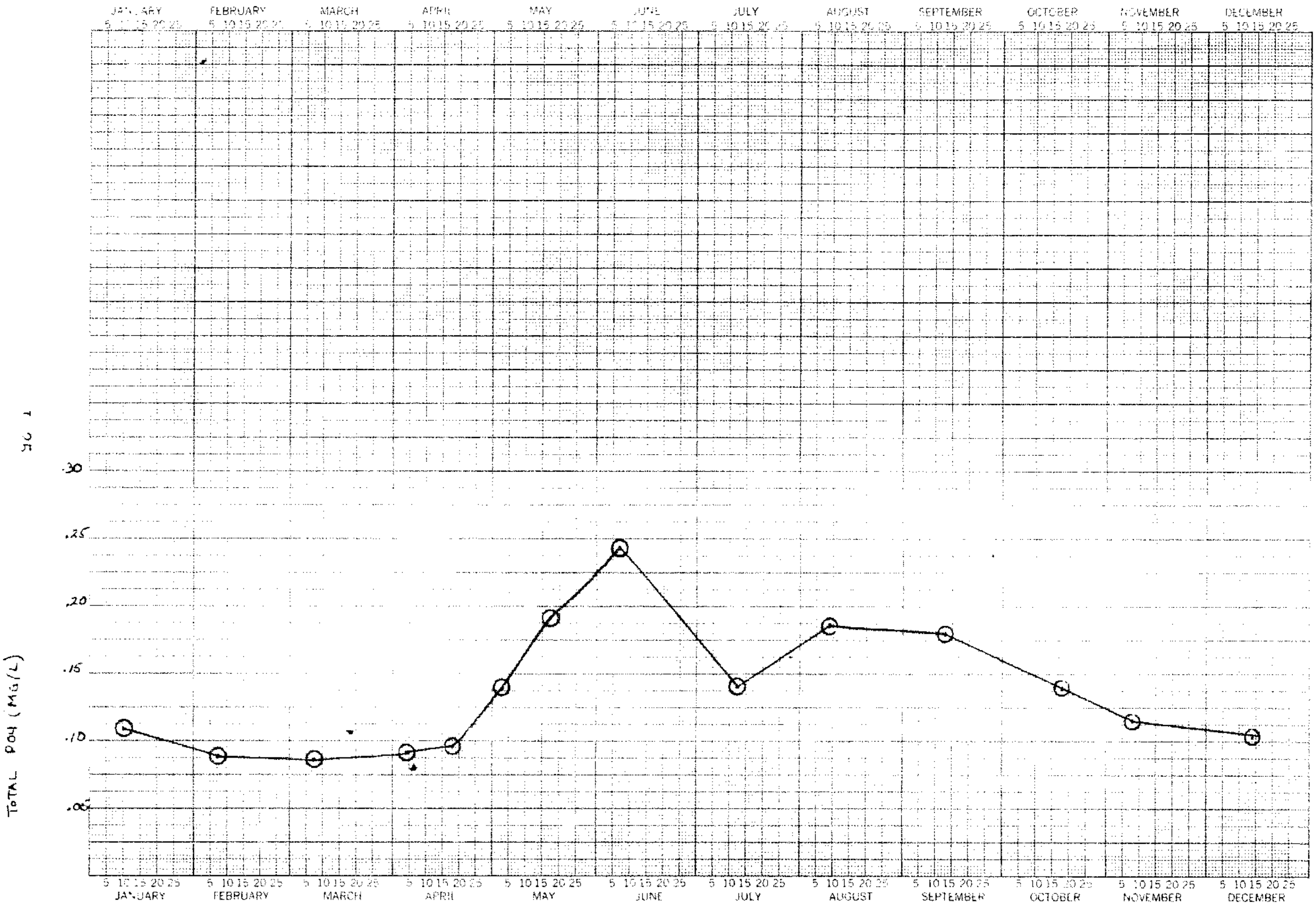


Fig 9 Daily Discharge vs. Total Phosphorous at S-78 (OK-1.0), 1978

46 2890

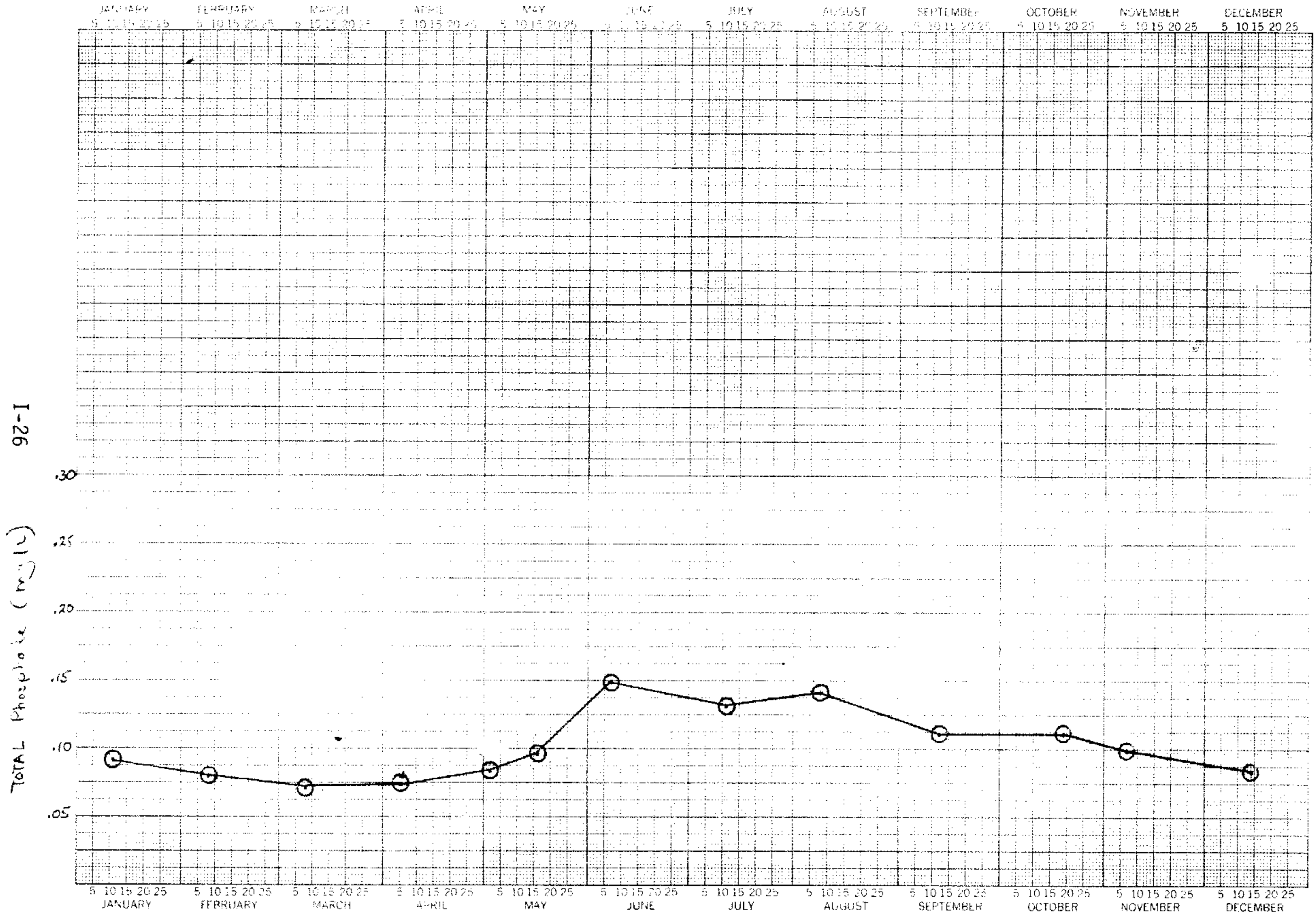
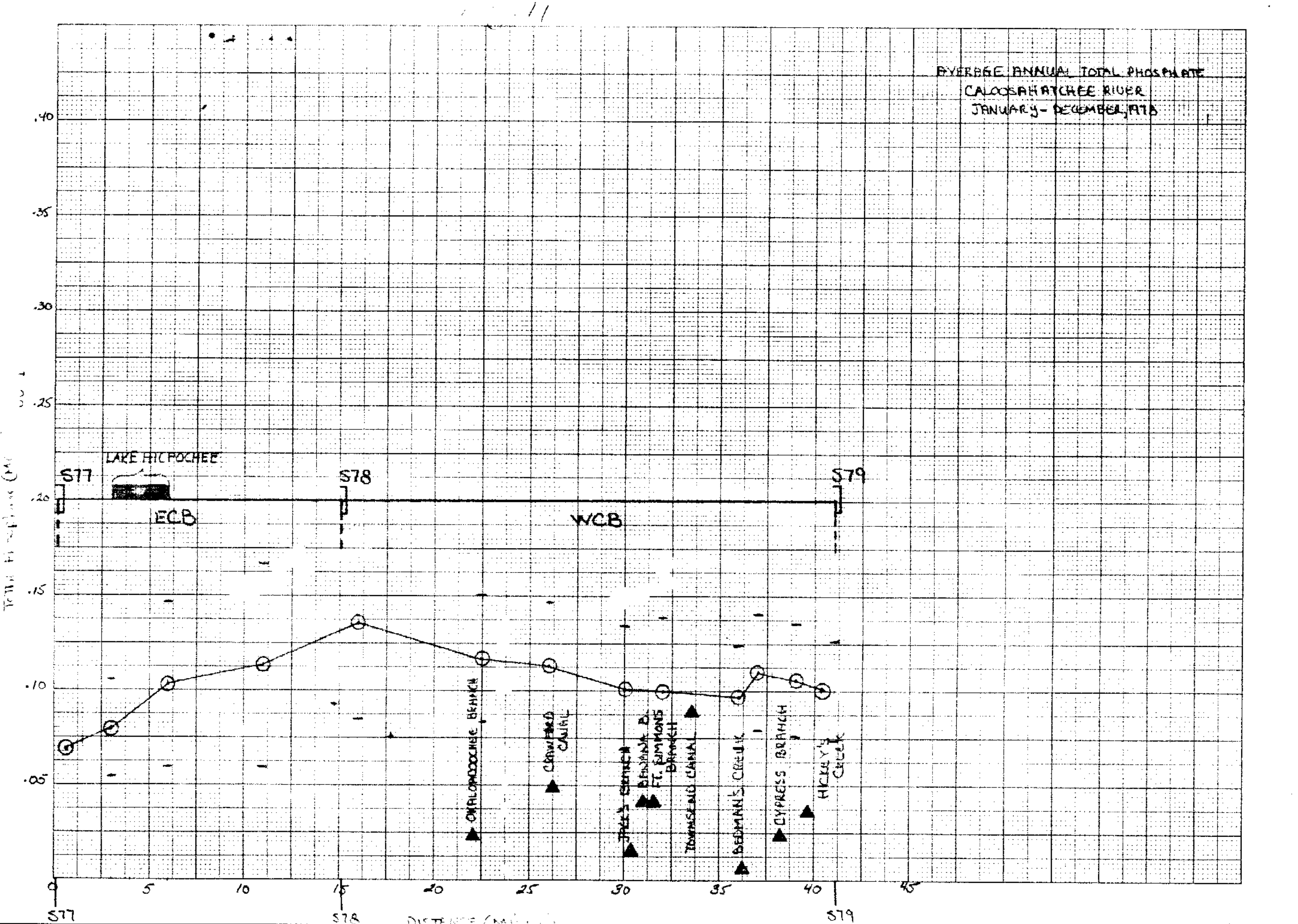


Fig 10 Daily Discharge vs. Total Phosphorous at S-79 (CR-403), 1978.

Unlike total nitrogen, total phosphorus demonstrated a twofold increase between S-77 and S-78 from 0.069 mg/l to 0.136 mg/l. The increased levels were not the result of inflows from Lake Okeechobee (Figure 11). Phosphorus increased linearly between the four stations downstream of S-77 indicating influencial sources of phosphorus were entering the River below S-77. Between S-78 and S-79, a marked decrease in the total phosphorus levels was identified (Figure 11). The improved quality of water in the WCB is probably the result of the improved quality of drainage from the tributaries as they consistently demonstrated better quality than found in the river. The major land use in association with the tributaries is forested uplands, undeveloped urban lands, and some agriculture (probably less than 20%). The water quality in the remaining areas to the East of the tributary sub-basins reflect primarily agricultural land use (probably greater than 80%) and demonstrate higher concentrations of phosphorus.



AVERAGE ANNUAL TOTAL PHOSPHATE
CALOOSAHATCHEE RIVER
JANUARY - DECEMBER, 1978
.40
.35
.30
.25
.20
.15
.10
.05
LAKE HICPOCHEE
S77
S78
S79
ECB
WCB
OKALOACOOCHEE BRANCH
CRAWFORD CANAL
JACK'S BRANCH
BENANA B.
FT. SIMMONS BRANCH
TOWNSEND CANAL
BEDMAN'S CREEK
CYPRESS BRANCH
HICKEY'S CREEK
0
5
10
15
20
25
30
35
40
45

RESULTS AND DISCUSSION

Conservative Parameters

Chloride: Chloride at S-77 demonstrated pronounced seasonal variability with low values occurring during the wet season while higher values occurred during the dry season (Figure 12). The average chloride concentration ranged from a low of 64.6 mg/l during the wet season to a high of 103.2 mg/l during the dry season (Table 7).

Chloride at S-78 demonstrated nominal seasonal variability with some lower values occurring during the wet season (Figure 13). Chloride at S-79 exhibited two distinct peaks during early May and again in early June followed by lowered values during the wet season (Figure 14). During the entire month of April and early May, no water releases were made through S-79. The high values during May (121.6 mg/l) and June (118.6 mg/l) were the average of moderate surface values and high bottom values. Since the downstream waters at S-79 are saline and no fresh water releases occurred during the elevated peaks in May and June, the increased chloride values are probably due to navigation lockages and the penetration of saline waters along the bottom waters at S-79. The influence of groundwater in the lower pool reach may also be contributing to the high chloride values.

The average annual chloride concentration in the WCB demonstrated an opposite trend to that found in the WCB. Chloride levels decreased between S-77 and S-78, then increased between S-78 and S-79. This poorer quality in the WCB appears to be the influence of the tributaries since all but three of the tributaries had higher chloride concentrations than the river (Figure 15).

After consideration of the nutrient data, the chloride data substantiates the influencial effects of rainfall, in the subsequent drainage of lands associated with the study area, on the quality of water in the Caloosahatchee River.

