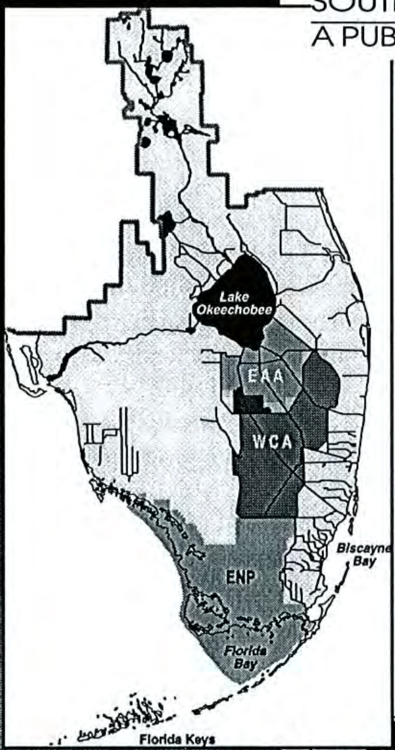
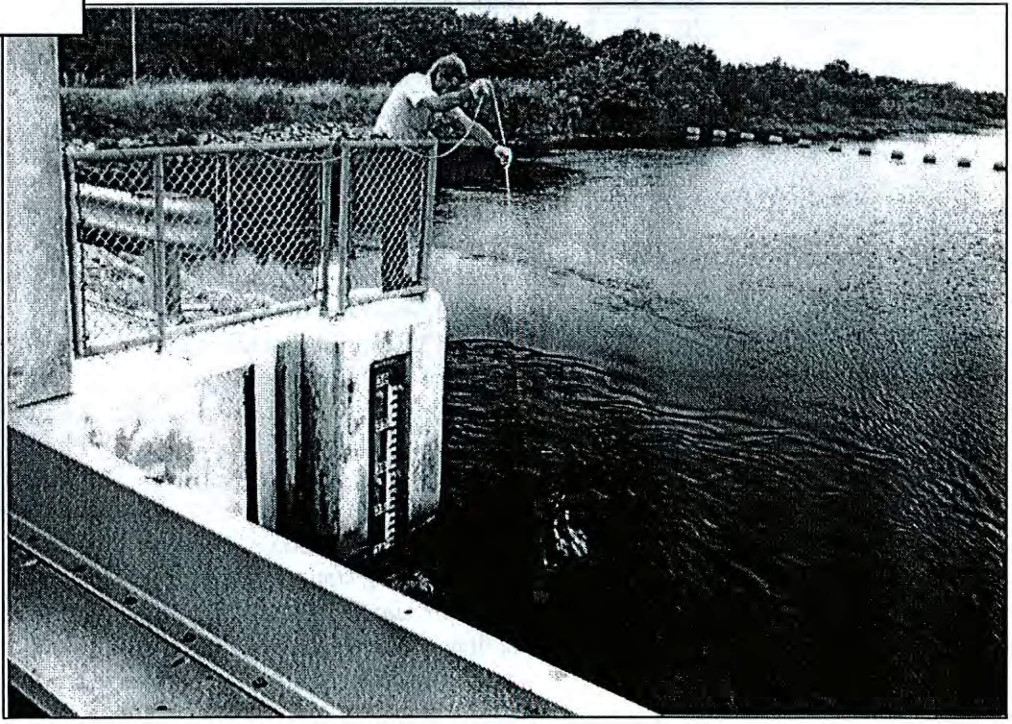
Water Quality Conditions Quarterly Report

SOUTH FLORIDA WATER MANAGEMENT DISTRICT • OCTOBER 1998
A PUBLICATION OF THE WATER RESOURCES EVALUATION DEPARTMENT



The above map is an overview of some of the major features in the South Florida Water Management District.

In this issue data collected in April, May and June 1998 are presented and discussed. The report also contains the percent total phosphorus load reduction for the Everglades Agricultural Area which is presented annually. Also, two new figures have been added to both the Everglades Nutrient Removal Project section and the Florida Bay section in response to frequently requested information.



Picture at right, grab sample being taken at pump station S65C located on the Kissimmee River.

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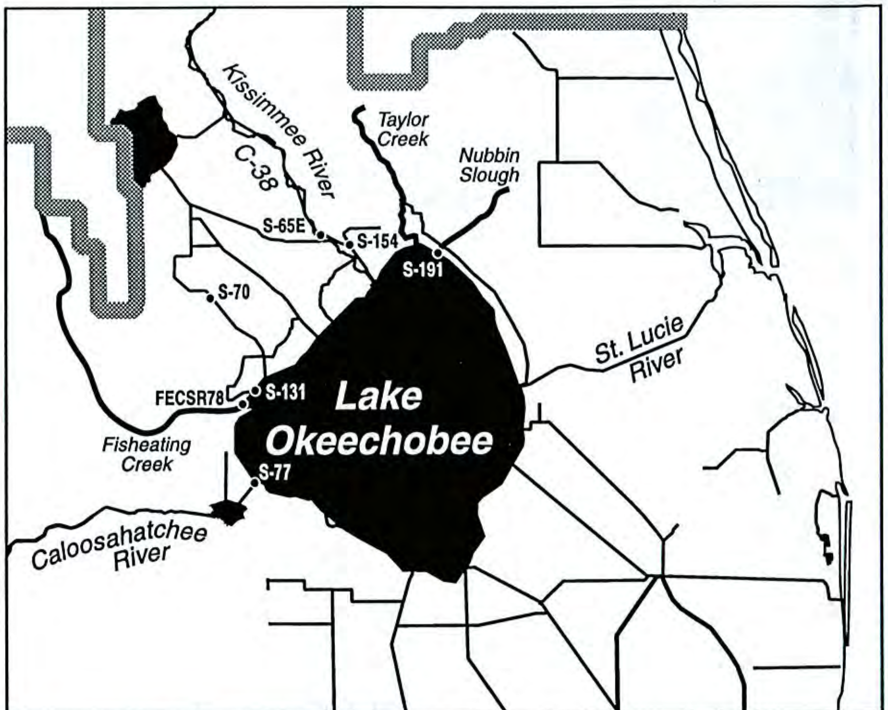
Lake Okeechobee Drainage Basin



Monthly total phosphorus loads to Lake Okeechobee for April, May and June 1998 were 29.2, 4.8 and 0.8 metric tons, respectively. The lowest phosphorus load to the lake for the past three years occurred in June 1998.

Phosphorus Loading and Rainfall Trends

Monthly total phosphorus loads and rainfall in the Lake Okeechobee drainage basin for the period from April 1996 through June 1998 are presented in **Figure 1.** Water quality and flow data from 26 monitoring stations located around Lake Okeechobee are used to calculate phosphorus loads to the lake. Calculations of monthly rainfall for Lake Okeechobee were expanded from five stations in the northeast and northwest sides of the lake to include 13 monitoring stations in the vicinity of the Kissimmee River and Lake Kissimmee. This expanded rainfall data set provides a better correlation with phosphorus loads to the lake. For comparison, monthly rainfall was also determined for the five monitoring stations (S65E, S70, S77, S131 and S191) used in previous years. These two sets of monthly rainfall are shown in **Figure 1**. Total phosphorus concentrations and loads presented in this section are provisional and are presently under review.

Over the past two years of water quality monitoring, phosphorus loads have generally exhibited a seasonal trend. Loads have generally decreased during drier months and increased following periods of heavy rainfall. Monthly loads computed for April, May and June 1998 were 29.2, 4.8 and 0.8 metric tons, respectively (**Figure 1**). The lowest phosphorus load to the lake for the past three years occurred in June 1998.

The total phosphorus load to Lake Okeechobee during the second quarter of 1998 was 34.8 metric tons or approximately 13 times lower than the total load reported for the first quarter of 1998 (446.2 metric tons) and 2 times lower than reported for the same period in 1997. The corresponding average rainfall at the 18 monitoring sites for the second quarter of 1998 was 1.2, 2.3 and 2.7 inches. Total rainfall recorded from April through June 1998 was approximately 10 inches lower than for the same period in 1997 (15.9 inches). Further, total flow from the Kissimmee River was six times lower during the second quarter of 1998 compared to that reported during the first quarter. Thus, the lower loads observed during the second quarter of 1998 can be attributed to drier conditions, reflected in lower rainfall throughout the watershed, as well as reduced releases from Lake Kissimmee.

Phosphorus Concentrations in the Tributaries/ Basins

Phosphorus targets for each basin were established under the 1989 Interim SWIM Plan. These targets were incorporated to ensure a reduction in phosphorus loads to Lake Okeechobee. Under this SWIM Plan, phosphorus concentrations in each basin must either be below 0.18 mg/L or at the 1989-discharge concentration (whichever is less).

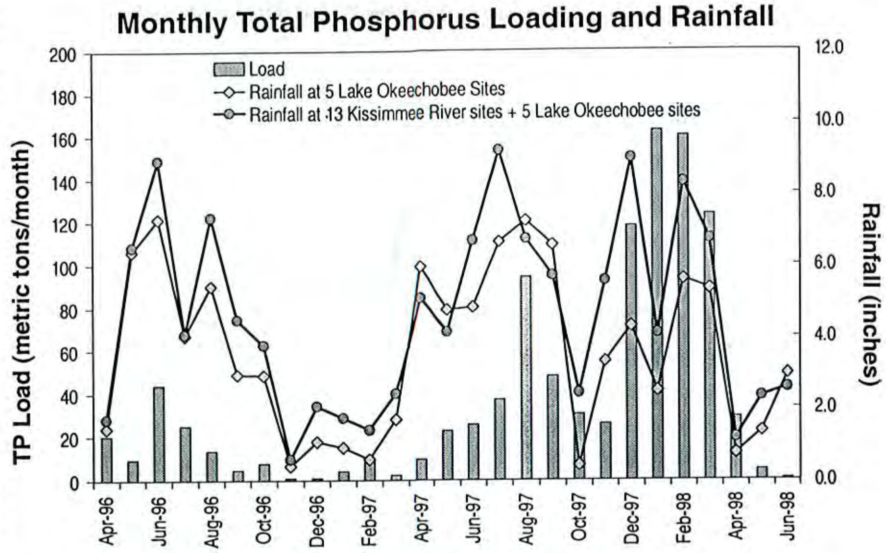


Figure 1. Monthly TP loads and rainfall for Lake Okeechobee.

Twelve-month moving average concentrations are determined using flow-weighted mean total phosphorus concentrations at four of the thirty-nine basins draining into Lake Okeechobee. The four basins chosen (Kissimmee River, S154, Fisheating Creek and Taylor Creek/ Nubbin Slough) are major contributors of the total phosphorus load into the lake. Comparisons of these 12-month moving average concentrations with their respective targets are presented in **Figure 2.**

The Kissimmee River Basin has consistently exhibited average phosphorus concentrations below the target concentration of 0.18 mg/L since June 1991 (**Figure 2a**). However, 12-month moving average phosphorus concentrations for the other three basins/tributaries have consistently been above the target level of 0.18 mg/L.

Twelve-month moving average phosphorus concentrations in the S154 Basin have remained relatively constant (averaging approximately 0.71 mg/L) from November 1997 through June 1998 (**Figure 2a**). A slight increase in phosphorus concentrations was observed from April to June 1998 coinciding with reduced flows to the lake during these months.

The average phosphorus concentration in Fisheating Creek continued to decrease during the second quarter of 1998 (**Figure 2b**). During the first half of 1998, the total phosphorus concentration in Fisheating Creek averaged approximately 0.19 mg/L.

Twelve-month moving average concentrations in the Taylor Creek/ Nubbin Slough Basin have remained relatively constant from October 1997 through June 1998 (averaging approximately 0.54 mg/L) (**Figure 2b**).

Chlorophyll a Concentrations

Chlorophyll *a* is a green pigment present in terrestrial and aquatic plants, including algae. This pigment functions to absorb visible light. The energy associated with the absorbed light is used to drive photosynthesis. Chlorophyll *a* concentrations are used to measure the living plant (or algal) material in a water body.

Naturally occurring algal populations present in Lake Okeechobee will, under certain weather and water quality conditions, form blooms. Algal blooms refer to dense concentrations of algae over large areas of a water body. Blooms can be composed of undesirable species harmful to other aquatic life, may form nuisance mats on the water surface, and create taste and odor in the potable water supply. If algal populations are large enough, they can also reduce oxygen levels in the water column during algal die-off resulting in invertebrate and fish kills.

Severe bloom conditions generally occur when chlorophyll *a* concentrations exceed 60 parts per billion (ppb). Concentrations between 40 and 60 ppb are indicative of moderate bloom conditions. The occurrence and effects of these bloom conditions on the lake depend on a variety of factors. However, persistence of bloom conditions over large areas may indicate an increase in nutrient concentrations.

Lake-wide chlorophyll *a* distributions for April through June 1998 are presented in **Figures 3a** through **3c**. During this period, chlorophyll *a* levels in Lake Okeechobee averaged approximately 20 ppb.

