TECHNICAL DOCUMENT IN SUPPORT OF CHAPTER 40E-61, WORKS OF THE DISTRICT WITHIN THE LAKE OKEECHOBEE BASIN

Revised

SEP 13 1989

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

I. INTRODUCTION

The South Florida Water Management District (District) is proposing to adopt Chapter 40E-61, Works Of The District Within the Lake Okeechobee Basin, to implement the Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee. The proposed rule establishes water quality standards and permitting procedures applicable to parcels of land in the Lake Okeechobee Drainage Basin. This document contains explanations of how the water quality standards were derived. Some supporting data has been included. All the relevant measurements and other data are too extensive and bulky to publish in this document. They are available in hard copy for inspection at the District Headquarters in West Palm Beach during regular working hours, and on magnetic tape and floppy disc at cost. Arrangements for inspection and tape rates should be made through Mike Slayton or Sarah Nall. Additional data needs or questions should be presented initially at a technical workshop.

II. TARGET LOAD

Section 373.4595(1), Florida Statutes, directs the District to design and implement a program to protect the water quality of Lake Okeechobee, and to achieve, by July 1, 1992, reductions of phosphorus loadings to the lake by the amount specified as excess in the District's Technical Publication 81-2. The target load specified in Publication 81-2 is 397 tons/year of phosphorus. The water quality standards in the proposed rule are designed to specify how much the controllable sources of phosphorus in the Lake Okeechobee Basin can contribute to the lake without exceeding the target load.

III. AVERAGE ANNUAL DISCHARGE CONCENTRATION PERFORMANCE STANDARD

A. DESCRIPTION

The Lake Okeechobee SWIM Plan outlines a new regulatory management approach based upon the development and implementation of phosphorus performance standards. The goal is to develop regulatory criteria which provide effective resource protection, are workable, attainable, and require minimal data collection. In order to achieve these characteristics, the Plan shifted from an areal loading standard to a concentration standard. A concentration standard has several desirable characteristics, including:

1. It lays the foundation for a uniform off-site discharge concentration performance standard.

2. It is less sensitive to hydrologic variation than mass loadings and provides a more effective means to track progress in reducing phosphorus levels entering the lake.

3. It can produce variable loading rate targets for each basin. If a fixed loading rate target was employed for each basin, then the target inflow concentration would in turn be different for each basin, which could result in the introduction of inequities within the same industry in terms of the primary standards to be achieved.

B. AVERAGE ANNUAL LAKE INFLOW PHOSPHORUS PERFORMANCE STANDARD

There are 37 inflows (sources) of phosphorus identified in the SWIM Plan which discharge into Lake Okeechobee. Of these 37 inputs, 3 are classified as non-controlled and 34 as controllable. Non-controlled sources are inputs to Lake Okeechobee which fall into one of the following two categories:

1. Direct rainfall on the surface of the lake;

2. Discharges from other lakes (e.g. Lake Istokpoga and Lake Kissimmee)

Controllable sources are the remaining 34 inflows that routinely discharge into the lake.

All of the non-controlled sources presently have sufficiently low concentrations of total phosphorus so that no improvement is necessary in order to discharge into the lake. The three uncontrolled sources (rainfall, S-65 Lake Kissimmee, and S-68 Lake Istokpoga) are not covered by the Rule.

The contribution of phosphorus from the three "uncontrolled" sources was subtracted from the target loading rate of 397 tons/year, resulting in an allocable phosphorus load from "controlled" sources of 285.5 tons/year. This 285.5 tons/year was then allocated to the 34 controllable sources under a discharge allocation formula, i.e. the 285.5 tons/year (converted to metric tons) was divided by the average annual discharge from all the controllable sources (1,100,184 acre-feet; Table 1), then converted to mg/L, resulting in an average annual total phosphorus concentration of 0.189 mg/L. A 0.18 mg/L average annual total phosphorus concentration establishes the maximum ultimate long-term average annual concentration standard for all inflows to Lake Okeechobee, and when achieved, will result in a long-term average annual target load of 397 tons/year.

C. OFF-SITE TOTAL PHOSPHORUS CONCENTRATION STANDARDS

1. <u>Sub-Basins with Current Phosphorus Discharges Less Than the Average Annual Lake Inflow Standard</u>

   Interim discharge limitations apply to basins which have an average annual total phosphorus concentration entering Lake Okeechobee of less than 0.18 mg/L. If the basins under interim discharge limitations were allowed to exceed their present discharge concentration up to a level of 0.18 mg/L while other basins are lowering their concentrations, the net benefit to the lake, in terms of total load reductions, will be reduced and therefore water quality improvements to the lake would be delayed. Also, if these basins are permitted to exceed their present discharge concentration up to 0.18 mg/L, enough "momentum" of increasing phosphorus concentrations may be built up as to exceed the 0.18 mg/L target and therefore, retrofitting could be required to correct problems that presently do not exist. The interim discharge limitations will provide a margin of safety of 42 tons/year.

Of the 34 controllable basins that routinely discharge into the lake, 19 have average annual total phosphorus concentrations over the period of record that are less than the 0.18 mg/L target concentration (Table 1). The performance standard for these 19 basins which currently exist below 0.18 mg/L will be established on the basis of interim discharge limitations for the existing average annual phosphorus concentration shown in Table 1. Discharge concentrations from these basins will not be allowed to exceed these current levels.

2. <u>Sub-Basins with Current Phosphorus Discharges Greater Than the Average Annual Lake Inflow Standard</u>

The performance standard for the 15 basins which have average annual phosphorus concentrations that exceed 0.18 mg/L must meet the target level of 0.18 mg/L at the point of inflow to the lake, on an average annual basis, by 1991. Establishment of 1991 as the target date for compliance with the ultimate lake inflow performance standard of 0.18 mg/L, one year prior to the 1992 date established in the SWIM legislation, will allow adequate time to assess compliance with the standard and provide opportunities to apply other measures as needed, to insure compliance with the ultimate standard by the legislatively mandated deadline of 1992.

Basins which currently exceed an average annual total phosphorus concentration of 0.18 mg/L will be required to make incremental reductions in phosphorus concentrations according to the following schedule:

Average Annual Lake Inflow Target Concentration Total Phosphorus (mg/L)		
WY 1989	0.66 mg/L	interim inflow standard
WY 1990	0.33 mg/L	interim inflow standard
WY 1991	0.18 mg/L	ultimate inflow standard
WY 1992	0.18 mg/L	ultimate inflow standard

These interim standards are based upon the following considerations:

a. the necessity to proceed in a timely and incremental manner to achieve the ultimate standard by 1992;
b. the reasonable expectations of meeting the standards if all users of the system make a good faith effort to comply; and
c. the necessity of the permitting process being effective without excessive resource commitments.

The three year phase-in schedule was developed by taking the basin with the highest average annual total phosphorus concentration and setting interim targets of approximately a one-third reduction in concentration each year. Specifically, TCNS has the highest average phosphorus concentration at a level of 0.947 mg/L (Table 1), therefore the first year interim standard was set at 0.66 mg/L or approximately one-third of the reduction necessary to reduce 0.947 mg/L to 0.18 mg/L. The second year was set at 0.33 mg/L or approximately two-thirds of the reduction necessary to achieve 0.18 mg/L.

D. DATA AND ASSUMPTIONS USED TO GENERATE LAKE INFLOW STANDARD AND DISCHARGE CONCENTRATION STANDARDS

This section provides technical data and explanations of how the average annual inflow phosphorus performance standard and off-site total phosphorus concentration standards for all 37 inflows to Lake Okeechobee were generated.

The historical period of record presented in the SWIM plan (14 years) for the major inflows (1973-1987) is used to estimate the long-term average annual flow that must be achieved to meet the target load of 397 tons/year. This is a reasonable assumption since the 14 year period of record includes a wide range of hydrologic conditions (2 droughts and several very wet years). During this period the lake reached its highest and lowest levels since construction of the Hoover Dike.

Section D.1. covers the average annual input (flow) data which is listed on the second column of Table 1. Section D.2. covers the average annual phosphorus load data which is listed on the third column of Table 1.

Table 1. Nutrient loads and Target Performance Standards for Controlled and Uncontrolled Lake Okeechobee Inflows

Inputs	Ave. Annual Input Discharge (ac-ft/yr)		Phosphorus (tons/yr) Load		Flow-Wtd Concs. (mg/L)		New Target Flow-Wtd Concs. (mg/L)	
	SWIM Plan[1]	Updated[2]	SWIM Plan[1]	Updated[2]	SWIM Plan[1]	Updated[2]	SWIM Plan[1]	Updated[2]
Controllable Sources								
C-38 Pool A (S-65A)	53,703	54,463	4.8	5.0	.066	.067	0.07	
C-38 Pool B (S-65B)	60,019	60,656	4.7	4.6	.058	.056	0.06	
C-38 Pool C (S-65C)	49,774	52,364	8.6	8.8	.127	.124	0.13	0.12
C-38 Pool D (S-65D)	110,085	112,307	39.6	39.9	.265	.261	0.18	
C-38 Pool E (S-65E)	39,294	33,440	25.5	30.0	.477	.660	0.18	
S-191 (TC/NS)	111,327		143.4	143.2	.947	.946	0.18	
S-71 (C-41) (Adj. for S-68)	80,922	92,296	43.5	47.7	.395	.380	0.18	
S-72 (C-40) (Adj. for S-68)	14,083	6,971	7.0	7.2	.366	.761	0.18	
S-84 (Adj. for S-68)	65,266	32,992	8.7	8.0	.098	.178	0.10	0.18
Fisheating Creek	155,734		50.9	44.7	.240	.210	0.18	
S-127 (L-48)	14,042		9.4	7.3	.492	.382	0.18	
S-129 (L-49)	10,730		3.4	2.6	.233	.180	0.18	
S-131	4,452		.9	0.8	.149	.132	0.15	
S-133	19,648		8.3	8.5	.311	.318	0.18	
S-135	18,219		3.9	2.8	.157	.113	0.16	0.11
S-154	30,810	25,740	33.5	27.8	.800	.795	0.18	
S-4	29,182	8,090	16.4	2.3	.413	.202	0.18	
Industrial Canal	22,672		10.6		.344		0.18	
S-236 (So. Fla. Conservancy)	9,535		1.2		.093		0.09	
Culvert 4 A (S Bay/ S Shore)	3,742		0.4		.079		0.08	
Culvert 12 (East Shore D.D.)	12,044		2.2		.134		0.13	
Culvert 12A (715 Farms)	3,369		1.2		.262		0.18	
Culvert 10 (East Beach D.D.)	6,245		2.4		.283		0.18	
S-2 (flood control)	69,364	67,891	15.5	14.8	.164	.161	0.16	
S-3 (flood control)	31,575	25,558	6.6	4.7	.154	.136	0.15	0.14
L-59E, L-59W, Culv. "A"	15,000		3.2		.157		0.16	
S-154C	2,000		.6		.221		0.18	
L-60E, L-60W	6,000		.8		.098		0.10	
L-61E, L-61W	22,000		2.8		.094		0.09	
Culvert 5 (Nicodemus Slough)	14,000		1.1		.058		0.06	
S-308C (C-44, S-153)	40,746		9.6	9.1	.173	.164	0.17	0.16
HGS-5 (WPB Canal)	3,557		.7		.137		0.14	
S-77 (East Caloosahatchee)	6,977		1.4		.148		0.15	
Culvert 10A (L-8)	35,674	25,377	4.6	3.4	.095	0.099	0.10	
Total Controllable	1,171,790	1,100,184	477.7	451.8	.300	.303		
Uncontrollable Sources								
Rainfall	1,119,322		72.2		.047			
S-65 (Lake Kissimmee)	579,217	578,897	33.1	33.0	.042			
S-68 (Lake Istokpoga)	153,541		12.5	6.3	.060	.030		
Total Uncontrollable	1,852,080	1,851,760	117.8	111.5	.047	044		

[1] The source for these columns is Table GOS-1 in the SWIM Plan for Lake Okeechobee. This table will be updated as more data becomes available.

[2] These columns contain updates to Table GOS-1, based on refined methodologies and more recent data

1. Discharge (Flows)

This section covers data relative to discharge (flows) from all 37 inputs. Data on flows into Lake Okeechobee may be obtained by several methods, which are described below.

The District records upstream stages, downstream stages, gate openings at spillways, and pump operations at pump stations. Each record may contain numerous instantaneous readings (raw data) in the course of a single day. Instantaneous discharge is calculated by a computational formula based on the characteristics of the particular discharge point and on these instantaneous readings. A mean daily discharge is then computed by integration if instantaneous discharges over time for one day and dividing the result by the amount of time in one day.

For example, a gated spillway may operate in the controlled (gate in water) or uncontrolled (gate out of water) category and in the free or submerged category (downstream stage above spillway crest). The categories that exists at any given instant are determined by the characteristics of the flow. Discharge is determined using a computer program based on a category-based flow calculation. The controlled-submerged category is most common.

As another example, a pump station may have several pump units. The pump speed and times of operation are recorded for each pump unit. The rating curves (flow equations) used are provided by the pump manufacturer or determined by field measurements. The pump unit, headwater, tailwater data, and rating curve are used to compute discharge through the individual pump unit. The sum of the instantaneous discharge at all units at a pump station forms a single instantaneous discharge for the station as a whole.

The District records the mean daily flow data in its data base. Mean daily flows have been recorded on magnetic tape, floppy disc and hard copy, and are available from the District at cost. The raw data and calculations by which mean daily flows are derived are extremely voluminous. They have been retained for some, but not all, structures relevant to proposed Rule 40E-61. Samples of raw data and computer sub-routines have been copied onto floppy discs and are available at cost.

Flow measurements are also taken by the United States Geological Survey (USGS). The USGS publishes its mean daily flows, which are then included in the District's database. Questions about raw data for these mean daily flows should be directed to the USGS.

In generating the standards in proposed Rule 40E-61, data measured by the USGS was used when available, and District data was used when USGS data was not available. The first column of Table 2 indicates the source of measured mean daily flow data. This is the source of data used in generating the standards in proposed Rule 40E-61, unless indicated otherwise on the other portions of Table 2.

There are several periods of time in several sub-basins for which no measured flow data is available. These are listed on Table 2 in the column entitled "Unavailable Measured Mean Daily Flow Data". The reasons why measured flow data is not available vary, for example, a measuring device may have been broken for a short period of time, a structure and flow meter may not have been constructed until late in the period of record, or complete records or raw data may not have been available.

When measured flow data was unavailable for a period of less than one month, estimates of the flows for that period of time were not calculated. The flows for those days are accounted for in the loading calculations. (The mean daily load for the days of the month for which measured flow data is available are multiplied by the total number of days in the month. See Section D.2.(b.) for further discussion of loading). These values are not considered "estimated" for the purpose of generating the standards in proposed Rule 40E-61, and are not discussed as estimates in the remainder of this document.

When flow data is unavailable for more than a one month period, flow is estimated. Several methods of estimation are used, depending on the quantity and quality of data available on which to base the estimate. The estimates for each period of unavailable flow data in each sub-basin is discussed following Table 2. The last column in Table 2 addresses estimates for unavailable measured flow data.

Table 2. Summary of Discharge (Flow) Data

Inputs (Sub-Basins)	Measured Mean Daily Flow Sources*	Unavailable Measured Mean Daily Flow Data			Flow Estimates Explained
		Start	End	Days	
Controllable Sources					
C-38 Pool A (S-65A)	SFWMD				No Gaps
C-38 Pool B (S-65B)	SFWMD	01/22/87	01/22/87	1	**
		11/11/87	11/11/87	1	**
		12/03/87	12/03/87	1	**
C-38 Pool C (S-65C)	SFWMD	01/01/87	01/05/87	5	**
		02/01/87	02/09/87	9	**
C-38 Pool D (S-65D)	SFWMD	06/08/78	06/08/78	1	**
		08/17/78	08/20/78	4	**
		01/01/87	01/05/87	5	**
		02/01/87	02/09/87	9	**
C-38 Pool E (S65E)	USGS	01/01/74	09/30/74	273	D.1.(a).
		09/01/87	09/30/87	30	
S-4	SFWMD	-	07/00/75		pump not in existance, no flows
		06/05/86	06/15/86	11	2
S-191 (TC/NS)	SFWMD	06/13/73	07/31/73	49	(D.1.b.)
		11/24/84	11/24/84	1	**
S-71 (C-41)	USGS	-	-	none	No Gaps
S-72 (C-40)	USGS	-	-	none	No Gaps
S-84	USGS	-	-	none	No Gaps
Fisheating Creek	USGS	01/03/84	01/08/84	6	**
S-127 (L-48)	SFWMD	-	-	none	No Gaps
S-129 (L-49)	SFWMD	01/31/73	01/31/73	1	**
		03/31/73	03/31/73	1	**
		05/31/73	05/31/73	1	**
		07/31/73	07/31/73	1	**
		08/31/73	08/31/73	1	**
		10/31/73	10/31/73	1	**
		12/31/73	12/31/73	1	**
		01/31/74	01/31/74	1	**
		03/31/74	03/31/74	1	**
		05/31/74	05/31/74	1	**
		07/31/74	07/31/74	1	**
		08/31/74	08/31/74	1	**
		10/31/74	10/31/74	1	**
		12/31/74	12/31/74	1	**
		01/31/75	01/31/75	1	**
		03/31/75	03/31/75	1	**
		05/31/75	05/31/75	1	**
		07/31/75	07/31/75	1	**
		08/31/75	08/31/75	1	**
		10/31/75	10/31/75	1	
		12/31/75	12/31/75	1	

Table 2 (Continued). Summary of Discharge (Flow) Data

Inputs (Sub-Basins)	Measured Mean Daily Flow Sources*	Unavailable Measured Mean Daily Flow Data			Flow Estimates Explained
		Start	End	Days	
Controllable Sources					
S-129 (L-49)	SFWMD	01/31/76	01/31/76	1	**
		03/31/76	03/31/76	1	**
		05/31/76	05/31/76	1	**
		07/31/76	07/31/76	1	**
		08/31/76	08/31/76	1	**
		10/31/76	10/31/76	1	**
		12/31/76	12/31/76	1	**
		01/31/77	01/31/77	1	**
		03/31/77	03/31/77	1	**
		05/31/77	05/31/77	1	**
		07/31/77	07/31/77	1	**
		08/31/77	08/31/77	1	**
		10/31/77	10/31/77	1	**
		12/31/77	12/31/77	1	**
		01/31/78	01/31/78	1	**
		03/31/78	03/31/78	1	**
		05/31/78	05/31/78	1	**
		08/31/78	08/31/78	1	**
		10/31/78	10/31/78	1	**
		01/31/79	01/31/79	1	**
		03/31/79	03/31/79	1	**
		05/31/79	05/31/79	1	**
		07/31/79	07/31/79	1	**
		05/31/80	05/31/80	1	**
		07/31/80	07/31/80	1	**
		10/31/80	10/31/80	1	**
		12/31/80	12/31/80	1	**
		01/31/81	01/31/81	1	**
		03/31/81	03/31/81	1	**
		05/31/81	05/31/81	1	**
		07/31/81	07/31/81	1	**
		08/31/81	08/31/81	1	**
		10/31/81	10/31/81	1	**
		12/31/81	12/31/81	1	**
		01/31/82	01/31/82	1	**
		03/31/82	03/31/82	1	**
		07/31/82	07/31/82	1	**
		08/31/82	08/31/82	1	**
		10/31/82	10/31/82	1	**
		12/31/82	12/31/82	1	**
		05/31/83	05/31/83	1	**
		07/31/83	07/31/83	1	**
		12/31/83	12/31/83	1	**
		10/31/85	10/31/85	1	**
		12/31/85	12/31/85	1	**
		01/31/86	01/31/86	1	**
		03/31/86	03/31/86	1	**
		05/01/86	05/30/86	30	***
		08/08/87	08/10/87	3	**

Table 2 (Continued). Summary of Discharge (Flow Data)

Inputs (Sub-Basins)	Measured Mean Daily Flow Sources*	Unavailable Measured Mean Daily Flow Data			Flow Estimates Explained
		Start	End	Days	
Controllable Sources					
S-131	SFWMD	05/01/86	05/30/86	30	***
S-133	SFWMD	05/01/86	06/30/86	61	***
		11/01/86	11/02/86	2	**
		07/19/87	07/21/87	3	**
		09/16/87	09/21/87	6	**
S-135	SFWMD	05/01/86	06/30/86	61	***
S-154	SFWMD	01/01/73	06/18/78	1,995	D.1.(b.)
		07/15/78	07/17/78	3	**
		09/22/78	10/15/78	24	**
		10/25/78	10/30/78	6	**
		11/16/78	12/04/78	19	**
		01/19/80	01/27/80	9	**
		12/19/81	12/20/81	2	**
		05/16/82	05/27/82	12	**
		05/14/85	06/13/85	30	**
		09/11/85	09/11/85	1	**
		04/16/86	04/30/86	15	**
		08/30/87	09/24/87	26	**
Industrial Canal		01/01/73	08/16/76	1,324	D.1.(d.)
		10/01/80	12/07/81	433	
		07/01/82	08/31/82	62	
S-236 (So. Fla. Conservancy)		04/01/73	09/30/87	5,296	D.1.(e.)
Culvert 4A (So Bay/ So Shore)		04/01/73	09/30/87	5,296	D.1.(f.)
Culvert 12 (East Shore D.D.)		04/01/73	09/30/87	5,296	D.1.(g.)
Culvert 12A (715 Farms)		04/01/73	09/30/87	5,296	D.1.(h.)
Culvert 10 (East Beach D.D.)		04/01/73	09/30/87	5,296	D.1.(i.)
L-59E, L-59W, Culv. "A"		04/01/73	09/30/87	5,296	D.1.(j.)
S-154C		04/01/73	09/30/87	5,296	D.1.(j.)
L-60E, L-60W		04/01/73	09/30/87	5,296	D.1.(j.)
L-61E, L-61W		04/01/73	09/30/87	5,296	D.1.(j.)
Culvert 5 (Nicodemus Slough)		04/01/73	09/30/87	5,296	D.1.(j.)
S-308C (C-44, S-153)	USGS	11/14/73	01/16/74	63	D.1.(k)
		03/22/74	07/16/81	2,673	
		12/29/81	02/24/82	57	
		09/12/83	01/04/84	114	
		10/07/86	12/03/86	57	
S-2 (flood control)	USGS	-	-	none	
S-3 (flood control)	USGS	-	-	none	

Table 2 (Continued). Summary of Discharge (Flow Data)

Inputs (Sub-Basins)	Measured Mean Daily Flow Sources*	Unavailable Measured Mean Daily Flow Data			Flow Estimates Explained
		Start	End	Days	
Uncontrollable Sources					
Rainfall					****
S-65 (Lake Kissimmee)	USGS	01/01/73 01/01/74	09/30/73 09/30/74	273 273	D.1.(m).
S-68 (Lake Istokpoga)	USGS	-	-	none	
HGS-5 (W.P.B. Canal)	USGS	05/08/74	06/25/74	49	D.2.b.26.
S-77 (East Caloosahatchee)	USGS	-	-	none	
Culvert 10A (L-8)	USGS	01/01/73 02/01/85 01/01/86	06/30/76 09/30/85 09/30/86	1,277 242 273	D. 1. (l.)

* The raw data for measured mean daily flow has been recorded on floppy discs, and is available upon request at actual cost. SFWMD database codes for measured sources are listed in Table 3.

** Less than one month period of unavailability. No flow estimate was calculated. Monthly means were used. See text, Section D.1.

*** Unavailable data later verified to be period of no flow.

****Rainfall quanity is rountinely monitored at seven sites in the vicinity of Lake Okeechobee, (Figur 1) and the SFWMD uses an average of these sites to estimate rainfall on the lake. It is known, however, that rainfall on the lake is generally less than in the immediate surrounding area and in this report, the volume of rainfall is set at 80% of the weighted average. Weather radar observation, satellite photos, customary practice, water budget calculations, and Riebsam et al., 1974 suggest that 80% is a reasonable value.

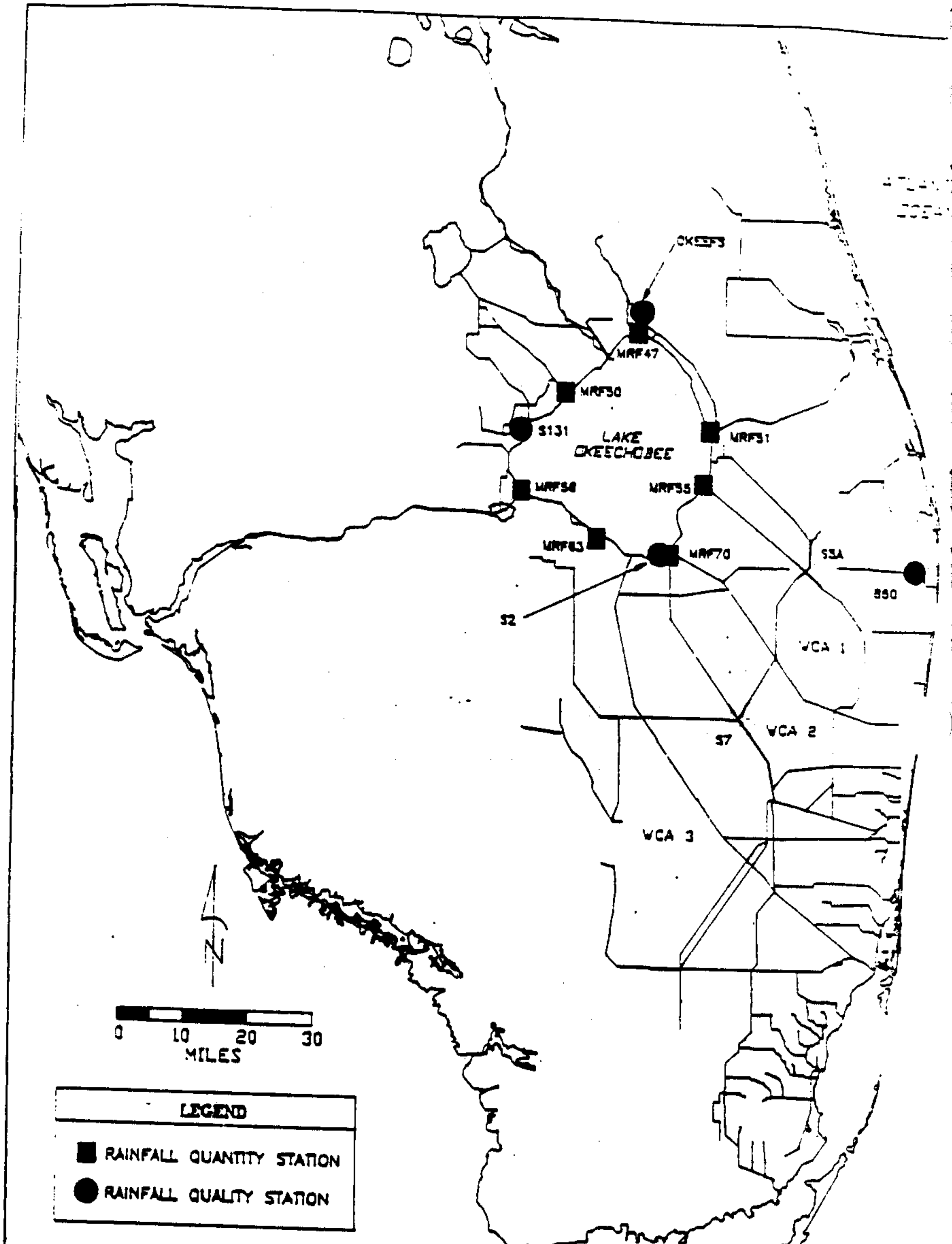


Figure 1. RAINFALL QUANTITY AND QUALITY RAINFALL STATIONS FOR LAKE OKEECHOBEE WA
AND PHOSPHORUS BUDGETS

Table 3. Sources of Mean Daily Flow Data Used in Calculation of Lake Okeechobee Tributary Loads

Tributary	Agency	SFWMD DB Code	Period Covered
S-65A	SFWMD	04430	10/72 - 09/86
S-65A	SFWMD	06801	10/86 - 09/87
S-65B	SFWMD	04436	10/72 - 12/86
S-65B	SFWMD	06841	01/87 - 09/87
S-65C	SFWMD	04458	10/72 - 09/87
S-65D	SFWMD	04470	10/72 - 09/87
S-65E	USGS	00241	10/72 - 09/87
S-4	SFWMD	06738	*
S-191	SFWMD	04530	10/72 - 06/86
S-191	SFWMD	06732	06/86 - 09/87
S-71	USGS	00094	10/72 - 09/87
S-72	USGS	00100	10/72 - 09/87
S-84	USGS	00249	10/72 - 09/87
Fisheating Creek	USGS	00090	10/72 - 09/87
S-127	SFWMD	06751	10/72 - 09/87
S-129	SFWMD	06812	10/72 - 03/87
S-129	SFWMD	04018	04/87 - 09/87
S-131	SFWMD	06813	10/72 - 04/87
S-131	SFWMD	04036	05/87 - 09/87
S-133	SFWMD	06814	10/72 - 05/87
S-133	SFWMD	04048	06/87 - 09/87
S-135	SFWMD	06815	10/72 - 05/87
S-135	SFWMD	04066	06/87 - 09/87
S-154	SFWMD	04952	06/78 - 04/87
S-2	USGS	00426	10/72 - 09/87
S-3	USGS	00539	10/72 - 09/87
S-65	USGS	00186	10/72 - 09/87
S-68	USGS	00246	10/72 - 09/87
HGS5	USGS	00313	10/72 - 09/87
S-77	USGS	00853	10/72 - 09/87
CULV10A	USGS	02855	07/76 - 09/87
S-308 (c)	USGS	00277	10/81 - 09/87

*See S-4 Loading Calculations

a. **C-38 Pool E (S-65E)**

The flow record for S-65E is nearly complete except for a 273-day gap in 1974 (Table 2). Missing monthly mean flows at S-65E can be reliably estimated from a regression model that uses monthly mean flow data from station S-65D upstream for the 1973/87 period:

S-65E (cfs/day) = -94.53 + 1.1188 * S65D (cfs/day)

Summary information on regression model: df = 1/180, r = 0.989, p = 0.0001, standard errors: Intercept = 20.488, Slope = 0.0122.

b. **S-191**

Flow estimates were required for two months (June and July, 1973) because actual data was unavailable to make standard calculations.

The District's Water Resources Division investigated four variations of regression models to estimate the missing 61-day period, and selected a fairly simple version in part because of period of unavailable data was brief, and because of apparent problems with the other options.

Linear regression was used to make point estimates and associated prediction intervals of mean monthly discharge, based on flow data from the USGS gauge on Taylor Creek above Okeechobee (USGS gauge no. 02274500; DBKEY no. 00265).

Except for the two missing months, concurrent calculated flow measurements were available for the S-191 and the USGS gauge for a period from January 1972 to December 1981. From an original sample of 118 observations, four points were deleted based on computerized statistical analysis (using STATGRAPHICS' interaction outlier rejections feature).

Two observations were rejected for being influence points and two were deleted as outliers. The mean monthly discharge scatterplot of S-191 versus Taylor Creek is shown in Figure 2. The regression line, the 95 percent confidence interval, and the 95 percent prediction interval are also shown in Figure 2. The actual formula used to generate the data and summary statistics are shown in Table 4.

The formula is: S-191 flow = 28.43 cfs + 2.113 * (Taylor Creek gauge-measured flow).

Converted to monthly total flow volume in thousands of acre-feet, the values are as follows:

Month	Volume	95% Prediction Interval
June 1973	17.4	(8.4, 26.4)
July 1973	33.8	(24.6, 43.0)

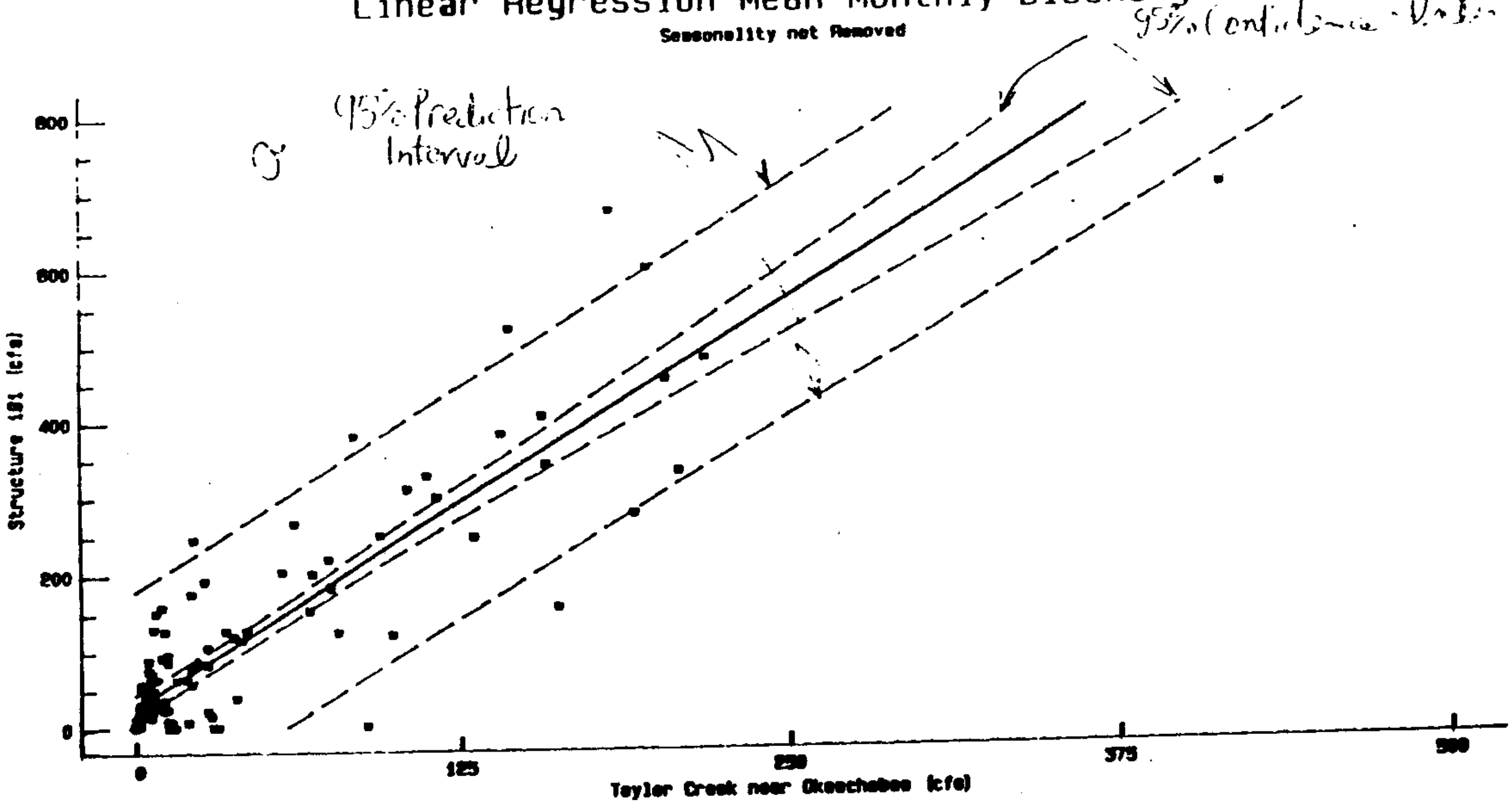
This represents the most adequate model (and estimates) of four that were investigated. While it is customary to account for seasonality when the sample contains monthly observations in a time series, the practice did not work with these observations. When the observations were standardized to remove the seasonality effect, the linear relationship became significantly weaker (coefficient of determination dropped to 0.54), and the monthly estimates of the mean and standard deviation were rendered questionable because of the small sample size (9 or 10). These calculations represented the second regression model investigated and it was rejected.

The third approach investigated was to only use June and July observations. This regression model had a falsely high coefficient of determination (0.93) because two of the eighteen observations were influence points, which had to be included to produce a valid model. Had the influence points been excluded, the July 1973 estimate would have been extrapolated.

The fourth and "next-best" alternative was to log-transform the entire set of observations. This was suggested by the data being markedly non-normal. Paired observations which contained a value of zero discharge were deleted, resulting in a sample size of 103. The model was not selected primarily because of the greater prediction intervals about the two estimates. Coefficients of determination cannot be compared when one or more of the models involve a variable transformation.

Linear Regression Mean Monthly Discharge

Seasonality not Removed



B0: 28.434 SE: 8.3734 T: 3.3957

B1: 2.1133 SE: 0.10379 T: 20.362

CORR: 0.88731 MSE: 5735.0 DF: 112

POINTS DELETED:

Figure 2

Table 4. Summary Statistics and Regression Output

	Taylor Creek	Structure 191
Mean (cfs)	42.9	119.0
Standard Deviation (cfs)	68.6	163.5
Sample Size	114	114

Regression Model: $S\text{-}191 = B_0 + B_1 * (\text{Taylor Creek})$

$B_0 = 28.43$ cfs	Standard Error:	8.37 cfs
$B_1 = 2.113$	Standard Error:	0.104
Correlation Coefficient (r) : 0.89	RMSE:	75.7 cfs
Coef. of Determination (r^2) : 0.79	DF:	112

c. S-154

The absence of both flow and stage data at S-154 between 1973 and mid-1978 required the development of a relatively conservative hydraulic model to estimate flows from this basin.

The selection of an appropriate methodology to model the S-154 discharges to Lake Okeechobee was limited by data availability for the basin. Available basin-wide data included daily rainfall, evaporation, and daily values for the discharge at the structure. Given the data constraints, the District decided that the best alternative was to develop a hydraulic model operated on daily time steps.

The hydrologic model's development and utilization is described in the following three sections. The first section discusses model development in which algorithms for simulating various components of the hydrologic cycle are presented. The second section describes model application to the S-154 basin and presents simulation results. The third section discusses the accuracy of simulated discharge values within the context of the model's ability to accurately represent the hydrology of the S-154 basin.

Computer code for the model was written in Pascal for use on IBM personal computers and compatible. It is titled PROGRAM RUNOFF. Accompanying graphics software has also been developed for analyzing model output, and all software will be made available at cost to interested parties upon request.

Model Development

A model was developed to estimate discharges from the S-154 basin. It consists of algorithms for simulating surface runoff, ground water flow to canal L-62, water table depth, and basin evapotranspiration. These are fundamental components of the hydrologic cycle, and as such, they need to be incorporated into any model of catchment hydrology. This section of the report presents algorithms for these components and details the manner in which they were incorporated into the model.

Table 5 presents algorithms used to simulate various components of the hydrologic cycle. Surface runoff is modeled by an expression developed by the United States Soil and Conservation Service (1985), and algorithms for all processes were used by Fan (1986) in the Upper Kissimmee Chain of Lakes model. Values for coefficients SC, SCOEF, HMAX, ROOT, and PCOEF contained in these algorithms are determined through model calibration. Runoff and evapotranspiration algorithms require daily values of precipitation and pan evaporation, which were obtained from historical records. Finally, total basin discharge was computed by adding values for surface runoff and ground water flow to L-62. Because the model contains no routing algorithms, it's only applicable to basins with a time of concentration of one day or less.

A flow chart illustrating the manner in which algorithms are incorporated into the hydrologic model is presented in Figure 3.

Model Implementation

The hydrologic runoff model was applied to the S-154 basin by first calibrating it and then verifying its results using historic data collected for the period 1979 through 1987. After calibration and verification had been completed, the model was used to generate basin discharge values for the years 1972 through 1978, a period for which historic discharge values were not available. This section of the report discusses the calibration and verification processes and use of the model to generate basin discharge values.

Historic data required for model calibration and verification includes daily values of observed rainfall, pan evaporation, and basin discharges. Rainfall data for the S-154 basin was developed from Thiessen weightings applied to measured values collected at District rainfall stations MRF43 (Belfort), MRF45 (structure S-65E), MRF160 (Bassinger), and MRF5034 (Okeechobee). Pan evaporation data was obtained from District pan evaporation station EVP609 (Lake Alfred), and gaps in these data were filled with measurements collected at stations EVP38 (Structure S-65C) and EVP938 (Moore Haven). Discharge values for the S-154 basin were collected at structure S-154.

Initially, a single set of parameter values for the runoff model were to be developed through calibration and verification, but consistent agreement could not be obtained between observed and simulated discharges using a single set of values. Therefore, individual years were classified as either wet, normal, or dry according to the amount of precipitation that fell in the basin in a given year, and sets of parameter values were developed for wet, normal, and dry years. The classification of a year as either wet, normal, or dry is given below.

year	rainfall (in)	classification
1979	61	wet
1980	45	dry
1981	39	dry
1982	71	wet
1983	65	wet
1984	49	normal
1985	50	normal

year	rainfall (in)	classification
1986	47	dry
1987	50	normal
average	51	

The model was calibrated for wet years using data collected during 1982 and 1983. It was calibrated for normal years with data collected during 1984 and 1985, and data collected during 1980 and 1981 was used for the dry year calibration. Figures 4, 5, and 6 compare observed and simulated values obtained for the wet, normal, and dry year calibrations respectively, and parameter values associated with model calibration are presented in Table 6. In all figures, observed discharges are represented by individual data points, and simulated discharges are represented by the solid line.

Figures 7, 8, and 9 compare observed and simulated discharge values for verification runs of the model. Verification of model parameters calibrated for wet years used historic data collected during 1979. Data collected during 1987 was used to verify the normal year calibration, and the dry year calibration was verified with data collected during 1986.

Estimates of discharges for each of the years 1972 through 1978 were generated using one of the three sets of parameters obtained through calibration and verification. Classification of these years as either wet, normal, or dry is presented below.

year	rainfall (in)	classification
1972	47	dry
1973	58	wet
1974	50	normal
1975	43	dry
1976	45	dry
1977	44	dry
1978	49	normal

Each initial soil moisture deficit for the years 1973 through 1978 is taken as the deficit of the final day of the previous year, and the initial soil moisture deficit for 1972 is the average of the deficits computed for the last day of all years. It was noted, that the effect of the initial soil moisture deficit on simulation results is negligible after two to three months of simulation.

Discussion of Results

Examination of Figures 3 through 9 indicates that the hydrologic runoff model simulated low discharges with acceptable accuracy, but it underestimated peak discharges by significant amounts. The model was purposely calibrated to perform in this conservative manner. If the model had been calibrated to accurately simulate peak discharges, it would have grossly over estimated annual discharge volumes. A comparison of simulated and observed discharge volumes is presented below. All values are in acre-feet and are given for the years used to calibrate the model.

Year	Observed	Simulated	Days of Observed Data Missing
	wet year calibration		
1982	77,000	58,000	12
1983	42,000	44,000	0
	normal year calibration		
1984	25,000	22,000	0
1985	14,000	18,000	32
	dry year calibration		
1980	6,700	6,100	9
1981	3,800	4,400	2

The model's inability to accurately simulate both low and peak discharges is attributed to the fact that it does not account for the presence of a structure at the S-154 basin's outlet. Effects of a structure on basin discharges were not incorporated into the model, because sufficient data on structure operation and its influence on basin discharges were not available to warrant the inclusion of a structure in the model. Therefore, although the modeling effort presented in this report is a best possible attempt to generate discharges from the S-154 basin, given the amount of information available about the basin, results generated by the effort should be viewed as rough estimates at best.

References

Fan, A. 1986. A ROUTING MODEL FOR THE UPPER KISSIMMEE CHAIN OF LAKES. Technical Publication 86-5. South Florida Water Management District. West Palm Beach, Florida.

USDA-SCS. 1985. NATIONAL ENGINEERING HANDBOOK. Section 4 - Hydrology. U.S. Department of Agriculture, Soil Conservation Service.