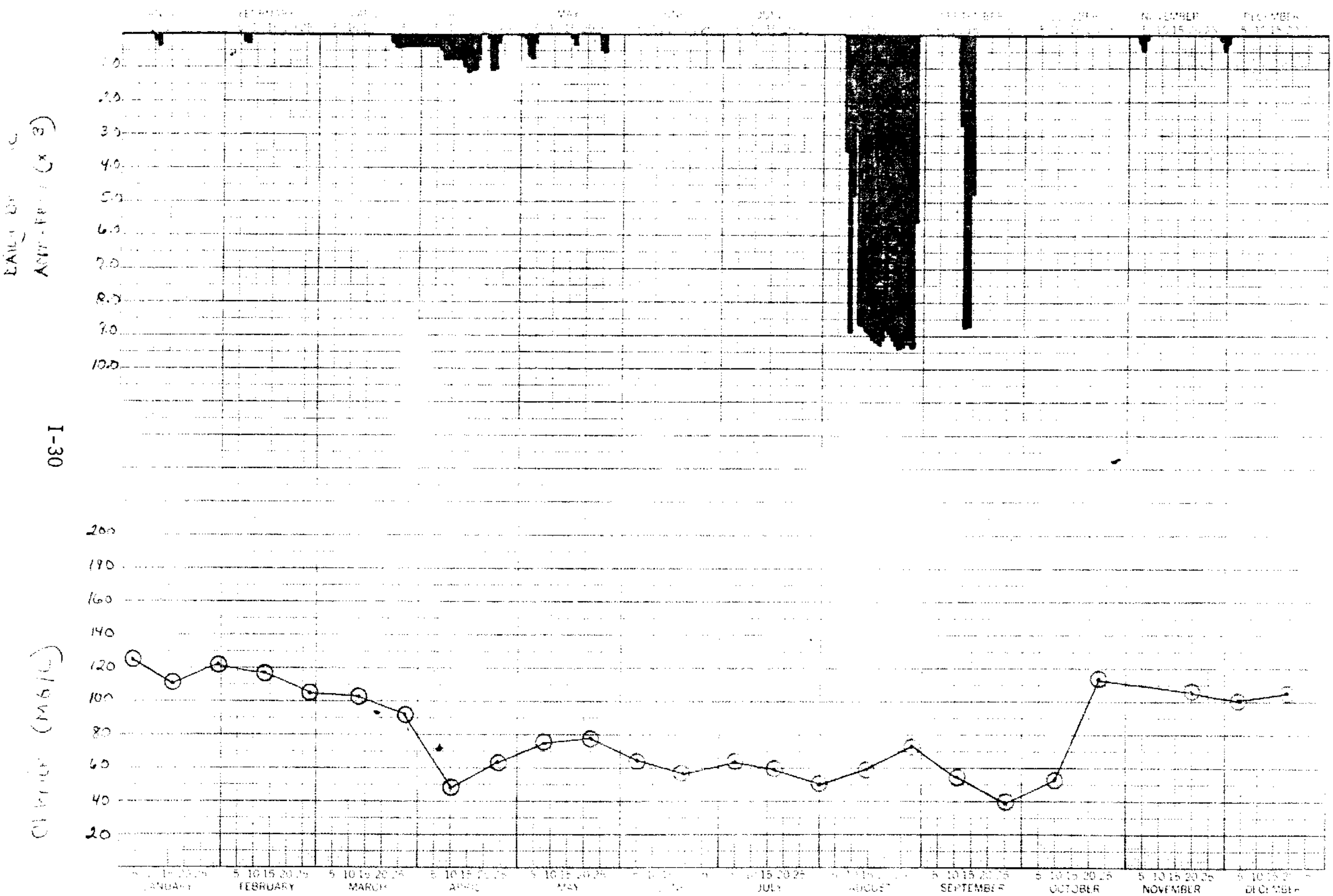


Fig. 12 Daily Discharge vs. Chloride at S-71, 1978

46 2890

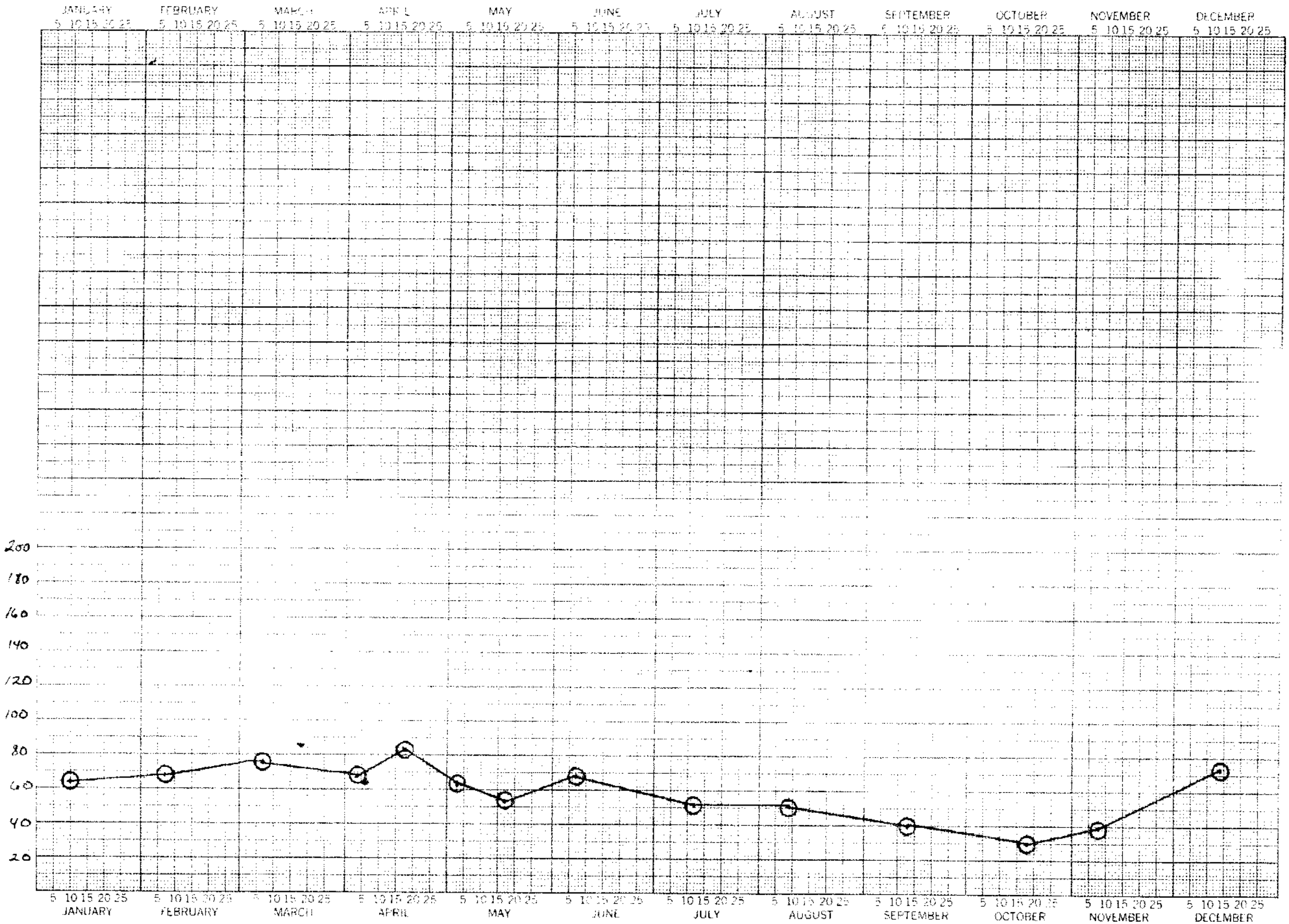


Fig. 8 Daily Discharge vs. Chlorinity at S-78 (CR-K.O), 1978

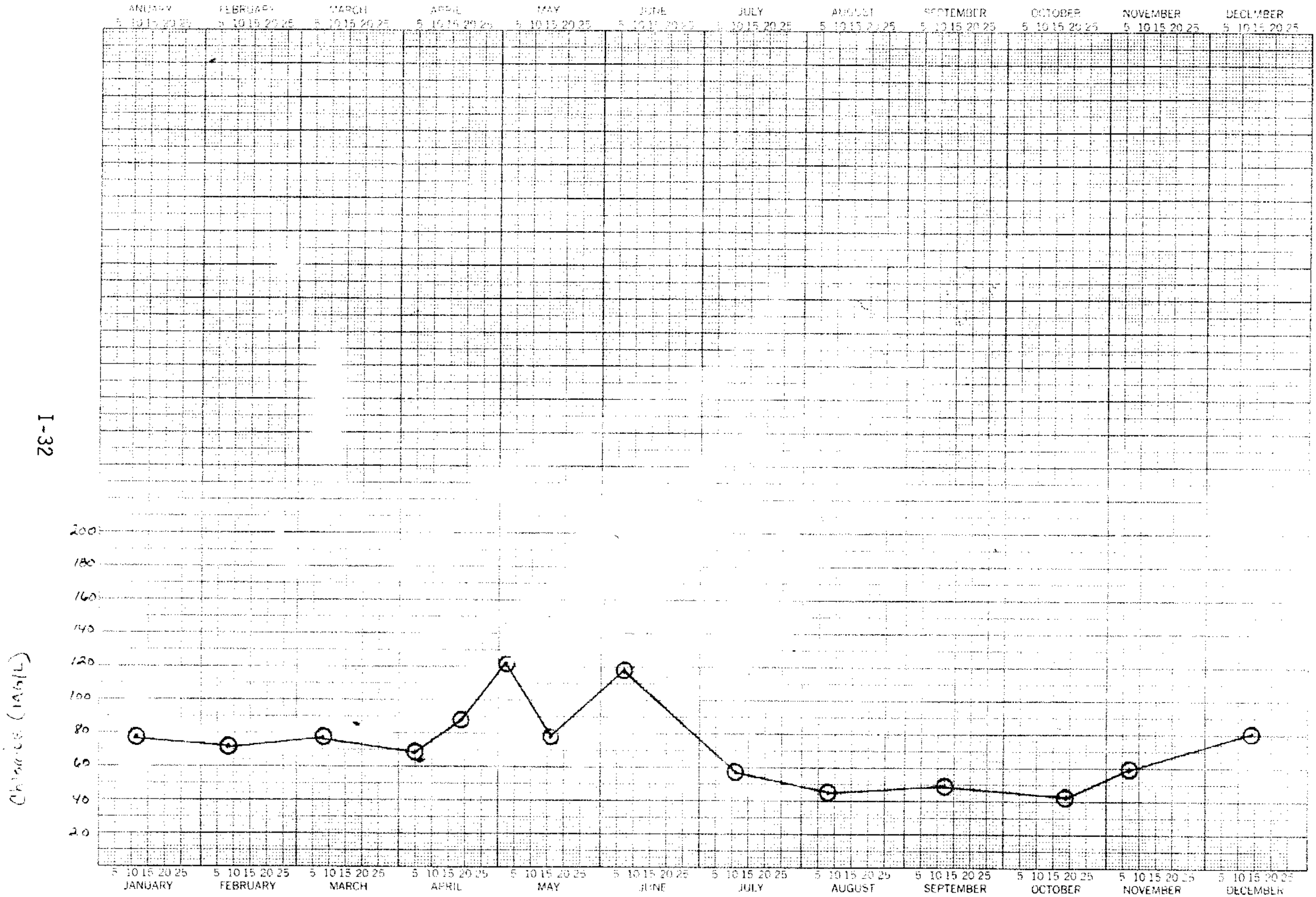
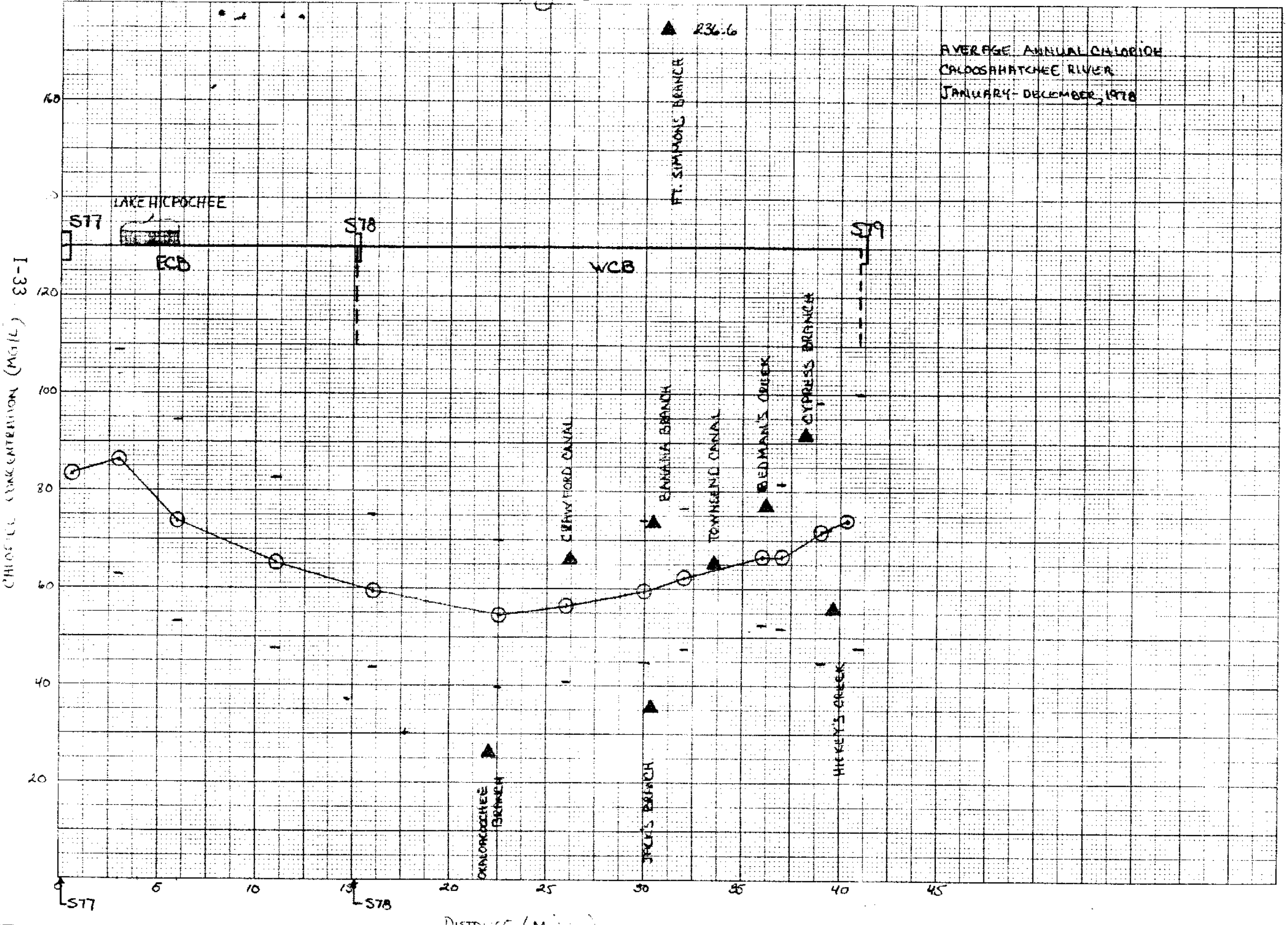


Fig 4 Daily Discharge vs. Chloride at S-78 (CE-40.3), 1978

Fig. 15


AVERAGE ANNUAL CHLORIDE
CALOOSAHATCHEE RIVER
JANUARY - DECEMBER, 1978
236.6
FT. SIMMONS BRANCH
LAKE HICPOCHEE
S77
S78
S79
ECB
WCB
CRAWFORD CANAL
BANANA BRANCH
TOWNSEND CANAL
BEDMAN'S CREEK
CYPRESS BRANCH
OKALOACOOCHEE BRANCH
JACK'S BRANCH
HICKEY'S CREEK
CHLORIDE CONCENTRATION (MG/L)
160
120
100
80
60
40
20
0
5
10
15
20
25
30
35
40
45
DISTANCE (MILES)

Tables 8a through 11 lists the mean, minimum, and maximum levels of all data for the Caloosahatchee River during 1978 and the sediment data.

TABLE 8a. SELECTED ANNUAL PHYSICAL CHEMISTRY DATA FOR THE CALOOSAHATCHEE RIVER

Station River:	Temp °C	D.O. mg/l	pH units	Sp. Cond. µmhos	Redox mv	Turb. JTU	Color units	Secchi meters
S-77	23.5	4.2	7.08	669	347	1.1	104	1.24
3.0	15.1-29.0	0.1-8.4	6.31-7.75	298-1000	190-420	0.3-2.0	35-194	0.64-2.03
	23.6	4.5	7.11	603	315	1.3	114	1.22
6.0	14.4-31.7	0.2-9.7	6.27-7.73	266-840	144-419	0.4-2.4	60-203	0.70-1.64
	23.7	5.3	7.19	581	314	1.4	119	1.19
11.0	15.1-31.7	0.3-9.0	5.99-7.79	324-820	232-429	0.5-2.7	80-200	0.69-1.70
S-78	23.9	5.7	7.15	564	301	1.6	113	1.22
16.0	15.7-31.1	0.4-9.2	6.39-7.69	336-742	100-404	0.8-3.7	90-149	0.74-1.68
	24.0	5.9	7.24	574	315	1.2	117	1.23
22.5	15.9-30.6	1.6-8.6	6.32-7.71	358-703	259-409	0.5-1.9	85-159	0.78-1.70
	24.2	5.2	7.22	557	298	1.1	115	1.30
26.0	15.6-32.0	0.5-9.4	6.51-7.70	344-715	132-390	0.7-1.9	81-173	0.90-1.88
	24.1	5.3	7.25	563	318	1.1	114	1.43
30.4	15.4-30.6	0.3-8.2	6.52-7.68	398-760	190-382	0.5-1.9	79-165	1.02-2.25
	23.8	5.4	7.26	577	319	1.1	112	1.35
32.0	15.7-31.3	0.2-7.9	6.52-7.63	398-798	221-371	0.5-2.0	79-162	0.94-2.01
	23.9	5.5	7.32	595	331	1.1	105	1.45
36.0	15.8-30.9	1.1-8.1	6.60-7.68	418-755	234-369	0.5-1.7	71-154	1.07-2.31
	23.9	5.5	7.32	611	312	1.1	106	1.44
37.0	15.5-30.6	0.7-8.1	6.60-7.69	458-1150	218-361	0.7-1.8	70-155	1.00-1.91
	23.9	5.5	7.33	635	285	1.0	105	1.49
39.0	15.4-32.0	1.1-8.1	6.63-7.68	446-1650	181-360	0.3-1.5	70-148	0.91-2.28
	24.0	5.7	7.37	668	296	1.0	103	1.45
40.3	15.5-31.4	1.2-8.2	6.69-7.70	450-2000	192-360	0.4-1.5	69-149	1.06-1.80
S-79								

mean
min-max

TABLE 8b. SELECTED ANNUAL PHYSICAL CHEMISTRY DATA FOR THE CALOOSAHATCHEE TRIBUTARIES

Tributary:	Temp °C	D.O. mg/l	pH units	Sp. Cond. µmhos	Redox mv	Turb. JTU	Color units
Okaloacooche Branch 22.0T	26.1 15.9-32.4	10.7 7.8-13.9	7.56 7.39-7.72	556 296-720	332 310-388	2.2 0.8-4.4	42 12-151
Crawford Canal 26.2T	26.2 19.2-29.9	6.4 5.0-8.6	7.23 7.0-7.34	647 534-732	354 318-409	1.7 0.7-2.4	84 65-105
Jack's Branch 30.3T	22.2 14.0-26.2	5.4 4.3-7.2	6.89 6.53-7.11	518 98-840	358 338-380	0.7 0.2-1.2	75 5-182
Banana Branch 30.4T	24.4 14.0-30.2	7.7 5.5-9.0	7.50 7.21-7.89	635 360-800	338 302-380	1.4 0.5-2.6	89 61-175
Ft. Simmons Branch 31.0T	24.1 14.2-30.1	8.0 7.2-9.2	7.51 7.40-7.71	1265 650-2680	340 310-390	1.7 0.4-2.6	68 50-105
Townsend Canal 33.5T	23.9 16.0-29.9	6.2 2.7-8.0	7.35 7.03-7.64	614 460-758	343 300-370	1.2 0.3-2.6	87 60-135
Bedman Creek 36.2T	22.5 13.6-27.8	6.4 4.9-8.1	7.46 7.19-7.70	797 664-1190	344 309-368	2.0 1.1-4.2	39 22-78
Cypress Creek 38.2T	21.4 14.5-26.6	4.4 2.8-6.2	7.07 6.69-7.31	745 280-969	359 316-379	1.6 0.7-3.0	69 35-118
Hickey Creek 39.6T	23.8 14.4-29.4	6.1 4.0-7.8	7.42 7.10-7.62	813 656-968	342 298-362	1.4 0.2-7.0	48 11-125

mean
min-max

TABLE 9a. SELECTED ANNUAL NUTRIENT CHEMISTRY DATA FOR THE CALOOSAHATCHEE RIVER

Station River:	TKN mg/l	NO_x mg/l	NH_4 mg/l	NO_2 mg/l	TPO_4 mg/l	$TdPO_4$ mg/l	OPO_4 mg/l	SiO_2 mg/l
S77	1.95	0.155	0.11	0.021	0.080	0.060	0.017	8.1
3.0	1.09-327	0.005-0.767	0.01-0.40	0.006-0.078	0.039-0.135	0.010-0.121	0.010-0.037	2.9-13.5
	1.80	0.129	0.09	0.022	0.103	0.084	0.065	6.7
6.0	0.91-3.05	0.004-0.467	0.01-0.25	0.004-0 053	0.025-0.197	0.027-0.161	0.009-0.137	3.4-10.0
	1.83	0.182	0.07	0.032	0.113	0.096	0.077	6.7
11.0	1.05-3.43	0.004-0.401	0.01-0.17	0.004-0.095	0.051-0.234	0.044-0.210	0.029-0.179	4.2-11.2
S78	1.71	0.191	0.06	0.028	0.136	0.113	0.095	6.9
16.0	0.81-2.64	0.038-0.321	0.02-0.12	0.005-0.083	0.073-0.248	0.072-0.226	0.059-0.199	5.1-10.4
	1.70	0.212	0.04	0.026	0.117	0.096	0.084	7.2
22.5	0.64-3.20	0.021-0 [illegible]51	0.01-0.10	0.004-0.072	0.076-0.197	0.017-0.161	0.051-0.149	6.2-9.6
	1.51	0.226	0.03	0.033	0.113	0.101	0.085	7.2
26.0	0.96-2.42	0.063-0.465	0.01-0.09	0.004-0.121	0.068-0.187	0.058-0.170	0.045-0.140	6.1-9.2
	1.52	0.224	0.03	0.026	0.101	0.092	0.075	6.8
30.4	0.82-2.48	0.004-0.368	0.01-0.09	0.004-0.117	0.063-0.178	0.057-0.168	0.046-0.137	5.4-8.4
	1.46	0.236	0.03	0.024	0.100	0.093	0.077	6.8
32.0	0.72-2.75	0.004-0.359	0.01-0.09	0.004-0.126	0.060-0.210	0.052-0.196	0.042-0.178	5.5-8.4
	1.41	0.266	0.03	0.028	0.097	0.089	0.074	6.9
36.0	0.66-2.81	0.004-0.390	0.01-0.05	0.004-0.147	0.061-0.165	0.057-0.149	0.045-0.122	5.2-8.7
	1.33	0.330	0.04	0.031	0.110	0.100	0.087	6.9
37.0	0.66-2.30	0.004-0.655	0.01-0.09	0.004-0.159	0.068-0.193	0.064-0.175	0.051-0.160	5.1-8.8
	1.27	0.326	0.03	0.030	0.106	0.097	0.092	6.9
39.0	0.56-2.25	0.019-0.559	0.01-0.08	0.04-0.160	0.070-0.167	0.064-0.159	0.051-0.140	4.9-8.8
	1.44	0.296	0.02	0.028	0.100	0.090	0.076	6.8
40.3	0.65-2.53	0.007-0.460	0.01-0.06	0.004-0.159	0.069-0.151	0.061-0.141	0.046-0.125	4.9-8.8
S79								

mean
min-max

TABLE 9b. SELECTED ANNUAL NUTRIENT CHEMISTRY DATA FOR THE CALOOSAHATCH EE TRIBUTARIES

	TKN	NO_x	NH_4	NO_2	TPO_4	$TdPO_4$	OPO_4	SiO_2
Tributary:								
Okaloacoochee Branch 22.0T	1.17 0.44-2.66	0.011 0.004-0.049	0.03 0.01-0.12	0.004 0.004-0.010	0.023 0.011-0.060	0.012 0.003-0.028	0.003 0.002-0.007	8.0 4.1-10.6
wford Canal 26.2T	1.42 0.93-1.85	0.180 0.039-0.560	0.02 0.01-0.04	0.007 0.004-0.015	0.049 0.023-0.107	0.041 0.014-0.100	0.027 0.009-0.063	6.7 4.6-9.6
Jack's Branch 30.3T	1.07 0.50-1.58	0.158 0.008-0.339	0.02 0.01-0.04	0.004 0.004-0.007	0.016 0.010-0.022	0.013 0.004-0.018	0.006 0.002-0.013	4.6 0.9-8.1
Banana Branch 30.4T	1.42 0.77-1.86	0.083 0.005-0.569	0.03 0.01-0.10	0.011 0.004-0.081	0.041 0.018-0.097	0.034 0.012-0.086	0.019 0.002-0.060	6.1 2.7-10.2
Ft. Simmons Branch 31.0T	1.37 0.75-2.25	0.181 0.021-0.917	0.03 0.01-0.11	0.015 0.004-0.134	0.041 0.021-0.077	0.032 0.016-0.062	0.020 0.005-0.048	8.7 3.8-14.1
Townsend Canal 33.5T	1.30 0.71-2.59	0.245 0.065-0.482	0.05 0.01-0.30	0.01 0.004-0.037	0.088 0.038-0.178	0.079 0.030-0.137	0.061 0.018-0.104	7.3 4.5-10.4
Bedman Creek 36.2T	0.88 0.28-1.91	0.056 0.018-0.202	0.01 0.01-0.02	0.004 0.004-0.004	0.007 0.002-0.013	0.005 0.002-0.017	0.002 0.002-0.004	7.6 5.3-9.9
Cypress Creek 38.2T	1.01 0.56-1.36	0.110 0.031-0.160	0.02 0.01-0.05	0.004 0.004-0.006	0.023 0.015-0.032	0.019 0.012-0.031	0.012 0.002-0.023	5.5 1.8-8.3
Hickey Creek 39.6T	0.96 0.20-2.08	0.062 0.004-0.294	0.01 0.01-0.02	0.006 0.004-0.018	0.036 0.011-0.084	0.028 0.007-0.007	0.019 0.002-0.053	7.3 5.8-9.1

mean
min-max

TABLE 10a. MISCELLANEOUS CHEMISTRY DATA FOR THE CALOOSAHATCHEE RIVER

	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	SO_4 mg/l	Alk meq/l	Hard mg/l
Station River:								
S77	54.4	16.4	56.0	5.1	86.3	40.1	3.1	208.4
3.0	24.4-99.5	6.4-23.9	19.0-75.3	2.7-7.1	37.7-113.7	17.5-73.2	0.93-4.94	87.4-338.9
	52.8	13.1	45.7	4.6	73.9	32.4	2.98	189.6
6.0	24.4-80.4	5.6-20.3	16.5-71.6	2.3-6.3	33.7-103.8	14.8-62.9	0.92-4.30	84.0-269.8
	57.8	11.5	40.3	4.4	65.1	27.2	3.19	194.6
11.0	33.6-85.8	6.0-17.1	19.7-66.3	2.4-5.9	38.4-94.5	15.1-54.0	1.62-4.56	112.5-278.0
S78	58.9	10.5	37.0	4.1	59.5	25.5	3.20	188.8
16.0	42.0-81.6	6.0-14.4	19.1-53.8	2.4-5.3	29.6-83.7	13.3-45.1	2.11-4.26	129.6-253.7
	58.1	10.0	35.7	4.0	54.9	25.8	3.18	187.1
22.5	41.6-75.6	6.0-13.8	20.3-52.9	2.3-5.0	31.4-76.9	14.0-46.3	2.28-4.12	128.4-233.1
	58.5	10.0	36.6	3.9	56.7	27.7	3.18	188.3
26.0	38.4-75.5	6.4-13.1	21.5-51.8	2.1-4.6	32.0-78.1	14.6-43.0	2.2-4.07	122.1-242.7
	57.1	10.0	36.9	3.6	59.5	28.4	3.07	184.8
30.4	42.4-75.4	7.1-12.6	21.0-51.9	1.7-4.6	39.6-79.0	15.9-42.5	2.33-3.89	139.5-240.0
	57.1	10.4	38.1	3.6	62.1	27.7	3.05	186.6
32.0	41.1-75.0	7.1-12.8	22.2-53.1	1.7-4.4	39.6-82.5	15.9-41.3	2.19-3.91	138.0-239.9
	60.6	10.8	38.8	3.4	66.5	30.8	3.20	195.3
36.0	42.0-77.1	7.7-13.5	23.8-54.8	1.6-4.3	42.6-88.5	15.9-43.0	2.44-4.04	144.7-247.9
	60.2	10.8	38.6	3.4	66.8	31.0	3.19	194.8
37.0	45.2-77.2	7.8-13.6	23.9-54.7	1.6-4.2	42.6-102.4	17.2-43.5	2.58-4.06	153.4-248.7
	61.3	11.3	39.0	3.4	71.6	31.7	3.18	199.5
39.0	49.3-77.7	7.7-15.6	22.6-55.3	1.6-4.2	43.4-176.3	17.7-41.0	2.63-4.04	166.3-250.0
	62.2	11.3	40.0	3.4	74.0	32.7	3.22	202.1
40.3 S79	49.6-78.4	7.8-14.2	23.1-59.6	1.6-4.2	42.6-149.1	17.5-43.5	2.70-4.02	165.7-254.0

mean
min-max

TABLE 10b. MISCELLANEOUS CHEMISTRY DATA FOR THE CALOOSAHATCHEE TRIBUTARIES

	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	SO_4 mg/l	Alk meq/l	Hard mg/l
Tributary:								
Okaloacoochee Branch 22.0T	95.0 46.6-122.1	3.6 2.5-4.4	16.4 9.9-20.3	1.0 0.5-2.3	26.2 17.2-31.0	36.1 11.7-90.2	4.43 2.26-5.35	252.0 126.5-319.7
Crawford Canal 26.2T	75.8 63.1-87.2	10.9 8.4-12.5	38.3 30.5-51.8	5.0 3.3-8.2	66.4 52.2-81.6	38.2 25.4-54.3	3.62 3.19-4.21	234.3 196.2-265.1
Jack's Branch 30.3T	70.4 13.0-122.5	6.0 1.2-10.2	19.3 5.7-31.2	1.2 0.2-2.6	35.4 9.8-50.6	14.2 5.6-20.6	3.36 0.51-6.61	200.5 37.5-342.3
Banana Branch 30.4T	73.2 38.7-162.2	12.5 7.7-15.1	43.1 22.8-57.0	4.2 2.3-6.5	73.8 41.6-96.5	41.1 15.1-71.7	3.39 2.09-4.10	234.0 128.2-465.6
Ft. Simmons Branch 31.0T	89.3 66.1-109.2	23.8 12.4-50.1	112.5 47.7-270.4	6.1 3.8-10.3	236.6 83.0-614.0	81.5 28.5-196.4	3.60 3.02-4.28	320.7 218.2-461.8
Townsend Canal 33.5T	66.2 54.0-78.9	11.1 8.0-13.6	38.6 28.5-54.7	3.9 2.9-5.1	65.1 47.6-85.8	34.4 22.0-55.3	3.41 2.71-4.27	211.0 167.6-244.1
Bedman Creek 36.2T	94.7 72.2-103.2	13.7 11.9-17.6	42.1 24.5-62.6	1.6 1.0-2.3	77.0 43.3-120.2	53.9 40.1-72.7	4.51 3.93-4.81	292.6 229.1-320.5
Cypress Creek 38.2T	84.8 26.2-111.1	12.0 4.9-15.8	42.4 18.2-55.8	1.3 0.8-1.6	91.6 39.5-119.9	17.2 8.7-23.1	3.83 1.09-5.11	261.1 85.4-341.2
Hickey Creek 39.6T	99.2 66.1-121.8	17.0 12.8-20.1	31.6 21.6-46.2	1.5 0.6-3.5	55.6 33.3-83.4	66.3 18.3-105.7	4.64 1.16-7.37	317.9 217.5-381.9

mean
min-max

TABLE 11 SEDIMENT DATA FOR THE CALOOSAHATCHEE RIVER

River Station	Redox MV	pH	% Concentration TKN	TEP*	K	Ca	Mg	TFe	Organic Matter	Texture
00.5	-190	6.73	.17	.047	.09	1.42	.05	.31	3.5	Loamy Sand
16.0	- 50	6.89	.66	.122	.24	4.70	.14	1.42	9.7	Sandy Clay Loam
26.0	-120	6.55	.08	.125	.40	4.69	.15	.68	3.7	Sandy Clay Loam
36.0	-110	6.80	.14	.294	.34	5.04	.78	1.25	4.3	Clay
40.3	- 80	6.80	.22	.314	.30	4.97	1.27	1.53	9.0	Clay

*TEP = Total Elemental Phosphorus

1979 PROGRAM DESIGN

As indicated by the data collected during 1978, program changes were made to identify the apparent increased nutrient levels in the East Caloosahatchee Basin. The 1978 program didn't have this ability built into it, therefore additional stations were necessary. Consequently, four additional river stations and five additional tributary stations were selected to better pinpoint the problem area and cause.