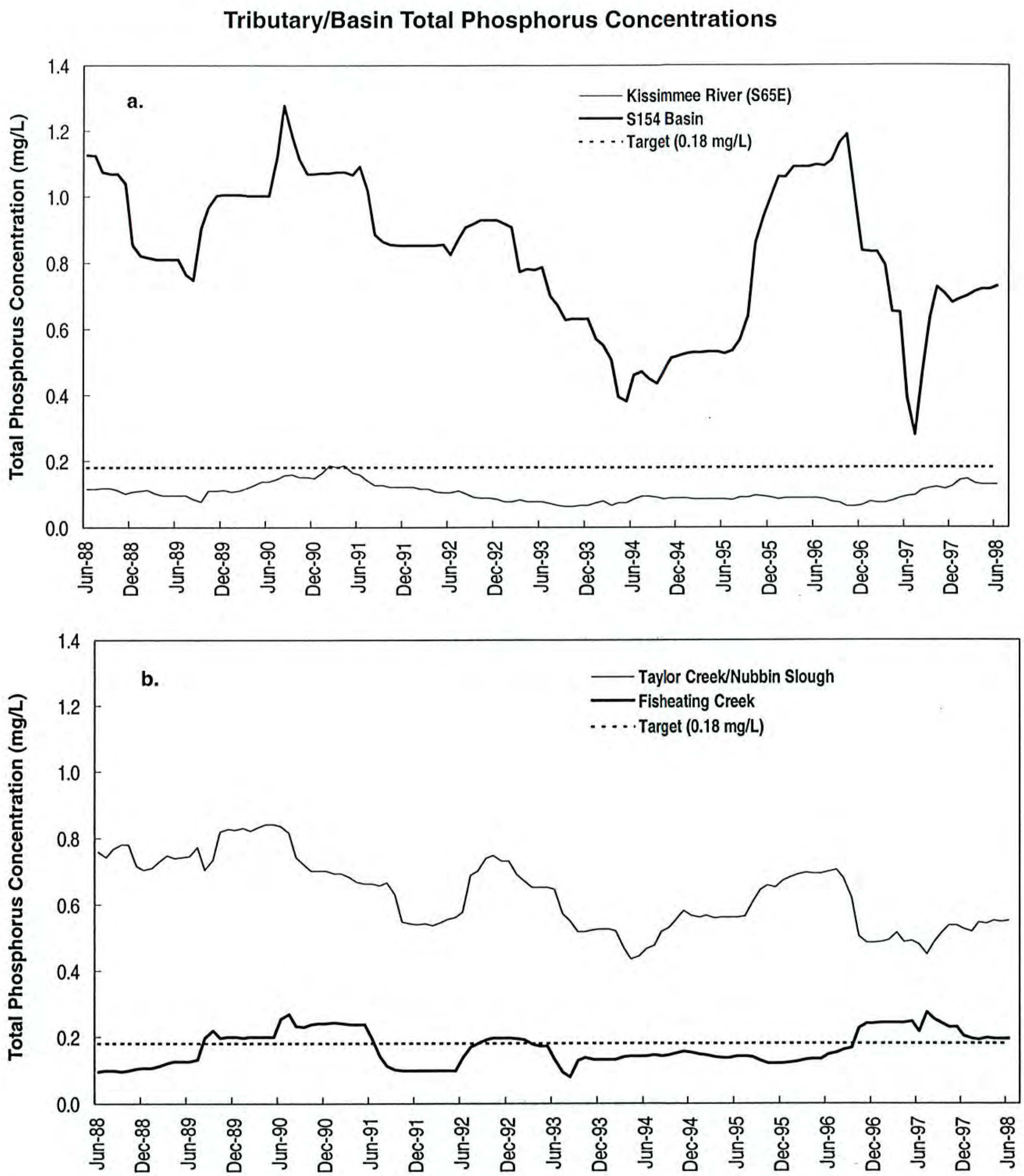


Figure 2. Twelve-month moving flow-weighted mean total phosphorus concentrations for four of the tributaries/ basins which drain into Lake Okeechobee.

During May 1998, an isolated moderate bloom condition was observed in the littoral zone located in the northwest portion of Lake Okeechobee (**Figure 3b**). This observed bloom covered approximately 2 percent of the surface water of the lake. In contrast, over 80 percent of Lake Okeechobee had chlorophyll *a* levels less than 20 ppb during May (**Figure 3b**).

No blooms were evident throughout the lake during either the April or June monitoring event (**Figure 3a** and **3c**). Chlorophyll *a* levels during both months were less than or equal to 20 ppb over the entire lake.

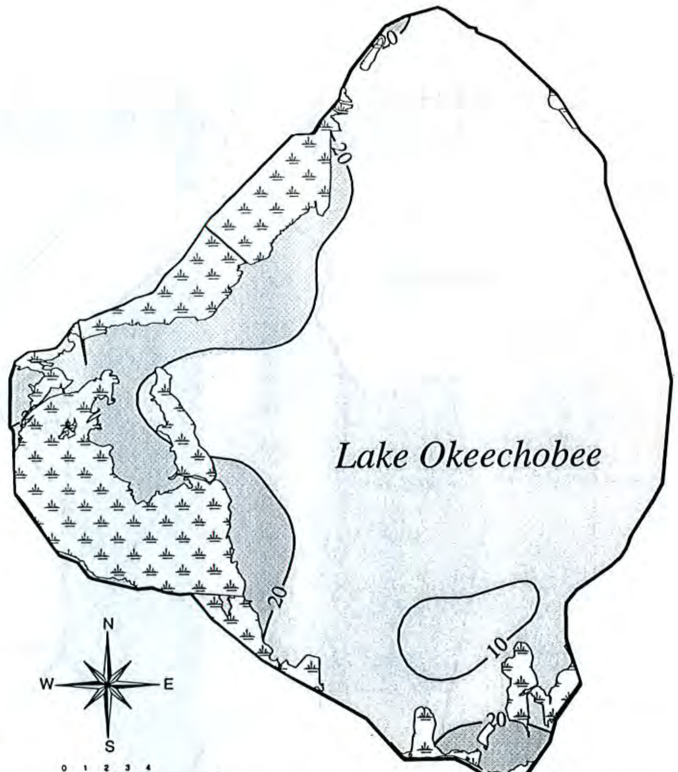


Figure 3a. Chlorophyll *a* values in Lake Okeechobee during the April 1998, sampling event.

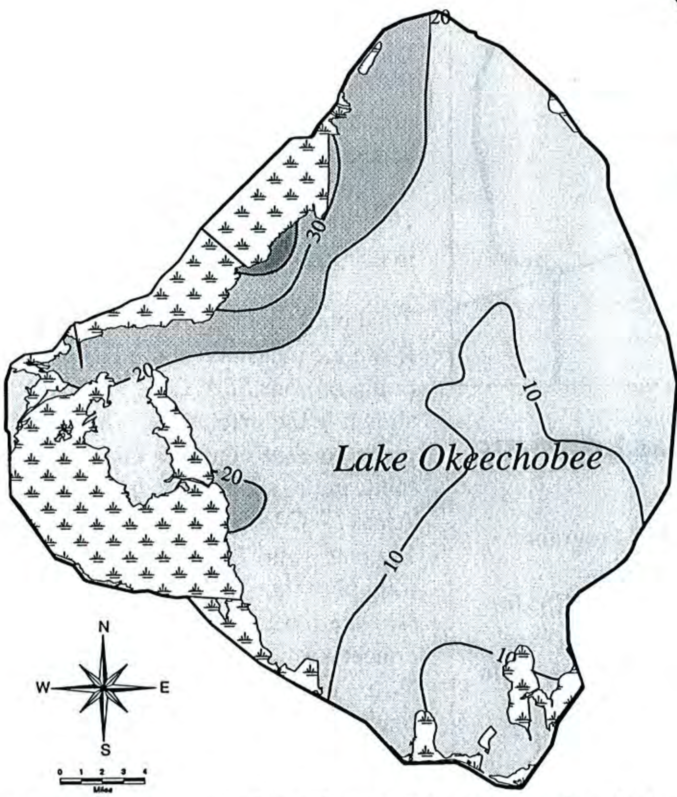
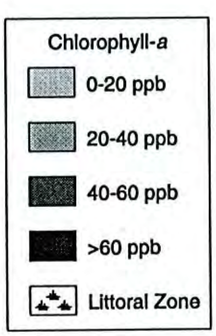


Figure 3b. Chlorophyll *a* values in Lake Okeechobee during the May 1998, sampling event.



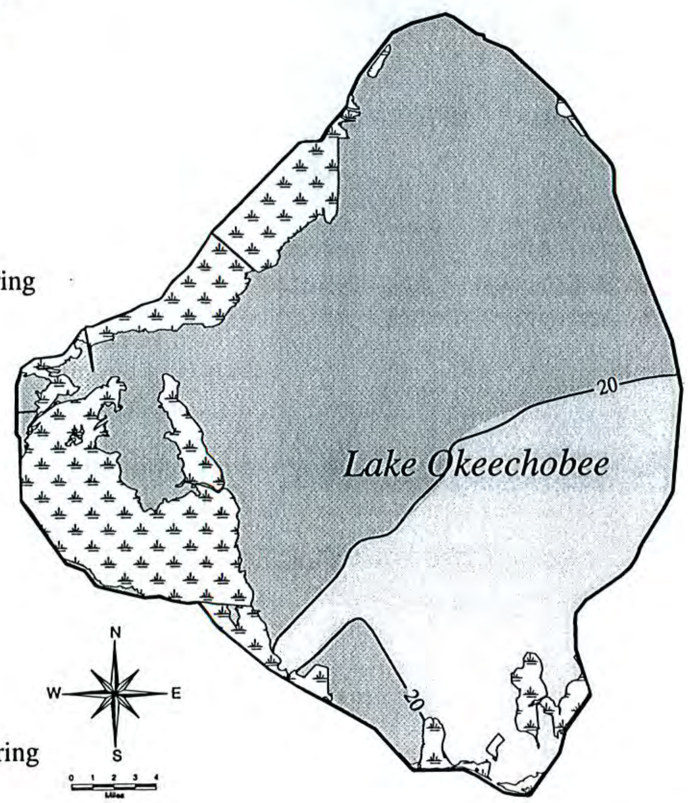
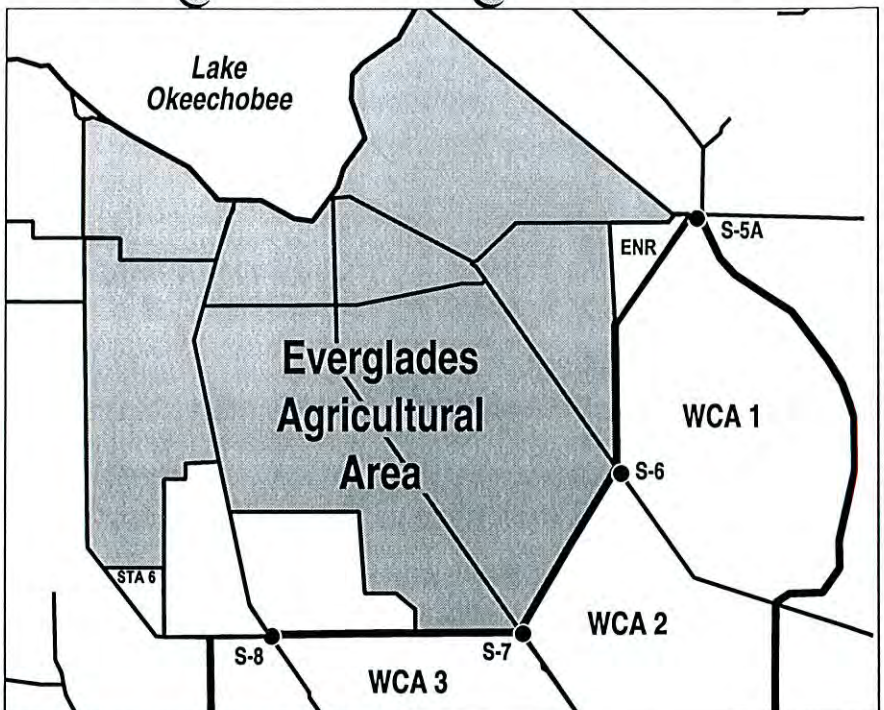


Figure 3c. Chlorophyll *a* values in Lake Okeechobee during the June 1998, sampling event.

Everglades Agricultural Area



Over the past three water years, phosphorus load reduction efficiency has decreased by approximately 35%. However, the 3-year moving average of 55% indicates a positive trend in load reduction.

Phosphorus Loading Trends

The Everglades BMP Program (Rule 40E-63, Florida Administrative Code (F.A.C.)) for the Everglades Agricultural Area (EAA) requires that the EAA basin achieve a 25 percent reduction in phosphorus discharge to the Everglades. This reduction is determined by comparing phosphorus discharges at the end of each 12-month water year period (May 1 through April 30) with the pre-BMP base period of October 1, 1978 through September 30, 1988. The first full year of BMP implementation was 1996.

Annual water year phosphorus load reductions calculated pursuant to Rule 40E-63, FAC, as well as the three-year moving average load reduction are presented in **Figure 4**. The 1998 water year (May 1, 1997 - April 30, 1998) exhibited a 34 percent reduction in phosphorus load, a drop from the 50 percent reduction of the previous water year. Over the past three water years, phosphorus load reduction efficiency has decreased by approximately 35%. However, the 3-year moving average of 55% indicates a positive trend in load reduction.

Unseasonably heavy rainfall during the first quarter of 1998 resulted in an unusually high total phosphorus load. The much drier conditions that occurred during the second quarter of 1998 produced low total phosphorus loads (**Figure 5**).

Total phosphorus concentrations and flows are measured at the District pump stations S5A, S6, S7, and S8 shown in the map above. These four pump stations convey a majority of the water to the Water Conservation Areas (WCAs) from the EAA. **Figures 6** and **7** present calculated total phosphorus loads and flow-weighted mean total phosphorus concentrations which enter WCAs. With the exception of S8, flows and loads at all the sites were lower in June 1998 than for the same month in previous years. Total phosphorus concentrations at S5A are typically higher than at the other pump stations. However, phosphorus concentrations measured at S5A and two of the pump stations (S6 and S7) in June 1998 were comparable.

High flows and accompanying total phosphorus loads at S8 for May and June were the result of District efforts to lower the higher-than-normal water level in Lake Okeechobee prior to the hurricane season.

Since last quarter, the phosphorus loads entering Storm Water Treatment Area 6 (**Figure 11**) have been included as part of the EAA phosphorus load calculation. During the second quarter of 1998, phosphorus loads entering STA 6 ranged from 0.0 to 0.8 metric tons compared to 0.0 to 0.3 metric tons at the by-pass and outflow from STA 6.

A summary of monthly flows measured at each structure during the second quarter of 1998 is presented in **Table 1**. In addition, total phosphorus loads for each structure during the reporting period are summarized in **Table 2**. Flow-weighted mean total phosphorus concentrations determined at the four pump stations during the second quarter of 1998 are presented in **Table 3**. Overall, flow-weighted mean concentrations at the four pump stations varied as a function of flow.