Table 5. Algorithms Used to Simulate Hydrologic Processes

Surface Runoff:

$$QS^t \qquad (R^t - RA^t)^2/(R^t - RA^t + S^t)$$

$$RA^t = SC * S^t$$

$$S^t = S^{t-1} + ET^t - R^t + QS^t + QG^t$$

QS^t	=	surface runoff on day t (in/day)
R^t	=	rainfall on day t (in/day)
RA^t	=	rainfall abstraction on day t (in/day)
S^t	=	soil moisture deficit for day t (in/day)
SC	=	soil moisture storage coefficient (-)
ET^t	=	evapotranspiration on day t (in/day)
OG^t	=	ground water discharge on day t (in/day)

Ground water Flow:

$$QG^t = SCOEF\,(HMAX - WT^t)/HMAX$$

QG^t	=	ground water discharge on day t (in/day)
SCOEF	=	potential ground water discharge (in/day)
HMAX	=	water table depth at which ground water flow ceases (ft)
WT^t	=	water table depth on day t (ft)

Evapotranspiration:

$$ET^t = PET^t(ROOT - WT^t)/ROOT$$

$$PET^t = PCOEF * EVAP^t$$

ET^t	=	evapotranspiration on day t (in/day)
PET^t	=	potential evapotranspiration on day t (in/day)
ROOT	=	water table depth at which evapotranspiration ceases (ft)
WT^t	=	water table depth on day t (ft)
PCOEF	=	pan coefficient at potential evapotranspiration (-)
$EVAP^t$	=	pan evaporation on day t (in/day)

Water Table Depth:

$$WT^t = S^t/(SC * 12)$$

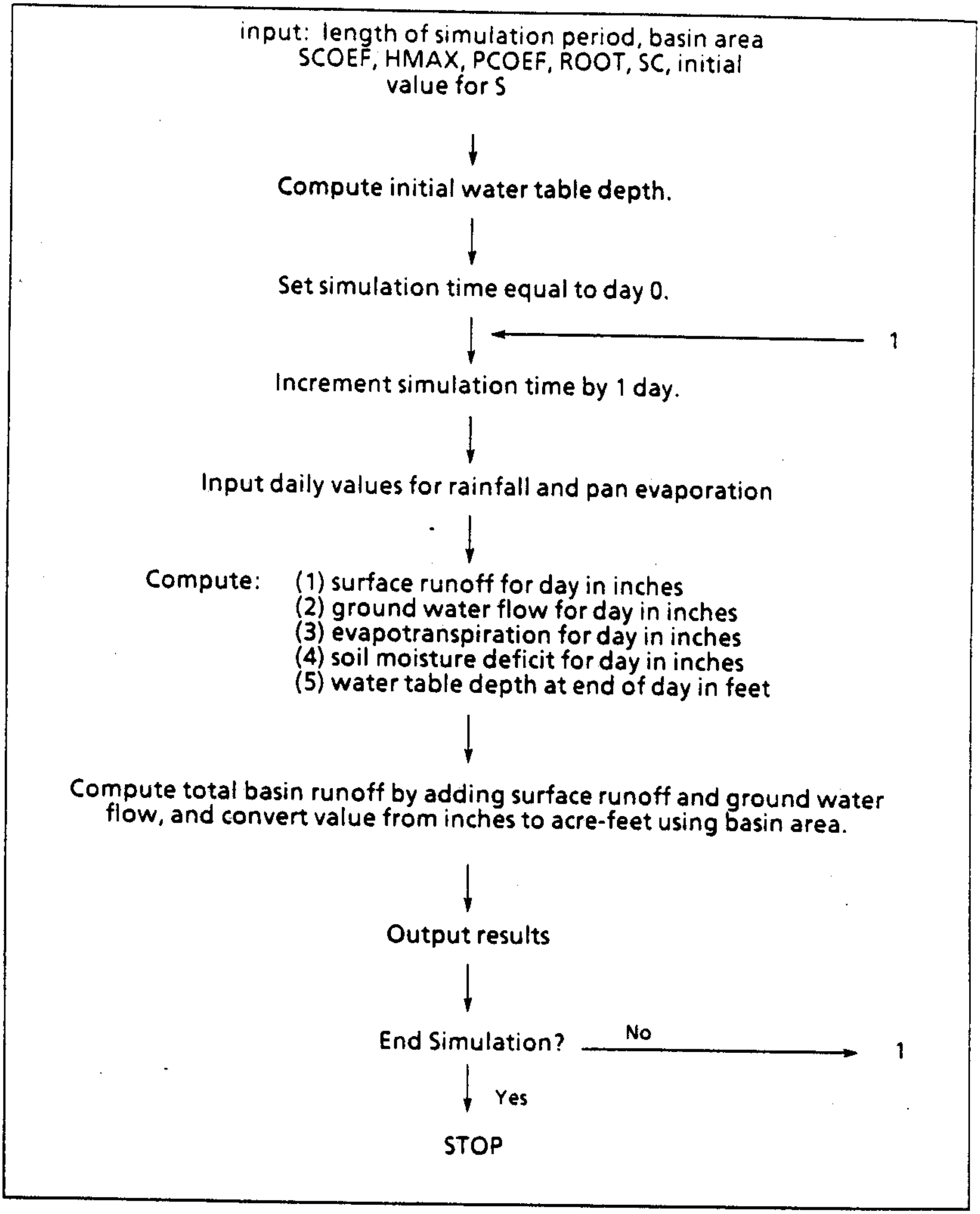
WT^t	=	water table depth on day t (ft)
S^t	=	soil moisture deficit on day t (in/day)
SC	=	soil moisture storage coefficient (-)

Table 6. Model Parameter Values

Parameter	Wet Year Calibration	Normal Year Calibration	Dry Year Calibration
SCOEF	0.20 in/day	0.088 in/day	0.0225 in/day
HMAX	5.00 ft	5.00 ft	5.00 ft
PCOEF	0.85	0.85	0.85
ROOT	9.00 ft	9.00 ft	9.00 ft
SC	0.20	0.20	0.20
init. soil moist. def.	6.00 ft	6.0 ft	6.0 ft

basin area: 33.25 sq. miles

Figure 3. Flow Chart for the Hydrologic Model



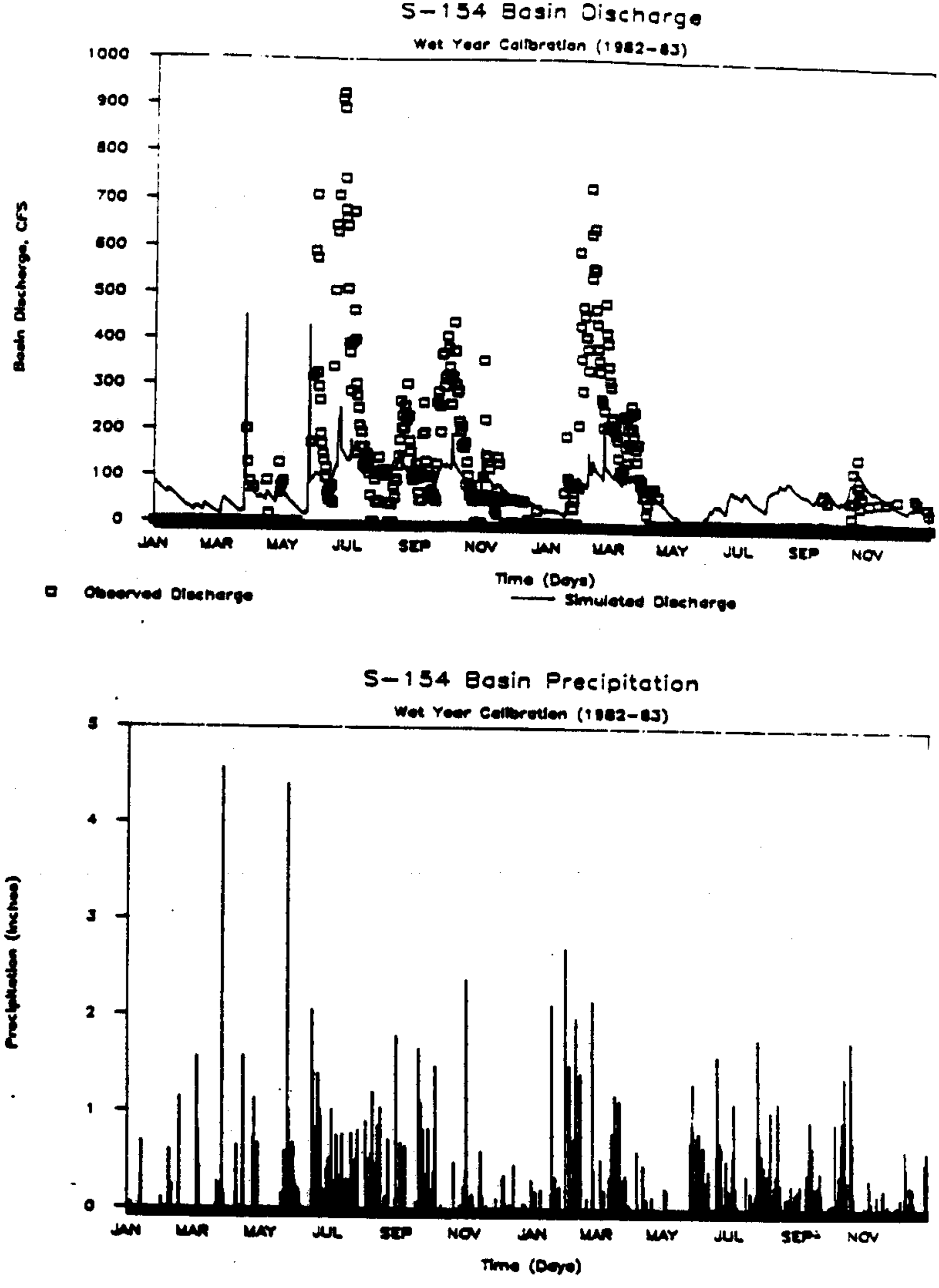


Figure 4 Wet Year Calibration (1982-1983)

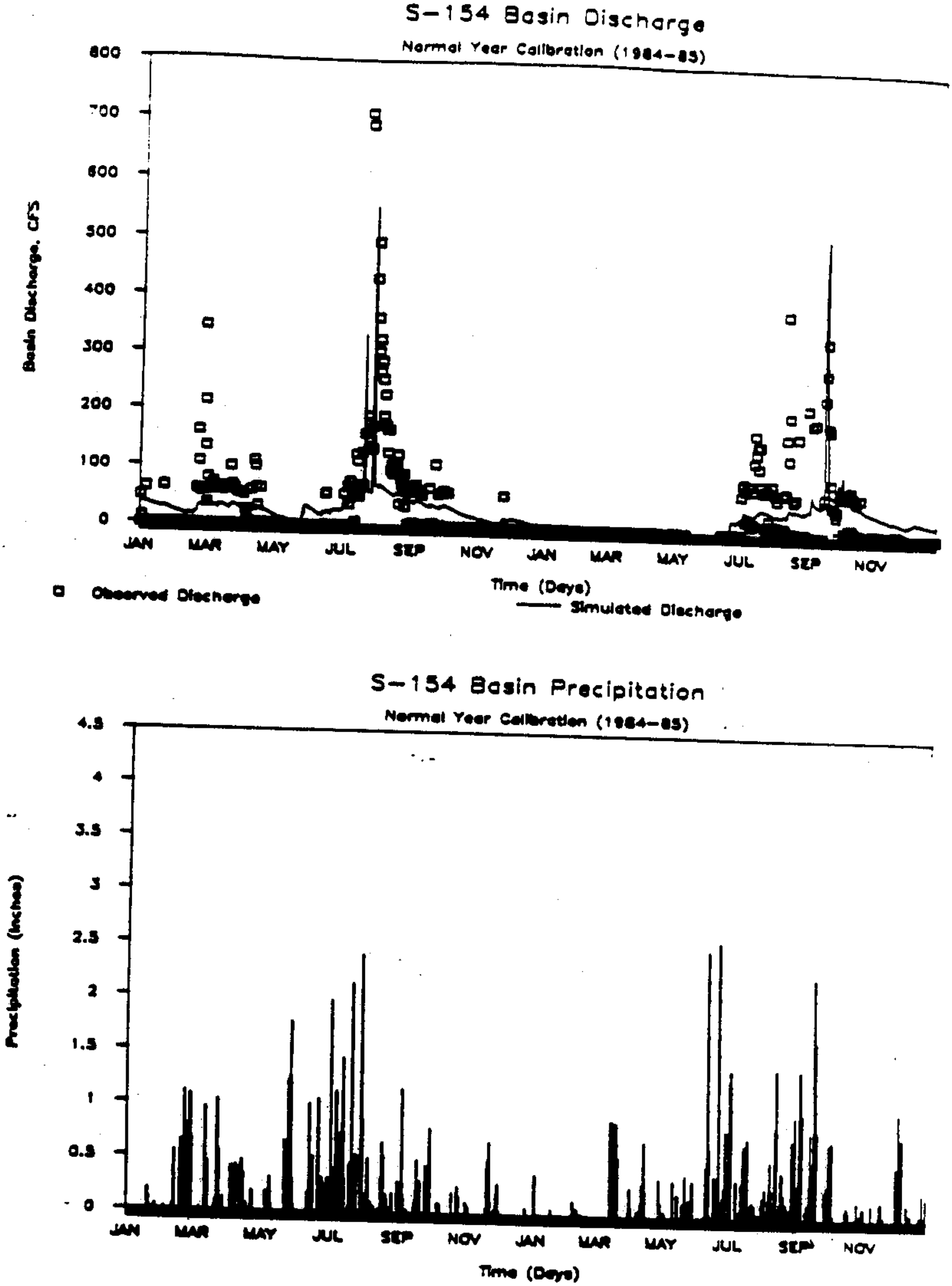
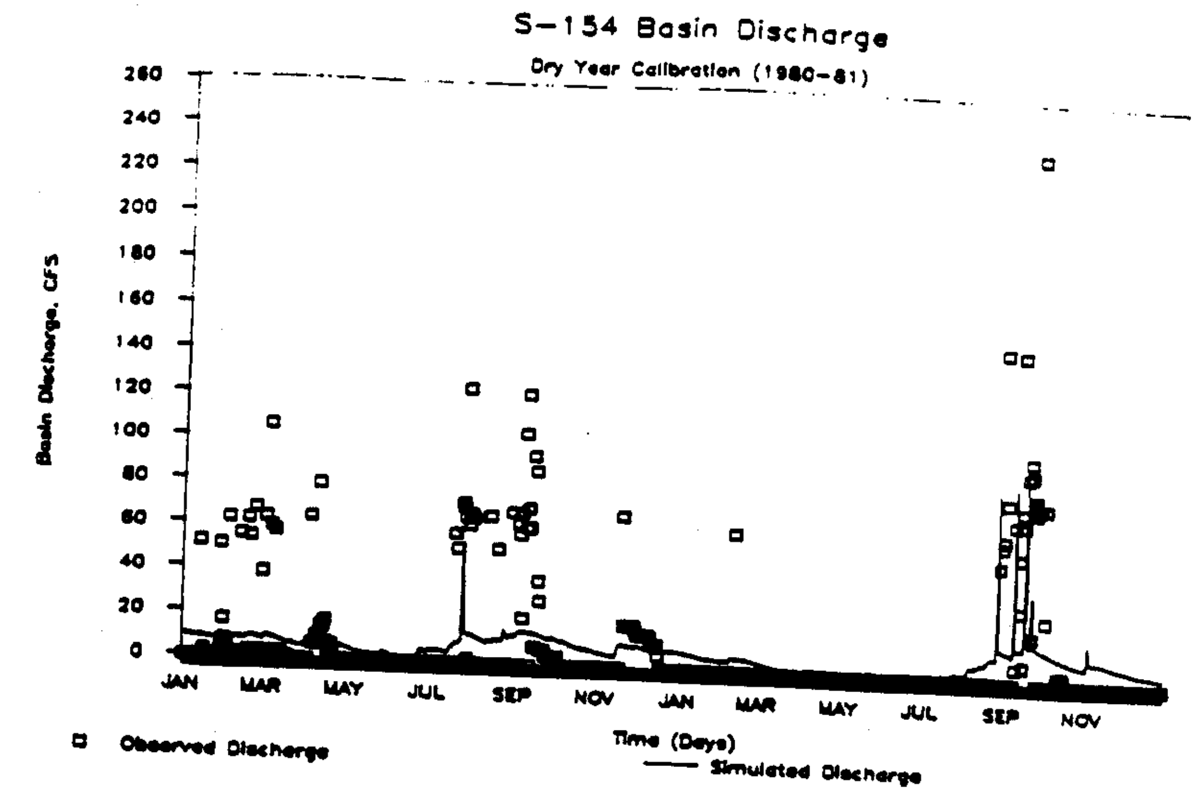


Figure 5 **Normal Year Calibration (1984-1985)**



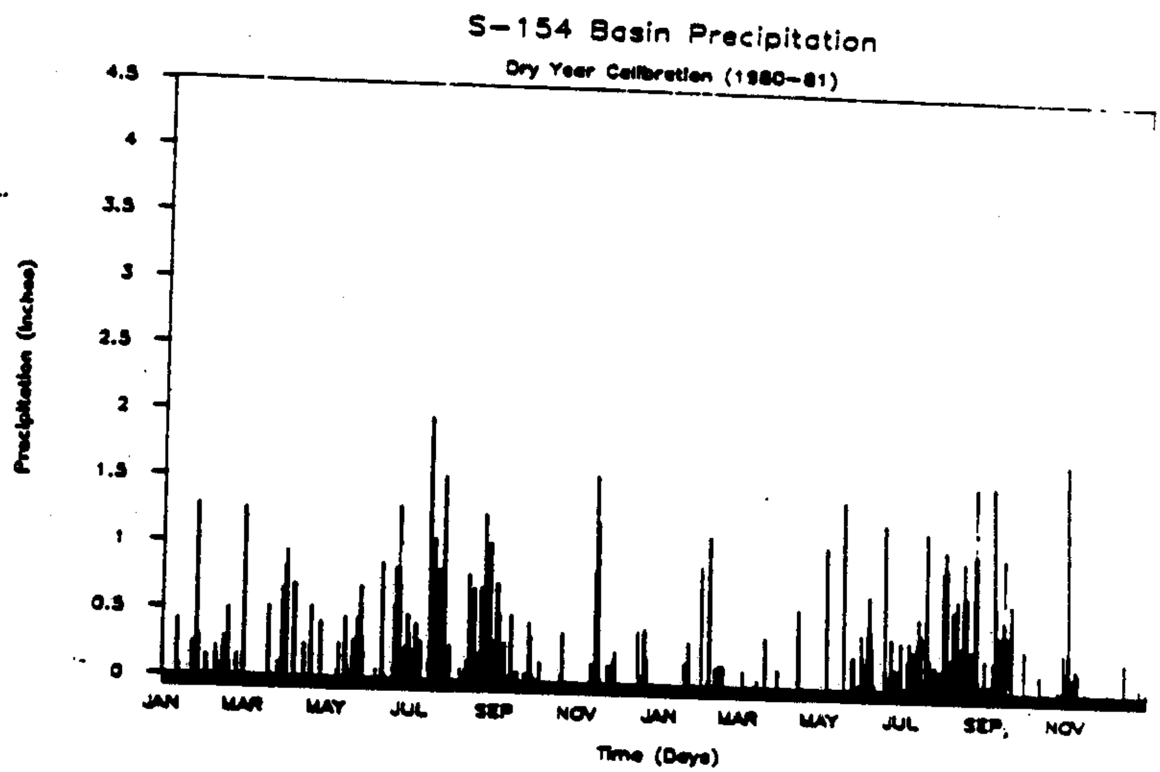
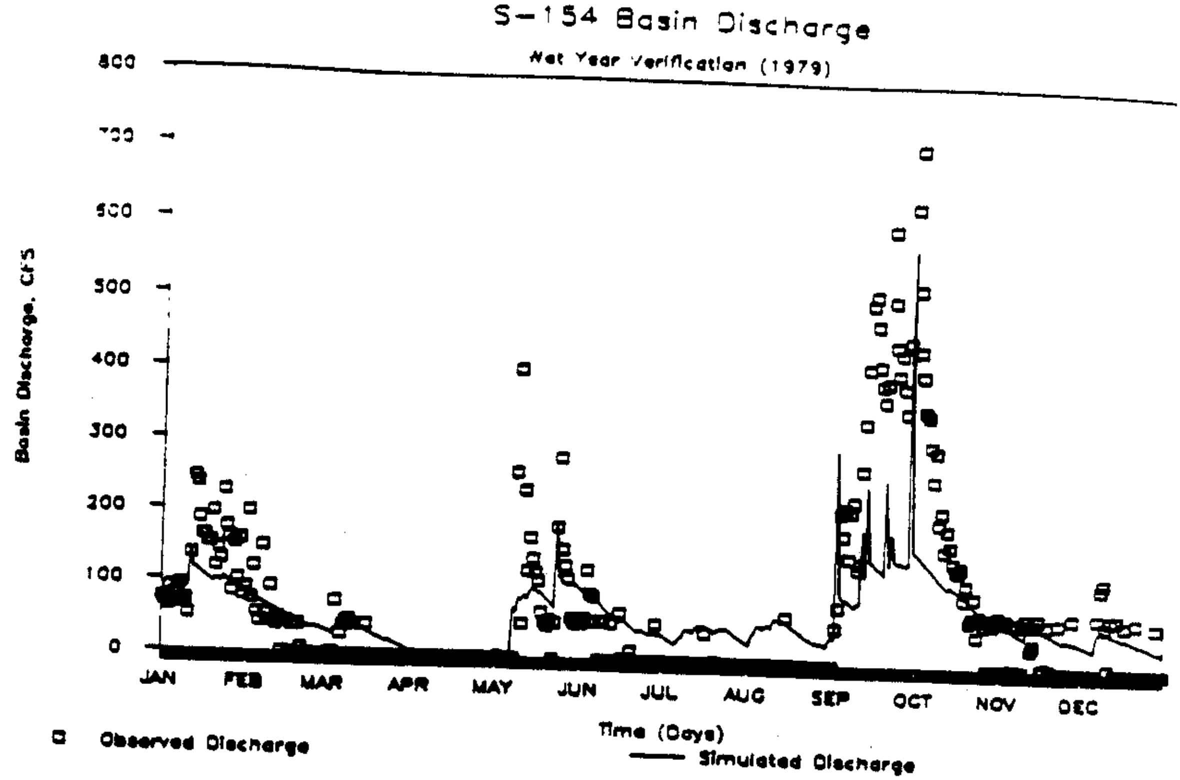


Figure 6 Dry Year Calibration (1980-1981)



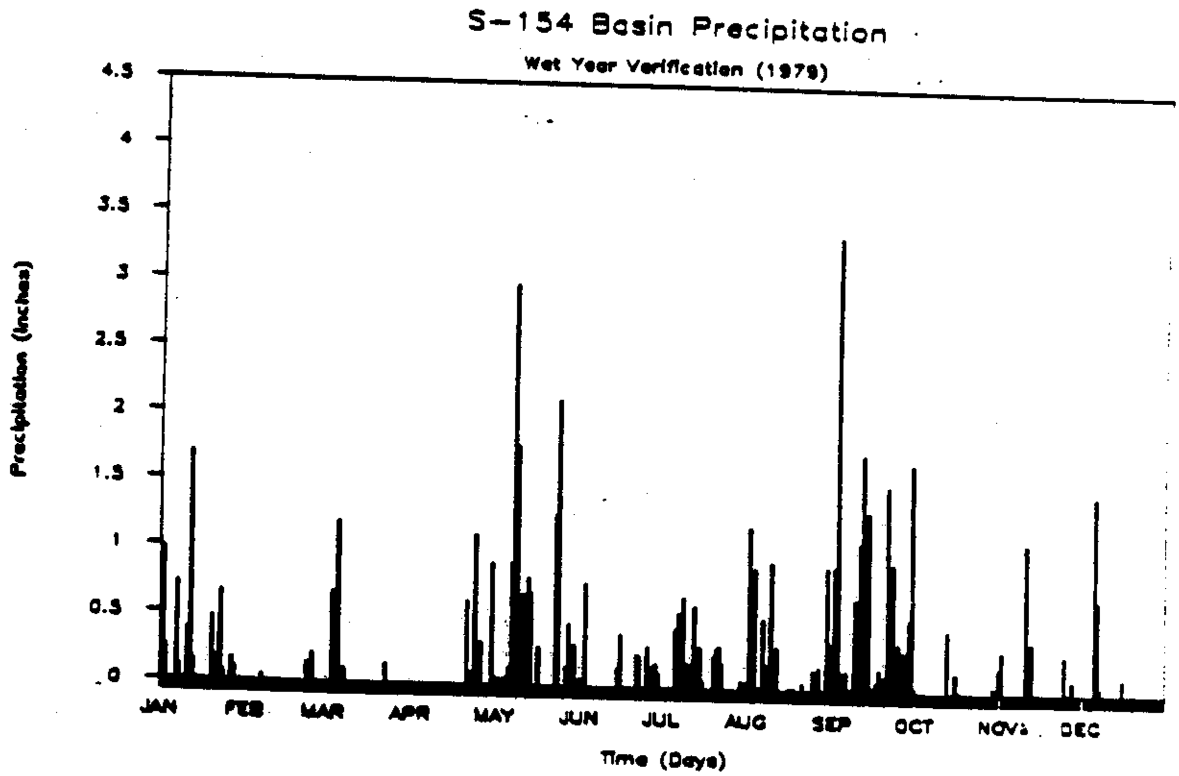
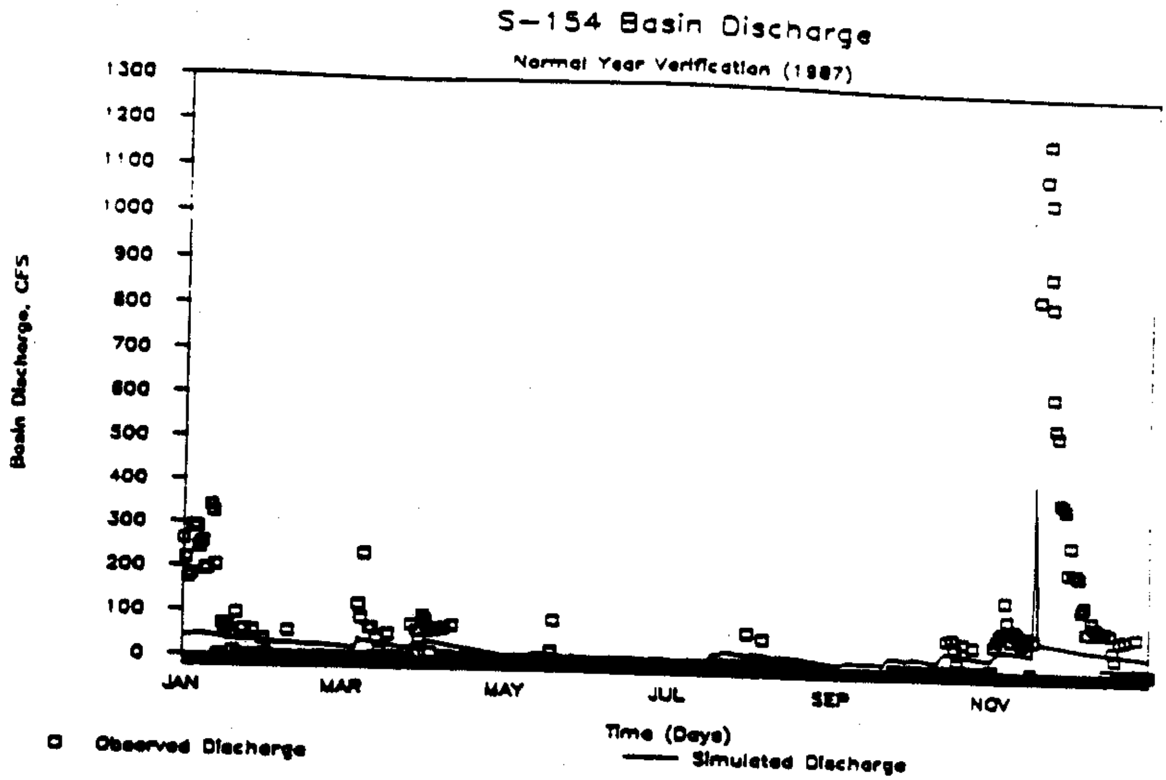


Figure 7 Wet Year Verification (1979)



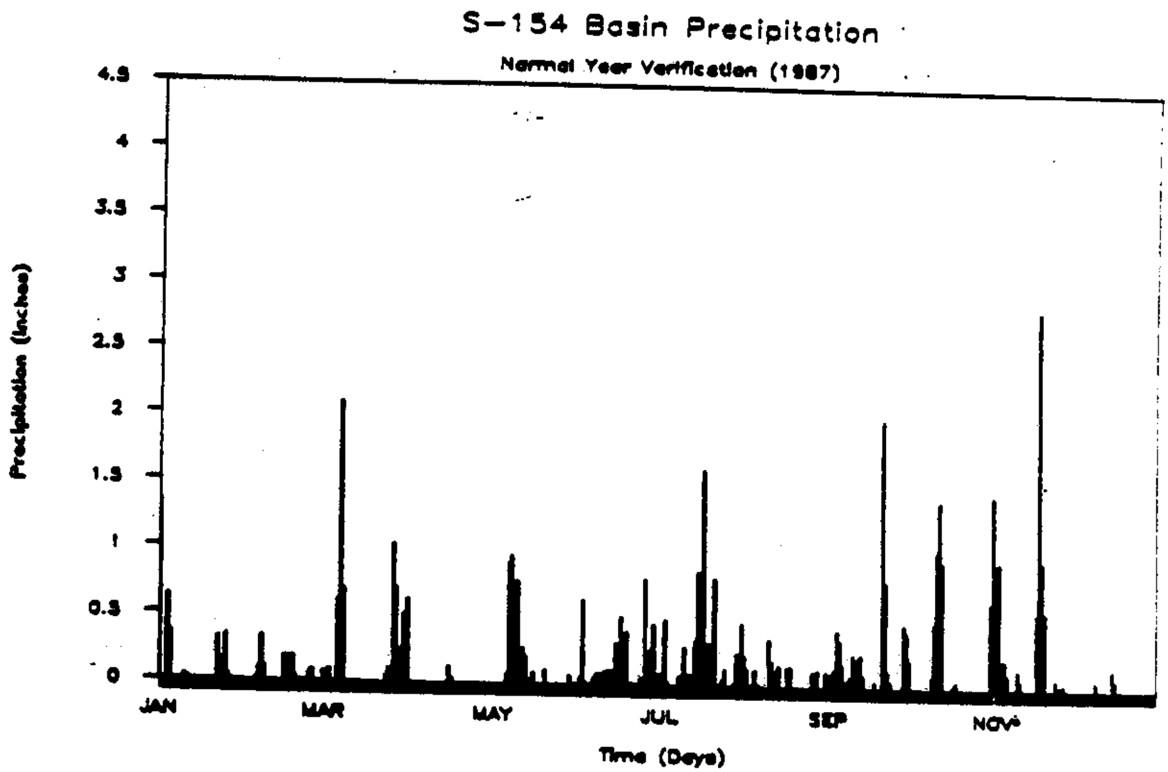


Figure 8 Normal Year Verification (1987)

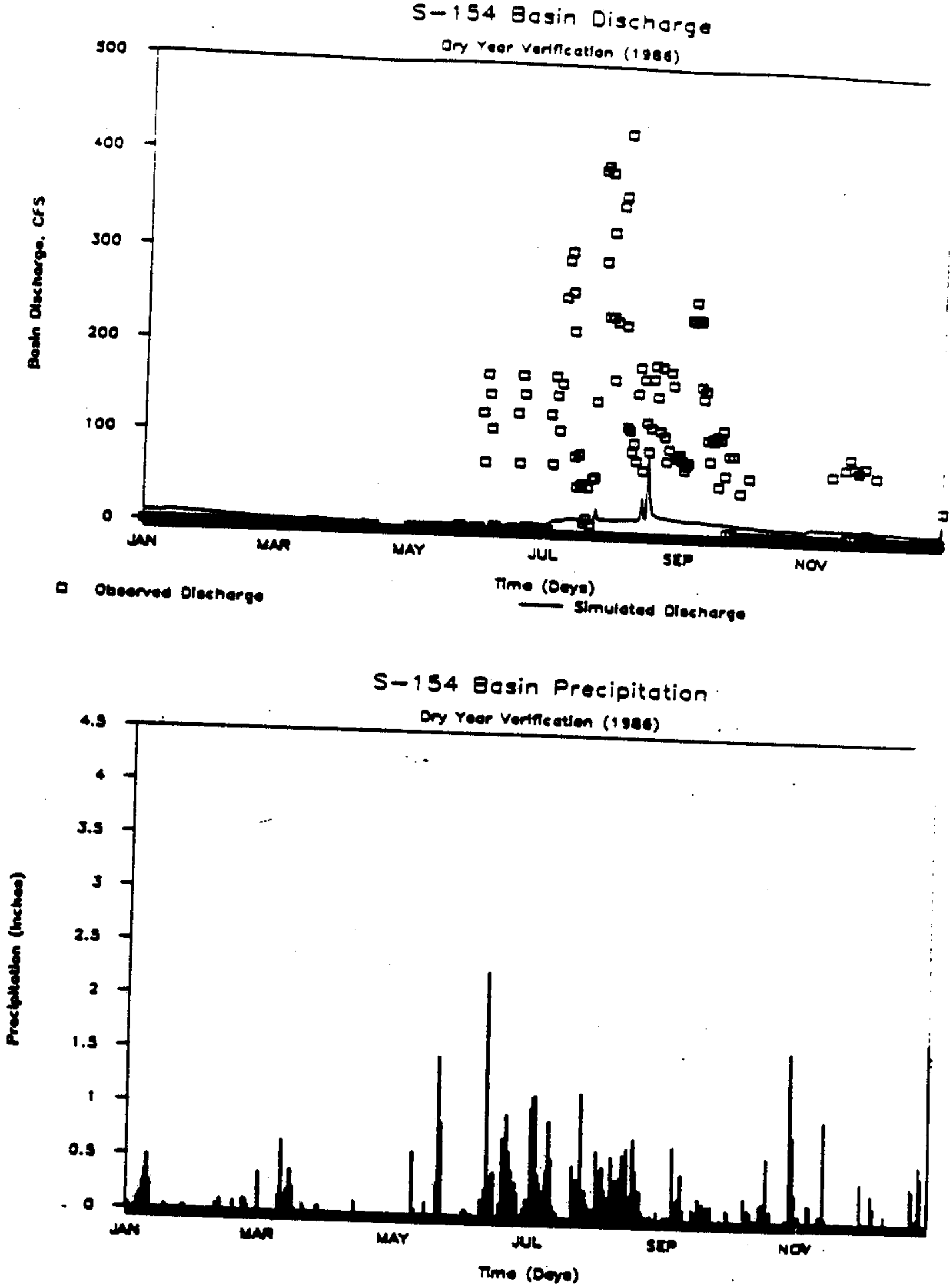


Figure 9 Dry Year Verification (1988)

d.-i. General Discussion

In order to estimate runoff pumped or discharged to Lake Okeechobee by the private drainage districts in the Everglades Agricultural Area (EAA) when pump or discharge records were not available, a rainfall versus runoff relationship was developed. This relationship is presented in Figure 10. It developed using discharge values from the East Shore, East Beach, and Bear Beach drainage districts, as reported by Fred Johns of the South Florida Conservancy District, and rainfall data collected at Belle Glade, Clewiston, Canal Point, Ritta, Miami Lock, East Shore, and Pelican. Table 7 presents the monthly discharge data reported by Fred Johns in inches and the monthly average of all seven rainfall stations used in the development of the curve in Figure 10. The rainfall/runoff curve presented in Figure 10 indicates inches of average monthly basin rainfall. To use the curve the sub-basin rainfall and area must be identified. The total area of the basin to which the curve is applicable is 76,670 acres. Sub-basin discharges are determined by multiplying inches of basin runoff by sub-basin areas with the appropriate conversion factor. Acreage figures used in calculations of flow data in c. through h. are presented in Table 8. Monthly rainfall values for each station, as well as the monthly average for all seven stations, are as currently recorded in the District's database are presented in Table 9. The data was entered into the database subsequent to development of the curve. Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

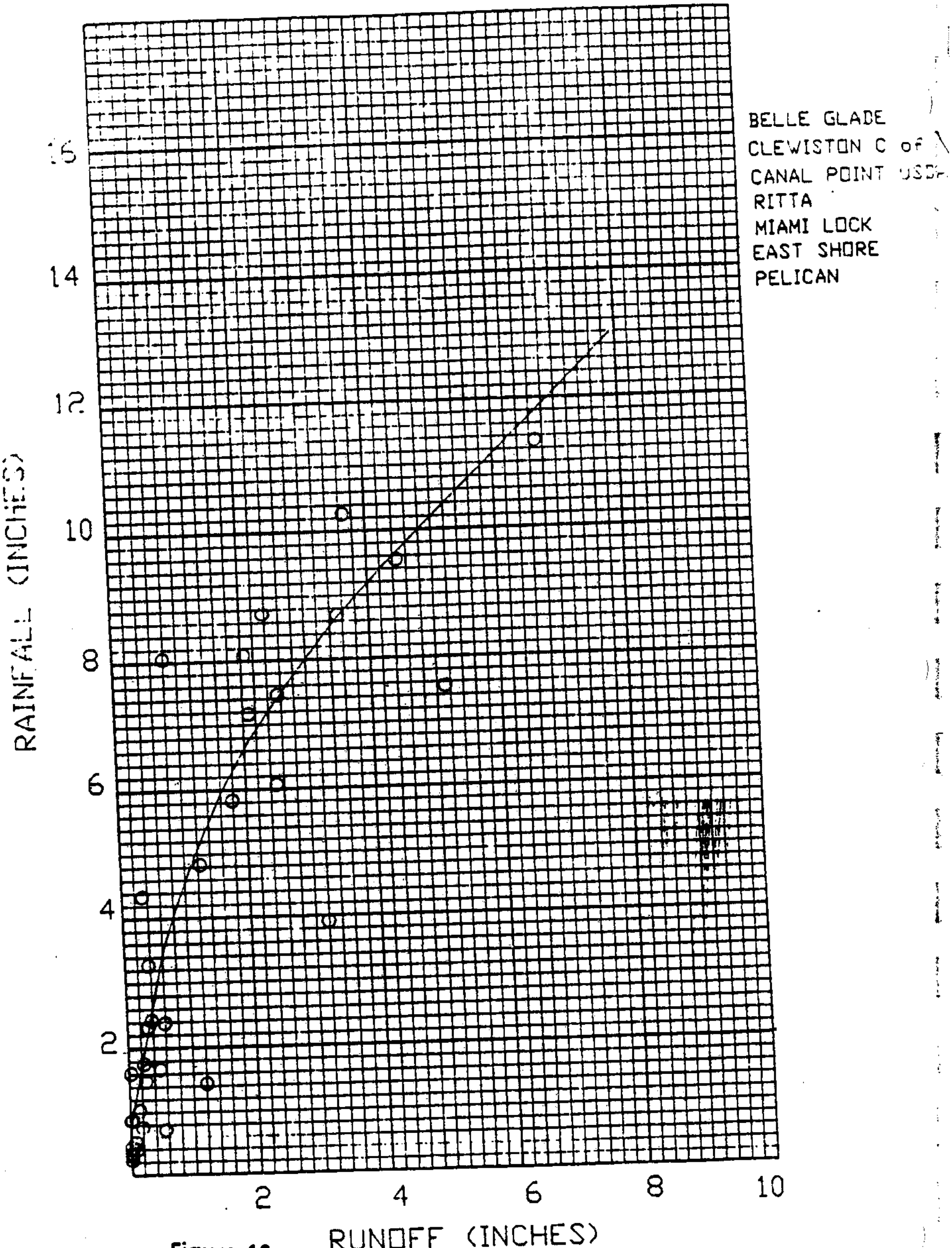


Figure 10

6/21/89

Table 7. Data Used to Develop the Rainfall/Runoff Curve

MONTH	1973			1974			1975		
	Rainfall* (inches)	Runoff** (inches)	Runoff*** cfs.	Rainfall* (inches)	Runoff (inches)	Runoff**** cfs.	Rainfall* (inches)	Runoff (inches)	Runoff**** cfs.
January	2.32	0.30	1862	0.72	0.00	0	0.52	0.00	0
February	1.61	0.17	1055	0.40	0.00	0	1.67	0.19	1179
March	2.43	0.33	2048	0.35	0.00	0	0.76	0.00	0
April	0.88	0.00	0	0.88	0.00	0	1.49	0.16	993
May	4.35	0.87	5401	3.28	0.55	3414	8.09	2.98	18499
June	7.17	2.30	14278	10.26	5.12	31784	8.69	3.48	21603
July	8.04	2.94	18251	11.32	6.75	41903	8.73	3.52	21852
August	6.07	1.63	10119	7.54	2.60	16140	5.83	1.50	9312
September	4.84	1.08	6704	7.46	2.55	15830	9.53	4.30	26694
October	2.38	0.39	2421	1.44	0.15	931	3.91	0.70	4345
November	0.24	0.00	0	1.76	0.20	1242	0.44	0.00	0
December	1.66	0.20	1242	1.03	0.06	372	0.31	0.00	0
			63381 vs 47890			111616 vs 116310			104477 vs 103510

* Rainfall values in this table might not correspond to the values in the District's data base (Table 9), which has been updated since development of the curve.

** Data reported by the South Florida Conservancy District.

*** Runoff in cfs. was estimated by multiplying the runoff in inches by the conversion factor of 6208.

**** Runoff in cfs. was estimated by multiplying the runoff in inches by the conversion factor of $\frac{74494}{12}$

Table 8.

Acreage figures used in calculations of flow data in c. through h.