Since Lake Okeechobee had been linked as a probable cause to the poor quality water (208 Study), closer attention was deemed necessary to respond to this argument. An automated sampler was installed at S-77 to collect a time composite sample during all discharge events.

Finally, all discrete top and bottom sampling was terminated and replaced with one composite sample from the surface and bottom depths. With the exception of certain field parameters, all nutrients, metals, etc. demonstrated no significant difference in the water column during 1978 (calculated data on file, 1978). The automatic sampler at S-77 has been installed and has already been used for data collection. A sediment review was again run in January, 1979 at all river stations with the results not yet available.

Problems Encountered:

No major problems were encountered during 1978. The delay in the installation of stream stage recorders was more an inconvenience than a problem. However, all recorders requested were finally installed in May 1978. The program met all 1978 objectives.

MATERIALS AND METHODS - 1979

Sample Frequency and Sample Collection

The frequency of sample collection is shown in Table 12 . Daily samples were collected at S-77 only during a discharge event. Based upon the data obtained during 1978 and in keeping with the goals and objectives of the program, all parameters were re-evaluated with some deletions and some additions as indicated in Table 13 (Memo Report, Redesign)

Station Locations: (Figures 16 and 17)

A.
1. CR-03.0, C-43 3 miles west of Moore Haven Lock (S-77)
* 2. CR-04.5, C-43 4.5 miles " " " " "
3. CR-06.0, C-43 6 miles " " " " "
* 4. CR-09.0, C-43 9 miles " " " " "
5. CR-11.0, C-43 11 miles " " " " "
* 6. CR-13.5, C-43 2.3 miles east of Ortona Lock (S-78)
7. CR-16.0, C-43 1.2 miles west " " "
* 8. CR-19.0, C-43 4.2 miles " " " "
9. CR-22.5, C-43 1.0 miles east of LaBelle Bridge (SR-29)
10. CR-26.0, C-43 2.5 miles west " " "
11. CR-30.4, C-43 1.6 miles west of Ft. Denaud Bridge (C-78A)
12. CR-32.0, C-43 3.6 miles " " " " "
13. CR-36.0, C-43 5.0 miles east of Franklin Lock (S-79)
• 14. CR-37.0, C-43 4.0 miles " " " "
15. CR-39.0, C-43 2.0 miles " " " "
• 16. CR-40.3, C-43 at Franklin Lock adjacent to Olga surface water intake at water plant

B. Tributary

* 1. CR-03.2T, Diston Island Canal at Diston Island, Hicpochee Pump
* 2. CR-04.3T, Whidden Corner Canal (C-5) at S.R. 80

B. Tributary (Continued)

* 3. CR-04.8T, C-19 at S-47D

* 4. CR-10.1T, Meander line Ditch at S.R. 78

* 5. CR-14.0T, Long Hammock Canal at S.R. 80

* 6. CR-14.9T, Goodno Canal at S.R. 80 near Ortona

7. CR-22.0, Okaloacoochee Branch at.S.R. 80 near Port LaBelle

8. CR-26.2T, Crawford Canal at S.R. 80

9. CR-30.3T, Jack's Branch at Norris Road

10. CR-30.4T, Banana Branch of Robert's Canal at C-78A

11. CR-31.0T, Ft. Simmon's Branch at C-78A

12. CR-33.5T, Townsend Canal at S.R. 80

13. CR-36.2T, Bedman's Creek at S.R. 80

14. CR-38.2T, Cypress Creek at S.R. 80

15. CR-39.6T, Hickey's Creek at S.R. 78

* Stations added during 1979

TABLE 2 1979 SAMPLE FREQUENCY

M= monthly
B= bimonthly
S= sediment

January

SUN	MON	TUE	WED	THU	FRI	SAT
	1					
7						
14	MS	MS	MS			
21						
28						

February

SUN	MON	TUE	WED	THU	FRI	SAT
				1		
4						
11	M	M	M			
18						
25						

March

SUN	MON	TUE	WED	THU	FRI	SAT
				1		
4						
11	M	M	M			
18						
25						

April

SUN	MON	TUE	WED	THU	FRI	SAT
1	B	B	B			
8						
15	M	M	M			
22						
29	B					

May

SUN	MON	TUE	WED	THUR	FRI	SAT
		1 B	B			
6						
13	M	M	M			
20						
27	B	B	B			

June

SUN	MON	TUE	WED	THUR	FRI	SAT
					1	
3						
10	M	M	M			
17						
24	B	B	B			

July

SUN	MON	TUE	WED	THUR	FRI	SAT
1						
8	M	M	M			
15						
22	B	B	B			
29						

August

SUN	MON	TUE	WED	THUR	FRI	SAT
			1			
5						
12	M	M	M			
19						
26						

September

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2						
9	M	M	M			
16						
23/30						

October

SUN	MON	TUE	WED	THU	FRI	SAT
	1					
7						
14	M	M	M			
21						
28						

November

SUN	MON	TUE	WED	THU	FRI	SAT
				1		
4						
11	M	M	M			
18						
25						

December

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2						
9						
16	M	M	M			
23						
30						

TABLE 3

PARAMETER LIST, 1979

I. River and Tributary Sites

A. Grab Samples

1. Field Measurements (2 meter profiles)

a. Physical Parameters: Redox, Temp., Conductivity, D.O., pH, Deth, Secchi Disc

2. Lab Measurements (Composite River, Surface Tributaries)

a. Physical Parameters: Turbidity, Color (all tributaries and 3 river stations), Total Suspended Solids (3 river stations only)

b. Nutrients: NO_x, NO_2, TKN, NH_4, TPO_4, $TdPO_4$, OPO_4

c. Major Constituents: Cl, Alk (3 river stations only)

d. Metals: TFe, Ca, Mg, Na, K

* e. Other: Floride

B. Daily Intensive Composite Samples (River only, Surface only)

1. Lab Measurements

a. Physical Parameters: Lab Conductivity

b. Nutrients: NO_x, NO_2, TKN, NH_4, TPO_4, $TdPO_4$, OPO_4

c. Major Constituents: Cl

C. Sediment Review Samples

1. Lab Measurements

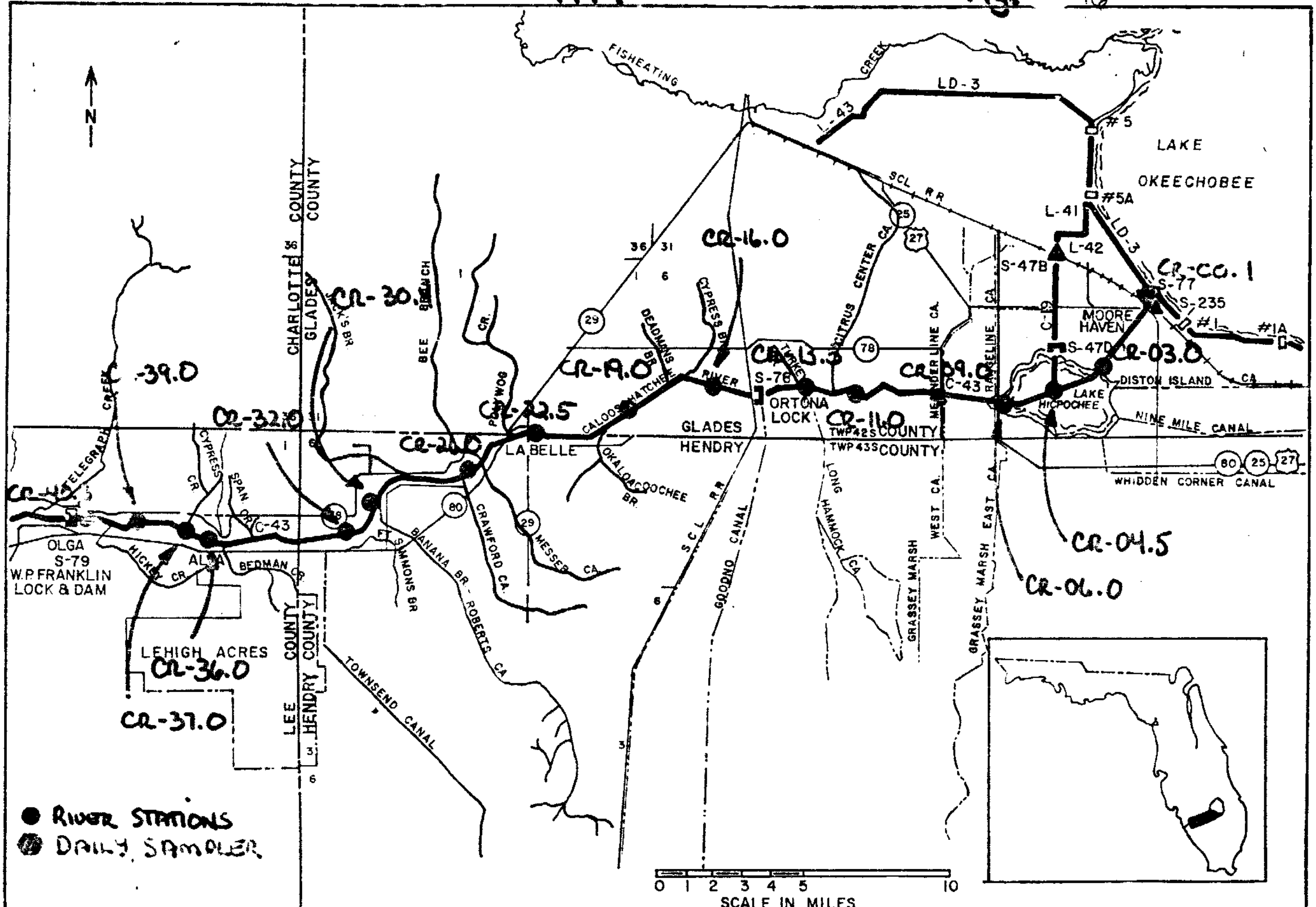
a. Physical Parameters: Texture, % Organic Matter

b. Nutrients: Total elemental P

* Additional parameters

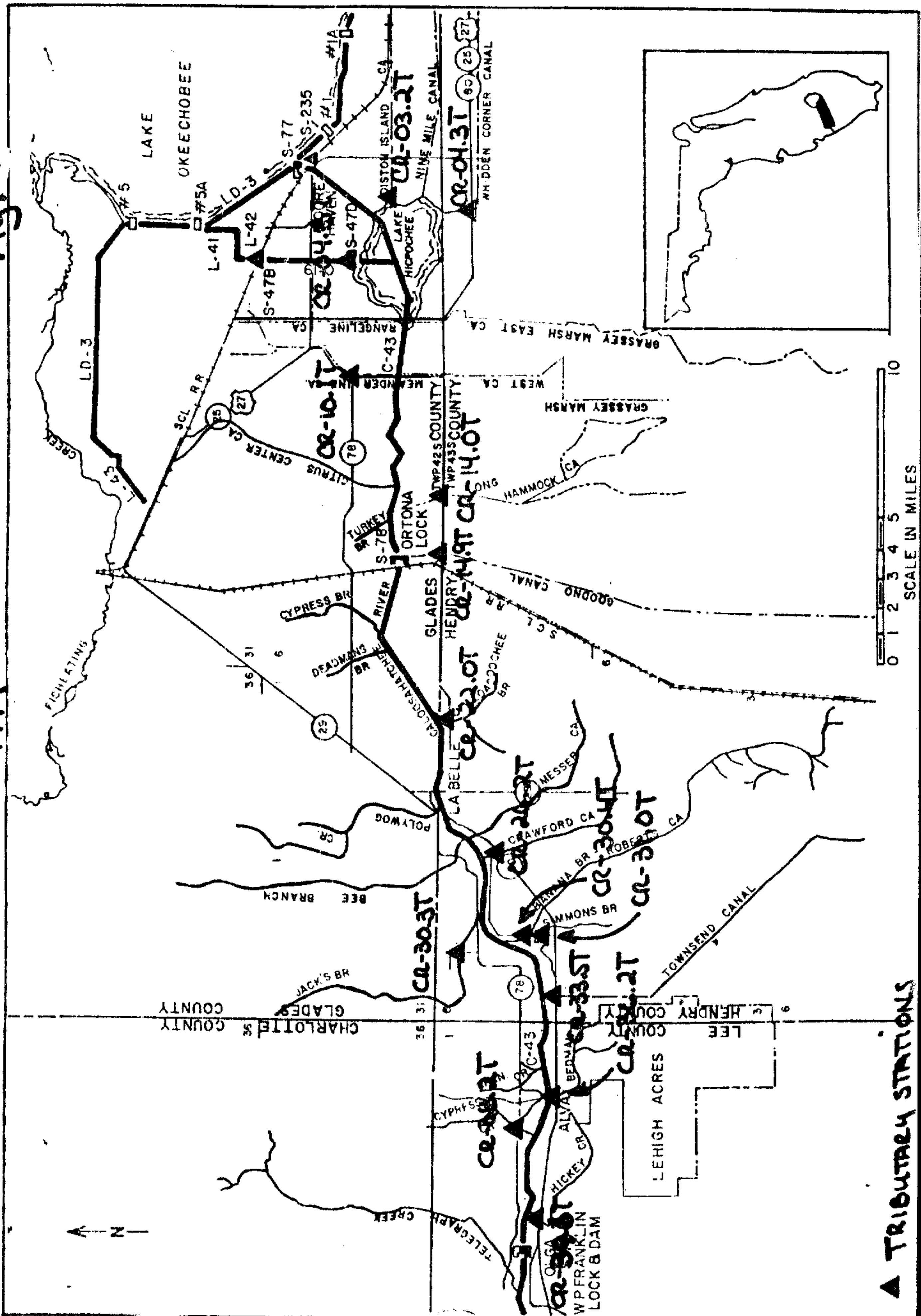
CALOOSAHATCHEE RIVER STUDY AREA

1979 Fig. 16



CALOOSAHATCHEE RIVER STUDY AREA

1979 Fig. 17



PART II

WATER QUALITY STANDARDS

Florida Administrative Code (FAC) Chapter 17-3 water quality criteria were adopted in 1972, revised in 1979, with the intent of maintaining and improving the quality of waters within the State of Florida. Table 14 lists the designated uses for all waters of the State. Surface water general criteria has been established for all waters in Florida with additional specific criteria adopted for waters of the State that have been classified according to designated uses.

There are two major groups of water quality parameters covered in Chapter 17-3, those with specific numeric criteria beyond which constitutes pollution, and those constituents for which no numerical threshold values have been established. These latter interpretive criteria cover any substance considered by the regulatory agency (FDER) to be deleterious and/or toxic according to designed uses.

Chapter 17-3 receiving water criteria are applied only after a reasonable opportunity for mixing with the receiving surface waters has been afforded. The reasonableness of the opportunity for mixing is stated to be dependent upon the condition of the receiving body of water, the nature, volume and frequency of the proposed waste including any possible synergistic effects with other pollutants or substances which may be present, and the cumulative effect of the proposed mixing zone and other mixing zones in the vicinity.

Due to the nature and design of this study, strict application of (FAC) Chapter 17-3 quality criteria is not possible. No provisions were made in the study design to delineate mixing zones or assess "natural background" levels.

However, a comparison between the water quality data collected during 1978 and (FAC) Chapter 17-3 quality criteria lends some perspective to the overall quality of waters in the Caloosahatchee River Study Area.

The Caloosahatchee River flows from Lake Okeechobee through a three county area and eventually reaches the estuaries of the Caloosahatchee River west of the W. P. Franklin Lock and Dam (S-79). The Caloosahatchee River's designated usage is divided at the Hendry-Lee County line with Glades and Hendry Counties being designated as Class III and Lee County as Class I-A due to the surface water intake for potable water supply by Lee County and the City of Fort Myers. The remainder of the tributaries discharging water to the Class I-A reach of the Caloosahatchee River in Lee County are designated Class III.

Presented in Table 15 are the mean, minimum, maximum, and numeric threshold values for nine select (FAC) Chapter 17-3 quality parameters for which measurements were taken at 12 river stations and 9 tributary stations in the Caloosahatchee River Study Area (Figure 4). Although other parameters have numerical criteria, there was a lack of sufficient data for their proper evaluation. This table covers the period January 1978 through December 1978. Sampling frequency was presented earlier in Part I (Table 5).

Alkalinity, ammonia, chloride, nitrate, and pH levels were at no time during 1978 outside the range limits established by the State criteria for fresh water or the quality criteria according to designated usage and as such will not be discussed further. Of the remaining parameters, total iron was in excess of the State criteria on occasion for Class I-A waters only while zinc and dissolved oxygen were beyond the limits established by the State criteria for both Class I-A and Class III waters.

Specific conductance ranged from 98 to 2680 μmhos/cm throughout the study area with a river and tributary average of 600 and 742 μmhos/cm, respectively.

TABLE 15 SELECT FAC CHAPTER 17-3 WATER QUALITY PARAMETERS

Class I-A

Parameter	Standard	River Reach Min.	River Reach Max.	River Reach Mean
Specific Conductance (μmhos/cm)	-	418	2000	628
pH	no specific criteria	6.6	7.7	7.3
Chloride (mg/l)	not >250.0 mg/l	42.6	176.3	76.3
T-Fe (mg/l)	not >0.3 mg/l	0.04	*0.78	0.25
Alkalinity (mg/l $CaCO_3$)	not <20 mg/l as $CaCO_3$	122.0	203.0	159.7
Zinc (mg/l)	not >0.03 mg/l	0.01	*0.07	0.03
Ammonia (mg/l ionized)	not >0.02 mg/l (mg/l un-ionized)	0.01	0.06	0.03
Dissolved Oxygen (mg/l)	not <5.0 mg/l	*0.7	8.2	5.6
Nitrate (mg/l)	not >10.0 mg/l	0.004	0.650	0.278

Class III

Parameter	Standard	River Reach Min.	River Reach Max.	River Reach Mean	Tributary Inflows Min.	Tributary Inflows Max	Tributary Inflows Mean
Specific Cond. (μmhos/cm)	-	266	1000	582	98	2680	742
pH	6.0 - 8.5	6.0	7.8	7.2	6.5	7.9	7.3
Chloride (mg/l)	no specific criteria	29.6	113.7	64.6	9.8	614.0	81.2
T-Fe (mg/l)	not >1.0 mg/l	0.05	0.84	0.26	0.02	0.93	.28
Alkalinity (mg/l $CaCO_3$)	not <20 mg/l as $CaCO_3$	46.0	247.0	155.8	25.5	368.5	194.1
Zinc (mg/l)	not >0.03 mg/l	0.01	*0.08	0.03	0.01	*0.09	0.02
Ammonia (mg/l ionized)	not >0.02 mg/l (mg/l un-ionized)	0.01	0.40	0.06	0.01	0.30	0.02
Dissolved Oxygen (mg/l)	not <5.0 mg/l	*0.10	9.7	5.2	*2.7	13.9	6.4
Nitrate (mg/l)	no specific criteria	0.004	0.723	0.170	0.004	0.783	0.110

* represents some values beyond the limits of State Standards

Chapter 17-3 states that the specific conductance shall not be increased more than 100% above background levels or to a maximum level of 500 μmhos/cm in those surface waters in which specific conductance of the water at the surface is less than 500 μmhos/cm; and shall not be increased more than 50% above background level or to a maximum of 5,000 μmhos/cm for predominantly fresh waters in which the specific conductance of the water at the surface is equal to or greater than 500 μmhos/cm. Specific conductance in the study area was usually greater than 500 μmhos/cm. The average specific conductance in the tributaries was higher than the average specific conductance in the river, however, at no time was the specific conductance in the tributaries 50% greater than in the river. The maximum specific conductance measured at any station was 2680 μmhos/cm (tributary station), a value considerably less than the maximum allowable level for predominantly fresh water.

The iron concentrations for the river and tributaries, collectively, ranged between .02 mg/l and 0.93 mg/l. The Class I-A criteria for iron in fresh waters is 0.30 mg/l while in Class III waters the criteria iron value shall not exceed 1.0 mg/l. Under no circumstances was the State criteria of 1.0 mg/l in the Class III water of the Caloosahatchee River area exceeded. The Class I-A waters, however, usually exceeded the 0.30 mg/l and probably reflects the effect of the tributary inflows in this reach.

The overall average for zinc in the river (0.03 mg/l) was only slightly higher than the tributaries (0.02 mg/l), with a collective range between 0.01 and 0.09 mg/l. FAC Chapter 17-3 indicates that zinc in Class I-A and Class III waters shall not exceed 0.03 mg/l. All stations, with the exception of the Okaloacoochee Branch (CR-22.0T), the Crawford Canal (CR-26.2T), and the Banana Branch of Robert's Canal (CR-30.4T) in the study area exceeded this criteria at some time during 1978.

The Chapter 17-3 criteria for dissolved oxygen for Class I-A and Class III Waters states that the dissolved oxygen shall not be less than 5 mg/l. Normal daily and seasonal fluctuations above this level shall be maintained for predominantly fresh waters. Dissolved oxygen, Table 16, in the river, ranged between 0.1 mg/l to 9.7 mg/l. The dissolved oxygen, Table 17, in the tributaries ranged between 2.7 and 1.39 mg/l with an overall mean of 5.3 mg/l for the River and 6.8 mg/l for the tributaries.

Table 16 includes the total number of dissolved oxygen measurements taken at each station (includes surface and bottom measurements) and the number of values less than 5.0 mg/l. The dissolved oxygen in the river frequently was less than 5.0 mg/l (23 to 66 percent of the measurements).

A review of the tributaries of the WCB indicates that the Okaloacoochee Branch (CR-22.0T), the Crawford Canal (26.2T), the Banana Branch of Roberts Canal (CR-30.4T), and Ft. Simmons Branch (CR-31.0T) were not below the State criteria at any time during 1978. The Okaloacoochee Branch, the Crawford Canal, and Ft. Simmons Branch are extremely small, shallow tributaries with relatively minimal flow. Biological activity with oxygen production probably accounts for the high dissolved oxygen levels. The Townsend Canal (CR-33.5T) discharged to the river very few times during 1978 but irrigation water was often pumped from the Caloosahatchee River to the Townsend Canal. The low dissolved oxygen values in the Townsend Canal probably reflect the low river oxygen values. Cypress Creek had dissolved oxygen values above 5.0 mg/l only a few times during 1978 and may also reflect the occurrence of river water ponded at its lower reach during minimal or no flow points.

In that no tributaries were sampled in the ECB, and the tributaries in the WCB, with respect to dissolved oxygen, had higher values than the River, it would appear that the depressed dissolved oxygen values were caused by something

TABLE 16. DISSOLVED OXYGEN REVIEW ON THE CALOOSAHATCHEE RIVER

River Stations	Min.	Max.	Annual Mean	Surface Mean	Bottom Mean	Total No. Samples	Total No. Samples <5.0 mg/l
Class III							
S-77	1.2	10.0		5.3		29	13
CR-03.0	0.1	8.4	4.2	5.1	3.4	58	38
CR-06.0	0.2	9.7	4.5	5.7	3.4	59	30
CR-11.0	0.3	9.0	5.3	5.9	4.8	56	23
CR-16.0	0.4	9.2	5.7	6.5	5.1	66	23
CR-22.5	1.6	8.6	5.9	6.8	5.0	56	13
CR-26.0	0.5	9.4	5.2	6.4	4.4	67	24
CR-30.4	0.3	8.2	5.3	6.1	4.5	67	18
CR-32.0	0.2	7.9	5.4	6.1	4.6	70	21
			5.2	6.0	4.4		
Class I-A							
CR-35.0	1.1	8.1	5.5	6.4	4.8	70	20
CR-37.0	0.7	8.1	5.5	6.4	4.8	70	24
CR-39.0	1.1	8.1	5.5	6.4	4.8	70	24
CR-40.3	1.2	8.2	5.7	6.7	6.0	69	19
			5.6	6.5	5.1		

TABLE 17. DISSOLVED OXYGEN REVIEW OF TRIBUTARIES IN THE CALOOSAHATCHEE RIVER STUDY AREA

Tributary Station	Minimum	Maximum	Annual Mean	Total No. Samples	Total No. Samples <5.0 mg/l
Class III					
Okaloacoochee Branch	7.8	13.9	10.7	14	0
Crawford Canal	5.0	8.6	6.4	11	0
Jack's Branch	4.3	7.2	5.4	13	3
Banana Branch	5.5	9.0	7.7	15	0
Ft. Simmons Branch	7.2	9.2	8.0	14	0
Townsend Canal	2.7	8.0	6.2	32	5
Bedman Creek	4.9	8.1	6.4	33	2
Cypress Creek	2.8	6.2	4.4	32	24
Hickey Creek	4.0	7.8	6.1	42	3

other than tributary input (i.e. configuration of the Caloosahatchee River, groundwater seepage, inflow from tributaries in the WCB, or a high organic load to the system).