Table 1. EAA Pump Station Flows (cfsd)

	Apr-98	May-98	Jun-98
S5A	3,087	5,667	1,805
S6	10,492	14,720	4,379
S7	1,504	4,496	1,951
S8	0	14,046	17,359

Table 2. EAA Pump Station Loads (metric tons/month)

	Apr-98	May-98	Jun-98
S5A	1.1	4.0	0.4
S6	2.5	3.7	1.0
S7	0.3	1.0	0.4
S8	0.0	3.6	3.4

Table 3. EAA Pump Station Flow-weighted Mean Concentrations (ppb)

	Apr-98	May-98	Jun-98
S5A	146	288	92
S6	98	103	90
S7	88	92	94
S8	0	105	81

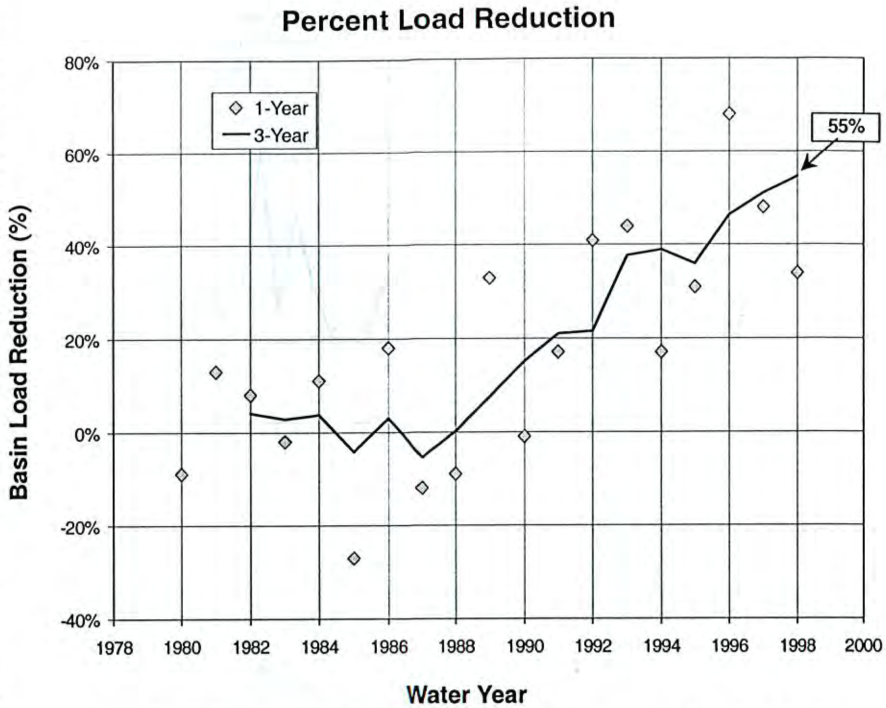


Figure 4. EAA Basin total phosphorus load reduction trends calculated in accordance with Rule 40E-63, F.A.C.

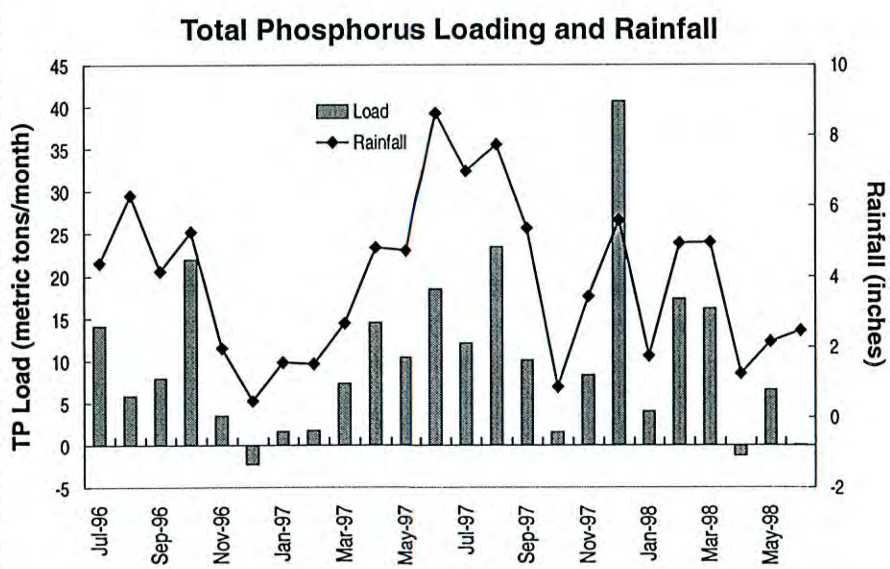


Figure 5. Monthly total phosphorus loads entering the WCAs from the EAA and monthly rainfall for the EAA.

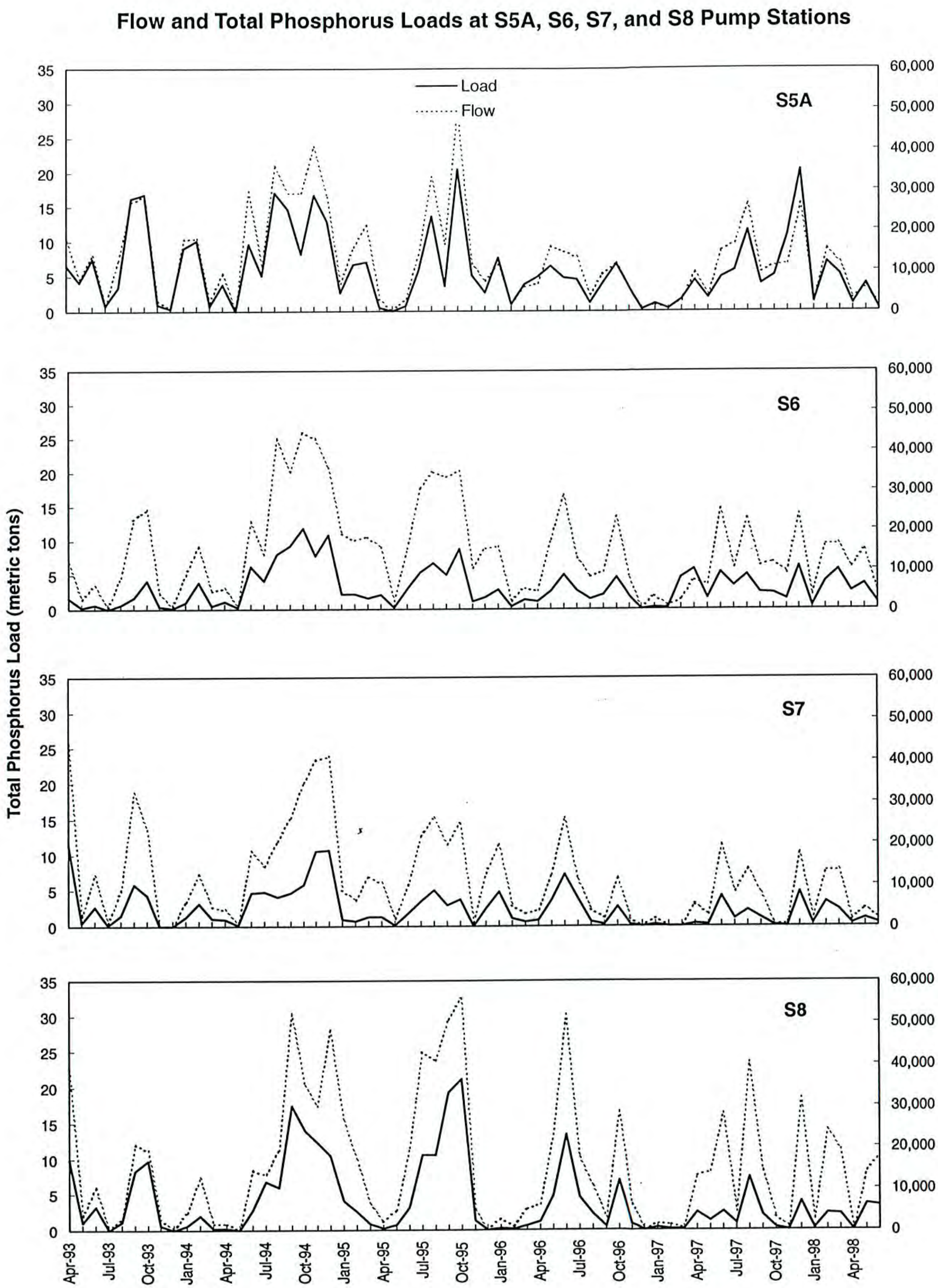


Figure 6. Monthly flows and calculated phosphorus loads at major EAA pump stations.

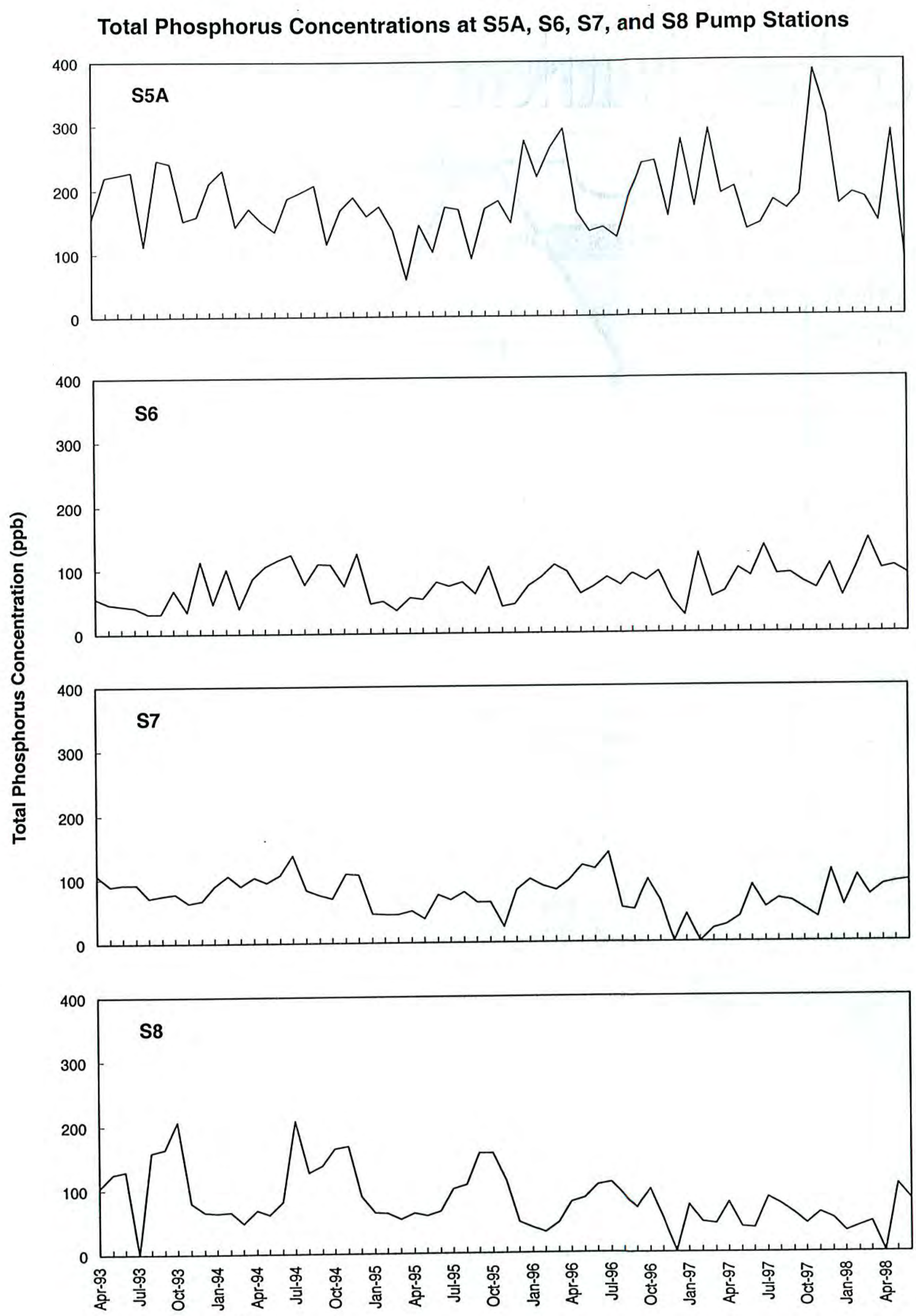
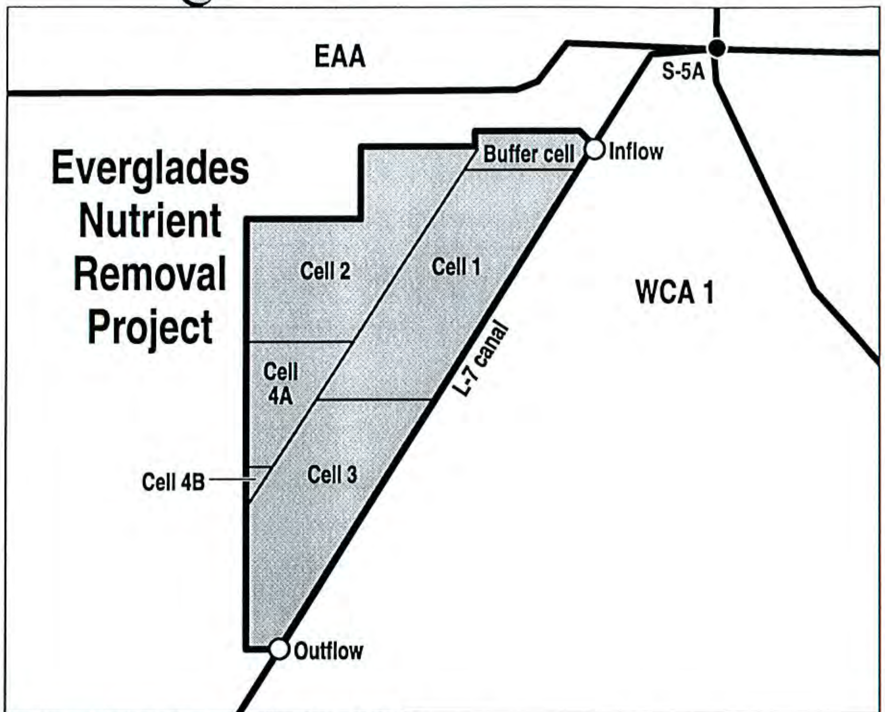


Figure 7. Monthly flow-weighted total phosphorus concentrations at major EAA pump stations.