Total private drainage basin summary:

	Acreage
East Beach	5,100
East Shore	8,450
715 Farms	2,750
South Shore	2,700
S-236	6,530
Mayacca Groves	2,800
PB Groves	640
Closter Farms	350
Clewiston	3,000
Thorton Nursery	70
Ridgedill	1,080
Pelican Lake	960
U. S. Sugar Ind. Co.	10,496
SFCDD	4,480
Sugarland	11,580
Diston Island	15,680
	76,670 AC

Industrial Canal and S-4 Area

Clewiston DD	3,000	AC
Thorton Nursery	70	
Ridgedill	1,080	
U. S. Sugar	10,496	
SFCD	4,480	
Sugarland	11,580	
Diston Island	15,680	
	46.386 / 76,670	= .605

Thornton Nursery	70	
Ridgedill	1,080	
U. S. Sugar	10,496	
SFCDD	4,480	
	16,126 / 76,670	= .210

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
1/72	1.43	.79	2.33	NA	NA	3.39	NA	1.99
2/72	1.51	1.31	1.99	NA	NA	2.05	NA	1.72
3/72	1.66	1.50	2.09	NA	NA	2.46	NA	1.93
4/72	7.69	3.61	4.03	NA	NA	6.22	NA	5.39
5/72	7.01	5.38	.00M	NA	NA	6.21	NA	6.20
6/72	7.10	9.00	9.99	NA	NA	8.51	NA	8.65
7/72	8.76	6.37	.00M	NA	NA	8.96	NA	8.03
8/72	5.75	5.76	2.50	NA	NA	6.95	NA	5.24
9/72	4.50	.79	1.77	NA	NA	2.84	NA	2.48
10/72	1.32	1.29	1.72	NA	NA	.28	NA	1.15
11/72	3.81	2.86	4.15	NA	NA	4.81	NA	3.91
12/72	1.45	1.32	2.42	NA	NA	2.26	NA	1.86
TOTALS	51.99	39.98	32.99	NA	NA	54.94	NA	48.53
1/73	2.53	2.04	2.66	NA	NA	2.85	NA	2.52
2/73	1.38	2.76	1.99	NA	NA	1.37	NA	1.88
2/73	4.27	2.68	2.00	NA	NA	3.27	NA	3.06
4/73	1.05	.83	.84	NA	NA	.96	NA	.92
5/73	4.22	3.88	5.03	NA	NA	3.12	NA	4.06

All values reported in this table are inches of rainfall

* Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

** The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
- A = 1-5 missing days in a given month
- B = 6-10 missing days in a given month
- C = 11-15 missing days in a given month
- D = 16-20 missing days in a given month
- E = 21-30 missing days in a given month
- M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
6/73	11.61	5.41	4.62	NA	NA	7.11	NA	7 19
7/73	12.43	7.06	6.03	NA	NA	9.16	NA	8 67
8/73	7.22	6.71	4.30	NA	NA	5.36	NA	5.90
9/73	3.47	5.39	5.74	NA	NA	3.52	NA	4 53
10/73	1.74	1.04	3.38	NA	NA	4.07	NA	2 56
11/73	.01	.20A	.98	NA	NA	.10	NA	.32
12/73	1.27	1.59	1.77	NA	NA	1.55	NA	1 55
TOTALS	51.20	39.59A	39.34	NA	NA	42.44	NA	43.14
1/74	.81	.17	2.12	.22B	.34C	.93	.38C	85
2/74	.19	.24	.58	.48	.05	.64	.10	33
3/74	.41	.37	.22	.90	.30	.17	.12	36
4/74	1.34	.89	1.37	.31	96	.33	.96	88
5/74	2.68	1.86	6.01	2.64	2.53	3.78	3.80	3 33
6/74	13.15	16.27	10.43	10.00	8.63	7.38	6.24	10 30
7/74	11.52	11.63	6.87	11.19	13.36	13.46	5.69B	11 27
8/74	7.20	9.00	5.89	7.17	7.88	10.95	2 02D	7 97
9/74	9.47	4.72	7.14	6.90A	9.00	8.35	7 05A	7 62
10/74	1.18	1.91	2.06	.44	.20	1.46	1.00	1 18

All values reported in this table are inches of rainfall

* Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

** The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily ave[illegible]ges as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
11/74	1.65	1.36	1.60	3.15	2.12	1.24	1.94	1.87
12/74	1.04A	1.09	.95	.75	.76	1.12	.58	.92
TOTALS	50.64	49.51	45.24	44.15B	46.13C	49.81	29.88	46.82
1/75	.08	.46	.46	.61	.28	.26	.70	.41
2/75	.25A	2.19	4.15	1.31	.33	1.29	1.67	1.61
3/75	.43	.55	1.00	.50	1.17	1.21	.53	.77
4/75	1.74	2.06	1.09	2.31	1.56	1.29	.53	1.51
5/75	5.56	9.99	10.13	7.21	8.40	7.18	4.39C	8.35
6/75	7.14	5.88	7.34	7.92	8.63	14.80	2.20D	8.63
7/75	13.69	8.65	7.72	3.91	8.50A	8.48	2.82C	8.11
8/75	5.13	3.29	4.52	2.96	7.85	7.38	9.39	5.79
9/75	8.37	7.89	8.95	7.15	10.29	13.17	8.78	9.23
10/75	5.74	2.00	4.36	1.42	3.36	4.36	6.32	3.94
11/75	.53	.22	.82	.05	.20	.71	.45	.43
12/75	.38	.18	.21	.19	.71	.22	.20	.30
TOTALS	49.04	43.36	50.75	35.54	51.28A	60.35	37.98D	49.06
1/76	.40	.41	.43	.05	.63	.88	.45	.46
2/76	2.93	1.76	2.11	2.00	3.06	3.16	2.86	2.55

All values reported in this table are inches of rainfall

* Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
- A = 1-5 missing days in a given month
- B = 6-10 missing days in a given month
- C = 11-15 missing days in a given month
- D = 16-20 missing days in a given month
- E = 21-30 missing days in a given month
- M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
3/76	1.41	.01	.30	.16	.17	.29	.47	40
4/76	.92	1.55	1.79	1.43	1.27	1.38	1.05	1.34
5/76	7.84	7.55	8.74	7.15	5.54	11.77	12.17	8.68
6/76	4.06	5.91	7.85	5.28	5.62	8.03	3.46B	6.07
7/76	5.58	3.30	2.07	2.48	4.24	9.70	4.66	4.58
8.76	6.94	3.31	7.49	6.06B	7.82	8.65	6.57	6.84
9/76	5.91	2.38	2.96	3.28	5.47	7.71	5.01A	4.70
10/76	.81	1.30	.26	.81	.89	.43	.20	67
11/76	1.66	2.24	2.26	1.64	1.68	2.47	2.80	2.11
12/76	1.85	1.94	2.41	1.68A	1.75	2.25	1.86C	1.97
TOTALS	40.31	31.66	38.67	32.02B	38.14	56.72	41.56C	40.38
1/77	5.26	2.98	3.62	3.80	3.83	.71	4.10	3.47
2/77	.76	1.59	.46	.96	.87	.86	.43	85
3/77	.30	2.37	.55	.57	.19	.46	.30	68
4/77	.53	.24	1.11	.03	.56	1.07	.50	58
5.77	7.90	9.13	3.01	7.31A	5.58B	10.89	5.82	7.55
6/77	1.53	5.08	5.83	4.64A	5.18A	3.24	2.85B	4.11
7/77	4.19	5.09	2.06	6.44C	5.62	6.29	5.72	5.21

All values reported in this table are inches of rainfall

*Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
8/77	6.86	6.80	6.84	6.08	5.96	8.04	4.77B	6.78
9/77	11.22	8.40	13.28	8.37	10.56	13.76	5.06B	10.88
10/77	.66	1.94	1.39	3.36	2.39	1.28	.90	1.70
11/77	4/16	11.14	6.17	9.06	7.02	5.57	5.94	7.01
12/77	3.56	4.06	6.59	3.88A	2.80	4.90	3.20	4.17
TOTALS	**46.93**	**58.82**	**50.91**	**54.50C**	**50.56B**	**57.07**	**39.59B**	**52.99**
1/78	2.06	2.29	2.34	3.39	2.19	1.82	1.91	2.29
2/78	1.11	1.26	1.42	1.31	1.38	1.42	1.25	1.31
3/78	2.32	2.53	3.73	2.22	2.57	3.72	2.85	2.85
4/78	1.94	1.66	2.02	1.36	1.28	1.55	1.37	1.60
5/78	11.42	8.68	5.69	12.34	10.45	10.46	8.01	9.58
6/78	6.42	4.87	15.47	8.24	5.31	7.33	16.64	9.18
7/78	8.63	6.72	6.22	6.29	13.98	5.79	8.12	7.96
8/78	12.37	9.99	10.41	9.15A	10.34	11.27	9.19	10.28
9/78	4.12	3.24	8.03	1.98	4.18	7.38	7.84	5.25
10/78	3.65	2.44	4.57	2.64A	5.05	4.47	3.07	3.75
11/78	2.77	3.06	2.37	1.96	3.14	3.09	2.69	2.73
12/78	4.70	4.06	4.55	3.88	4.64	5.46	4.93	4.60

All values reported in this table are inches of rainfall

*Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
- A = 1-5 missing days in a given month
- B = 6-10 missing days in a given month
- C = 11-15 missing days in a given month
- D = 16-20 missing days in a given month
- E = 21-30 missing days in a given month
- M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
TOTALS	**61.51**	**50.80**	**66.82**	**54.77A**	**64.51**	**63.76**	**67.87**	61.38
1/79	3.98	5.35	5.89	3.122	3.84	5.52	5.81	4.79
2/79	.25	.16	.16	.04	.13	.10	.21	.15
3/79	1.01	.84	2.72	1.78	1.85	1.85	1.64	1.67
4/79	1.81	.85	.78	1.21A	1.46	1.32	1.77	1.39
5/79	6.85	3.60	4.65	5.56	3.50	6.47	4.20	4.98
6/79	3.77	1.06	2.34	1.85	1.22	1.80	3.85	2.27
7/79	7.92	2.51	2.85	4.69	2.27	4.33	6.19	4.39
8/79	5.39	4.72	4.09	5.60	4.38	6.95	10.93	6.01
9/79	13.61	13.69	11.96	13.23	8.68	11.33	12.06	12.08
10/79	3.07	1.60	3.52	2.47	3.96	2.60	1.70	2.70
11/79	4.80	5.74	2.52	4.64	4.63	2.51	2.24	3.87
12/79	2.89	1.68	2.10	1.53A	1.66	1.85	1.91	1.95
TOTALS	**55.35**	**41.80**	**43.58**	**45.72A**	**37.58**	**46.63**	**52.51**	**46.24**
1/80	6.08	6.19	3.06	4.31	4.36	4.17	3.57	4.53
2/80	1.17	1.15	1.89	1.84	1.59	1.64	1.56	1.55
3/80	1.85	2.21	1.94	2.28	2.04	2.26	2.46	2.15
4/80	5.77	4.70	5.08	6.48	6.12	8.07	4.42	5.81

All values reported in this table are inches of rainfall

*Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
5/80	6.51	3.56	4.15	5.40	6.26	4.29	5.90	5.15
6/80	1.26	3.16	5.10	1.38	2.32	2.64	3.74	2.80
7/80	7.18	4.66	7.52	3.25	3.75	6.93	4.90	5.46
8/80	3.65	5.65	5.96	5.12	4.95	4.22	5.03A	4.92
9/80	7.54	3.22	16.08	7.28	3.58	6.39	6.17	7.18
10/80	1.02	1.58	1.42	2.03	.78	1.65	1.04	1.36
11/80	3.42	3.09	1.59	1.78	1.37B	1.54	1.56	2.11
12/80	.73	.78	.62	.79	.81	.65	.48	.69
TOTALS	46.18	39.95	54.41	41.94	37.93B	44.45	40.83A	43.71
1/81	.68	.68	.54	.51	.45	.59	.46	.56
2/81	2.42	1.53	1.62	1.06	1.79	1.31	1.10	1.55
3/81	1.52	2.17	2.27	1.42	1.23	2.04	1.39	1.72
4/81	.41	.20	.16	.20	.13	.15	.00	.18
5/81	6.32	2.23	3.18	3.44	2.40	2.45	2.50	3.22
6/81	4.28	4.70	7.16	6.68	5.15	3.82	4.65	5.21
7/81	3.42	2.25	4.05	3.20	3.66	1.91	2.50	3.00
8/81	17.35	11.96	13.50	8.91	9.23	14.14	10.05	12.16
9/81	4.89	3.31	5.12	1.97	2.02	5.27	5.21	3.97

All values reported in this table are inches of rainfall

* Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

** The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
10/81	.13	1.03	.35	.92	.31	.42	.48	52
11/81	3.62	2.09	1.97	2.17	2.53	2.54	2.41	2 48
12/81	.85	.10	.27	.04	.11	07	.02	21
TOTALS	**45.89**	**32.25**	**40.19**	**30.52**	**29.01**	**34.71**	**30.77**	**34.76**
1/82	.52	.77	.51	.46	.57	97	1.35	74
2/82	1.81	2.46	4.41	1.68	2.45	3.97	1.30	2 58
3/82	8.13	4.31	8.02	3.77	3.81	5 89	5.07	5 57
4.82	2.88	1.28	2.80	2.13	1.39	3.38	2 14	2 29
5/82	11.75	13.13	5.57	8.00	3.48	8.49	6.50	8 13
6/82	12.60	11.11	7.97	9.78A	10.00	12.33	8.09	10 39
7/82	6.02	6.31	4.60	5.52	3.94	5.21	5.50	5 30
8/82	8.12	4.54	6.80	4.81	6.46	7.75	4.61	6 16
9/82	12.42	6.92	7.88	5.29A	10.45A	11.04	7.64	8 50
10/82	2.76	1.86	4.96	1.22	2.23	6.32	2.86	3 17
11/82	.67	.70	1.17	.79	1.35	1.24	1.14	1 01
12/82	.80	1.09	.72	.37	.35	.87	32	65
TOTALS	**68.48**	**54.48**	**55.41**	**43.82A**	**46.48A**	**67.46**	**46.52**	**54 48**
1/83	3.91	3.97	3.80	3.47	3.61	3.97	3.07	3 69

All values reported in this table are inches of rainfall

***Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.**

****The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.**

Legend:
- A = 1-5 missing days in a given month
- B = 6-10 missing days in a given month
- C = 11-15 missing days in a given month
- D = 16-20 missing days in a given month
- E = 21-30 missing days in a given month
- M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
2/83	8.89	8.09	9.79	9.77	8.12	7.83	8.56	8 72
3/73	4.17	5.15	5.16	4.72	4.87	5.65	4.21	4 85
4/83	1.40	1.16	1.80	2.41	2.05	2.81	2.47	2 01
5/83	.47	.74	1.27	1.39	1.00	.94	2.71	1 22
6/83	11.69	9.33	7.65	9.16	8.61	13.34	7.06	9 55
7/83	6.75	7.63	2.02	2.26B	6.88	2.65	3.18D	5 10
8/83	6.37	4.15	5.09	3.70	6.92	6.37	.00M	5 43
9/83	6.84	3.83	5.77	5.79A	2.97	7.46	9.43	6 06
10/83	5.09	6.69	14.16	6.34	7.21	9.59	11.12	8 60
11/83	1.46	1.65	1.22	1.37	1.38	2 00	.87	1 42
12/83	4.40	3.54	3.65	2.78	3.88	4.02	4 20	3 78
TOTALS	61.44	55.93	61.38	53.16B	57.50	66.63	56.88M	60.42
1/84	.25	.21	.05	.03	.00	.14	08	11
2/84	1.26	3.63	3.57	2.82	2.33	4.48	3.73	2 97
3/84	3.80	5.64	5.14	4.70	5.28	4.42	4.71	4 81
4/84	5.50	5.63	2.18	6.37	5.10	5.20	2.87	4 69
5/84	7.97	9.72	7.85	8.86	5.57	5.99	10 84	8 11
6/84	3.18	2.95	6.80	4.00	3.77	5/12	6 93	4 68

All values reported in this table are inches of rainfall

*Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
7/84	6.79	12.69	6.20	8.32	6.54	12.58	5.73	8.41
8/84	4.04	3.51	4.00	2.17	2.28	2.77	2.57	3.05
9/84	7.84	7.68	8.07	7.27A	7.09	8.80	8.46	8.11
10/84	.71	.24	.68	.31	.33	1.05	.23	51
11/84	2.37	1.24	8.33	2.02	2.06	3.47	4.84	3.48
12/84	.10	.05	1.12	.00	.58	.66	45	42
TOTALS	43.81	53.19	53.99	46.86A	40.93	53.68	51.44	49.35
1/85	.76	.55	1.20	.72	1.21	.90	63	85
2/85	.08	.36	.19	.00	.00	.16	.09	13
3/85	1.00	2.74	3.48	3.55	3.12	2.02	2.76	2.67
4/85	5.49	- 3.15	3.43	5.39	4.69	4.30	4.18	4.38
5/85	3.40	4.64	2.14	5.89	4.33	4.06	1.31	3.40
6/85	4.30	4.14	4.59	4.86	4.23	8.09	6.31	5.22
7/85	7.83	9.64	7.82	5.59	6.37A	8.40	8.44	7.74
8/85	5.53	8.55	4.96	7.26A	5.19	4.83	4.31	5.80
9/95	9.63	8.13	8.70	5.57	5.62	11.34	9.70	8.38
10/85	3.34	4.60	3.67	3.33	4.06	7.66	6.08	4.68
11/85	1.54	1.50	.83	1.07A	2.51	2.79	1.27	1.64

All values reported in this table are inches of rainfall

*Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
- A = 1-5 missing days in a given month
- B = 6-10 missing days in a given month
- C = 11-15 missing days in a given month
- D = 16-20 missing days in a given month
- E = 21-30 missing days in a given month
- M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
12/85	2.20	2.16	3.08	1.82	2.27	3.54	3.10	2.60
TOTALS	**45.10**	**50.16**	**44.09**	**43.05A**	**43.60**	**58.09**	**48.18**	**47.47**
1/86	3.59	3.21	2.90	2.87	2.91	2.30	1.93A	2.81
2/86	2.13	.82	.88	1.71	2.00	.81	1.37A	1.39
3/86	5.06	5.10	5.28	4.30A	3.81	4.11	2.06	3.99
3/86	.41	.25	.00	.27	.24	.20	.08	21
5/86	3.18	1.99	3.11	1.16	1.12	2.25	3.09	2.27
6/86	6.96	13.03	13.15	12.42	13.61	10.84	9.97	11.43
7/86	8.17	6.75	11.83	7.81A	3.27B	6.93	6.81	7.95
8/86	6.05	6.86	5.21	5.68	7.85	7.89	5.61A	6.46
9/86	4.27	5.18	5.31	6.16	5.93	6.29	6.50	5.66
10/86	3.49	2.11	2.28	1.16	2.73	4.82	3.36	2.85
11/86	2.47	.54	1.70	1.21	.31	1.59	92	1.25
12/86	3.19	2.73	3.19	3.77	3.70	2.78	4.90	3.47
TOTALS	**48.97**	**48.57**	**54.84**	**48.52A**	**47.48B**	**50.81**	**46.60A**	**49.73**
1/87	2.10	3.04	3.51	.90A	1.10	3.56	1.75	2.41
2/87	1.69	1.67	1.10	1.56A	1.44	1.47	1.05	1.43
3/87	6.45	4.58	7.09	4.32A	5.32	6.21	5.70	5.68

All values reported in this table are inches of rainfall

*Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

**The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

Table 9. Rainfall Information Used in the Estimation of Inflows to Lake Okeechobee from Industrial Canal and Private Pumps*

Date	Station I.D. MRF6119	Station I.D. MRF6039	Station I.D. MRF6042	Station I.D. MRF68C	Station I.D. MRF71	Station I.D. MRF133	Station I.D. MRF131	Average**
4/87	.06	.03A	.11	.00	.17	.04	.00	06
5/87	2.26	.86	3.21	.34	3.89	2.83	3 32	2 39
6/87	8.28	3.83	6.99	4.64	9.47	2.81	4.69	5 82
7/87	4.40	3.12	5.73	5.71	3.90	7.47	6.52	5 26
8/87	4.33	7.17	1.75	3.10	3.62	3.33	.06	3 34
9/87	3.83	2.83	6.63	3.80	5.88	5.73	2.47A	4.49
10/87	3.50	5.17	6.25	2.79A	2.44	3.30	3 99	3 90
11/87	8.33	9.86	8.84	7.64	9.01	9.29	6.89	8 55
12/87	.25	.31	.29	.11	.05	.28	20A	21
TOTALS	45.48	42.47A	51.50	34.91A	46.29	46.32	36.63A	43.53

All values reported in this table are inches of rainfall

* Several values have been updated, so differ from the values reported in Table 7 upon which the curve was developed. District staff determined that the updated values have no significant effect on development of the rainfall curve.

** The program averages rainfall on a daily basis for a group of stations. If, on a given day, a station has missing data, the program averages the remainder of the stations ignoring the missing station. The program sums the individual stations and sums the daily average to obtain the monthly sums of each station and the monthly average sum for all the stations. When missing data exists at one or more stations, the average of the monthly sum of the stations will not equal the sum of the daily averages as reported in Table 7a.

Legend:
A = 1-5 missing days in a given month
B = 6-10 missing days in a given month
C = 11-15 missing days in a given month
D = 16-20 missing days in a given month
E = 21-30 missing days in a given month
M = entire month missing

d. **Industrial Canal and S-4:**

Industrial Canal and S-4 Drainage Area: For the period January 1972 through December 1975, prior to the construction of the S-4, the immediate area of the Industrial Canal and lands now drained by the pump station were discharged via the Industrial Canal and Culverts 1, 1A, and 2. Runoff from a total of 46,530 acres, listed below, were discharged through these structures:

Clewiston DD	3,000	AC
Thorton Nursery	70	
Ridgedill	1,080	
U.S. Sugar	10,496	
SFCD	4,480	
Sugarland	11,580	
Diston Island	15,680	
	46,386	

To estimate the discharge for this period the ratio 46,530 AC/76,670AC = .605 was multiplied times the curve-generated flow for the entire basin, based on actual rainfall data from the seven stations previously mentioned, which values are shown in Table 7. Prior to the construction of S-4, all the inflows to the lake from both the Industrial Canal and S-4 drainage basins went to the lake rather than the Industrial Canal.

S-4: Measured flow data is available for the period after construction of the S-4 Structure, beginning in January 1976. Measured data is unavailable only for a 10-day period in 1986. (See Table 2 and text in Section D.1.).

In recent years an effort has been made by the District to minimize pumpage at S-4 by increasing flow through S-235. Since this constitutes a change in the management of the basin and in order to be consistent with the approach as applied to S-2 and S-3 of using only the period of record reflecting current water management practices, only data from WY 1985 to 1987 was used to estimate the contribution from S-4.

The actual contribution from the S-4 basin may be greater than presented in Table 1 for the following additional reasons:

1. The period WY 85-87 is only for 3 years and may not represent the full range of variability.

2. The period WY 85-87 occurred during a period of low lake stages. At stages greater than 15.5 to 16.0 feet the S-310 lock on the Industrial Canal is closed and the flow from the Industrial Canal would be diverted to the S-4 basin. This could increase the pumpage at S-4 and subsequently increase the loadings.

3. The period WY 85-87 was a normal to below normal rainfall period. During periods of normal to above normal rainfall, the loadings attributable to S-4 would be greater.

Industrial Canal: Measured flow data is available for the period May 1984 through December 1987 (USGS Data from a Flow Meter in the Lock Structure S-310).

Because readings from earlier meters in the Industrial Canal are considered unreliable, the flow data from January 1972 to April 1984 were estimated using a rainfall versus runoff curve shown in Figure C previously developed by the District for this basin. Separate calculations were made using the curve for the period from January 1972 through December 1975 and the period from January 1976 through April 1984 to account for changes in surface water management practices after construction of the S-4 pump station in the mid-1970s.

For the period January 1976 - April 1984, the Industrial Canal received drainage from about [illegible],126 acres, as listed below:

South Florida Conservancy D.D.	4,480	
Thorton Nursery	70	
Ridgedill	1,080	
U.S. Sugar	10,496	
	16,126	AC

Estimated flows for the period from January 1976 to April 1984 were generated from the above mentioned curve using the ratio 16,126 AC/ 76,670 AC. The resulting ratio of 0.21, was multiplied times flow data generated by the curve, based on actual rainfall data from rainfall stations from Belle Glade, Clewiston, Canal Point, Ritta, Miami Lock, East Shore, and Pelican. Monthly rainfall values for each station as well as monthly averages for all seven stations are presented in Table 7.

e. S-236 (South Florida Conservancy Drainage District)

From January 1980 through December 1987 pumping logs furnished by the South Florida Conservancy Drainage District were used to obtain the number of hours per month that pumps were in operation at S-236. Although the design capacity of these pumps is 38,150 gpm, discharge tests indicated that their actual capacity is closer to 36,000 gpm, or 6.626 acre-feet per hour. Monthly discharges were estimated by multiplying pumping capacity times the number of hours per month the pumps were in operation times the number of pumps at S-236. Three pumps are located at S-236.

Pumping logs do not exist prior to 1980, and for the period January 1972 through December 1979, the rainfall/runoff curve was used to generate monthly discharges out of the S-236 sub-basin. The sub-basin area of 6,530 acres was multiplied by curve generated flow depths to yield monthly discharge volumes.

f. Culvert 4A (South Bay/South Shore Drainage District)

Pumping logs do not exist for this sub-basin, and monthly discharge values had to be estimated. Two methods were employed, one of which utilizes existing data for three nearby, similarly managed drainage districts. The other method uses the rainfall/runoff curve.

The period January 1980 through December 1987, values of monthly discharge per acre were developed from pumping data for the S-236, East Shore, and East Beach sub-basins. These values were then multiplied by the area of the South Shore Drainage District (2,700 acres) to yield monthly discharge values. An example of this procedure is presented below, in which the total combined area of the S-236, East Shore, and East Beach sub-basins is 20,080 acres

SUB-BASIN	JANUARY, 1986 DISCHARGES ACRE-FEET MONTH
S-236	934
East Shore	704
East Beach	302
TOTAL	1,940

discharge/acre: 1,940 ÷ 20,080 = 0.097 acre/month

South Shore D.D. discharge: 0.097 × 2,700 = 261 acre-feet

The rainfall/runoff curve was used to generate monthly discharge values from January 1972 through December 1979. The sub-basin area of 2,700 acres was multiplied by runoff depths to generate discharge volumes.

g. Culvert 12 (East Shore Drainage District)

From January 1980 through December 1987 pump logs furnished by the South Florida Conservancy Drainage District were used to obtain the number of hours per month that pumps were in operation at Culvert 12. Three units with a pumping capacity of 60,000 gpm each are located at Culvert 12, and monthly discharges were calculated by multiplying pumping capacity times hours of operation times number of pumps.

From January 1972 through December 1979 the rainfall/runoff curve was used to generate monthly sub-basin discharge values. Runoff depths obtained from the curve were multiplied times the sub-basin area of 8,450 acres to compute discharge volumes.

h. Culvert 12A (715 Farms)

Pump logs do not exist for this sub-basin, and monthly discharge values had to be estimated. Two methods were employed, one of which utilizes existing data for a nearby sub-basin. The other method uses the rainfall/runoff curve.

For the period January 1980 through December 1987, values of monthly discharge per acre were developed for the East Beach Drainage District. These values were then multiplied by the area of the Culvert 12A sub-basin (2,750 acres) to yield monthly discharge values. Both the Culvert 12A sub-basin and the East Beach Drainage District are operationally similar in that they both employ equally inefficient pumps to discharge water out of their catchment areas.

From January 1972 through December 1979 the rainfall/runoff curve was used to generate monthly sub-basin discharge values. Runoff depths obtained from the curve were multiplied times sub-basin area to compute discharge volumes.

i. **Culvert 10 (East Beach Drainage District)**

From January 1980 through December 1987 pump logs furnished by the South Florida Conservancy Drainage District were used to obtain the number of hours per month that pumps were in operation at Culvert 10. Although the design capacity of each pump is 50,000 gpm, field tests indicate an operational capacity of 30,000 gpm. Three pumps are located at Culvert 10, giving a total capacity of 90,000 gpm, or 5.6 acre-feet per hour. Monthly discharges were computed by multiplying total pumping capacity times the number of operational hours per month.

From January 1972 through December 1979 the rainfall/runoff curve was used to generate monthly sub-basin discharge values. Runoff depths obtained from the curve were multiplied times the sub-basin area of 5,100 acres to compute discharge volumes.

j. **L-59E, L-59W, Culvert A, S-154C, L-60E, L-60W, Culvert 5/Nicodemus Slough**

The complete lack of operational or stage data posed problems estimating discharge volumes for these small, low-flow sub-basins. District technical staff assigned an average annual runoff value of 9 inches to each sub-basin, which represents the average of annual runoff for the other sub-basins located around Lake Okeechobee.

SUB-BASIN	AREA SQ. MILES	ANNUAL DISCHARGE ACRE-FEET
L-59E, L-59W, Culvert A	30	15,000
S-154C	4	2,000
L-60E, L-60W	12	6,000
L-61E, L-61W	44	22,000
Culvert 5/Nicodemus Slough	28	14,000

k. **S-308C**

Runoff to the St. Lucie Canal was estimated using a rainfall-runoff model. Prior to the 1978 completion of the Port Mayaca Lock Structure (S-308) all of the runoff to the St. Lucie Canal was assumed to go to the lake whenever the lake stage was below the regulation schedule. After 1978 records of the S-308 flows are acceptable and were used in the computation.

A rainfall runoff relationship for the St. Lucie Canal was developed using daily rainfall records at stations in the St. Lucie and Port Mayaca Locks. The average value of both stations was used as daily rainfall.

Rainfall records were available since 1942. The runoff was estimated using a mass balance approach in the St. Lucie Canal. The period of record examined was from June 1, 1978, through February 28, 1979. A regression line was derived with an 0.85r. The equation for this line is:

$$Y = 0.0009487X + 0.40048$$

where

Y = RF in inches

and

X = Runoff in cfs

A comparison between the District estimation technique as well as similar estimations performed by the Corps of Engineers (COE) and the Soil Conservation Service is shown in Figure 11.

l. Culvert 10A

Measured data by the USGS exists from 1976 up to date. Prior to 1976, the COE estimated the flow using a water budget approach on a monthly basis. The estimated COE values were used prior to 1976. USGS measured values were used since.

m. S-65

The flow record for S-65 is complete after September 1974 (Table 7). Monthly mean flows for the period prior to September 1974 at S-65 can be reliably estimated from a regression model that uses monthly mean flow data from station S65A downstream for the 1973-87 period:

S65 (cfs/day) = -77.175 + 0.9929 * S65A (cfs/day)

Summary information on regression model: df = 1/171, r = 0.97, p = 0.0001, standard errors: Intercept = 23.45 Slope = 0.0192.

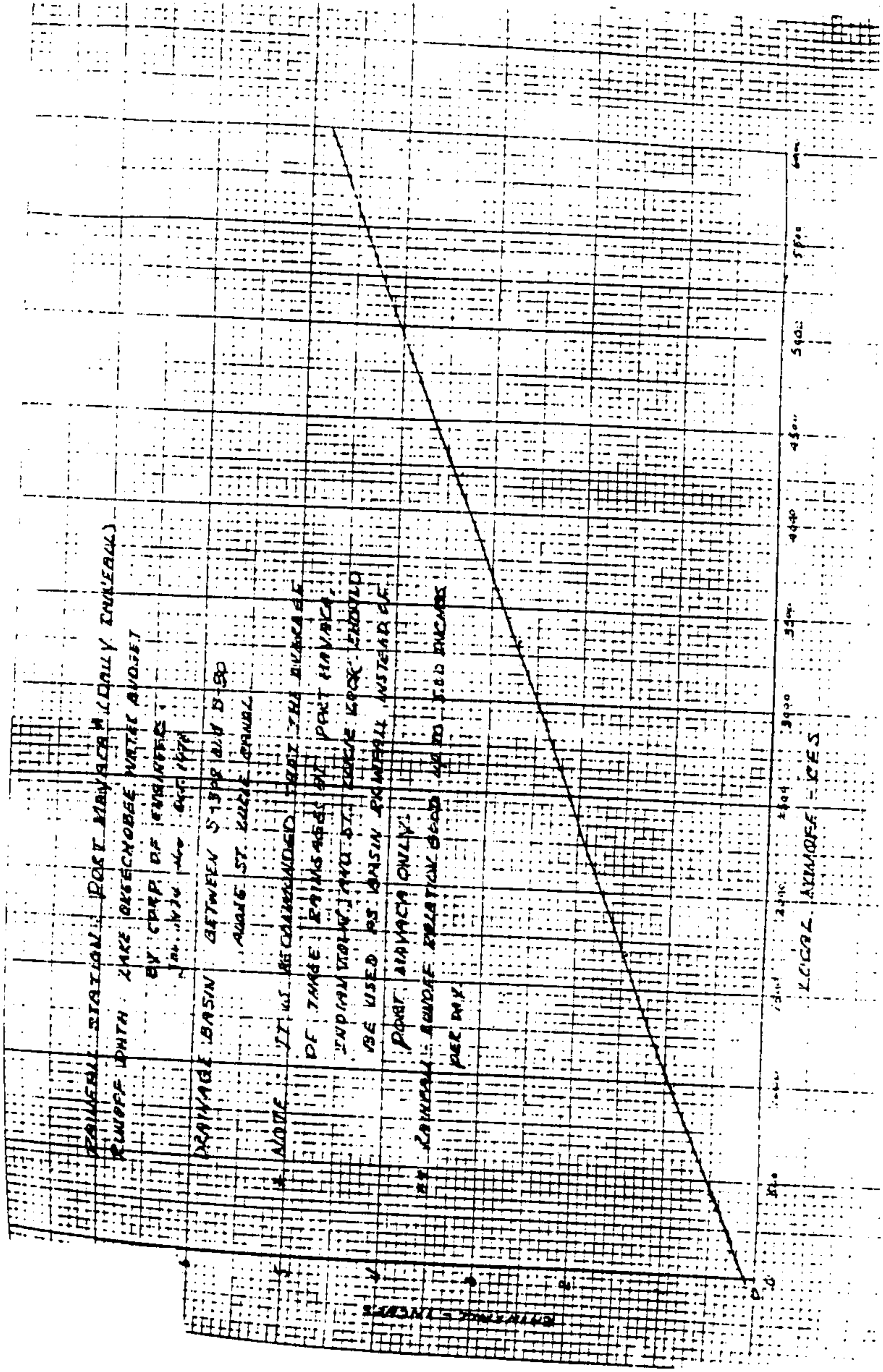


Figure 11

2. Water Quality/ Phosphorus Load

Mass transport (load) means the amount of phosphorus carried into Lake Okeechobee by tributaries. It cannot be measured directly in tributaries (except in special circumstances), so is calculated based on available measurements. For the period of April 1973 to September 1987, there are 3,132 (174 x 18) possible monthly inflow loading values for the 18 major inflows to Lake Okeechobee.

A standard formula (integration of the product of flow and phosphorus concentration measurements over time) was used to calculate monthly inflow loading values when data on both flow and phosphorus concentration was available by direct measurement. The standard formula, based on data collected by measurement, was applied to calculate about 85 percent of the 3,132 monthly loads.

Specific formulas appropriate for a particular tributary were applied to estimate monthly loads when data on flow or phosphorus concentration, or both, was not available by direct measurement. Specific formulas were applied to about 15 percent of the 3,132 monthly loads. This methodology can be expected to produce a reliable value for mean annual phosphorus load for each of the inflow points, since few of the mean annual loads for individual sites are sensitive to the inclusion of estimated loads (see detailed discussion below).

Flow data, measured and estimated, is discussed in the Section D. 1. of this report. Phosphorus concentration sampling and data is discussed in Section D.2.(a.) Phosphorus loading calculations are discussed in Section D.2.(b.).

a. **Water Quality Sampling Data**

Water quality samples are collected routinely every two weeks at Lake Okeechobee tributary sites. Physical parameters and nutrients are measured. At most sites, grab-samples are collected. Flow proportional automatic water samplers have been installed at a few sites. The station locations are identified on Figure 2 and Table 10 (which also includes frequency of collection information). The stations and collection location are described on Table 11. Rainfall stations are described on Table 12 and Figure 1.

The data obtained from the sampling is stored in Water Quality Databases or in the hydrologic database (DBHYDRO) at the District. This data has been loaded onto magnetic tape, floppy discs and hard copy, and is available from the District at cost. When available, phosphorus and flow measurements from these databases were used in calculating phosphorus loads from sub-basins in the Lake Okeechobee basin. When phosphorus measurements were not available, phosphorus load was estimated by appropriate formula. See section D.2.(b.) below. Table 13 summarizes the source of water quality data.

INFLOWS / OUTFLOWS MONITORING PROGRAM

SFWMD STA ID	LAT	LONG	Location	POR	Physical Parameters	Nutrients	Major Ions	Trace Metals	Pesticide Species	Other	US/DS
CULV4A	264056	804502	Pump Sta West of Belle Glade	1979-P	BW	BW	QTR	BA			US
CULV10	264753	804146	Pump Sta at SR441 in Pahokee	1979-P	BW	BW	QTR	BA			US
CULV10A	265501	803650	Culverts at West End of L8 at Okeechobee	1987-P	BW	BW	QTR	BA			DS
CULV12	264455	804105	Pump Sta 2 Miles S of Pahokee on SR441	1979-P	BW	BW	QTR	BA			US
CULV12A	264634	804137	Pump Sta 11/2 Miles S of Pahokee on SR441	1979-P	BW	BW	QTR	BA			US
FECSR78	265744	810715	Fisheating Creek and SR78	1973-P	BW	BW	QTR	BA	QTR	QTR	
HGS5	265145	803755	Hurricane Gate near Card Point	1973-P	BW	BW	QTR	BA			DS
Induscan	264514	805508	Industrial Canal in Clewiston at SR832	1982-P	BW	BW	QTR	BA			
S2	264200	804300	Pump Sta S2 at South End of Lake Okee	1973-P	BW	BW	QTR	BA	QTR	QTR	US
S3	264155	804825	Pump Sta S3 at South End of Lake Okee	1973-P	BW	BW	QTR	BA	QTR	QTR	US
S4	264722	805743	Pump Sta S4 at South End of Lake Okee	1976-P	BW	BW	QTR	BA	QTR	QTR	US
S65E	271335	805742	S65E on the Kissimmee River	1973-P	BW	BW	QTR	BA			US
S71	270201	811811	S71 on Harney Pond Canal (C41)	1973-P	BW	BW	QTR	BA			US
S72	270532	810023	S72 on Indian Prairie Canal (C40)	1973-P	BW	BW	QTR	BA			US
S77	265023	810618	Caloosahatchee River and Lake Okee	1973-P	BW	BW	QTR	BA			US
S84	271250	805584	On C41A Canal	1973-P	BW	BW	QTR	BA			US
S127	270719	805346	Pump Sta S127 NW Side of Lake Okee	1973-P	BW	BW	QTR	BA			US
S129	270147	810006	Pump Sta S129 NW Side of Lake Okee	1973-P	BW	BW	QTR	BA			US
S131	265843	810526	Pump Sta S131 W Side of Lake Okee	1973-P	BW	BW	QTR	BA			US
S133	271228	804802	Pump Sta S133 N Side of Lake at Taylor Cr	1973-P	BW	BW	QTR	BA			US
S135	270510	803941	Pump Sta S135 NE Side of Lake Okee	1973-P	BW	BW	QTR	BA			US
S154	271241	805506	Gate Structure on L62 at C38	1978-P	BW	BW	QTR	BA			US
S169	264545	815730	Gate Structure Near S310 in Clewiston	1985-P	BW	BW	QTR	BA			US
S191	271135	804535	Bridge at SR441 and Nubbin Slough	1973-P	BW	BW	QTR	BA	QTR	QTR	US
S236	264340	805111	Pump Sta South Side of Lake Okee	1979-P	BW	BW	QTR	BA			US
S308C	265904	803717	Lake Okee and the St Lucie Canal	1973-P	BW	BW	QTR	BA			US
L59E			Culvert on West Side of C-38	1987	3	3					
L59W			Culvert on East Side of S-72	1987	3	3					
C38W			Culvert "A" on West Bank of C-38	1987	3	3					
L60E			Culvert on West Side of S-72	1987	3	3					
L60W			Culvert on East Side of S-71	1987	3	3					
L61E			Culvert on West Side of S-71	1987	3	3					
L61W			Culvert Flowing to Fisheating Cr	1987	3	3					
CULV5			Nicodemus Slough at SR78	1987	3	3					
S-154C			Structure on East Bank of C-38	1987	3	3					

POR = Period of Record for Nutrients, Physical Parameters, and Major Ions
W = Weekly
BW = Bi-Weekly (Twice/Month)
3 = Three Times in 1987

M = Monthly
QTR = Quarterly
BA = Bi-Annually (Twice/Year)
P = Present

US = Upstream
DS = Downstream
Other = PCB's

Table 11. Water Quality Collection Station Descriptions

S-65A	(Alias: 00430/ 06801) a large gate and boat lock structure located on the Kissimmee River 10.5 miles south of S-65 The water flows southward through this structure, ad the water samples are collected from the upstream side.
S-65B	(Alias: 00436/ 06841) a large gate and boat lock structure located on the Kissimmee River 12 miles south of S-65A. The water flows southward through this structure, and the water samples are collected from the upstream side.
S-65C	(Alias: 04458) a large gate and boat ock structure located on the Kissimmee River nine miles south of S-65B. The water flows southward through this structure, and the water samples are collected from the upstream side.
S-65D	(Alias: 00470) a large gate and boat lock structure located on the Kissimmee River nine miles south of S-65C. The water flows southward through this structure, and the water samples are collected from the upstream side.
S-65E	(Alias: 00241) large gate and lock type structure on the Kissimmee River 8.5 Miles northwest of Lake Okeechobee. This is the southern-most structure on the Kissimmee River, and it discharges into Lake Okeechobee. Water samples are collected from the upstream side of the structure.
S-4	(Alias: S4 03760, 06738) SFWMD controlled water pumping station on the C-20 canal near Clewiston that pumps water into Lake Okeechobee. The water samples are collected on the upstream side of the pump station by a flow proportional automatic water sampler, or by grab sample when no pumping occurs.
S-169	gate structure near the boat ramp and the S-310 boat locks in Clewiston. This structure lets water flow toward S-4 in the C-20 canal. The water samples are collected from the upstream side of the structure.
S-191	(Alias: 04530, 06732) large gate structure on the north side of Lake Okeechobee at Nubbin Slough. Releases into Lake Okeechobee, samples are collected from the upstream side of the structure.
S-71	(Alias: 00094, 04814) gate structure located near the west side of Lake Okeechobee in Harney Pond Canal (C-41) about 1.5 miles north of SR-78. The water samples are collected from the upstream side of the structure.
S-72	(Alias: 00100, 04820) gate structure located near the northwest side of Lake Okeechobee, in Indian Prairie Canal (C-40) about 2 miles northwest of SR-78. Water samples are collected from the upstream side of this structure.
S-84	(Alias: 00249, 04844) gate structure at the intersection of C-41A and the Kissimmee River. Water flows into the Kissimmee River through this structure. Water samples are collected from the upstream side of the structure.
FECSR78	(Alias: FISHP, 00090, 09652) bridge on highway SR-78 where it crosses Fisheating Creek. The water flows toward Lake Okeechobee at this point.
S-127	(Alias: S127 PMP, 04006, 06751) SFWMD-controlled pump station located on the rim canal on the northwest side of Lake Okeechobee. This station is located between the Indian Prairie canal and the Kissimmee River. Pumps into Lake Okeechobee, samples are collected from the upstream side of the structure.
S-129	(Alias: S129 PMP, 04018, 06812) SFWMD-controlled pumping station on the rim canal on the northwest side of Lake Okeechobee. This structure is located between Harney Pond Canal and Indian Prairie Canal. Pumps into the lake, water samples are collected from the upstream side of the structure.
S-131	(Alias: S131 PMP, 04036) SFWMD-controlled water pumping station located on the west side of Lake Okeechobee, north of Fisheating Creek. Pumps into Lake Okeechobee. Water samples are collected from the upstream side of the structure.

Table 11. (Continued). Water Quality Collection Station Descriptions

S-133	(Alias: S133 PMP, 04048, 06814) SFWMD-controlled pump station on the north side of Lake Okeechobee near Taylor Creek. Pumps into the lake, samples collected from the upstream side of the structure.
S-135	(Alias: 04066, 06815) SFWMD-controlled pump station and boat lock located on the northeast side of Lake Okeechobee near J&S Fish Camp. Pumps into Lake Okeechobee. Samples are collected from the upstream side of the structure.
S-154	(Alias: 04952, 07803) small gate structure located on the north side of the Kissimmee River about halfway between Lake Okeechobee and S-65E. This structure regulates flow from the L-62 canal into the river. Water samples are collected from the upstream side of the structure.
INDUSCAN	bridge over the Industrial Canal in Clewiston on county road 832.
S-236	small pump station on US-27 between S-3 and Clewiston that serves the South Florida Conservancy District. Pumps into Lake Okeechobee. The water samples are collected from the upstream side of the pump station.
CULV4A	small pump station (Culvert 4A) on US-27 2.5 miles west of South Bay that serves the South Shore Drainage District. Pumps into Lake Okeechobee. The water samples are collected from the upstream side of the pump station.
CULV10 CULV12A CULV12	pump stations on the south east side of Lake Okeechobee near Pahokee that pump water from nearby agricultural fields (sugar cane) intothe lake. These pump stations serve the East Beach Drainage District, 715 Farms, and East Shore Drainage District, respectively. Water samples are collected from the upstream side of each structure.
S-308C	(Alias: 00277) C.O.E. Boat Lock and release structure on the St. Lucie Canal at Lake Okeechobee. Water generally flows out of the lake through this structure into the St. Lucie Canal (C-44), but depending upon lake stage and rainfall, discharge into the lake is also possible. Water samples are collected from the lake side of this structure.
S-2	(Alias: S2 TOTAL, 00426) SFWMD controlled water pumping station located on the south side of Lake Okeechobee near South Bay. Pumped discharge into Lake Okeechobee from the confluence of the Hillsboro and North New River Canals. Samples are collected from the upstream side of the pump station by a flow proportional automatic water sampler.
S-3	(Alias: S3 PMP, HGS3, 00539, 06491) SFWMD controlled water pumping station located on the south side of Lake Okeechobee between South Bay and Clewiston. Pumps from the Miami Canal into Lake Okeechobee. The water samples are collected on the upstream side of the pump station by a flow proportional automatic water samplers.
HGS5	(Alias: HGS5X 00313) hurricane gate on the east side of Lake Okeechobee near Canal Point. Structure is operated by the Corps of Engineers. Flow is out of the lake when structure is open. Samples are collected from downstream side. Flow into the lake is possible only when lake stage is below 11.5 feet.
S-65	(Alias: 00186) a large gate and boat lock structure located on the Kissimmee River (C-38) State Road 60 at the south end of Lake Kissimmee. The water flows in a southernly direction through this structure and the water samples are collected from the upstream side.
S-77	large gate and boat lock structure operated by the Corps of Engineers (COE). Located at the head of the Caloosahatchee river, regulates flow from Lake Okeechobee into the river. Depending on lake stage and precipitation, water may occasionally flow into the lake from this structure. Water samples are collected from the lake side of the structure.
Culv 10A	(Alias 02855) structure operated by Corps of Engineers on southeast side at L-8 Canal. Allows flow into or out of the lake, but flow is primarily out of the lake. Flow into the lake is considered an uncontrollable source.