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TABLE 14 CLASSIFICATION OF WATERS

Classification	Designated Uses
Class I-A	Potable Water Supplies - Surface waters
Class I-B	Potable and Agricultural Water Supplies and Storage - Groundwaters
Class II	Shellfish Propagation or Harvesting - Surface waters
Class III	Recreation, Propagation and Management of Fish and Wildlife - Surface waters
Class IV	Agricultural Water Supplies - Surface water
Class V-A	Navigation, utility, and industrial uses - surface waters
Class V-B	Fresh water storage, utility and industrial uses - Groundwaters

APPENDIX A

WATER QUALITY EVALUATION OF PERMIT
NOS. 50-00143-S AND 50-00143-W
(SUCROSE GROWERS)

Prepared by

Water Chemistry Division

RESOURCE PLANNING DEPARTMENT
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

June 1, 1977

INTRODUCTION

The findings of a Public Hearing resulting from the Application for Water Use, Surface Water Management and Right of Way Occupancy Permits by Sucrose Growers and Roger Hatton stipulated that a water quality monitoring program be conducted to determine whether or not the applicant's discharge resulted in water quality degradation of C-51 (West Palm Beach Canal). The following report is the results and evaluation of the monitoring programs conducted by both the applicant and the District from January 1976 to March 1977.

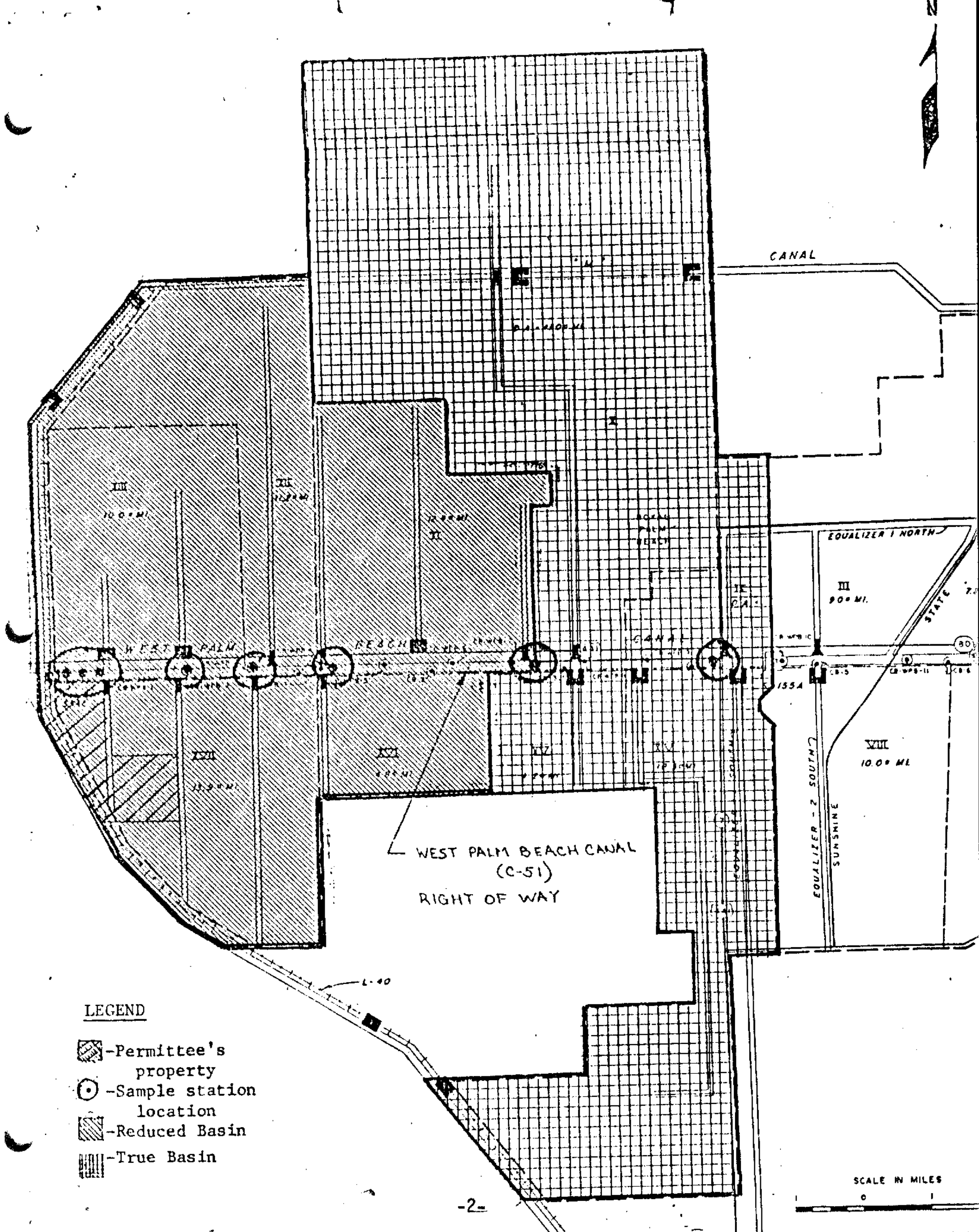
The West Palm Beach Canal (C-51) is located on an east/west axis between Conservation Area No. 1 on the west and the Lake Worth intracoastal waterway to the east. C-51 is approximately 22 miles in length and traverses urban areas along the eastern reach and agricultural areas along the western reach. Drainage of the canal to the Lake Worth intracoastal is by gravity flow with an average annual discharge to Lake Worth of approximately 671,000 acre-feet.

The C-51 basin has been divided into an eastern and western half for planning purposes by the District especially in relation to possible backpumping of the western half. The divide is usually considered to be State Road 7 (U.S. 441). Only the western basin is considered in this evaluation since the discharge under study is on the extreme western end of the canal.

There are approximately 120 square miles of drainage area tributaries to Western C-51. Although the predominate soils type in the basin is poorly drained sandy soils, the permittee's property is located on organic soils (Terra ceia) which are undoubtedly remnants of the original Everglades. The land use within the basin is mainly agricultural with some remaining forest and wetlands and some urban development.

A series of related water control structres and the S-5A pumping stations are located at the western end of the basin. These structures control water

FIG. 2 WESTERN C-51 DRAINAGE BAS



releases into the canal primarily for irrigation purposes during dry periods. There are numerous private drainage connections to the canal between S-5A and S.R. 7 which result in a rather complicated hydrologic system. A complete description of the S-5A complex and the drainage connections to C-51 are on file at the District with the original permit.

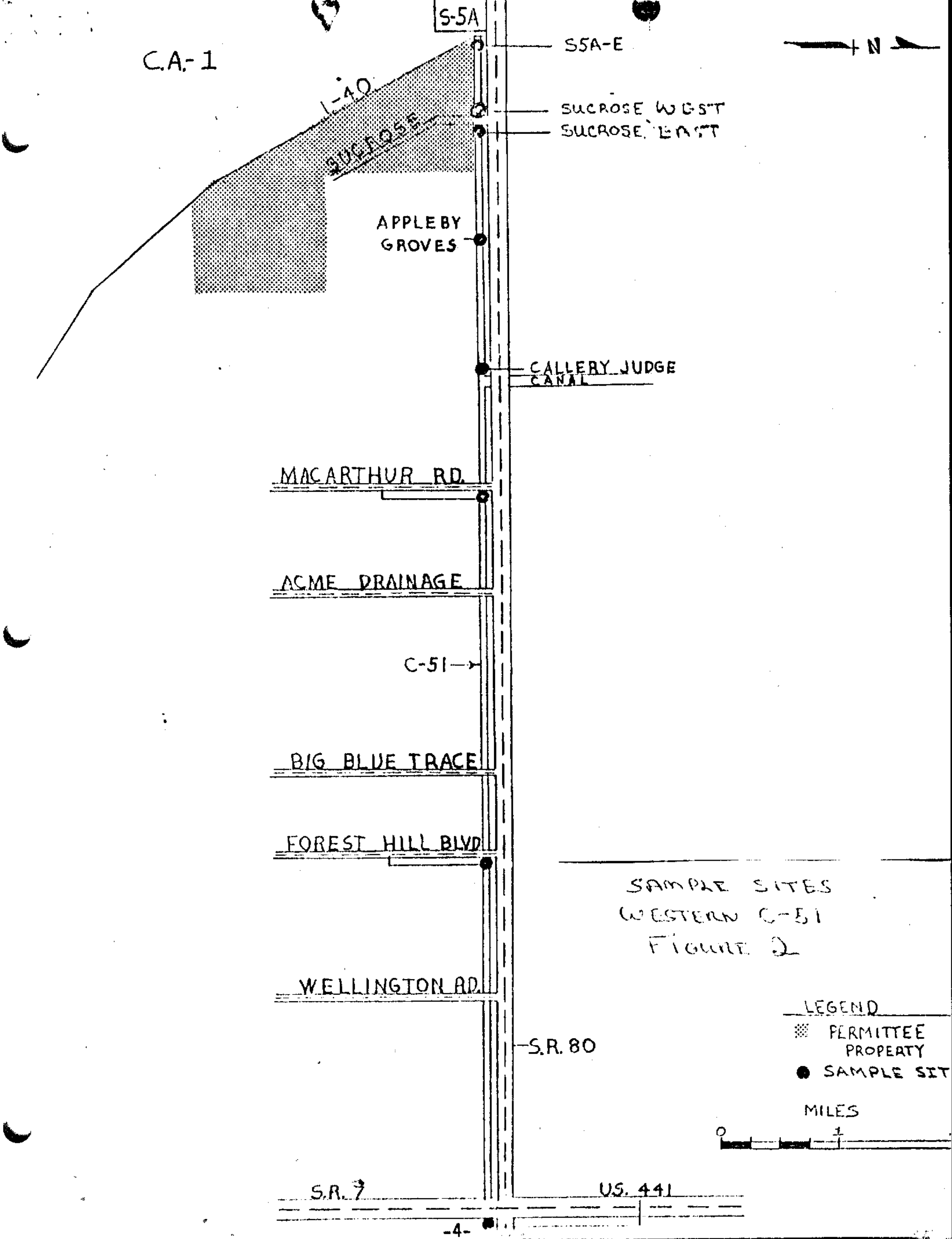
Methods

For the purposes of hydrologic calculations in this evaluation a reduced drainage area was considered. Figure 1 shows the entire and the reduced basin as well as the permittee's property. The reduced basin is approximately 52 square miles with the permittee's property being 3 square miles or 5% of the basin.

As stipulated in the special conditions of the temporary permit, two monitoring programs were conducted during this evaluation. The permittee monitored the quantity and quality of the discharge and the District monitored the quality of the receiving waters.

The quantity of discharge was estimated from daily logs of pumping hours supplied by the permittee. Water quality samples were collected once a month during the wet season from May to October by Paul R. McGinnes and Associates of North Palm Beach, Florida. Two additional samples were also collected in January and March. These samples were analyzed according to Standard Methods for a) All nitrogen species b) total phosphorus c) total dissolved solids d) turbidity and e) dissolved oxygen.

The District's sampling program consisted of eight stations along C-51 between S-5A and S.R. 7 as shown in Figures 1 and 2. Originally there were


S-5A
S5A-E
N
C.A.-1
L-40
SUCROSE WEST
SUCROSE EAST
SUCROSE
APPLEBY GROVES
CALLERY JUDGE CANAL
MACARTHUR RD.
ACME DRAINAGE
C-51
BIG BLUE TRACE
FOREST HILL BLVD
SAMPLE SITES
WESTERN C-51
FIGURE 2
WELLINGTON RD.
S.R. 80
LEGEND
PERMITTEE PROPERTY
SAMPLE SIT
MILES
0
1
S.R. 7
US. 441

six stations but the Sucrose West station was added to provide a better record of quality upstream of the discharge and the Callery Judge Canal Station was added to account for effects due to other downstream discharges. These stations were sampled biweekly during the wet season and approximately monthly during the dry season.

Dissolved oxygen, temperature, specific conductivity and pH were measured at each station using a Hydrolab$^{(R)}$ Surveyor II. These measurements were made at the surface and at 1 meter intervals to the bottom of the canal.

Water samples for laboratory analyses were collected at approximately 1/2 meter below the surface.

Dissolved nutrient and major anion samples were preserved by filtration through 0.45 micron membrane filters. Samples for major cation and trace metal analysis were also filtered and preserved with concentrated nitric acid (2 drops/ 100 ml). Unfiltered aliquots of samples were collected for total nutrient analysis. All samples were stored on ice in polyethylene bottles. Laboratory analysis of the water samples was performed within one to two weeks following collection. Samples were stored in the laboratory at 4^{o} C in the dark.

The routine chemical analyses performed on each sample included the following parameters:

1. Dissolved nutrients (nitrate plus nitrite, nitrite, ammonia, ortho-phosphate, and total dissolved phosphate)
2. Total phosphorus, total Kjeldahl nitrogen and turbidity
3. Major cations and anions (calcium, magnesium, sodium, potassium, chloride and sulfate)
4. Alkalinity
5. Trace metals (copper)

The analytical chemistry methods used in this study were either recommended or approved by the Environmental Protection Agency or the American Public

Health Association. Most analyses were performed on either a Technicon Industrial Systems II AutoAnalyzer or a Perkin Elmer Model 107 Atomic Absorption Spectrophotometer. Trace metal analyses were performed on a Perkin Elmer Model 306 Atomic Absorption Spectrophotometer with a Perkin Elmer Heated Graphite Atomizer.

RESULTS AND EVALUATION

A summary of the water quality data of the permittee's discharge is shown in Table 1. All other basic data collected and utilized in the evaluation of the permittee's discharge is on file with the District. These data include all water chemistry data collected by the SFWMD,as well as, hydrologic data for the applicant's discharge and western C-51 basin.

Since the quantity and to some extent the quality of discharge is dependent upon rainfall, a summary of the 1976 rainfall at S-5A is shown in Figure 3. As a comparison to the study period conditions, the 20 year average of rainfall at S-5A is also shown. Total rainfall for 1976 (50 inches) appears to be somewhat below average (56 inches) but analyses of the 20 year period of record indicates that there were seven years in the last 20 during which rainfall was less than 1976, Thus the study year can be described as below normal but not an extremely dry year. Estimated total rainfall in the entire western C-51 basin as derived from 3 raingauges in the basin was 52 inches for 1976. Although this is somewhat greater than the rainfall recorded at S-5A it is still below average.

The applicant's daily discharge record is shown in Figure 4 and to some extent reflects the rainfall pattern. A maximum daily pumpage of slightly over 220 acre-feet occurred on August 5, 1976. Discharges frequently exceeded 100 acre-feet per day. The months of May through August appear to be the months of highest discharge although no data is available for January, November and December. August appeared to be the period of most intensive pumpage with over 50 acre-feet per day being pumped every day of the month. Total discharge recorded for the study period was just under 10,000 acre-feet.

It can be assumed that the applicant's pumpages for 1976 represent average values if rainfall conditions are considered to be the controlling factor.

TABLE 1. PERMITTEE DATA

Date	Total-N mg/l	Total Org.-N mg/l	Total Inorg.-N mg/l	NO_3-N mg/l	NO_2-N mg/l	NH_4-N mg/l	TPO_4-P mg/l	D.O. mg/l	Turbidity mg/l
1976									
February	4.67	0.25	4.40	1.70	0.120	2.60	0.05	-	3.0
March	1.58	0.26	1.32	0.80	0.022	0.50	0.07	6.1	4.8
April	-	-	-	-	-	-	-	-	-
May	3.63	0.30	3.33	0.70	0.026	2.60	0.045	2.8	17.00
June	5.64	2.25	3.39	0.80	0.041	2.55	0.025	3.4	3.2
July	5.36	1.95	3.41	0.75	0.010	2.65	0.030	6.3	6.9
August	5.07	1.85	3.22	0.80	0.025	2.40	0.100	3.8	3.6
September	-	-	-	-	-	-	-	-	-
October	2.13	1.45	0.68	0.40	0.034	0.25	0.010	7.4	3.5
November	4.38	2.20	2.18	0.70	0.134	1.35	0.050	7.7	6.0
December	-	-	-	-	-	-	-	-	-
1977									
January	5.27	2.20	3.07	0.85	0.120	2.10	0.025	7.6	6.3
February	5.16	1.70	3.46	0.60	0.057	2.80	0.025	7.8	1.5
March	4.30	2.35	1.95	1.00	0.154	0.80	0.050	6.2	2.3

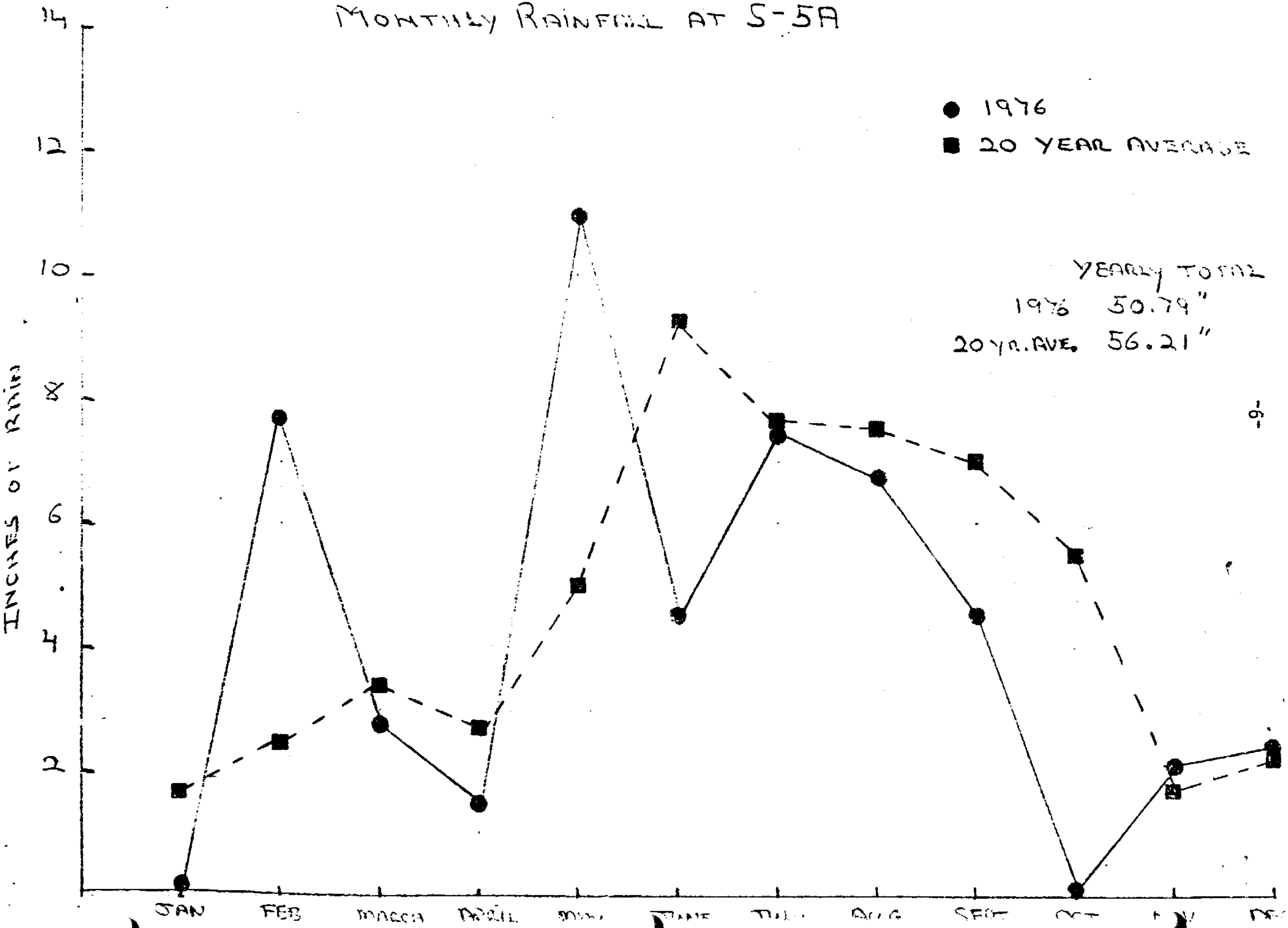
DIEL DATA

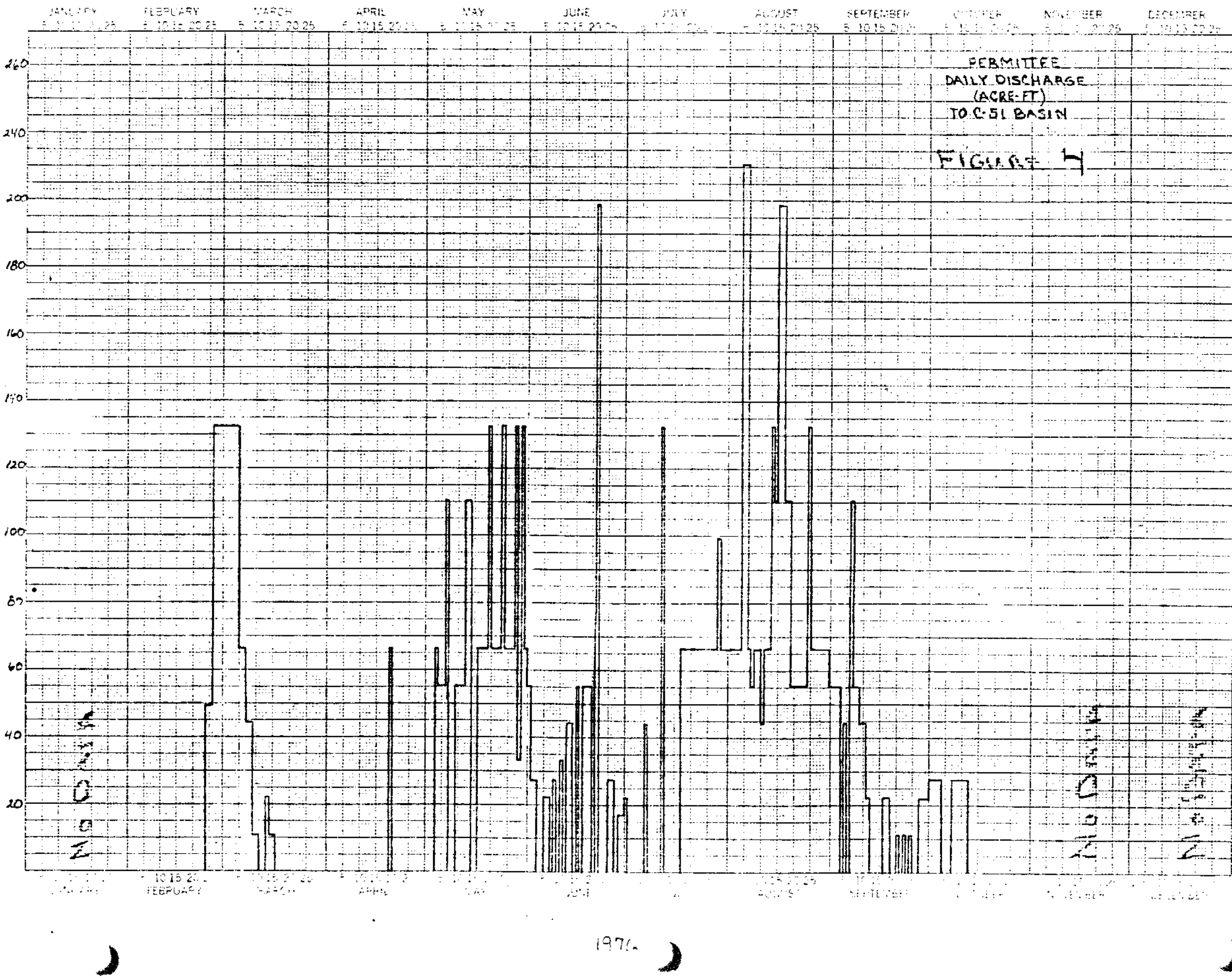
June 17-19, 1976

Time	Total-N mg/l	Total Org.-N mg/l	Total Inorg.-N mg/l	NO_3-N mg/l	NO_2-N mg/l	NH_4-N mg/l	TPO_4-P mg/l	D.O. mg/l	Turbidity mg/l
10:00	5.3	2.6	2.73	0.95	0.078	1.7			2.9
16:00	4.6	2.3	2.30	0.5	0.049	1.75			2.0
22:00	4.5	2.3	2.24	0.25	0.035	1.95			43
04:00	5.1	1.95	3.22	0.85	0.023	2.35			24
10:00	3.2	1.75	1.43	0.6	0.032	0.8			3.1
16:00	2.5	1.75	0.73	0.5	0.034	0.2			30
22:00	2.3	1.65	0.64	0.45	0.038	0.15			30
04:00	2.6	1.7	0.88	0.7	0.034	0.15			22

Pumps running approximately 6/17 08:00 to 6/17 18:00
and 6/18 08:00 to 6/18 18:00.