Everglades Nutrient Removal Project



The average monthly total phosphorus load reductions for April, May and June 1998 were 47%, 84% and 93%, respectively. The overall average monthly load reduction since November 1994 is 76%.

The Everglades Nutrient Removal Project (ENR) is a prototype for a series of Stormwater Treatment Areas (STAs) designed to reduce total phosphorus loads from agricultural wastewater prior to its release it into the Everglades.

Phosphorus Concentrations

Specific Condition 5 of the Florida Department of Environmental Protection (FDEP) permit number 502232569, which authorizes the operation of the ENR, requires that progress be made toward reducing the total phosphorus load in the waters destined for the Everglades. The primary performance objective of the ENR Project is to ultimately achieve a long-term average of 75% phosphorus load reduction before it is released into the Loxahatchee National Wildlife Refuge (WCA 1). **Figure 8** demonstrates that the ENR Project has maintained a load reduction of greater than 75% except for the 12-month period ending in December 1997, when reduction was slightly lower at 74%. As a demonstration project for larger-scale application of stormwater management system technology, the ENR project will also be evaluated as to its ability to achieve, in combination with the implementation of Best Management Practices (BMPs), a long term annual flow-weighted mean total phosphorus concentration of 50 ppb or less as a secondary performance objective.

Water flowing into the ENR from the EAA is filtered through a four-cell wetland system. Each cell contains different combinations of aquatic plants from the Everglades with an affinity for removing total phosphorus and other contaminants. Approximately 28 days are required for inflow water to travel through the system. The percent reduction of

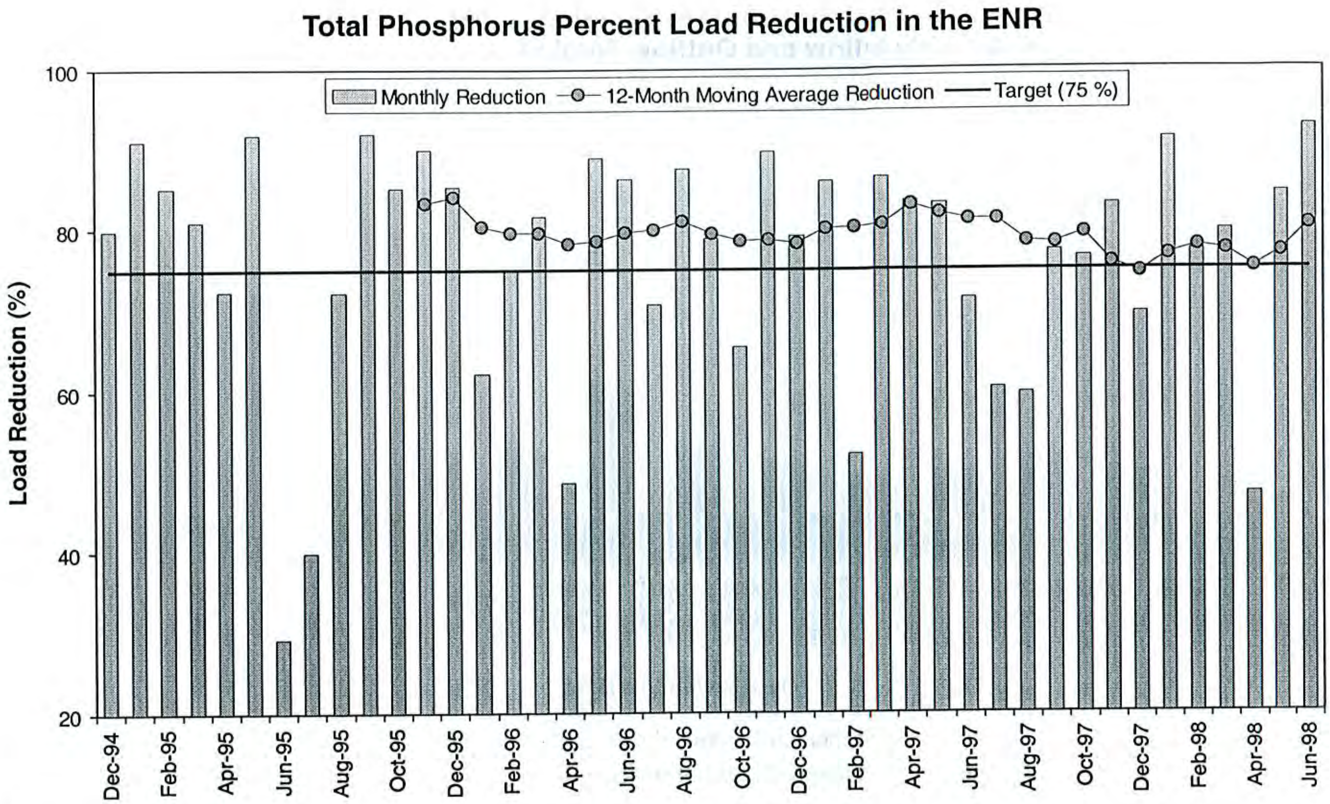


Figure 8. Monthly percent reduction of total phosphorus in the ENR Project.

total phosphorus is determined by comparing the total phosphorus load at the outflow with the total phosphorous load at the inflow during the previous month **(Figure 9)**.

Results from the ENR Project have validated the premise that constructed wetlands (i.e. STAs) on former agricultural land can effectively remove total phosphorus from EAA runoff and achieve the interim outflow concentration limit of 50 ppb or less as shown in **Figure 10**.

The monthly total phosphorus load reduction for April, May, and June were 47%, 84%, and 93%, respectively.

The monthly average flow-weighted mean total phosphorus concentrations at inflows to the ENR were 90, 160 and 130 ppb in April, May, and June, respectively. Even though inflow concentrations from May and June were among the highest in the past year of monitoring, outflow concentrations were comparable to those reported for previous months **(Figure 10)**. The outflow concentrations were 30, 20, and 30 ppb for April through June, respectively.

Mercury Concentrations

The mercury data for both inflow and outflow stations in the ENR are currently under review and were not available for inclusion in this Water Quality Conditions Quarterly Report.

ENR Monthly Inflow and Outflow Total Phosphorus Loads

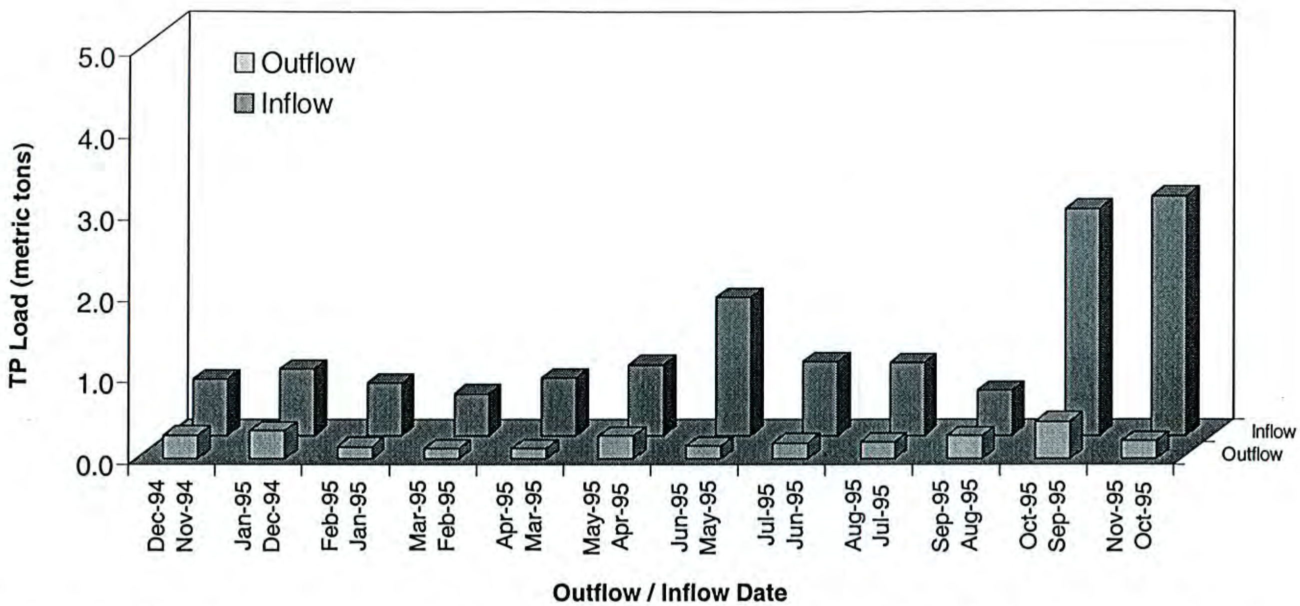


Figure 9. Monthly average flow-weighted mean total phosphorus loads for the ENR Project. Each pair of bars is labeled with two dates. The first date (the later month) refers to the outflow and the second date (the earlier month) refers to the inflow.

Total Phosphorus Concentrations at Inflow and Outflow Sites at ENR

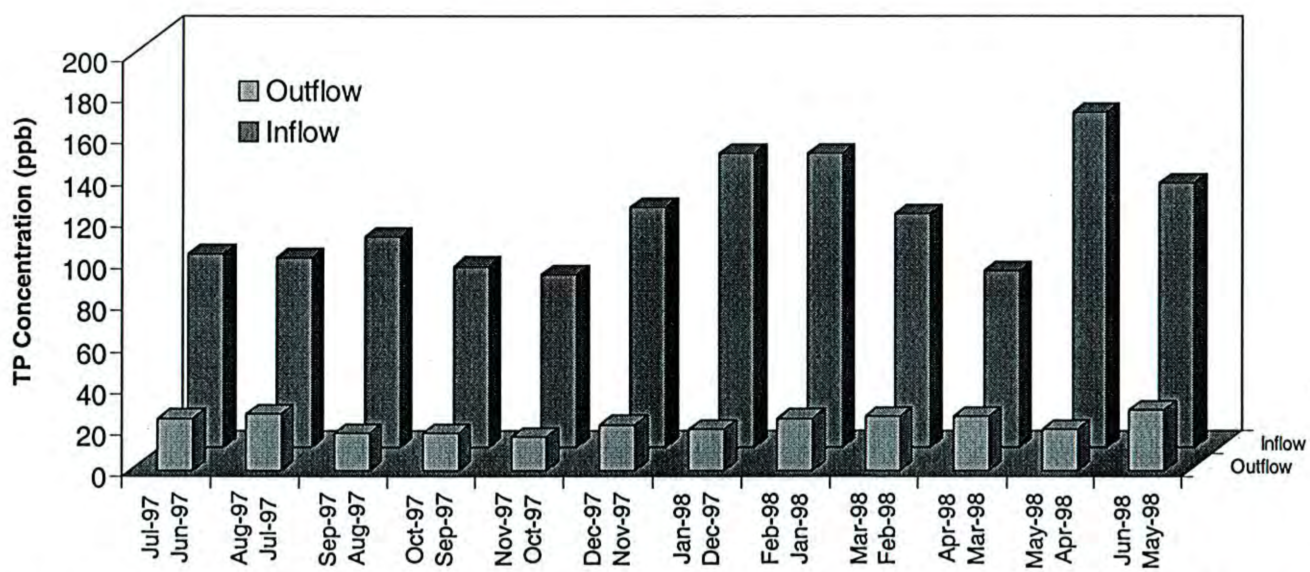
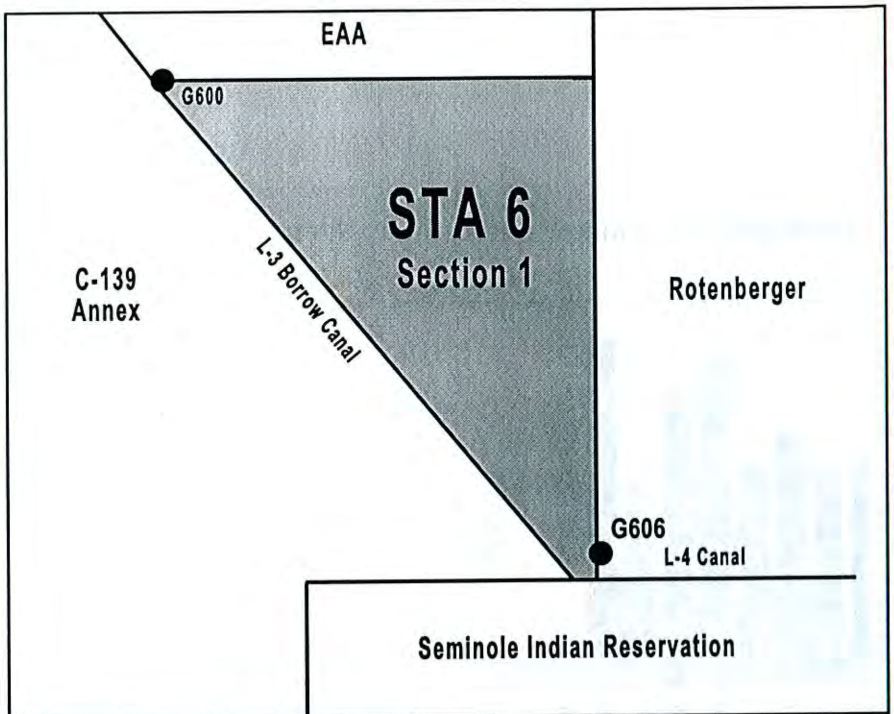


Figure 10. Monthly average flow-weighted mean total phosphorus concentrations for the ENR Project. Each pair of bars is labeled with two dates. The first date (the later month) refers to the outflow and the second date (the earlier month) refers to the inflow.

Storm Water Treatment Area 6



Drought conditions during first and second quarters of 1998 resulted in few flow proportion water quality samples being collected at the STA-6 inflow and outflow sites. The average reduction in total phosphorus concentrations since the project began in December 1997 is 66%.