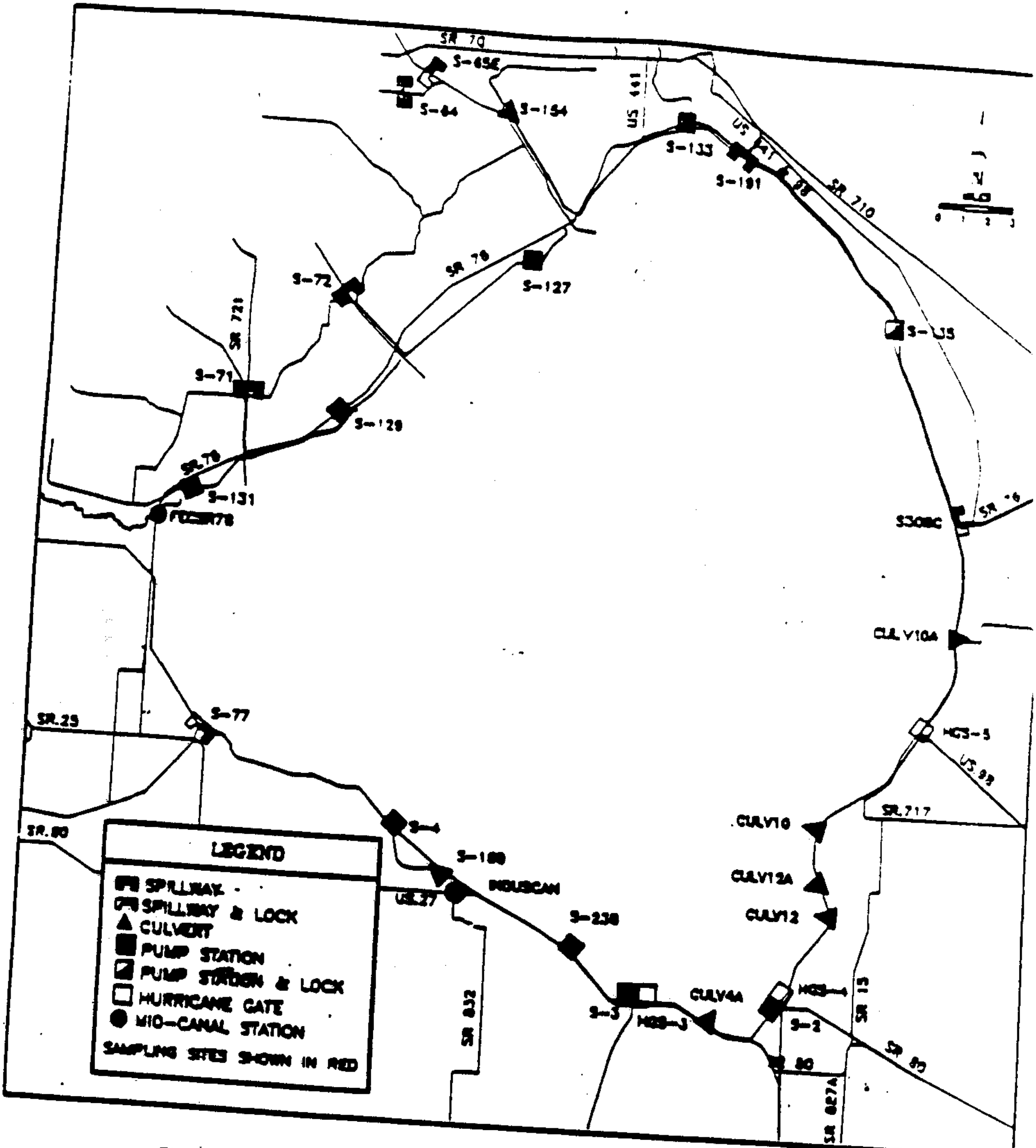


Figure 12. **LOCATION OF SAMPLING STATIONS FOR THE LAKE OKEECHOBEE INFLOW/OUTFLOW MONITORING PROGRAM**

Ta le 12. Rain all Data

The District estimated the monthly phosphorus concentration of rainfall on Lake Okeechobee from the monthly geometric mean of samples taken from six bulk precipitation collectors located around the lake (Figure 12). The period of record at these sites is listed below.

Site	Period of Record
B-50	02/79 to 09/87
Okeechobee Field Station	11/74 to 09/87
S-131	12/74 to 04/85
S-2	10/74 to 06/87

Table 13. Summary of Tributary Water Quality (Phosphorus Concentration) Data

Sampling Stations	Unavailable Measured Phosphorus Data April 1973 - September 1987			Loading Calculations Explained
	Start	End	Days	
Controllable Sources				
C-38 Pool A (S-65A)	04/01/73	06/13/73	73	D.2.b.1.
	09/10/75	10/29/75	49	
	10/29/75	02/11/76	105	
	02/11/76	05/19/76	98	
	10/21/76	12/07/76	47	
	12/07/76	01/24/77	48	
	01/24/77	03/22/77	57	
	03/22/77	05/24/77	63	
	05/24/77	07/26/77	63	
	07/26/77	09/21/77	57	
	09/21/77	11/30/77	70	
	11/30/77	01/25/78	56	
	01/25/78	03/22/78	56	
	03/22/78	05/31/78	70	
	02/19/80	04/16/80	57	
	06/27/84	08/22/84	56	
C-38 Pool B (S-65B)	04/01/73	06/13/73	73	D.2.b.2.
	09/11/75	10/29/75	48	
	10/29/75	02/11/76	105	
	02/11/76	05/19/76	98	
	10/22/76	12/07/76	46	
	12/07/76	01/24/77	48	
	01/24/77	03/23/77	58	
	03/23/77	05/24/77	62	
	05/25/77	07/26/77	62	
	07/27/77	09/21/77	56	
	09/21/77	12/01/77	71	
	12/01/77	01/25/78	55	
	01/25/78	03/23/78	57	
	03/23/78	05/31/78	69	
	02/19/80	04/16/80	57	
	06/27/84	08/22/84	56	
C-38 Pool C (S-65C)	04/01/73	06/13/73	73	D.2.b.3.
	09/11/75	10/28/75	47	
	11/18/75	02/10/76	84	
	02/11/76	05/11/76	90	
	12/06/76	01/25/77	50	
	01/25/77	03/21/77	55	
	03/23/77	05/23/77	61	
	05/23/77	07/25/77	63	
	07/25/77	09/20/77	57	
	09/20/77	11/29/77	70	
	12/01/77	01/24/78	54	
	01/24/78	03/21/78	56	
	03/21/78	05/31/78	71	
	02/19/80	04/16/80	57	
	06/27/84	08/22/84	56	

Table 13 (Continued). Summary of Tributary Water Quality (Phosphorus Concentration) Data

Sampling Stations	Unavailable Measured Phosphorus Data April 1973 - September 1987			Loading Calculations Explained
	Start	End	Days	
Controllable Sources				
C-38 Pool D (S-65D)	04/01/73	06/13/73	73	D. 2. b. 4.
	09/12/75	10/28/75	46	
	11/18/75	02/10/76	84	
	02/12/76	05/11/76	89	
	10/19/76	12/06/76	48	
	12/06/76	01/25/77	50	
	01/25/77	03/21/77	55	
	03/21/77	05/23/77	63	
	05/23/77	07/25/77	63	
	07/25/77	09/20/77	57	
	09/20/77	01/24/78	126	
	01/24/78	03/21/78	56	
	03/21/78	05/30/78	70	
	02/19/80	04/16/80	57	
	06/27/84	08/22/84	56	
C-38 Pool E (S65E)	11/18/75	02/12/76	86	D. 2. b. 5.
	02/12/76	05/11/76	89	
	10/19/76	12/06/76	48	
	12/06/76	01/25/77	50	
	01/25/77	03/21/77	55	
	03/21/77	05/23/77	63	
	05/23/77	07/25/77	63	
	07/25/77	09/20/77	57	
	09/20/77	12/01/77	72	
	12/01/77	01/24/78	54	
	01/24/78	03/21/78	56	
	03/21/78	05/30/78	70	
S-4 (Includes Station S-169)	11/12/80	12/31/80	49	D. 2. b .6.
	12/29/81	02/24/82	57	
	04/14/83	02/28/84	320	
	03/27/84	06/04/84	69	
	01/03/85	02/26/85	54	
S-191 (TC/NS)	03/19/74	05/13/74	55	D. 2. b. 7.
	03/04/80	04/30/80	57	
	12/29/81	04/05/82	97	
	04/09/84	07/31/84	113	
	02/26/85	04/23/85	56	
S-71 (C-41)	03/21/74	05/13/74	53	D. 2. b. 8.
	12/29/81	02/24/82	57	
	04/26/83	08/02/83	98	
	08/02/83	10/25/83	84	
	11/21/83	02/28/84	99	
	04/09/84	06/04/84	56	
	06/04/84	07/31/84	57	

Table 13 (Continued). Summary of Tributary Water Quality (Phosphorus Concentration) Data

Sampling Stations	Unavailable Measured Phosphorus Data April 1973 - September 1987			Loading Calculations Explained
	Start	End	Days	
Controllable Sources				
S-72 (Includes Station C-40)	03/21/74	05/13/74	53	D. 2. b. 9.
	12/29/81	02/24/82	57	
	04/26/83	06/21/83	56	
	09/27/83	02/28/84	154	
	03/27/84	06/04/84	69	
	06/04/84	07/31/84	57	
S-84	09/12/75	10/28/75	46	D. 2. b. 10.
	11/18/75	02/12/76	86	
	02/12/76	05/11/76	89	
	10/19/76	10/09/78	720	
	12/29/81	02/24/82	57	
	04/15/83	08/30/83	137	
	08/30/83	02/29/84	183	
	02/29/84	06/04/84	96	
	06/04/84	07/31/84	57	
	07/31/84	09/25/84	56	
Fisheating Creek	03/21/74	05/13/74	53	D. 2. b. 11.
	12/29/81	02/24/82	57	
	04/15/83	09/27/83	165	
	09/27/83	03/27/84	182	
	03/27/84	06/04/84	69	
	06/04/84	07/31/84	57	
	02/03/87	04/28/87	84	
	08/04/87	10/13/87	70	
S-127 (L-48)	04/22/74	05/14/79	1,848	D. 2. b. 12.
	11/04/81	12/29/81	55	
	12/29/81	02/24/82	57	
	02/24/82	05/04/82	69	
	05/04/82	07/01/82	58	
	04/26/83	08/02/83	98	
	01/03/85	02/26/85	54	
S-129 (L-49)	04/22/74	05/14/79	1,848	D. 2. b. 13.
	12/29/81	02/24/82	57	
	02/24/82	05/04/82	69	
	04/25/84	07/31/84	97	
	01/03/85	02/26/85	54	
S-131	04/08/74	05/14/79	1,862	D. 2. b. 14.
	12/29/81	02/24/82	57	
	02/24/82	05/04/82	69	
	05/04/82	06/30/82	57	
	08/25/82	10/20/82	56	
	10/20/82	12/06/82	47	
	04/15/83	06/21/83	67	
	06/21/83	08/16/83	56	
	08/16/83	10/25/83	70	
	04/09/84	06/04/84	56	
	06/04/84	07/31/84	57	
	01/03/85	02/26/85	54	

Table 13 (Continued). Summary of Tributary Water Quality (Phosphorus Concentration) Data

Sampling Stations	Unavailable Measured Phosphorus Data April 1973 - September 1987			Loading Calculations Explained
	Start	End	Days	
S-133	01/29/74	03/19/74	49	D. 2. b. 15.
	03/19/74	05/14/79	1,882	
	12/29/81	02/24/82	57	
	02/24/82	05/04/82	69	
	05/04/82	07/01/82	58	
	06/07/83	08/02/83	56	
	01/03/85	02/26/85	54	
	07/30/85	09/24/85	56	
	08/04/87	09/29/87	56	
S-135	04/22/74	05/14/79	1,848	D. 2. b. 16.
	12/29/81	02/24/82	57	
	02/24/82	05/04/82	69	
	05/04/82	07/01/82	58	
	04/09/84	06/04/84	56	
	06/04/84	07/31/84	57	
	01/03/85	02/26/85	54	
	07/30/85	09/24/85	56	
	08/04/87	10/13/87	70	
S-154	04/01/73	11/07/73		D. 2. b. 17.
	09/12/75	10/28/76	46	
	11/18/75	02/12/76	86	
	02/12/76	05/11/76	89	
	05/11/76	07/20/76	70	
	10/19/76	12/01/77	408	
	12/01/77	01/24/78	54	
	01/24/78	03/21/78	56	
	03/21/78	10/23/78	216	
	12/29/81	02/24/82	57	
	12/22/82	02/17/83	57	
	04/15/83	10/25/83	193	
	10/25/83	02/29/84	127	
	02/29/84	07/31/84	153	
	07/31/84	09/25/84	56	
	11/18/86	01/07/87	59	
Industrial Canal			*	D. 2. b. 18.
S-236 (So. Fla. Conservancy)			*	D. 2. b. 18.
Culvert 4A (So. Bay/ So. Shore)			*	D. 2. b. 18.
Culvert 12 (East Shore D.D.)			*	D. 2. b. 18.
Culvert 12A (715 Farms)			*	D. 2. b. 18.
Culvert 10 (East Beach D.D.)			*	D. 2. b. 18.
L-59E, L-59W, Culv. "A" (C-38W)			*	D. 2. b. 19.
S-154C			*	D. 2. b. 19.
L-60E, L-60W			*	D. 2. b. 19.
L-61E, L-61W			*	D. 2. b. 19.
Culvert 5 (Nicodemus Slough)			*	D. 2. b. 19.

Table 13 (Continued). Summary of Tributary Water Quality (Phosphorus Concentration) Data

Sampling Stations	Unavailable Measured Phosphorus Data April 1973 - September 1987			Loading Calculations Explained
	Start	End	Days	
S-308C (C-44, S-153)	11/14/73	01/16/74	63	D. 2. b 20.
	03/22/74	07/16/81	2,673	
	12/29/81	02/24/82	57	
	09/12/83	01/04/84	114	
	10/07/86	12/03/86	57	
S-2 (flood control)	10/23/73	01/30/74	99	D. 2. b. 21.
	01/30/74	03/21/74	50	
	03/21/74	05/28/74	68	
	10/28/74	12/23/74	56	
	12/23/74	06/09/75	168	
	10/04/76	12/27/76	84	
	02/07/77	05/16/77	98	
	10/03/77	12/05/77	63	
	03/05/79	04/30/79	56	
	05/30/79	07/24/79	55	
	12/02/80	01/27/81	56	
	12/29/81	02/18/82	51	
	04/14/83	09/25/84	530	
	09/25/84	07/02/85	280	
	03/12/86	05/20/86	69	
	09/09/86	11/18/86	70	
	11/18/86	01/22/87	65	
	03/31/87	07/08/87	99	
	07/08/87	09/29/87	83	
S-3 (flood control)	10/23/73	07/08/74	258	D. 2. B. 22.
	09/03/74	12/09/74	97	
	12/09/74	05/28/75	170	
	11/17/75	01/28/76	72	
	03/23/76	05/17/76	55	
	10/04/76	12/27/76	84	
	02/07/77	05/16/77	98	
	10/03/77	12/05/77	63	
	02/05/79	04/30/79	84	
	05/30/79	07/24/79	55	
	04/17/80	06/28/80	69	
	11/06/81	02/24/82	110	
	12/21/82	02/17/83	58	
	04/14/83	03/27/84	348	
	03/27/84	07/31/84	126	
	07/31/84	09/25/84	56	
	09/25/84	04/09/85	196	
	04/09/85	07/02/85	84	
	09/09/85	12/30/85	112	
	03/11/86	05/20/86	70	
	11/18/86	01/22/87	65	
	02/18/87	07/08/87	140	
	08/04/87	09/29/87	56	

Table 13 (Continued). Summary of Tributary Water Quality (Phosphorus Concentration) Data

Sampling Stations	Unavailable Measured Phosphorus Data April 1973 - September 1987			Loading Calculations Explained
	Start	End	Days	
Uncontrollable Sources				
Rainfall				D. 2. b. 23.
S-65 (Lake Kissimmee)	09/10/75	10/29/75	49	D. 2. b. 24.
	10/29/75	12/29/75	61	
	02/11/76	05/19/76	98	
	10/20/76	12/07/76	48	
	12/07/76	01/24/77	48	
	01/24/77	03/22/77	57	
	03/22/77	05/24/77	63	
	05/24/77	07/26/77	63	
	07/26/77	09/21/77	57	
	09/21/77	11/30/77	70	
	11/30/77	01/25/78	56	
	01/25/78	03/22/78	56	
	03/22/78	05/31/78	70	
	02/19/80	04/16/80	57	
	06/27/84	08/22/84	56	
S-68 (Lake Istokpoga)	04/01/73	09/30/87	5,296	D. 2. b. 25.
HGS-5 (W.P.B. Canal)	03/20/74	05/28/74	69	D. 2. b. 26.
	12/29/81	02/24/82	57	
	05/24/83	07/19/83	56	
	08/02/83	11/21/83	111	
	12/05/83	01/31/84	57	
	01/31/84	04/09/84	69	
	05/07/84	07/31/84	85	
	02/03/87	03/31/87	56	
	07/21/87	09/29/87	70	
S-77 (East Caloosahatchee)	03/21/74	05/28/74	68	D. 2. b. 27.
	01/08/80	03/19/80	71	
	07/19/83	02/28/84	224	
	06/04/86	07/29/86	55	
Culvert 10A (L-8)	07/27/82	04/15/83	262	D. 2. b. 28.
	04/15/83	01/14/86	1,005	
	01/14/86	04/23/87	464	
	05/04/87	06/24/87	51	
	10/13/87	12/08/87	56	
	12/08/87	02/16/88	70	
	06/07/88	08/30/88	84	

*Minor tributaries not recorded in District data base. See loading calculation explanation.

b. Loading Calculations

The standard method for calculating load and specific formulas used when measurements were not available is discussed below. The monthly loadings for the 18 major tributaries to Lake Okeechobee are summarized on Table 14. The loadings listed on Table 14 are based on measured data, unless accompanied by a footnote reference (E, Q, C, B, or M). The references are explained in the following discussion and at the end of the table.

The standard method was used when both phosphorus and daily flow measurements were available. It is the preferred method of Scheider, et al. (1978), and takes into account the fact that flow is routinely measured more frequently (daily) than phosphorus (bi-weekly). To calculate loading, daily flow measurements were multiplied by the concentration measurement nearest in time to the date of the flow. This is illustrated by the following graph:

```
------->  <-------  ------->  <-------  ------->  <-------  ------->  <-------
|------ + ------|------- + ------|------ + ------|------ + ------|
```

| = Biweekly Phosphorus Measurement
- = Daily Flow Measurement

When this method was used, no footnote reference is indicated on Table 14.

An actual phosphorus measurement was assumed to be the best available approximation of in-stream concentration for a period extending up to 45 days of either side of the measurement. However, when this period extended into a calendar month adjacent to that of the actual measurement, the loading value is footnoted with an "E". This is illustrated by the following graph:

```
                                                      16 Days          May 1
April 1                                            ----------------->
|----- + -----|----- + -----|----- + -----|----- + ----- + --/-----|
```

| = Biweekly Phosphorus Measurement
- = Daily Flow Measurement

When flow measurements are unavailable for periods of less than one month, the average load for the remaining days of the month was substituted for the missing days. This was accomplished by taking the mean daily load for the measured days in each month and then multiplying by the total number of days in the month. In months with complete records, this calculation has no effect. These values are not considered "estimates" and are not footnoted on Table 14.

When phosphorus measurements are unavailable, but flow records are complete, a regression method was used to estimate flow-weighted concentration from the flow data. Using the complete period of record for a given site, monthly mean flow-weighted concentration was regressed on monthly mean flow to produce a predictive equation. In most tributaries to Lake Okeechobee, variations in flow, rather than changes in concentration, dominate the variation in monthly mean loads. Therefore, with a reasonably complete record of concentration, it is generally possible to estimate average load from flow values alone with good accuracy. Some general benefits of using this approach for estimating flow-weighted concentrations are that (1) the mean and variance of total phosphorus in the actual data, and (2) the phosphorus - flow relationship seen in the actual data are very nearly preserved in the estimated data. (See discussion for individual sub-basins D.2.(b.) 1-22.)

A flow chart outlining the loading calculations procedure is provided in Figure 12.

FIGURE 13. LAKE OKEECHOBEE LOADING CALCULATIONS FLOWCHART

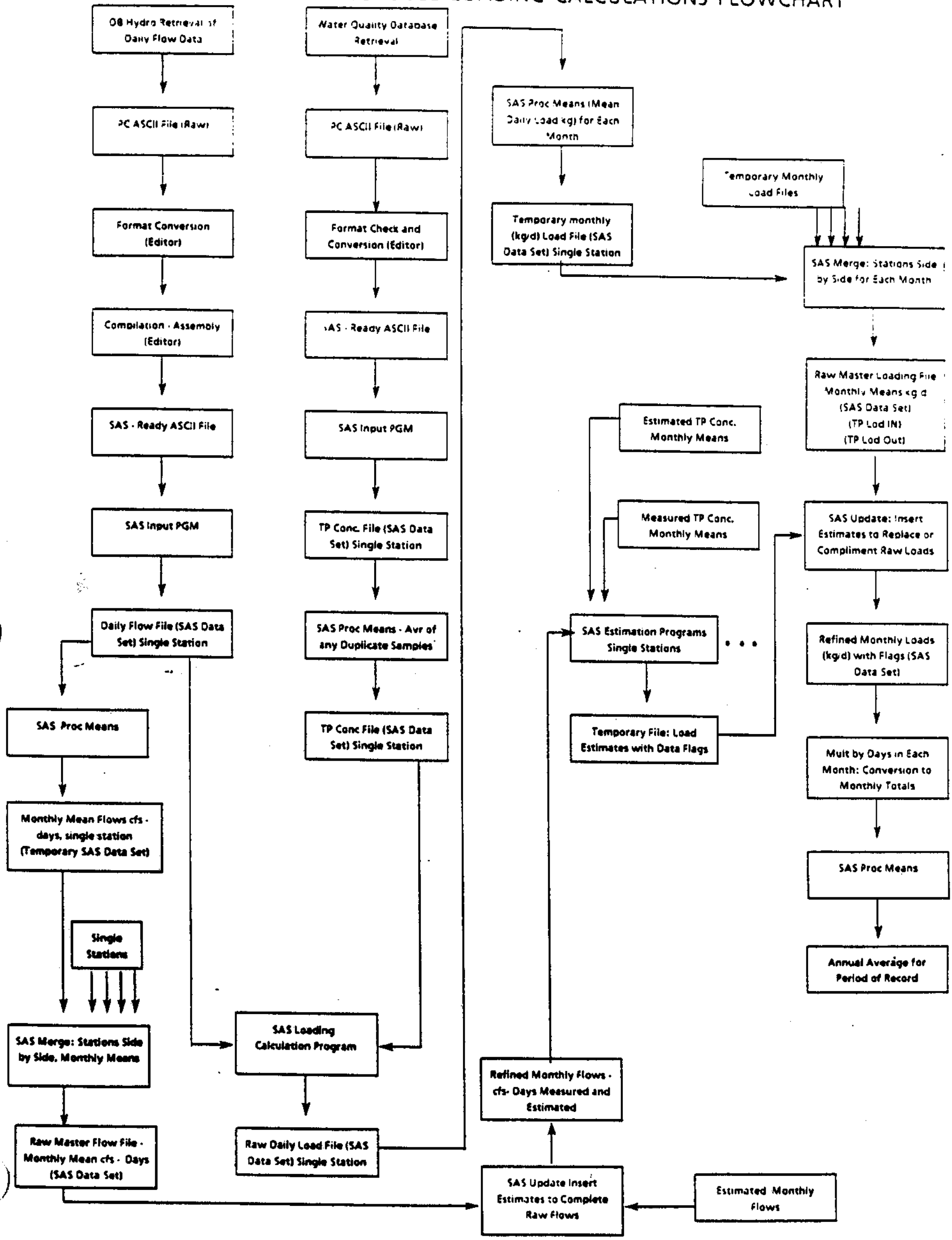


Table 14a. Major Tributary Inflow Phosphorus Loadings (Kg/Month) to Lake Okeechobee

YEAR	MTH	S127	S129	S131	S133	S135	S154	S191	S2	S3	S308C	S4	S65E	S71	S72	S77	S84	HGS5	FEC
1973	4	10	11	3	26	4	500B	191	0	0	0Q	.	12989	262	16	0	1002	0	196
1973	5	12	11	2	26	4	335B	487	123	0	88Q	.	7310	500	0	0	429	0	9
1973	6	50	14	2	66	10	2569B	14988Q	1076	0	880Q	.	2250	3421	105	0	152	0	67
1973	7	21	475	3	80	5	8082B	24255Q	16803	2012	3192Q	.	19842	18942	3437	0	5393	0	1512
1973	8	190	285	13	82	117	7566B	48328	8452	366	1368Q	.	21935	5910	2627	0	5819	0	10407
1973	9	243	148	201	3011	310	5357B	18239	2466	189	1195Q	.	27320	30243	2454	0	6284	0	8174
1973	10	1669	131	37	2927	843	3539B	15963	641	32	854Q	.	6654	8057	671	0	1426	0	2808
1973	11	59	19	11	593	22	488Q	6258	0	0	0Q	.	1106	414	50	0	31	0	188
1973	12	0	56	0	171	0	210Q	725	1166C	321C	0B	.	296	275	17	0	12	0	89
1974	1	1	93	0	0	0	69Q	1077	624	32C	55Q	.	0Q	26	0	0	0	.	111
1974	2	4	0	1	0	0	0Q	697	0	0	0Q	.	2745Q	0	0	0	0	.	33
1974	3	3	1	1	2	2	0Q	647	78	0	83Q	.	705Q	0	0	0	0	.	10
1974	4	4	0	1	0	0	0Q	793E	0	0	0B	.	1854Q	0	8E	0	0	.	0
1974	5	1E	0	2E	0	0	0Q	114	235	0	0B	.	2320Q	87	0	2	0	.	2
1974	6	0	181C	1C	0	0	119Q	3655	8496E	4780E	2113B	.	4166Q	2899	2233	2614	1301	.	695
1974	7	2617C	1287C	535C	1857C	304C	12609Q	46225	14733	6956	0B	.	92149Q	26075	5060	0	8357	.	33907
1974	8	2232C	514C	845C	3070C	751C	2627Q	48459	7704	123	0B	.	41440Q	18534	2639	0	9572	.	25772
1974	9	994C	245C	287C	410C	225C	719Q	10985	1670	397	309B	.	14001Q	8446	1092	0	2434	.	7194
1974	10	524C	179C	303C	496C	150C	396Q	12514	474	132C	357B	.	4047	1291	379	0	325	0	773
1974	11	0	45C	0	0	0	141Q	2013	634E	25E	71B	.	476	250	0	0	0	0	23
1974	12	94C	134C	6C	218C	59C	134Q	3115E	1274	94	0B	.	448	104	0	0	0	0	132
1975	1	0	70C	0	196C	0	19Q	1282	0	0	0B	.	285	0	0	0	0	0	70
1975	2	0	5C	0	0	0	6Q	1276	0	0	148B	.	266	0	0	0	0	0	23
1975	3	0	7C	1C	0	0	1Q	125	0	0	0B	.	492	0	0	0	0	0	5
1975	4	0	7C	2C	0	0	0Q	653	0	0	0B	.	2871	0	0	0	3	0	0
1975	5	0	4C	0	0	0	0Q	99	3801C	352	663B	.	3197	204	0	0	0	1981	2
1975	6	0	2C	0	0	0	21Q	2026	7086	2104	606B	.	5585	2622	878	0	106	0	1593
1975	7	0	0	0	0	0	319Q	7839	13798	1404	2736B	.	14794	5806	1864	0	373	0	11811
1975	8	0	0	0	0	0	237Q	17480	3623	430	0B	.	16644	7191	126	0	2178	0	2589
1975	9	0	27C	32C	0	0	236Q	24435	8141	3054	811B	.	8046	4122	159	0	1961	0	6312
1975	10	193C	81C	42C	676C	33C	205Q	11304	5801	988	107B	.	10209	4231	0	0	1890	0	3699
1975	11	0	14C	0	0	0	125Q	3703	916	151	0B	.	6294	649	0	0	329	0	160
1975	12	0	0	0	0	0	367B	4312	0	0	0B	.	1212C	0	0	0	0	0	51
1976	1	0	0	0	0	0	238B	1289	17	0	0B	.	902C	0	0	0	0	0	57
1976	2	0	0	0	0	0	20Q	1857	3627E	116E	0B	.	3264	0	0	0	0	0	23
1976	3	0	0	0	0	0	115B	850	3154	0	0B	.	14744C	0	0	0	1E	0	129
1976	4	0	0	0	0	0	58B	1195	96E	0	0B	.	6569C	0	0	0	0	0	0
1976	5	0	0	0	0	0	140Q	35298	3834	740	2176B	.	3554	504	71	0	93	1619	16
1976	6	170C	498C	84C	0	0	804B	61550	2827	221	1012B	.	20612	5061	1918	0	2357	0	593
1976	7	0	0	16C	0	0	197Q	19110	1673	34	330B	.	9090	3400	455	0	261	0	13426
1976	8	145C	384C	214C	482C	229C	223Q	31981	8756	1283	1409B	.	16632	5084	1354	0	552	0	15296
1976	9	419C	71C	37C	659C	223C	169Q	13398	4638	835	448B	.	8664	3047	227	0	793	0	5631
1976	10	0	316C	410C	95C	34C	148Q	4571	0	41	104B	.	1969	1487	0	0	86	0	1314
1976	11	0	95C	79C	380C	33C	376B	3261	292C	41C	557B	0	745E	251	2	0	10E	0	265
1976	12	0	111C	15C	0	26C	306B	4076	993	0	0B	0	15249	0	0	0	0	0	111
1977	1	421C	264C	54C	0	175C	285B	5563	1838	367	473B	0	5939	143	0	0	24C	0	293
1977	2	135C	92C	22C	87C	25C	184B	3609	102	0	0B	1605	3830E	0	0	0	25C	0	178
1977	3	0	71C	13C	93C	33C	136B	1742	0	0	0B	443	5537	243	0	0	0	0	139
1977	4	0	30C	0	0	0	4B	218	0	0	0B	540	606E	115	0	0	0	0	11
1977	5	0	0	0	0	0	1B	624	5545	2286	0B	21	7	384	0	0	0	0	82

Table 14a (Continued) Major Tributary Inflow Phosphorus Loadings (Kg/Month) to Lake Okeechobee

1977	6	0	0	0	0	0	241B	5147	633	71	0B	6133	130E	2517	348	0	0	0	2310
1977	7	0	0	0	0	0	234B	1804	0	11	0B	0	117	79	52	0	0	0	375
1977	8	0	0	0	0	0	324B	3767	3396	378	691B	0	144E	1578	0	0	0	0	1725
1977	9	0	0	0	0	0	583B	35725	13393	9137	1880B	0	5227	13640	2051	0	25C	0	6329
1977	10	0	0	0	0	0	496B	3895	477	0	1336B	15716	1396E	172	0	0	0	0	1214
1977	11	0	78C	35C	0	0	476B	10733	4352E	2979C	779B	175	2329E	1556	0	0	0	0	675
1977	12	1385C	874C	551C	825C	187C	970Q	38351	3472	157	448B	1000	9249	8668	4303	0	229C	0	5986
1978	1	532C	196C	64C	430C	240C	1402Q	14893	2556	25	135B	3402	8289	1086	374	0	129C	0	660
1978	2	455C	162C	36C	167C	104C	1478B	12508	747	17	0B	436	11198E	1495	48	0	146C	0	582
1978	3	1310C	306C	127C	951C	230C	449Q	29486	865	278	186B	116	14165	12815	2575	0	398C	0	2626
1978	4	0	34C	0	47C	0	600B	4016	161	281	65B	1216	3033E	122	0	0	30C	0	62
1978	5	0	32C	0	0	0	411B	2299	5348	1147	452B	65	4276	2011	20	0	101C	0	1507
1978	6	164C	163C	34C	123C	101C	1604C	8315	2625	219	0B	6636	12088	4076	252	0	517C	0	457
1978	7	806C	162C	64C	1002C	202C	4253C	21336	5932	1048	0B	892	48686	14338	4151	0	3484C	0	2665
1978	8	781C	377C	185C	1462C	296C	5972C	22421	5528	968	0B	5828	63964	13507	5513	0	4578C	0	14142
1978	9	294C	97C	13C	950C	399C	4510C	29429	1615	318	0B	10472	4659	7547	2053	0	350E	0	2719
1978	10	480C	204C	150C	424C	455C	355	17906	989	0	0B	602	4870	2308	184	0	801	0	384
1978	11	540C	191C	79C	309C	266C	424	6941	1957	274	0B	67	1175	3481	0	0	284	0	117
1978	12	368C	248C	64C	561C	308C	662	10831	4098	347	16B	138	3365	1543	64	0	283	0	238
1979	1	2227C	1019C	459C	1967C	805C	6150	43882	1206	66	0B	588	26411	31979	2963	0	3223	0	10021
1979	2	238C	168C	47C	552C	141C	840	9268	0	0	0B	1216	11187	1421	129	0	676	0	1018
1979	3	422C	118C	29C	409C	179C	169	7275	121	41C	0B	0	3637	3559	330	0	728	0	2162
1979	4	517E	12E	0	0	0	0	1479	803	123	0B	100	341	299	0	0	0	0	24
1979	5	6743	268	59	4418	178	5652	26169	1814	274	0B	0	12581	8776	2656	0	2515	0	516
1979	6	78	40	11	269	0	1121	4756	0	0	0B	163	3095	1639	289	0	341	0	2362
1979	7	0	34	0	285	59	22	9805	0	0	0B	0	4750	1232	0	0	0	0	712
1979	8	0	111	0	378	67	10	12535	105	119	0B	115	5849	16133	441	0	172	0	1205
1979	9	9416	3239	208	9620	3410	18161	132422	3927	3126	0B	0	91344	54391	12257	0	9531	0	35687
1979	10	3564	1431	595	2760	1817	9940	13185	991	939	0B	9745	32328	9385	2485	0	1809	0	17060
1979	11	703	622	120	633	7991	1141	2772	2030	386	0B	3187	2684	554	0	0	40	0	1365
1979	12	1592	327	137	1037	513	1017	4482	406	424	0B	395	6159	771	67	0	405	0	674
1980	1	562	324	159	724	480	104	5992	1249	323	0B	1435	3942	392	0	0	151	0	368
1980	2	689	284	127	489	274	144	10893	0	0	0B	2532	5507	439	25	0	497	0	986
1980	3	254	94	50	432	245	167	8247	0	103	0B	304	7417	250	27	0	523	0	530
1980	4	1203	181	54	758	206	360	9176	118	314	0B	215	7260	2332	205	0	1431	0	170
1980	5	232	163	19	274	252	0	4569	0	0	140B	1443	4485	746	117	0	128	0	5
1980	6	473	97	12	92	21	0	887	0	0	0B	0	167	31	36	0	0	0	2
1980	7	362	125	34	934	166	458	8083	0	0	0B	60	1919	1145	315	0	29	0	212
1980	8	431	194	18	1151	19	295	2083	0	47	0B	156	2927	1150	160	0	0	0	1009
1980	9	878	674	36	1851	375	1319	18918	1315	44	0B	2316	8327	1213	35	0	12	0	3400
1980	10	0	0	9	334	30	16	3441	0	0	0B	2820	1229	0	0	0	0	0	523
1980	11	91	7	0	115	0	425	5118	0	0	0B	0	1508	0	0	0	0	0	121
1980	12	0	0	0	0	26	372	7395	0	0	0B	37	1628	0	0	0	0	0	94
1981	1	0	0	0	0	0	0	1398	0	0	0B	0	682	0	0	0	0	0	27
1981	2	0	0	0	0	0	28	3168	0	0	0B	0	791	93	0	0	0	0	417
1981	3	0	0	0	0	0	0	1032	0	0	0B	0	300	0	0	0	0	0	102
1981	4	0	0	0	0	0	0	0	0	0	0B	0	28	0	0	0	3	0	1
1981	5	0	0	0	0	0	0	162	0	0	155B	0	16	0	0	0	0	494	0
1981	6	0	0	0	0	0	0	162	23	185	0B	0	5	0	0	134	0	0	0
1981	7	0	0	0	0	0	0	391	0	41	540Q	0	6	1674	357	477	0	0	0
1981	8	0	0	0	0	0	134	68188	27715	7333	1234Q	0	549	4203	696	5107	141	962	20
1981	9	0	0	0	0	0	2981	69182	11122	7586	.	0	16946	8297	529	8416	1215	0	15809
1981	10	0	0	0	0	0	347	2817	0	0	1295	0	737	0	0	0	0	0	1128
1981	11	0	0	0	0	0	0	1289	13306	2407	49	0	187	0	0	0	0	0	85

Table 14a (Continued) Major Tributary Inflow Phosphorus Loadings (Kg/Month) to Lake Okeechobee

1981	12	0	0	0	0	0	0	877	0	0	0	0	32	0	0	0	0	0	7
1982	1	0	0	0	0	0	0	800E	9E	0	0	0	76	0	0	0	0	0	10
1982	2	0	0	0	0	0	0	1668C	5296	0	0	0	78	0	0	0	0	55	17
1982	3	0	0	0	0	0	1070E	15299E	8055	281	0	0	1773	5455	136E	6	223C	1412	332
1982	4	0	0	0	0	0	1752	19885	539	0	691	0	10752	8818	240	0	982	0	969
1982	5	0	877	0	0	0	6055	5580	5947	1663	0	0	10896	5256	1743	511	1412	1867	619
1982	6	2217E	2738E	339	0	0	47210	45893	17261	6407	0	0	44068	29584	7931	544	7054	0	53069
1982	7	872	1111	294	2428	258	19708	24863	5520	109	0	6139	30703	8638	3137	0	4547	0	20556
1982	8	2158	389	180	3724	260	9484	25182	4789	1759	0	5788	18357	4789	1017	0	2472	0	14630
1982	9	1281	183	34E	3927	240	11765E	16965	5235	2039	0	1942	12295	5621	495	0	1369	0	5044
1982	10	1665	276	188	3398	290	13038	18586	683	0	0	241	15728	13124	581	0	2057	0	9950
1982	11	573	59	67E	1310	238	3260	8911	0	0	0	96	2073	950	56	0	797	0	1003
1982	12	285	76	49	549	135	183	4835	0	0	0	0	1246	199	0	0	15	0	77
1983	1	892	441	168	804	302	1801E	9432	1200	1009E	0	0	4080	1874	0	0	332	0	436
1983	2	9191	2840	842	3932	757	22479	33616	4263	9396	0	1460	68544	28457	5115	0	10706	0	15601
1983	3	7166	1667	660	1666	741	12950	11120	741	73	0	12573	44461	18928	2172	0	6796	0	12795
1983	4	1426	182	57	390	265	1818	2403	0	0	0	4276	23969	7350	40	0	2512	0	2027
1983	5	135E	39E	0	92E	72	0	377	0	0	0	67	5442	338E	0	0	729E	0	39
1983	6	97C	83	15	706	502	0	2686	2622C	1756C	0	0	1174	2173C	448	0	863C	0	138
1983	7	214E	273	31E	363E	183	0	1406E	0	0	0	2366	6274	2480E	281	0	530C	0	556
1983	8	692	245	17	1086	605	0	5285	0	0	0	462	9984	3627	81	0	1116	0	3241
1983	9	1473	254	60C	1596	1010	219C	5083	711C	0	0	392	6536	3193C	1065	0	231E	0	3863
1983	10	3427	280	58	3716	811	1286	16447	865C	387C	0	676	1294	882	210E	0	152C	0	2244
1983	11	1042	140	29	1326	269	306E	3392	0	0	0	911	826	1203	209C	0	455C	0	1311
1983	12	844	180	38E	1994	298	405C	5807	48C	0	0	0	7614	879E	0	0	579C	0	818
1984	1	886	165	36	968	233	463E	6378	0	0	0	1854	8648	1633C	0	0	518C	0	330
1984	2	839	293	33	1907	324	2498	14968	0	0	0	0	11620	1650	388	0	687	0	420
1984	3	2110	539	88	1439	289	3204E	12047E	1715C	859	0	660	12596	6136	301	0	2076E	0	13055
1984	4	1025	450	83	973	106	884C	3486	412C	0	0	6467	15757	2973	57E	0	753C	0	4143
1984	5	191E	50E	0E	384E	58E	3C	6628C	2948C	312C	0	5124	17727	3268E	150E	0	1269C	0	2484
1984	6	68	8E	19	996	149	87C	3858C	178C	0	0	4737	6132	1971	38	0	317	0	6975
1984	7	1052	48	114	6536	615	9766	16645	520C	107	0	3499	42186	28042	3623	0	8458	0	32446
1984	8	1704	27	42	3919	130	11613E	7091	0	0	0	38269	33321	4818	227	0	1175E	0	7846
1984	9	1072	38	10	1432	343	1493	10785	1898	1359	0	16725	2927	384	0	0	212	0	1200
1984	10	163	25C	0	329	130	256	6153	624E	511E	0	744	915	122	0	0	144	0	358
1984	11	108	35	0	352	191	43	3804	467C	425C	0	708	1219	327	0	0	90	0	122
1984	12	37	0	7	360	76	0	2199	0	0	0	0	392	0	0	0	0	0	157
1985	1	0	0	0	154	0	0	3253	0	0	0	0	0	0	0	0	0	0	30
1985	2	0	0	0	0	0	0	899	0	0	C	0	131	0	0	0	0	0	8
1985	3	0	6E	0	0	0	0	997E	216C	73E	4123	0	0	117	0	0	0	0	3
1985	4	0	0	0	0	0	0	1413	924C	308	3589	0	254	0	0	0	0	0	4
1985	5	0	0	0	0	0	0	15	0	127C	1095	449	3608	0	0	0	0	0	0
1985	6	0	0	0	0	0	0	1826	0	0	2192	0	433	0	0	0	0	0	78
1985	7	0	0	0	0	0	3338	5666	8099	5525	1372	0	5848	1197	0	0	29	0	10904
1985	8	0	0	0	0E	0E	2691	17771	8218	9960E	6238	0	7865	1313	0	0	30E	0	9018
1985	9	42	290	97	634	571	3746	44760	12341E	1948	24315	316	19489	10792	62	0	1769	0	7426
1985	10	20	39	0	344	25	1871	8572	0	0	6967	1048	8623	3985	0	0	396	0	0
1985	11	0	41	0	0	0	305	2322	0	0	62	0	863	1301	0	0	141	0	0
1985	12	0	40	0	77	29	0	2518	0	0	3371	48	803	330	0	0	40	0	0
1986	1	15	65	0	0	57	0	1481	0	0	2017	0	5894	312	0	0	10	0	221
1986	2	29	30	0	115	0	0	695	0	0	549	0	7018	94	49	0	0	0	50
1986	3	64	165	19	265	33	0	1257	886	0	707	0	7242	3606	0	0	564	0	1632
1986	4	0	0	0	47	0	0	0	0	0	144	976	2892	223	0	0	64	0	175
1986	5	0	.Q	0	0Q	0Q	5	0	0	0	124	0	2864	14	0	0	0		0

ble 14a (Continued) Major Tributary Inflow Phosphorus Loadi... g/Month) to Lake Okeechobee

1986	6	0	0	0	0Q	0Q	1671	21963	1889	2166	8971	0	9355	1368	102	0	100	0	6996
1986	7	55	18	42	333	484	17017	33644	0	0	13079	1366	32488	4852	590	0	3308	0	12397
1986	8	1278	134	64	841	283	11727	26660	0	0	2236	0	30982	12536	5070	0	1519	0	3613
1986	9	1142	117	44	472	556	8737	19848	0	0	0	0	11850	7909	306	0	204	0	5971
1986	10	457	54	0	244	52	174	4200	0	0	0	156	504	387	0	0	0	0	692
1986	11	361	39	10	234	100	1529	6279	0	0	0	688	2166	716	25	0	114	0	598
1986	12	283	74	11	294	103	73E	3783	0	0	0	0	1287	0	0	0	0	0	86
1987	1	1790	672	66	846	197	7726	13380	0	0	0	175	15353	2118	406	0	182	0	1185
1987	2	449	72	11	197	80	157	2088	0	0	0	0	8784	1186	0	0	37	0	89
1987	3	711	225	64	593	156	2337	5837	147	0	0	0	9358	1075	26	0	430	0	855
1987	4	229	79	22	241	0	1618	3170	0	0	0	205	20669	2632	18	0	585	0	988
1987	5	0	12	0	255	147	254	1484	0	0	0	0	6334	1496	77	0	547	0	78
1987	6	0	0	0	52	0	0	1494	0	0	1696	0	5	53	0	0	0	0	1
1987	7	0	0	0	140	107	101	2540	0	0	1668	0	2369	246	0	0	0	0	661
1987	8	41	0	16	0	21	276	356	0	0	1954	0	2818	4342	99	0	8	0	2468
1987	9	0	0	0	0	0	0	412	0	0	3535	100	5539Q	10144	0	0	40	0	4563

DATA FLAGS:
"B" BOTH FLOW AND PHOSPHORUS CONCENTRATION ESTIMATED -SEE TEXT FOR METHODOLOGY
"C" ESTIMATED PHOSPHORUS CONCENTRATION - SEE TEXT FOR METHODOLOGY
"E" PHOSPHORUS MEASUREMENT MADE WITHIN 45 DAYS, BUT DURING ADJACENT CALENDAR MONTH
"Q" ESTIMATED FLOW - SEE TEXT FOR METHODOLOGY.