FIGURE 3
MONTHLY RAINFALL AT S-5A




PERMITTEE
DAILY DISCHARGE
(ACRE-FT)
TO C-51 BASIN
FIGURE 4
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
20
40
60
80
100
120
140
160
180
200
240
260
No Data
No Data
No Data
1976

However since the applicant's property is contiguous with Conservation Area 1 along L-40 there is a possibility that seepage from the Conservation Area into the applicant's property may be a significant factor in determining pumpage rates. Thus the water levels in the Conservaton Area rather than rainfall conditions may be the controlling factor on water management for the applicant. Unfortunately there are no quantitative data on seepage into the property to substantiate the seepage relationship. At any rate, the annual variations in seepage rates are likely to be less than variations in rainfall and thus the 1976 pumpages are probably typical of what can be expected in the future assuming the land use and management practices remain the same.

Since generalized statements on the water quality of both the permittee's effluent and the receiving water (C-51) will be discussed within the evaluation itself, no general statements on water quality will be made at this point.

Four basic criteria have been developed to evaluate the impact of the applicant's discharge on the water quality of the receiving waters. Briefly, these criteria are:

1. <u>Historical</u>

   This method uses water quality data collected on C-51 prior to the construction of the applicant's drainage system as a standard against which the data collected after construction and operation can be compared.

2. <u>State Standards</u>

   The appropriate Florida water quality standards are applied to the evaluation data to determine if violations occurred.

3. <u>Areal Comparison</u>

   This method is essentially an extension of number 2 above, but uses data for parameters for which there are no numeric standards. The evaluation consists of determining whether or not statistically significant changes in water quality values occurred, downstream of the applicant's discharge compared to values recorded upstream during the same time period.

4. Loading Comparisons

Estimates of total nitrogen and total phosphorus exports from the applicant's property were calculated and compared to loadings from the rest of the C-51 basin, S-5A drainage basin and a similar agricultural site.

Aside from the inherent limitation imposed on the evaluation due to the design of the study, there are a number of additional limitations placed on this evaluation. In an effort to reduce the length and complexity of the evaluation most of the evaluation has been limited to "wet season" (June to October) data. It was felt that if any significant impacts were occurring they would be most evident during periods of greatest discharge. As indicated in the introduction, The West Palm Beach Canal is a major drainage artery and has a large number of secondary drainage system connections. Since a detailed analyses of the complex mixing characteristics which must exist in such a system has not been performed there have been a number of simplifying assumptions made concerning the physical characteristics of the canal. Finally this study and other studies of Florida's east coast canals indicate that the quality characteristics of the systems are highly transitory during active periods. That is, when the canals are functioning as drainage system, the time during which any water mass is in the canal can be very short (<24 hours) due to the limited storage capacity of the canal. Since the sampling program consisted of grab samples rather than integrated samples, the water chemistry data may represent only very limited examples of the range of conditions that might exist in the system.

Historical Comparisons

A study of the water quality in the western reach of C-51 between State

TABLE 2. HISTORICAL COMPARISON

	S-5A		MacArthur Rd.		State Road 7	
Parameter	1974	1976	1974	1976	1974	1976
D.O.	3.1	2.9	2.3	2.6	2.5	2.3
pH	7.16	6.90	7.11	7.07	7.32	7.18
Sp. Cond.	648	715	600	1092	513	749
Turb.	2.8	6.2	6.7	8.9	8.1	4.8
Inorg N	0.61	1.18	0.45	1.03	0.41	0.73
Total N	2.84	2.98	2.49	2.87	1.72	2.25
$O-PO_4$	0.062	0.040	0.066	0.046	0.051	0.048
Total P	0.084	0.060	0.095	0.065	0.094	0.064
Na	59.8	109.1	60.8	134.1	39.4	91.6
Ca	53.5	69.9	65.1	99.8	67.6	94.1
Cl	91.1	141.9	99.0	221.1	75.2	127.5
Alk	3.32	5.38	3.71	7.47	3.84	6.66

Road 7 and S-5A was conducted in 1974 by the District. Three of the four sampling sites in that study were identical to sites used in this evaluation. Also the frequency of sampling, methods of sampling, and laboratory methods of analyses were nearly identical in the two studies. Since the 1974 data were collected prior to the construction and operation of the drainage system in question, a comparison of the two data sets may indicate the nature and degree of impact by the new discharges on the C-51 receiving waters.

Table 2 is a summary of mean wet season values of selected parameters measured in the 1974 and 1976 studies at the three common stations. For both years the means were calculated from approximately 10 - 12 surface grab samples collected at biweekly intervals between June and October. In comparing the data in Table 2 it is important to remember that the S-5A station is upstream of the permittee's discharge while the MacArthur Road Station is about 2 miles downstream and the State Road 7 site is about 8 miles downstream. The S-5A station is especially critical since it represents a control station for comparisons in that it should reflect only temperal changes in water quality from 1974 to 1976. The station downstream of the discharge will reflect both overall temporal changes and possible effects due to the additional discharges.

Casual inspection of the data in Table 2 indicate that there has been an apparent change in water quality in C-51 from 1974 to 1976. At all three stations nitrogen concentrations, especially inorganic nitrogen, have increased. Conversely, phosphorus concentrations show a decrease at all three stations with the principal decrease being in the ortho-phosphorus species. The specific conductivity and the major inorganic ions sodium, chloride, calcium and alkalinity have apparently increased from 1974 to 1976 at all three stations. However, the MacArthur Road stations show a much greater increase in these parameters than the other two stations.

In an effort to determine whether the apparent effects on water chemistry (Table 2) are due to the existence of the new discharge or to time, analysis of variance techniques (ANOVA) were employed. The statistical testing was carried out using two analysis of variance models with subsequent testing of the error terms (residuals) to determine which model accounted for the data the best. Model I was a simple two-way ANOVA of station and year which accounted for differences between stations without regard to year and differences between years without regard to stations. Model II was a three-way ANOVA combining Model I with an additional factor to account for the new discharge.

The results of these statistical tests indicated that at the 95% confidence level there were no significant effects on any water quality parameters attributable to the permittee's discharge. The significance of the statistical analyses is of course governed by the laws of statistics rather than the principles of environmental sciences. Therefore, the lack of statistically significant differences between 1974 and 1976 data at the downstream stations should not automatically be considered a test for environmentally significant impact.

State Standards

Chapter 17-3 of the Florida Administrative Code provides numerical water quality criteria for waters of the state. Specifically Sections 3.02 and 3.03 describe minimum conditions of all waters at all times and Section 3.09 contains the criteria for Class III Waters (recreation-propogation and management of fish and wildlife) which is the classification of the West Palm Beach Canal. Most of the Florida Standards are receiving water standards which stipulate that an effluent may not cause a specifically stated change in the receiving waters after a "reasonable opportunity for mixing" has been allowed. In the evaluation of this discharge, it was assumed that the Appleby Groves Station which is one mile downstream of the applicant's discharge provided sufficient mixing opportunity.

Precedent or ambient conditions were considered to be represented by the data collected at the two stations upstream of the discharge (S-5A and Sucrose-West). The station just downstream of the discharge (Sucrose-East) can be considered as representative of the discharge itself although discharge was actually observed only 3 times during the sampling program. Water quality data were not collected for all the parameters for which there are numerical standards since some parameters were not pertinent to this evaluation.

Chloride

The maximum allowable chloride value for all fresh waters is 250 mg/l. Table 3 is a summary of the chloride values by month at each station. The summary is limited to the wet season months (June to October). The data indicate that greater than 250 mg/l chloride values occurred downstream of the applicant's discharge during the months of May and October. Since no data were collected at the Sucrose W station just upstream of the discharge in May it is not known if these high values were also occurring above the discharge. Only one chloride value for each station was measured in October except at the Sucrose East station. Although the value at Appleby Groves is definitely above 250 mg/l the value just downstream of the discharge (Sucrose East) is much lower and very similar to the values upstream of the discharge. It appears therefore that the source of the high chlorides may be between the applicant's discharge and the Appleby Groves stations. It should also be noted that there was very little discharge by the applicant during October. As pointed out earlier August was the month of highest discharge and Table 3 indicates that chloride values along the entire canal were highly variable. Maximum recorded chloride values exceeded 250 mg/l at all stations both upstream and downstream of the applicant's discharge except at the U.S. 441 station which is almost 10 miles downstream of the discharge. For all other months chloride concentration at all stations were generally between 100 and 200 mg/l.

Specific Conductivity

The maximum allowable specific conductivity for all fresh waters is 500 micromhos per centimeter (μmhos/cm). Table 4 is a summary of specific conductivity data for C-51 similar to the chloride data in Table 3. As can be seen from the table, specific conductivities were generally greater than 500 μmhos both above and below the applicant's discharge during the months from May to October. There were several months (June, July, and October) during which large increases in specific conductivity were recorded just downstream of the applicant's discharge at Station Sucrose East but maximum conductivity values tended to occur further downstream at the Appleby Groves Station. This is consistent with the chloride data that indicated a source of high conductivity water between the Sucrose East and Appleby Grove stations.

Copper

The concentration of copper is not to exceed 0.50 mg/l (500 micrograms per liter) for all waters at all times. Since copper is often applied as a micronutrient in South Florida this parameter was monitored during the evaluation. Table 5 is a summary of the copper data measured at each station during the June to October period. It should be noted that all the values are in micrograms per liter (μg/l). It is obvious from the table that only very trace amounts of copper exist in the C-51 basin and that all stations recorded values well below the maximum State standard of 500 μg/l.

Turbidity

For Class III waters turbidity values may not increase more than 50 Jackson units (JTU) above background. Table 6 is a summary of the turbidity values recorded in C-51 between June and October. As can be seen from the table there were no values above 50 JTU at any station at any time. The highest turbidity value recorded in C-51 was 39.0 JTU at the Callery Judge Canal Station in July.

The applicant's discharge was intensively monitored during June and recorded a high value of 43.0 JTU. Generally the turbidity values in C-51 were below 20 JTU and many values were even below 10 JTU.

pH

For Class III waters the pH should not be below 6.0 nor above 8.5 pH units. In addition no effluent should cause a change of more than 1.0 pH units from the ambient value. Table 7 is a summary of the pH values in C-51 similar to the previous summary tables. The summary table indicates although there was some variation in pH from month to month at all stations there was very little change in pH along the canal during any specific month. A pH of 5.8 was recorded at the S-5AE station in July but otherwise all values were between 6.3 and 7.8 and there were no changes of more than 1.0 pH unit attributable to the applicant's discharge.

Dissolved Oxygen

For Class III waters the dissolved oxygen concentration should not average less than 5.0 mg/l and no single value should be less than 4.0 mg/l within a 24 hour period. Figure 5 is a summary of the average dissolved oxygen values recorded at each station in C-51 between June and October. Also shown in the figure are the maximum and minimum values recorded at each station. It is obvious from the figure that every station along the West Palm Beach Canal fails to meet the dissolved oxygen criteria for Class III waters. The average dissolved oxygen value at all stations was between 2.5 and 3.5 mg/l. The minimum values recorded were in all cases close to 1.0 mg/l while maximum values were as high as 8.4 (Callery Judge Canal Station) and exceed 4.0 mg/l at all stations except the U.S. 441 station. It should be pointed out that these values are six month averages rather than 24 hour averages as stipulated in the Rule but analyses of individual values does not significantly change the conclusions evident in Figure 5. It should be pointed out that the dissolved oxygen concentrations

TABLE 3

AVERAGE CHLORIDE (MG/L) AND RANGE

1976	May	June	July	August	September	October
S-5AE	*142.8 121.5-164.1	70.0 70.0-70.0	88.3 86.7-90.9	186.6 72.3-269.8	117.6 45.1-190.0	234.6 234.6-234.6
Sucrose-West	-	86.0 86.0-86.0	89.2 88.9-89.4	192.1 74.9-257.2	109.6 28.2-191.0	244.8 244.8-244.8
Sucrose-East	281.7 269.2-294.1	135.3 135.3-135.3	118.7 90.4-147.0	202.1 100.7-272.2	117.5 44.5-190.4	249.9 248.7-251.1
Appleby Groves	282.6 242.1-323.1	205.7 205.7-205.7	111.4 92.2-130.5	231.9 163.8-280.3	71.7 71.7-71.7	410.7 410.7-410.7
Callery Judge Canal	166.3 93.2-242.1	-	106.7 96.0-117.4	203.8 83.2-267.5	66.2 66.2-66.2	459.2 459.2-459.2
MacArthur Dairy Rd.	201.4 182.2-220.5	162.6 162.6-162.6	145.7 96.0-195.4	252.8 198.3-295.1	120.3 85.6-155.0	446.7 446.7-446.7
Forest Hill Blvd.	152.6 150.3-154.9	142.2 142.2-142.2	119.9 92.5-147.2	239.7 185.6-274.6	120.7 87.0-154.4	233.1 233.1-233.1
US 441	117.8 108.8-126.7	95.3 95.3-95.3	77.8 74.3-81.2	179.7 107.6-228.8	113.0 77.2-148.7	132.1 132.1-132.1

* Average
Min. - Max.

TABLE 4

AVERAGE SPECIFIC CONDUCTIVITY (μmhos/cm^2)

1976	May	June	July	August	September	October
S-5AE	*860 840-880	600 600-600	634 600-650	848 380-1300	450 260-640	1400 1300-1500
Sucrose-West	-	695 695-695	678 645-800	1400 600-2000	485 310-660	1175 1150-1200
Sucrose-East	1100 1000-1200	1000 1000-1000	1158 650-2300	1105 700-1800	515 370-660	1560 1500-1800
Appleby Groves	1700 1700-1700	1200 1200-1200	786 670-900	1140 800-1300	480 480-480	2200 2000-2400
Callery Judge Canal	1350 1300-1400	-	813 705-1000	1233 900-1500	620 620-620	2033 1600-2300
MacArthur Dairy Rd.	1175 1150-1200	1150 1150-1150	1071 725-1300	1233 1100-1300	580 550-610	2033 2000-2100
Forest Hill Blvd.	990 990-990	1000 1000-1000	820 730-1000	1288 1100-1400	585 550-620	1400 1400-1400
US 441	850 850-850	830 830-830	708 670-760	1000 600-1250	550 510-590	933 900-1000

* Average
Min.-Max.

TABLE 5

AVERAGE COPPER CONCENTRATION (μgms/1)

1976	June	July	August	September	October
S-5AE	3.5 3.5-3.5	0.8 0.6-1.2	1.3 < 0.6-2.1	2.1 1.6-2.6	1.7 1.7-1.7
Sucrose-West	2.9 2.9-2.9	0.8 0.8-0.8	< 0.6 < 0.6-<0.6	3.0 < 0.6-5.5	2.4 2.4-2.4
Sucrose-East	-	1.0 1.0-1.0	0.6 < 0.6-1.0	1.2 < 0.6-3.3	< 0.6 < 0.6-<0.6
Appleby Groves	1.5 1.5-1.5	1.0 1.0-1.0	< 0.6 < 0.6-<0.6	< 0.6 < 0.6-<0.6	0.7 0.7-0.7
Callery Judge Canal	-	0.8 0.8-0.8	< 0.6 < 0.6-<0.6	1.8 1.8-1.8	0.8 0.8-0.8
MacArthur Dairy Rd.	3.1 3.1-3.1	1.1 1.1-1.1	< 0.6 < 0.6-<0.6	1.0 < 0.6-1.3	< 0.6 < 0.6-<0.6
Forest Hill Blvd.	2.4 2.4-2.4	0.8 0.8-0.8	< 0.6 < 0.6-<0.6	3.0 < 0.6-5.5	< 0.6 < 0.6-<0.6
US 441	4.2 4.2-4.2	0.6 0.6-0.6	1.3 < 0.6-2.5	2.4 2.4-2.4	< 0.6 < 0.6-<0.6

*Average
Min. - Max.

TABLE 6

AVERAGE TURBIDITY (JTU) AND RANGE

1976	May	June	July	Aug.	Sept.	Oct.
S5AE	* 6.4 6.4-6.4	15.1 15.1-15.1	12.7 5.7-15.1	4.9 3.1-5.8	4.5 3.2-5.7	1.8 1.8-1.8
Sucrose -West		7.2 7.2-7.2	9.6 3.9-15.2	4.1 1.8-5.6	2.9 1.8-3.9	3.9 3.9-3.9
Sucrose Discharge	17.0	17.8 2.0-43.0	6.9	3.6	-	3.5
Sucrose-East	7.5 7.5-7.5	10.0 10.0-10.0	8.4 2.2-14.5	2.8 2.1-3.4	3.4 1.7-4.4	1.6 1.6-1.7
Appleby Groves	11.0 10.0-11.0	6.3 6.3-6.3	5.1 3.0-8.6	3.5 2.6-4.2	1.6 1.6-1.6	1.4 1.4-1.4
Callery Judge Canal	11.5 11.0-12.0	-	23.4 7.8-39.0	5.0 3.2-8.2	5.6 5.6-5.6	2.2 2.2-2.2
MacArthur Dairy Rd.	27.5 27.5-27.5	17.0 17.0-17.0	5.7 1.2-10.1	8.0 2.8-17.0	15.0 15.0-15.0	3.7 3.7-3.7
Forest Hill Blvd.	11.0 11.0-11.0	10.0 10.0-10.0	4.8 2.3-7.2	3.5 2.5-4.7	8.9 3.8-14.0	2.6 2.6-2.6
U.S. 441	5.6 5.6-5.6	10.2 10.2-10.2	3.0 2.1-3.8	2.8 2.2-3.2	7.7 3.3-12.0	3.3 3.3-3.3

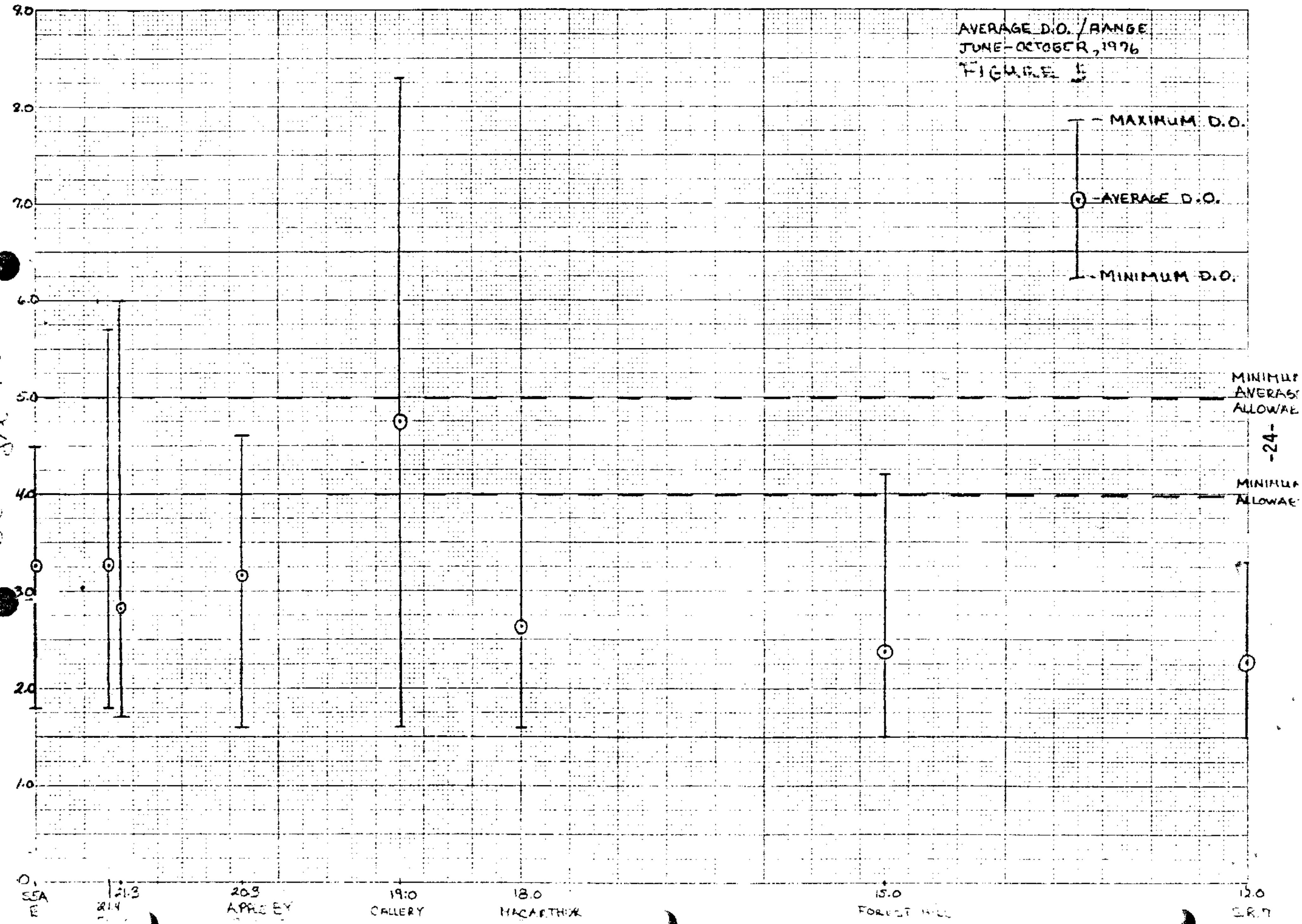
* Average
Min. - Max.

TABLE 7

AVERAGE pH AND RANGE

1976	May	June	July	August	September	October
S-5AE	*7.35 7.1-7.5	7.10 7.1-7.1	7.0 5.8-7.6	6.8 6.7-6.9	6.95 6.7-7.2	-
Sucrose-West	-	7.10 7.1-7.1	7.20 6.2-7.8	6.6 6.6-6.6	7.00 6.8-7.2	-
Sucrose-East	7.20 7.1-7.3	7.10 7.1-7.1	7.41 7.0-7.75	6.48 6.4-6.5	7.00 6.8-7.2	-
Appleby Groves	7.10 7.0-7.2	7.00 7.0-7.0	7.50 7.3-7.7	6.25 6.2-6.3	6.80 6.8-6.8	-
Callery Judge Canal	7.20 7.1-7.3	-	7.66 7.4-7.8	6.37 6.3-6.4	7.00 7.0-7.0	-
MacArthur Dairy Rd.	7.48 7.2-7.8	7.10 7.1-7.1	7.46 7.3-7.7	6.30 6.3-6.3	7.00 6.9-7.1	-
Forest Hill Blvd.	7.43 7.2-7.8	7.10 7.1-7.1	7.53 7.2-7.7	-	6.95 6.8-7.1	-
US 441	7.43 7.3-7.6	7.10 7.1-7.1	7.40 7.2-7.6	-	7.00 6.9-7.1	-

* Average
Min. - Max.