Background

Stormwater Treatment Area 6 (STA6), Section 1 began full operation on December 9, 1997. It occupies an existing detention area associated with United States Sugar Corporation's (USSC) Southern Division Ranch, Unit 2 development, except for one acre which is within the adjacent Rotenberger Tract. STA6 provides a total effective treatment area of approximately 870 acres. The source of water for STA6 comes solely from USSC's Unit 2 pump station.

Phosphorus Concentrations

Based on the 1992 Settlement Agreement, all Storm Water Treatment Areas (STAs) are to achieve a long term average flow-weighted mean total phosphorus concentration of 50 ppb or less at points of discharge from the EAA into the WCAs. Because of drought conditions that occurred during the first and second quarters of 1998, very little flow was measured at both inflow and outflow sites. As a result, only three samples were collected at the inflow site (G600), and only one sample was collected at outflow site G606 (**Figure 11**). For the second quarter of 1998, total phosphorus concentrations at the inflow averaged 70 ppb, while the outflow averaged 28 ppb. The total phosphorus concentration was reduced by 60% during the second quarter of 1998. This amount is based on one sample collected at the beginning of April. Overall reduction in phosphorus concentrations has averaged 66% since the project began in December 1997.

Total Phosphorus Concentrations at Inflow and Outflow Sites at STA6

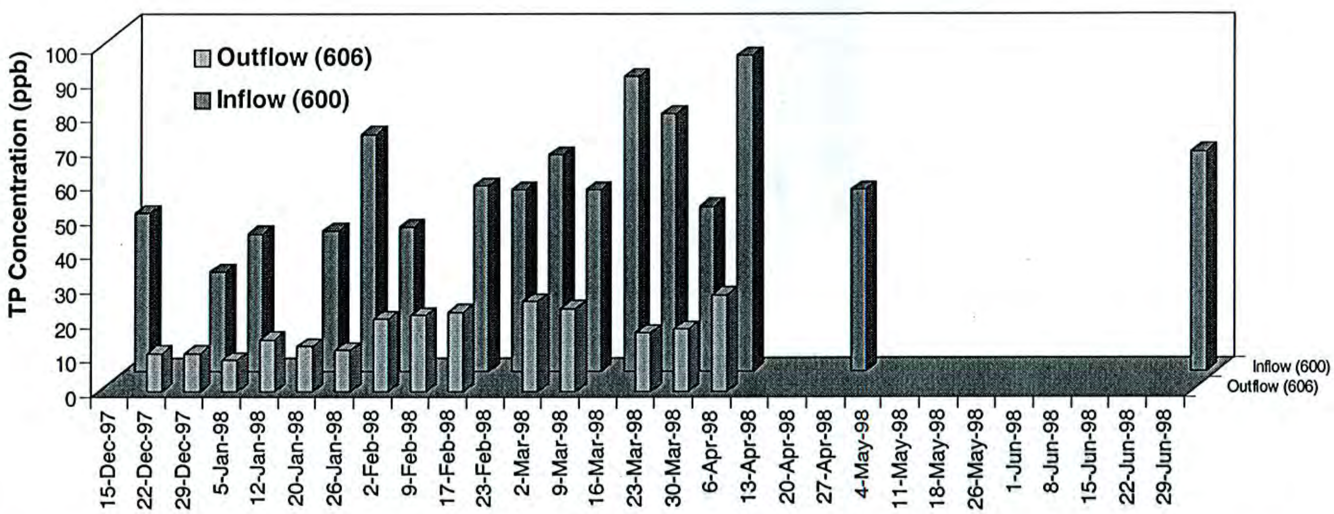
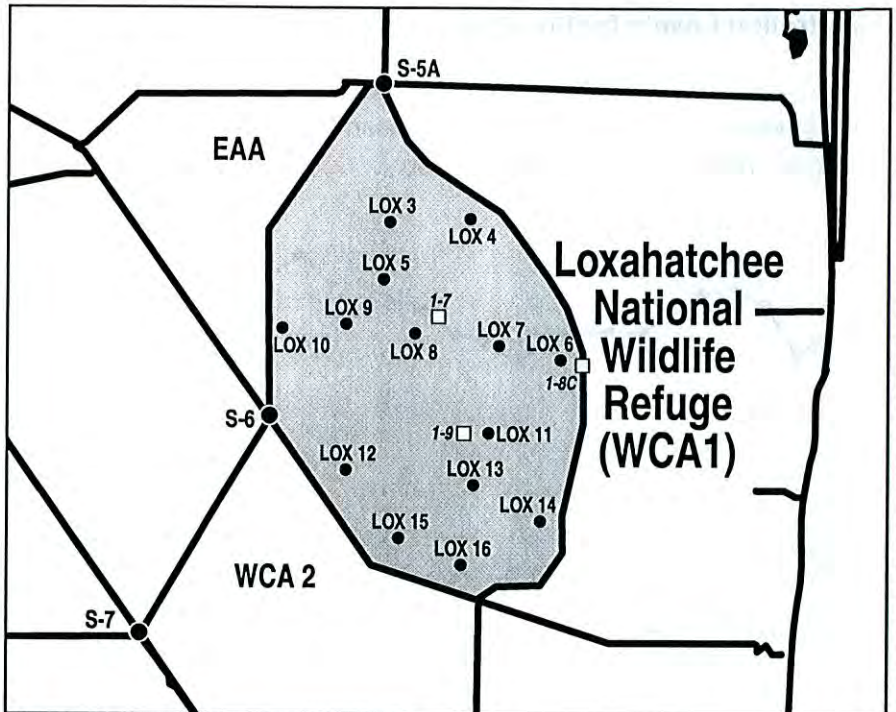


Figure 11. Comparison of the weekly autosampler composite total phosphorus concentrations from the inflow and outflow sites within STA 6, Section 1.

Loxahatchee National Wildlife Refuge

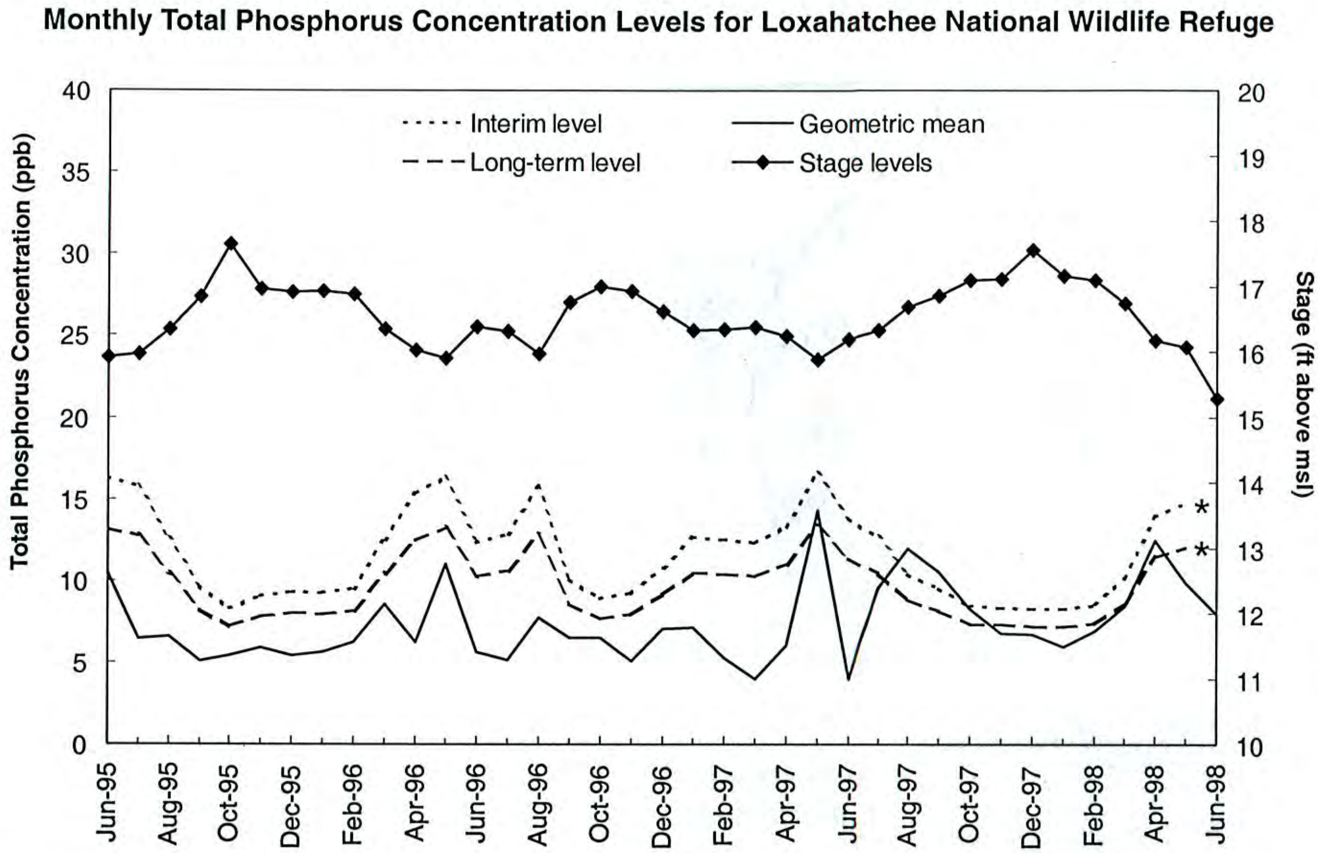


The geometric mean concentrations were below the interim and long-term concentration levels in April and May. The levels could not be calculated for June because the average stage was too low.

Phosphorus Concentrations

The Settlement Agreement entered into by the federal government, the State of Florida and the District in 1992 to end the Everglades lawsuit stipulates interim and long-term phosphorus concentration levels for the Loxahatchee National Wildlife Refuge (WCA1). The interim and long-term concentration levels must be met by February 1, 1999 and December 31, 2006, respectively. These target concentrations vary monthly because they are calculated as a function of water stage levels measured at three gaging stations (1-7, 1-8C, and 1-9) within the Refuge. Total phosphorus concentrations are determined in water samples collected at the 14 interior marsh stations (Lox 3 through Lox 16) shown on the map above.

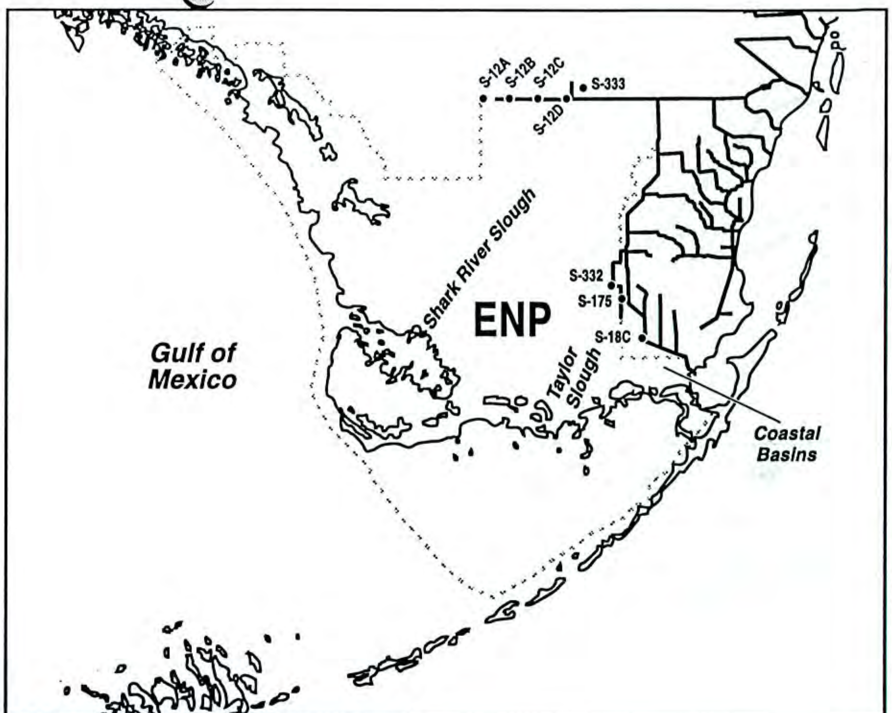
The geometric means calculated from total phosphorus concentrations measured in water samples collected in April, May and June 1998 were 12.4, 9.8 and 7.9, respectively. These mean concentrations were below the interim and long-term concentration levels in April and May (**Figure 12**). The calculated interim and long term limits in April were 13.9 and 11.4 ppb, respectively. In May, the calculated interim and long term limits were 14.8 and 12.1 ppb, respectively. The average stage for June 1998 was 15.3 feet. This level is below the minimum stage of 15.4 feet required by the Settlement Agreement to calculate valid phosphorus concentration limits. Therefore, no limits were calculated for June. The average stages for April and May were 16.2 feet and 16.1 feet, respectively.



* Limits were not applicable for the June 1998 sampling event because the average stage was lower than 15.4 feet.

Figure 12. Monthly total phosphorus geometric mean concentration levels for the Loxahatchee National Wildlife Refuge compared to the interim and long-term targets. The observed concentrations and targets are adjusted for fluctuations of water elevation.

Everglades National Park



The 12-month moving average total phosphorus concentration for Shark River Slough during the second quarter of 1998 was 8.8 ppb. For Taylor Slough and the Coastal Basins the 12-month moving flow-weighted mean concentrations were 10.3 ppb for April and May and 6.6 ppb for June 1998.

Shark River Slough

The Settlement Agreement of 1992 also set separate interim and long-term total phosphorus concentration limits for Shark River Slough to be met by October 1, 2003 and December 31, 2006, respectively. The long-term total phosphorus concentration limit for inflows into Shark River Slough represents the concentrations delivered during the Outstanding Florida Waters baseline period of March 1, 1978 to March 1, 1979, and is adjusted for variations in flow. In addition, the Settlement Agreement requires that phosphorus concentrations be presented as 12-month moving flow-weighted means.