Table 14b. KISSIMMEE RIVER STRUCTURES TOTAL PHOSPHORUS LOADINGS (KG/MONTH)

YEAR	MONTH	S-65	S-65A	S-65B	S-65C	S-65D
1972	10	.	.	.	.	.
1972	11	.	.	.	.	.
1972	12	.	.	.	.	.
1973	1	.	.	.	.	.
1973	2	.	.	.	.	.
1973	3	.	.	.	.	.
1973	4	.	.	.	.	.
1973	5	.	.	.	.	.
1973	6	57Q	152	129	382	853
1973	7	379Q	643	2533	3681	8448
1973	8	2011Q	2696	4246	7741	9188
1973	9	8326Q	5016E	9523E	12674E	13370
1973	10	1216	1771	3035	3365	3789
1973	11	10	125	117	99	177
1973	12	31	174	97	175	451
1974	1	50Q	228	34	4	192
1974	2	1531Q	1661	1152	1263	2485
1974	3	407Q	528	438	582	605
1974	4	574Q	633	568	773	1053
1974	5	1334Q	1190	1158	1975	2235
1974	6	1129Q	1961	2365	4357	5092
1974	7	11386Q	23611	33187	40124	63306
1974	8	11316Q	11362	15001	23292	27130
1974	9	4665Q	4800	6124	7085	10088
1974	10	1315	1160	1402	1781	2932
1974	11	110	338	356	131	306
1974	12	3	224	96	47	165
1975	1	94	277	70	75	135
1975	2	176	325	35	29	93
1975	3	330	714	389	323	306
1975	4	1654	2180	2160	2041	2419
1975	5	2453	2443	2270	2302	2656
1975	6	611	959	985	1486	3318
1975	7	8	776	1346	2626	9337
1975	8	1875	3818	7250	7397	10687

e 14b (Continued). KISSIMMEE RIVER STRUCTURES TAL PHOSPHORUS LOADINGS (KG/MONTH)

YEAR	MONTH	S-65	S-65A	S-65B	S-65C	S-65D
1975	9	3409	5276	4767	7458	7259
1975	10	1690	2709	3476	5347	7075
1975	11	1397E	1969E	2706E	3205	4327
1975	12	428	725C	272C	105E	337E
1976	1	229E	203E	49E	24E	299E
1976	2	1463	1696	1413	1635	2231
1976	3	5637C	2046E	1829E	2079E	2854E
1976	4	2742C	1517E	957E	1177E	2247E
1976	5	2325	1673	1425	2179	2974
1976	6	60	1244	1265	5407	13322
1976	7	421	753	1298	3496	6220
1976	8	6347	5305	7406	10004	30637
1976	9	2512	3376	3952	4085	8136
1976	10	177	794	657	619	1769
1976	11	223E	306E	11E	46E	1237E
1976	12	10009	3871	3526C	9637	15437
1977	1	6438	6382	5600	6699	5458
1977	2	4227E	4550E	3768E	5090E	3662E
1977	3	3638	5898	5422	8249	4403
1977	4	908E	1272E	595E	1241E	994E
1977	5	284	274	0	132	450
1977	6	0E	428E	0	0	879E
1977	7	28	312	64	0	2751
1977	8	47E	93E	0	0	3670E
1977	9	0	310	955	1285	7024
1977	10	0C	128E	170E	297E	2500E
1977	11	1	63	205E	704	1503C
1977	12	2E	359E	949	4014	5119C
1978	1	8634	6163	7320	6910	7628
1978	2	7494E	6791E	8021E	8310E	9066E
1978	3	5871	5397	6919	8824	10493
1978	4	1700E	2715E	1869E	2627E	2989E
1978	5	2616	2866	2588	2914	4698
1978	6	2	2535	3297	2950	8939
1978	7	52	6234	6125	8258	24230
1978	8	9548	12279	11859	12288	41283
1978	9	691	1070	1652	2523	5686
1978	10	4	444	765	1625	4883
1978	11	4	72	153	571	1848

1978	12	579	801	896	1752	3305
1979	1	7135	8065	11118	10688	19057
1979	2	9721	8946	8857	9507	11411
1979	3	2507	2664	2802	2854	3460
1979	4	3	18	132	318	417
1979	5	4800	4493	5431	6719	10878
1979	6	1	127	127	972	2107
1979	7	1	245	773	1893	2221
1979	8	3	895	1121	2308	3137
1979	9	1947	10151	16007	17448	60108
1979	10	4089	5221	4796	7567	34957
1979	11	163	434	405	1810	3004
1979	12	2771	2986	2249	3172	4853
1980	1	2672	2599	3437	3275	3600
1980	2	3062	3545	2900	3719	3936
1980	3	4378E	4579E	3493E	6469E	8013E
1980	4	2200	2655	1995	4050	11104
1980	5	4002	2622	2871	2858	4174
1980	6	134	399	107	183	109
1980	7	46	561	121	162	583
1980	8	3	1504	662	764	2417
1980	9	2	816	387	1562	12325
1980	10	168	524	0	43	544
1980	11	123	396	0	0	204
1980	12	12	253	16	0	141
1981	1	43	204	0	0	17
1981	2	4	203	35	98	222
1981	3	102	282	0	0	7
1981	4	163	158	0	0	0
1981	5	98	137	0	0	0
1981	6	1	0	0	0	0
1981	7	0	0	0	0	0
1981	8	3	1149	131	90	261
1981	9	2	5364	4169	6548	11700
1981	10	4	121	87	358	404E
1981	11	2E	121	349	287	267
1981	12	1	0	0	69	0
1982	1	1	0	0	0	0
1982	2	1	0	0	152	0

...e 14b (Continued). KISSIMMEE RIVER STRUCTURES TOTAL PHOSPHORUS LOADINGS (KG/MONTH)

YEAR	MONTH	S-65	S-65A	S-65B	S-65C	S-65D
1982	3	1	277	261	622	1304
1982	4	791	1281	1367	2263	10002
1982	5	3611	3664	3765	4142	7313
1982	6	4971	7270	10877	9817	29482
1982	7	8021	7239	9868	11272	16628
1982	8	7983	6857	9077	10538	12713
1982	9	5283	5152	5595	7314	12608
1982	10	2952	5399	6137	7201	11544
1982	11	460	848	495	1022	1941
1982	12	196	439	156	706	1174
1983	1	849	1295	951	647	3310
1983	2	7247	14094	19428	25452	47978
1983	3	14976	14505	19743	22139	34186
1983	4	15451	15422	16999	15523	19807
1983	5	7364	5461	5384	4436	5079
1983	6	51	590	641	791	878
1983	7	4498	3867	3843	4690	5112
1983	8	7153	6072	5761	6393	8494
1983	9	2984	2685	3101	3295	4530
1983	10	0	139	0	47	1372
1983	11	0	49	0	0	705
1983	12	5185	6398	5331	6078	6559
1984	1	6160	6050	5380	5669	6270
1984	2	7568	6086	6925	7437	8327
1984	3	3772	3873	3137	3856	10762
1984	4	12395	10219	9940	9465	12449
1984	5	14417	10707	11520	13415	13829
1984	6	275	577	1389	3170	4278
1984	7	2006E	2225E	4017E	6818E	13799E
1984	8	9208	8784	8629	9505	19126
1984	9	760	1080	842	1088	2917
1984	10	0	212	271	164	499
1984	11	647	1145	2188	797	1193
1984	12	0	260	500	538	736
1985	1	0	0	7	9	0
1985	2	0	0	119	16	0
1985	3	277	367	676	21	0
1985	4	1177	450	493	294	387
1985	5	5055	3445	5173	4088	3846

RIVER STRUCTURES TOTAL PHOSPHORUS LOADINGS (KG/MONTH)

YEAR	MONTH	S-65	S-65A	S-65B	S-65C	S-65D
1985	6	345	784	488	236	1597
1985	7	0	2020	655	2201	4506
1985	8	4079	4341	9085	8962	9019
1985	9	2719	4407E	10862	9365	22802
1985	10	1149	1630	2110	2229	5221
1985	11	3	106	170	442	1471
1985	12	1	69	559	661	1552
1986	1	5774	3330	3601	3409	4513
1986	2	4738	3112	4149	6172	4703
1986	3	560	3919	3508	6569	5097
1986	4	2088	2061	2537	3278	3354
1986	5	2295	2408	2373	3313	3744
1986	6	54	628	939	951	1895
1986	7	0	3222	3132	5373	18712
1986	8	1484	3820	2985	4333	17926
1986	9	2015	2537	2533	3295	6598
1986	10	77	523	706	313	585
1986	11	0	386	1212	1399	3087
1986	12	170	399	977	637	1471
1987	1	9463	11760	7380	7551	10697
1987	2	10546	7485	8458	7187	7694
1987	3	6306	4661	5374	5682	6656
1987	4	13610	15830	11891	11248	14109
1987	5	3729	3440	3901	4353	5765
1987	6	0	0	5	0	6
1987	7	164	347	833	125	4712
1987	8	0	123	821	288	5447E
1987	9	0	730	2080	1478	11274

1. C-38 Pool A (S-65A)

The flow record for S-65A is complete for the 1974-1987 water years (annual average = 633,360 ac/ft). During the 168-month period from June 1973 to September 1987 there is one month in which there is not a proximate measurement of phosphorus concentration (Flag = 'C') for loading calculations (Table 13).

Loads at S-65A for the period of missing phosphorus data were estimated as follows:

a. For the month with measured flow, but no proximate phosphorus measurement (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

   TP(mg/L) = .046

   This conversion factor was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/144, r = 0.05, P = 0.47, Standard Error of conversion factor = 0.0026).

   TP loads for this situation (Flag = 'C') were calculated by multiplying the estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a good approximation to the calculated loads (average estimate = 95 percent of calculated load, correlation between estimated and calculated load = 0.92).

   The estimate of annual average TP load for S-65A over the 14-year period of record is not sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load (WY 74-87) for S-65 is 34.6 metric tonnes (38.2 tons), if estimated data are included, the annual average load is 34.5 metric tonnes (38.0 tons/yr). The difference between measured and measured-plus-estimated load is about 2 percent the average annual load from this structure and less than 0.1 percent of the total uncontrollable load to the lake.

   The values reported in Table 1 for S-65A loads and flows have been adjusted by subtracting the average load and flow of S-65 from the average totals given in the preceeding paragraph.

2. C-38 Pool B (S-65B)

The flow record for S-65B is essentially complete (annual average = 694,016 ac/ft) for the 1974-1987 water years and no flows were estimated. During the 168-month period from June 1973 to September 1987 there are two months in which there is not a roximate measurement of phosphorus concentration (Flag = 'C') or loading calculations (Table 13).

he load at S-65B for these periods of missing phosphorus data were stimated as follows:

. For the two months with measured flow, but no proximate phosphorus measurement (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP(mg/L) = .049

This conversion factor was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/139, r = 0.04, P = 0.19, Standard Error of conversion factor = 0.0025).

TP loads for this situation (Flag = 'C') were calculated by multiplying the estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a good approximation to the calculated loads (average estimate = 108 percent of calculated load, correlation between estimated and calculated load = 0.93).

The estimate of annual average TP load for S-65B over the 14-year period of record is not sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load (WY 74-87) for S-65 is 38.9 metric tonnes (42.8 tons), if estimated data are included, the annual average load is 38.7 metric tonnes (42.6 tons/yr). The difference between measured and measured-plus-estimated load is about 0.5 percent the average annual load from this structure and less than 0.05 percent of the total uncontrollable load to the lake.

The values reported in Table 1 for S-65B loads and flows have been adjusted by subtracting the average load and flow of S-65A from the average totals given in the preceeding paragraph.

C-38 Pool C (S-65C)

The flow and total phosphorus records for S65-C are essentially complete for the period October 1973 - September 1984 (annual average = 746,380 ac/ft) and no flows or phosphorus concentrations were estimated for this structure. The annual average phosphorus load for this structure was 46.63 metric tonnes (51.4 tons/yr).

The values reported in Table 1 for S-65C loads and flows have been adjusted by subtracting the average load and flow of S-65B from the average totals given in the preceeding paragraph.

4. S-65D

The flow record for S-65D is essentially complete for the 1974-1987 water years (Table 2) and no flows were estimated (annual aveage = 858,687 acf/t). During the 168-month period from June 1973 to September 1987 there are two months in which there is not a proximate measurement of phosphorus concentration (Flag = 'C') for loading calculations (Table 13).

The load at S-65D for these periods of missing phosphorus data were estimated as follows:

a. For the two months with measured flow, but no proximate phosphorus measurement (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

   TP(mg/L) = .084

   This conversion factor was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/142, r = 0.09, P = 0.26, Standard Error of conversion factor = 0.0056).

   TP loads for this situation (Flag = 'C') were calculated by multiplying the estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a good approximation to the calculated loads (average estimate = 107 percent of calculated load, correlation between estimated and calculated load = 0.88).

   The estimate of annual average TP load for S-65D over the 14-year period of record is not sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load (WY 74-87) for SR65 is 83.4 metric tonnes (91.9 tons), if estimated data are included, the annual average load is 82.8 metric tonnes (91.3 tons/yr). The difference between measured and measured-plus-estimated load is about 0.6 percent the average annual load from this structure and less than 0.1 percent of the total uncontrollable load to the lake.

   The values reported in Table 1 for S-65D loads and flows have been adjusted by subtracting the average load and flow of S-65C from the average totals given in the preceeding paragraph.

5. C-38 Pool E (S-65E)

During the 168-month period from October 1972 to September 1987 there are four months in which there is not a proximate measurement of phosphorus concentration (Flag = 'C') for loading calculations (Table 13).

Loads at S-65E for periods of missing flow or phosphorus data wer estimated as follows:

a. For months with measured flow, but no proximate phosphorus measurement (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

   TP(mg/L) = .1149 - 0.00000607 * Cfs/day (monthly mean)

   This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the entire period of record (df = 1/160, r = 0.125, P = 0.11, Standard Errors: intercept = 0.0071 slope = 0.0000038). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the negative correlation that may exist between flow and TP concentration at S-65E.

   TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a good approximation to the calculated loads (average estimate = 98 percent of calculated load, correlation between estimated and calculated load = 0.79).

b. For months in which phosphorus data were available but flow data were estimated (Flag = 'Q'), the measured TP concentration was converted to a flow-weighted concentration and then multiplied by the estimated flow for the month. The conversion to flow-weighted concentration was based on the regression relationship:

   TP (flow-weighted mg/L) = .01105 + 0.9212*TP (grab sample mg/L)

   This relationship was based on regression of flow-weighted TP on grab-sample TP for the S-65E period of record for which both flow and TP were actually measured (df = 1/147, r = 0.93, P = 0.0001, Standard Errors: Intercept = 0.00391, slope = 0.0305).

   The estimate of annual average TP load for S-65E over the 15-year period of record not sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-65E is 108.3 metric tonnes (119.3 tons), if estimated data are included, the annual average load is 111.3 metric tonnes (122.6 tons/yr). The difference between measured and measured-plus-estimated load is about 2.8 percent the average annual load from this structure and only 0.7 percent of the total controllable load to the lake.

   The values reported in Table 1 for S-65E loads and flows have been adjusted by subtracting the average load and flow of S-65D from the average totals for S-65E for the period October 1973 - September 1987 (flow = 892,128 acft/yr, load = 121.29 tons/yr).

6. S-4 Phosphorus Loading Calculations

The daily flow record for S-4 is nearly complete for the July 1974 to September 1987 period, with an 11 day gap in June 1986 (Table 2). During the 139 month period March 1976 to September 1987 there are 6 months in which pumping occurred without a proximate measurement of phosphorus concentration (Flag = 'C') (Table 13). Flow-proportional phosphorus sampling was added to routine grab sampling at this site in August 1982. However, to keep the loading calculations consistent across the entire period of record, only grab-sample phosphorus data were used in the loading calculations. In addition, all phosphorus samples collected when water was flowing out of the lake (discharge code = 3) were excluded from the S-4 inflow loading calculations.

Phosphorus loadings for S-4 during months of missing flow or phosphorus data were estimated as follows:

For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP (mg/L) = 0.214 + 0.0000347*Cfs/day (monthly mean)

This conversion was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-4 (df = 1/72, $r = 0.39$, $p = 0.0001$, Standard Errors: Intercept: 0.0388, Slope: 0.00000963). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the significant correlation that exists between flow and TP concentration at S-4.

TP loads for this situation (Flag = 'C') were calculated by multiplying the average flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a good approximation to the calculated loads (average estimate = 100.0 percent of calculated load, correlation between estimated and calculated load = 0.83).

The estimate of annual average TP load for S-4 over the 15 year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (flags = blank or 'E'), the annual average load for S-4 is 18.02 metric tonnes (19.85 tons), if estimated data are included, the annual average load is 18.06 metric tonnes (19.90 tons/yr vs 16.4 tons/yr originally reported in the SWIM plan). The difference between measured and measured-plus-estimated loads is 0.2 percent of the load from this structure and less than 0.01 percent of the total controllable load to the lake.

DBCODES for Flow Data used in calculating S-4 loads:

PERIOD			DBCODE
01-01-74	-	12-13-77	06738
12-14-77	-	12-31-78	03760
01-01-79	-	06-23-82	06738
06-24-82	-	02-16-86	03760
02-17-86	-	03-24-87	06738
03-25-87	-	09-30-87	03760

This scheme makes maximum use of "verified" data (DBCODE 03760) with provisional data (DBCODE 06738) used only when verified data is not available.

7. S-191 Phosphorus Loading Calculations

The flows record at S-191 are nearly complete, with a gap in June and July of 1973 (Table 13). Monthly flows for this period were estimated by District staff. See Section D1.b.

There are periods between October 1973 and September 1987 during which total phosphorus was not measured at S-191, for a total of nine months in which suitable phosphorus measurements were unavailable for S-191 loading calculations (Table 13). In addition, one extreme TP value (04/09/73, 0.010 mg/L, more than three standard deviations below the mean), was excluded from the loading calculations.

Loads at S-191 for periods of missing flow or phosphorus data were estimated as follows:

a. For months with flow measurements and no proximate phosphorus measurement (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP(mg/L) = .8595 + 0.000162 * Cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/159, r = 0.16, P = 0.0415, Standard Errors: intercept = 0.0221 slope = 0.00007885). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-191.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 99 percent of calculated load, correlation between estimated and calculated load = 0.97).

b. For the two months in which phosphorus data were available but flow data were estimated (Flag = 'Q'), the measured average TP concentration was multiplied by the estimated flow for the month.

The estimate of annual average TP load for S-191 over the 15-year period of record is not sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-191 is 131.4 metric tonnes (144.8 tons), if estimated data are included, the annual average load is 129.9 metric tonnes (143.2 tons/yr vs. 143.4 tons as originally reported in the SWIM plan). The difference between measured and measured-plus-estimated load is about 1.1 percent of the average annual load from this structure and 0.3 percent of the total controllable load to the lake.

8. S-71 Phosphorus Loading Calculations

The daily flow record for S-71 is complete for the October 1972 to September 1987 period. The phosphorus concentration data for this site has three short gaps (Table 13) during non-zero flow periods for which concentrations needed to be estimated (Flag = 'C').

Phosphorus loadings for S-71 during months of missing flow or phosphorus data were estimated as follows:

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

$$TP (mg/L) = 0.1596 + 0.0001525 * Cfs/day \text{ (monthly mean)}$$

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-71 (df = 1/131, $r = 0.40$, $p = 0.0001$, Standard Errors: Intercept = 0.0126, slope = 0.0000306). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-71.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 104 percent of calculated load, correlation between estimated and calculated load = 0.92).

The estimate of annual average TP load for S-71 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (flags = blank or 'E'), the annual average load for S-71 is 45.7 metric tonnes (50.3 tons), if estimated data are included, the annual average load is 45.4 metric tonnes (50.0 tons). The difference between measured and measured-plus-estimated loads is about 0.6 percent of the load from this structure and 0.06% of the total controllable load to the lake.

The values reported in Table 1 for loads and flows at S-71 have been adjusted to remove a portion of the uncontrollable load from S-68 (see S-68 loading calculations). The loading values in Table 14 have NOT been adjusted.

9. S-72 Phosphorus Loading Calculations

The daily flow record for S-72 is complete for the October 1972 to September 1987 period. There is one month during which flow occurred without approximate measurement of phosphorus concentration (Table 13). Phosphorus flow-weighted concentration was estimated (Flag = 'C') as follows:

TP (mg/L) = 0.2025 + 0.000135*Cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-72 (df = 1/87, r = 0.11, p = 0.30, Standard Errors: Intercept = 0.016, slope = 0.00013). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate any correlation that may exist between flow and TP concentration at S-72.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 103 percent of calculated load, correlation between estimated and calculated load = 0.95).

The estimate of annual average TP load for S-72 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (flags = blank or 'E'), the annual average load for S-72 is 7.34 metric tonnes (8.1 tons), if estimated data are included, the annual average load is 7.27 metric tonnes (8.0 tons/yr). The difference between measured and measured-plus-estimated loads is about 0.9 percent of the load from this structure and 0.02 percent of the total controllable load to the lake.

The values reported in Table 1 for loads and flows at S-72 have been adjusted to remove a portion of the uncontrollable load from S-68 (see S-68 loading calculations). The loading values in Table 14 have NOT been adjusted.

10. S-84 Phosphorus Loading Calculations

The daily flow record for S-84 is complete for the October 1972 to September 1987 period. There are a number of gaps in the phosphorus data record (Table 13) for which phosphorus concentrations were estimated (Flag = 'C'). One total phosphorus measurement (.910 mg/L, 05/08/74) was judged erroneous (differing from the TP mean for this site by more than 18 standard deviations) and was excluded from the loading calculations.

Phosphorus loadings for S-84 during months of missing flow or phosphorus data were estimated as follows:

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP (mg/L) = 0.0609 + 0.0000181*cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-84 (df = 1/88, r = 0.16, p = 0.13, Standard Errors: Intercept = 0.0054, slope = 0.000012). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the correlation that may exist between flow and TP concentration at S-84.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 98 percent of calculated load, correlation between estimated and calculated load = 0.92).

The estimate of annual average TP load for S-84 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (flags = blank or 'E'), the annual average load for S-84 is 10.3 metric tonnes (11.3 tons), if estimated data are included, the annual average load is 10.1 metric tonnes (11.1 tons/yr). The difference between measured and measured-plus-estimated loads is about 2 percent of the load from this structure and 0.04 percent of the total controllable load to the lake.

The values reported in Table 1 for loads and flows at S-84 have been adjusted to remove a portion of the uncontrollable load from S-68 (see S-68 loading calculations). The values in Table 14 have NOT been adjusted.

11. Fisheating Creek Phosphorus Loading Calculations

The daily flow record for Fisheating Creek is complete for the October 1972 to September 1987 period with only a 6-day gap in January, 1984 (Table 2). During the 174-month period April 1973 to September 1987 (Table 13) there are nine months in which flow occurred without a proximate measurement of phosphorus concentration (Flag = 'C'). In addition, one extreme TP measurement (07/08/74, 1.28 mg/L, 6.6 standard deviations above mean TP for this site) was excluded from the loading calculations.

Phosphorus loadings for Fisheating Creek during months of missing flow or phosphorus data were estimated as follows:

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

   TP (mg/L) = 0.1539 + 0.00005564*Cfs/day (monthly mean)

   This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at Fisheating Creek (df = 1/146 r = 0.20, p = 0.015, Standard Errors: Intercept: 0.01104, Slope: 0.00002262). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the significant correlation that exists between flow and TP concentration at Fisheating Creek.

   TP loads for this situation (Flag = 'C') were calculated by multiplying the average flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a good approximation to the calculated loads (average estimate = 97 percent of calculated load, correlation between estimated and calculated load = 0.90).

   The estimate of annual average TP load for Fisheating Creek over the 15-year period of record is not sensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for Fisheating Creek is 41.9 metric tonnes (46.2 tons), if estimated data are included, the annual average load is 40.6 metric tonnes (44.7 tons/yr vs. 50.9 tons/yr originally reported in the SWIM plan which did not exclude the TP outlier). The difference between measured and measured-plus-estimated loads is about 3 percent of the load from this structure and 0.3 percent of the total controllable load to the lake.

12. S-127 Phosphorus Loading Calculations

The daily flow record for S-127 is complete for the October 1972 to September 1987 period. There are 32 months in the period of record for which suitable phosphorus concentration data are unavailable (primarily 5/74 - 4/79) for S-127 (Table 13).

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP (mg/L) = 0.3264 + 0.001257*Cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly mean) for the period of record at S-127 (df = 1/100, r = 0.23, p = 0.02, Standard Errors: Intercept = 0.028, slope = 0.00053). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-127.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the estimated monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 107% of calculated load, correlation between estimated and calculated load = 0.954).

The estimate of annual average TP load for S-127 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-127 is 6.63 metric tonnes (7.3 tons), if estimated data are included, the annual average load is 6.67 metric tonnes (7.4 tons/yr vs. 9.4 tons/yr reported in the SWIM plan). The difference between measured and measured-plus-estimated loads is about 1 percent of the load from this structure and 0.4 percent of the controllable load to the lake.

13. S-129 Phosphorus Loading Calculations

The daily flow record for S-129 is nearly complete for the October 1972 to September 1987 period. There are numerous one-day gaps throughout the record and a 30-day gap in May 1986 (Table 2). The gap in May 1986 corresponds to a dry period during which the pump was not operated and thus zero flows were not recorded. Zero flow was assumed in the loading calculations during this 30-day period. Phosphorus concentration data for this site are not available for the period May 1974 - April 1979, and there is a total of 50 months for which suitable phosphorus measurements are not available for S-129 loading calculations (Table 13).

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

   TP (mg/L) = 0.1046 + 0.001438*Cfs/day (monthly mean)

   This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-129 (df = 1/121, r = 0.50, p = 0.0001, Standard Errors: Intercept = 0.0070, slope = 0.00022). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-129.

   TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 92 percent of calculated load, correlation between estimated and calculated load = 0.962).

   The estimate of annual average TP load for S-129 over the 15-year period of record is relatively insensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-129 is 2.38 metric tonnes (2.62 tons), if estimated data are included, the annual average load is 2.34 metric tonnes (2.58 tons/yr vs. 3.4 tons originally reported in the SWIM plan). The difference between measured and measured-plus-estimated loads is about 2 percent of the load from S-129 and less than 0.01 percent of the controllable load to the lake.

14. **S-131 Phosphorus Loading Calculations.**

The daily flow record for S-131 is nearly complete for the October 1972 to September 1987 period. There is a 30-day gap in May 1986 (Table 2) that corresponds to a dry period during which this pump station did not operate and thus zero flows were not recorded. Zero flow was assumed in the loading calculations for this 30-day period. Phosphorus concentration data for this site are not available for the period May 1974 - April 1979, and there is a total of 42 months for which suitable phosphorus measurements are not available for S-131 loading calculations (Table 13). Note also that one erroneous phosphorus measurement (4/22/74, TP = 1.000 mg/L) was excluded from the loading calculations for S-131.

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP (mg/L) = 0.0772 + 0.002581*Cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-131 (df = 1/59, r = 0.66, p = 0.0001, Standard Errors: Intercept = 0.0056, slope = 0.00038). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-131.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be an extremely good approximation to the calculated loads (average estimate = 99 percent of calculated load, correlation between estimated and calculated load = 0.97).

The estimate of annual average TP load for S-131 over the 15-year period of record is somewhat sensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-131 is .514 metric tonnes (.57 tons). If estimated data are included, the annual average load is .73 metric tonnes (.83 tons/yr vs. .9 tons originally reported in the SWIM plan). The difference between measured and measured-plus-estimated loads is about 43 percent of the load from S-131 but less than 0.1 percent of the total controllable load to the lake.

15. S-133 Phosphorus Loading Calculations

The daily flow record for S-133 is complete for the October 1972 to September 1987 period, with the exception of a 61-day gap in May-June 1986 (Table 2). This 61-day gap corresponds to dry periodduring which this pump station did not operate, and thus zero flows were not recorded. Zero flow is assumed in the loading calculations for this 61-day period. Phosphorus concentration data for this site are not available for the period April 1974 - April 1979, and there are 34 months in the period of record for which suitable phosphorus measurements are not available for S-133 loading calculations (Table 13).

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

$$TP\ (mg/L) = 0.2304 + 0.001049 * Cfs/day\ (monthly\ mean)$$

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-133 (df = 1/74, r = 0.42, p = 0.0002, Standard Errors: Intercept = 0.0181, slope = 0.00026). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-133.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 101 percent of calculated load, correlation between estimated and calculated load = 0.93).

The estimate of annual average TP load for S-133 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-133 is 7.75 metric tonnes (8.54 tons), if estimated data are included, the annual average load is 7.71 metric tonnes (8.49 tons/yr vs. 8.3 tons originally reported in the SWIM plan). The difference between measured and measured-plus-estimated loads is less than .5 percent of the load from S-133 and less than 0.02 percent of the total controllable load to the lake.

16. S-135 Phosphorus Loading Calculations

The daily flow record for S-135 is complete for the October 1972 to September 1987 period, with the exception of a 61-day gap in May-June 1986 (Table 2). This 61-day gap corresponds to a dry period during which this pump station did not operate and thus zero flows were not recorded. Zero flow was assumed in the loading calculations for this 61-day period.

Phosphorus concentration data for this site are not available for the period April 1974 - April 1979, and there is a total of 34 months for which suitable phosphorus measurements are unavailable for S-135 loading calculations (Table 13). Two phosphorus measurements at this site were excluded from the loading calculations (7/23/29 and 8/06/79). The first of these measurements indicated a TP concentration of 1.105 mg/L (more than three standard deviations above the mean TP for this site) and the second indicated non-detectable concentrations of TP when significant amounts of soluble reactive P ("Ortho" P) were detected.

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP (mg/L) = 0.0709 + 0.000415*Cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-135 (df = 1/71, r = 0.55, p = 0.0001, Standard Errors: Intercept = 0.0057, slope = 0.000075). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-135.

TP loads for this situation (Flag = 'C') were calculated by multiplying the regression estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be an excellent approximation to the calculated loads (average estimate = 100.2 percent of calculated load, correlation between estimated and calculated load = 0.98).

The estimate of annual average TP load for S-135 over the 15-year period of record is totally insensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-135 is 2.59 metric tonnes (2.85 tons), if estimated data are included, the annual average load is 2.58 metric tonnes (2.84 tons/yr vs. 3.9 tons originally reported in the SWIM plan). The difference between measured and measured-plus-estimated loads is less than 1 percent of the load from S-135 and less than 0.001 percent of the total controllable load to the lake.

17. S-154 Phosphorus Loading Calculations

Flows at S-154 were not measured prior to June 1978 and monthly flows for the period prior to June 1978 were estimated.

Additionally, there are periods between October 1973 and September 1987 during which total phosphorus was not measured at S-154. There is a total of 43 months in the period of record for which suitable phosphorus measurements are unavailable for S-154 loading calculations (Table 13).

Loads at this structure for periods of missing flow or phosphorus data were estimated as follows:

a. For months with estimated flow and no proximate phosphorus measurement (Flag = 'B'), the flow-weighted phosphorus concentration was estimated as:

TP(mg/L) = .634 + 0.00127 * Cfs/day (monthly mean)

This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/79, r = 0.32, P = 0.0037, Standard Errors: intercept = 0.044 slope = 0.000425). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that exists between flow and TP concentration at S-154.

TP loads for this situation (Flag = 'B') were calculated by multiplying the regression estimate of flow-weighted concentration by the estimated monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 97 percent of calculated load, correlation between estimated and calculated load = 0.94).

b. For months in which phosphorus data were available but flow data were estimated (Flag = 'Q'), the measured TP concentration was converted to a flow-weighted concentration and then multiplied by the estimated flow for the month. The conversion to flow-weighted concentration was based on the regression relationship:

TP (flow-weighted mg/L) = .11 + .8617*TP (grab sample mg/L)

This relationship was based on regression of flow-weighted TP on grab-sample TP for the S-154 period of record for which both flow and TP were actually measured (df = 1/62, r = 0.934, P = 0.0001, Standard Errors: Intercept = 0.032, slope = 0.0417).

c. For months in which measured flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the method of loading calculation was the same as described in 'A' above (Flag = 'B') except that actual measured monthly flows were used.

The estimate of annual average TP load for S-154 over the 15-year period of record is somewhat sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-154 is 35.1 metric tonnes (38.6 tons), if estimated data are included, the annual average load is 25.2 metric tonnes (27.8 tons/yr vs. 33.5 tons as originally reported in the SWIM plan). The difference between measured and measured-plus-estimated load is about 28 percent of the average annual load from this structure and 2 percent of the total controllable load to the lake.

18. Industrial Canal, S-236, Culvert 4A (South Shore Drainage District), Culvert 12A (715 Farms), Culvert 10 (East Beach Drainage District) and Culvert 12 (East Shore Drainage District)

The data record for these six minor tributaries is too short and incomplete to estimate monthly loads by the methods described above. Except for the Industrial Canal, water quality grab samples have been collected every two to four weeks since May 1979. Sampling of the Industrial Canal at this same interval began in May 1982. However, discharges from S-236, and Culverts 10 and 12 were calculated from pump operating logs that were supplied to the District from the drainage districts. No operation data were available for Culverts 4A and 12A, and discharges were estimated for these sites from the operation of nearby pump stations. Industrial Canal discharge through the Clewiston lock was calculated from USGS data from 1984-1987. Discharges for the period before 1984 were estimated (See Section B1).

Total phosphorus loads for these six tributaries were calculated by multiplying the total discharge by the average concentration for the month. For months when no water quality samples were taken, the average values for the period of record were used to calculate the monthly loadings. Thus, monthly phosphorus concentrations and loads for the earlier years are estimates based on data from the most recent years. Phosphorus outputs that resulted from irrigation discharges at these sites were not estimated because of the lack of discharge data.

19. L-59E and L-59W; Culvert A; and S-154C; L-60E and L-60W; L-61E and L-61W; and Culvert 5 / Nicodemus Slough

To account for additional inputs from these small near-lake basins, loading was estimated from available data and previous modeling efforts. Discharges were estimated from the hydrologic model for basins on the northwest side of the lake. Phosphorus concentrations for these small inflows were averages of three samples taken at each structure from April to September 1987. Loads were calculated by multiplication of estimated annual inflow by average concentration.

20. S-308C Inflow Phosphorus Loading Calculations

Flows at S-308C inflow were not measured prior to August 1981, and monthly flows for the period prior to August 1981 were estimated. Additionally, there are periods between October 1973 and September 1987 during which total phosphorus was not measured at S-308C (Table 13).

Loads at this structure for periods of missing flow or phosphorus data were estimated as follows:

a. For months with estimated flow and no proximate phosphorus measurement (Flag = 'B'), the flow-weighted phosphorus concentration was estimated as:

   TP(mg/L) = .1266 + 0.0000922 * Cfs/day (monthly mean)

   This equation was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/23, r = 0.30, P = 0.15, Standard Errors: intercept = 0.0235 slope = 0.000061). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the positive correlation that may exist between flow and TP concentration at S-308C Inflow.

TP loads for this situation (Flag = 'B') were calculated by multiplying the regression estimate of flow-weighted concentration by the estimated monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a good approximation to the calculated loads (average estimate = 97 percent of calculated load, correlation between estimated and calculated load = 0.84).

b. For months in which phosphorus data were available but flow data were estimated (Flag = 'Q'), the measured TP concentration was converted to a flow-weighted concentration and then multiplied by the estimated flow for the month. The conversion to flow-weighted concentration was based on the regression relationship:

TP (flow-weighted mg/L) = .0282 + .8196*TP (grab sample mg/L)

This relationship was based on regression of flow-weighted TP on grab-sample TP for the S-308C inflow period of record for which both flow and TP were actually measured (df = 1/23, r = 0.90, P = 0.0001, Standard Errors: Intercept = 0.0144, slope = 0.0824).

c. For months in which measured flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the method of loading calculation was the same as described in 'A' above (Flag = 'B') except that actual measured monthly flows were used.

The estimate of annual average TP load for S-308C inflow over the 15-year period of record is sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load for S-308C inflow is 15.3 metric tonnes (16.8 tons), if estimated data are included, the annual average load is 8.3 metric tonnes (9.1 tons/yr vs. 9.6 tons as originally reported in the SWIM plan). The difference between measured and measured-plus-estimated load is about 45 percent of the average annual load from this structure but only 1.5 percent of the total controllable load to the lake.

21. S-2 Phosphorus Lake Inflow Loading Calculations

The daily flow record for S-2 is complete for the October 1972 to September 1987 period. During the 172-month period from June

1973 to September 1987 (Table 13) there are 13 months in which pumping occurred without a proximate measurement of phosphorus concentration (Flag = 'C'). Flow-proportional phosphorus sampling was added to routine grab sampling at this site in August 1981. However, to keep the loading calculations consistent across the entire period of record, only grab-sample phosphorus data were used in the loading calculations. In addition, all phosphorus samples collected when water was flowing out of the lake (discharge code = 3) were excluded from the S-2 inflow loading calculations.

Phosphorus loadings for S-2 during months of missing flow or phosphorus data were estimated as follows:

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as a constant:

   TP (mg/L) = 0.1352

   This conversion was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-2 (df = 1/102, r = 0.0, p = 0.60, Standard Error of constant: 0.0108). There was no significant correlation between inflow and concentration at this site.

   TP loads for this situation (Flag = 'C') were calculated by multiplying the average flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a very good approximation to the calculated loads (average estimate = 97 percent of calculated load, correlation between estimated and calculated load = 0.90).

   The estimate of total annual average TP load for S-2 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (Flags = blank or 'E'), the annual total average load for S-2 is 25.96 metric tonnes (28.6 tons), if estimated data are included, the annual average load is 24.85 metric tonnes (27.4 tons/yr). The difference between measured and measured-plus-estimated loads is about 4.3 percent of the load from this structure and 0.25 percent of the total controllable load to the lake.

b. For purposes of the SWIM Plan, the historical data collected at S-2 since 1979 were used because this was the period that the Interim Action Plan was in effect. The IAP was implemented on July 1, 1979 and an eight-year period of record (October 1979-September 1987) was used to calculate the average annual values reported in Table 1. However, the IAP was suspended twice to allow additional discharges into the lake for water storage during drought periods and this "water supply" backpumping had to be eliminated from the period of record.

The first suspension of the IAP occurred from May 15, 1981 to August 16, 1982. The second suspension was from July 12 to September 23, 1985. During these two periods, as much EAA runoff as possible was pumped north to Lake Okeechobee through S-2 and S-3. Some of this water was backpumped to enhance the water supply of the lake, but certain rainfall events required backpumping for flood protection in the EAA. Backpumping in this latter case would have occurred even if the IAP had been in effect. To determine how much discharge would have occurred under the IAP during these periods, an analysis was undertaken to discriminate between the backpumping that was strictly for water supply and that which was necessary for flood protection.

The flood protection backpumping was estimated using equations that estimated required flood protection backpumping from the EAA as a function of the historical total runoff that left the EAA (either south to the Water Conservation Areas or north to the lake). For each month when the IAP was suspended, the total discharge and phosphorus load at S-2 was multiplied by the fraction of discharge attributed to flood protection backpumping.

After the discharges and loads resulting from water supply backpumping were eliminated from the period of record, the average annual values for the October 1979-September 1987 period were calculated. Additional data regarding these calculations are available upon request.

22. S-3 Phosphorus Lake Inflow Loading Calculations

The daily flow record for S-3 is complete for the October 1972 to September 1987 period. During the 171-month period July 1973 to September 1987 (Table 13) there are 8 months in which pumping occurred without a proximate measurement of phosphorus concentration (Flag = 'C'). Flow-proportional phosphorus sampling was added to routine grab sampling at this site in August 1981. However, to keep the loading calculations consistent across the entire period of record, only grab-sample phosphorus data were used in the loading calculations. In addition, all phosphorus samples collected when water was flowing out of the lake (discharge code = 3) were excluded from the S-3 inflow loading calculations.

Phosphorus loadings for S-3 during months of missing flow or phosphorus data were estimated as follows:

a. For months in which flow occurred at the site, but for which there was no proximate measurement of phosphorus concentration (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

TP (mg/L) = 0.0767 + 0.0001043*Cfs/day (monthly mean)

This conversion was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record at S-3 (df = 1/88, r = 0.28, p = 0.007, Standard Errors: Intercept: 0.00925, Slope: 0.000038). In function, this equation uses the ACTUAL TP mean for the complete period of record, and adjusts it to incorporate the significant correlation that exists between flow and TP concentration at S-3.

TP loads for this situation (Flag = 'C') were calculated by multiplying the average flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured (and flow is non-zero), the estimated loads prove to be a good approximation to the calculated loads (average estimate = 98 percent of calculated load, correlation between estimated and calculated load = 0.79).

The estimate of total annual average TP load for S-3 over the 15-year period of record is insensitive to the inclusion of estimated phosphorus data. Using only actual data (flags = blank or 'E'), the annual total average load for S-3 is 8.47 metric tonnes (9.33 tons), if estimated data are included, the annual average load is 8.39 metric tonnes (9.24 tons/yr). The difference between measured and measured-plus-estimated loads is less than 1 percent of the load from this structure and 0.01 percent of the total controllable load to the lake.

As in the discussion of S-2 above, the historical data collected at S-3 since 1979 was used because this was the period that the Interim Action Plan was in effect. The IAP was implemented on July 1, 1979 and an eight-year period of record (October 1979-September 1987) was used to calculate the average annual values reported in Table 1. However, the IAP was suspended twice to allow additional discharges into the lake for water storage during drought periods and this "water supply" backpumping had to be eliminated from the period of record. The procedure used to take out this additional backpumping is described above in the section on S-2.

After the discharges and loads resulting from water supply backpumping were eliminated from the period of record, the average annual values for the October 1979-September 1987 period were calculated. Additional data regarding these calculations are available upon request.

23. Rainfall

The phosphorus loads attriibutable to direct rainfall on the surface of the lake were calculated by the following methodology. All programs and data files (except **RAINWQ**) are included. Table 10 presents the period of record for the rainfall phosphorus concentration data at the four stations used in this analysis. Figure 1 presents the locations of these stations.