AVERAGE D.O. / RANGE
JUNE-OCTOBER, 1976
FIGURE 5
- MAXIMUM D.O.
- AVERAGE D.O.
- MINIMUM D.O.
MINIMUM AVERAGE ALLOWABLE
MINIMUM ALLOWABLE
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
18.0
15.0
12.0

in the permittee's effluent was often well above 5.0 mg/l.

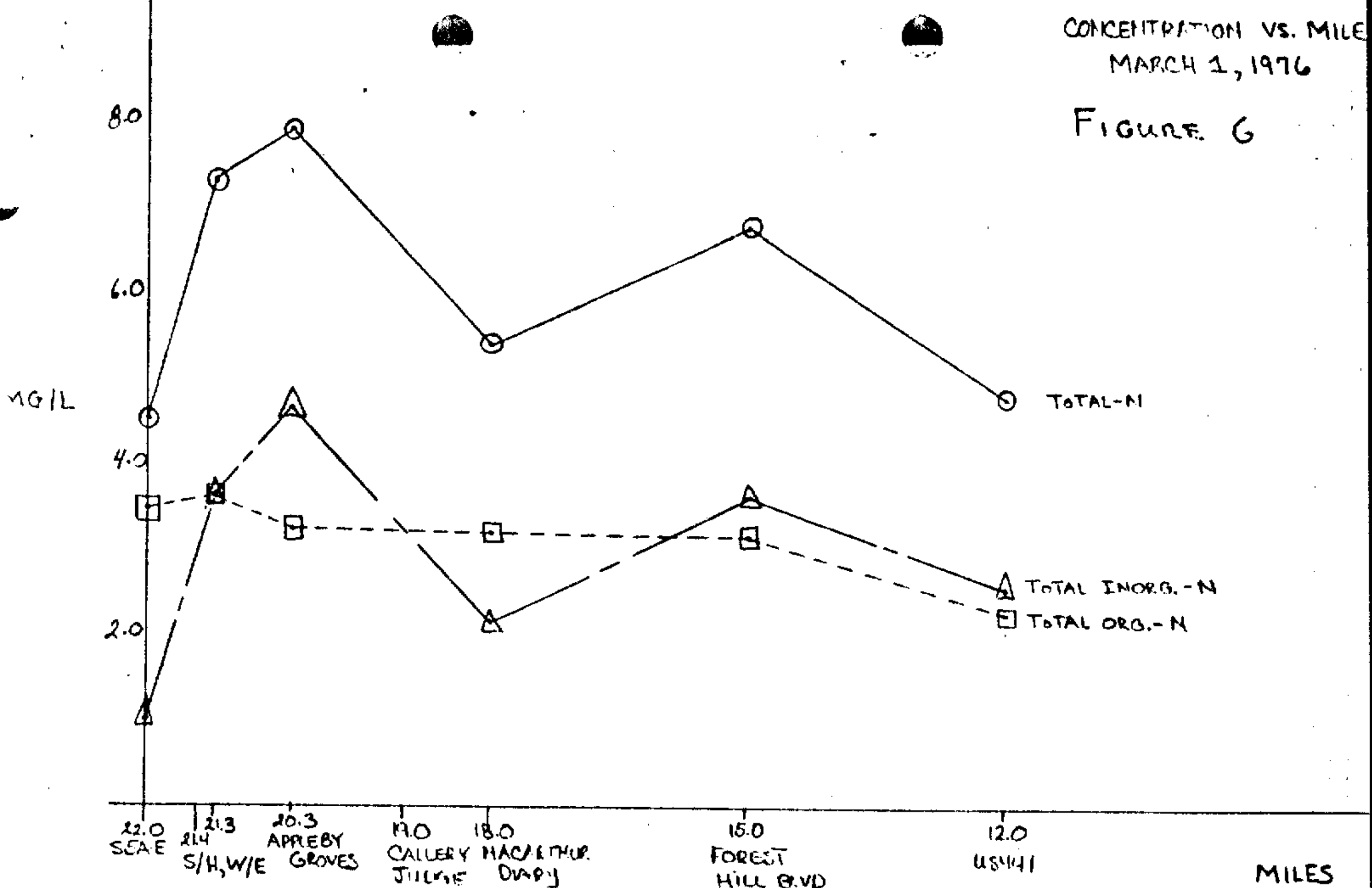
Area Analyses

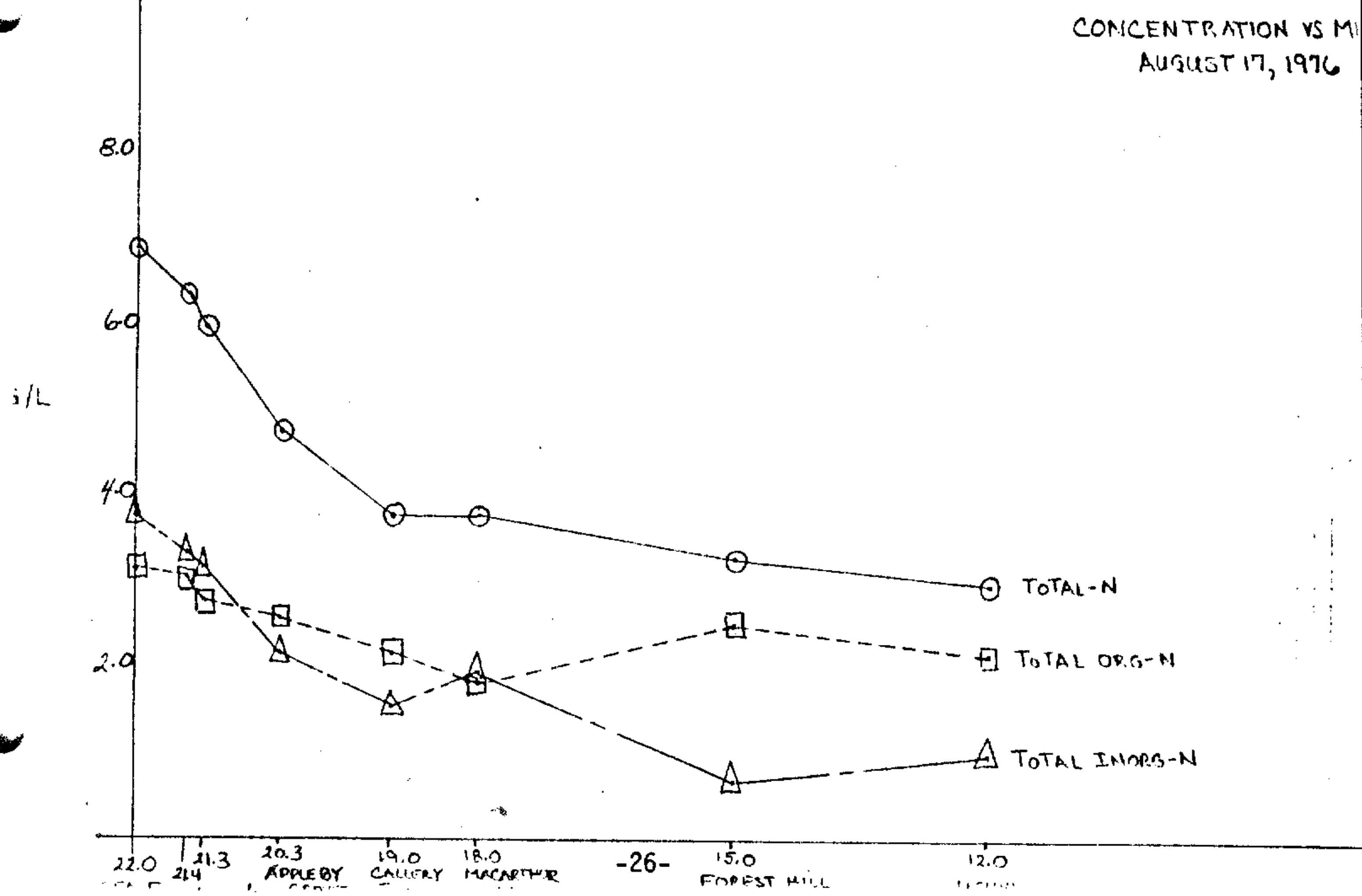
One obvious way to evaluate the impact of a discharge on a receiving stream is to compare the upstream quality to the downstream quality. This is essentially what was done in applying the state standards in the previous section. Unfortunately there are no standards for many water quality parameters including the major nutrients, phosphorus and nitrogen. Evaluation of impact on the receiving waters based on these parameters is, therefore, a value judgement. In the evaluation of this particular discharge three approaches have been used.

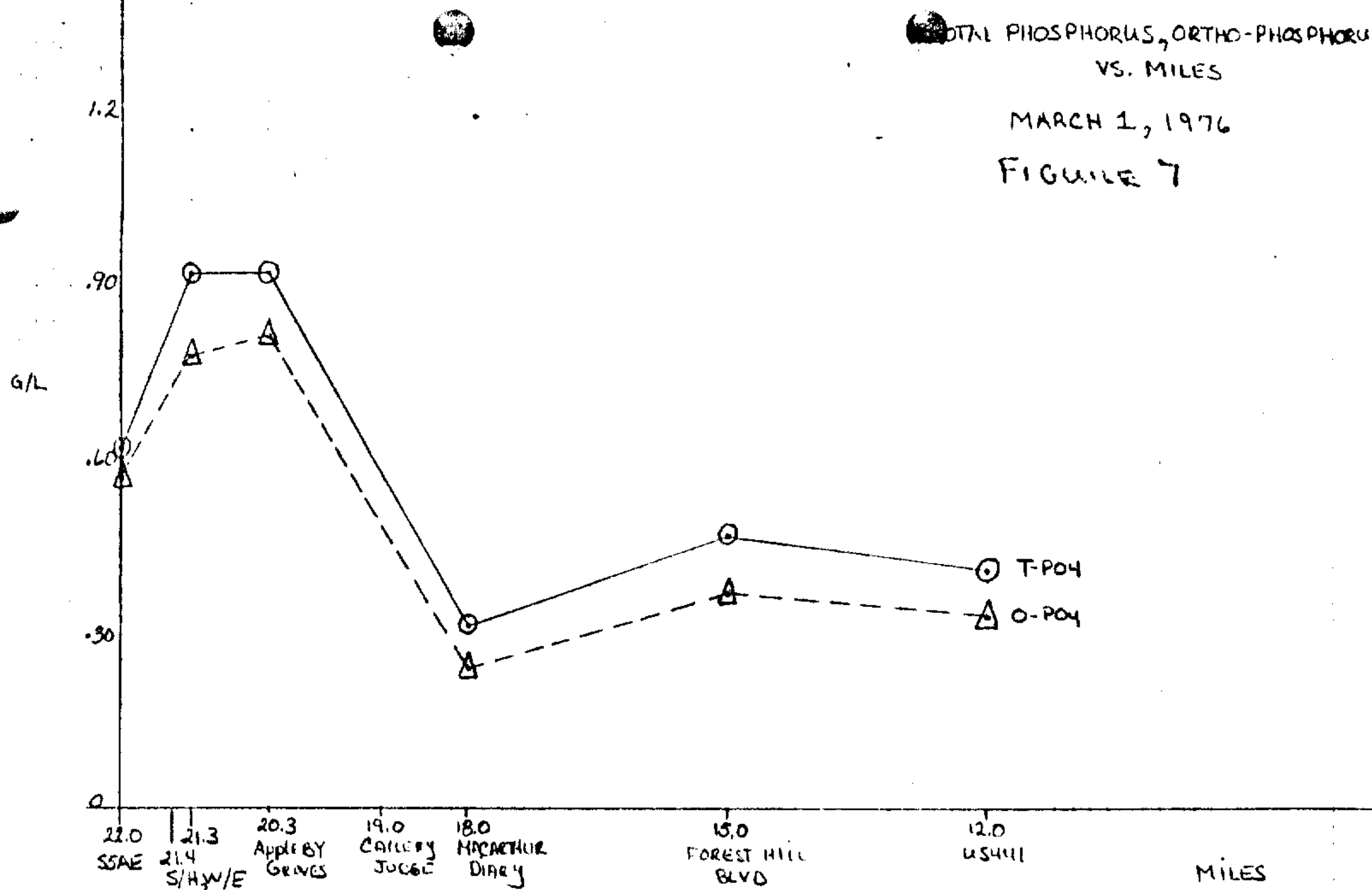
1. Specific cases
2. Seasonal cases
3. Statistical analyses

Two examples of the distribution of nitrogen, phosphorus and chloride in C-51 are shown in Figures 6, 7 and 8 respectively. The two cases are represented by the March 1, 1976 and August 17, 1976 data. The March data represents an isolated mid-spring discharge event of several days duration (February 24 to March 1). This discharge was the result of an unusual rainfall event and/or is associated with the initial drainage of the property. The August data represents a more typical wet season discharge since daily pumping had been occurring for 31 straight days prior to the sampling.

The apparent impact of these discharges on the canal was considerably different. There was substantial increase in nitrogen and phosphorus values downstream of the permittee's discharge during the March event. However there was little or no impact on the chloride values. During August the trend is almost exactly opposite. The nitrogen and phosphorus values appear to decrease downstream of the permittee's discharge while chloride values are higher. As pointed out earlier the increased chloride may be due to an unidentified source between the Sucrose East and Appleby Groves stations.


CONCENTRATION VS. MILE
MARCH 1, 1976
FIGURE 6
MG/L
8.0
6.0
4.0
2.0
TOTAL-N
TOTAL INORG.-N
TOTAL ORG.-N
22.0
SEA-E
21.4
21.3
S/H, W/E
20.3
APPLEBY
GROVES
19.0
CALLERY
JUDGE
18.0
MACARTHUR
DAIRY
15.0
FOREST
HILL BLVD
12.0
US441
MILES


CONCENTRATION VS MI
AUGUST 17, 1976
8.0
6.0
4.0
2.0
TOTAL-N
TOTAL ORG-N
TOTAL INORG-N
22.0
21.4
21.3
20.3
APPLEBY
19.0
CALLERY
18.0
MACARTHUR
15.0
FOREST HILL
12.0


TOTAL PHOSPHORUS, ORTHO-PHOSPHORUS
VS. MILES
MARCH 1, 1976
FIGURE 7
G/L
1.2
.90
.60
.30
0
T-PO4
O-PO4
22.0
SSAE
21.4
21.3
S/HW/E
20.3
APPLEBY
GROVES
19.0
CALLERY
JUDGE
18.0
MACARTHUR
DAIRY
15.0
FOREST HILL
BLVD
12.0
US441
MILES

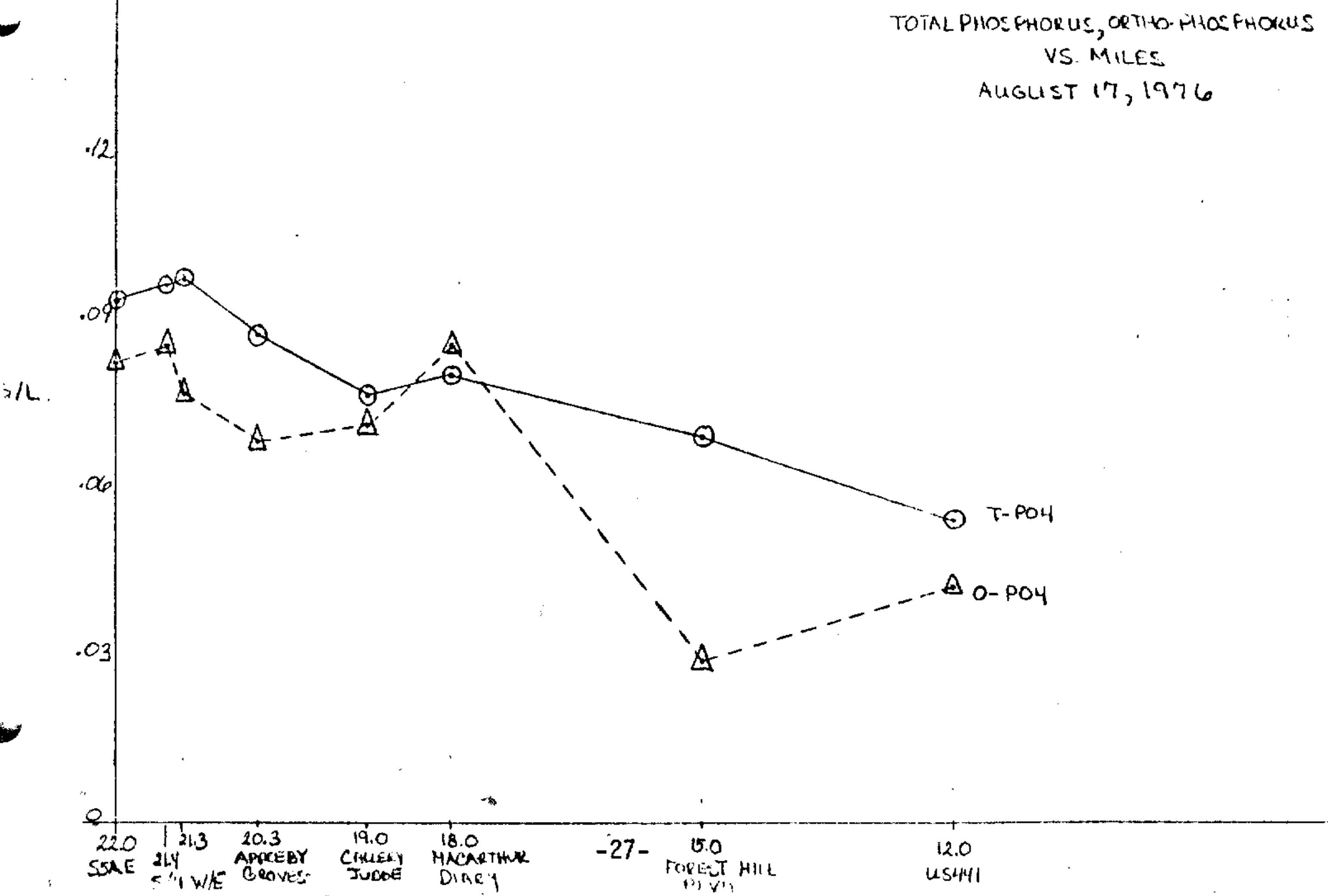
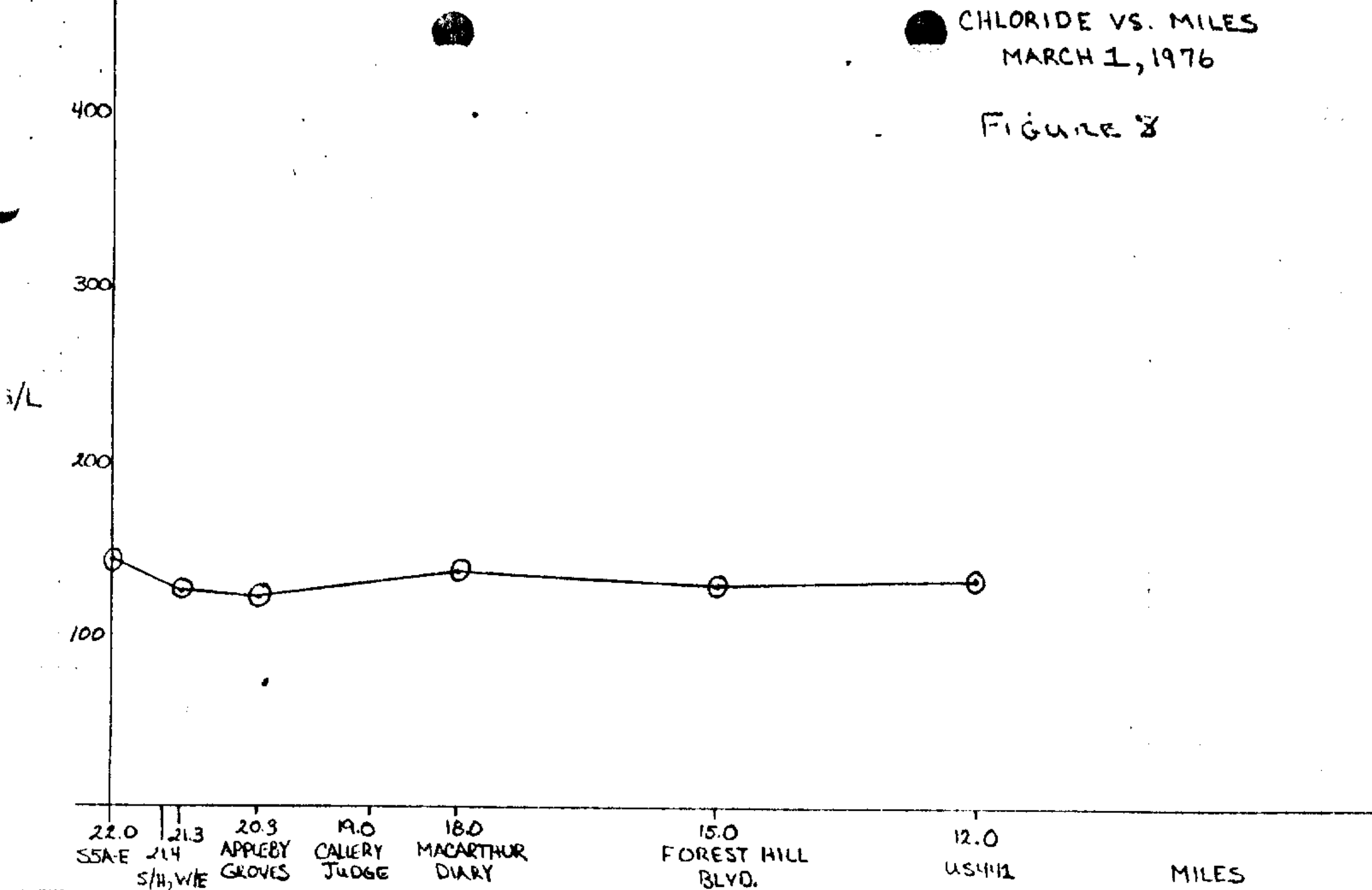
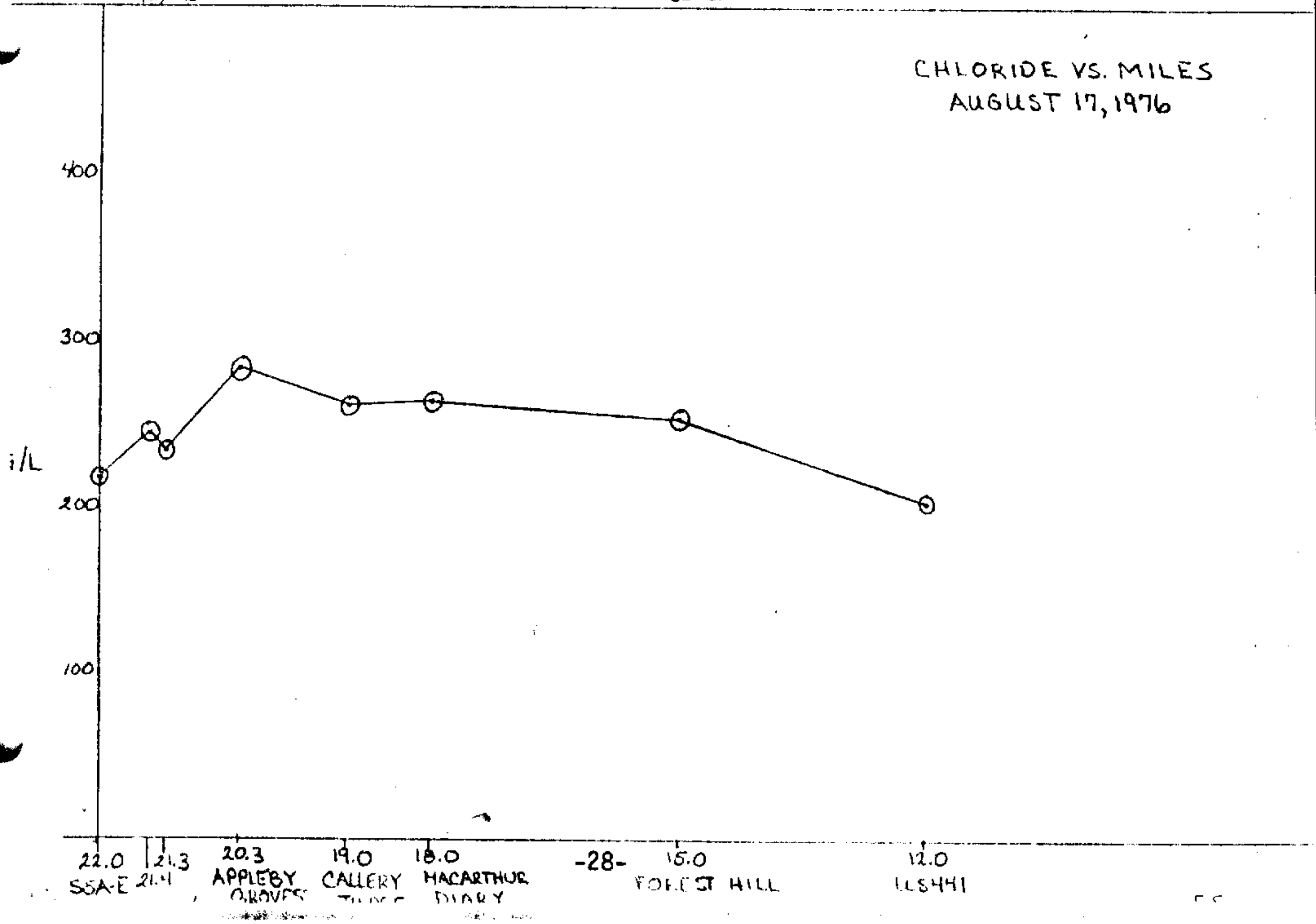