Inflow concentrations of total phosphorus to the Everglades National Park through Shark River Slough are compared to the interim and long-term limits at the end of each water year, i.e. September 30. As indicated in **Figure 13a** both limits have not been exceeded for the last three water years of monitoring.

Composite total phosphorus concentrations for each sampling event and the associated 12-month moving flow-weighted mean concentrations for the last two years at inflow structures S12A, S12B, S12C, S12D, and S333 are presented in **Figure 13b**. Sampling event data are included in this figure to indicate the variation in total phosphorus concentrations at inflow points over time.

The Settlement Agreement stipulates that the frequency of composite concentrations greater than 10 ppb total phosphorus in a water year must not exceed a calculated value based on annual flow through the five inflow structures. During the 12-month period ending June 1998 the percent of samples that had total phosphorus concentrations greater than 10 ppb was 42.9. This value is lower than the allowable limit of 43.4 percent of samples exceeding the 10 ppb limit.

The 12-month moving average total phosphorus concentration for April 1998 was 8.6 ppb. Flow-weighted mean concentrations of total phosphorus for the 12-month periods ending May and June 1998 were both 8.8 ppb.

Taylor Slough and The Coastal Basins

Under the Settlement Agreement, a single limit for total phosphorus of 11 ppb (to be met by December 31, 2006) was set for Taylor Slough and the Coastal Basins. This limit is compared with the 12-month moving flow-weighted mean concentration

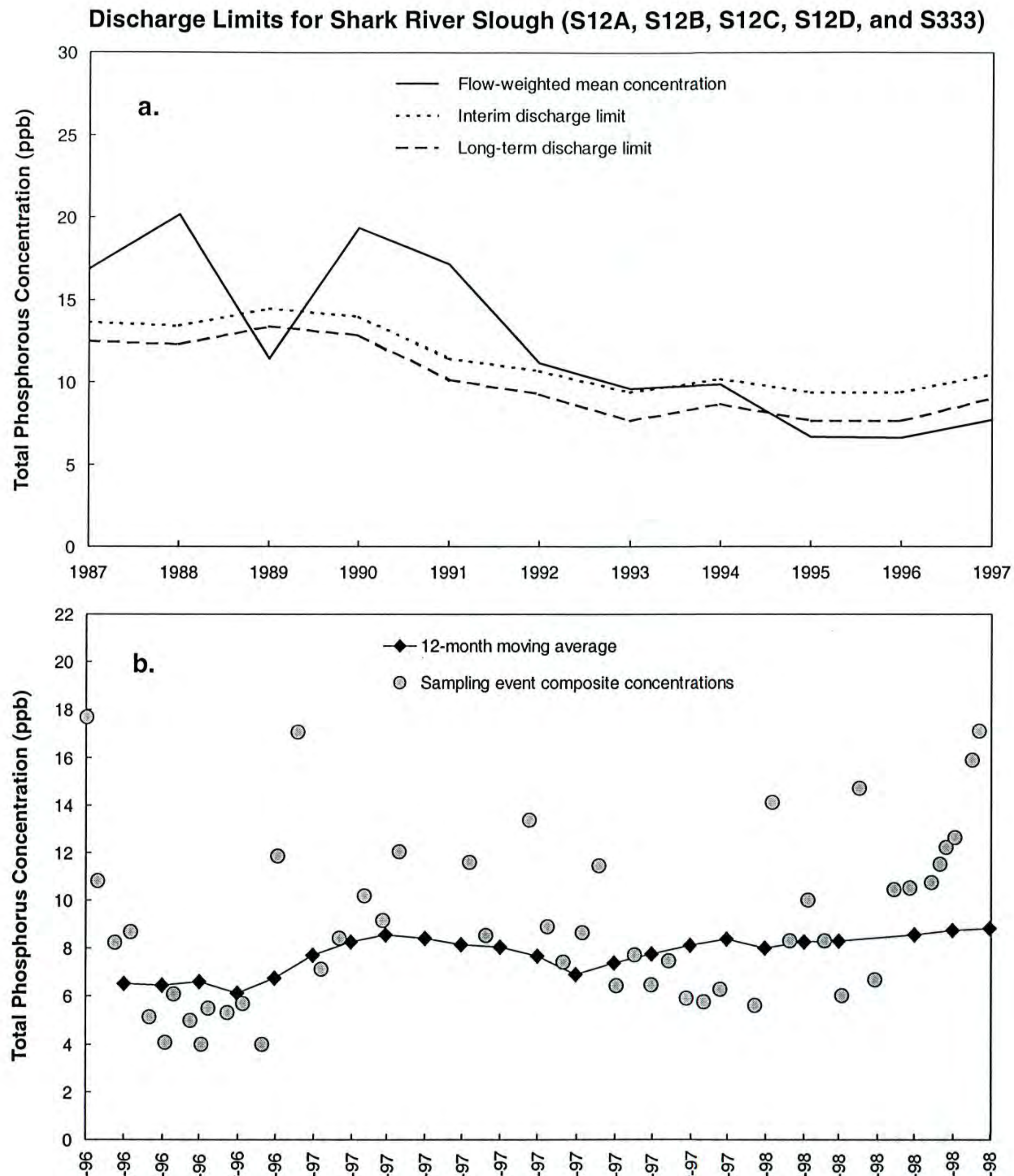


Figure 13. 12-month moving flow-weighted mean total phosphorus concentrations in the inflows to Everglades National Park (ENP) through Shark River Slough compared to the interim and long-term targets. **a.** Concentrations at the end of each water year. **b.** 12-month moving average concentration at the end of each month and the composite concentration for each sampling event.

entering the ENP through Taylor Slough and the Coastal Basins at the end of each water year, i.e. September 30.

The flow-weighted mean concentration for Water Year 1997 was 9.8 ppb (**Figure 14a**). The flow-weighted mean concentrations of total phosphorus for the 12-month periods ending April and May 1998 were both 10.3 ppb, respectively (**Figure 14b**). The 12-month period ending in June 1998 had a flow-weighted mean concentration for total phosphorus of 6.6 ppb (**Figure 14b**).

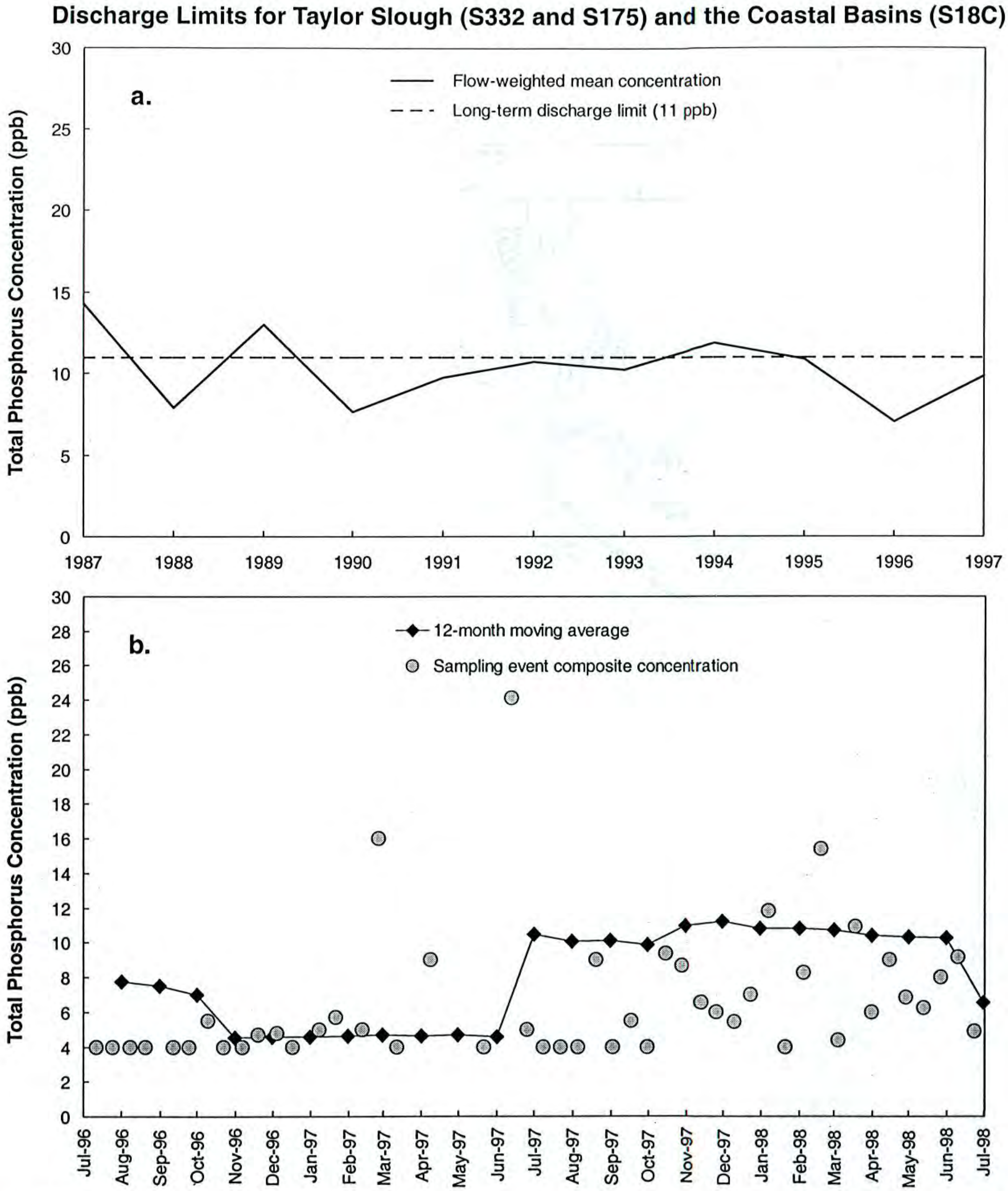
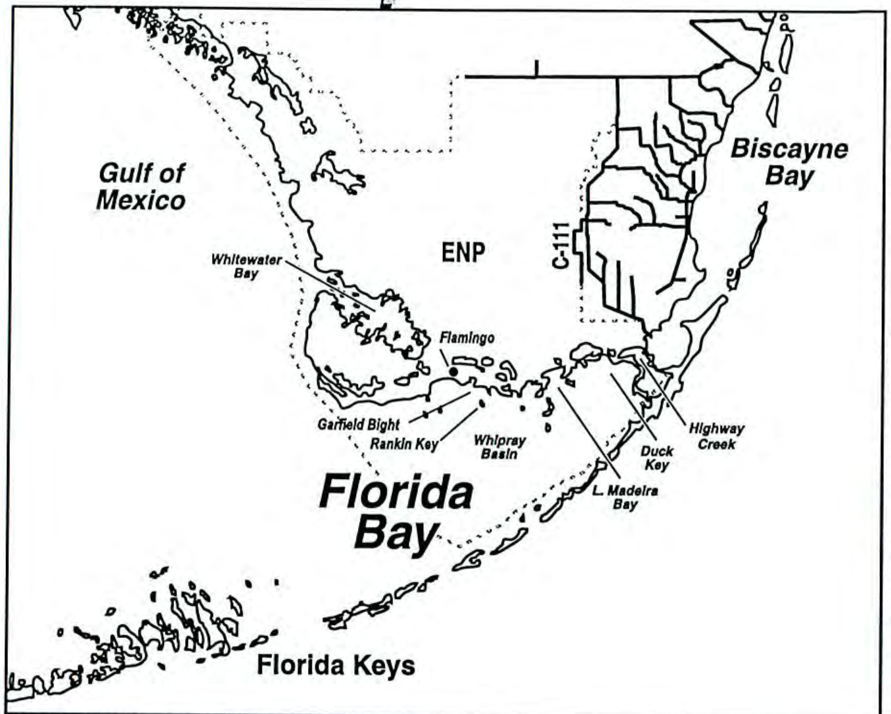


Figure 14. 12-month moving flow-weighted mean total phosphorus concentrations in the inflows to Everglades National Park (ENP) through Taylor Slough and the Coastal Basins compared to the long-term target. **a.** Concentrations at the end of each water year. **b.** 12-month moving average concentration at the end of each month and the composite concentration for each sampling event.

Figure 14b also presents composite total phosphorus concentrations for each sampling event and the associated 12-month moving flow-weighted mean concentrations at the two points of inflow to Taylor Slough (S332 and S175) and the inflow point to the Coastal Basins (S18C). The Settlement Agreement also stipulates that the frequency of composite samples greater than 10 ppb total phosphorus in a water year must not exceed a fixed value of 53.1 percent. For the 12-month period ending in March 1998, only 13 percent had concentrations greater than 10 ppb.

Florida Bay



Salinities measured at stations in Florida Bay during the first half of 1998 were within their historical ranges. Chlorophyll a levels observed during the second quarter of 1998 were similar to or lower than those reported for the same period in 1997.

As part of the Everglades Forever Act, the District, in collaboration with the Everglades National Park and Florida International University, is required to monitor water quality in Florida Bay. Salinity and chlorophyll *a* are used as indicators of water quality within Florida Bay.

Salinity

As an estuary, Florida Bay requires a properly maintained salinity regime for the overall ecological health of the bay. Salinity is defined as the grams of salt dissolved in a kilogram of water and is expressed in units of parts per thousand (ppt). Within the bay, salinity is affected by freshwater input, in the form of rainfall and surface water runoff from the Everglades and tidal transport that introduces seawater into the bay from the Gulf of Mexico. Because the bay is a shallow and wide lagoon, evaporation will also affect salinity.

When evaporation exceeds freshwater input, portions of the bay can become hypersaline. Water conditions in the bay are considered hypersaline when salinity exceeds 35 ppt, which is the approximate mean salinity of ocean water.

Salinities measured at monitoring sites in Florida Bay from April through June 1998 are shown in **Figures 15a**, **15b**, and **15c**. Salinity levels over most of the bay during the April 1998 monitoring event were less than 35 ppt (**Figure 15a**). However, one station located in the southern boundary of the bay exhibited hypersaline conditions. Salinities measured in Florida Bay for the April monitoring ranged from 5.0 ppt to 36.6 ppt.