RAINFALL LOADING METHODOLOGY

File Name: **RAINWQ**
Project X Sample type 1
Stations B-50, OKEEFS, S2,S131

↓

File **RAINWQ** reformatted through text editor (CYBER XEDIT)
1. all parameters deleted except for OPO4 and TPO4
2. file split into four station files
   - Station B-50 called **B5**
   - Station OKEEFS called **OK**
   - Station S2 called **S2**
   - Station S-131 called **S1**

↓

Files **B5**, **OK**, **S2** and **S1** are input to program *PAPC* which is stored in file **PAGM**. Program *PAPC* generates output file called **MRTPC**

File **LOKMRF** contains the arithmetic mean of the monthly rainfall (in inches) for the following six DBHYDRO stations:
MRF47, MRF50, MRF58, MRF70, MRF55, MRF51

↓

Files **MRTPC** and **LOKMRF** are input to program *RPLOAD* which is stored in file **LPLOAD**. Program *RPLOAD* generates output file called **LOAD.**

↓

File **LOAD** is input to program *YAVE* to produce average annual load attributable to direct rainfall on surface of the lake (i ~ 72.2 tons)

FILE NAME: B5 (STATION B-50)
MISSING VALUE = 9.000

MNDYYR	OPO4	TPO4
20279	.048	.000
30979	.033	.000
42679	.002	.016
43079	.021	.041
50879	.008	.026
51579	.002	.022
51779	.006	.022
61579	.012	.021
62579	.002	.018
62480	.002	.005
71780	.004	.032
52781	.002	.005
101481	.002	.004
102881	.008	.016
110581	.004	.002
110681	.003	.003
123081	.004	.007
11482	.000	.080
20182	.004	.014
21782	.000	.000
30882	.004	.016
31182	.004	.010
32982	.004	.006
32982	.274	.300
50382	.004	.009
50482	.004	.004
52382	.004	.009
52482	.000	.013
52582	.000	.067
52782	.004	.005
52882	.004	.007
60182	.049	.050
60182	.000	.006
60282	.004	.006
60582	.000	.007
60782	.004	.004
61482	.004	.021
61782	.010	.011
61882	.004	.007
61882	.004	.022
62182	.004	.005
62382	.000	.203
62382	.000	.047
81182	.000	.000
81382	.124	.141
81682	.004	.006
82382	.004	.014
90682	.011	.028
90882	.004	.004

MNDYYR	OPO4	TPO4
100482	.005	.010
102982	.004	.018
110182	.004	.008
110582	.004	.005
110882	.004	.004
110982	.004	.004
111682	.004	.014
111682	.004	.010
10583	.004	.012
10783	.004	.007
11183	.004	.004
12083	.006	.016
12183	.004	.004
12383	.004	.040
12483	.004	.004
12883	.004	.007
20283	.010	.016
20383	.007	.013
21283	.016	.022
21383	.005	.007
21383	.006	.007
21683	.004	.004
22783	.004	.081
22783	.004	.052
22783	.004	.020
22783	.004	.014
53183	.016	.026
53183	.028	.035
60183	.012	.017
60583	.004	.007
60783	.004	.013
60883	.004	.009
60983	.004	.007
63083	.004	.025
71183	.030	.054
80183	.004	.016
80983	.004	.010
81583	.005	.028
81783	.004	.004
82583	.004	.009
91983	.004	.014
92683	.004	.004
100483	.004	.004
101183	.004	.006
101883	.004	.011
102483	.004	.004
110383	.004	.007
121283	.004	.005
122283	.004	.040

MNDYYR	OPO4	TPO4
123083	.040	.040
11984	.009	.032
20384	.005	.032
21284	.004	.019
31384	.021	.035
32384	.006	.017
32384	.004	.004
40484	.006	.019
40984	.004	.012
41084	.004	.007
52384	.005	.010
52984	.004	.004
62584	.004	.020
62784	.023	.011
82384	.010	.027
83184	.014	.039
91884	.020	.057
91984	.020	.061
92084	.035	.157
92684	.205	.640
102684	.004	.046
102684	.004	.014
110584	.004	.004
112484	.004	.004
32185	.013	.042
41585	.004	.004
41585	.004	.004
50685	.006	.009
52385	.007	.027
61485	.171	.204
70185	.018	.015
72485	.004	.009
123185	.004	.010
10886	.018	.043
10886	.156	.171
10986	.004	.006
11086	.004	.004
11386	.004	.004
21886	.004	.017
31686	.004	.024
32886	.004	.009
33186	.004	.018
51586	.077	.200
52886	.017	.058

MNDYYR	OPO4	TPO4
60986	.011	.012
61686	.026	.076
62586	.010	.011
62886	.037	.043
70786	.016	.018
71586	.005	.013
72886	.005	.011
80486	.004	.018
81286	.004	.000
81886	.004	.009
90186	.008	.041
90886	.004	.011
101386	.004	.022
102086	.006	.013
102786	.004	.033
110386	.004	.012
111086	.004	.016
111786	.004	.011
112486	.005	.020
120186	.004	.035
120886	.004	.007
122986	.004	.022
20987	.004	.025
22387	.004	.042
30987	.008	.017
31687	.006	.009
40687	.011	.014
41387	.059	.074
60887	.201	.280
62687	.066	.099
71087	.036	.065
72487	.054	.050
80787	.005	.017
91187	.006	.092
92587	.004	.026
100287	.004	.004
110687	.004	.012
121187	.008	.018
21788	.009	.044
31888	.030	.028
32588	.008	.024
52088	.014	.114
53188	.008	.011
62388	.008	.007

FILE NAME: (STATION EEFS)

MNDYYR	OPO4	TPO4
111974	.013	.044
120974	.000	.000
121774	.071	.075
20775	.076	.083
22475	.000	.000
30575	.012	.015
32175	.000	.000
41675	.000	.000
51475	.000	.000
53175	.002	.009
63075	.003	.019
70775	.110	.000
71475	.042	.057
72175	.011	.017
80475	.005	.010
81875	.006	.012
82575	.000	.000
90875	.024	.033
91575	.029	.053
92275	.017	.029
92975	.017	.019
100675.	.107	.120
102075	.027	.037
110375	.029	.000
111075	.018	.000
111775	.005	.018
122275	.064	.000
30876	.025	.000
41976	.039	.064
51776	.022	.025
60176	.020	.023
62876	.019	.034
71276	.000	.000
80676	.068	.104
80976	.008	.011
82376	.000	.000
90776	.022	.024
100476	.014	.015
111576	.028	.038
122776	.009	.028
12477	.044	.072
51677	.082	.084
53177	.095	.100
61377	.016	.029
62777	.061	.065
71177	.119	.170
72577	.123	.130
80877	.015	.031
82277	.015	.014
90677	.207	.217
100377	.128	.234

MNDYYR	OPO4	TPO4
103177	.037	.038
120577	.002	.052
121977	.002	.005
11678	.009	.027
22778	.002	.015
31378	.008	.015
42478	.013	.018
60578	.004	.033
70578	.005	.009
71778	.000	.000
73178	.017	.028
81478	.006	.013
82878	.000	.000
91178	.009	.011
92578	.009	.017
102378	.002	.013
12379	.005	.080
20579	.002	.010
43079	.000	.000
51479	.006	.017
52979	.019	.028
61179	.044	.052
62579	.027	.114
70979	.019	.044
72479	.002	.023
90579	.002	.013
92179	.002	.022
121179	.011	.023
12280	.000	.000
20580	.103	.112
30480	.011	.024
31880	.002	.019
41780	.016	.016
43080	.002	.012
51380	.017	.032
52880	.013	.022
62580	.025	.036
70880	.019	.030
72480	.024	.028
82080	.032	.042
12781	.022	.159
21181	.024	.032
22481	.000	.000
60281	.061	.096
61781	.024	.077
63081	.050	.149
80781	.007	.019
81181	.011	.062
82681	.002	.008
91081	.009	.024
92381	.018	.027

MNDYYR	OPO4	TPO4
22682	.039	.063
40282	.008	.021
50482	.004	.014
60182	.004	.004
81982	.402	.453
92882	.000	.000
100182	.021	.039
12083	.006	.024
52583	.136	.155
60383	.004	.031
60983	.004	.034
62483	.005	.020
62783	.005	.017
70783	.007	.014
80283	.004	.017
80883	.004	.016
83083	.137	.224
101083	.288	.400
101483	.117	.150
101783	.078	.105
102583	.000	.000
22384	.065	.114
22984	.013	.027
32784	.172	.307
41684	.032	.125
60884	.077	.156
61884	.185	.267
71884	.004	.021
40885	.021	.029
41385	.011	.017
41685	.008	.010
50685	.053	.103
52885	.004	.024
61385	.020	.122
62785	.014	.025
70385	.004	.026
71985	.004	.012
72485	.004	.008
72985	.004	.000
80585	.000	.009
80685	.033	.008
81285	.004	.009
81585	.004	.004
90385	.013	.054
90985	.035	.264
91785	.004	.000
91985	.005	.007
92685	.004	.024
120585	.004	.018
11086	.004	.007
31686	.208	.240
61986	.023	.030

MNDYYR	OPO4	TPO4
62386	.004	.019
62686	.004	.015
63086	.007	.009
70886	.023	.024
72486	.009	.030
72886	.019	.048
80786	.004	.021
81486	.004	.016
81886	.009	.018
82186	.010	.018
90286	.057	.080
90486	.023	.052
90686	.004	.014
90986	.004	.019
100386	.085	.094
101586	.014	.021
103086	.010	.051
111486	.004	.039
120586	.004	.023
122986	.004	.011
10287	.004	.314
30987	.004	.009
32787	.130	.196
63087	.039	.085
112487	.008	.019
21788	.008	.038
31588	.014	.060
33088	.008	.039
52088	.037	.133
53188	.008	.010
62388	.009	.048
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

MNDYYR	OPO4	TPO4
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

MNDYYR	OPO4	TPO4
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

FILE NAME: S2 (STATION S2)

MNDYYR	OPO4	TPO4
102174	.002	.000
120974	.006	.034
30375	.002	.091
31775	.017	.048
32475	.091	.201
41475	.018	.040
51175	.015	.041
51875	.002	.005
60175	.014	.030
60875	.005	.010
63075	.051	.000
70775	.002	.009
71475	.002	.045
72175	.008	.014
72875	.019	.021
80475	.014	.021
81175	.031	.038
82575	.000	.000
90875	.054	.069
91575	.016	.019
92275	.002	.005
92975	.025	.038
100675	.006	.010
102075	.000	.000
102775	.005	.068
110375	.005	.008
121675	.098	.189
30876	.000	.000
30876	.000	.000
60176	.047	.071
62876	.022	.030
71276	.077	.099
80976	.039	.044
82376	.000	.000
90776	.028	.043
92076	.025	.027
111576	.057	.085
122776	.000	.000
12477	.051	.072
51677	.076	.171
61377	.102	.162
71177	.091	.109
80877	.065	.074
82277	.011	.016
90677	.014	.022
91977	.004	.022
100377	.002	.017
103177	.121	.157
112177	.022	.060
120577	.090	.106
121977	.049	.057
22778	.143	.168
31378	.056	.068
50878	.072	.075
52278	.000	.000
61978	.054	.074
70578	.105	.125
73178	.057	.066
81478	.053	.063
82878	.037	.045
91178	.045	.052
92578	.020	.038
102378	.021	.040
112078	.197	.245
20579	.031	.046
51579	.002	.094
62579	.120	.244
71079	.059	.083
72479	.067	.093
80779	.109	.161
82079	.026	.056
90579	.004	.008
91979	.007	.008
100179	.006	.015
101579	.017	.042
111579	.012	.024
121279	.042	.059
20580	.028	.030
22080	.086	.107
30480	.039	.054
41780	.033	.044
52880	.031	.032
62580	.064	.091
70880	.080	.132
72480	.062	.082
82080	.051	.067
100180	.022	.068
120280	.084	.225
12781	.105	.202
21081	.002	.071
22481	.000	.000
32481	.090	.136
60281	.042	.084
61781	.030	.058
63081	.046	.063
72881	.044	.073
81181	.114	.183
82681	.003	.014
90981	.016	.039
92381	.022	.032

MNDYYR	OPO4	TPO4
110481	.000	.000
120181	.040	.073
20282	.148	.271
21882	.103	.129
22682	.032	.062
30982	.042	.044
33182	.030	.052
41982	.041	.072
52582	.000	.157
52882	.008	.020
60182	.004	.009
60782	.004	.005
62282	.011	.022
63082	.018	.030
72782	.051	.074
80282	.004	.010
80982	.012	.033
81282	.004	.017
81982	.005	.012
82482	.085	.000
90982	.000	.067
100582	.004	.012
101382	.007	.008
112282	.065	.074
122182	.311	.393
10583	.073	.113
20183	.022	.046
30283	.038	.055
31583	.132	.185
41483	.158	.234
80283	.083	.121
81683	.111	.145
83083	.031	.057
91283	.019	.031
92783	.019	.037
102483	.013	.029
122083	.139	.183
31384	.187	.270
32784	.074	.140
40984	.045	.076
42584	.012	.025
60484	.016	.040
71084	.031	.110
91084	.024	.054
101884	.041	.096
120584	.059	.076
12985	.071	.070
32685	.181	.254
40985	.005	.127
50685	.004	.050
61885	.039	.057
70285	.015	.053

MNDYYR	OPO4	TPO4
73085	.000	.071
82785	.078	.104
90985	.004	.018
92485	.004	.010
100885	.013	.016
123085	.064	.101
11486	.112	.147
12886	.017	.041
22586	.087	.116
31186	.041	.069
52286	.033	.067
61786	.033	.071
70186	.012	.019
73086	.024	.042
82686	.053	.089
90986	.004	.026
92386	.004	.009
100786	.004	.024
102186	.021	.038
110486	.024	.033
121886	.087	.174
10787	.034	.052
20387	.064	.115
21887	.054	.104
31787	.044	.062
33187	.092	.121
33187	.092	.121
61087	.101	.130
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

MNDYYR	OPO4	TPO4
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

MNDYYR	OPO4	TPO4
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

FILE NAME :S1 (STATION S-131)

MNDYYR	OPO4	TPO4
102474	.031	.028
120274	.018	.098
21775	.065	.060
33175	.007	.005
42875	.006	.018
51275	.076	.089
51975	.000	.000
53075	.002	.005
62475	.004	.028
63075	.017	.038
70775	.010	.000
71475	.007	.014
72175	.014	.023
72875	.000	.000
80475	.010	.017
81175	.000	.000
81875	.000	.000
90175	.050	.059
91575	.058	.067
92275	.007	.010
92975	.017	.024
100675	.025	.033
110375	.068	.075
122975	.045	.000
30876	.000	.000
41976	.023	.029
61476	.036	.032
62876	.018	.026
71276	.036	.058
80976	.058	.076
82376	.005	.010
100476	.007	.016
101876	.017	.020
111576	.145	.145
12477	.011	.027
40477	.046	.061
61377	.082	.116
62777	.013	.034
80877	.000	.000
82277	.028	.038
90677	.184	.204
100377	.012	.023
120577	.002	.014
121977	.000	.000
11678	.026	.030
22778	.064	.070
31378	.009	.016
42478	.033	.050
50878	.002	.017
60578	.048	.077
61978	.031	.038

MNDYYR	OPO4	TPO4
70578	.094	.091
71778	.048	.064
73178	.031	.033
81478	.026	.036
82878	.045	.054
91178	.064	.075
92578	.021	.023
102378	.024	.044
112078	.029	.038
120478	.036	.065
12379	.012	.025
20579	.011	.018
31979	.030	.047
43079	.093	.109
50379	.000	.000
51479	.041	.054
52979	.040	.061
72479	.040	.089
82079	.007	.024
90579	.014	.028
91879	.007	.007
100179	.004	.012
101579	.092	.000
111579	.021	.037
121279	.014	.031
12380	.002	.017
20580	.007	.009
22080	.029	.045
30480	.028	.034
41780	.005	.013
43080	.004	.017
52880	.017	.020
62580	.009	.015
70880	.005	.020
72480	.015	.035
100180	.027	.040
101480	.000	.000
111280	.000	.000
120280	.075	.074
12781	.061	.101
21081	.036	.062
22481	.000	.000
32481	.000	.000
60281	.000	.000
61781	.031	.043
63081	.037	.047
71681	.078	.134
72881	.000	.000
82681	.007	.020
91081	.006	.009
92381	.058	.077

MNDYYR	OPO4	TPO4
22682	.073	.058
30982	.020	.040
41982	.167	.263
60182	.048	.065
61482	.024	.038
70182	.050	.088
71282	.053	.075
72782	.116	.161
80982	.012	.024
82582	.108	.127
90982	.004	.009
92182	.089	.150
100582	.136	.161
110182	.422	.513
122182	.941	.951
10483	.361	.364
21783	.027	.042
30283	.141	.145
32983	.174	.201
62183	.441	.622
71983	.149	.181
81683	.092	.112
91283	.117	.134
102483	.008	.019
110883	.135	.158
32784	.038	.047
40984	.034	.064
60484	.019	.050
71084	.025	.104
82984	.039	.066
101884	.380	.714
120584	.029	.043
40985	.104	.140
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

MNDYYR	OPO4	TPO4
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000
888888	.123	9.000

FILE NAME: PAGM

```
*** PROGRAM TO COMPUTE ARITHEMETIC AND GEOMETRIC TP CONC. FOR LOK
          PROGRAM PAPC(B5,OK,S1,S2,RR,RR2,TAPE1 = B5,TAPE2 = OK,TAPE3 = S1,
          $ TAPE4 = S2,TAPE5 = RR,TAPE6 = RR2)
C         FIND AVERAGE TP CONCENTRATION
          DIMENSION AM(4),GM(4),UL(4),JN(4),GG(300),HH(300),MMM(300),
          $ IYY(300)
C         UL - UPPER LIMIT OF CONCENTRATION, ABOVE WHICH BIRD DROPPINGS
C         MAYBE DETECTED IN THE SAMPLE
          UL(1) = .114
          UL(2) = .196
          UL(3) = .161
          UL(4) = .202
          MONTH = 10
          IYEAR = 74
   50     DO 8 J = 1,4
          AM(J) = 0.
          GM(J) = 1.
    8     JN(J) = 0
          DO 20 ITP = 1,4
   10     READ(ITP,15) MN,ND,IY, CC
          IF(MN .EQ. 99) GO TO 100
   15     FORMAT(3I2,6X,F6.3)
          IF(IY .GT. IYEAR) THEN
                BACKSPACE ITP
                GO TO 20
          ENDIF
          IF(MN .GT. MONTH) THEN
                BACKSPACE ITP
                GO TO 20
          ENDIF
          IF(CC .GT. UL(ITP) ) GO TO 10
          IF(CC .LT. 0.0001) GO TO 10
          JN(ITP) = JN(ITP) + 1
          FK = JN(ITP)
          AM(ITP) = (AM(ITP)*(FK-1) + CC)/FK
          IF(FK .LE. 1.) THEN
                GM(ITP) = CC
                GO TO 10
          ENDIF
          GM(ITP) = ( (GM(ITP)**(FK-1.) )*CC )**(1/FK)
          GO TO 10
   20     CONTINUE
          ARM = 0.
          GOM = 1.
          STN = 0.
          GSTN = 0.
          DO 30 I = 1,4
          IF(JN(I) .LE. 0) GO TO 30
          ARM = ARM + AM(I)
          IF(GM(I) .LE. 0.0001) GO TO 30
          GSTN = GSTN + 1.
          GOM = GOM*GM(I)
```

```
          STN = STN + 1
   30     CONTINUE
          IF(STN .LE. 0) GO TO 40
          ARM = ARM/STN
          GOM = GOM**(1./GSTN)
   40     WRITE(5,42) MONTH,IYEAR, ARM, GOM, (AM(I),I = 1,4),(GM(J),J = 1,4)
          WRITE(*,42) MONTH,IYEAR, ARM, GOM
   42     FORMAT(2I4,2F8.3, 4F5.3,2X,4F5.3)
          MONTH = MONTH + 1
          IF(MONTH .GE. 13) THEN
                MONTH = 1
                IYEAR = IYEAR + 1
          ENDIF
          GO TO 50
CFILL-IN MISSING MONTH
  100     REWIND 5
          DO 120 J = 1,300
  120     READ(5,42,END = 125) MMM(J),IYY(J),GG(J),HH(J)
  125     JJ = J-1
          DO 150 J = 1,JJ
          IF(GG(J) .GT. 0.0001) GO TO 150
          AB = GG(J-1)
          GB = HH(J-1)
          DO 140 K = J + 1,JJ
          IF(GG(K) .LT. 0.0001) GO TO 140
          AF = GG(K)
          GF = HH(K)
  140     CONTINUE
          GG(J) = (AB + AF)/2.
          HH(J) = SQRT(GB*GF)
  150     CONTINUE
          DO 160 J = 1,JJ
          WRITE(6,42) MMM(J),IYY(J), GG(J), HH(J)
  160     CONTINUE
  300     STOP
          END
```

*** DATA FILE NAME: MRTPC (LOK MONTHLY RAINFALL TP CONC).
*** ARMITH. MEAN GEO. MEAN

Month	Year	Arithmetic Mean	Geometric Mean
10	74	.028	.028
11	74	.044	.044
12	74	.085	.058
1	75	.076	.046
2	75	.102	.060
3	75	.063	.022
4	75	.029	.027
5	75	.059	.014
6	75	.033	.025
7	75	.056	.019
8	75	.033	.023
9	75	.035	.028
10	75	.069	.047
11	75	.045	.024
12	75	.189	.189
1	76	.128	.082
2	76	.098	.054
3	76	.082	.044
4	76	.047	.043
5	76	.025	.025
6	76	.036	.033
7	76	.079	.076
8	76	.103	.028
9	76	.030	.029
10	76	.017	.016
11	76	.089	.078
12	76	.028	.028
1	77	.057	.052
2	77	.062	.043
3	77	.065	.039
4	77	.061	.061
5	77	.132	.125
6	77	.095	.076
7	77	.130	.127
8	77	.043	.027
9	77	.022	.022
10	77	.049	.036
11	77	.060	.060
12	77	.059	.035
1	78	.029	.028
2	78	.084	.056
3	78	.033	.025

Month	Year	Arithmetic Mean	Geometric Mean
4	78	.034	.030
5	78	.055	.017
6	78	.055	.051
7	78	.085	.072
8	78	.053	.048
9	78	.036	.029
10	78	.032	.028
11	78	.038	.038
12	78	.065	.065
1	79	.053	.045
2	79	.025	.020
3	79	.047	.047
4	79	.069	.053
5	79	.059	.036
6	79	.051	.039
7	79	.070	.063
8	79	.066	.048
9	79	.014	.012
10	79	.035	.025
11	79	.031	.030
12	79	.038	.035
1	80	.017	.017
2	80	.069	.050
3	80	.037	.034
4	80	.024	.021
5	80	.026	.026
6	80	.037	.022
7	80	.049	.040
8	80	.055	.053
9	80	.061	.044
10	80	.088	.068
11	80	.078	.049
12	80	.074	.074
1	81	.154	.148
2	81	.083	.141
3	81	.136	.136
4	81	.102	.070
5	81	.005	.005
6	81	.103	.083
7	81	.140	.073
8	81	.049	.028
9	81	.035	.029

Month	Year	Arithmetic Mean	Geometric Mean
10	81	.010	.008
11	81	.003	.002
12	81	.040	.023
1	82	.080	.080
2	82	.075	.069
3	82	.033	.027
4	82	.047	.039
5	82	.040	.020
6	82	.022	.013
7	82	.091	.087
8	82	.097	.055
9	82	.054	.030
10	82	.056	.030
11	82	.041	.022
12	82	.054	.028
1	83	.050	.028
2	83	.037	.031
3	83	.133	.121
4	83	.100	.066
5	83	.093	.068
6	83	.019	.017
7	83	.034	.027
8	83	.062	.038
9	83	.059	.032
10	83	.046	.015
11	83	.083	.033
12	83	.106	.060
1	84	.032	.032
2	84	.048	.037
3	84	.069	.044
4	84	.063	.045
5	84	.007	.006
6	84	.065	.046
7	84	.078	.062
8	84	.050	.046
9	84	.057	.056
10	84	.063	.049
11	84	.004	.004
12	84	.060	.057
1	85	.070	.070

Month	Year	Arithmetic Mean	Geometric Mean
2	85	.069	.050
3	85	.042	.042
4	85	.072	.033
5	85	.044	.034
6	85	.065	.056
7	85	.043	.027
8	85	.056	.027
9	85	.035	.013
10	85	.016	.016
11	85	.042	.024
12	85	.043	.026
1	86	.038	.016
2	86	.067	.044
3	86	.043	.033
4	86	.055	.034
5	86	.063	.062
6	86	.042	.031
7	86	.026	.023
8	86	.058	.040
9	86	.028	.022
10	86	.036	.031
11	86	.029	.026
12	86	.071	.036
1	87	.052	.052
2	87	.072	.060
3	87	.072	.037
4	87	.044	.032
5	87	.056	.034
6	87	.105	.103
7	87	.058	.057
8	87	.017	.017
9	87	.059	.049
10	87	.004	.004
11	87	.016	.015
12	87	.018	.018
1	88	.043	.025
2	88	.041	.041
3	88	.038	.035
4	88	.053	.035
5	88	.067	.036

```
FILE NAMEL: LPLOAD
*** PROGRAN RPLOAD - COMPUTE MONTHLY TP LOAD TO LOK IN G*10**6
   PROGRAM RPLOAD(LOKMRF,MRTPC,LOAD,TAPE1 = LOKMRF,TAPE2 = MRTPC,
      $ TAPE3 = LOAD)
C          COMPUTE MONTHLY TP LOAD TO LOK IN G*10**6
C          AREA OF LOK  =  500,000 ACRES
           AREA = .5*43560.*(12.*2.54)**2
C          SINCE RAINFALL IN INCHES; CONC. IN MG/L
           CONST = AREA*2.54/(1000.*1000.)
           SAL = 0.
           SGL = 0.
   10      READ(1,15,END = 100) M1,IY1, RF
   15      FORMAT(I2,2X,I2,F6.2)
           READ(2,17) M2,IY2,AM,GM
   17      FORMAT(2I4,2F8.3)
           IF(M1 .NE. M2  .OR. IY1 .NE. IY2) GO TO 100
           AL = CONST*RF*AM
           SAL = SAL + AL
           GL = CONST*RF*GM
           SGL = SGL + GL
           WRITE(3,19) M1,IY1,AL,GL,SAL,SGL
   19      FORMAT(2I4,4F10.2)
           WRITE(*,19) M1,IY1,AL,GL
             IF(M1 .EQ. 9) THEN
                SAL = 0.
                SGL = 0.
           ENDIF
           GO TO 10
  100      STOP
           END
```

FILE NAME: LOKMRF

MONTH	YEAR	6 STATION MEAN RAINFALL (INCHES)
10	74	1.02
11	74	1.47
12	74	1.04
1	75	.34
2	75	2.01
3	75	.95
4	75	1.11
5	75	6.31
6	75	4.89
7	75	7.71
8	75	3.35
9	75	7.06
10	75	2.85
11	75	.44
12	75	.32
1	76	.30
2	76	1.77
3	76	.34
4	76	1.18
5	76	6.73
6	76	5.13
7	76	4.82
8	76	6.77
9	76	3.77
10	76	1.09
11	76	2.28
12	76	1.48
1	77	3.33
2	77	.85
3	77	.99
4	77	.55
5	77	4.50
6	77	3.94
7	77	4.33
8	77	6.52
9	77	6.92
10	77	1.60
11	77	5.96
12	77	4.23
1	78	1.97
2	78	1.18
3	78	2.37
4	78	1.55
5	78	5.13
6	78	6.55
7	78	6.64
8	78	5.46
9	78	5.19
10	78	2.74
11	78	2.34

MONTH	YEAR	6 STATION MEAN RAINFALL (INCHES)
12	78	3.51
1	79	4.79
2	79	.17
3	79	1.98
4	79	1.80
5	79	5.23
6	79	1.70
7	79	3.10
8	79	5.44
9	79	12.72
10	79	1.55
11	79	2.40
12	79	1.65
1	80	3.28
2	80	1.31
3	80	.61
4	80	4.05
5	80	3.81
6	80	3.20
7	80	4.72
8	80	5.97
9	80	5.06
10	80	1.13
11	80	2.04
12	80	.63
1	81	.78
2	81	1.52
3	81	1.14
4	81	.19
5	81	2.67
6	81	3.16
7	81	3.94
8	81	9.34
9	81	3.71
10	81	.62
11	81	1.15
12	81	.10
1	82	.48
2	82	1.74
3	82	6.63
4	82	1.81
5	82	6.71
6	82	7.01
7	82	5.50
8	82	5.72
9	82	5.89
10	82	2.28
11	82	1.15
12	82	.68
1	83	3.78

MONTH	YEAR	6 STATION MEAN RAINFALL (INCHES)
2	83	8.87
3	83	4.32
4	83	1.71
5	83	2.05
6	83	6.81
7	83	5.27
8	83	4.74
9	83	3.72
10	83	6.68
11	83	1.22
12	83	2.72
1	84	.34
2	84	3.28
3	84	4.49
4	84	2.75
5	84	6.27
6	84	4.75
7	84	8.38
8	84	3.41
9	84	5.18
10	84	.43
11	84	3.23
12	84	.27
1	85	.53
2	85	.22
3	85	2.23
4	85	3.64
5	85	1.99
6	85	5.15
7	85	5.57
8	85	3.83
9	85	6.46

MONTH	YEAR	6 STATION MEAN RAINFALL (INCHES)
10	85	3.16
11	85	.82
12	85	2.55
1	86	2.10
2	86	1.50
3	86	3.70
4	86	.19
5	86	2.04
6	86	9.69
7	86	6.38
8	86	6.01
9	86	5.19
10	86	3.58
11	86	1.27
12	86	4.11
1	87	1.12
2	87	1.24
3	87	4.58
4	87	.18
5	87	2.16
6	87	4.69
7	87	4.55
8	87	1.90
9	87	5.33
10	87	4.78
11	87	6.10
12	87	.41
1	88	1.79
2	88	2.40
3	88	2.77
4	88	1.13
5	88	2.85

FILE NAME: LOAD
*** OUTPUT
*** PLOAD TO LOK IN G*10**6
*** ESTIMATES FOR 10-1972 TO 9-1973: ARITHMETIC: 69.79; GEOMETRIC: 38.64
10-1973 TO 9-1974: 107.04 58.12

MM	YR	ARITH	GEOM	12 MON SUM AR.	GEOM
10	74	1.47	1.47	1.47	1.47
11	74	3.32	3.32	4.79	4.79
12	74	4.54	3.10	9.34	7.89
1	75	1.33	.80	10.66	8.70
2	75	10.54	6.20	21.20	14.89
3	75	3.08	1.07	24.28	15.97
4	75	1.65	1.54	25.93	17.51
5	75	19.13	4.54	45.06	22.05
6	75	8.29	6.28	53.36	28.33
7	75	22.19	7.53	75.55	35.86
8	75	5.68	3.96	81.23	39.82
9	75	12.70	10.16	93.93	49.98
10	75	10.11	6.88	10.11	6.88
11	75	1.02	.54	11.12	7.43
12	75	3.11	3.11	14.23	10.54
1	76	1.97	1.26	16.21	11.80
2	76	8.91	4.91	25.12	16.71
3	76	1.43	.77	26.55	17.48
4	76	2.85	2.61	29.40	20.09
5	76	8.65	8.65	38.05	28.74
6	76	9.49	8.70	47.54	37.44
7	76	19.57	18.83	67.11	56.26
8	76	35.84	9.74	102.95	66.01
9	76	5.81	5.62	108.76	71.63
10	76	.95	.90	.95	.90
11	76	10.43	9.14	11.38	10.04
12	76	2.13	2.13	13.51	12.17
1	77	9.76	8.90	23.27	21.07
2	77	2.71	1.88	25.98	22.94
3	77	3.31	1.98	29.28	24.93
4	77	1.72	1.72	31.01	26.65
5	77	30.53	28.91	61.54	55.56
6	77	19.24	15.39	80.77	70.95
7	77	28.93	28.26	109.70	99.22
8	77	'14.41	9.05	124.11	108.26
9	77	7.82	7.82	131.94	116.09
10	77	4.03	2.96	4.03	2.96
11	77	18.38	18.38	22.41	21.34
12	77	12.83	7.61	35.23	28.95
1	78	2.94	2.83	38.17	31.78
2	78	5.09	3.40	43.27	35.18
3	78	4.02	3.05	47.29	38.22
4	78	2.71	2.39	49.99	40.61
5	78	14.50	4.48	64.49	45.10
6	78	18.52	17.17	83.01	62.27
7	78	29.01	24.57	112.02	86.84
8	78	14.87	13.47	126.89	100.31
9	78	9.60	7.74	136.49	108.04

MM	YR	ARITH	GEOM	12 MON SUM AR.	GEOM
10	78	4.51	3.94	4.51	3.94
11	78	4.57	4.57	9.08	8.51
12	78	11.73	11.73	20.80	20.24
1	79	13.05	11.08	33.85	31.32
2	79	.22	.17	34.07	31.49
3	79	4.78	4.78	38.85	36.27
4	79	6.38	4.90	45.23	41.18
5	79	15.86	9.68	61.09	50.85
6	79	4.46	3.41	65.55	54.26
7	79	11.15	10.04	76.70	64.30
8	79	18.45	13.42	95.15	77.72
9	79	9.15	7.84	104.31	85.56
10	79	2.79	1.99	2.79	1.99
11	79	3.82	3.70	6.61	5.69
12	79	3.22	2.97	9.83	8.66
1	80	2.87	2.87	12.70	11.53
2	80	4.65	3.37	17.35	14.89
3	80	1.16	1.07	18.51	15.96
4	80	5.00	4.37	23.50	20.33
5	80	5.09	5.09	28.59	25.42
6	80	6.09	3.62	34.68	29.04
7	80	11.89	9.70	46.56	38.74
8	80	16.88	16.26	63.44	55.00
9	80	15.86	11.44	79.30	66.45
10	80	5.11	3.95	5.11	3.95
11	80	8.18	5.14	13.29	9.09
12	80	2.40	2.40	15.68	11.48
1	81	6.17	5.93	21.86	17.42
2	81	6.48	11.01	28.34	28.43
3	81	7.97	7.97	36.31	36.40
4	81	1.00	.68	37.31	37.08
5	81	.69	.69	37.99	37.77
6	81	16.73	13.48	54.72	51.25
7	81	28.35	14.78	83.07	66.03
8	81	23.52	13.44	106.59	79.47
9	81	6.67	5.53	113.27	85.00
10	81	.32	.25	.32	.25
11	81	.18	.12	.50	.37
12	81	.21	.12	.70	.49
1	82	1.97	1.97	2.68	2.46
2	82	6.71	6.17	9.38	8.64
3	82	11.24	9.20	20.63	17.84
4	82	4.37	3.63	25.00	21.46
5	82	13.79	6.90	38.79	28.36
6	82	7.93	4.68	46.72	33.04
7	82	25.72	24.59	72.44	57.64
8	82	28.52	16.17	100.96	73.81
9	82	16.35	9.08	117.31	82.89
10	82	6.56	3.52	6.56	3.52
11	82	2.42	1.30	8.99	4.82
12	82	1.89	.98	10.87	5.79
1	83	9.71	5.44	20.59	11.23
2	83	16.87	14.13	37.45	25.37
3	83	29.53	26.87	66.98	52.23

MM	YR	ARITH	GEOM	12 MON SUM AR.	GEOM
4	83	8.79	5.80	75.77	58.03
5	83	9.80	7.16	85.57	65.20
6	83	6.65	5.95	92.22	71.15
7	83	9.21	7.31	101.43	78.46
8	83	15.10	9.26	116.53	87.72
9	83	11.28	6.12	127.81	93.83
10	83	15.79	5.15	15.79	5.15
11	83	5.20	2.07	21.00	7.22
12	83	14.82	8.39	35.82	15.61
1	84	.56	.56	36.37	16.17
2	84	8.09	6.24	44.47	22.40
3	84	15.92	10.15	60.39	32.56
4	84	8.90	6.36	69.29	38.92
5	84	2.26	1.93	71.55	40.85
6	84	15.87	11.23	87.42	52.08
7	84	33.59	26.70	121.01	78.78
8	84	8.76	8.06	129.77	86.84
9	84	15.17	14.91	144.95	101.75
10	84	1.39	1.08	1.39	1.08
11	84	.66	.66	2.06	1.75
12	84	.83	.79	2.89	2.54
1	85	1.91	1.91	4.80	4.44
2	85	.78	.57	5.58	5.01
3	85	4.81	4.81	10.39	9.82
4	85	13.47	6.17	23.86	16.00
5	85	4.50	3.48	28.36	19.47
6	85	17.20	14.82	45.56	34.30
7	85	12.31	7.73	57.87	42.03
8	85	11.02	5.31	68.90	47.34
9	85	11.62	4.32	80.52	51.66
10	85	2.60	2.60	2.60	2.60
11	85	1.77	1.01	4.37	3.61
12	85	5.64	3.41	10.00	7.02
1	86	4.10	1.73	14.11	8.74
2	86	5.17	3.39	19.27	12.14
3	86	8.18	6.28	27.45	18.41
4	86	.54	.33	27.98	18.74
5	86	6.61	6.50	34.59	25.24
6	86	20.92	15.44	55.51	40.68
7	86	8.53	7.54	64.03	48.22
8	86	17.92	12.36	81.95	60.58
9	86	7.47	5.87	89.42	66.45
10	86	6.62	5.70	6.62	5.70
11	86	1.89	1.70	8.52	7.40
12	86	15.00	7.60	23.51	15.01
1	87	2.99	2.99	26.51	18.00
2	87	4.59	3.82	31.10	21.82
3	87	16.95	8.71	48.04	30.53
4	87	.41	.30	48.45	30.83
5	87	6.22	3.77	54.67	34.60
6	87	25.31	24.83	79.98	59.43
7	87	13.56	13.33	93.54	72.76
8	87	1.66	1.66	95.20	74.42
9	87	16.16	13.42	111.36	87.84

MM	YR	ARITH	GEOM	12 MON SUM AR.	GEOM
10	87	.98	.98	.98	.98
11	87	5.02	4.70	6.00	5.69
12	87	.38	.38	6.38	6.06
1	88	4.62	2.69	11.00	8.75
2	88	4.99	4.99	15.99	13.74
3	88	6.17	5.68	22.16	19.43
4	88	2.61	1.73	24.78	21.16
5	88	16.80	9.03	41.58	30.18

FILE NAME: YAVE

```
*** PROGRAM YAVE - TO COMPUTE AVERAGE YEARLY PHOSPHATE LOADING
      PROGRAM YAVE(LOAD,LPYA, TAPE1 = LOAD, TAPE2 = LPYA)
C           COMPUTE YEARLY LAKE OKE PHOSPHEROUS LOADING
            DIMENSION AM(15),GM(15)
C
            K = 1
      20    DO 30 I = 1,11
      30    READ(1,35,END = 50) CC
      35    FORMAT(28X,2F10.2)
            READ(1,35) AM(K),GM(K)
            WRITE(*,35) AM(K),GM(K)
            K = K + 1
            GO TO 20
C
      50    KT = K-1
            SAM = 0.
            SGM = 0.
            DO 60 K = 1,KT
            SAM = SAM + AM(K)
      60    SGM = SGM + GM(K)
C           RAINFALL IN THE LAKE IS THOUGHT TO BE LESS THAN AROUND THE LAKE
C           AND LAKE ITSELF DOES NOT GENERATE P INTO THE AIR, A CORRECTION
C           FACTOR OF 0.8 IS APPLIED
C           ALSO CONVERT METRIC TONNES TO ENGLISH TONS
            SAM = SAM/FLOAT(KT)*0.8*1.1
            SGM = SGM/FLOAT(KT)*0.8*1.1
            WRITE(*,65) SGM
            WRITE(2,65) SGM
            WRITE(*,66) SAM
            WRITE(2,66) SAM
      65    FORMAT(' YEARLY MEAN, GEOMETRIC = ', F8.2)
      66    FORMAT(' YEARLY MEAN, ARITHMETIC = ', F8.2)
            STOP
            END
```

24. S-65

During the 168-month period from June 73 to September 87 there are two months in which there is not a proximate measurement of phosphorus concentration (Flag = 'C') for loading calculations (Table 13).

Loads at S-65 for periods of missing flow or phosphorus data were estimated as follows:

a. For months with measured flow, but no proximate phosphorus measurement (Flag = 'C'), the flow-weighted phosphorus concentration was estimated as:

   TP(mg/L) = .04110

   This conversion factor was derived by regression of actual flow-weighted TP on actual daily mean cfs (monthly scale) for the period of record (df = 1/128, r = 0.05, P = 0.57, Standard Error of conversion factor = 0.0024).

   TP loads for this situation (Flag = 'C') were calculated by multiplying the estimate of flow-weighted concentration by the monthly flow to yield an estimated monthly load. When this procedure is applied to the period of record for which FLOW AND CHEMISTRY are actually measured, the estimated loads prove to be a good approximation to the calculated loads (average estimate = 95 percent of calculated load, correlation between estimated and calculated load = 0.92).

b. For months in which phosphorus data were available but flow data were estimated (Flag = 'Q'), the measured TP concentration was converted to a flow-weighted concentration and then multiplied by the estimated flow for the month. The conversion to flow-weighted concentration was based on the regression relationship:

   TP (flow-wt mg/L) = 0.001994 + 0.95319*TP (grab sample mg/L)

   This relationship was based on regression of flow-weighted TP on grab-sample TP for the S-65 period of record for which both flow and TP were actually measured (df = 1,128, r = 0.98, P = 0.00001, Standard Errors: Intercept = 0.000799, slope = 0.01695).

   The estimate of annual average TP load for S-65 over the 14-year period of record is not sensitive to the inclusion of estimated flow and phosphorus data. Using only actual data (Flags = blank or 'E'), the annual average load (WY 74-87) for S-65 is 29.3 metric tonnes (32.3 tons), if estimated data are included, the annual average load is 30.0 metric tonnes (33.0 tons/yr, vs 33.1 reported in the SWIM plan). The difference between measured and measured-plus-estimated load is about 2 percent the average annual load from this structure and less than 0.1 percent of the total uncontrollable load to the lake.

25. S-68

The flow record for S-68 is complete for the October 1972 - September 1987 period (annual average = 153,541 ac/ft). There were no measurements of total phosphorus at S-68 for the period October 1, 1973 to September 30, 1987 and loads for this site were calculated using a constant value for total phosphorus of 0.030 mg/L (6.25 tons/year) This value for total phosphorus was based on the average of 12 monthly samples collected by District from February 1988 to February 1989.

The load from S-68 is considered uncontrollable, and must be subtracted from the measured loads entering the lake at downstream structures. The flow from S-68 divides into three branches enroute to the lake, and the total flow and load from S-68 must be partitioned among these three branches.

This partitioning was accomplished as follows (method recommended by Water Resources Division):

a. The total flow from S-68 is first partitioned between S-82 and S-83. Average daily flows for the period of record at these two structures are about equal (S-82 = 110 cfs, S-83 = 122 cfs) and so half of the S-68 discharge is allocated to each branch.

b. There are no additional branches below S-83, and S-84 is allocated half (0.50) of the S-68 discharge and load.

c. The remaining half of the S-68 discharge and load is partitioned between S-71 and S-72 based on the relative daily mean flows at S-70 and S-75 for the period of record (S-70 = 130 cfs, S-75 = 44 cfs). S-71 is allocated 3/8 (.375) of the total S-68 discharge and load, and S-72 is allocated the remaining 1/8th (.125).

d. These allocations of the S-68 discharge and load are then subtracted from the total discharge and loads measured and calculated for S-71, S-72, and S-84.

Total Discharge and Load (Uncorrected for S-68) Annual Average for 73-87 Water Years

	Ac/Ft	TP (Tonns/yr)	TP Flow Weighted Concentration
S-71	149,874	50.0	0.246
S-72	26,164	8.0	0.225
S-84	109,762	11.1	0.074

S-68 Discharge and Load Allocations Annual Average for 73-87 Water Years

	Ac/Ft	TP (Tonns/yr)	TP Flow Weighted Concentration
S-71	57,578	2.3	N/A
S-72	19,193	.8	N/A
S-84	76,770	3.1	N/A

Discharge and Load (Corrected for S-68) Annual Average for 73-87 Water Years

	Ac/Ft	TP (Tonns/yr)	TP Flow Weighted Concentration
S-71	92,296	47.7	0.380
S-72	6,971	7.2	0.760
S-84	32,992	8.0	0.178

26. HGS5 Inflow Loading Calculations

The data for HGS5 inflow are complete except for a gap from January to September 1974. During this period, the lake was above elevation 11.5 except for a two-month period from May 8 to June 25. At lake stages above 11.5, water cannot be discharged into the lake through HGS5, and the loading calculations assume that during the dry period between May 8 and June 25, inflows through HGS5 were negligible.

Although there are gaps in the phosphorus data, none of these occur during periods of HGS5 flow into the lake, and thus NO phosphorus concentrations were estimated for this site.

27. S-77 Inflow Loading Calculations

The flow records for S-77 are complete for the period October 1973 to September 1987. There are no periods of S-77 inflow to Lake Okeechobee that are not represented by actual phosphorus concentration measurements. No estimates were used in the calculation of S-77 inflow loadings to the lake.

28. Culvert 10A

Culvert 10A (L-8 Canal) is a minor controllable inflow to Lake Okeechobee, and flow at this structure has been monitored by the USGS since 1976. The flow record is fragmented (Table 2) with two major gaps in 1985 and 1986. Total phosphorus measurements have been made at Culvert 10A since 1982, but routine (bi-weekly) samples have only been taken since April 1987.