TOTAL PHOSPHORUS, ORTHO-PHOSPHORUS
VS. MILES
AUGUST 17, 1976
G/L.
.12
.09
.06
.03
0
T-PO4
O-PO4
22.0
SSAE
21.4
21.3
S/HW/E
20.3
APPLEBY
GROVES
19.0
CALLERY
JUDGE
18.0
MACARTHUR
DAIRY
15.0
FOREST HILL
12.0
US441

Figure 8



CHLORIDE VS. MILES
MARCH 1, 1976
400
300
200
100
/L
22.0 S5A-E
21.4 S/H, W/E
21.3
20.3 APPLEBY GROVES
19.0 CALLERY JUDGE
18.0 MACARTHUR DIARY
15.0 FOREST HILL BLVD.
12.0 US441
MILES



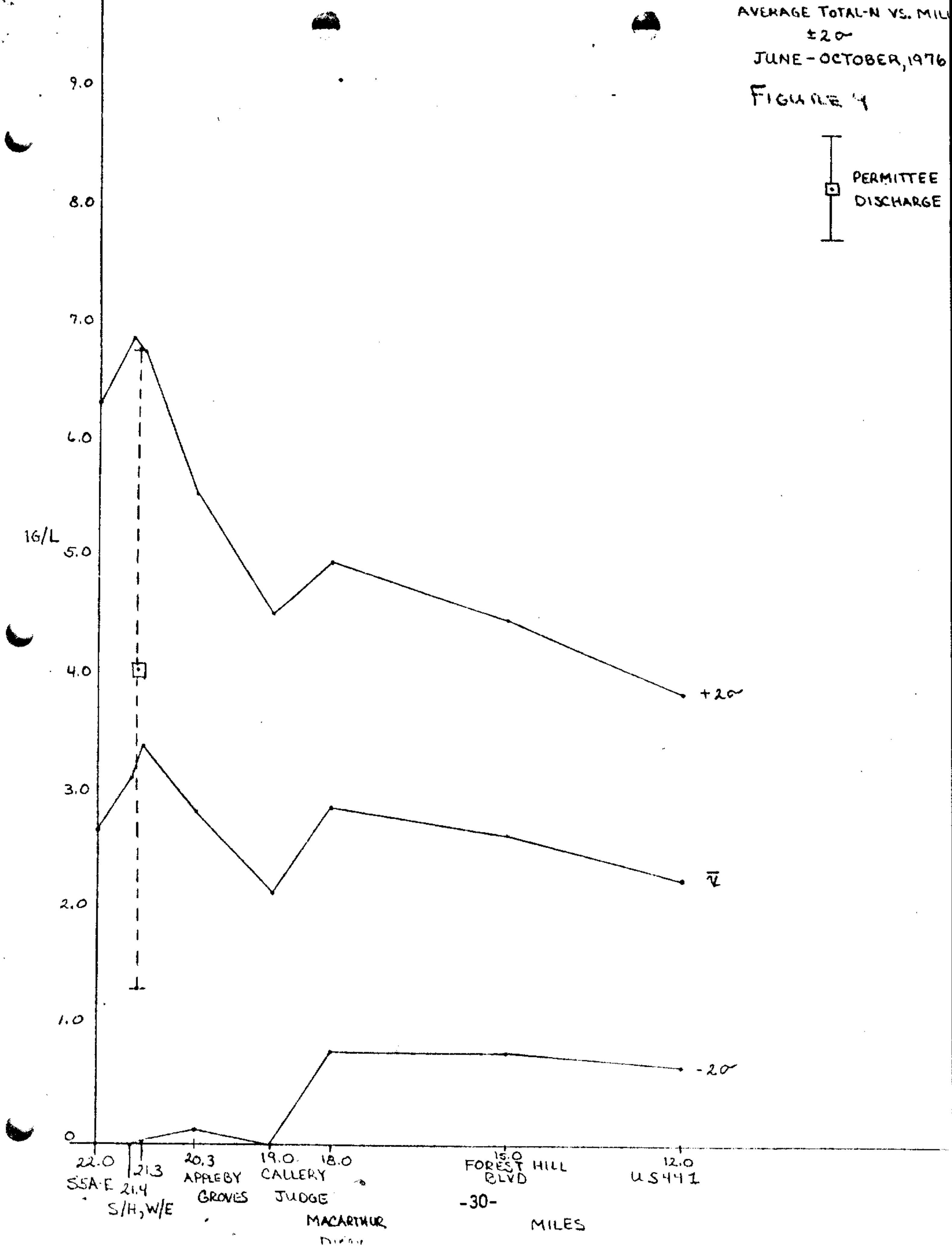
CHLORIDE VS. MILES
AUGUST 17, 1976
400
300
200
100
/L
22.0 S5A-E
21.4
21.3
20.3 APPLEBY
19.0 CALLERY
18.0 MACARTHUR
15.0 FOREST HILL
12.0 US441

Figures 9 and 10 illustrate the distribution of the average wet season (June to October) values of total nitrogen and total phosphorus along the western reach of C-51. The variability of the data at each station is indicated by also plotting two standard deviation of the means. The relationship of the permittee's discharge to the instream values is given by including the mean value and two standard deviations of the permittee's effluent as measured during the same time period.

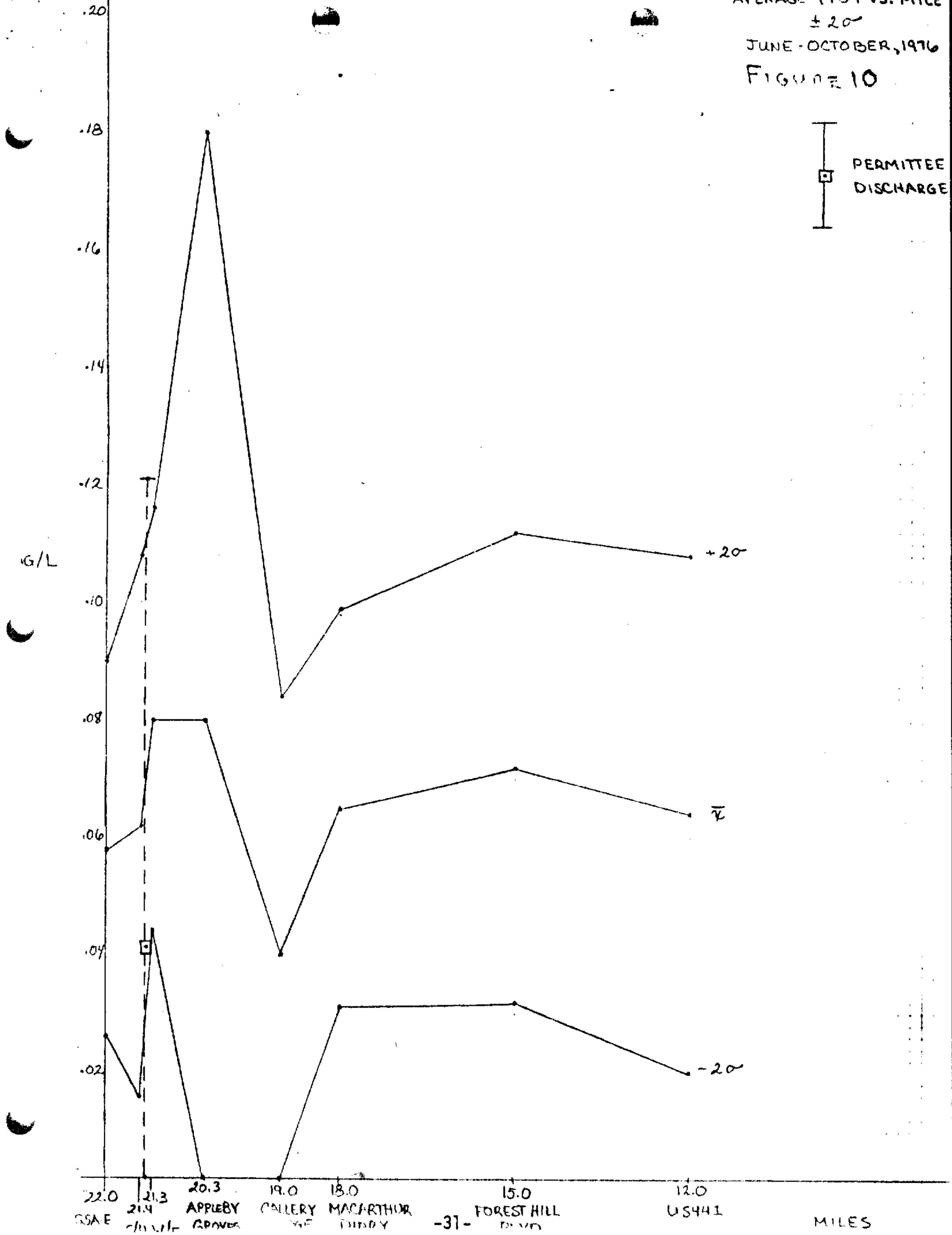
These plots illustrate some of the difficulties encountered in evaluating this discharge. Although the mean total phosphorus values in C-51 show a substantial increase just downstream of the permittee's discharge (station Sucrose East), the mean total phosphorus concentration of the effluent is considerably below the instream values both upstream and downstream of the discharge. On the other hand, the mean total nitrogen concentrations show only a minor increase downstream of the discharge, but the effluent concentrations are substantially higher than all instream values. The fact that the effluent and instream samples were not collected simultaneously may account for this apparent discrepancy.

In general the plots indicate that there is considerable variability in the western third of the basin (S-5AE to Callery Judge Canal) while the eastern two-thirds (MacArthur Dairy to U.S. 441) is more stable. Since the western third of the basin is the critical area for assessing impact of the permittee's discharge, the variability of the data is that area makes evaluation difficult.

The third method of evaluating the discharge by comparing upstream and downstream data employs statistical analyses of the differences between upstream and downstream samples. The upstream values were taken from Station S-5AE and Sucrose West. Downstream values were derived from stations Sucrose East and Appleby Groves. Data collected at these stations from June through October was then subjected to a one-way analysis of variance to test for significant upstream/downstream differences. Upstream and downstream means for all parameters



AVERAGE TOTAL-N VS. MIL
±2σ
JUNE-OCTOBER, 1976
FIGURE 4
PERMITTEE DISCHARGE
9.0
8.0
7.0
6.0
MG/L
5.0
4.0
3.0
2.0
1.0
0
+2σ
x̄
-2σ
22.0
SSA-E
21.4
21.3
S/H, W/E
20.3
APPLEBY GROVES
19.0
CALLERY JUDGE
18.0
MACARTHUR
15.0
FOREST HILL BLVD
12.0
US441
MILES



AVERAGE ... VS. MILE
± 2σ
JUNE-OCTOBER, 1976
FIGURE 10
PERMITTEE DISCHARGE
.20
.18
.16
.14
.12
G/L
.10
.08
.06
.04
.02
+2σ
x̄
-2σ
22.0
21.4
21.3
20.3
APPLEBY GROVES
19.0
18.0
MACARTHUR
15.0
FOREST HILL
12.0
US441
MILES

tested as well as the results of the tests are listed in Table 8.

As can be seen from the Table only four parameters, total phosphorus, conductivity, turbidity and copper were found to have statistically significant differences. Of these four turbidity and copper actually have lower values downstream of the discharge. As was mentioned earlier in the section on historical comparisons, the significance of these differences is based on statistical rather than environmental principles. Thus it is important to point out that although the differences were not statistically significant all nitrogen parameters did have higher mean concentrations below the discharge than above it.

Loading Analysis

One of the more common concerns regarding nonpoint source agricultural runoff is the rate at which basic nutrients (nitrogen and phosphorus) are transported by drainage water from the site into a receiving body of water. From the perspective of the receiving water, this process is regarded as a nutrient addition or "load" to the receiving stream, lake, etc. The rates at which lakes can safely assimilate nutrients has received intensive study and critical loading rate values have been established. However, the "safe" loading rates to streams (canals), wetlands and estuaries are an area of great uncertainty and no critical values have been established.

There has been a considerable amount of interest in the mechanism by which nonpoint sources generate their nutrient loads. These studies have indicated that land use, soil type, drainage system design and rainfall patterns all influence the export of nutrients by nonpoint sources. The loading analyses attempted in this evaluation are a simple comparison of mass, areal and volumetric loading rates for total nitrogen and total phosphorus from various related basins. Since the receiving waters associated with these basins are either canals, wetlands or estuaries only relative comparison can be made.

TABLE 8. UPSTREAM/DOWNSTREAM CONTRASTS

Parameter	Upstream	Downstream	Significance (95% Confidence)
Total Phosphorus	0.06 m6/l	0.08 mg/l	Yes
Ortho-Phosphorus	0.03 mg/l	0.04 mg/l	No
Total Nitrogen	2.89 mg/l	3.16 mg/l	No
NO_x	0.78 mg/l	0.80 mg/l	No
NH_4	0.30 mg/l	0.38 mg/l	No
Inorganic Nitrogen	1.08 mg/l	1.17 mg/l	No
Organic Nitrogen	1.89 mg/l	2.17 mg/l	No
Conductivity	829 mhos/cm	1076 mhos/cm	Yes
Turbidity	7 JTU	4 JTU	Yes
Copper	1.76 µg/l	.98 µg/l	Yes

Four basins and their nitrogen and phosphorus loads are summarized in Table 9. The permittee loads to C-51 were calculated for the 1976 calendar year using the quantity and quality data supplied by the permittee. Since these data were limited (only 7 chemistry samples and no discharge record for January, November or December), the calculated loads are at best rough estimates of the actual load. Export from the western C-51 basin for calendar year 1976 was calculated at the Forest Hill Blvd. station rather than at S.R. 7 due to the inability to accurately estimate flows at S.R. 7. The basin export has been corrected for nonbasin inputs at S-5AE using discharge and quality data at S-5AE.

The loadings into Conservation Area I from the S-5A drainage basin were taken from SFWMD data collected in 1974 (SFWMD Technical Publication in preparation).

The fourth basin is the Vaughn Plantation which is a 4,200 acre sugar cane plantation on the Miami Canal studied by the SFWMD in cooperation with the U. S. Sugar Corporation in 1974-75. The loading values in the table are from unpublished SFWMD data and written communication from Dr. Earl Shannon, Black, Crow and Eidsness 1976. The time period for the calculation is April 1974 to April 1975.

For each basin, loading rates have been expressed in 3 different units. The mass loading rate is simply the total mass of nitrogen or phosphorus exported from the basin for the year. The areal loading rate is the total mass divided by the total area of the drainage basin and in this case is expressed as grams per square meter. The third rate of loading is really a flow weighted average concentration and is calculated by dividing total mass by total volume of runoff.

If it can be assumed that the flow and chemical concentrations measured at the Forest Hill Blvd. station are representative of the net effect of all tributary drainage basins in C-51 then comparison of the permittee's loadings to the C-51 loadings provide some indication of the relative contribution the permittee makes to the basin. The data in Table 9 indicates that the permittee is making a significant contribution in terms of total nitrogen but not in terms of phosphorus.

TABLE 9. LOADING SUMMARY

Basin	Area (Acres)	Discharge Volume (Acre-Feet)	Nitrogen Load (Annual) Mass (Metric Tons)	Nitrogen Load (Annual) Areal (g/m^2)	Nitrogen Load (Annual) Volumetric (mg/1)	Phosphorus Load (Annual) Mass (Metric Tons)	Phosphorus Load (Annual) Areal (g/m^2)	Phosphorus Load (Annual) Volumetric (mg/1)
Permittee	1,800	9,158	44.7	6.1	3.97	0.60	0.08	0.05
Western C-51	37,208	32,255	84.0	0.5	2.12	14.0	0.09	0.35
S-5A	138,000	293,690	2535	4.5	7.02	39.0	0.07	0.11
Vaughn Plantation	4,200	9,964	97.2	5.2	7.0	0.43	0.02	0.04

Although the permittee's land area is only 5% of the total basin, the total nitrogen mass loading for the permittee is 50% of the total basin and the areal loading rate is 10 times the rate for the entire basin. On a volumetric basis the effect of the permittee's nitrogen loading is not so dramatic since the discharge volume for the permittee was almost 30% of the total basin discharge and the volumetric loading rate is less than twice the basin average.

Conversely, the phosphorus data indicates that the permittee's discharge is very typical of the basin as a whole. The total phosphorus mass loading for the permittee is approximately 5% of the total basin and therefore the areal loading rates for the permittee and the total basin are essentially identical. The volumetric loading rate or flow weighted average phosphorus concentration is significantly lower for the permittee compared to the total basin.

The loadings for the S-5A basin were included to give some indication of the potential effects of backpumping the western C-51 basin including the permittee's drainage to Conservation Area 1. These data indicate that the mass, areal and volumetric loading rates of nitrogen to Conservation Area I from the S-5A basin are already quite high and that neither the permittee nor the western C-51 basin would be a significant addition to the current loadings. Of course it should be noted that the S-5A loading data are for 1974 while the permittee and western C-51 data are for 1976. With regards to phosphorus loading, it appears that the addition of the western C-51 basin to the S-5A loadings could cause a significant increase in the loadings to Conservation Area I. However, as discussed above, the permittee's phosphorus contribution to the western C-51 loadings are rather minor.

There are some interesting similarities and differences between the loading characteristics for the permittee and the Vaughn Plantation. The loading rates for nitrogen from the two properties are very similar especially when expressed on an areal basis. However the phosphorus areal loading rate is much higher for the permittee's discharge compared to the Vaughn discharge. The volumetric loading rates show just the opposite trend. The phosphorus volumetric loading rates for both areas are very similar but the nitrogen volumetric loading for the Vaughn Plantation is twice the rate for the permittee.

It is tempting to conclude from the data in Table 9 that nitrogen loading is a function of area while phosphorus loading is a function of volume of discharge. However, it must be remembered that these data were collected at different time periods using different data sets for the calculations. Regardless of these differences, it is apparent that the permittee's loading characteristics are more similar to those of the Vaughn Plantation and the S-5A basin than of the C-51 basin.

Both the Vaughn Plantation and the permittee's property as well as the majority of the S-5A drainage basin are areas of organic soils while the majority of the western C-51 basin is sandy soils. The loading data in Table 9 indicate that the organic soils export nitrogen at a high rate but do not export excessive amounts of phosphorus. Conversely, the sandy soils of the western C-51 basin appear to have a relatively low rate of nitrogen export and much higher rates of phosphorus export.

violations of minimum criteria had occurred. Of the selected parameters analyzed, dissolved oxygen, specific conductivity and chloride did not meet minimum criteria for Class III waters. However, the criteria were not met at both the upstream and downstream stations so although the permittee's discharge may be contributing to the degraded water quality conditions in C-51 it is not the major causative factor. There is some evidence that the high specific conductivity and chloride values are due to groundwater seepage in the drainage system through this area and therefore may be considered "natural". The low dissolved oxygen values are not unique to the West Palm Beach Canal but are an endemic problem in most conveyance canals throughout south Florida.

3. Areal Comparisons

Water quality parameters downstream of the permittee's discharge were compared to values upstream of the discharge using graphic and statistical techniques. These comparisons were made primarily for parameters for which there are no standards. The graphic analyses were inconclusive. For a minor specific discharge event there appeared to be a considerable increase in downstream concentrations of phosphorus and nitrogen but there were little or no effects apparent during long term discharge periods. Comparisons of the average total phosphorus and total nitrogen concentration in the permittee's effluent to average concentrations in the receiving waters were to some degree contradictory. The total phosphorus concentration in C-51 was significantly increased downstream of the discharge but average effluent values were below those of the receiving water. On the other hand nitrogen concentrations in the effluent were higher than the receiving waters but no significant increase was measured downstream of the discharge.

The mean wet season concentrations of total phosphorus and specific conductivity were significantly higher downstream of the discharge than they were upstream

SUMMARY AND DISCUSSION

An evaluation of the potential impact on the quality of water in the western reach of C-51 (West Palm Beach Canal) by the permittee's discharge has been undertaken. The data set available to attempt this evaluation consisted of the daily pumpage record of the permittee and approximately monthly water quality samples of the effluent. These samples were analyzed for several nitrogen species, total phosphorus, dissolved oxygen, turbidity and several other parameters. The receiving waters were also sampled biweekly for the period February 1976 to March 1977 both upstream and downstream of the discharge. These samples were analyzed for the same parameters as the effluent plus major inorganic ions and the trace metal copper. Associated meterological and hydrological data for the western C-51 basin were also utilized in order to quantify the evaluation.

The evaluation was primarily limited to the wet season period (June to October) of 1976 within C-51 between S-5A and U.S. 441. Four methods of evaluation were employed.

1. Historical Comparison

   Data collected in 1974 (one upstream and two downstream of the permittee's discharge) are identical to stations sampled in 1976 and were compared statistically to determine the relative effects of time and discharge on the quality of water downstream of the discharge. For all parameters tested which included nutrients, dissolved oxygen and major ions there were no statistically significant impacts which could be attributed in the addition of a new discharge in 1976.

2. State Standards

   The Florida water quality standards for Class III waters as outlined in Chapter 17-3 of the Florida Administrative Code were used to determine if of the discharge based on statistical testing. The means of all nitrogen species were higher downstream of the discharge than they were upstream but the differences were not statistically significant.

4. Loading Analyses

The exports of nitrogen and phosphorus from the permittee's property were compared to the loadings from the western C-51 basin, the S-5A drainage basin and a previously studied sugar cane plantation (Vaughn Plantation). Comparisons indicated that the loadings from the permittee's property were similar to those of the other plantation and the entire S-5A drainage basin. They further indicated that the permittee's nitrogen loadings to C-51 were a significant portion of the entire basin load but that phosphorus loadings were reasonable given the land area and volume of discharge involved.

In order to put the various methods of evaluation used in this analysis into perspective, it is necessary to attempt to define the intrinsic value of the receiving waters, C-51. The objective of this study was to determine if the discharge of the permittee's effluent would have an adverse impact on the receiving waters. It has been assumed that adverse impact would be loosely defined as a condition created by the discharge which would result in a significant reduction in the "value" of C-51. Conditions which would cause a significant impact would include:

1. Public Health problem caused by toxic or pathogenic substances.
2. Severe quality degradation which would preclude current uses.
3. General degradations affecting the natural biota of this aquatic system.

One method of defining the intrinsic value of C-51 is to refer to its classification as Class III waters. The water quality for Class III waters are designed to protect and promote fish and wildlife benefits and other recereational benefits. The identification of the fish and wildlife resources of this canal and in fact any canal is difficult since the canals are not natural bodies of water. The canal does seem to support an undefined population of fish, turtles, alligators, ducks, and other aquatic birds. Types and distribution of invertebrate and phytoplankton populations are unknown. There is little vegetation of any consequence in the western reach of the canal. The recreational benefits on the canal include some fishing and minor boating activities.