Hypersaline conditions were observed in the central portion of Florida Bay during both May and June monitoring events (**Figures 15b** and **15c**). Salinity average 29.5 ppt in May compared with 26.9 ppt in April. Additionally, salinities measured in May ranged from 6.0 to 38.7 ppt. In June, salinities in Florida Bay averaged 31.4 ppt and ranged from 3.9 to 42.7 ppt.

During both May and June, the central portion of Florida Bay (from Whipray basin north to Garfield Bight) exhibited the highest salinity levels (**Figure 15c**). This area of the bay contains small basins surrounded by shallow seagrass banks that extend towards the western edge of Florida Bay. As a result of the bathometry of this region it is especially vulnerable to hypersaline conditions. Lower runoff during this seasonally drier period also contributed to the elevated salinities

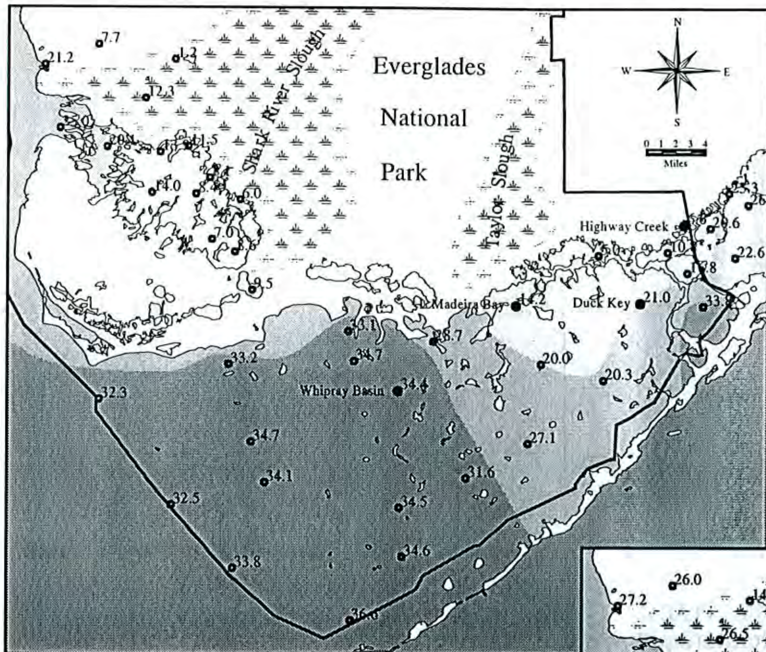


Figure 15a. Salinity in Florida Bay and waters along the western coast of the Everglades National Park for April 1998 (Data collected by Florida International University).

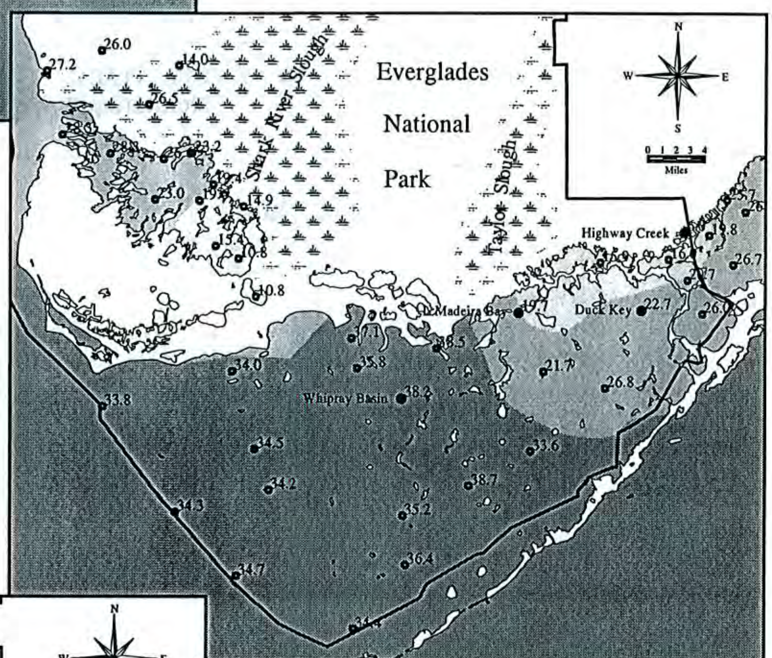


Figure 15b. Salinity in Florida Bay and waters along the western coast of the Everglades National Park for May 1998 (Data collected by Florida International University).

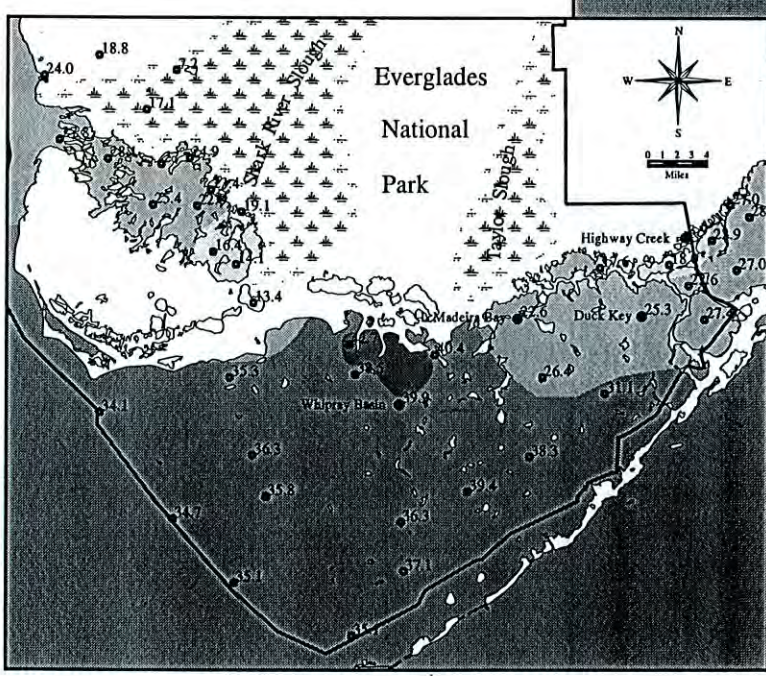


Figure 15c. Salinity in Florida Bay and waters along the western coast of the Everglades National Park for June 1998 (Data collected by Florida International University).

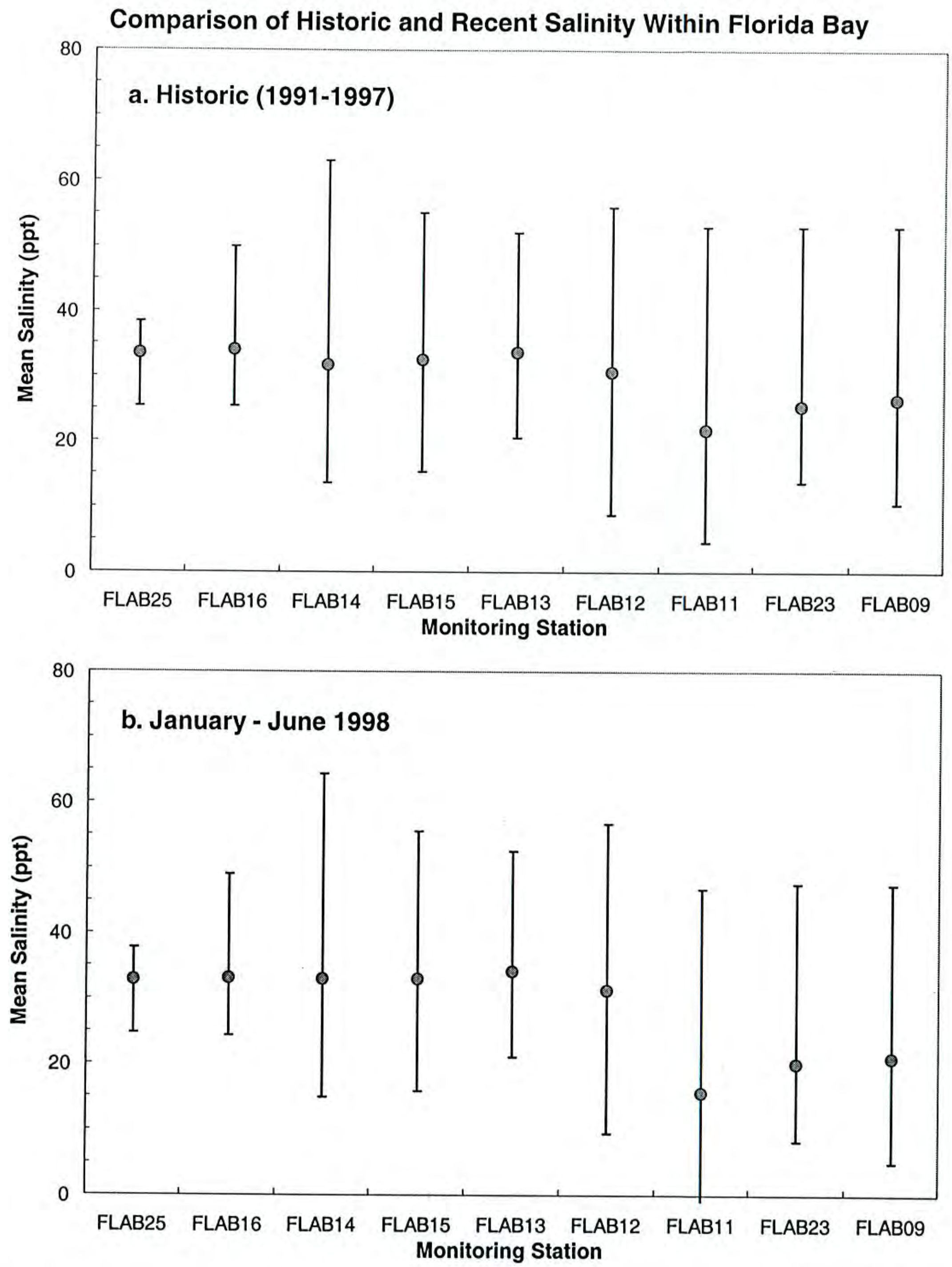


Figure 16. Comparison of historic salinity **a.** with salinities measured during the first six months of 1998 **b.** at nine stations in Florida Bay. Closed circles indicate mean concentration and error bars indicate range in salinity.

observed during the second quarter of 1998, especially in May and June.

Overall, salinities measured in Florida Bay during the second quarter of 1998 were lower than those recorded during same period in 1997.

Figure 16 compares mean salinity and range of salinity at 9 stations in Florida Bay for the historic (1991 - 1997) period and the first half of 1998. Stations were selected along a west to east transect to depict salinity changes from the Gulf of Mexico to the eastern boundaries of Florida Bay.

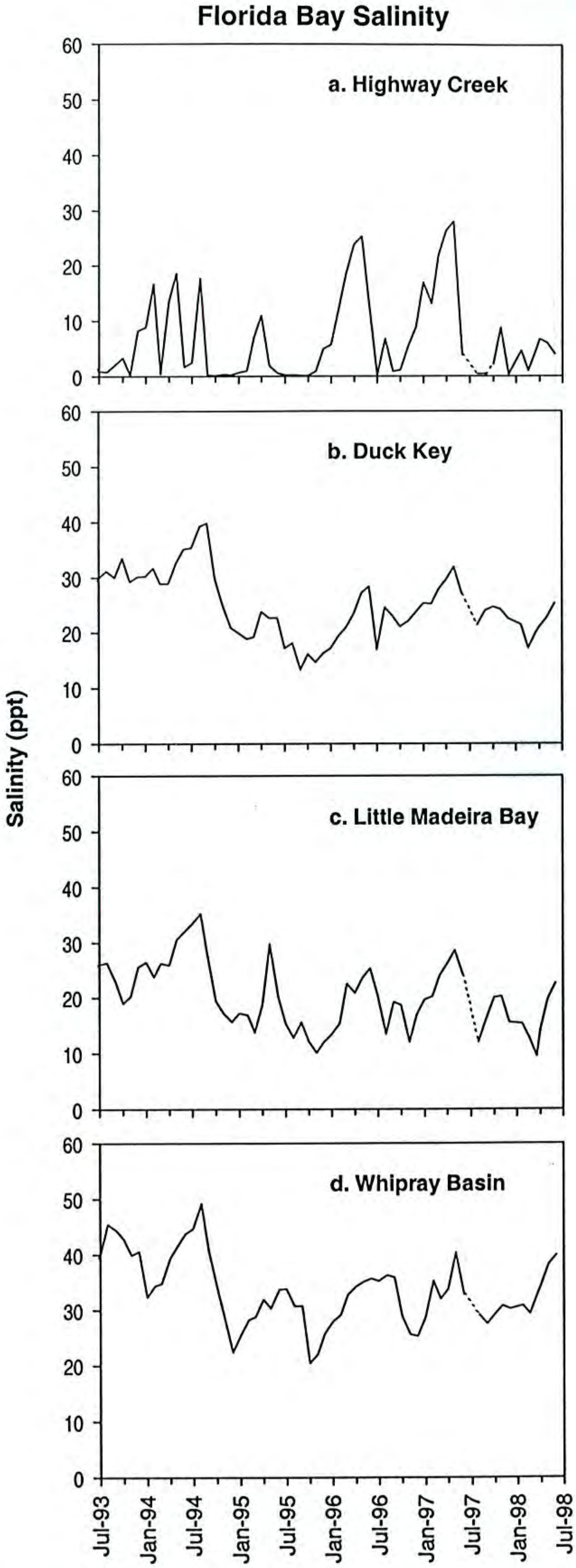


Figure 17. Salinity at four sites in Florida Bay from July 1, 1993 through June 30, 1998. Data are from individual grab samples collected monthly (dashed line indicates missing data).

The overall mean salinity at the 9 monitoring stations during the first half of 1998 were slightly lower than the mean historic salinity for these stations. In the eastern section of the bay salinities in the first half of 1998 averaged 5 to 6 ppt lower than during the historic period (**Figure 16**). Similar differences in average salinities were observed at stations in the western portion of Florida Bay for both periods. Monitoring stations located in the central portion of Florida Bay exhibited slightly higher mean salinities for the first six months of 1998 compared with the period from 1991 through 1997. Overall, salinities measured at the 9 monitoring stations during the first half of 1998 were within their respective historical range (**Figure 16**).