Because of the limited data available for this minor inflow, the annual average phosphorus load was calculated from averaged flow and concentration data. Annual average inflow to the lake at Culvert 10A for the period 10/01/76 through 09/30/87 was calculated (35.05 cfs/day x 365 days/yr x 1.9836 ac-ft/cfs-day = 25,377 ac-ft/yr) and then multiplied by the average inflow concentration of total phosphorus (discharge codes 1 and 2, 0.096 mg/L) for the period May 4, 1982 through October 11, 1988. The result is an uncontrollable inflow load of 3.4 tons/yr. (4.6 tons/yr was estimated in the SWIM plan).

E. ASSIMILATIVE COEFFICIENT CALCULATED

1. Discussion

The ability of wetland systems to absorb and retain phosphorus is critical to the management of the basins contributing to Lake Okeechobee. Wetland systems; depressions, marshes, and swamps (herein referred to as **wetlands**) and ditches, channels, and ditched wetlands (herein referred to as **channels**) compose the flowpaths through which phosphorus is transported to the lake. The assimilative capacity of wetlands for phosphorus refers to the ability of the components of the wetland system to remove and retain phosphorus from the water column. Although wetland systems have been reported to assimilate a large mass of P for short periods and then later release some phosphorus, this analysis describes the net, long-term assimilative capacity. The long-term assimilation is an average behavior that will vary year-to-year. There were two basic approaches evaluated in calculating an assimilative coefficient: a basin-wide average assimilation and a site-specific assimilation. The basin-wide average approach was employed in the SWIM plan because the site-specific approach would of introduced inequities among the same industry within the same basin. The basin-wide average approach relies upon the relatively poorer quality of water being discharged close to the lake being diluted over the course of a year by the good quality of water coming from the upstream areas.

Estimates of phosphorus assimilation rates have been calculated for basins draining mineral soils, but insufficient scientific data are available for estimating phosphorus assimilation in canals and wetlands draining muck soils, generally found south of the lake. If and when sufficient, scientifically-reliable data become available for estimating phosphorus assimilation in canals and wetlands draining muck soils, an assimilation coefficient will be developed and incorporated into future revisions of the SWIM plan.

2. Methodology

The calculation of the assimilative capacity for specific sites is a two-fold process. First the assimilative nature of the wetland systems must be evaluated. In terms of total phosphorus in solution this means the calculation of an assimilation coefficient "a" for depressional wetlands and channels. The next step is to determine the length of flow path from the selected site to the Lake or other receiving body. The flow path is partitioned into wetland length and channel length. The assimilation coefficient "A" is calculated for each type and summed.

The ability of wetland systems to assimilate phosphorus differs due to variations in the biological, chemical, and physical character of each wetland. In this analysis wetland systems have been split into two main categories depressional wetlands and channels. The depressional wetlands are recognized primarily by the accumulation of organic muck in the sediment. These wetlands may be further characterized as swamps or marshes. Channel wetlands refer to ditches such as farm drainage ditches, and canals such as the channelized portion of Taylor Creek. The channels are generally sand bottom, characteristic of conveyance systems. They may be over-grown and may have a significant floodplain that may become important during storm events. Although the assimilative capacity of these varied systems may be unique, these two categories provide a practical means to distinguish wetland systems.

a. Biological Mechanisms of Assimilation

Several processes account for phosphorus assimilation in wetland and channel systems. These include uptake and retention by plants and microbes, and adsorption onto organic and inorganic materials in streambeds and floodplains. The importance of each of these processes depends on that physical character of the wetland. The physical character determines the retention time for water and solutes, the type of bed sediments and the degree of interaction with floodplain vegetation.

The most important characteristic is the degree of channelization. In general un-channelized, depressional wetlands accumulate organic sediment. Organic matter may accumulate from incoming sediment or formed in place from vegetative detritus. Channels are designed to be conveyance structures for efficient drainage of upland areas. These systems do not accumulate organic sediments. The inorganic bed sediments in this area are both sand and clay materials. The ditch sides often expose subsurface spodic horizons. The depressional wetlands generally contain stands of woody vegetation and aquatic macrophytes. The channelized systems may have vegetated banks and floodplains that interact with the water and solutes during storm events. In un-maintained systems the channelized ditches will be overgrown in time increasing the assimilative capacity.

Biologic growth has three effects on the assimilative capacity. First, phosphorus uptake and retention in permanent biomass by woody plants is an important but minor component of P assimilation. The component may account for 5 to 10 percent of the P assimilation. A second effect is the accumulation of vegetative detritus. Plant uptake and litter fall is an important component of P assimilation. Although this vegetative uptake is only a short term phenomena, the retention of the litter P as it decomposes represents a large accumulation of P. It has been reported that 50 percent of litter P remains in the accumulated detritus (Rosendahl, 1976). This phosphorus was highly resistant to further release. In wetland systems where this sediment can accumulate net P assimilation is greater. Finally, the accumulated organic sediment provides an additional source of assimilative capacity. The organic acids in the sediment provide sorption sites for chemical bonding of phosphorus.

b. Chemical Mechanisms of Assimilation

The primary mechanism for phosphorus retention is sorption and precipitation in wetland sediments. The diagram in Figure 14 illustrates the transport and transformations of phosphorus in these wetland systems. Phosphorus in the water column occurs in the form of ortho-phosphorus and reactable-organic phosphorus. The phosphorus molecule is highly reactive in natural systems and generally does not

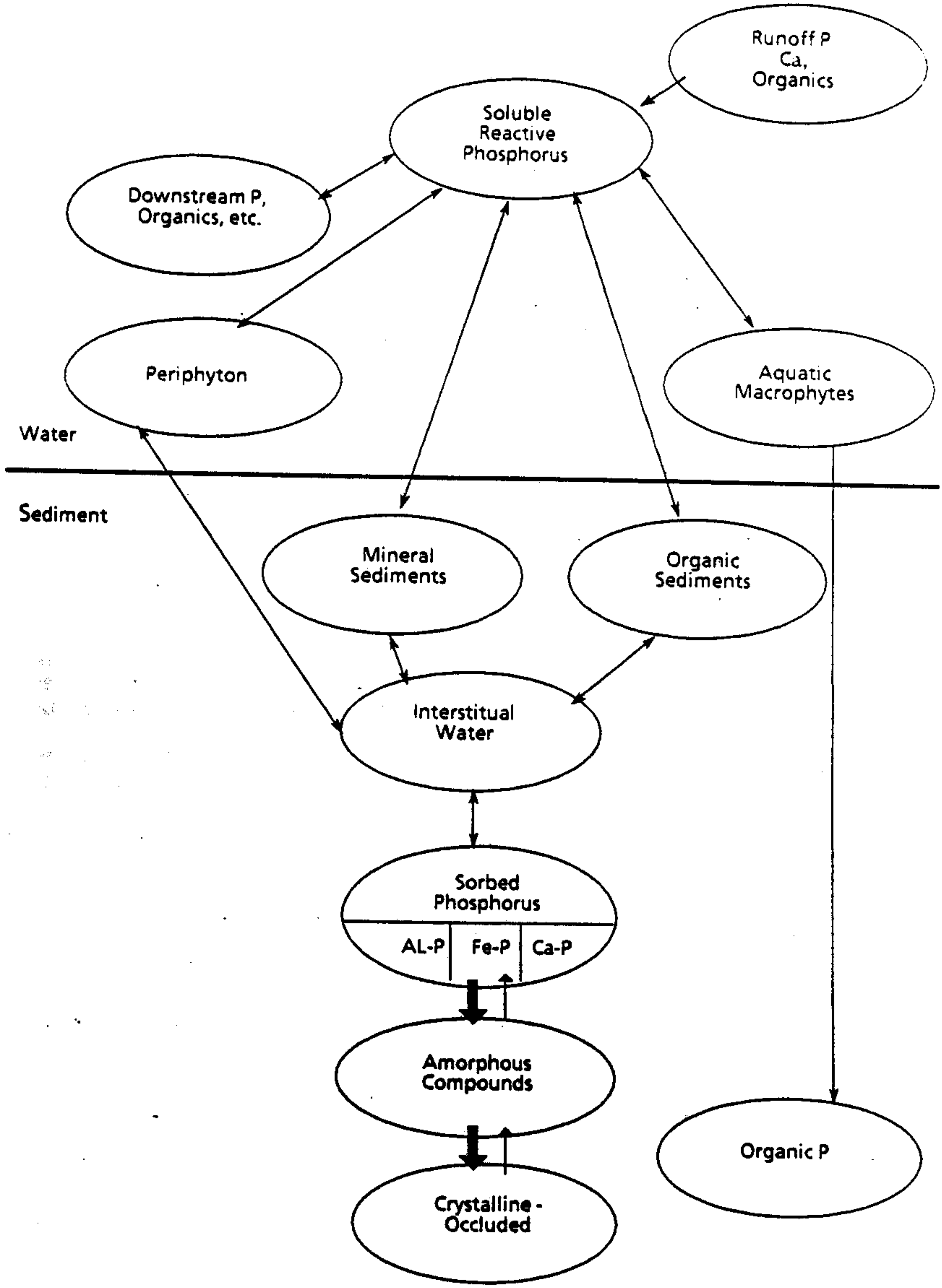


Figure 14. Schematic of Phosphorus Transformations

occur in high concentrations. It rarely occurs in the ortho-form. More commonly it occurs in an organic form either as free organic molecules or in living tissue. This source of phosphorus is digestible under acid treatment such with the colorimetric determination of SRP (Minear et al., 1985). Two types of soluble unreactive phosphorus (SUP) have been reported in the water column (Heath, 1985). A high molecular weight material that released P following irradiation with sunlight, similar to the photoreduction of ferric ions associated with those compounds. Those compounds were found to behave the same as humic acids in anion-exchange chromatography. These materials are often associated with long-term retention. The second class of SUP are phosphomonoesters (PME) that release P through hydrolytic action of phosphatases.

Soluble P may be assimilated by aquatic macrophytes, periphyton, or adsorbed onto organic and inorganic bed sediments. Phosphorus may also be deposited as organic detritus. As discussed above, detrital accumulation occurs primarily on the floodplain. Phosphorus released from detritus may enter the stream water column or enter interstitual water where further reactions with sediments occur.

A potentially important pathway of P transport from the water column into the sediment is through periphyton. Microbes growing on the sediment surface may assimilate a large amount of P and release the P into the sediment as well as water. Phosphorus may be forced into the sediments where further sorption occurs (Brown et al., 1978).

From the sediment-water interface P diffuses into sediment pores where additional sorption occurs. Phosphorus diffusion occurring due to a concentration gradient may be downward where stream concentration exceed the equilibrium phosphorus concentration (EPC) of the sediment or upward from sediments super-saturated with P. In the sediment P is sorbed to organic and inorganic materials. The P sorption may occur as a physical sorption based on charge imbalances on particle surfaces with is referred to as physical adsorption. Sorption may also occur as ligand exchange with hydroxyl groups on organic or inorganic surfaces (Figure 15). The mineral materials consist of Al and Fe oxides and hydroxides. In this region they occur primarily as surface coatings on sand grains called sesquioxides. These coatings are poorly organized structures that are constructed by bridged metal-oxygen bonds. Phosphorus sorption consists of electrostatic and ligand exchange with OH groups on the surface (Figure 15). The electrostatic sorption is dependent on the pH of the water column, where more bonding occurs at lower pH, and the conductivity of the water. Once adsorbed to the surface P molecules are not static. They interact with surrounding molecules often forming more stable bonds. The end result is that the P molecules become part of the surface and a new surface is formed attracting additional P.

Ligand exchange occurs on humic and fulvic acid surfaces as well as iron and aluminum oxide and hydroxide surfaces. If the stream waters or sediments provide a source of Iron (Fe) or Aluminum (Al) ions, ligand exchange may be followed by additional adsorption of Fe and Al followed by additional P. This results in the generation of layers of Al-P and Fe-P on the sediment particles. The P in these particles slowly becomes less available to sediment pore water dissolution. Over time the P may become part of a P mineral that is highly insoluble. This process is the transformation from labile P to a non-labile form of P (Figure 15).

The P in the pore water is in a state of near equilibrium, dynamic equilibrium, with the mineral components of the bed sediments. The phase diagram presents the conditions under which the solid phase of a mineral or the dissolved components are favored (Figure 16). In the figure, the solid phase is indicated by the region of hatching. When concentration of the constituent ions, Al, Fe, and Ca exceed concentrations of 10 to 20 mg l^{-1} P the formation of the mineral solid-phase is preferred (Stumm and Morgan, 1970). Consequently in the tributaries of LKR and TC/NS where the pH range is 6.0 - 7.5 and the concentration of Ca^{2+} is approximately 20 - 30 mg l^{-1} the formation of apatite is favored. In the pore water P may diffuse toward the water column if surface water concentrations are less than interstitial concentrations.

Syers and Iskandar (1981) reported in their review of phosphorus chemistry in soil that 21.7 mg Kg^{-1} can be adsorbed by hydrous ferric oxide gel from a solution of 3.1 mg P l^{-1} in the pH range 5.0 to 7.7. Similarly 0.4 mg Kg^{-1} can be adsorbed by amorphous aluminum hydroxide from a solution of 3.8 mg P l^{-1}. However, the aluminum hydroxide was active at a lower pH (4-5). Generally P sorption is decreased in the range of pH from 5 to 8. This is due to several factors which are not clearly understood. Competition for chemical binding sites on Al and Fe by OH and small molecular-weight organic acids may decrease the sorption of P. Further, Al is precipitated and the number of sites is reduced.

This process is dependent on the availability of Al, Fe, and Ca ions. Although abundant in the upland subsoils the abundance of Al in the streams has not been quantified. Total ion occurs in the range 0.1 to 1.0 mg l^{-1} (District, unpublished data, 1985). It appears likely that sufficient Al and Fe are available for increased sorption of P. However in the pH range of the water occurring in the basin it is more likely that Ca-P compounds are formed. Approximately, calcium enters the waterways at twice the mass loading of phosphorus from dairy sites. Phosphorus may also sorb to organic molecules formed during decomposition of the organic detritus. These molecules, humic and fulvic acids, have a large affinity of phosphorus based on the presence of acids groups in their structure. Significant amounts of P may be sorbed to the surface and retained as part of the overall structure. If the detritus continues to accumulate a significant mass of P will be permanently stored.

Phosphorus changes slowly from a sorbed form that is in quasi-equilibrium with the interstitial pore-water to more resistant compounds. With time under stable conditions the compounds will form crystalline or occluded P minerals that are highly resistant to P release. Phosphorus in that form will not likely be re-released following the change in land use from dairy to pasture.

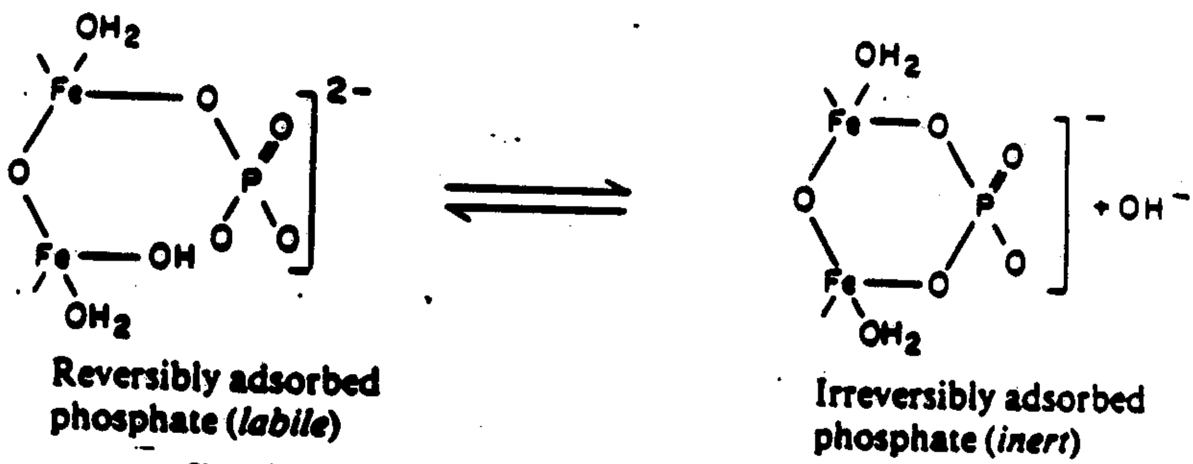


Figure 15 Phosphate binding mechanism for iron and aluminum hydroxides.

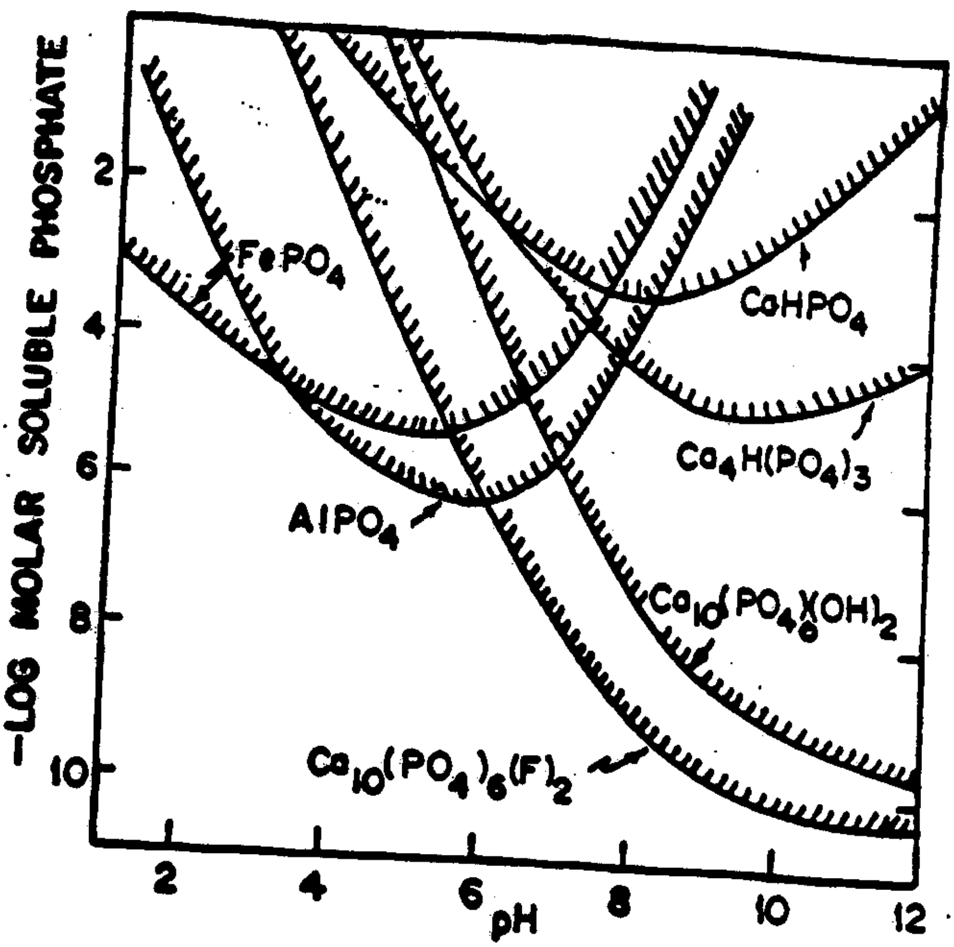


Figure 16 Phase diagram for phosphate solubility

c. Factors Affecting Assimilation of Phosphorus

1. Phosphorus Assimilation Kinetics

Phosphorus assimilation kinetics are another area of concern in the estimation of the assimilation capacity of the wetlands and channels. It is necessary to evaluate the effect of retention time on the assimilation processes. Phosphorus assimilation can be separated into rapid and slow changes. The rapid processes are almost instantaneous and can be described as equilibrium. The initial adsorption of phosphorus onto sediments and some assimilation processes by periphyton are rapid. The SRP in the water column generally is in equilibrium with phosphorus that is physically absorbed to exposed sediment surfaces. At low stream velocity and shallow flow characteristic of these basins, instantaneous absorption is controlled by the concentration gradient between the water column and the sediment. Except for very high flow conditions, stream velocity rarely limits this exchange. This will occur only in clean ditched tributaries.

Phosphorus assimilation by chemical reaction can best be described by rapid first order kinetics. Millward et al., (1985) reported that P removal by Fe^{3+}-derived precipitates was a first order rate reaction. The values of the rate coefficient varied from 0.11 min^{-1} at 2° C and pH = 7.9 to 0.02 min^{-1} at 15° C and pH = 7.3. The reaction rate was found to be related to pH, $\log k = 9.2 - 0.64pH$. The half-life on fresh Fe(III) and Fe(II) was < 1 min. and < 20 min. on aged Fe(II) precipitates. The rate of reaction for P on iron sediments is very fast and comparable to the residence time of the water in these stream reaches. It has been reported that phosphorus uptake in natural fresh water systems behaves according to first order kinetics Heath (1985). This is apparently true of both phosphorus limited and phosphorus sufficient systems. Heath found that phosphorus assimilation was partitioned into two main components: Active biological uptake, and passive inorganic sorption onto sediment.

Somponge (1981) investigated the kinetics of phosphorus sorption on three native soils characteristic of stream sediments in the Okeechobee basin. The sorption rates estimated as first order reactions:

Basinger fine sand	0.0366	day^{-1}
Placid fine sand	0.081	day^{-1}
Samsula Muck	0.0285	day^{-1}

These values indicate that it would require 23 to 66 days for the phosphorus concentration to be reduced from 1.2 mg l^{-1} to 0.18 mg l^{-1}. That residence time could be achieved by ponding or slow flow through the wetlands to the Lake. In the case of slow flow, the average discharge in the tributaries of LKR and TC/NS varies from 1 to 15 cfs. In these creeks the residence time ranges from 1 to 7 days. The retention time in the L-63 canal is one to two weeks if plug flow occurs. If there is incomplete mixing of inflow water the residence time may be substantially greater for a large portion of the phosphorus. At low flow, the travel time through the stream channels and canals is approximately three weeks. This provides a reasonable amount of time for phosphorus sorption in a native watershed. In these watersheds, where additional material; calcium, iron and organic matter, are loaded to the system with phosphorus, this is a conservative estimate of sorption kinetics. During high flow a large portion of the flow will occur in the floodplain where flow will decrease and sorption will increase.

The analysis based on these rate constants only accounts for phosphorus sorption onto soil materials. This does not account for microbial uptake or other assimilation processes. From this analysis it is reasonable that there is sufficient reaction time for sorption to occur on the bed sediments. The reaction rates of phosphorus with specific soil materials such as Fe- and Al-oxides indicate that a large amount of phosphorus is assimilated very quickly. There is also sufficient evidence to indicate that phosphorus uptake by periphyton is sufficiently rapid at the average flow rates occurring in the basin.

2. Environmental Factors

Assimilation depends on the substrate characteristics, phosphorus concentration in the water column, and electrolyte composition of the discharge waters. The greater the availability of metal ions, Al, Fe, Ca, the greater the adsorptive capacity of the system. The metal ions may be supplied by the sediments, adjacent upland soils through erosion, or supplied with barn washoff. In particular high concentrations of Ca may be found in barn washoff due to the high content of Ca in dairy feed. The additions of the ions increases the capacity of the sediments with time such that the labile and non-labile P pools will grow.

The electrolytic properties of the stream water such as pH, Eh, and conductivity affect the sorptive capacity of the sediments. The pH of the water column and the bed sediments determine the predominant assimilation chemistry. At low pH (4.5 -5.5) the accumulation of Fe- and Al- phosphates is dominant. The uptake by microbes is small. At pH 6.5- 7.5 the accumulation of Ca-phosphates is favored although sorption onto Fe-oxides is still great and microbial growth and assimilation is greatly increased. The effect of Eh, redox potential is mixed. At low Eh, reducing conditions, greater P is adsorbed at high P concentrations while the reverse is true at low TP concentrations (Somponge, 1981). The accumulation of P is increased in some soils following wetting and drying cycles. During the wet period ferric iron is reduced and becomes highly soluble. As the iron re-oxidizes during the dry period Fe-P compounds are formed. Depending on the character of the mineral soils, the Fe-P may become unavailable for release following re-wetting.

The hydraulic character of the wetland systems also has an important impact on assimilation, the flow pattern determines distribution and retention time of phosphorus. At low stage flow is probably confined to a small channel with mineral bed sediment. At higher stage the flow path may include a substantial floodplain (Figure 17). In the floodplain velocity decreases and the reaction time is greatly increased. The degree of interaction depends on the size and location of the floodplain. Ditching may reduce the degree of floodplain interaction. Often the major release of phosphorus occurs during storm events that increase the stage and the interaction with the floodplain.

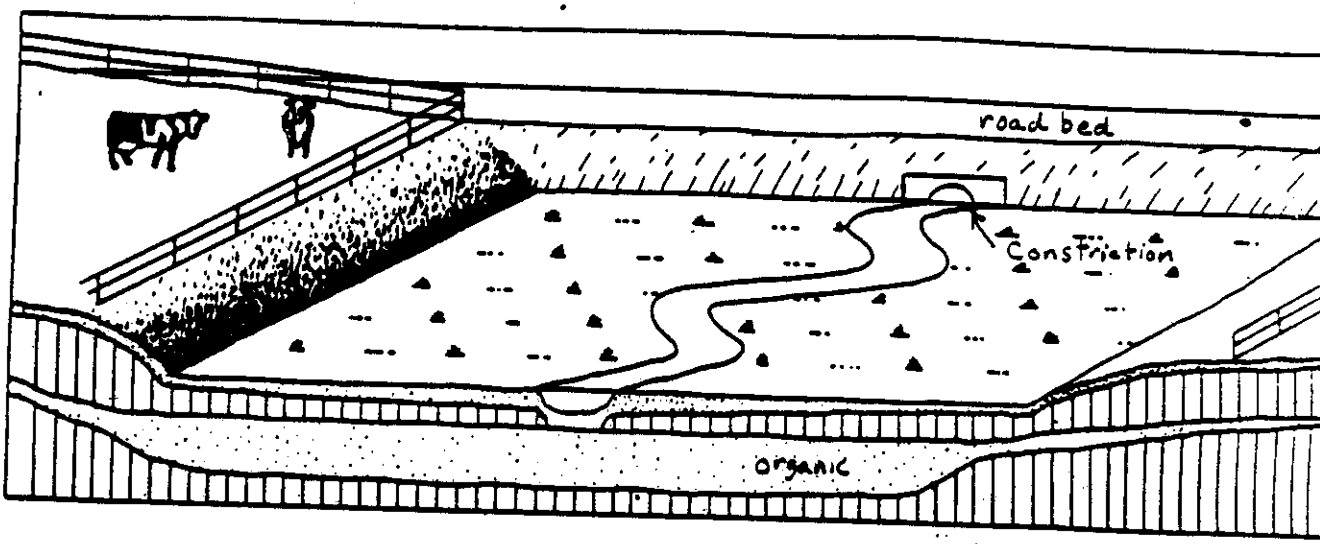
3. Management Factors

The management of the wetland systems greatly effects the assimilative capacity for phosphorus. Any activity that enhances flow across the floodplain increases the likelihood of P sorption and retention. Phosphorus may be trapped as organic sediment, assimilated by periphyton and macrophytes, or sorbed by sediments. The increased retention time due to reduced flow rates and infiltration of ponded water greatly increased assimilation. Harvesting wetland vegetation mechanically or by flash-grazing provides a means of reducing the standing crop of phosphorus and increasing long term assimilation. In general any activity that increases the retention time will improve assimilation. Although increased retention time appears to reduce the flood protection, these activities are not necessarily contradictory. Improved management of the upland pastures may also improve wetland assimilation of P. Liming soils and thus increasing runoff concentration of calcium should increase the potential for P assimilation.

4. Experimental Evidence for P Assimilation

Experimental evidence for P assimilation in bed sediments exists for two wetlands in the Lower Kissimmee River basin. The 25 ac. wetland receiving discharge from W.F. Rucks Dairy and the 5 ac. wetland receiving discharge from Dry Lake 1 & 2 Dairies have been intensively surveyed by University of Florida researchers under contract to the District (Reddy et al.,1989). A series of sediment samples have been collected from each site and various phosphorus fractions extracted to determine the partitioning of phosphorus at each site. The results indicate that approximately 50 percent of the P content of these soils are highly resistant to release.

The research team has also investigated the decomposition and release of P from various plant tissue. Samples of plant litter and herbaceous tissue were placed in litter bags and the decomposition was monitored with time. The plant tissue decomposed quickly. Only 20 to 60 percent of the dry matter was still present after 8 weeks in the marsh. The degree of decomposition depended on the plant species and the wetland location. In the same period only 2 percent of the litter decomposed further. Although fresh plant material decomposes quickly and releases P, plant litter is much more highly resistant to decomposition and leaching loss of phosphorus.



Low flow in stream, high flood across marsh or swamp

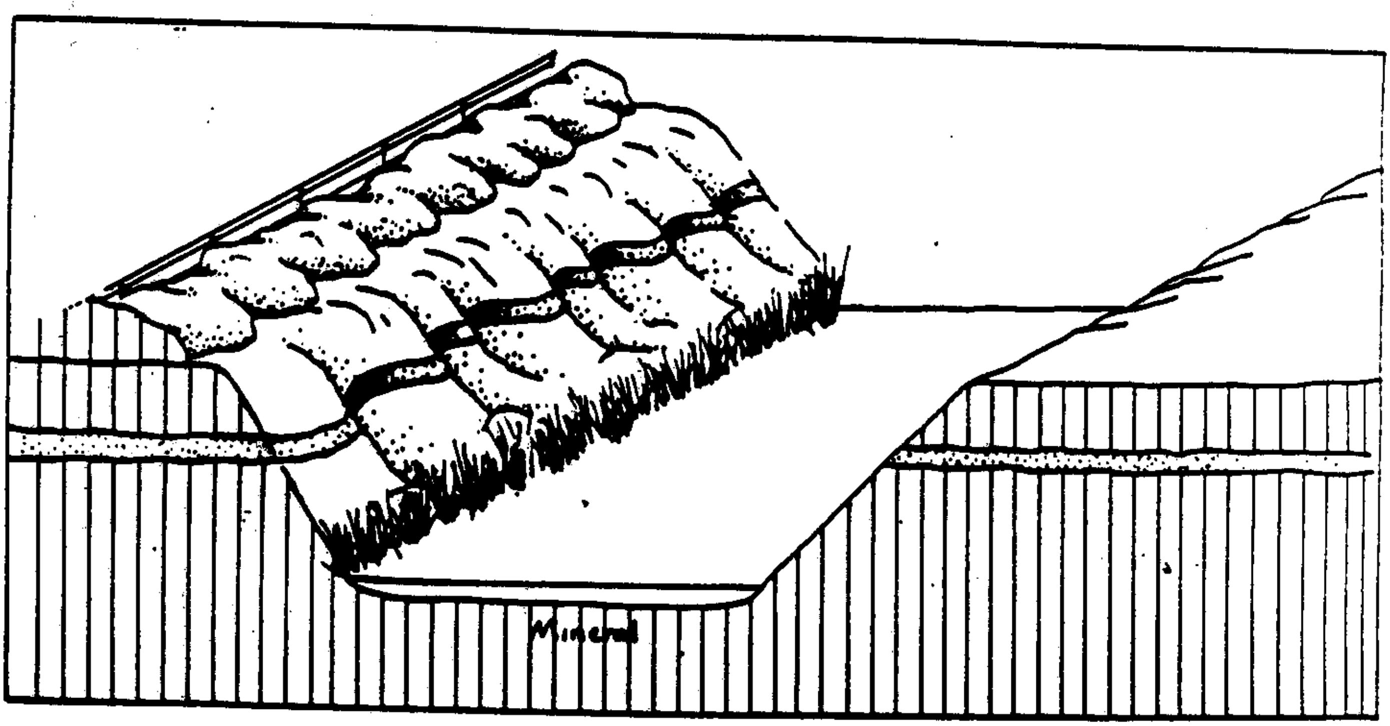


Figure 17. Flow through dredged wetland or creek

3. Estimation of Phosphorus Assimilation

The analysis of the assimilative coefficients is separated into two phases, evaluation of the process and estimation of the coefficients. First the phosphorus assimilation coefficients are calculated for the wetland systems occurring in a given basin. Then the linear length of flow-paths through those wetlands are estimated from maps and MarkHurd aerial imagery for the basin. The assimilation coefficient is calculated as a length-weighted sum of the assimilative coefficients for each component wetland. In this section the analysis of phosphorus assimilation will be presented. In the following section, Application, the estimation of the assimilative coefficients for each basin will be described. General discussion on the basin-wide application of assimilative coefficients will be presented in the last section.

a. Mathematical Description of Assimilation

Assimilation of phosphorus by wetlands was determined by evaluating the phosphorus retention in different wetland systems in the Lower Kissimmee River. The data for these calculations were taken from several different District studies (Federico et al., 1978; Goldstein, 1986; Davis, 1982; Ritter and Flaig, 1986; Ritter and Allen, 1982; and unpublished District data). These studies cover the range of phosphorus concentrations that are reasonable for those expected in Okeechobee County. These data were selected where input and output data for phosphorus were available for a section of wetland. In some studies phosphorus loads and concentration data were available. In the remainder only TP concentration data were used. In particular, the analysis of channels is limited in this respect relative to swamps and marshes. Historically more effort has been made to evaluate the net uptake of phosphorus by wetland systems whereas little effort has been made to determine the assimilative capacity of ditches, canals, and streams.

Phosphorus retention was evaluated by simple loss of P from the water column. Plant uptake, sediment adsorption and precipitation, or other retention mechanisms were grouped together. Sites were selected where single inflows and outflows were involved and lateral inputs were minor. In this way the impact of dilution was minimized.

The evaluation of phosphorus retention with distance through the wetland followed a first order process. The output concentration was a function of the input concentration reduced by an exponential factor.

$$C_o = C_i \exp - (a X)$$

where:

C_o - downstream [TP] (mg l^{-1})
C_i - upstream [TP] (mg l^{-1})
a - assimilation coefficient (m^{-1})
X - length of wetland (m)

This relationship was used to effectively route phosphorus through wetland areas of the Taylor Creek/ Nubbin Slough basin (Bottcher et al., 1986). It has also been used to model retention of phosphorus in other systems (Kadlec and Hammer, 1982). This model was verified with TP data from Boney Marsh, Higlands Co. Fl (Davis, 1982). For data from Boney Marsh TP data were collected at several points along a 1640 m wetland. The input concentration decreased from 0.042 mg l^{-1} to 0.015 mg l^{-1} at 1310 m. The concentrations remain constant through the remainder of the wetland. The exponential function fit the decrease in concentration well, correlation coefficient r^2 = 0.92. The assimilation coefficient was calculated to be 0.00063 m^{-1} (.97 mi^{-1}). This relationship was applied to other systems by solving the following equation:

$$a = 1/X \ln [C_o/C_i]$$

Based on a comparison of other sites (Table 15) results indicate that a value of 0.0004 m^{-1} (0.64 mi^{-1}) is a reasonable, conservative estimate for wetland assimilation.

It was assumed that an exponential decrease in concentration occurred at other sites since only two sample points are available for most wetland sections. At Boney Marsh there is an apparent build up of organic sediments at the inflow decreasing toward the discharge point. If these sediments are responsible for P retention, then the location of sediments at other locations is key to evaluating P retention. Since the location, quantity, and content of sediments have not been reported for other sites, an exponential decrease downstream is adopted. This is a reasonable approach that accounts for site to site variability.

In some wetland systems (Kadlec and Hammer, 1978) it has been reported that the build up of sediment and phosphorus has an upper limit. As the limit is reached, phosphorus sorption downstream becomes more important. It seems reasonable from those studies to conclude that once the wetland is saturated, phosphorus elusion will occur. However, in those systems chemical reaction rates and particularly decomposition of organic detritus are much slower than in south Florida. In south Florida wetlands phosphorus reacts to form non-labile sediments more quickly and the decomposition may provide a greater number of reaction sites. As long as sediments can accumulate in these wetlands, the annual retention capacity will not substantially decrease.

b. Review of Wetland Phosphorus Uptake

A summary of phosphorus assimilation in wetlands is presented in Table 16. This table shows the average annual retention of phosphorus for various wetlands in south Florida. Phosphorus uptake is determined on a per area basis to provide a measure and range of the assimilative capacity for different wetland systems. The flow-weighted, average-annual, total phosphorus concentration is provided to show that assimilation occurs over a range of concentrations. From this table it appears that there is a wide range of assimilative capacities.

However, three of the data require further explanation. The Armstrong Slough data is an average of three years of data (Table 15). During the third year the Slough was a net exporter of phosphorus.

Table 15. Wetland Phosphorus Assimilation Summary

Site	Period	Average Annual P Uptake $g/m^2/yr$	Average Annual [TP] mg/L
Ash Slough	1979-81 1980*	2.5 0.79	0.93 0.77
Armstrong Slough	1979-81	5.1	0.12
Chandler Slough	1975 1976	0.73 3.6	0.28 0.35
Boney Marsh	1978	0.42	0.041

This may indicate that the value of 5.1 g/m^2 is not sustainable in steady-state. The phosphorus uptake at Ash Slough over the same three year period was apparently 2.5 g/m^2 per year. There was no discharge during a prolonged period such that the wetland was not a flowing system but rather a receiving water body. In that condition, the average annual uptake may be artificially high. Goldstein (1986) analyzed the wetland phosphorus retention for five storms that were spaced over a period of a year (Table 16). These data were used to evaluate the assimilative capacity of the wetland. For those data the average-annual, flow-weighted concentration was 0.77 mg l^{-1} and the phosphorus retention was approximately 0.79 g/m^2. At the Chandler Slough site very different phosphorus retention rates were calculated for two years (Federico et al., 1978). In 1975 water quality data was collected periodically for the entire year. In 1976 the spring flush of nutrients which accompanies the first major runoff event following the dry season was not sampled. Consequently the phosphorus retention was probably over estimated. A reasonable interpretation of data from these three sites indicates that 4 - 8 kg P ha^{-1} yr^{-1} are retained in these wetlands. Although more phosphorus may be assimilated during dry periods or as a result of high loads, the stream systems are net sinks for phosphorus over a range of inflow concentrations.

This estimate of assimilative capacity is low compared to other wetland systems. Richardson and Davis (1987) reviewed several wetlands and concluded that net assimilation of 20 - 40 kg P ha^{-1} yr^{-1} was reasonable for many systems. Some wetland systems in Florida loaded with municipal wastewater have assimilated 40 kg P ha^{-1} yr^{-1} Dierberg and Brezonik (1978). One explanation for the difference is the lack of even distribution of phosphorus in the Chandler, Armstrong, and Ash wetlands. In these wetlands most of the flow was probably conducted down the primary channel and little of the floodplain was affected. Consequently the actual area involved may have been less than half the total.

c. Review of Water Quality Monitoring Data

The analysis of phosphorus assimilation was conducted on selected sites in the Lower Kissimmee River basin where upstream and downstream monitoring samples were collected. The sites were selected where

Table 16. Wetland Assimilation of Phosphorus

	Event	Load	Export	Retained	Total P Concen-tration	Runoff	Retention
Ash Slough	1	283	167	116	1.83	154	1.43
	2	87	15	72	0.96	91	.89
	3	18	14	4	0.07	232	.05
	4	294	210	43	1.41	209	.53
	5	195	112	83	0.43	452	1.02
	Ave.	877	103	63.6	0.77		.79
	Year	kg/ha	kg/ha	kg/ha	mg/L	$10^6 m^3$	$g/m^2/yr$
Ash	79	563	317	246			
	80	7.3	0	7.3			
	81	488	322	166			
	Ave.				0.93		2.5
Armstrong	79	950	198	752	0.12	7.69	6.21
	80	3,390	1,930	1,460	0.33	10.2	12.1
	81	1,550	1,930	-380	0.05	28.0	-3.14
	Ave.				0.12		5.04

sufficient data exists to evaluate assimilation and the influence of lateral inflows between the sampling points was minimal. Two sites immediately fit this profile, Otter Creek between Potter Rd. and Hwy 68, and the outfall ditch on C&M Dairy. Other sites provide some upstream-downstream water quality pairs, but the data were insufficient for this analysis.

This approach can be illustrated by analysis of water quality data collected for a 1.5 mi reach of Otter Creek (Figure 14). At this site grab samples were collected biweekly at stations TCHW 04 and TCHW 06 for a period from 1978 to present. These samples were analyzed for nitrogen and phosphorus species including total phosphorus concentration (TP). The TP data were used to evaluate the assimilation coefficient for typical ditched streams. The Otter Creek watershed contains approximately 2900 ha. (7100 ac.) of which approximately 10 percent of the area drains into the stream reach between the two sample sites. The soils of this area are primarily Myakka fine sand, although there is a large area of Pomello fine sand adjacent to the sampled stream reach. The Myakka soil is poorly drained with a spodic horizon within 40 cm of the surface. The Pomello soil is characterized by a deeper spodic horizon (>140 cm) and better internal drainage. More surface runoff is expected from the upper portion of the watershed than along the monitored stream reach that is primarily Pomello. In the reach section dilution may be as great as 10 percent due to ground water seepage of cleaner water from the adjacent land area. In the following analysis 10 percent dilution with pure water is assumed, actual dilution is less since the lateral inputs originate from dairy and improved beef pasture and supply additional phosphorus.

The upstream (04) and downstream (06) TP data were compared based on annual mean concentrations, and paired comparisons from biweekly data for the period of record. The ratio C_o/C_i was calculated for each comparison (Table 7). The values ranged from 0.49 to 0.89 indicating an apparent high degree of assimilation. Although the annual mean concentrations are not significantly different the pair-wise comparisons are significant. The input annual average TP concentrations range from 1.85 to 5.11 mg P l^{-1}. Over this range the assimilation coefficient varies from 0.04 to 0.13 mi^{-1}. Phosphorus assimilation appears to be related to the inflow phosphorus concentration. The amount of P assimilated increases with increasing concentration. The equilibrium phosphorus concentration (EPC), the concentration at which P is neither sorbed nor released increases. This indicates that the labile pool of weakly sorbed P grows and the potential for formation of P minerals is increased. Following the decrease of inflow phosphorus concentration the EPC similarly decreases, thus retaining sorbed P and reducing the potential for P loss from the sediments.

Table 17. Analysis of Phosphorus Assimilation for Otter Creek, Okeechobee County, Florida, Between Stations TCHW 04 and TCHW 06

I. Mean Annual Total Phosphorus Concentrations from Biweekly Sampling

Year	TCHW 04 (Inflow) mg/L ((mg/L)^2)		TCHW 06 (Outflow) mg/L ((mg/L)^2)		C_o/C_i
	Mean	Var	Mean	Var	
1978	4.80	(2.89)	3.58	(0.73)	.75
1979	4.92	(7.86)	3.01	(0.35)	.61
1980	5.11	(16.6)	2.53)	(2.4)	.49
1981	2.72	(16.4)	1.58	(0.68)	.58
1982	1.85	(0.29)	1.65	(0.27)	.89
1983	2.27	(1.65)	1.90	(1.2)	.84
1984	2.77	(1.2)	2.30	(0.75)	.83

1. Long-term biweekly Average Concentrations and C_o/C_i for period of record:
Station 04 3.58 C_o/C_i = .66
Station 06 2.35

2. Evaluation of the paired comparisons for the period of record indicate a ratio value of 0.84. The calculated value of "a" is:

$$a = \frac{1}{1.5} \ln(0.84) = 0.11 \text{ mi}^{-1}$$

3. If 10% dilution is considered the ratio increases to 0.94 indicating less phosphorus assimilation and the resulting value of "a" is:

$$a = \frac{1}{1.5} \ln(0.94) = 0.04 \text{ mi}^{-1}$$

As part of the BMP water quality monitoring program, the outfall from C&M dairy has been monitored for a year. There are two sampling sites separated by 0.4 mile. The outfall ditch that discharges from a pond to Cypress Slough has been overgrown with vegetation for a while. The average inflow and outflow total phosphorus concentrations indicate that P has been assimilated along the ditch (Table 8). The assimilation coefficient "a", 0.55, is much greater than would be expected by a ditch. This is due to the accumulated vegetation that provides a nutrient trap. Assimilation in this ditch is much greater than the Otter Creek site. This may be representative of overgrown channels.