Despite the classification of the canal as Class III waters its primary use remains as flood control and water supply. During the wet season the canal drains surface runoff to the east for eventual discharge to Lake Worth. During the dry season water is released into the canal from S-5AE to provide irrigation water for various agricultural uses.

Considering the value of C-51 and the adverse impact criteria listed above, the analysis of data collected during this evaluation does not indicate any well defined cases of adverse impact due to the permittee's discharge.

The initial concern about the discharge involved the effects of excess nutrient loadings into C-51. Consequently little data were collected which are appreciable to public health issues. The data collected for the one potentially toxic element, copper, indicate that the levels of this parameter in C-51 are well below the concentrations of concern.

The only water quality degradations apparent in the evaluation were increases in specific conductivity, chloride and total phosphorus. The possibility that these degradations would preclude any of the current uses of C-51 are considered to be slight. Furthermore there is some uncertainty that these water quality changes can be solely attributed to the permittee's discharge since evaluations using historical data do not confirm the evaluation using only upstream and downstream data.

Due to the nature of the canal itself it is practically impossible to predict what subtle general impacts the additional discharge with its high nitrogen loading will have on the natural resources of the cânal. Since the residence time of water in the canal is relatively short during periods of high discharge it is unlikely that any enrichment effects due to loading increases are impacting the canal itself. The ultimate impacts, if any, are probably felt by the ultimate receiving waters which in this case is Lake Worth.

Of the parameters which do not meet minimum criteria for Class III waters, dissolved oxygen is the most critical. Low dissolved oxygen values are a common problem in most canals and limit their usefulness as aquatic habitat. The low values are probably due to lack of reaeration, benthic oxygen demand and warm temperatures. There does not appear to be any significant aggravation of the dissolved oxygen problem due to the permittee's discharge and in fact the effluent often had dissolved oxygen concentrations higher than the receiving waters. The high total dissolved solids as estimated by the specific conductivity and chloride concentrations are less significant in terms of over all water quality. There is some evidence that these parameters are elevated due to groundwater seepage rather than surface runoff.

Recommendations:

1. Since the water quality problems in western C-51 appear to be general and there is little evidence of specific impacts due to the permittee's discharge, it is recommended that the permittee be granted a Surface Water Management Permit.
2. Since the evaluation study has identified current water quality problems within the western C-51 basin it is recommended that area wide basin criteria be established to address these problems, especially dissolved oxygen.
3. Since there is a potential for this basin to be backpumpted into the environmentally sensitive Conservation Areas, it is recommended that discharge

permit include special conditions to:

a) Renew the monitoring program to provide better estimate of nutrient loading.

b) Work toward establishing best management practices to reduce nutrient loading in the event that current loading rates are found to be detrimental to wetlands.

DIRECT CALCIUM AND MAGNESIUM DETERMINATION BY A MODIFIED ATOMIC ABSORPTION SPECTROPHOTOMETRY ASPIRATION SYSTEM

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INTRODUCTION

We have adapted the double capillary system (DCS) as described by Singhal, *et al.* (1, 2) to the rapid determination of calcium and magnesium in natural water systems.

In the air-acetylene flame, calcium and magnesium absorbances are lowered due to interferences from elements such as phosphorus (3). The addition of lanthanum or strontium to samples and standards corrects for the chemical interference. Usually a 0.1% to 1.0% solution of lanthanum or strontium is added volumetrically to samples. This is time-consuming and may be a source of error. Also, the high levels of calcium and magnesium found in some natural waters require dilution to bring them within the linear working range of atomic absorption.

The double capillary system (DCS) provides a convenient means to pretreat and dilute each natural water sample as it is aspirated directly into the burner mixing chamber. Ward and Biechler (4) have presented a study of interferences using a similar system, with the nitrous oxide-acetylene flame.

MATERIALS AND METHODS

Our DCS consists of a "T", fitted with two polyethylene tubes, connected to the nebulizer. Singhal, and coworkers, have described a method whereby a reagent solution is aspirated through one arm of the "T" while standards or samples are aspirated through the other. Leiritie and Mattsson (5) have discussed a modified sample addition method for the determination of various elements using a similar aspiration system.

The "T" is available through Elkay Products (No. PT-2). The bottom of the "T" is fitted to the adjustable nebulizer by a short 0.015-in. polyethylene tube from Technicon. The two arms of the "T" are then fitted with 9-in. lengths of the same tubing.

Standards were prepared from 1000-ppm stock solutions. The reagent solution consisted of 0.5% La_2O_3 w/v and 2.5% HCl v/v.

INSTRUMENTAL CONDITIONS

All data were obtained using a Perkin-Elmer Model 306 atomic absorption spectrophotometer equipped with a Model 056 Multirange Recorder, and Intensitron® hollow cathode lamps. Calcium was measured at 422.7 nm with a spectral bandwidth of 1.4 nm and magnesium at 285.2 nm with a spectral band width of 0.7 nm.

The high concentrations of calcium and magnesium in the samples analyzed in this study required that the burner be rotated approximately 90° to reduce the cell path length. A reducing air-acetylene flame was used for calcium and an oxidizing flame for magnesium. The adjustable nebulizer was set at an uptake rate of approximately 2.8 ml/min. for both tubes of the "T" while aspirating deionized water.

RESULTS AND DISCUSSION

The major concern involving the DCS was reliability. A noticeable drop in aspiration rate using the DCS was observed with the 0.015-in. tubing. Aspirating with both tubes from a 10-ml graduated cylinder produced an uptake rate of 2.8 ml/min. A rate of 2.8 ml/min. was also observed for a 0.5% La_2O_3/2.5% HCl solution. Larger tubing was tried in an attempt to increase the amount of sample introduced to the flame. Although the aspiration rate increased, new problems occurred.

A tubing size of 0.030-in. i.d. was found to cause an apparent increase in the concentration reading of an 80 mg/l calcium solution if the sample level was held constant and diluent level was allowed to drop approximately 4.5 in. A decrease in concentration reading was observed if the diluent side was held constant and the sample level dropped approximately 4.5 in. Similar results were obtained using 0.023-in. i.d. tubing.

The 0.015-in. i.d. tubing was found to produce no significant variations (Table I). The standard level was held constant and the diluent level varied from full to three-fourths, to one-half, and finally one-fourth. A mean of 83.0 mg/l, with a coefficient of variation of 2.2% was found. The diluent was then held constant and the 80-mg/l standard level changed. Three readings (full, half, and three-fourths) gave a mean of 80.6 mg/l with a coefficient of variation of 1.0%.

Water samples selected at random were analyzed by the conventional single tube aspiration method (4) and the DCS method. Results are given in Table IIa. Percent difference was calculated by assuming that the single aspiration system was the standard value. No significant difference was found.

Environmental Protection Agency (E.P.A.) standard reference samples were analyzed as accuracy checks (Table IIb). The E.P.A. values were assumed to be the standard value for percent difference calculations. Both systems gave similar results.

Mean, standard deviation, and percent coefficient of variation data were compiled by replicate analyses of a sample periodically run throughout a routine analysis (Table III).

The percent recovery data were calculated from the formula:

$$\frac{S_a - 1/2U_e}{1/2\,S_k} \times 100 = \%\ \text{recovery}$$

Where:

S_a is the standard addition experimental value
U_e is the unknown experimental value
S_k is the known standard value

The formula assumes a 1:1 dilution of an unknown with an appropriate standard.

The working ranges obtained for calcium and magnesium using the DCS were 2.5 mg/l to 160.0 mg/l and 1.0 mg/l to 40.0 mg/l respectively.

It is not known whether the DCS produces an exact 1:1 dilution. However, the dilution ratio is constant and, therefore, normal calibration is not affected (6).

CONCLUSION

The DCS as a peripheral tool to atomic absorption spectrophotometry appears to have added a useful dimension

TABLE I
Comparison of Percent Change in Sample Concentration with Respect to Tubing Inside Diameter

Tubing Size	*% Apparent Increase in Concentration (Sample Level Held Constant)*	*% Apparent Decrease in Concentration (Diluent Level Held Constant)*
Technicon® 0.015-in. I.D.	0.56	2.47
Intramedic® 0.023-in. I.D.	12.46	13.26
Technicon® 0.030-in. I.D.	14.06	13.70

TABLE II
Calcium-Magnesium Data Comparison in Natural Waters (mg/l)

A.

Sample No.	*Dual Aspiration*	*Single Aspiration*	*% Difference*
	mg/l Ca		
H120	46.0	47.2	2.5
H122	81.1	81.2	0.1
R166	53.2	54.8	2.9
I502	8.9	8.6	−3.5
F1104	23.2	24.4	4.9
F1108	8.2	7.8	−5.1
F1112	66.4	64.8	−2.5
F1114	63.9	64.2	0.5
E041	39.6	38.8	−2.1
A224	160.3	162.0	1.0
	mg/l Mg		
YB694	15.4	14.9	−3.4
YB698	6.3	6.3	0.0
YB702	19.8	20.0	1.0
B498	15.7	15.1	−4.0
B510	5.2	5.0	−4.0
YC719	14.7	14.2	−3.5
YC739	15.0	14.6	−2.7

B.

Element	*EPA*	*Dual Aspiration*	*% Difference*	*Single Aspiration*	*% Difference*
Calcium	9.0	9.6	−6.7	8.4	6.7
	36.0	37.9	−5.3	33.4	7.2
Magnesium	2.1	2.0	4.8	2.0	4.8
	8.2	8.2	0.0	7.8	4.9

to an already powerful analytical technique and is adaptable to the analysis of natural waters.

The tubing size is a major factor in the performance of the system as was shown. Using the correct tubing size satisfactorily eliminates head pressure effects found with larger tubing.

The DCS method of direct analysis for Ca and Mg provides for simultaneous chemical treatment thus avoiding any pretreatment with its associated errors.

The overall performance of the DCS for high concentrations of calcium and magnesium has been shown to be as reliable as the single aspiration system (Table II) and is being used routinely in this laboratory with great success. Quality control measures (*i.e.*, standard additions and independent standard reference samples) have shown the system to be reliable.

Two other elements which are found in high concentrations in some natural waters are sodium and potassium. We are determining these elements routinely using the DCS, in this instance as a dilution device to accommodate the high concentrations of sodium and potassium found in the samples studied.

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TABLE III
Statistical Data Computed on Randomly Chosen Natural Water Samples, Analyzed by the DCS

Sample No.	*n*	$\bar{X}$	*% C.V.*	*Ue**	*Sk**	*Sa**	*% Recovery**
Element: Calcium							
YB694	3	48.3	0.8	48.8	100.0	79.6	110.4
YA703	8	44.7	2.7	43.5	50.0	47.8	104.2
Element: Magnesium							
YB694	3	15.4	0.8	15.4	30.0	22.5	98.7
YA703	4	15.1	0.5	15.1	20.0	17.5	99.5

*All defined within text.

6-6-79

A LITERATURE SUMMARY - THE FRESH WATER, SURFACE WATER QUALITY OF FLORIDA'S LOWER WEST COAST

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INTRODUCTION

Florida's Lower West Coast has been partitioned into nine basins according to their respective hydrologic characteristics. These basins are:

1. East Caloosahatchee Basin
2. West Caloosahatchee Basin
3. Telegraph Swamp Basin
4. Tidal Caloosahatchee Basin
5. North Coastal Basin
6. Island Basin
7. Estero Bay Basin
8. West Collier Basin
9. East Collier Basin

The development of a Water Use Plan for these areas necessitated a need to know not only the present quality of the water resources but also the general emphasis with respect to the direction of previous studies and the need for future studies. This level of understanding could best be gained through a review of the available literature.

One basic guideline was established in the selection of references. The reference had to have a review of some fresh water chemistry ~~(as opposed to brackish or marine waters, excluding strictly estuarine environments)~~ and would include only references to surface waters. ~~or surface waters as affected by either groundwaters or brackish waters.~~ Of the 147 references specific to the nine basin area, those that met this specific guideline are listed in Tables and .

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TABLE GENERAL AND SPECIFIC FRESH WATER, SURFACE WATER QUALITY REFERENCE LIST FOR SELECT STREAMS AND CANALS IN FLORIDA'S LOWER WEST COAST

RIVER	*BASIN	REFERENCES
Barren River	9	1, 11, 18, 25, 32, 41, 46, 47, 58, 61, 64, 68, 72, 82, 88, 90, 95, 99, 114, 116, 125, 127, 129, 142
Caloosahatchee River	1, 2, 4	5, 6, 8, 18, 24, 25, 33, 36, 41, 43, 44, 46, 47, 52, 67, 68, 70, 85, 95, 99, 100, 102, 114, 115, 116, 127, 129, 136
Cocohatchee River	8	4, 18, 25, 32, 46, 72, 95, 99, 114, 116, 127, 129
Estero River	7	18, 25, 41, 46, 47, 95, 99, 100, 114, 116, 127, 129
Falka Union Canal	8	11, 18, 25, 32, 41, 46, 47, 72, 82, 95, 99, 114, 116, 125, 127, 129
Gator Slough	5	18, 25, 46, 47, 95, 99, 114, 116, 127, 129
Golden Gate Canal	8	4, 18, 25, 32, 41, 46, 47, 52, 68, 72, 82, 95, 99, 114, 116, 127, 129
Garden River	8	4, 18, 25, 32, 41, 46, 47, 72, 95, 99, 114, 116, 127, 129
Henderson Creek	8	18, 25, 32, 41, 46, 47, 72, 95, 99, 114, 116, 127, 129, 144, 146
Hendry Creek	7	18, 25, 46, 47, 95, 99, 116, 127, 129
Imperial River	7	18, 25, 41, 46, 47, 70, 95, 99, 100, 104, 114, 116, 127, 129
Lely Canal	8	18, 25, 46, 47, 72, 99, 114, 116, 127, 129
Mallock Creek	7	18, 25, 46, 47, 95, 99, 116, 127, 129
Orange River	4	18, 25, 41, 43, 46, 47, 70, 95, 99, 114, 115, 116, 127, 129
Spring Creek	7	18, 25, 46, 47, 99, 116, 127, 129
Ten Mile Canal	7	18, 25, 41, 46, 47, 95, 99, 116, 127, 129
Townsend Canal	2	18, 25, 33, 41, 46, 47, 95, 99, 102, 114, 116, 117, 119
Turner River	9	18, 25, 46, 47, 58, 72, 82, 95, 99, 114, 116, 127, 129

*Basin Code:

1 - East Caloosahatchee Basin
2 - West Caloosahatchee Basin
3 - Telegr[illegible] Swamp Basin
4 - Tidal Caloosahatchee Basin
5 North Coastal Basin
Island Basin
7 - Estero Bay Bas
8 - West Collier Ba
9 - East Collier Ba

TABLE GENERAL AND SPECIFIC FRESH WATER, SURFACE WATER QUALITY REFERENCE LIST FOR SELECT LAKES AND MAJOR WETLANDS ON FLORIDA'S LOWER WEST COAST.

LAKES	*BASIN	REFERENCES
Deep Lake	9	51, 83, 104, 110
Halfway Pond	4	No Data Found
Lake Hicpochee	1	114
Lake Trafford	8	50, 52, 68, 95, 104

WETLANDS	*BASIN	REFERENCES
Big Cypress Swamp	8, 9	1, 72, 73, 82, 137, 143
Corkscrew Swamp	8	72
Fahkahatchee Stand	8	11, 72, 82, 95, 125
Okaloacoochee Slough	2, 9	44, 45, 82, 114
Six Mile Cypress	7	64, 95
Telegraph Swamp	3	No Data Found

*Basin Code:

1 - East Caloosahatchee Basin
2 - West Caloosahatchee Basin
3 - Telegraph Swamp Basin
4 - Tidal Caloosahatchee Basin
5 - North Coastal Basin
6 - Island Basin
7 - Estero Bay Basin
8 - West Collier Basin
9 - East Collier Basin

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Since the references selected were ~~so~~ varied, a comparative evaluation would have been difficult without some additional guidelines. Consequently, three specific guidelines were established to determine which specific references ~~should~~ could be included in this text.

First, the references ~~must~~ had to include some discussion of the data collected. Some of the data, including Supplemental Data on the Water Quality in the Lower West Coast, Florida by the South Florida Water Management District, 1976-1978, and "Nutrient Concentrations of Surface Waters in Southern Florida, September 1970 to April 1975" by W. L. Miller, ~~for example,~~ included extensive sampling over the entire Lower West Coast. However, the data ~~is~~ was not accompanied by any text or evaluation.

Secondly, the references ~~must~~ had to include general aquatic chemistry with some discussion of nutrient levels. ~~While the first guideline dealt with extremely specific data of single areas of interest,~~ This guideline ~~attempted~~ to omit data very general in nature including map series such as the pH of Water in Florida Streams and Canals, 1970, or Color of Water in Florida Streams and Canals, 1969. This guideline also ~~attempted to~~ omitted very specific parameters from a detailed analysis including, as examples, the "Geochemistry of Mercury in Three Estuaries from the Gulf of Mexico" by Anders W. Andren, 1973, or the "Impact of Pesticides on Phytoplankton in Everglades Estuaries" by Stanley A. Moore, 1973.

Finally, the data ~~must~~ had to have been collected between 1969 and 1979. Some data including the Water Resources of Southeastern Florida by Garald Parker, et al., 1955, or "Dissolved Phosphorus in Florida Waters" by Howard T. Odum, 1953, provide valuable historic data. However, due to the progressive growth in the Lower West Coast and the continually changing water resource patterns, more recent data would more likely typify the current water quality.

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The omission of numerous references according to the established guidelines does not lessen their importance, rather, it facilitates a review of the water quality on the Lower West Coast. With this document, the interested reader can be directed to references in areas of particular concern.

Some of the conclusions reported here may appear to contradict that of other authors. Strict interpretation of the information presented must be tempered by consideration of the sampling dates, study duration, analytical and data handling methods, and a realization that the environment in general is not static but constantly changing.

Wetlands

The wetland areas of the Lower West Coast of Florida represent almost 50% of the total area (SFWMD, 1979). Of the six major wetlands of Southwest Florida, no data was found for Telegraph Swamp, and of the nine basins, no major wetlands are located in the East Caloosahatchee Basin, the Tidal Caloosahatchee Basin, or the North Coastal Basin.

Carter, et. al., 1973, studied the ecosystems associated with the Big Cypress Watershed and found that surface waters in the Fahkahatchee strand consistently had greater concentrations of total phosphorus, total organic carbon, total Kjeldahl nitrogen, apparent color, and tannin and lignin "like" compounds than did the drainage canals. The results demonstrate the total dependence of the South Florida ecosystem on the hydroperiod. Alkalinity, dissolved oxygen, and turbidity were higher in the canals, as were the quantities of nutrients transported. Surface waters were free from any detectable levels of pesticides.

Klein, et. al., 1975, described the quantity and quality of surface water and groundwater and their interrelation with the estuarine and marine waters of

South Florida. Nine areas were identified, according to land use, to illustrate their effect upon the water quality. Only two of these areas were located in the Lower West Coast; the Big Cypress Watershed and the urban areas to the west. The Big Cypress Watershed was used comparatively to represent low nitrogen and phosphorus levels which generally were lower than the other areas considered.

Little, et. al., 1970, during a one month study in March 1970, conducted physical, chemical, and biological studies at 34 stations including various canals, the Big Cypress Swamp, the Fahkahatchee Strand, and the Okaloacoochee Slough. This report concluded that arbitrary development has resulted in deteriorated water quality and increased concentrations of certain elements potentially toxic to aquatic life. Low nutrient levels in waters of the Big Cypress indicated relatively low enrichment as a result of either assimilation or accumulation in the sediments. Total phosphorus levels averaged less than 0.1 mg/l at all stations with the highest recorded value being 0.38 mg/l. Seepage to the Gulf Atlantic Corporation (GAC) canal system accounts for the significantly elevated values for hardness, alkalinity, and sulfate as compared to the remaining swamp.

Lakes

There are only four major lakes of interest (surface area greater than 25 acres) on the Lower West Coast. These are Halfway Pond, Lake Hicpochee, Lake Trafford, and Deep Lake. The four lakes are located in four separate basins; the East Caloosahatchee Basin, the Tidal Caloosahatchee Basin, and the East and West Collier Basins. No data was found for either Halfway Pond or Lake Hicpochee.

Goolsby, et. al., 1976, and Joyner, 1973, summarized the general water

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quality throughout the State and specific areas of central and southern Florida, respectively, including some specific information on Lake Trafford. They also identified a general lack of available information in Lee and Hendry Counties.

Schneider[110] studied the limnology of a meromictic sinkhole lake (Deep Lake) in South Florida with emphasis on the morphometric and climatic reasons contributing to the maintenance of meromixis. The physical, chemical, and biological interactions were observed with the conclusion that the general chemical properties occurred in concentration ranges normally found in South Florida. The major chemical concentrations of the surface waters were lower during the wet periods and higher during the dry periods indicating that dilution and concentration (including evaporation, seepage, run-off from surrounding wetlands high in dissolved solids, etc.) play an important role in the quality of surface waters in Deep Lake.

Canals, Rivers, and Streams

Of the 18 major canals, rivers, and streams of importance on the Lower West Coast of Florida, eight revealed a general lack of information including Gator Slough, Hendry Creek, the Imperial River, Mullock Creek, the Orange River, Spring Creek, Ten Mile Creek, and the Estero River.

Black, Crow, and Eidsness, 1975, attempted to develop a comprehensive water management plan in Northwest Collier County while maintaining a quality environment through the protection of valued natural resources. Water quality data was documented for the Gorden River Area, Golden Gate Canal Watershed, and the Cocohatchee River Area. Total nitrogen, particularly in the fresh water locations of the Cocohatchee River System during the rainy season, is relatively high indicating a considerable degree of enrichment due to land run-off from agricultural areas. During the dry season, total nitrogen concentrations fall to one-fourth the wet season levels. Phosphate levels are generally low.

Carter, et. al., 1973, studied the ecosystems associated with the Big ypress Watershed and found the canals transported much greater quantities of nutrients than did the surrounding wetlands. Alkalinity, dissolved oxygen, and turbidity were higher in the canals, however, nutrient levels and color were generally lower while detectable levels of pesticides were not found.

Environmental Science and Engineering, 1977, in the "Final Water Quality Report for the Big Cypress Study Area" indicated that nutrient levels tended to decline during the dry season in the Cocohatchee River and Golden Gates Areas with phosphorus levels in the Cocohatchee River Canal being generally higher than at other sites. Generally, the results indicate that the water quality leaving the canals contains excessive levels of nutrients.

Environmental Science and Engineering, 1977, in "The Final Report for the Caloosahatchee River Study Area" indicated that the water entering from Lake Okeechobee is as good or better than that downstream with the eastern river portions being of poorer quality than the western portions. Generally the water quality in the river is better than that of the tributaries sampled and nutrient levels are high with water entering the river being rich in nitrogen and phosphorus.

Goolsby, 1976 presented an analysis of the historical water quality data collected in Central and Southern Florida. Total nitrogen and total phosphorus concentrations for about 2,000 samples from the area averaged 1.82 and 0.15 mg/l, respectively with 77% of the nitrogen being organic and 80% of the phosphorus being soluble ortho-phosphate.

Little, et al., 1970, during March 1970, examined the physical, chemical, and biological characteristics of the Big Cypress Area. It was indicated that an ecosystem shift was occurring from wet prairies, marshes, and sloughs to a

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canal system. The drainage canals exhibited a deterioration in quality due to the transport of wastes from residential, commercial, industrial, and agricultural land use. Increased levels of iron, lead, and aluminum in the GAC canal were detected in greater amounts than what would normally exist. Hardness, alkalinity, and sulfate demonstrated a significant increase in the GAC canal relative to the adjacent wetlands due to the seepage of groundwater.

O'Donnell[102] studied the water quality of canals in Hendry County, mainly the Caloosahatchee River and Townsend Canal. The quality of water in the Caloosahatchee River, at LaBelle, was generally good except for the color.

Tabb[125] during two sampling trips in late 1975 and early 1976 obtained data which indicated that the general quality of the Golden Gate Water System was good.

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