Salinity measurements made during the last five years at monitoring sites in Highway Creek, Duck Key, Little Madeira Bay and Whipray Basin are presented in **Figure 17.** A summary of salinities recorded from March 1998 through June 1998 for these monitoring stations are presented in **Table 4.**

The four monitoring stations located in Florida Bay generally exhibited a decrease in salinities from March 1997 through March 1998 (**Figure 17**). During the second quarter of 1998, salinities increased at Duck Key, Little Madeira Bay and Whipray Basin (**Table 4**). In contrast, Highway Creek, due to its proximity to a freshwater source, exhibited decreasing salinities during the second quarter (**Table 4**). The magnitude of the change in salinity at each site varied as a function of distance from a freshwater source. Decreased rainfall and freshwater inputs as well as increased evaporation in the bay resulted in higher salinities.

Table 4. Salinity (ppt)

	Mar-98	Apr-98	May-98	Jun-98
Highway Creek	4.7	6.6	6.0	3.9
Duck Key	19.9	21.0	22.7	25.3
L. Madeira Bay	9.5	14.2	19.7	22.6
Whipray Basin	32.8	34.4	38.2	39.9

Chlorophyll a Concentrations

Large areas of dense algal communities can affect the overall health of the Florida Bay ecosystem. Chlorophyll *a* concentrations measured in the bay are an indicator of algae (phytoplankton) biomass. Regional chlorophyll *a* concentrations in Florida Bay and the west coast of the Everglades National Park are depicted in **Figures 18a, 18b** and **18c** for the months of April through June 1998.

Florida Bay Chlorophyll *a* Concentrations

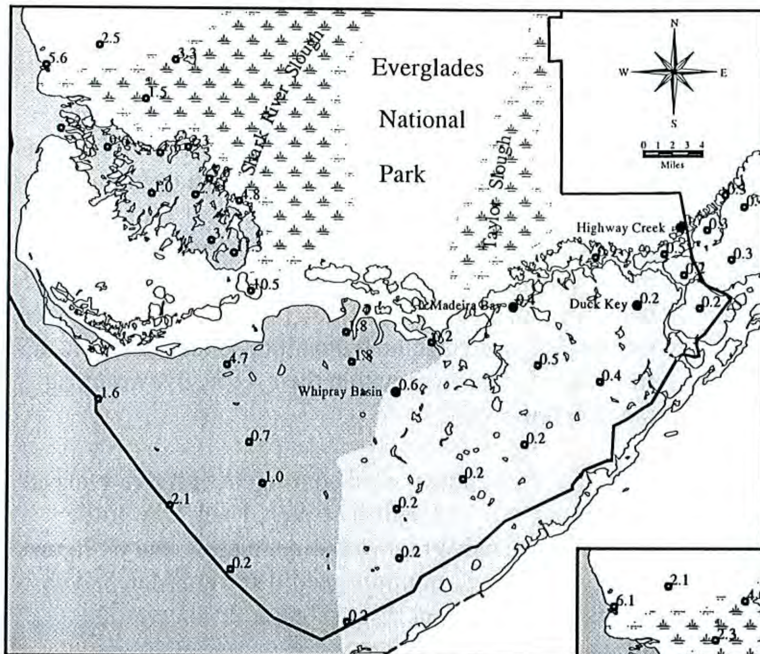


Figure 18a. Concentrations of chlorophyll *a* in Florida Bay and waters along the western coast of the Everglades National Park for April 1998 (Data collected by Florida Atlantic University).

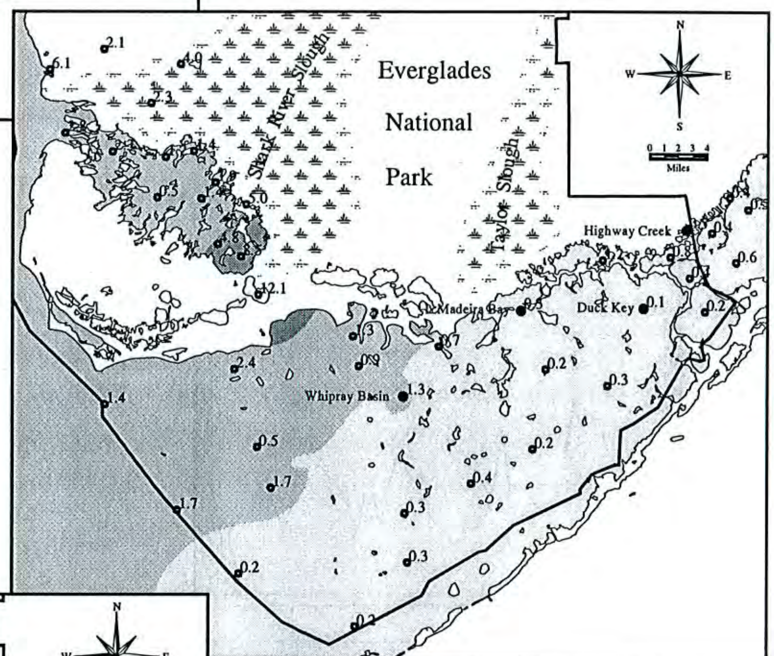
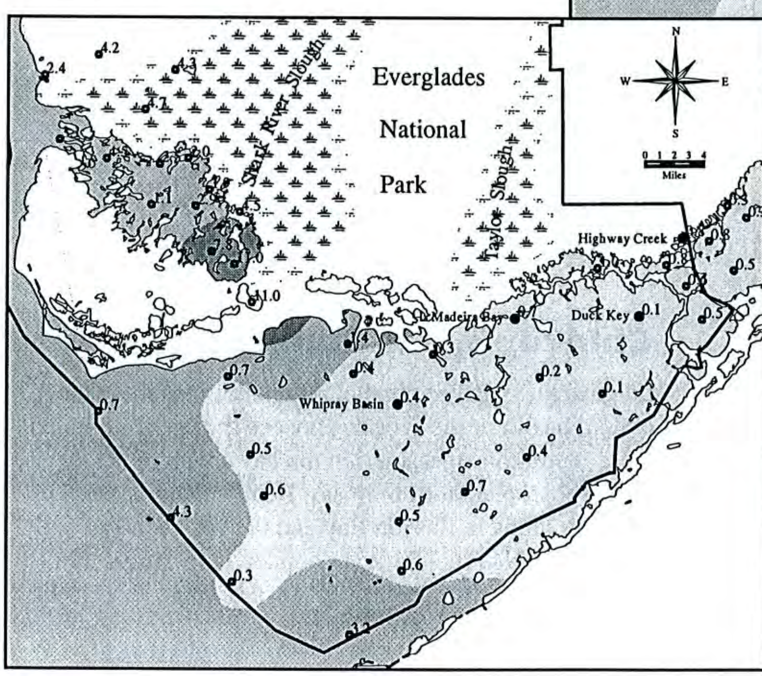


Figure 18b. Concentrations of chlorophyll *a* in Florida Bay and waters along the western coast of the Everglades National Park for May 1998 (Data collected by Florida International University).



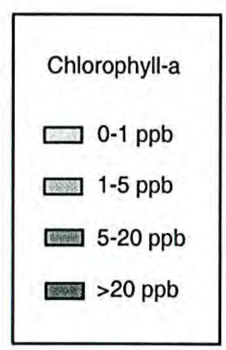


Figure 18c. Concentrations of chlorophyll *a* in Florida Bay and waters along the western coast of the Everglades National Park for June 1998 (Data collected by Florida International University).

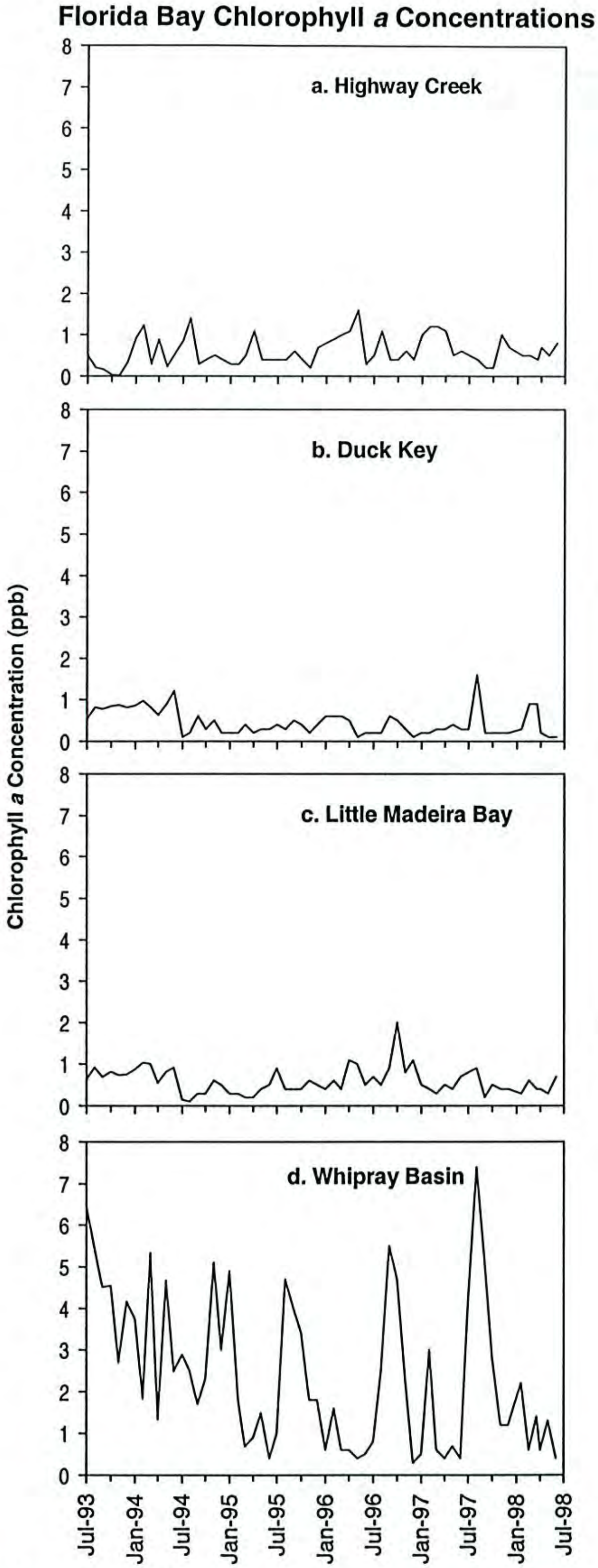


Figure 19. Chlorophyll *a* concentrations at four sites in Florida Bay from July 1, 1993 through June 30, 1998. Data are from individual grab samples which are collected monthly.

Chlorophyll *a* concentrations throughout the bay averaged 0.8 ppb during the second quarter of 1998. The lowest chlorophyll *a* levels in Florida Bay were observed in May. During this month, chlorophyll *a* concentrations ranged from 0.1 to 2.4 ppb (**Figure 18b**), with higher chlorophyll *a* concentrations generally observed in the western portion of the bay.

The highest chlorophyll *a* concentrations recorded during the second quarter were observed in June 1998 (**Figure 18c**). A maximum chlorophyll *a* concentration of 4.3 ppb was reported at the western boundary of Florida Bay. The next highest chlorophyll *a* concentration (3.2 ppb) was measured at the southernmost monitoring site in the bay.

The eastern and southern portion of Florida Bay generally had chlorophyll *a* concentrations below 2.0 ppb (**Figures 18a, 18b**, and **18c**). Generally, chlorophyll *a* levels observed during the second quarter of 1998 were similar to or lower than those reported for the same period in 1997.

Chlorophyll *a* concentrations measured at four sampling stations in Florida Bay over the past five years of monitoring are presented in **Figure 19**. Additionally, concentrations measured at these sampling stations from March 1998 through June 1998 are summarized in **Table 5**

Chlorophyll *a* concentrations at Highway Creek and Little Madeira Bay were relatively unchanged during the period from March 1998 through May 1998 with a slight increase in chlorophyll *a* levels observed in June at both sites (**Table 5**). In contrast, chlorophyll *a* levels in Duck Key exhibited a decrease from 0.9 ppb in March 1998 to 0.1 ppb in June 1998 (**Table 5**). Chlorophyll *a* levels in Whipray Basin varied between 0.4 ppb in June to 1.4 ppb in March (**Table 5**).

Table 5. Chlorophyll *a* concentrations (ppb)

	Mar-98	Apr-98	May-98	Jun-98
Highway Creek	0.4	0.7	0.5	0.8
Duck Key	0.9	0.2	0.1	0.1
L. Madeira Bay	0.4	0.4	0.3	0.7
Whipray Basin	1.4	0.6	1.3	0.4

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GLOSSARY

12-month moving average

The mean (arithmetic average) of data from 12 consecutive months. As the latest month is added to the data set, the earliest month is dropped from the data set

flow-weighted mean

The arithmetic average adjusted for flow:

$$\bar{x} = \frac{\left(\sum_{i=1}^{i=n} q_i c_i\right)}{\left(\sum_{i=1}^{i=n} q_i\right)}$$

q = flow
c = concentration

geometric means

The nth root of individual data values that have been multiplied:

$$G = \sqrt[n]{x_1 x_2 \ldots x_n}$$

units of concentration measurement

(assuming density of water = 1.0)

grams/kilograms (g/kg)	=	1 part /thousand	(ppt)
milligram/Liter (mg/L)	=	1 part/million	(ppm)
microgram/Liter (µg/L)	=	1 part/billion	(ppb)
nanogram/Liter (ng/L)			

3-year moving average

The mean (arithmetic average) of data from 3 consecutive annual values. As the latest year is added to the data set, the earliest month is dropped from the data set.

WATER QUALITY CONDITIONS QUARTERLY REPORT
SOUTH FLORIDA WATER MANAGEMENT DISTRICT • OCTOBER 1998
A PUBLICATION OF THE WATER RESOURCES EVALUATION DEPARTMENT

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