Table 18. Phosphorus Assimilation in Wetlands

Study	Inflow [TP] mg/L	Outflow [TP] mg/L	Wetland Length m	Phosphorus Assimilation	
				mile $^{-1}$	(m^{-1})
Boney Marsh (1982)	0.042	0.015	1,310	.97	(.00063)
Ash Slough (1986)	0.90	0.76	304	.89	(.007)
Chandler Slough (1975)	0.276	0.232	4,900	.058	(.00056)
Monitoring Program					
Otter Creek (1980)	5.11	2.53	3,200	.13	(.00008)
Otter Creek (1984)	2.77	2.30		.043	(.00003)
C & M Dairy (1987)	5.2	4.01	762	.55	(.00034)

- **The impact of dilution in these studies due to lateral inflows was evaluated. The channel segments were carefully surveyed to determine the potential for lateral inflows. This would result in potential dilution due to increased flow but little additional phosphorus. In the present analysis the effect of dilution was estimated proportional to contributing land area. In a study in north Florida the impact of dilution was similarly evaluated. Evaluating the removal of phosphorus from secondary effluent in a flow-through swamp in north Florida, it was reported that TP concentrations were reduced 90 percent (Boyle Eng., 1981).** However, the reduction was attributed to dilution of cleaner water infiltrating the wetland from lateral sources. The impact of dilution was determined by evaluating changes in conductivity. Since the waste water was the primary source of conductivity, which behaved as a conservative tracer, reductions in conductivity were prescribed to be due to dilution. At the sites used in this study the time series of conductivity data was evaluated for changes in conductivity between upstream and downstream sites. Since dilution was not apparent there is additional evidence to suggest that dilution by lateral inflows was a minimal problem.

4. Calculation of Basin Scale Phosphorus Assimilation Coefficients

a. Estimation of Assimilation Coefficient "A"

Estimation of the assimilative coefficient for any site depends primarily on the nature of the downstream wetlands. Based on the above discussion of the assimilative capacity of wetlands, the assimilation coefficient has been shown to be independent of the input concentration of a large range of values. Further, the assimilation is calculated considering single sources with little dilution or other lateral impacts. Consequently the summation of additional loads from other adjacent landuses does not impact the assimilation coefficient for the site in question.

Theoretically the addition of P loads from adjacent landuses should not impair the assimilation of P. From monitoring data, assimilation occurs over a range of TP concentrations from 0.04 to 5 mg l^{-1}. The dynamic equilibrium of sorption processes in the sediment adjusts to the inflow concentration.

Further it is not expected that TP concentrations will approach the upper range limit. The addition of more sources along a stream reach produce additional discharge inflows at 1.2 mg l^{-1} will combine to yield an outflow of 1.2 mg l^{-1} with a greater discharge. Although this may not be true in the extreme case of high phosphorus loads along an entire wetland, the assimilation coefficients "a" were calculated based on ditch and wetland systems that are now highly loaded.

b. Estimation of Wetlands and Canals

The assimilation coefficient "A" is calculated base on a summation of the linear flowpath through wetlands and channels. For each site the flowpath from the outfall of ownership to the appropriate receiving water (C-38 or the Lake) was identified. The flowpath was partitioned into wetland and channel based on field experience of District staff and aerial photography. (In basins considered in this report the District has been conducting intensive water quality monitoring. Consequently most of the wetlands are well known.) Based on the management scenarios it was possible to characterize a given wetland as a channel for a more conservative estimate of A. The total length of each wetland type was determined since channel segments are not contiguous. The assimilative capacities for each wetland type were calculated and summed.

$$A = \exp(a_w * X_w + a_c * X_c)$$

where,

a_w - assimilation coefficient for wetlands, 0.64 mi^{-1}

X_w - summed length of flowpaths through wetlands, mi

a_c - assimilation coefficient for channels, 0.05 mi^{-1}

X_c - summed length of flowpaths through channels, mi

These calculations were conducted for various management scenarios used to determine the most probable assimilation coefficient for each basin.

The calculations for TC/NS basin:

Average length of wetlands, X_w = 2.03 mi.

Average length of channels, X_c = 11.9 mi.

Where $C_i = C_o * A$

$A = \exp(0.64*2.03 + 0.05 * 11.9) = 6.7$

C_o = 0.18 mg/L; Lake average annual lake inflow target concentration

C_i = 1.2 mg/L; Average annual offsite discharge concentration

The basis for extrapolation of the assimilative coefficients developed in the Taylor Creek/ Nubbin Slough basin is that these estimates are based on a highly channelized system. This results in a much lower and conservative assimilative coefficient than expected for other basins with a greater extent of wetlands.

There is some uncertainty in the calculation of the above values due to the nature of the wetland systems. The separation of flowpaths into wetlands and channels is difficult due to the partial ditching of many wetlands in Lower Kissimmee River. With drainage paths approaching 25 miles, for some sites, the impact of mis-identification of wetlands may be important. Another factor is the unique characteristics of each wetland system. Sediment trapping capability, size of floodplain surface and percent of flow occupying the floodplain at different stages, and chemical characteristics of the bed sediments are important variables in determining the correct assimilation coefficient. In this analysis those variabilities were not considered in favor of using an average value for all basins.

5. Summary and Conclusion

Based on phosphorus analysis conducted on wetland sediments at two dairy sites it was determined that wetland systems in the mineral soil basins have the capability to assimilate phosphorus. Phosphorus mass balance data from several wetland uptake studies were evaluated to determine assimilative capacity. A first order process was hypothesized to describe the decrease in total phosphorus concentration with distance downstream. This process was supported by water quality data from Boney Marsh and data from the literature. The first order process was applied to District water quality data to determine appropriate assimilation coefficients "a" for wetlands and channels.

Conservative estimates of permanent phosphorus assimilation rates have been calculated for these basins An average assimilation coefficient of 6.7 will be applied to all basins which are characterized as mineral soils located north of a line from the Caloosahatchee River to the St. Lucie Canal. This results in an average annual off-site discharge total phosphorus concentration of 1.2 mg/L.

LITERATURE CITED:

Barrow, N.J. Evaluation and utilization of residual phosphorus in soils. Chat 13. pp.333-359. In The Role of Phosphorus in Agriculture. American Society of Agronomy, Madisco, WI.

Boyle Eng. Corp. (1981) Tertiary Treatment of wastewater using flow-through wetland systems. NSF Grant PFR78-19199 Report OR-NO4-101-50.

Brown, E.J., R.F. Harris, and J. F. Koonce. (1979). Kinetics of phosphate uptake by aquatic microorganisms: deviations from a simple Michaelis-Menten equation. Limnol. Oceanogr. 23:26-34.

Davis, S. M. (1981) Mineral flow in the Boney Marsh, Kissimmee River. Tech. Pub. 81-1, South Florida Water Management District, West Palm Beach.

Dierberg, F.E. and P.L. Brezonik. (1978). Nitrogen and phosphorus mass balances in a cypress dome receiving wastewater. In K. C. Ewel and H.T. Odum (eds.) Cypress swamps. University of Florida Press, Gainesville.

Bottcher, A.B., L.B. Baldwin, K.L. Campbell, C.D. Haetwole, R.S. Mansell, and B.A. Burgoa. (1986) Deveolpment and verification of an analytical model for assessing the impact of agricultural practices on water quality and quantity. Final Report to South Florida Water Management District, West Palm Beach.

Federico, A.C., J.F. Milleson, P.S. Millar, and M. Rossen. (1978). Environmental studies in the Chandler Slough watershed. Tech. Pub. 78-2. South Florida Water Management District, West Palm Beach.

Goldstein, A. L. (1986). Upland detention/retention demonstration project final report. Tch. Pub. 86-2. South Florida Water Management District, West Palm Beach.

Heath, R. T. (1985). Phosphorus dynamics and the effects of dissolved organic phosphorus compounds in a new reservoir on the Savannah River, U.S.A.. In J.N. Lester and P.W.W. Kirk (eds.) Proc. of the Inter. Conf. Management strategies for phosphorus in the environment, Lisbon 1-4 July 1985.

Kadlec, R.H. and D.E. Hammer. (1982). Pollutant transport in wetlands. Environmental Progress 1:206-211.

Lock, M.A. and P.H. John. (1979). The effect of flow patterns on uptake of phosphorus by river periphyton. Limnol. Oceanogr. 24:376-383.

Millward, G.E., S.A. Crosby, M. Whitfield, E.I. Butler, and D.R. Turner (1985). The heterogeneous chemical reactivity of phosphate wastes with iron oxides. In J.N. Lester and P.W.W. Kirk (eds.) Proc. of the Inter. Conf. Management strategies for phosphorus in the environment, Lisbon 1-4 July 1985.

Minear, R.A., J. Elwood, and P. Mulholland. (1985) Phosphorus chemical form differentiation in aquatic environments.

Olsen, S.R. and F.E. Khasawneh. (1981). Use and limitations of physical-chemical criteria for assessing the status of phosphorus in soils. Chapt. 14 pp. 361-409. In The Role of Phosphorus in Agriculture. American Society of Agronomy, Madisco, WI.

Reddy, K.R. Reddy, D.A. Graetz, and R.L. Voss. (1988) Distribution of phosphorus in stream sediments and associated wetlands. Final Report, Task 2.3.1 contract 532-M87, South Florida Water Management District.

Riebsame, W.E., Woodley, W.L. and Davis, F.E. 1974. Radar inference of Lake Okeechobee rainfall for use in environmental studies, Weatherwise, 27 (5):pp 206-211.

Ritter, G.J., and L.H. Allen, Jr. (1982) Taylor Creek headwaters project phase I report; water quality. Tech. Pub. 82-8. South Florida Water Management District, West Palm Beach, Fla.

Ritter, G.J. and E.G. Flaig. (1986). 1986 annual report; rural clean waters .programTech. Memo. South Florida Water Management District, West Palm Beach.

Richardson, C. and J.A. Davis. (1987). Natural and artificial wetland ecosystems: ecological opprotunities and limitations. pp. 819-854. In K.R. Reddy and W.H. Smith (eds.). Aquatic plants for water treatment and resource recovery. Magnolia Publishing, Orlando.

Rosendahl, P. (1976). Physical and water quality aspects of meandering and channelized streams- Orthophosphorus model in Kissimmee River Florida: case study. PhD Dissertation, Univ. of Miami, Coral Gables, Fla.

Sonzongni, W.C., P.D. Uttormark, And G.F. Lee. (1973). The phosphorus residence time model: theory and application. Institute for Environmental Sciences, University of Texas, Dallas, Texas.

Stumm, W. and J.O. Leckie. (1971). Phosphate exchange with sediments; its role in the productivity of surface waters. 5th International Water Pollution Research Conference.

Stumm, W. and J.J. Morgan (1970) Aquatic Chemistry. Wiley-International, John Wiley & Sons, Inc. New York.

Syers, J.K. and I.K. Iskandar. (1981). Soil-phosphorus chemistry. pp.571-599. In I.K. Iskandar (ed.) Modeling wastewater renovation. John Wiley & Sons. New York.

F. DISCHARGE LIMITATIONS FOR SUB-BASINS SUBJECT TO AN ASSIMILATIVE COEFFICIENT (SUB-BASINS NORTH OF LAKE OKEECHOBEE WITH MINERAL SOILS)

The average annual off-site concentration standard applies to all discharges from a land use at the property boundary.

Each drainage basin which drains mineral soils has an inherent capacity to assimilate phosphorus within wetlands, streams and canals. A reasonable and conservative average assimilation coefficient of 6.7 was calculated and was applied to all mineral soil basins from the Caloosahatchee River north to the St. Lucie Canal. See the previous section for methodology for calculating the assimilative coefficient of 6.7.

The average annual off-site discharge concentration limitation is derived by multiplying the lake inflow average annual target concentration by the assimilative coefficient of 6.7 for mineral soil basins north of the lake. This results in an ultimate average annual off-site discharge total phosphorus concentration of 1.2 mg/L for basins which currently discharge an average annual total phosphorus concentration in excess of 0.18 mg/L. For mineral soil basins currently discharging less than 0.18 mg/L, the ultimate off-site discharge limitation was calculated by multiplying the assimilative coefficient of 6.7 by the current average annual concentration.

The concentration standard for improved pasture of 0.35 mg 1^{-1} was selected based on evaluation long-term water quality monitoring data and specific assessment of pasture runoff. Measurements of total phosphorus concentrations consist primarily of improved pasture. During the past five years best management practices (BMP) have been installed to improve water quality. Total phosphorus concentrations have averaged 0.33 mg 1^{-1} during this period. A specific assessment of runoff water quality from improved pastures was conducted during the "Upland Detention/Retention Demonstration Project" (Goldstein, 1986). The results of that study indicated that total phosphorus concentration from well managed, typical improved pasture were below 0.35 mg 1^{-1}. With the appropriate BMPs a well managed improved pasture should be able to achieve this total phosphorus concentration in discharge water as a long term average.

Insufficient scientific data are available for estimating phosphorus assimilation in canals and wetlands draining muck soils, generally found south of the lake. If and when sufficient scientifically reliable data becomes available for estimating phosphorus assimilation in canals and wetlands draining much soils, an assimilation coefficient will be developed and incorporated into future revisions of the SWIM Plan. Since no assimilative coefficient could be derived, the ultimate off-site discharge concentration for much soil basis is no greater than 0.18 mg/L.

G. SUMMARY OF APPLICABLE DISCHARGE LIMITATIONS

The following table presents the average annual off-site phosphorus discharge standards for all basins draining into Lake Okeechobee.

Table 19. Phosphorus Discharge Concentration and Areal Loading Rates to Works of the District Within the Lake Okeechobee Drainage Basin

Inputs	Assimilative Coefficient	Lake Inflow Total Phosphorus Concentration Limitations (mg P/L) *			Off-site Total Phosphorus Discharge Concentration Limitations (mg P/L) *			Implementation Date for permit requirements (time period after effective date of rule)
		1989 Interim Limitation	1990 Interim Limitation	1991 & 1992 Ultimate Limitation	1989 Interim Limitation	1990 Interim Limitation	1991 & 1992 Ultimate Limitation	

1. Discharge from parcels in the following sub-basins may not exceed these Off-Site Total Phosphorus Discharge Concentration Limitations (Column 2). If the parcel's current average off-site discharge concentration is greater, that discharge concentration may be maintained so long as it does not exceed 0.18 mg/L.

S-236 (So. Fla. Conservancy)	1.0	0.09	0.09	0.09	0.09	0.09	0.09	Effective Date
Culvert 4A (So. Bay/So. Shore)	1.0	0.08	0.08	0.08	0.08	0.08	0.08	Effective Date
Culvert 12 (East Shore D.D.)	1.0	0.13	0.13	0.13	0.13	0.13	0.13	Effective Date
~~L-59E, L-59W, Culv. "A"~~	~~1.0~~	~~0.16~~	~~0.16~~	~~0.16~~	~~0.16~~	~~0.16~~	~~0.16~~	~~Effective Date~~
S-2 (flood control)	1.0	0.16	0.16	0.16	0.16	0.16	0.16	Effective Date
S-3 (flood control)	1.0	0.14	0.14	0.14	0.14	0.14	0.14	Effective Date
~~HG-5~~ S-351 (W.P.B. Canal)	1.0	0.14	0.14	0.14	0.14	0.14	0.14	Effective Date
S-77 (East Caloosahatchee)	1.0	0.15	0.15	0.15	0.15	0.15	0.15	Effective Date
Culvert 10A (L-8)	1.0	0.10	0.10	0.10	0.10	0.10	0.10	Effective Date

*These refer to average annual concentrations (See Text).

2. Discharge from parcels in the following sub-basins may not exceed 1.2 mg/L. If the parcel's current average concentration is less than 1.2 mg/L, that discharge concentration must be maintained, however, it is not required to be maintained below the Lake Inflow Total Phosphorus Concentration Limitations (Column 1).**

C-38 Pool A (S-65A)	6.7	0.07	0.07	0.07	0.47	0.47	0.47	Effective Date
C-38 Pool B (S-65B)	6.7	0.06	0.06	0.06	0.40	0.40	0.40	Effective Date
C-38 Pool C (S-65C)	6.7	0.12	0.12	0.12	0.80	0.80	0.80	Effective Date
S-84	6.7	0.18	0.18	0.18	1.20	1.20	1.20	Effective Date
S-131	6.7	0.13	0.13	0.13	0.87	0.87	0.87	Effective Date
S-135	6.7	0.11	0.11	0.11	0.74	0.74	0.74	Effective Date
L-60E, L-60W	6.7	0.10	0.10	0.10	0.67	0.67	0.67	Effective Date
L-61E, L-61W	6.7	0.09	0.09	0.09	0.60	0.60	0.60	Effective Date
Culvert 5 (Nicodemus Slough)	6.7	0.06	0.06	0.06	0.40	0.40	0.40	Effective Date
S-308C (C-44, S-153)	6.7	0.16	0.16	0.16	1.07	1.07	1.07	Effective Date
S-129 (L-49)	6.7	0.18	0.18	0.18	1.20	1.20	1.2	Effective Date
L-59E, L-59W, Culv. "A"	6.7	0.16	0.16	0.16	1.07	1.07	1.07	Effective Date

*These refer to average annual concentrations (See Text).

**For parcels in or converted to improved pasture the current average discharge concentration is 0.35 mg/L (average annual concentration). Any discharge in excess of this must be reduced to 0.35 mg/L.

Inputs	Assimilative Coefficient	Lake Inflow Total Phosphorus Concentration Limitations (mg P/L) (Current Basin Inflow Concentration)			Off-site Total Phosphorus Discharge Concentration Limitations (mg P/L)			Implementation Date for Permit Requiremen
		1989 Interim Limitation	1990 Interim Limitation	1991 & 1992 Ultimate Limitation	1989 Interim Limitation	1990 Interim Limitation	1991 & 1992 Ultimate Limitation	Effective Date

3. Discharge from parcels in the following sub-basins may not exceed the Off-Site Total Phosphorus Discharge Concentration Limitations <u>(Column 1)</u> listed below or the parcel's current average discharge concentration whichever is less, unless the current concentration is below 0.18 mg/L,in which case it may rise to 0.18 mg/L.

Industrial Canal	1.0	0.34	0.33	0.18	0.34	0.33	0.18	12 mths
S-4	1.0	<u>0.20</u>	<u>0.20</u>	0.18	<u>0.20</u>	<u>0.20</u>	0.18	24 mths
Culvert 12A (715 Farms)	1.0	0.26	0.26	0.18	0.26	0.26	0.18	24 mths
Culvert 10 (East Beach D. D.)	1.0	0.28	0.28	0.18	0.28	0.28	0.18	24 mths

4. Discharge from parcels in the following sub-basins may not exceed the Off-Site Total Phosphorus Discharge Concentration Limitation <u>(Column 2)</u> listed below. If the parcel's current average discharge concentration is lower than 1.2 mg/L, discharge may not exceed the current concentration, unless the current concentration is below 0.18 mg/L, in which case it may rise to 0.18 mg/L.**

S-154	6.7	0.66	0.33	0.18	4.42	2.21	1.2	90 days
S-191 (TC/NS)	6.7	0.66	0.33	0.18	4.42	2.21	1.2	90 days
S-71 (C-41)	6.7	0.38	0.33	0.18	2.68	2.21	1.2	12 mths
S-72 (C-40)	6.7	0.66	0.33	0.18	4.42	2.21	1.2	12 mths
S-127 (L-48)	6.7	0.38	0.33	0.18	2.55	2.21	1.2	12 mths
C-38 Pool E (S-65E)	6.7	0.66	0.33	0.18	4.42	2.21	1.2	<u>90 days</u> ~~12 mths~~
C-38 Pool D (S-65D)	6.7	0.26	0.26	0.18	1.74	1.74	1.2	24 mths
S-133	6.7	0.32	0.32	0.18	2.14	2.14	1.2	12 mths
S-154C	6.7	0.22	0.22	0.18	2.21	2.21	1.2	24 mths
Fisheating Cr.	6.7	0.21	0.21	0.18	1.40	1.40	1.2	24 mths

**For parcels in or converted to improved pasture the current average discharge concentration is 0.35 mg/L (average annual concentration). Any discharge in excess of this must be reduced to 0.35 mg/L.

H. MONITORING AND ENFORCEMENT

1. Discussion

The maximum phosphorus off-site concentration limitation applies only to those basins which currently have inflow concentrations to the lake greater than 0.18 mg/L and have an assimilative capacity assigned. The purpose of the maximum off-site concentration standard is to provide an indication of when a land use has a high probability of not meeting the applicable annual performance standard. If the maximum off-site concentration standard is exceeded, action should be taken immediately to determine the source of the excessive discharge and to take appropriate steps to reduce it.

Table 20 presents the values, which if exceeded, indicate that there is greater than a 50 percent probability off-site discharge limitation will not be met. The propabilities are presented for several numbers of samples collected.

Table 20. Total Phosphorus Concentration Exceedance Values

Average Annual Off-Site Target Phosphorus Concentration mg/L	1	2	3	4	5	6
≦.30	5.401	1.541	.735	.457	.325	.300
.31	5.544	1.579	.752	.467	.333	.310
.32	5.688	1.616	.769	.477	.340	.320
.33	5.831	1.654	.786	.486	.348	.330
.34	5.974	1.691	.803	.496	.355	.340
.35	6.118	1.729	.821	.506	.363	.350
.36	6.261	1.767	.838	.516	.370	.360
.37	6.404	1.804	.855	.526	.378	.370
.38	6.547	1.842	.872	.535	.385	.380
.39	6.691	1.879	.889	.545	.393	.390
.40	6.834	1.917	.906	.555	.400	.400
.41	7.014	1.965	.928	.568	.410	.410
.42	7.195	2.013	.950	.580	.420	.420
.43	7.375	2.061	.972	.593	.430	.430
.44	7.555	2.109	.994	.606	.440	.440
.45	7.736	2.157	1.016	.619	.450	.450
.46	7.916	2.204	1.037	.631	.460	.460
.47	8.096	2.252	1.059	.644	.470	.470
.48	8.276	2.300	1.081	.657	.480	.480
.49	8.457	2.348	1.103	.669	.490	.490
.50	8.637	2.396	1.125	.682	.500	.500
.51	8.815	2.443	1.147	.695	.510	.510
.52	8.992	2.491	1.169	.708	.520	.520
.53	9.170	2.538	1.190	.720	.530	.530
.54	9.348	2.585	1.212	.733	.540	.540
.55	9.526	2.633	1.234	.746	.550	.550
.56	9.703	2.680	1.256	.759	.560	.560
.57	9.881	2.727	1.278	.772	.570	.570
.58	10.059	2.774	1.299	.784	.580	.580
.59	10.236	2.822	1.321	.797	.590	.590
.60	10.414	2.869	1.343	.810	.600	.600
.61	10.586	2.915	1.365	.823	.610	.610
.62	10.758	2.962	1.386	.835	.620	.620
.63	10.930	3.008	1.408	.848	.630	.630
.64	11.102	3.054	1.429	.861	.640	.640
.65	11.274	3.101	1.451	.874	.650	.650
.66	11.445	3.147	1.472	.886	.660	.660
.67	11.617	3.193	1.494	.899	.670	.670
.68	11.789	3.239	1.515	.912	.680	.680
.69	11.961	3.286	1.537	.924	.690	.690
.70	12.133	3.332	1.558	.937	.700	.700

Table 20 (Continued). Total Phosphorus Concentration Exceedance Values

Average Annual Off-Site Target Phosphorus Concentration mg/L	1	2	3	4	5	6
.71	12.305	3.379	1.580	.950	.710	.710
.72	12.478	3.425	1.602	.963	.720	.720
.73	12.650	3.472	1.623	.976	.730	.730
.74	12.822	3.518	1.645	.989	.740	.740
.75	12.995	3.565	1.667	1.002	.750	.750
.76	13.167	3.612	1.689	1.015	.760	.760
.77	13.339	3.658	1.711	1.028	.770	.770
.78	13.511	3.705	1.732	1.041	.780	.780
.79	13.684	3.751	1.754	1.054	.790	.790
.80	13.856	3.798	1.776	1.067	.800	.800
.81	14.053	3.851	1.800	1.081	.810	.810
.82	14.251	3.904	1.825	1.096	.820	.820
.83	14.448	3.956	1.849	1.110	.830	.830
.84	14.645	4.009	1.873	1.124	.840	.840
.85	14.843	4.062	1.898	1.139	.850	.850
.86	15.040	4.115	1.922	1.153	.860	.860
.87	15.237	4.168	1.946	1.167	.870	.870
.88	15.434	4.220	1.970	1.181	.880	.880
.89	15.632	4.273	1.995	1.196	.890	.890
.90	15.829	4.326	2.019	1.210	.900	.900
.91	16.023	4.378	2.043	1.224	.910	.910
.92	16.217	4.430	2.068	1.239	.920	.920
.93	16.411	4.483	2.092	1.253	.930	.930
.94	16.605	4.535	2.116	1.268	.940	.940
.95	16.799	4.587	2.141	1.282	.950	.950
.96	16.993	4.639	2.165	1.296	.960	.960
.97	17.187	4.691	2.189	1.311	.970	.970
.98	17.381	4.744	2.213	1.325	.980	.980
.99	17.575	4.796	2.238	1.340	.990	.990
1.00	17.769	4.848	2.262	1.354	1.000	1.000
1.01	18.003	4.910	2.290	1.371	1.010	1.010
1.02	18.237	4.972	2.319	1.387	1.020	1.020
1.03	18.471	5.034	2.347	1.404	1.030	1.030
1.04	18.705	5.096	2.375	1.420	1.040	1.040
1.05	18.939	5.158	2.404	1.437	1.050	1.050
1.06	19.173	5.220	2.432	1.454	1.060	1.060
1.07	19.407	5.282	2.460	1.470	1.070	1.070
1.08	19.641	5.344	2.488	1.487	1.080	1.080
1.09	19.875	5.406	2.517	1.503	1.090	1.090
1.10	20.109	5.468	2.545	1.520	1.100	1.100
1.11	20.290	5.517	2.568	1.534	1.110	1.110

Table 20 (Continued). Total Phosphorus Concentration Exceedance Values

Average Annual Off-Site Target Phosphorus Concentration mg/L	1	2	3	4	5	6
1.12	20.471	5.567	2.592	1.548	1.120	1.120
1.13	20.651	5.616	2.615	1.562	1.130	1.130
1.14	20.832	5.665	2.639	1.576	1.140	1.140
1.15	21.013	5.715	2.662	1.590	1.150	1.150
1.16	21.194	5.764	2.685	1.603	1.160	1.160
1.17	21.375	5.813	2.709	1.617	1.170	1.170
1.18	21.555	5.862	2.732	1.631	1.180	1.180
1.19	21.736	5.912	2.756	1.645	1.190	1.190
1.20	21.917	5.961	2.779	1.659	1.200	1.200
1.21	22.048	5.998	2.797	1.670	1.210	1.210
1.22	22.179	6.035	2.816	1.681	1.220	1.220
1.23	22.311	6.073	2.834	1.693	1.230	1.230
1.24	22.442	6.110	2.853	1.704	1.240	1.240
1.25	22.573	6.147	2.871	1.715	1.250	1.250
1.26	22.704	6.184	2.889	1.726	1.260	1.260
1.27	22.835	6.221	2.908	1.737	1.270	1.270
1.28	22.967	6.259	2.926	1.749	1.280	1.280
1.29	23.098	6.296	2.945	1.760	1.290	1.290
1.30	23.229	6.333	2.963	1.771	1.300	1.300
1.31	23.456	6.394	2.991	1.787	1.310	1.310
1.32	23.682	6.454	3.019	1.804	1.320	1.320
1.33	23.909	6.515	3.047	1.820	1.330	1.330
1.34	24.136	6.575	3.075	1.837	1.340	1.340
1.35	24.363	6.636	3.103	1.853	1.350	1.350
1.36	24.589	6.696	3.130	1.869	1.360	1.360
1.37	24.816	6.757	3.158	1.886	1.370	1.370
1.38	25.043	6.817	3.186	1.902	1.380	1.380
1.39	25.269	6.878	3.214	1.919	1.390	1.390
1.40	25.496	6.938	3.242	1.935	1.400	1.400
1.41	25.639	6.978	3.262	1.947	1.410	1.410
1.42	25.781	7.019	3.282	1.959	1.420	1.420
1.43	25.924	7.059	3.302	1.972	1.430	1.430
1.44	26.066	7.100	3.322	1.984	1.440	1.440
1.45	26.209	7.140	3.342	1.996	1.450	1.450
1.46	26.351	7.180	3.362	2.008	1.460	1.460
1.47	26.494	7.221	3.382	2.020	1.470	1.470
1.48	26.636	7.261	3.402	2.033	1.480	1.480
1.49	26.779	7.302	3.422	2.045	1.490	1.490
1.50	26.921	7.342	3.442	2.057	1.500	1.500

The information in Table 20 can be used to assist a landowner in evaluating his system's anticipated performance during the course of a year:

1. If the phosphorus concentration of an outflow water sample is found to be 39.6 mg/L, then there is at least a 90 percent probability that the piece of property would not be able to meet the target mean concentration of 1.2 mg/L in the next 12 month period.

2. Any concentration over 1.2 mg/L is a warning that requires further monitoring. There is at least a 70 percent probability that the target mean of 1.2 mg/L would not be met when the concentration of seven (7) samples exceeded 1.2 mg/L, but none of them exceeded 1.3 mg/L.

2. <u>Methodology</u>

Property-level phosphorous concentration data collected at 74 locations around the lake (Taylor Creek/Nubbin Slough, S-154, and Lower Kissimmee River basins) was used in this analysis (Table 21). The sampling frequency was mostly bi-weekly, but varied from weekly to monthly. The data points were considered to be independent of each other and collected at random time intervals. Considering the hydrologic conditions of the area, independent samples should have a minimum of a two day separation. The record lengths varied from four months to over two years. Even though most of the mean concentrations from those locations were much higher than the desired target mean, at all locations there were always some measurements of very low concentration. The basic concept of this analysis was to use the lower than target mean concentration events, which occur in the existing data and which are also expected to occur in the future to compensate for the events of higher than target mean concentration. The procedures are:

a. For each sampling location, rank the concentrations from low to high. Let the ranked concentration be denoted by C_i, $i = 1,\ldots,N$. N is the total number of data. C_1 is the lowest concentration in the location.

b. Given a target mean concentration, C_T, take only the sampled concentrations that are less than the target mean. Let these concentrations be denoted by C_i, $i = 1,\ldots,n$. n is the total number of existing data of C_i that is less than CT. The sum of difference, B, B = sum $(C_T - C_i)$, $i = 1,\ldots,n$ is the buffer available to compensate for the occurrence of events having higher than C_T.

c. The B value for the jth sampling location be denoted by B_j. Compute all B_j, $j = 1,\ldots,74$.

d. For the non-exceeding level of any one sample, B_j is used to compute statistical moments to define a Pearson III distribution. This analysis follows the detail procedures found in "Statistical Methods in Hydrology" by C.T. Haan (The Iowa State University Press, Ames, Iowa, 1977). Other references are "Handbook of Applied Hydrology" by V.T. Chow (McGraw-Hill, 1964) and "Probability and Statistics in Hydrology" by V. Yevjevick (Water Resources Publications, Littleton, Co. 80161, 1972).

e. An analysis of skewness showed that coefficients of skewness vary from -0.7 for the target mean concentration of 0.3 mg/L to -1.1 for the target mean concentration of 1.7 mg/L. The coefficient of skewness for a target mean concentration of 1.2 mg/L concentration, is about -1. In order to maintain a smooth graduation of levels in the transition from one target concentration to the other, a unified coefficient of skewness of -1.0 was adopted for the entire analysis.

f. For non-exceeding level of F samples, the data B_j/F is used for similar distribution analysis. This is equivalent to assuming each of the F exceeding events occurred exactly at B_j/F value. This simplification, however, results in liberal non-exceeding level, which in turn gives at least the confidence as computed from the selected distribution.

g. A Fortran program was written for this analysis. To smooth out the graduation, the program computes the target concentrations in 0.1 mg/L increment and then linearly interpolating for increments of 0.01 mg/L. The Fortran program used to calculate the maximum off-site discharge concentration and a listing of the stations used in the analyses follows. The raw data is available upon request. Distributions were performed computationally and not graphically (See Table 22).

Table 21. Station Descriptions Used to Calculate Maximum Off-Site Discharge Concentration Standards

KREA	01	272736.00	805523.00	FISH SLOUGH AT N W 240th ROAD
KREA	07	272433.00	810237.00	LARSON DAIRY TRIB.W AT NW 160th DR
KREA	08	272430.00	810222.00	LARSON DAIRY TRIB E AT NW 160th DR
KREA	09	272554.00	810319.00	LARSON D ASH SLU OFF OLD PEAVINE TR
KREA	10	271919.00	810250.00	BUTLER DAIRY OUTFALL UNDERHILL RD
KREA	14	271651.00	810114.00	PUMP ON CLEMONS RANCH & LARSON D RD
KREA	16	271808.00	805855.00	PLATTS BLUFF D OUTFALL NW 156th ST
KREA	18	271951.00	810035.00	YATES MARSH N AT SCL RAILROAD
KREA	19	271442.00	800110.00	M A WILLIAMS QUEEN BEE RD OFF HWY70
KREA	20	272020.00	805628.00	SANDFLY GULLY N.OF FLYIN"G" AT US98
KREA	21	272705.00	805630.00	W F RUCKS D OUTFALL OFF EAGLE IS.RD
KREA	21A			DOWNSTREAM OF W F RUCKS D OUTFALL
KREA	23	273052.00	810355.00	ASH SLOUGH VIKING PROPERTY AT WEIR
KREA	25	272612.00	805925.00	TURKEY SLU.SO.OF FLYING"G" D US 98
KREA	27	272635.00	805950.00	CHANDLER SLOUGH WEST AT NW.220th ST
KREA	31	271435.00	805553.00	TRIB TO L-62 W.OF POPASH SLU HWY 70
KREA	32	271839.00	805405.00	5 MI N OF DRY LAKE DAIRY #1 US 98
KREA	32A	271820.00	805355.00	AT DRY LAKE DAIRY #1 AT US 98
KREA	32B			UPSTREAM OF DRY LAKE DAIRY #1
KREA	33	271745.00	805323.00	5 MI S OF DRY LAKE DAIRY #2 US 98
KREA	34	271140.00	805047.00	FERRELL DAIRY OUTFALL AT HWY 78
KREA	34A	271153.00	805148.00	FERRELL D. OUTFALL AT FERRELL D RD
KREA	35	271120.00	805410.00	IN L-59 AT C-38 SW SIDE OF KISS RV
KREA	36	271228.00	805147.00	WOLF DAIRY OUTFALL EAST OF LEMKIN CREEK
KREA	37	271220.00	805925.00	RUCK'S DAIRY OUTFALL SOUTH OF C-41A CANAL
KREA	38	271215.00	800005.00	BRIGHTON DAIRY #1 OUTFALL
KREA	38A	271212.00	805958.00	BRIGHTON DAIRY #1 OUTFALL UPSTREAM
KREA	39	271520.00	810137.00	MURPHY WHITE DAIRY OUTFALL OFF HWY 70
KREA	39A			MURPHY WHITE DAIRY OUTFLOW-GRAB SITE-TO CLEMONS RANCH
KREA	40	271731.00	810129.00	LARSON DAIRY #2 OUTFALL LARSON D RD
KREA	40A			DOWENSTREAM FROM KREA 40
KREA	41	271715.00	810105.00	BUTLER DAIRY #2 OFF BOAT RAMP ROAD
KREA	41A	271720.00	810207.00	BUTLER DAIRY #2 OUTFALL S OF KREA41
KREA	42	271855.00	805540.00	OUTFALL FOR FLYING "G" DAIRY
KREA	43	272052.00	805925.00	C & M RUCKS DAIRY OUTFALL
KREA	43A	272510.00	815745.00	C & M DAIRY DOWNSTREAM OF KREA 43
KREA	44	272302.00	800592.00	LAMB ISLAND DAIRY OUTFALL OFF LAMB ISLAND ROAD
KREA	44A			LAMB ISLAND DAIRY OUTFLOW TO CYPRESS SLOUGH
KREA	45	272512.00	810745.00	PALMER DAIRY OUTFALL POOL C
KREA	46	272523.00	805742.00	C&M DAIRY OUTFALL SOUTH OF EAGLE ISLAND ROAD
KREA	47	272720.00	805929.00	EAGLE ISLAND DAIRY OUTFALL SOUTH
KREA	48	271113.00	805115.00	EAGLE BAY AT HWY 78
KREA	49	271753.00	805337.00	DRY LAKE DAIRY #1&2 OUTFALL

Ta le 21 Continue . Station Descriptions Use to Calculate Maximum Off-Site Discharge Concentration Standards

KREA	49A			DOWNSTREAM OF KREA 49
KREA	54	271740 00	810022 00	POOL E DOUGHERTY CUTOFF
KREA	55	271803.00	810038.00	LARSON AND BUTLER DAIRY RUNOFF
KREA	66	272252 00	810604 00	FOUR E'S FISH CAMP AT US 98
KREA	IR1			DRY LAKE #2 RUN OFF FROM SOUTHERN SPRAY IRR. FIELD
KREA	IR2			DRY LAKE #2 RUN OFF FROM NORTHERN SPRAY IRR. FIELD
TCNS	202	272415.00	805134 00	H&T RUCKS #2 AT LITTLE BIMINI
TCNS	203	272421.00	805133.00	MCARTHUR #4 & 5 AT LITTLE BIMINI
TCNS	205	274400.00	804751 00	MCARTHUR #1 & 2 HAYFIELD RUNOFF
TCNS	208	272354.00	804921 00	WILSON RUCKS RUNOFF AT OTTER CREEK
TCNS	210	272254.00	805116 00	H&T RUCKS #3 RUNOFF TO WEST OTTER CREEK AT POTTER RD
TCNS	211	272302.00	804904 00	H&T RUCKS #1 RUNOFF. EAST OTTER CREEK AND POTTER RD
TCNS	216	271710 00	805043.00	SLOAN RAY DAIRY RUNOFF AT WOLFF CREEK
TCNS	220	271513.00	804612.00	MOSQUITO CREEK BELOW LARSON DAIRIES AT HWY. 70
TCNS	221	271337.00	804650.00	MURPHY WHITE DAIRY ABOVE FP&L SUB STAT OFF HWY. 710
TCNS	223	271610.00	804220 00	DAVIE DAIRY #2 RUNOFF ON FARM
TCNS	224	271549 00	804204.00	DAVIE DAIRY RUNOFF BELOW #1 & #2
TCNS	225	271234.00	804412.00	NEW PALM DAIRY RUNOFF ABOVE NEWCOMMER DAIRY
TCNS	226	271215.00	804429.00	NEWCOMMER DAIRY RUNOFF
TCNS	227	271252.00	804417 00	RED TOP DAIRY RUNOFF
TCNS	229	271027 00	804210.00	ENRICO DAIRY RUNOFF TO HENRY CREEK
TCNS	231	270946 00	803842.00	UNDERHILL DAIRY RUNOFF OFF MARTIN GRADE ROAD
TCNS	234	271513 00	804203 00	POSEY DAIRY AT HWY 70 & BERMAN RD
TCNS	242	272453.00	804750 00	MCARTHUR FARMS BARN RUNOFF AT OTTER CREEK
TCNS	251	271250.00	804445 00	RED TOP DAIRY DISCHARGE TO NUBBIN SLOUGH

Table 22. Fortran Program for Calculating Off-Site Maximum Discharge Concentration Standards

```
      PROGRAM NOEXC(DATA,RR,R99,R90,R80,R70,R50,TAPE1 = DATA,TAPE2 = RR,
      $ TAPE3 = R99,TAPE4 = R90,TAPE5 = R80,TAPE6 = R70,TAPE7 = R50)
C     TO COMPUTE NON EXCEEDANCE OFF-SITE OUTFLOW TOTAL PHOSPHORUS CONC.
      DIMENSION CM(800),RCM(800),DMAX(15,7,250),CALOW(15),
      $ AA(7,5),BB(7,5),CC(7,5)
C
      DO 10 I = 1,15
   10 CALOW(I) = 0.10*FLOAT(I) + 0.200
C
      K = 1
   15 J = 1
   20 READ(1,25,END = 300) MM,MD,IY,CM(J)
   25 FORMAT(3I2,F10.3)
      IF(MM .GT. 89) GO TO 30
      J = J + 1
      GO TO 20
   30 NJ = J-1
C
      QMAX = 0.0
      DO 60 J = 1,NJ
      IF(CM(J) .GT. QMAX) QMAX = CM(J)
   60 CONTINUE
      JTR = 0
      CONCMX = QMAX
   70 QMXN = 0.
      DO 80 J = 1,NJ
      IF(JTR .GE. NJ) GO TO 100
      IF(CM(J) .GT. QMAX) GO TO 80
      IF(CM(J) .GE. QMAX) THEN
         JTR = JTR + 1
         JR = NJ-JTR + 1
         RCM(JR) = CM(J)
         GO TO 80
         ENDIF
C
      IF(CM(J) .GT. QMXN) QMXN = CM(J)
   80 CONTINUE
      QMAX = QMXN
      IF(QMAX .LE. 0.) GO TO 100
      GO TO 70
C
  100 DO 200 I = 1,15
C
```

Table 22 (Continued). Fortran Program for Calculating Off-Site Maximum Discharge Concentration Standards

```
          FN = 0.
          TOT = 0.
          DO 150 J = 1,NJ
          IF(RCM(J) .LE. 0.) GO TO 150
          IF(RCM(J) .GE. CALOW(I) ) GO TO 160
          TOT = TOT + RCM(J)
          FN = FN + 1.
    150   CONTINUE
C
    160   DO 180 N = 1,7
          DMAX(I,N,K) = -1.
          IF(FN .LE. 2.) GO TO 180
          EN = 26-N
          EX = CALOW(I)*26.-TOT*EN/FN
          DMAX(I,N,K) = EX/FLOAT(N)
    180   CONTINUE
C
    200   CONTINUE
C
          K = K + 1
          GO TO 15
C
    300   KN = K-1
          DO 600 I = 1,15
            FN = 0.
          AVE = 0.
          STD = 0.
C
          DO 380 N = 1,7
C
          DO 320 K = 1,KN
          IF(DMAX(I,N,K) .LE. 0.) GO TO 320
          FN = FN + 1.
          AVE = AVE + DMAX(I,N,K)
    320   CONTINUE
C
          AVE = AVE/FN
          DO 340 K = 1,KN
          STD = STD + ( DMAX(I,N,K)-AVE )**2
    340   CONTINUE
C
          STD = SQRT( STD/(FN-1.) )
          BB(N,1) = AVE + 1.588*STD
          IF(BB(N,1) .LE. CALOW(I) ) BB(N,1) = CALOW(I)
          BB(N,2) = AVE + 1.128*STD
          IF(BB(N,2) .LE. CALOW(I) ) BB(N,2) = CALOW(I)
```

Table 22 (Continued). Fortran Program for Calculating Off-Site Maximum Discharge Concentration Standards

```
          BB(N,3) = AVE + .852*STD
          IF(BB(N,3) .LE. CALOW(I) ) BB(N,3) = CALOW(I)
          BB(N,4) = AVE + .544*STD
          IF(BB(N,4) .LE. CALOW(I) ) BB(N,4) = CALOW(I)
          BB(N,5) = AVE + 0.164*STD
          IF(BB(N,5) .LE. CALOW(I) ) BB(N,5) = CALOW(I)
    365   FORMAT(I3,8F8.3)
          WRITE(2,366) N,CALOW(I),(BB(N,LCF),LCF = 1,5)
    366   FORMAT(I6,2X,F6.2,2X,8F8.3)
    380   CONTINUE
C
          IF(I .EQ. 1) GO TO 500
C
C
          DO 490 M = 1,9
          TC = TA + 0.01*FLOAT(M)
C
          DO 450 K = 1,7
          DO 440 LCF = 1,5
          DLT = BB(K,LCF)-AA(K,LCF)
          DLT = DLT/10.
          CC(K,LCF) = AA(K,LCF) + DLT*FLOAT(M)
    440   CONTINUE
C
    450   CONTINUE
C
          DO 470 LCF = 1,5
          NF = 2 + LCF
    470   WRITE( NF, 475) TC, (CC(K,LCF),K = 1,7)
    475   FORMAT(8X,F6.2,2X,8F8.3)
C
    490   CONTINUE
C
    500   TA = CALOW(I)
          DO 510 LCF = 1,5
          DO 510 K = 1,7
    510   AA(K,LCF) = BB(K,LCF)
C
          DO 520 LCF = 1,5
          NF = 2 + LCF
    520   WRITE( NF, 475) CALOW(I), (BB(K,LCF),K = 1,7)
C
    600   CONTINUE
          STOP
          END
```